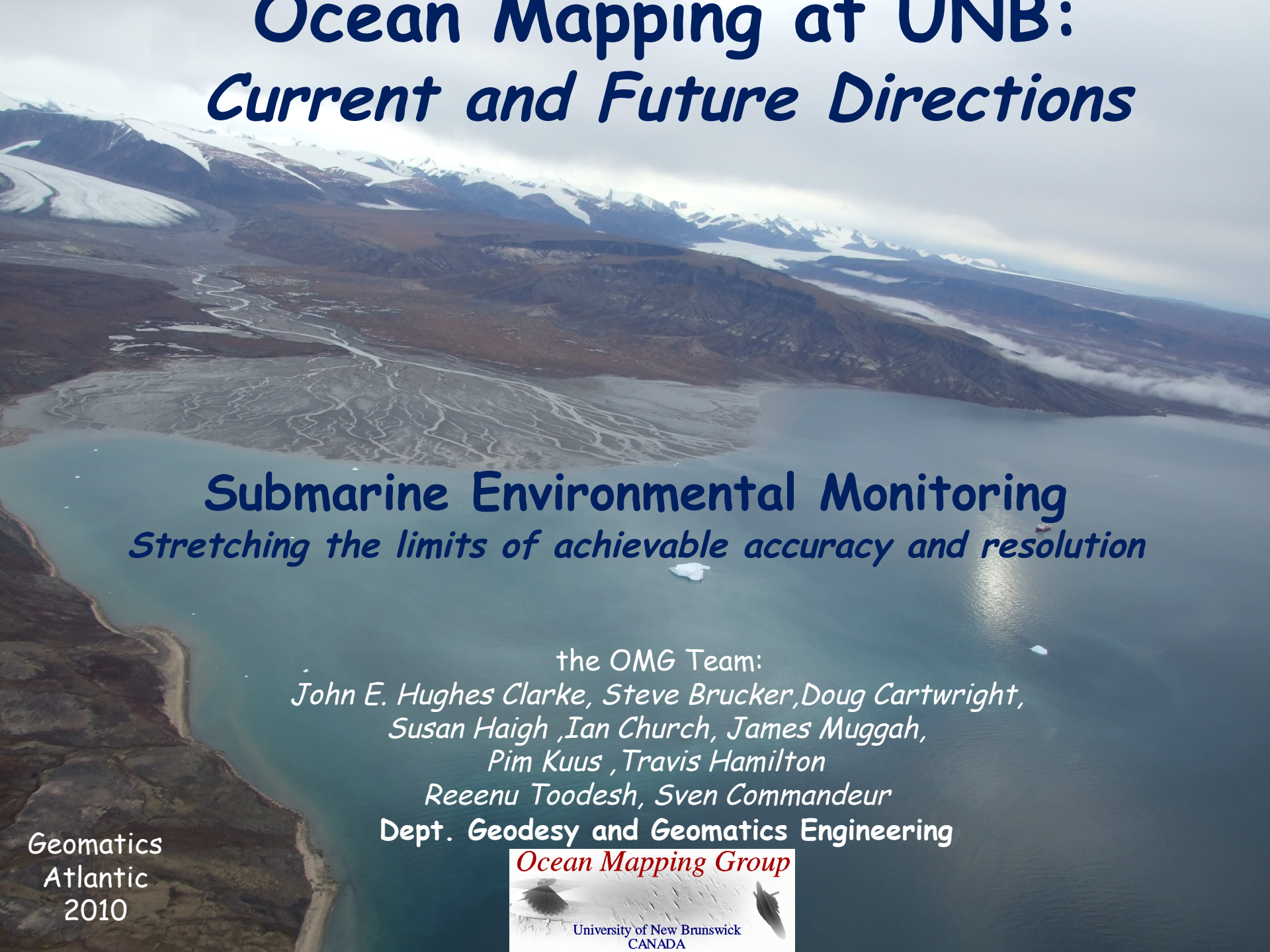
Ocean Mapping at UNB:
Current and Future Directions



Submarine Environmental Monitoring
Stretching the limits of achievable accuracy and resolution

the OMG Team:

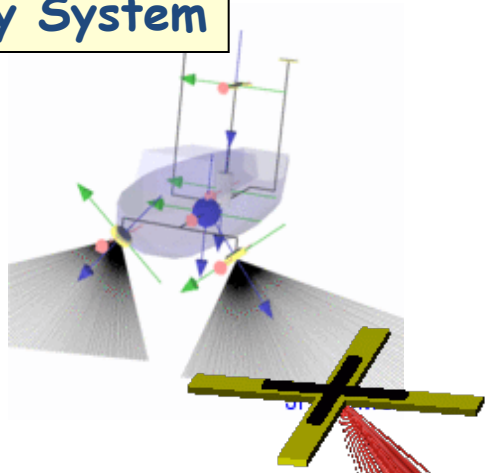
John E. Hughes Clarke, Steve Brucker, Doug Cartwright,
Susan Haigh , Ian Church, James Muggah,
Pim Kuus , Travis Hamilton
Reeenu Toodesh, Sven Commandeur

Dept. Geodesy and Geomatics Engineering

Ocean Mapping Group
University of New Brunswick
CANADA

Geomatics
Atlantic
2010

Components of Integrated Survey System



Active Research Projects:

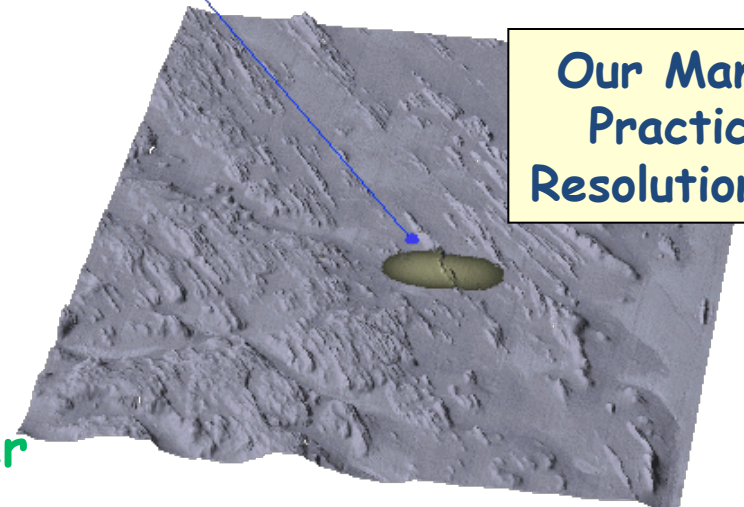
Port of Saint John – 2008-2014
Oceanographic – sound speed variability

Arctic Fjord Deltas 2006-2010
(hopefully renewed to 2017)
Fjord Dynamics.
Plans for next 7 years.

Squamish Delta BC (2004-2009)
4 years of observations
Future Plans (2010/2011 operations)

What controls our achievable:

- **Horizontal Positioning**
- **Vertical Positioning**
- **Orientation**
- **Maximum Range**
- **Range Resolution**
- **Angular Resolution**
- **Water Levels**
- **Sound Speed**
- **Seabed Backscatter**



Our Mandated Interest:
Practically Achievable Resolution and Uncertainty

Ocean Mapping Group
University of New Brunswick
CANADA

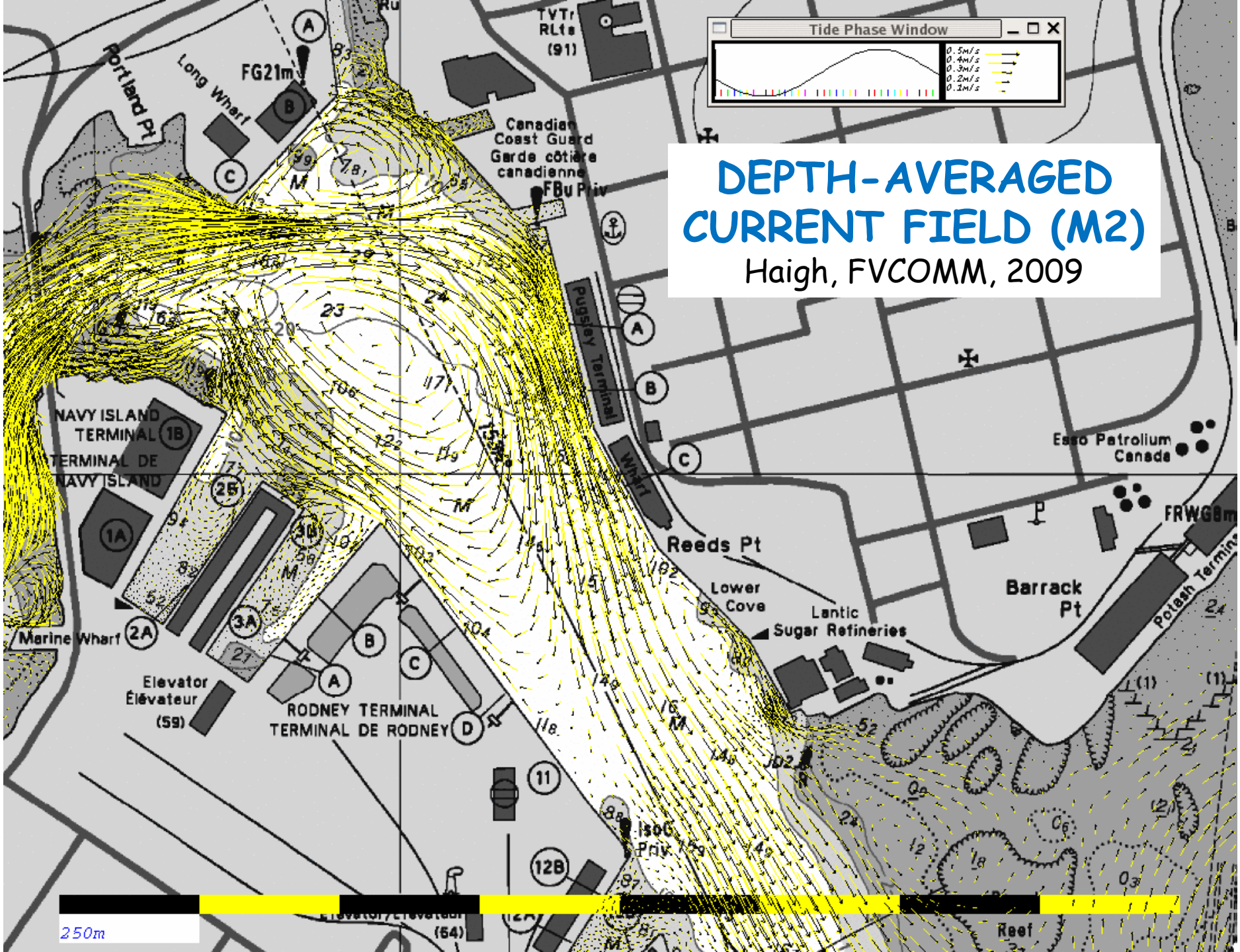
Areas of Operation

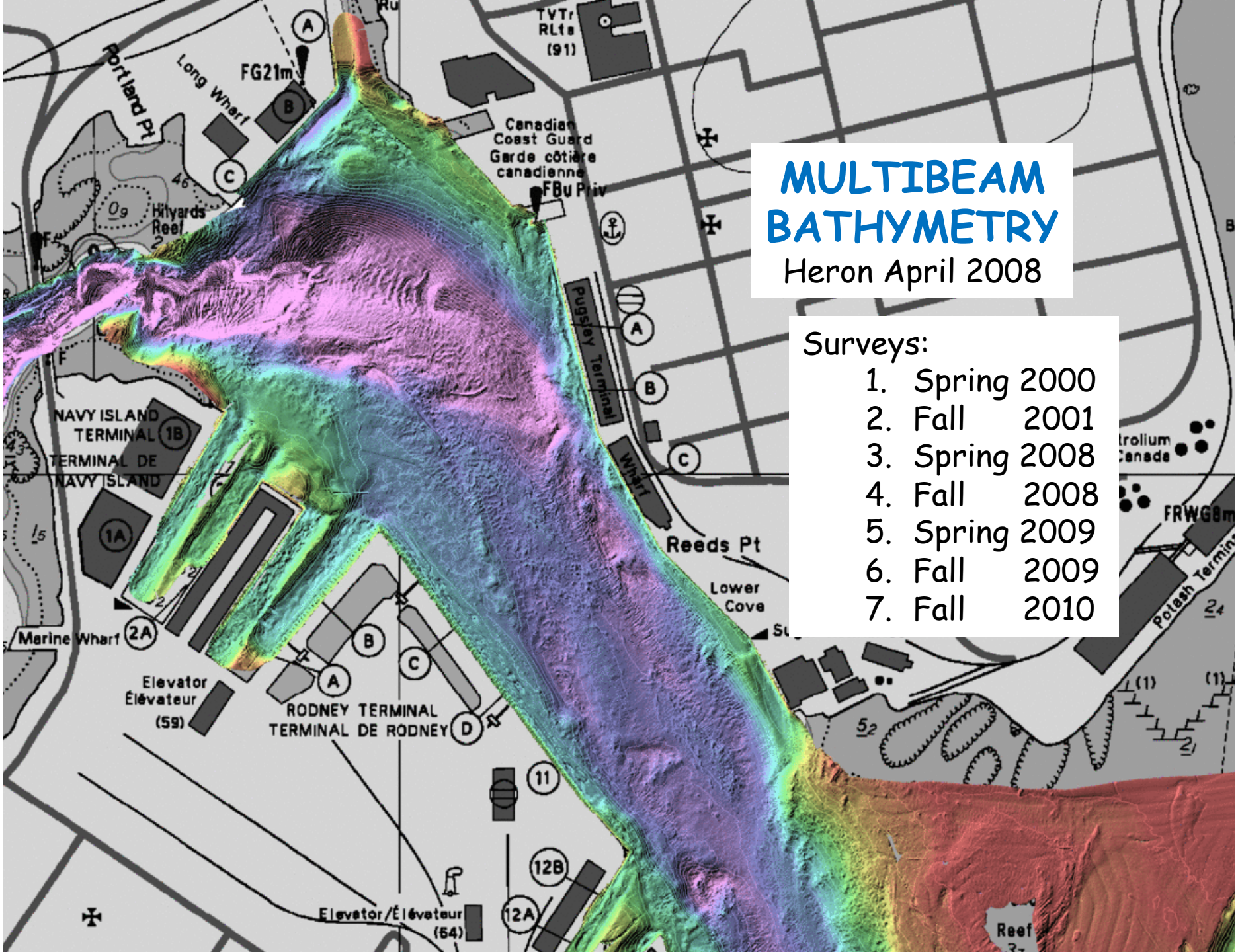
An improved understanding of the sedimentation, circulation, and ecology of Saint John Harbour

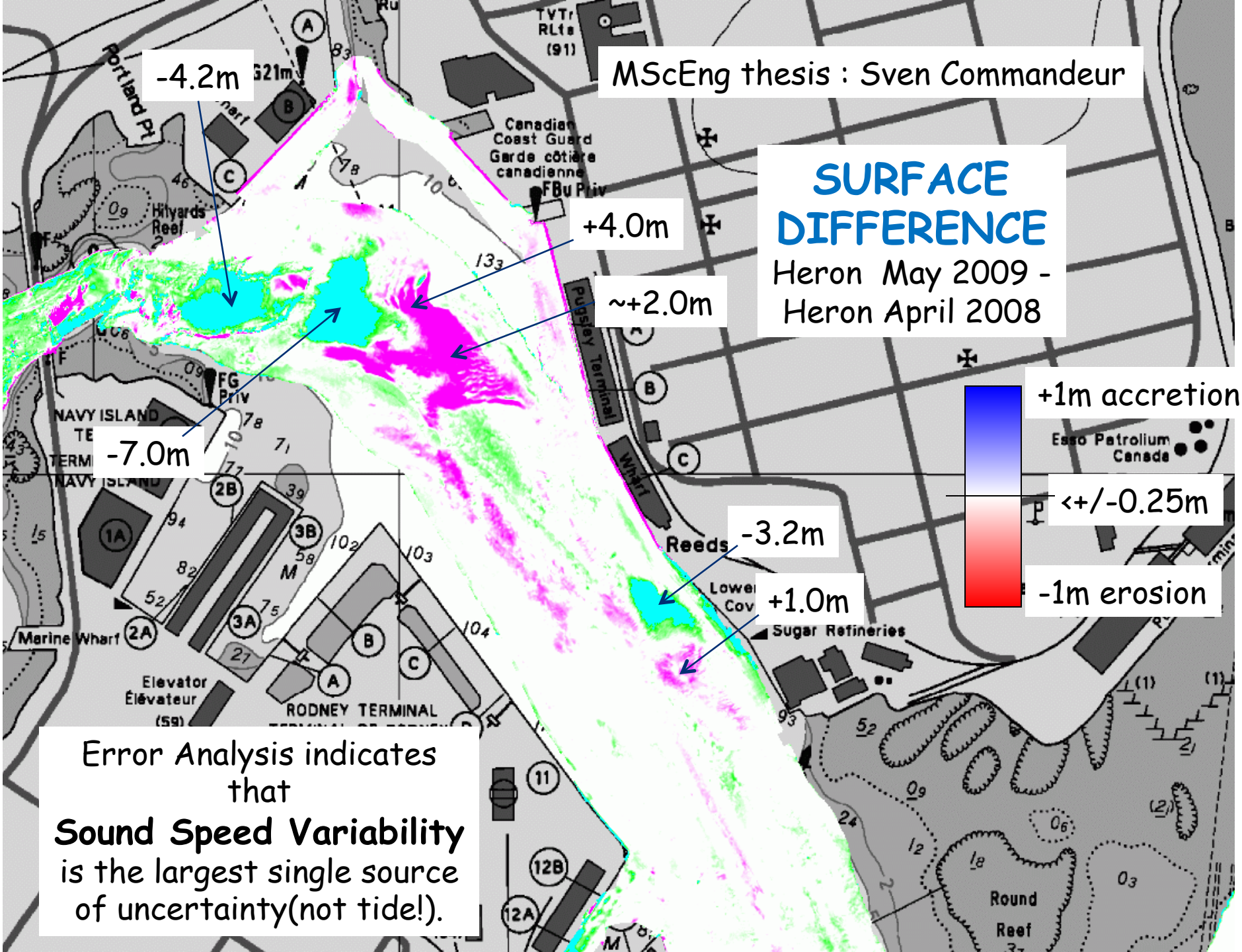
4 years NSERC CRD (with Port of Saint John)
2010-2014 C$660,000
GGE - Civil – Biology - INRS

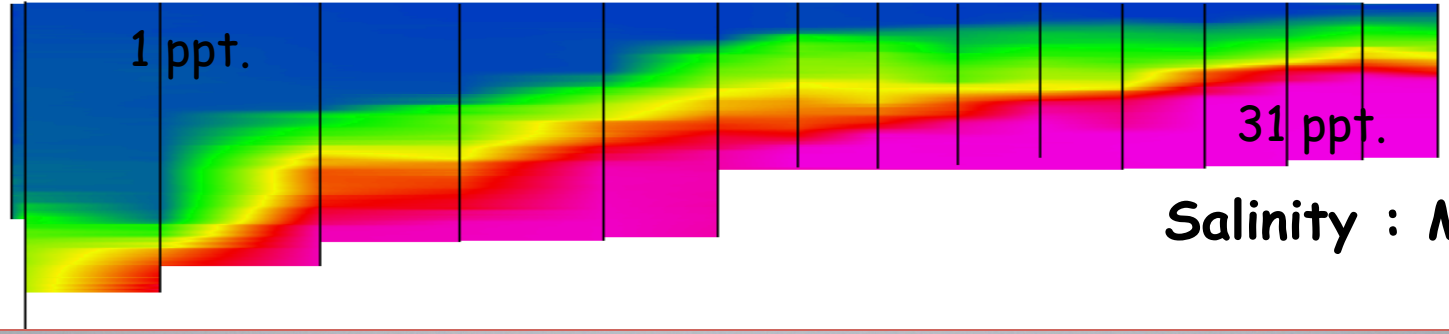
The Challenge:

- **MacroTidal** + Rapid Phase and Amplitude Variations
  (Reversing Falls)
- **Extreme Oceanographic Variability:**
  Saint John River Discharge – Strong seasonal signal
- **Critical Commercial Requirement** :
  Predicting sedimentation for dredging operations


Tide Phase Window
0.5m/s
0.4m/s
0.3m/s
0.2m/s
0.1m/s
DEPTH-AVERAGED CURRENT FIELD (M2)
Haigh, FVCOMM, 2009
Port Hand Pt
Long Wharf
FG21m
Canadian Coast Guard
Garde côtière canadienne
FBu Priv
Pugsley Terminal
Wharf
NAVY ISLAND TERMINAL
TERMINAL DE NAVY ISLAND
Esso Petrolium Canada
FRWG8m
Reeds Pt
Lower Cove
Lantic Sugar Refineries
Barrack Pt
Potash Termina
Marine Wharf
Elevator
Élévateur
(59)
RODNEY TERMINAL
TERMINAL DE RODNEY
Isog Priv
Reef
250m


MULTIBEAM
BATHYMETRY
Heron April 2008
Surveys:
1. Spring 2000
2. Fall 2001
3. Spring 2008
4. Fall 2008
5. Spring 2009
6. Fall 2009
7. Fall 2010
Portland Pt
Long Wharf
FG21m
Canadian Coast Guard
Garde côtière canadienne
FBu Priv
Hilyards Reef
Pugsley Terminal
Wharf
NAVY ISLAND TERMINAL
TERMINAL DE NAVY ISLAND
Reeds Pt
Lower Cove
Marine Wharf
Elevator
Élévateur
(59)
RODNEY TERMINAL
TERMINAL DE RODNEY
Elevator/Élévateur
(54)
Reef


MScEng thesis : Sven Commandeur
SURFACE DIFFERENCE
Heron May 2009 - Heron April 2008
-4.2m
+4.0m
~+2.0m
-7.0m
-3.2m
+1.0m
+1m accretion
<+/-0.25m
-1m erosion
Error Analysis indicates that
Sound Speed Variability
is the largest single source of uncertainty(not tide!).
Portland Pt
Canadian Coast Guard
Garde côtière canadienne
Hilyards Reef
Pugsley Terminal
Wharf
Reeds
Esso Petrolium Canada
NAVY ISLAND
Marine Wharf
Elevator
Élévateur
RODNEY TERMINAL
Sugar Refineries
Round Reef

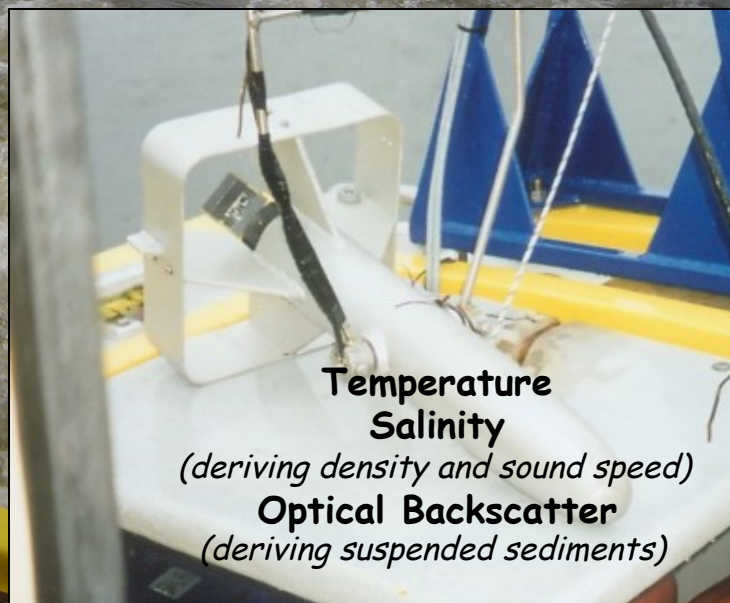


Salinity : MVP-30

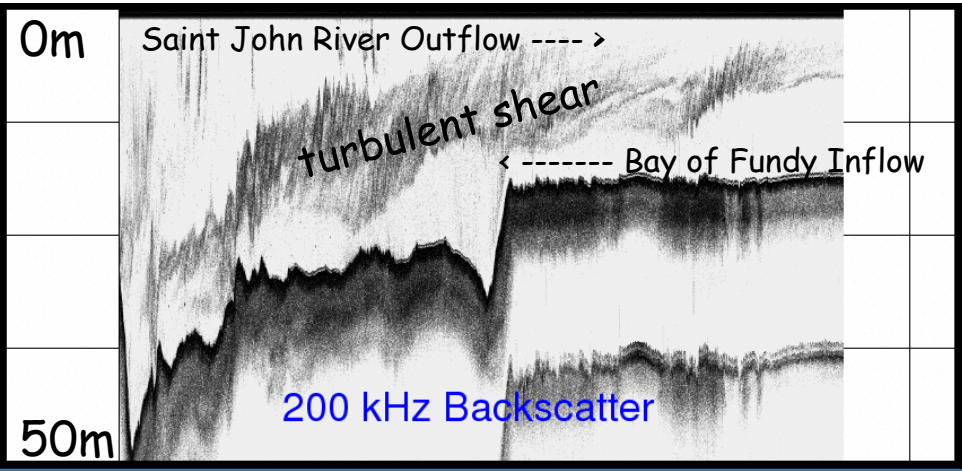
Longitudinal Oceanographic Sections

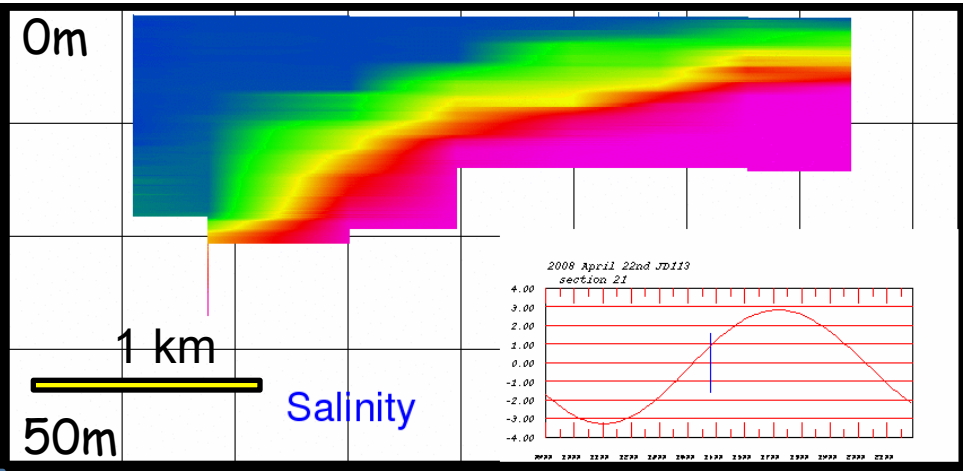
(Main Harbour and Courtney Bay Channel)
repeated 20x over a tidal cycle

MScEng thesis : Reenu Toodesh



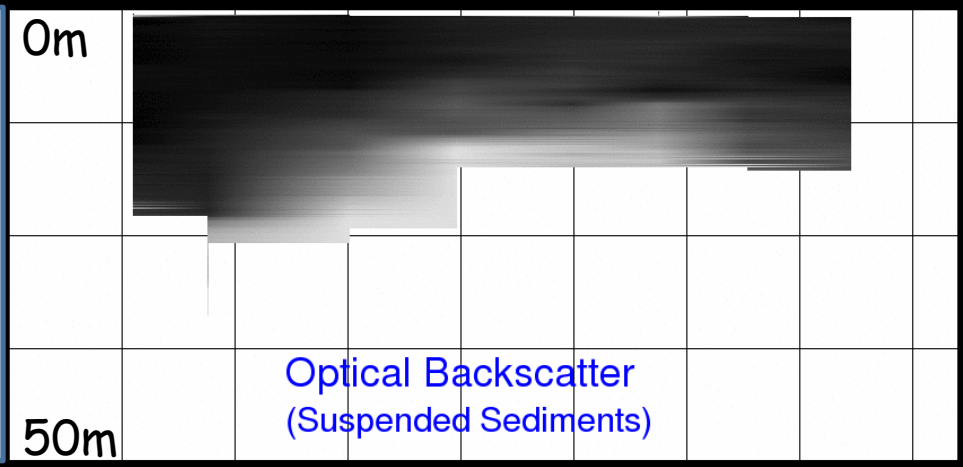
Temperature
Salinity
(deriving density and sound speed)
Optical Backscatter
(deriving suspended sediments)

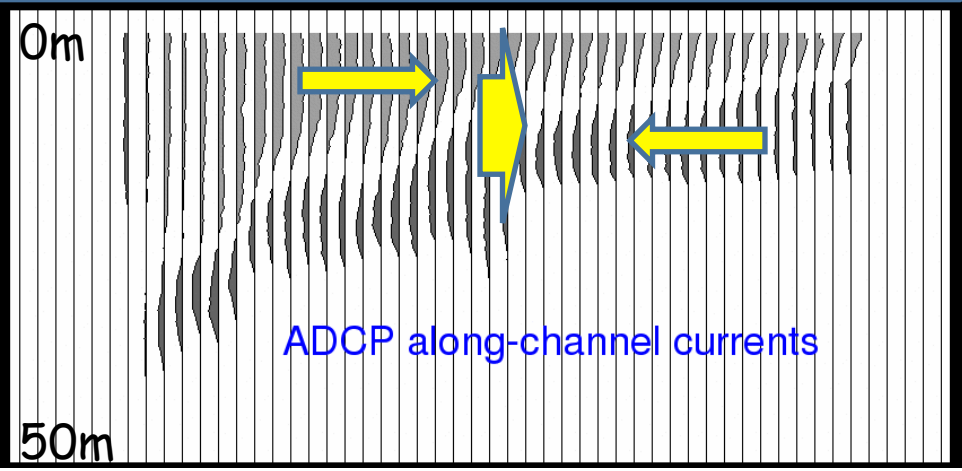


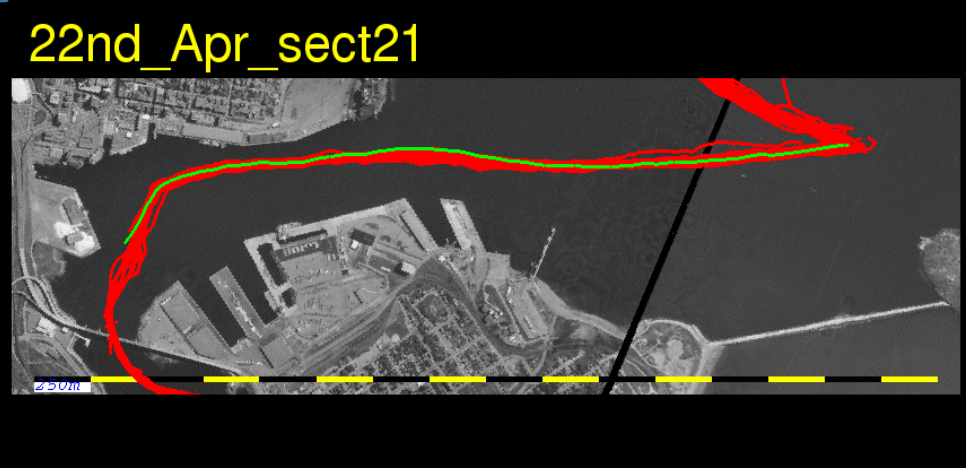


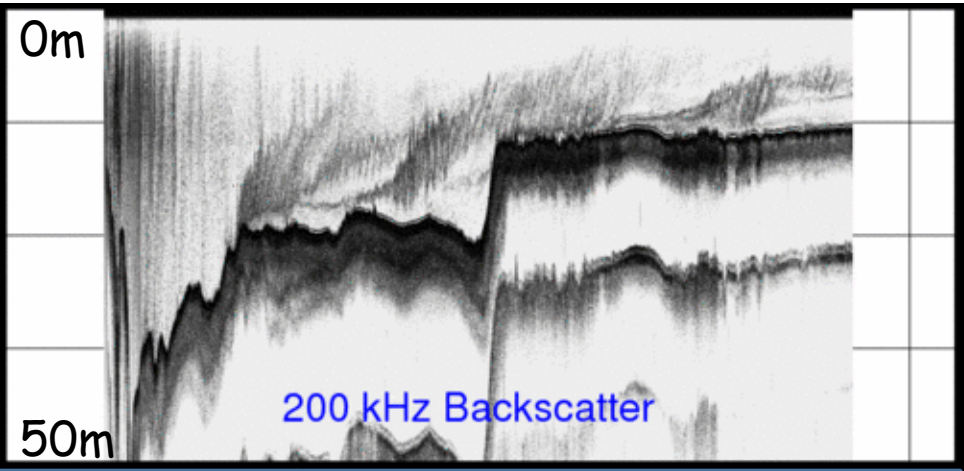
Imaging Estuarine Circulation of the Harbour over a tidal cycle.

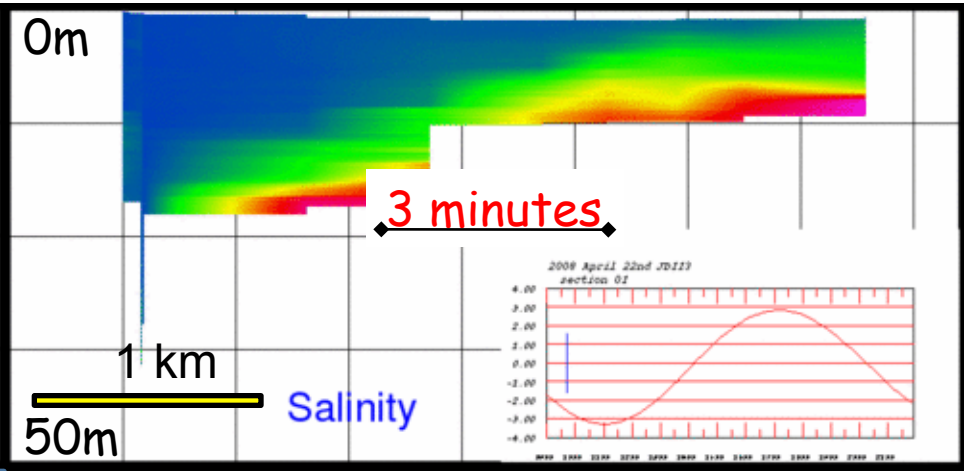
The salt water/Freshwater interface is the largest single source of bathymetric uncertainty.
It is also the mechanism for reintroduction of suspended sediments into the docks.











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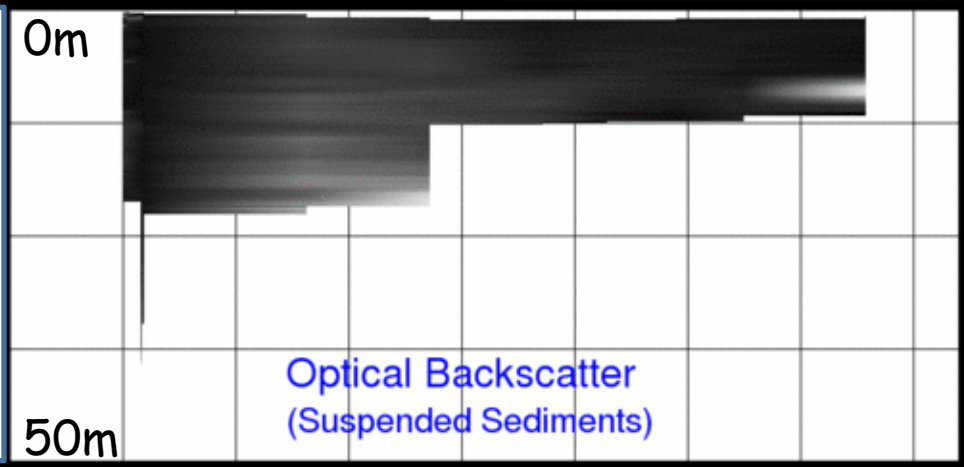
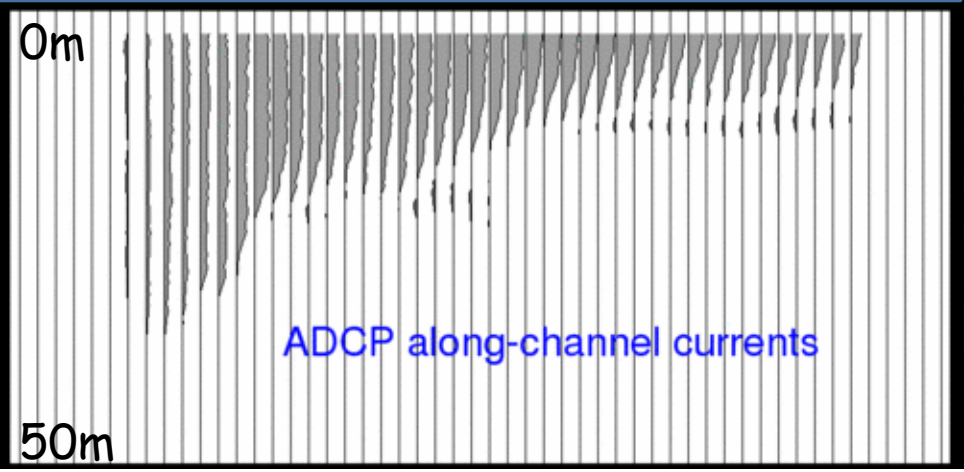
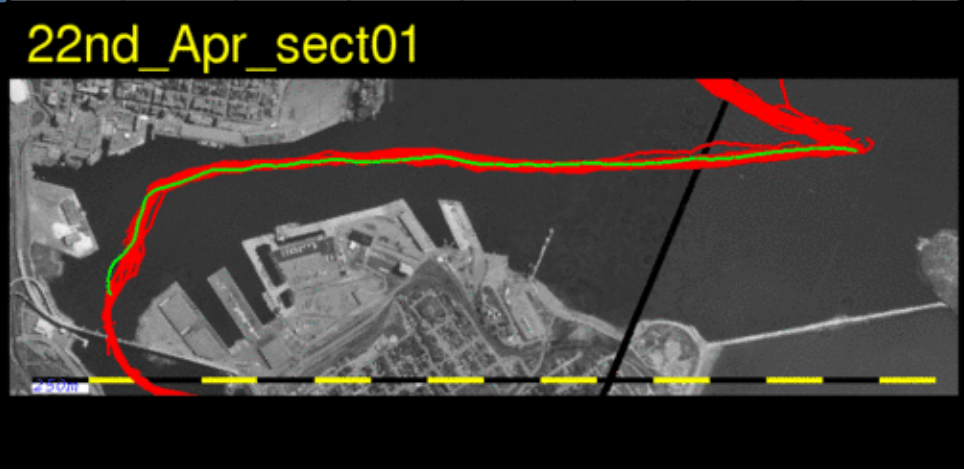
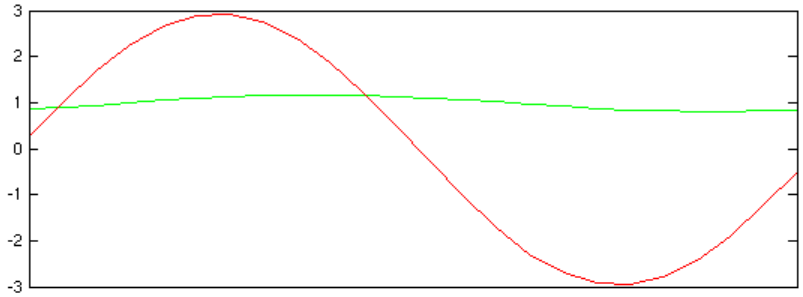
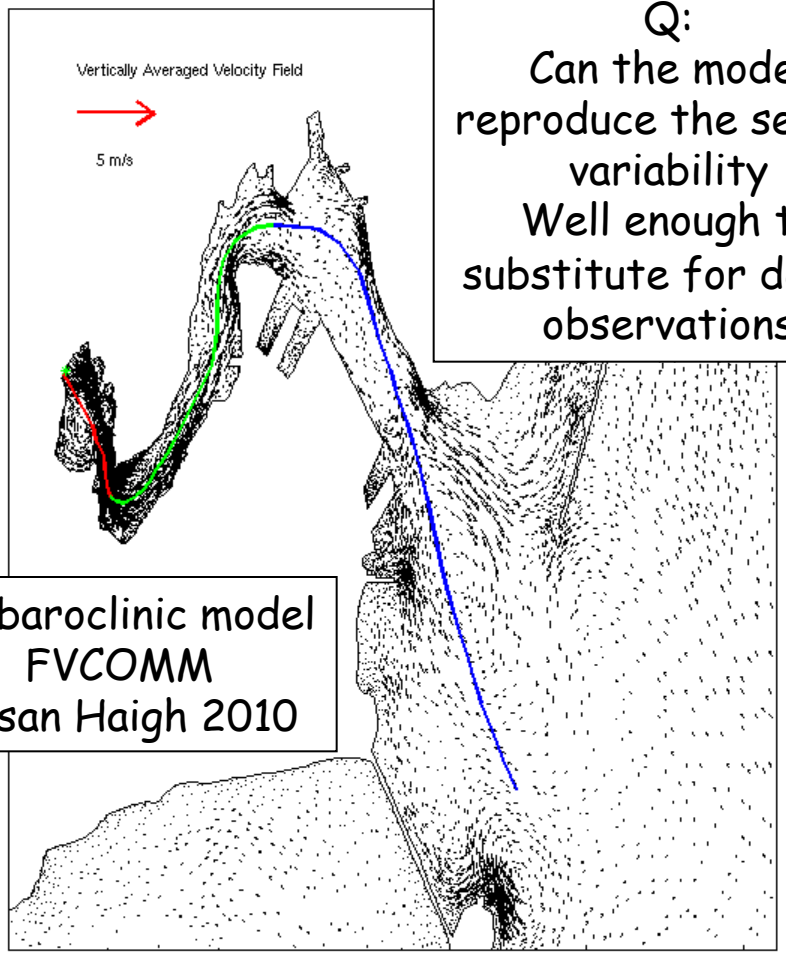




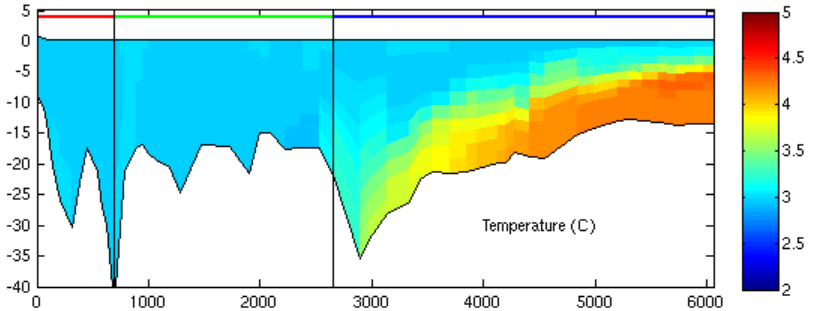


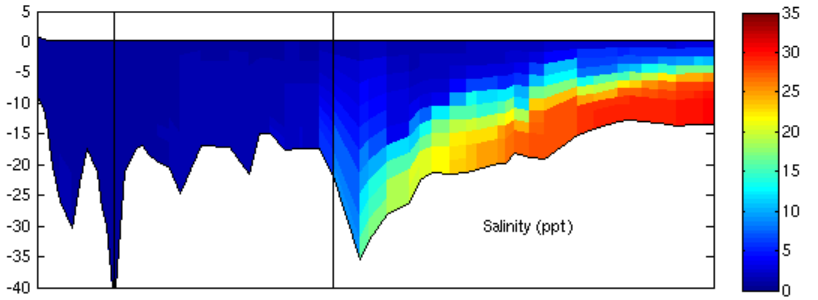


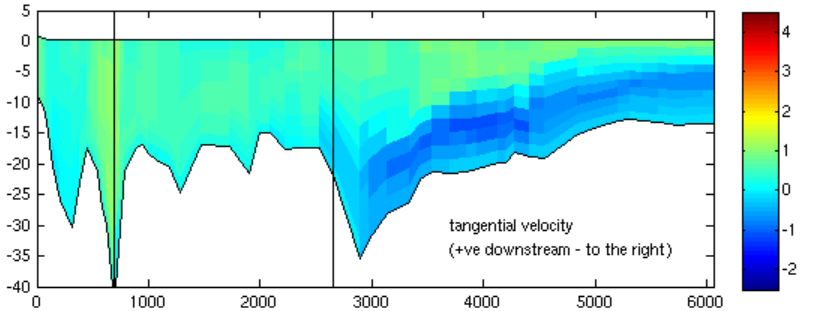


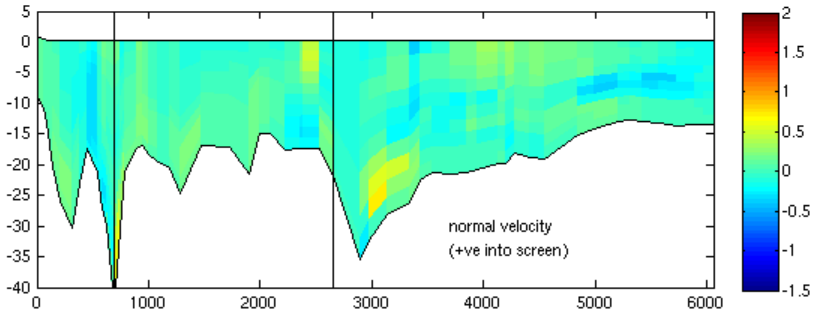
Q:
Can the model reproduce the season variability
Well enough to substitute for dense observations

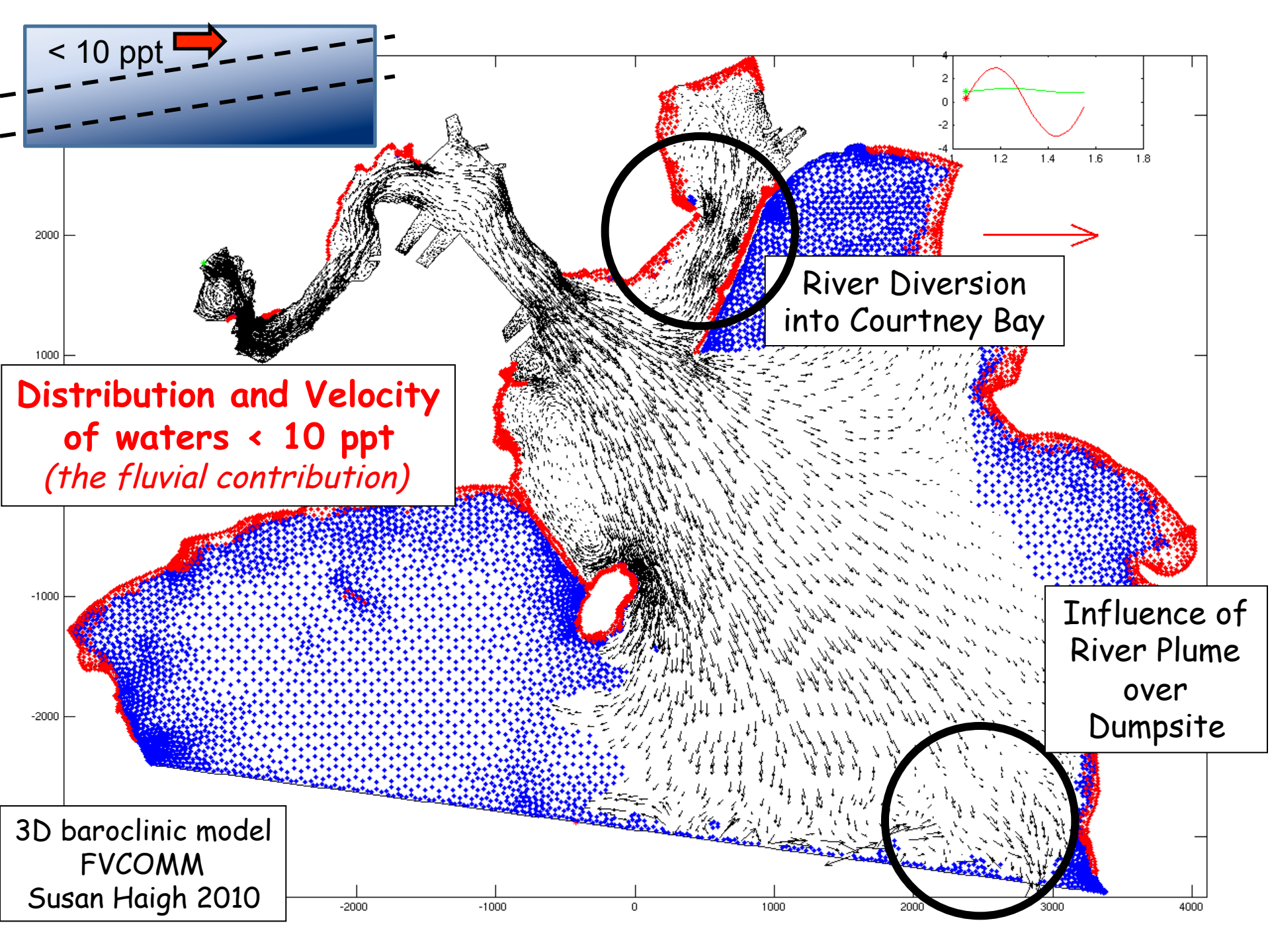
3D baroclinic model
FVCOMM
Susan Haigh 2010

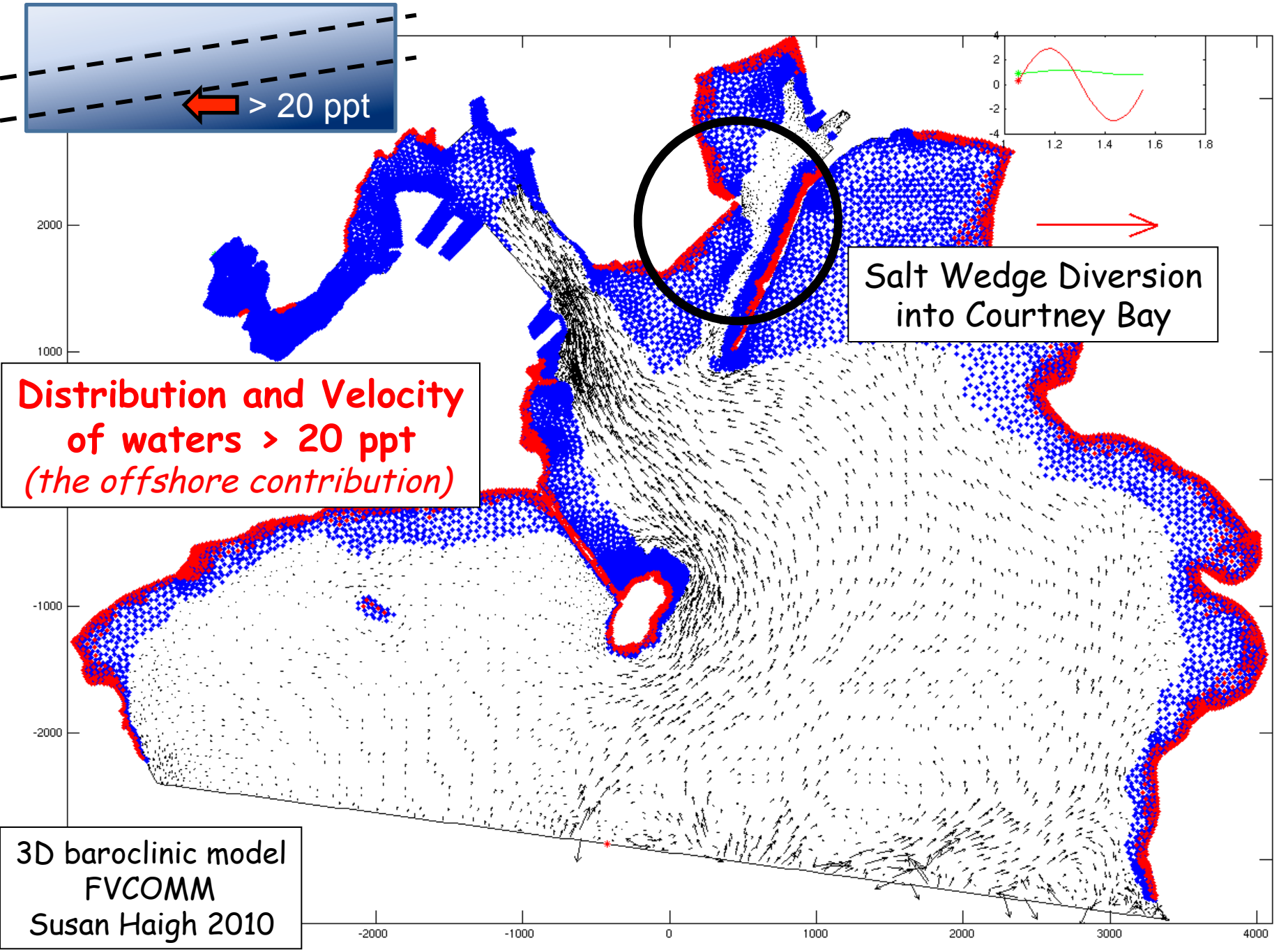








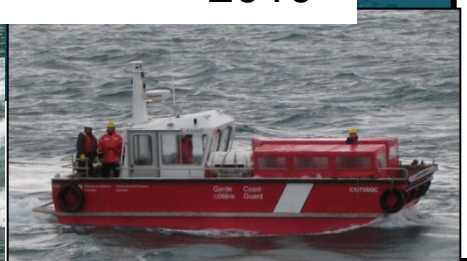

< 10 ppt
River Diversion into Courtney Bay
Distribution and Velocity of waters < 10 ppt
(the fluvial contribution)
Influence of River Plume over Dumpsite
3D baroclinic model
FVCOMM
Susan Haigh 2010
2000
1000
-1000
-2000
-2000
-1000
0
1000
2000
3000
4000
1.2
1.4
1.6
1.8


> 20 ppt
Salt Wedge Diversion into Courtney Bay
Distribution and Velocity of waters > 20 ppt
(the offshore contribution)
3D baroclinic model
FVCOMM
Susan Haigh 2010
2000
1000
-1000
-2000
-2000
-1000
0
1000
2000
3000
4000
1.2
1.4
1.6
1.8

CCGS Amundsen – Research Icebreaker 2003-2017

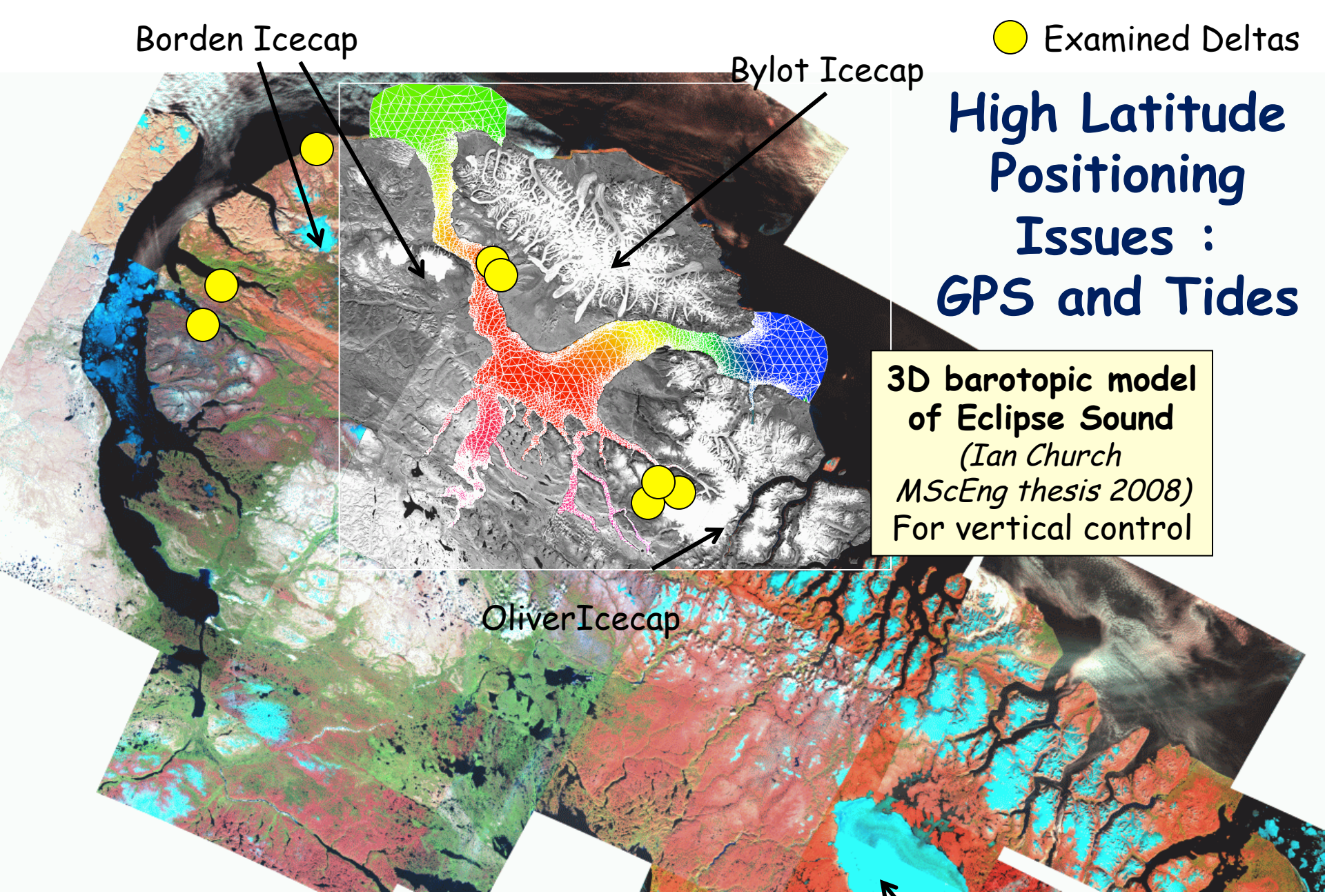
Complimentary Inshore Capability

2006/2008 2010



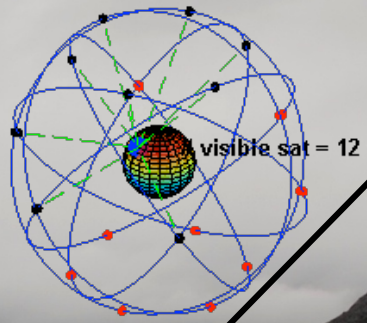
UNB Mapping Personnel : 2010

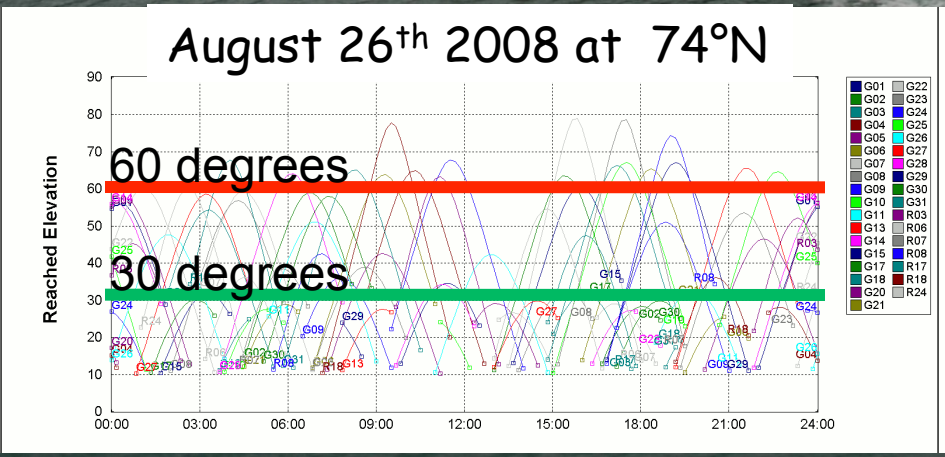
LEG 1: Quebec City to Kugluktuk		
•Steve Brucker	BSE.GGE	2004
•James Muggah	ME.GGE	2010
•Hesham Elghazy	ME.GGE	2011
LEG 2: Kugluktuk to Sachs Harbour		
•Doug Cartwright	ME.GGE	2002
•Ian Church	MScEng.GGE	2008
•Sven Commandeur	ME.GGE	2011
•Jose de la Madrid	ME.GGE	2010
LEG 3: Sachs Harbourt to QuebecCity		
•Pim Kuus	MScEng.GGE	2008
•Travis Hamilton	BSE.GGE	2010

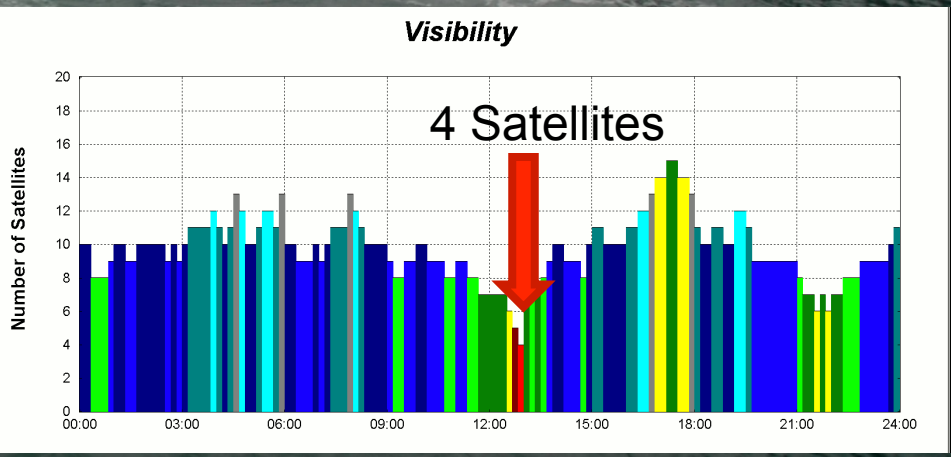


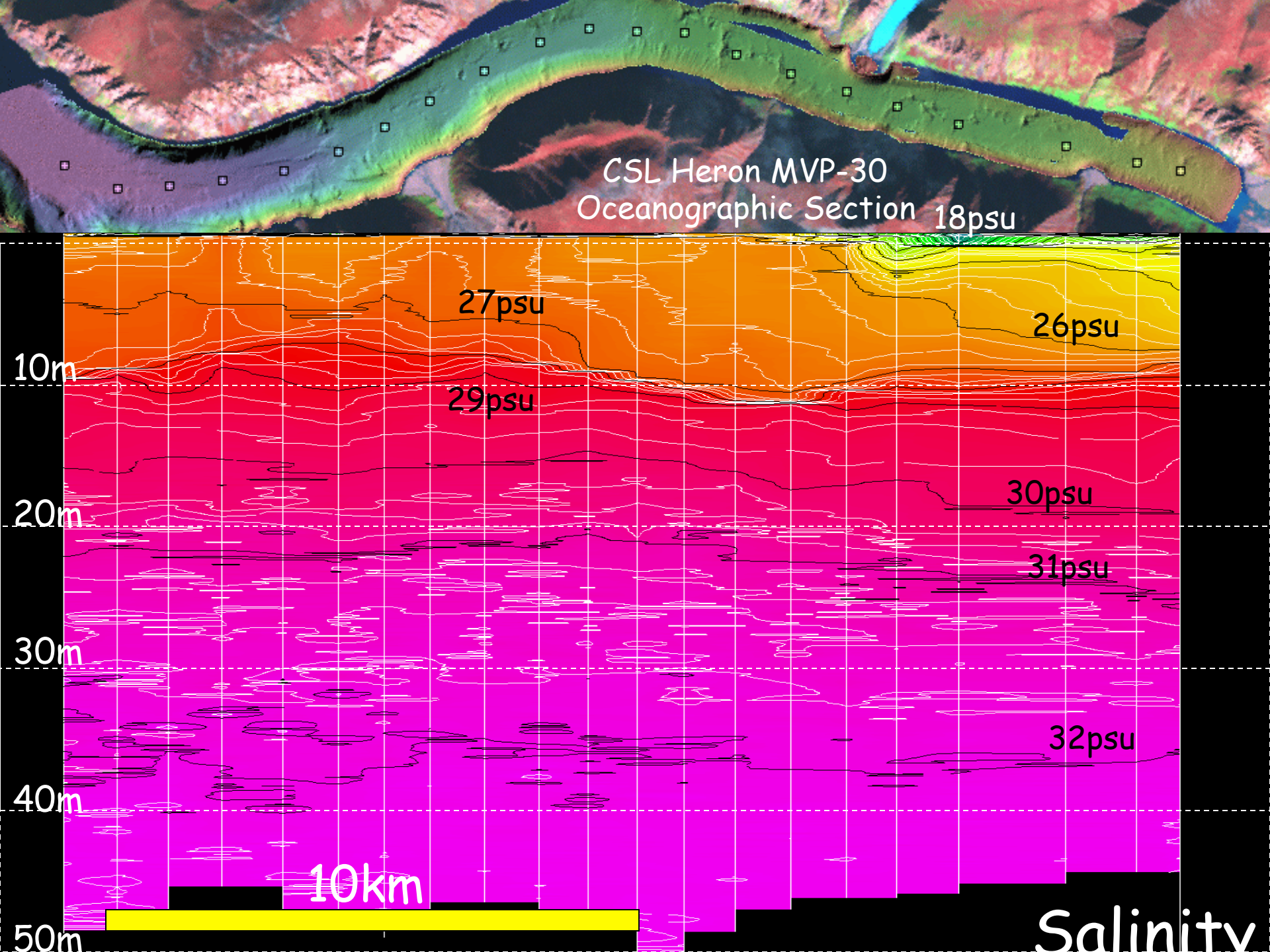
Baffin Island Permanent Icecaps

High Latitude Satellite Masking 74°N







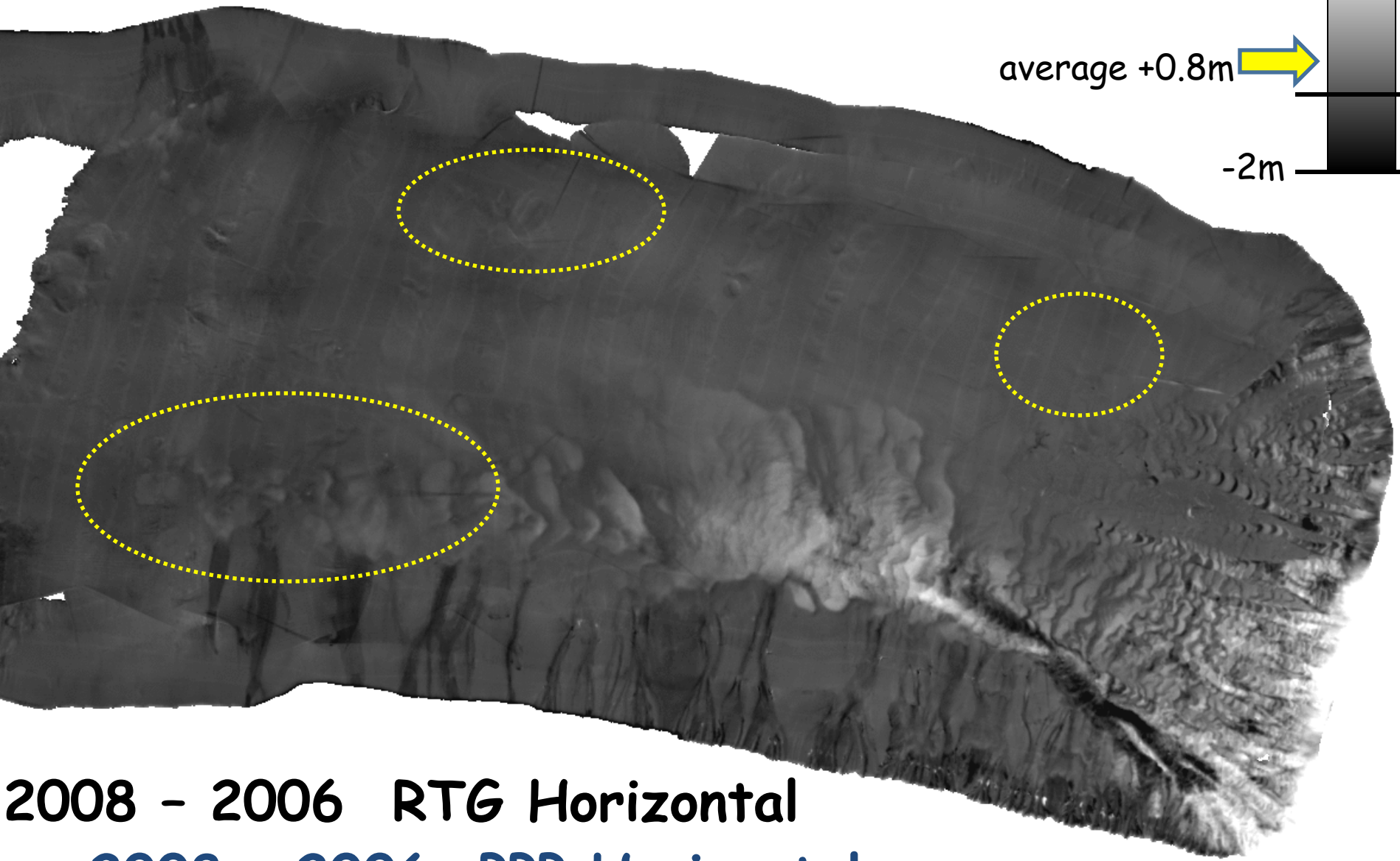

CSL Heron MVP-30
Oceanographic Section
18psu
27psu
26psu
29psu
30psu
31psu
32psu
10m
20m
30m
40m
50m
10km
Salinity

500m
100m

80m
70m
60m
50m
40m

2006 v. 2008

BIANNUAL SURFACE DIFFERENCES



2008 – 2006 RTG Horizontal

2008 – 2006 PPP Horizontal

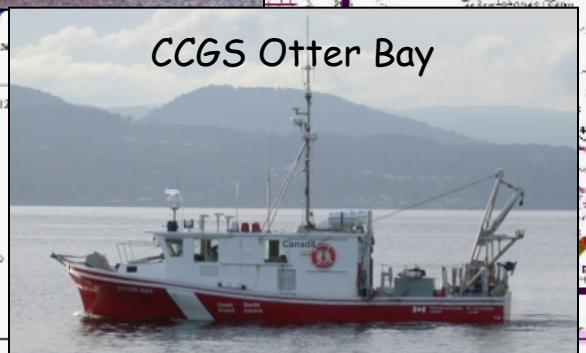
Both surfaces use : Hydrodynamic Model for Tides.

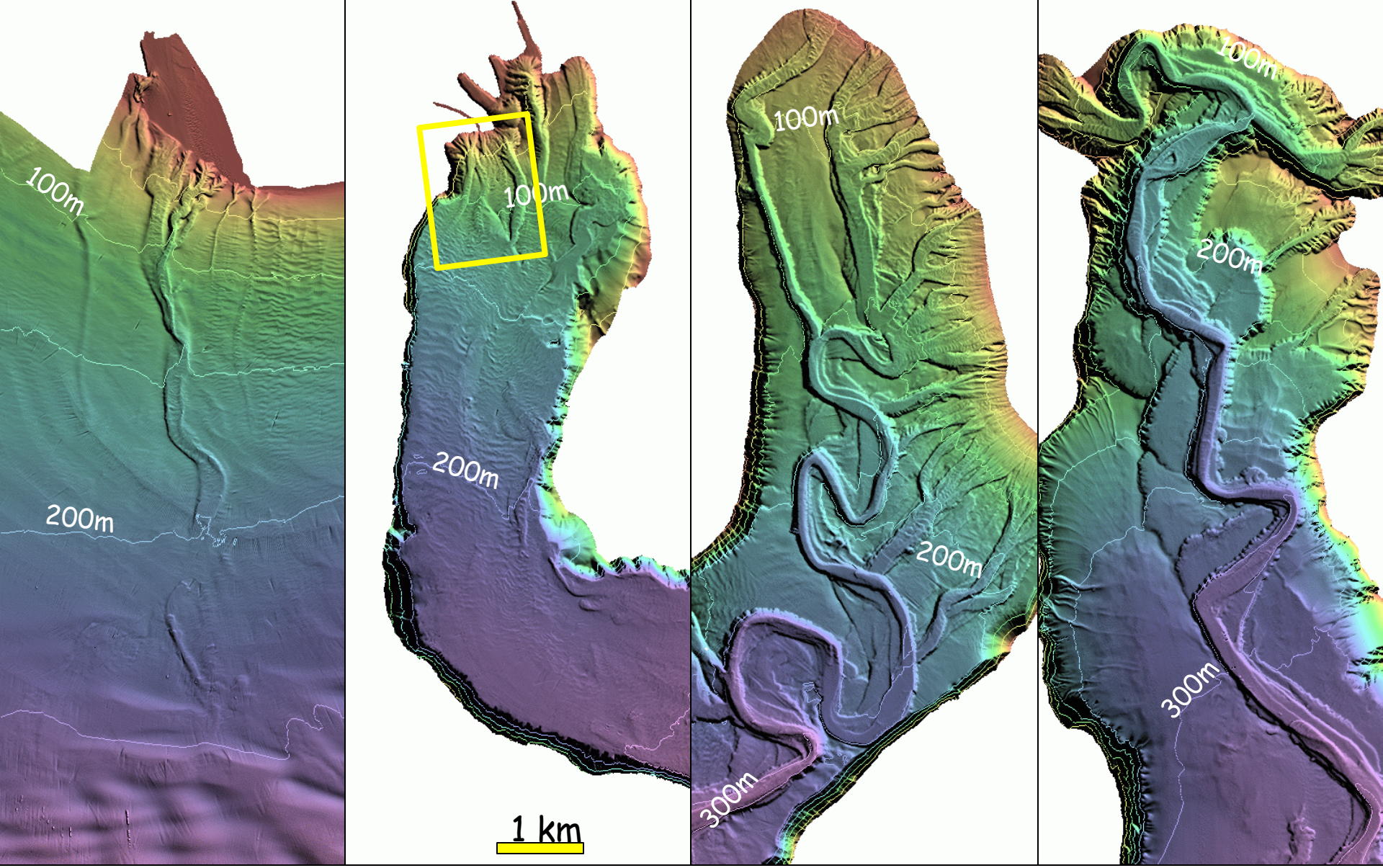
Fjord Delta Operations

2004-2009

NRCan/CHS/UNB collaborative operations

Loci of Sediment input





Sands Head Sea Valley, Georgia Basin

Squamish and Chekamus Delta Howe Sound

Klinaklini and Franklin Delta Knight Inlet

Homathko and Southgate Delta Bute Inlet

Squamish River Discharge: 2003-2009

411mm October 15th -18th 2003
2630 m^3/s

Discharge
m^3/s

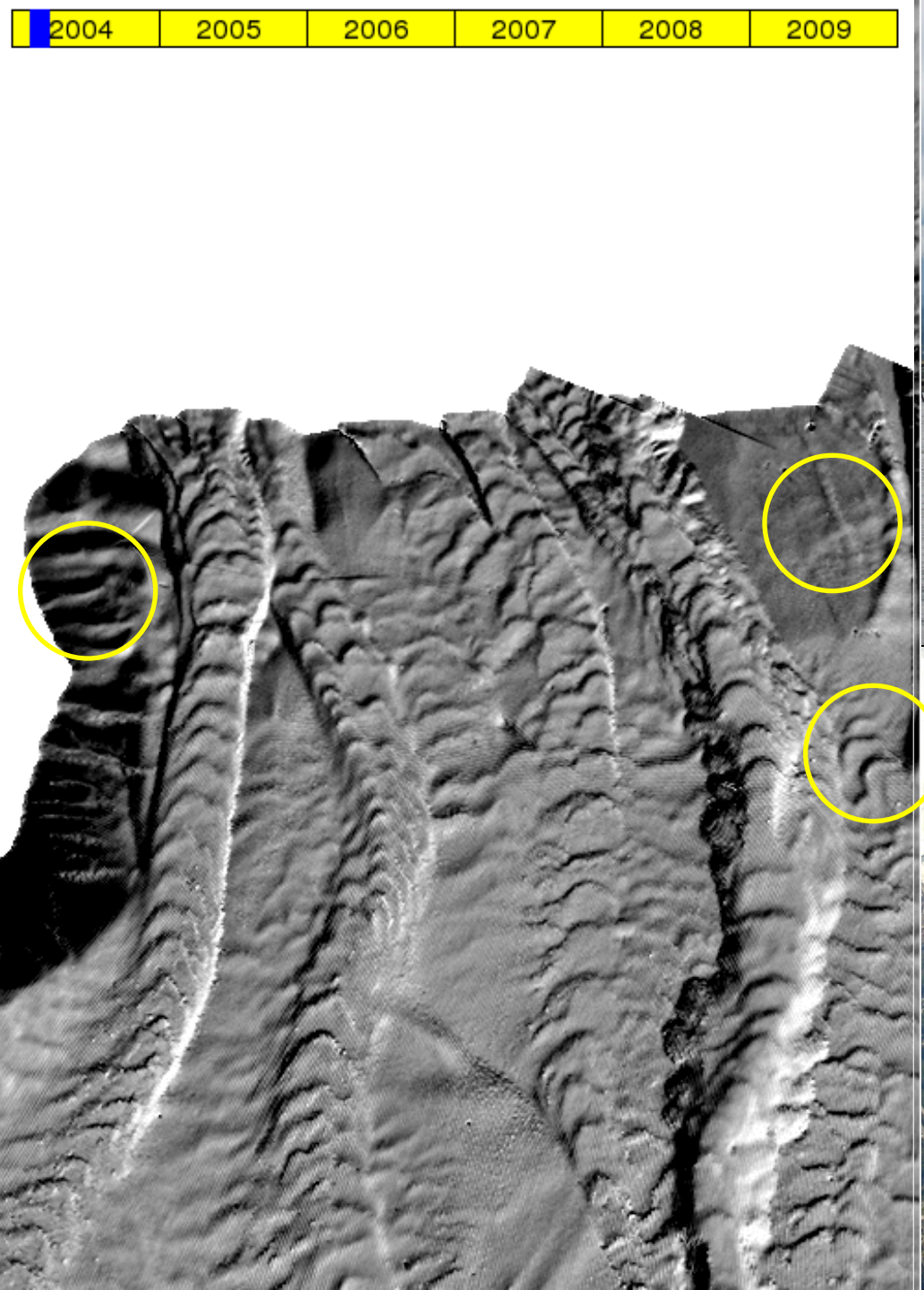
1500

1000

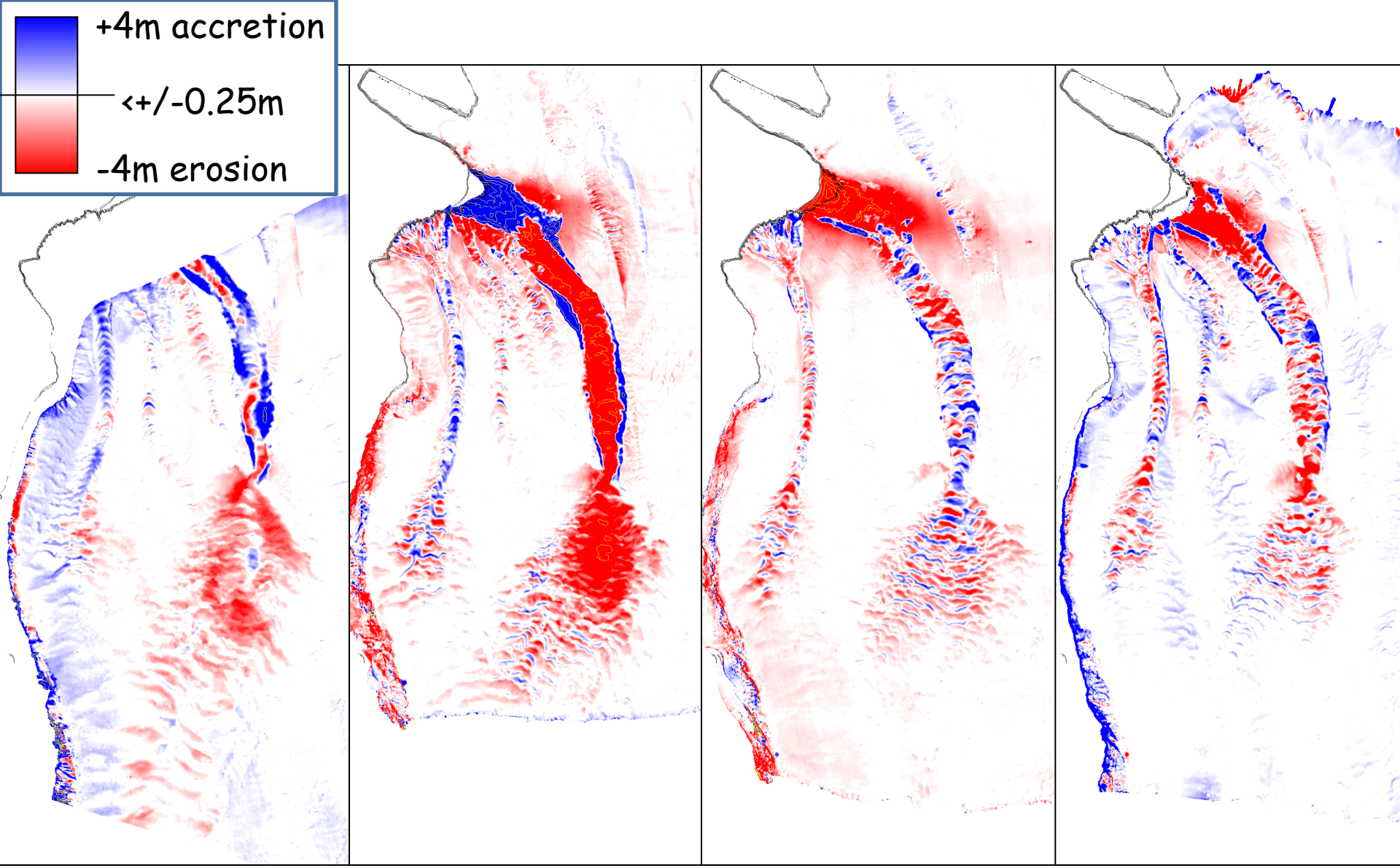
500

2003 2004 2005 2006 2007 2008 2009

Source : **SQUAMISH RIVER NEAR BRACKENDALE (08GA022), Environment Canada, http://scitech.pyr.ec.gc.ca**



Change Analysis
Squamish Port and Delta Mouth
British Columbia



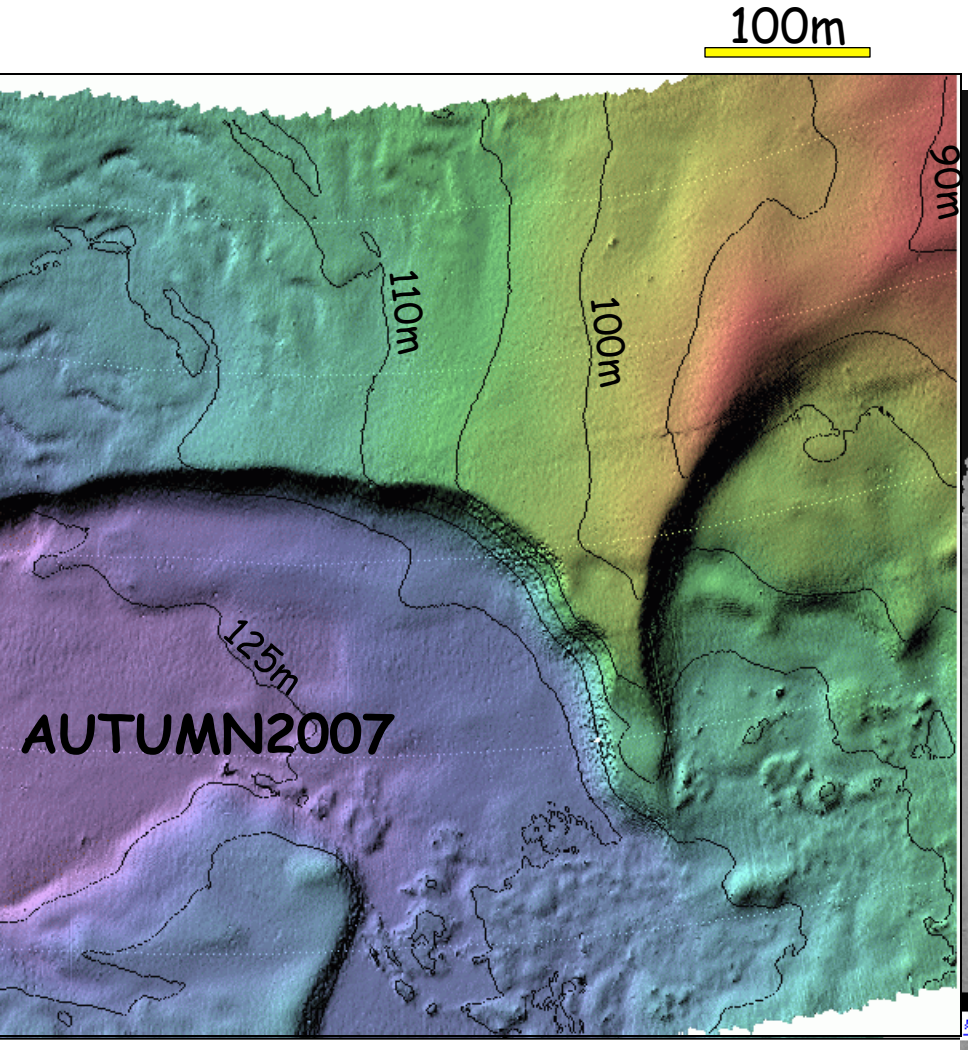
Summer of 2004 and 2005

Summer of 2006

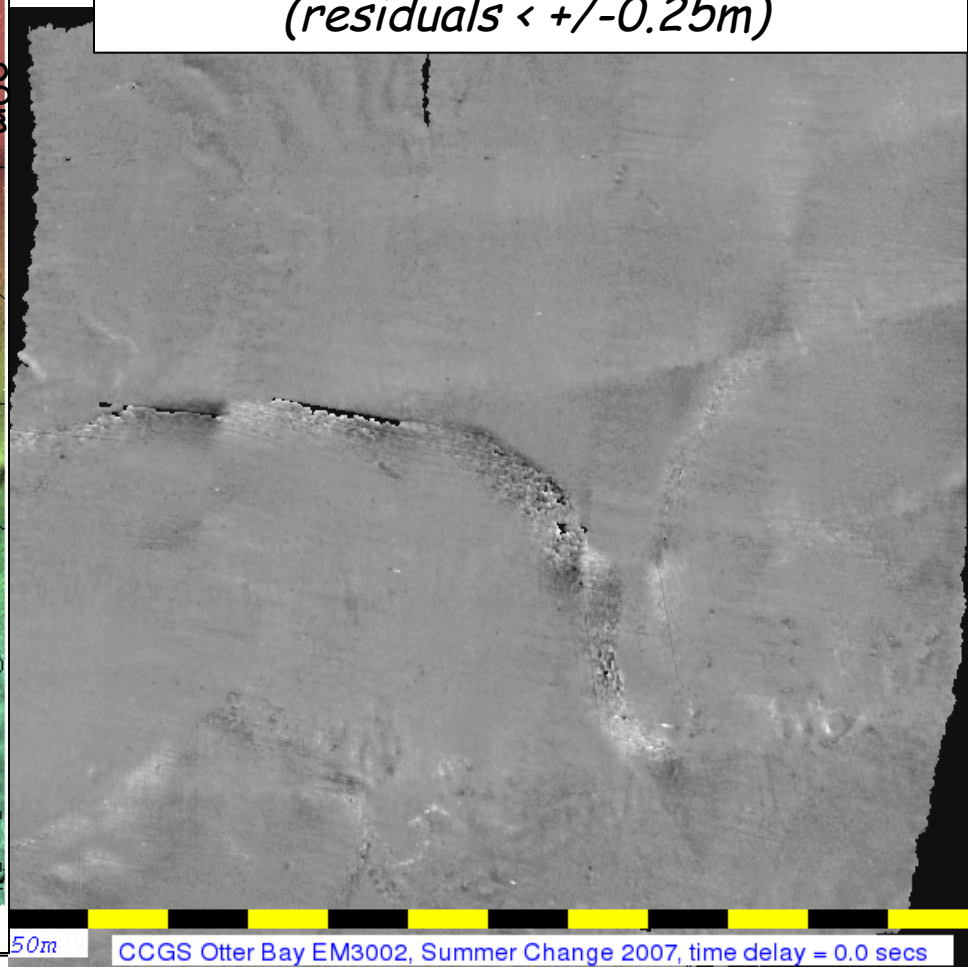
Summer of 2007

Summer of 2008

Insights into fjord prodelta evolution AND limitations of survey methodology



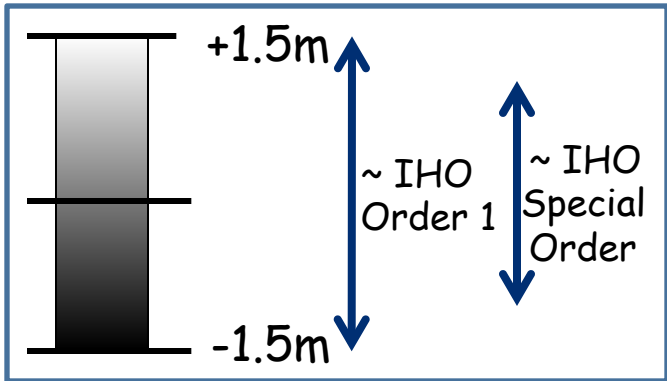
Excellent Survey Pair (RTK v. RTK)
(residuals < +/-0.25m)



What is the limit of Achievable Change Detection?.

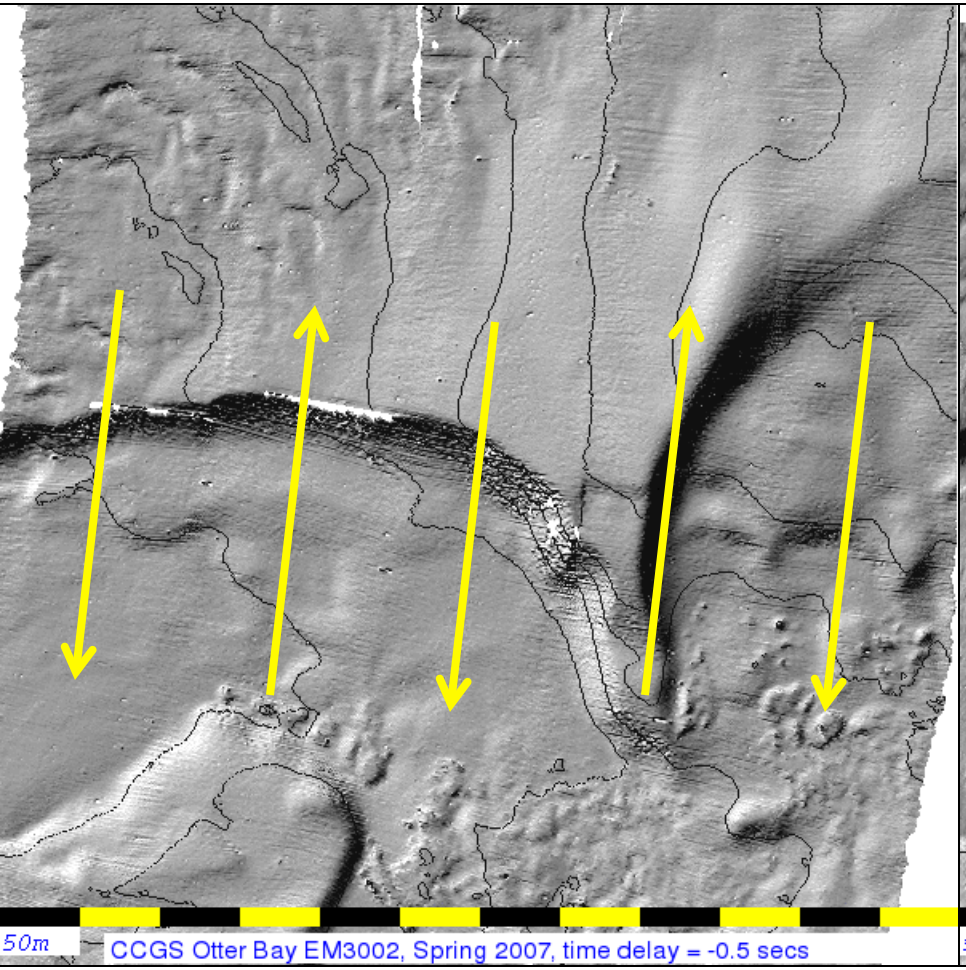
No real change in debris flow morphology
Dunes "shouldn't" have moved"

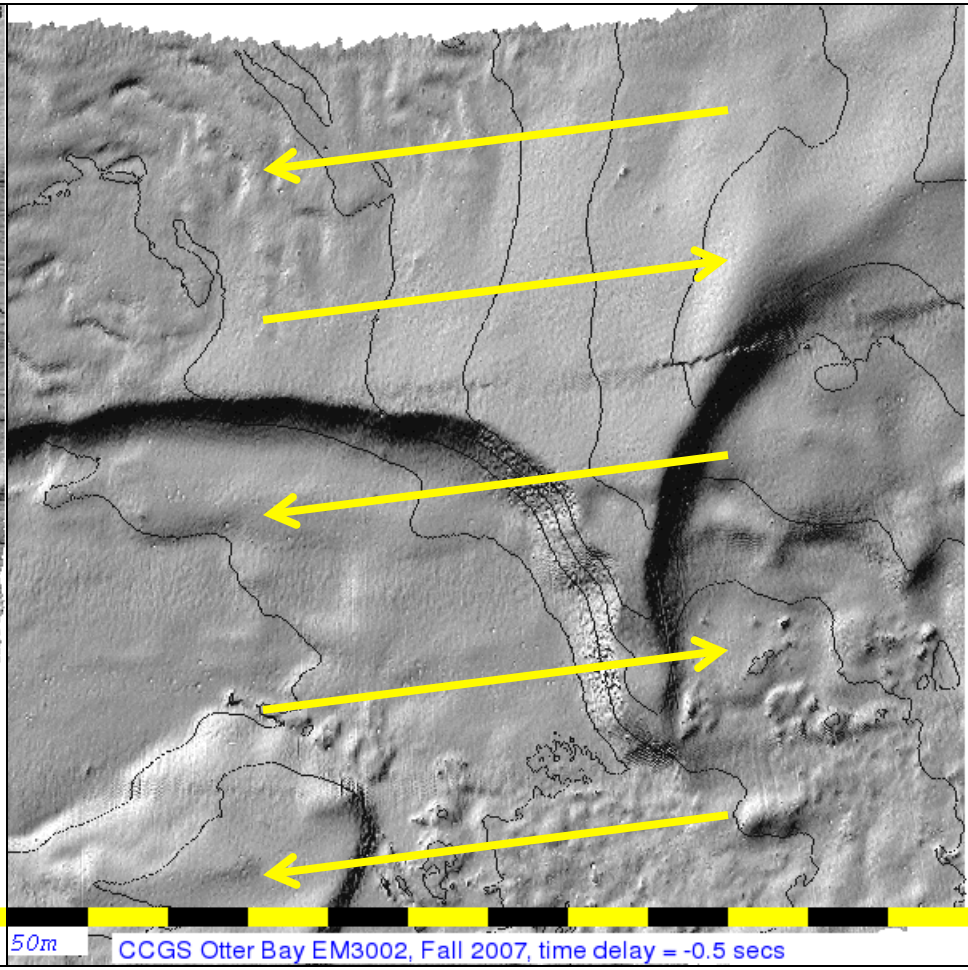
VERTICAL DIFFERENCE



Spring 2007 Survey Lines
Across-Fjord

Autumn 2007 Survey Lines
Along-Fjord





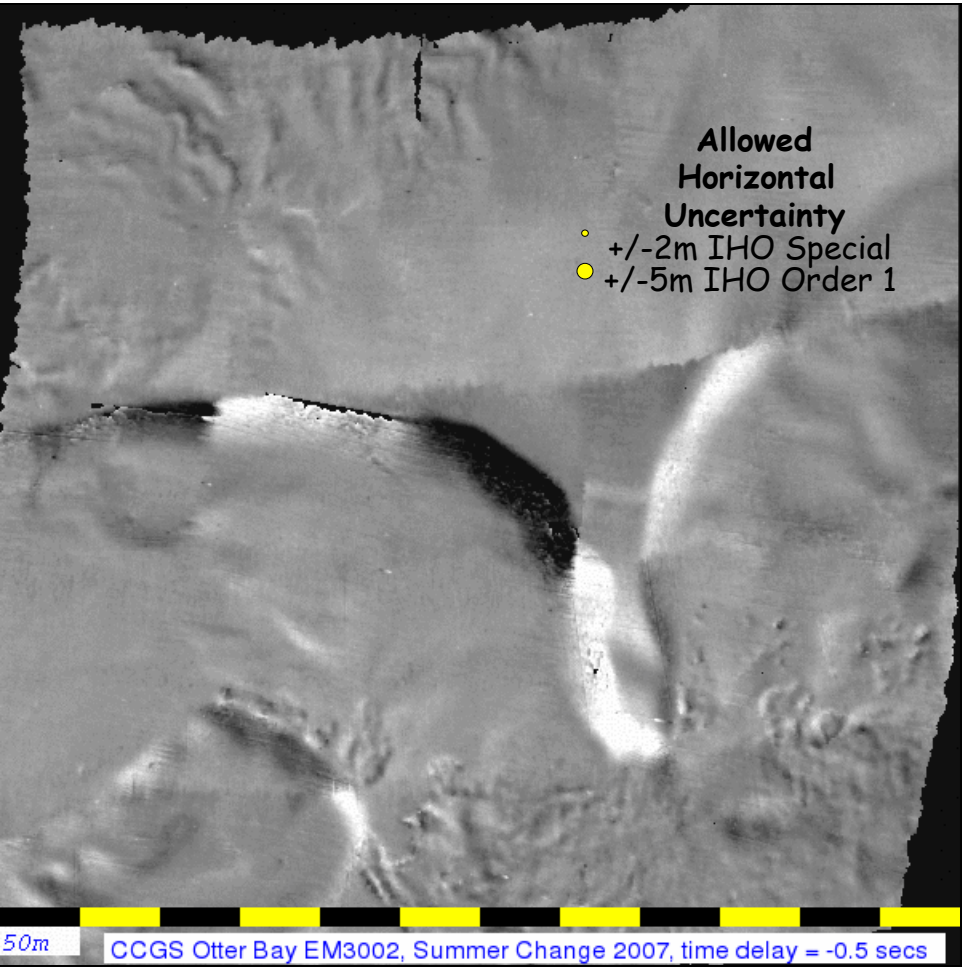
Effect of Varying Time-Delay +/- 0.5 seconds.

(at 10 knots = +/- 2.5m along-track)

Allowed Horizontal Uncertainty
+/-2m IHO Special
+/-5m IHO Order 1

Inter-Survey Surface Differences

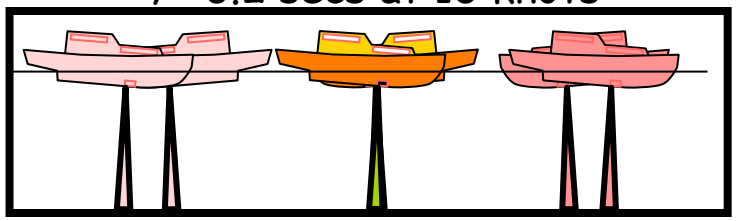
+/- 0.5 secs at 10 knots
(= ~ +/-2.5m horizontal bias)



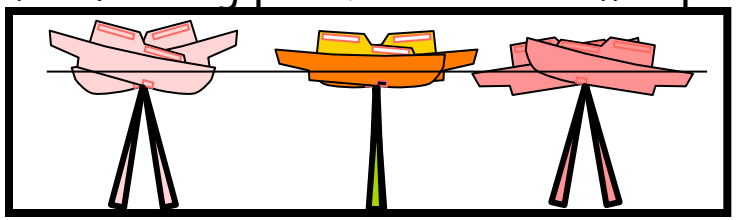
Spatial Pattern Recognition
can aid in deducing systematic bias

Equivalent Errors to generate +/- 1m positioning uncertainty

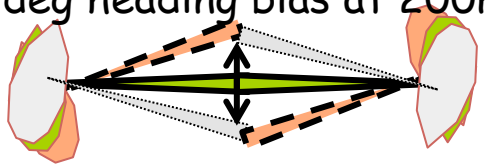
+/- 0.2 secs at 10 knots



+/- 0.57 deg pitch bias at 100m depth



+/- 0.29 deg heading bias at 200m offset

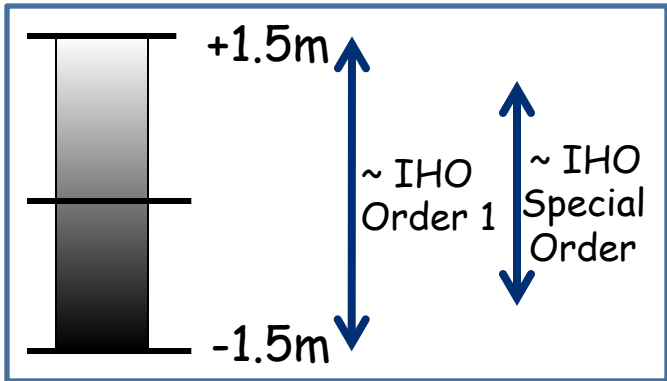


SRF measurement or sign errors

Differential GPS *(not RTG/PPP/RTK/PPK)*

Bad SV Geometry in fjord

VERTICAL DIFFERENCE



CSL Heron

2002 - 2009

Fundy - Arctic

Atlantic Canada Opportunities Agency

KONGSBERG

CFI

C$340,000

EM3002
300kHz
multibeam

200kHz/28 kHz
profiler

3.5 kHz
subbottom
profiler

200 kHz
sidescans

Only sunk once!

CSL Heron
2010 modifications

FI NB IF INNOVATION

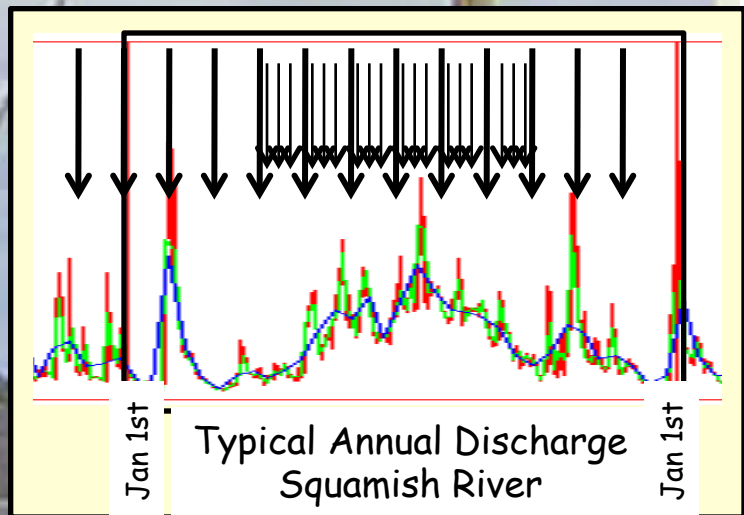
KONGSBERG

CFI

C$1,000,000

EM3002

EM710 1°x2°



In Summary:

- Current and Future Research Program of the Ocean Mapping Group addresses :

Submarine Environmental Monitoring

-While addressing the **oceanographic and/or sedimentlogical** interests of our partners *(and JHC!)*

-We are able to operationally test **multi-sensor integration problems**.

Provides a particularly rich learning and research environment for all of our graduate students, faculty and staff.

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Canadian Hydrographic Service

Geological Survey of Canada

Sponsors of:

Ocean Mapping Group

University of New Brunswick CANADA

ArcticNet

Esso Imperial Oil

bp

Officers and crew of
CCGS Amundsen
CCGS Henry Larsen
CCGS Matthew
CCGS Vector