19th IAHR International Symposium on Ice
"Using New Technology to Understand Water-Ice Interaction"
July 6 to 11, 2008
Vancouver, British Columbia, Canada

Iceberg Calving Frequency from Field Observations

Stephen Bruneau[1], Eugene Manning[2], Kris Rogers[3]
1 Assistant Professor Engineering, Memorial University of Newfoundland
2 M.Eng Candidate, Memorial University of Newfoundland
3 Engineering Student, Memorial University of Newfoundland

CONTENTS

A – INTRODUCTION TO WORK

B - GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

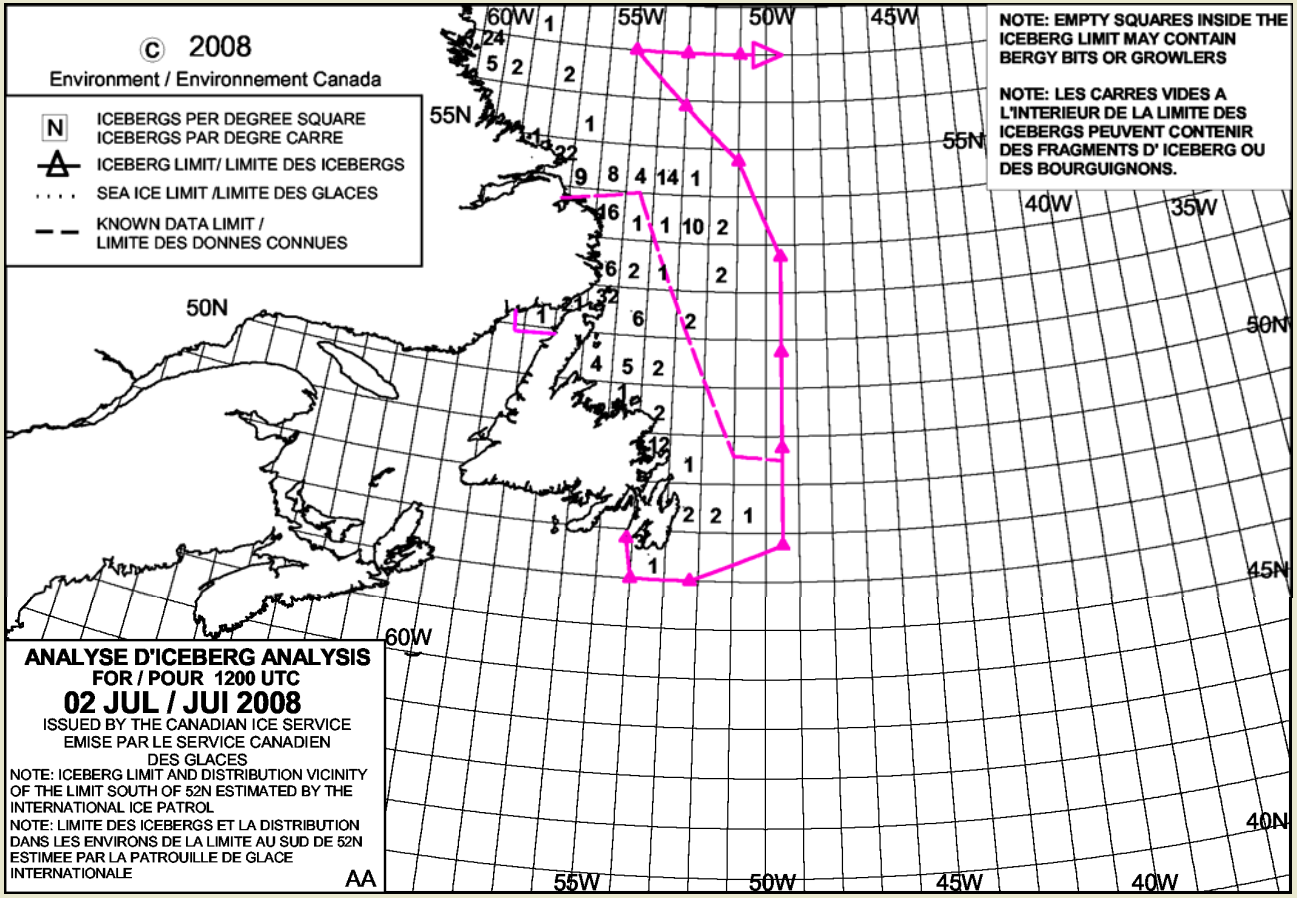
C - FIELD PROGRAM 2007 – TIME LAPSE RECORDING

D - UTILITY OF DATA AND FUTURE PLANS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

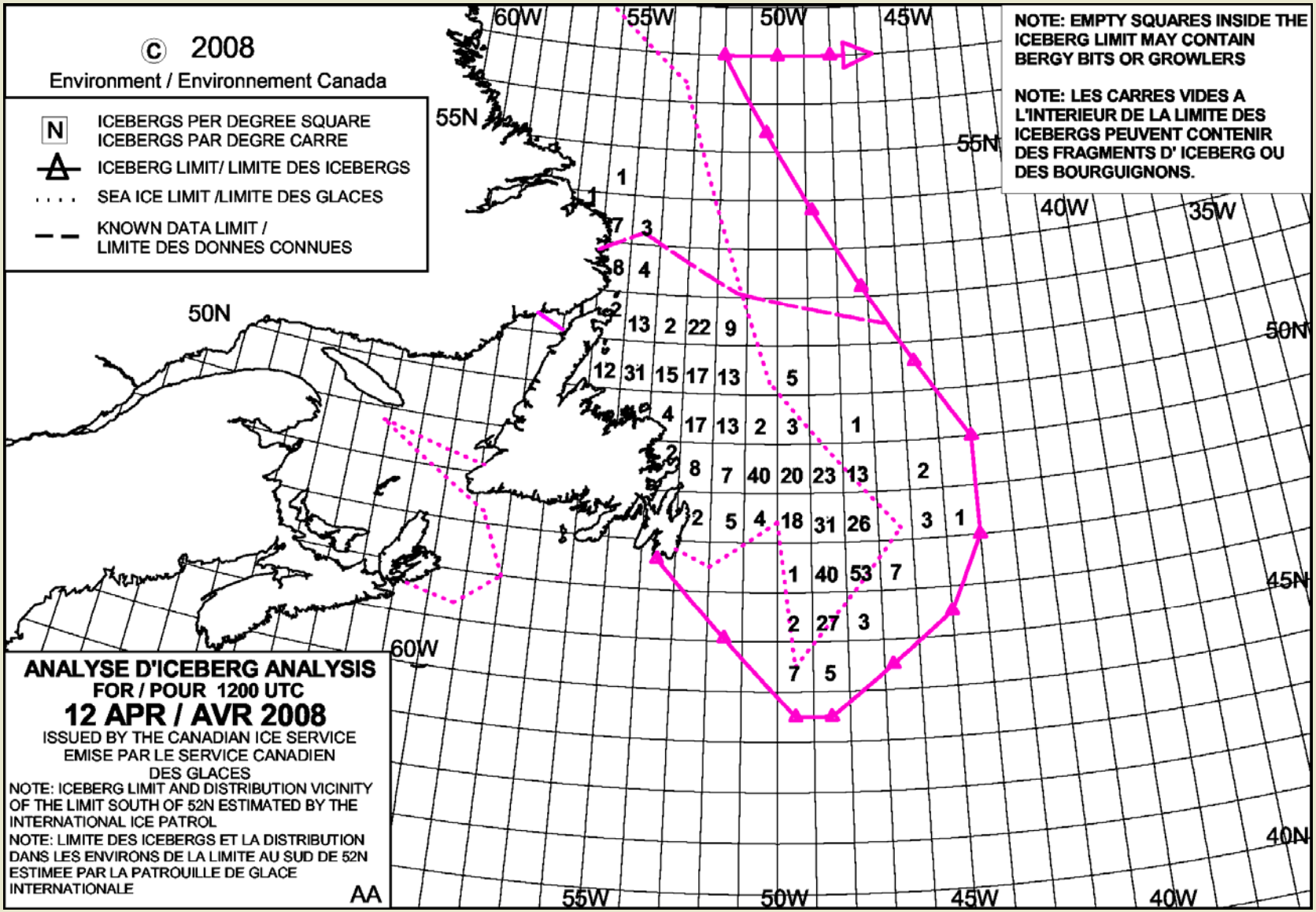
PURPOSE OF WORK

Forecasts which are based on drift and deterioration models are required because it is not presently feasible to continuously monitor all bergs entering waters where they may be a risk to commercial activities



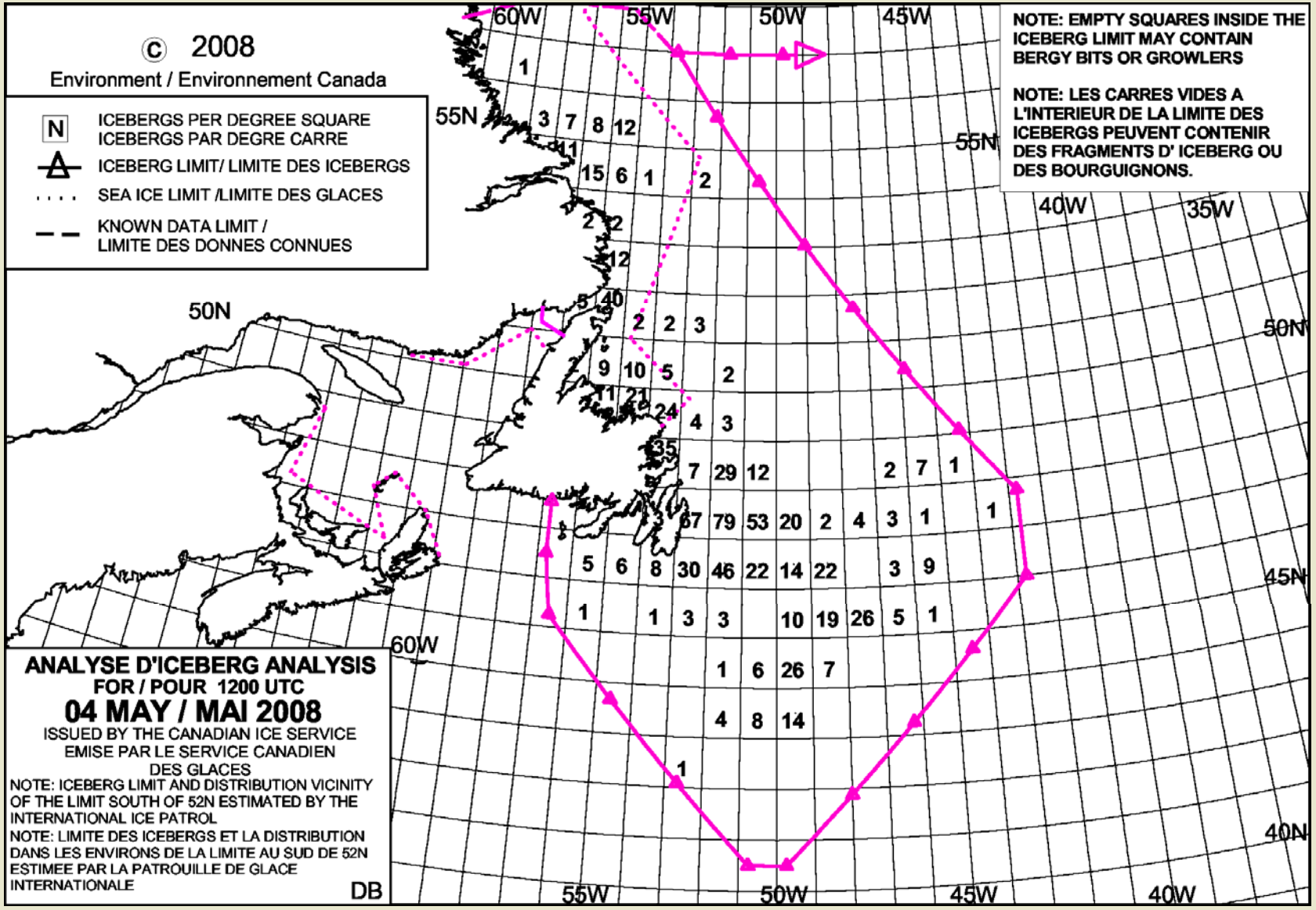
Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

PURPOSE OF WORK



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

PURPOSE OF WORK



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

PURPOSE OF WORK

Frequency

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

PURPOSE OF WORK

Understanding the nature and rate of various iceberg mass-reducing mechanisms is important for accurate forecasting of iceberg position and size.

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

PURPOSE OF WORK

Deterioration is presently modeled by the Canadian Ice Service using the following approach:

"An Operational Iceberg Deterioration Model" by Kubat et al. (2007). The deterioration model is based on a number of melting processes:

$$dL/dt = -(Vs + Vb + Vf + Vwe + Vc)$$

Where:
L Iceberg waterline length
t Time
Vs Melt rate due to Surface Melting
Vb Melt rate due to Buoyant Convection
Vf Melt rate due to Forced Convection
Vwe Melt rate due to Wave Erosion
Vc Melt rate due to Calving

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

PURPOSE OF WORK

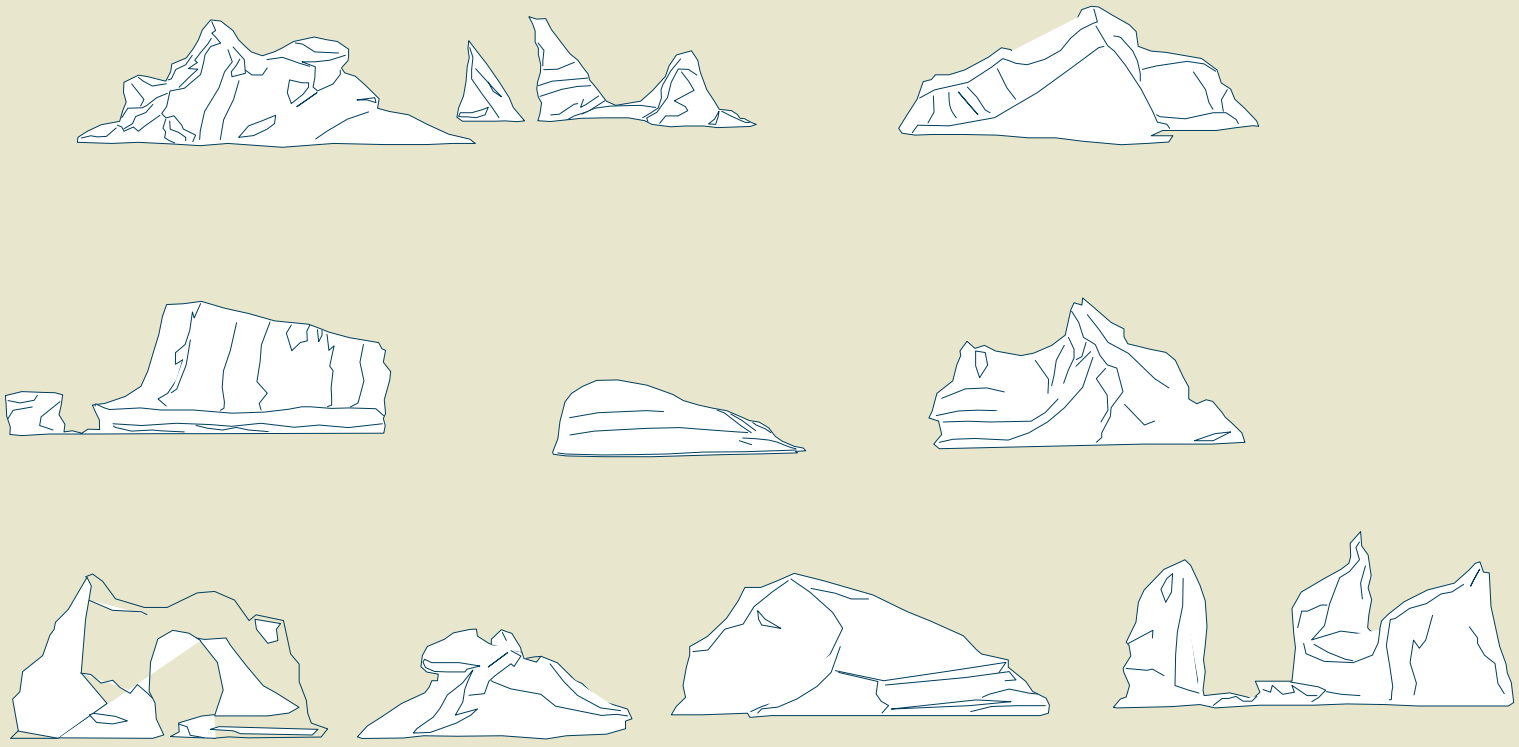
Calving rate Vc may be one of the easiest quantities in the operational model to measure in the field and thus use for calibrations.

PURPOSE OF WORK

So let us begin with a review of what is observed when icebergs deteriorate.

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION



GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

The surface observed from small to large scale

1 **Bubbles** burst audibly above water – air bubbles rise to surface from below

2 **Cuspate** surface forms over entire berg under various conditions and at various scales, primarily 5-25cms in size underwater where the pattern is most often observed.

3 **Surface cracks** resembling a loose web of crisscrossing white ribbons buried in the ice often appear during rapid melting at the wave wash zone. These appear to be shallow fractures from surface thermal expansion.

4 **Furrows** result from channeled water erosion on the ice surface from either convective water streams driven by ascending air bubbles or above water from surface meltwater runoff or wave runup and drainage.

5 **Fractured surface** like un-crumpled paper (sharp, angular, faceted) with each flat plane measured in meters on all above-water surfaces where calving has removed ice. Typically seen only on vertical or near vertical orientation.

6 **Rubble mounds** occur on lower levels that are relatively horizontal and overshadowed by calving surfaces above. Typically resemble refrozen avalanches and are usually quite solid.

7 **Waterline notching** from rapid erosion in the wave action zone looks like a constricting waistline belt which continuously reorients. The exposing of more or less of it at various inclinations often indicates the recent melting history analogous to the debris on a tidal beach or the growth rings of a tree.

8 **Curvy subsurface geometry** with angular corners where large melting surfaces meet characterizes below water shape

9 **Pinnacled** shape forms with spires, arches, drydocks. Multiple islands are common in latter day deteriorated bergs.

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Cuspate surface and stream furrows

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

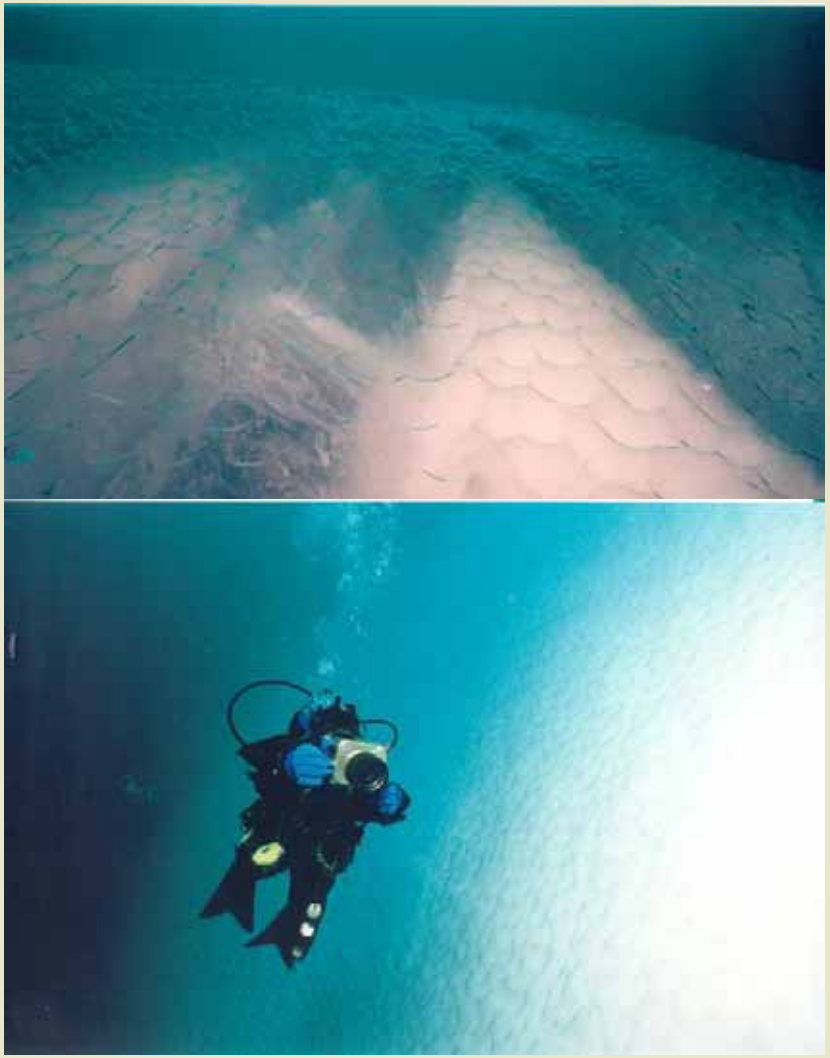
Cuspate Surface Scales

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Cuspate Surface Scales

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

May 17th

May 29th

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

May 31st, 2008

June 4, 2008

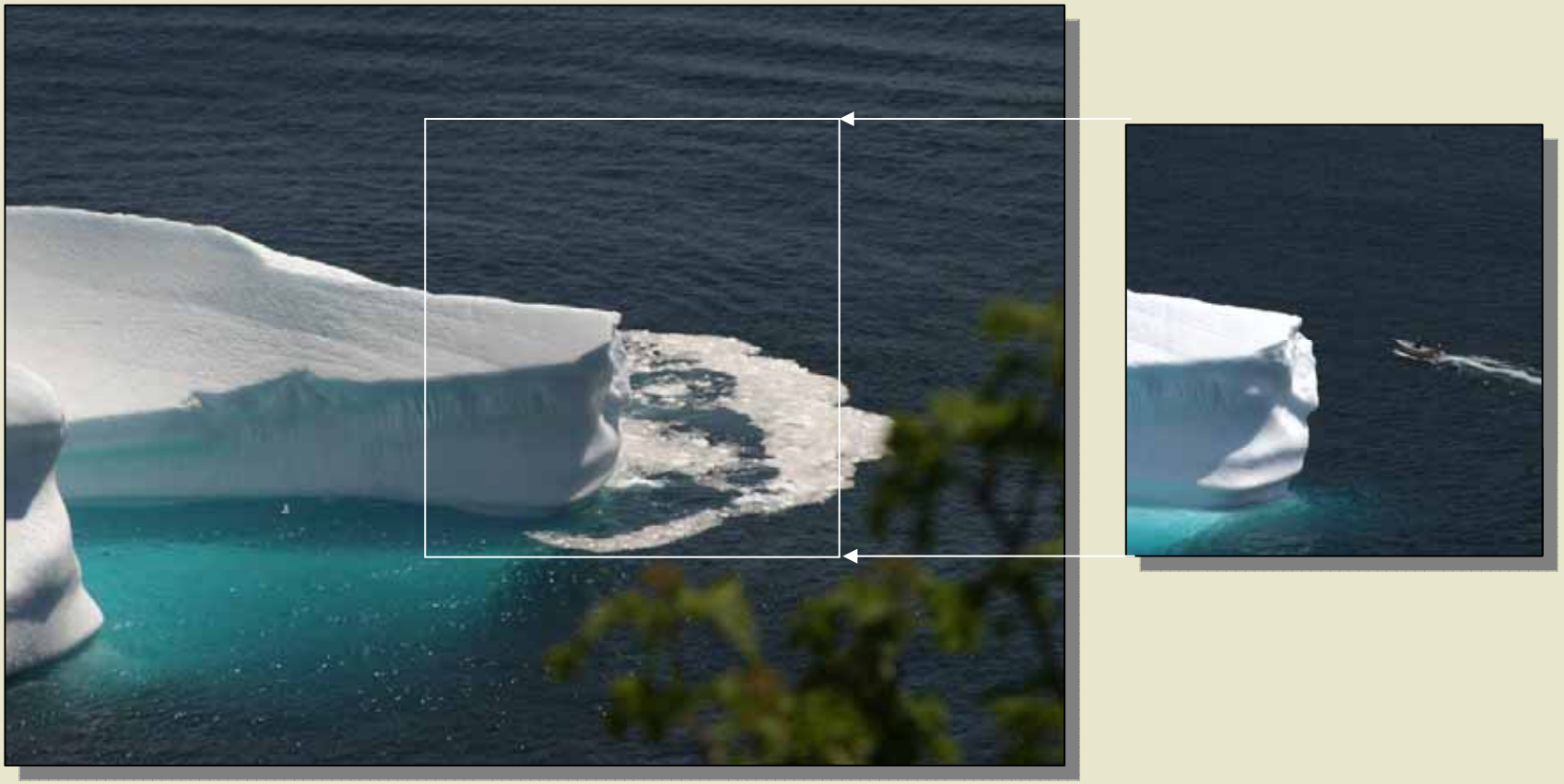
Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

GENERAL OBSERVATIONS OF ICEBERG DETERIORATION

Calving is discrete and can be see and quantified



FIELD PROGRAM 2007

Continuation of work from 2005 and earlier

First laptop-based system and a Remote camera system

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

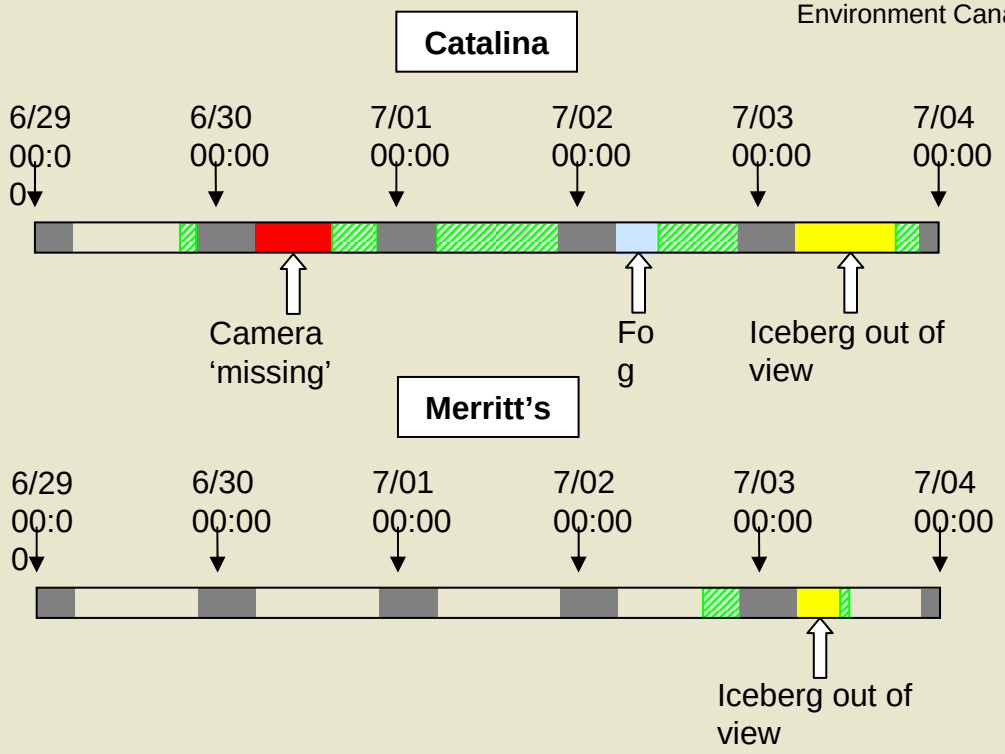
FIELD PROGRAM 2004

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2004

Observation and Analysis of Iceberg Calving - June/July 2004
Contract Report Prepared for:
Canadian Ice Service
Environment Canada

Location	Calving Events	
	Date/Time	**Size**
Catalina	6/30/16:00	Medium
	6/30/18:57	Small
	6/30/19:22	Small
	6/30/19:32	Large (iceberg rolled)
	7/1/08:35	Small
	7/1/10:37	Small
	7/2/17:41	Medium
	7/3/18:30	Medium
Merritt's Harbour	7/2/20:00	Medium



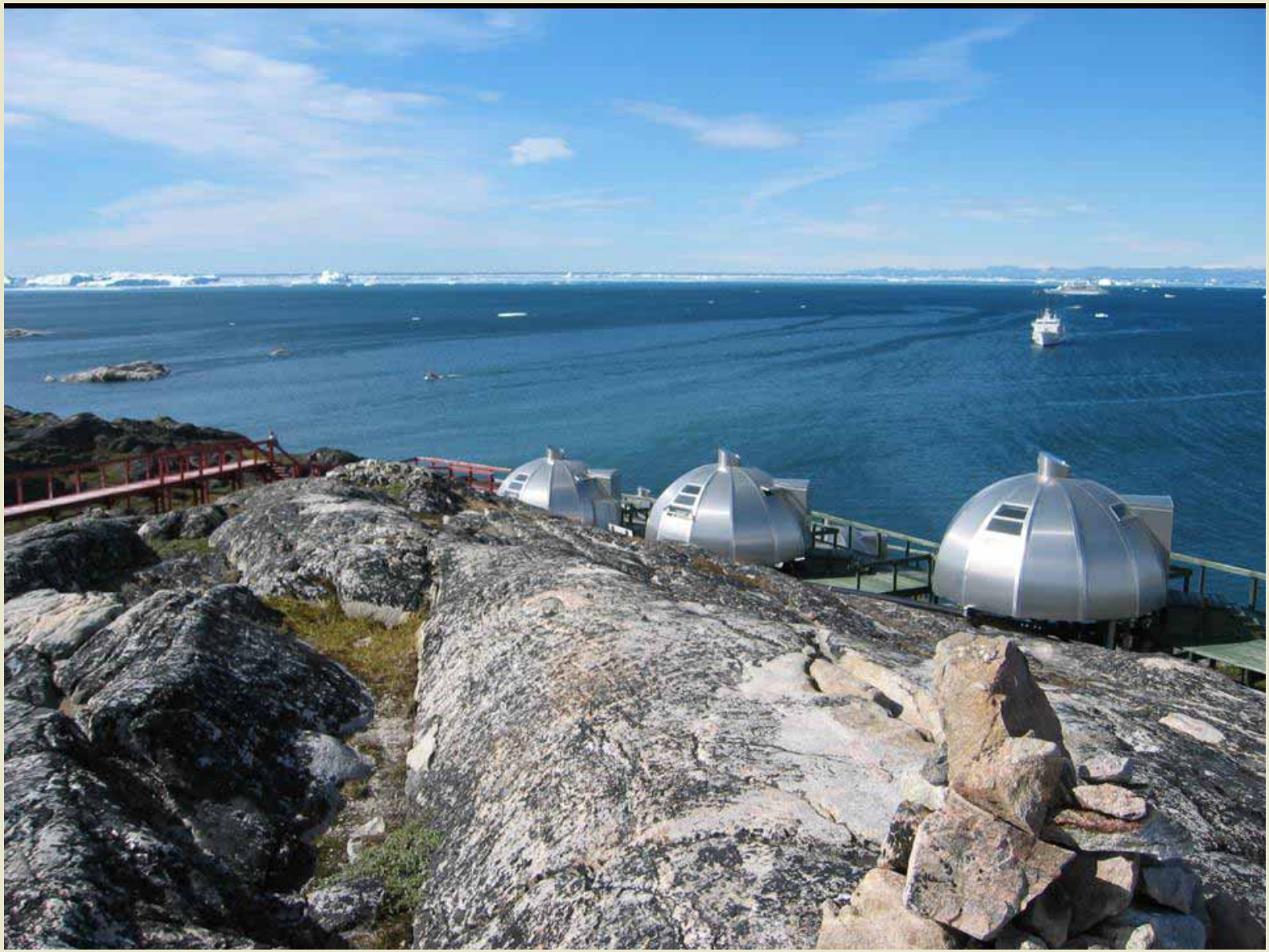
Small: single growler, few bits of brash,

Medium: a few large pieces, several smaller and a noticeable halo of brash in the surrounding water,

Large: Noticeable change in berg shape and orientation, large quantities of floating ice rubble of all sizes, some sintered piles of brash noticeable.

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2005



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2005

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2005

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2005

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

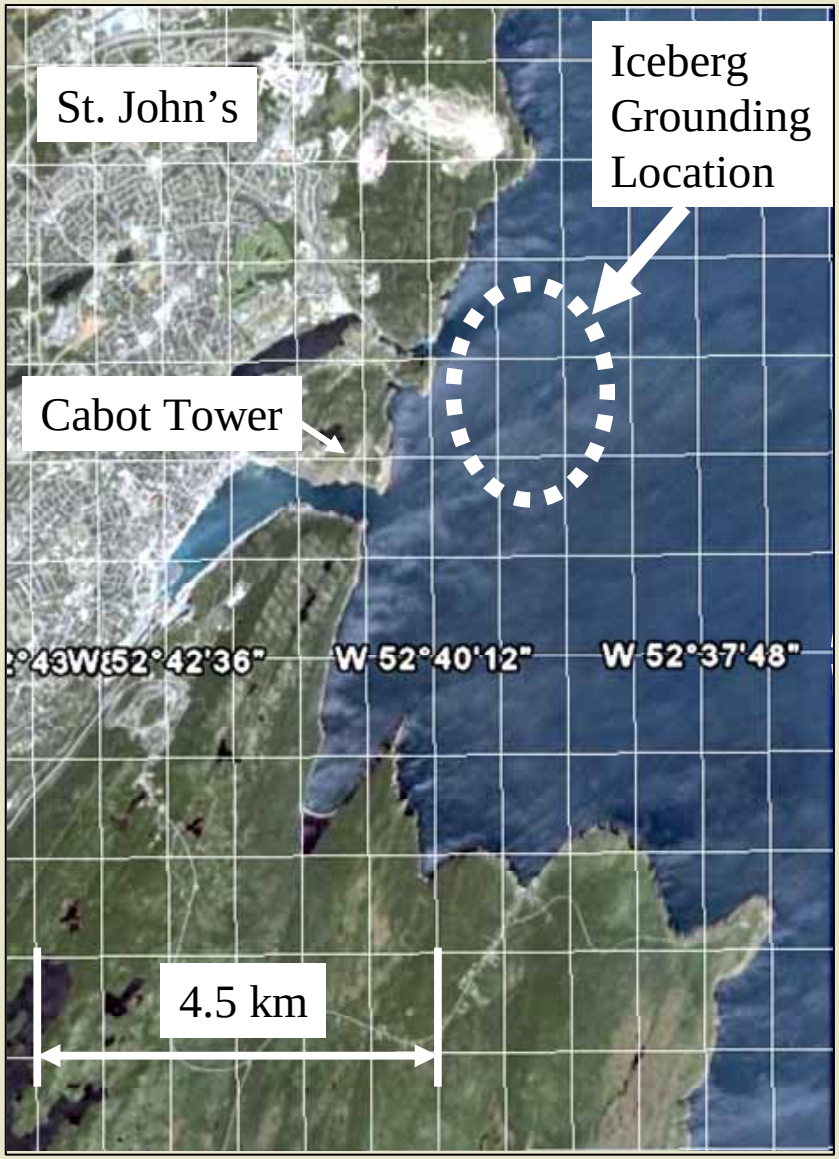
FIELD PROGRAM 2005

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2005

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

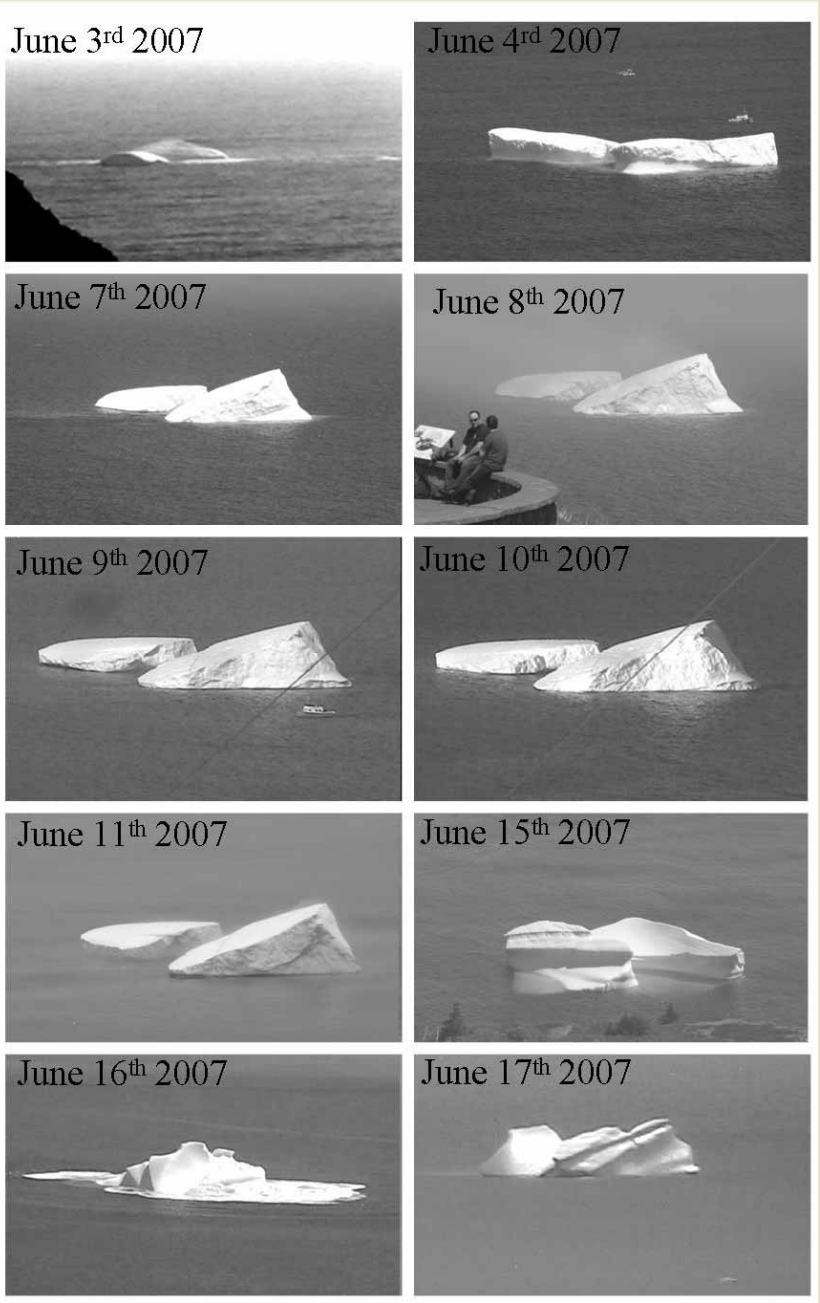
Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

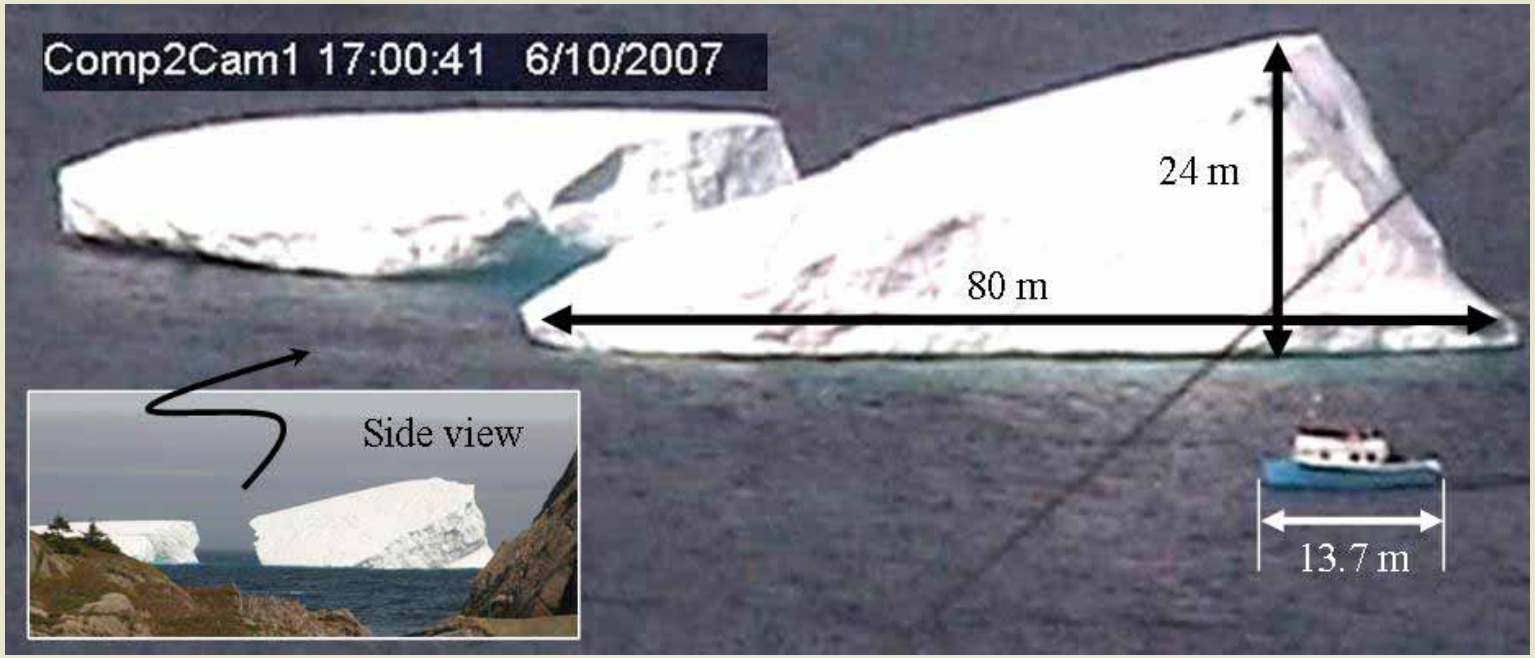
Summarizing. . .



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

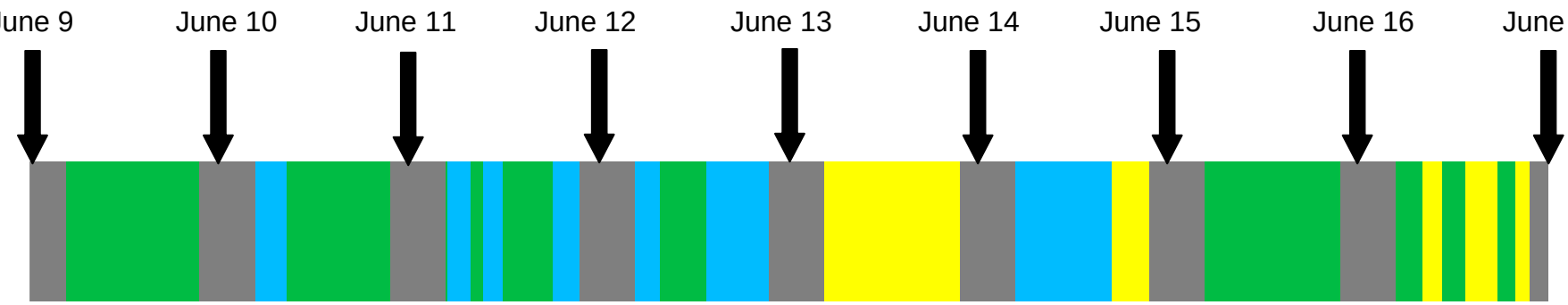
FIELD PROGRAM 2007

Continuation of work from 2005 and earlier



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007



GREEN **Periods of clear view**
GREY **Darkness**
BLUE **Fog**
YELLOW **Out of view**

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

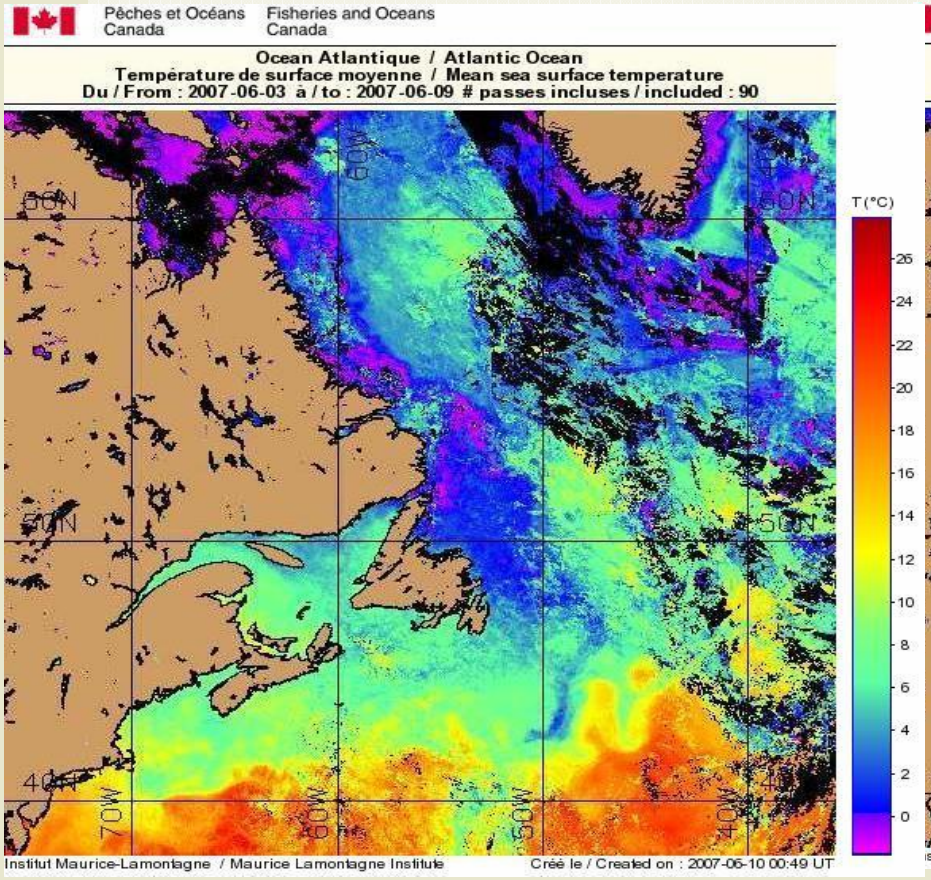
FIELD PROGRAM 2007

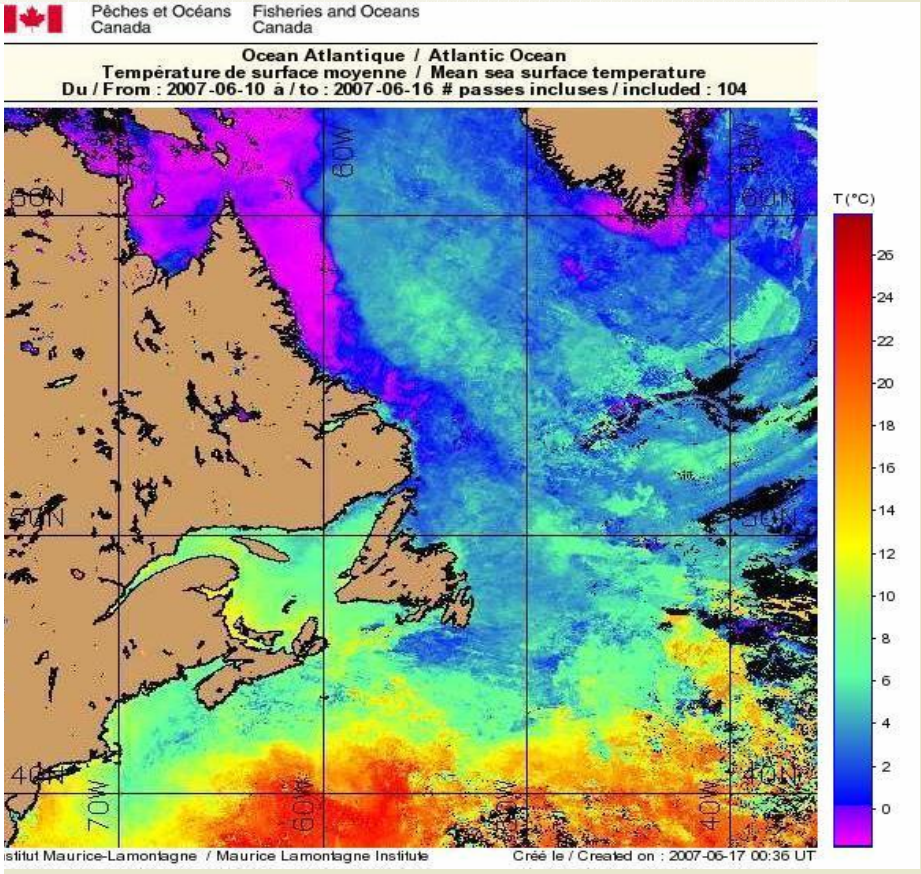
Iceberg Calving Events Signal Hill June 9th to June 17th			
Day	Time of Calving Event	Classification	Comments
June 9th	10:04	small	
	13:55	small	
	15:22	small	
	16:23	medium	
	17:01	small	
	21:28	small	night at 21:30
June 10th	10:21	small	daylight at 4:30, foggy until 8:30
	11:06	medium	
	17:11	large	
	18:13	small	dark at 21:30
June 11th	4:41	small	daylight at 4:30
	7:45	small	foggy 4:50 to 7:45
	14:36	small	foggy 9:15 to 11:45
	16:31	large	
	17:07	small	foggy 18:00 to dark at 21:30
June 12th	9:01	medium	daylight at 4:30, foggy until 7:40
	10:38	small	
	11:31	medium	
	12:58	small	foggy 13:30 to dark
June 13th			berg out of frame
June 14th			foggy until 16:45
			no calving events observed, view of berg obstructed
June 15th	9:34	small	
	11:42	large	
June 16th	8:00	medium	berg drifted out of frame at 9:00
			camera repositioned at 10:25
	11:30	large	berg rolled
			drifted out of frame at 13:30
			back in frame at 17:30
			out of frame at 19:45

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

Continuation of work from 2005 and earlier

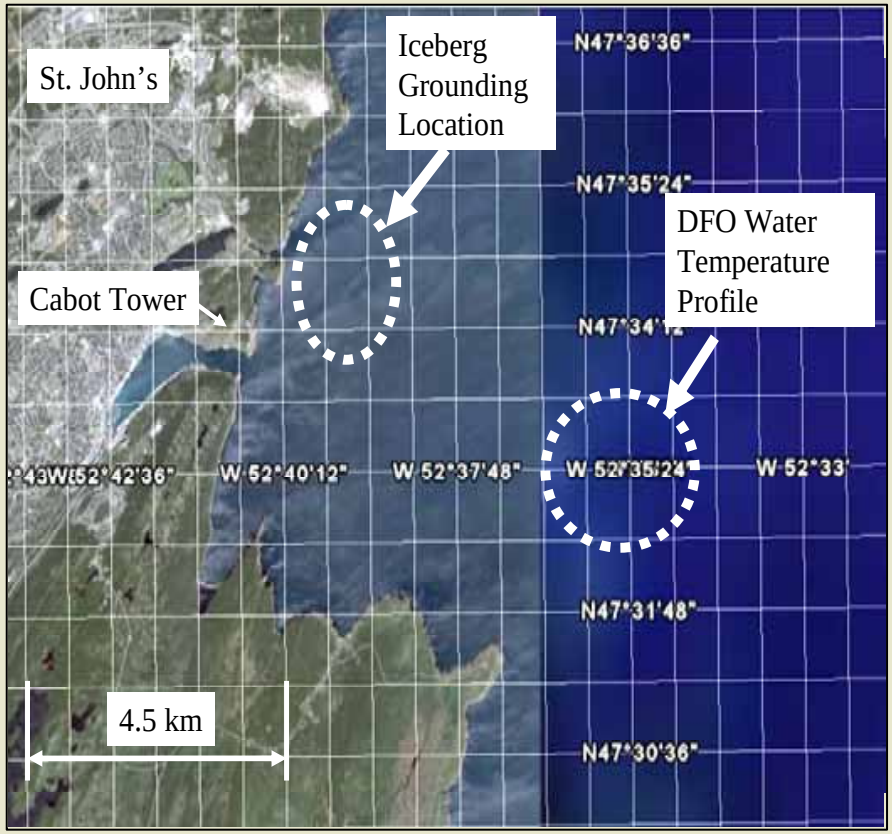


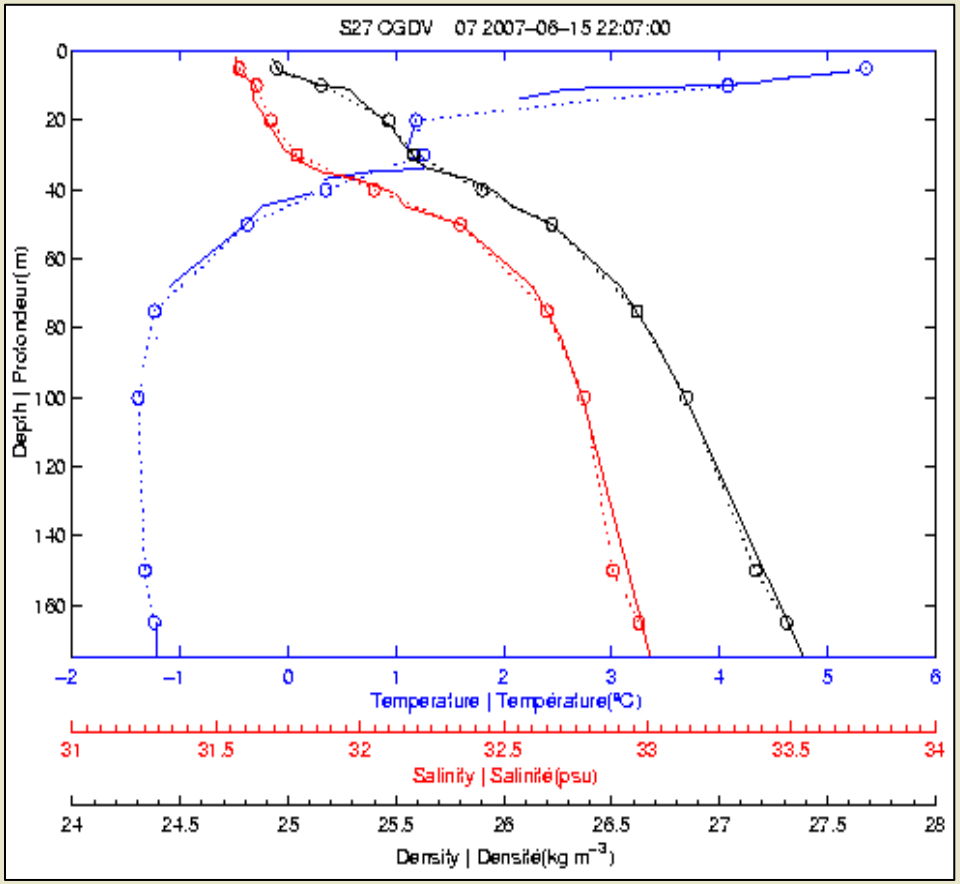


Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007

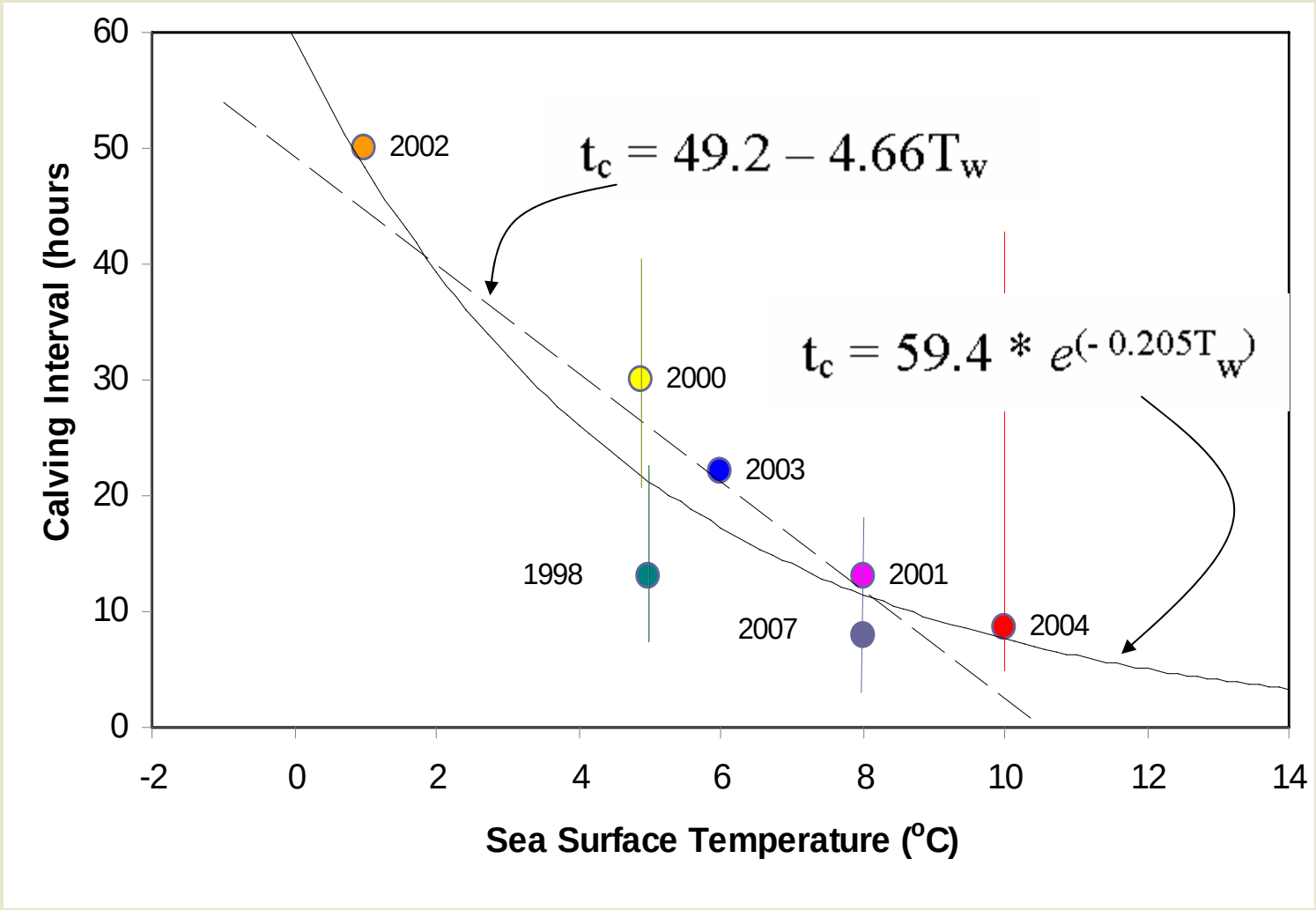
Continuation of work from 2005 and earlier





Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007



Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2007 conclusion

Steve Bruneau, *Assistant Professor Engineering, Memorial University of Newfoundland*

FIELD PROGRAM 2008 . .

Thanks for your time
Questions?