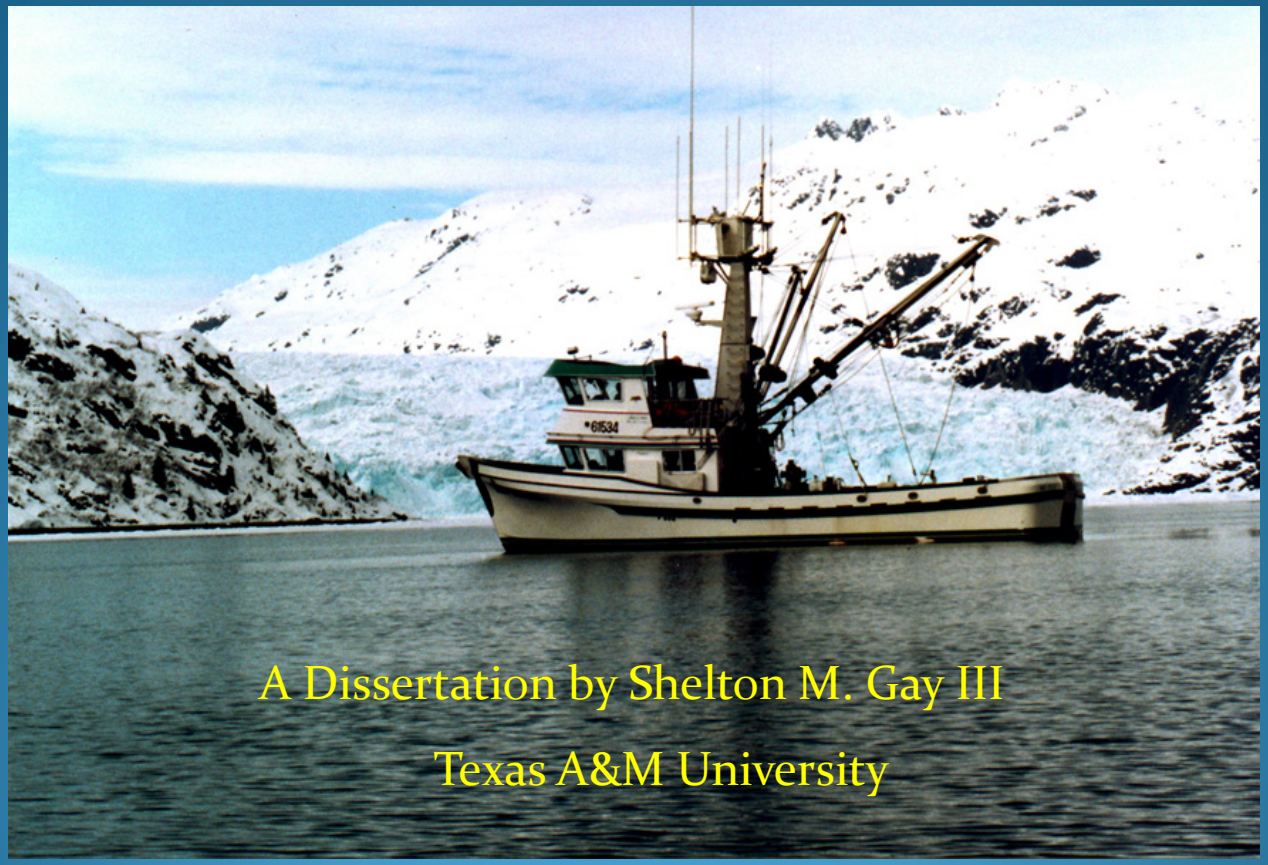
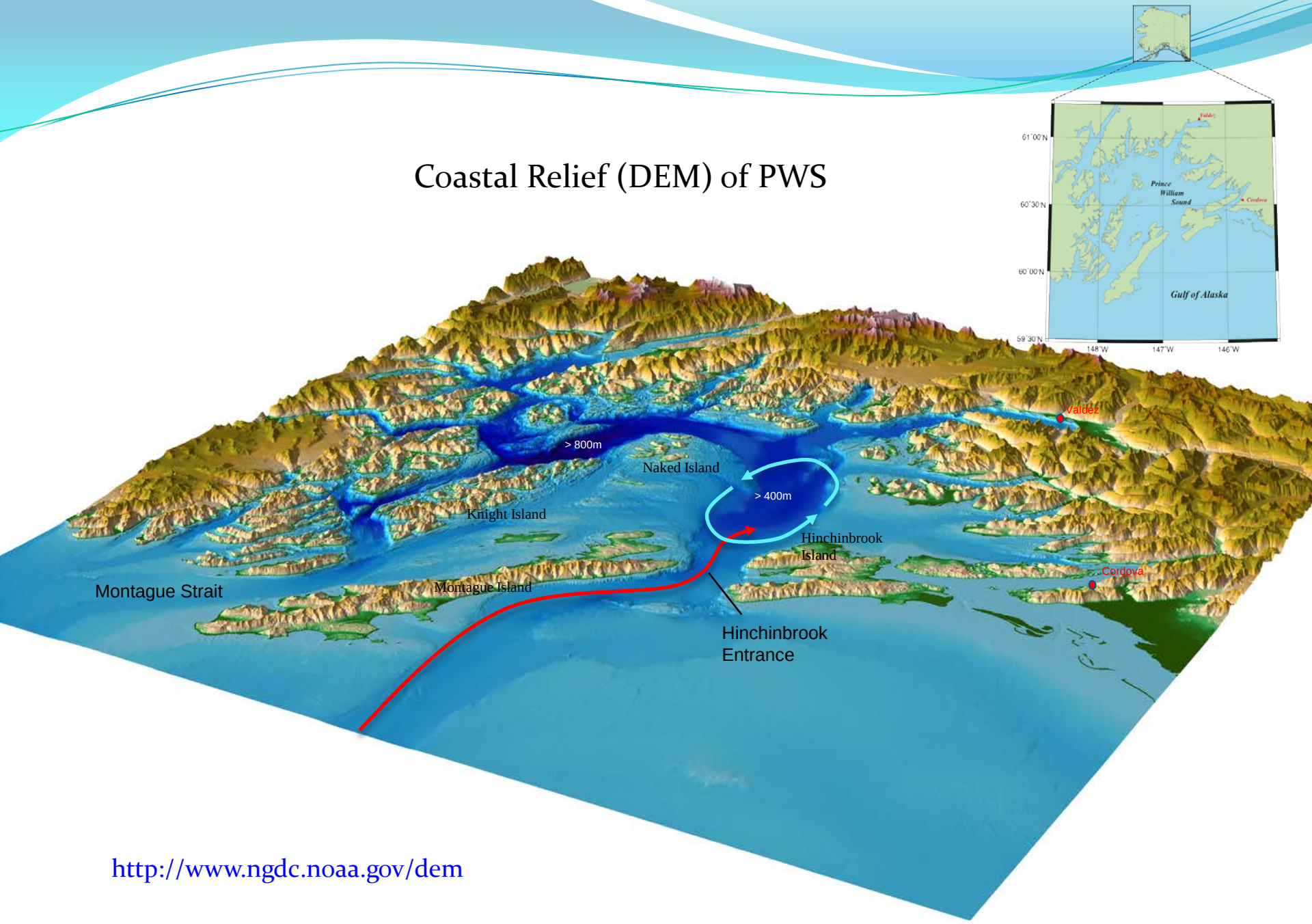
ESTUARINE CONDITIONS AND WATER EXCHANGE IN FJORDS OF PRINCE WILLIAM SOUND, ALASKA



A Dissertation by Shelton M. Gay III

Texas A&M University

Coastal Relief (DEM) of PWS



http://www.ngdc.noaa.gov/dem

Introduction

Part A:

- Regional and sub-regional climate
- Physical characteristics of small PWS fjords

  Examples of basin types

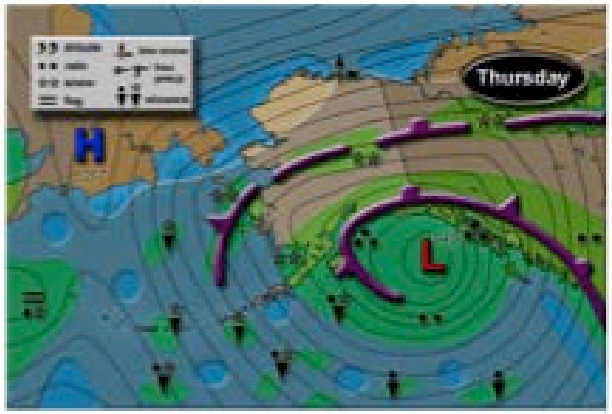
  General Variation in hydrography

  Effects of extraneous (allochthonous) glacial water

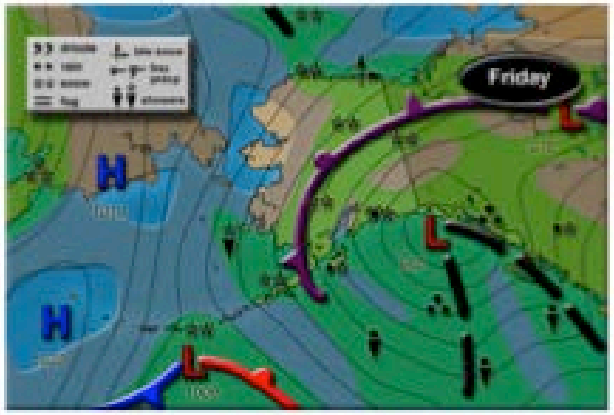
- Estuarine conditions in relation to watershed topography
- Principal component analysis of freshwater contents
- Summary and conclusions

Climatic Scenarios in Mid Fall 2009, and Late Winter and Summer 2010

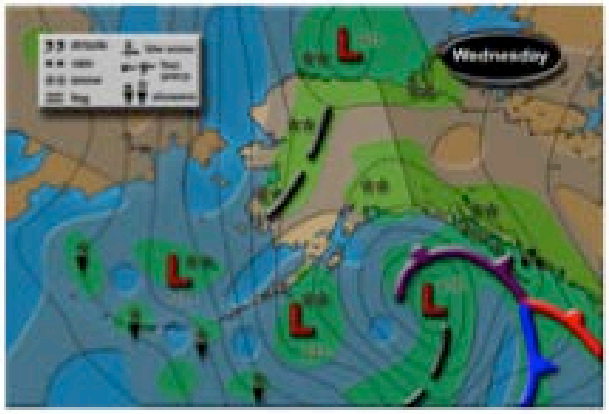
a) Fall 2009: Nov. 5



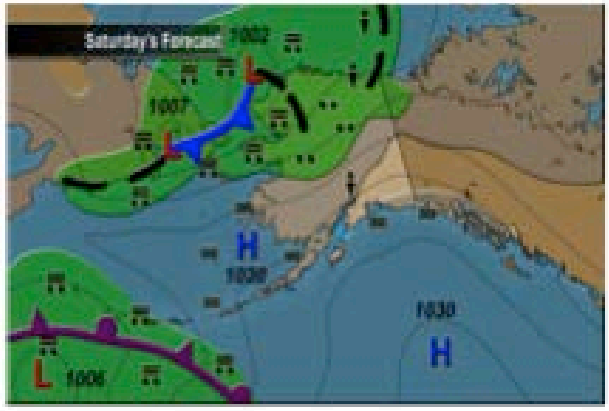
b) Fall 2009: Nov. 6



c) Late Winter 2010: Mar. 9



d) Summer 2010: July 17



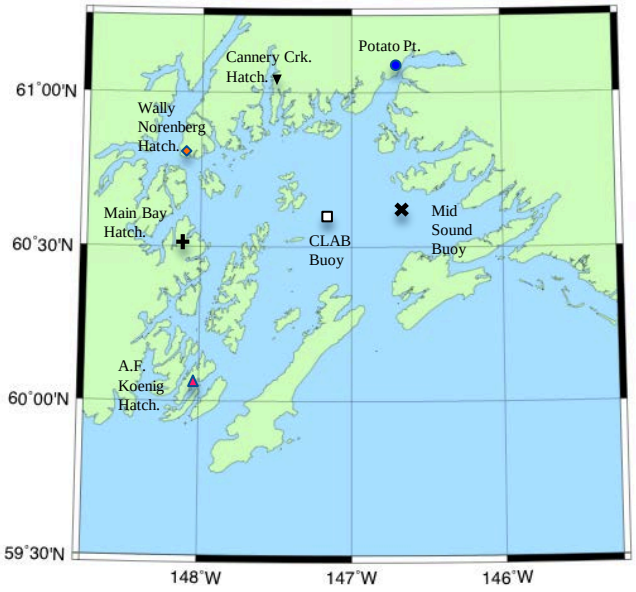
Monthly Mean Air Temperatures and Monthly Precipitation in Sub-Regions of PWS 1994-1998

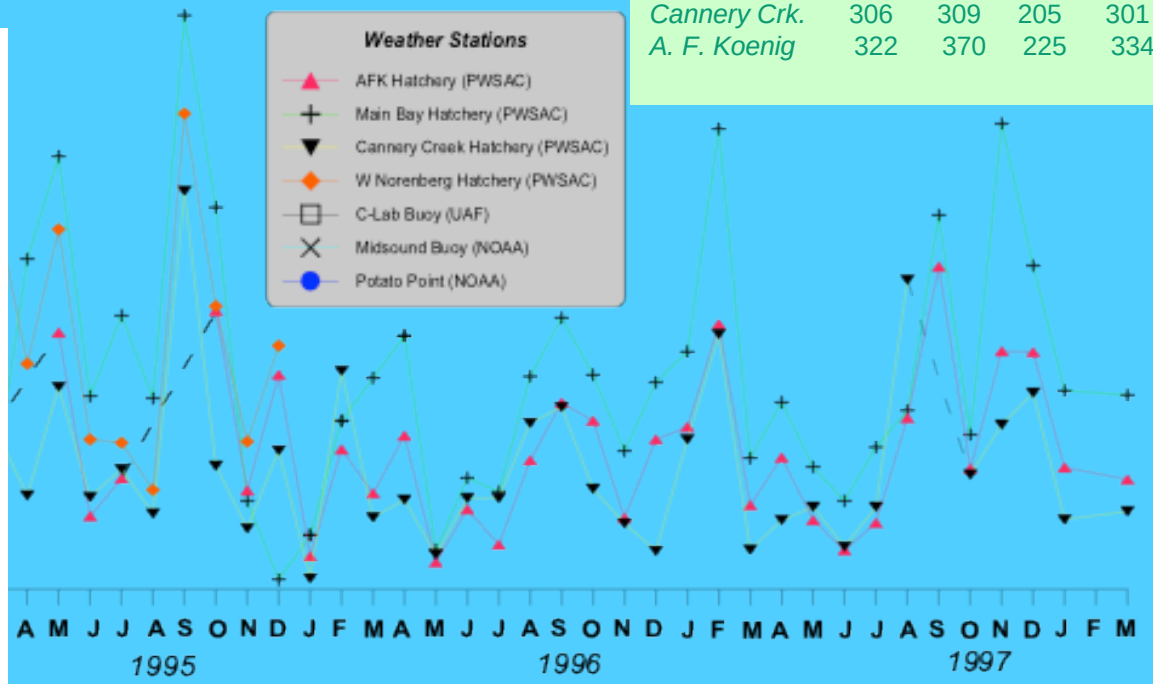
from Gay and Vaughan (2001)

Total Annual Precipitation (cm)

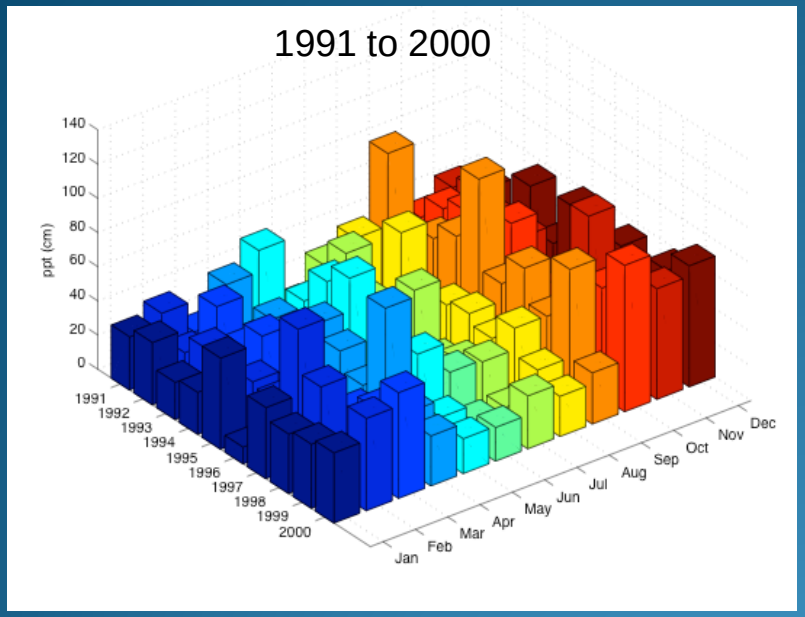
	1994	1995	1996	1997
Main Bay	413	538	347	501
Cannery Crk.	306	309	205	301
A. F. Koenig	322	370	225	334

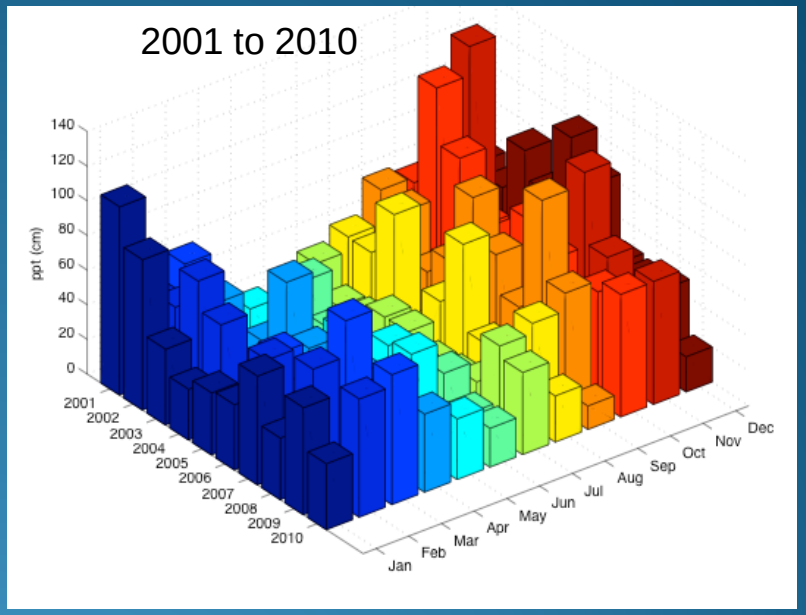
Met. Station Locations within PWS

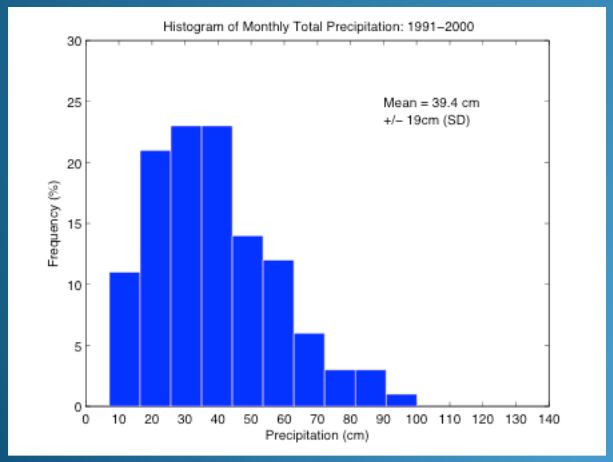




Monthly Total Precipitation in 1991 to 2000 and 2001 to 2010

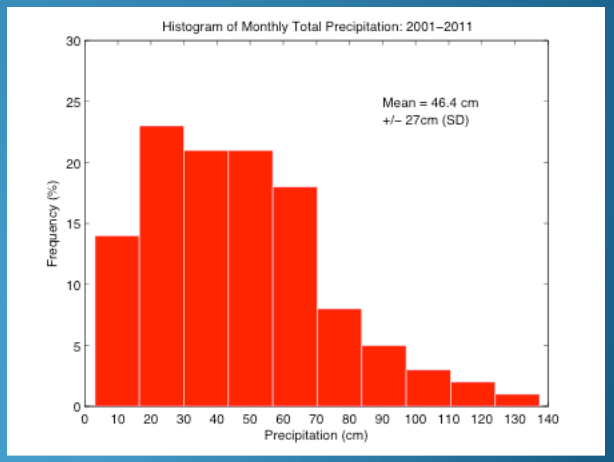






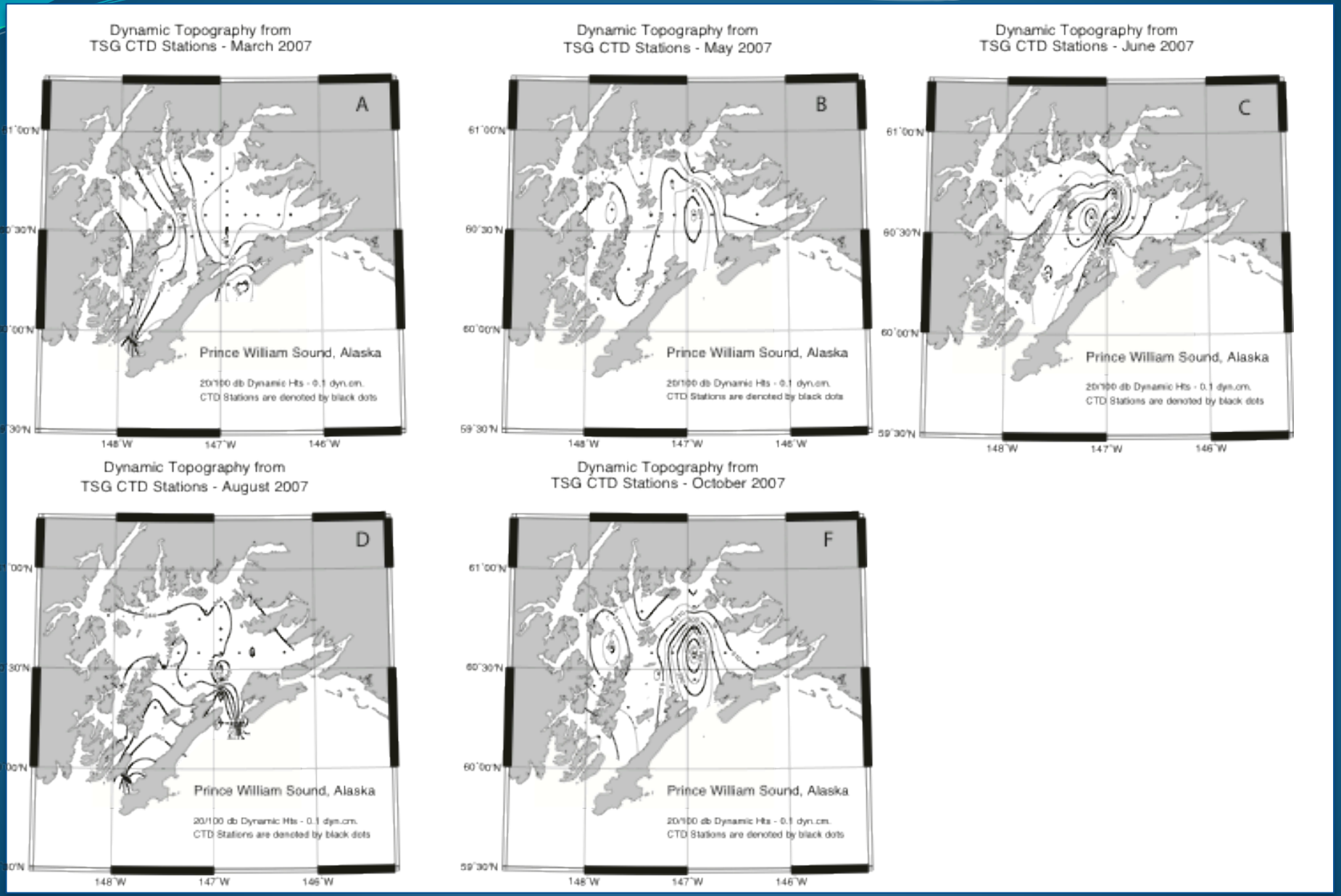
Difference between means (+ 7*cm*) is significant:

at the 98% level (p = 0.02) .



Baroclinic-Geostrophic Circulation in Central PWS

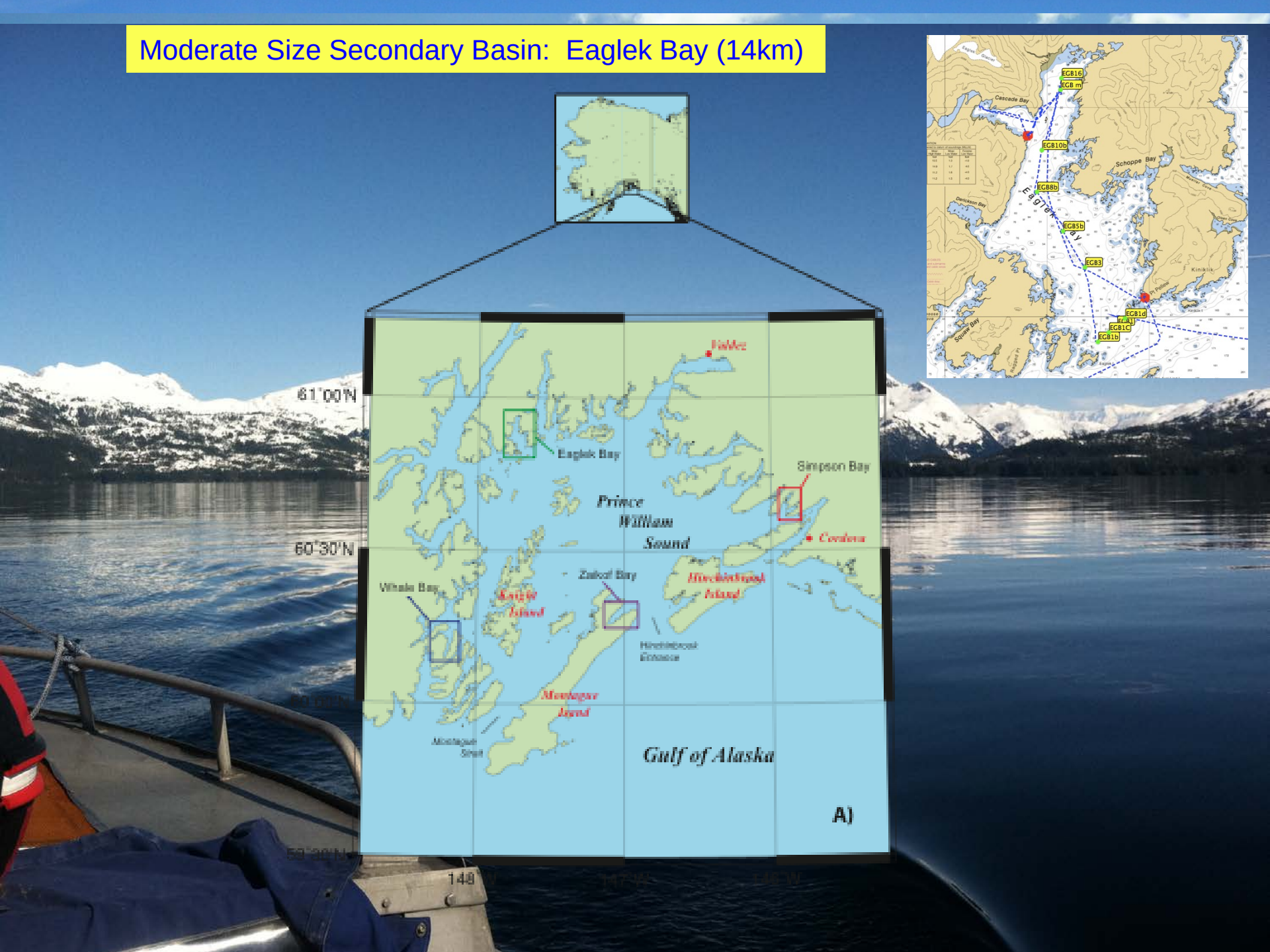
Baroclinic-Geostrophic Circulation in Central PWS

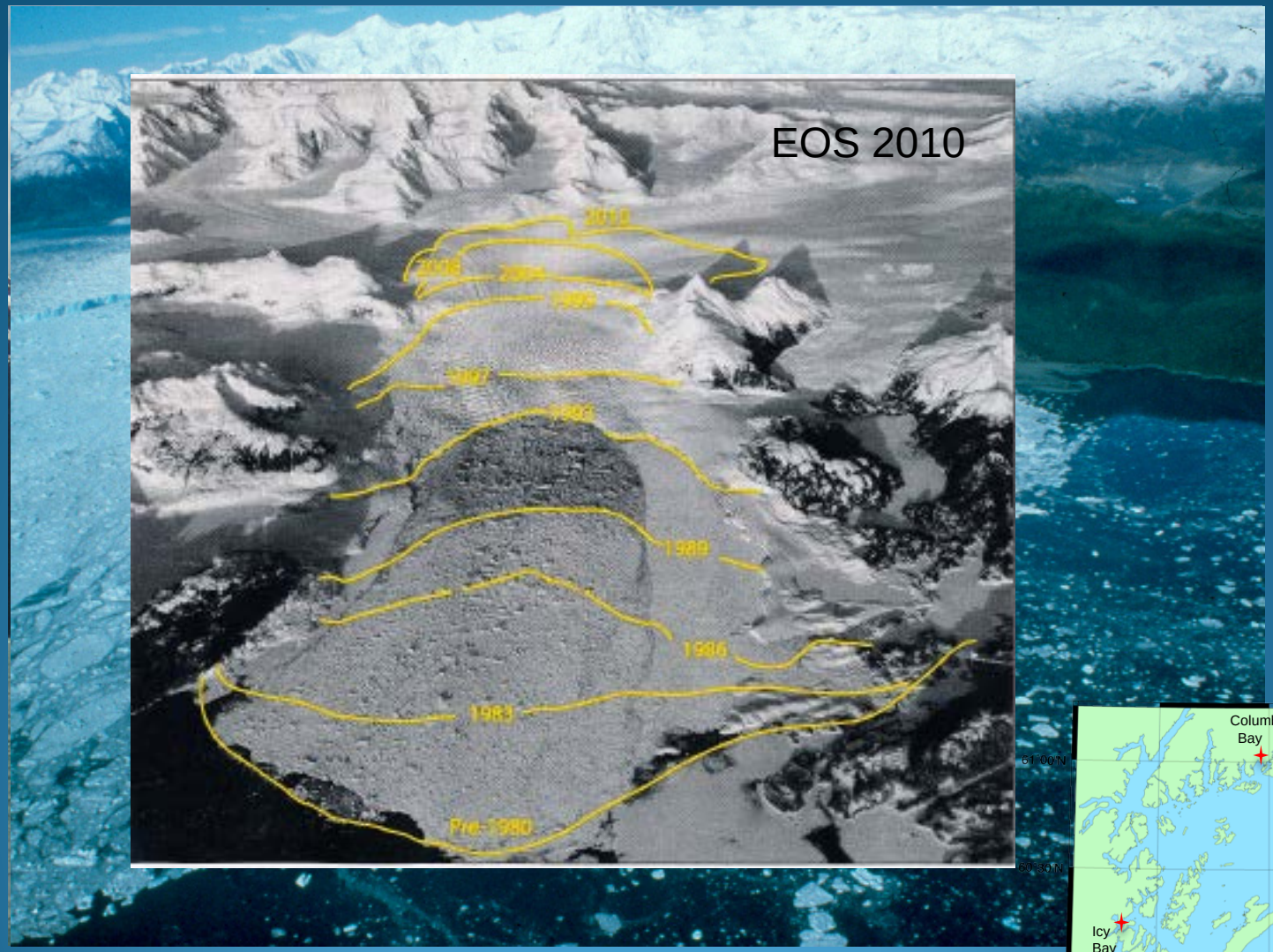


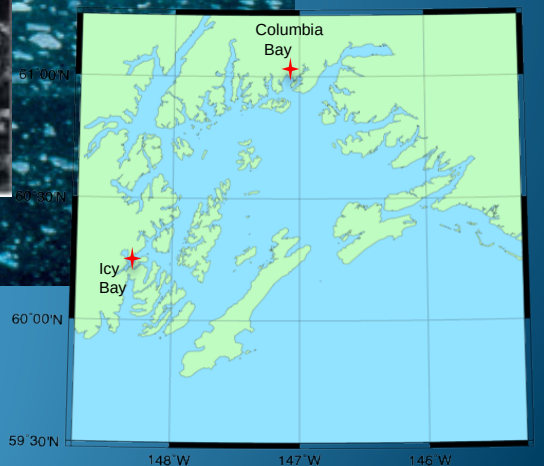
Physical Characteristics of PWS fjords

- Examples of basin types
- General variation in hydrography
- Effects of allochthonous glacial water within small fjords
- Estuarine conditions in relation to watershed topographic parameters

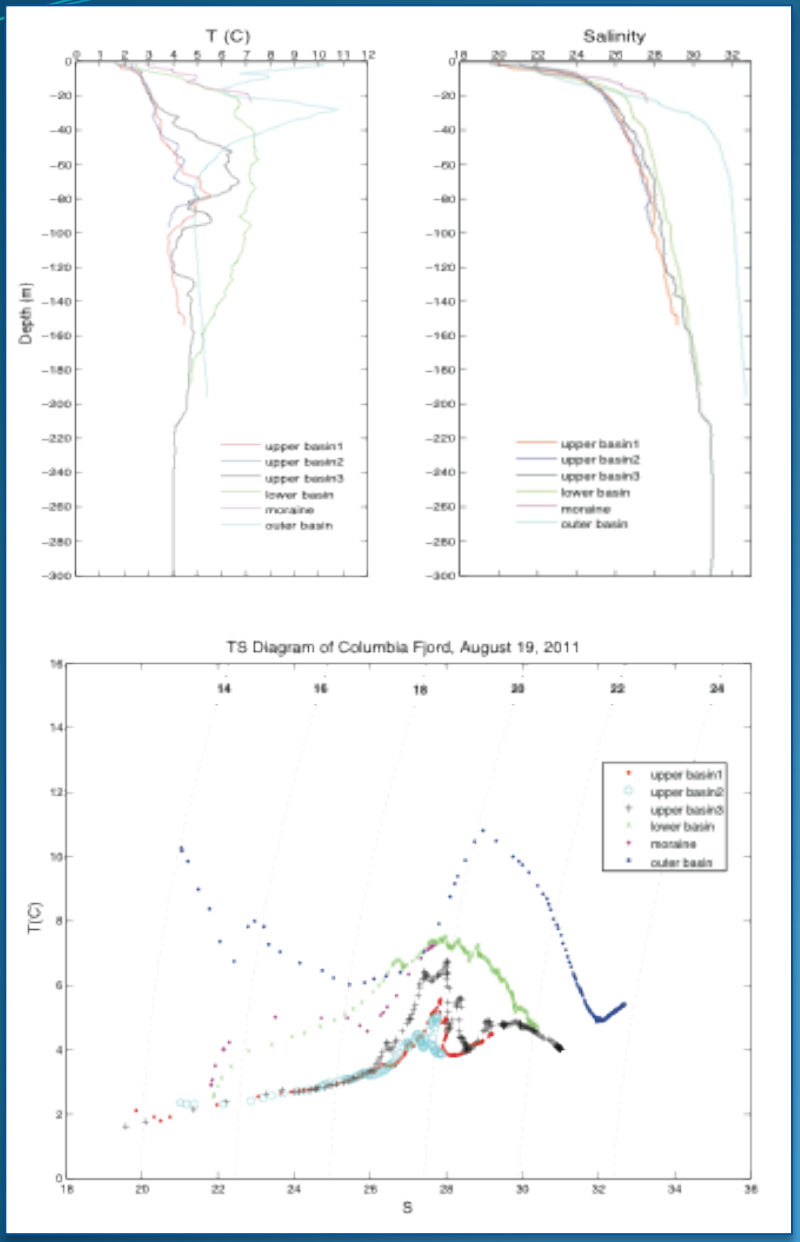
Moderate Size Secondary Basin: Eaglek Bay (14km)




EOS 2010
2010
2008
2004
1995
1997
1993
1989
1986
1983
Pre-1980

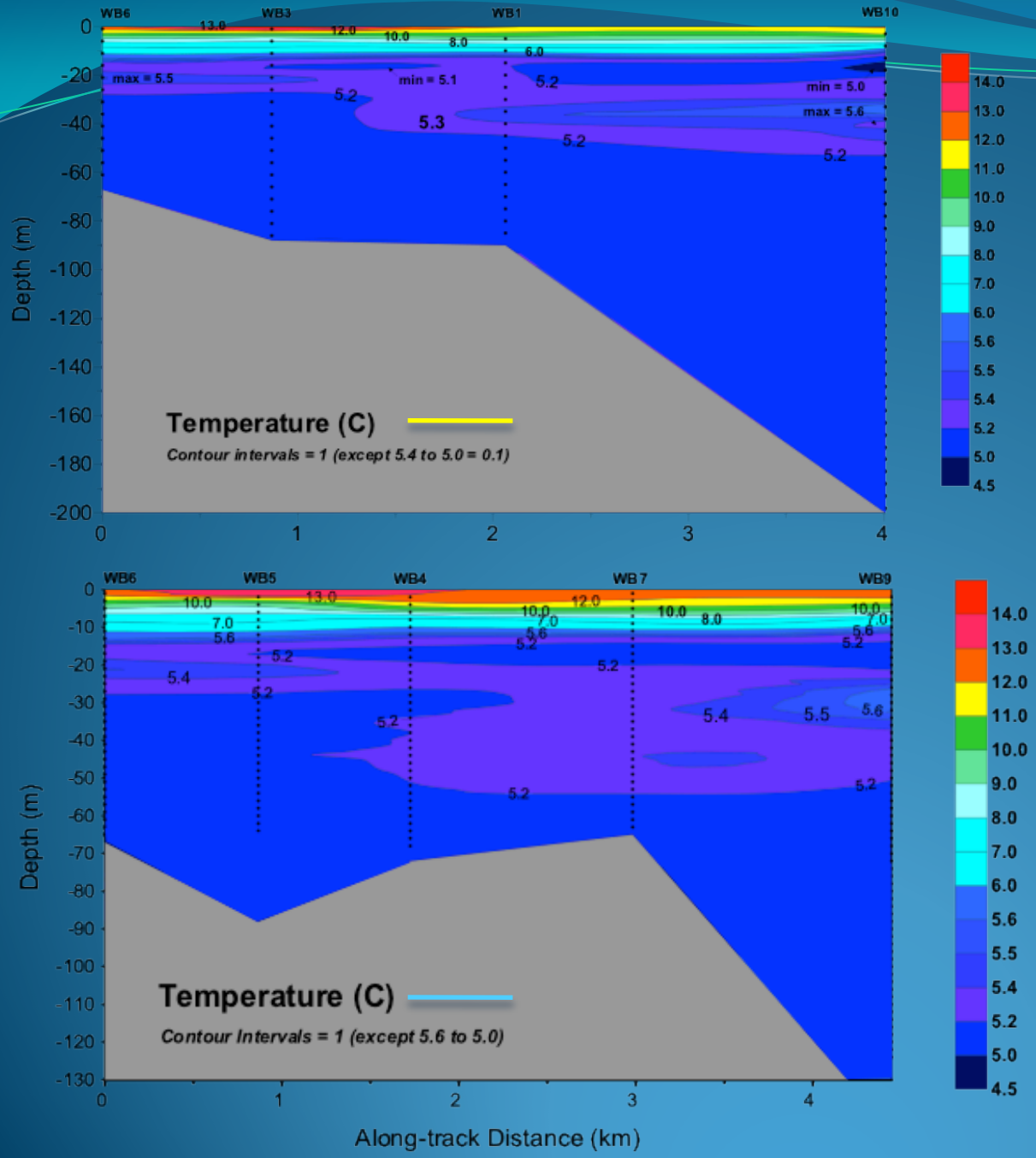

Columbia
Bay
Icy
Bay
61°00'N
60°30'N
60°00'N
59°30'N
148°W
147°W
146°W

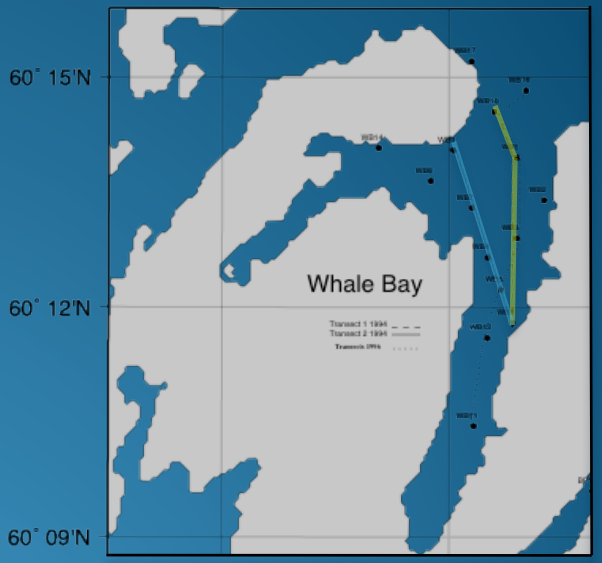
Temperature and Salinity Characteristics of Columbia Fjord in August 2011

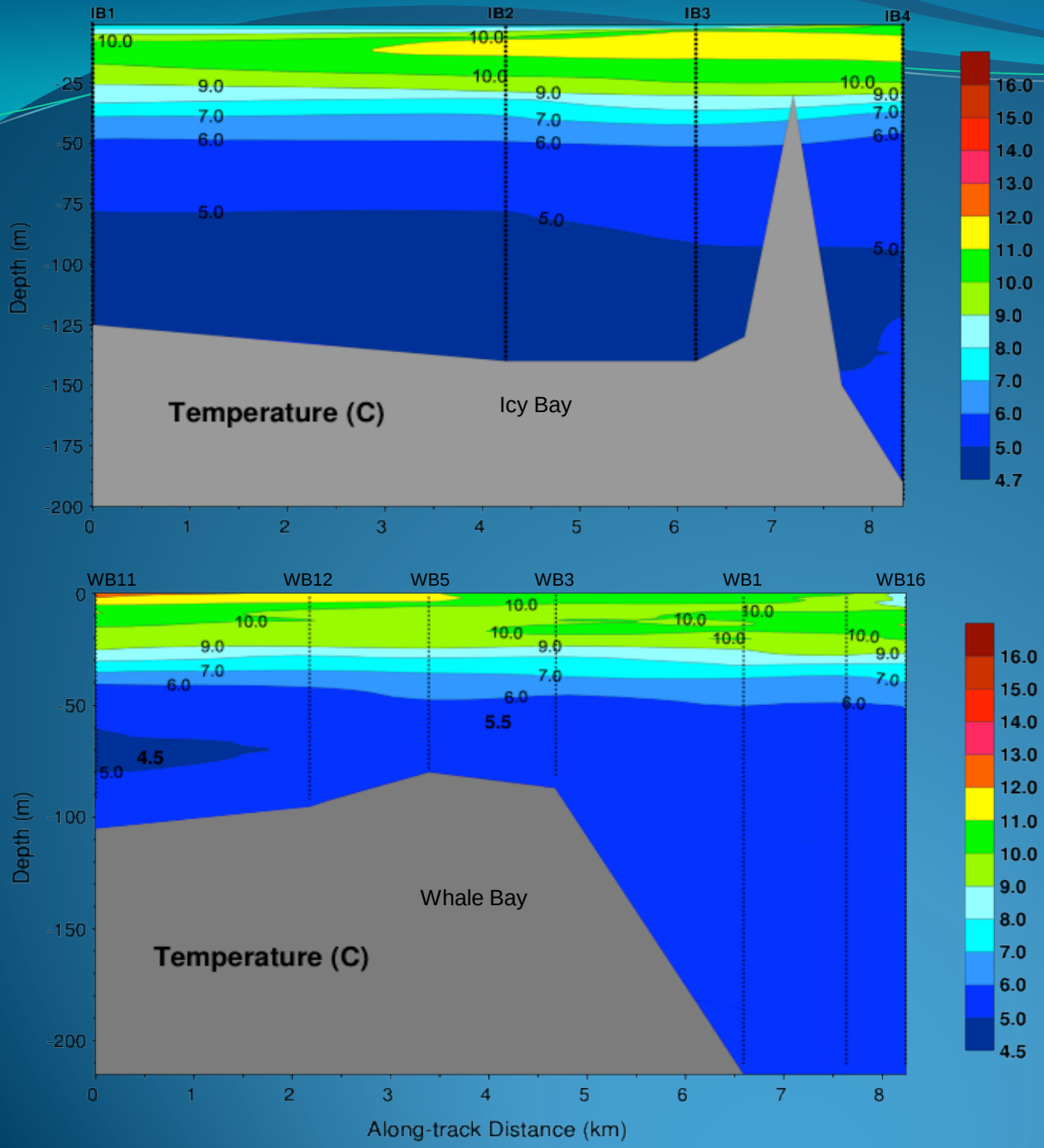


Cruise track & photos courtesy of Dave Janka

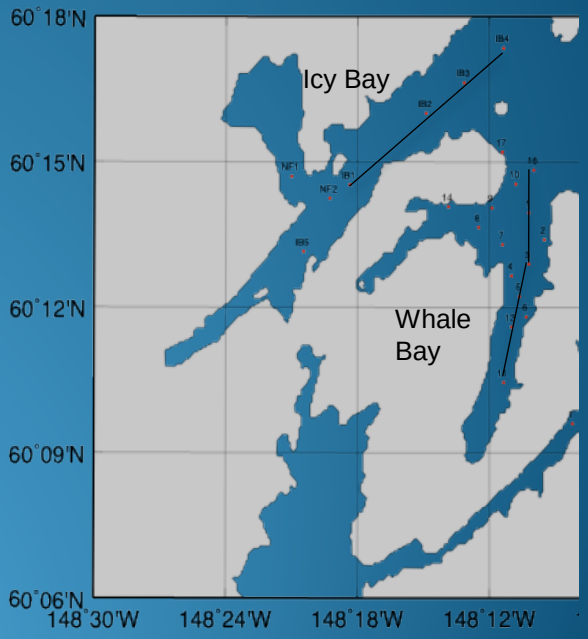
Effects of Glacial Water at Whale Bay in 1994

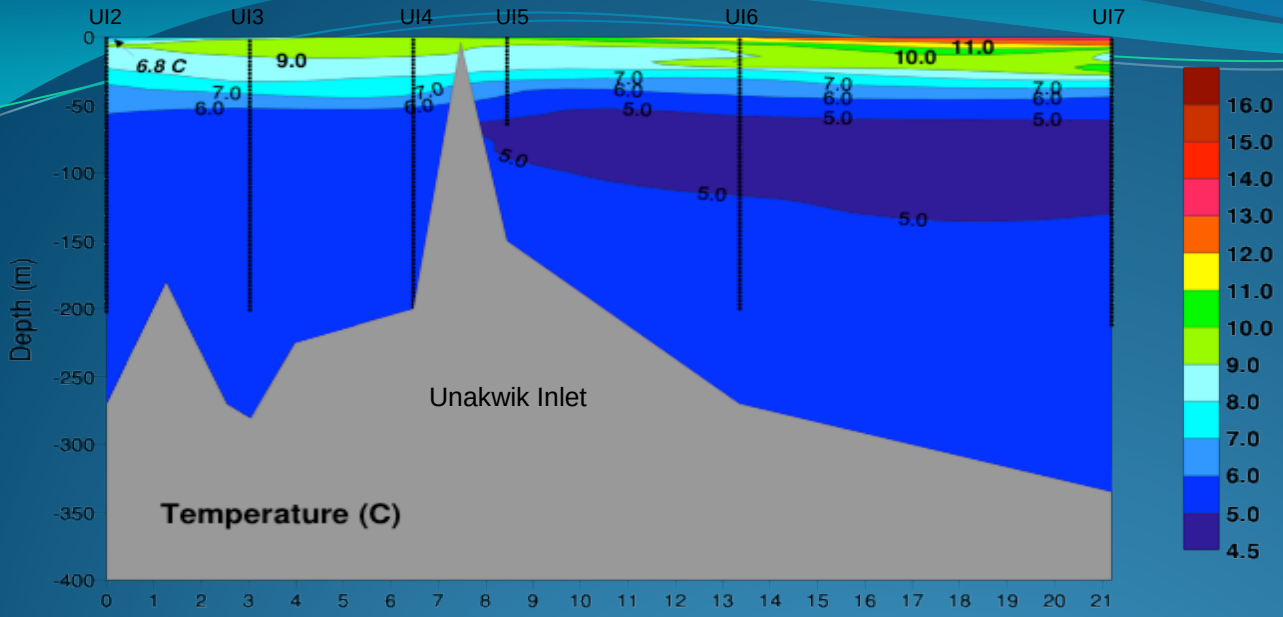


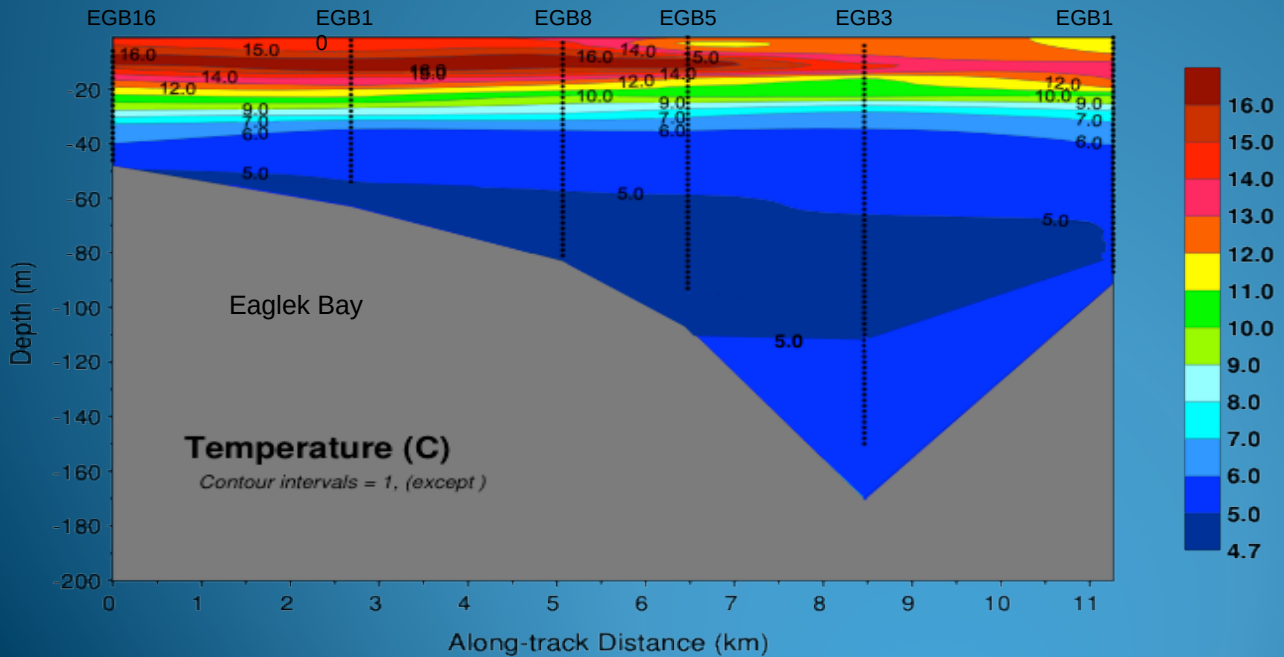




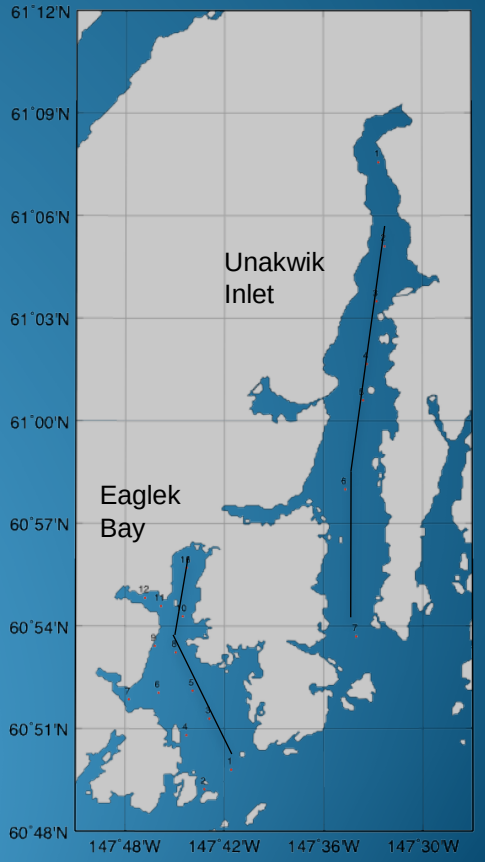
Glacial Water from Icy Bay Affecting Temperatures in Whale Bay again in 1996







Glacial Water from Unakwik Inlet affects Temperatures in Eaglek Bay in 1996 and 1997



Estuarine conditions in relation to watershed characterisitics

Hypotheses:

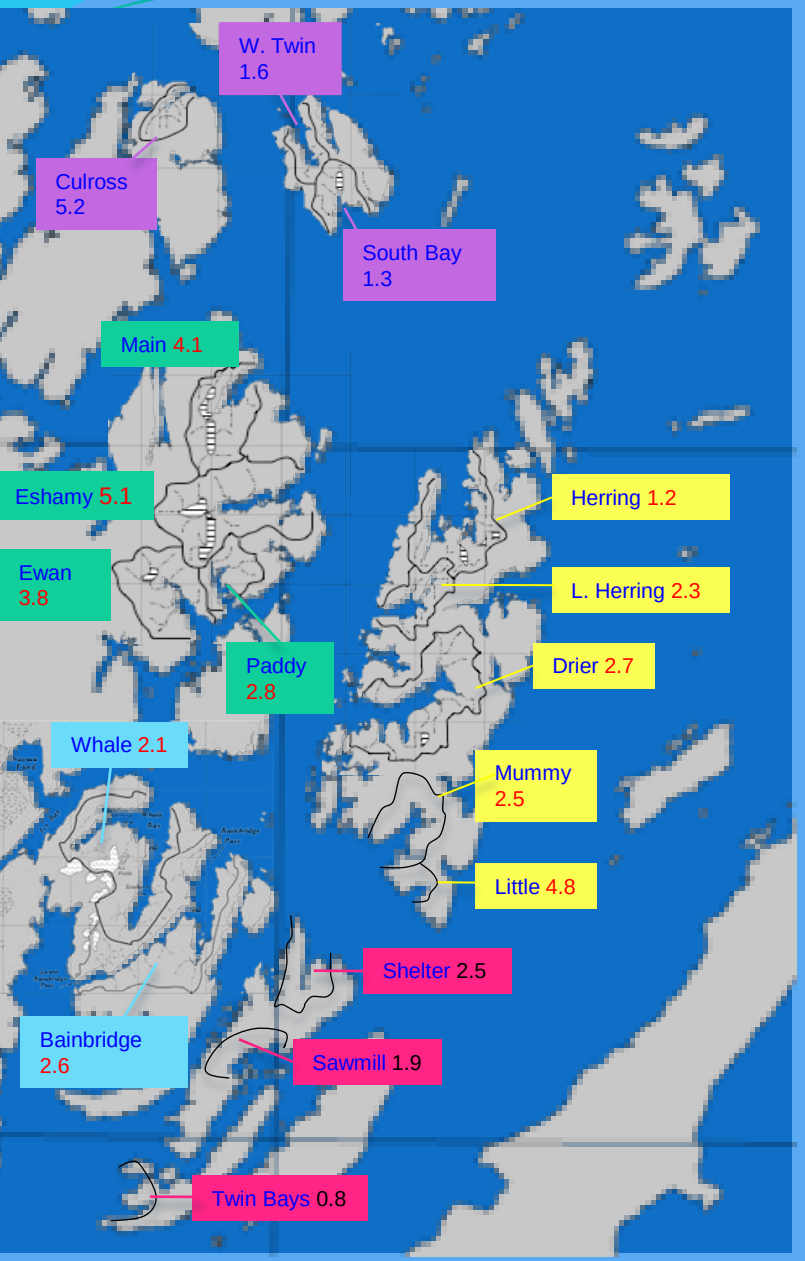
To test for a significant relationship between the freshwater input and

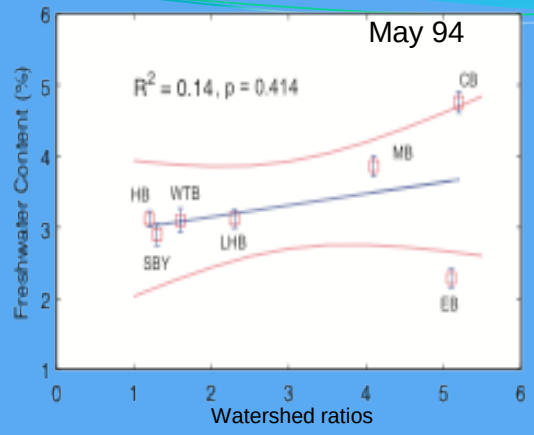
1) Watershed to fjord basin area ratios (watershed ratios),

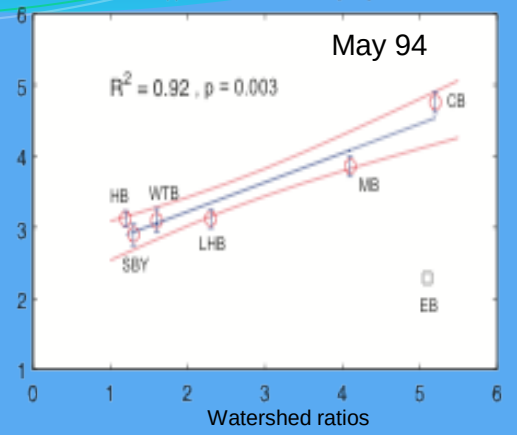
2) Watershed size (catchment area), and

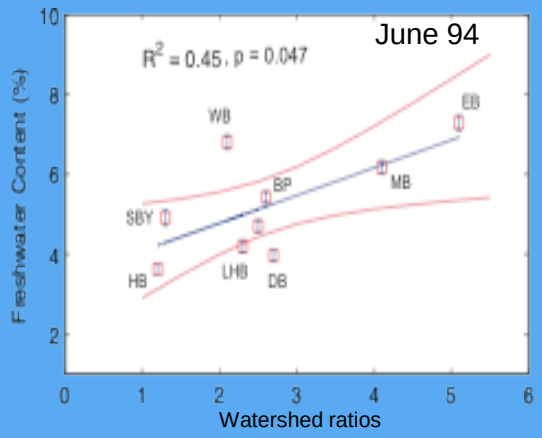
3) Watershed elevations (higher = more stored precipitation)

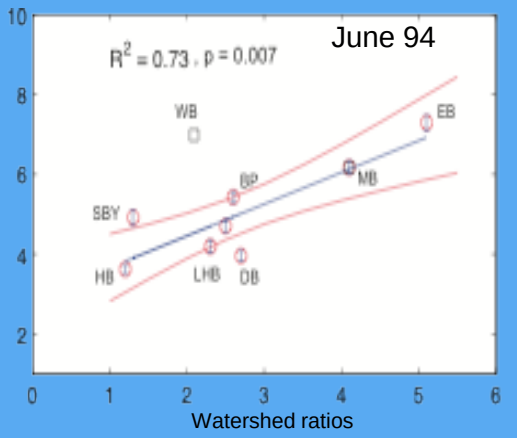
Regressions of FWC to Watershed Ratios in 1994

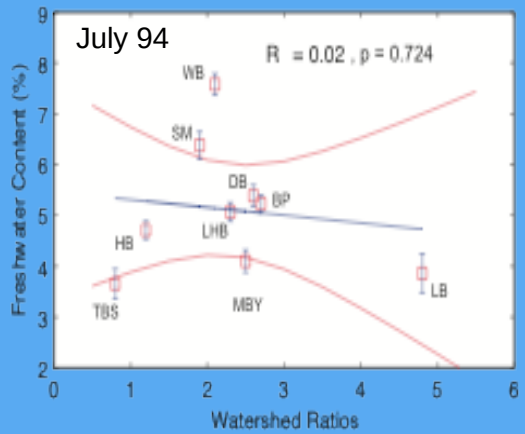


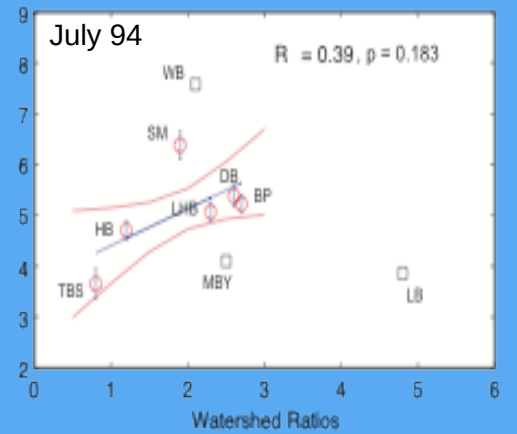




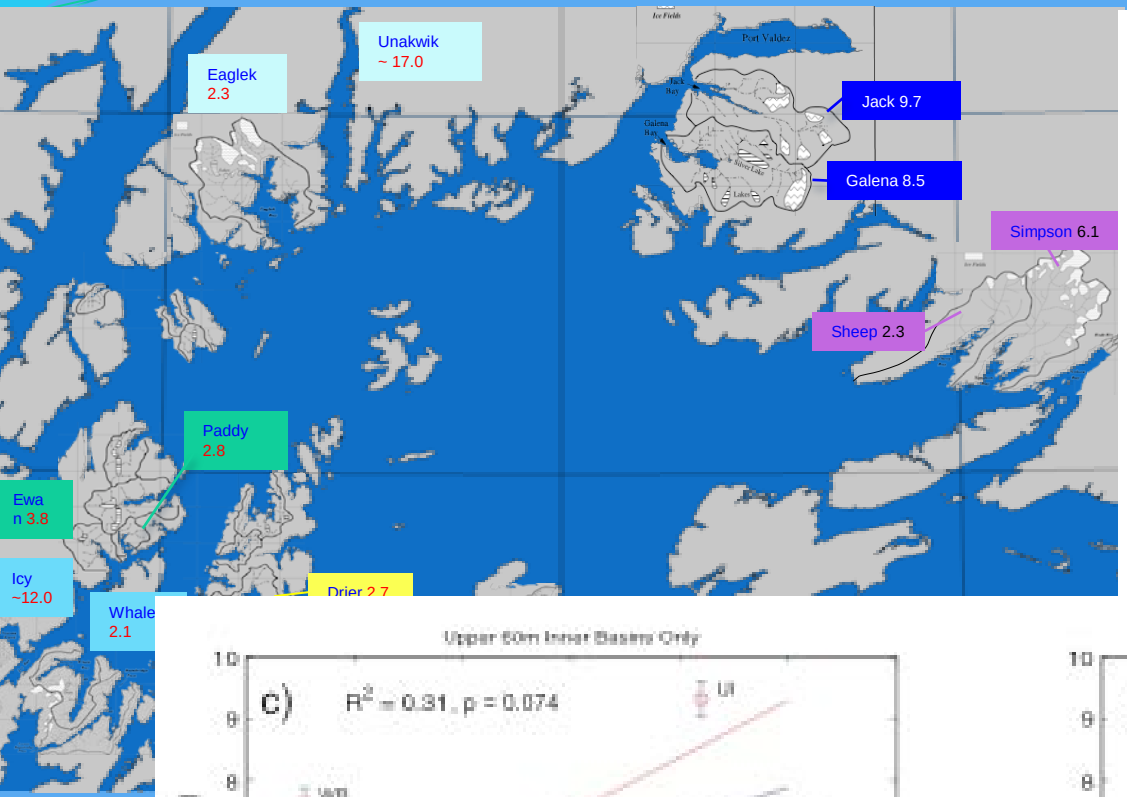


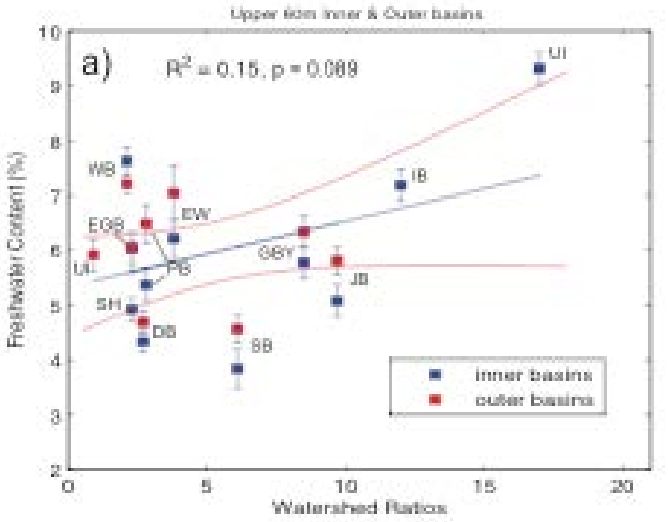


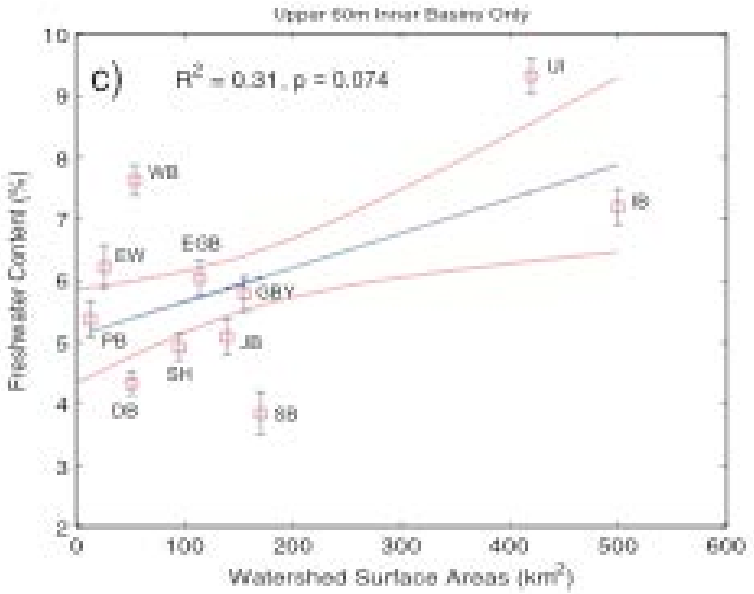


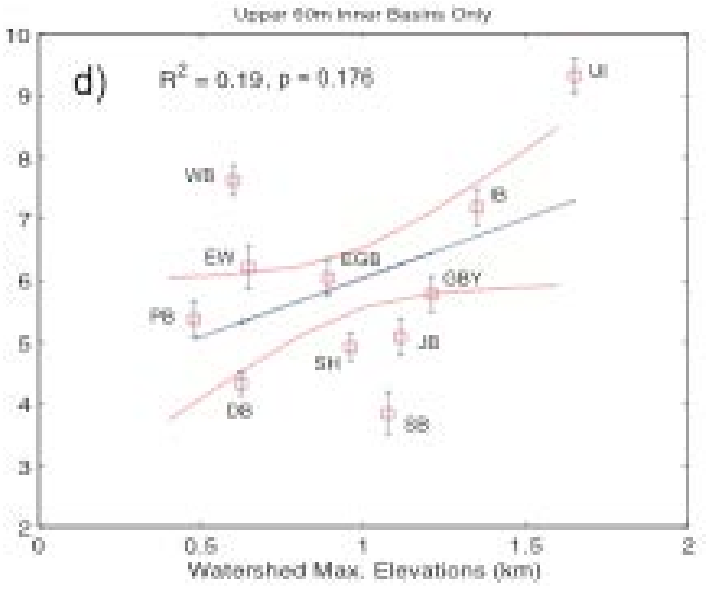


Estuarine Conditions in relation to Watershed Ratios, Maximum Elevations and sizes in 1996









Example of Glacial Advection in August 2003

Principal Components of Freshwater Contents

Objectives:

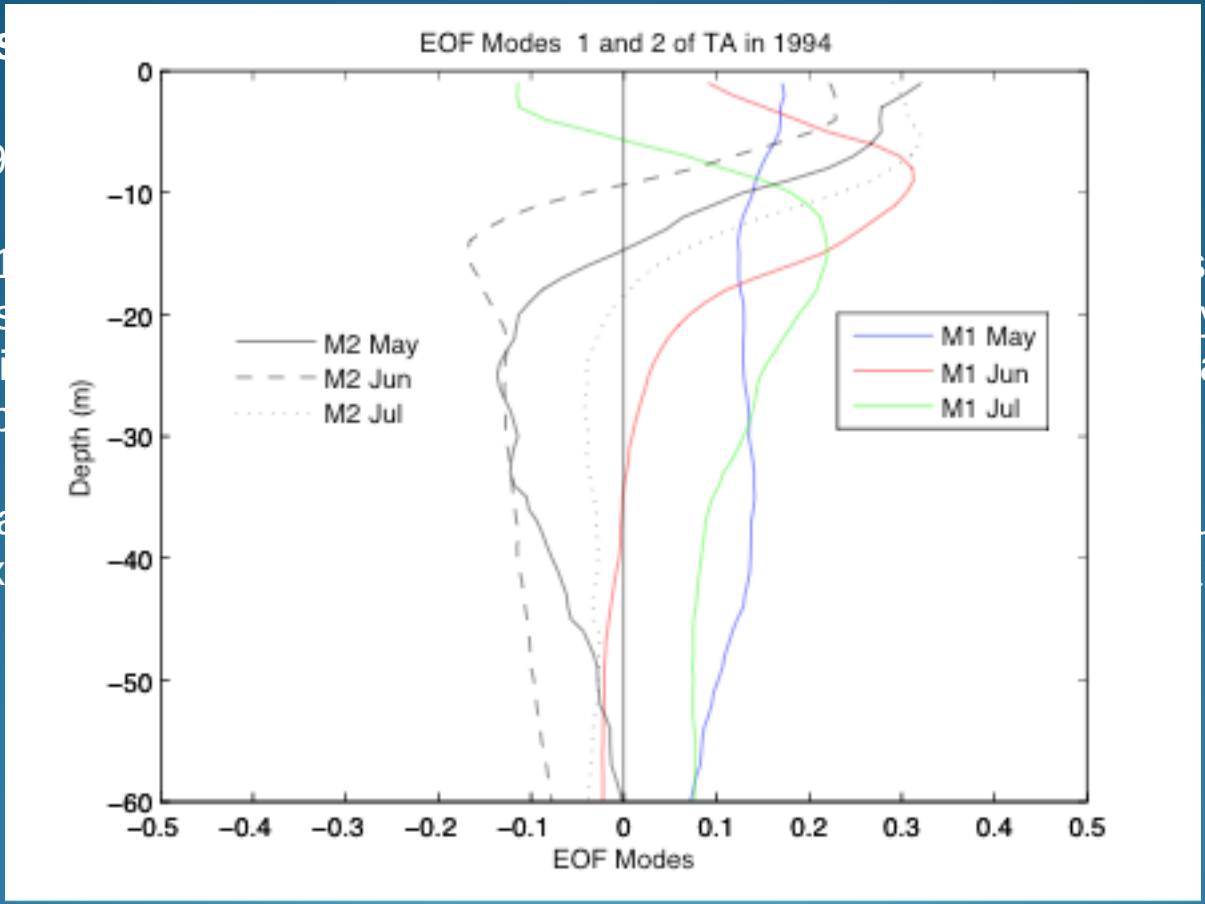
• Quantify the modes of variance in freshwater content anomalies (FWCA) among fjords (i.e. based on the deviation from the mean FWC profile of all sites).

• Determine how the modes relate to the distribution of FWC and physical processes within fjords.

• Map the spatial distribution of variance in FWC among sites in PWS.

Principal Components of Freshwater Contents

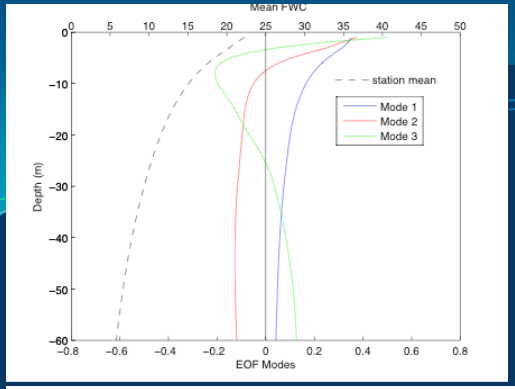
Results



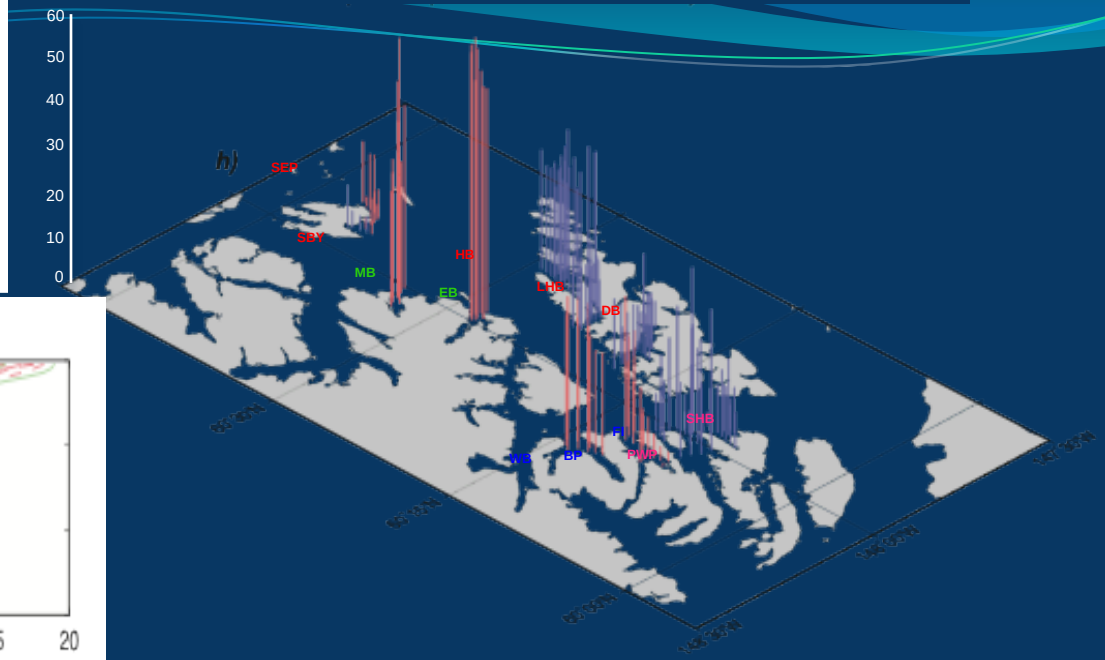
• 95 to 9

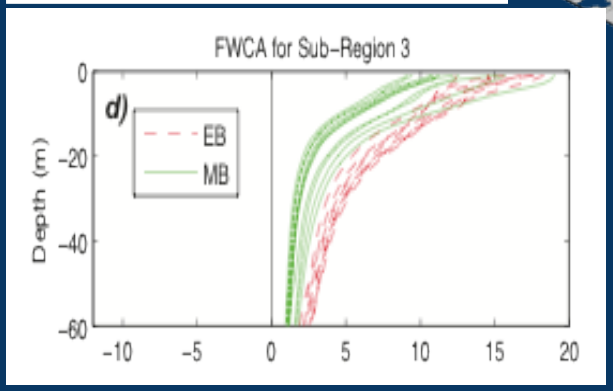
• Mode 1 s mode 2 indicates y mostly surface i and salty over dep

• A simila uch more complex nce.

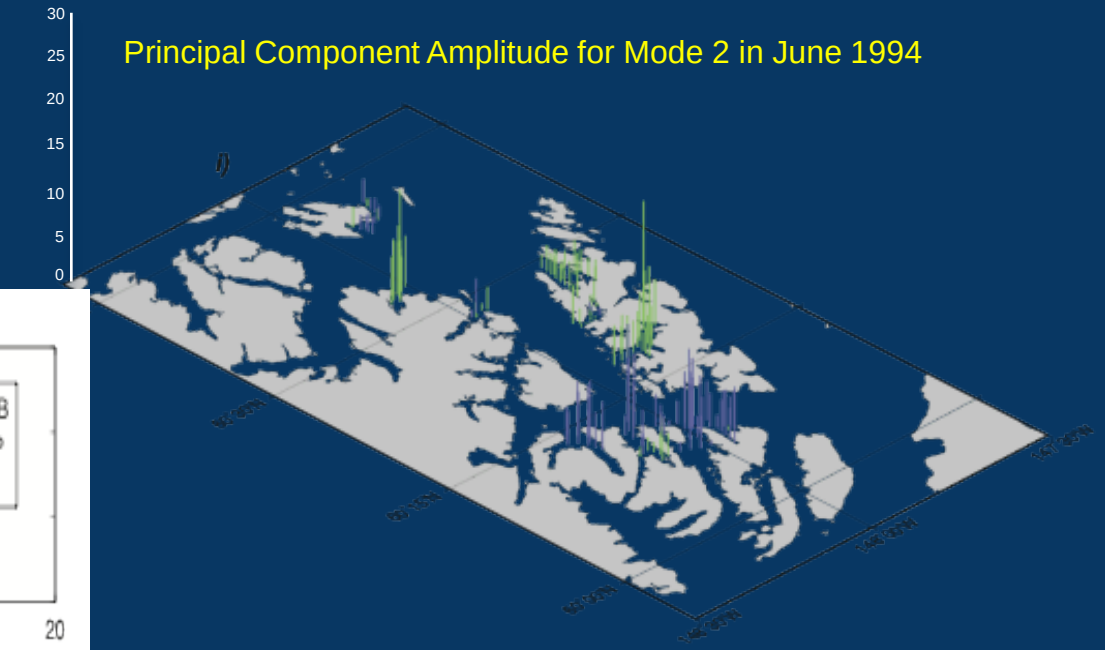


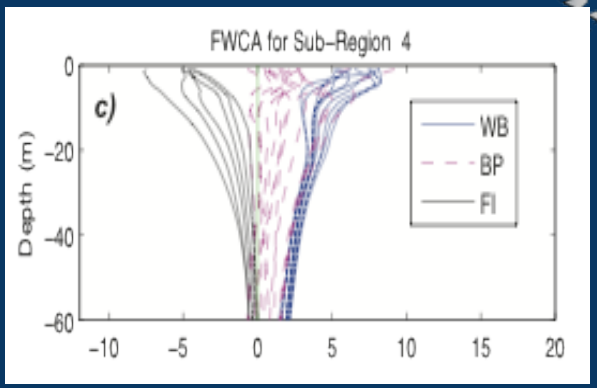
Principal Component Amplitude for Mode 1 in June 1994



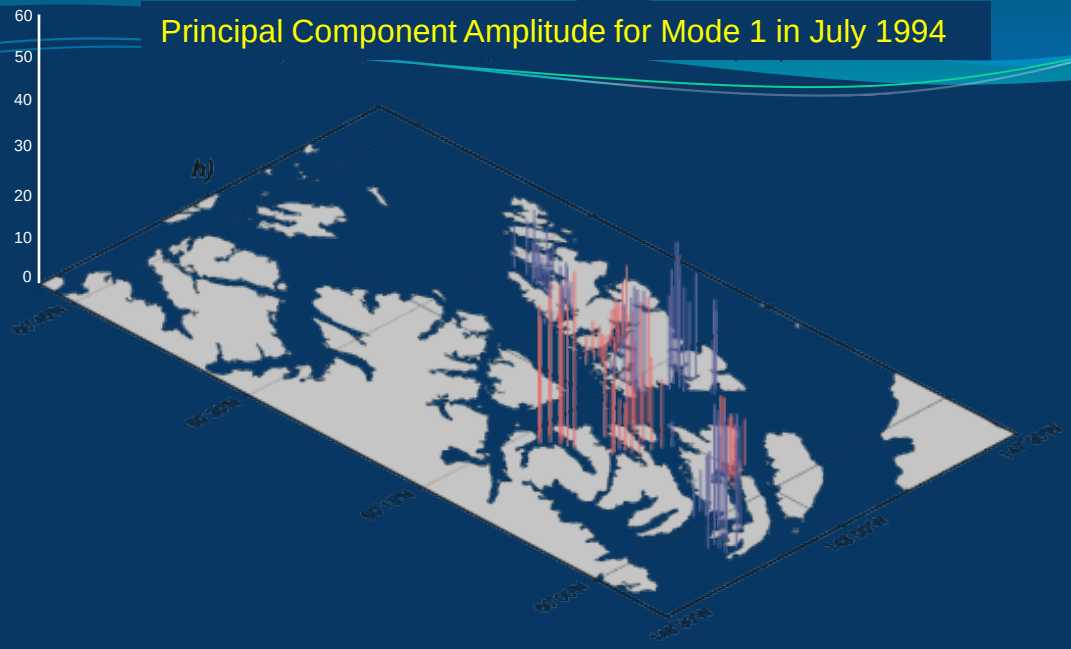


Principal Component Amplitude for Mode 2 in June 1994

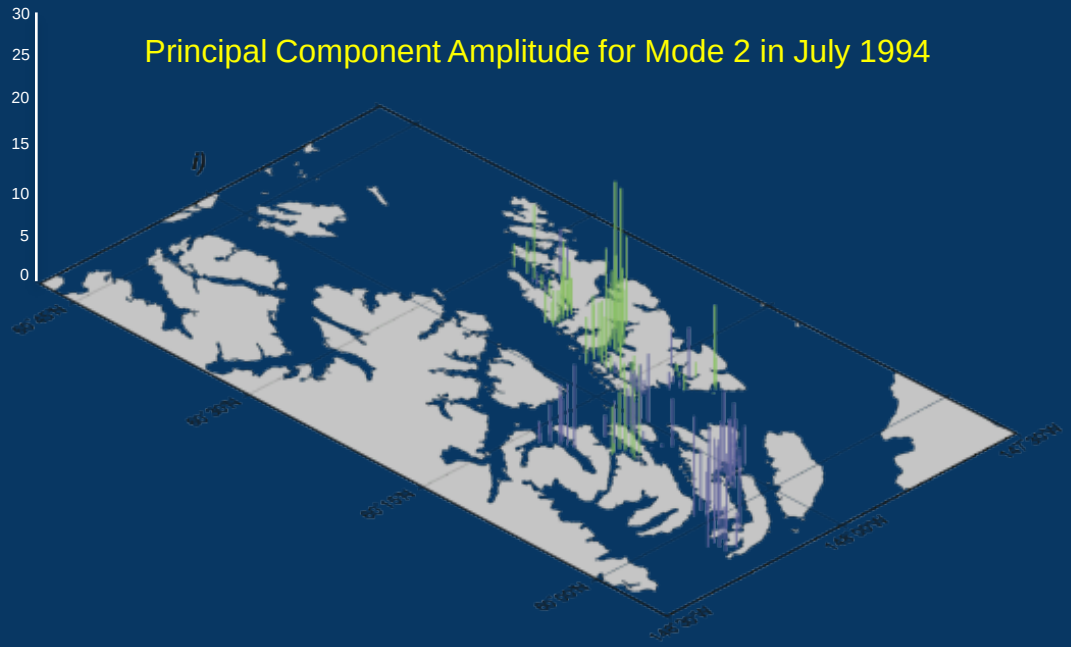




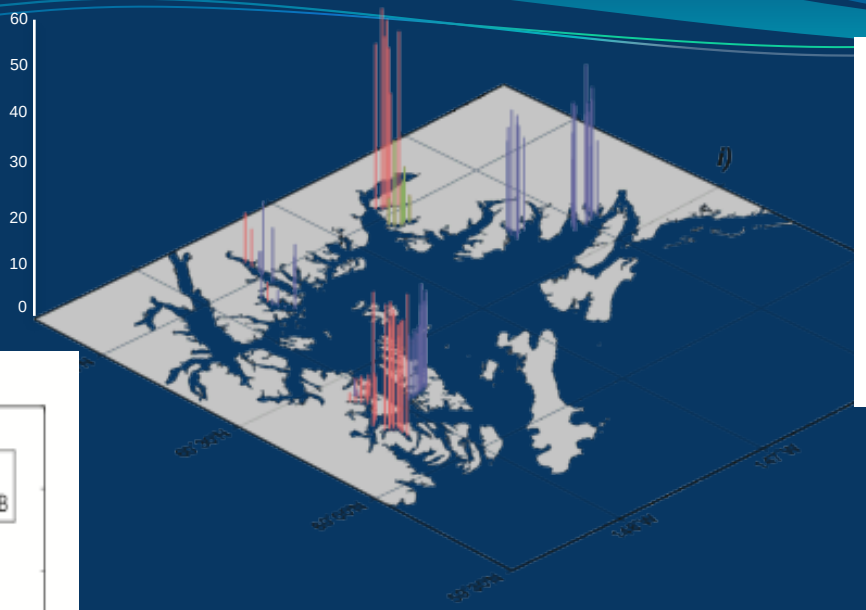
Principal Component Amplitude for Mode 1 in July 1994

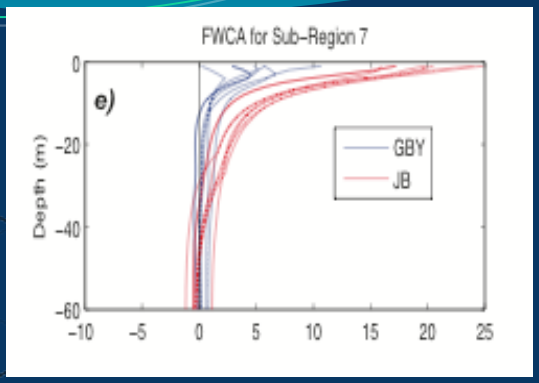


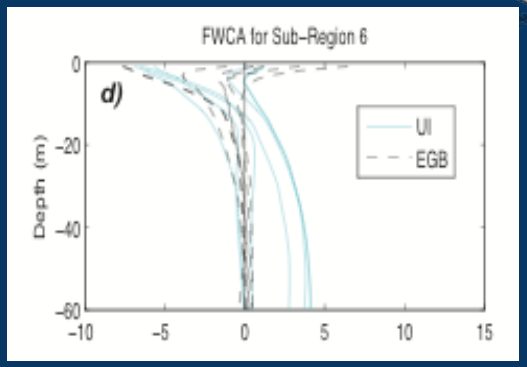
Principal Component Amplitude for Mode 2 in July 1994



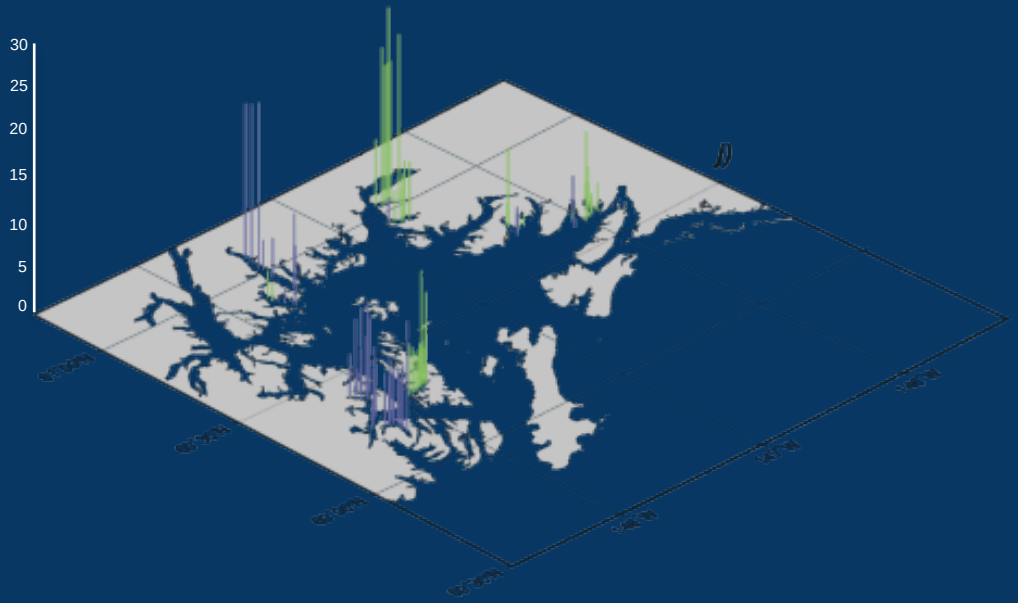
Principal Component Amplitude for Mode 1 in July 1996







Principal Component Amplitude for Mode 2 in July 1996



Summary and Conclusions

• Small fjords with high freshwater input exhibit large, positive mode 1 PCAs, but whereas positive mode 2 *PCA*s indicate stratification, negative values indicate subsurface freshening.

• In many cases, the effects of local watersheds are superseded by the advection of extraneous fresh water, particularly from glacial fjords. In at least one case (Whale) the glacial advection creates extreme fresh conditions relative to the WSR in all years.

• In contrast, fjords not influenced by glacial advection have physical properties mainly determined by local climate, hydrology and, in certain cases, the concentrating effects of high WSRs.

• In 1994, subsurface freshening from glacial advection influenced hydrographic conditions of small fjords in western PWS, as far south as Flemmng I. and possibly N. Elrington Pass and Sawmill Bay.

• In 1996, high subsurface *FWC* was again observed in Whale Bay and also to the north in Dangerous Pass and two small fjords located in the pass, Ewan and Paddy Bay, indicating that southward advection from glacial regions to the north (or south?) also occurred that summer.

• Similar conditions to the above were observed in Perry Pass in 1994.

General Conclusions

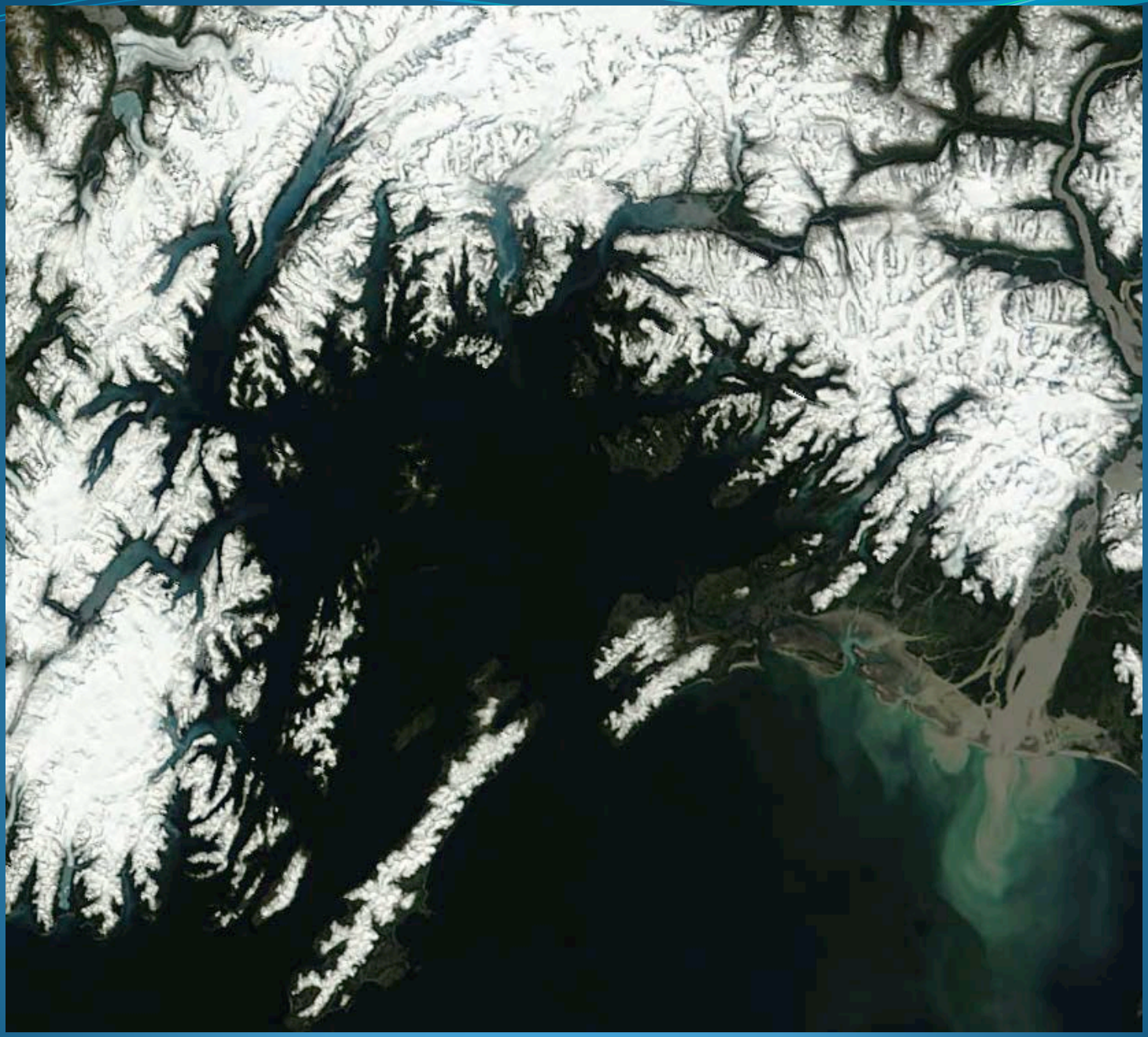
• Most small fjords in PWS do not contribute significantly to the Freshwater Content of the Sound in the spring and summer, and hence have little affect on the baroclinic flow from PWS to the Gulf of Alaska.

• This is instead dominated by advection of water from regions containing tidewater glaciers.

• More recent hydrography data in PWS and some of the small fjords from 2006 to 2012 and satellite imagery in 2013 indicate freshwater input from glacial advection within PWS may be occurring earlier than in the previous decade.

• This could be linked to climate changes that are now taking place in the Arctic.

Example of Glacial Advection in May 2013



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Acknowledgements

- The SEA Research was sponsored by the Exxon Valdez Oil Spill Trustee Council

- Gratitude is given to the captains and crews of the M/V Auklet, F/V Miss Kayley and the F/V Kyle David for making the field programs successful.

- Special thanks are extended to all the people who helped collect CTD data, in particular Loren Tuttle, Nick Peters, Andy Craig and James Thorne.

- Many of the photos in the talk are courtesy of Dave Janka, captain of the M/V Auklet.

Thanks - Questions