Current, Recent, Future work and big questions in Alaska

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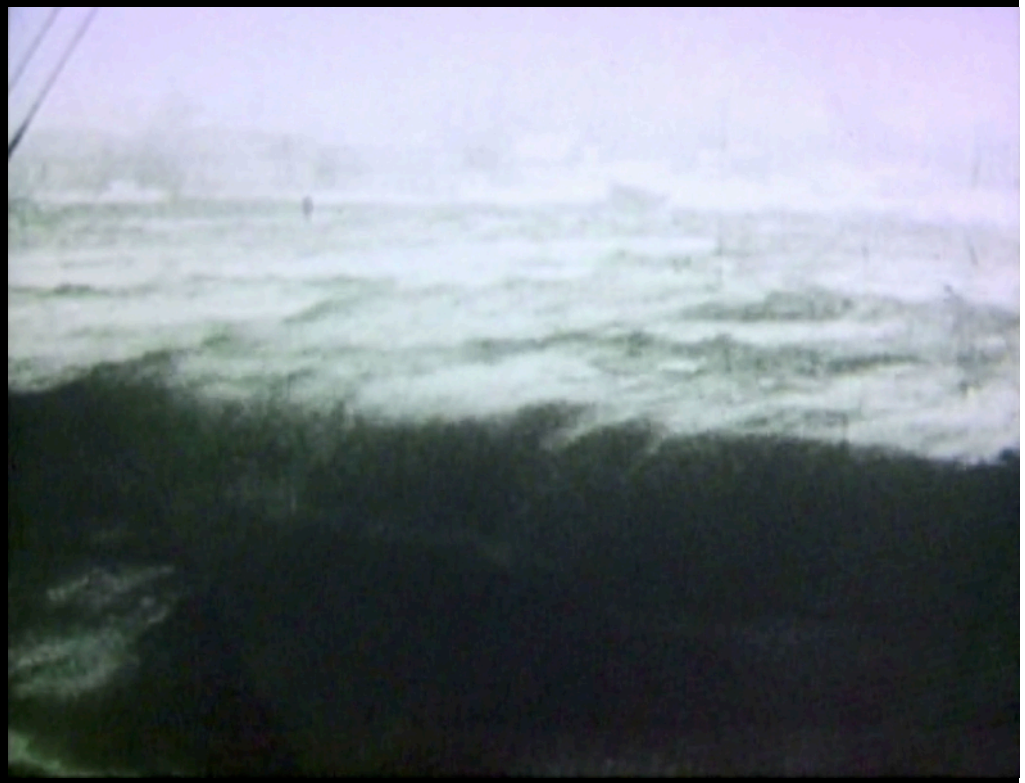

NTHMP-USGS Feb. 2016

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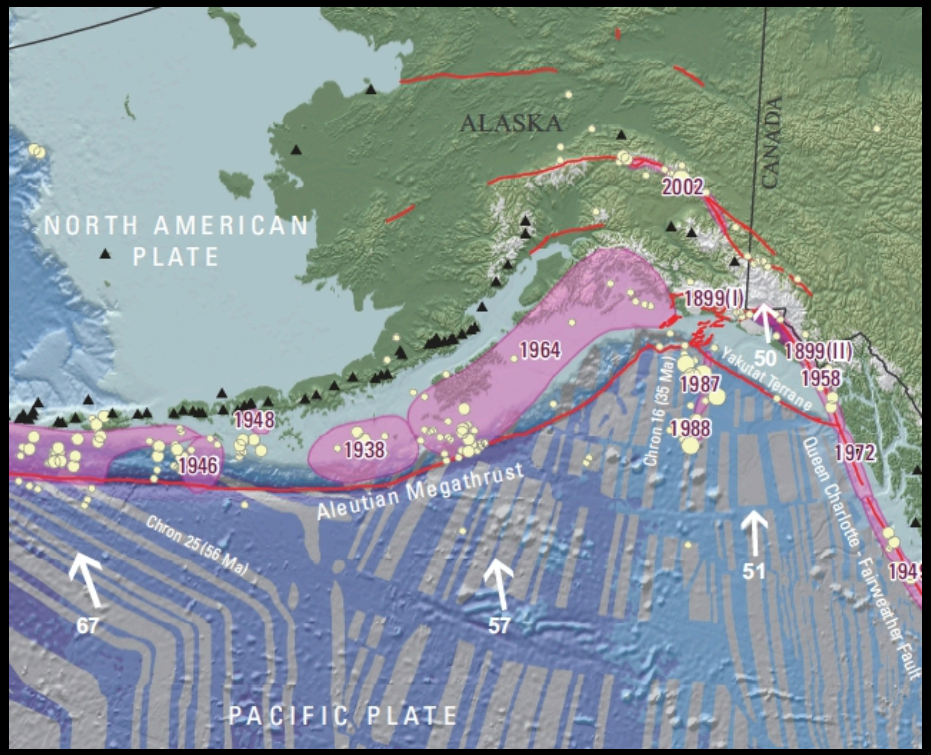
1964 M9.2 Great Alaska Earthquake

- M9.2 or 9.3+
- Second largest
- shaking lasted ~4.5 minutes
- Ground accelerations were ~0.14-.18g
- ~900yrs since prior event – spans LIA
- Mean recurrence ~600 yrs



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Tsunami damage in Alaska

- In Alaska, 106 of 122 deaths were tsunami related (87%)
- 85 of these 106 deaths were related to submarine landslide generated tsunamis (80%)
- The fjords of coastal Alaska are an ideal geologic environment for producing submarine landslides

USGS

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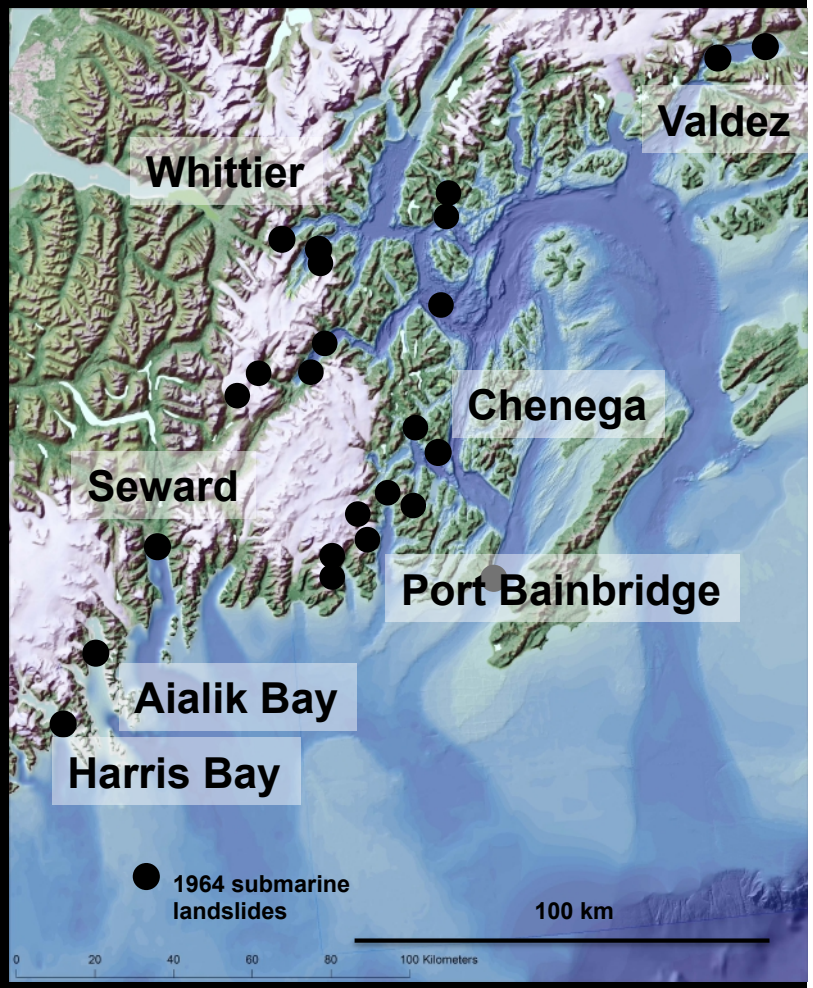
Submarine landslides

- There were numerous submarine landslides caused by the earthquake
- Impacted shorelines within 1.5 minutes of start of shaking
- The earthquake is the warning



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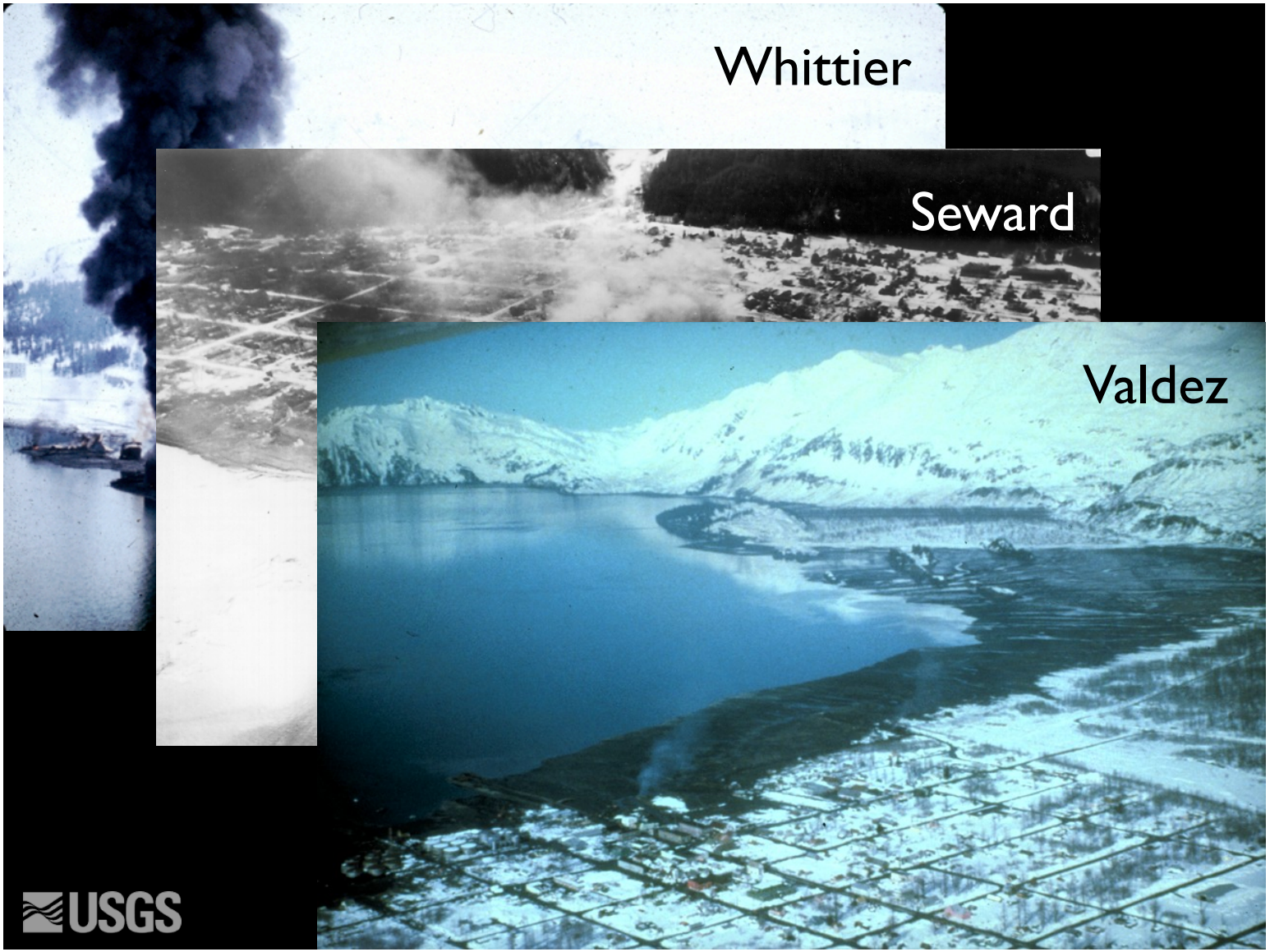

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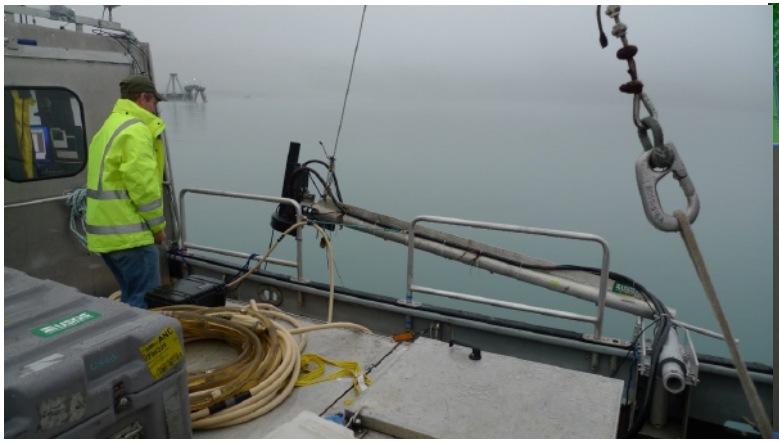
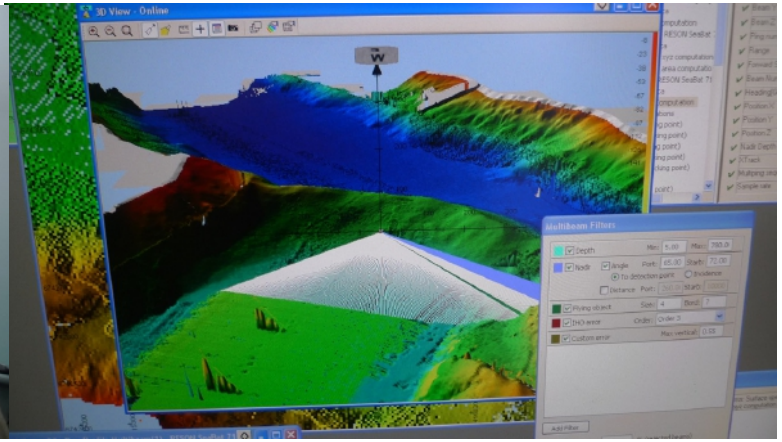
Our Data

Town	Fatalities	Fjord	Multibeam (post 1964)	Pre 1964 bathy	lidar	sparker seismics	chirp	1964 observations	cores	on-land deposits	SASW	tsunami models
Valdez	32	Port Valdez	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Whittier	12	Passage Canal	Y	Y	Y	Y	Y	Y	N	N	N	Y
Chenega	23	Lower Dangerous Passage	Y	Y	N	Y	N	Y	N	N	N	Y
–	–	Port Bainbridge	Y	Y	N	Y	N	~Y	N	N	N	N
Seward	12	Resurrection Bay	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
–	–	Aialik Bay	Y	Y	N	Y	N	N	N	N	N	N
–	–	Harris Bay	Y	Y	N	Y	N	N	N	N	N	N





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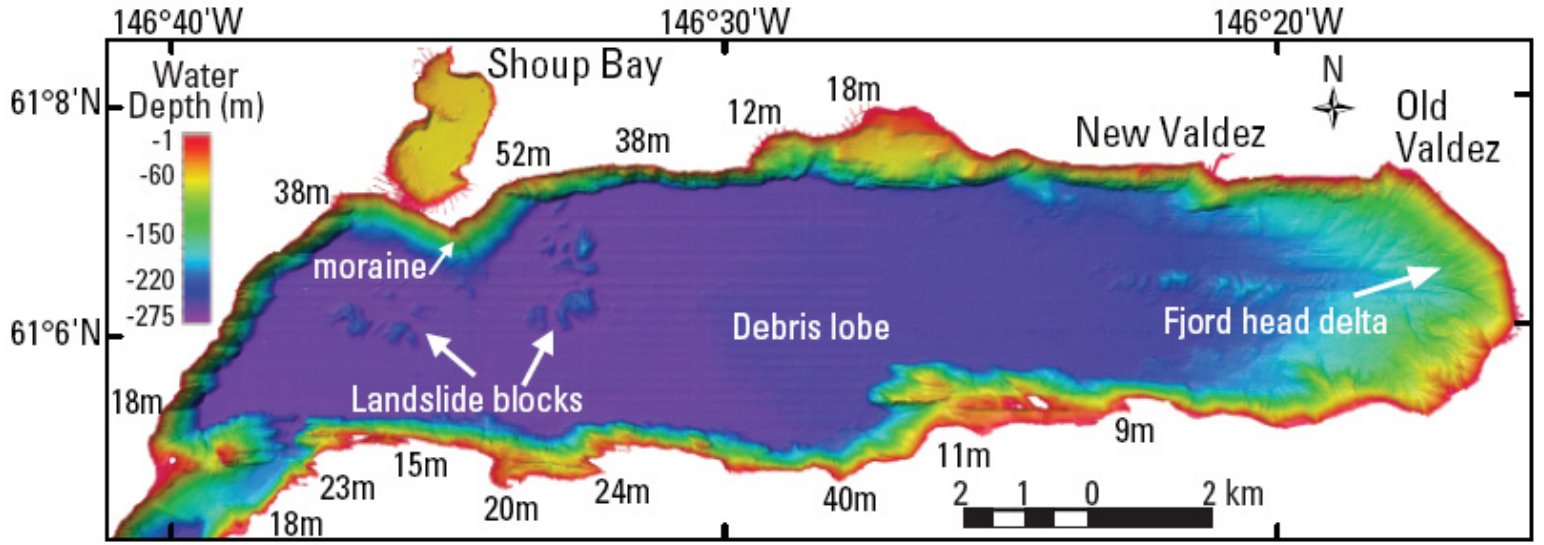
Port Valdez - Valdez



Bathymetry map

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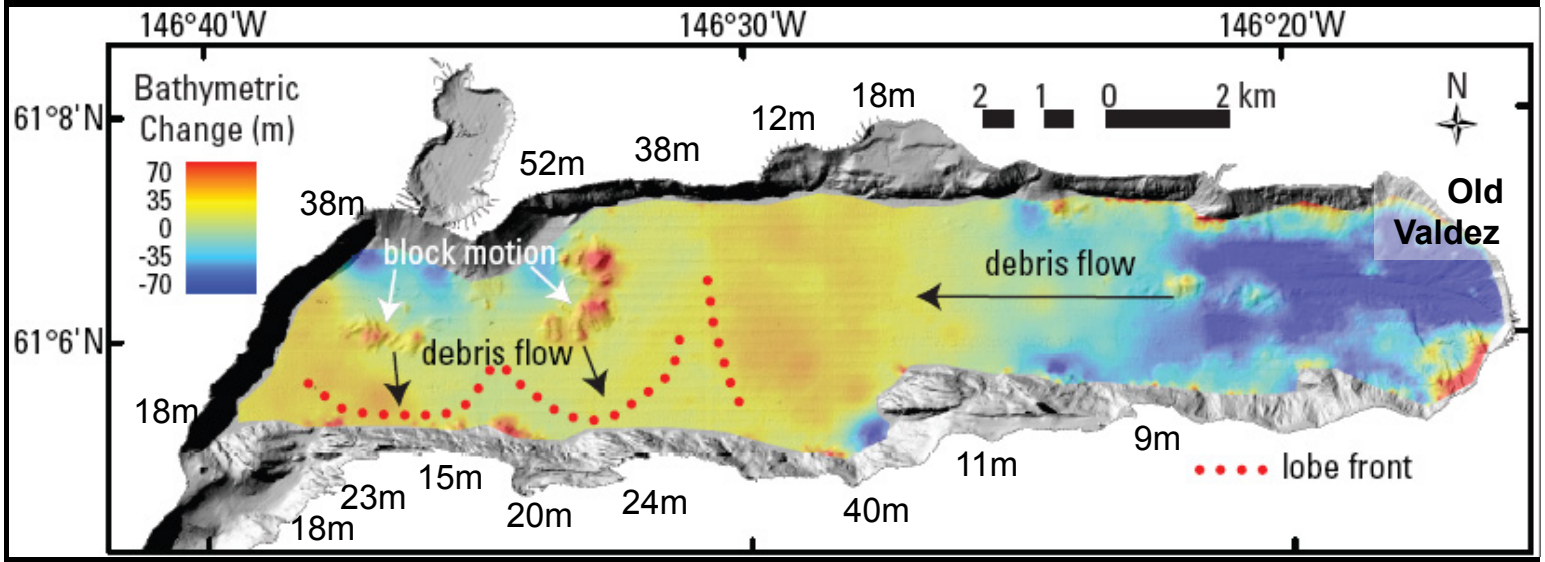

Bathymetry difference map

- 2 major slide areas
- Erosive flows
- Large blocks from Shoup Bay moraine
- Record of 6 major slides in seismic profiling

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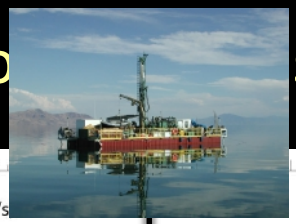
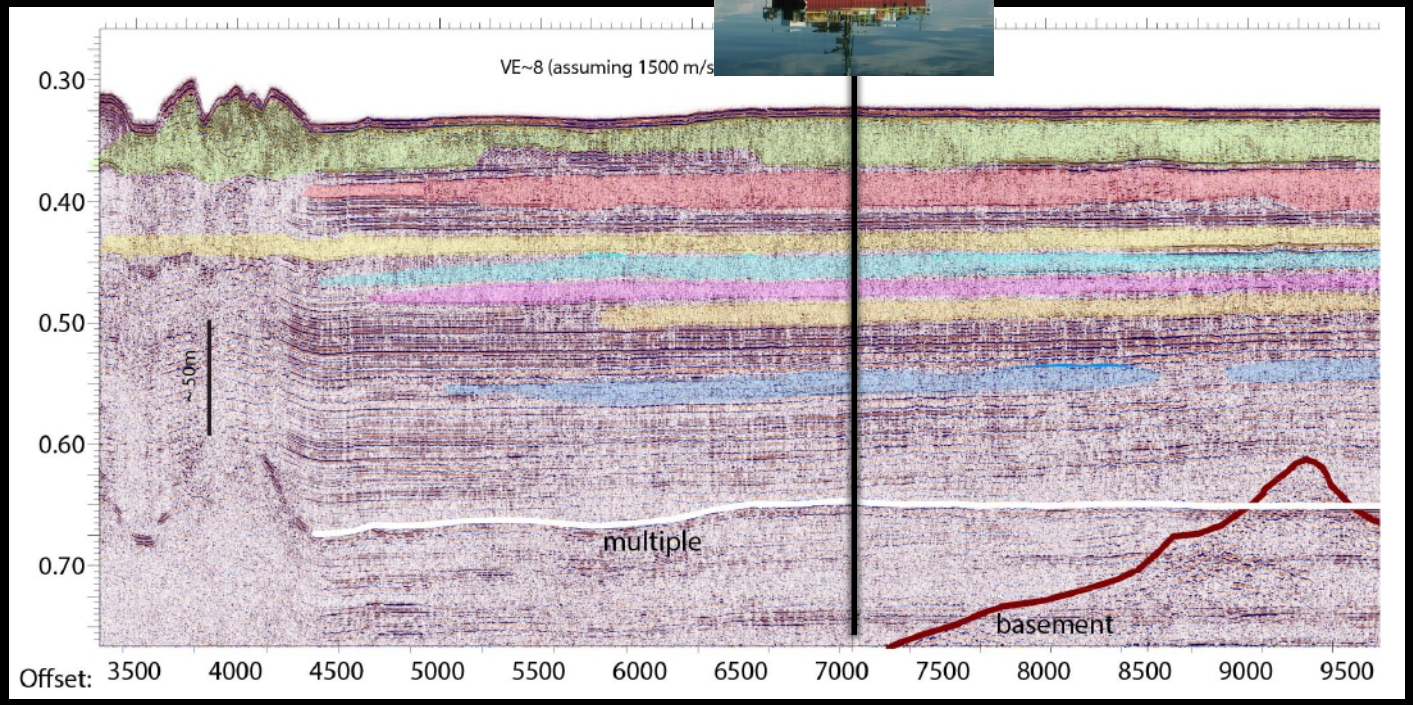
Sub-bottom profiles sho  s debris flows



- 1964 and 7 pre 1964 submarine landslides
- International Continental Drilling Program workshop proposal submitted
- If funded, workshop at 2016 AGU

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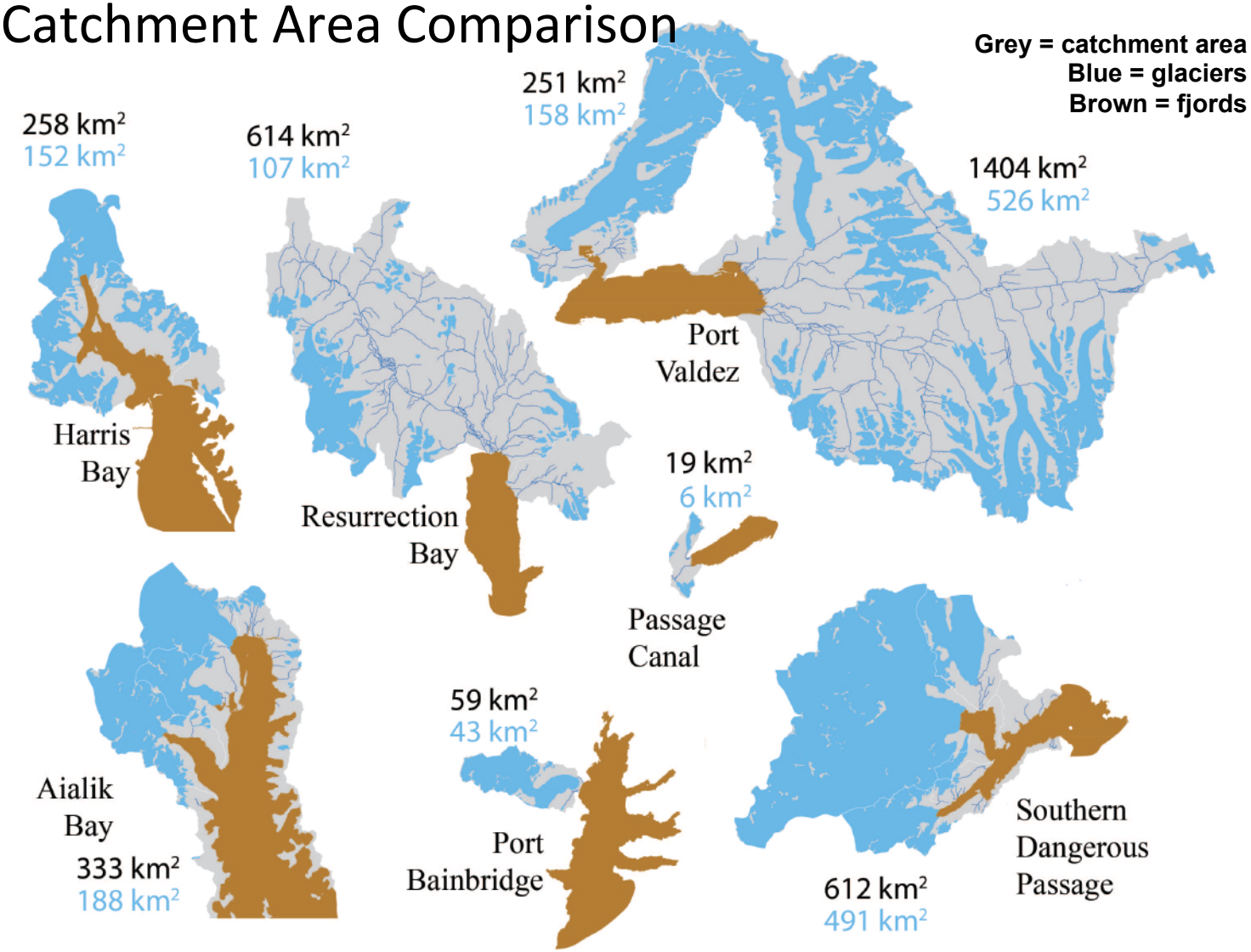
Catchment Area Comparison



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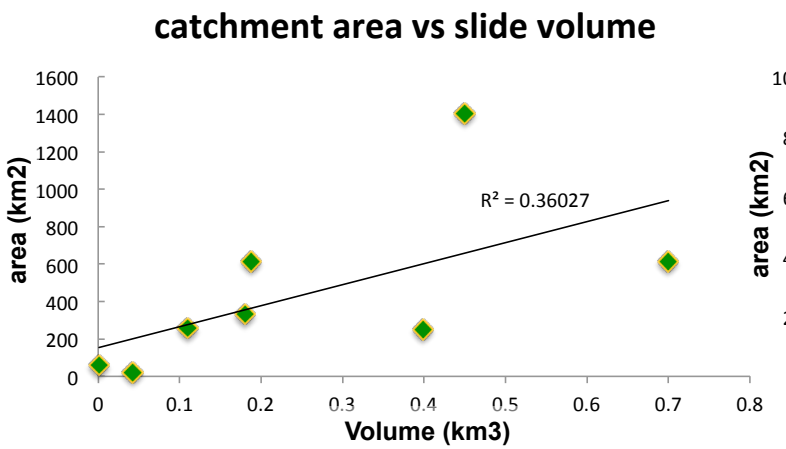
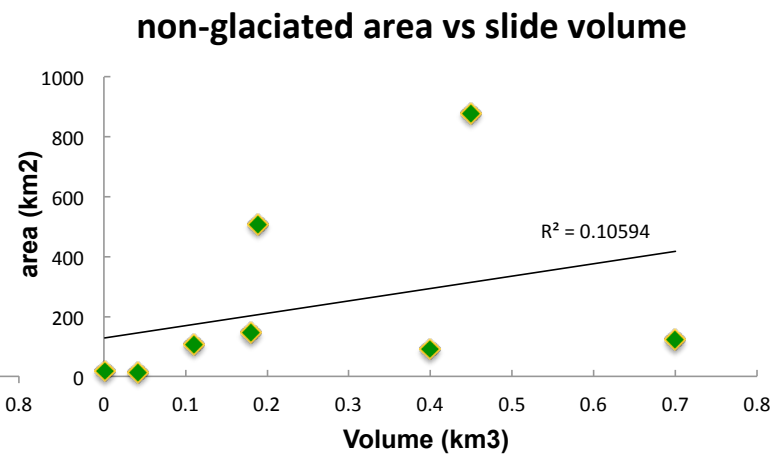
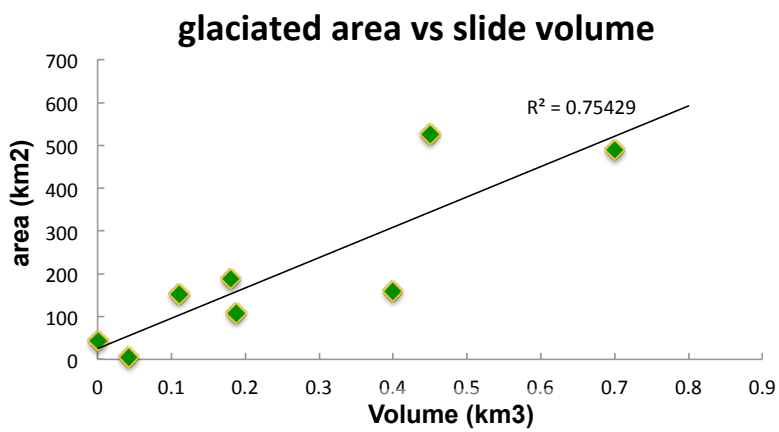
Catchment comparison







- Suggests glaciers produce most sediment that fails
- Sediment is not stored in valleys
- Predictive tool?

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Urban-ization at Seward, Alaska

all streams entering head of Resurrection Bay have been diverted

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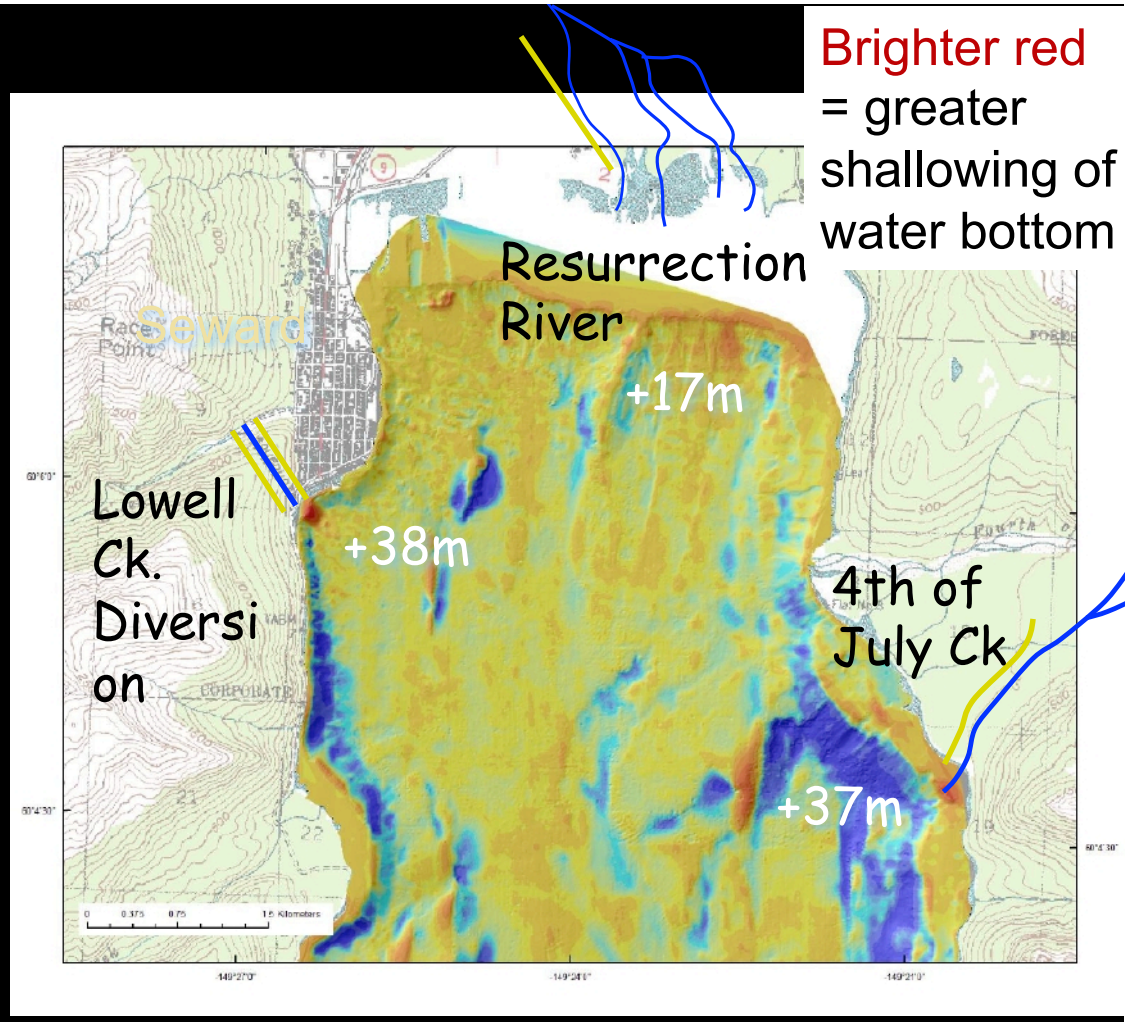
The next submarine mass failure

- Are we safer?
- Will the channelization of flow and focusing of sedimentation cause more frequent but smaller mass failures?
- Or will the focusing make for larger failures than what would have happened if the streams had been allowed to wander?



Bathymetric difference map 1965-2001

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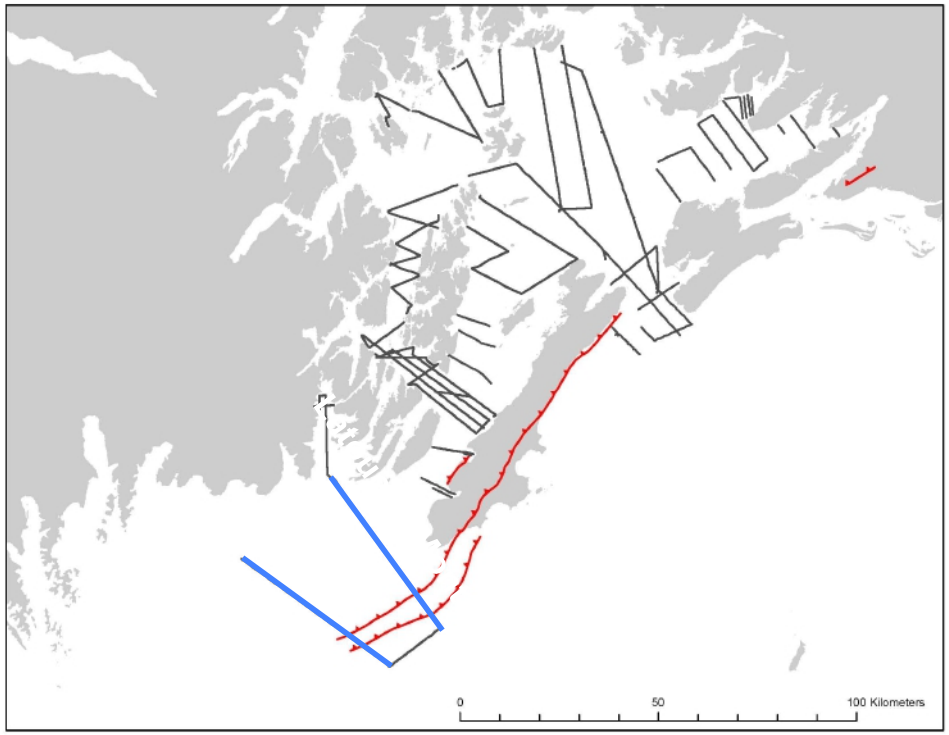
Active faulting

R/V Alaskan Gyre



- 800 km of new 300-500 J sparker data collected in 2009 and 2011
- Single and multi channel
- Blue lines show splay faults SW of Montague Island

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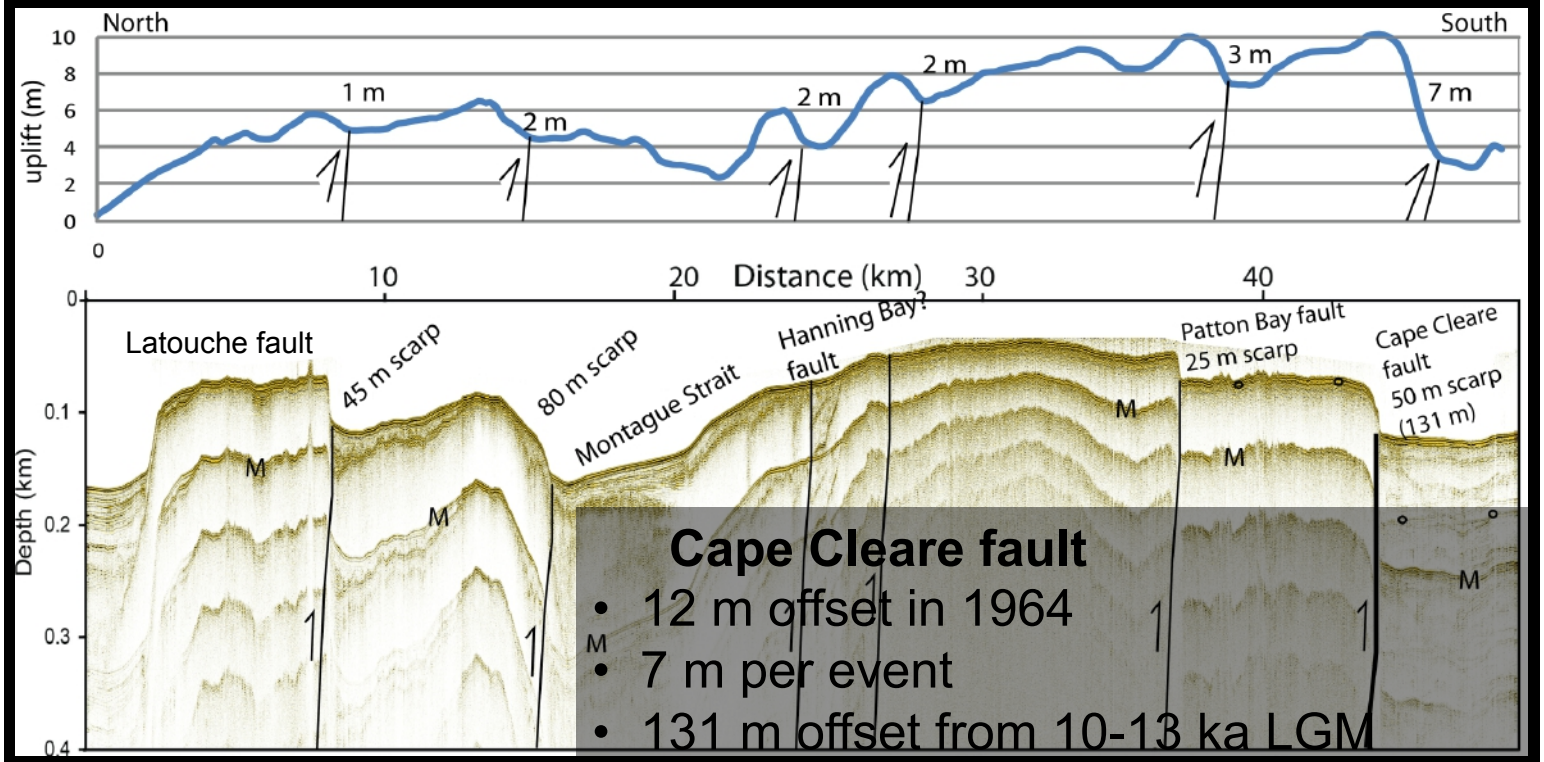
Latouche-Montague Strait profile



Cape Cleare fault

- 12 m offset in 1964
- 7 m per event
- 131 m offset from 10-13 ka LGM

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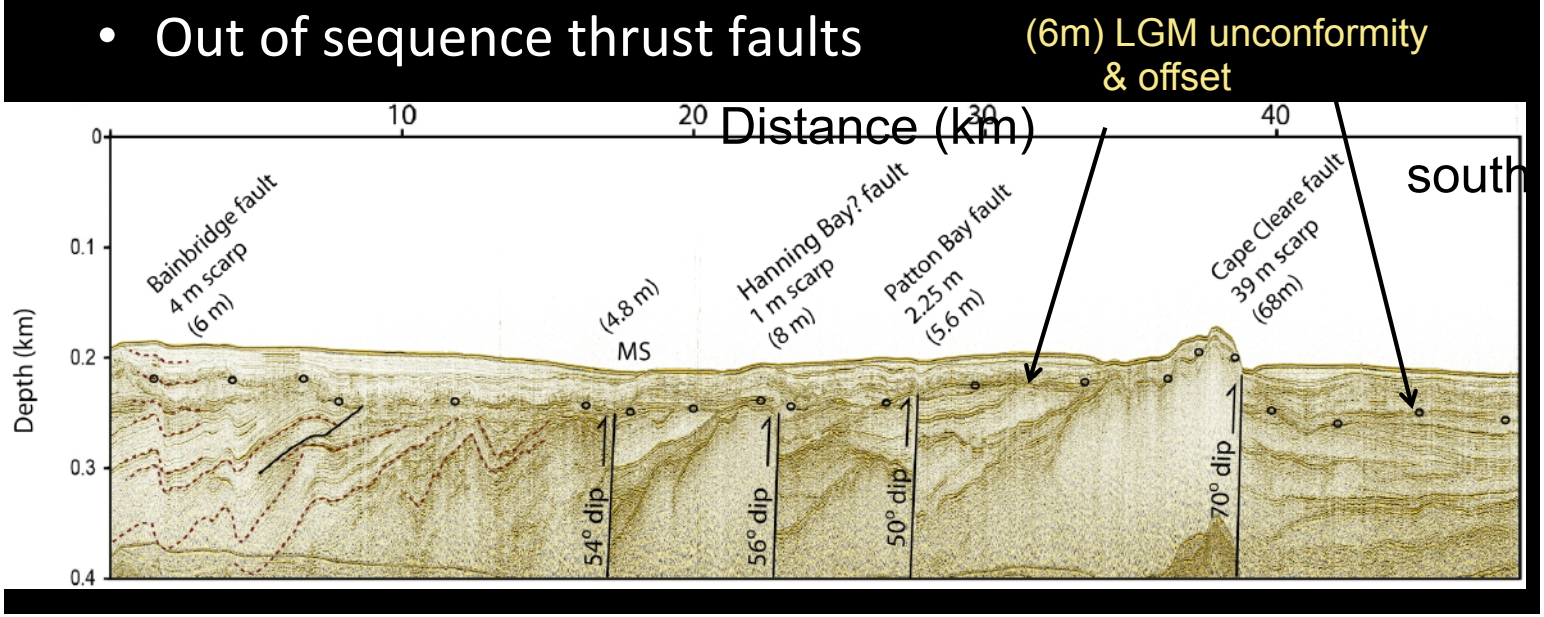
Junken Trough seismic profile

- Cape Cleare fault ruptured in 1964 with 12m offset
- 5 active (tsunamogenic?) fault scarps identified
- Transition from broad folding to high angle faulting
- Out of sequence thrust faults



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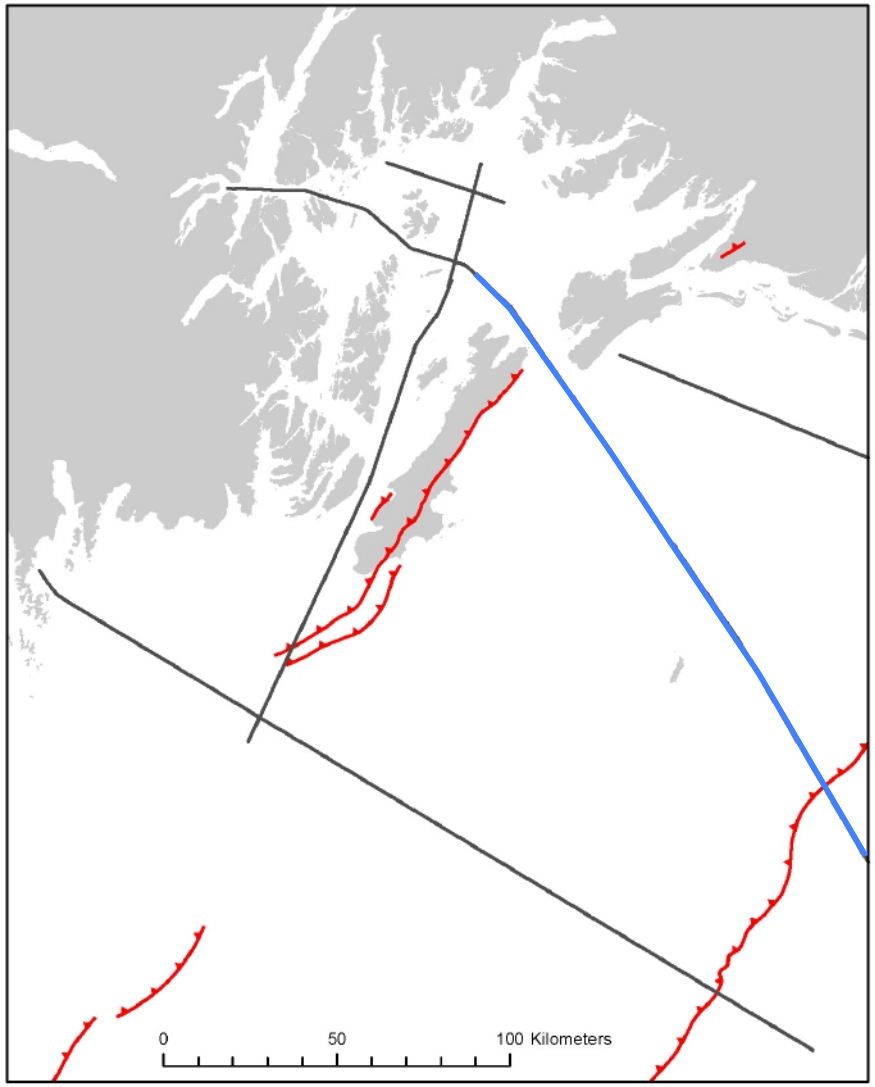
What do the splay faults look like?

- USGS TACT profiles
- 1980s large airgun source



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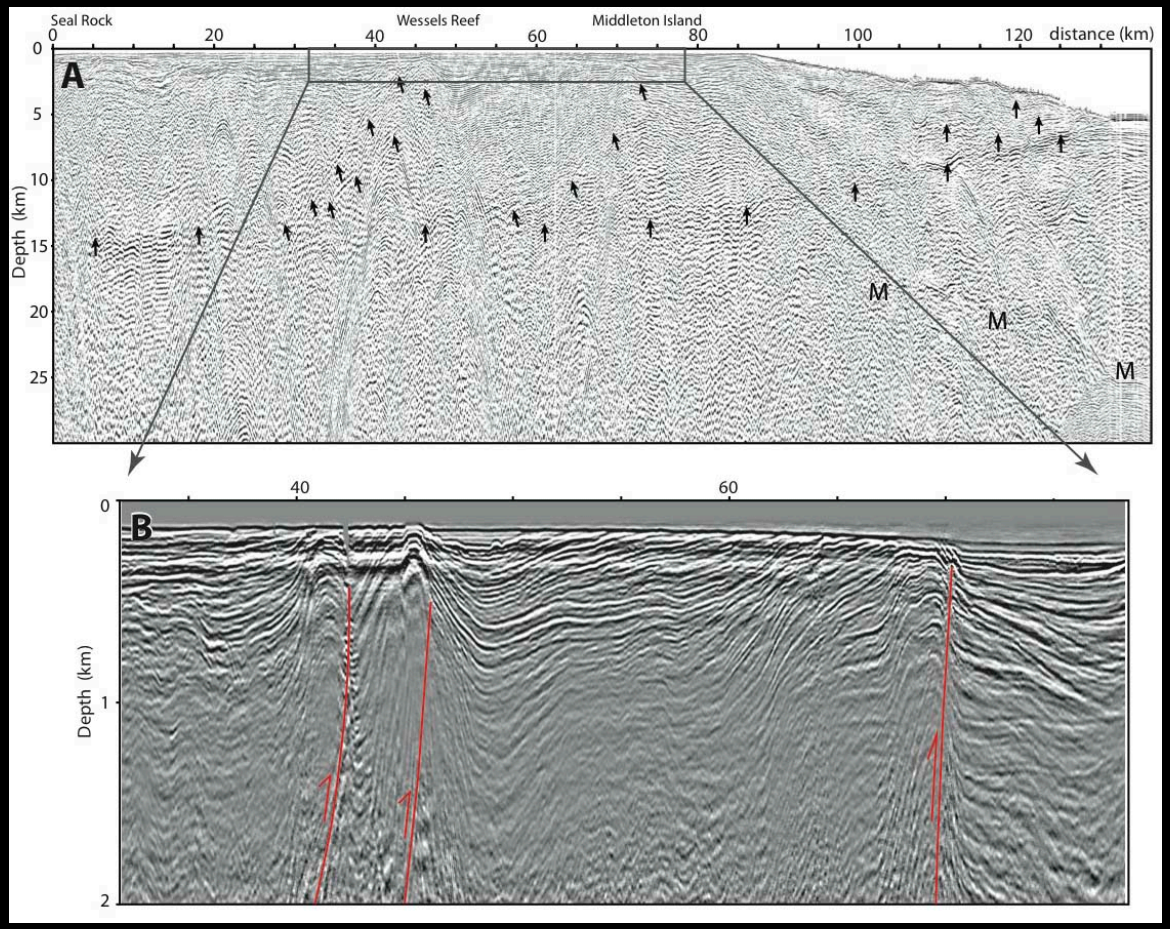
Imaging Splay Faults

- TACT profile
- Splays root into décolle-ment



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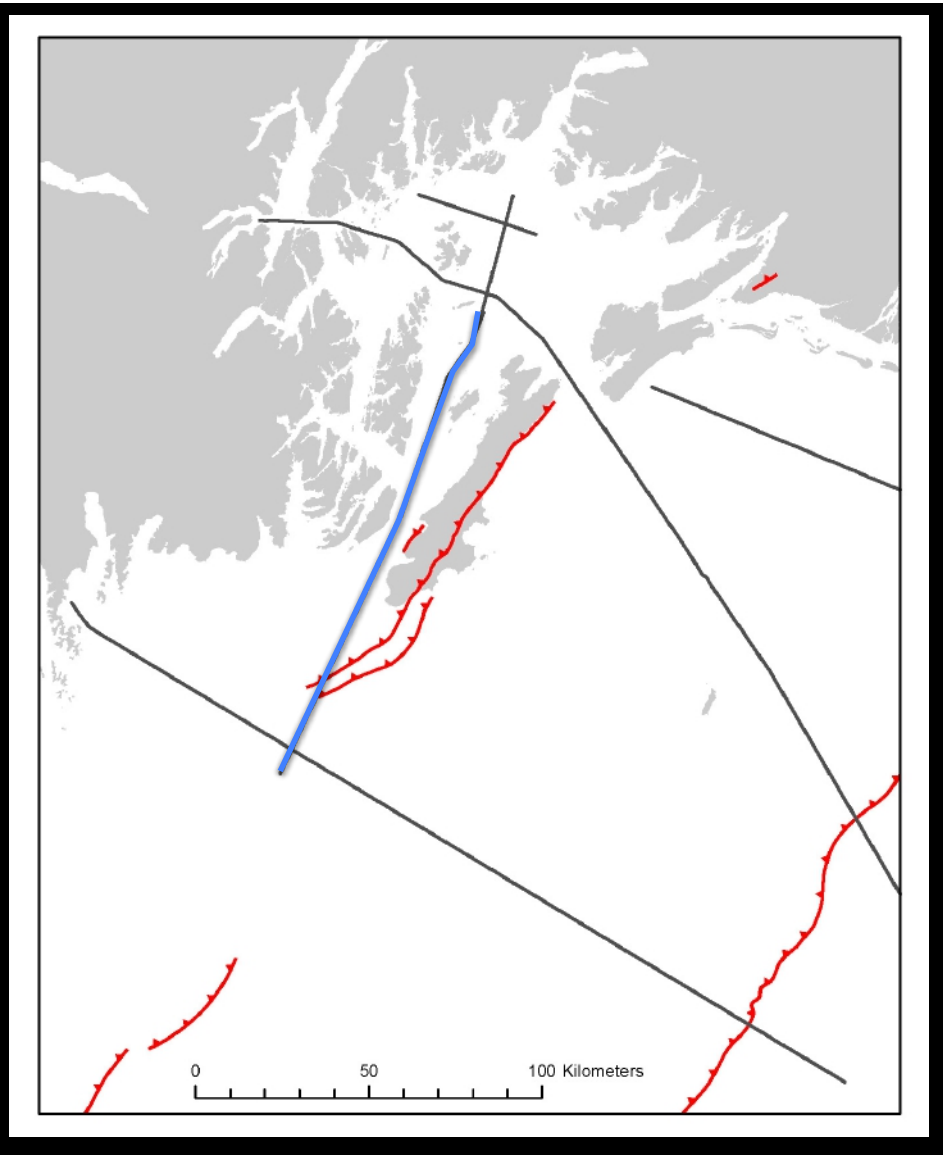

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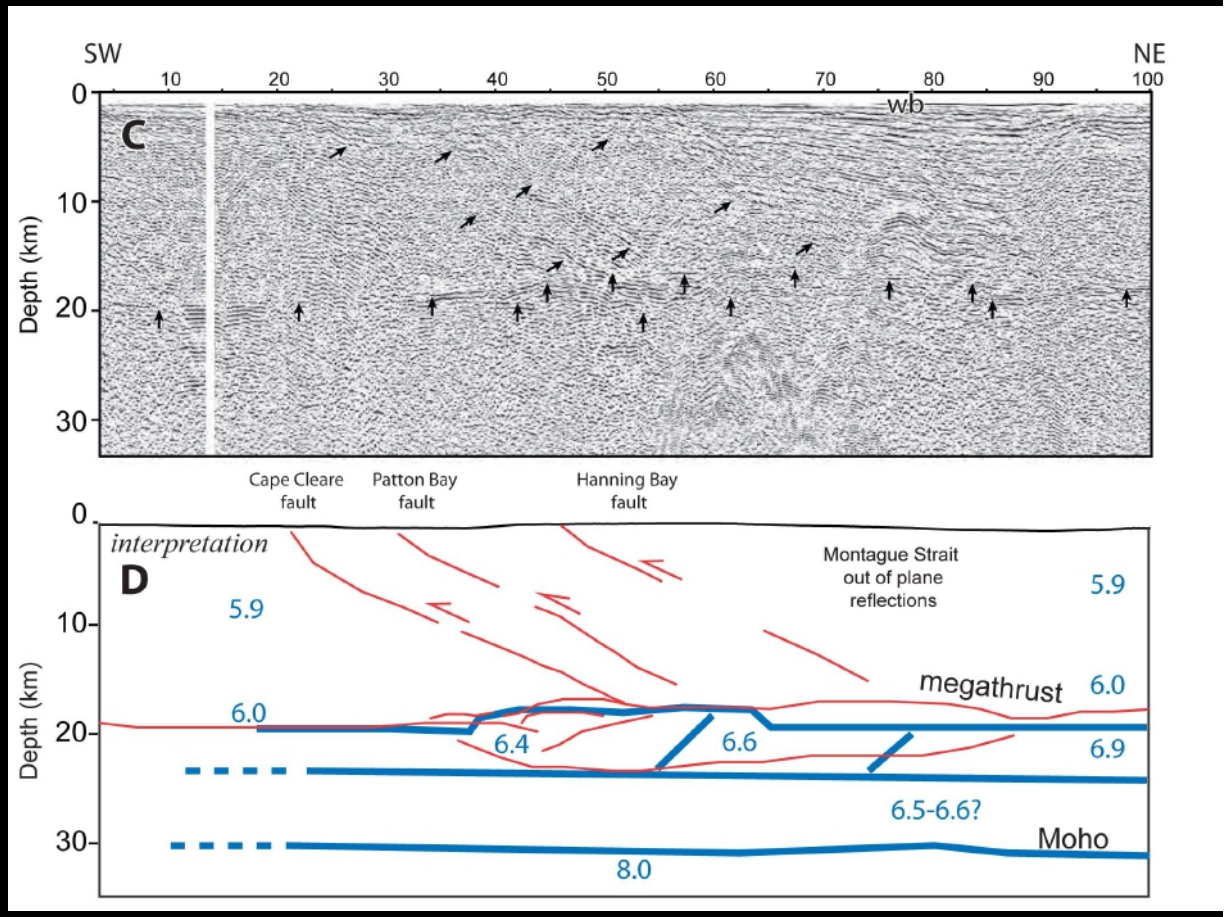
Imaging Splay Faults

- TACT profile – Montague Strait
- Interpre-tation
- with refraction velocities



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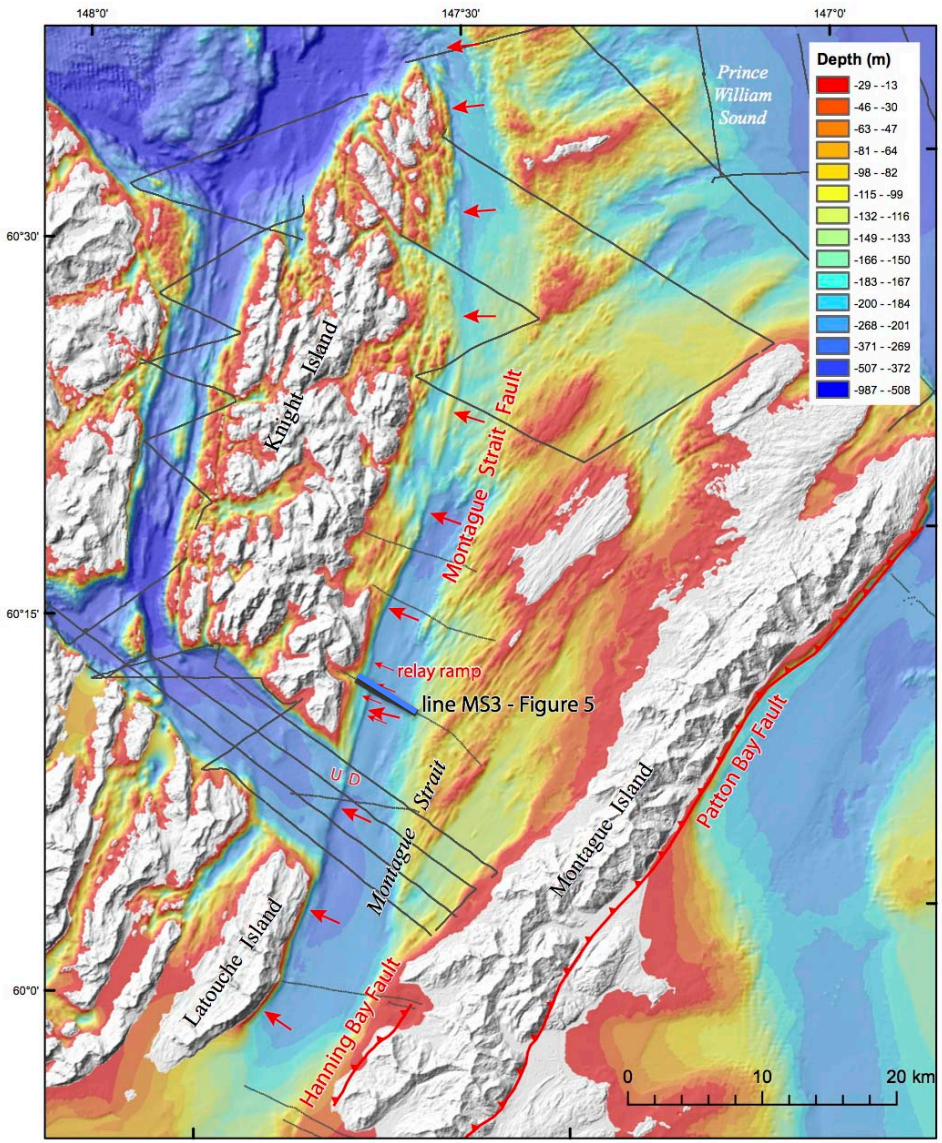
Montague Strait fault

- Longest sea-bottom scarp in all of PWS
- Apparent normal (w-side-up) offset
- Stepover
- Lies in hanging wall of Patton Bay system



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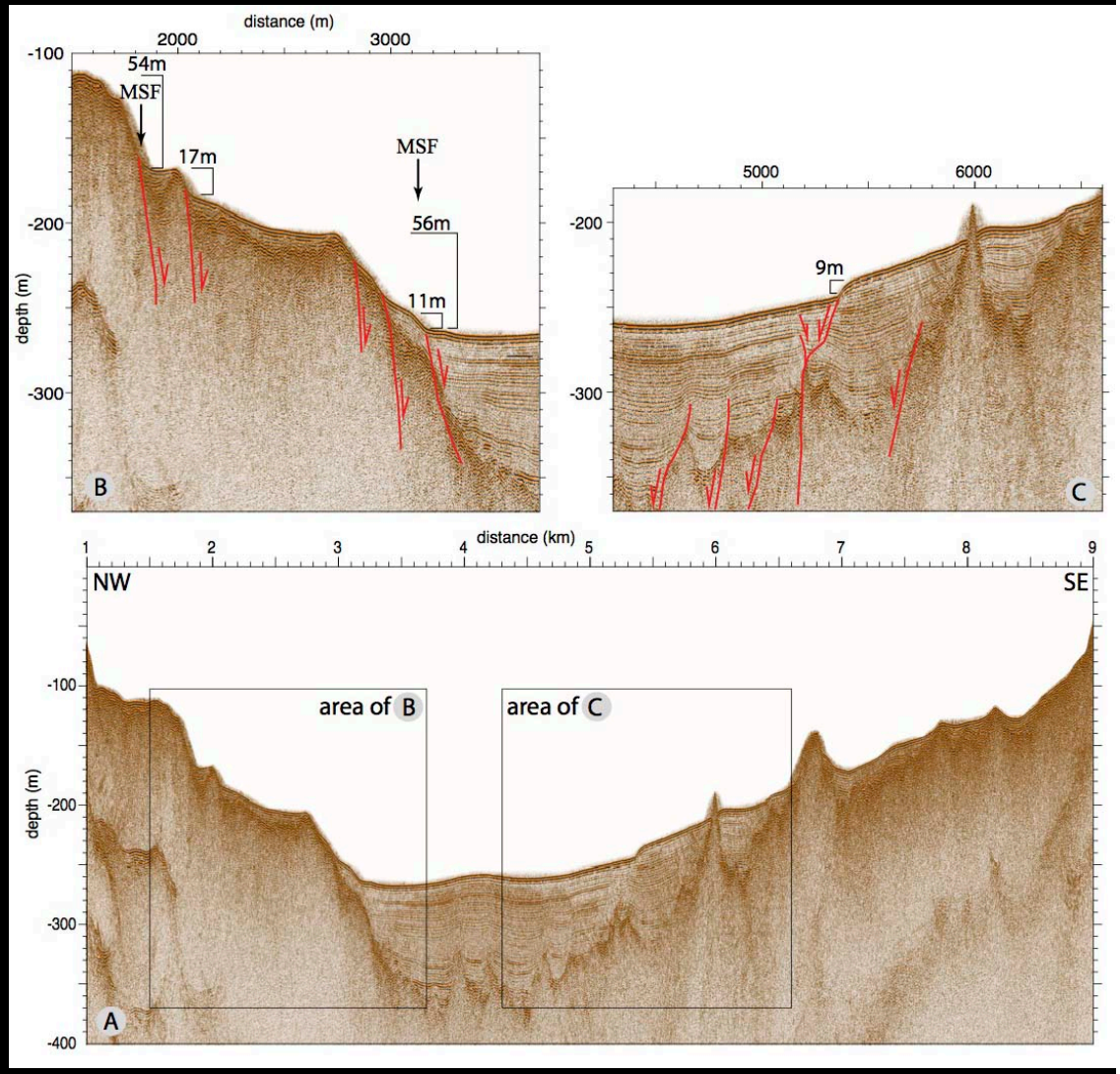
Relay Ramp

- Normal faulting on scarps
- Both sides of Montague Strait



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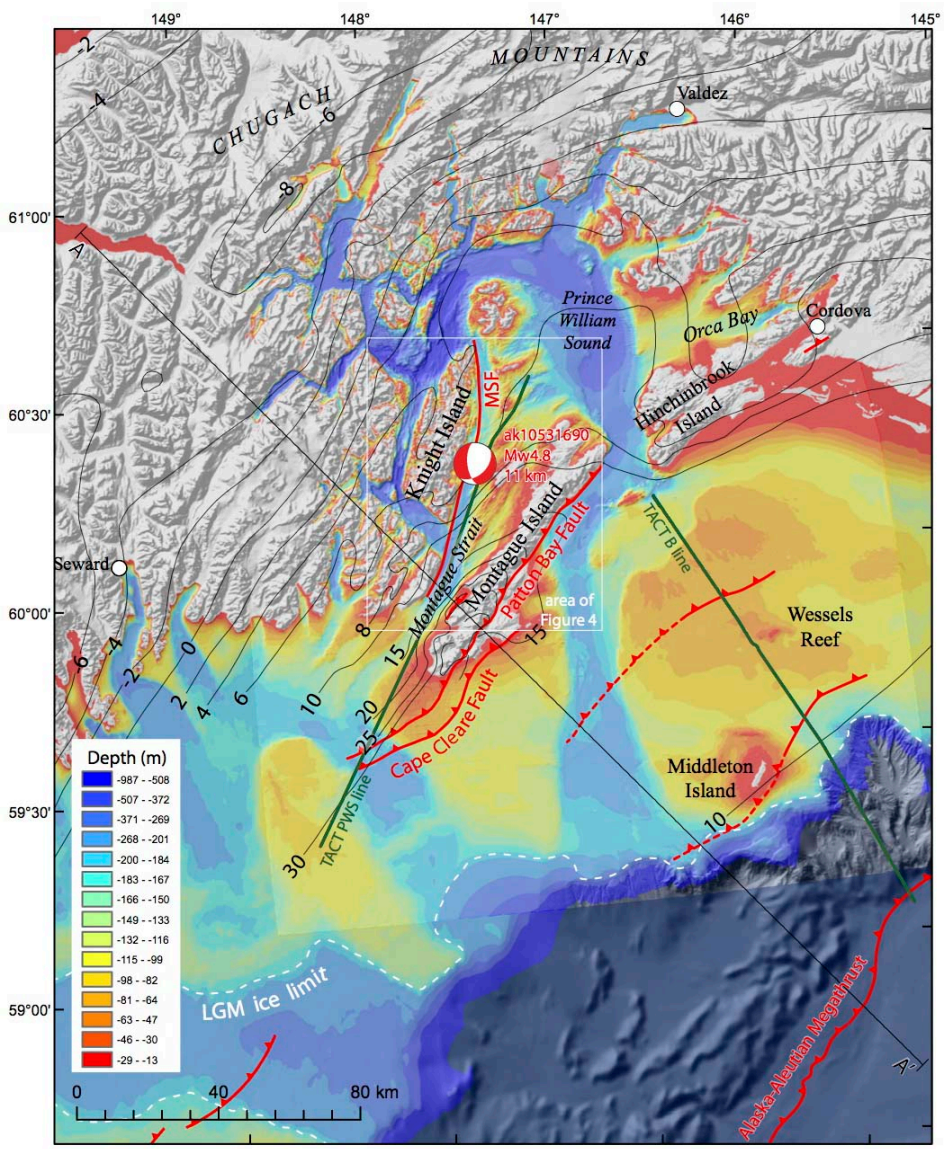
Normal fault earthquake

- Located on the Montague Strait fault
- M4.8
- Depth 11 km
- M2.8 aftershock



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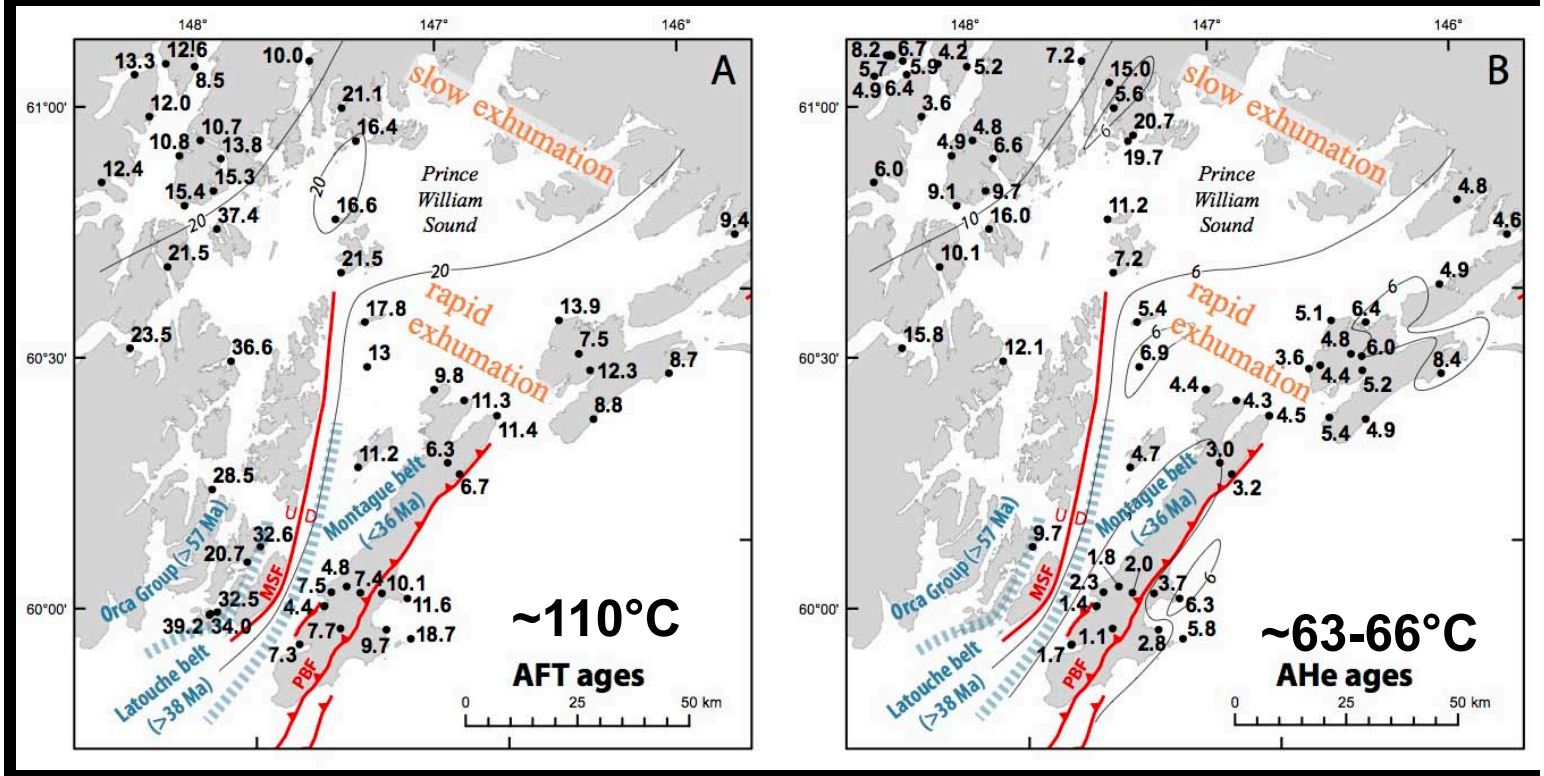
Thermochronology data for PWS



- A region of rapid and slow exhumation
- These regions have a different thermal and accretionary history

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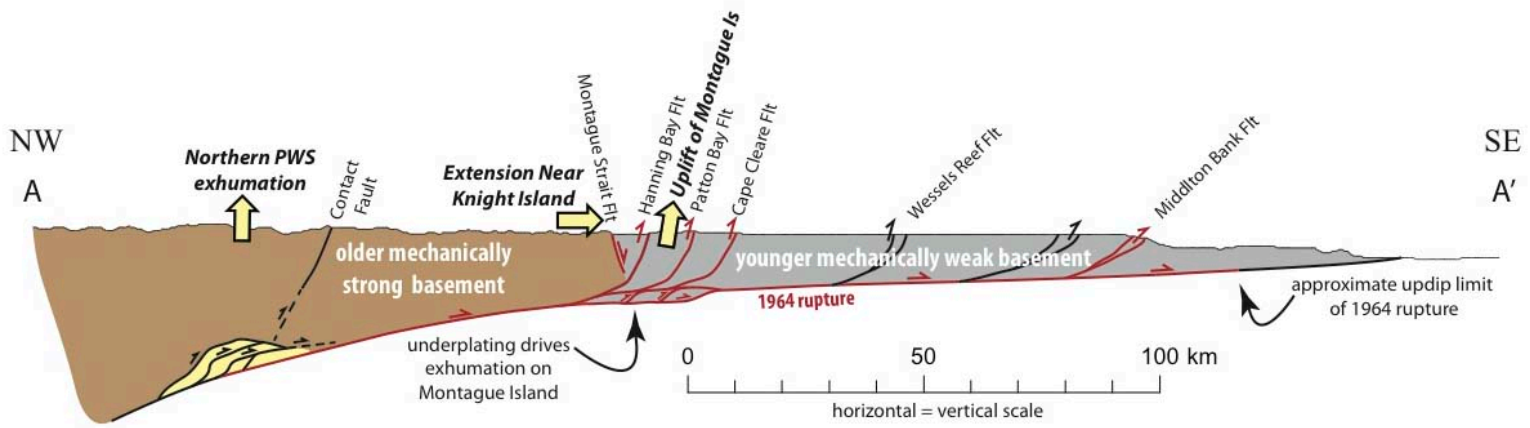
Cross section



- Normal faulting above a ramp-flat geometry on the megathrust splay
- Extension is required to accommodate exhumation on Montague Island
- Exhumation likely driven by underplating

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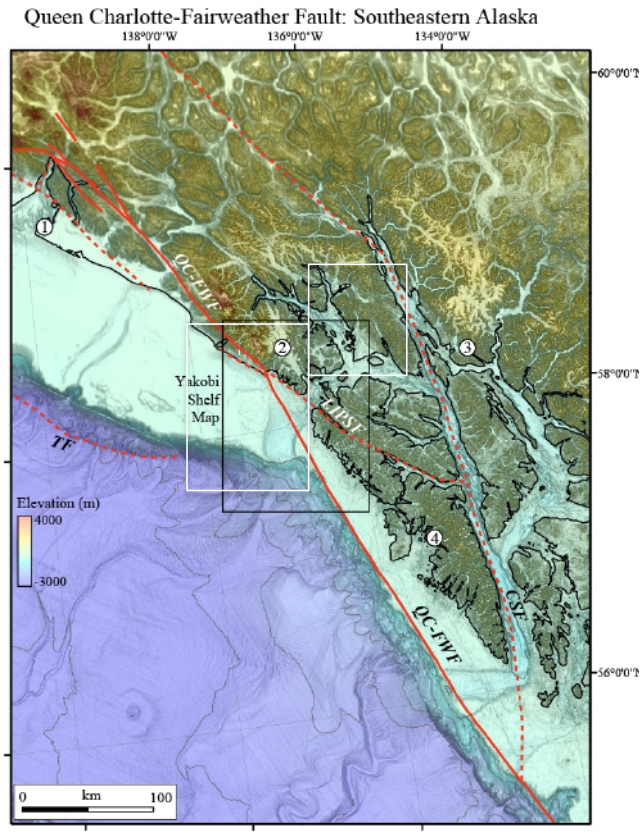
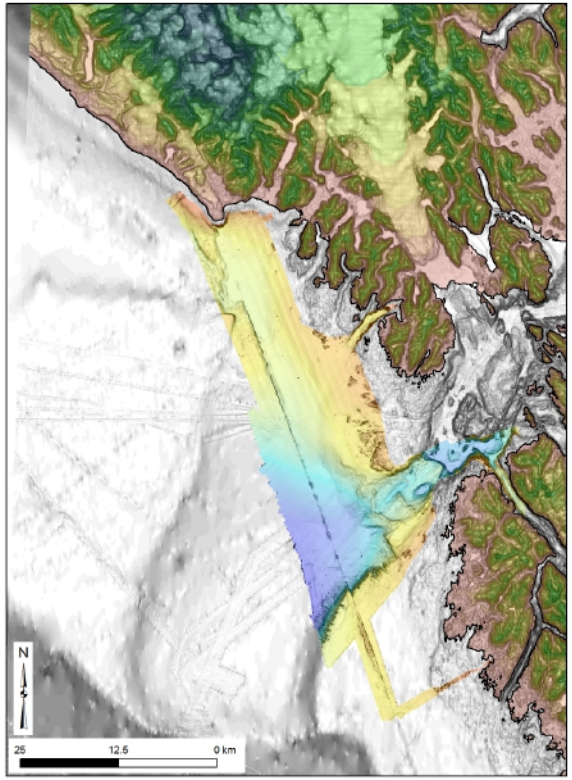
New work – Queen Charlotte-Fairweather fault

Successfully completed the first systematic, high-resolution marine geophysical survey of the QCFF in US territory (May and August, 2015). Mapped 75 km of northernmost offshore section.





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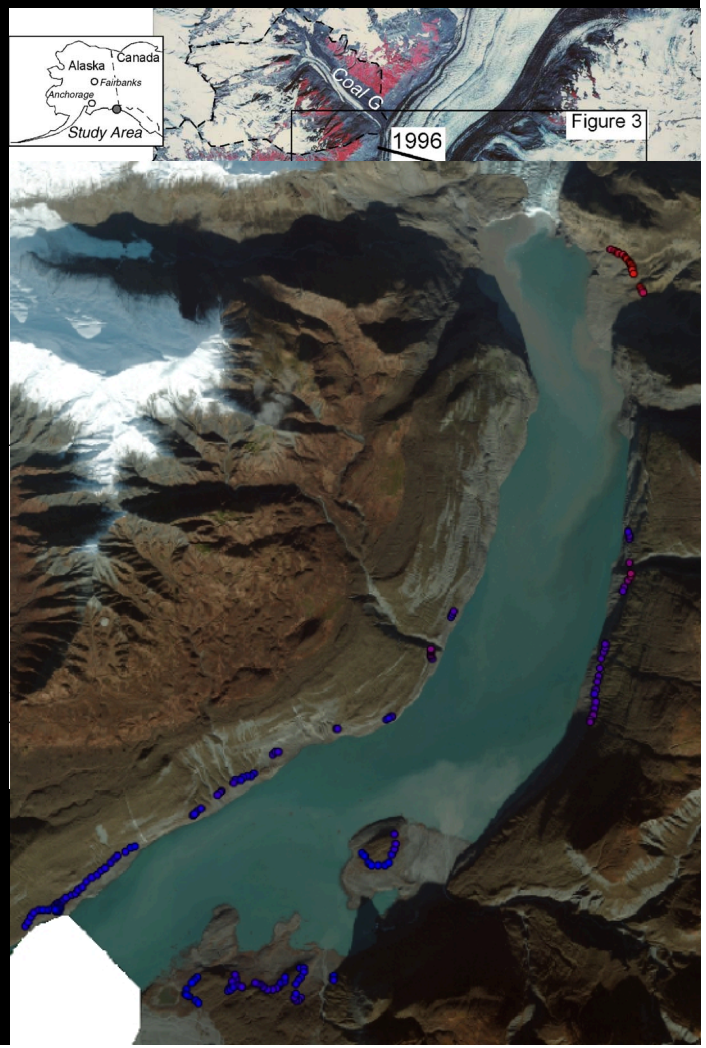
Taan Fjord Landslide Tsunami

- Oct. 17th landslide in Taan Fjord, an arm of Icy Bay, near Mt. St. Elias
- 150-210Mt material slide, some entered bay, produced a tsunami with max runup of ~150 m, and average of 20 m bay
- Tsunami measured on Yakutat and Elfin Cove tide gauges
- Investigations planned for this coming summer. Efforts lead by Colin Stark at Columbia University
- NSF Rapid proposal to document event includes 9 co-PIs & 14 collaborators



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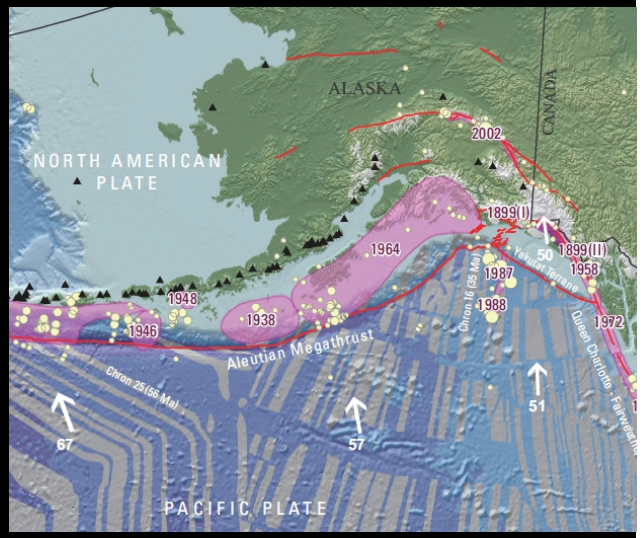
Big Questions

- How common is Tohoku? N=1
  - Need seafloor geodesy
- Are there near-trench M8s that are not recorded in the onland paleoseismic record but produce tsunamis?
  - Need offshore paleoseismology
- Do faults above megathrust rupture independently?
  - Difficult to address in the paleorecord
- How is urbanization affecting submarine landslide potential?
  - More frequent small slides? More frequent big ones?



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