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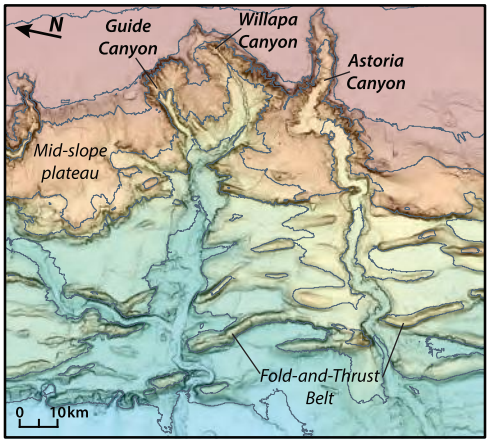
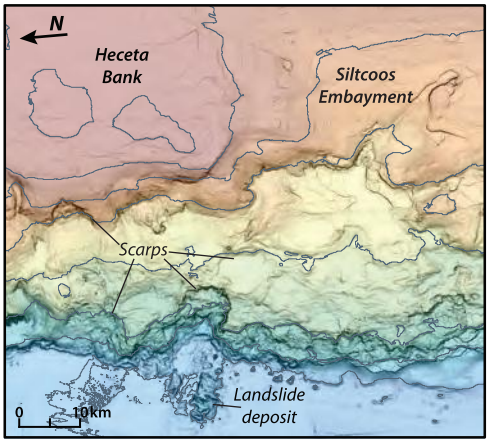
Subduction Zone Marine Geohazards Project Plans

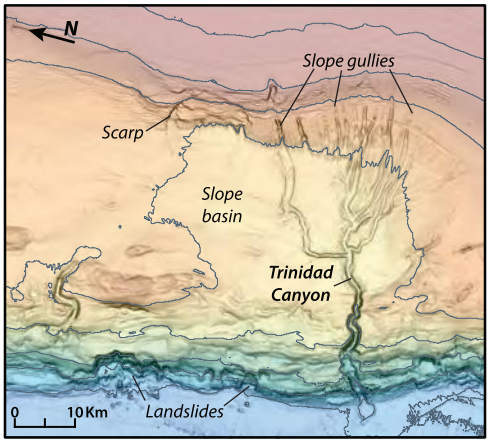
Subduction zone earthquakes, tsunamis, volcanoes, and landslides are some of the most dangerous and powerful natural hazards on Earth. The largest earthquakes on Earth occur within subduction zones at the interface between the downgoing and overriding plate. While locking and strain accumulation occurs in deeper regions, much of slip in megathrust earthquakes occurs at shallow depths along the plate interface, which has great potential to initiate large tsunamis associated with seafloor displacement. With an initial focus along the Cascadia margin, ongoing and planned work will provide key onshore/offshore constraints that feed directly into earthquake, tsunami, and landslide hazard assessments and situational awareness products.



Northern Cascadia: Landward verging thrust faults expressed in a distinct fold belt across the prism.



Central Cascadia: Seaward verging thrust faults result in a steep, irregular seafloor prone to landslides.



Southern Cascadia: Gullies and canyons cut across basins; landslides occur at the base of the slope.

Preliminary morpho-tectonic analyses highlight distinct along-strike variations in morphology along the Cascadia margin that may reflect spatial variations in megathrust behavior. Identification and regional mapping of active fault structures will provide insight to this segmentation pattern, earthquake recurrence intervals, stress/strain accommodation and variations in coastal uplift or subsidence. We plan to investigate the linkages between fluvial systems, dispersal pathways, tectonic basins, fault interactions, seafloor morphology, and offshore storage locations, which will help to identify basins prone to strong shaking, areas of the slope susceptible to landslides, and/or optimal environment(s) for marine paleoseismology studies.

Key scientific questions:

To what extent and how frequently do potentially tsunamigenic upper plate structures rupture with the megathrust?

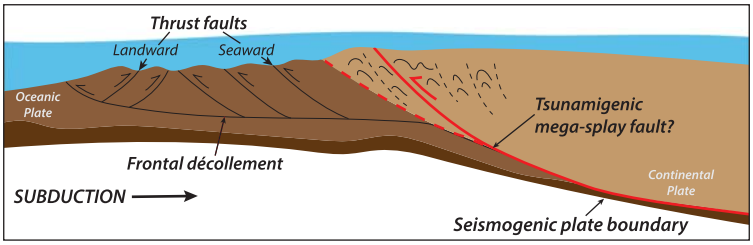
How do along strike variations in the morphology and structure of the overriding plate relate to possible segmentation of the megathrust?

How is sediment delivered and redistributed across the continental shelf and slope?

How does earthquake shaking translate to slope failure?

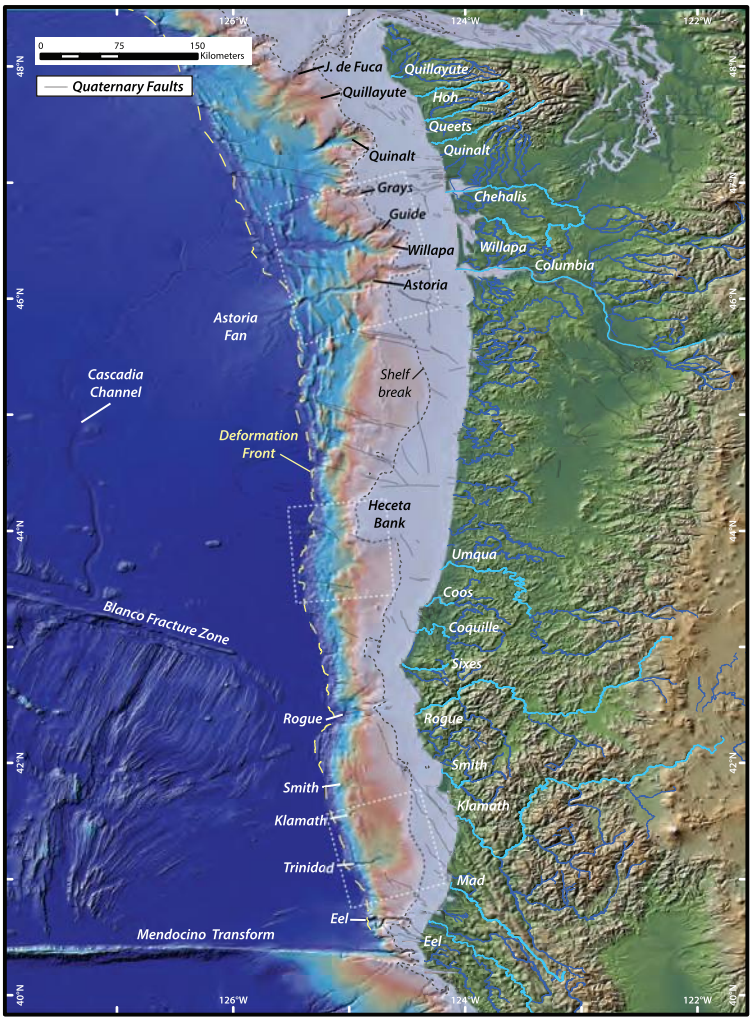
What is the role of fluids in subduction zone processes?

Where are the most active upper plate faults located?

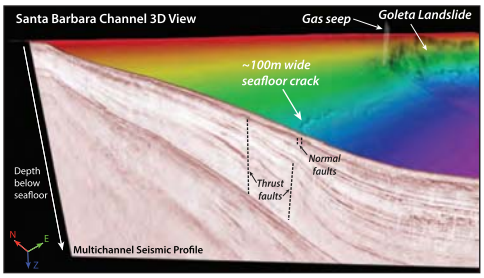


Modified from Bangs et al., Science 2007

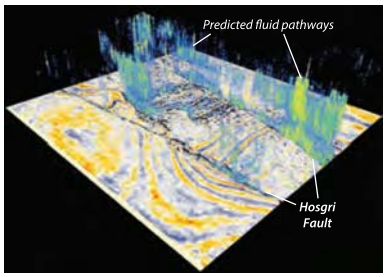
Simplified diagram of a subduction zone



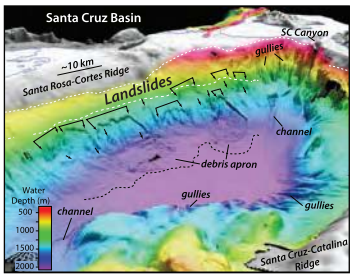
Map of the Cascadia Subduction Zone



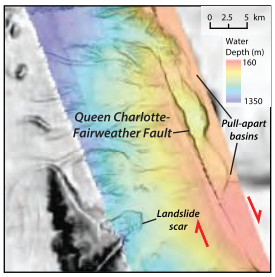
Combining multibeam bathymetry and seismic profiles provides a 3D view of marine geohazards.



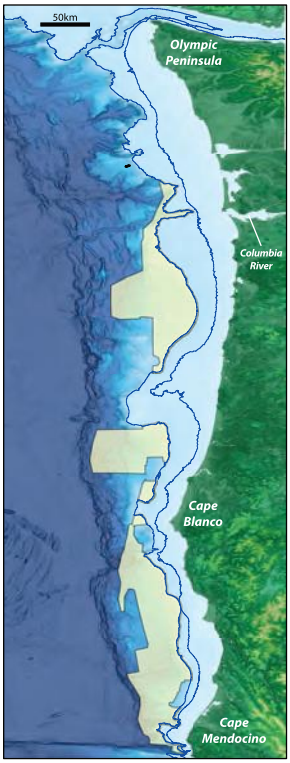
3D multichannel seismic data reveal how fluids may nucleate along fault strands.



Numerous submarine landslides ring the Santa Cruz basin offshore California.



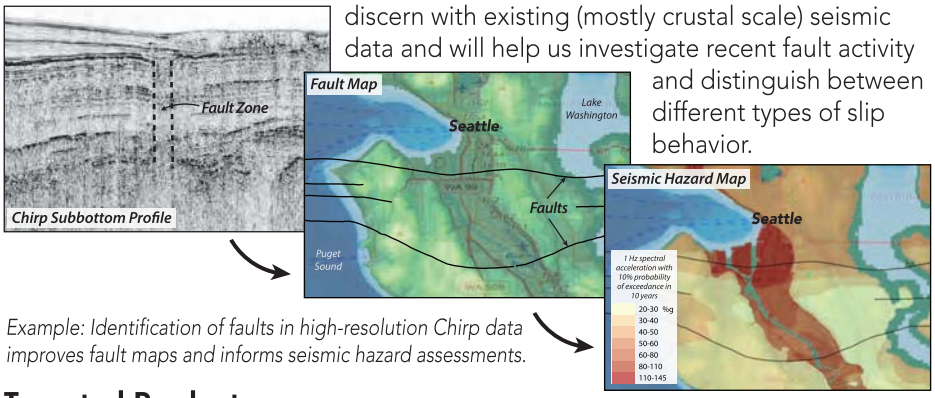
Fault offset is clearly visible on the seafloor off SE Alaska.



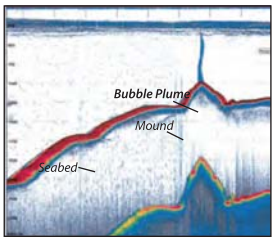
USGS-NOAA FY18 Planned multibeam surveys with the Rainier

Integrating high resolution geophysical surveys and geological sampling to investigate subduction zone hazards

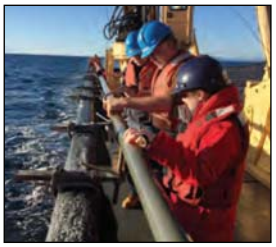
High resolution imaging of the seafloor and shallow subsurface is necessary to characterize the margin morphology, identify submarine landslides and better delineate the structure of the upper plate and connections to the megathrust. These data will provide insight into shallow deformation features that are difficult to discern with existing (mostly crustal scale) seismic data and will help us investigate recent fault activity and distinguish between different types of slip behavior.



Example: Identification of faults in high-resolution Chirp data improves fault maps and informs seismic hazard assessments.



Water column sonar records newly discovered seabed seeps.



Sediment cores provide ages, event history & stratigraphy.

Targeted Products:

Earthquake Recurrence History	3D Fault/Geologic Model	Quaternary sediment distribution & properties
Bathymetry / Backscatter & Seep Distribution	Hazard Maps (earthquake, landslide, tsunami)	Event Response (e.g., rapid OBS deployments)

	2018	2019	2020	2021	2022
Field Work Plans/Goals	Comprehensive **multibeam bathymetry & backscatter** between *200-1600m water depth* High-resolution 2-D geophysical surveys (**Chirp subbottom, Sparker MCS, Magnetometer**) *Southern Cascadia*	Systematic characterization of the upper plate structure High-resolution 2-D geophysical surveys (**Chirp subbottom, Sparker MCS, Magnetometer**) *Northern & Central Cascadia*	High resolution **3-D (P-cable) MCS** in targeted regions *(e.g., Northern & Southern Cascadia comparsion sites)*	Seabed sampling: Ship based piston and gravity cores Targeted ROV surveys and sampling *Cascadia sites TBD*	Follow up work in Cascadia, Alaska or other U.S. subduction zones
	Ideally, these high-resolution 2D & 3D surveys will be paired with deeper crustal scale studies conducted in conjunction with research partners. *Additional multibeam surveys also will be conducted as opportunities arise.*				
Potential Partners	NOAA, BOEM, Ocean Exploration Trust, Humboldt State University, University of Washington, Oregon State University, MBARI, GEOMAR, NSF, Canadian Geological Survey and others working in Cascadia or on related subduction zone hazards				

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The USGS plan, entitled ***Reducing Risk Where Tectonic Plates Collide—A Plan to Advance Subduction Zone Science***, is available online: *https://doi.org/10.3133/cir1428*