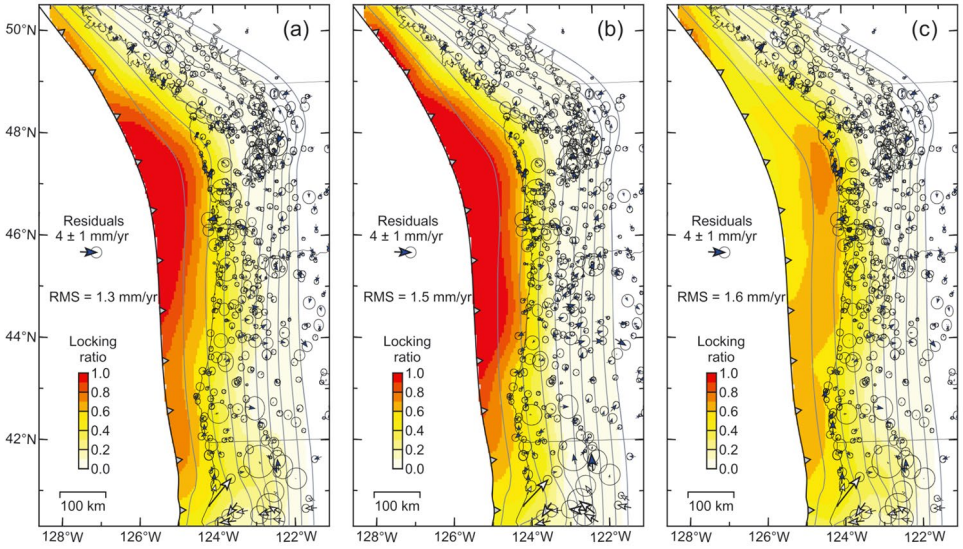
OCEAN NETWORKS CANADA

Plate motion velocities offshore of northern Cascadia from five years of seafloor geodesy with the NCSZO

Jesse Hutchinson | PhD | Oct. 27, 2025

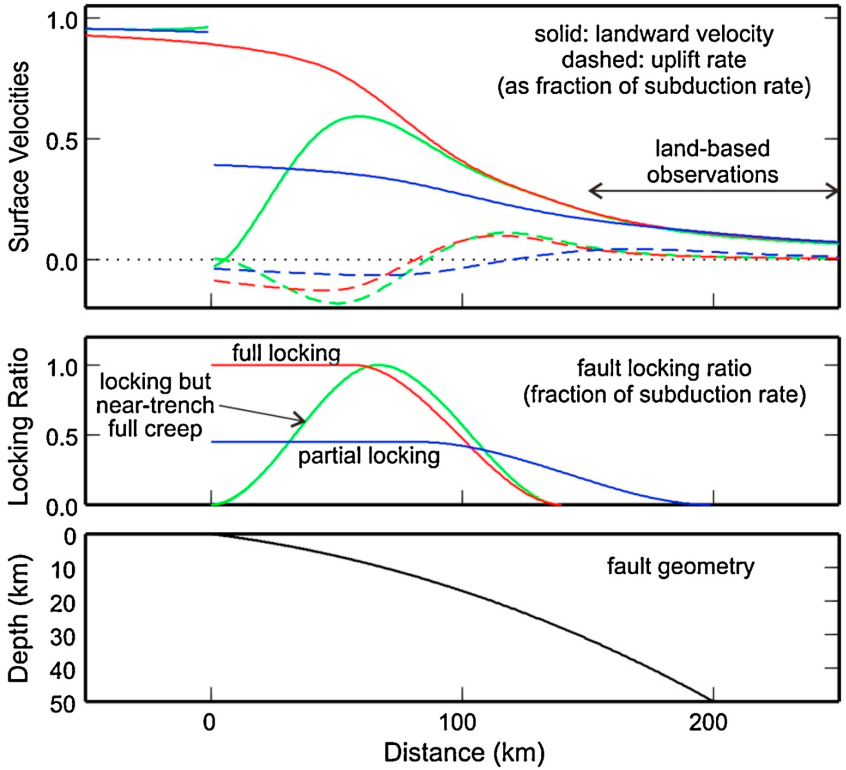
A UNIVERSITY OF VICTORIA INITIATIVE

Subduction zone locking scenarios



80 km locking depth 30 km locking depth Fault creep

[*Li et al.*, 2018]

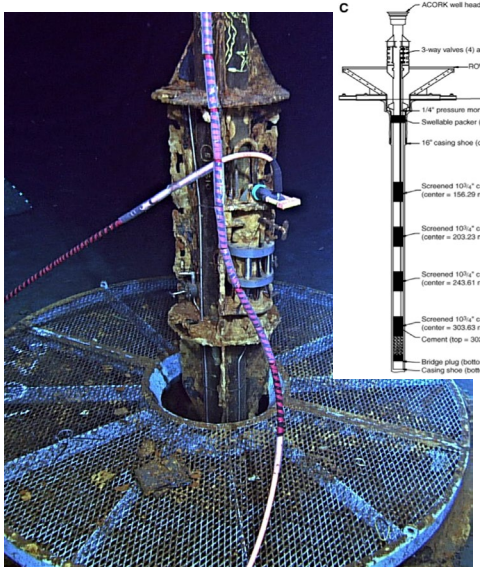


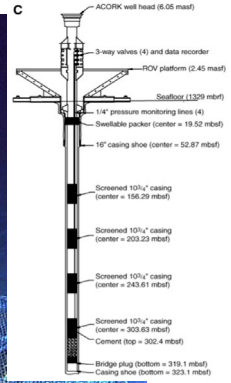
[*Wang and Tréhu*, 2016]

GPS measurements on land do not provide sufficient constraints for offshore locking pattern!

How do we measure deformation?

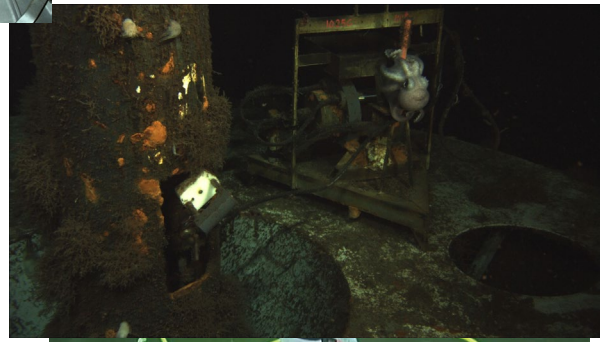
Seismometers

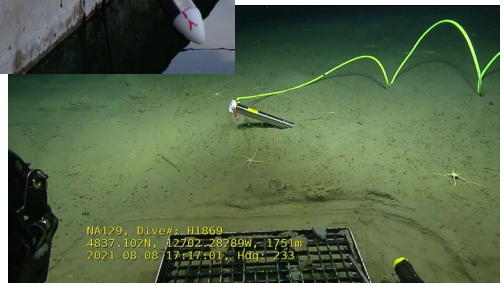


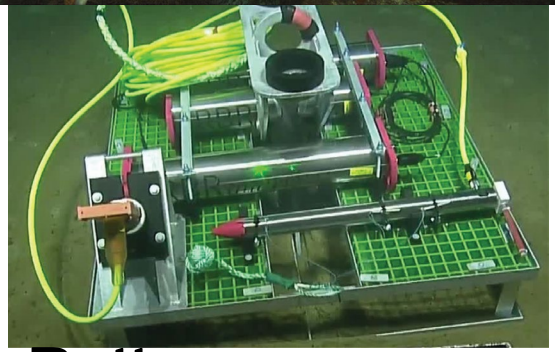


CORKs

Tiltmeters

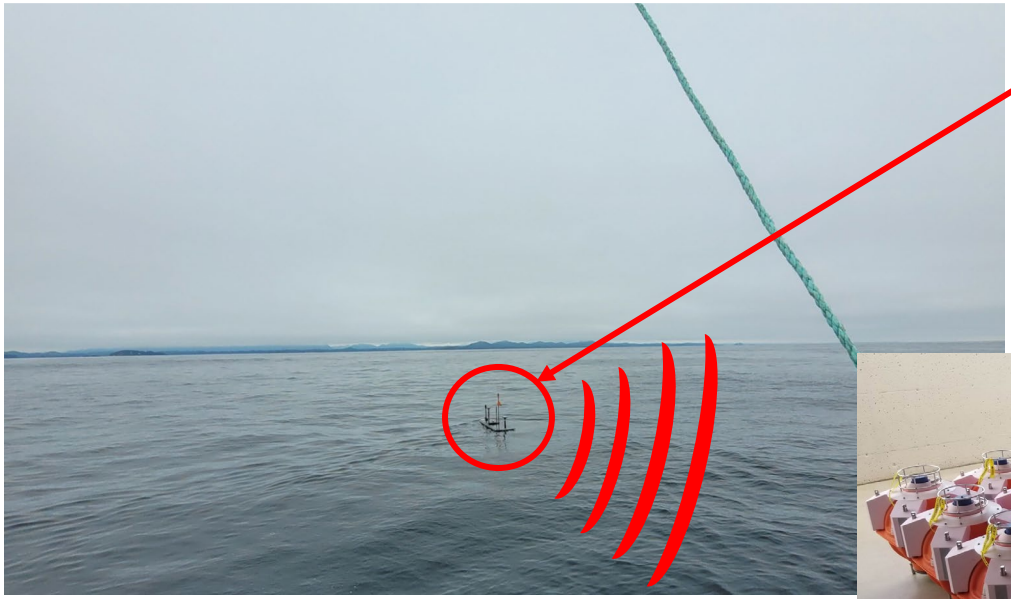






Bottom pressure recorders

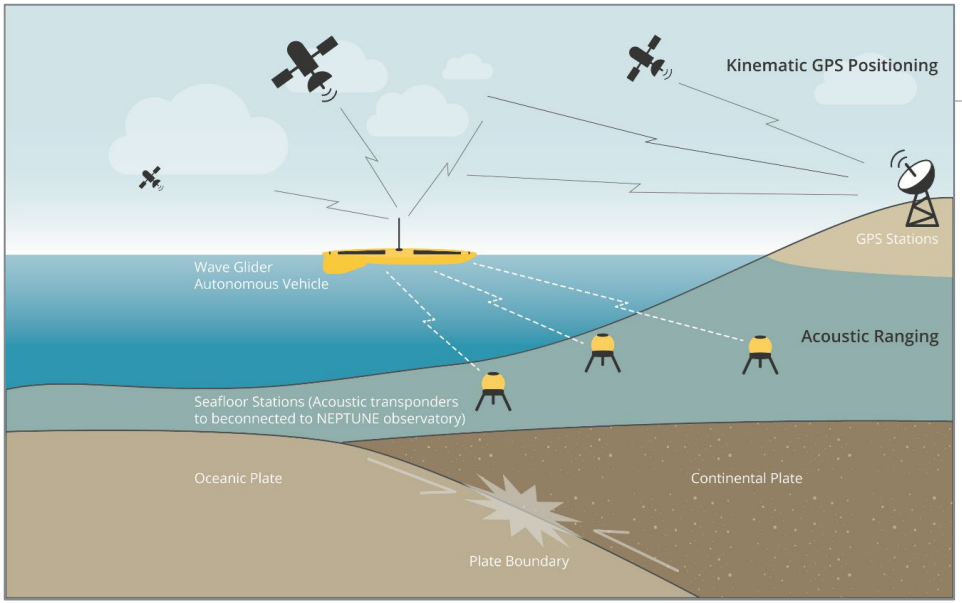
And…



GNSS-Acoustic

FETCH seafloor transponders

Locating the transponder arrays

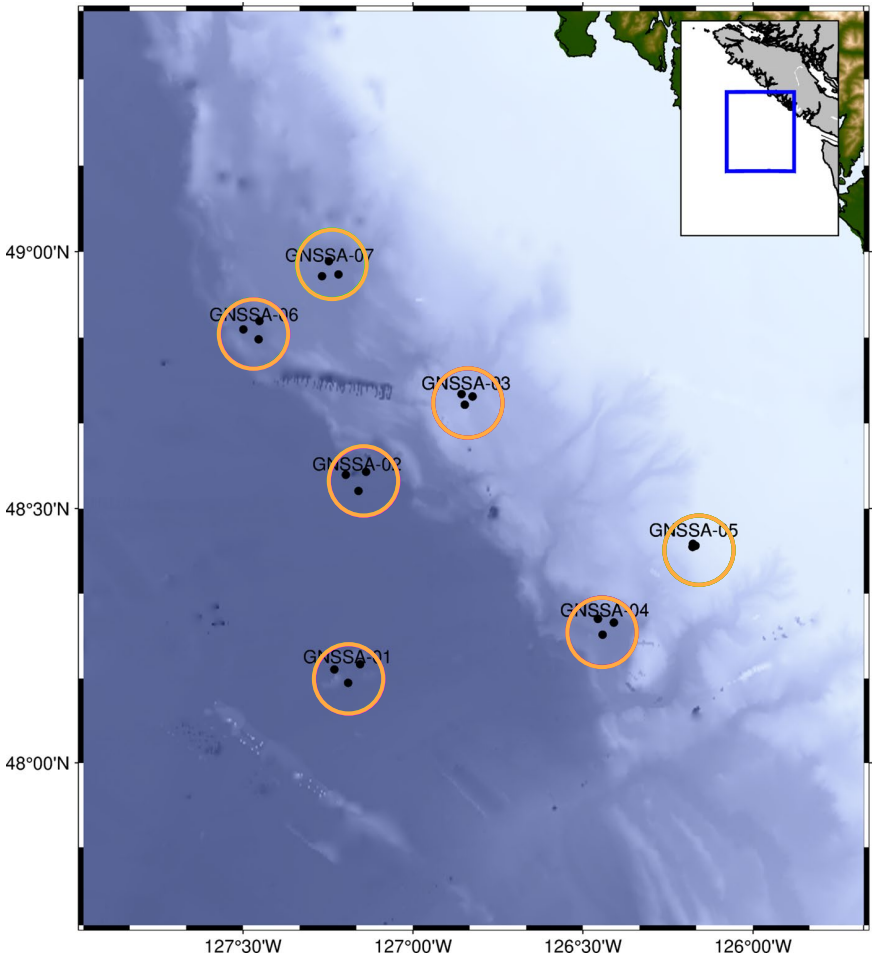


- The Wave Glider is highly modular. Currently, we use the equipped antennas track the GNSS-derived position, and use a transducer payload to send and receive signals from the seafloor transponders.
- For accurate location of the seafloor transponders, 10s of thousands of acoustic interrogations are necessary. These allow us to determine the two-way travel time and effectively triangulate the positions of the transponders within several cm accuracy.


OCEAN NETWORKS CANADA
NCSZO SEAFLOOR GEODESY SITES
BRITISH COLUMBIA
VANCOUVER ISLAND
Explorer Plate
Pacific Plate
PACIFIC OCEAN
Juan de Fuca Plate
North American Plate
WASHINGTON - USA
Strait of Georgia
Juan de Fuca Strait
Port Alberni
Vancouver
VENUS Observatory
Clayoquot Slope
1250 m
Folger Passage
20 m - 100m
Middle Valley
2400 m
NEPTUNE Observatory
Barkley Canyon
400 m -1000 m
Endeavour
2300 m
Cascadia Basin
2660 m
Shore Station
Node
Geodesy Experiment
Wave Glider
Fibre-optic Cable
Fault Line
Spreading Centre
Subduction Zone
100 km
0
Bathymetry
(100 m contour lines)
-3500 m
N
W
E
S
AN INITIATIVE OF
University of Victoria
Data Sources:
Datum: WGS84
Projection: Mercator
Date Created: 24 November 2015

NCSZO Wave Glider Expeditions

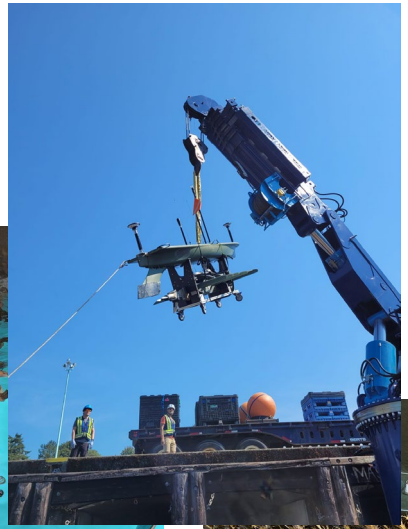
- Four Wave Glider expeditions have been completed.
  - 1) Aug. - Sep. 2021. Three sites visited.
  - 2) July - Aug. 2022. Seven sites visited.
  - 3) Sep. - Oct. 2024. Five sites visited.
  - 4) Jun. - Aug. 2025. Seven sites visited*
- Technical issues with power supply to the instrument payload have led to intermittent failures, but perseverance led to the success of these missions.
- There was not a 2023 mission not due to new Transport Canada regulations and a mechanical issue with the thrudder.



*Sites 03 and 04 were visited twice, 05 is missing one transponder

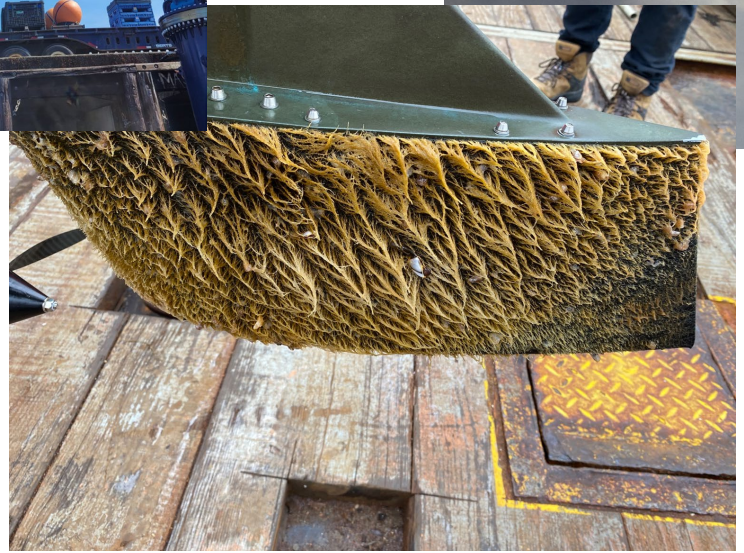
Photos from the deployment of the fourth GNSSA-01 FETCH transponder during 2023

2025 Retrieval



Crabs

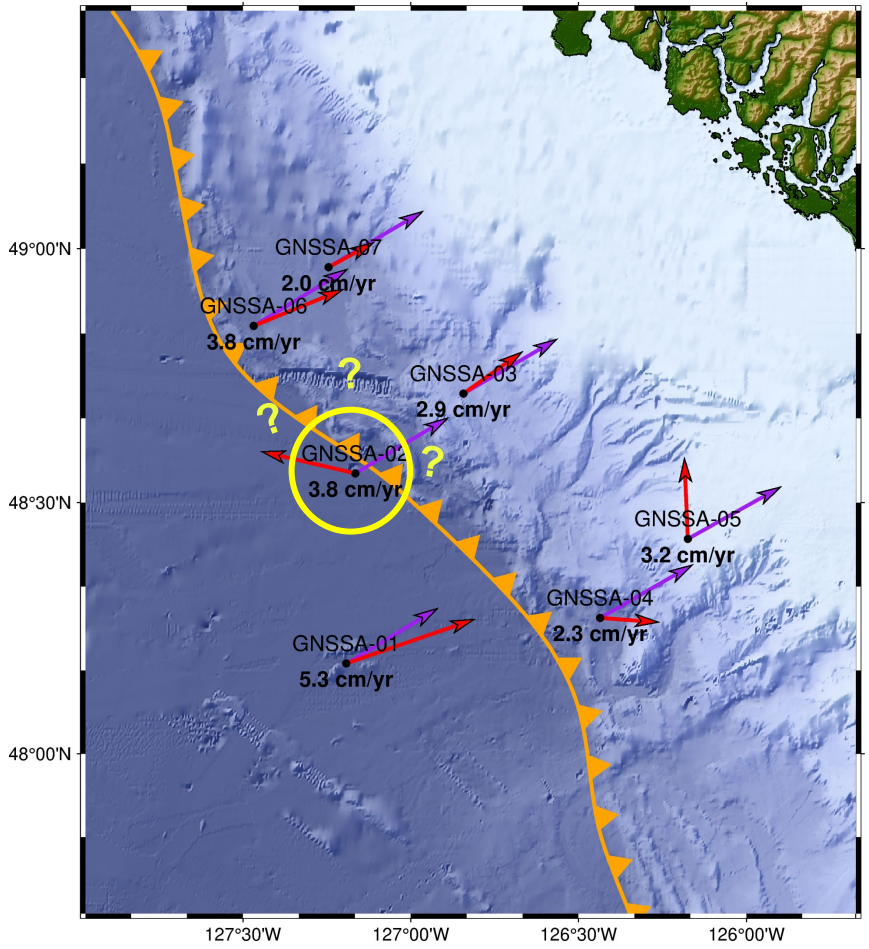
Goose-necked barnacles

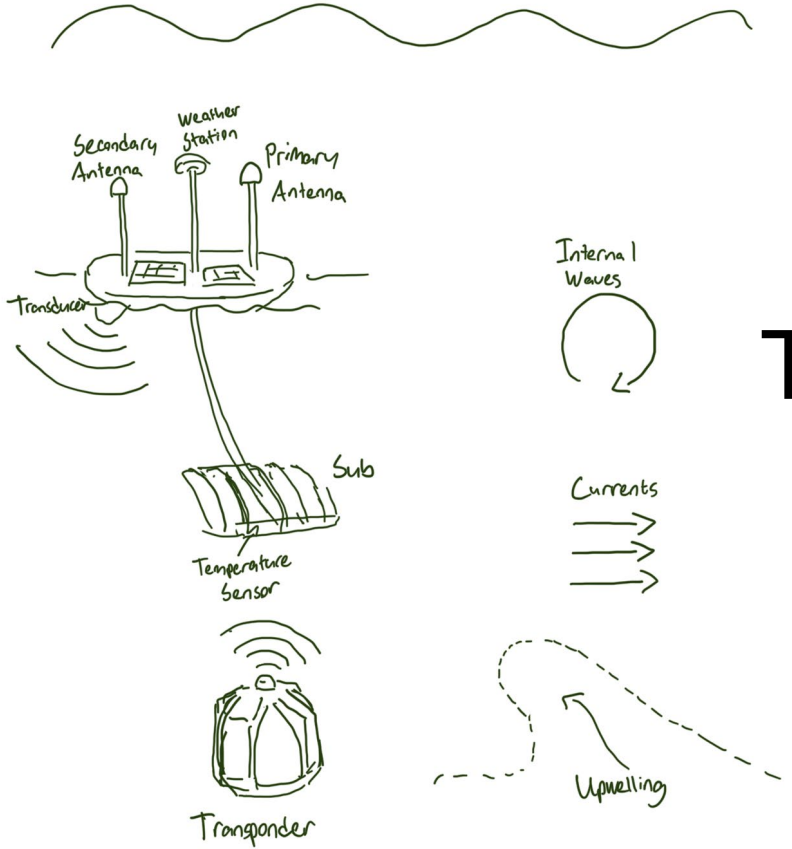


And algae (?)... oh my!

Determining plate velocities

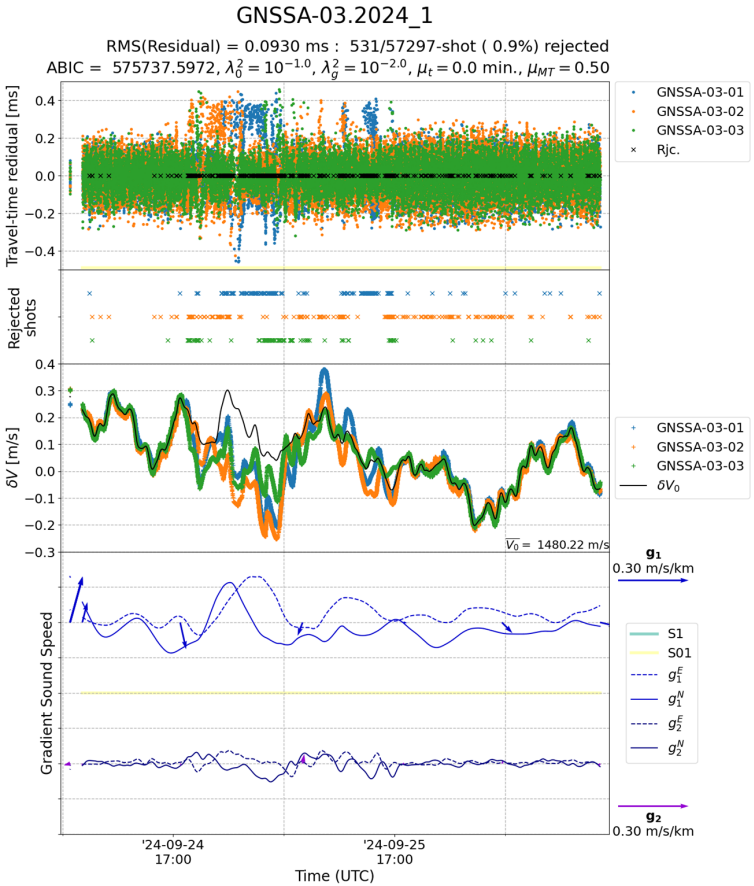
- From two or more surveys, we can begin estimating absolute (global reference frame) plate velocities with GARPOS.
- These velocities can be compared to North America to compute relative plate velocities.
- Year-to-year vectors are velocities are converging toward good solutions.
- Expected velocities are ~4 cm/yr, but we don't know exactly what to expect. These are first-time observations!
- GNSSA-01 results have improved significantly with the addition of a fourth transponder.
- The velocity vector is surprising for GNSSA-02 and bears further investigation.



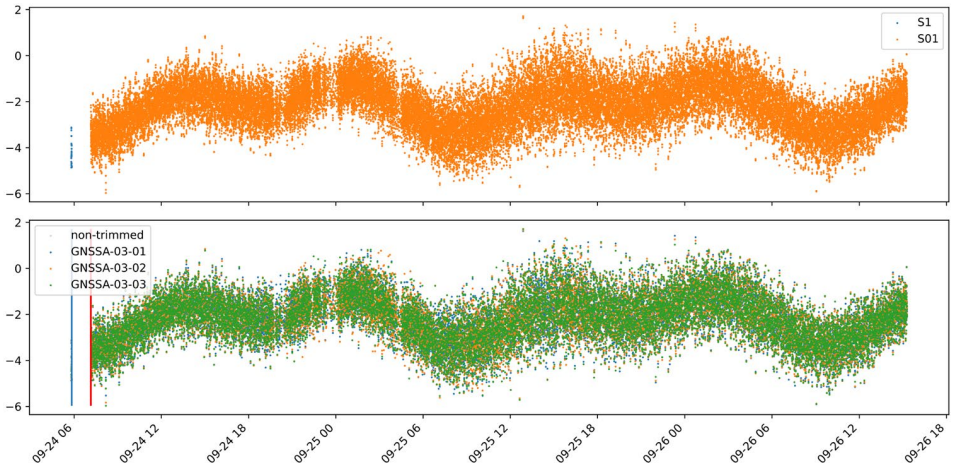

Secondary Antenna
Weather Station
Primary Antenna
Transducer
Sub
Temperature Sensor
Transponder
Internal Waves
Currents
Upwelling

Thank you!

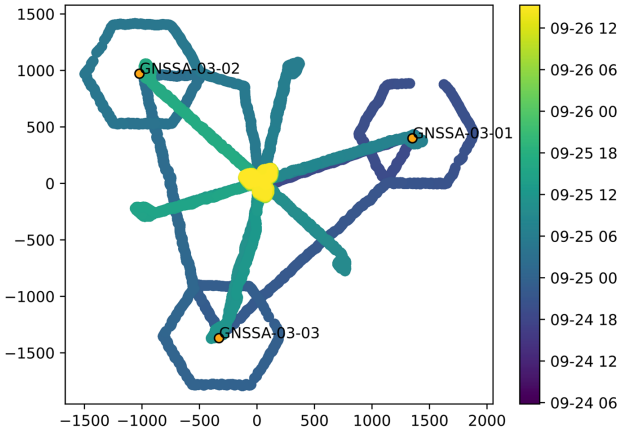
2024 Campaign Results



Good results at GNSSA-03. Could anomalous travel-times be due to internal waves?



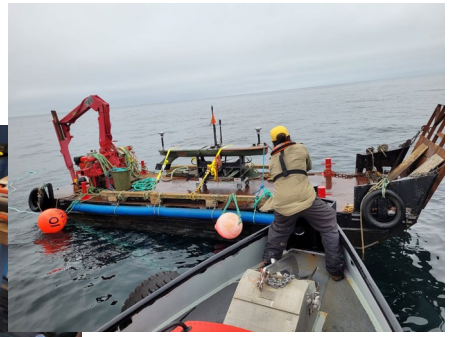
Transducer height vs datetime at GNSSA-03.



Coordinates for the waveglider at GNSSA-03; shows our streamlined sailing pattern.

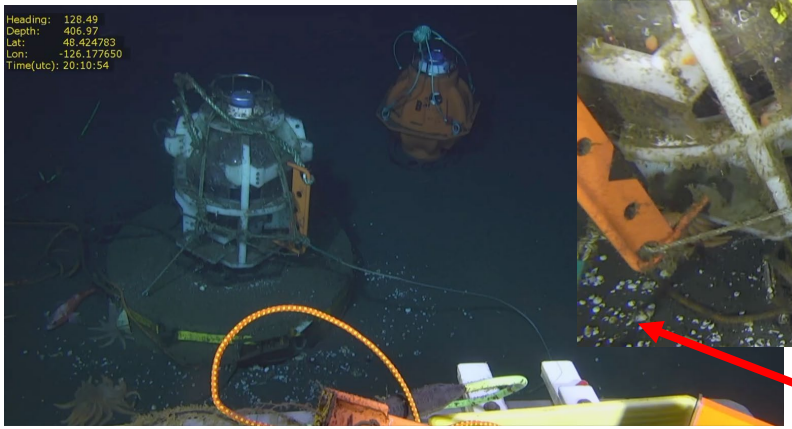
Technical Difficulties and Challenges

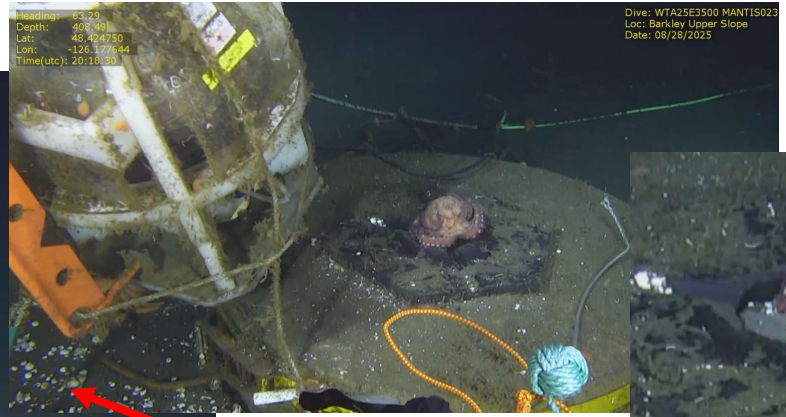
- During the retrieval of the WaveGlider during Oct. 2024, the WaveGlider was damaged, losing both GNSS antennas and masts, the mast with the light and weather station, and a solar panel.
- Our engineers replaced the masts, antennas, solar panel and light within the year, and we were able to successfully deploy in June 2025.
- The payload failure issue plaguing us since 2022 never surfaced during our 2025 campaign.



Technical Difficulties and Challenges

- The GNSSA-05-03 FETCH went offline shortly after the installation of a VPS onsite during May 2025.
  - An autonomous FETCH was deployed in place of the cabled sensor, however, this was not done before the WaveGlider had to be retrieved.
  - As a benefit, the VPS can “talk” to all three seafloor transponders.





Octopus snacks