The role of upwelling fronts in structuring trophic dynamics and ecosystem function.

Brian K. Wells[1,2], Jarrod A. Santora[1], David Huff[2], Meredith Everett[3], Jack Barth[4], Eric Bjorkstedt[1,5]

[1] SWFSC, Fisheries Ecology Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Santa Cruz, CA, USA. E-mail: brian.wells@noaa.gov
[2] NWFSC Fish Ecology Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Newport, OR, USA
[3] NWFSC Conservation Biology Division, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA
[4] College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
[5] Department of Fisheries Biology, Telonicher Marine Laboratory, Cal Poly Humboldt, Arcata, CA, USA

Oregon State University

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Goals and Mission Overview

Use autonomous vehicles (primarily Slocum gliders) equipped with passive and active acoustic instruments to augment data collection along the Washington coast to demonstrate the efficacy of these tools to quantify how the ecosystem affects salmon and how ecosystem components are reliant on salmon.

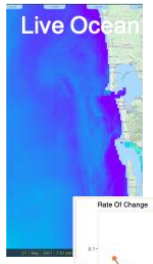
Objective 1: Characterize the biological and physical characteristics of upwelling fronts.

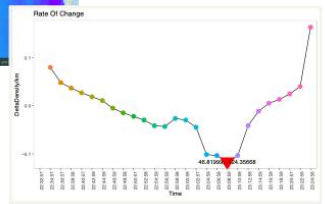
Objective 2: Characterize forage assemblages around fronts

Objective 3: Observe salmon behavior relative to fronts

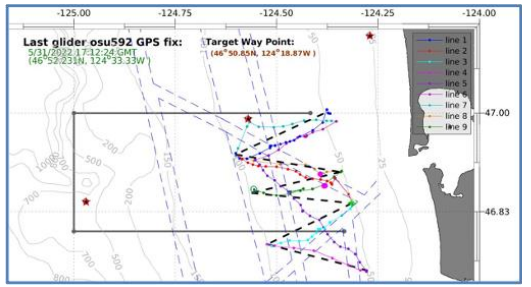
Objective 4: Evaluate predation behavior around fronts

Goals and Mission Overview





Study design



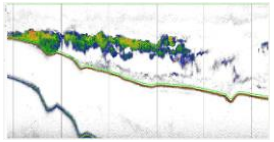
1. Where are fronts?

3. Who is there - eDNA?

5. How do salmon behave near fronts
– Receivers on glider and along coast?

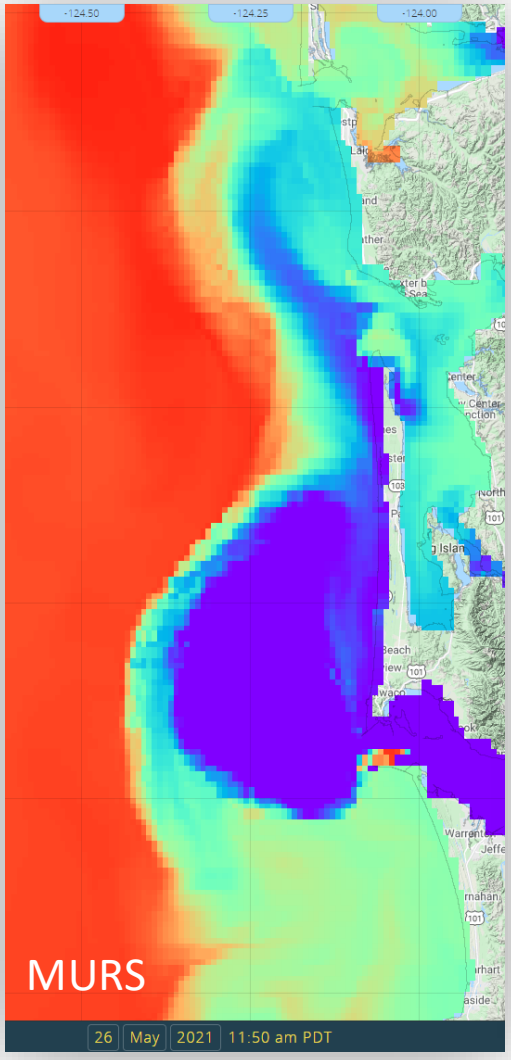
2. Spatial observations of forage?

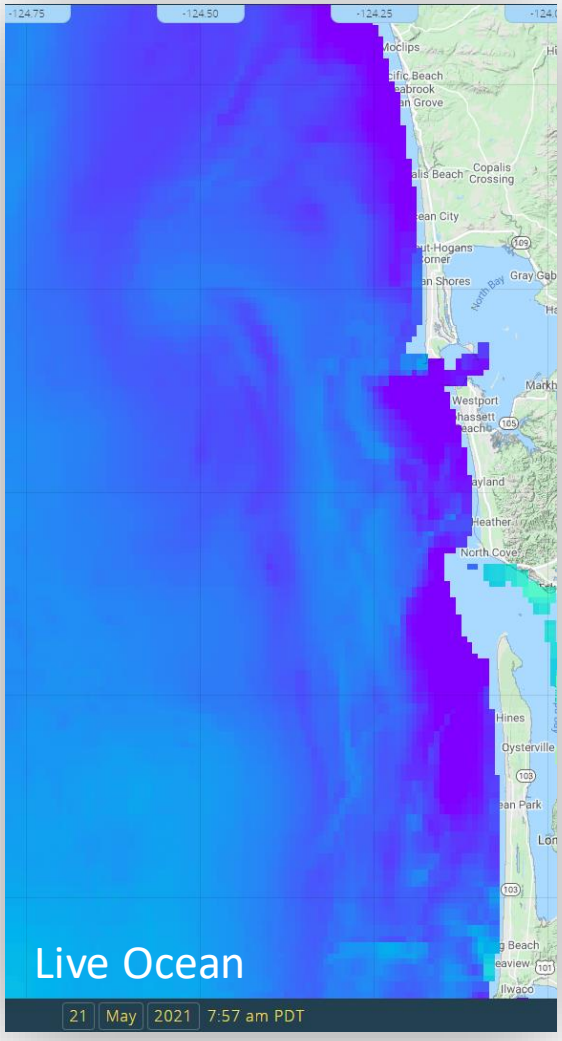
4. Susceptibility of salmon to predation near fronts?



Objective 1: Characterize the biological and physical characteristics of upwelling fronts

Combination of remote sensing and oceanographic modeling was used to contextualize the front currently and a few days out.

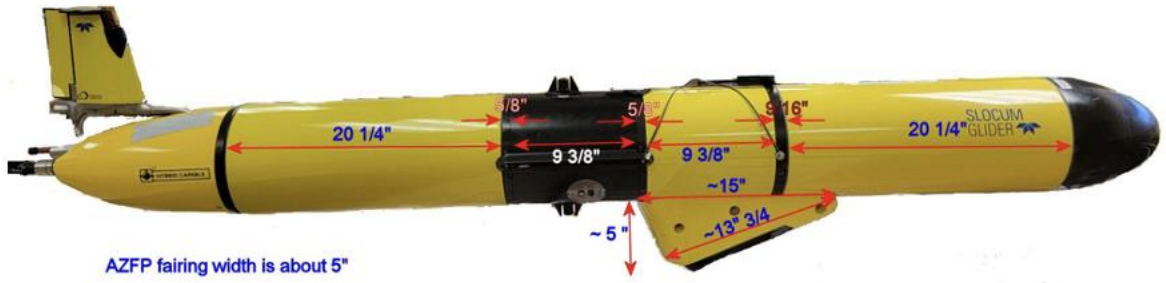




Objective 1: Characterize the biological and physical characteristics of upwelling fronts

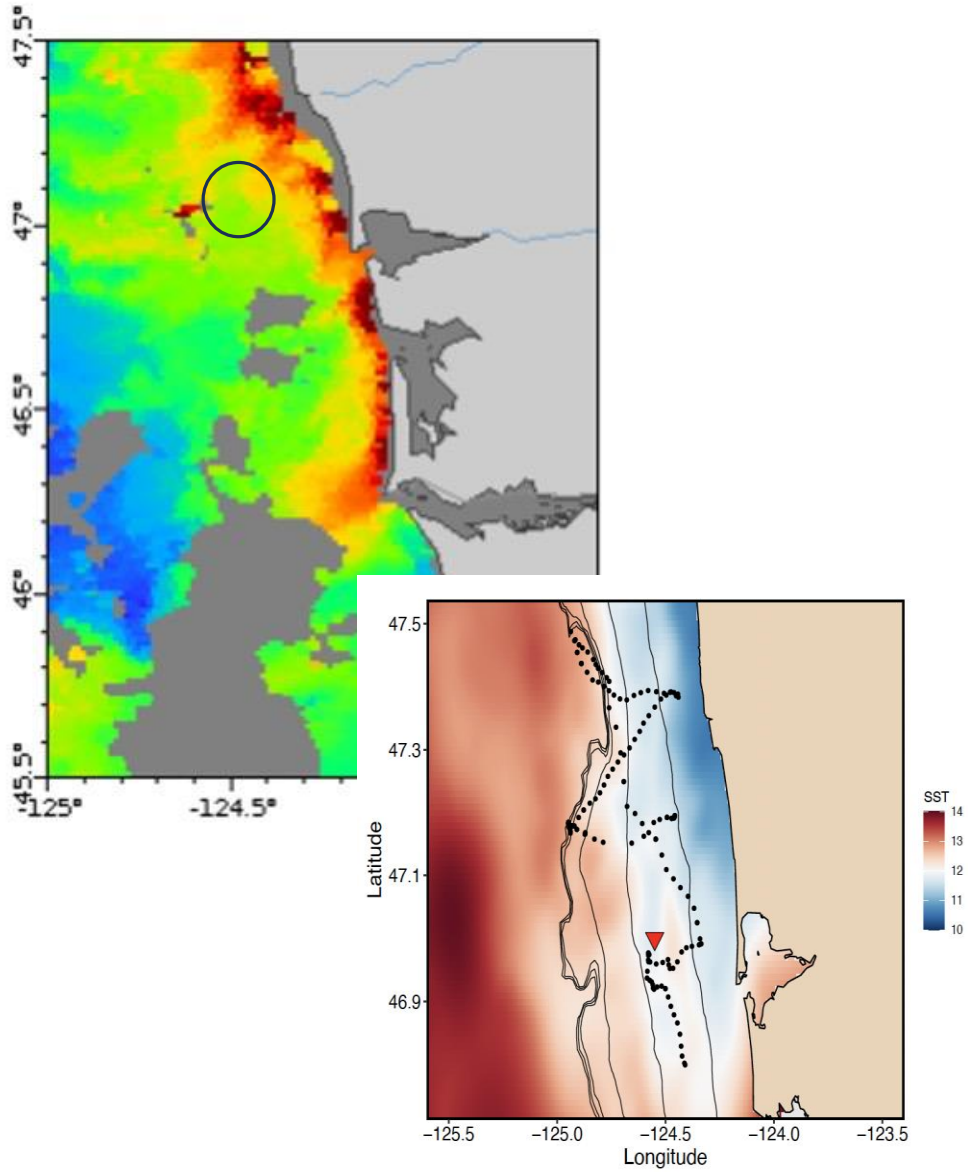
A Slocum glider equipped with Vemco tag receiver and CTD was deployed off of Grays Harbor region in May 2021, 22, and 23

Gear	Type	Specifications
Slocum Glider	TWR G2 with thruster	200-m
Active Acoustics	ASL Acoustic Zooplankton Fish Profiler (AZFP)	67-kHz, 120-kHz, 200-kHz
Acoustic receiver	Vemco in TWR science bay	69 Hz
CTD, optics and DO	Seabird CTD and optics; Aanderaa optode for DO	CTD, O2, chlorophyll-flourescence, light backscatter, CDOM-fluorescence



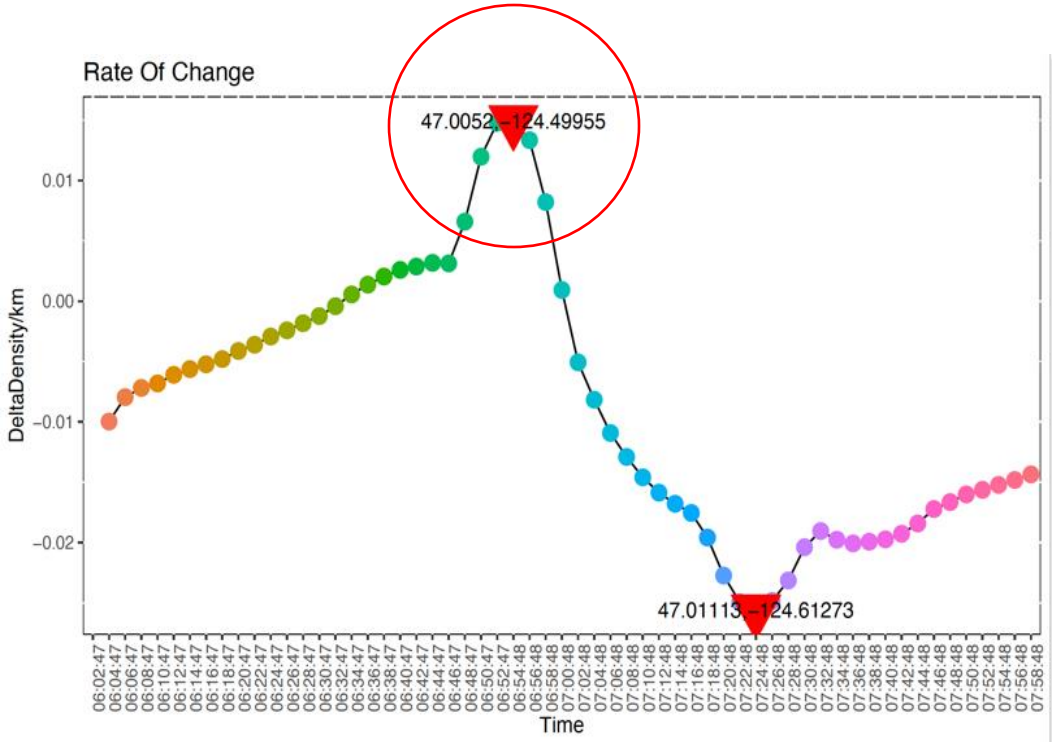
Objective 1: Characterize the biological and physical characteristics of upwelling fronts

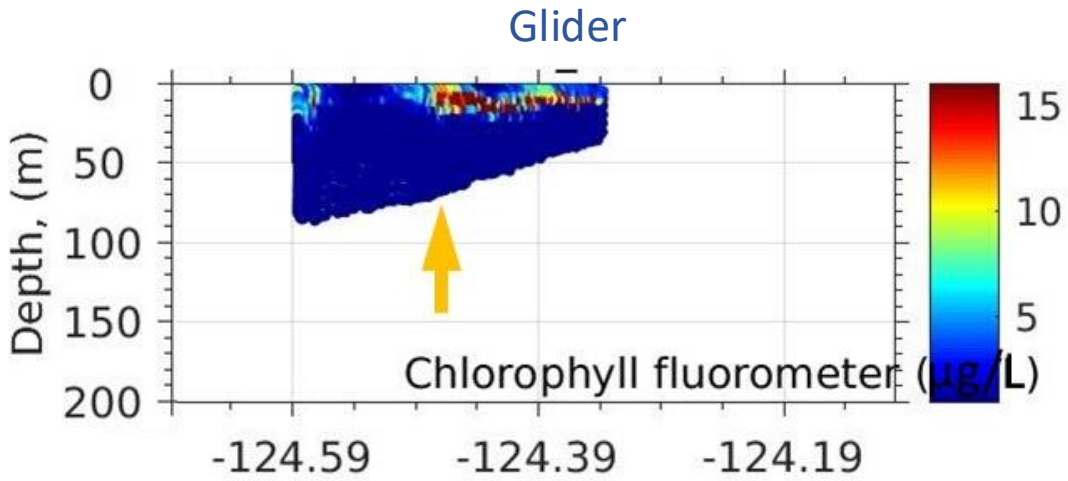
We identified the front and defined the sample sites



Objective 1: Characterize the biological and physical characteristics of upwelling fronts

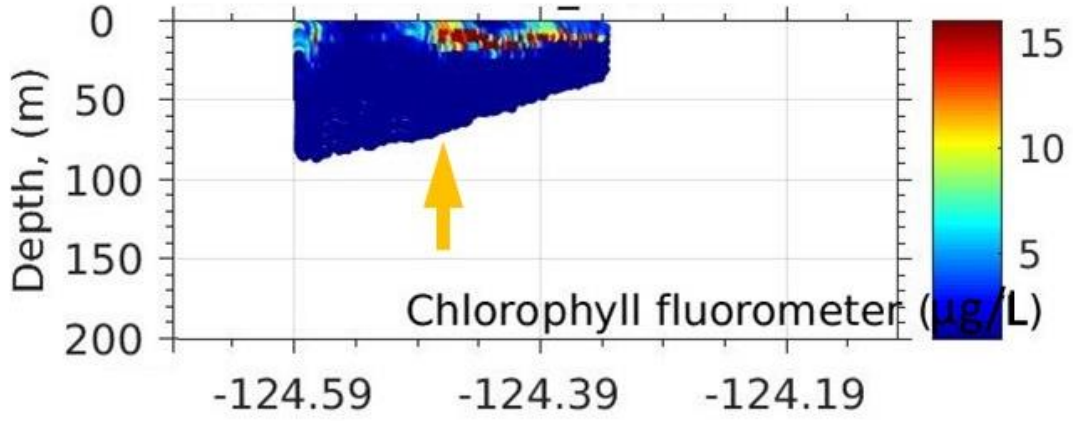
In situ we identified the front and defined the sample sites

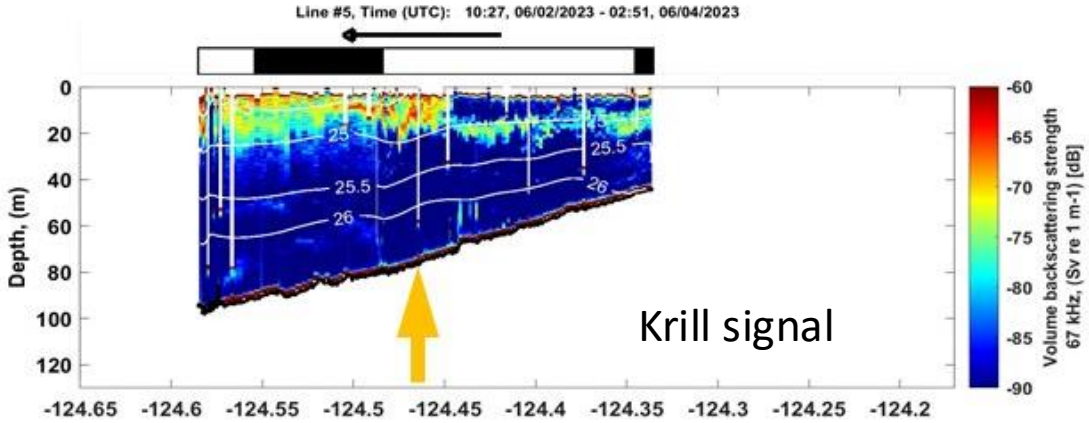




Objective 2: Characterize forage assemblages around fronts

The front clearly was visible with Chlorophyll and there were more likely krill offshore.

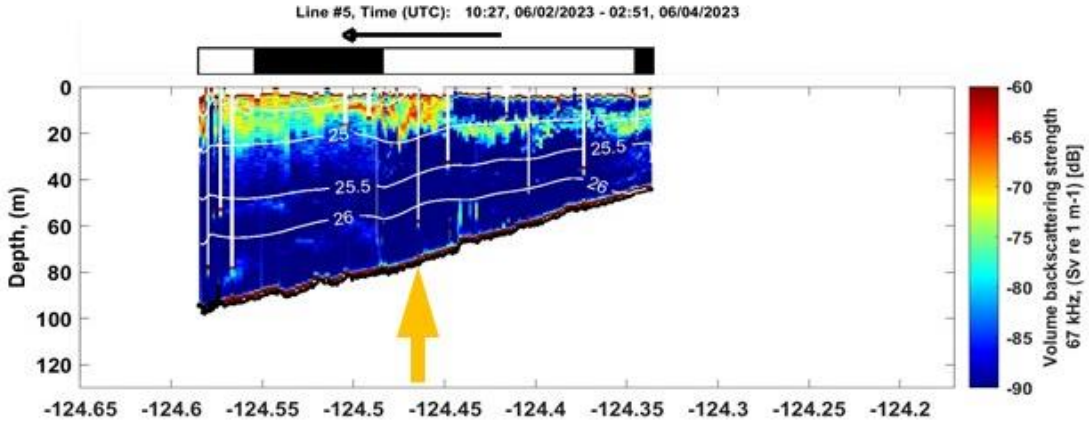


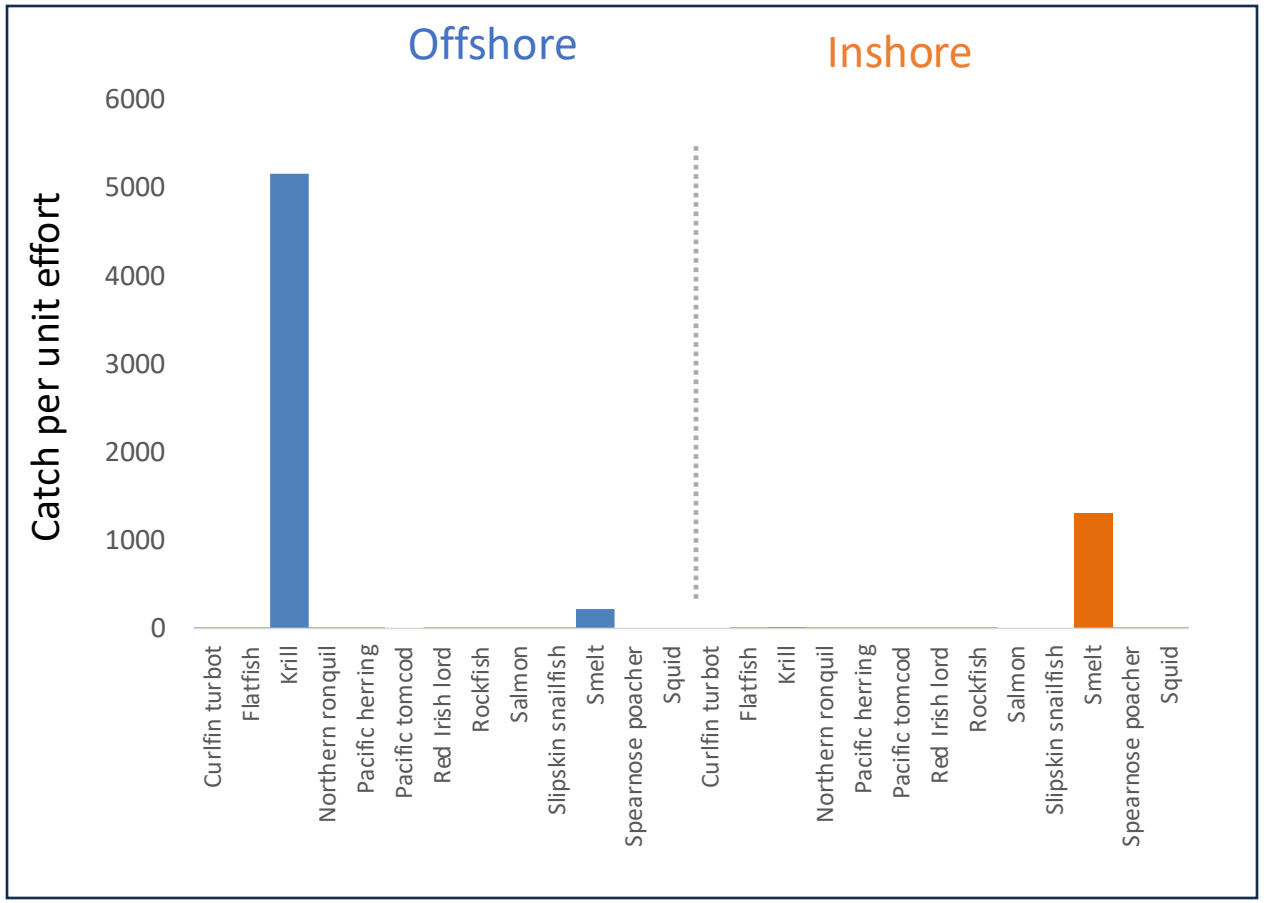


Objective 2: Characterize forage assemblages around fronts

Trawl data confirms that the abundance of krill was greater offshore of the front and smelts dominated inshore.

Values of other species were minimal or zero





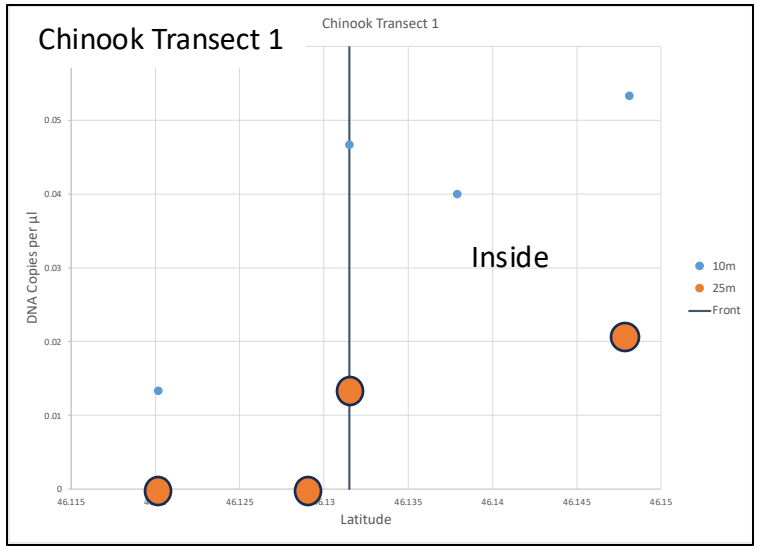
Objective 3: Observe salmon behavior relative to fronts

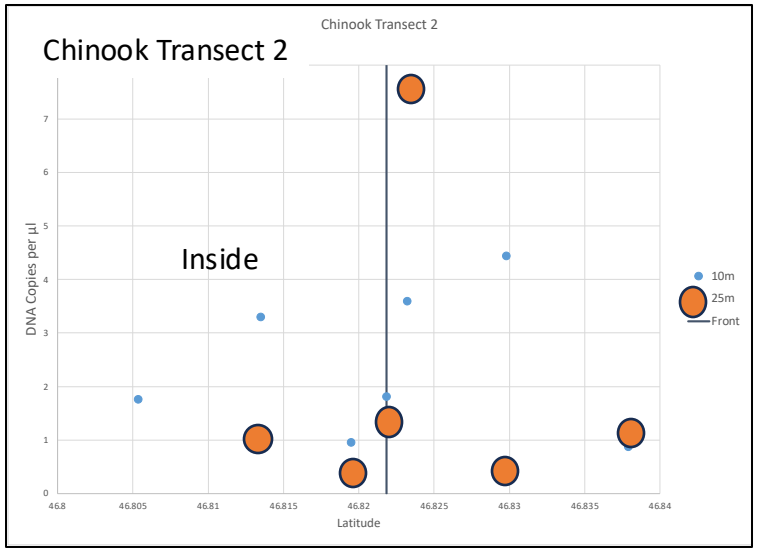
Sampled water replicates for eDNA at 7 stations:

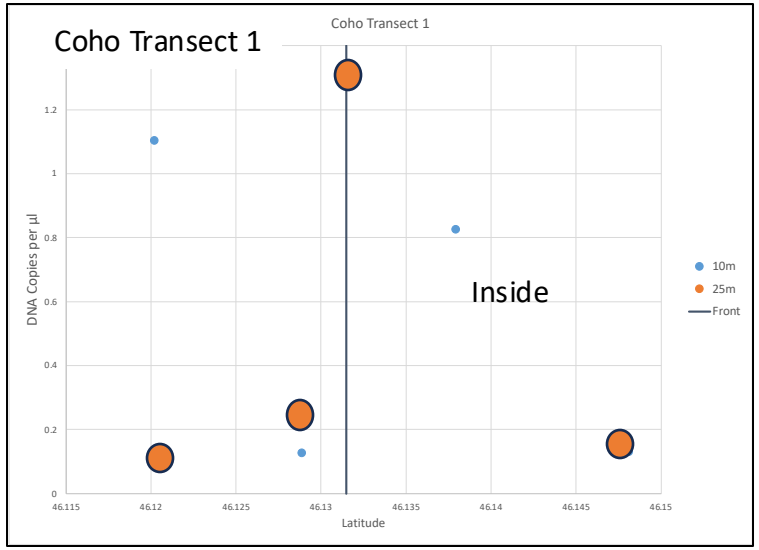
3000 Inside Front, 1500 Inside, 500 Inside, 0, 500 Outside, 1500 Outside, 3000 Outside. We sampled for forage and salmon abundance.

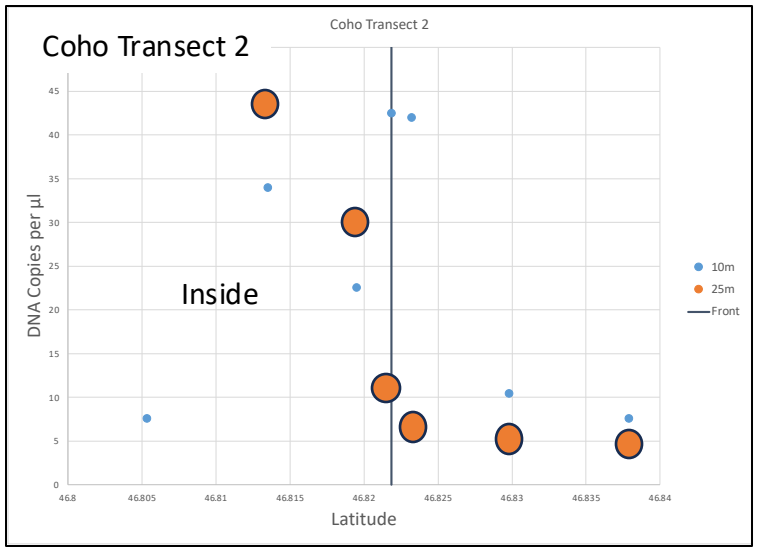
Objective 3: Observe salmon behavior relative to fronts

Salmon distribute on and inside of and on fronts. These fronts are from an earlier year, 2021 and is preliminary data









Objective 3: Observe salmon behavior relative to fronts

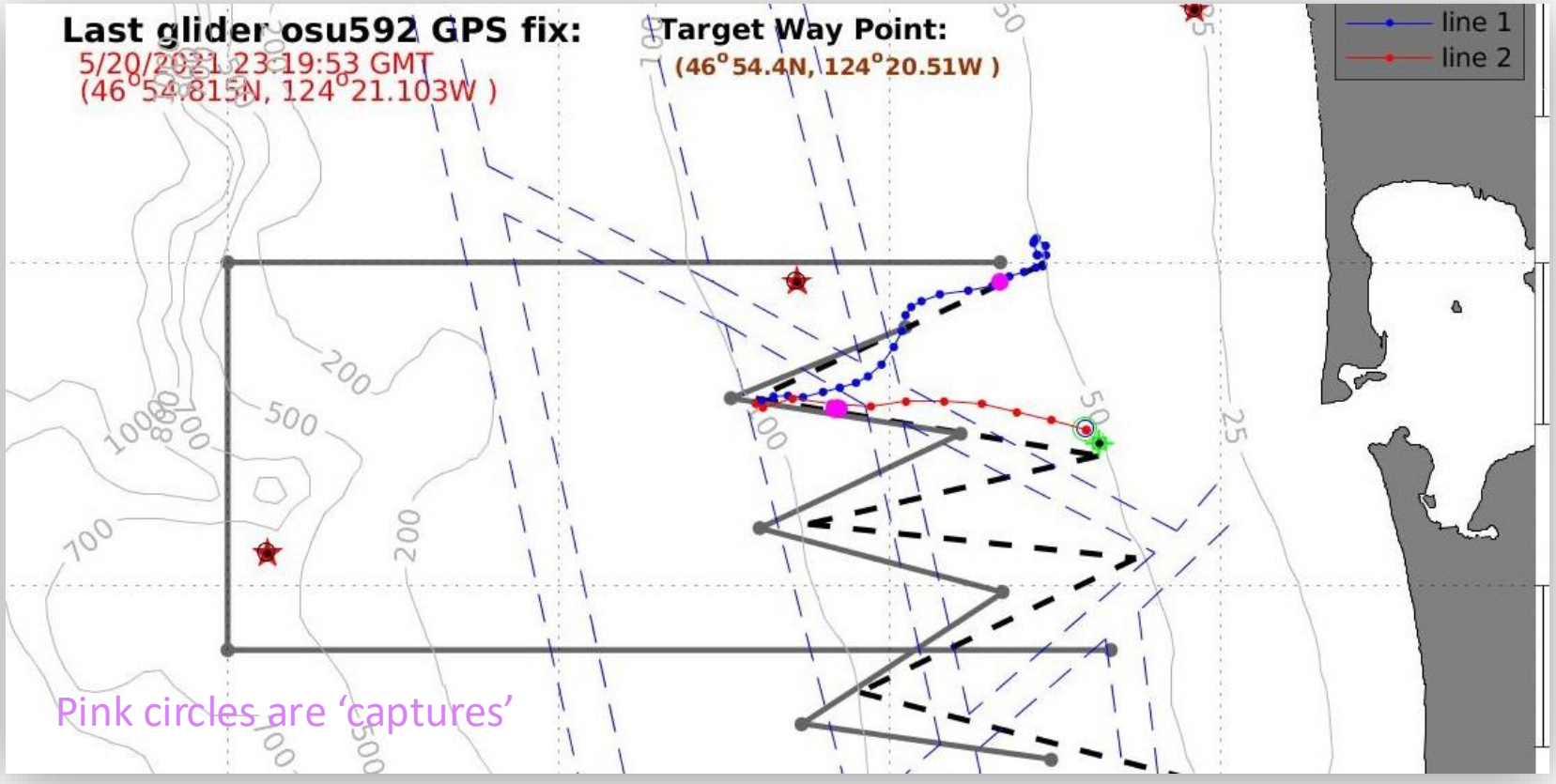
We tagged a number of salmon with Vemco pingers

Purse seining salmon

Tagging

Objective 3: Observe salmon behavior relative to fronts and *plumes*

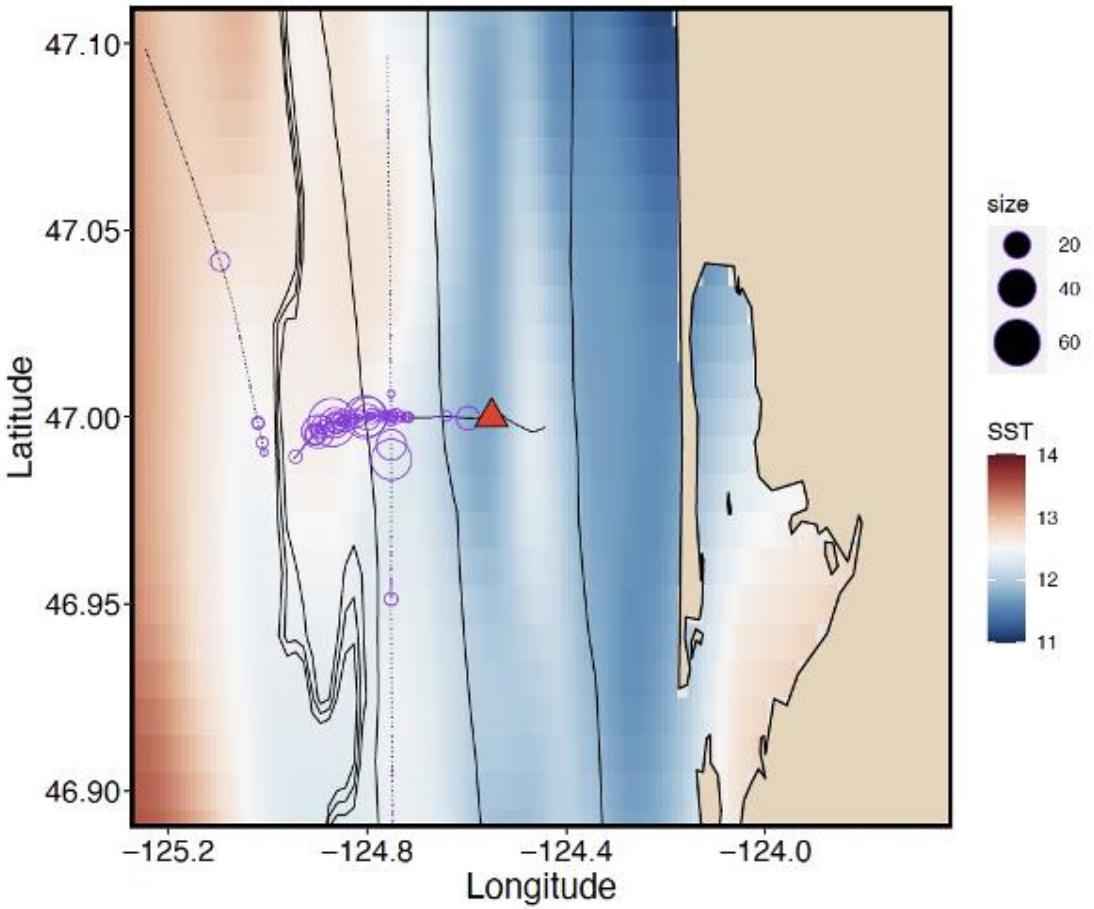
Salmon were also detected from receivers on the glider as it transited on and around fronts. This provides a more regional perspective. Same fronts as previous eDNA



Objective 4: Evaluate predation behavior around fronts

We had bird observer on the bridge estimating their abundance and distribution.

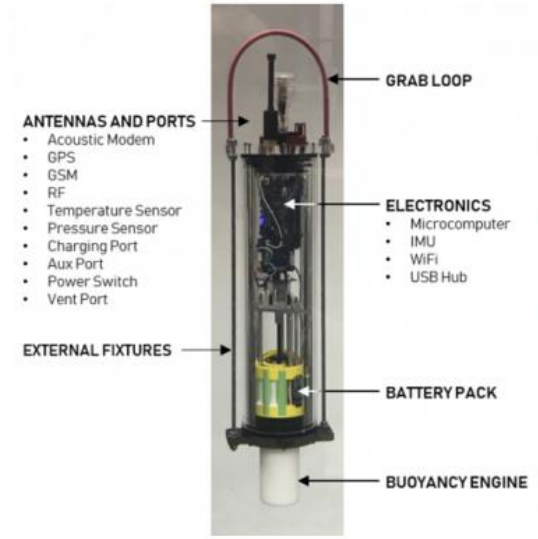
Common murre distribute at and offshore of the front



Objective 4: Evaluate predation behavior around fronts

We modified autonomous oceanographic bouys as Predation Event Recorders that captured predation events and the physical characteristics associated with them. These are deployed around the front and on it.

Inconclusive results as of yet.



A µFloat schematic.

Figure 7: Shown is the uFloat, baiting the device, and imagery of a predation event.

Conclusions

Fronts represent oceanographic and biological structuring of forage, salmon and predators.

Autonomous vehicles provide never-before-used high-resolution data capable of refining our diagnosis of frontal impact and importance.

Questions

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Benefits to NOAA/ Societal Impact

- This effort demonstrates the efficacy of these tools to quantify how the ecosystem affects salmon and how ecosystem components are reliant on salmon thereby moving the agency towards informed EBM.

- The incorporation of ecosystem considerations in fish stock assessment has been slow. Improving confidence in forecasting salmon recruitment and resilience under future climate change and ecosystem variability requires identifying processes underlying observed statistical relationships.