# Glider observations of downwelling processes and zooplankton distributions in Clayoquot Canyon

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# Motivation

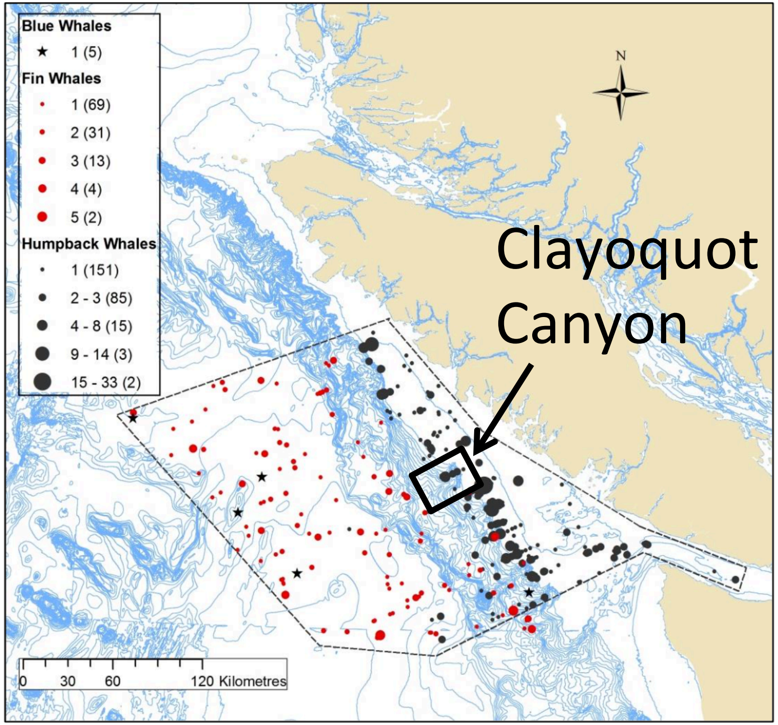
To understand the mesoscale mechanisms in a downwelling regime around a submarine canyon that influence zooplankton distribution, which in turn helps describe biological habitats in offshore waters

# West Coast of Vancouver Island: Biological Habitat

Observations suggest canyons are biological habitat (e.g. for whales)

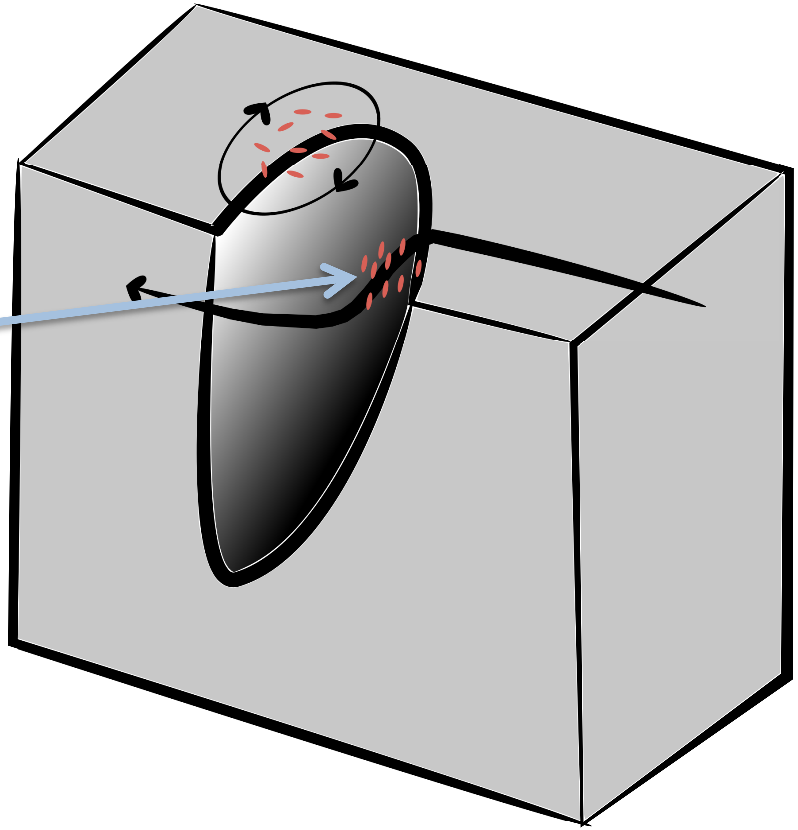
Submarine canyons enhance upwelling and downwelling and could aggregate zooplankton

State of the Oceans, 2015



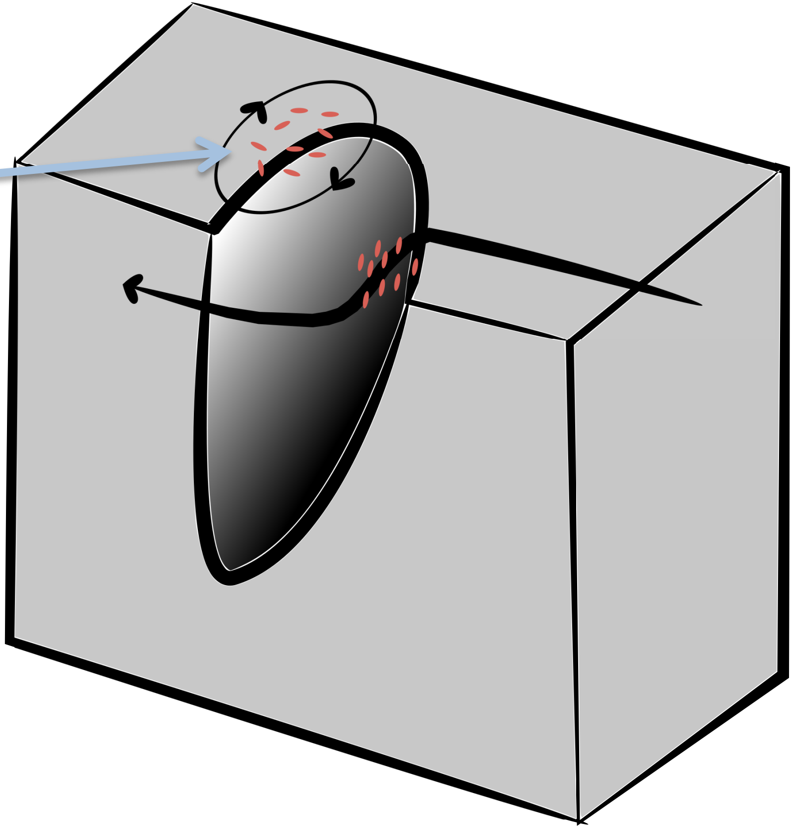
# Canyon Dynamics and Zooplankton Aggregations

Upwelling/downwelling creates vertical flows that zooplankton swim against to maintain ideal light levels



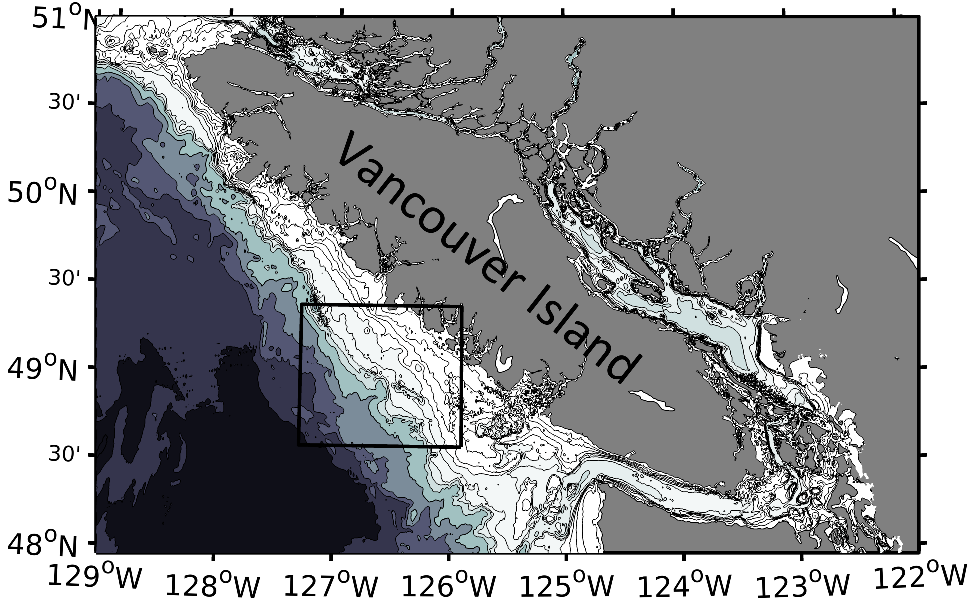
# Canyon Dynamics and Zooplankton Aggregations

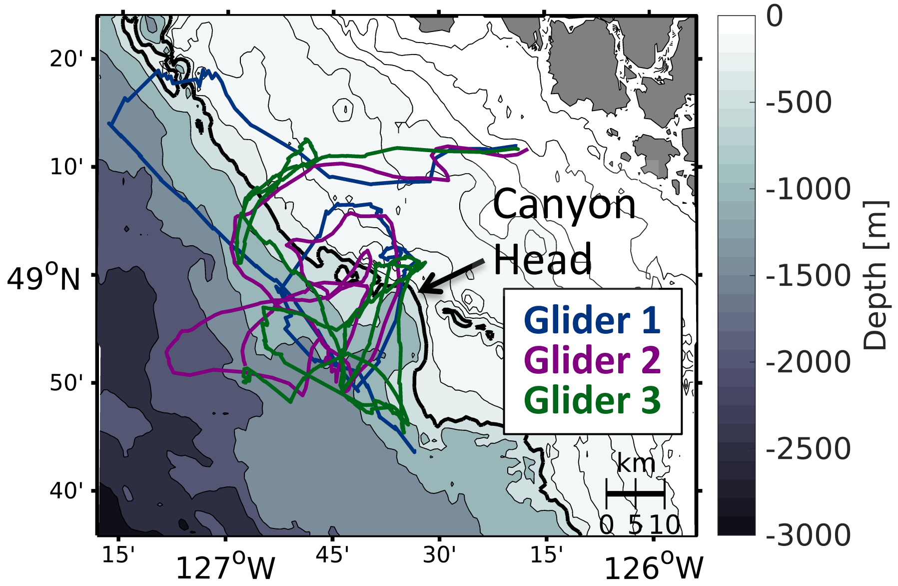
Canyon eddies can retain zooplankton



# Glider Campaign: Clayoquot Canyon

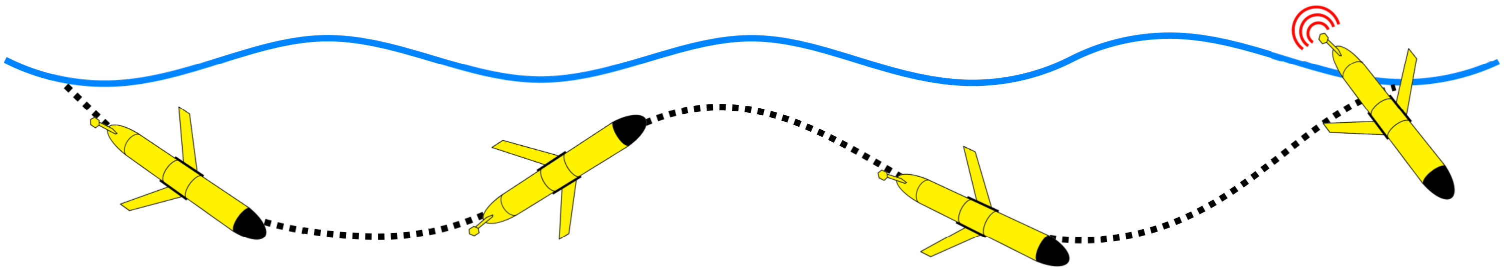
## January 30 – February 18 2017, 9 Canyon Transects



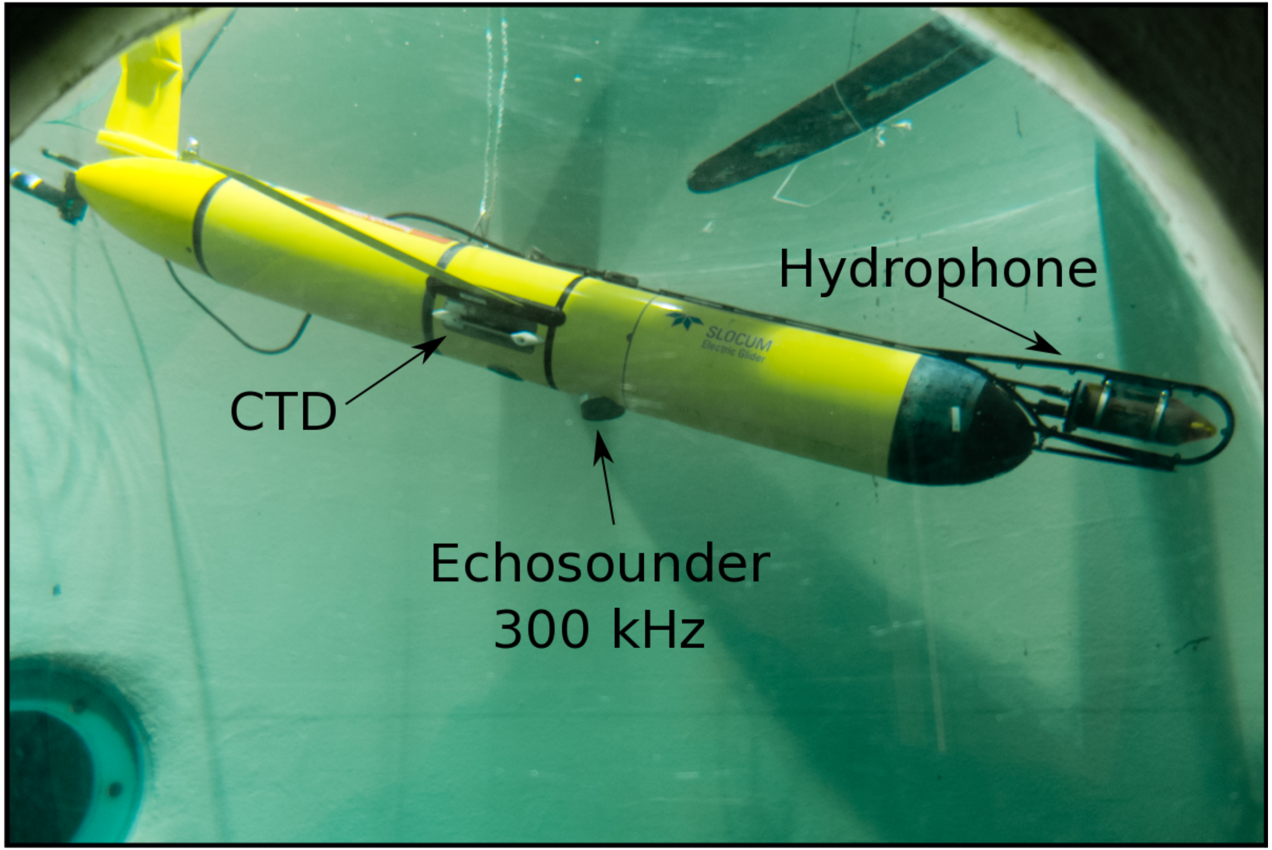
# Glider Advantages

1. Obtain high time and space resolution data over extended periods of time
2. Collect observations during adverse weather conditions, including stormy downwelling seasons
3. Equipped with a range of specialized sensors

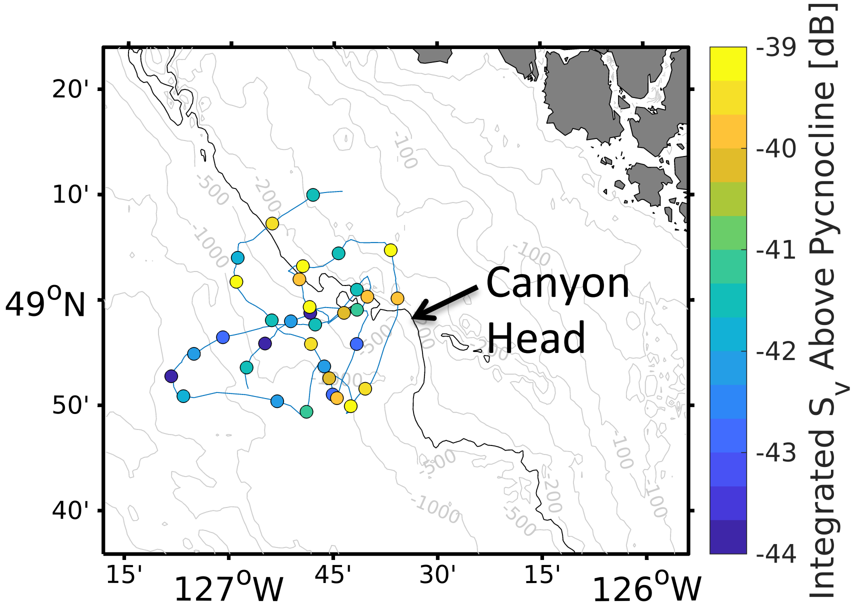


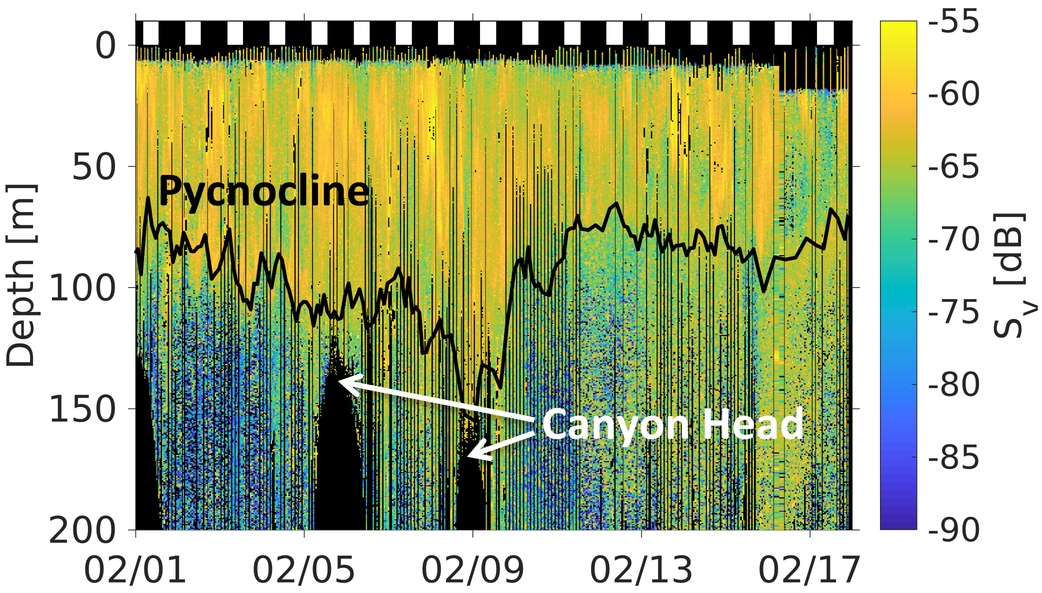
Glider drawing credit: Robin Matthews

# Glider Sensor Instrumentation



# Zooplankton around Clayoquot Canyon



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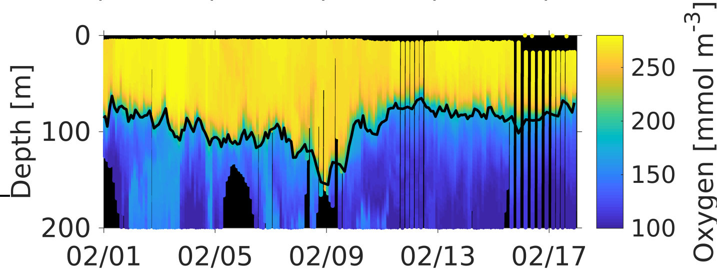


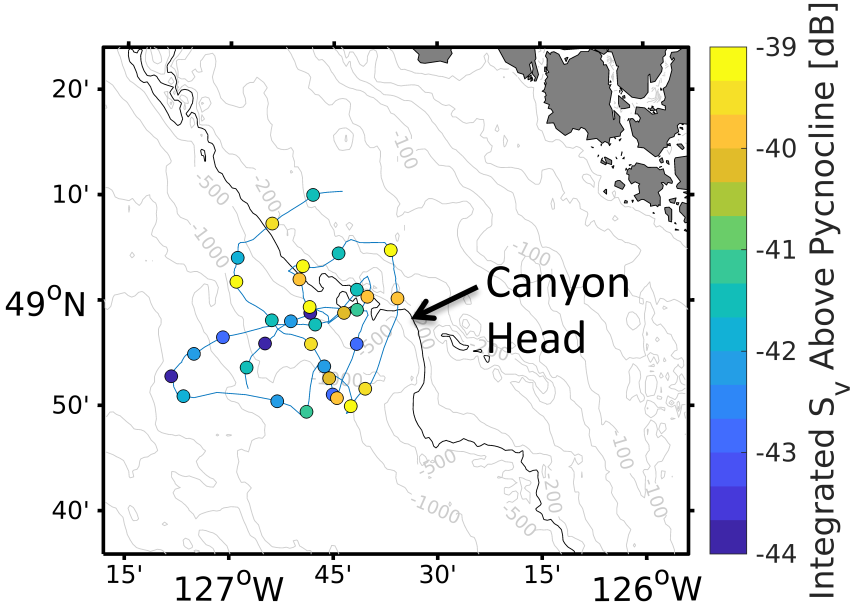


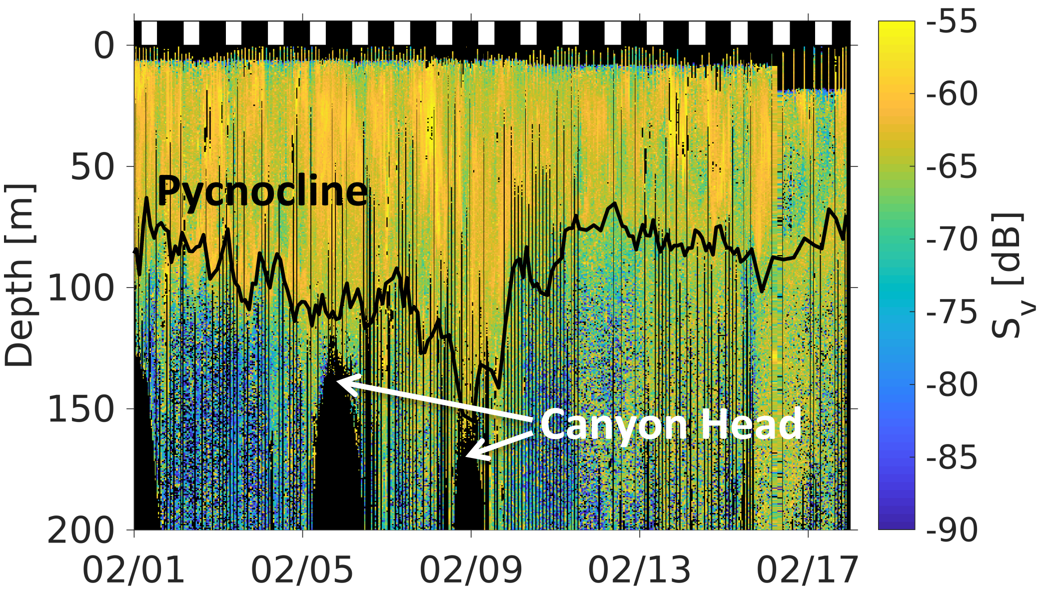

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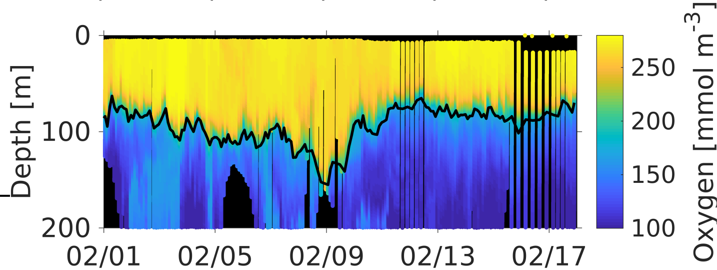
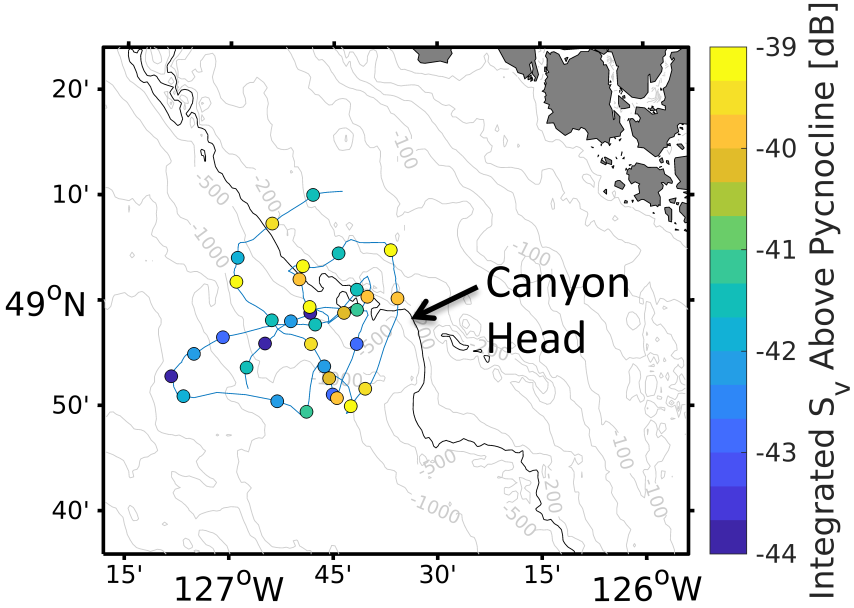
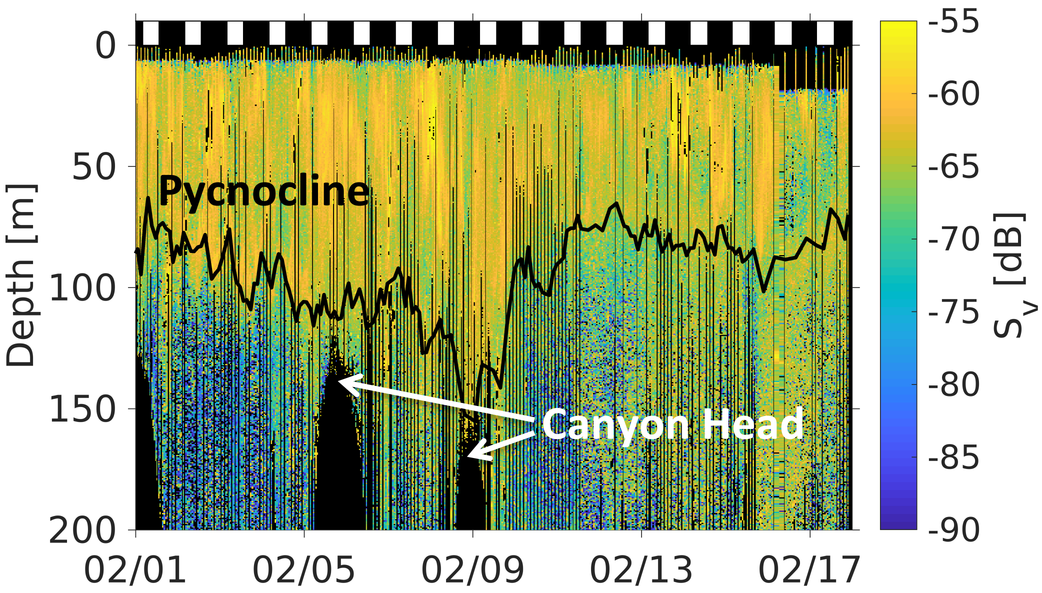


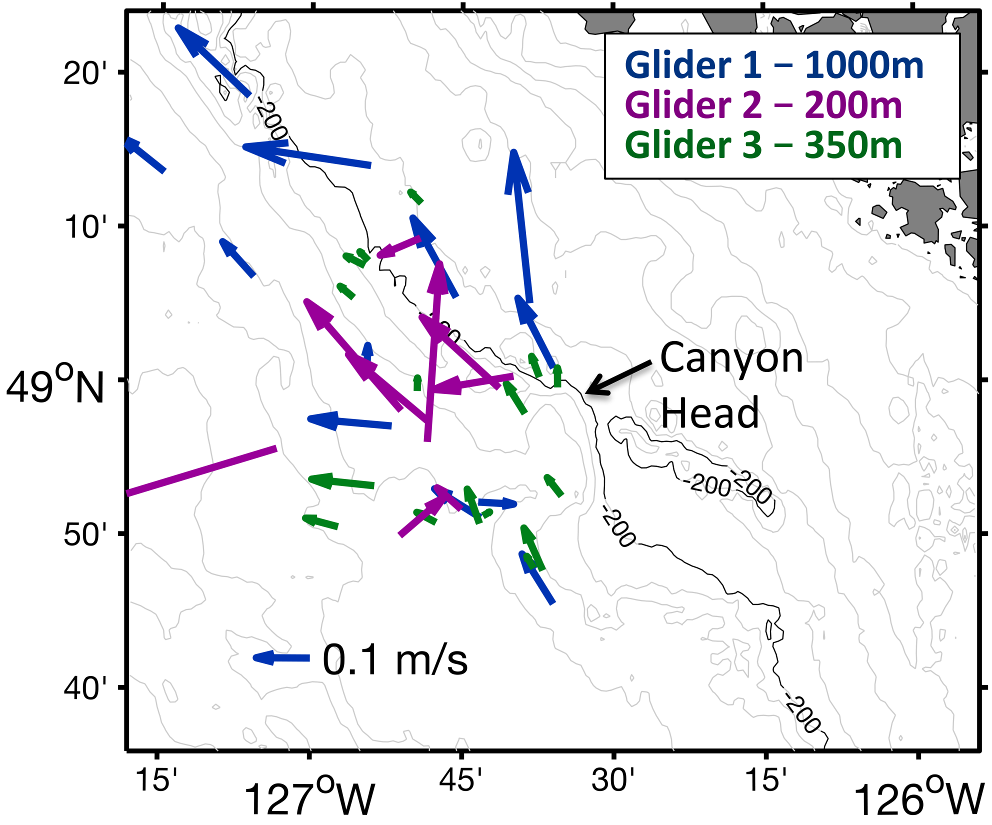




What physical processes influence the distribution of zooplankton in Clayoquot Canyon?

# Northwest Current

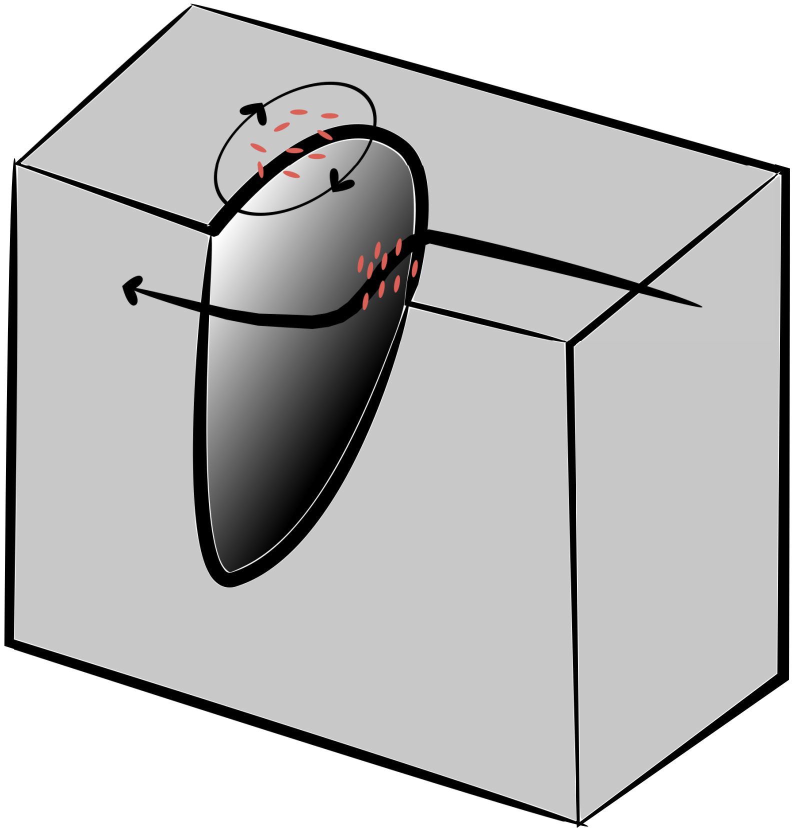
Depth averaged velocities show northwest current

- precondition for downwelling



# Canyon Downwelling Hypothesis

Strong northward currents over the canyon suggest downwelling may occur



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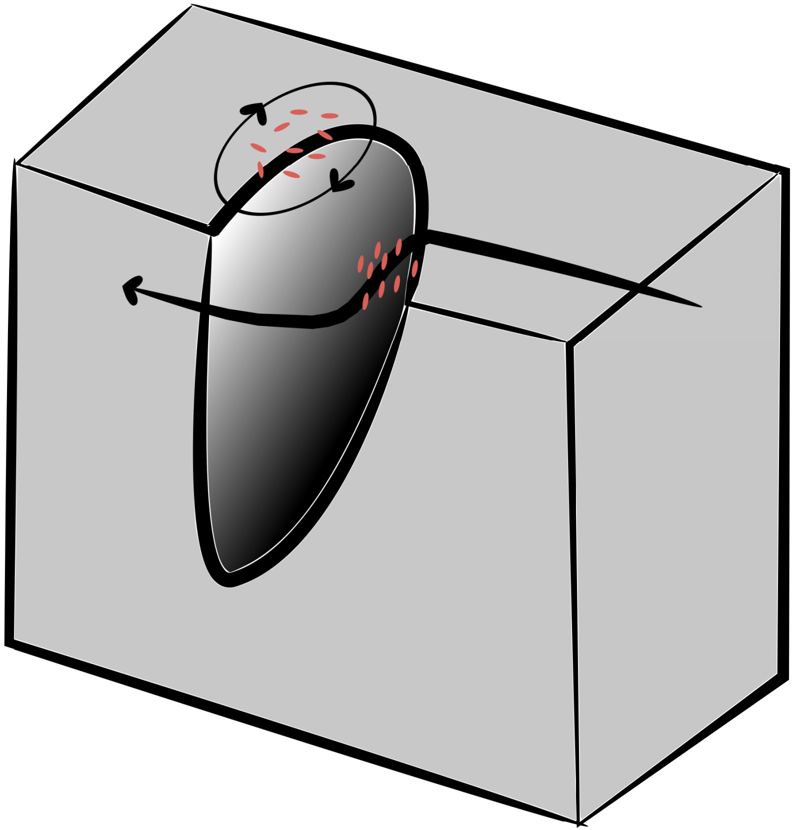
Strong northward currents over the canyon suggest downwelling may occur

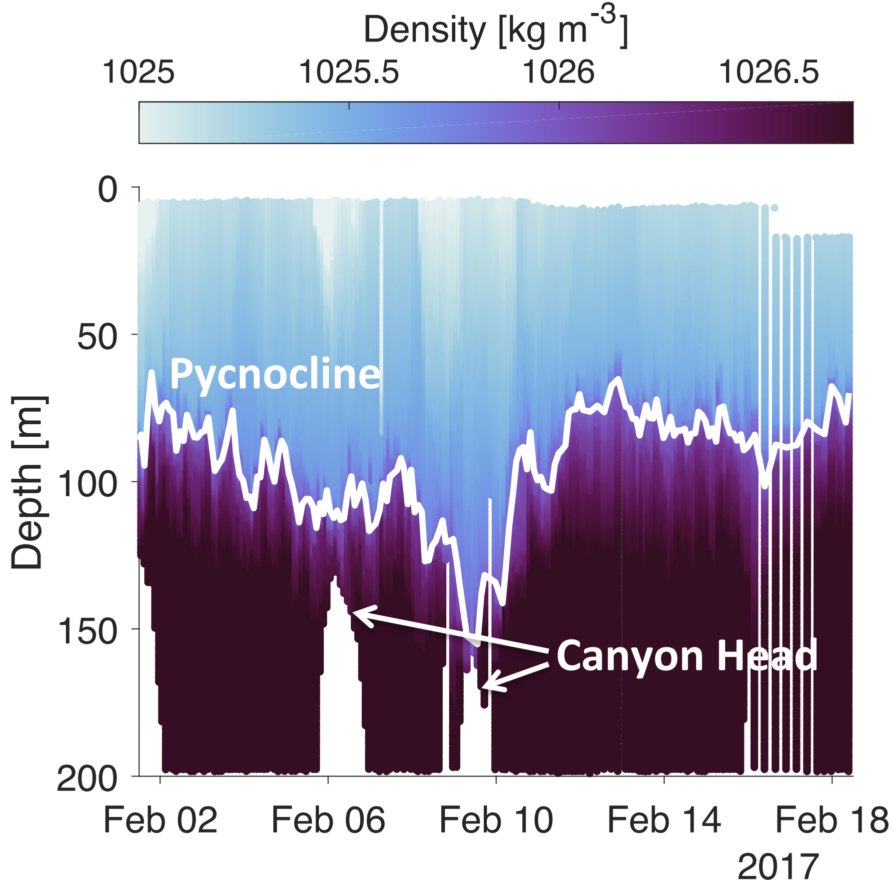
- Deeper pycnocline over canyon



# Pycnocline Definition

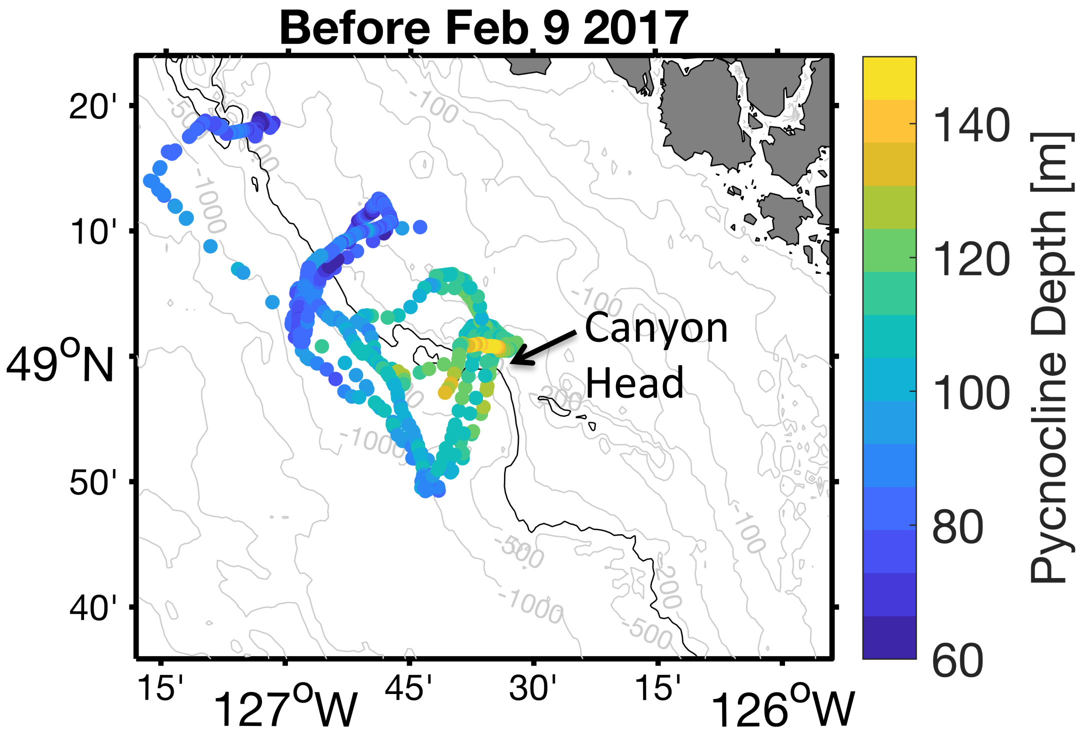
Density difference from a near-surface value

$$z_{pyc} = z(\rho - \rho_{25m} = 0.4\ \text{kg/m}^3)$$



# Pycnocline Depth: Spatial Distribution

Deeper pycnocline found within canyon



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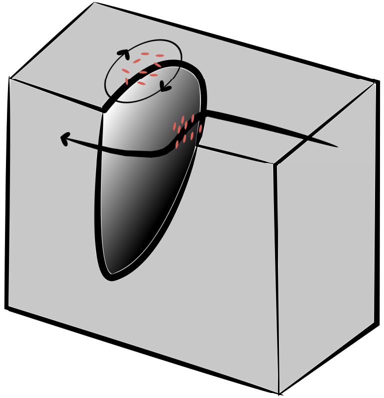

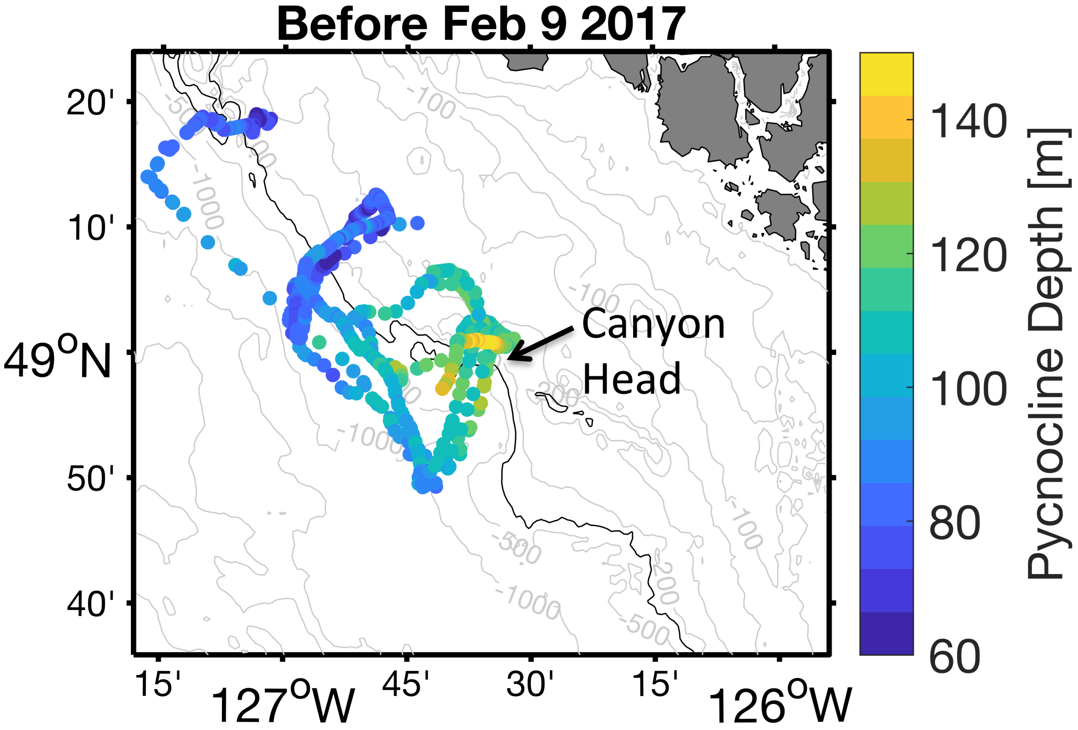

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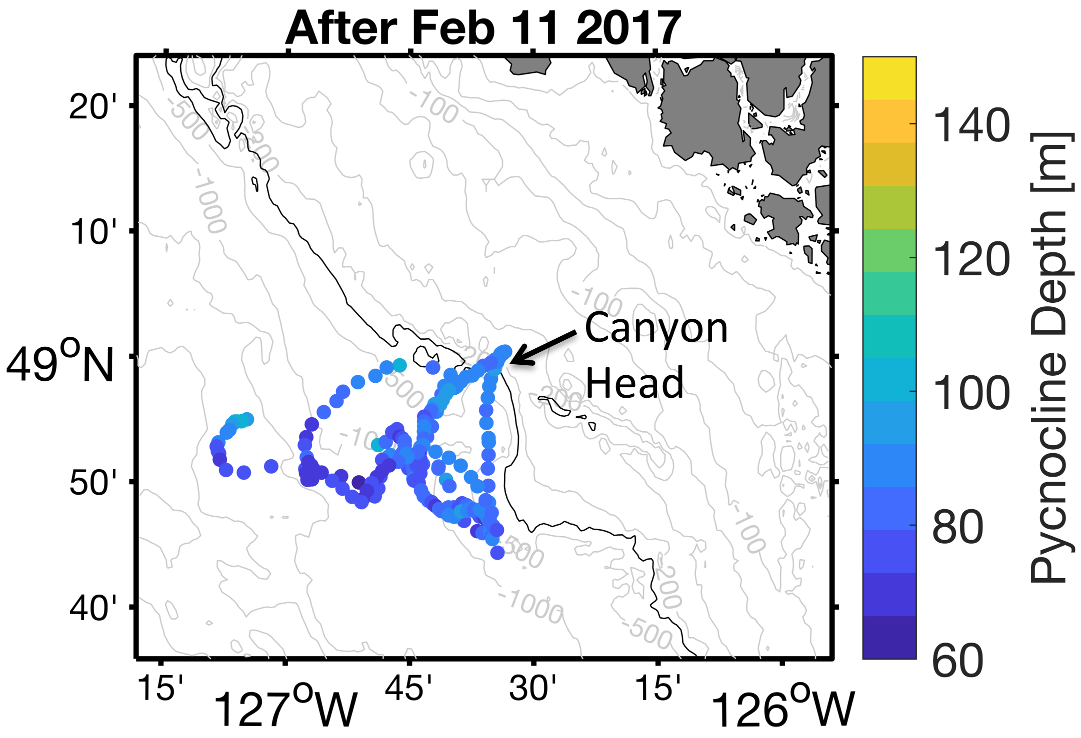
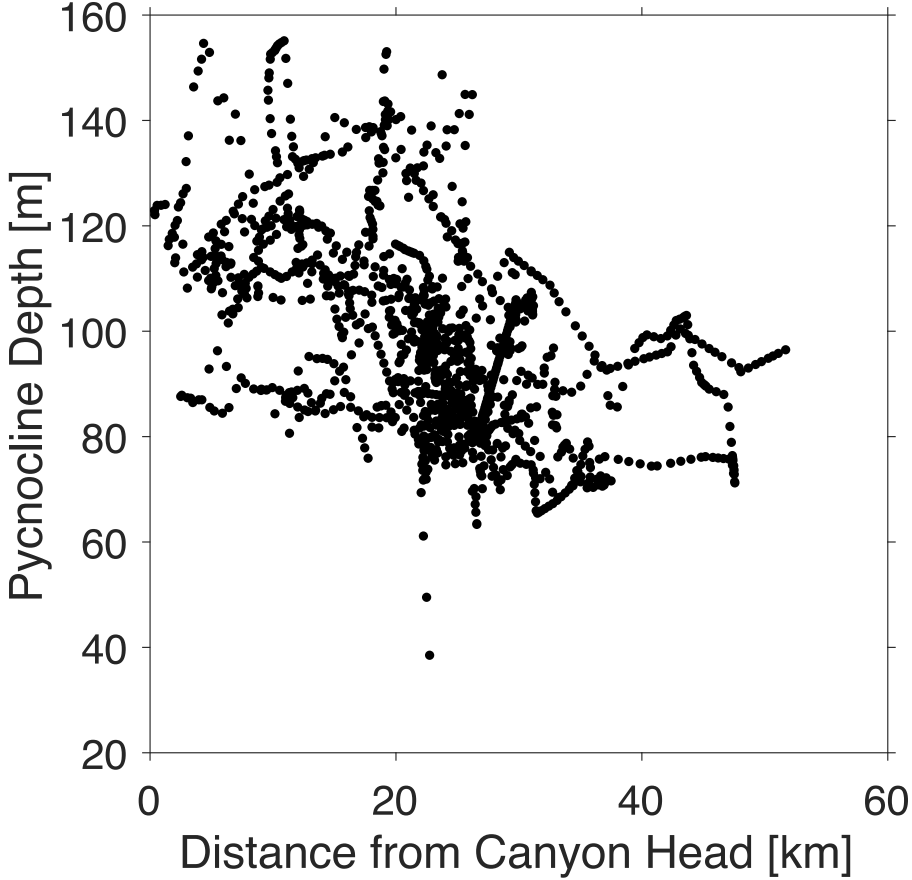
Deeper pycnocline found within canyon

. . . even later on, though less prominent



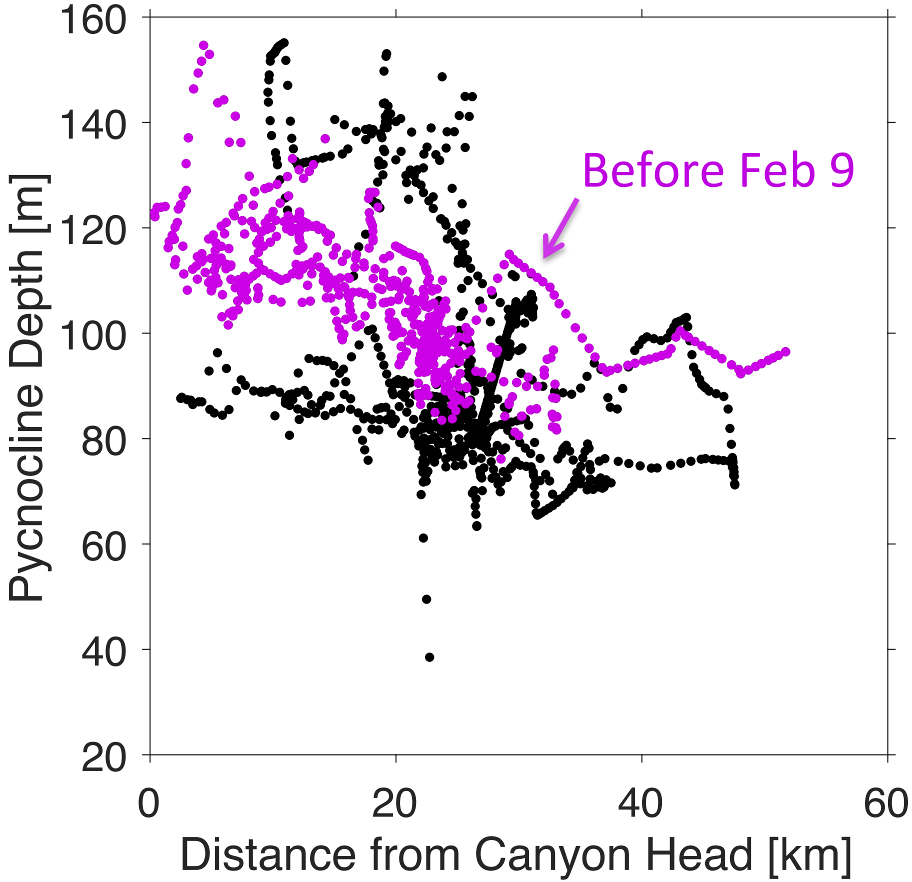
# Pycnocline Depth-Distance to Canyon Head Relationship

Pycnocline tends to be deeper near canyon head

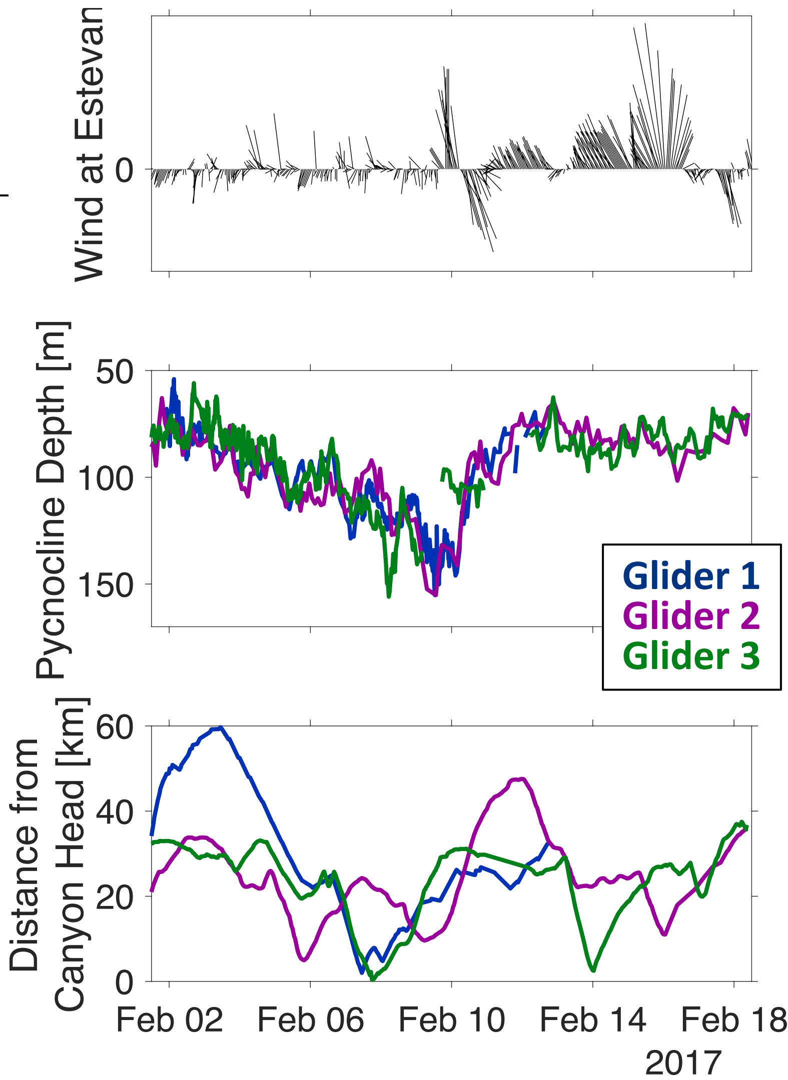


# Pycnocline Depth-Distance to Canyon Head Relationship

- Pycnocline tends to be deeper near canyon head
  - Clearly seen before Feb 9 2017

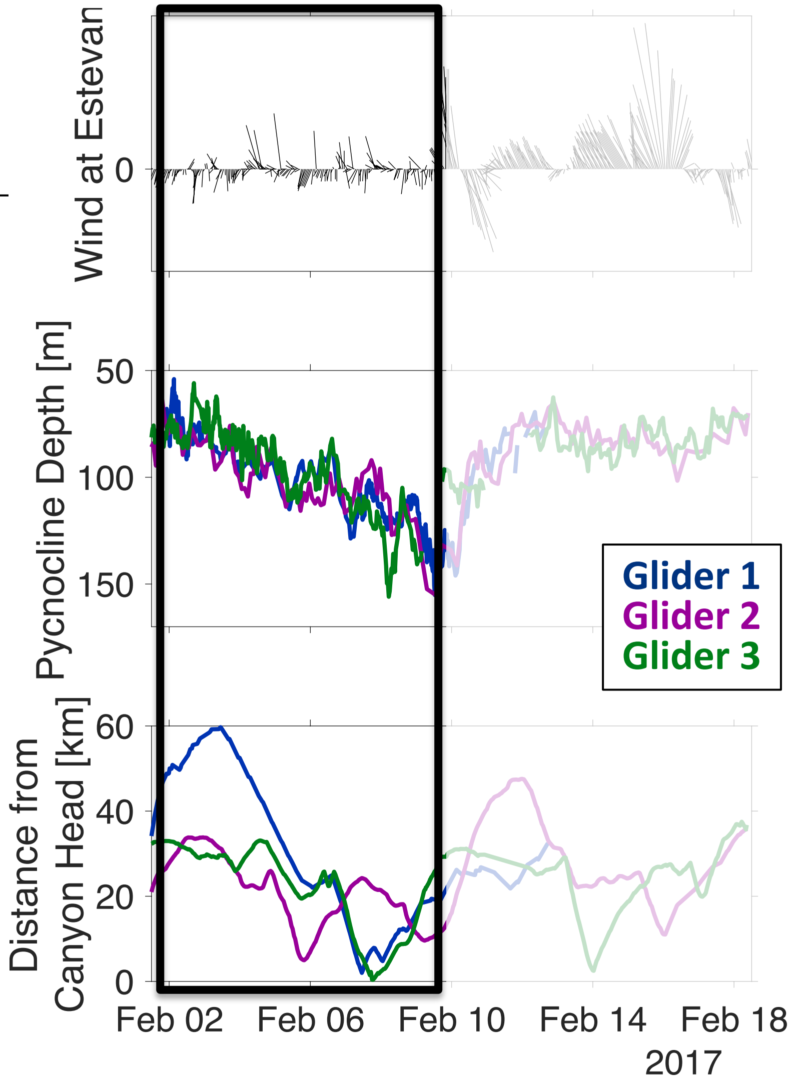


# Pycnocline Depth:
# Temporal Distribution



# Pycnocline Depth:
# Temporal Distribution

Pycnocline deepens for first half of mission



# Pycnocline Depth:
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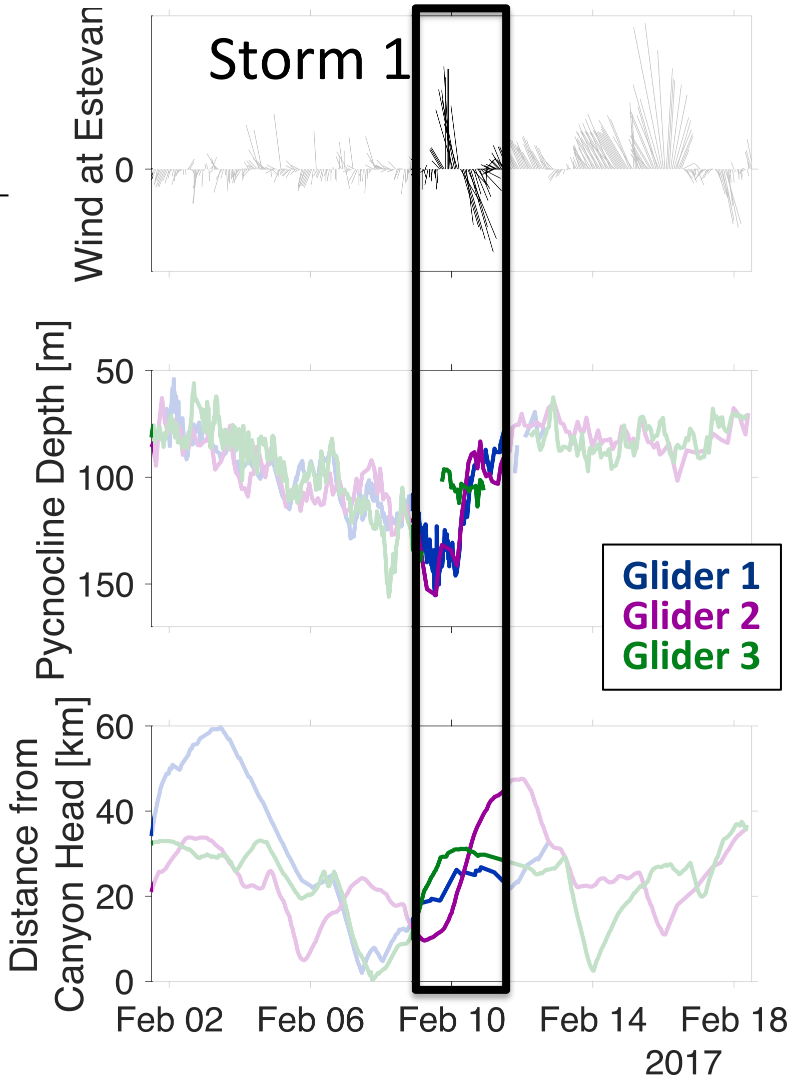
Storm passes through which coincides with a shoaling the pycnocline

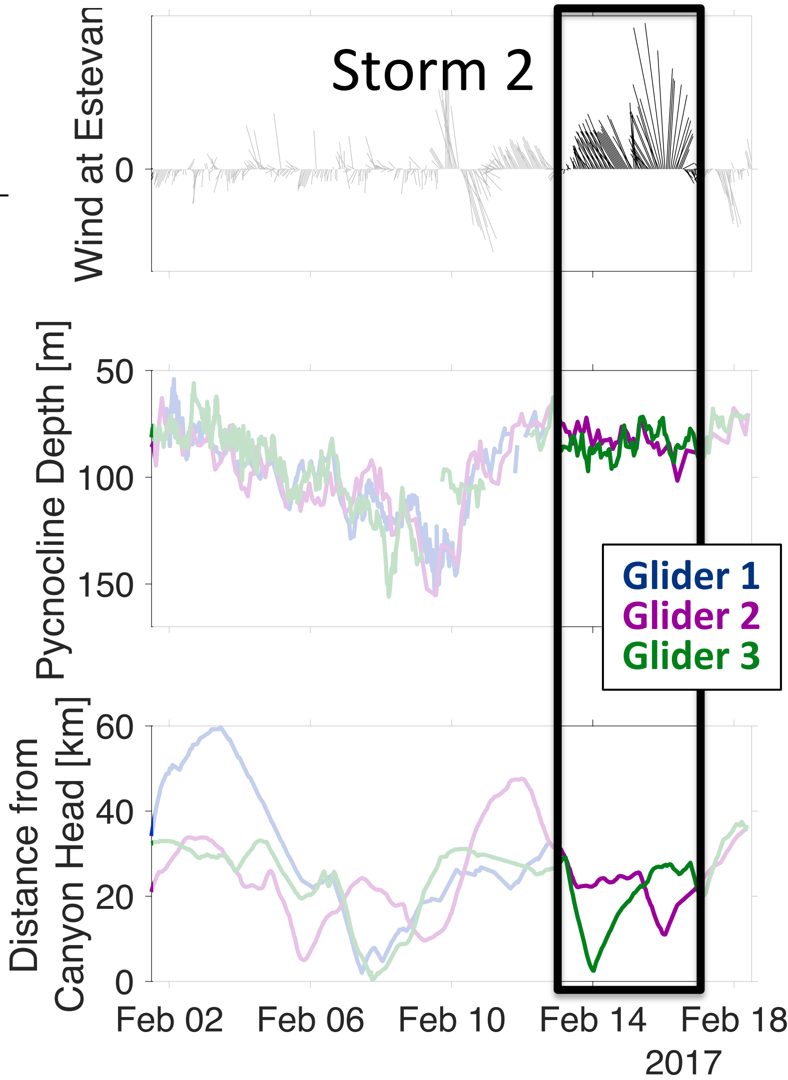


# Pycnocline Depth:
# Temporal Distribution

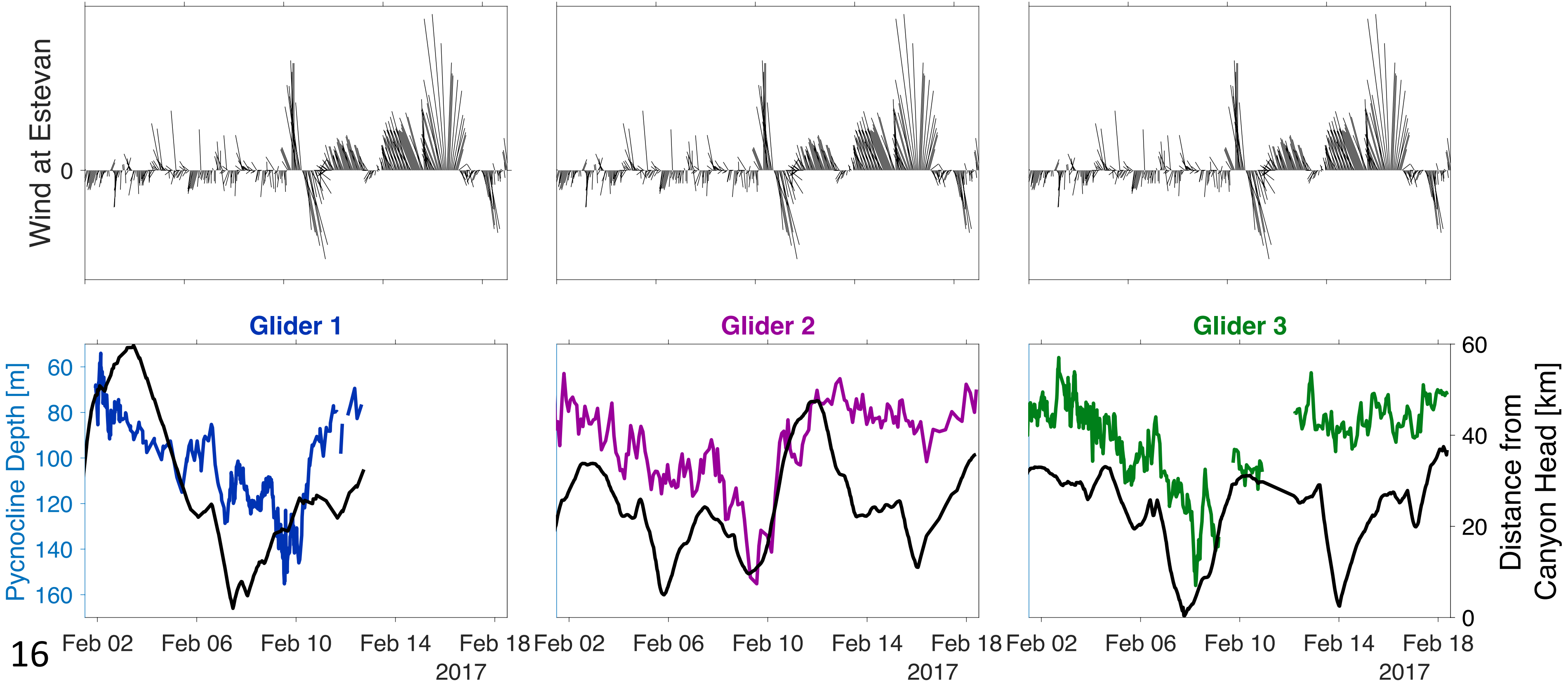
Pycnocline deepens for first half of mission

Storm passes through which coincides with a shoaling the pycnocline

Second storm has little influence on pycnocline depth



# Convolution of Space and Time



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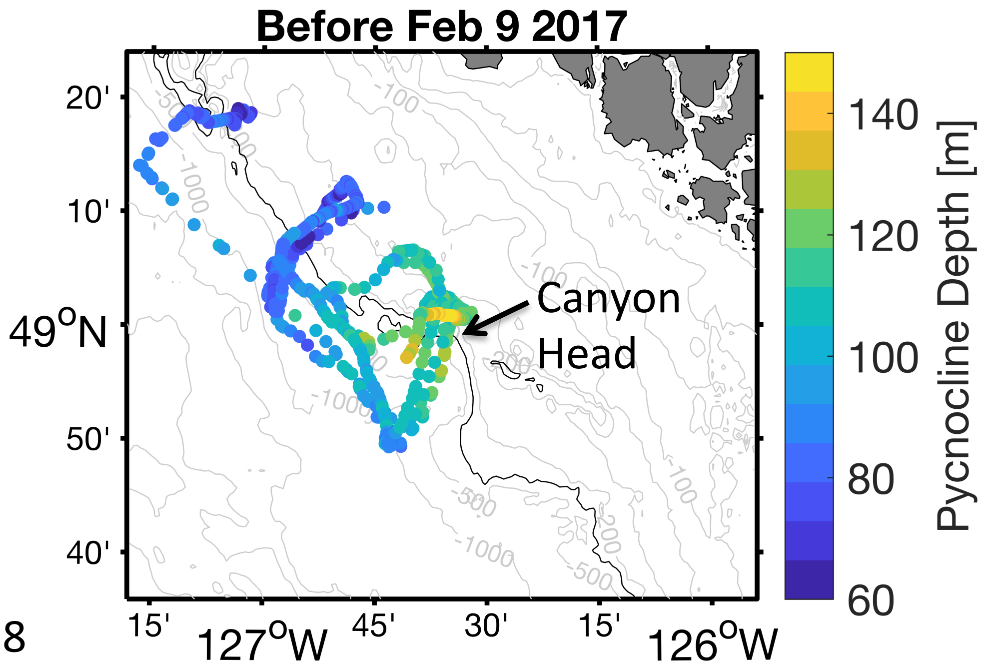
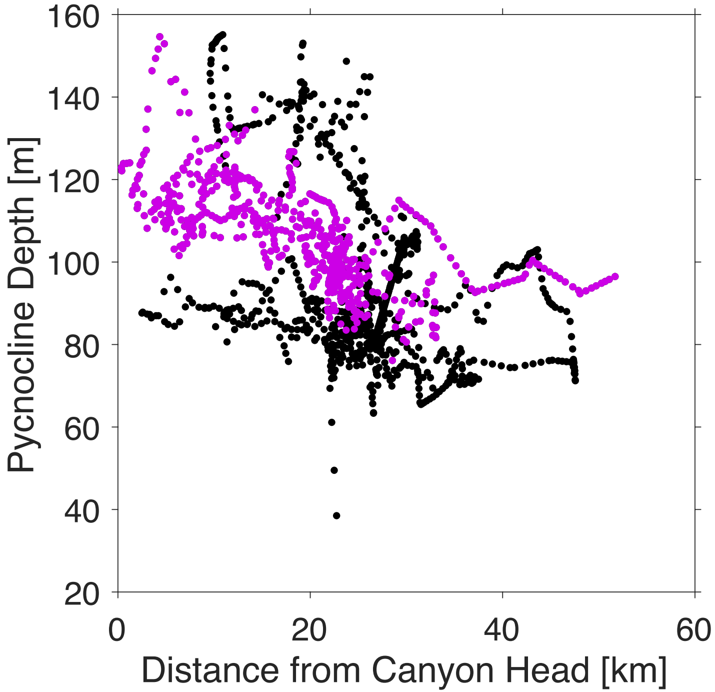
- Are canyon dynamics the only process influencing the pycnocline depth?

# Suggestions That Canyons are Important

## Pycnocline tends to be deeper near canyon head



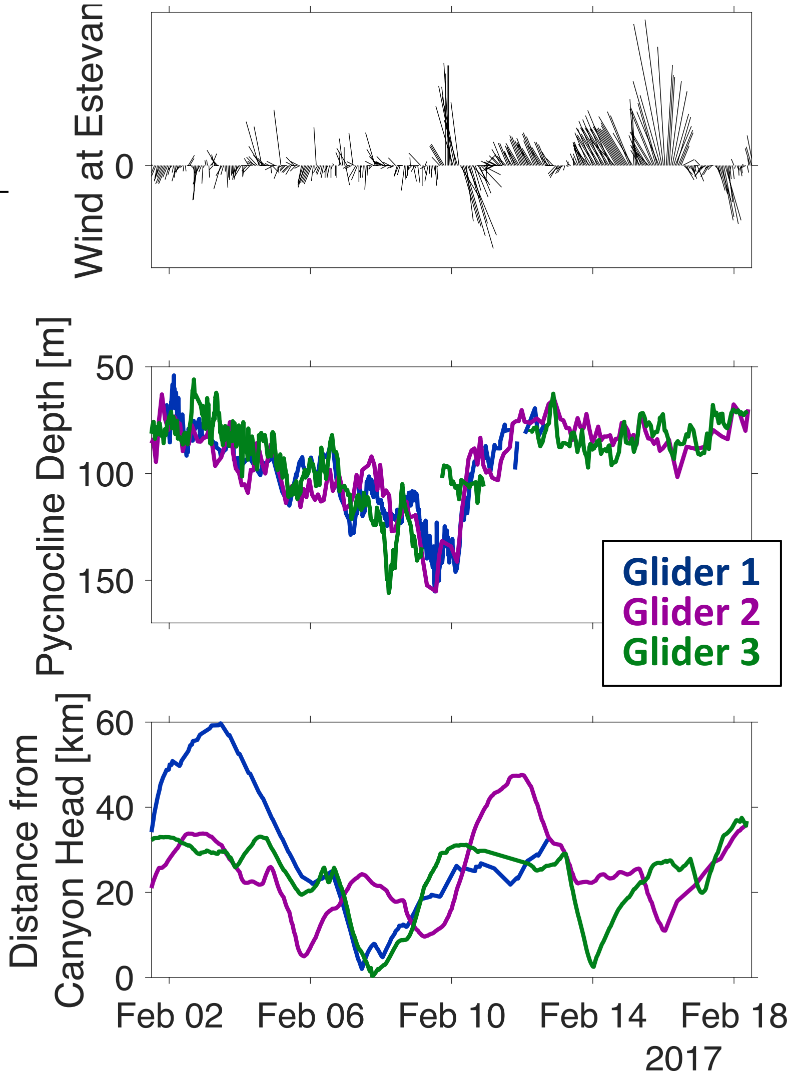



# Canyons Dynamics May Not be the Only Important Process

It appears that there is a strong temporal signal in the pycnocline depth

- Steady deepening despite multiple transects of shelf break

- Sometimes transient storms appear to be important



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Given the slow moving nature of gliders, it can be difficult to separate spatial and temporal features within the data

- Are canyon dynamics the only process influencing the pycnocline depth?
- Are other temporal processes also at play?

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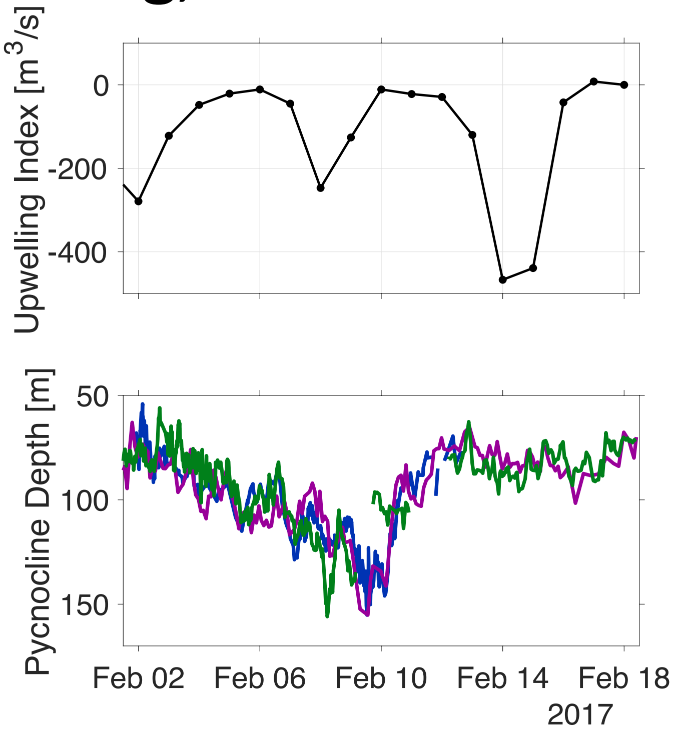

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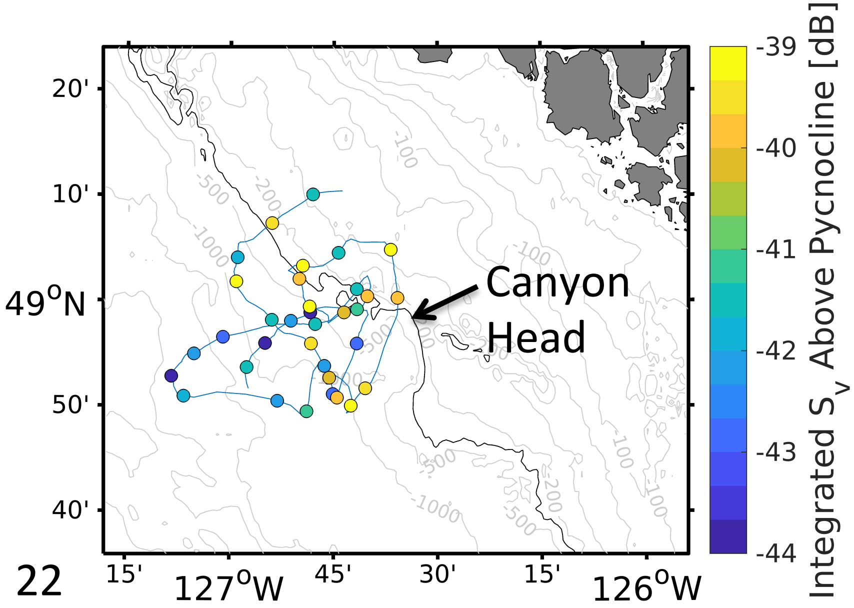
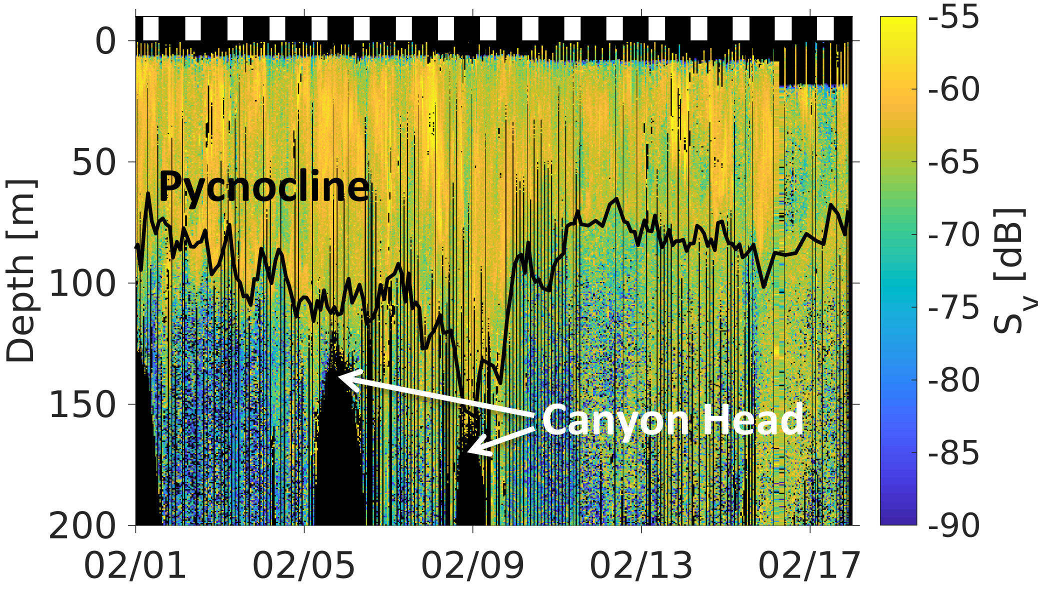
1. Temporal variability in wind-driven coastal downwelling
2. Transient storm dynamics
3. Eddy feature
4. Coastal trapped wave

# Implications for Zooplankton Distribution

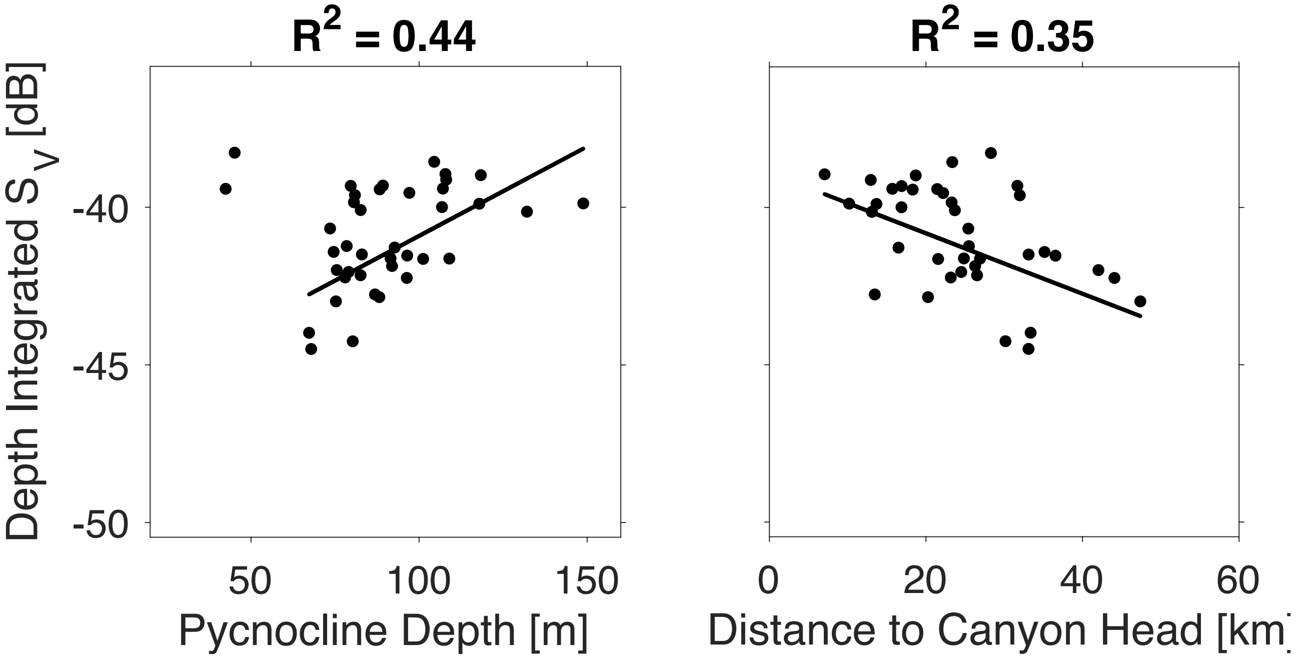
## Is zooplankton backscatter also correlated with pycnocline depth and proximity to the canyon?



# Zooplankton Distribution: Above Pycnocline

Integrated zooplankton Sv larger at **deeper** pycnocline depths and **closer** to the canyon head



# Summary

Understanding zooplankton distributions requires accounting for mechanisms that give rise to spatial and temporal variability

It can be difficult to untangle spatial and temporal information and processes from glider data, but we see evidence that both are occurring

- Spatial Canyon Dynamics: deeper pycnocline found near canyon head
- Temporal Dynamics: steady deepening of pycnocline over time, storms disrupt pycnocline depth features

# Acknowledgements


Glider deployments possible with help from:

- Ocean Tracking Network
- Ocean Networks Canada
- UBC glider team
- UVic Whale Lab

Funding from MEOPAR WHaLE Project