

Synergy between fishery expansion and oceanographic variability drives changes in central North Pacific fisheries catch



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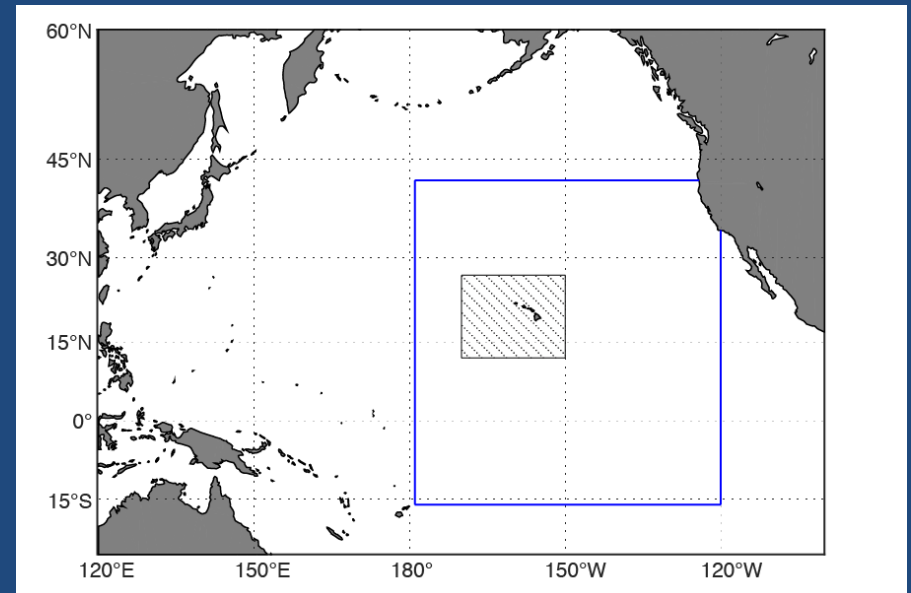
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Hawaii-based Longline Fishery - 2015

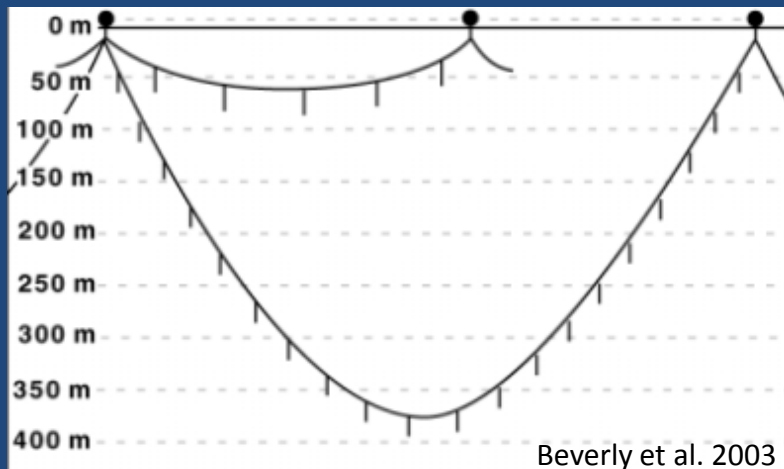
- Total Landings:
 - \$97 million (6th in US)
 - 32 million pounds (27th in US)
- 142 vessels
- 49 million hooks
- 13 million km²
- 229,221 bigeye
- 20,381 swordfish



Deep-Set Bigeye Fishery

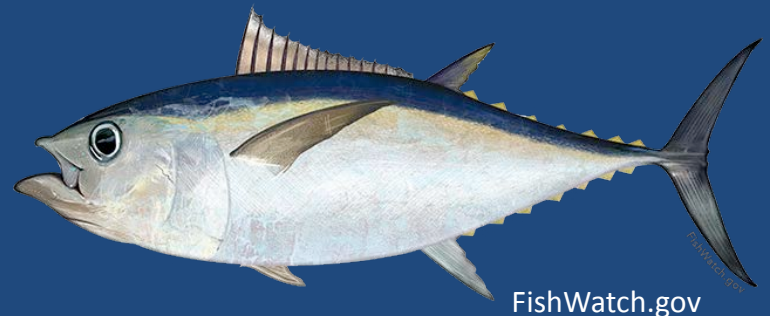
Deep Sets

- ≥ 10 hooks per float
- Daytime
- Hooks set between 100 – 400 m below surface
- Median hook depth: 250 m



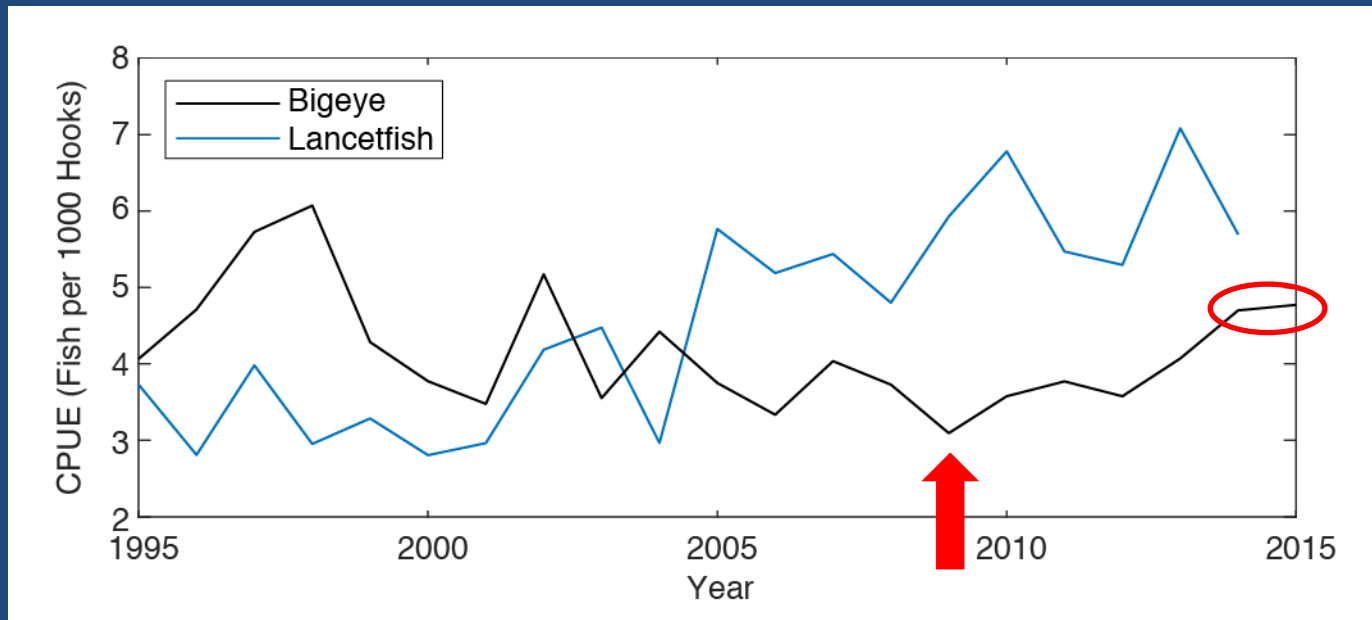
Bigeye Tuna

- Forage at depth during the day
- Depth range of 200 – 400 m
- Dive to temperatures between 8 – 14 °C
- Oxygen threshold for performance: $\sim 1 \text{ mL L}^{-1}$



Objective

- How has oceanographic variability – both spatial and temporal – impacted Hawaii’s longline fishery?

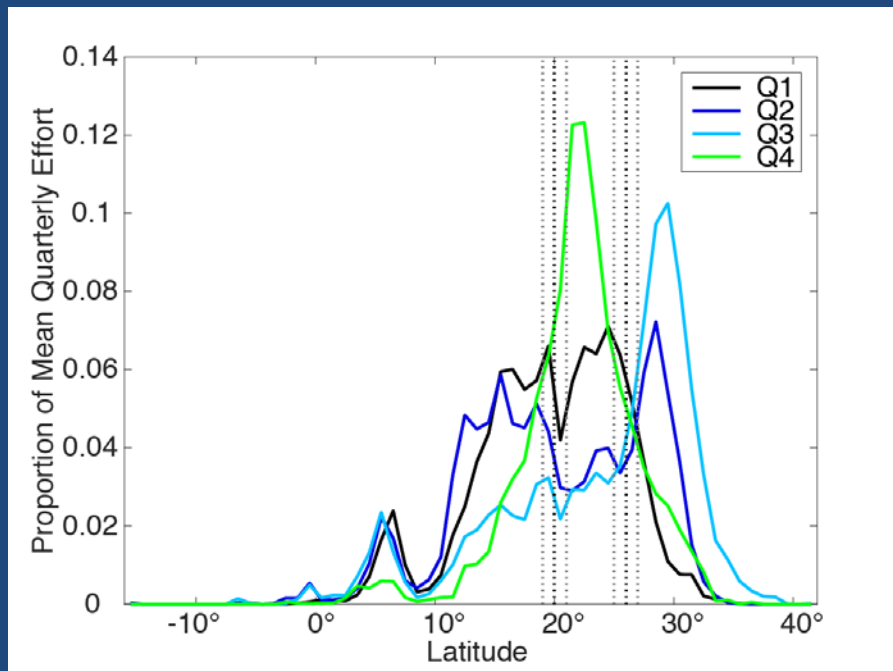


Data Used

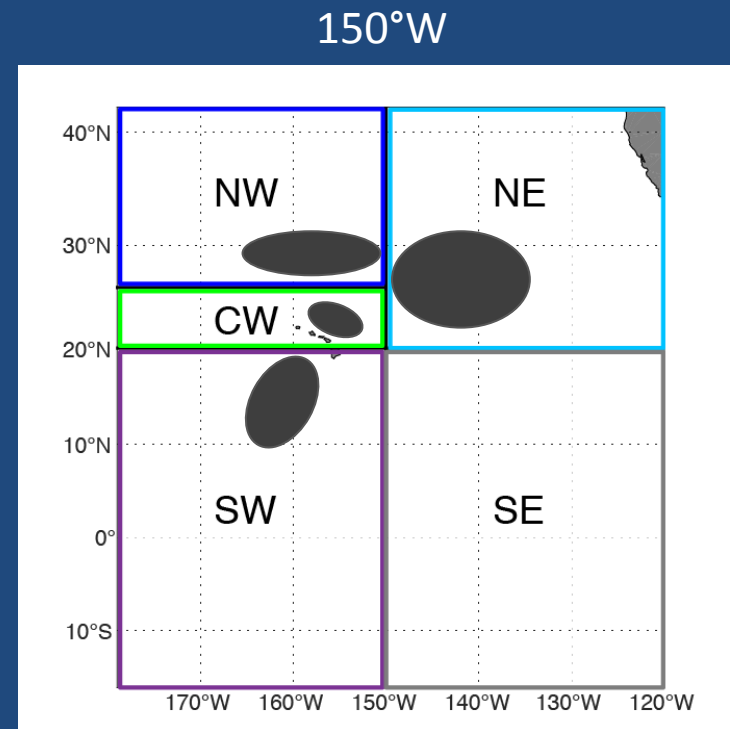
- Hawaii-based longline data
 - Logbook data: all effort & commercial catch
 - Observer data: effort & full catch, 20% fishery coverage
- International longline effort data
 - Western and Central Pacific Fisheries Commission (WCPFC) & Inter-American Tropical Tuna Commission (IATTC) publically available data
- Oceanographic data
 - Global Ocean Data Assimilation System (GODAS) reanalysis: four-dimensional temperature
 - World Ocean Atlas 2013 (WOA13): three-dimensional oxygen
- 1995 – 2015
- Gridded to $1^{\circ} \times 1^{\circ}$ horizontal resolution

Methodology

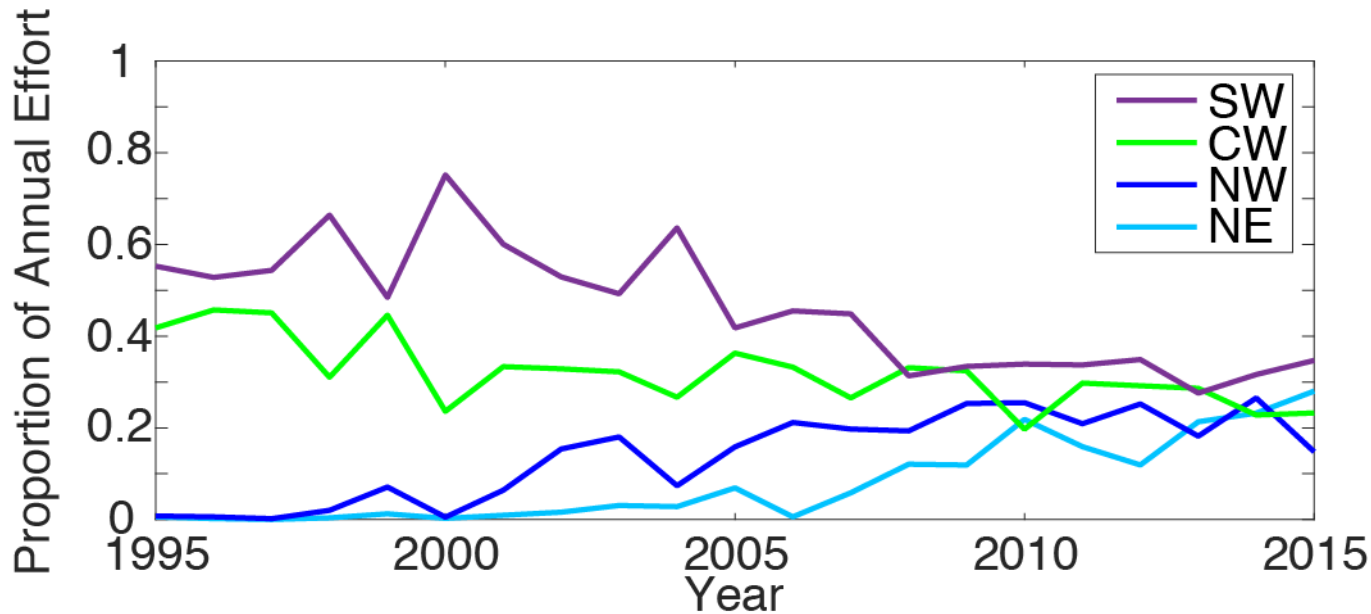
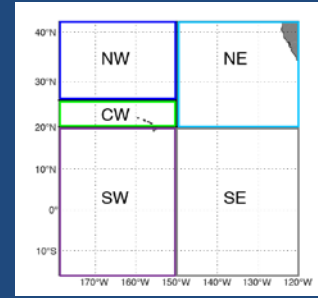
- Quarterly temporal resolution
- Regional spatial resolution



26°N
20°N



Shift in Fishing Distribution



SW: -23%
CW: -20%
NW: +16%
NE: +26%

Drivers of Fishery Expansion

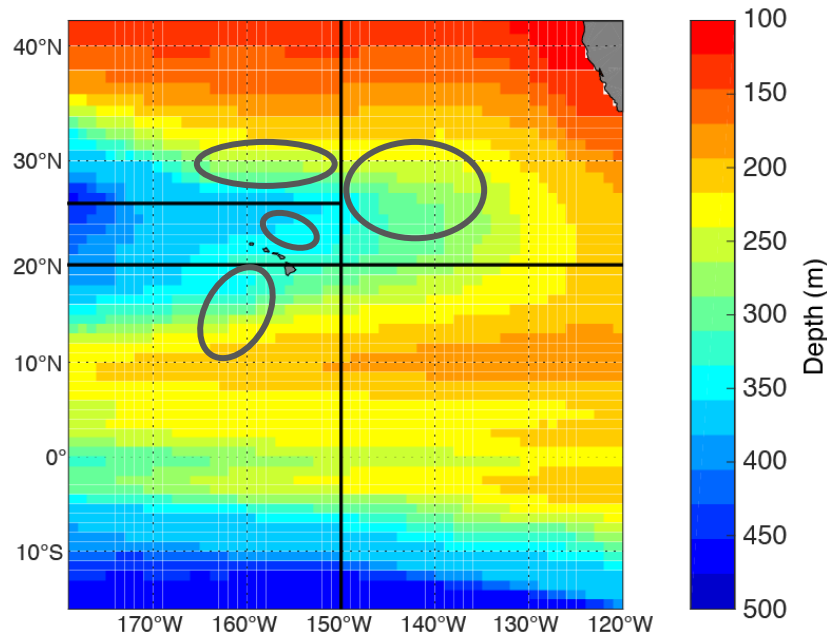
- High target catch, relatively low discard rates, and little international competition

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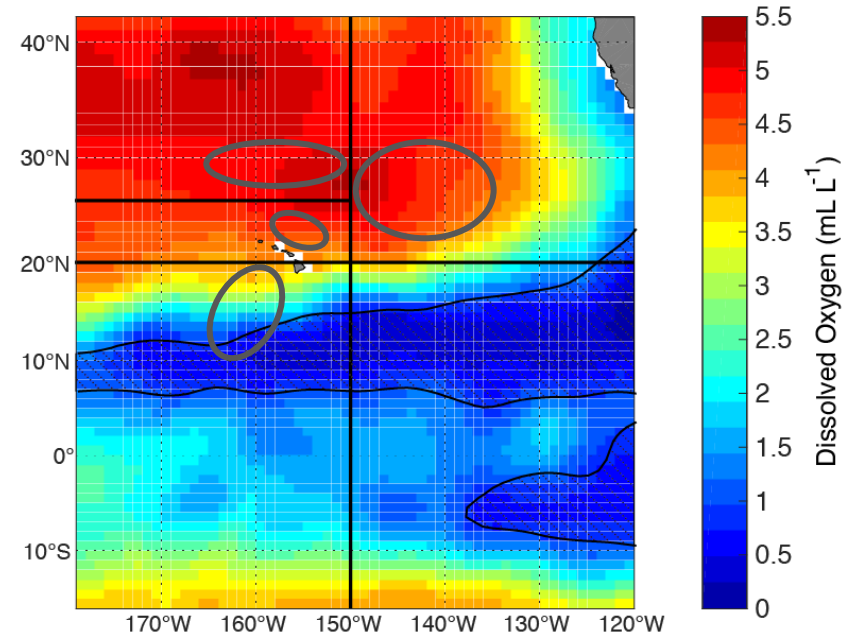
- **Synergy with oceanographic variability**

Oceanographic Variability - Spatial

Average depth of preferred bigeye thermal habitat, 8 – 14 °C



Average 300 m oxygen concentration

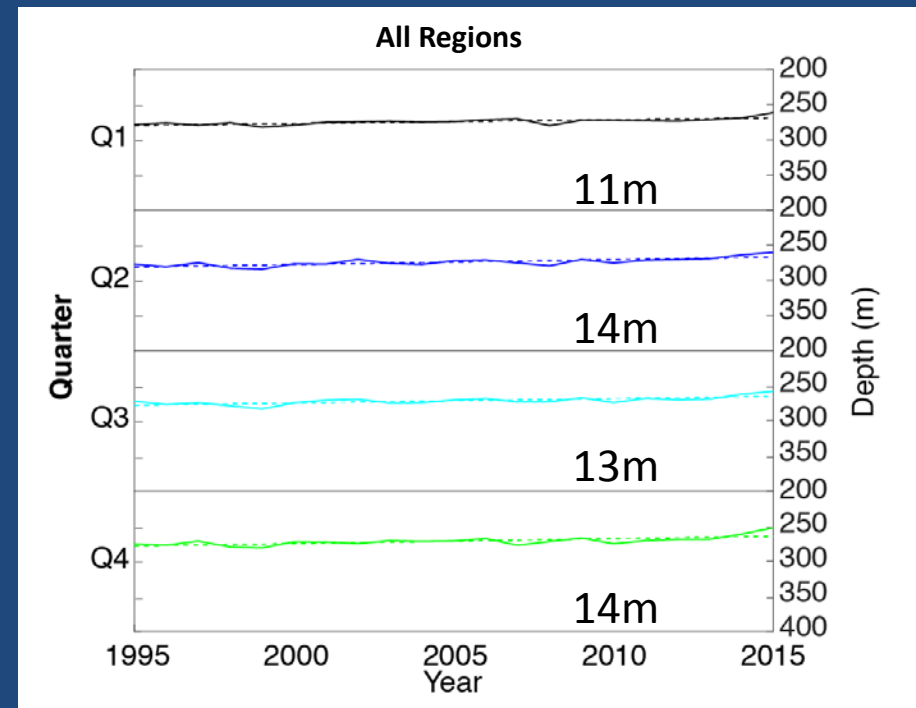
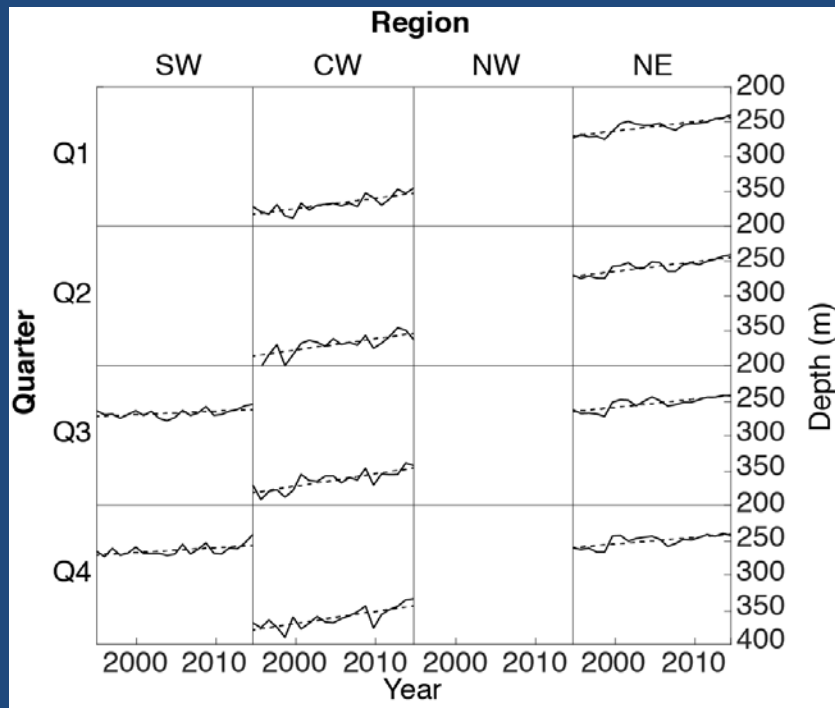


Deep-set hook depth: 100 – 400 m with median depth of 250 m

Oceanographic Variability - Temporal

- Average depth of preferred bigeye thermal habitat, 8 – 14 °C, across all grid cells fished

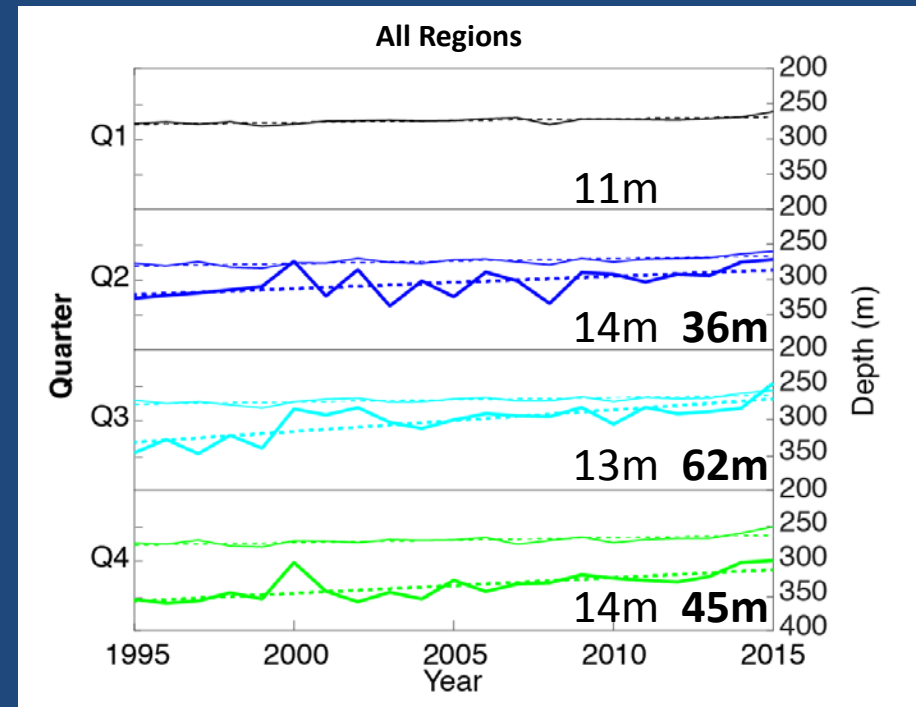
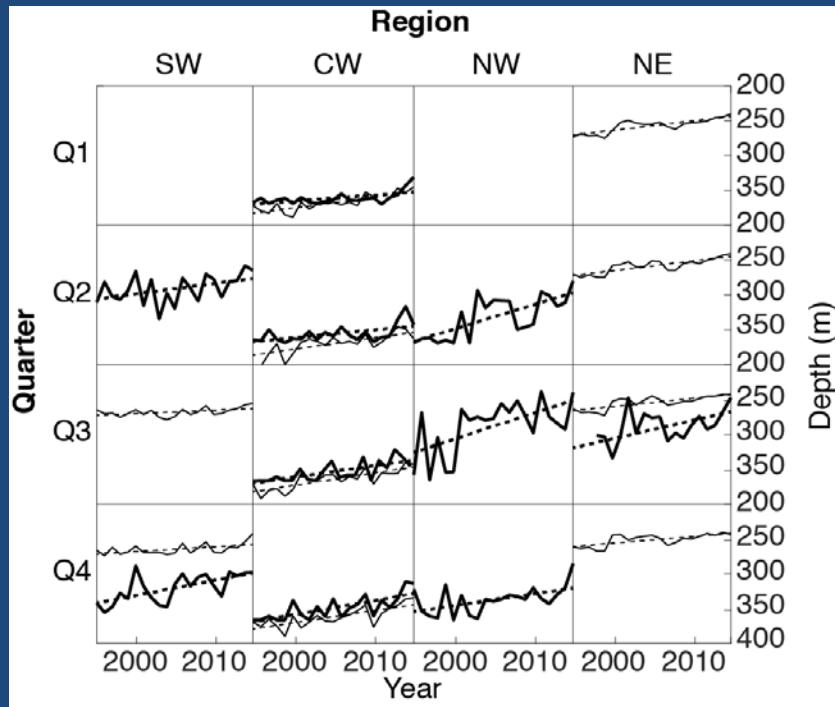
----- Significant linear fit ($p < 0.05$)



Oceanographic Variability - Temporal

- Effort-weighted average depth of preferred bigeye thermal habitat, 8 – 14 °C

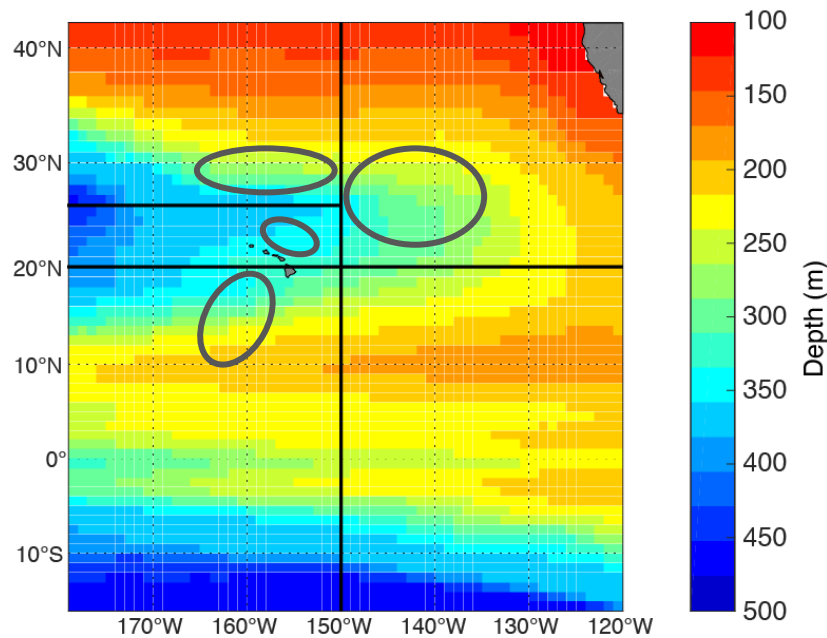
----- Significant linear fit ($p < 0.05$)



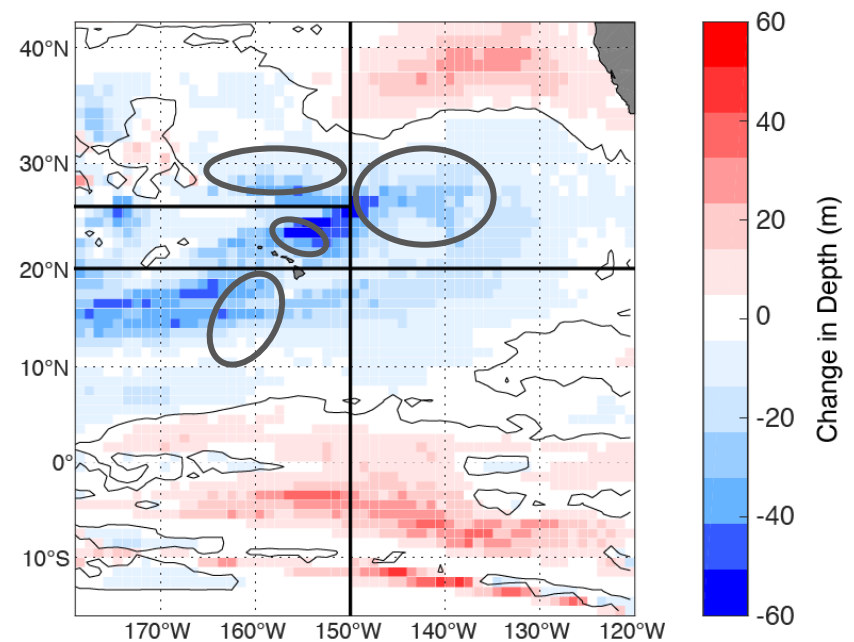
Oceanographic Variability - Spatiotemporal

Depth of preferred bigeye thermal habitat, 8 – 14 °C

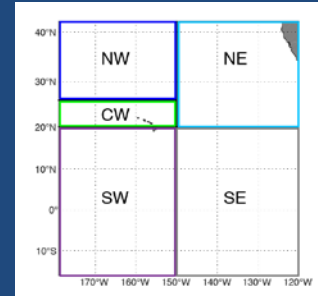
Time Series Mean



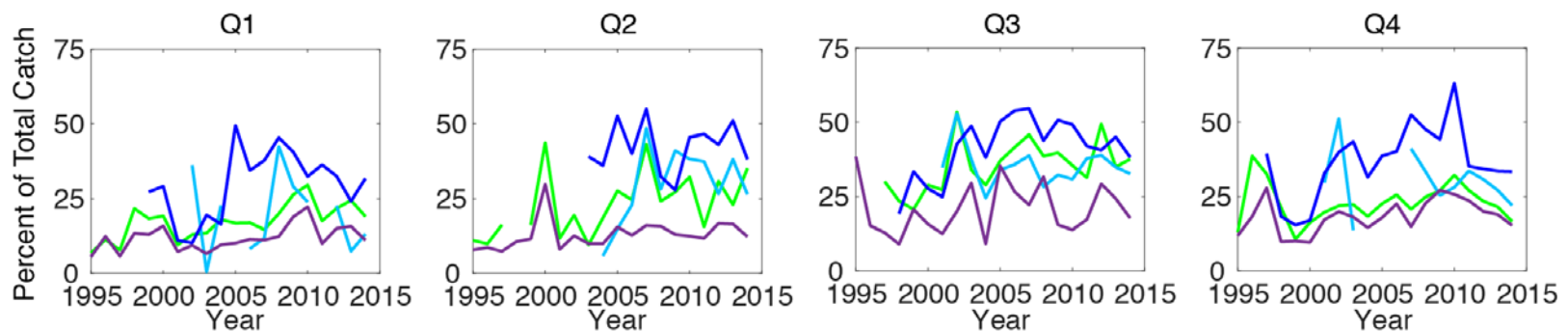
2014 – 2015 Anomaly



Lancetfish



- Catch rates increased in response to fishery expansion: NW region
- Very little know about this species, but work is underway
 - Influence of local oceanography? Transition zone?
 - Seasonal behavior?



Conclusions

- Regional oceanography a driving factor in fishery movement
- Fishery movement has shaped catch magnitude and composition
- Interannual oceanographic variability has also influenced catch
- Such oceanographic and spatiotemporal context can aid in ensuring ecological and financial sustainability