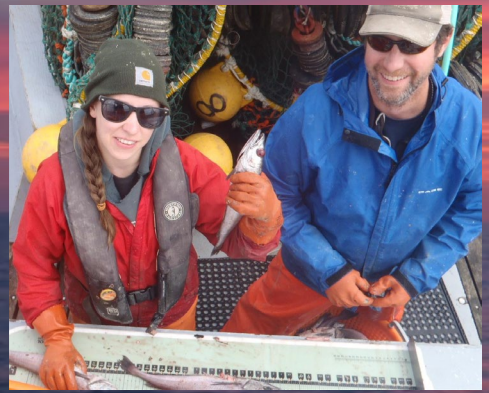
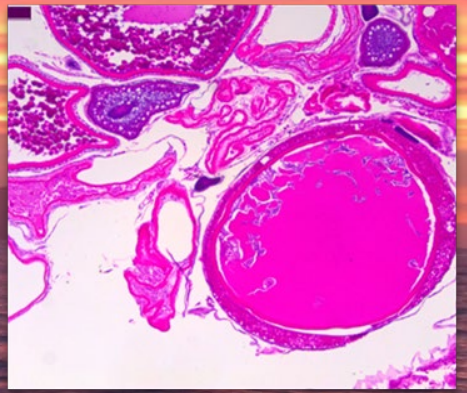
Decadal-scale reproductive variability in Pacific Hake and why it's important to capture for sustainable management





Melissa A. Head NOAA/NWFSC
Collaborators: Alicia Billings, Vanessa Tuttle, Aaron Berger, Kelli Johnson, Scott Heppell

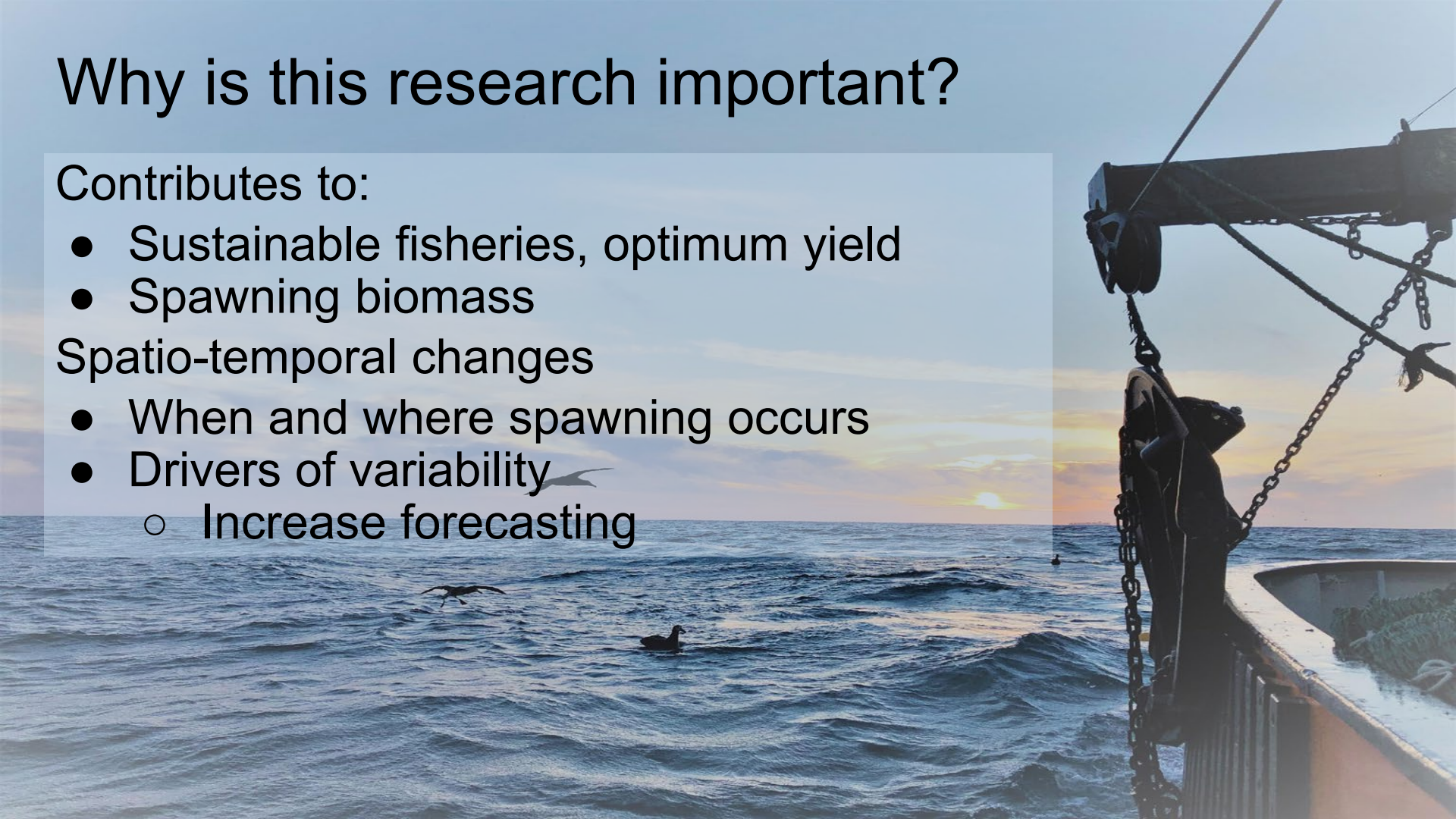
Why is this research important?

Contributes to:

- Sustainable fisheries, optimum yield
- Spawning biomass

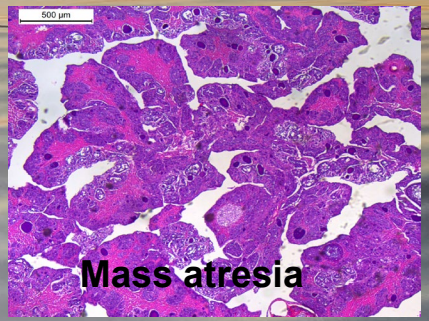
Spatio-temporal changes

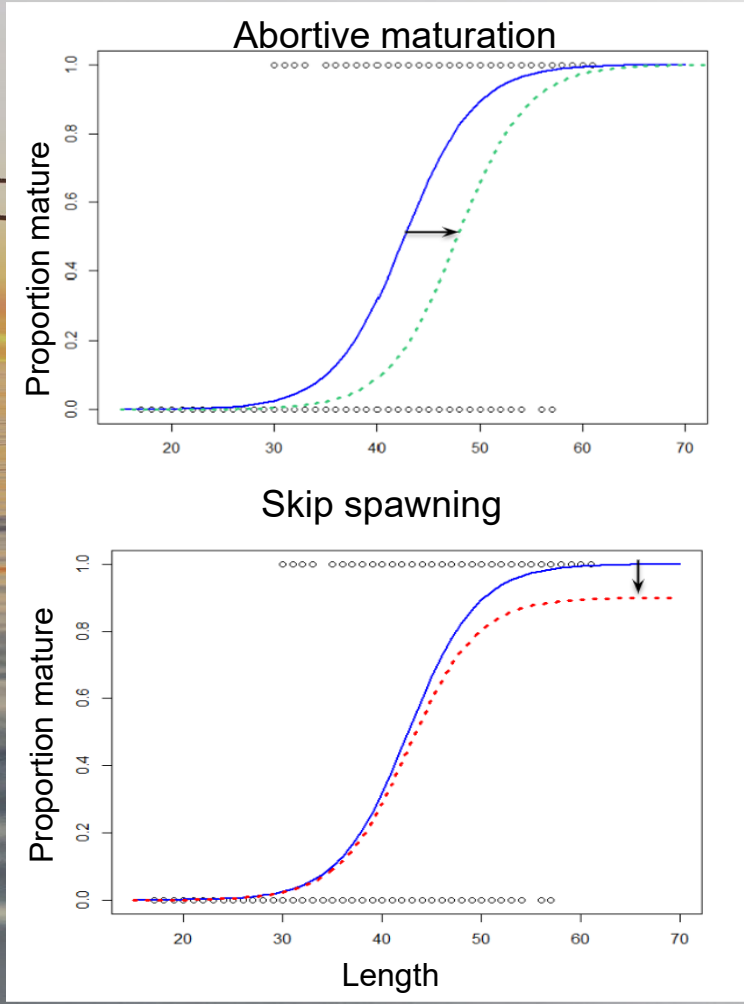
- When and where spawning occurs
- Drivers of variability
  - Increase forecasting



Goals

- Accurate histological estimates
  - Biological and Functional maturity

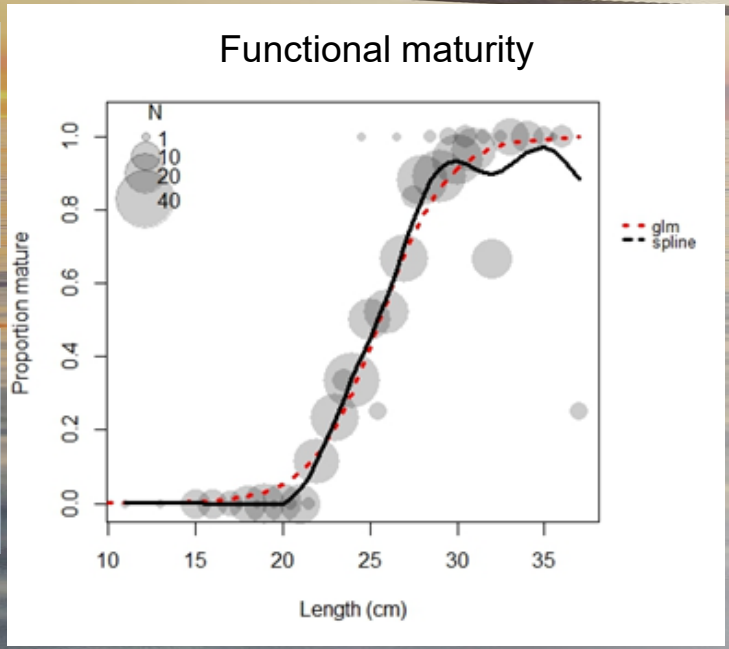




Goals

- Accurate histological estimates
  - Biological and Functional maturity
  - GLM and cubic spline models

- Spatio-temporal variability
  - Spawning and maturity
- Define reproductive strategy



Head et al. 2020

Life-History background

- Most abundant groundfish
- Fast growing, short lived (~20 yrs)
- Three genetically distinct stocks
- Historical estimates: ~38 cm, 3–4 yrs
- Multiple modes of egg development
- Spawn January to March off S. CA
- Latitudinal variability in spawning

References: Best 1963; Macgregor 1966,1971; Ermakov 1982; Bailey et al. 1982; Hollowed 1992, Dorn and Saunders 1997; Iwamoto et al. 2004; Edwards et al. 2022; Longo et al. in review

Environmental variability

Mean SST from 1982 - 2009

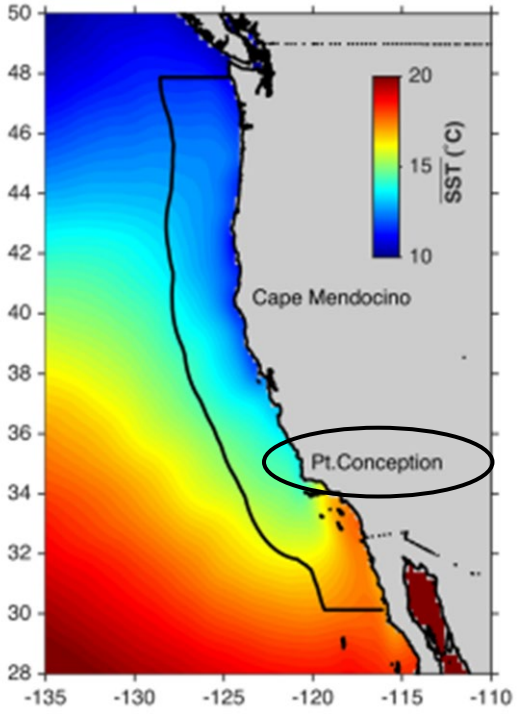
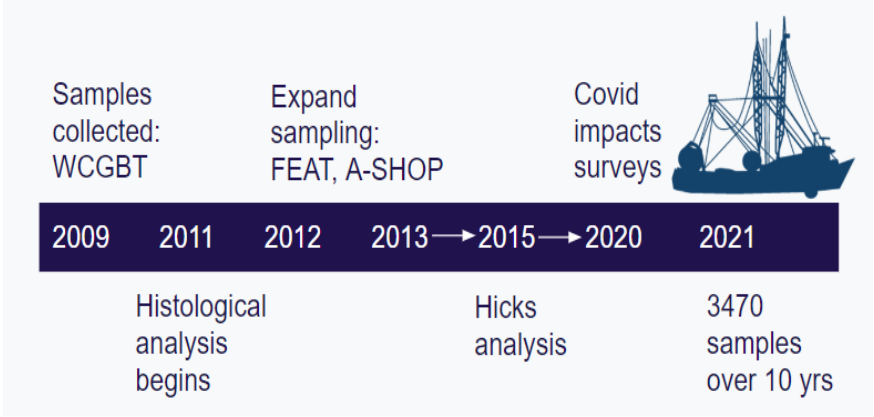


Figure credit: Jacox et al. 2017

Annual / Seasonal

- Summer upwelling, winter downwelling
- Weaker productivity in the South
- Increase in temperature with decreasing latitude
- El Nino and La Nina
- Warm Blob

Research background



- Dr. Hicks uncovered spatial patterns
- Size at maturity smaller South of Pt. Conception
- Further investigate variability

2015 Pacific hake maturity analysis

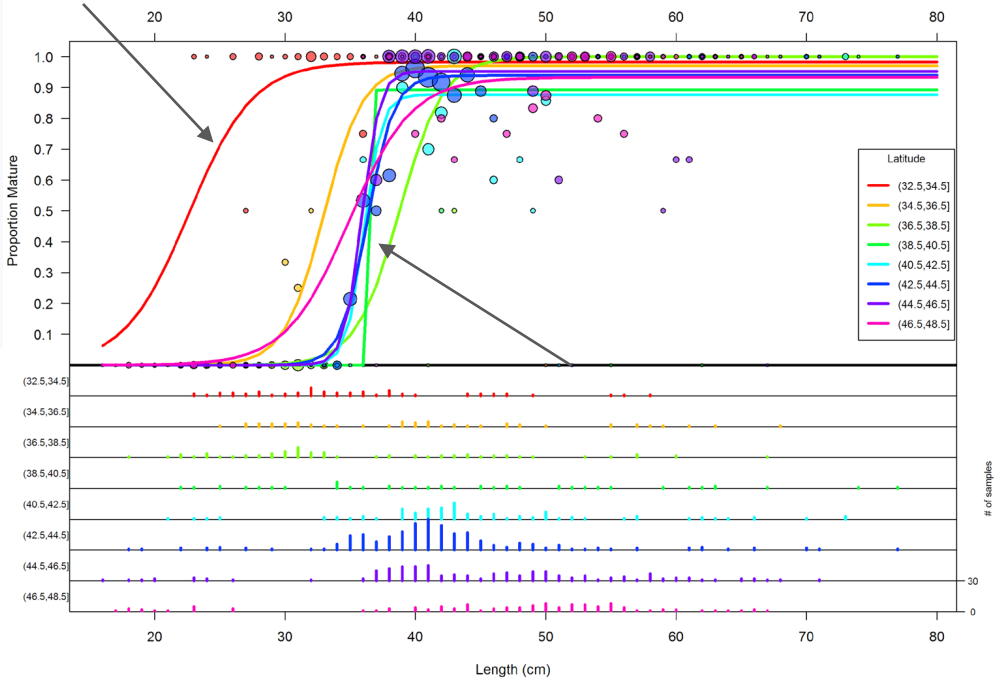
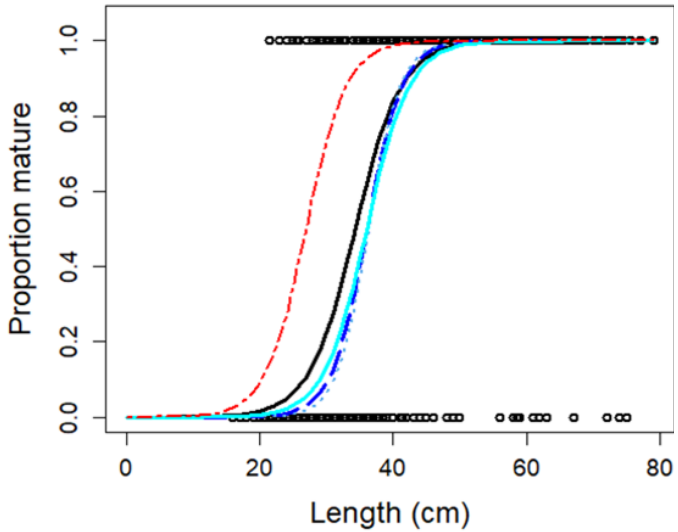


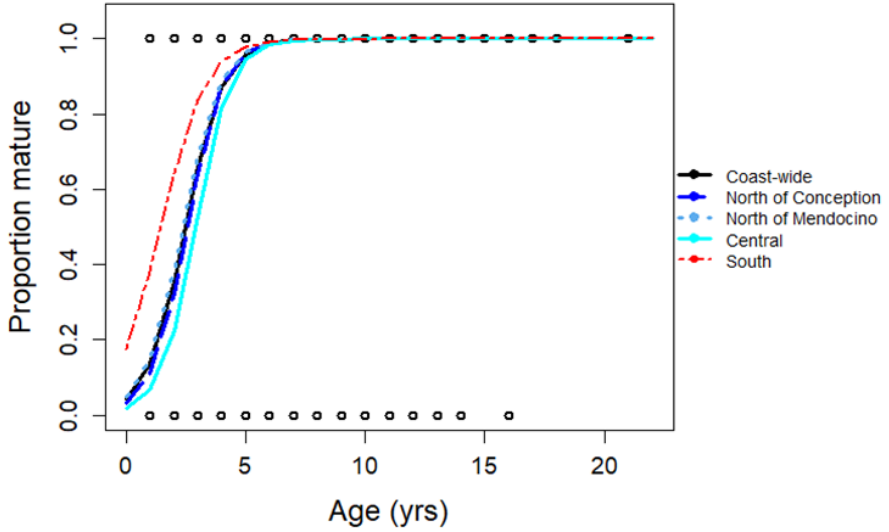
Figure credit: Dr. Allan Hicks

Spatial variability - Confirm earlier analysis

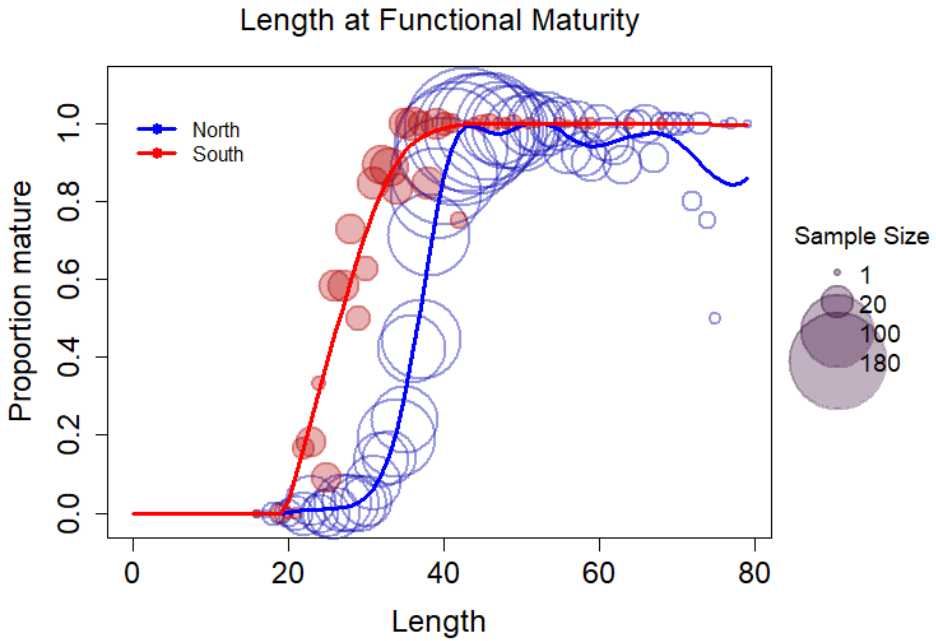
Length at functional maturity

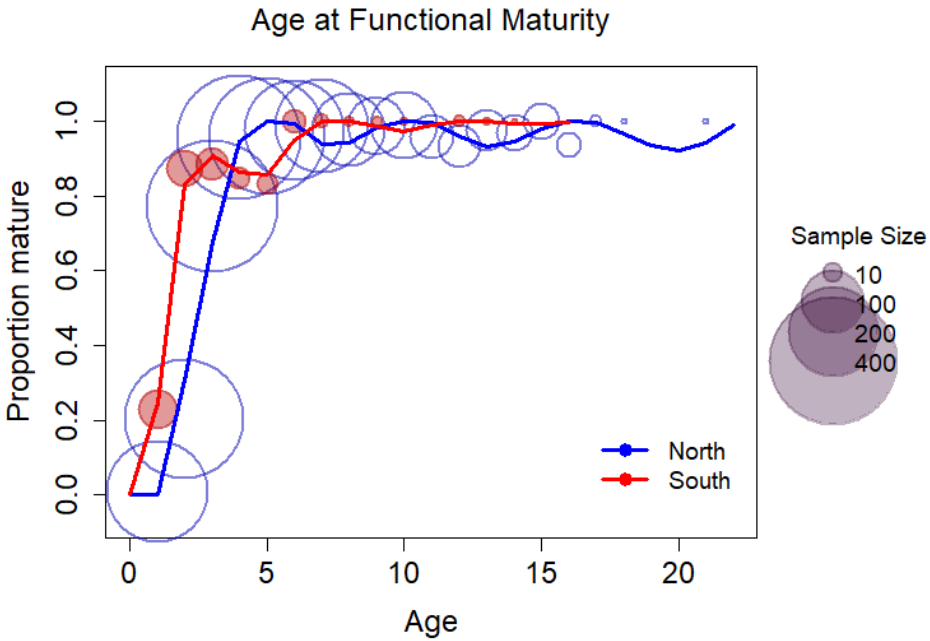


Age at functional maturity



Spatial variability

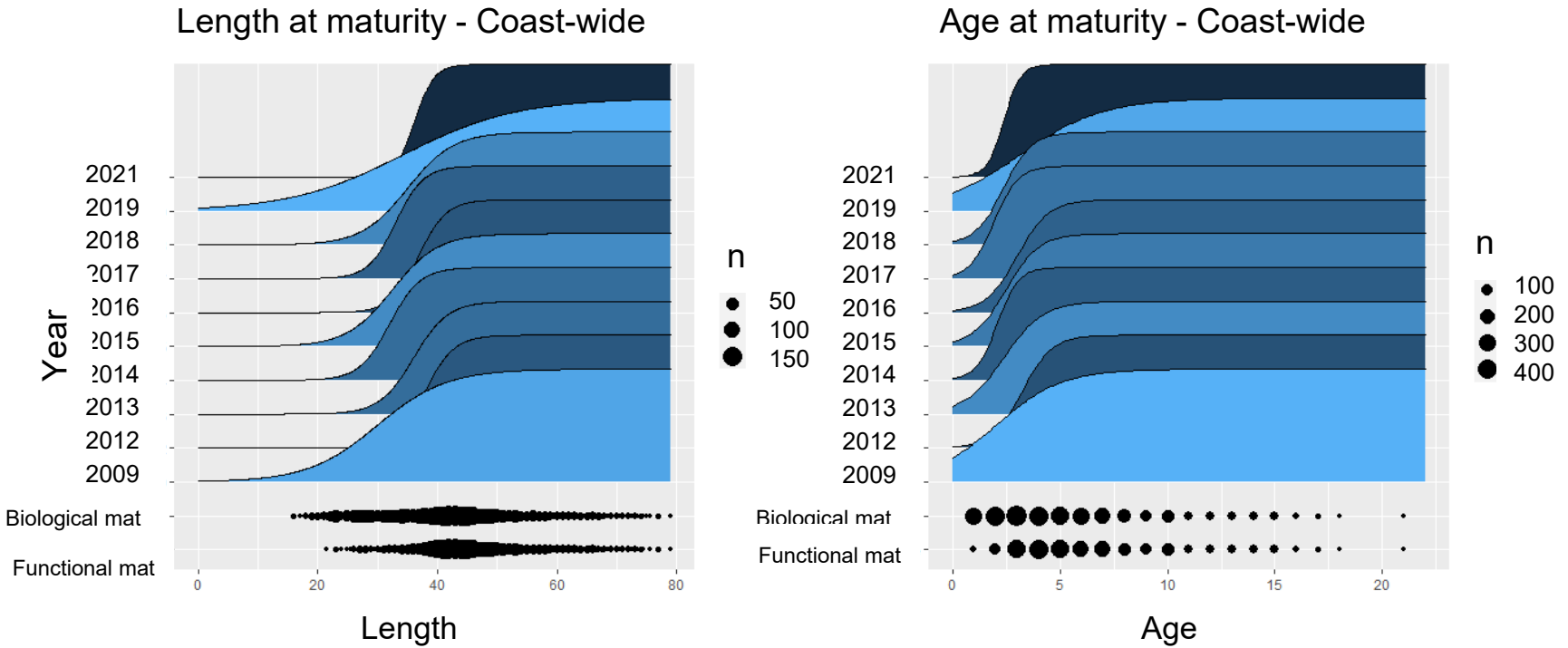




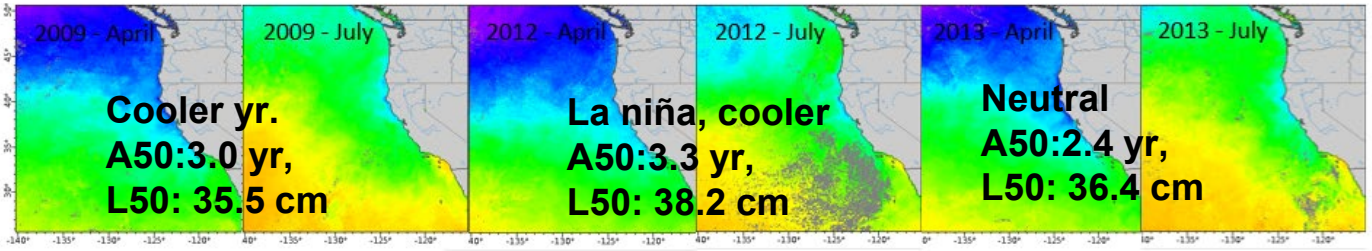
North	South
36.09 (±0.10)	27.00(±0.79)

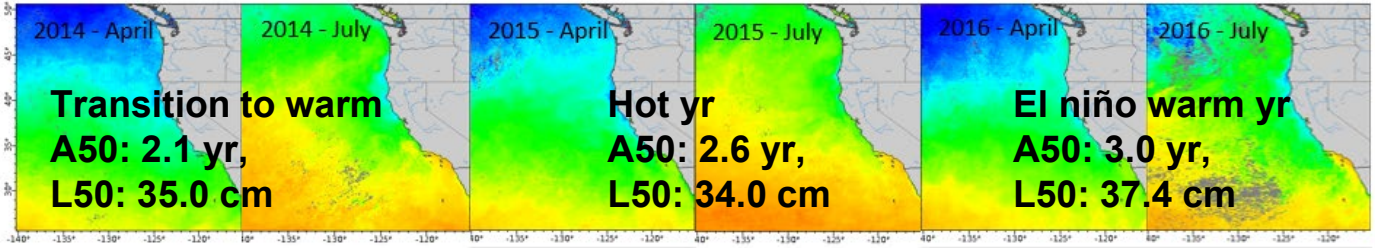
North	South
2.56 (±0.01)	1.45 (±0.09)

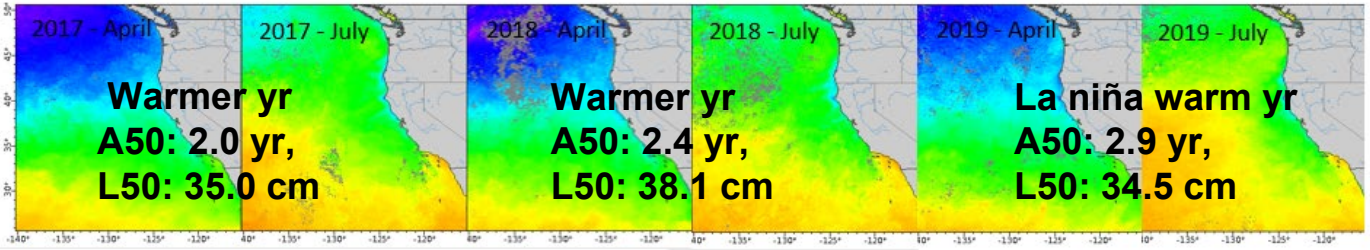
Interannual variability



Range of L50 results - North	L_{50} range coast-wide	Range of A50 results - North	A_{50} range coast-wide
34.0 - 38.2 cm	29.9 - 37.9	2.0 - 3.3 yrs	2.0 - 3.3





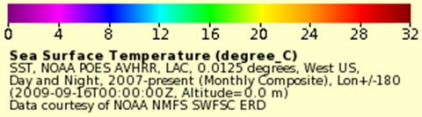


Highest A50:
2009, 2012

Lowest A50:
2014, 2017

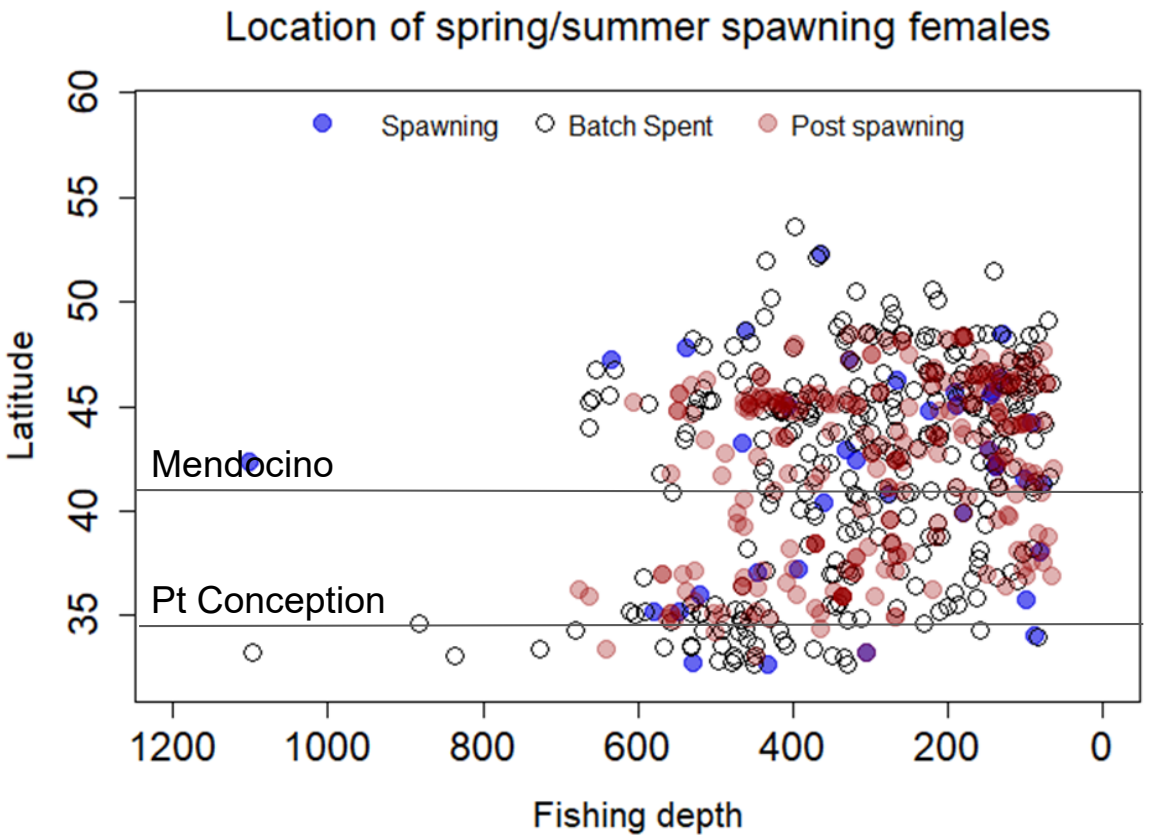
Highest L50:
2012, 2018

Lowest L50:
2015, 2019

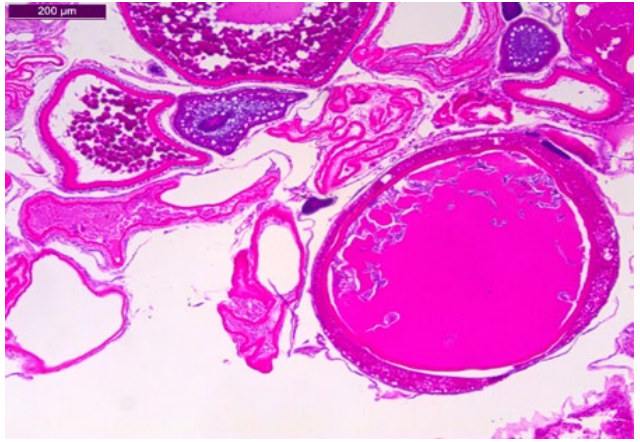


Data courtesy of NOAA's Coastwatch ERDDAP program

Trends in spawning



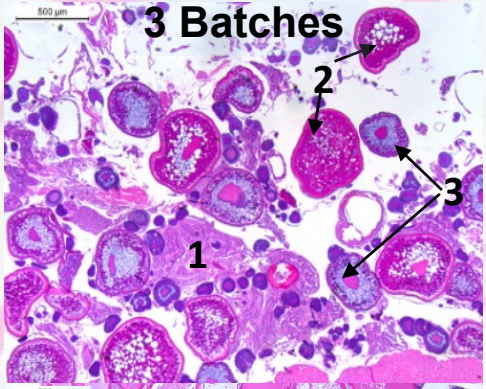
Spawning in August off WA

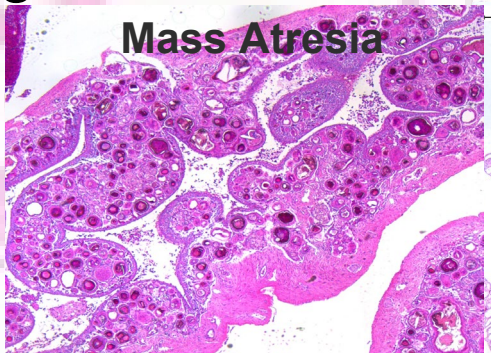


Histological image of spawning

What in the hake is going on here?

- Dynamic strategy
- Indeterminate batch spawners
  - Multi-modal development
  - Multiple batches
    - Spatio-temporal variability
    - Increase with age
  - Senescence, skip spawning
- Protracted spawning season
- Spawn along entire coast





Summary

- Accurate histological estimates
  - 36 (N) - 27 (S) cm
  - 2.5 (N) - 1.4 (S) yrs
  - Historical estimates: 38 cm, 3–4 yrs
- Interannual variability in maturity
  - Environmental relationship
  - Increase forecasting
- Defining spawning season challenging
  - Along entire coast, throughout year, variable

Acknowledgements

NWFSC stock assessment team current and former, special thanks to Dr. Jason Cope and Dr. Jim Hastie

FEAT and A-SHOP teams, special thanks to Alicia Billings, Vanessa Tuttle, and fisheries observers.

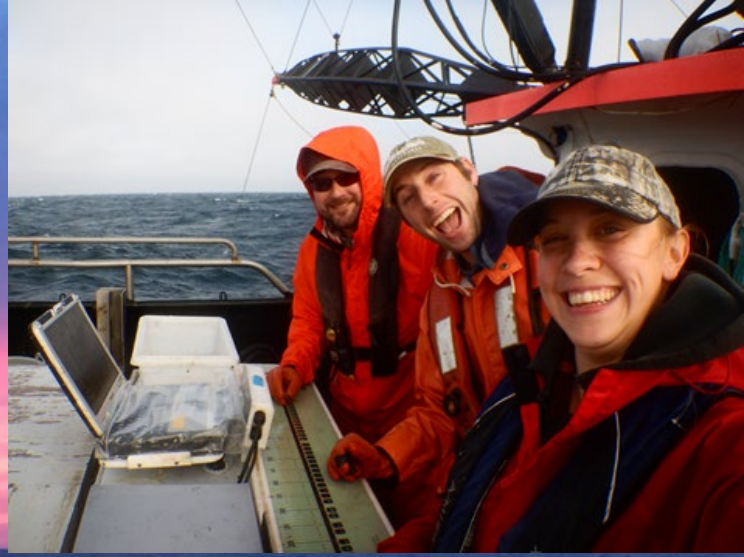
WCGBT survey scientists, captains, and crew. Special thanks to my supervisor Dr. Aimee Keller

Dr. Scott Heppell, Dr. Will White, and Dr. Scarlett Arbuckle

Any Questions?

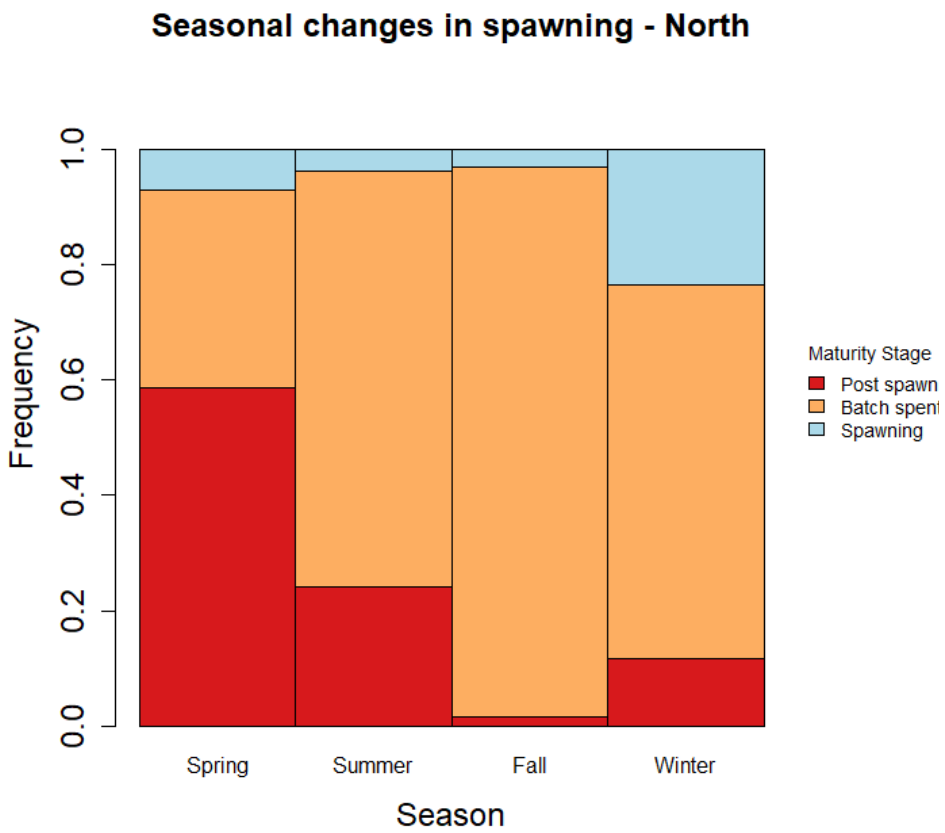
Contact:

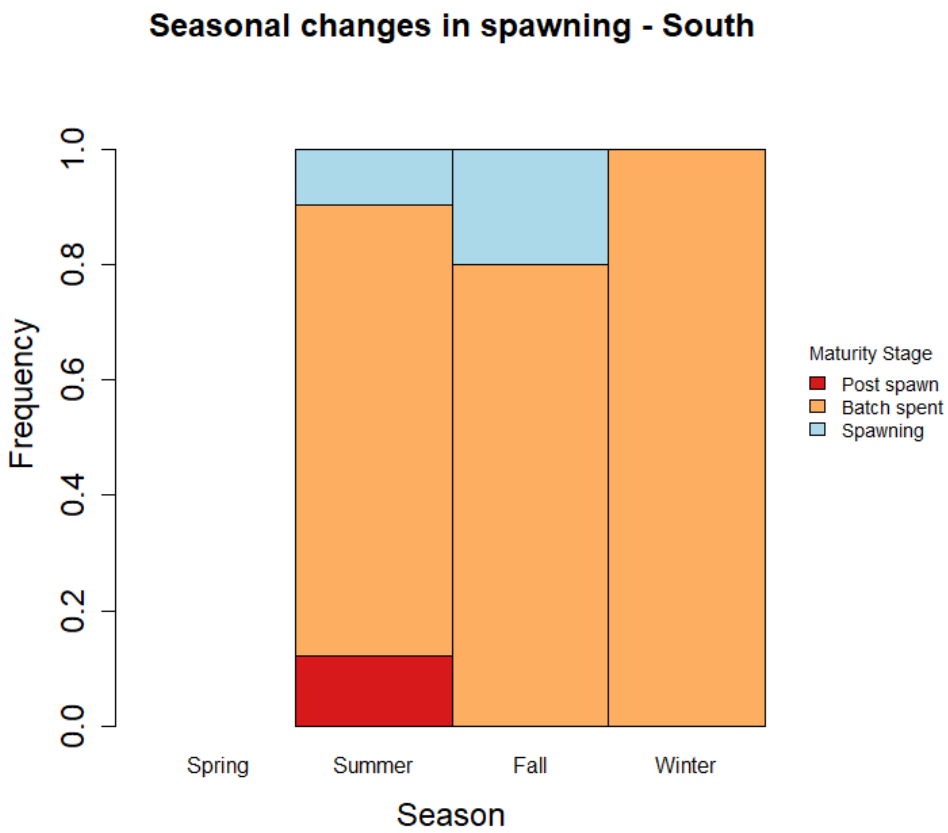
melissa.head@noaa.gov



BONUS SLIDES – for questions

Trends in spawning





Physiological indicators of reproductive status to inform Pacific hake stock assessment

Can measurements of lipids and/or gene expression tell us which females will fail to mature?

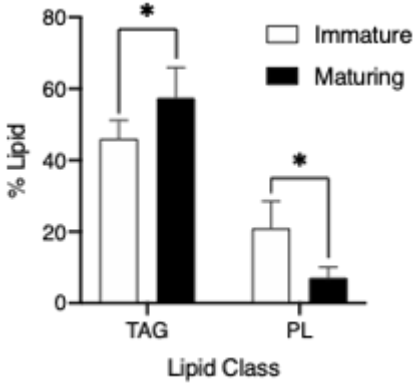
●Liver lipid-class analyses for hake sampled in 2017 indicated that two types of lipid (triacylglycerols (TAG) and phospholipids (PL)) were inversely related and predictive of immature vs. maturing female Pacific hake (see graph to the right).

●Levels of these lipids were also uniquely and significantly shifted when aborted ovarian follicles were observed, suggesting they could be used as indices for skip spawning in hake.

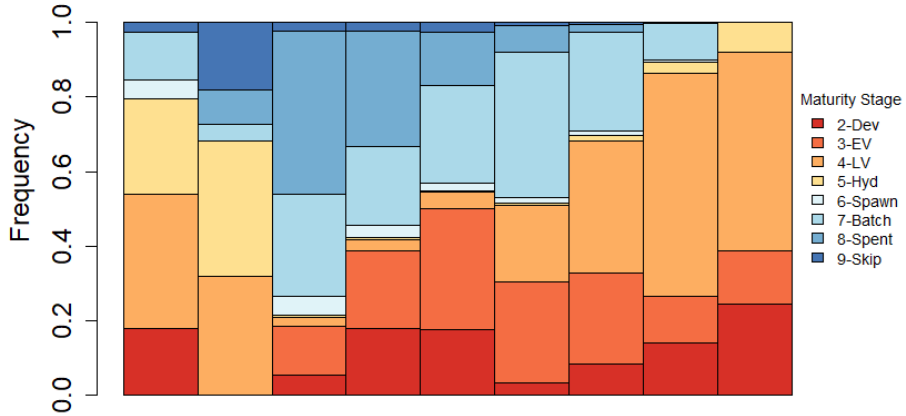
●Gene expression assays were developed for 4 hake ribosomal RNAs that should reveal shifts in basal RNA production.

●Similar to the liver lipids, ratios of these ribosomal RNAs in hake gonads were significantly different among immature and maturing females.

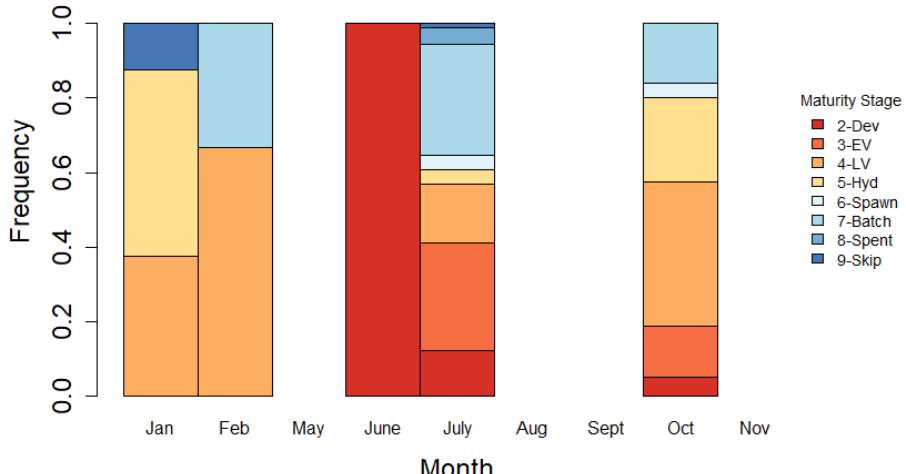
●Our initial results indicate that lipid and/or gene expression analyses hold promise as indicators of reproductive status to supplement gonadal histology and improve hake stock assessments.



Pacific Hake reproductive cycle - North



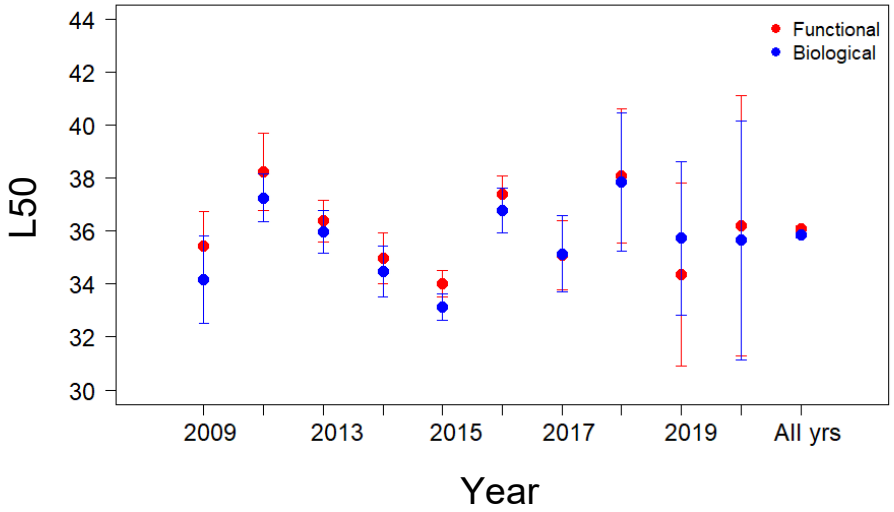
Pacific Hake reproductive cycle - South



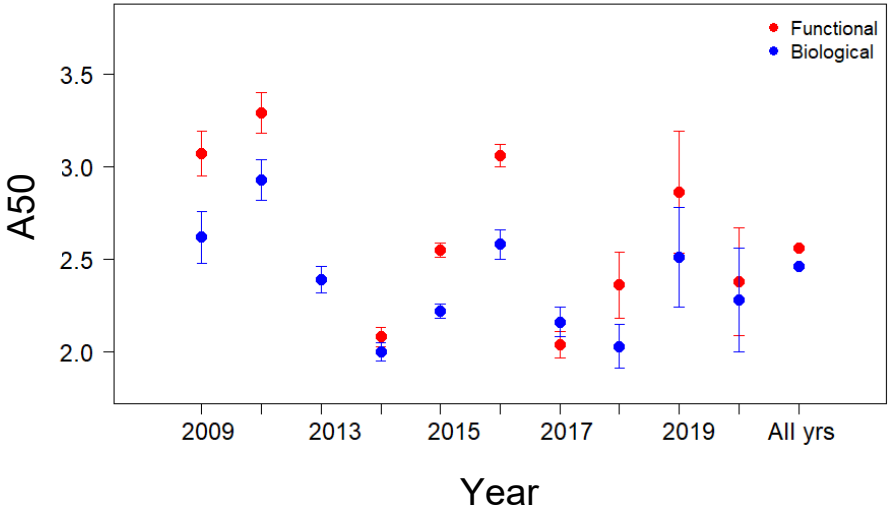
Maturity by year

Mean size range	Mean age range
40 - 43.6	4.4 - 5.3

Length at 50% maturity - North



Age at 50% maturity - North



Range of L50 results - North	Range of A50 results - North
34.0 - 38.2 cm	2.0 - 3.3 yrs

Next steps

- Incorporate spatial-time varying rates of maturity
- Increase annual sampling to track trends and identify drivers of variability
- Secure additional funding to:
  - Compare U.S. West Coast to Canada
  - Batch fecundity research, how does it vary annually, spatially, and by age