Assessing maturity, skipped spawning, and abortive maturation for fisheries managers: a case study of *Sebastes pinniger*

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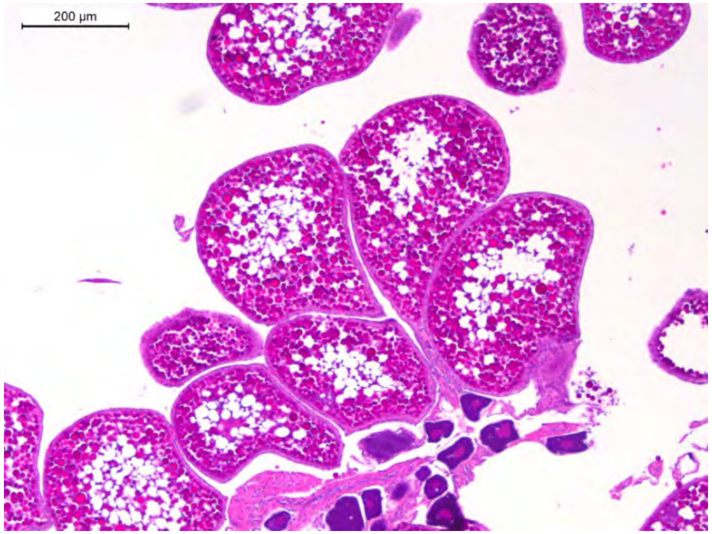
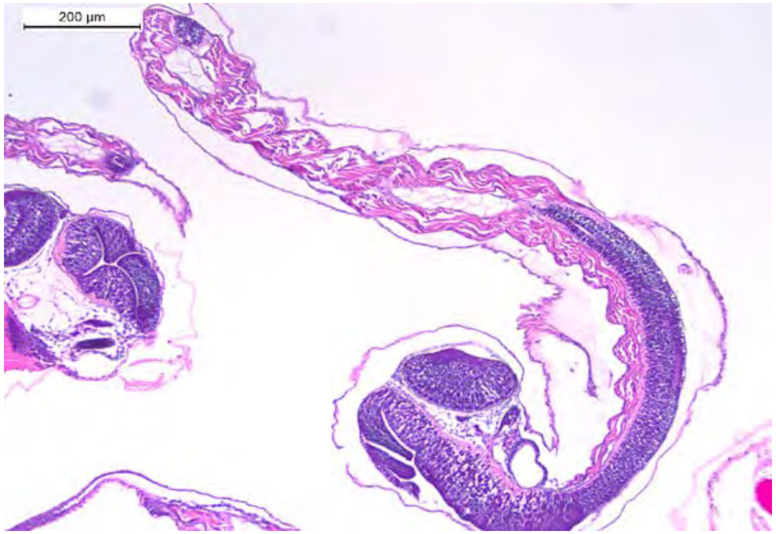
NWFSC reproductive biology program

- Initiated in 2009 to address need for updated life history information in stock assessments
    - Species-specific maturity and fecundity data needed to accurately estimate spawning biomass and recruitment
- Life history parameters may shift in response to fishing pressure or oceanographic conditions
- 11,000 ovaries, 36 species, 6 sampling platforms,7 stock assessment

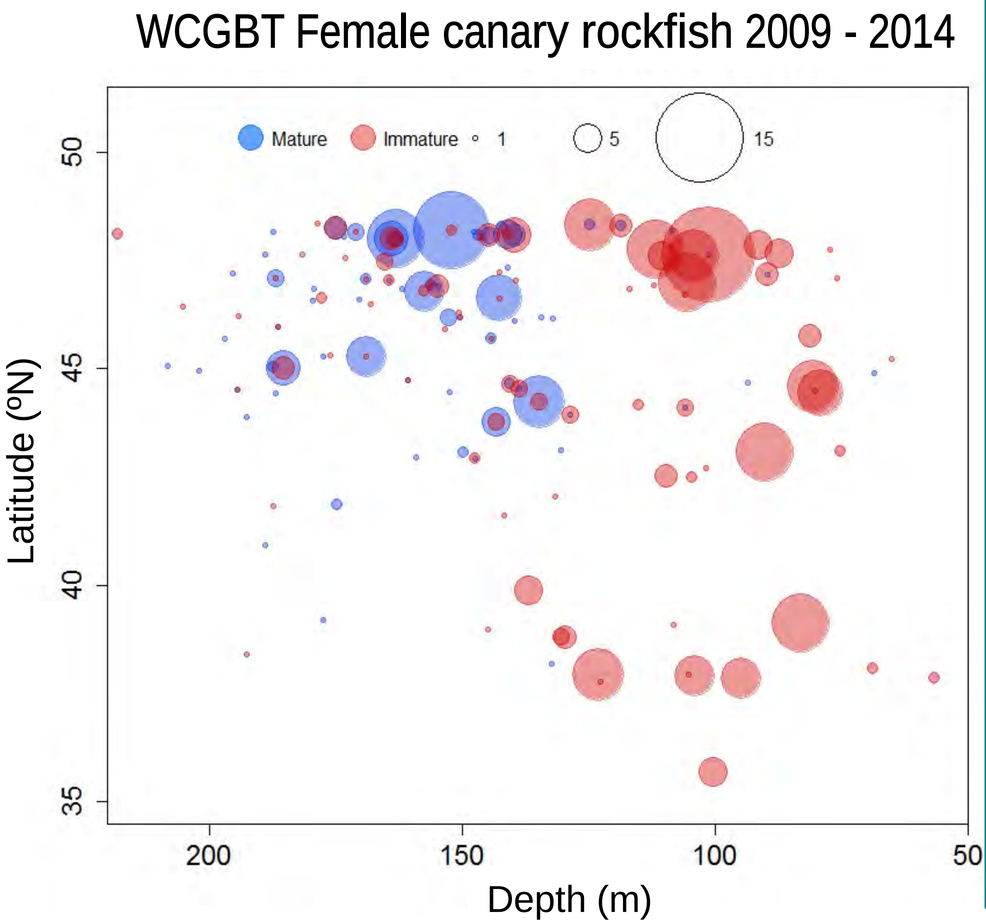




Canary rockfish, *Sebastes pinniger*

- Distribution: West Coast < 300 m
- Habitat: primarily rocky
- Long lived: max age 95 yrs
- Commercially important: may limit fisheries
- Livebearers, spawning in the winter
- Maturity sampling:
  - WCGBT 2009 – 2015 (n = 533)
  - ODFW 2014 – 2016 (n = 308)

Value of survey data



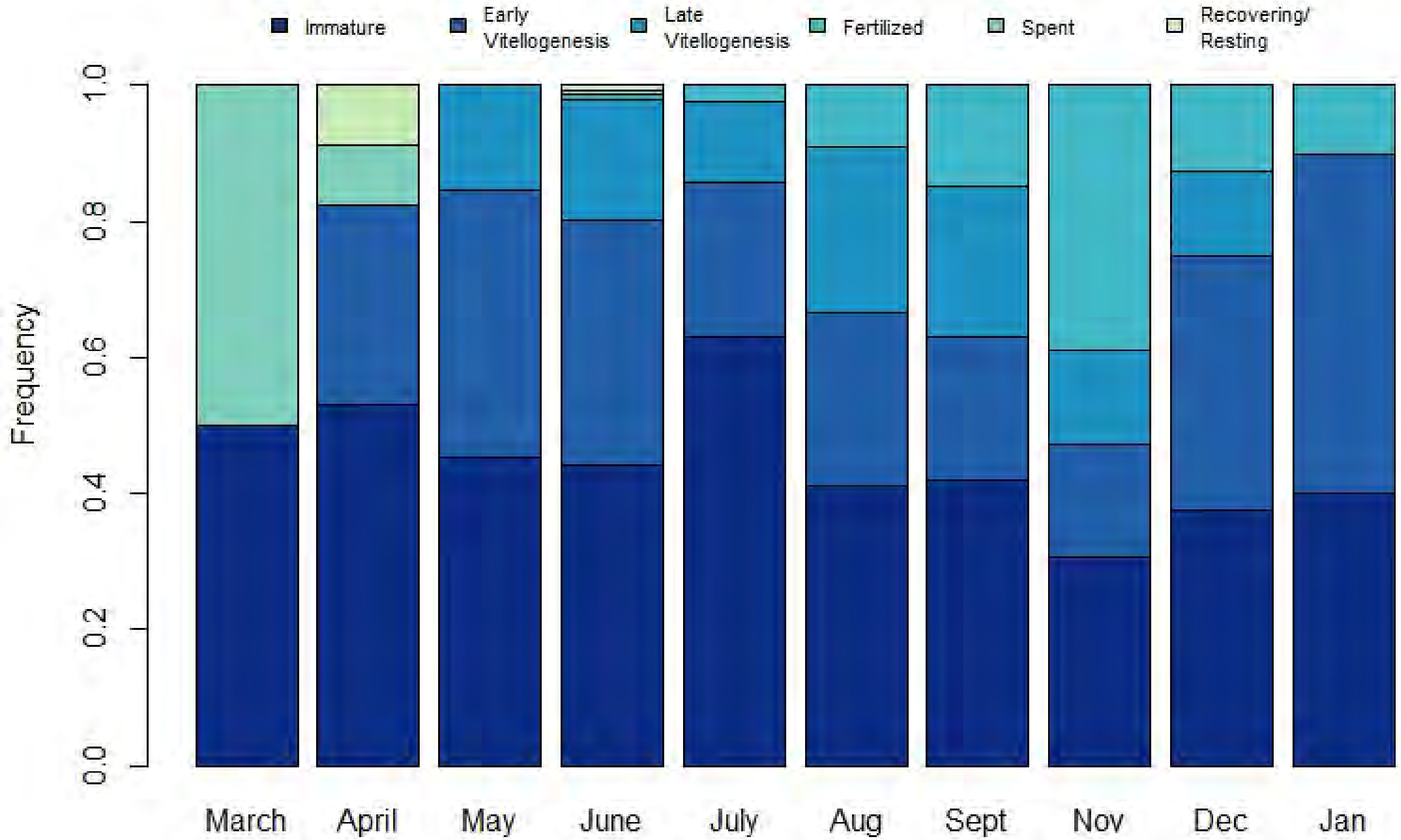
Spatial variation

- Survey range: U.S. – Canada to U.S. – Mexico, 55 – 1280m
- Spatial shifts in maturity correlated with environment (warm vs cold yrs, etc.)

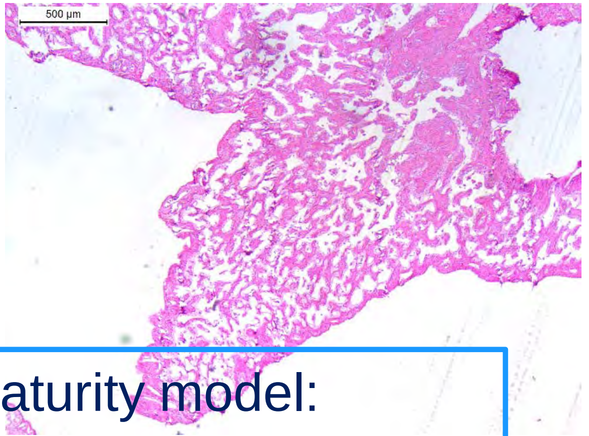
Temporal variation

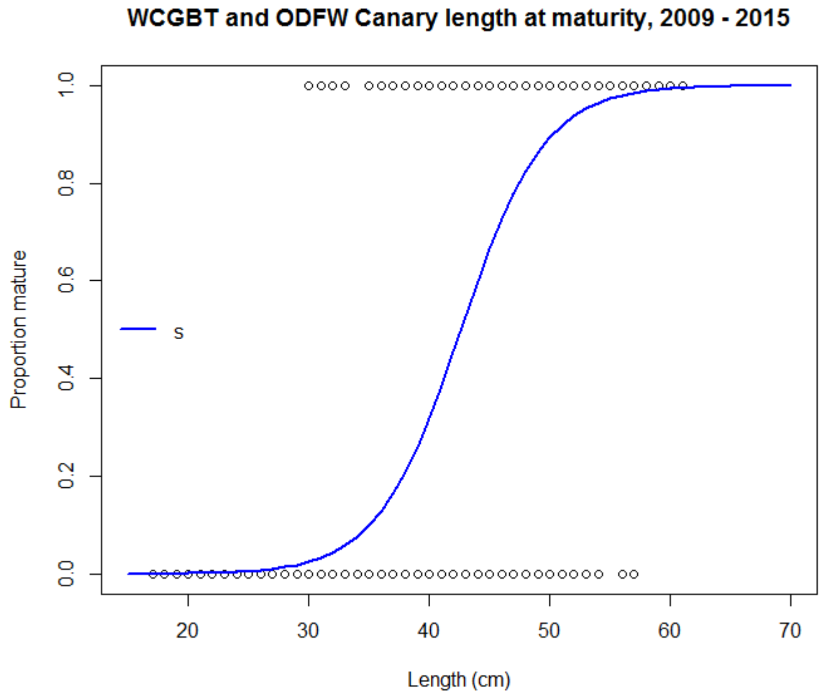
- Survey period: May – July, Aug. – Oct.
- Reproductive development
- Inter-annual reproductive variability (skipped spawning, size/age in maturity, etc.)

Seasonal pattern of development, WCGBT and ODFW

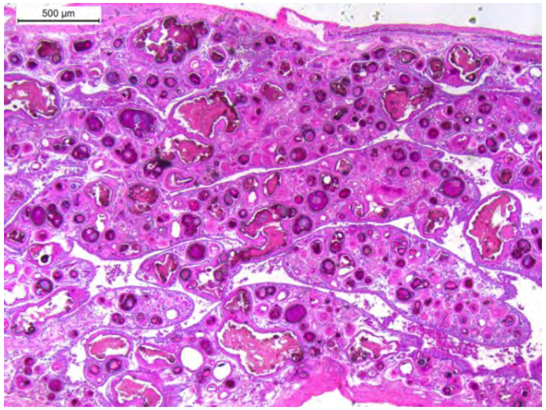


Standard maturity ogive (term: *s*)

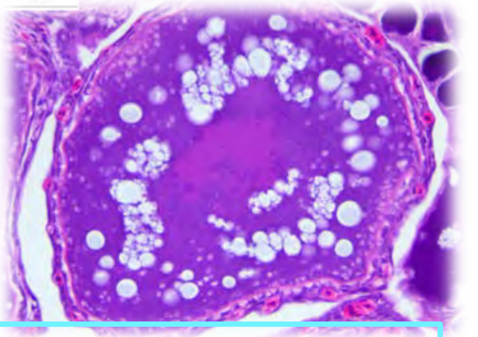


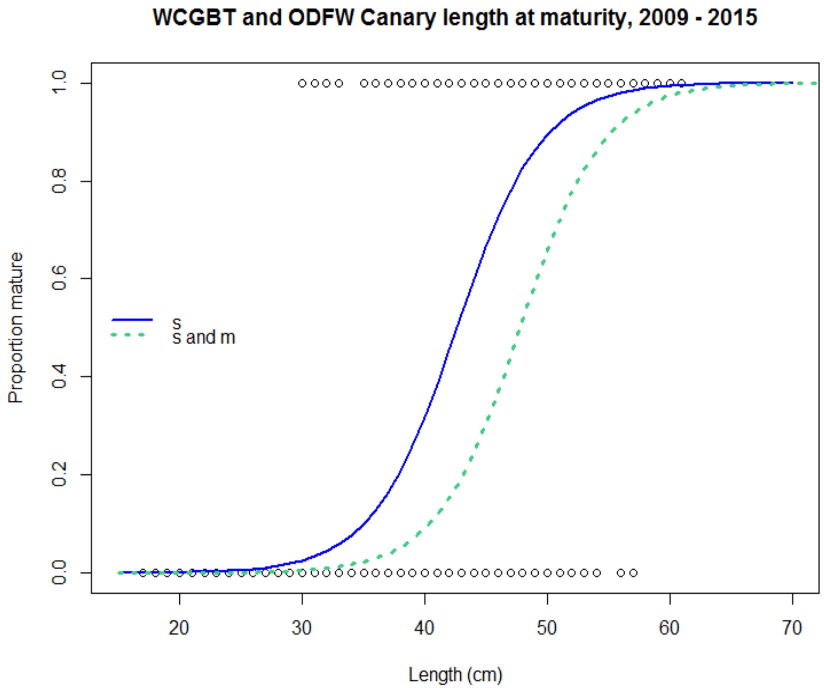


- Common maturity model:
  0 (immature) or 1 (mature)
- Maturity a function of length/age
- Assumes once a fish is sexually mature it will contribute to spawning biomass annually
- Oversimplifies reproductive behaviors: abortive maturation, skip spawning, senescence

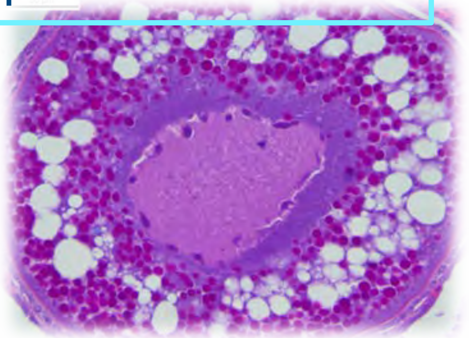


Abortive maturation (term: *m*)



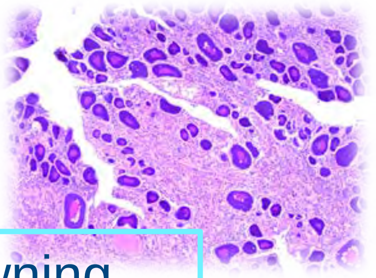


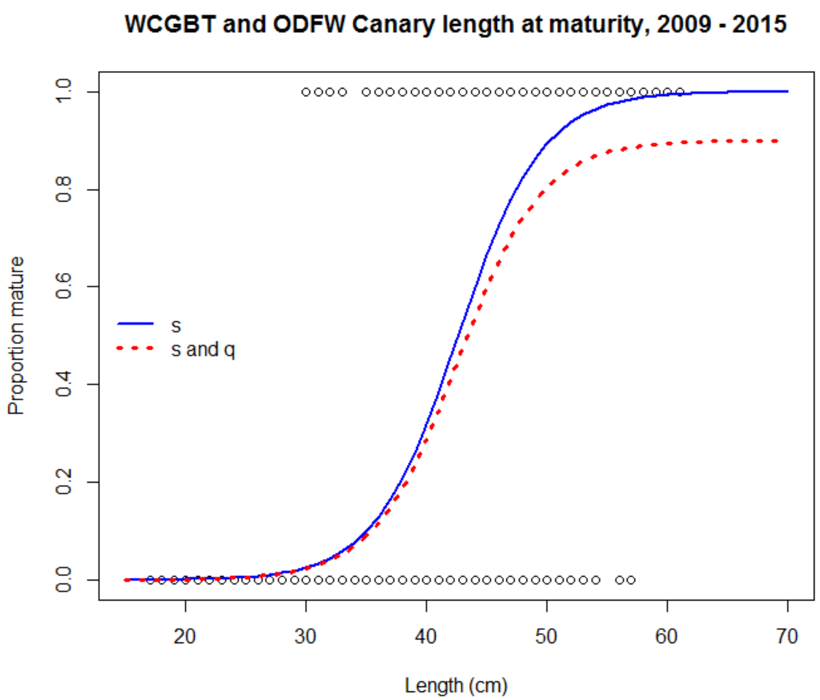
- Dummy runs common in juveniles
- Not accounting for *m* outside of spawning season underestimated length at maturity
- Understanding this relationship helps predict probability of spawning
- New model will attempt to estimate *m*



Dashed green line includes increased threshold hold for estimating maturity, accounts for *m*

Skip spawning (term: *q*)

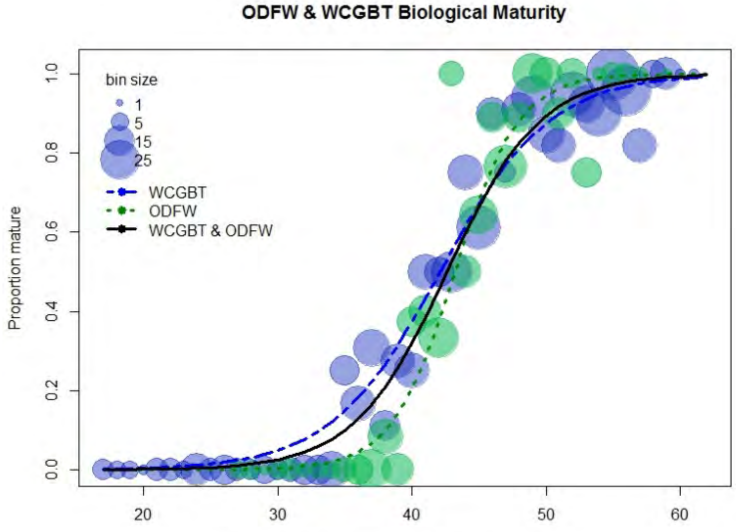


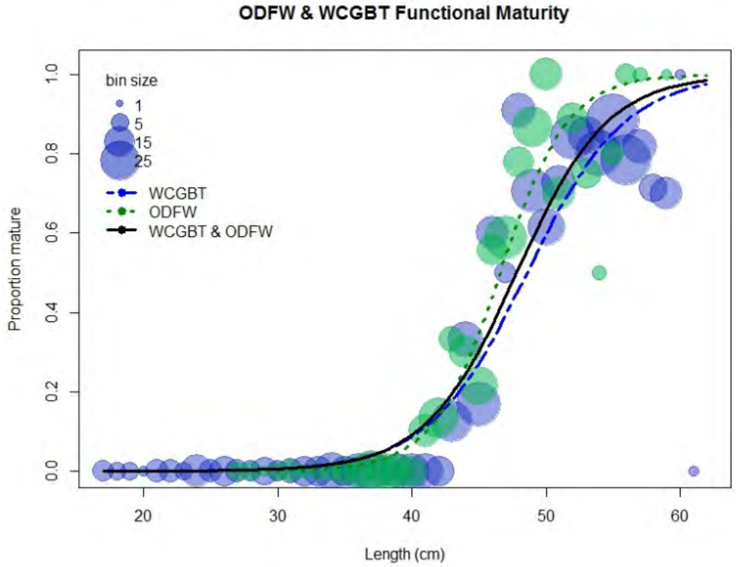


Dashed red line shows how '*q*' could be incorporated into logistic model, with an estimated asymptote of 0.9

- Mature fish forego spawning
  - usually due to poor nutrition
  - may be related to climate (i.e. el Niño, warming oceans)
  - variability among species
- Standard maturity model assumes an asymptote of 1
  - overestimates spawning biomass
- New model estimates asymptote < 1, accounts for skip spawning

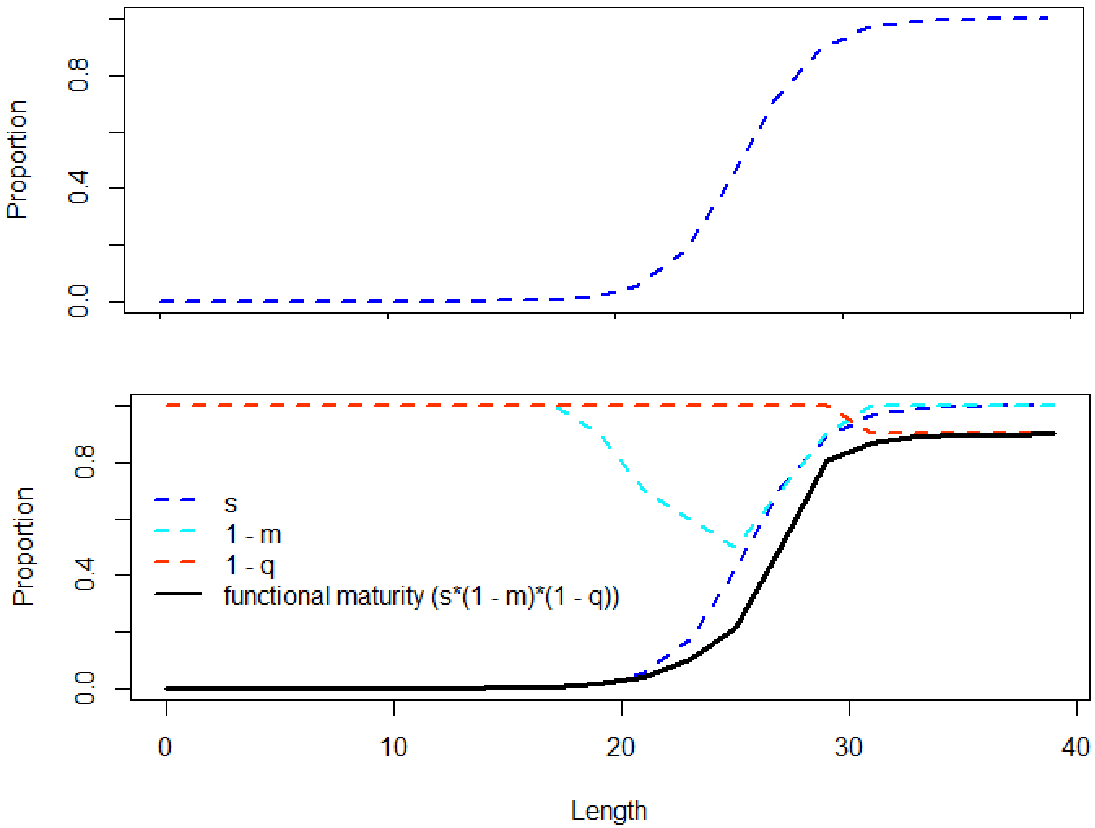
Comparative Analysis





- Do size at maturity estimates match up?
- Previous method for maturity: based solely on the presence of yolk
    - Not acceptable method for identifying potential spawners outside of the spawning season
    - Dummy runs common in L_{10}
- When is the energy investment large enough to indicate spawning?
    - Threshold for maturity status outside of season increased to 25% yolk development
    - Matched up with observations in the spawning season

New model approach



Probability of spawning in a given year: $f\,(s, m, q)$
where s = if fish spawned before,
m = unprogressive mature oocytes (abortive maturation),
q = skip spawner (not maturing but spawned previously)

- Standard maturity ogive(*s*) does not reflect the fluidity of reproductive patterns
- Estimating maturity out of season, need to predict m
- Account for skip spawning
    - Asymptote <1
- Functional maturity:
    - Estimates potential spawners
    - Better for management models
- Working on incorporating these variables into a more flexible model type
    - Each sp. will be explored separately

Conclusion

- Previous method for estimating maturity outside spawning season, underestimated size at maturity
- Investigate ecosystem variables: habitat, food availability, upwelling, oceanographic patterns and how they relate to abortive maturation and skip spawning
- Examine spatial and temporal variation
- Monitor important sp. in changing oceans, establish long-term time series
    - Inform climate vulnerability analysis models

Acknowledgements

Thank you to the entire WCGBT survey (Aimee Keller, Keith Bosley, John Buchanan, Aaron Chappel, Douglas Draper, Peter Frey, John Harms, Daniel Kamikawa, Victor Simon, John Wallace and countless volunteers), Todd Hay and Beth Horness for data, Hook and Line survey of the Southern California bight special thanks to John Harms, our partners at Oregon Dept. of Fish and Wildlife and Washington Dept. Fish and Wildlife for all of the valuable winter samples and input. The NWFSC stock assessment team, especially Jason Cope and James Thorson. The NOAA MARVLS group for assistance with reproductive analysis, special thanks to Susanne McDermott and Sandi Neidetcher at the ASFC for their expertise and maturity/fecundity trainings.