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

WCGBT Female canary rockfish 2009 - 2014

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
- Reproductive development
- Inter-annual reproductive variability (skipped spawning, size/age in maturity, etc.)
Seasonal pattern of development, WCGBT and ODFW

- Immature
- Early Vitellogenesis
- Late Vitellogenesis
- Fertilized
- Spent
- Recovering/Resting

Frequency

March | April | May | June | July | Aug | Sept | Nov | Dec | Jan
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: $q$)

- 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

Dashed red line shows how ‘$q$’ could be incorporated into logistic model, with an estimated asymptote of 0.9
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 L10
- 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
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