2023 Petrale Sole Stock Assessment Pre-assessment Workshop

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20 March 2023

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Outline

- Background
- Data
  - Landings
  - Discards
  - Fishery length and age compositions
  - Fishery-independent data
  - Biological parameters
- Modeling considerations
  - Exploring changes to model structure
  - Inclusion of winter fishery CPUE
  - Seasonal structure
  - Sex-specific selectivity
  - Environmental index of recruitment
- Additional activities

Background

Photo: Ian Taylor at Town & Country Market Shoreline

Photo: anonymous NWFSC staff on WCGBT Survey

Background: assessment history

- Stock was declared overfished in 2009
- Declared rebuilt in 2015 (reference points also changed)

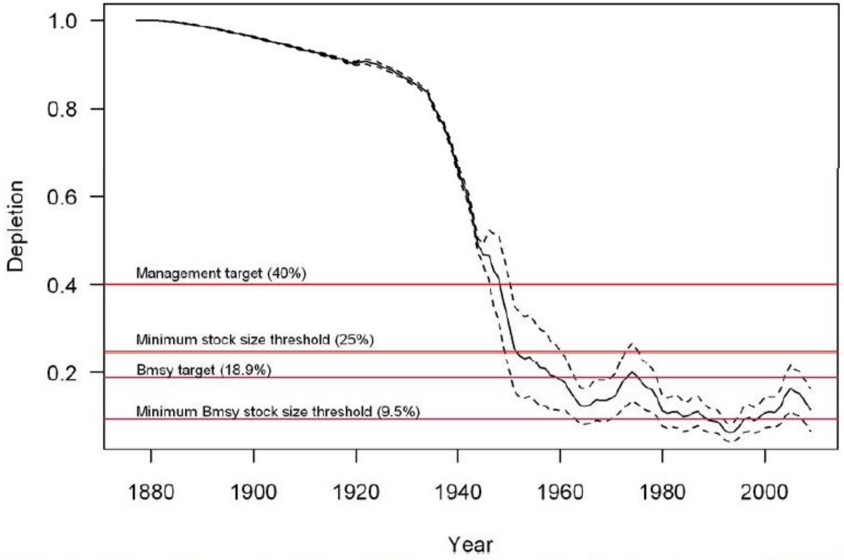


Figure e. Time series of depletion level as estimated in the base case model (round points) with approximate asymptotic 95% confidence interval (dashed lines) and alternate states of nature (light lines).

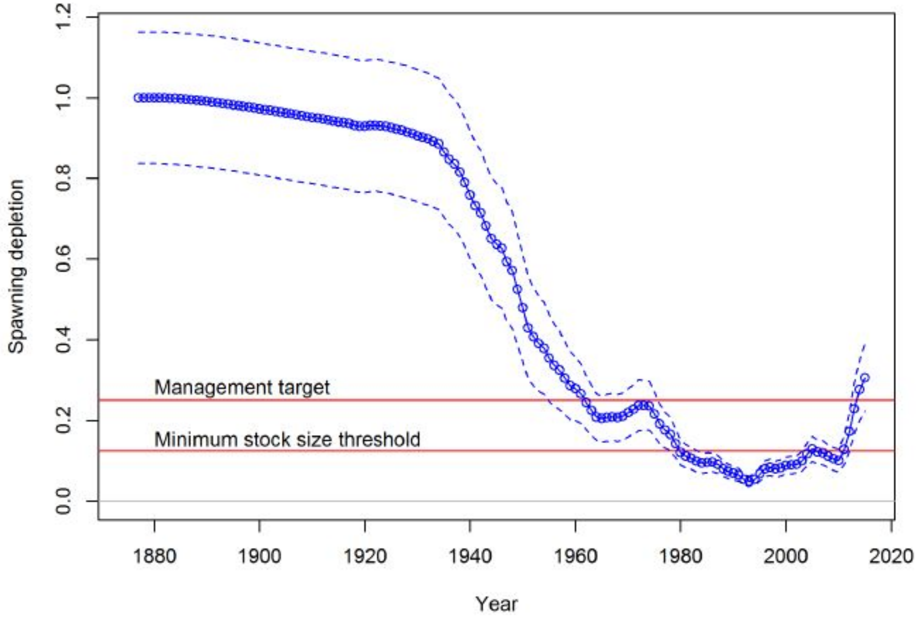


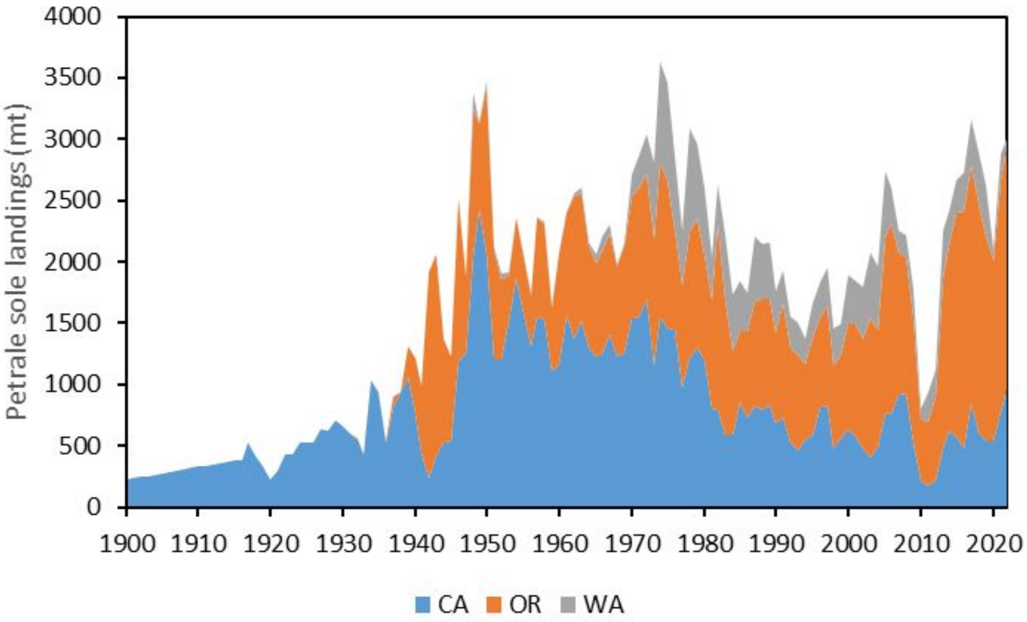
Figure 107. Time series of depletion level as estimated in the base case model (round points) with approximate asymptotic 95% confidence interval (dashed lines).

Background: assessment history

- Stock was declared overfished in 2009
- Declared rebuilt in 2015 (reference points also changed)
- Frequent assessments during rebuilding period
- Assessment last updated in 2019
- Full assessment in 2023 will be the first since 2013

Data

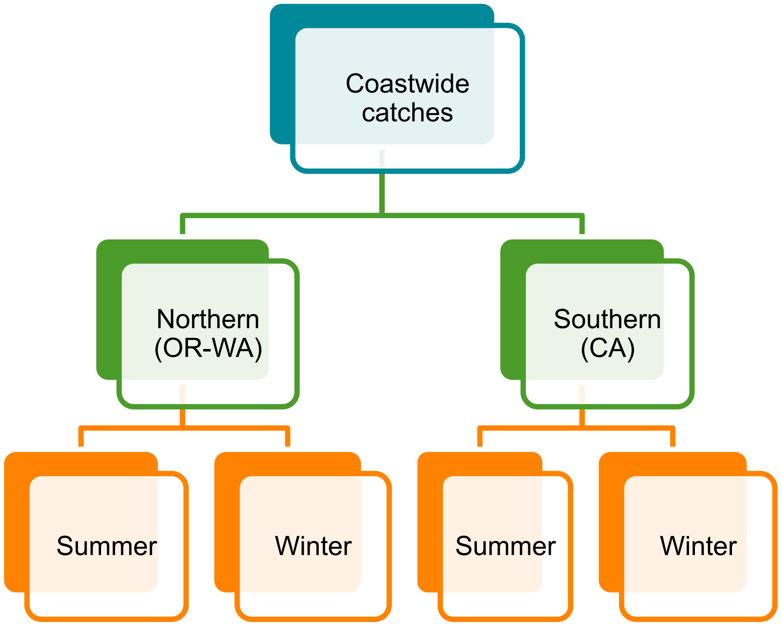
History of stock exploitation

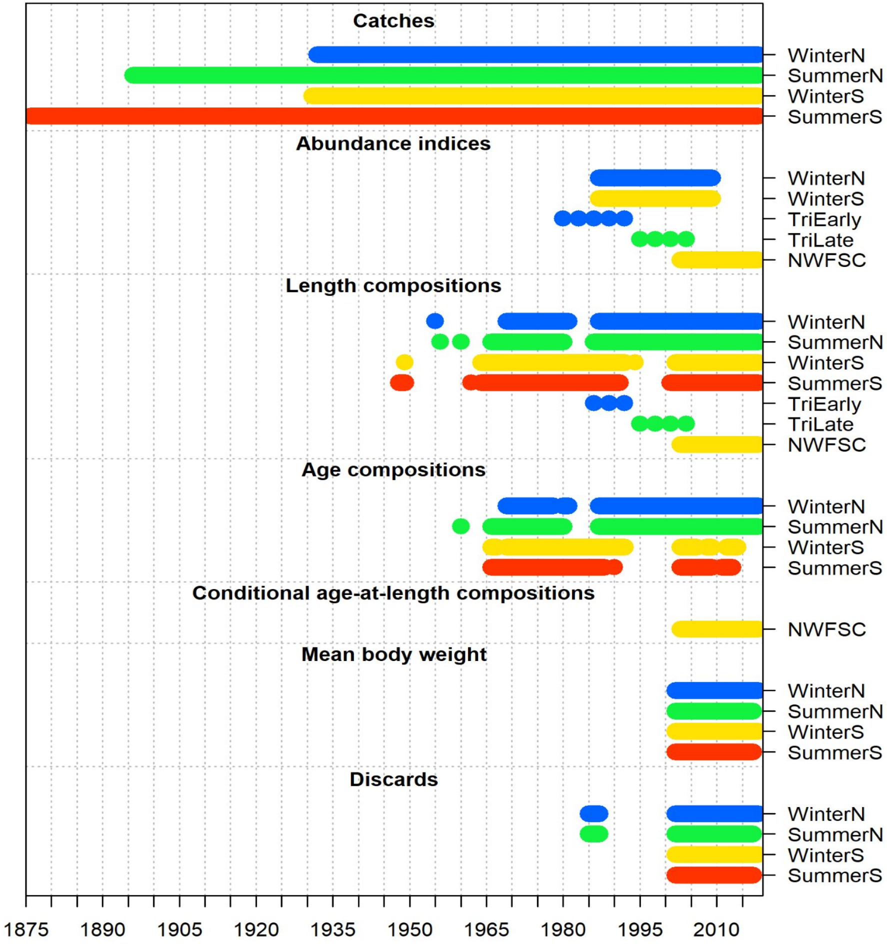


- Started in California in the late 1800s;
- Extended north, to Oregon and Washington starting in the 1930s;
- Early concerns about stock depletion in the 1950s;
- Targeting of winter spawning aggregations developed through the 1950s and 1960s.

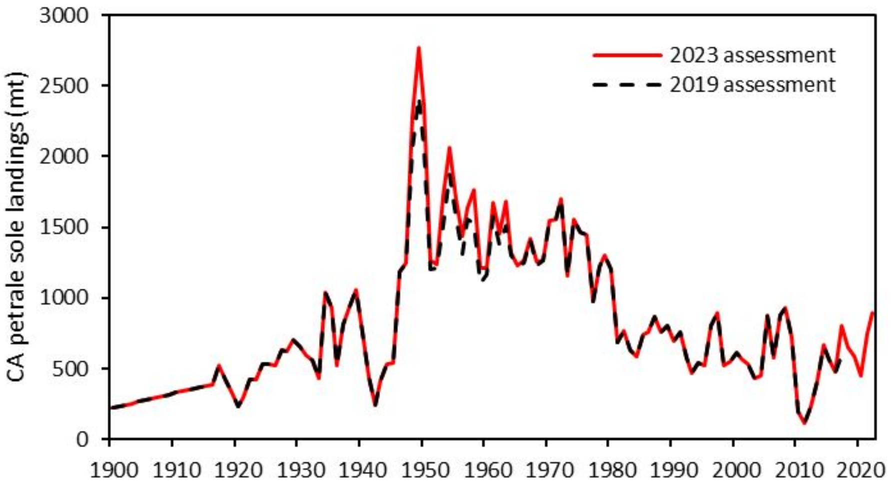
Photo credit: NOAA Central Library Historical Fisheries

Data sources used in 2019 assessment



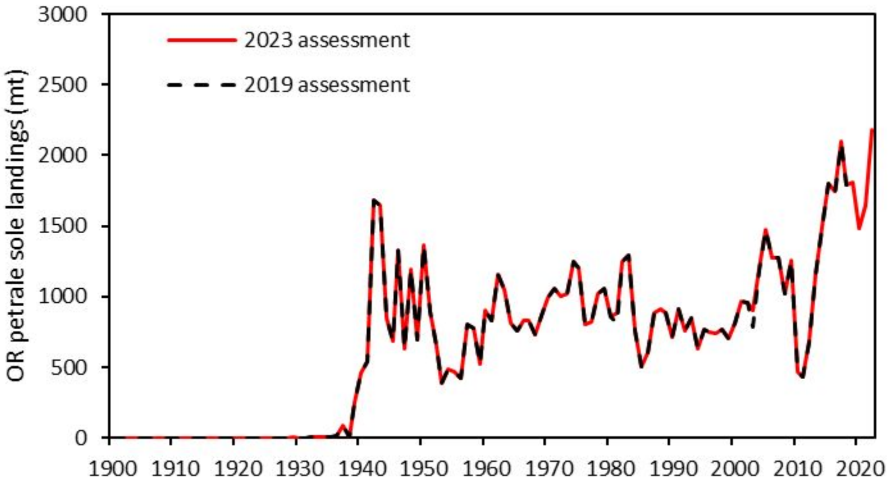


Landings by state: California



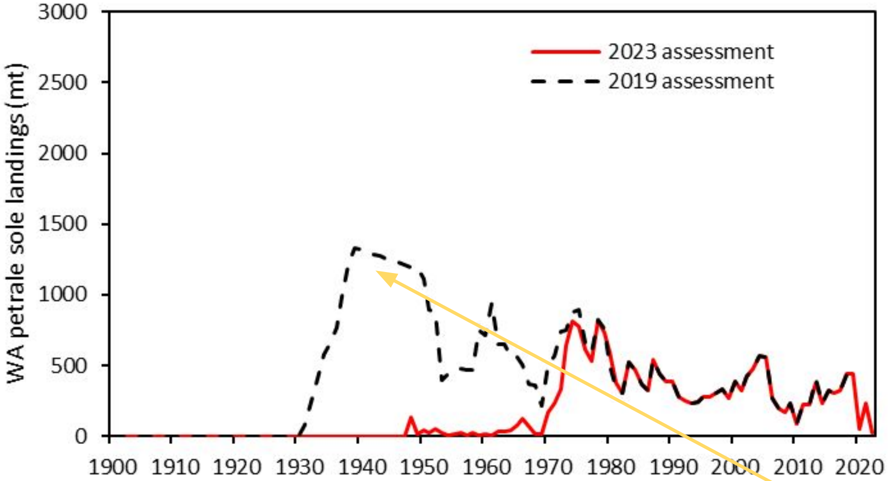
- 1916-1930: CDFG Fish Bulletins;
- 1931-1968: Ralston et al (2010); plus OR-WA catches landed in CA; 1969-1980: CalCOM;
- 1981-2022: PacFIN.

Landings by state: Oregon



- 1896-1986: Karnowski et al (2014);
- 1987-2022: PacFIN.

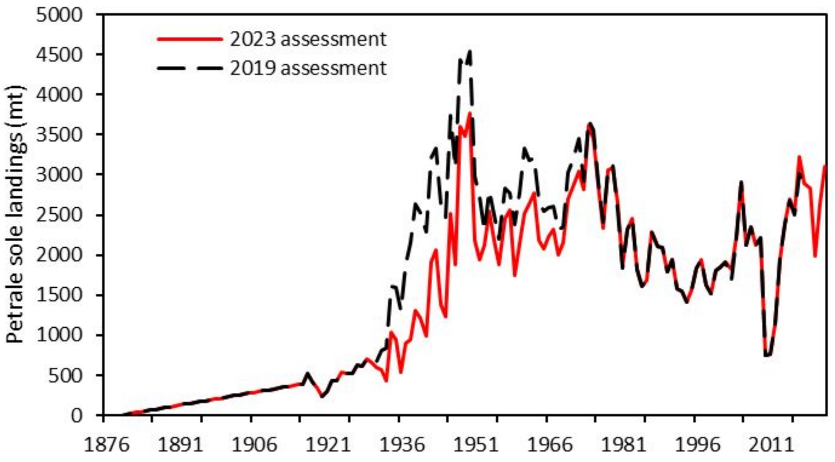
Landings by state: Washington

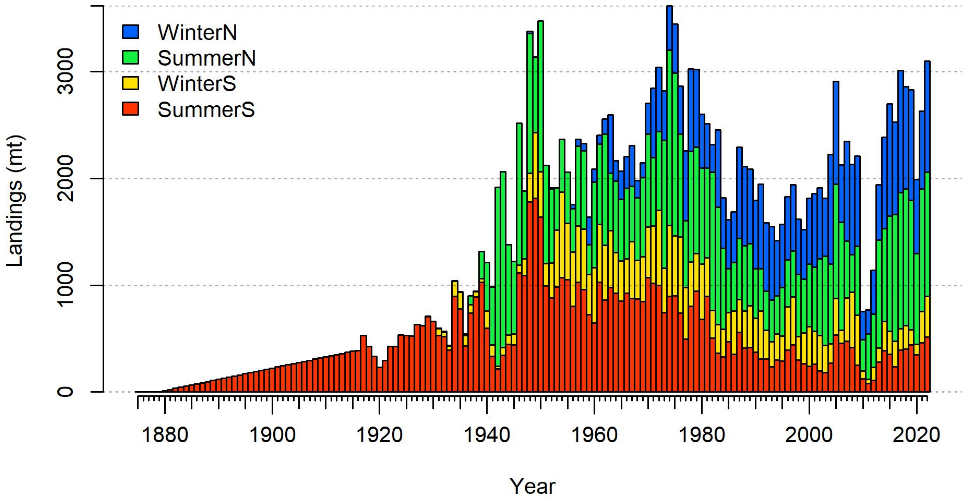


- 1930-1947: linear interpolation;
- 1948-1979: WDFW;
- 1981-2022: PacFIN.

Sources for previous landings history not fully understood. WDFW has double-checked the updated time series.

Coastwide landings





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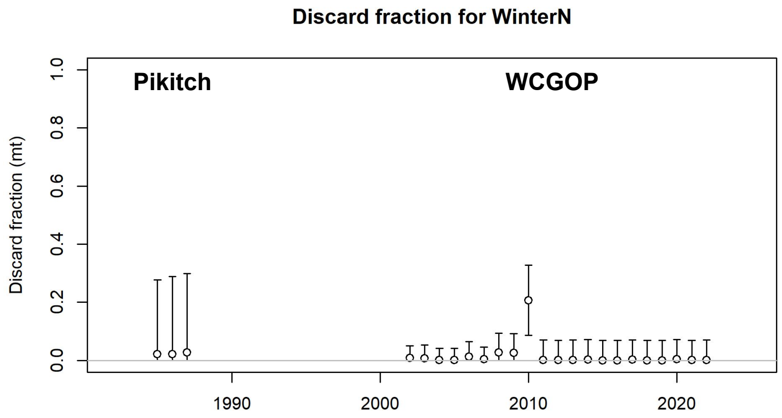
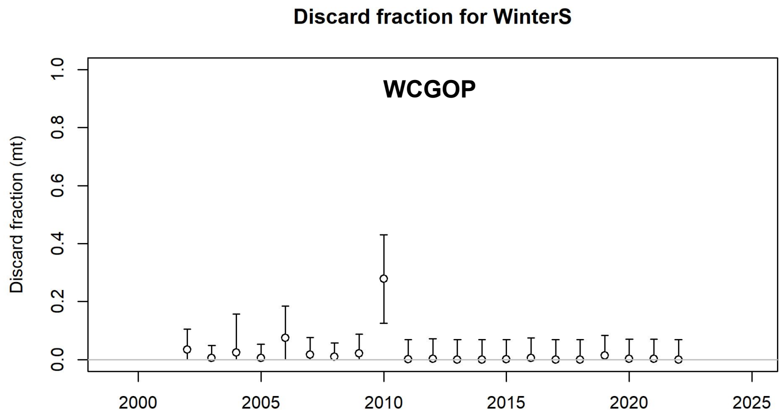
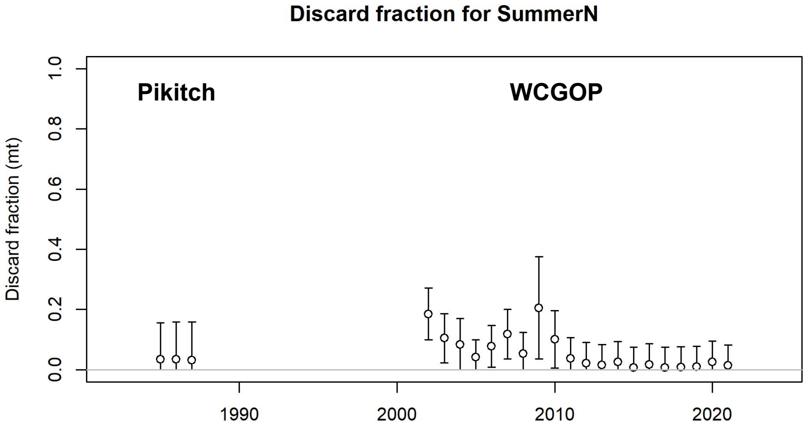
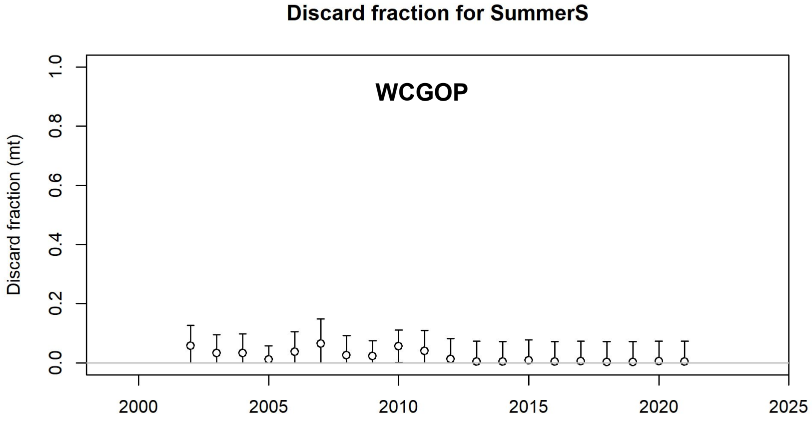
Discard fraction is low

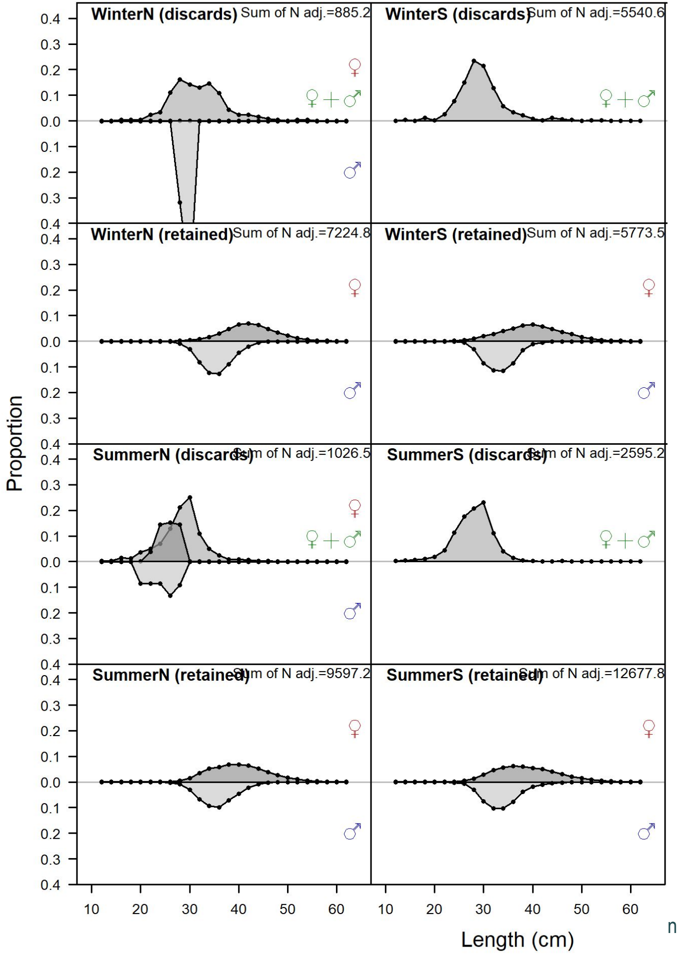




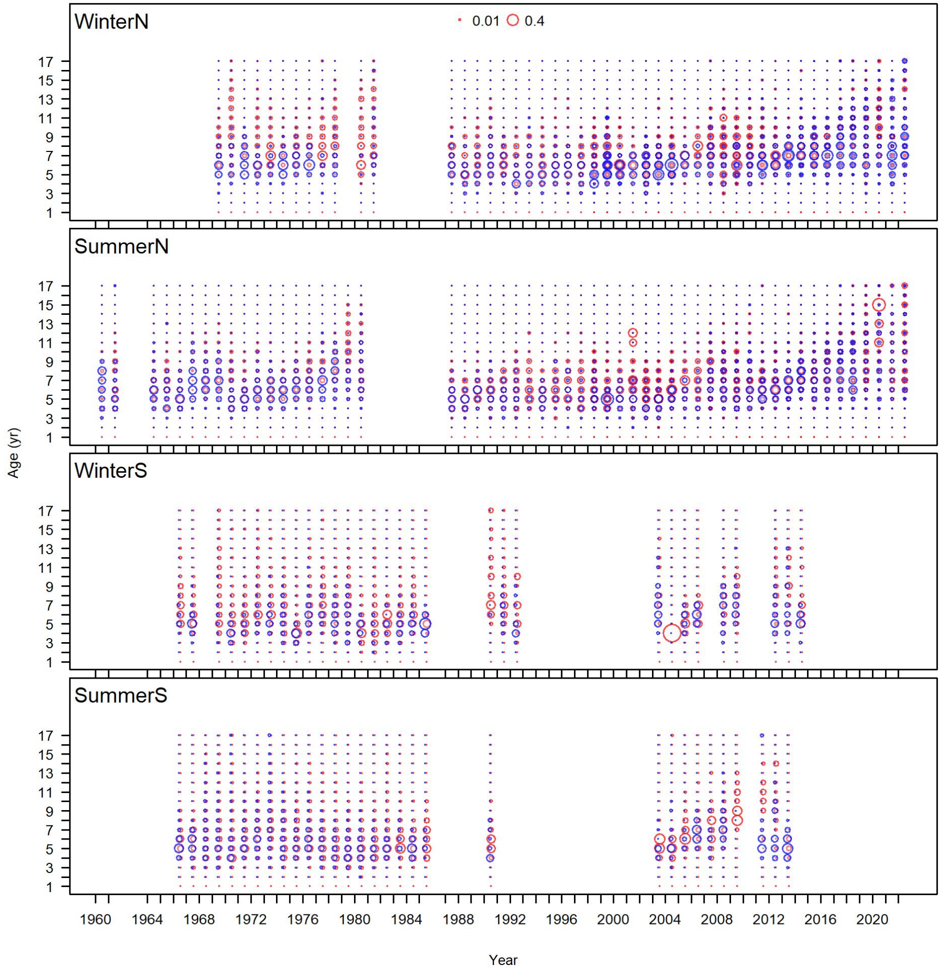




Fishery length compositions



Fishery age compositions



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Fishery-independent data

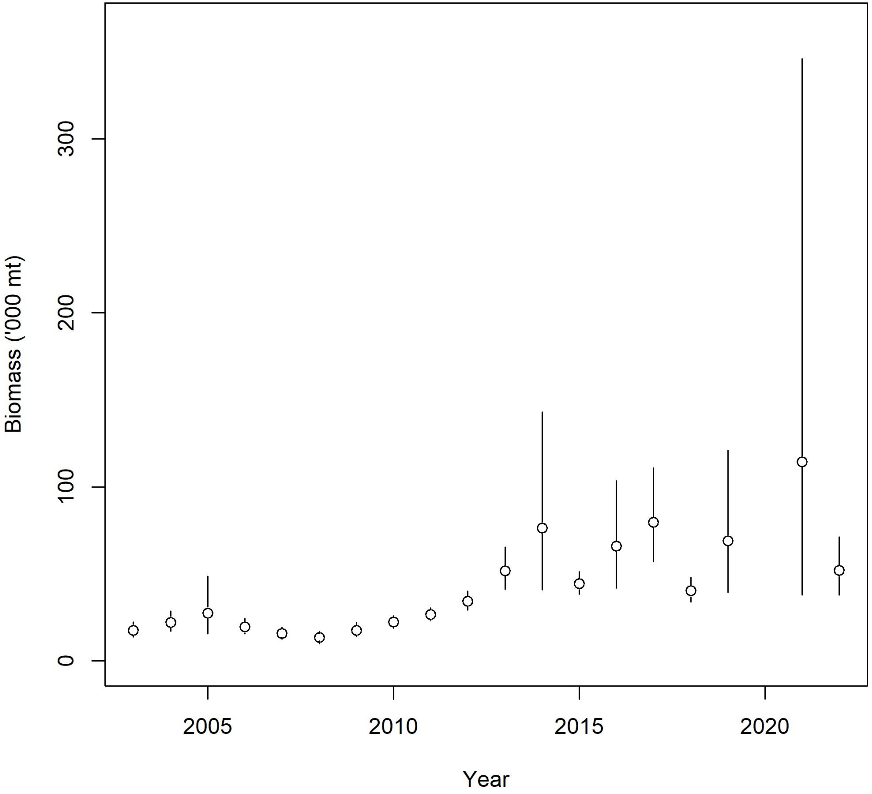
Included in the assessment:

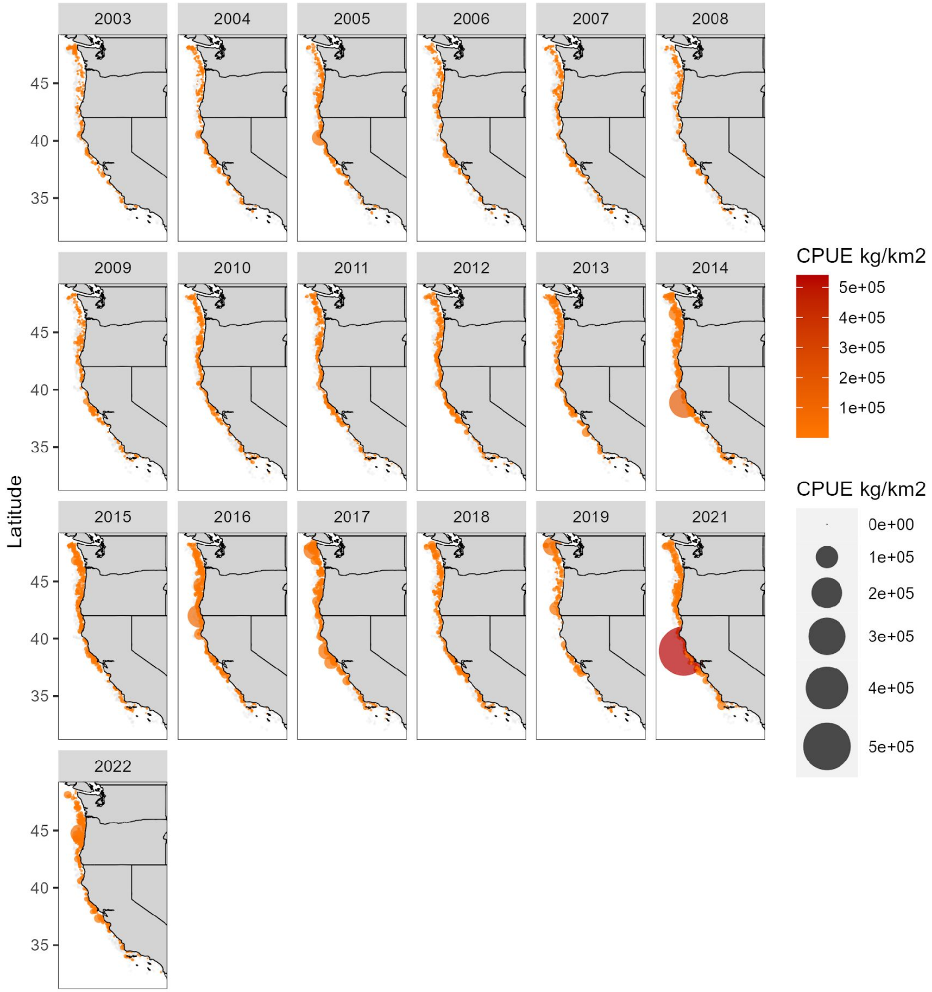
- WCGBTS (2003-present)
- AFSC triennial shelf survey (1980-2004)

Evaluated but not included, due to limited amount of data:

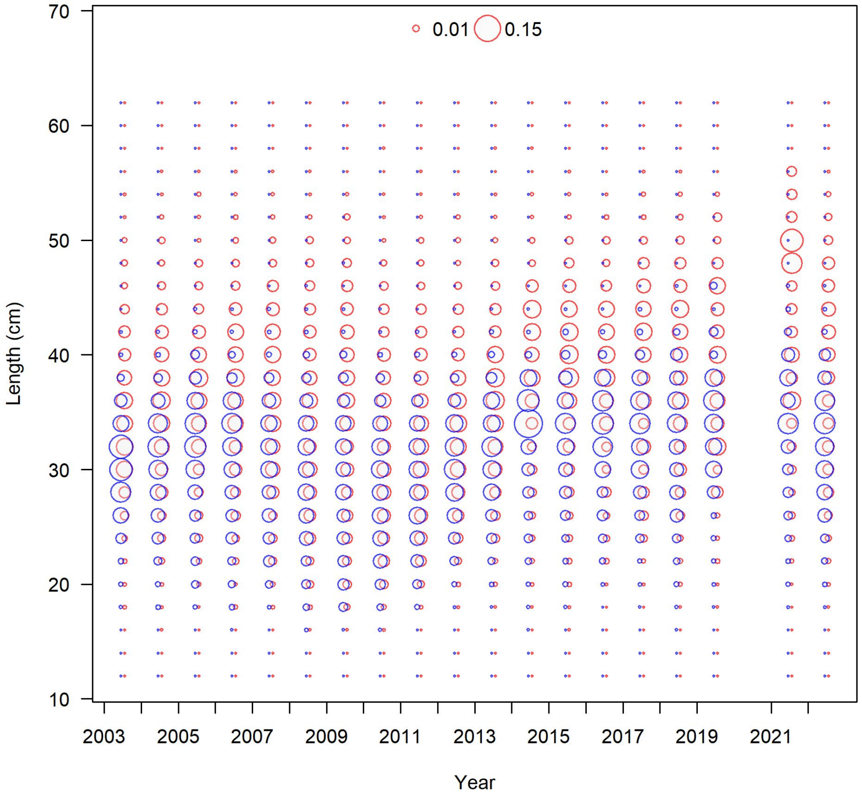
- NWFSC slope survey (1999-2002)
- AFSC slope survey (1997, 1999-2001)

WCGBT Survey index

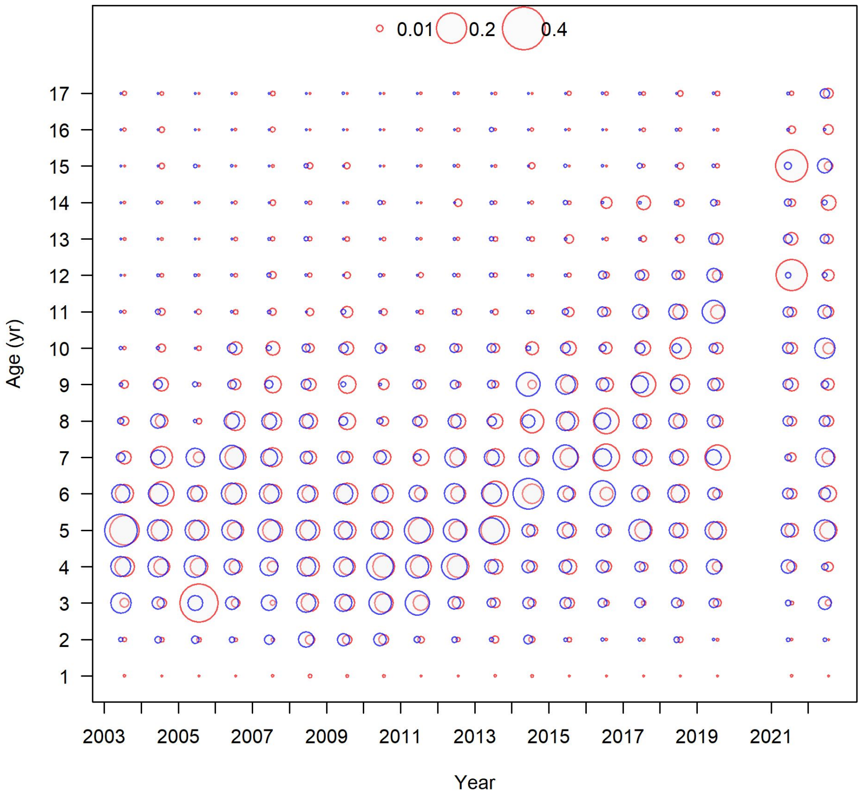




WCGBTS lengths



WCGBTS ages



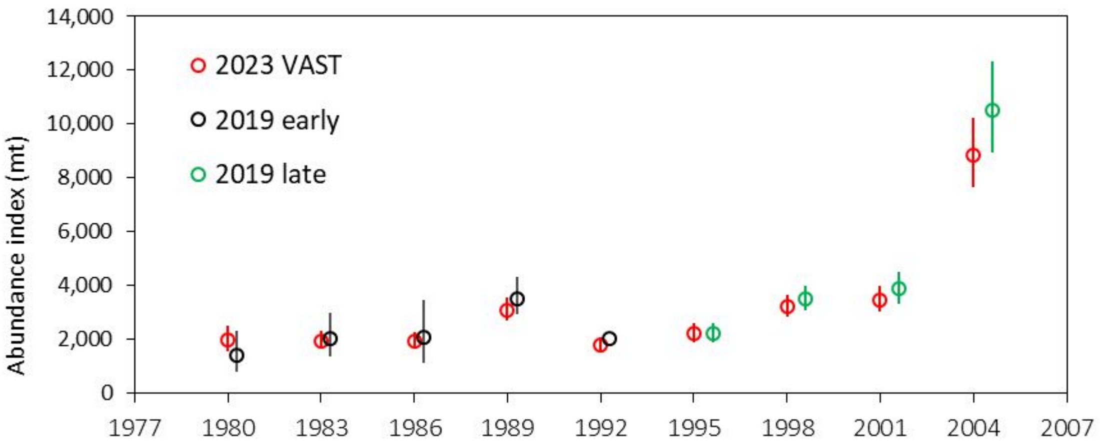
AFSC triennial shelf survey

2013 and 2019 assessments: treated as two separate indices

- to account for change in survey timing and depth coverage in 1995.

2023 assessment: plan to use as a single index,

- with offset on catchability and selectivity for ≥1995.



 U.S. Department of

Biological parameters

Natural mortality

- Hamel prior to be slightly revised based on Hamel and Cope (2022) (will use max age for females=32 years and for males=29 years)
- Female and male M expected to be independently estimated in the model

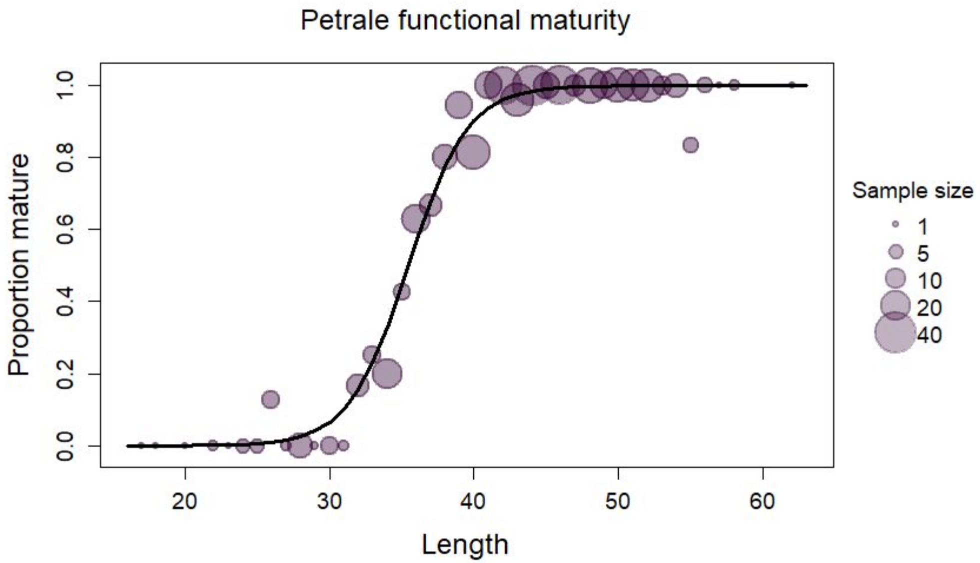
Growth – fully estimated in the model

Fecundity – updated

Maturity -updated

Biological parameters: maturity

- Previous assessment used Hannah et al. (2002) maturity estimates.
- “Due to limited data, new studies on the maturity at length or age for petrale sole would be beneficial.” (2019 petrale update)
- New maturity ogive from Melissa Head based on 583 samples collected in 2015-2021 by ODFW, WDFW and NMFS
- Length at 50% maturity estimated at 35.5 cm
- Similar to 33.1 cm estimated by (Hannah et al. 2002) (based on samples from a narrower geographic range)



Biological parameters: fecundity

- Estimate of fecundity at size used in 2019 update as a sensitivity analysis
- Expected to be included in the 2023 assessment

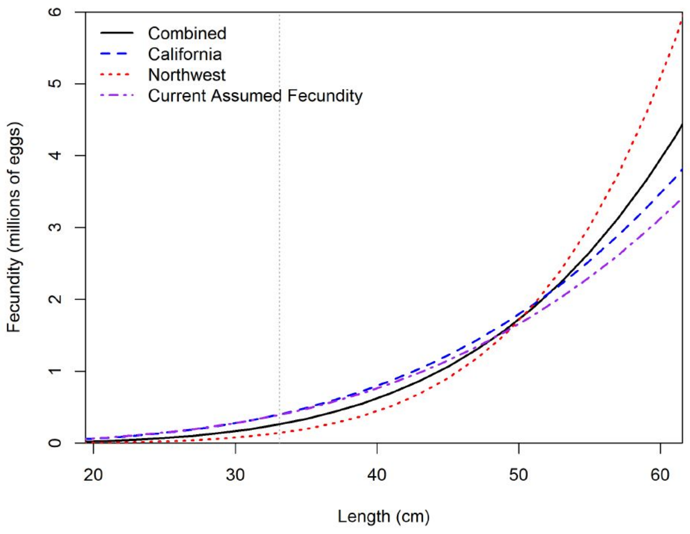
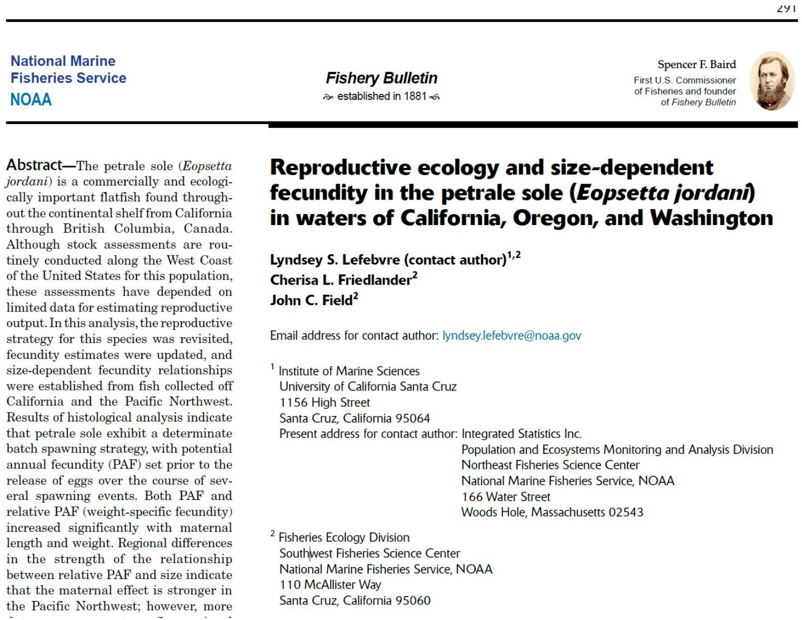


Figure 41: Estimated fecundity-at-length for petrale sole based on Lefebvre et al. (in press).



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National Marine Fisheries Service
NOAA

Fishery Bulletin
established in 1881

Spencer F. Baird
First U.S. Commissioner of Fisheries and founder of *Fishery Bulletin*

Abstract—The petrale sole (*Eopsetta jordani*) is a commercially and ecologically important flatfish found throughout the continental shelf from California through British Columbia, Canada. Although stock assessments are routinely conducted along the West Coast of the United States for this population, these assessments have depended on limited data for estimating reproductive output. In this analysis, the reproductive strategy for this species was revisited, fecundity estimates were updated, and size-dependent fecundity relationships were established from fish collected off California and the Pacific Northwest. Results of histological analysis indicate that petrale sole exhibit a determinate batch spawning strategy, with potential annual fecundity (PAF) set prior to the release of eggs over the course of several spawning events. Both PAF and relative PAF (weight-specific fecundity) increased significantly with maternal length and weight. Regional differences in the strength of the relationship between relative PAF and size indicate that the maternal effect is stronger in the Pacific Northwest; however, more

Reproductive ecology and size-dependent fecundity in the petrale sole (*Eopsetta jordani*) in waters of California, Oregon, and Washington

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Modeling considerations

Exploring impact of changes to model structure

- Too many parameters can result in less robust estimates (304 estimated parameters in 2019 update)
- Including conflicting data in an assessment model typically reduces uncertainty rather than increases it
- More parsimonious models are easier to keep up to date
- Model run time is about 30 minutes to estimate all the parameters and their uncertainty—faster runs allow more models to be explored

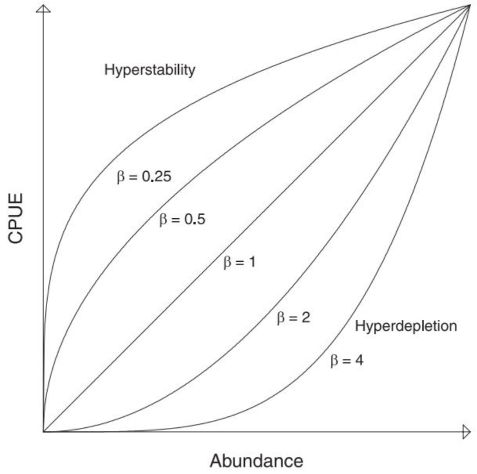
Modeling issue 1: fishery catch-per-unit-effort

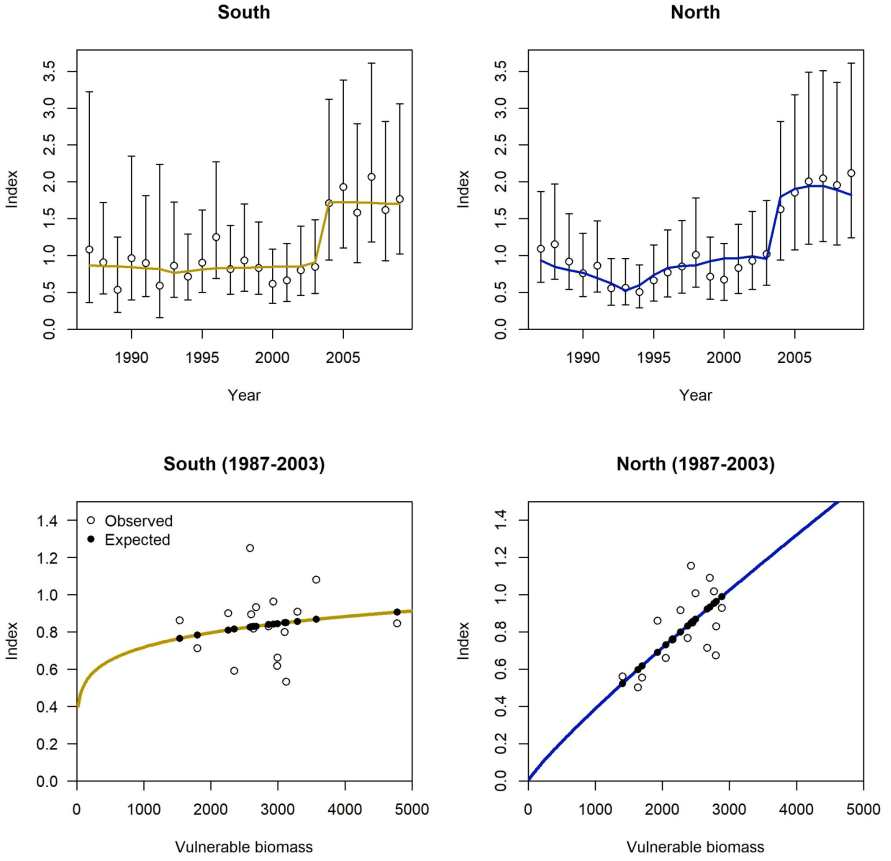
- CPUE index for years starting in 1987 first used for petrale in 1999 assessment
- Index later updated and extended to cover period 1987–2009 (overfishing declaration impacted CPUE)
- CPUE increased significantly in 2004 at the same time as the vessel buyback
- CPUE is modeled as non-linearly related to abundance due to concerns about hyperstability when fishing on spawning aggregations

Modeling issue 1: fishery catch-per-unit-effort

Harley et al.

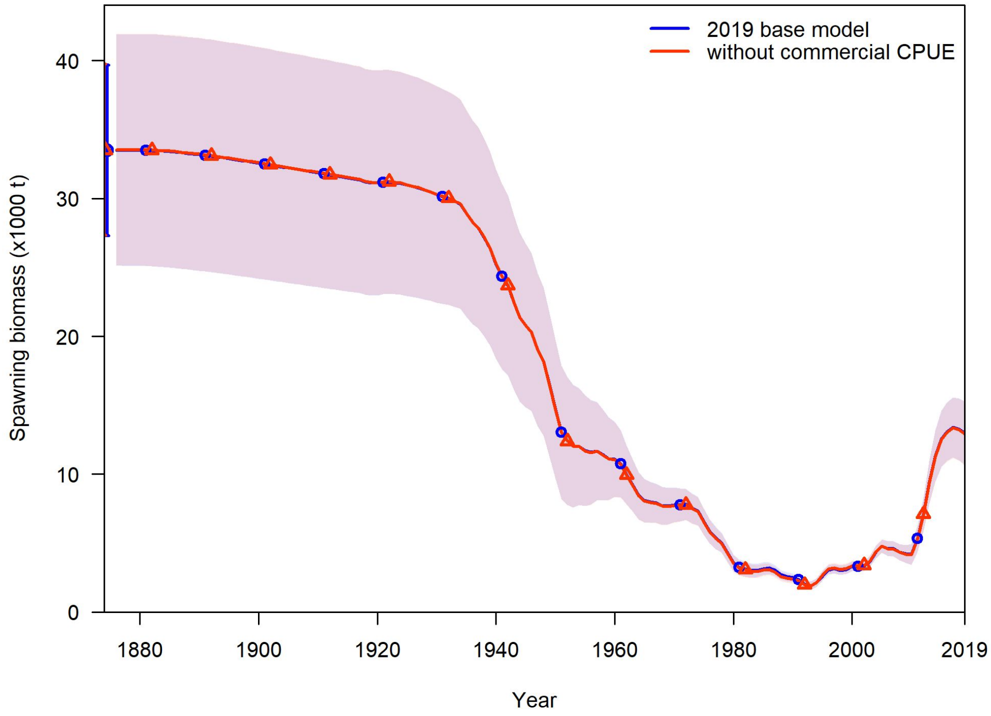
Fig. 1. Relationship between CPUE and abundance based on different values of the shape parameter β.





Modeling issue 1: fishery catch per unit effort

- Almost zero influence on 2019 update assessment



Modeling issue 1: fishery catch per unit effort

- Lack of influence of fishery CPUE is good news
- Indicates survey data provides the information we need to monitor changes in abundance:
    - long enough, including a period of increasing abundance
    - changes in survey index are consistent with signals from length and age data
- Proposal: CPUE can be removed from the assessment
- Can be included in sensitivity analysis

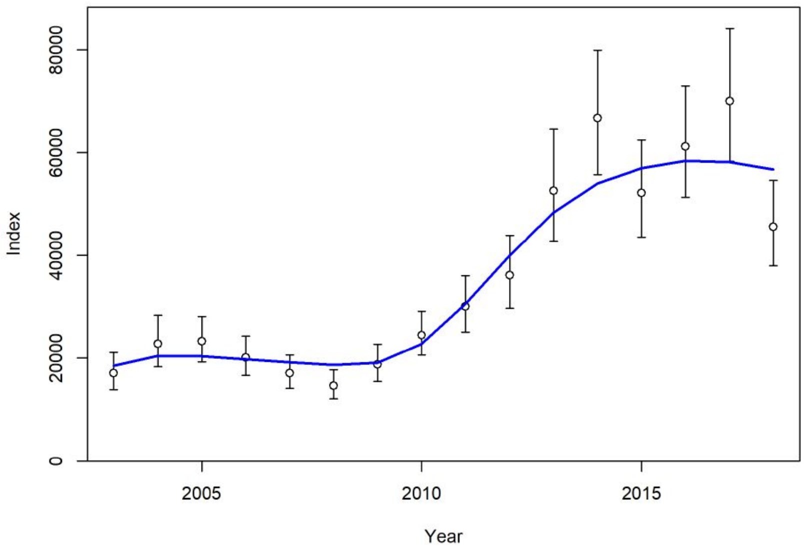


Figure 61: Fit to the NWFSC West Coast Groundfish Bottom Trawl Survey time series for petrale sole.

From 2019 update assessment

Modeling issue 2: seasonal structure

"Because of the marked seasonality in the landings of petrale sole, and because biological samples from the commercial fishery indicate considerable seasonal changes in the size and age composition (e.g., Fig. 3), with larger and older fish taken on the spawning grounds, in the assessment model the landings data were separated into two time periods, a winter season (November-February) and a summer season (March-October)."

-1999 petrale assessment

Figure 2a. Monthly landings of petrale sole by state, 1991-98.

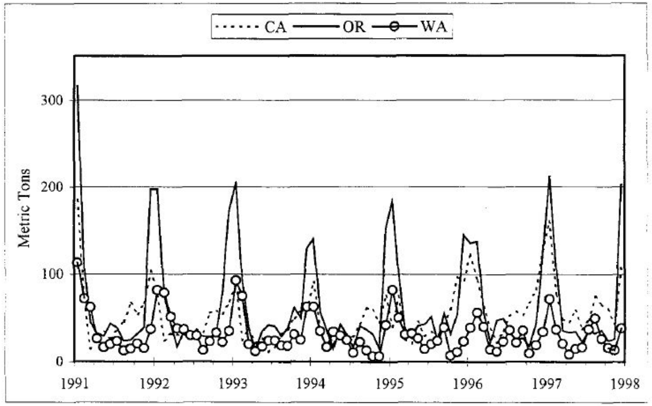
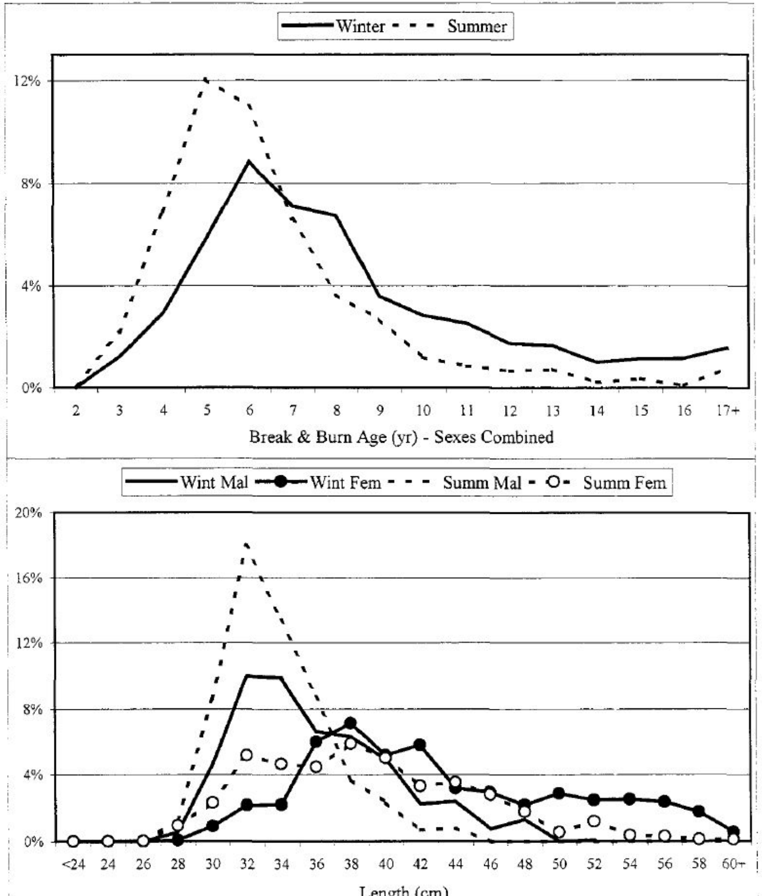
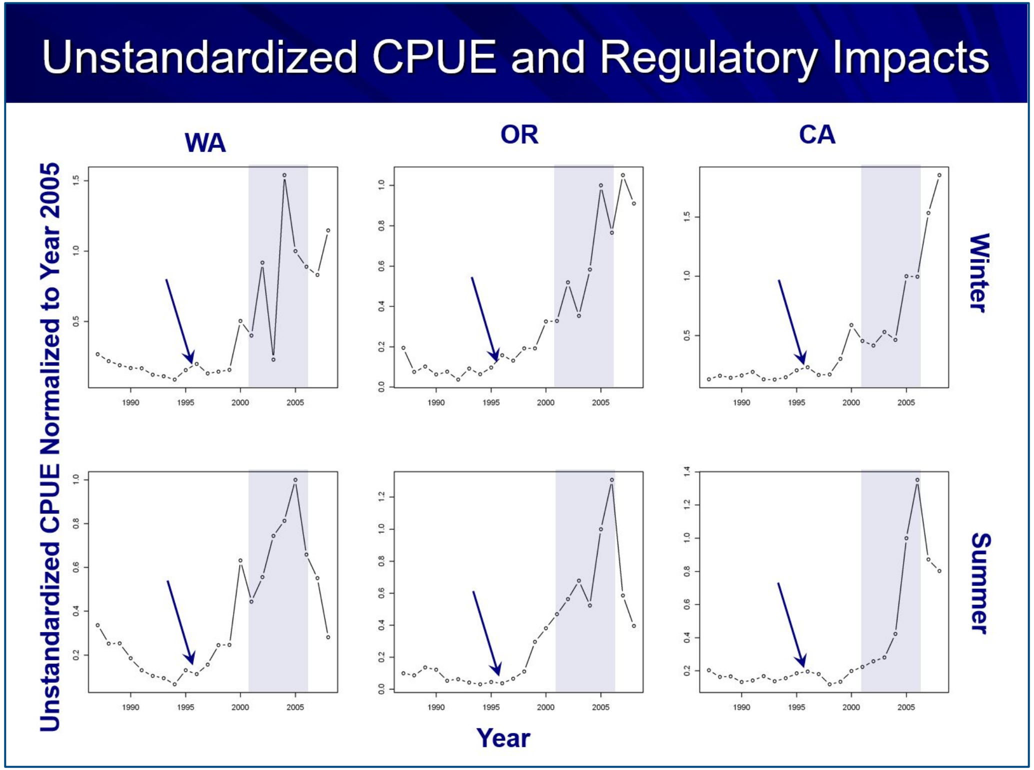


Figure 3. Examples of seasonal changes in age and size composition in market samples of petrale sole. Oregon market samples from the northern stock, 1981-83 average compositions.



Modeling issue 2: seasonal structure

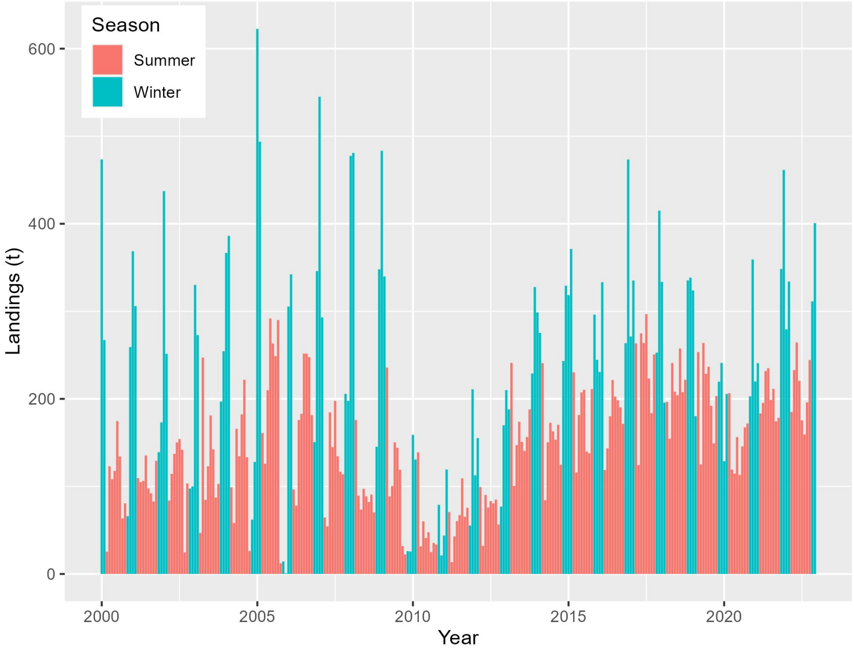
- CPUE trends were different in winter vs summer
- Only winter CPUE included in assessment models
- CPUE for fishing on spawning aggregations presumed to be more representative of the population size
- If CPUE index no longer included in the model, it doesn't impact choice of seasonal structure

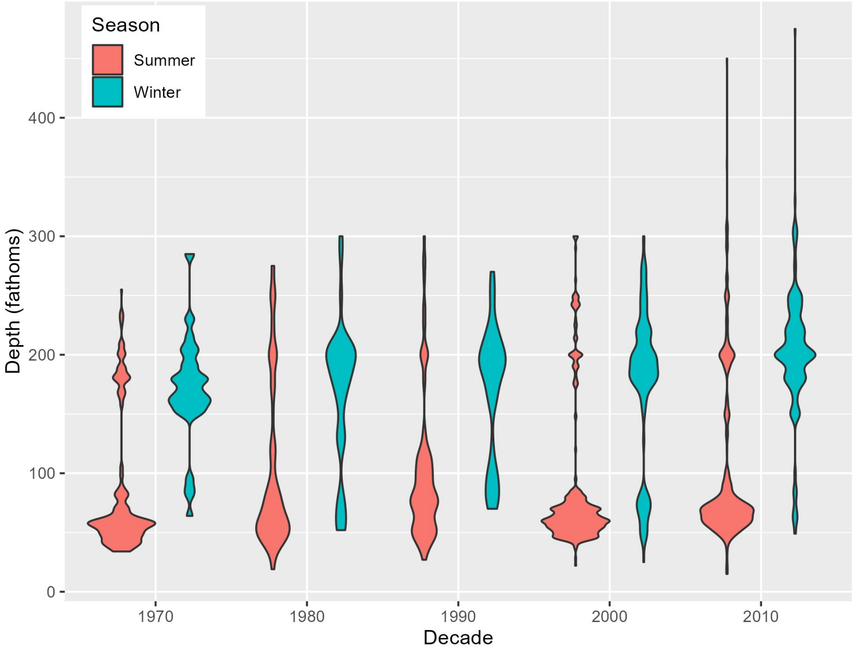


Slide from Haltuch et al. "Reconciling uncertain and conflicting trends in petrale sole abundance" (presentation at 2010 NMFS NSAW meeting)

Modeling issue 2: seasonal structure

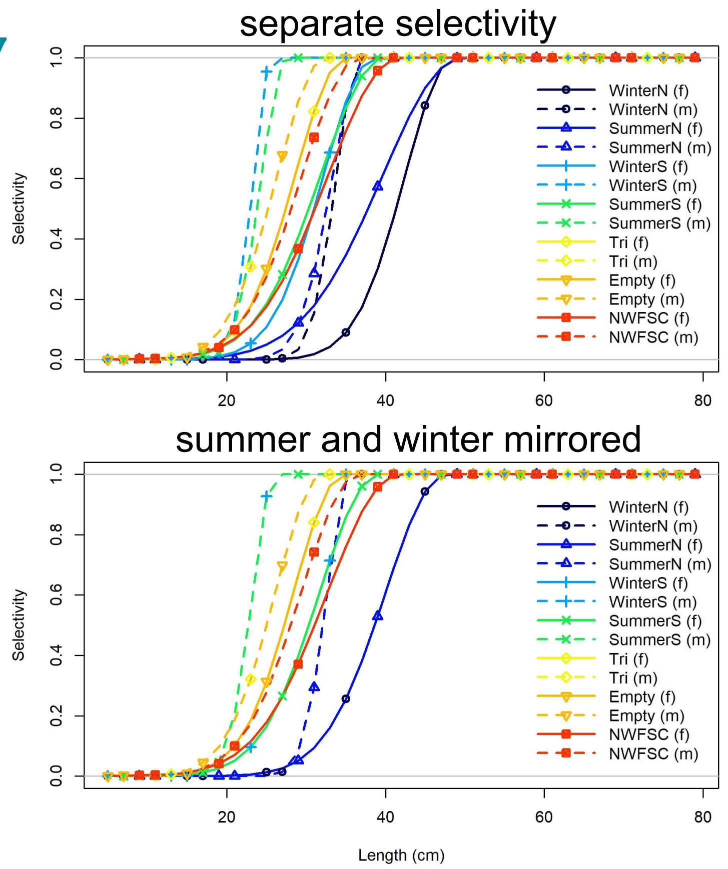
Patterns of winter having more landings from deeper water has continued in recent years





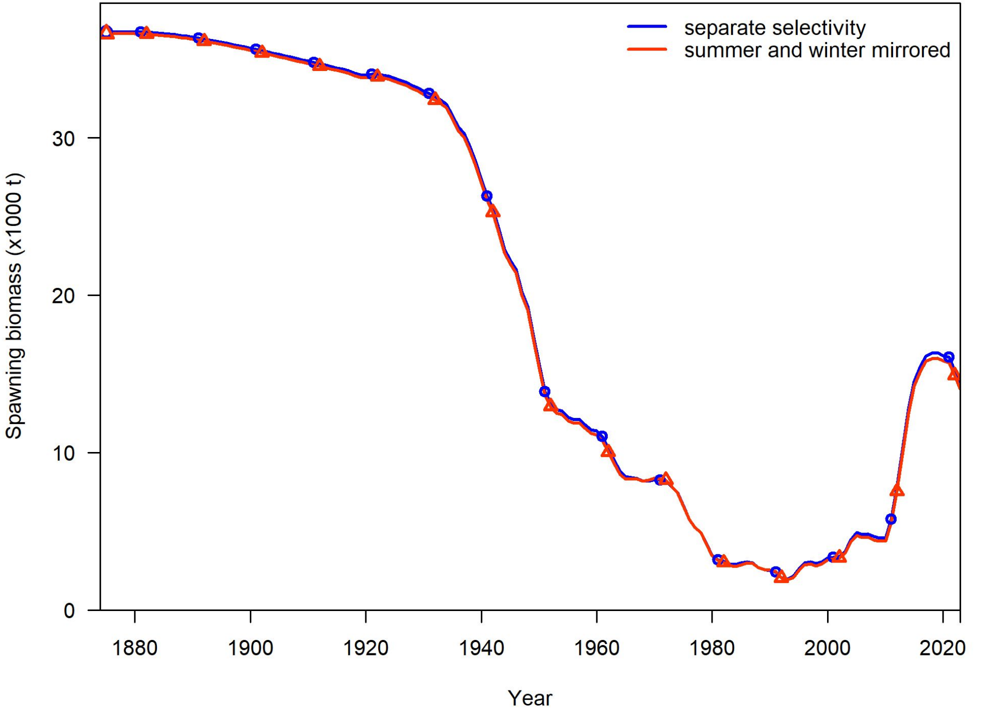
Seasonal structure investigation: impact of separate selectivity

- Separate selectivity parameters for Summer and Winter fisheries in North and South
- Mirroring selectivity requires 22 fewer parameters



Seasonal structure investigation 2: impact of separate selectivity

- Separate selectivity parameters for Summer and Winter fisheries in North and South
- Mirroring selectivity requires 22 fewer parameters
- Mirroring selectivity has negligible impact

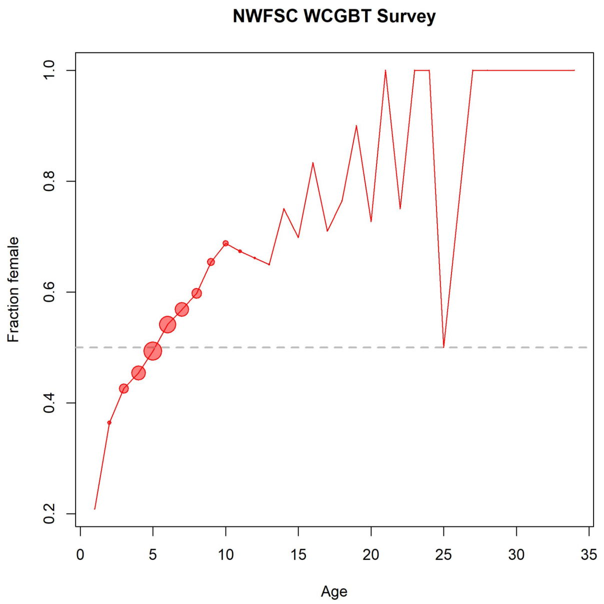


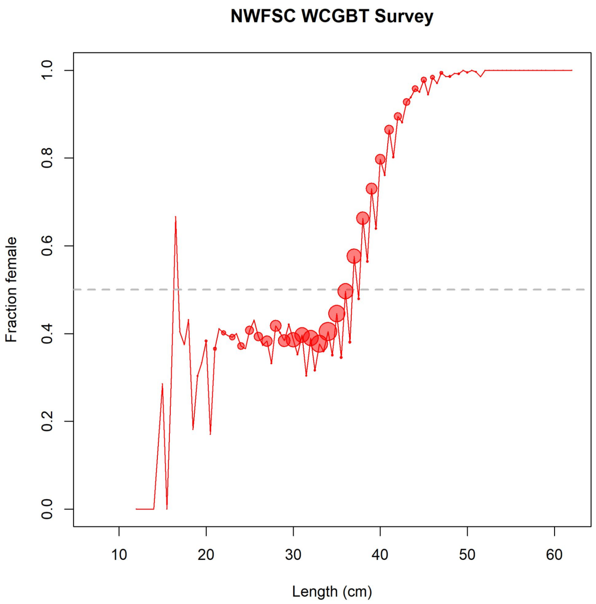
Plan for seasonal structure in 2023 assessment

- We are planning to develop seasonal and annual model in parallel to compare the impact of aggregating all samples to the annual level and adding more recent data to both models
- If results are similar, we are likely to propose the annual model as the basis for management with the seasonal model as a sensitivity analysis
- If results differ significantly (seasonal vs annual), that will be useful information to explore more deeply
- Model that isn't chosen will be sensitivity analysis

Modeling issue 3: sex-specific selectivity

- More males than females in small age and size bins
- Sex-specific selectivity required to get reasonable fit to length comps





Modeling issue 3: sex-specific selectivity

- Many other flatfish have environmental sex determination
- Stock Synthesis includes option to estimate sex ratio of recruits
- Sex-specific selectivity may still be appropriate–we will investigate

Seminars in Cell & Developmental Biology 20 (2009) 256–263

Contents lists available at ScienceDirect

Seminars in Cell & Developmental Biology

journal homepage: www.elsevier.com/locate/semcdb

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Review

Sex determination in flatfishes: Mechanisms and environmental influences

J. Adam Luckenbach*, Russell J. Borski, Harry V. Daniels, John Godwin

Department of Biology, North Carolina State University, Raleigh, NC 27695, USA

A R T I C L E I N F O

Article history:
Available online 11 December 2008

Keywords:
Environmental sex determination
Temperature-dependent sex determination
TSD
Sex differentiation
Aromatase

A B S T R A C T

Flounder of the genus *Paralichthys* exhibit a unique mode of sex determination where both low and high temperatures induce male-skewed sex ratios, while intermediate temperatures produce a 1:1 sex ratio. Male differentiation is thus easily induced in genetic females creating a combination of genetic (GSD) and environmental sex determination (ESD). Since male flounder become reproductively fit at substantially smaller body sizes than females, temperature or other environmental variables that elicit lower growth rates may also influence sex differentiation toward male development. This review covers our current knowledge of sex determination and differentiation in flatfishes including possible adaptive significance of ESD and involvement of factors such as aromatase (*cyp19*).

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SCIENTIFIC REPORTS

OPEN

Warmer waters masculinize wild populations of a fish with temperature-dependent sex determination

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Published online: 25 April 2019

J. L. Honeycutt[1], C. A. Deck[1], S. C. Miller[2], M. E. Severance[1], E. B. Atkins[1], J. A. Luckenbach[3], J. A. Buckel[2], H. V. Daniels[2], J. A. Rice[2], R. J. Borski[1] & J. Godwin[1]

Southern flounder (*Paralichthys lethostigma*) exhibit environmental sex determination (ESD), where environmental factors can influence phenotypic sex during early juvenile development but only in the presumed XX female genotype. Warm and cold temperatures masculinize fish with mid-range conditions producing at most 50% females. Due to sexually dimorphic growth, southern flounder fisheries are dependent upon larger females. Wild populations could be at risk of masculinization from ESD due to globally increasing water temperatures. We evaluated the effects of habitat and temperature on wild populations of juvenile southern flounder in North Carolina, USA. While northern habitats averaged temperatures near 23 °C and produced the greatest proportion of females, more southerly habitats exhibited warmer temperatures (>27 °C) and consistently produced male-biased sex ratios (up to 94% male). Rearing flounder in the laboratory under temperature regimes mimicking those of natural habitats recapitulated sex ratio differences observed across the wild populations, providing strong evidence that temperature is a key factor influencing sex ratios in nursery habitats. These studies provide evidence of habitat conditions interacting with ESD to affect a key demographic parameter in an economically important fishery. The temperature ranges that yield male-biased sex ratios are within the scope of predicted increases in ocean temperature under climate change.

Modeling issue 4: environmental recruitment index

- Published in 2019
- Environmental driver of recruitment estimated from oceanographic data covering the period 1981–2010
- “Four oceanographic variables explained 73% of the variation in recruitment not accounted for by estimates based exclusively on the spawning stock size.”
- Nick Tolimieri is in the process of extending index to recent years
- We are hoping to include this in the 2023 assessment

ORIGINAL ARTICLE

FISHERIES OCEANOGRAPHY WILEY

Oceanographic drivers of petrale sole recruitment in the California Current Ecosystem

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Abstract

This paper investigates environmental drivers of U.S. West Coast petrale sole (*Eopsetta jordani*) recruitment as an initial step toward developing an environmental recruitment index that can inform the stock assessment in the absence of survey observations of age-0 and age-1 fish. First, a conceptual life history approach is used to generate life-stage-specific and spatio-temporally specific mechanistic hypotheses regarding oceanographic variables that likely influence survival at each life stage. Seven life history stages are considered, from female spawner condition through benthic recruitment as observed in the Northwest Fisheries Science Center West Coast Groundfish Bottom Trawl Survey (age-2 fish). The study area encompasses the region from 40 to 48°N in the California Current Ecosystem. Hypotheses are tested using output from a regional ocean reanalysis model outputs and model selection techniques. Four oceanographic variables explained 73% of the variation in recruitment not accounted for by estimates based exclusively on the spawning stock size. Recruitment deviations were (a) positively correlated with degree days during the female precondition period, (b) positively correlated with mixed-layer depth during the egg stage, (c) negatively correlated with cross-shelf transport during the larval stage, and (d) negatively correlated with cross-shelf transport during the benthic juvenile stage. While multiple mechanisms likely affect petrale sole recruitment at different points during their life history, the strength of the relationship is promising for stock assessment and integrated ecosystem assessment applications.

Additional activities

Collaboration with Canadian scientists

- An assessment is being conducted for Petrale Sole in Canadian waters in 2023
  - First since 2009
  - Led by Mackenzie Mazur and Kendra Holt at DFO
- Planned collaborations in 2023 include:
  - Comparison of index trends on both sides of the border
  - Comparison of length comps, especially from the Triennial in years that include BC waters
  - Comparison of estimated recruitment time-series
  - Sensitivity analysis to including catch and possibly comps and/or index from Canada as an additional fleet in the U.S. assessment and maybe the opposite in the Canadian assessment
- Petrale is a transboundary stock
  - The most recent STAR panel (2013) recommended including more information about the petrale fishery in Canada in future assessment reports

Questions, comments, concerns?

Large petrale catch from 15 minute tow in 2021 WCGBT Survey, photos by John Buchanan