Ecology and Management of North Pacific Armorhead in International Waters of the North Pacific

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**Members of NPFC's Small Working Group on North Pacific Armorhead and Splendid Alfonsino*

What is a North Pacific Armorhead?

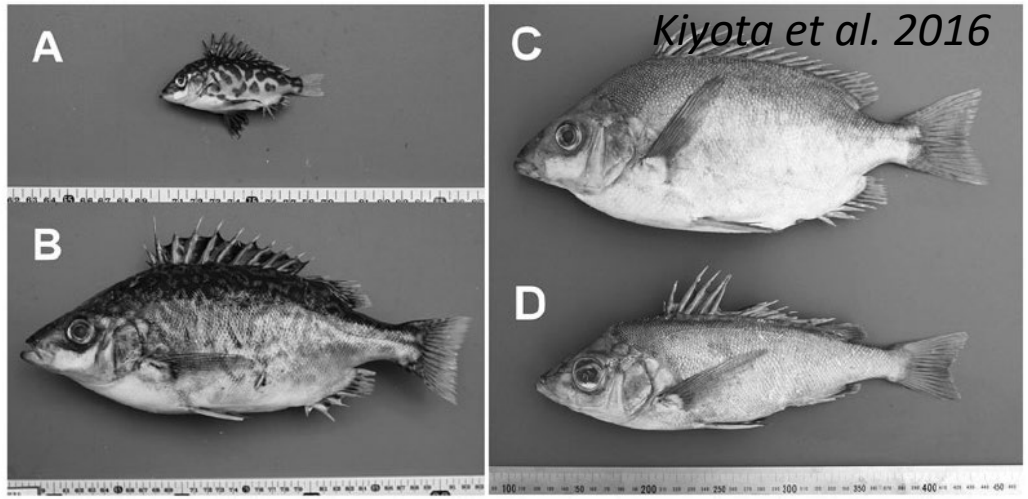
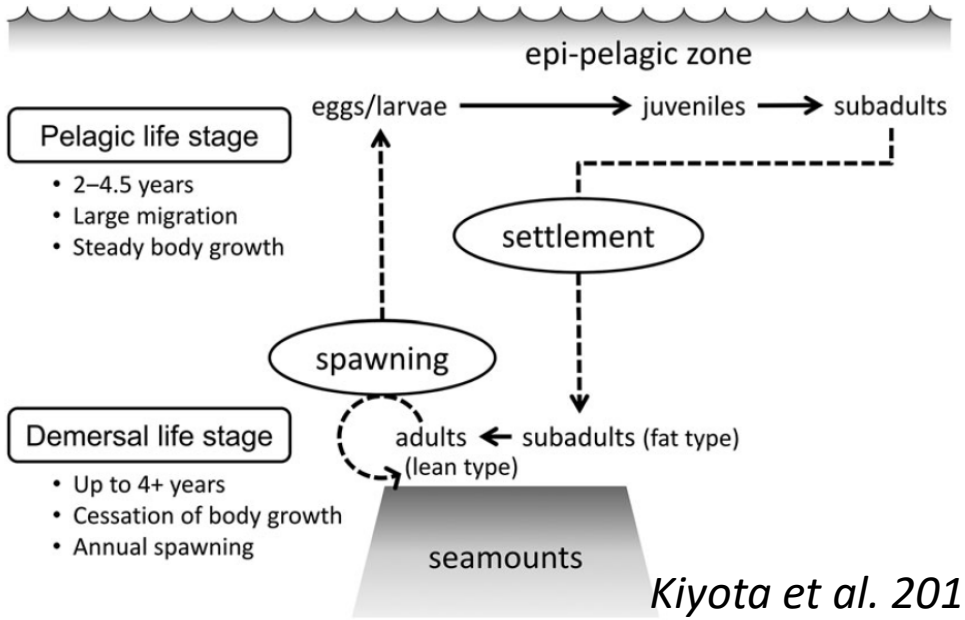
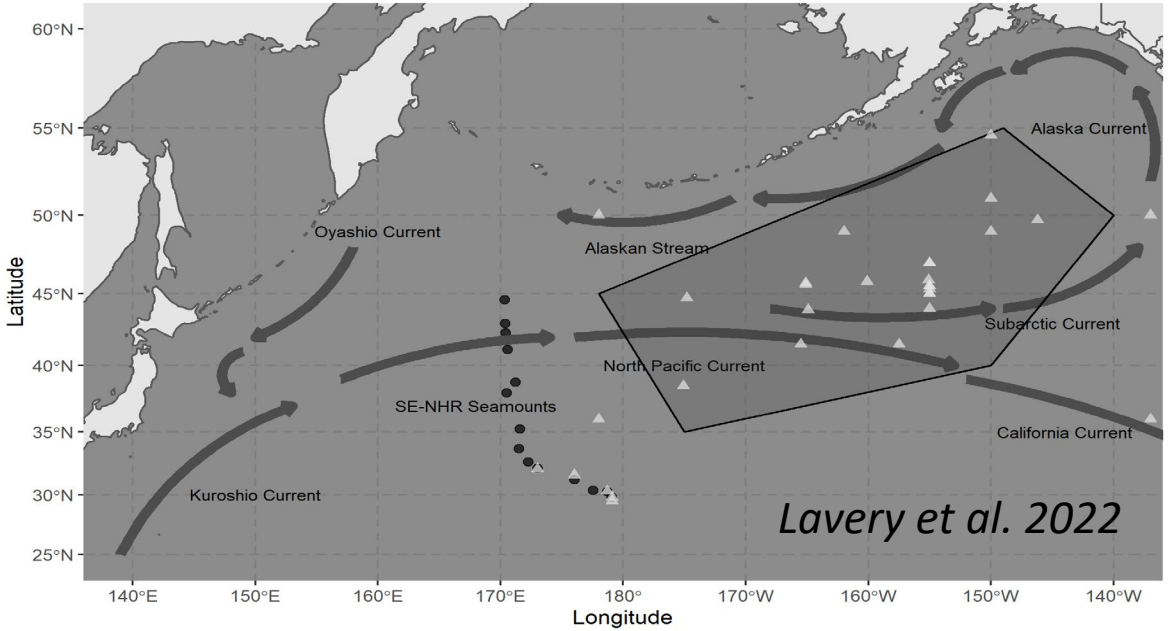


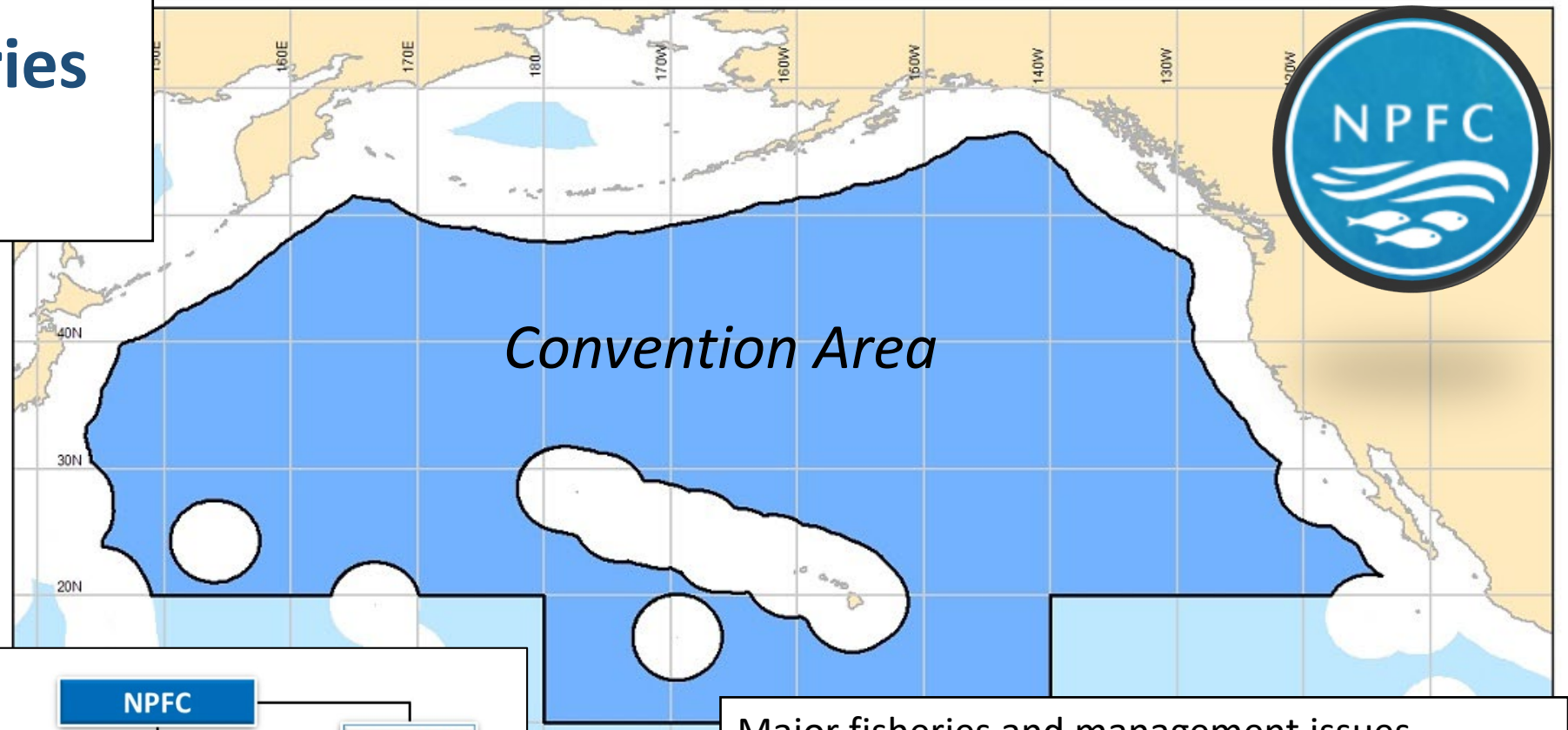
FIGURE 1. Photographs of *Pentaceros wheeleri*. (*A*) Pelagic juvenile, (*B*) pelagic subadult, (*C*) demersal adult (fat type), (*D*) demersal adult (lean type).



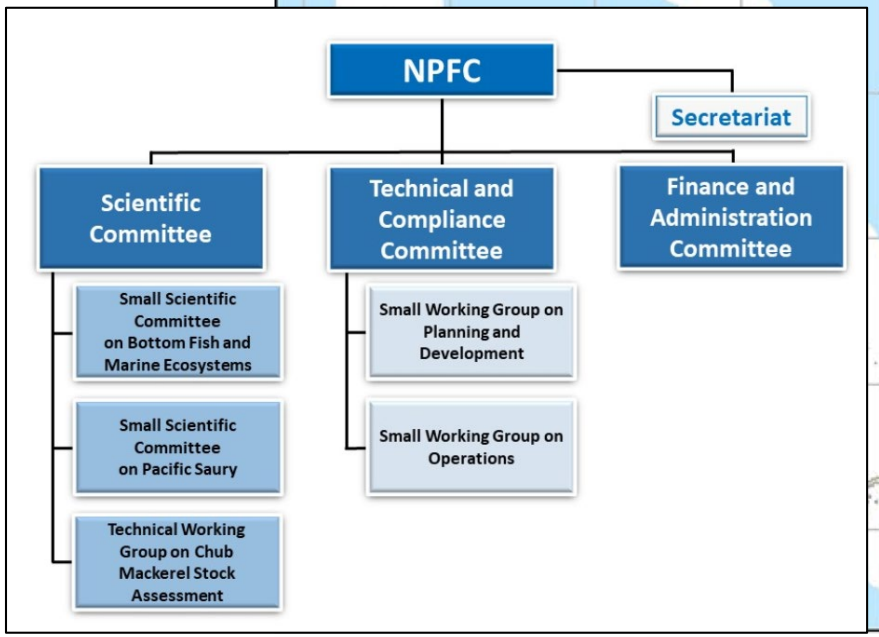
Kiyota et al. 2016



North Pacific Fisheries Commission

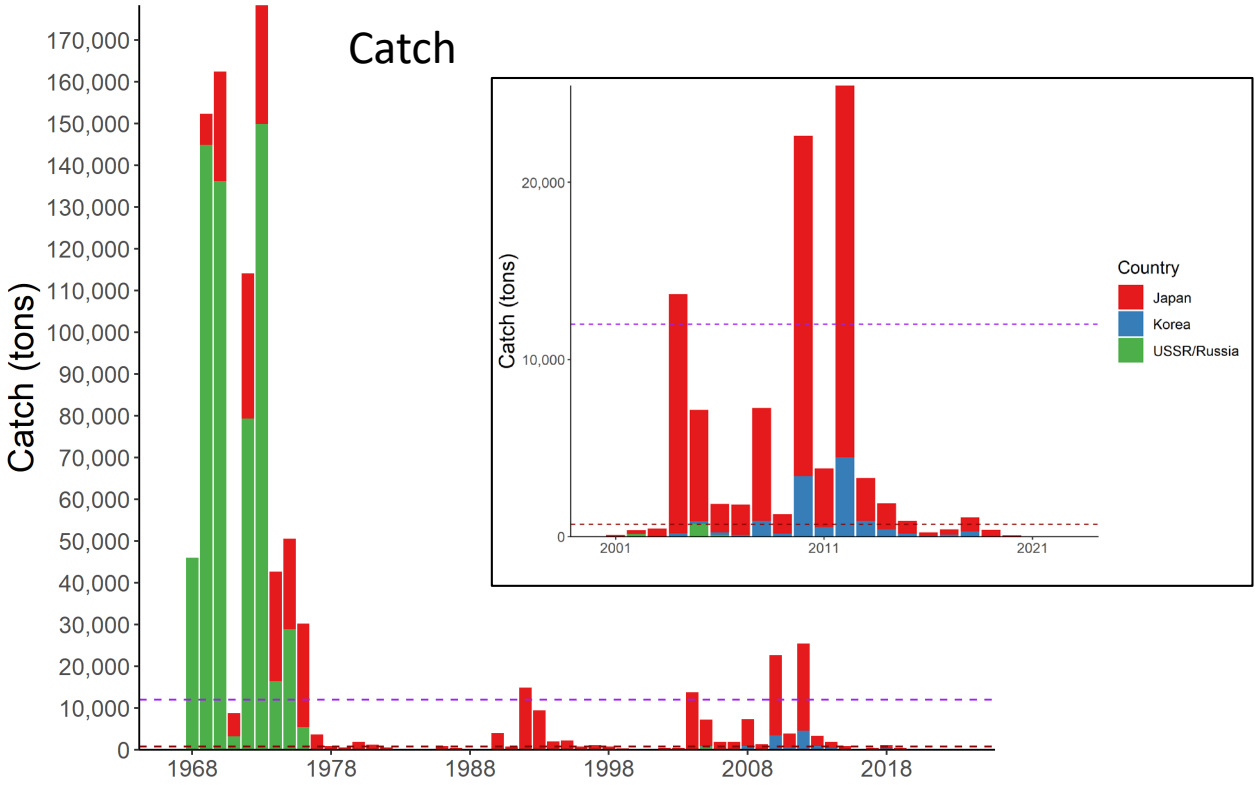


Members
Canada
China
Chinese Taipei
European Union
Japan
Korea
Russian Federation
USA
Vanuatu

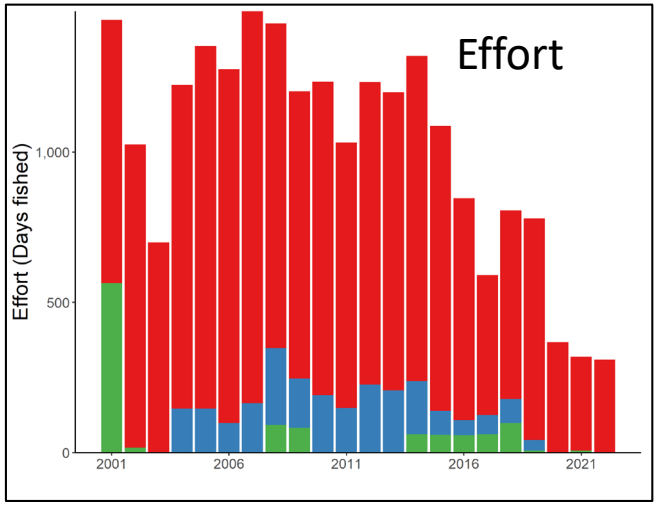


Major fisheries and management issues
Pacific saury
Chub and blue mackerel
Japanese sardine
Squids (neon flying, Japanese)
North Pacific Armorhead
Splendid alphonsino
Sablefish
Other bycatch species
Vulnerable Marine Ecosystems (corals/sponges)

Historical Fishing and Management (requires consensus among Members)



- Bottom trawl and sunken gillnet gear
- Heavily exploited in 1960's-1970's
  - Russia, Japan
  - Included seamounts in US waters
- Recent catches have relied on "strong" recruitment events
  - Japan, Korea
- Effort has declined in last decade
  - Only a single trawler and gillnetter from Japan
  - Splendid Alfonsino also targeted (also at historical low catches)
- Limited catch or effort limits – encouraged catch levels for high (12,000 t) and low (700 t) recruitments
- Total Japan catch cannot exceed 15,000 t, number of vessels set at historical levels
- Closure during November-December to protect spawning
- Recruitment monitoring carried out by fishery



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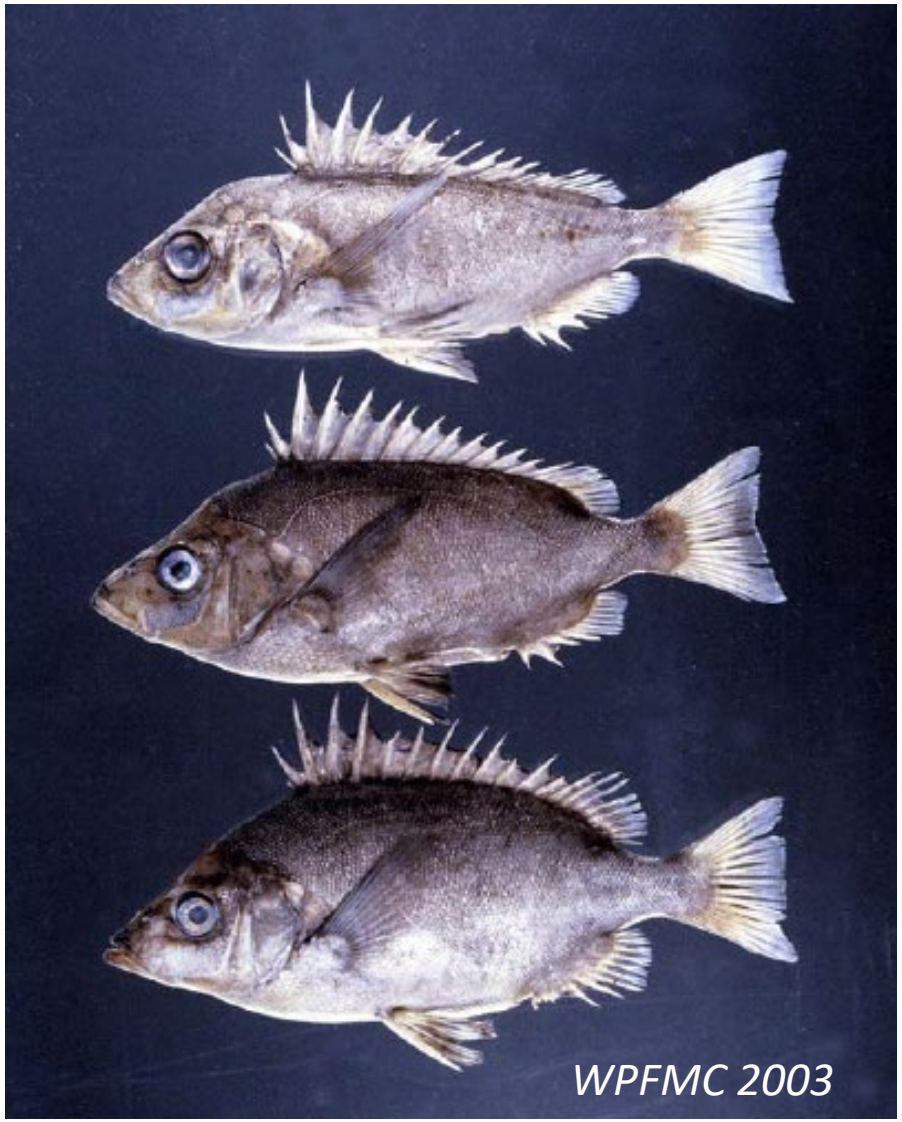
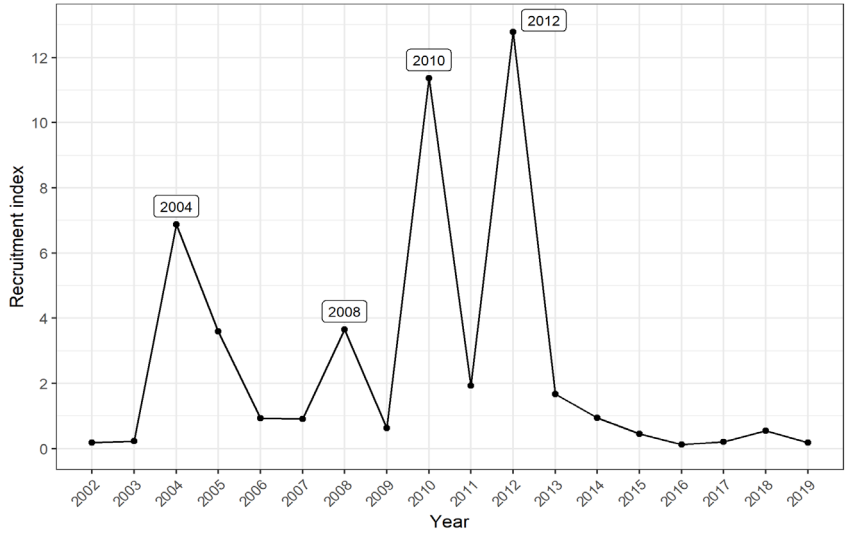


Analysis of recruitment relationships to oceanography (Lavery et al. 2022 – Fisheries Oceanography)

Objectives

- Compare recruitment in NPA and large-scale oceanographic conditions
- Investigate NPA recruitment pathways using lagrangian particle tracking approach (OceanParcels)
- Examine larval dispersal in relation to presumed nursery grounds in the northeast Pacific



Received: 10 February 2022 | Revised: 2 September 2022 | Accepted: 5 September 2022
DOI: 10.1111/fog.12612

ORIGINAL ARTICLE

FISHERIES OCEANOGRAPHY WILEY

Effects of oceanography on North Pacific armorhead recruitment in the Emperor Seamounts

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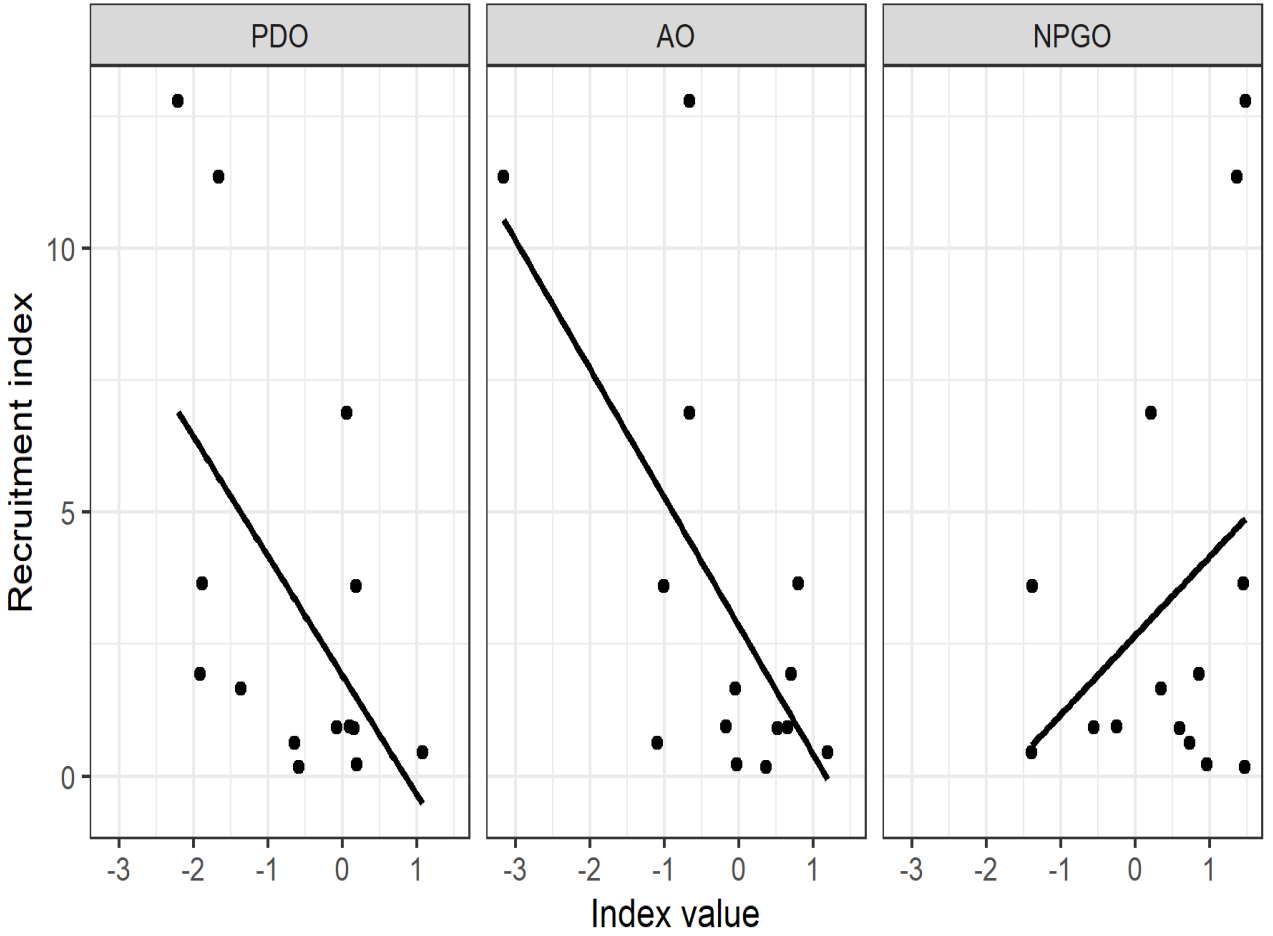
Abstract

The North Pacific armorhead (NPA), *Pentaceros wheeleri*, is thought to exhibit an extended post-spawning epipelagic phase in which larvae disperse to the northeast Pacific Ocean. Current understanding of juvenile distribution, development, and mechanisms that drive recruitment variation, however, remains largely incomplete. The objective of this study was to compare a time series of NPA recruitment to established climate indices and to environmental covariates to explore drivers of the NPA life cycle. Additionally, this work investigates potential larval NPA transport pathways and their positional relationships to the proposed northeastern nursery grounds. Using Lagrangian particle tracking, trajectories of passive larvae were simulated at depths of 0 and 15 m for 18 years (2001–2018) from the Southern Emperor-Northern Hawaiian Ridge (SE-NHR) natal habitat. Dispersal distances and particle

Climate correlation analysis

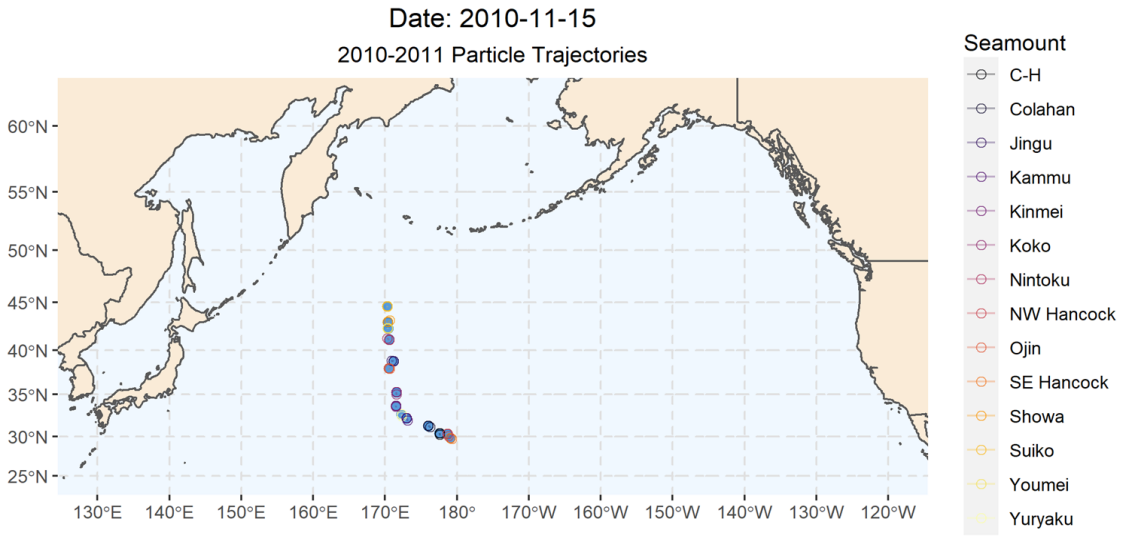
- Indices found to exhibit correlation with recruitment index
  - AO during winter months December-February (R^2 =0.435, p =0.003)
  - PDO during summer months from June-August (R^2 = 0.35, p= 0.01)
  - NPGO during spring months from March-May (R^2 =0.23, p =0.04)

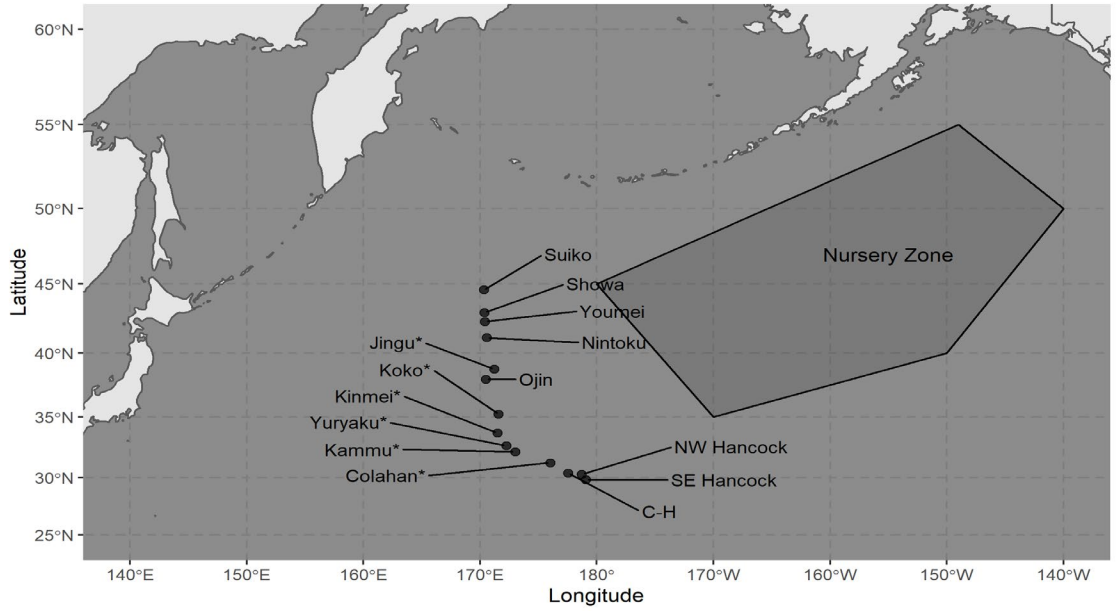
  - Autocorrelation in the recruitment index was low (r = 0.34 at 2 year lag) but sample size was small



Methods

- Recruitment time series estimated from mean of annual catch for 2002-2019
- Common climate indices obtained: PDO, AO, NPGO, ALPI, NPI, ONI
- Ocean surface current dataset at 0 m depth and 15 m depth obtained from the Globcurrent project (https://marine.copernicus.eu) for 2001-2018
- Implemented OceanParcels virtual particle simulator (https://oceanparcels.org/)
- Released particles daily for 120 days from 6 central SE-NHR seamounts over November-March spawning season
- Linear regression and generalized additive models fit to explore relationship between recruitment and environmental variables



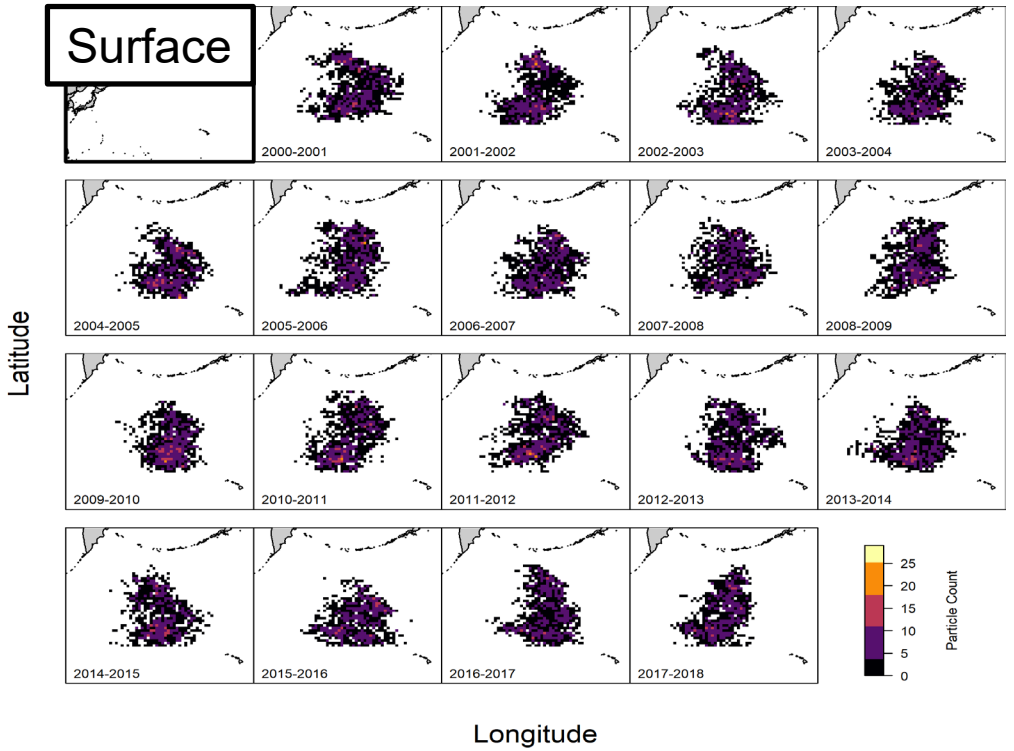


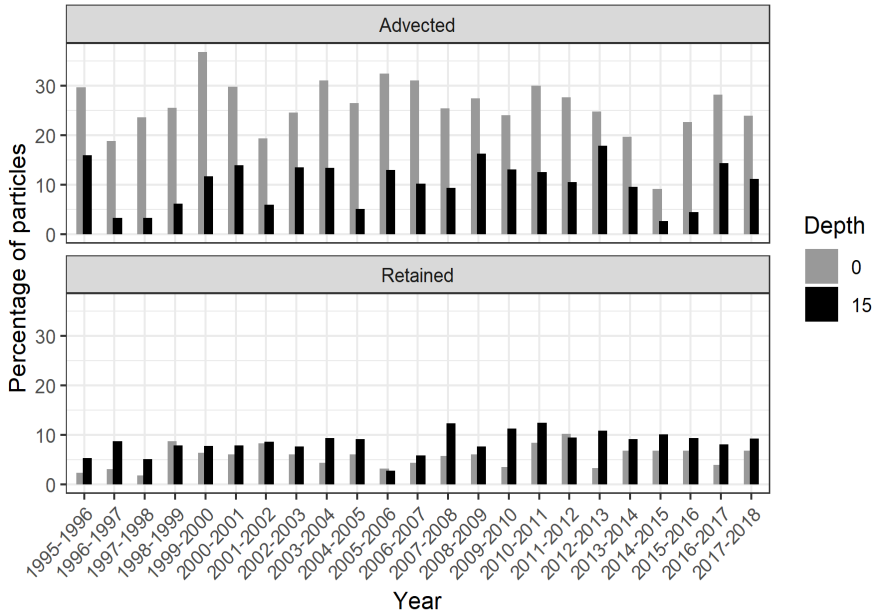
Particle advection

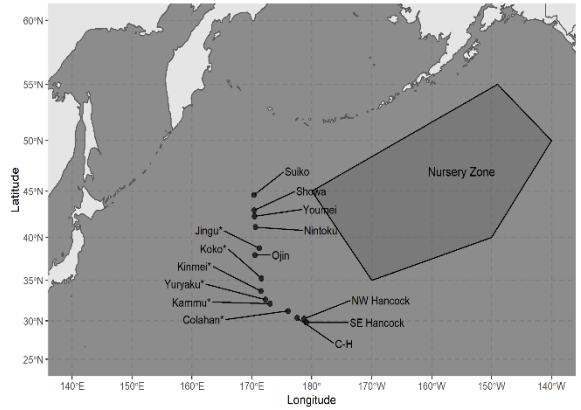
- Compared recruitment index at both a 1 year and 2 year lag to particle trajectory data; straight line distance, cumulative distance, end longitude and end latitude

- Calculated % particles retained at SE-NHR and % particles advected towards nursery

- Moderately significant relationship between recruitment and % particles advected to nursery at 1 year lag (p= 0.031, r^2=0.26)







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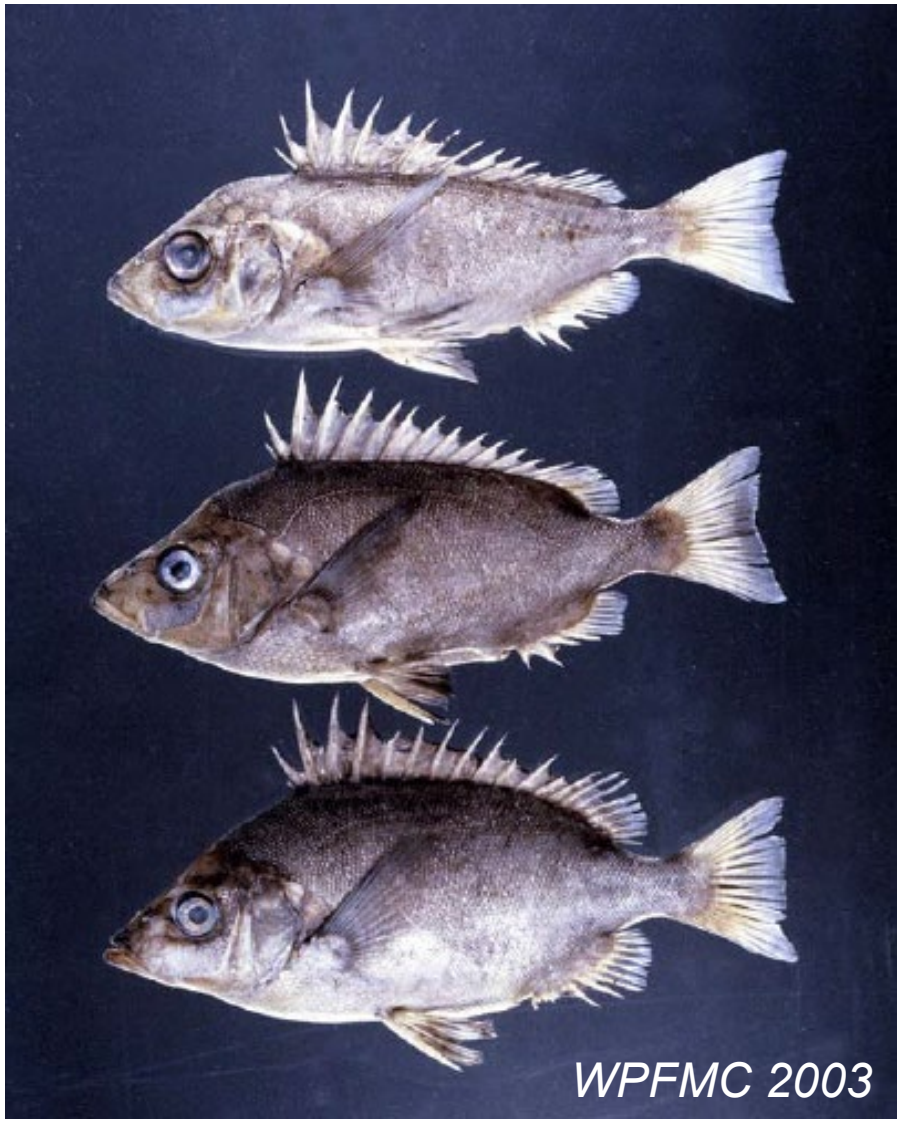
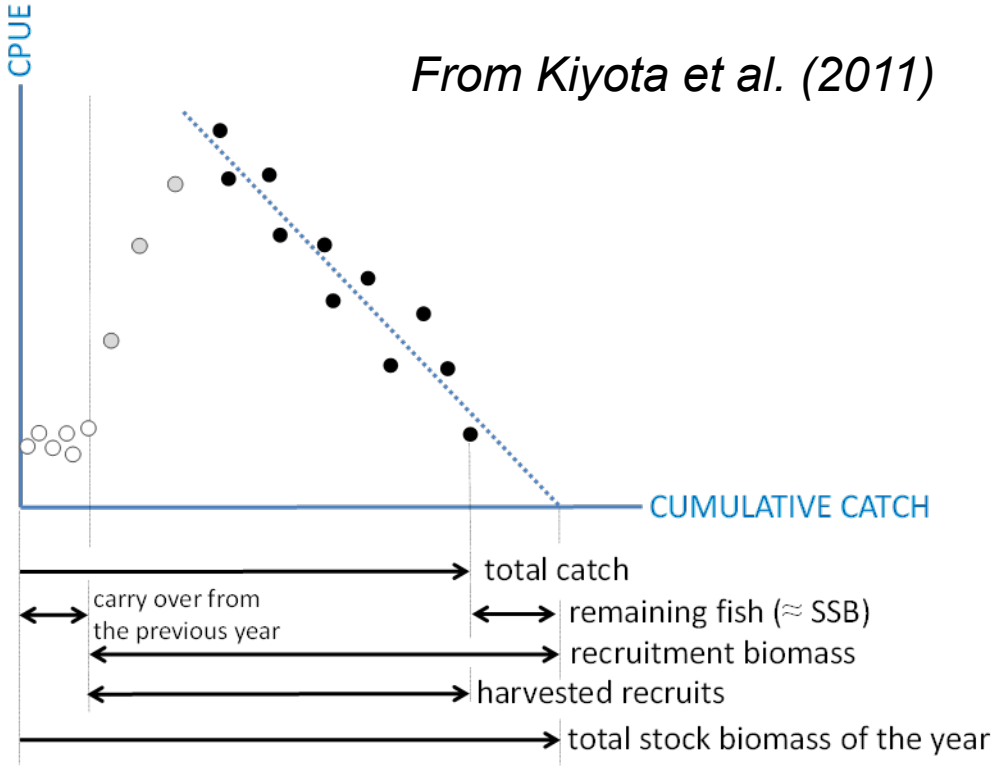


Methods: Fitting SR relationship – without S or R



From Kiyota et al. (2011)

Potential sources

- Kiyota et al. 2014 depletion estimates by seamount of SSB
  - 2005-2012
- Somerton and Kikkawa 1992
  - 1978-1983, lost to history(?)
- Monthly catch by seamount from Wetheral and Yong (1986)
  - 1969-1981
- Borets 1975
  - 1968-1975, age structured model, ages questioned
- Monitoring survey
  - 2017-2023, different type of recruitment time series and no SSB

Methods

Simple Ricker S-R curve with environmental covariates (Quinn and Deriso 1999, Dorn 2002)

Arctic Oscillation (Hamouda et al. 2021)

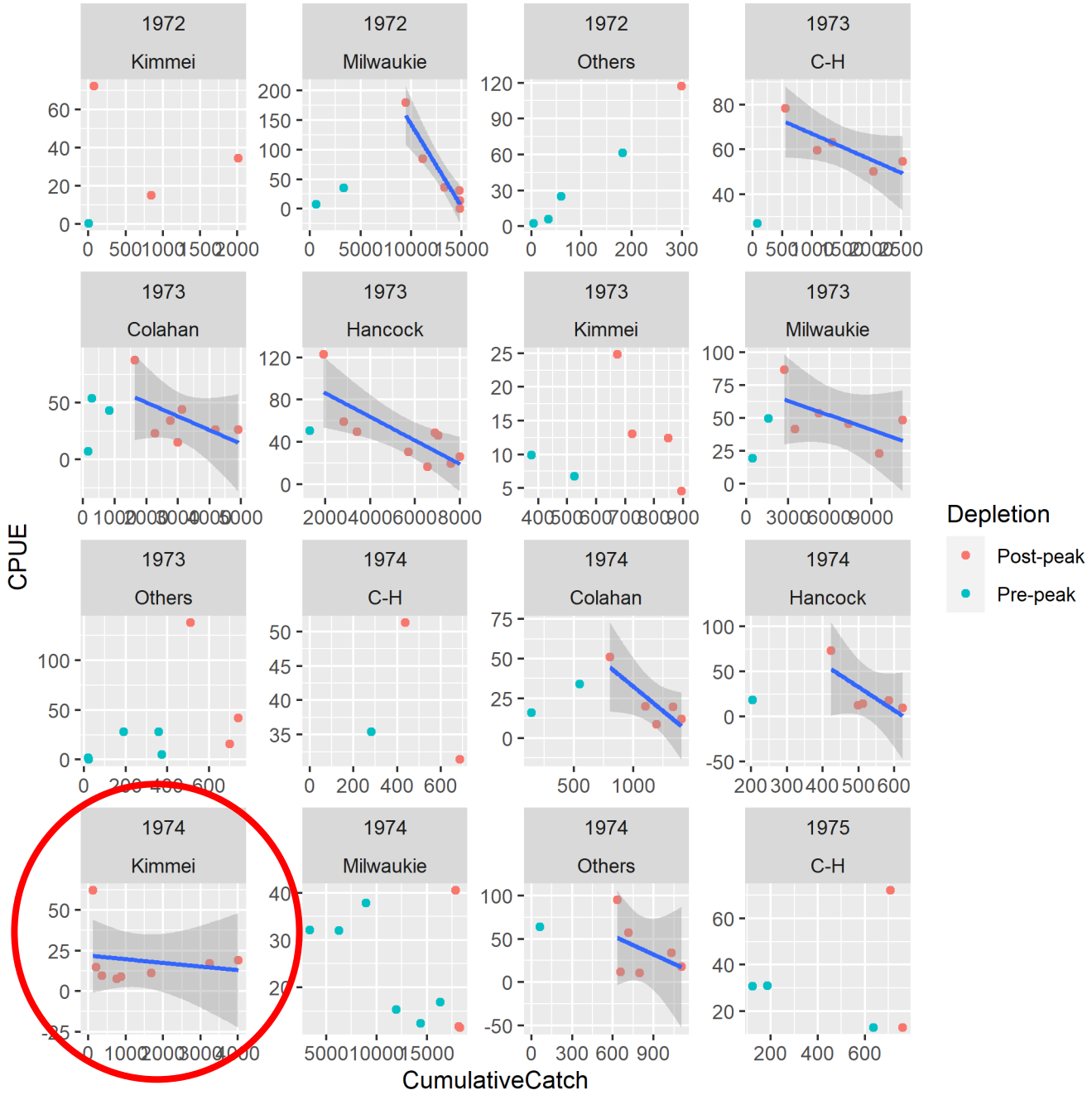
NWS Climate Prediction Center (https://cps.ncep.noaa.gov)

Aleutian Low Pressure Index (Surry and King 2015)

NCAR Research Data Archive (https://rda.ucar.edu/)

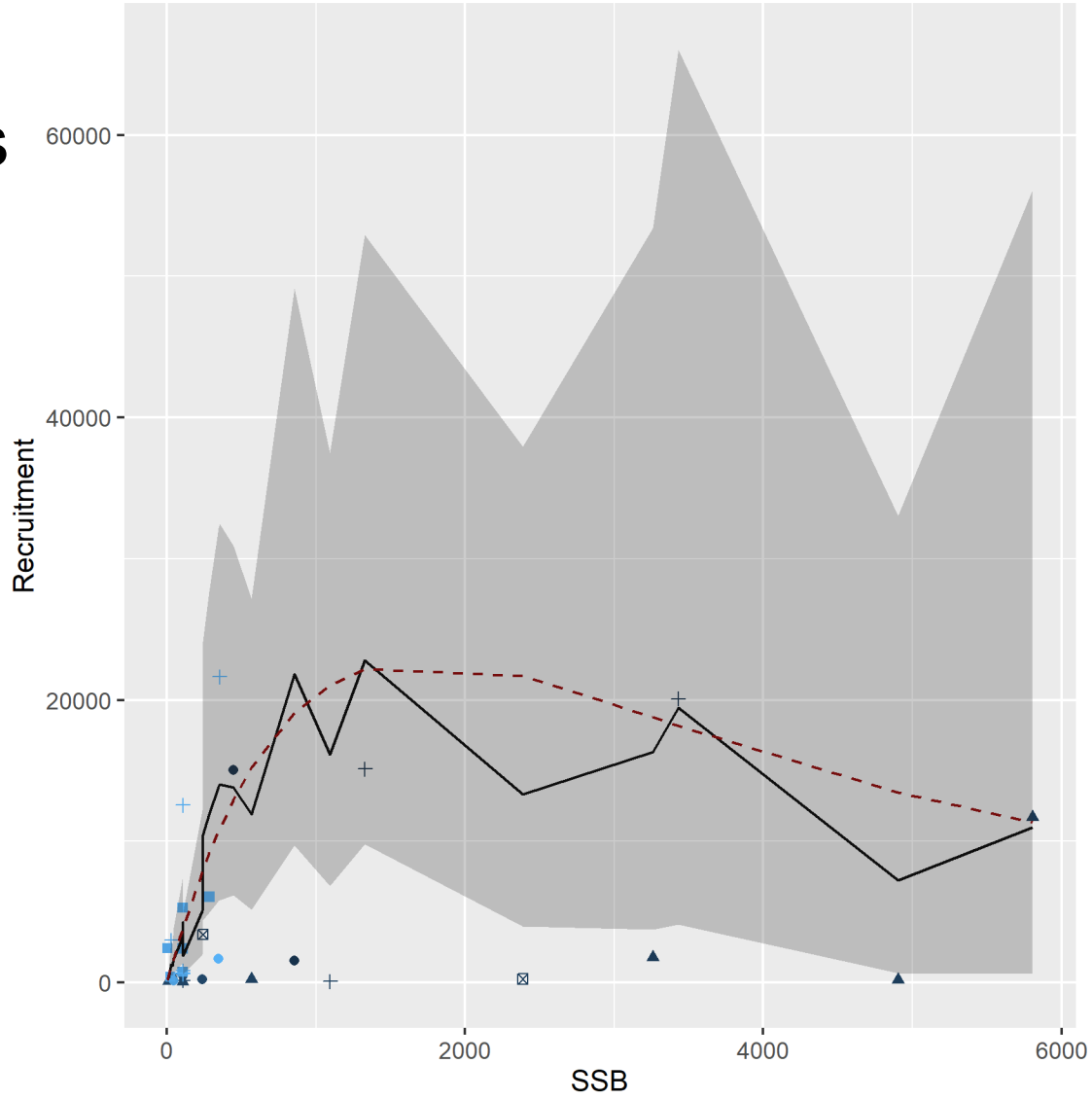
Bayesian w/ R and Stan (https://www.weirdfishes.blog/blog/fitting-bayesian-models-with-stan-and-r/)

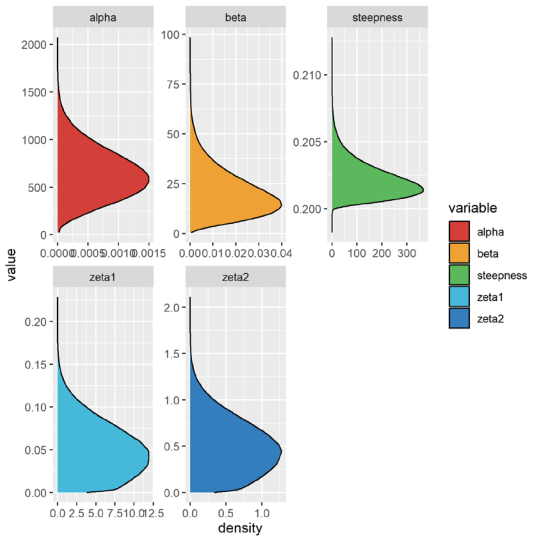
Depletion estimates



Results & Conclusions

- N = 32 year/seamount combinations
- Model explains ~28% of recruitment variability
- Unsatisfying 95% credible intervals
- Need better and more data in order to make this work





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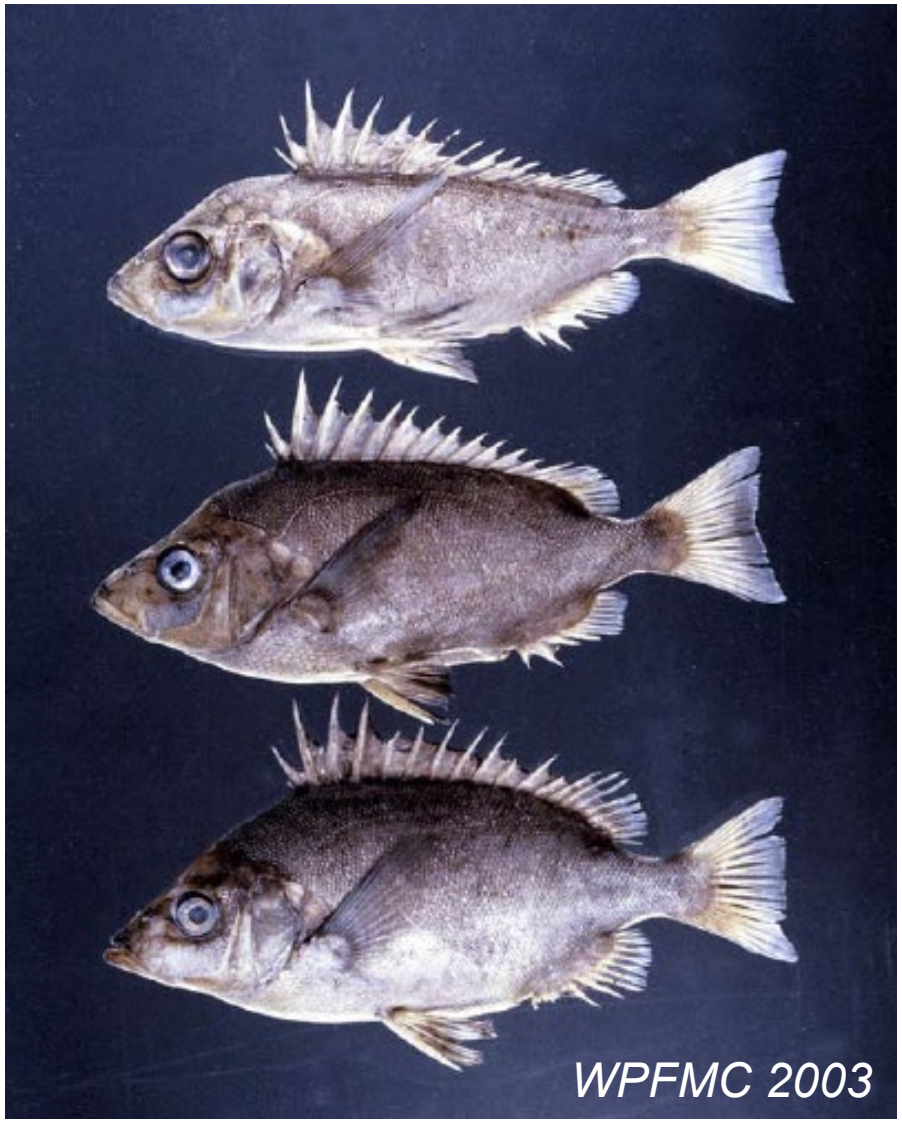
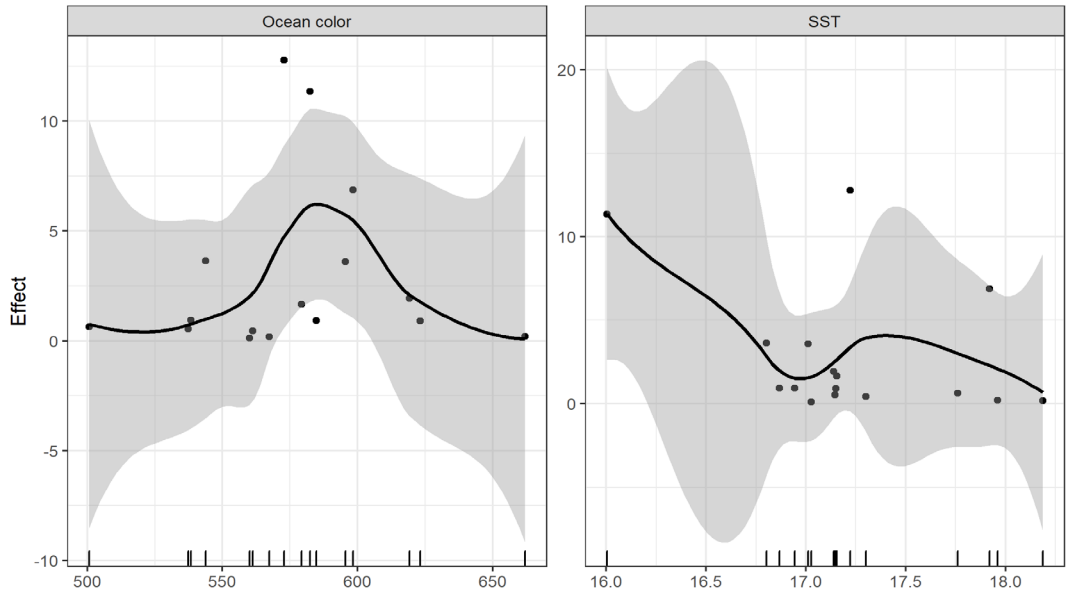
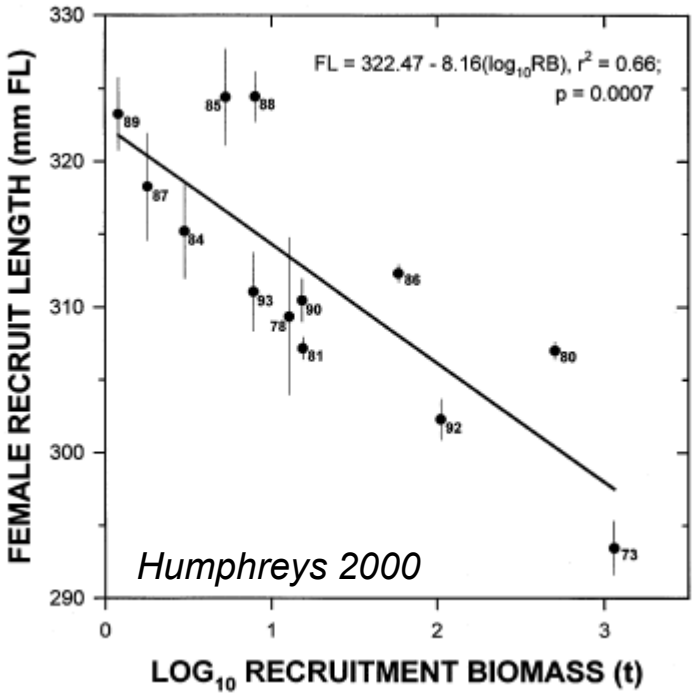
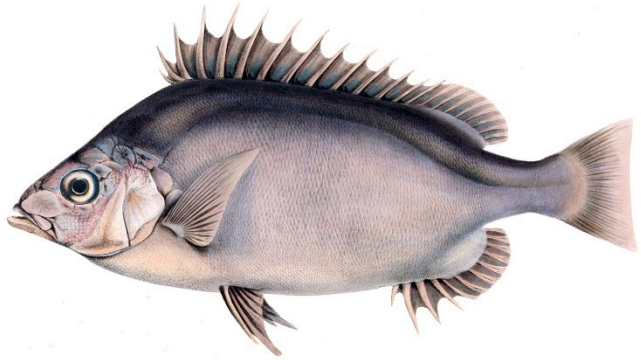


Recruitment mechanisms?

- Non-linear relationships between recruitment and SST and yearly mean chlorophyll-a
- Humphreys 2000 study found strong correlation between size of recruits and recruitment biomass
- Faster growth = Shorter pelagic duration = Less mortality?







Life history based model

Egg production

SSB/Fecundity at size/age

- Randomly eaten (M = 0.54, Somerton and Kikkawa 1992)?
- Shrank to fatness ratio of 0.1?
- Captured by fishery (F)

Egg/larval stages

- Drifted to nursery in 120 days? (Lavery, Yonezaki et al 2017)
- Grew to 42 mm? (21-50 mm) (Murakami et al 2016, Boehlert and Sasaki)

Drift model

Spatially explicit bioenergetics/growth

Mortality & time

Mortality * time

Spatially explicit bioenergetics/ negative growth

Pelagic juveniles

- Randomly eaten (M)?
- Grew to 27 cm? (15-33 cm) (Humphreys et al. 2000)
- Achieved fatness ratio of 0.2?

Spatially explicit bioenergetics/growth

Mortality * time

Settlement to benthos

Adult

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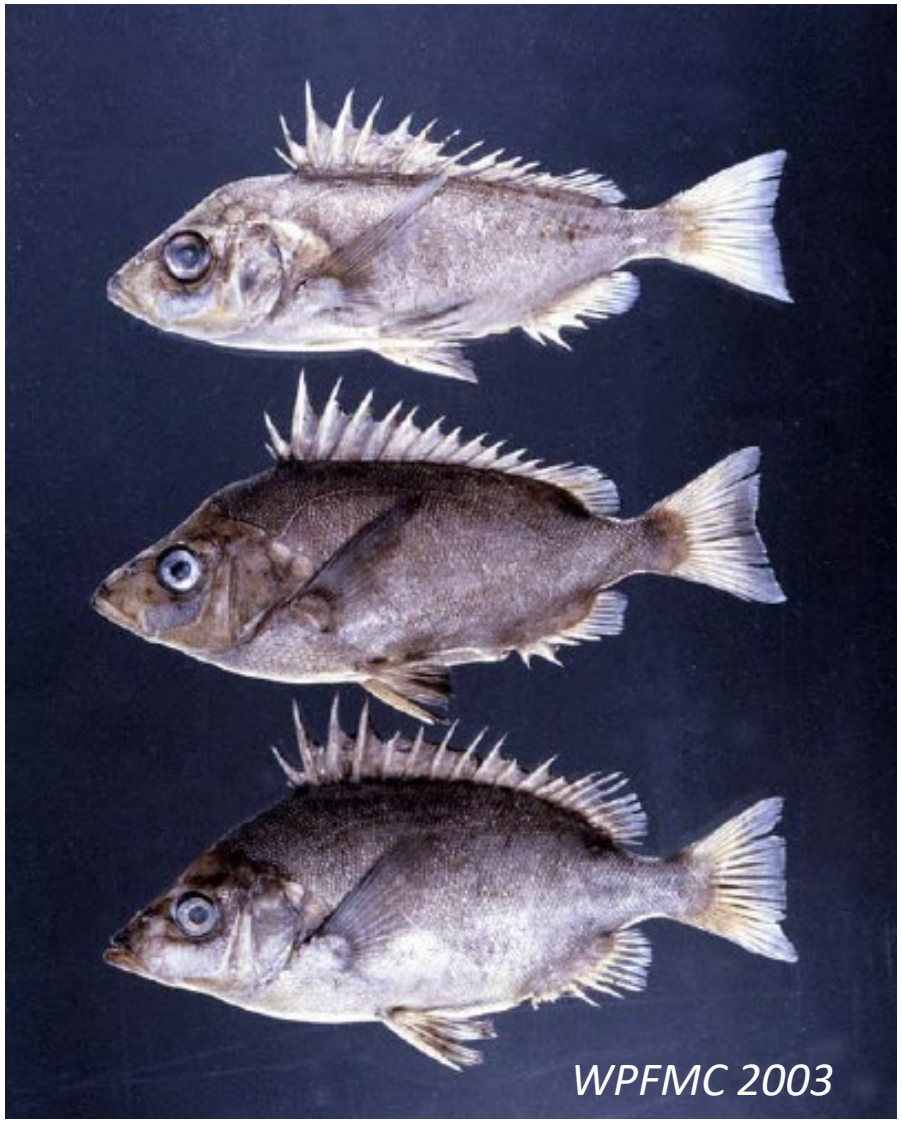
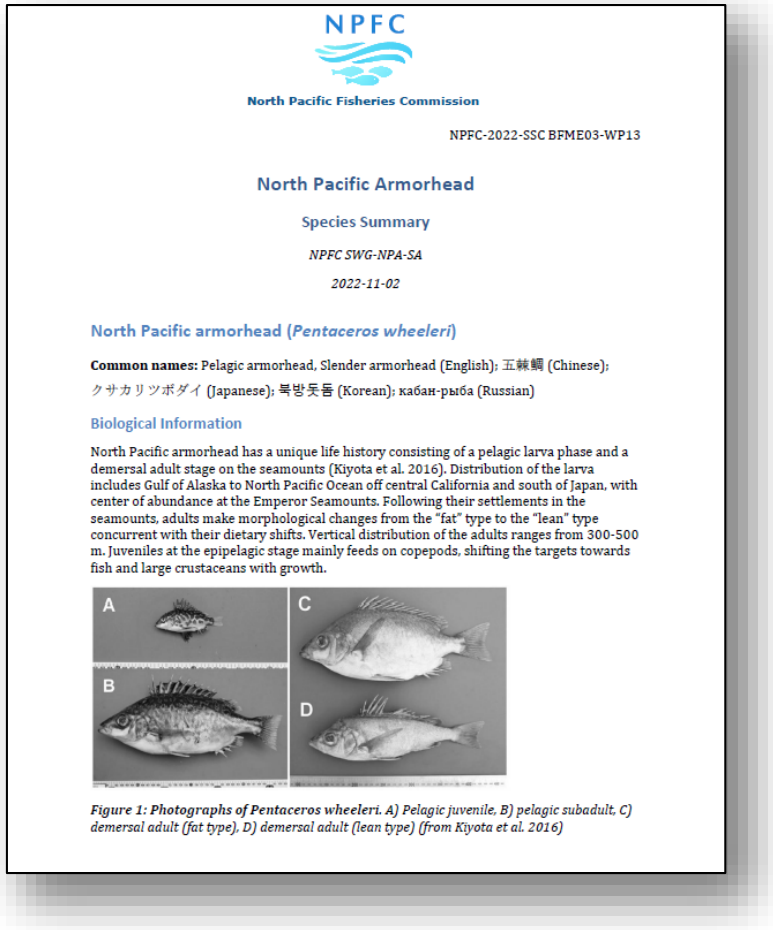


Other ongoing work by Members and the SWG NPA & SA

- Exploration of growth curve from length frequency distributions
- Fecundity by length (+) and fecundity by fatness ratio (--)
- Continuing work to standardize commercial CPUE
- Exploration of acoustic survey methods (Japan)
- Species summaries (updated annually)



NPFC

North Pacific Fisheries Commission

NPFC-2022-SSC BFME03-WP13

North Pacific Armorhead

Species Summary

NPFC SWG-NPA-SA

2022-11-02

North Pacific armorhead (*Pentaceros wheeleri*)

Common names: Pelagic armorhead, Slender armorhead (English); 五棘鯛 (Chinese); クサカリツボダイ (Japanese); 북방돗돔 (Korean); кабан-рыба (Russian)

Biological Information

North Pacific armorhead has a unique life history consisting of a pelagic larva phase and a demersal adult stage on the seamounts (Kiyota et al. 2016). Distribution of the larva includes Gulf of Alaska to North Pacific Ocean off central California and south of Japan, with center of abundance at the Emperor Seamounts. Following their settlements in the seamounts, adults make morphological changes from the "fat" type to the "lean" type concurrent with their dietary shifts. Vertical distribution of the adults ranges from 300-500 m. Juveniles at the epipelagic stage mainly feeds on copepods, shifting the targets towards fish and large crustaceans with growth.

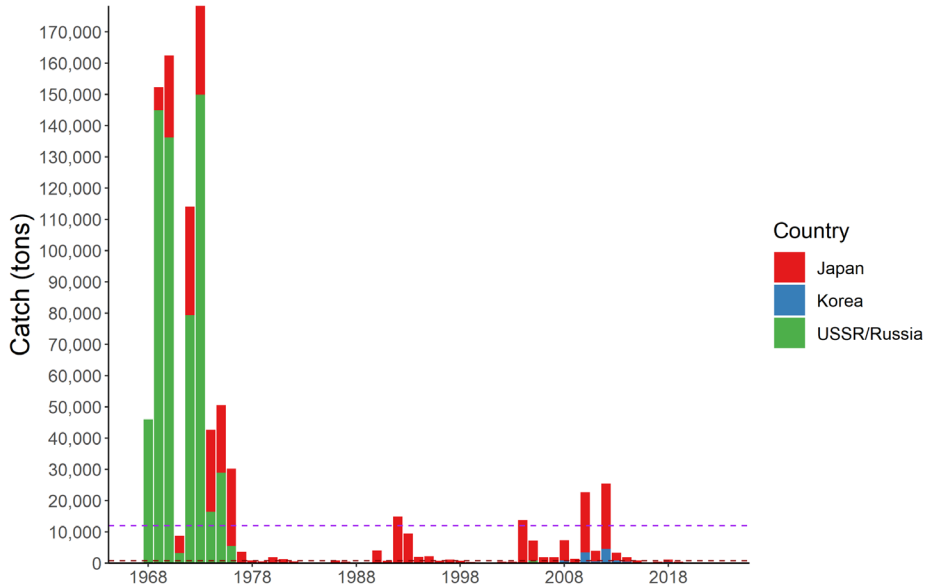
Figure 1: Photographs of Pentaceros wheeleri. A) Pelagic juvenile, B) pelagic subadult, C) demersal adult (fat type), D) demersal adult (lean type) (from Kiyota et al. 2016)

Next steps

- Filling the boxes on conceptual/IBM/Bioenergetics modeling
- Alternative life history based methods for assessment
- Insert your great idea here _____

Summary and Conclusions

- NPA has a strange life history
- Some evidence of environmental correlations with recruitment and SSB
- Episodic recruitment is difficult to predict
- Catch sustained by large recruitment events – none since 2012
- Commercial extinction in the next few years or a new “boom”?
- Limited data on this species so providing advice is challenging



Acknowledgements

- Merrill Rudd (Scaleability)
- Robert Humphreys (PIFSC retired)
- Masashi Kiyota, Shiroh Yonezaki, Bungo Nishizawa, Taro Ichii, Takaaki Hasegawa (NRIFSF – JFREA)
- Jennifer Boldt, Mackenzie Mazur (DFO)
- Sonia Batten (PICES), Clare Ostle (MBA)
- Jodi Pirtle, Pete Hulson, Kalei Shotwell, Georgina Gibson (NOAA AFSC & AKR)
- Gordon Kruse (UAF retired)
- Janelle Curtis, Alex Zavolokin (NPFC)
- Andy Mezirow (Gray Light Sportfishing)

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