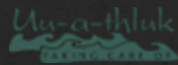


05/05/2026

Modelling predator-prey dynamics for a rebuilding Pacific Herring population

Presenter: Jaclyn Cleary



The Team



Jaclyn Cleary



Ashleen Benson



Sean Cox



Sam Johnson

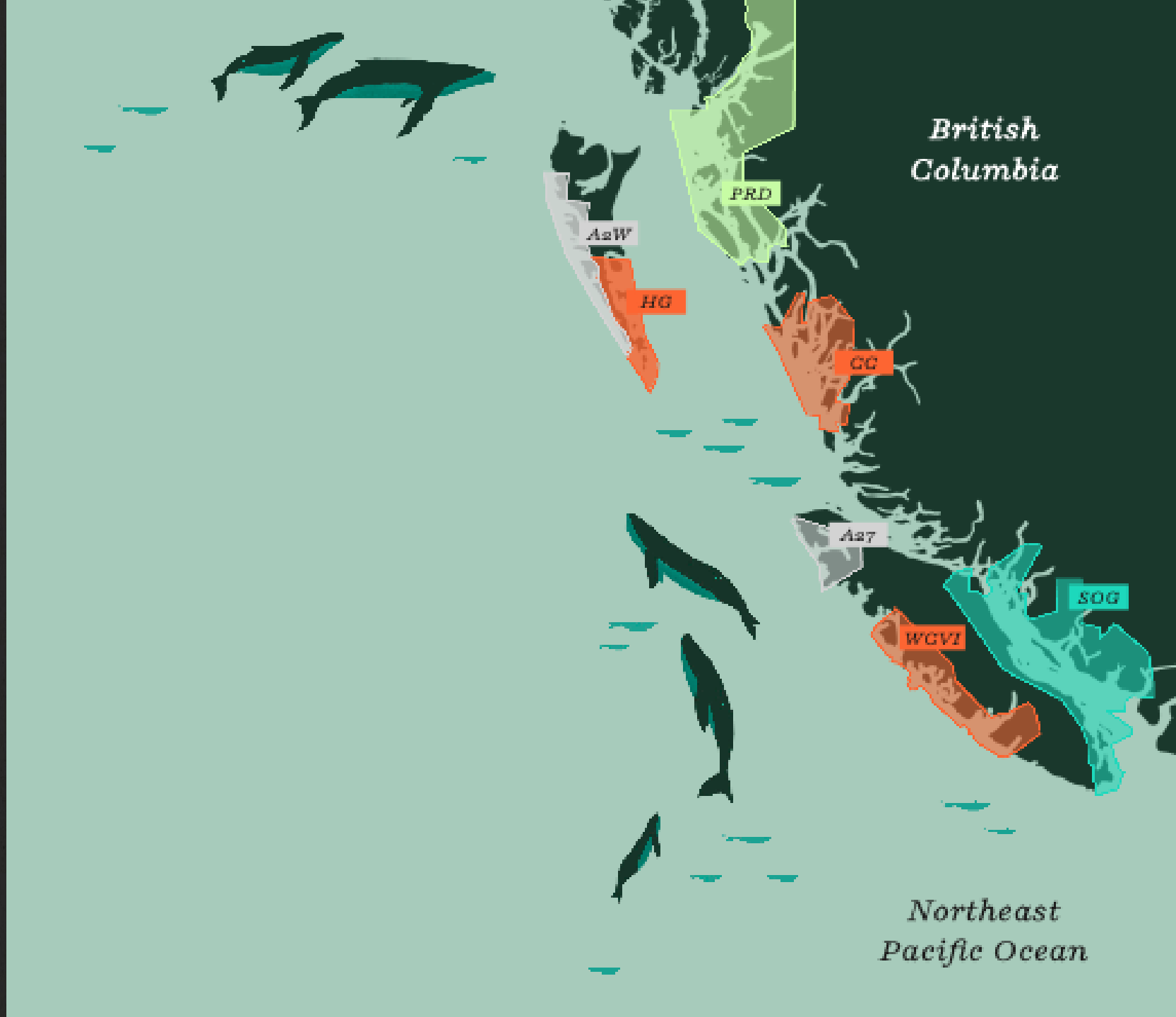


Beau Doherty

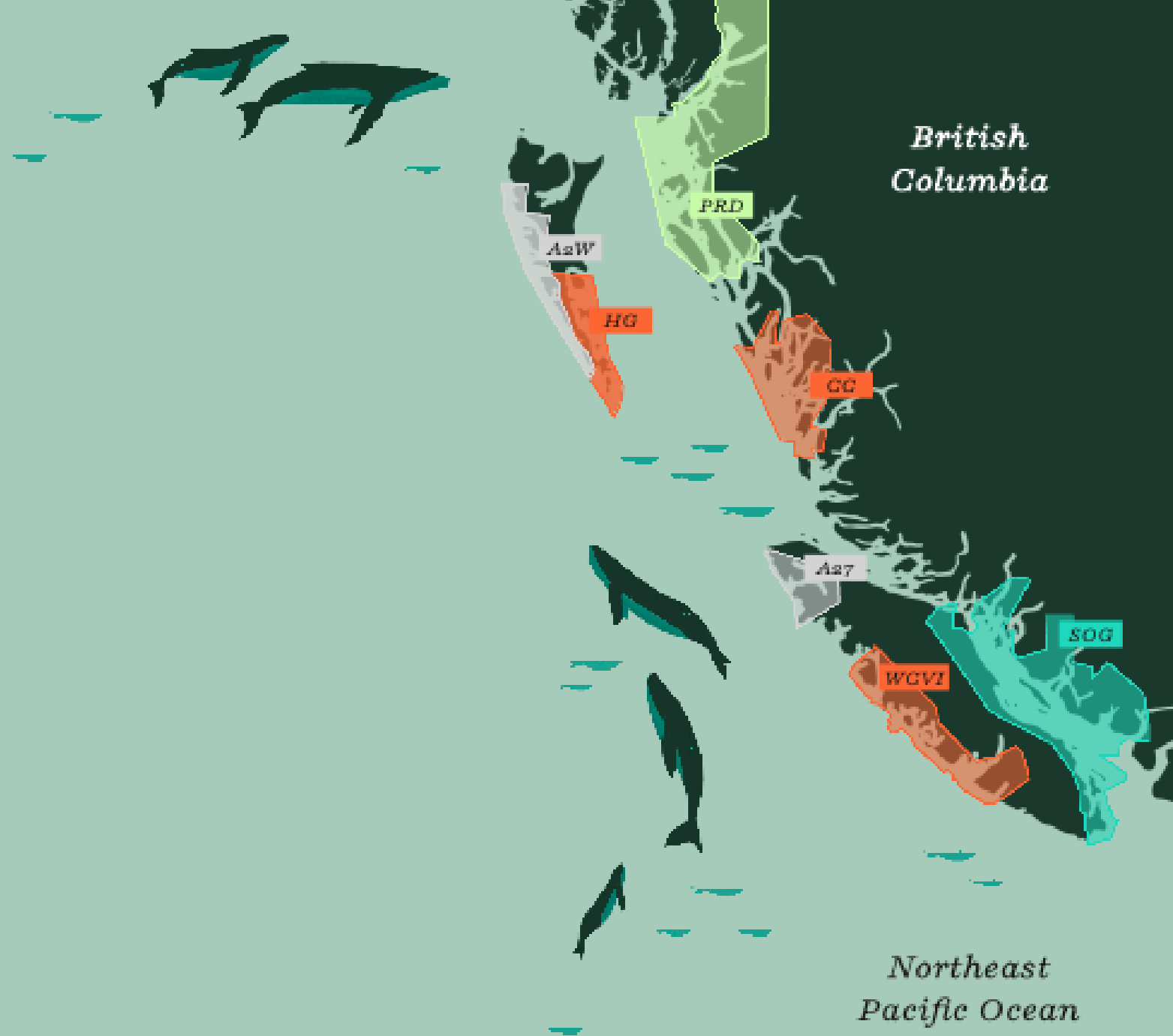
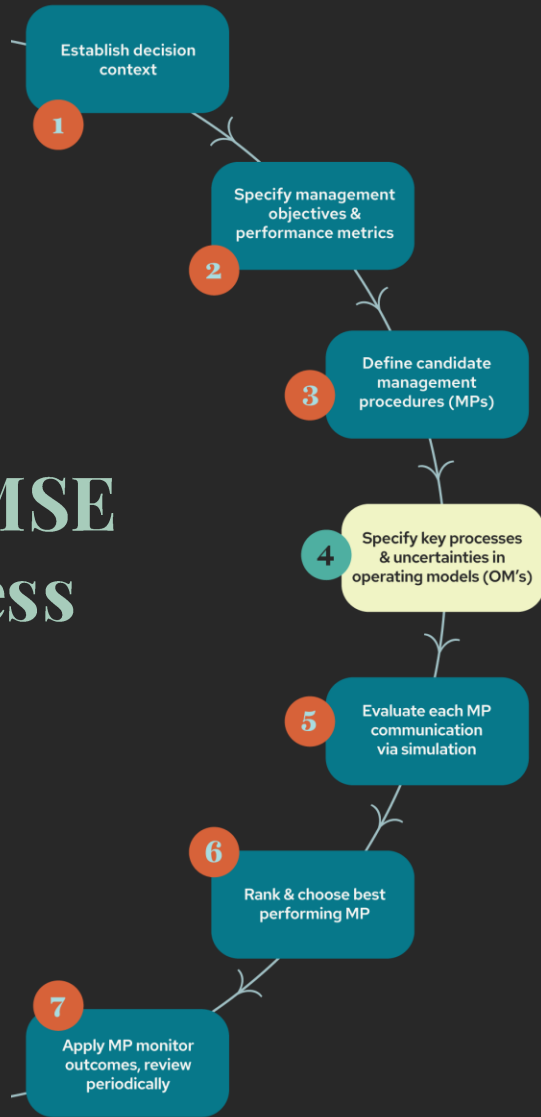


Jim Lane

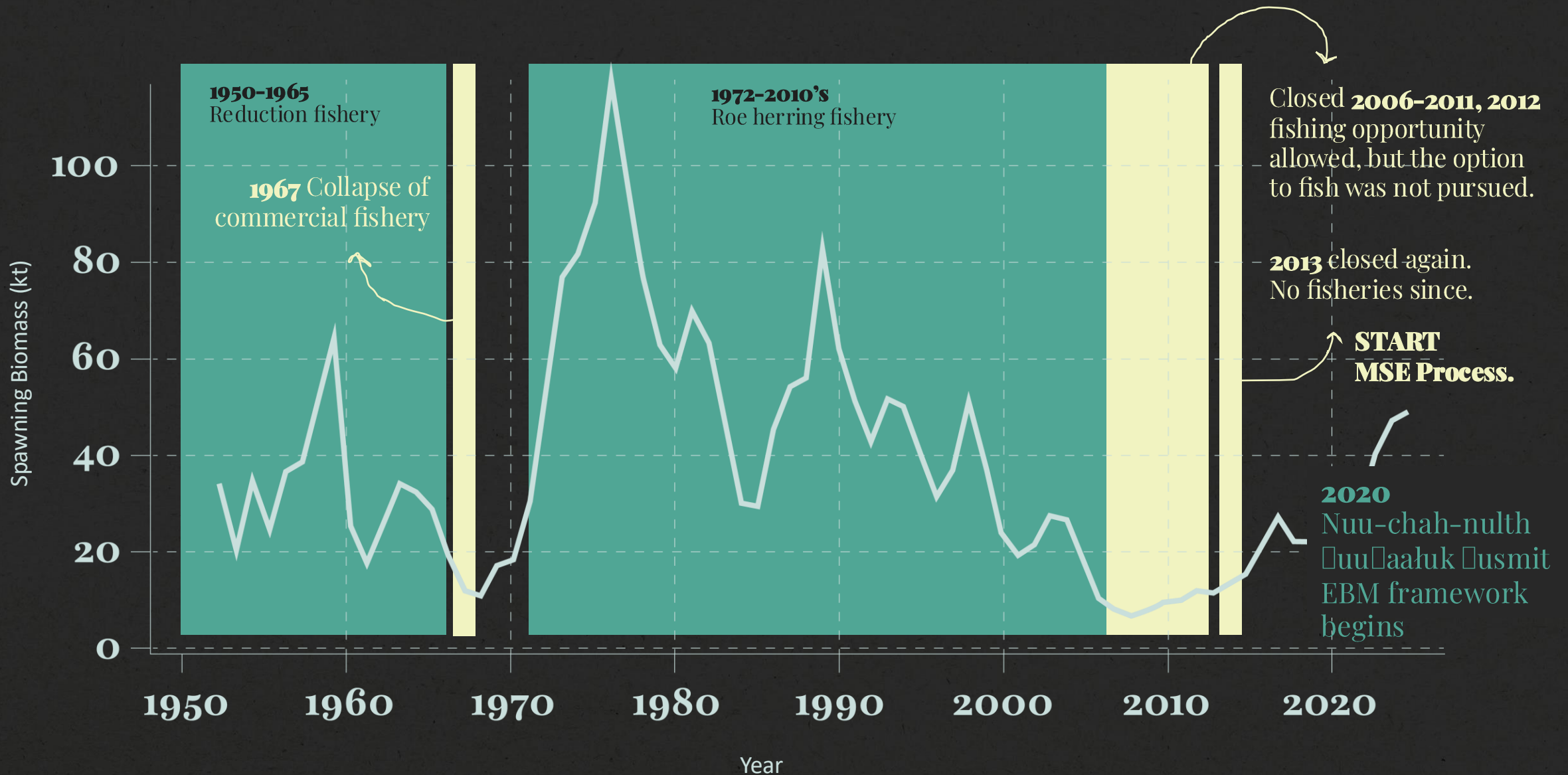
BC Pacific Herring Stock Areas



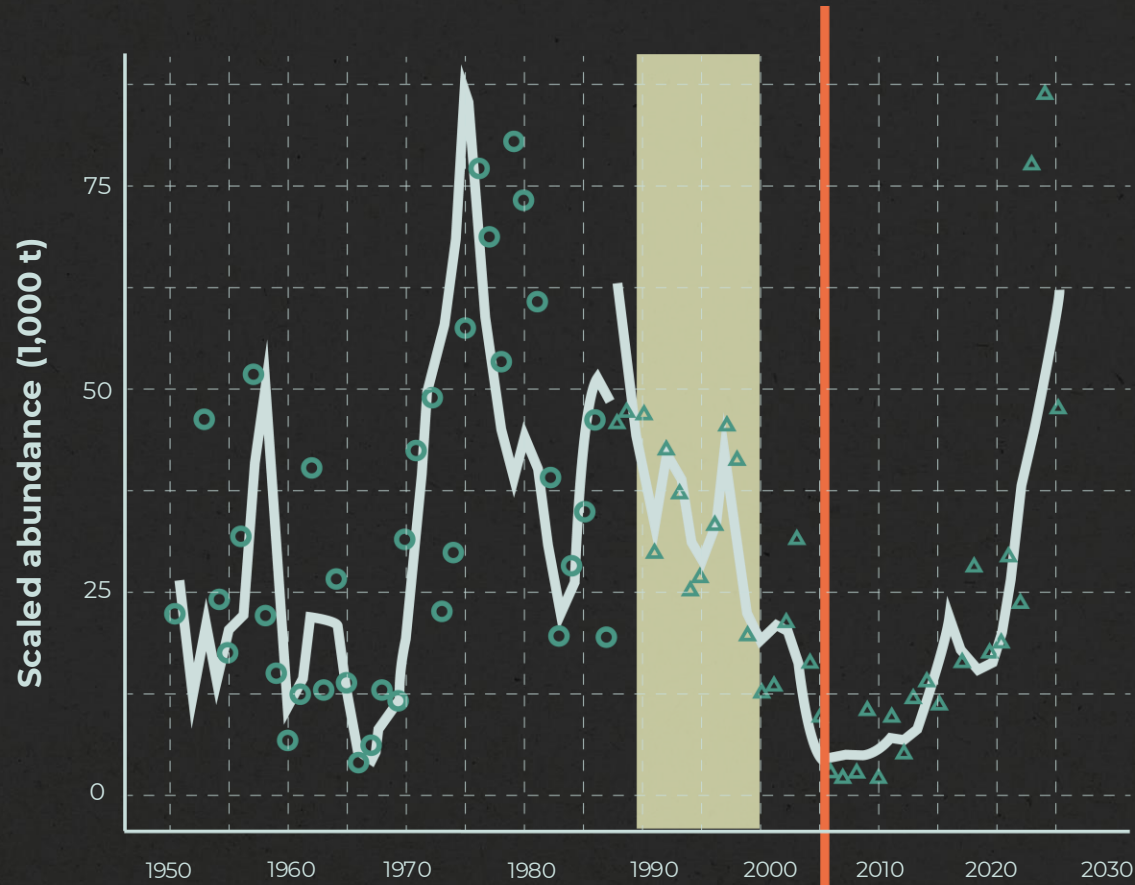
The MSE Process



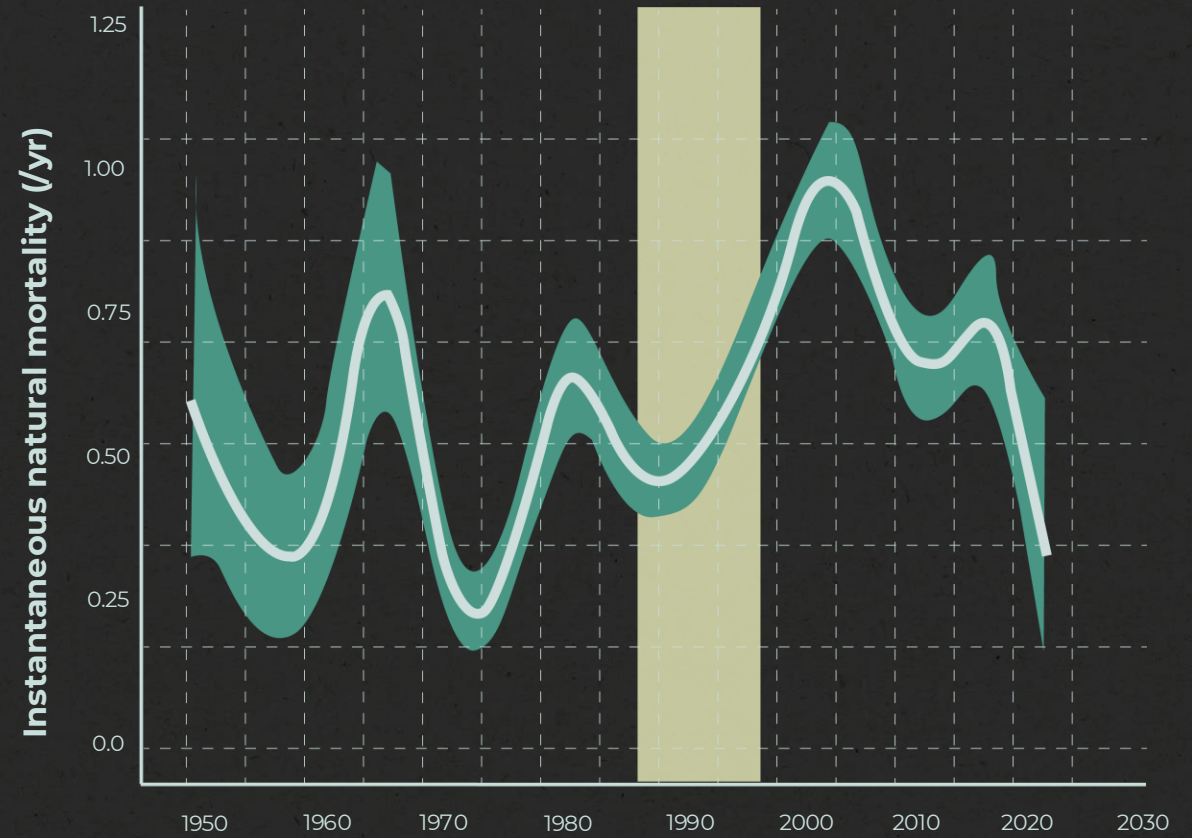
WCVI History and Context



WCVI Herring abundance & natural mortality

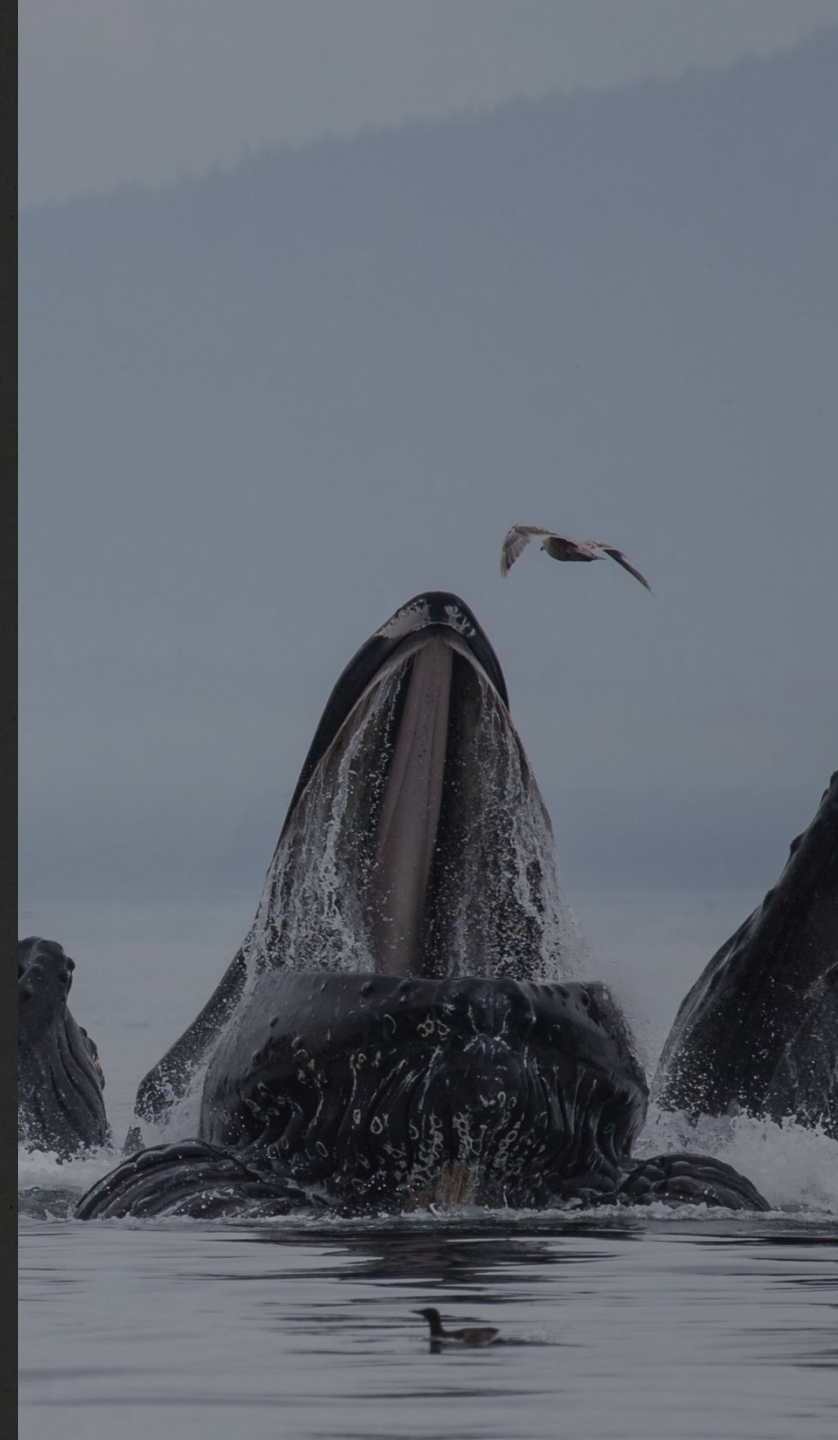


2006-2025:
no commercial harvest



An ecosystem approach is integral to any discussion about Pacific herring

1. Herring spawning: the annual process of depositing eggs (because it is visible, occurs close to shore, access)
2. Herring distribution: where they are, where they spawn, and how this relates to access for all harvesters (subsistence or commercial)
3. Their role as a key forage species in the northwest Pacific Ocean (dependent predators), and
4. The human dimension



Advancing WCVI Herring Management through the Nuu-chah-nulth  uu aakuk  usmit (Taking Care of Herring) Program

Predation and other at sea
influences on herring

Aggregate and spatial/sub-stock
management approach

Potential for in-season
management options

Estimating herring consumption via bio-energetic requirements of predators

MAJOR PREDATORS

- Pacific Hake (Small [< 50 cm], Large [> 50 cm])
- Humpback Whales (Winter and Summer feeding groups)
- Stellar Sea Lions
- Harbour Seals
- Grey Whales

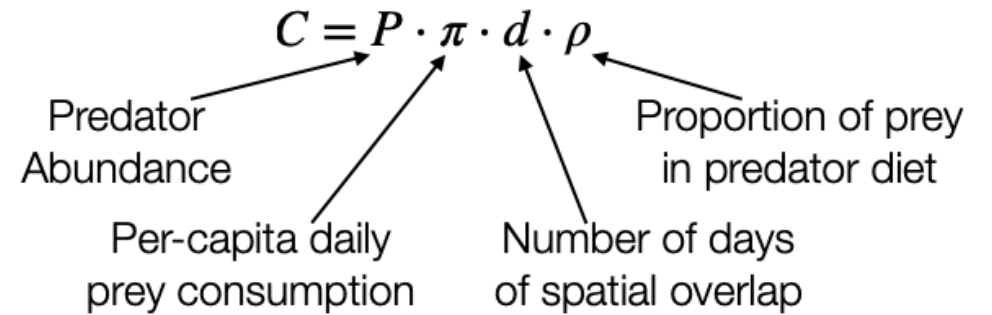
Estimating herring consumption via bio-energetic requirements of predators

Total Natural Mortality = Predation Mortality + Basal Mortality

- Pacific Hake
- Humpback Whales
- Stellar Sea Lions
- Harbour Seals
- Grey Whales
- Disease
- Starvation
- Post-spawn mortality
- Senescence
- Unreported catch
- Other predators

Modelling predation mortality via bio-energetic requirements of predators

- **Bio-energetics:** determining the annual consumption of herring by each predator, based on predator energy requirements, diet, herring energy content, and spatio-temporal overlap
- Predator consumption of herring (C) based on four factors

$$C = P \cdot \pi \cdot d \cdot \rho$$


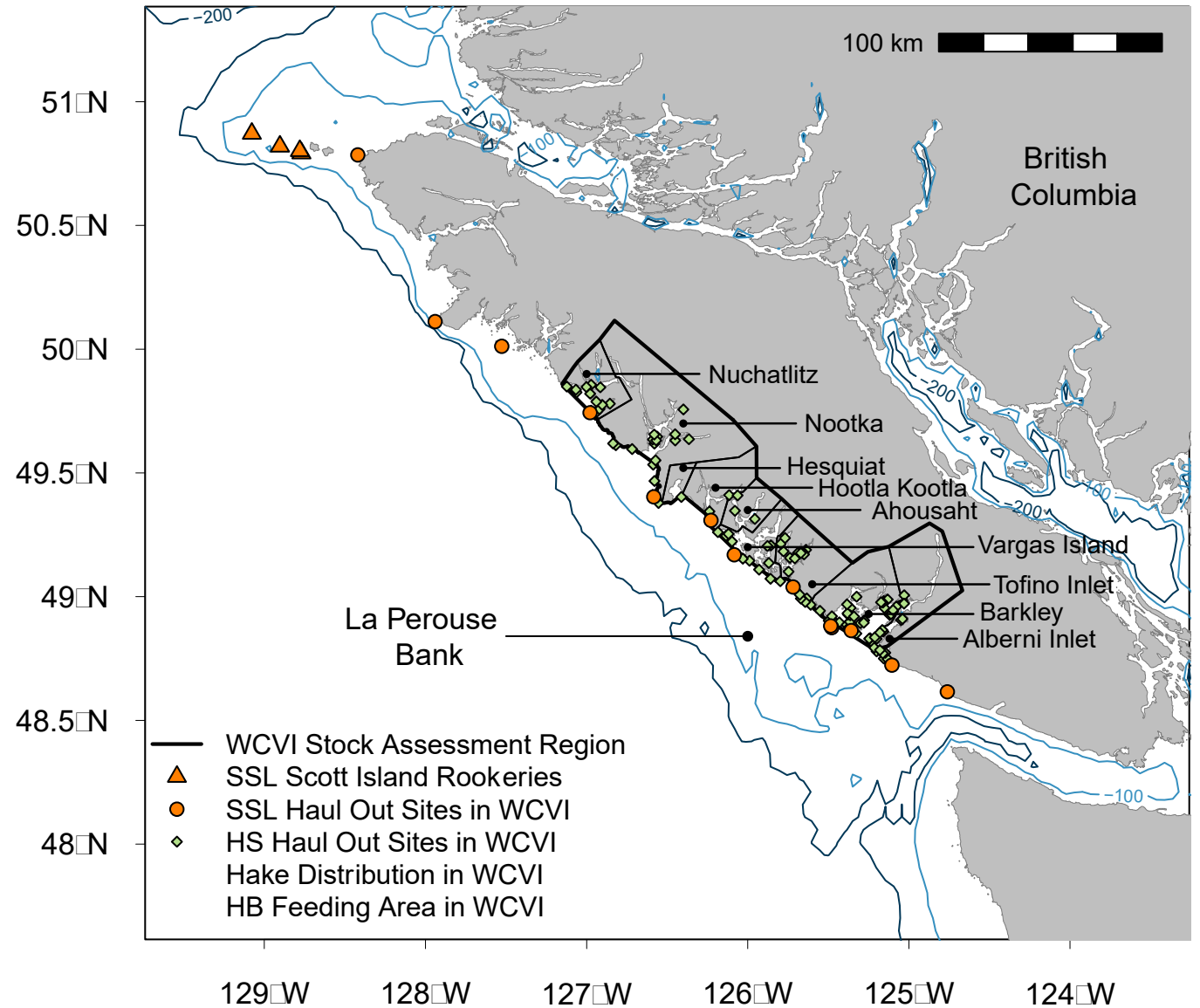
Predator Abundance

Per-capita daily prey consumption

Number of days of spatial overlap

Proportion of prey in predator diet

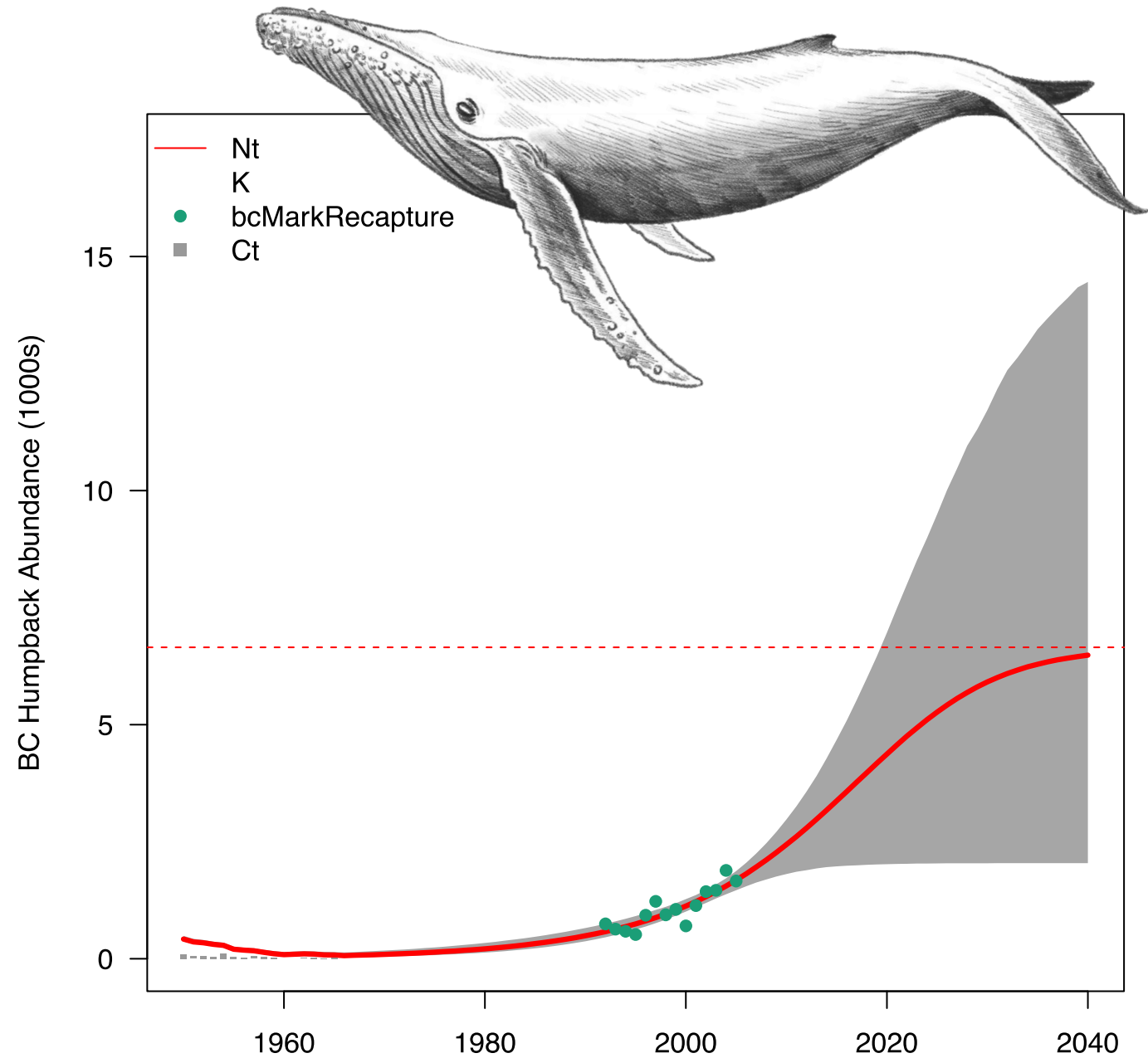
Overlapping habitat of Herring and their predators in WCVI



BC Humpback Whales

DATA ACQUIRED

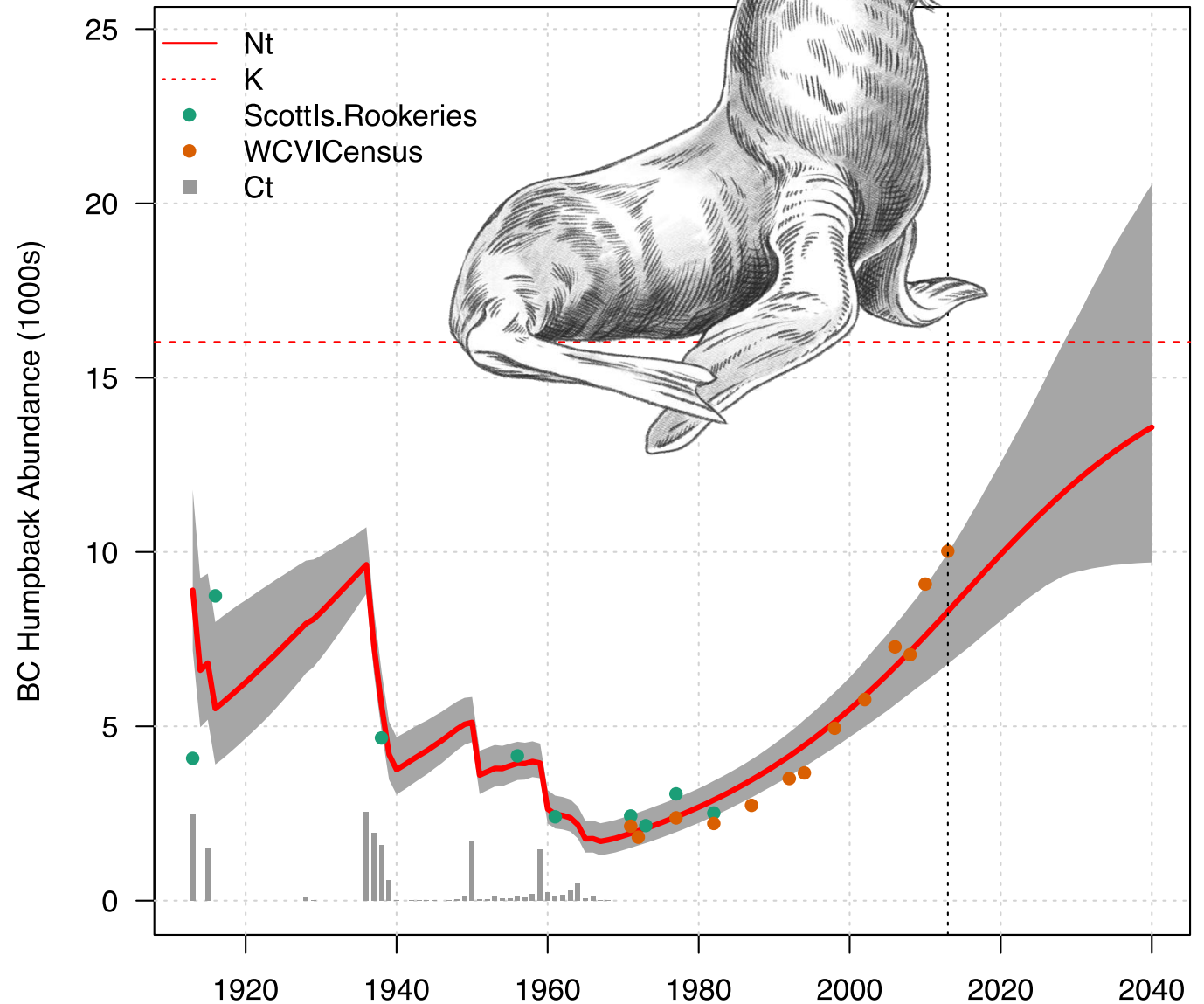
- Mark-recapture estimates used as absolute abundance (Ford et al. 2009)
- Commercial whaling records (Nichol and Heisse 1992)
- Estimate that 13% of BC Humpback population is feeding in WCVI (Nichol et al. 2010)



WCVI Steller Sea Lions

DATA ACQUIRED

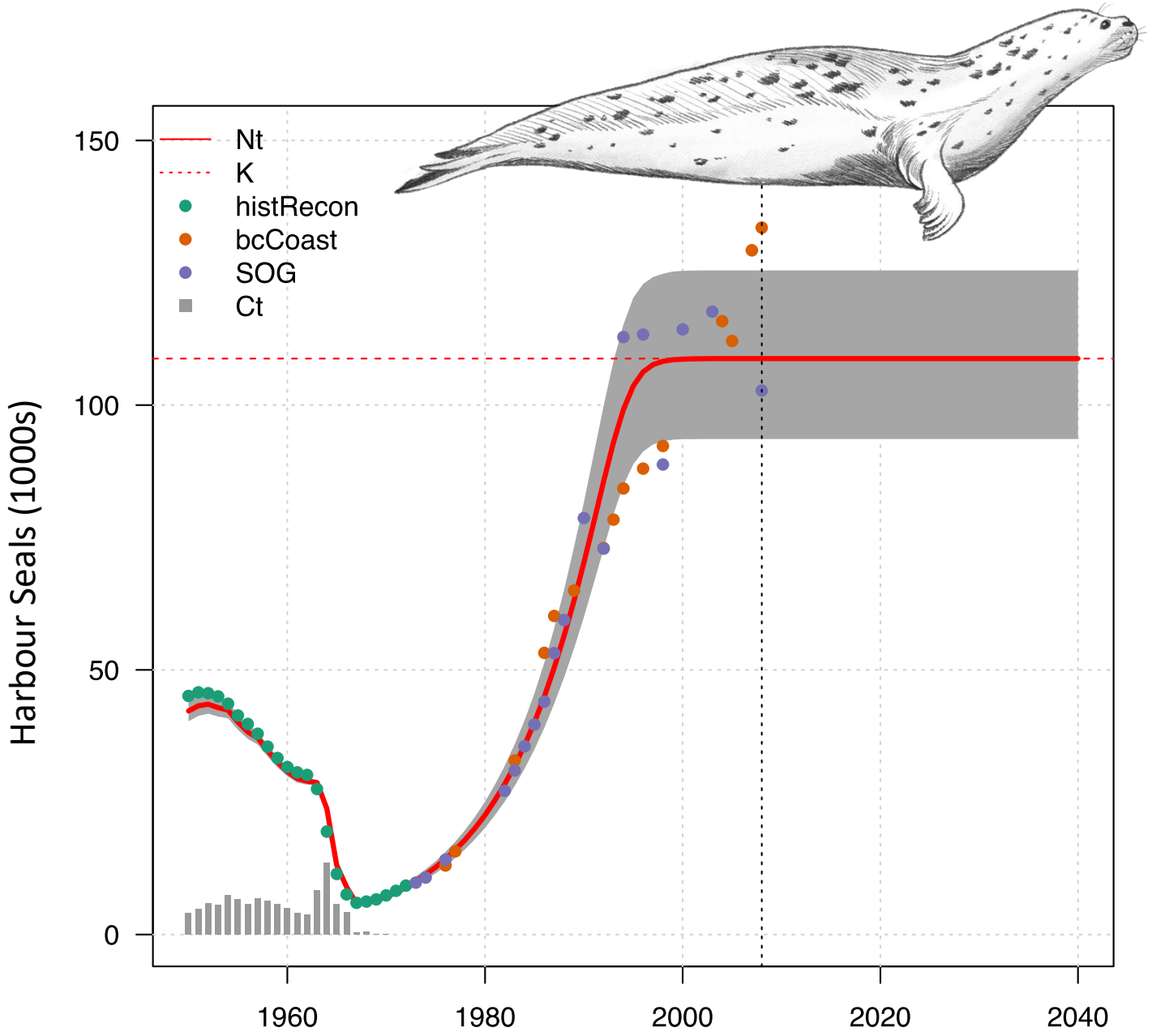
- Relative abundance index from rookery counts (1913-1982)
- Absolute abundance from census (1971-2012)
- Assumes population was harvested prior to 1913



BC Harbour Seals

DATA ACQUIRED

- non-SOG (Olesiuk 2010)
- SOG
- Historical reconstruction of absolute abundance (1950-1972) (DFO 2010)
- Assume 5.1% of population is feeding in WCVI SAR (Olesiuk 2010)

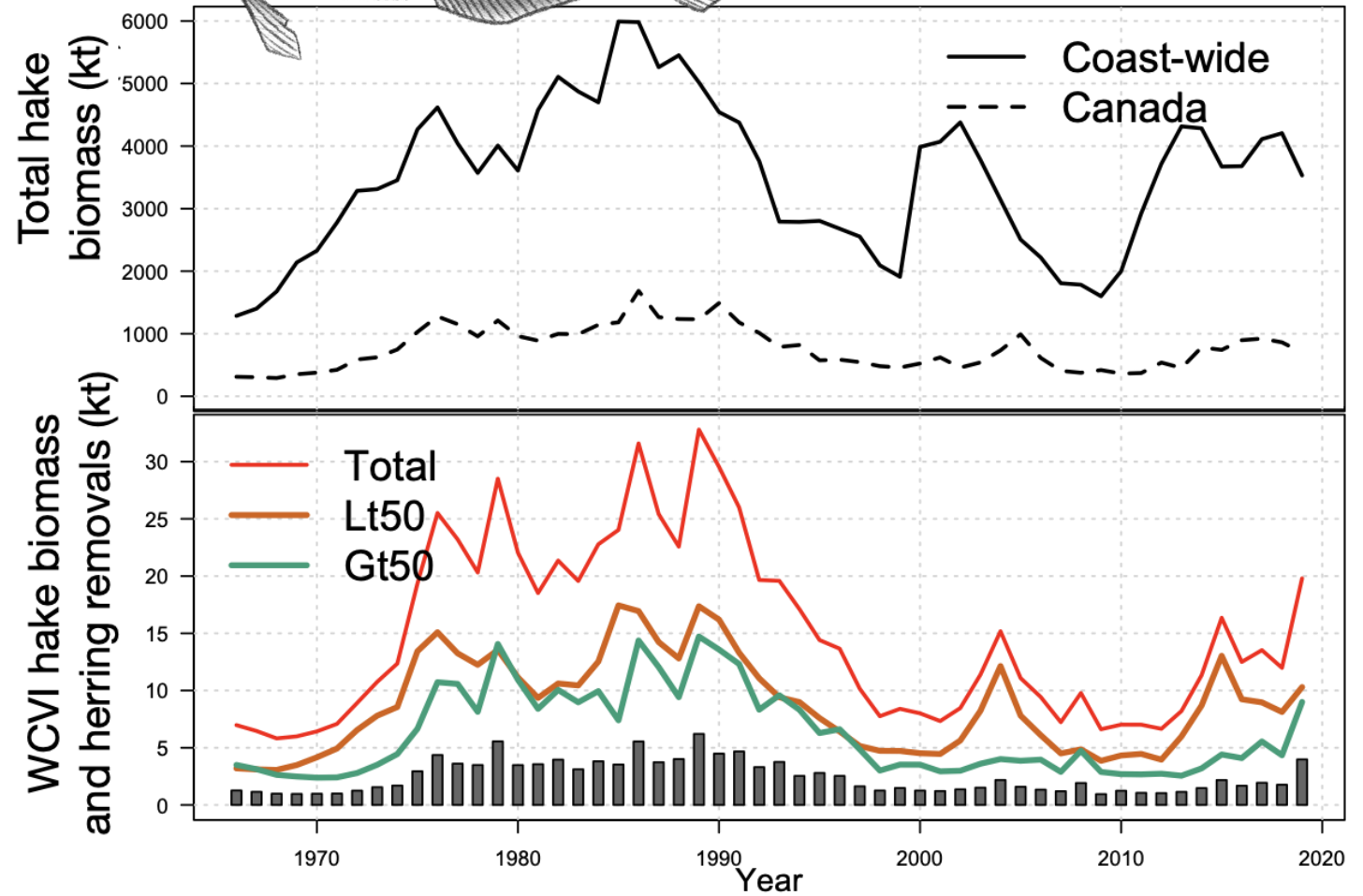
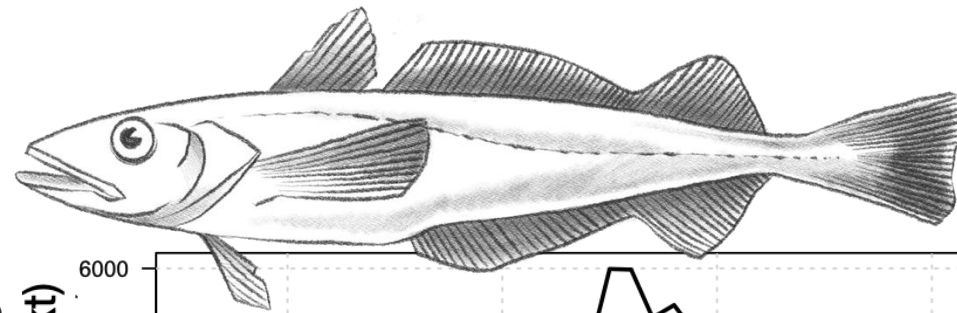


Spatial estimates of WCVI Pacific Hake Biomass

MODEL ESTIMATES

Acoustic survey data used to apportion annual coastwide biomass into WCVI biomass-at-age

Two piscivorous Hake predator length classes



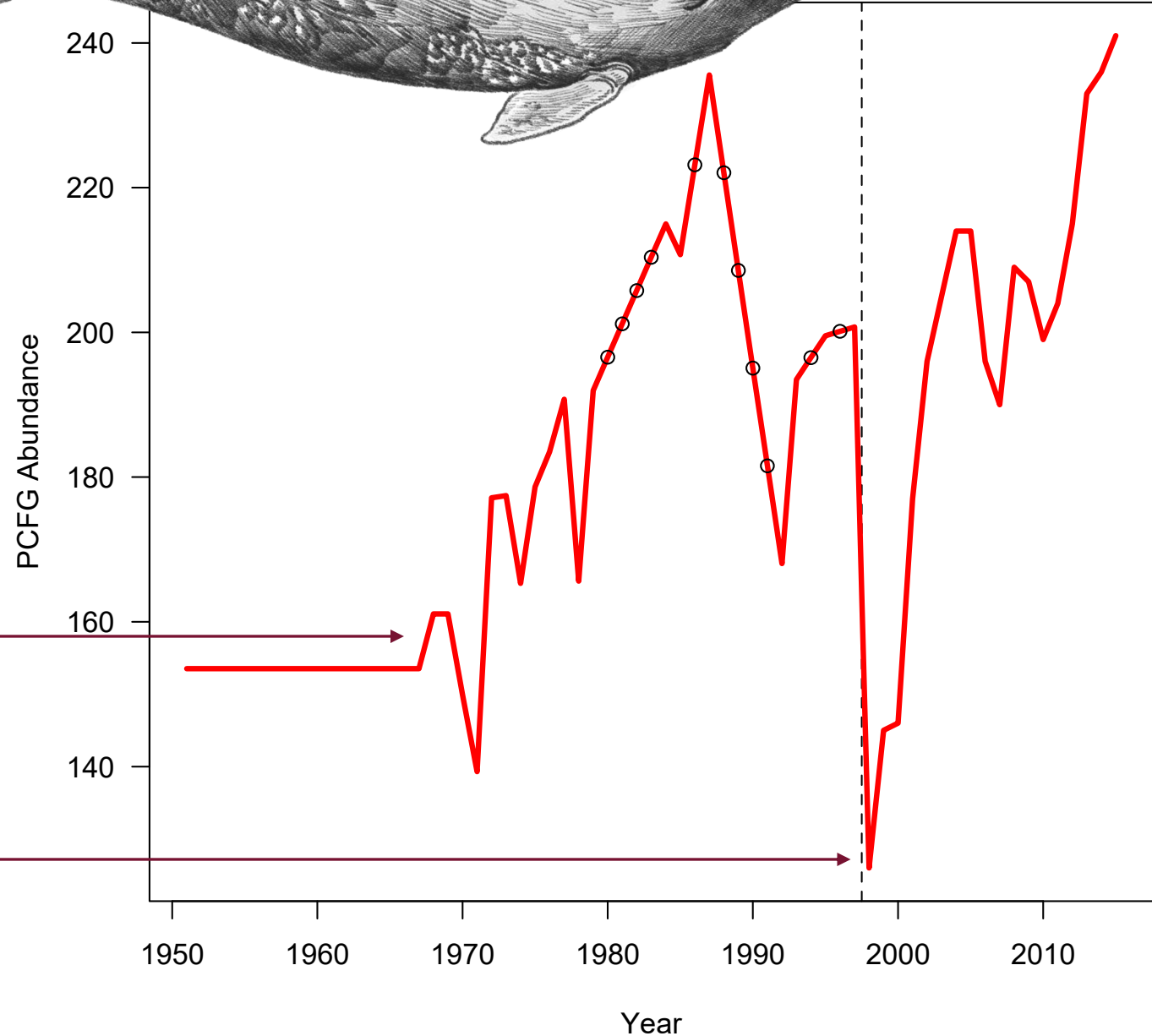
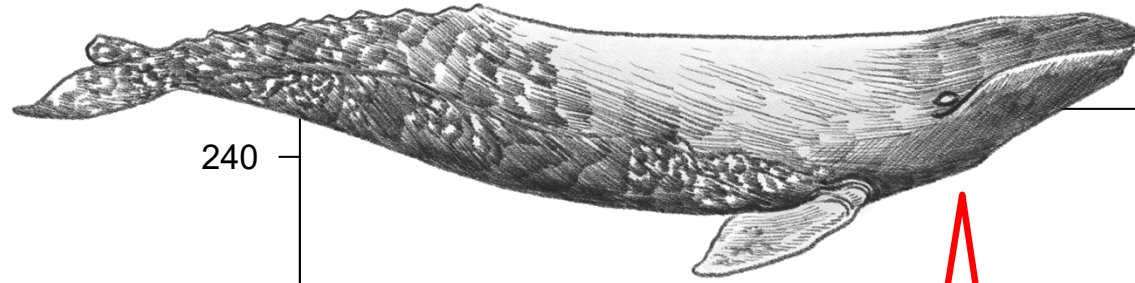
Gray Whales

MODEL ESTIMATES

Pacific Coast Feeding Group appear to be primary sub-population with potential for feeding on eggs in WCVI

1960-1997 estimated as proportion of Eastern North Pacific stock abundance estimates (Durban et al. 2017)

Abundance estimates 1998-2015 (Gavrilchuk et al. 2021)

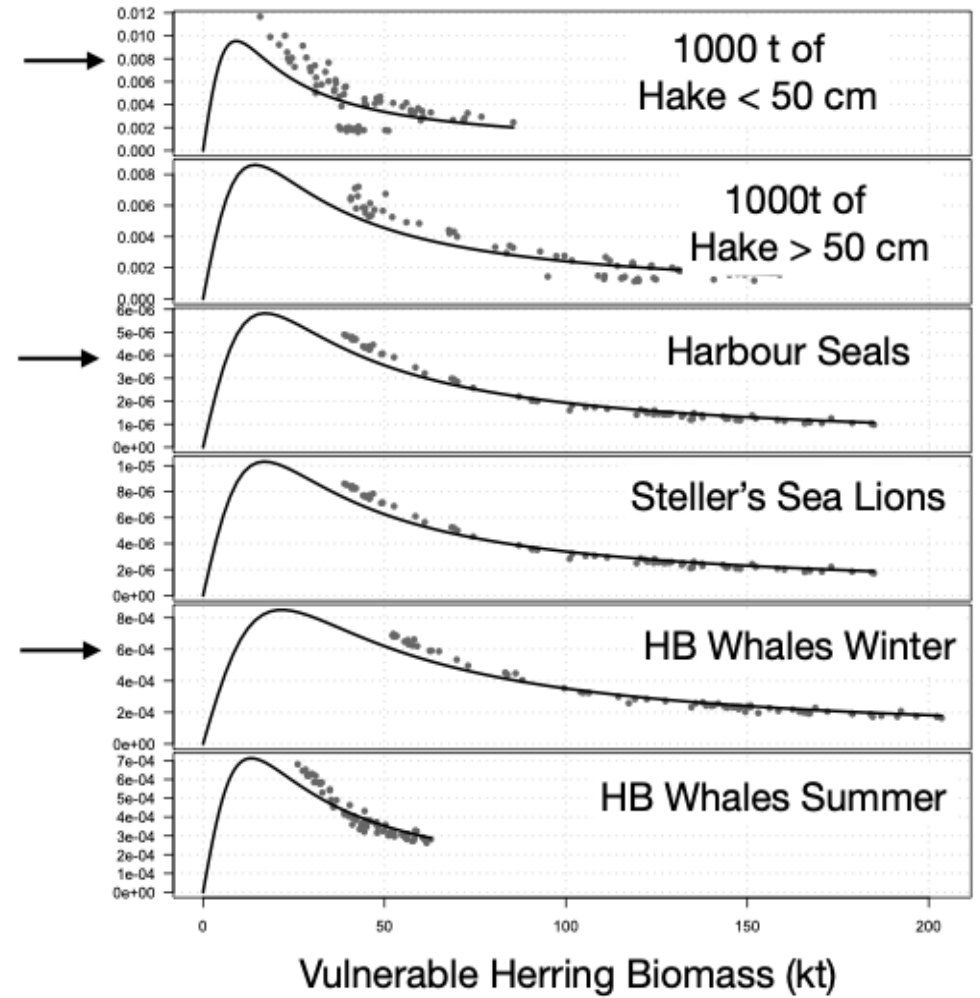


Predation mortality
"exerted" on WCVI
herring biomass based
on predator size,
distribution and season

Every 1000 t of hake
consumes
roughly 0.8% of
available herring

Each seal consumes
roughly
0.0004% of available
herring

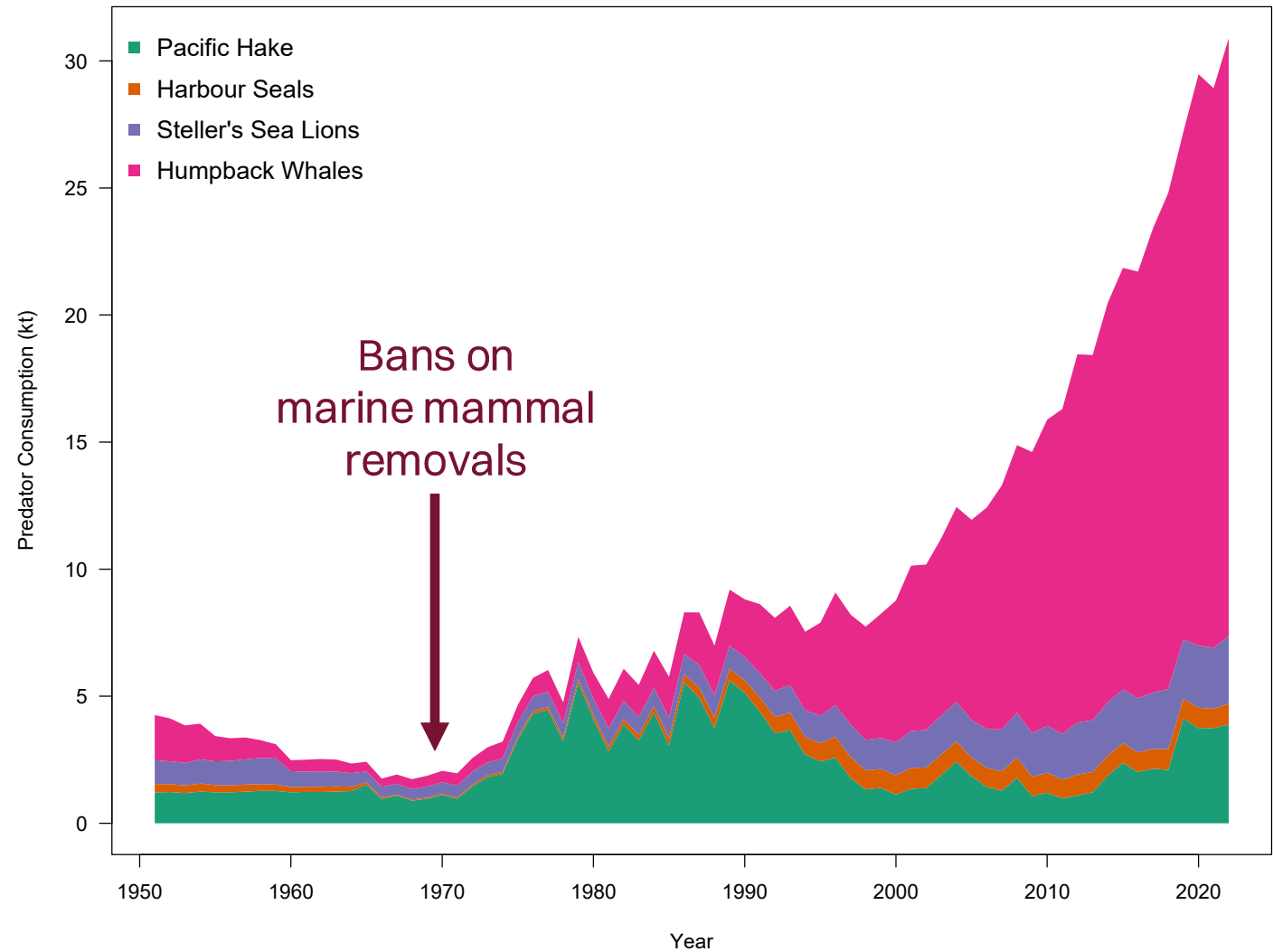
Each whale consumes
roughly
0.06% of available
herring



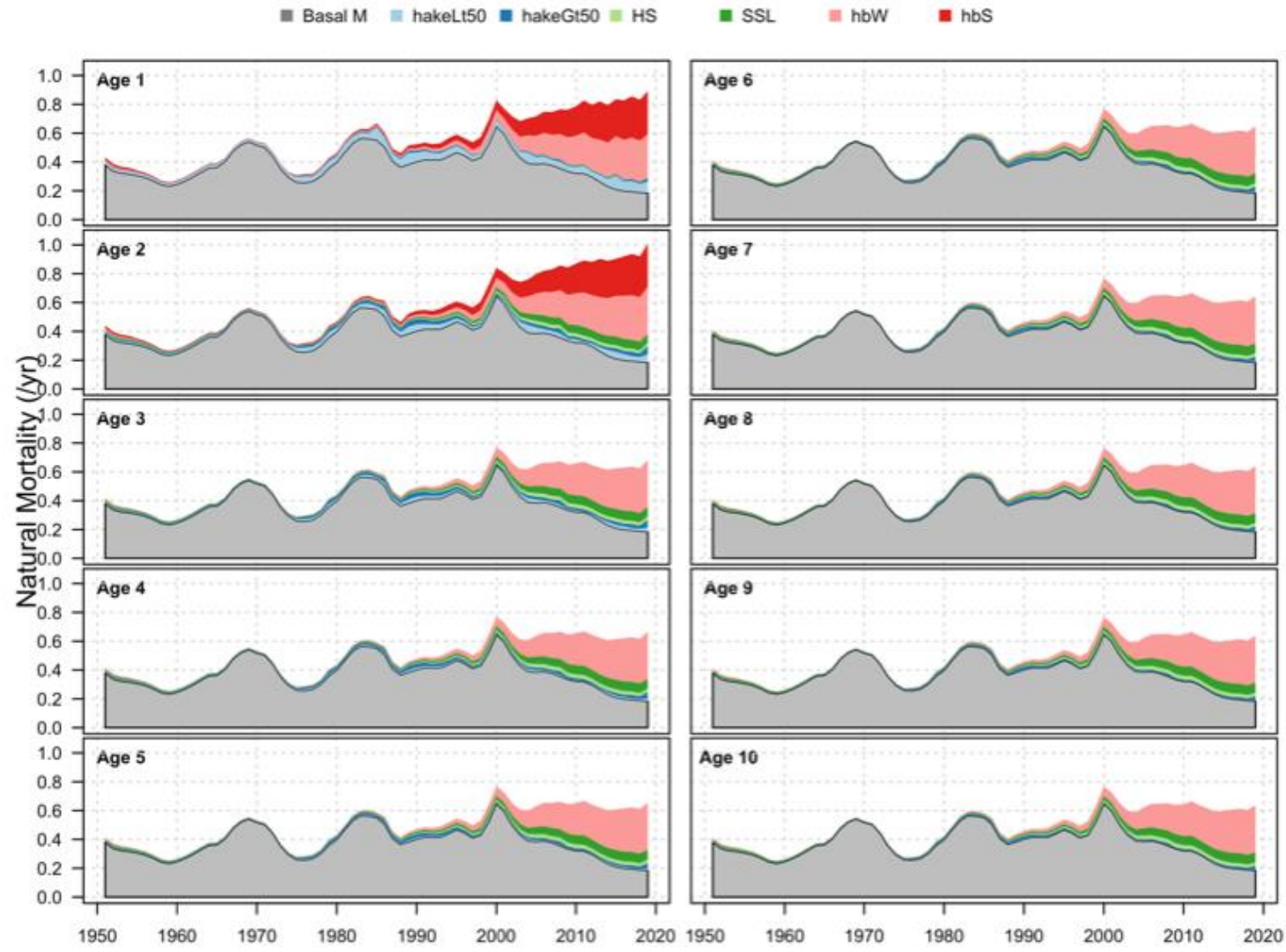
Predators consume a lot of herring

Total predation mortality estimated from a combination of consumption and predator abundance

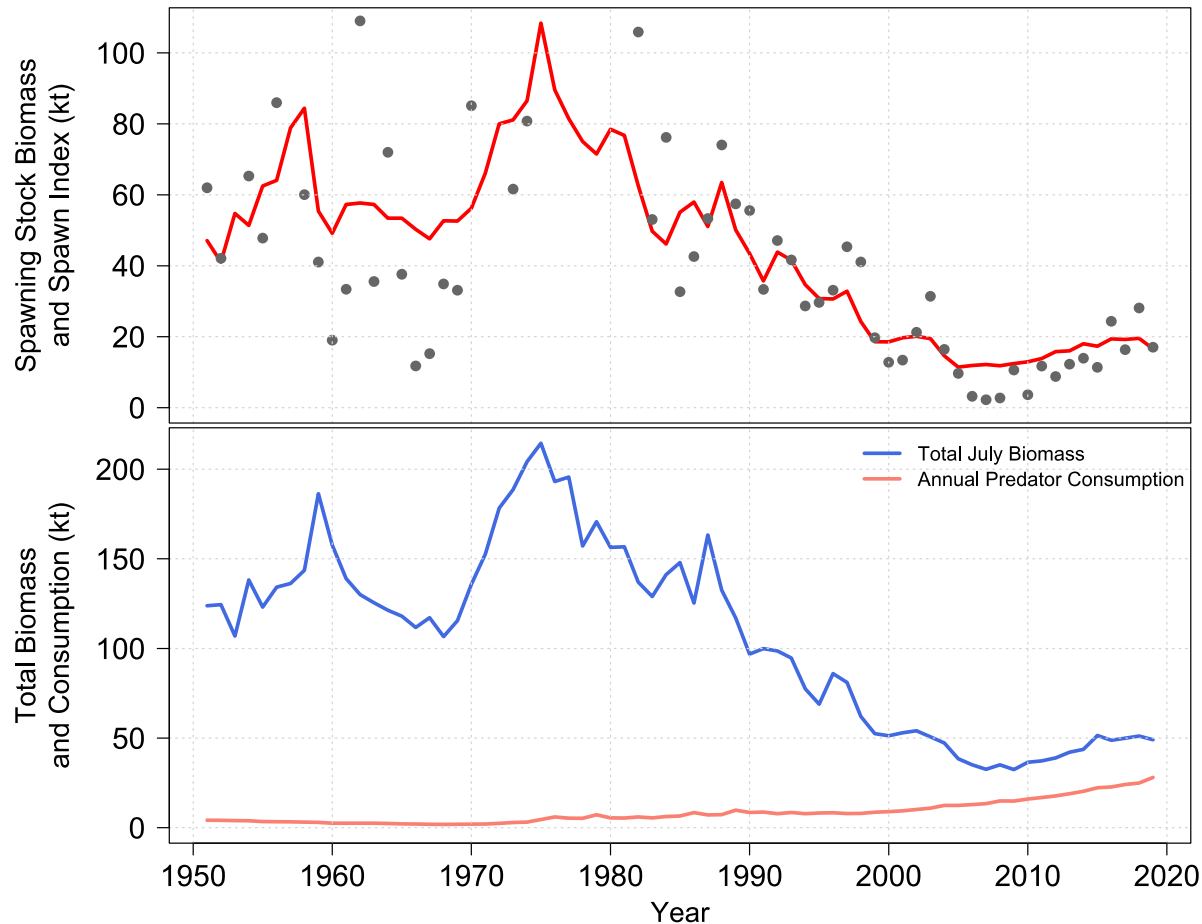
Total predator consumption is used as observed catch input for fitting herring operating models



**Predation
component of
natural mortality
increased since 1990**



Nuu-chah-nulth  uu aahuk  usmit (Taking Care of Herring): Insights



Predator model agrees with DFO single stock model

Predator consumption is approaching total biomass

WCVI stock is still highly productive but for 10+ years, mammals removing all new production.

No stock assessment model would predict this.



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Influence of predation mortality on past and future dynamics of Pacific Herring: implications for stock status and future biomass

 Beau Doherty,  Samuel D. N. Johnson,  Ashleen J. Benson, Sean P. Cox, Jaclyn S. Cleary, Jim Lane

doi: <https://doi.org/10.1101/2024.07.12.603178>