Assessment of Pacific herring (*Clupea pallasii*) populations in the northeast Pacific Ocean

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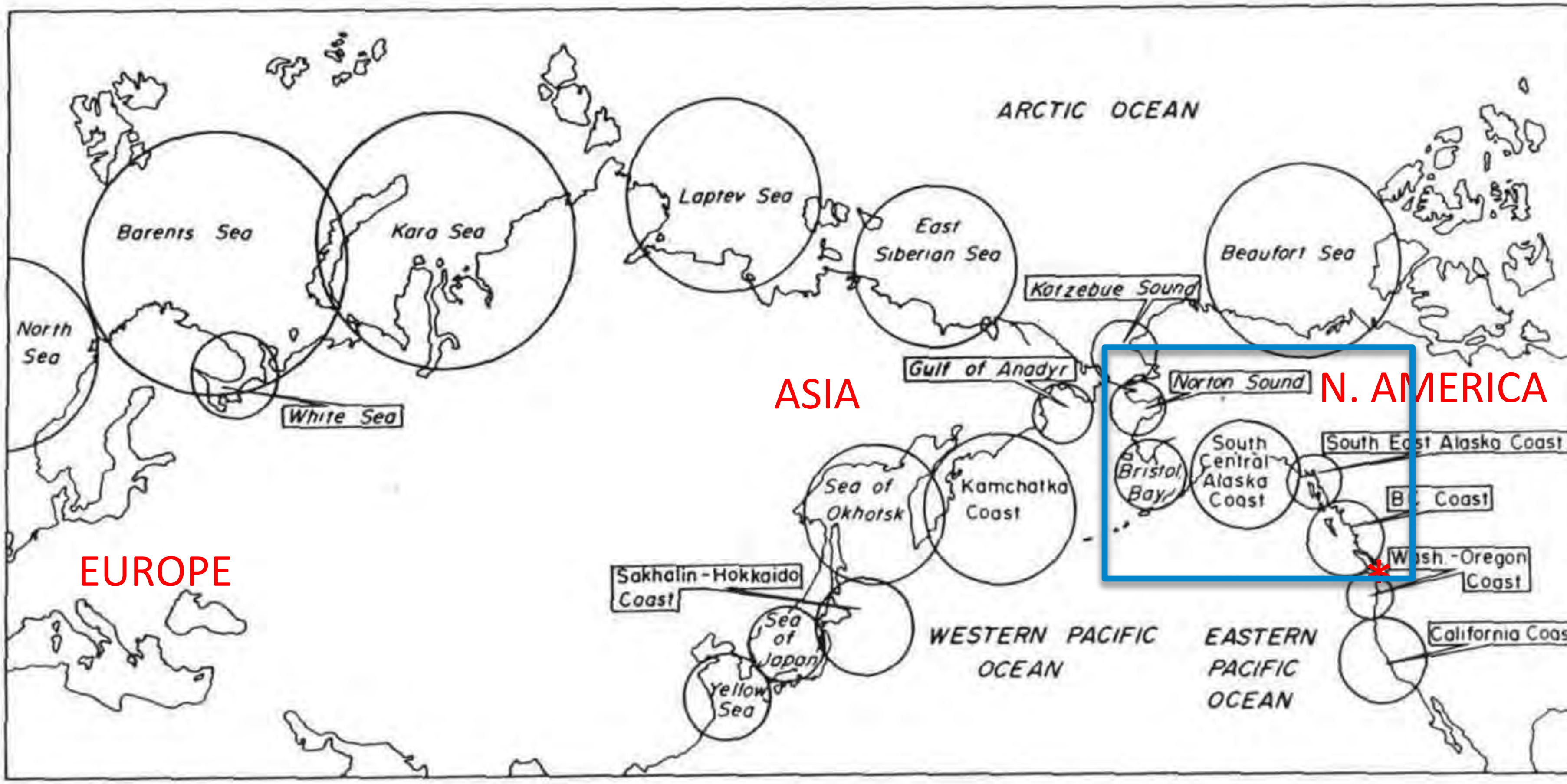
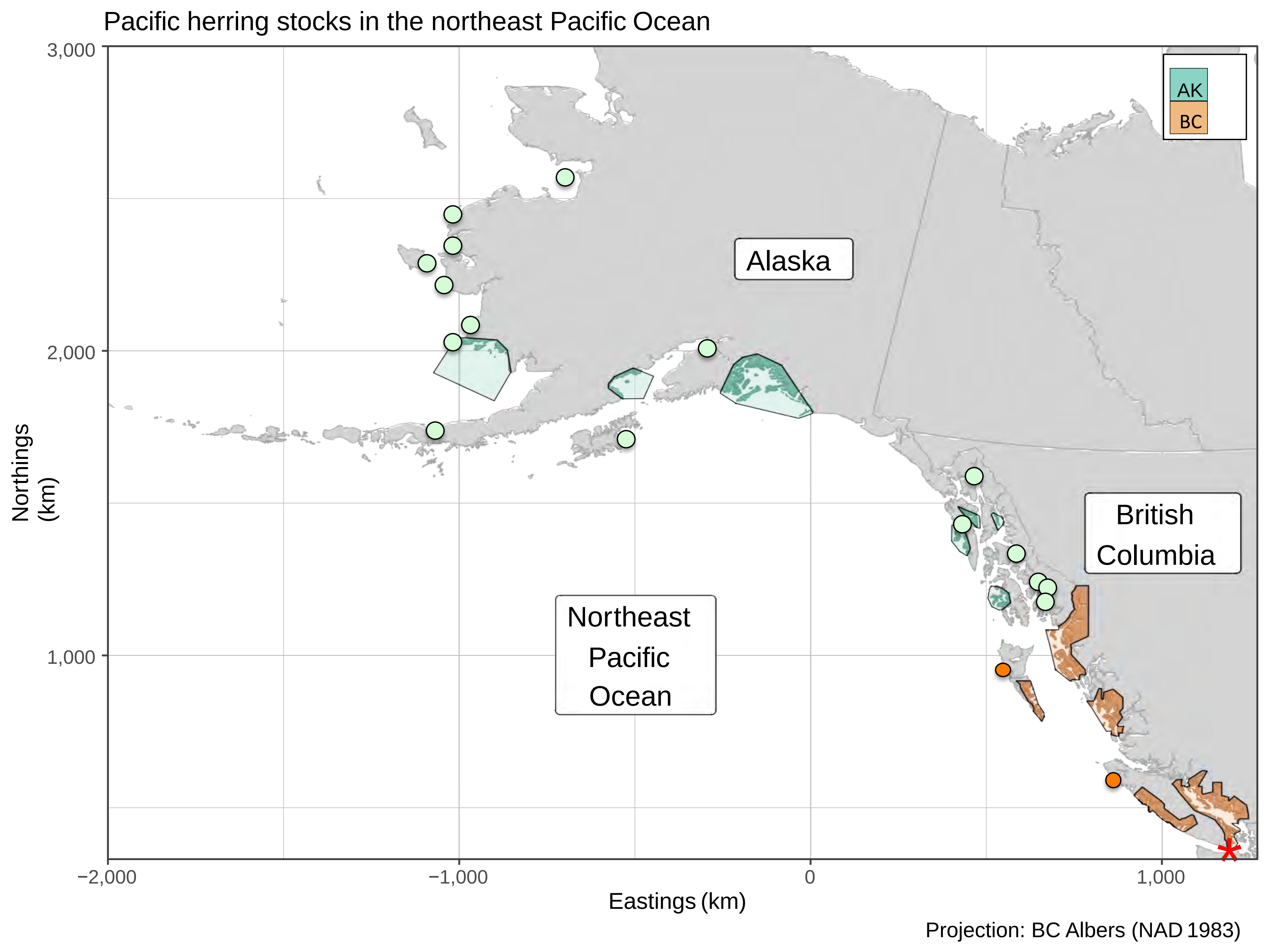
Overview of British Columbia (Canada) and Alaska (USA) Pacific herring

- Populations and fisheries
- Surveys and stock assessment methods
- Biggest challenges
- Collaboration and advancement

Global distribution of herring stocks throughout eastern North Atlantic, Arctic and Pacific oceans

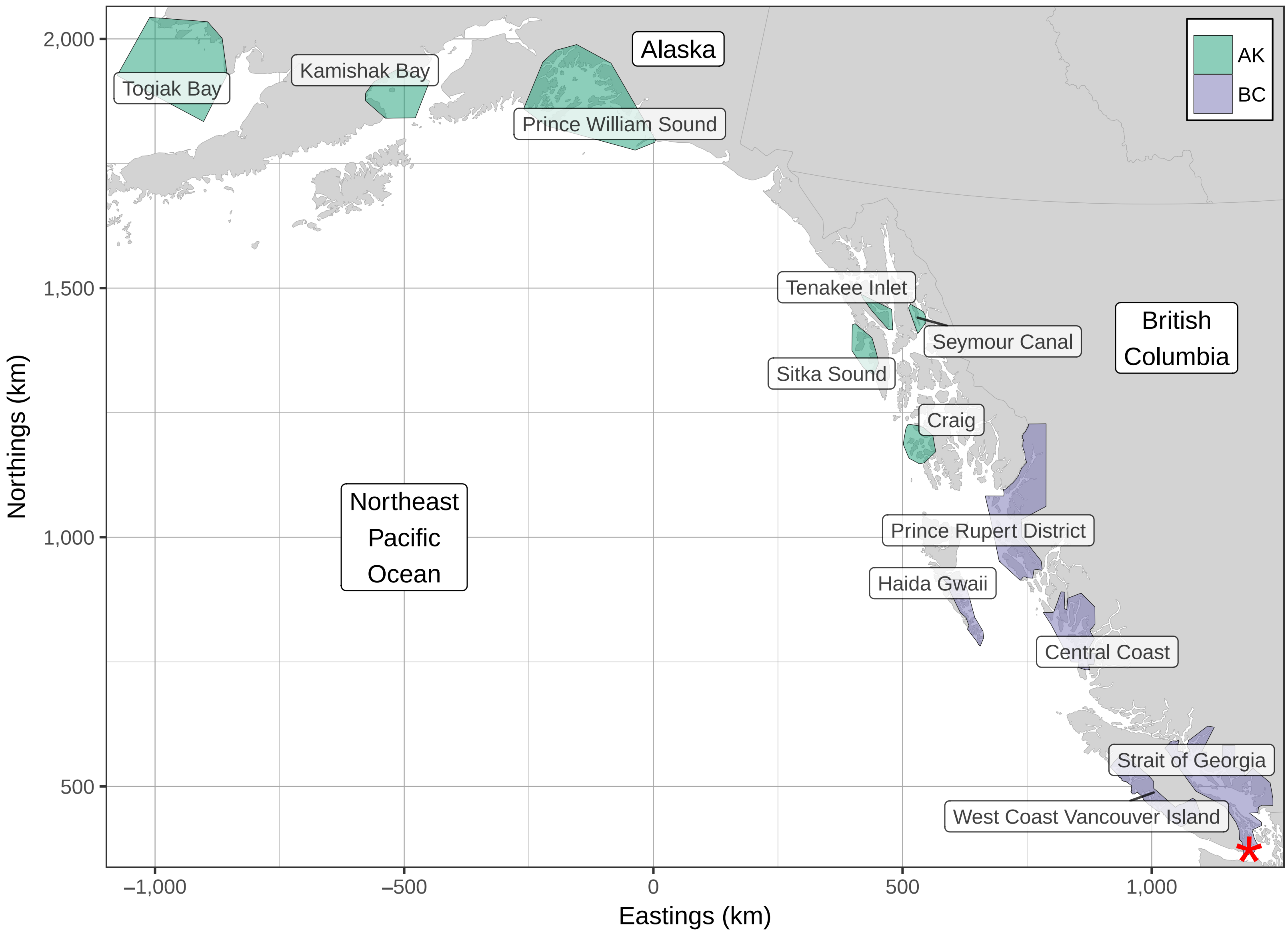


Hay 1985. CJFAS



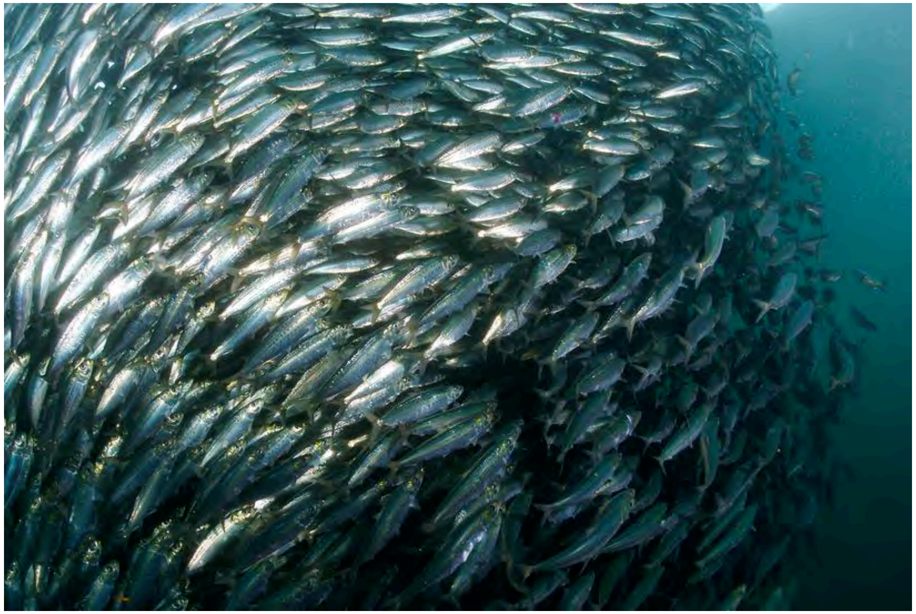
Pacific herring stocks in the northeast Pacific Ocean
3,000
2,000
1,000
Northings (km)
−2,000
−1,000
0
1,000
Eastings (km)
AK
BC
Alaska
British Columbia
Northeast Pacific Ocean
Projection: BC Albers (NAD 1983)

Pacific herring stocks in the northeast Pacific Ocean that are assessed with age-structured assessment models



Significance of herring in the Northeast Pacific …

- Key forage fish



Significance of herring in the Northeast Pacific …

- Key forage fish
- High cultural and socio-ecological value for BC Coastal First Nations and Native Alaskans

Photo credits: Sitka Tribe of Alaksa, H.Kitka

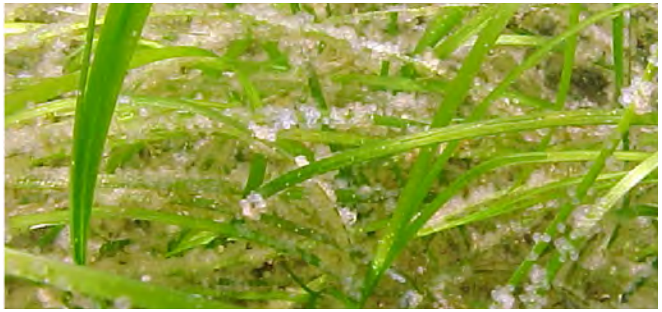
Significance of herring in the Northeast Pacific …

- Key forage fish
- High cultural and socio-ecological value for BC Coastal First Nations and Native Alaskans
- Important commercial industry

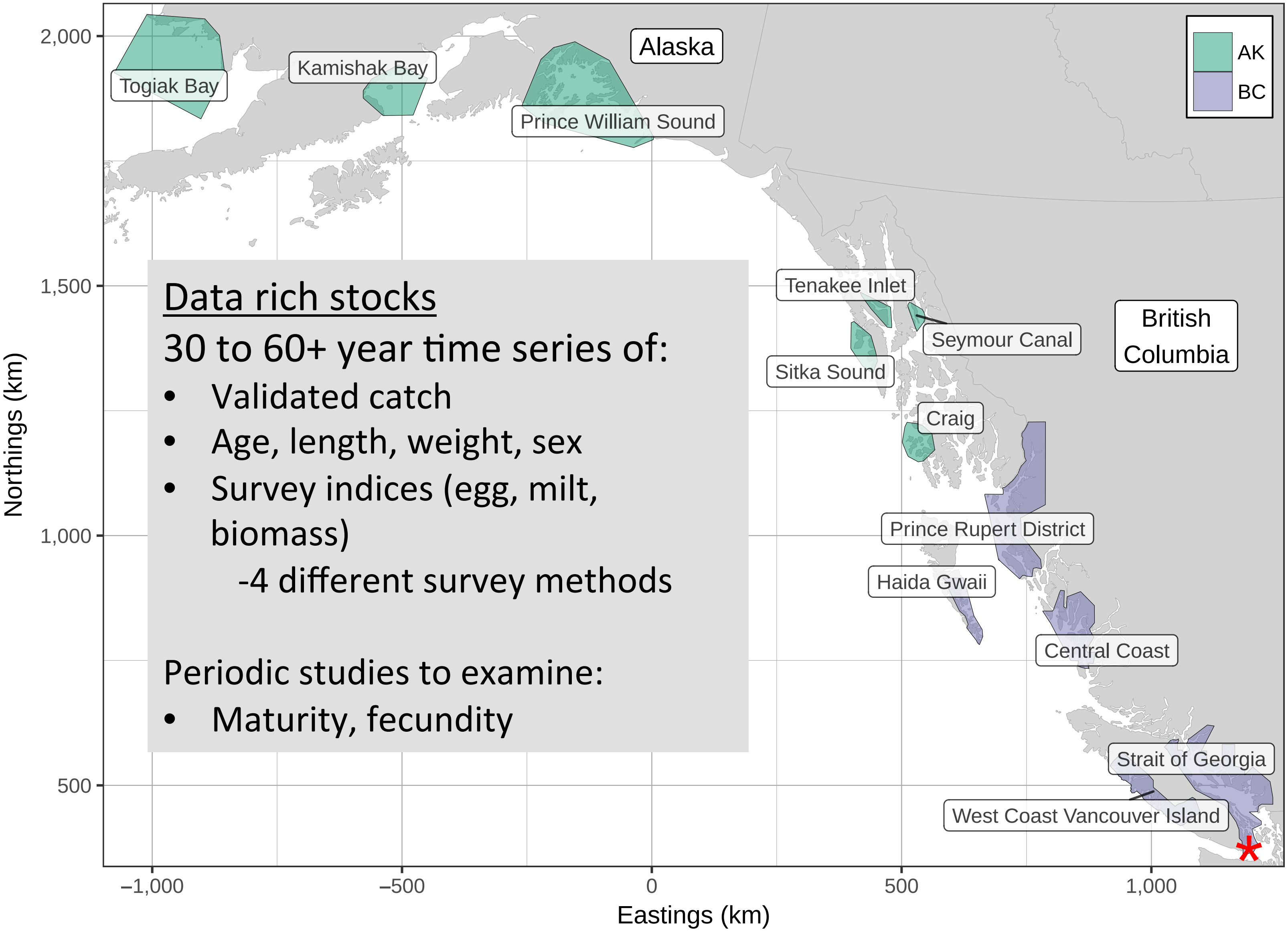
Surveys

Stock assessment models

Biomass trends



Available data:



<u>Data rich stocks</u>

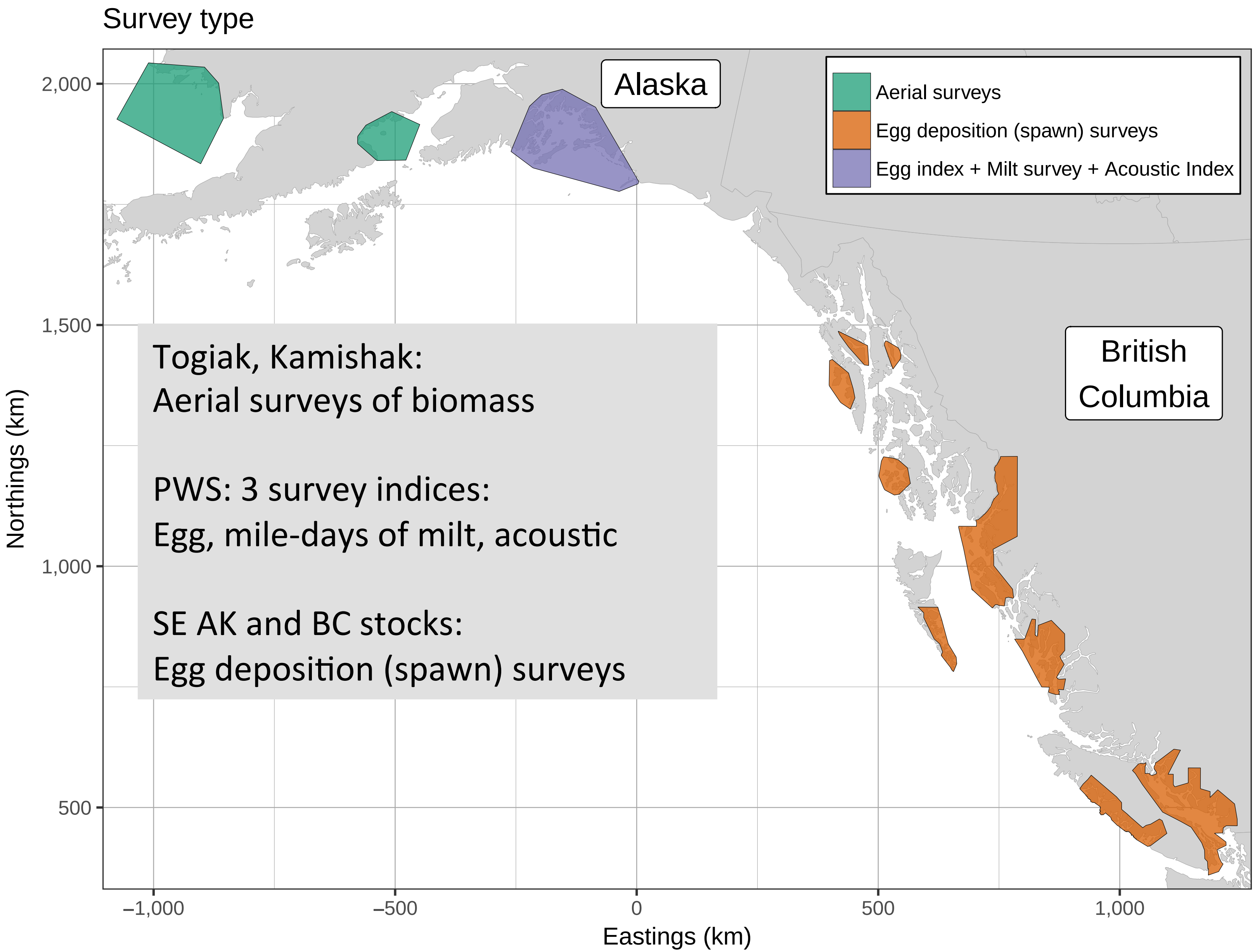
30 to 60+ year time series of:

- Validated catch
- Age, length, weight, sex
- Survey indices (egg, milt, biomass)
  - -4 different survey methods

Periodic studies to examine:

- Maturity, fecundity

Survey methods and locations:



Togiak, Kamishak:
Aerial surveys of biomass

PWS: 3 survey indices:
Egg, mile-days of milt, acoustic

SE AK and BC stocks:
Egg deposition (spawn) surveys

Feb-June: Aerial photos of herring spawn activity

Typical colour of Pacific ocean

Herring milt turning water aqua blue

Photo credit: K. Daniel

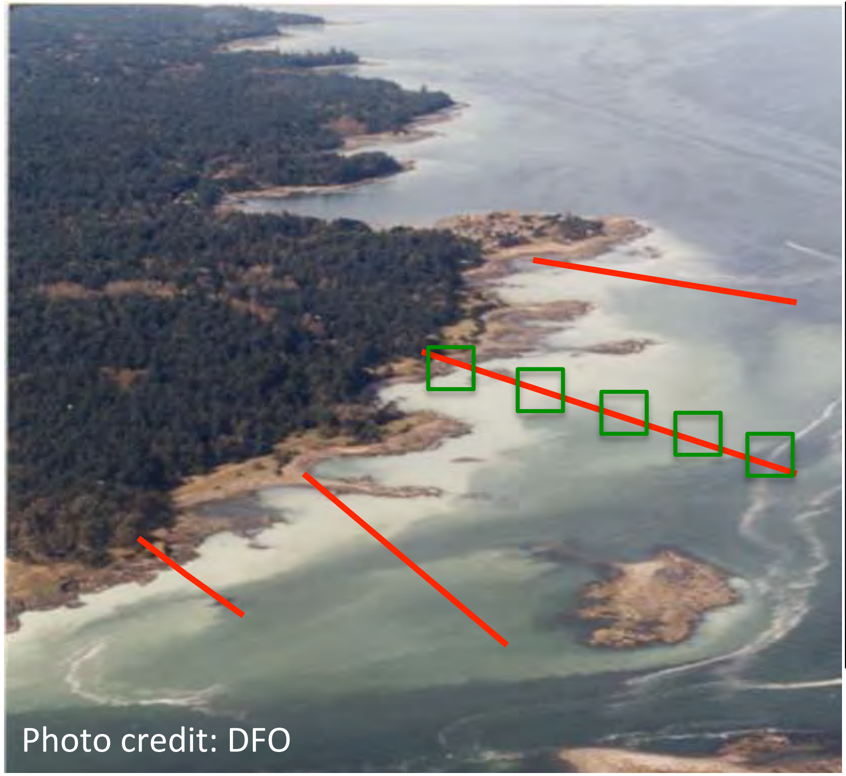


Photo credit: DFO

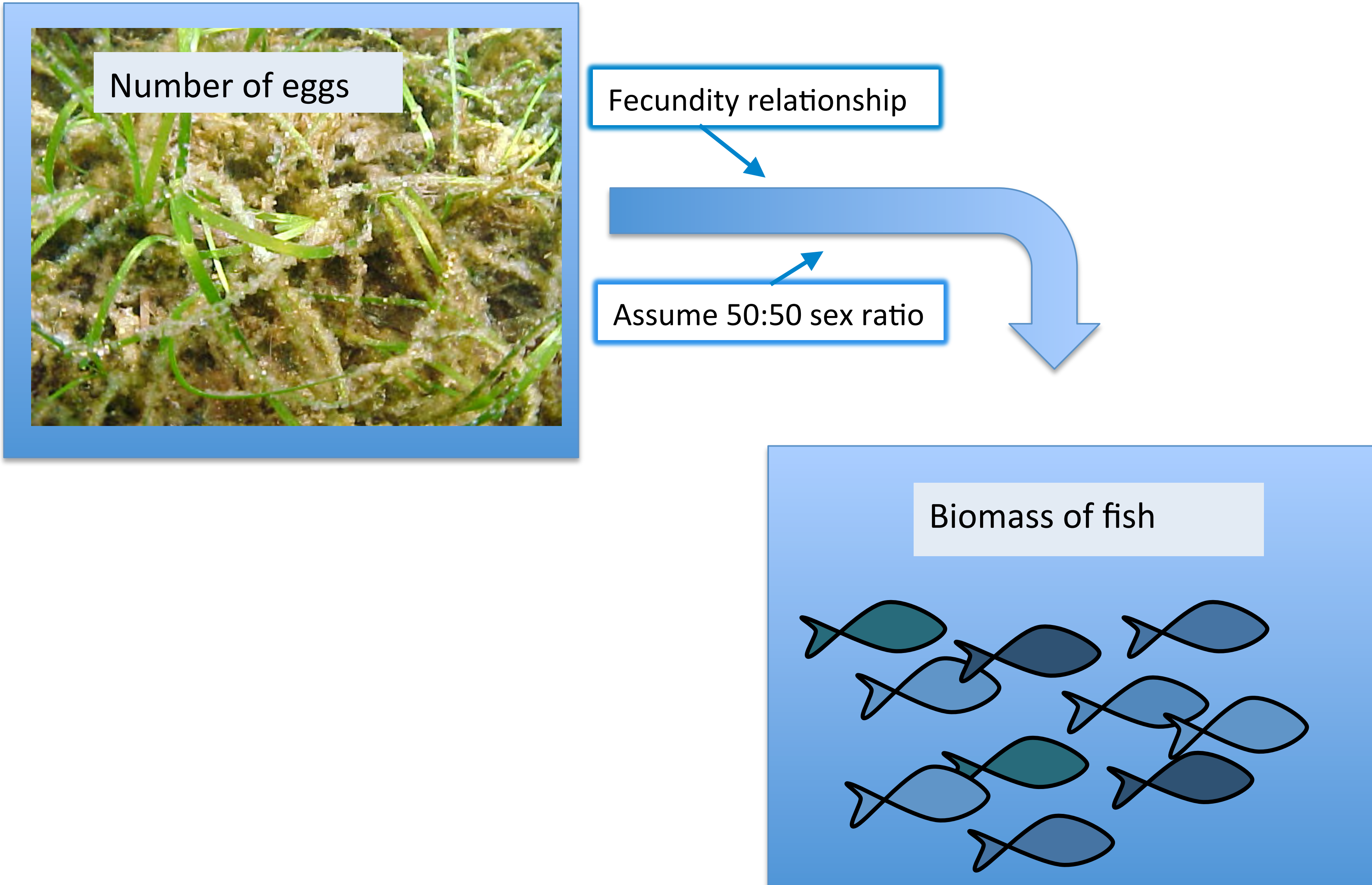
Herring egg surveys:

1) Identify spawn from flights
2) Determine shoreline length of spawn
3) Transect and quadrat placement
4) Collect quadrat data (egg layers/numbers, vegetation type and percent)
5) Extrapolate to total survey area (shoreline length, spawn width (i.e. transect length), egg density)

Photo credit: ADFG, S.Dressel

Photo credit: DFO, K.Daniel

Eggs to fish


Number of eggs
Fecundity relationship
Assume 50:50 sex ratio
Biomass of fish

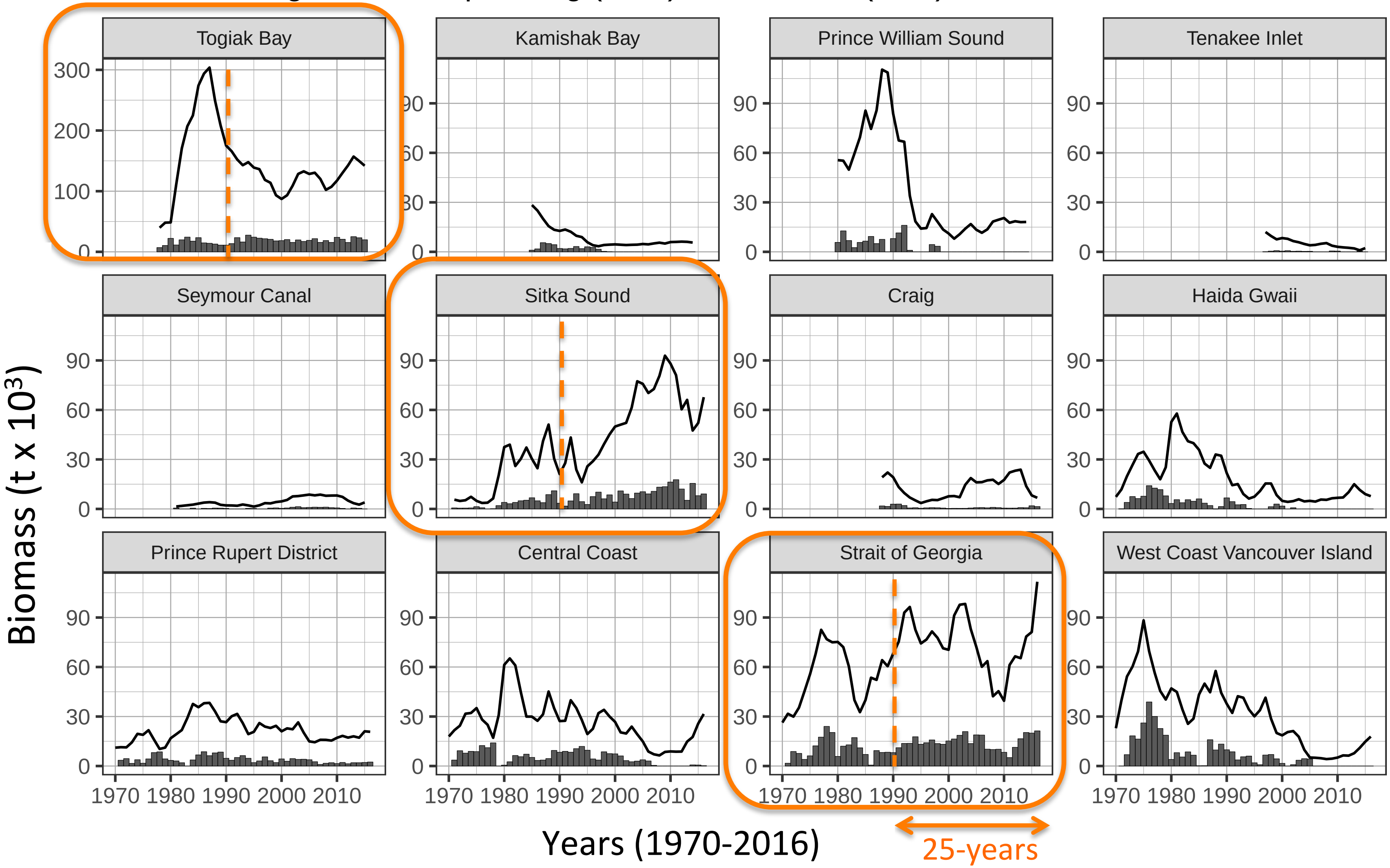
Approaches to stock assessment are similar among regions

BC	BC and Alaska	Alaska
Minimize negative log likelihood for catch data, relative abundance index, age-composition, and stock-recruit relationships (given priors distributions and penalty functions)	**Catch age models**, fitted to: • Survey index • Proportions at age (obs) • Weight at age (obs) • Catch (obs/ validated) Objective function	*Least squares to minimization* differences between obs. and estimated total or relative abundance index, age-compositions, and stock-recruit relationships (not all)
Fixed maturity at age Estimated deviations in *M* using random walk	Models estimate: • Selectivity • Recruitment • Maturity at age • Natural mortality	Estimated using logistic function over all years or in time blocks Estimated over all years or in time blocks
Bayesian estimation: SB_t and SB_{T+1} reflect median values of marginal posterior distributions and credible intervals	• Spawning biomass and uncertainty	Frequentist estimation: SB_t and SB_{T+1} reflect point estimates, and bootstrapped confidence intervals (not all)

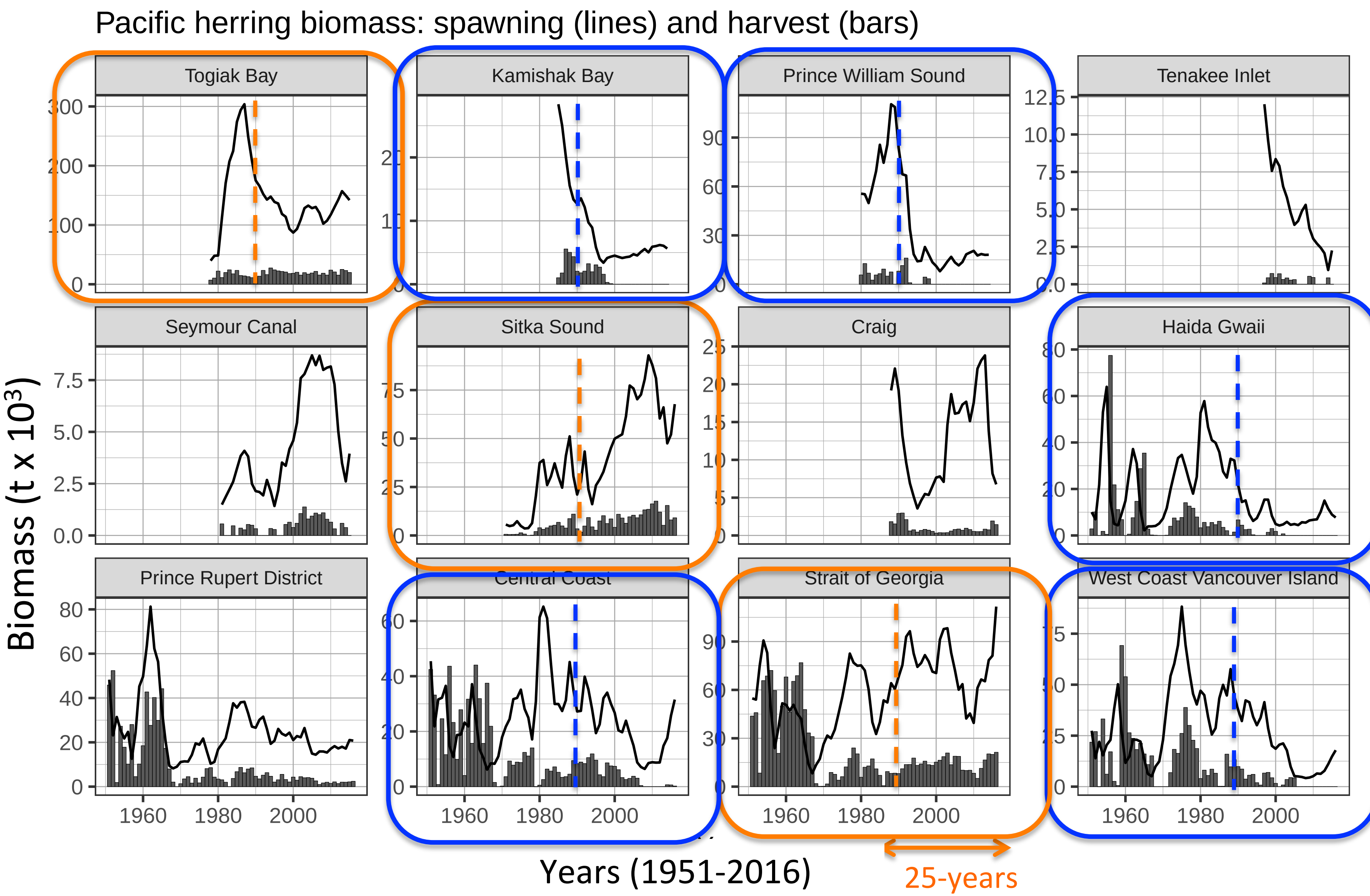
Overview of stock status

Stocks with highest overall biomass in recent 25-years

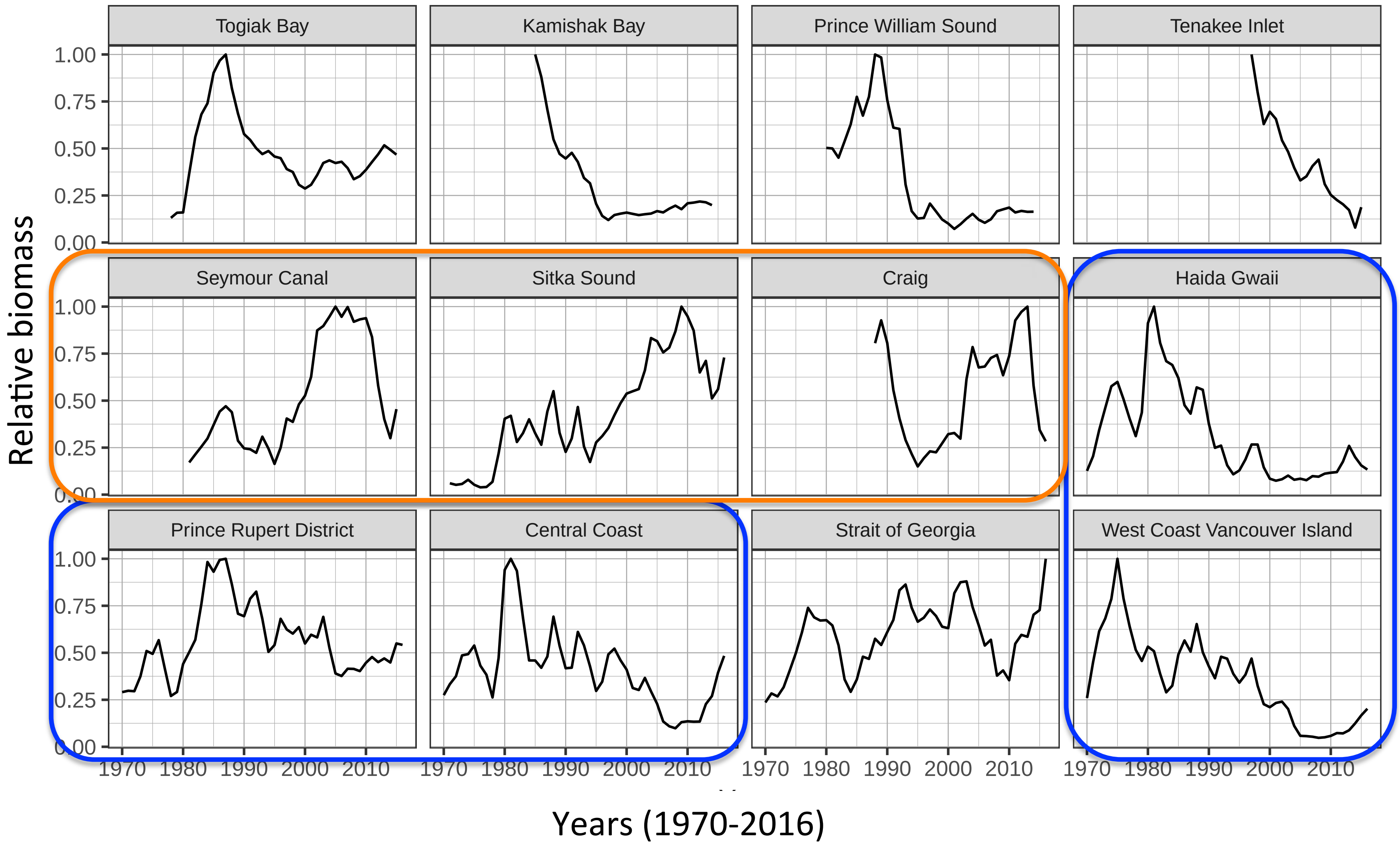
Pacific herring biomass: spawning (lines) and harvest (bars)



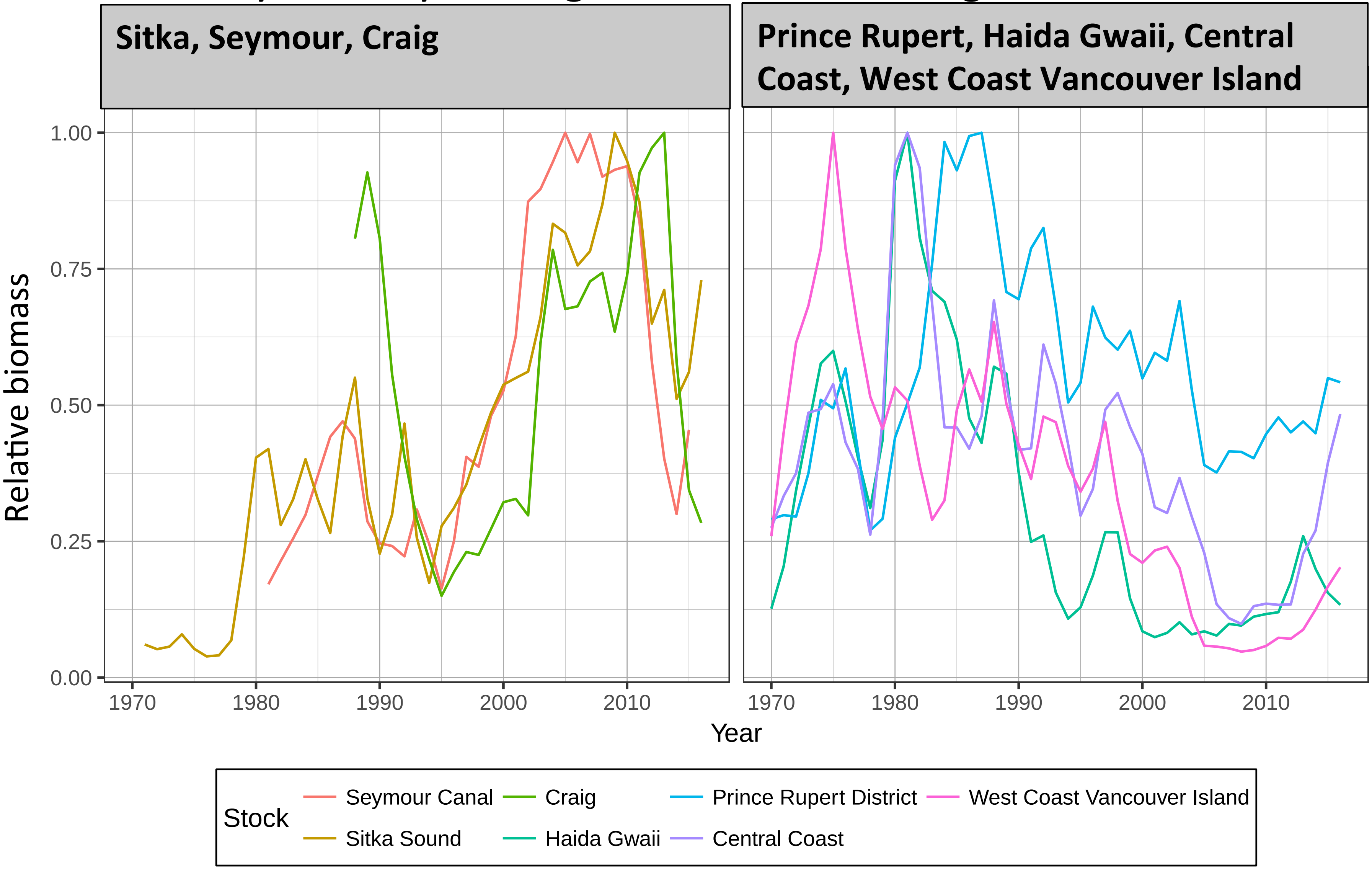
Stocks experiencing low biomass trends in recent 25-years



Biomass synchrony among stocks between regions…



Biomass synchrony among stocks between regions…

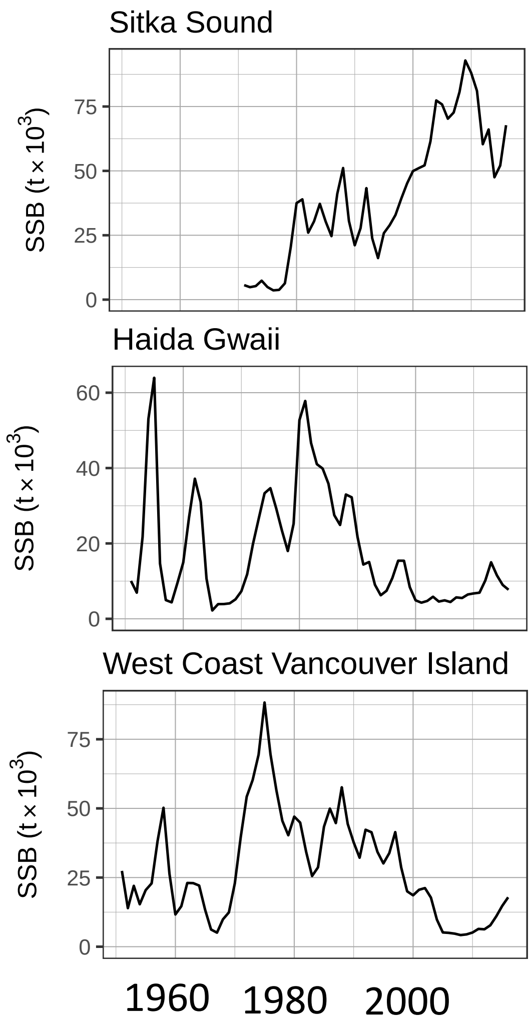


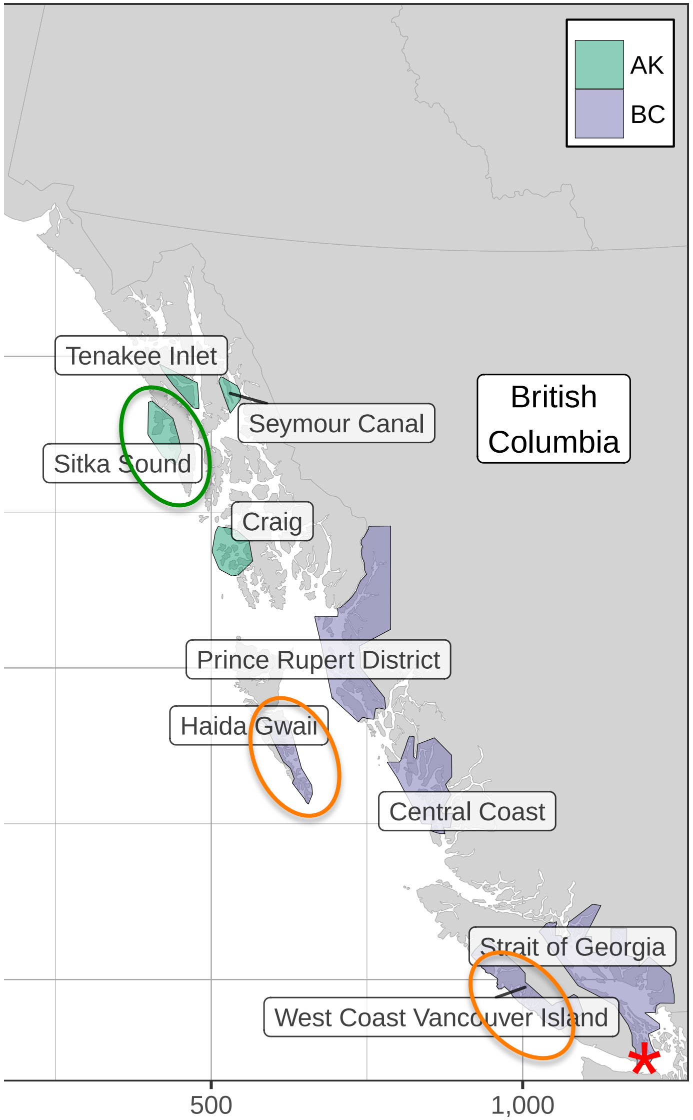
Opposing trends between regions…

Sitka

Haida Gwaii

West Coast Vancouver Island





What are the biggest challenges to assessing (AK-BC) Pacific herring stocks, and,
What can we learn from each other?

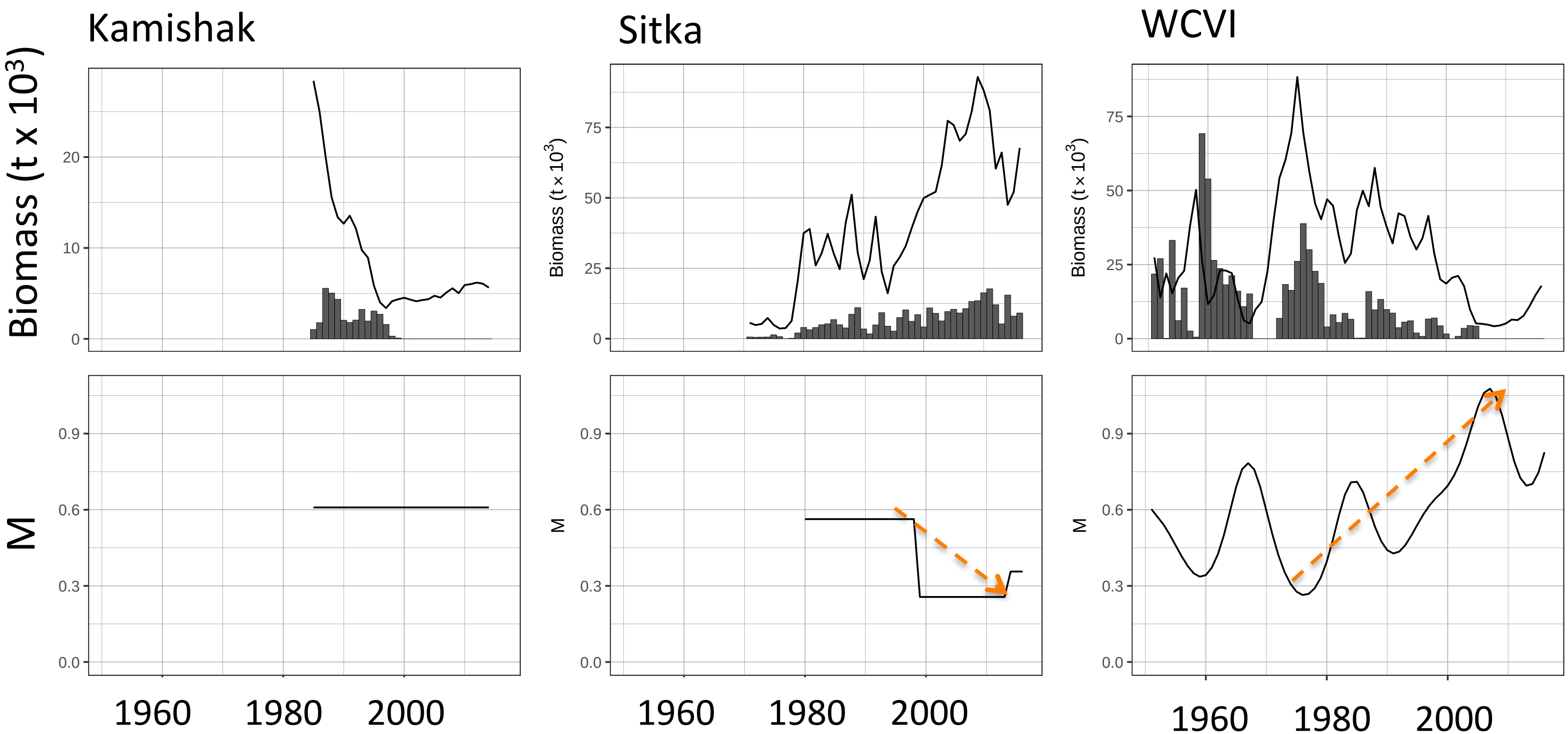
What are the biggest challenges to assessing (AK-BC) Pacific herring stocks, and, What can we learn from each other?

- Stability in data collection programs: securing funding for annual surveys and stock assessment
- Nonstationarity: coping with time varying changes in growth, maturity and natural mortality in stock assessment and in the estimation of biological reference points

Example: Estimating natural mortality

- According to Clark (1999, CJFAS): Natural mortality is the most influential parameter in fisheries stock assessments, relating directly to estimated stock productivity, sustainable catch, optimal exploitation rates and calculation of reference points.

Example: Estimating natural mortality

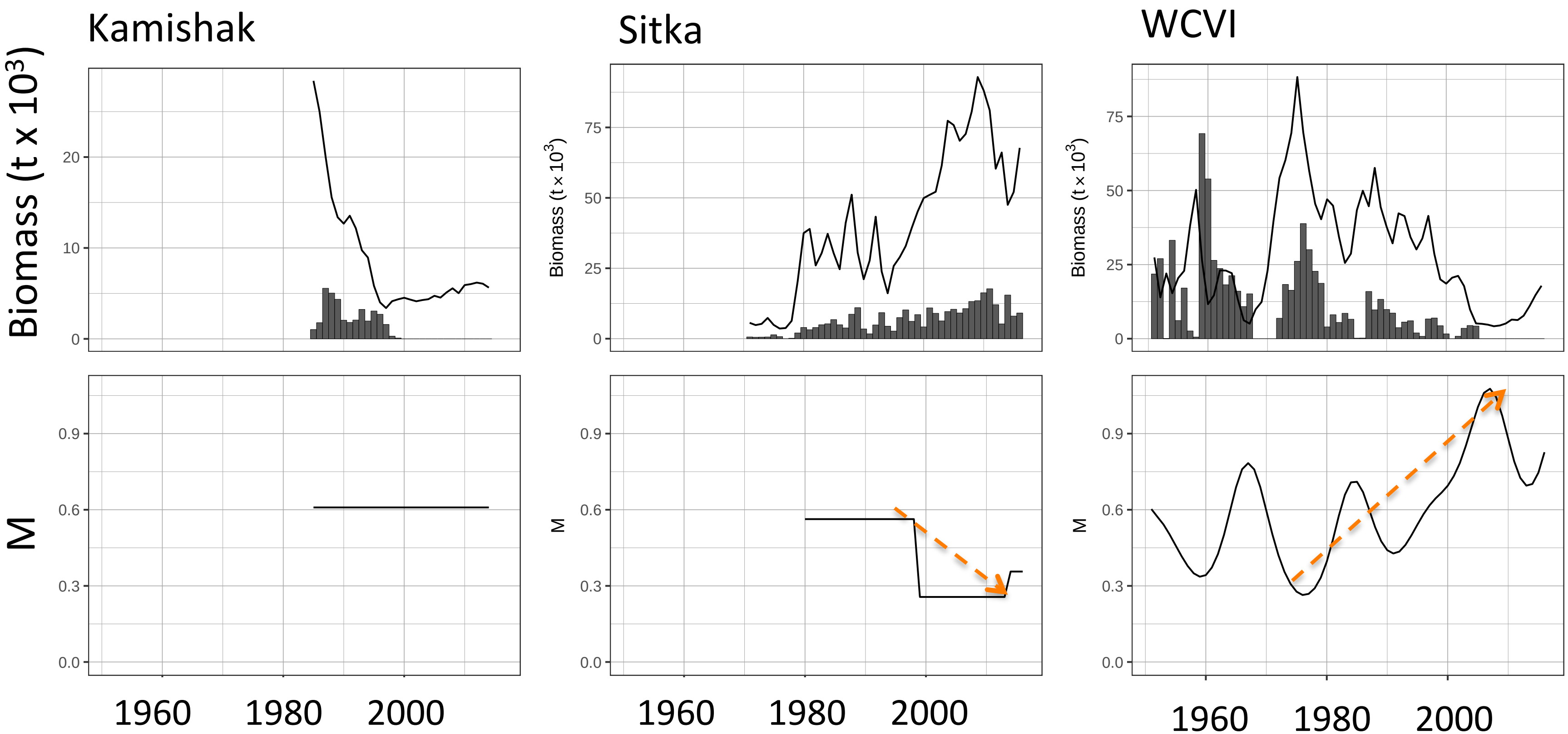


Estimating constant *M* across time

Estimating *M* in time blocks according to changes in PDO if it results in improved model fits (defined by AICc criterion)

Estimating time varying deviations in *M* using a random walk, with cubic spline interpolating

Example: Estimating natural mortality



Addressing critical challenges through collaborations:

- Can we further investigate nonstationarity (e.g., in *M*) within stock assessment models using a joint simulation study to identify best approaches for estimating *M* for herring
- Adopting similar approaches for estimating *M* could provide consistent basis for estimating biological reference points (e.g., B_0) that are comparable across regions

What are the biggest challenges to assessing (AK-BC) Pacific herring stocks, and, What can we learn from each other?

Other areas for collaboration:

Catch age models, fitted to:

- Survey index
- Proportions at age (obs)
- Weight at age (obs)
- Catch (obs/ validated)

Objective function

Models estimate:

- Selectivity
- Recruitment
- Maturity at age ← Field study
- Natural mortality ← Simulation study

- Spawning biomass and uncertainty

Joint studies to investigate changes in weight-age, fecundity, and growth

What are the biggest challenges to assessing (AK-BC) Pacific herring stocks, and, What can we learn from each other?

- We're keen on developing on-going collaborations to help us address current challenges such that both countries can advance our respective herring stock assessment programs with more synchrony and improve assessment approaches for this key forage species

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