What will influence Chilko Lake sockeye salmon as climate changes?

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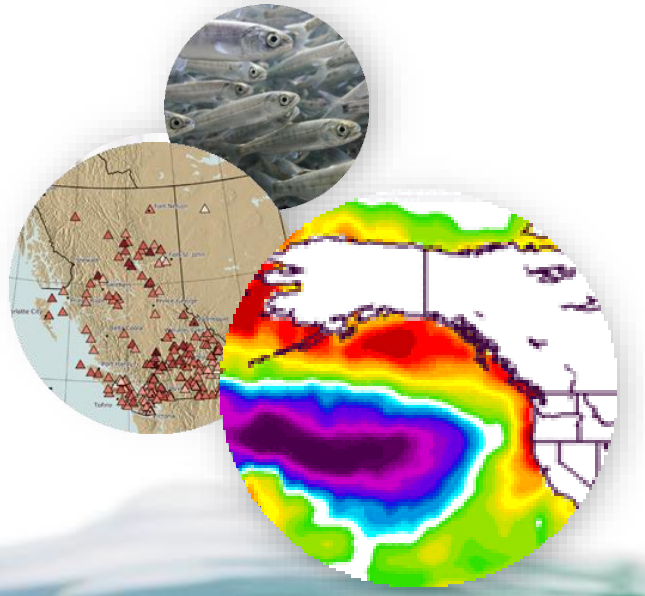
PICES Annual Meeting

Oct 17, 2019



Fisheries and Oceans Canada

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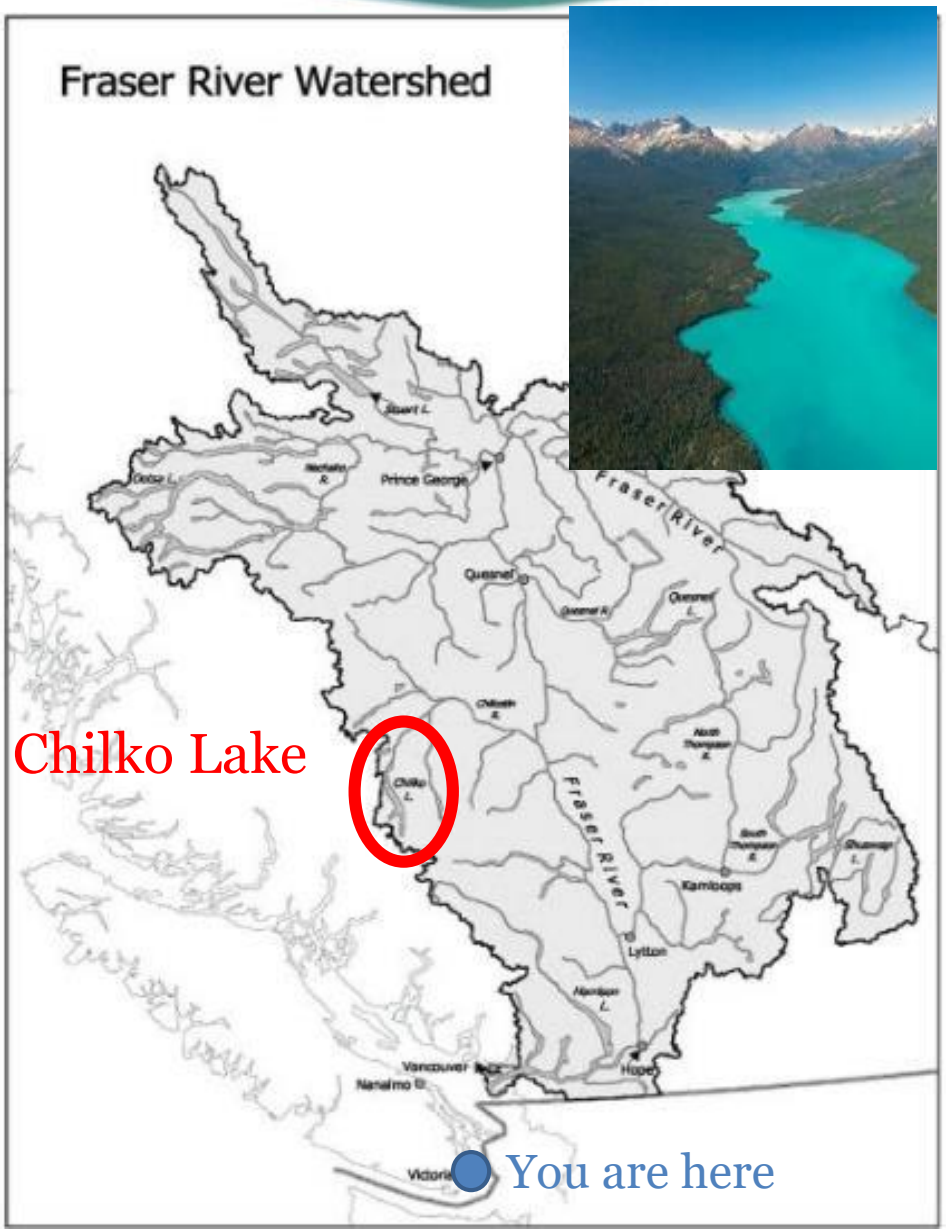
Background

- 70km long x 3-5km wide
- Total area = 185 km²
- Important spawning habitat for sockeye salmon



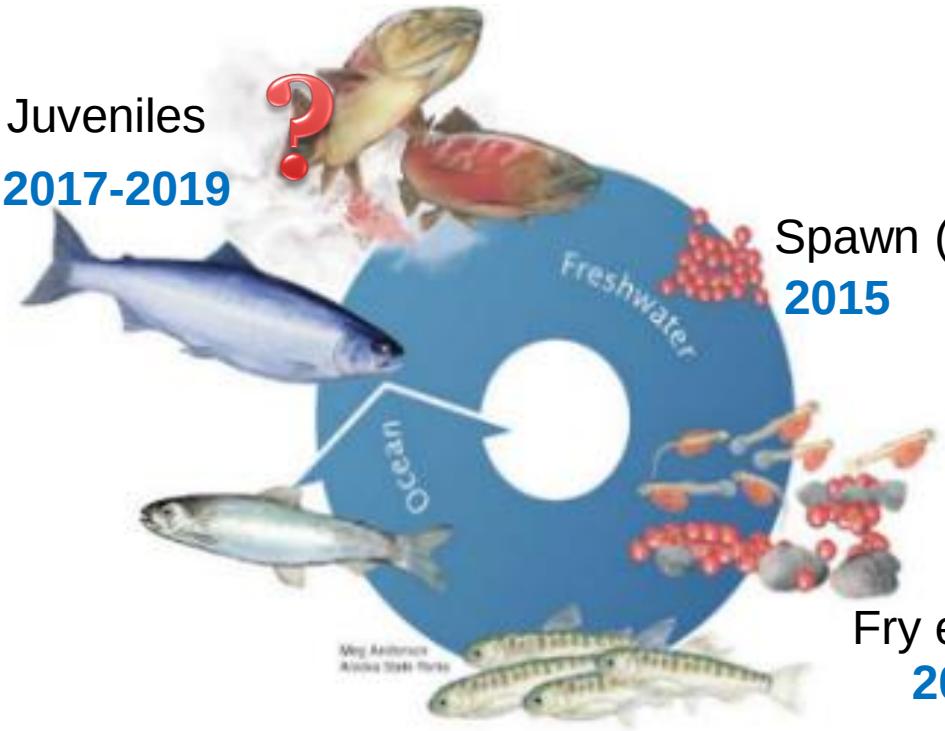
Life History

Recruitment

2019

Juveniles

2017-2019



Spawn (eggs)

2015

Fry emergence

2016

Data Available

Spawners/Recruits 1948-2019

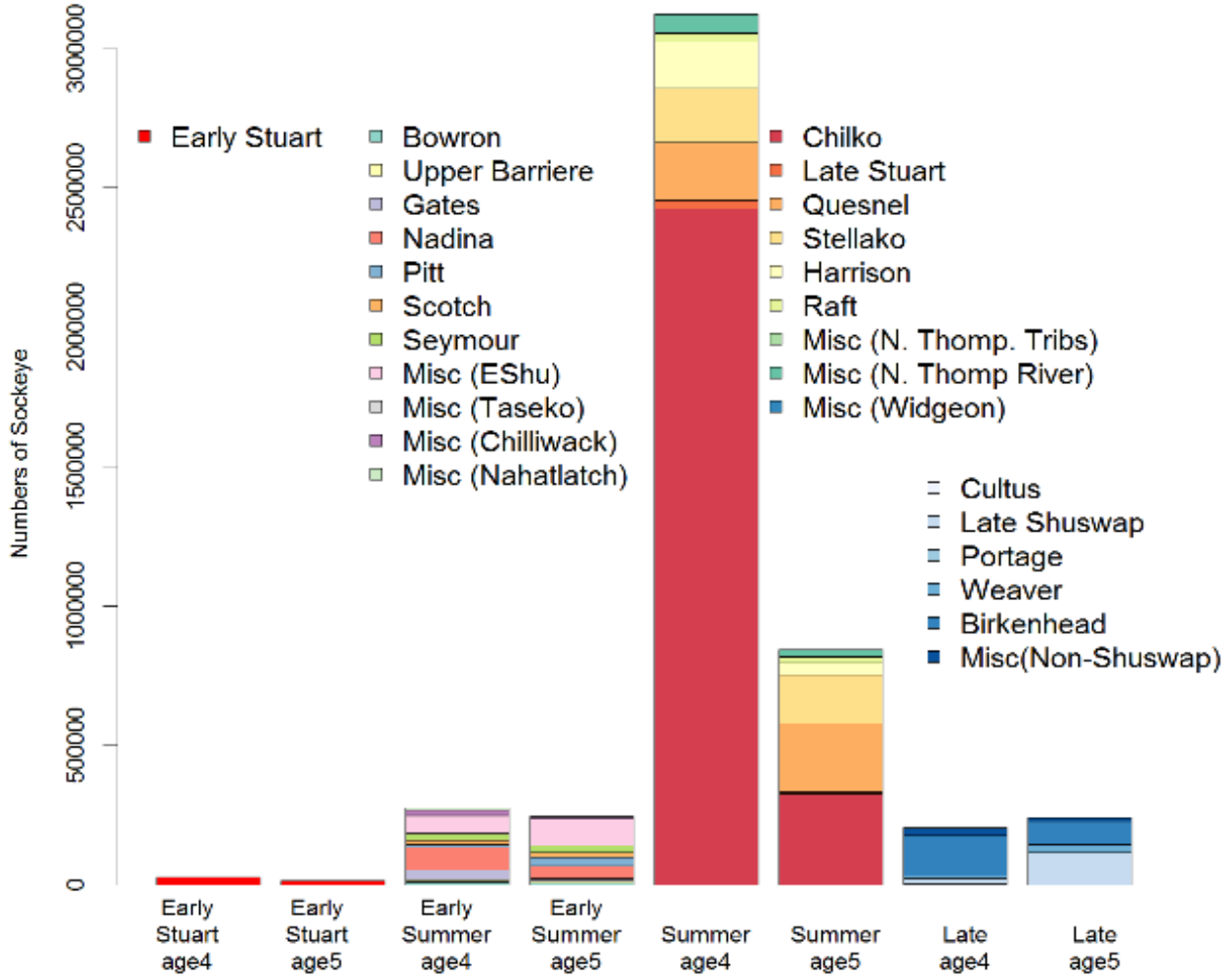
Juvenile 1949-2018

Smolts

2017

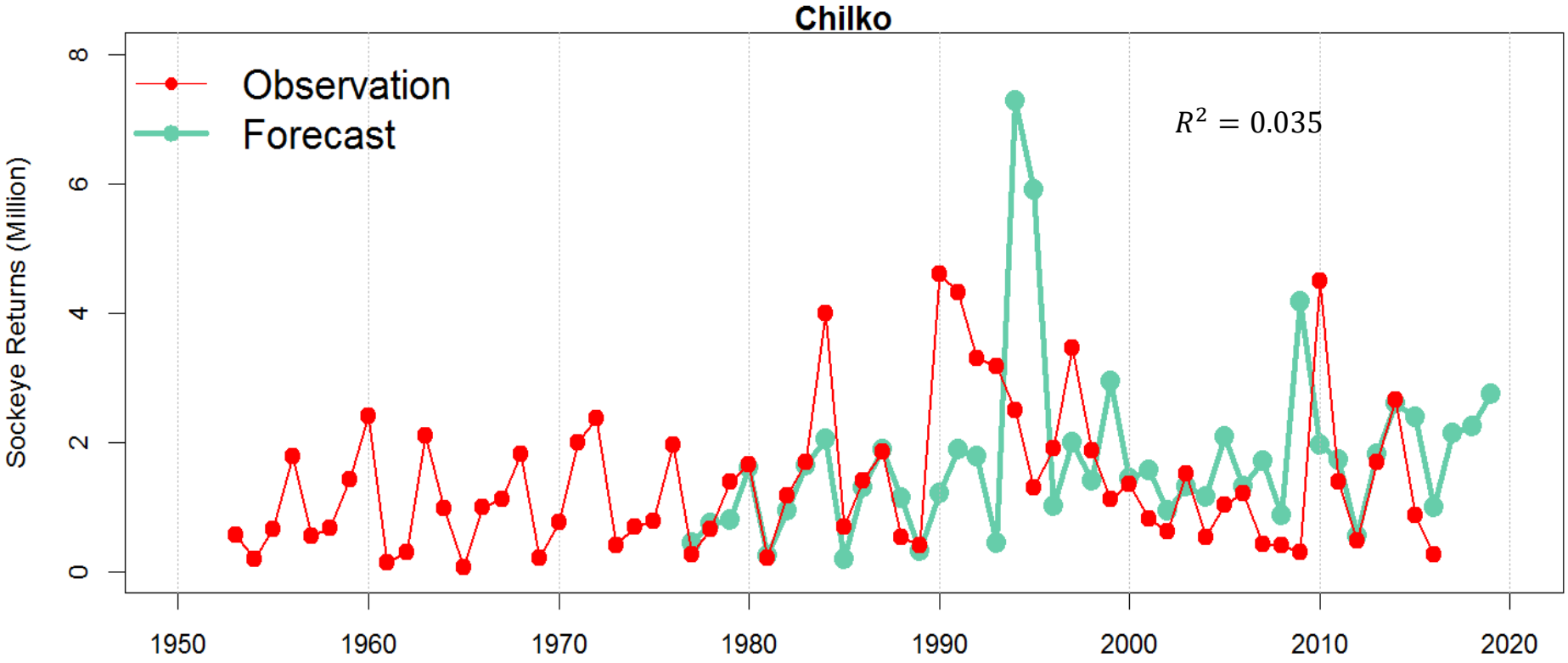
Background

2019 Sockeye Pre-season Forecast



$(DFO, 2019)$

Historical Pre-season Forecast



Current Forecast Model

- Biological model (Power model) with one environmental variable: SST @ Pine Island
- Selected from 9 models (including Ricker models, Power models and Larkin models)
- Environmental co-varies considered: SST @ Entrance Island, Fraser River discharge and PDO

Objectives

- Collect additional environmental info from freshwater and ocean
- Develop a quantitative predictive model of the influence of multiple environmental variables on sockeye recruitment
- Identify key environmental variable(s)
- Evaluate model performance by comparing predictions with available fisheries data
- Application: update forecast with new method

Data

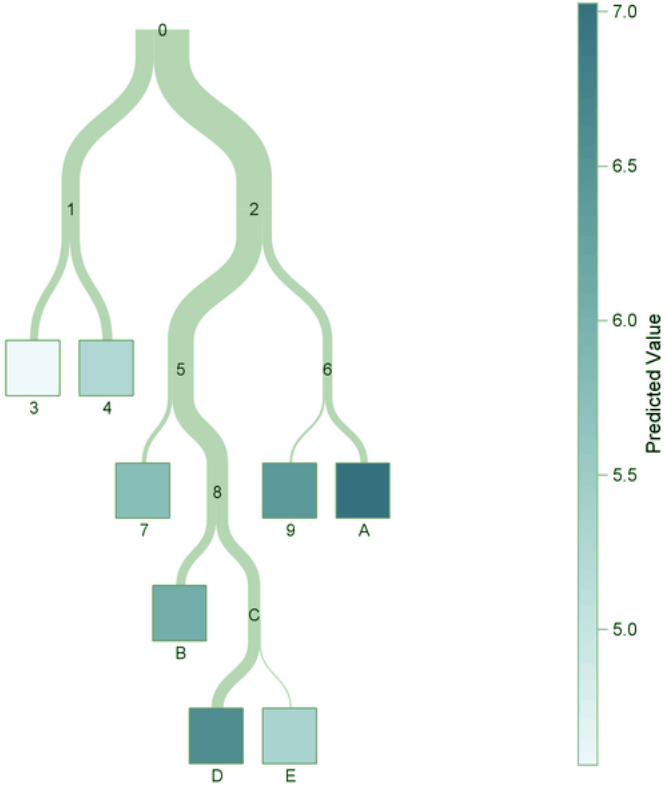
- Fisheries Data (Same as what was used in the 2019 forecast)
  - Spawners and Juveniles (DFO)
  - Recruits (Pacific Salmon Commission)

- Environmental Data
  - River: discharge, temperature (DFO)
  - Ocean: SST (lighthouses and COBE model), SSS (lighthouses), regional upwelling and downwelling favored wind stress (DFO and NOAA)
  - Ocean/Climate Indices: PDO, NPGO, MEI, NOI, ALPI, Bifurcation index (NOAA and DFO)

Model Boosted Regression Trees (BRT)

- A Tree-based method combines two algorithms
  - Regression Trees (models that relate a response to their predictors by recursive binary splits)
  - Boosting (an adaptive method for combining many simple models to give improved predictive performance)

- Available in R
  - Package name: “dismo” Version 1.1-4 and “gbm” Version 2.1.5
  - References (De’ath, 2007; User manual Elith et al., 2008)

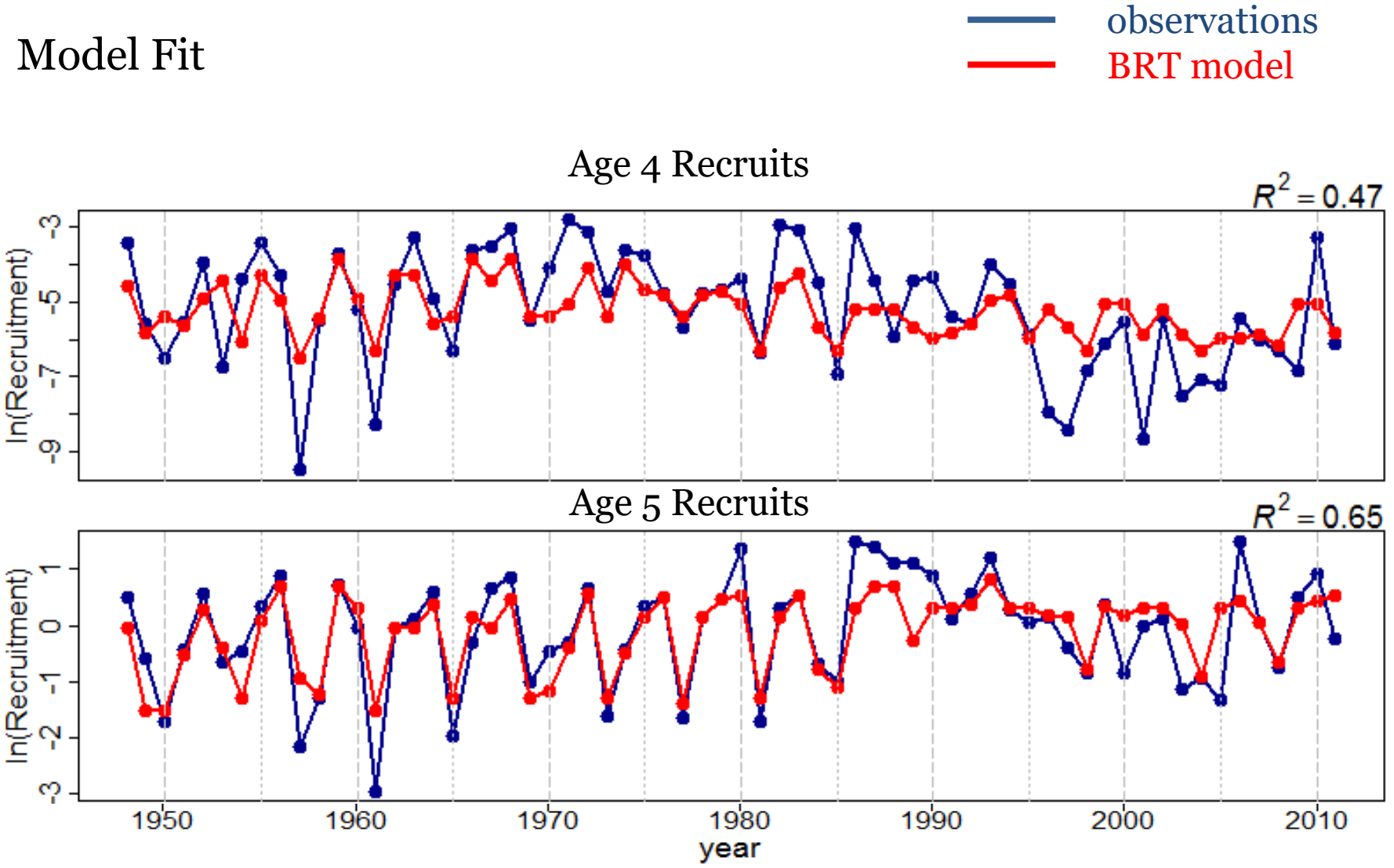


log(Recruits) ~ BRT (Spawners/juveniles, environmental variables)

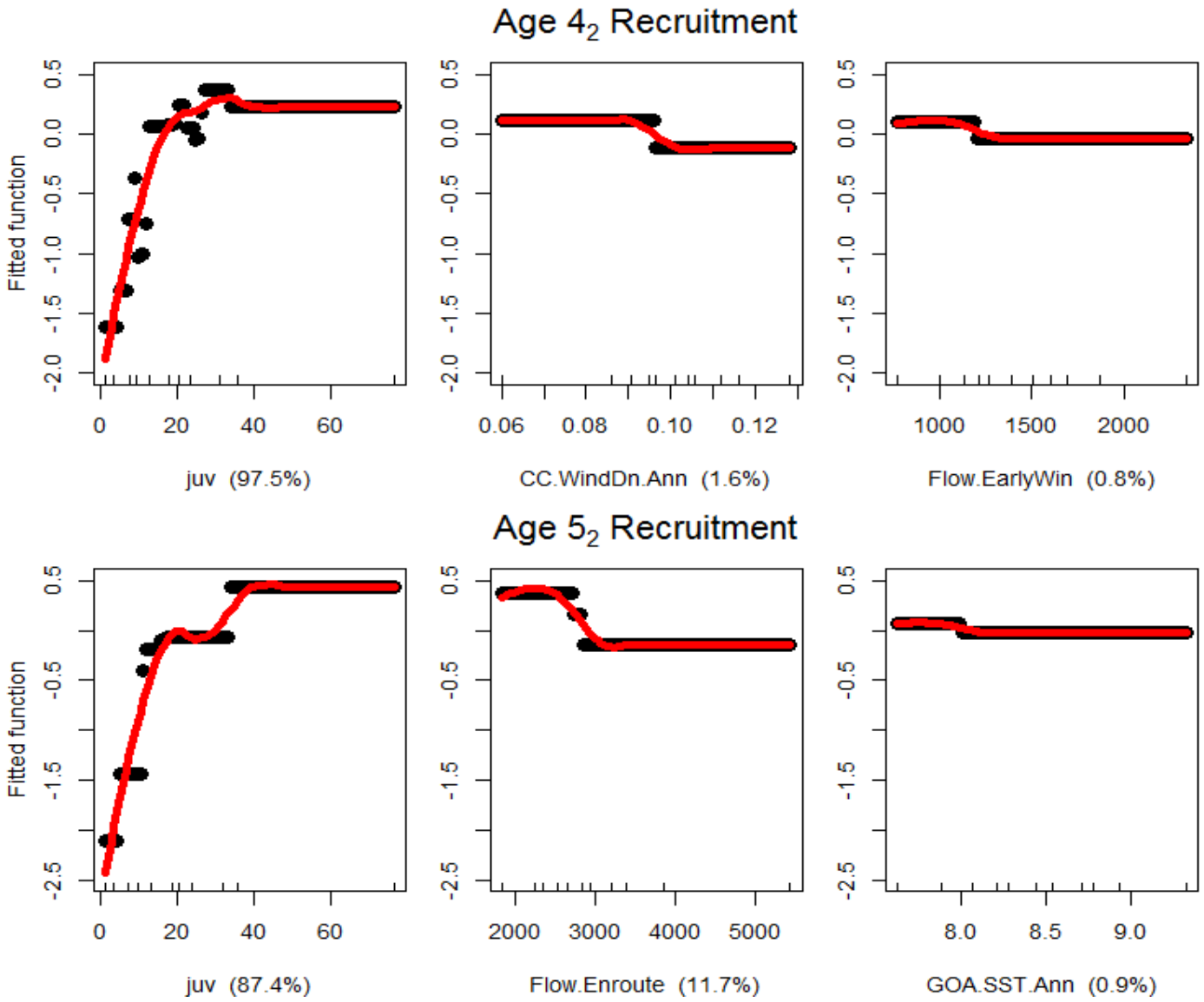
Model Boosted Regression Trees (BRT)

	Current Model	BRT Model
Model setup	Parametric	Non-parametric
Relationship linearity	Linear (Treated Linear) only	Linear or Non-linear
Numbers of environmental variables considered	None (Naïve/biological model/Sibling model) One (biological-env model)	Multiple
Data Structure	Normal	Normal or Skewed
Sensitivity to outliers	Somewhat	No
Sensitivity to scale	Yes	No
Ability of handling Missing Data	No	Yes

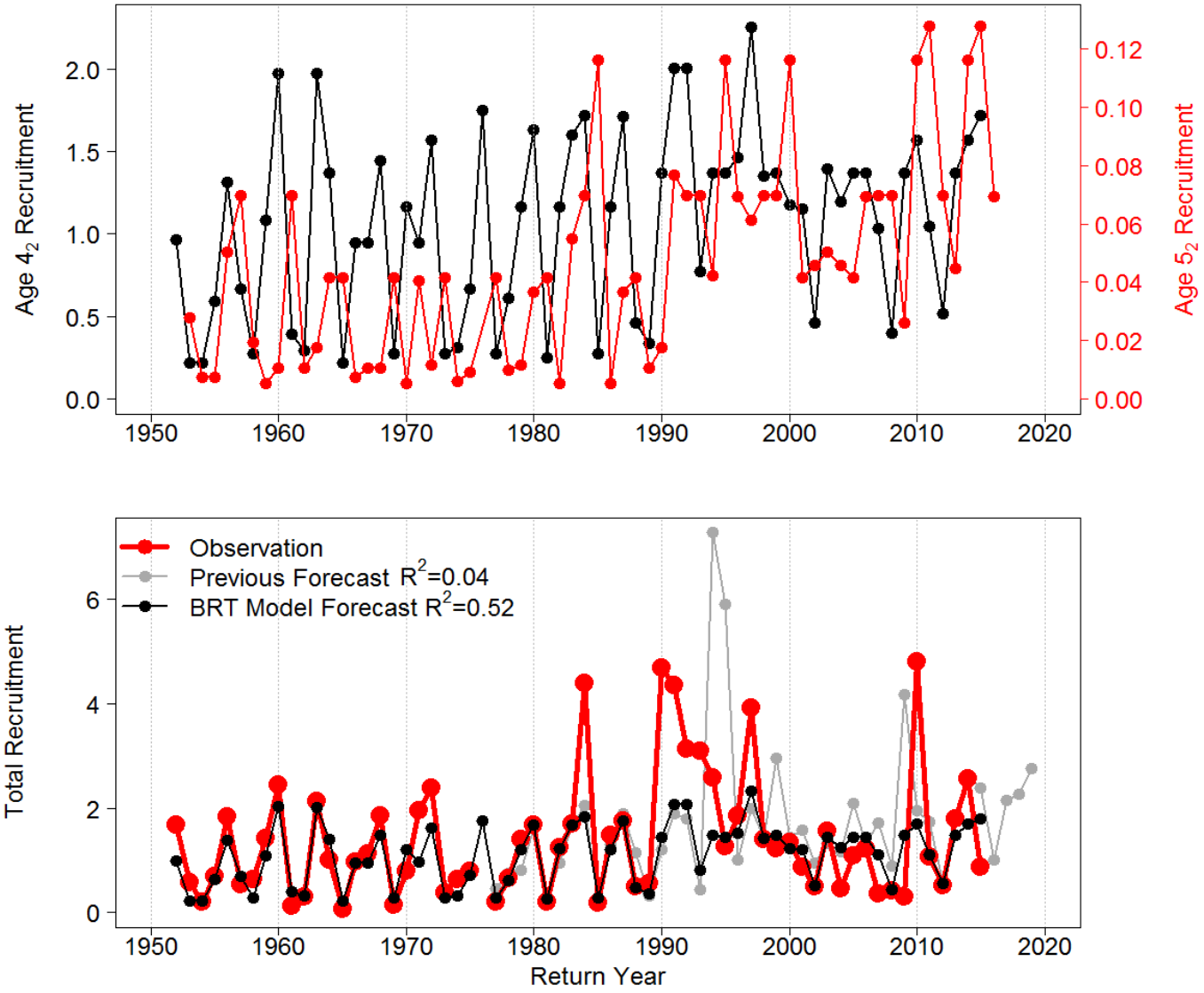
Model Fit


observations
BRT model
Age 4 Recruits
$R^2 = 0.47$
ln(Recruitment)
-3
-5
-7
-9
Age 5 Recruits
$R^2 = 0.65$
ln(Recruitment)
1
0
-1
-2
-3
1950
1960
1970
1980
1990
2000
2010
year

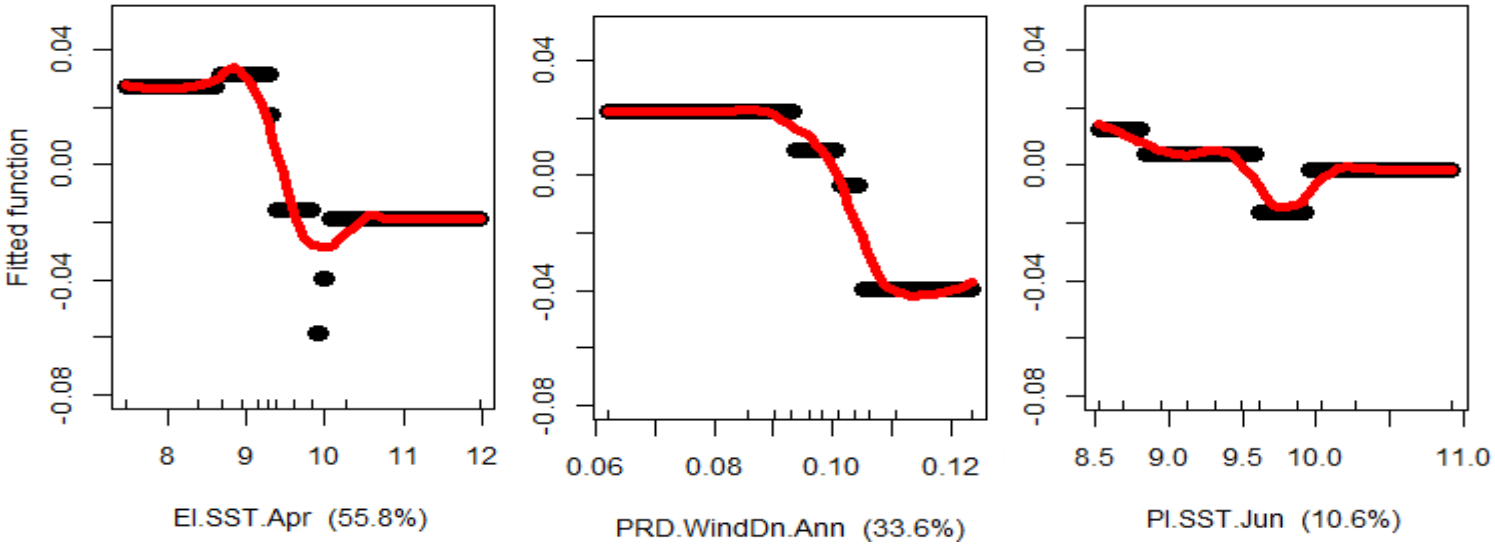
Relative contributions



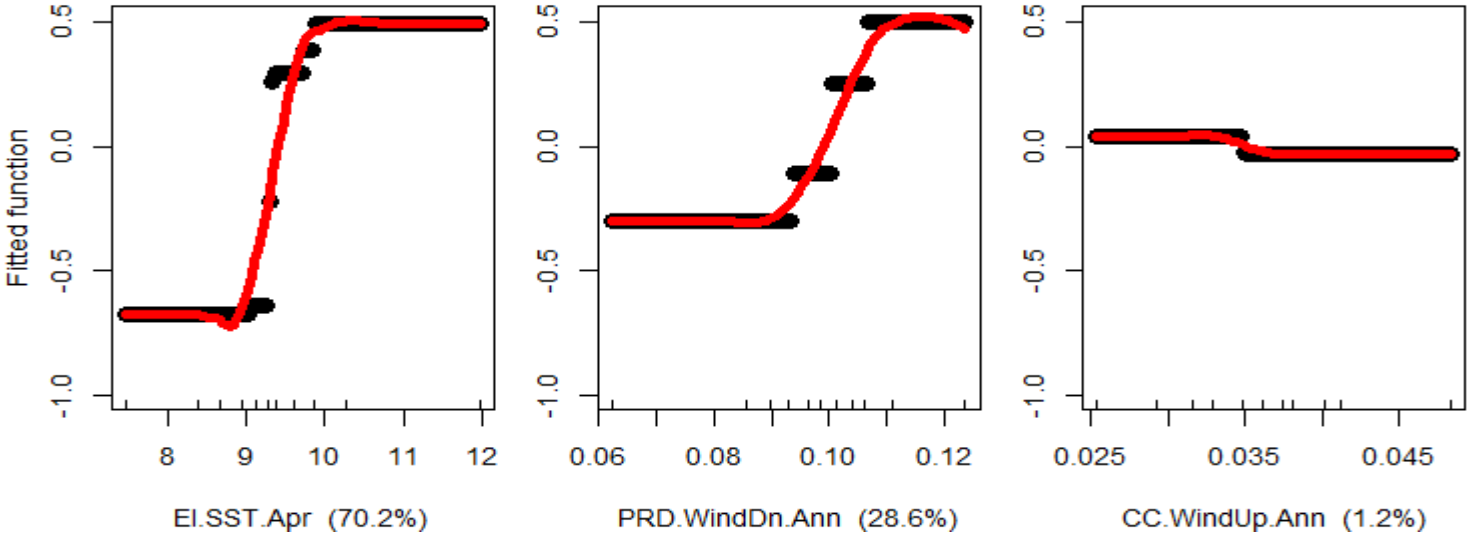
Forecast model

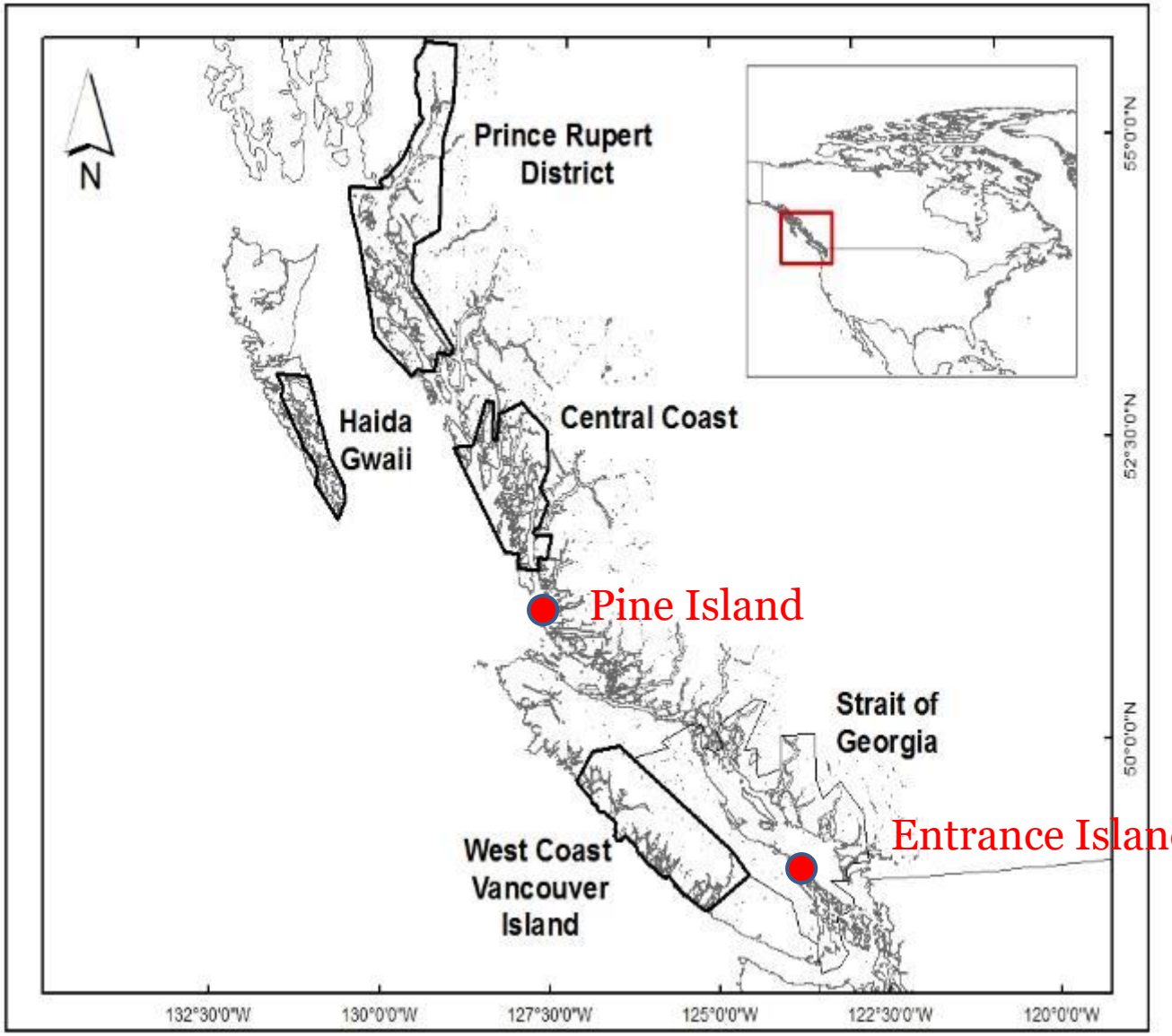


Age 4_2 Proportion



Age 5_2 Proportion




N
Prince Rupert
District
Haida
Gwaii
Central Coast
Pine Island
Strait of
Georgia
Entrance Island
West Coast
Vancouver
Island
132°30'0"W
130°0'0"W
127°30'0"W
125°0'0"W
122°30'0"W
120°0'0"W
55°0'0"N
52°30'0"N
50°0'0"N

Summary

- BRT models are developed to study age-specific stock-recruits relationship coupled with multiple environmental co-varies.

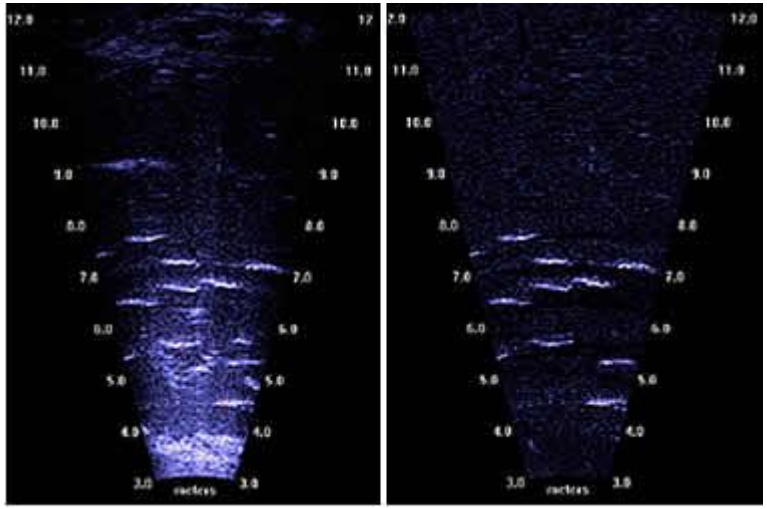
- We found that both age-4 and age-5 recruit showed a Beverton-Holt like relationship rather than Ricker/Power model.

- Environmental variables played a small role for S-R but seems to largely impact age proportion.

- These results are useful for future forecast as it seems to have better performance comparing to current forecast models.

Future Work

- Manuscript preparation
- 2020 Fraser Sockeye Forecast
- Application: Other stocks/species
- Collaboration opportunities



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- Ocean Data

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- Others

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Photo: S Grant