Evaluation of modeling methods for assessing and comparing the abundance of two size classes of eulachon in British Columbia

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Eulachon life history & Importance

- Spawn in lower reaches of rivers
- Larvae move to estuary and sea
- Spend most of their lives at sea
- Return to spawn at age 2-5(?)

- Traditionally important for BC First Nations
- Important forage fish in the coastal ecosystem
- High in fat content (“candlefish”)
- Consideration as Threatened in Canada
- Captured as bycatch in shrimp fisheries

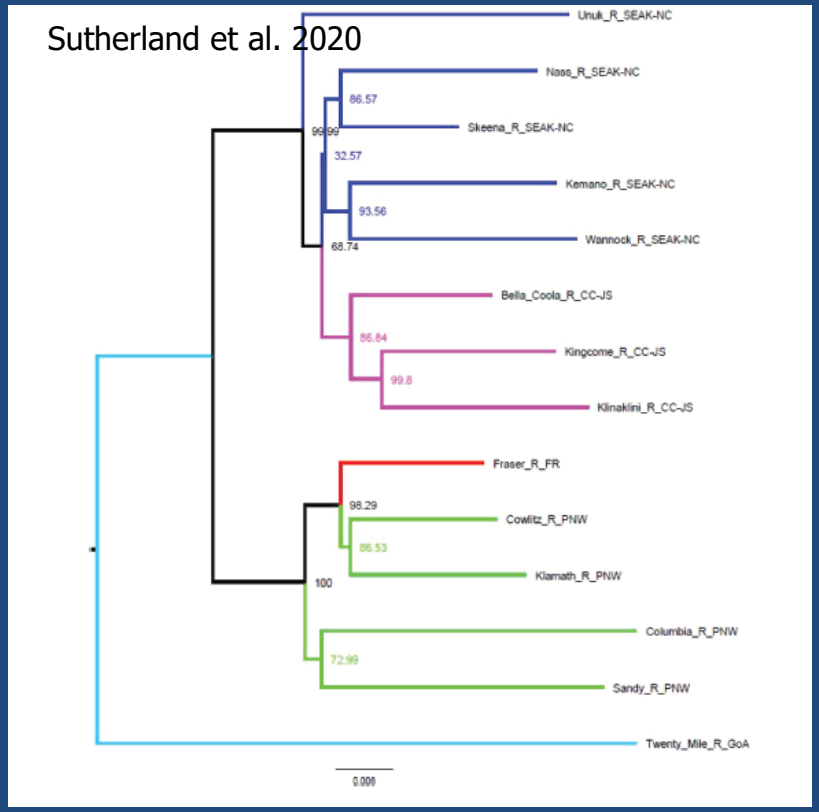
Objectives:

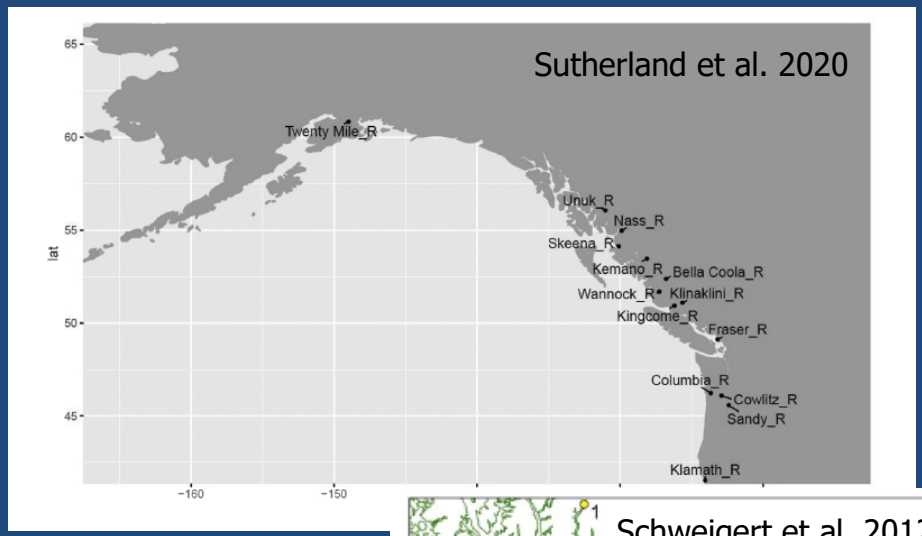
- Compare indices of abundance from five methods
  - Design-based stratified random survey
  - Two kriging methods
  - Two spatio-temporal modeling approaches

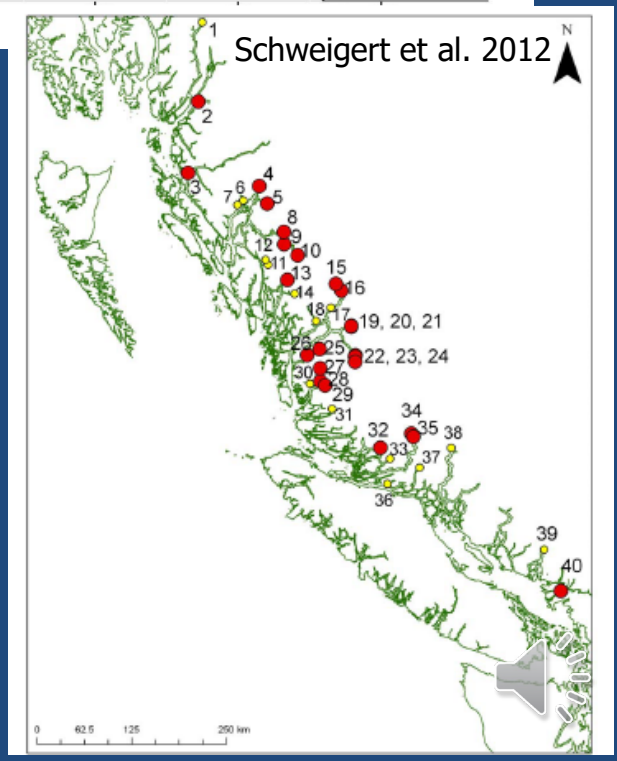
- Compare trends in the annual index of abundance to
  - climate indices and oceanographic variables known to influence the abundance of small pelagic fishes

- Generate insights into the environmental drivers of small pelagic fish abundance and recruitment

Study area and stock structure



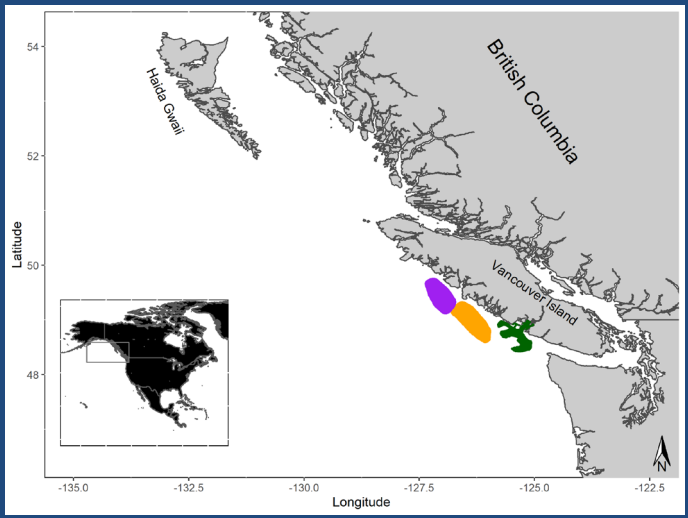


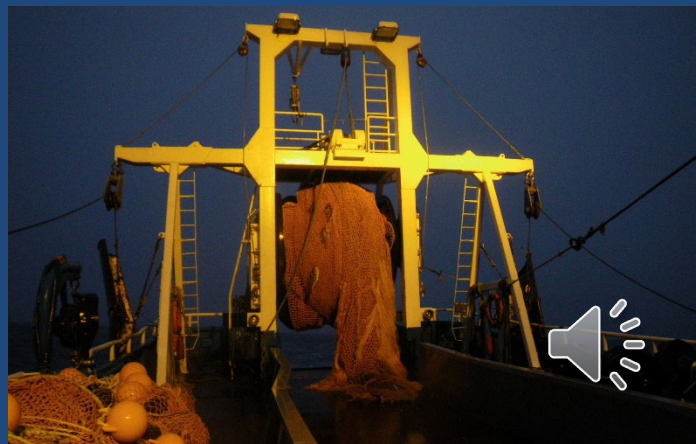


- Lots of rivers support eulachon in BC of varying sizes
- Fraser River is one of the largest and most important (#40)
- Some evidence of regional separation (maybe a lot of mixing though – Sutherland et al. 2020)

Small mesh bottom trawl survey

- Small mesh bottom trawl survey conducted in April/May/June each year since 1975
- Targets shrimp to produce biomass estimate
- Eulachon is a bycatch species
- Survey methodology varied by year
- 3 strata off the West Coast of Vancouver Island
- Stations per year from 67 – 189 (mean = 105)





Model types

1. Stratified random sampling – design based
    a. 2-3 strata, varying n stations per strata, CPUE = weight (kg)/area swept

2. Ordinary kriging*
    a. Gstat package

3. Fixed rank kriging (Kang and Cressie, 2011)
    a. FRK package

4. VAST (Thorson 2019)
    a. Spatial-temporal modeling

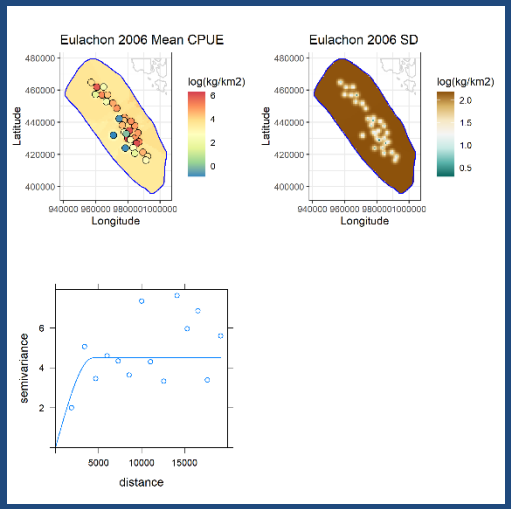
5. sdmTMB (Anderson et al. 2022)
    a. Spatial-temporal modeling with covariate (depth)

All analyses done in R

Model comparisons were done using CV and model diagnostics (preliminary)

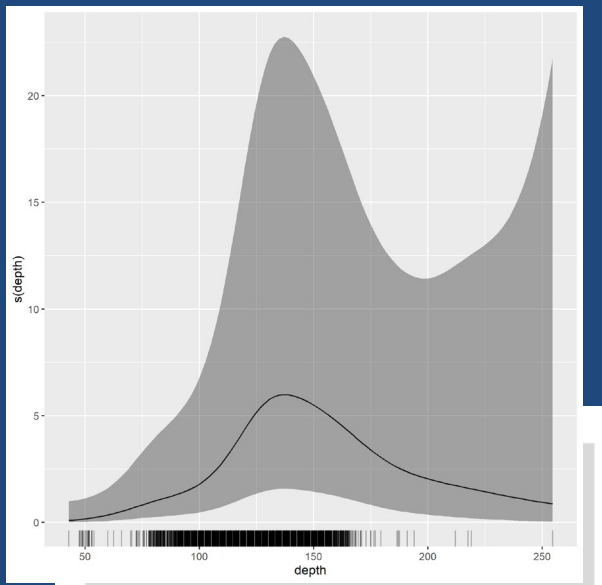
Model fitting

Ordinary kriging

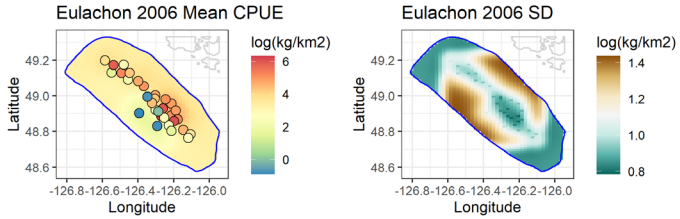


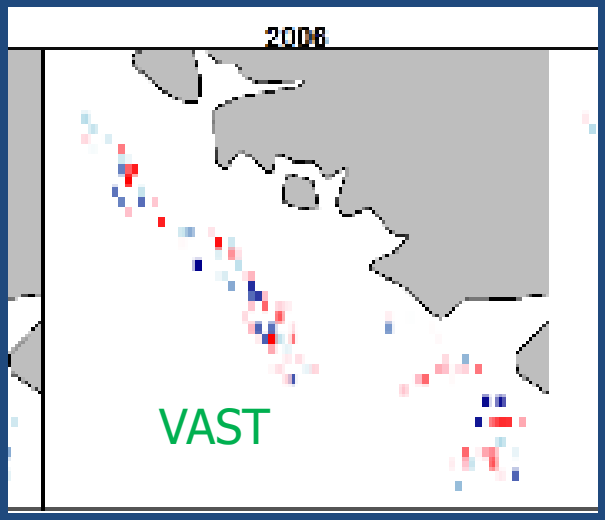
- Nothing outstanding
- All models appeared to converge
- Depth was not very helpful
- More work to be done here

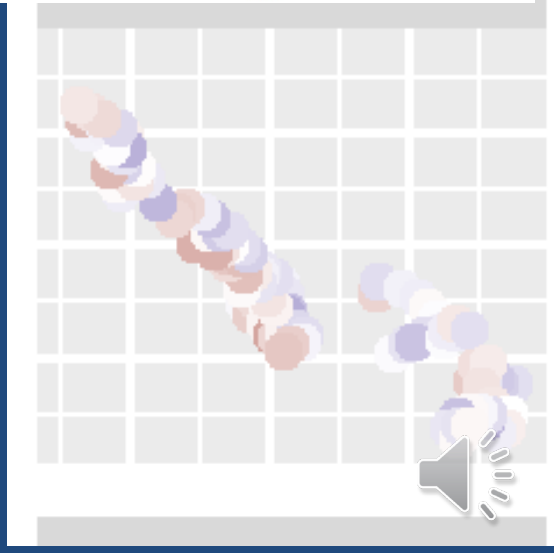
sdmTMB



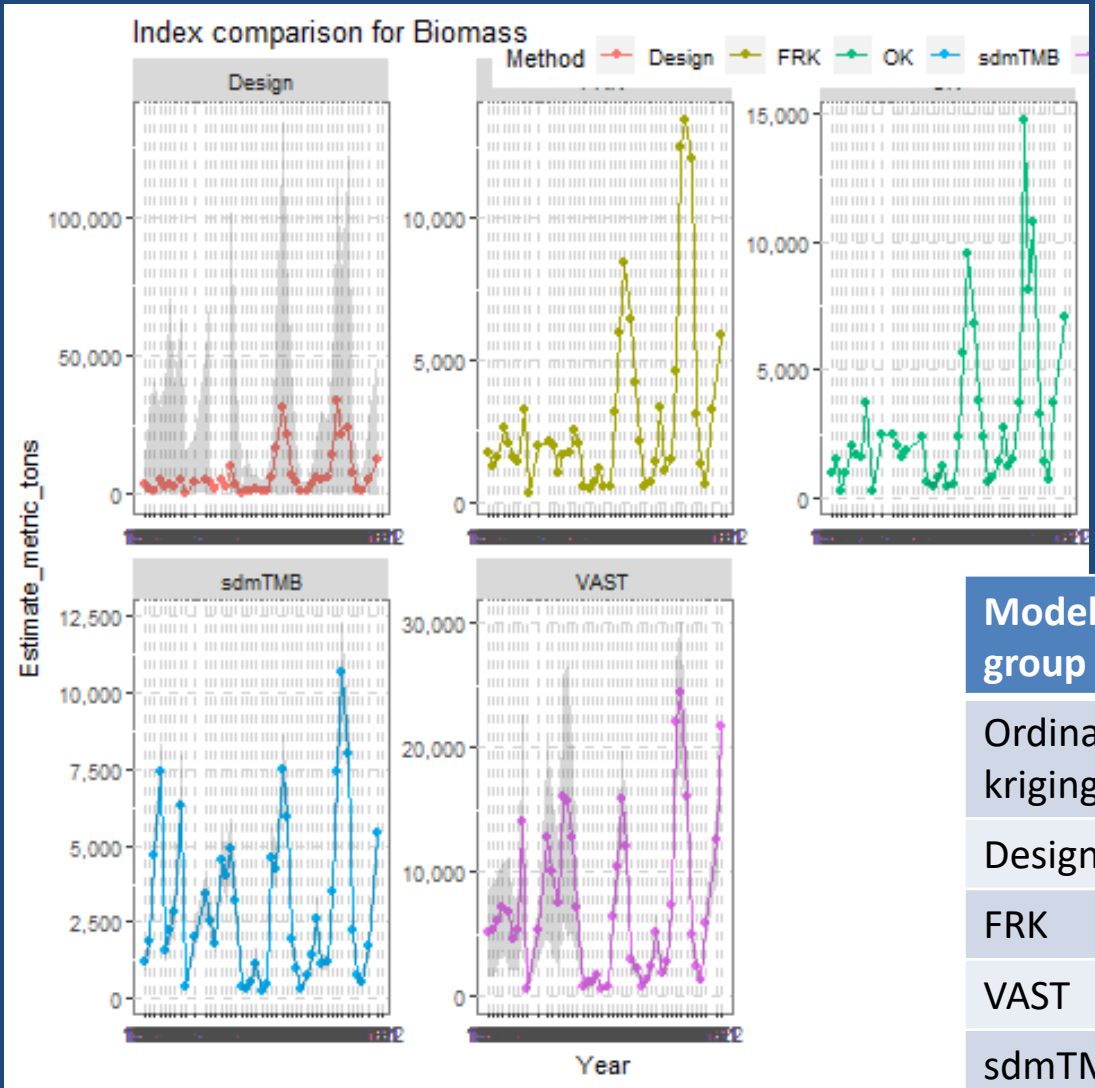
FRK kriging





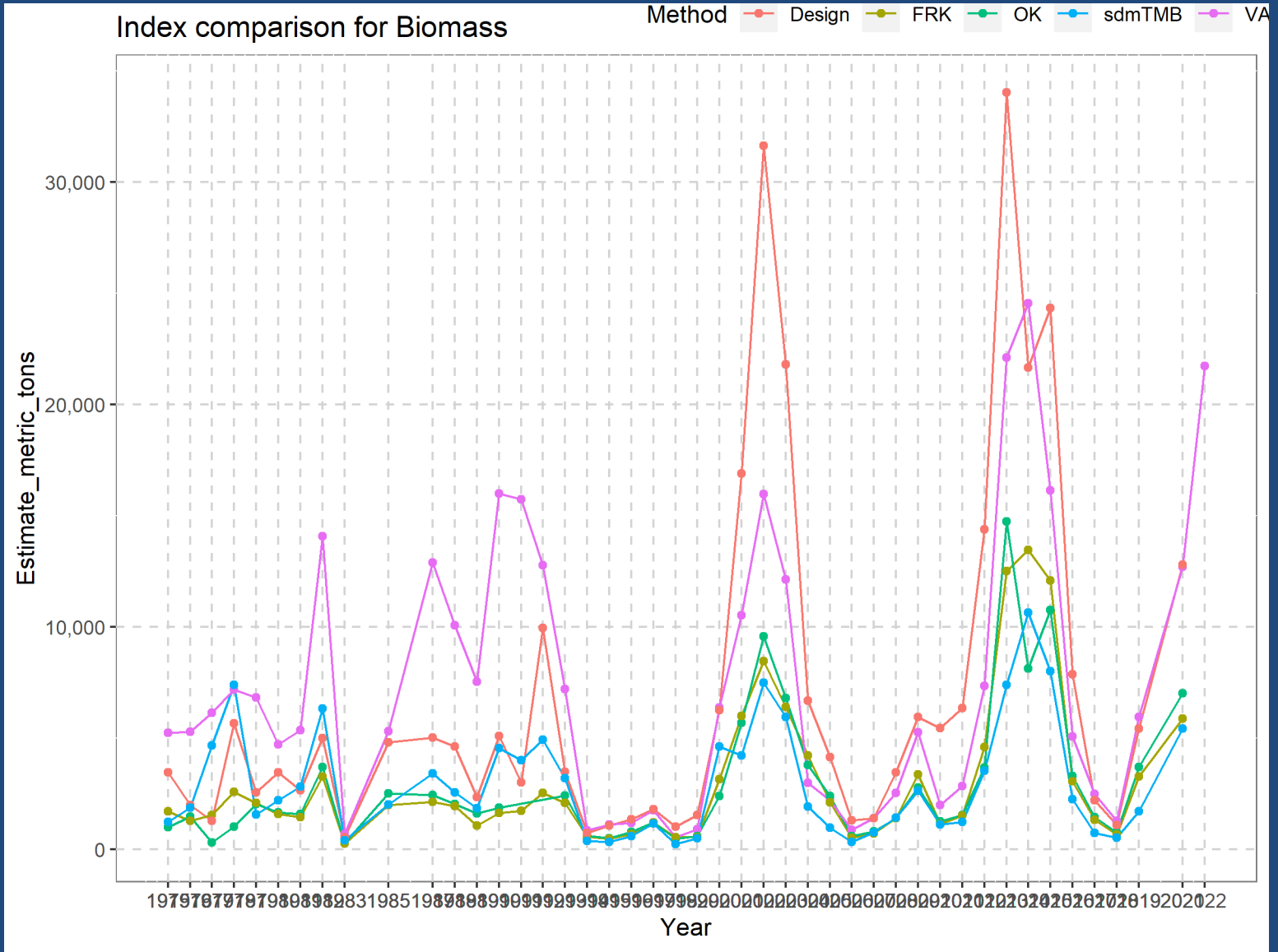


Which is the best?

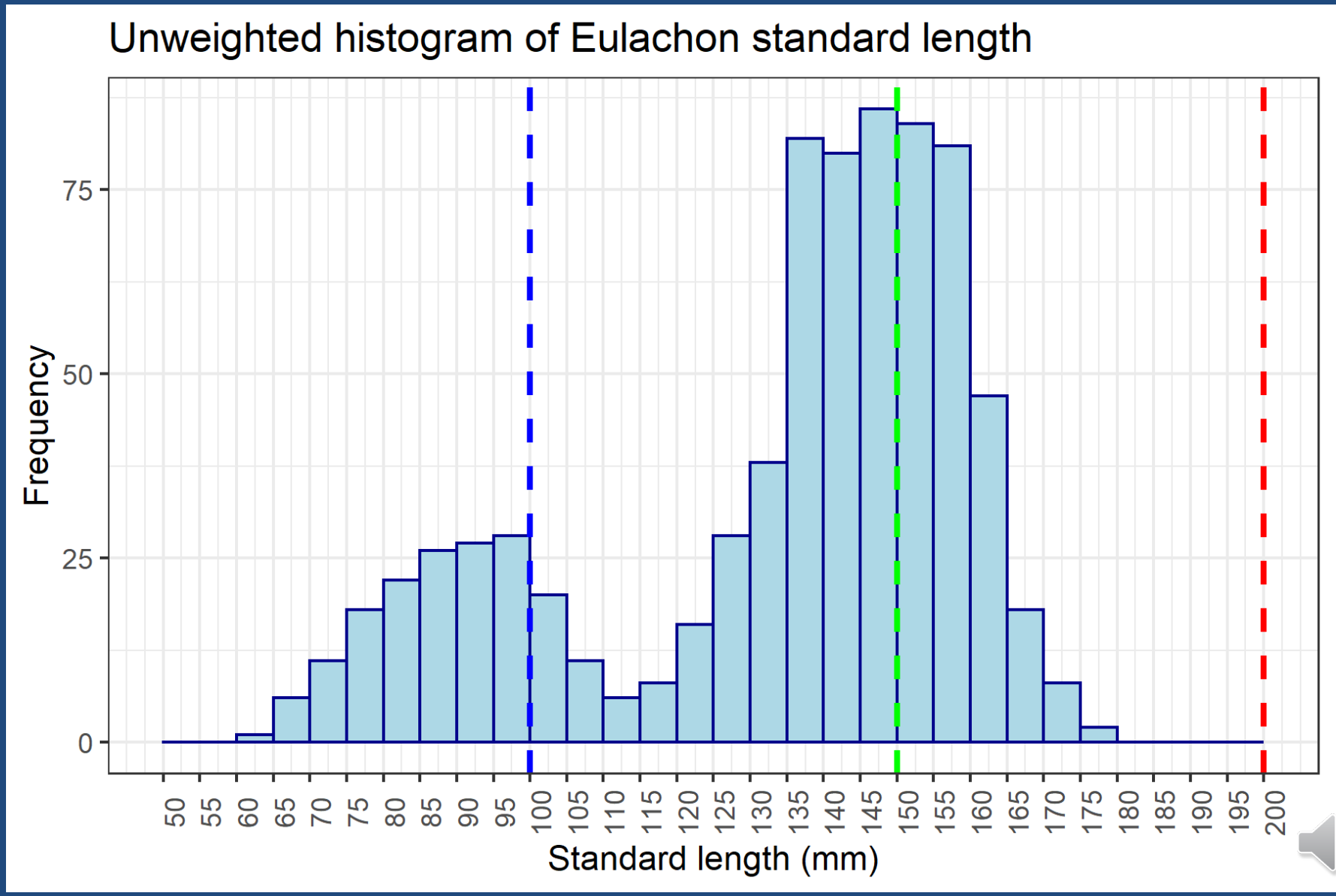


Modeled group	Mean CV	Mean CV (since 2010)
Ordinary kriging	> 1	> 1
Design	1.0	0.83
FRK	0.65	0.57
VAST	0.21	0.13
sdmTMB	0.12	0.11

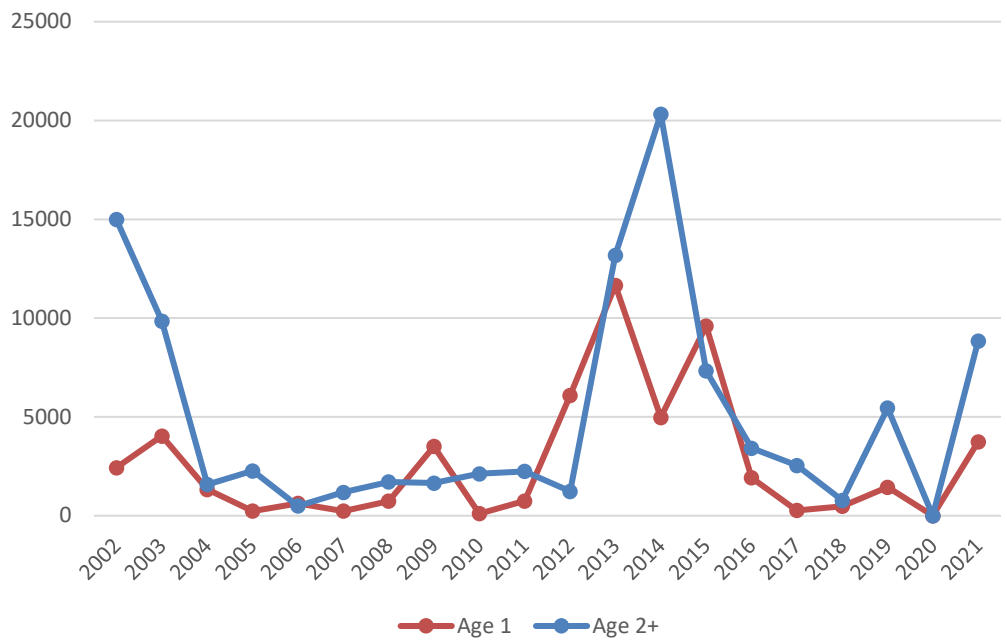
Which is the best?



Multispecies approach



Two size class results



Lagged 1 year, r = 0.73

Fraser River Eulachon Egg and Larval Survey SSB Index

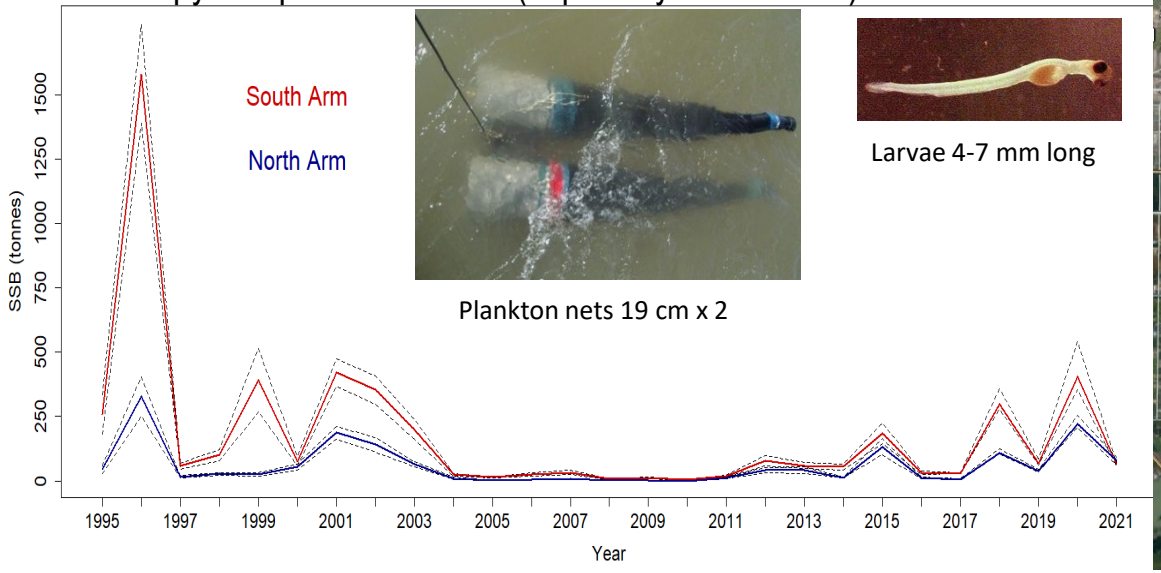
- ≥ 1995, 7-week core period starting mid to late April, biweekly sampling
- Samples from **North** and **South Arm** sites part of index time series
- Samples from **New Westminster** sites exploratory

- **2021 SSB index moderately low ~141 tonnes combined**
- Interannual variability with no reliable forecasting methods

- Clumpy samples since 2018 (especially with freshet)

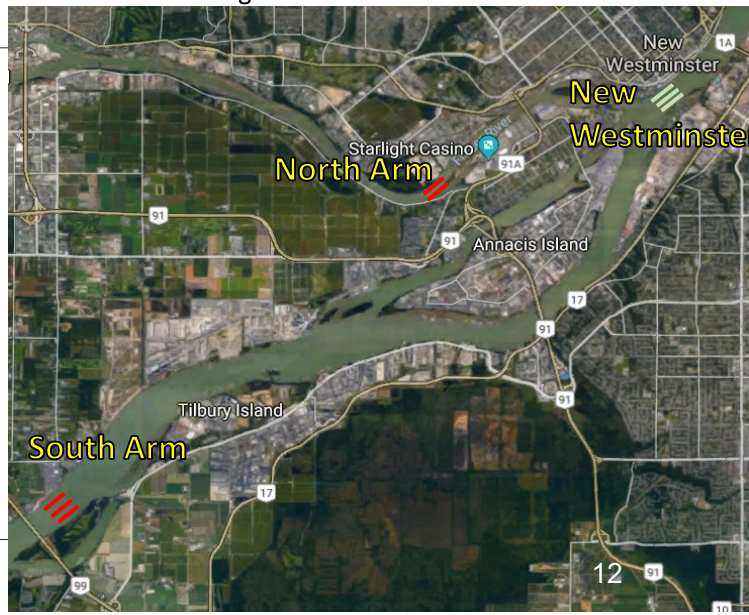
Captain Wilfred Wilson observing the catch!

Nic Ens counting larvae and eggs

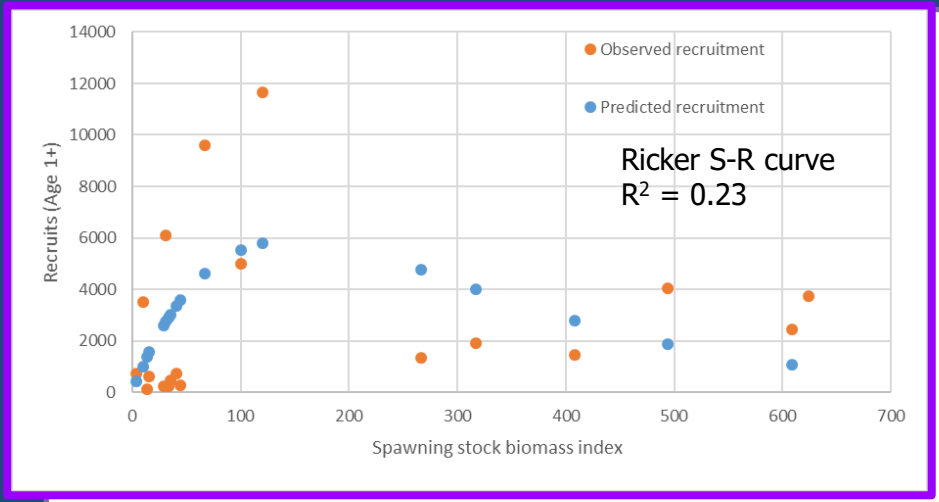


Plankton nets 19 cm x 2

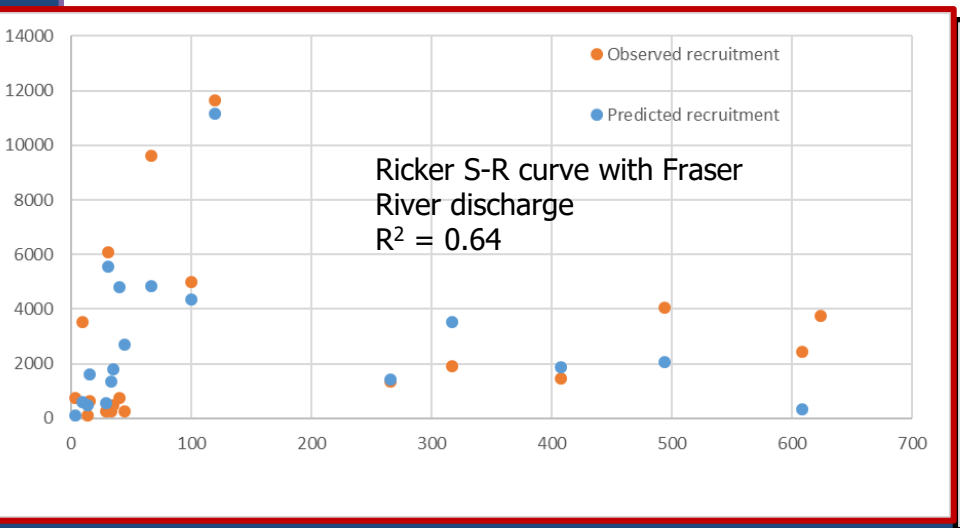
Larvae 4-7 mm long

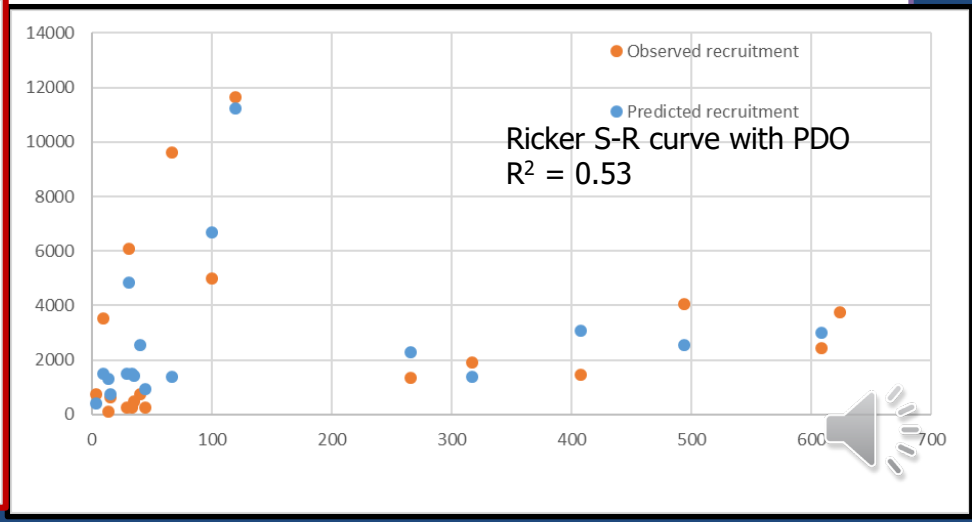


Comparison to SSB and environmental drivers

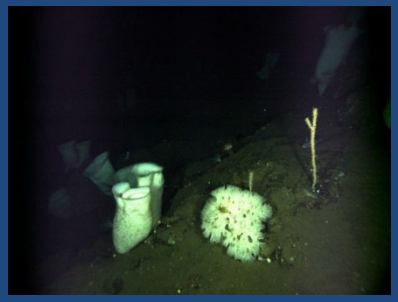


ALPI
AO
ENSO indicators
NGPO
NPI
SOI
Copepod biomass
Spring SST anomalies
Fraser River discharge at Hope





Conclusions/Future Work



- Most indices agree with the general direction of the time series, although perhaps not the magnitude
- Spatial-temporal models appear to have better goodness of fit statistics and solve some of the issues with messiness
- There does appear to be a stock-recruit relationship
- Adding environmental covariates improves the fit
  - PDO & Fraser discharge improves the variance explained in the number of recruits
- More work is needed on this analysis and the underlying data, but we should be able to contribute to future status updates for this species