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CHESAPEAKE BIOLOGICAL LABORATORY

CBT Forage Indicator Development

SFGIT Winter meeting

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1/7/2022

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Project Goals

- Address stated needs of Chesapeake Bay Program:
  - Calculate and provide updated forage population indices
  - Explore new variants of the forage population indices
  - Relate forage population indices to forage climate indices

- Focal forage taxa
  - Bay Anchovy (*Anchoa mitchilli*)
  - Polychaetes (marine annelids)

Images: https://www.inaturalist.org/guide_taxa/829795, https://en.wikipedia.org/wiki/Nereididae

Methods: Forage indices

- Biota data sources
  - Chesapeake Bay Program
  - TIES/ChesFIMS
  - MD DNR/VIMS Seine survey
  - Juvenile fish & blue crab trawl survey (VIMS)
- Environmental data sources
  - Chesapeake Bay Program
  - VIMS Ferry Pier/Goodwin Is. CBNERR
  - CBL Pier time-series
  - NOAA National Data Buoy Center
  - NOAA Physical Sciences Laboratory
- Taxon index variants
  - Bay Anchovy
    - Age-1+ spawning stock index (Spring-ES)
    - Age-0 recruit index (LS-Autumn)
    - Total (annual index)
  - Polychaetes
    - Nereididae
    - Total (all taxa)

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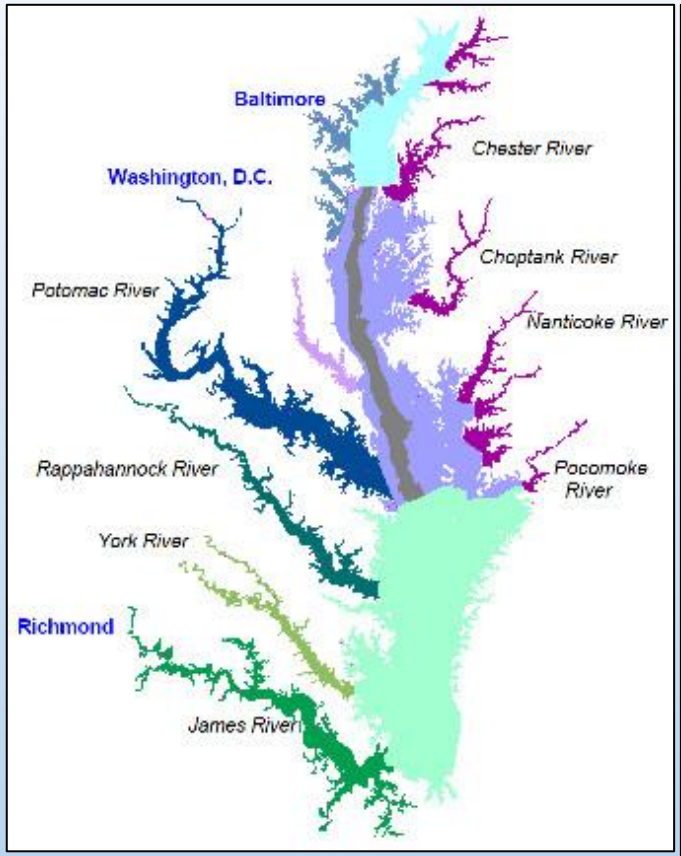
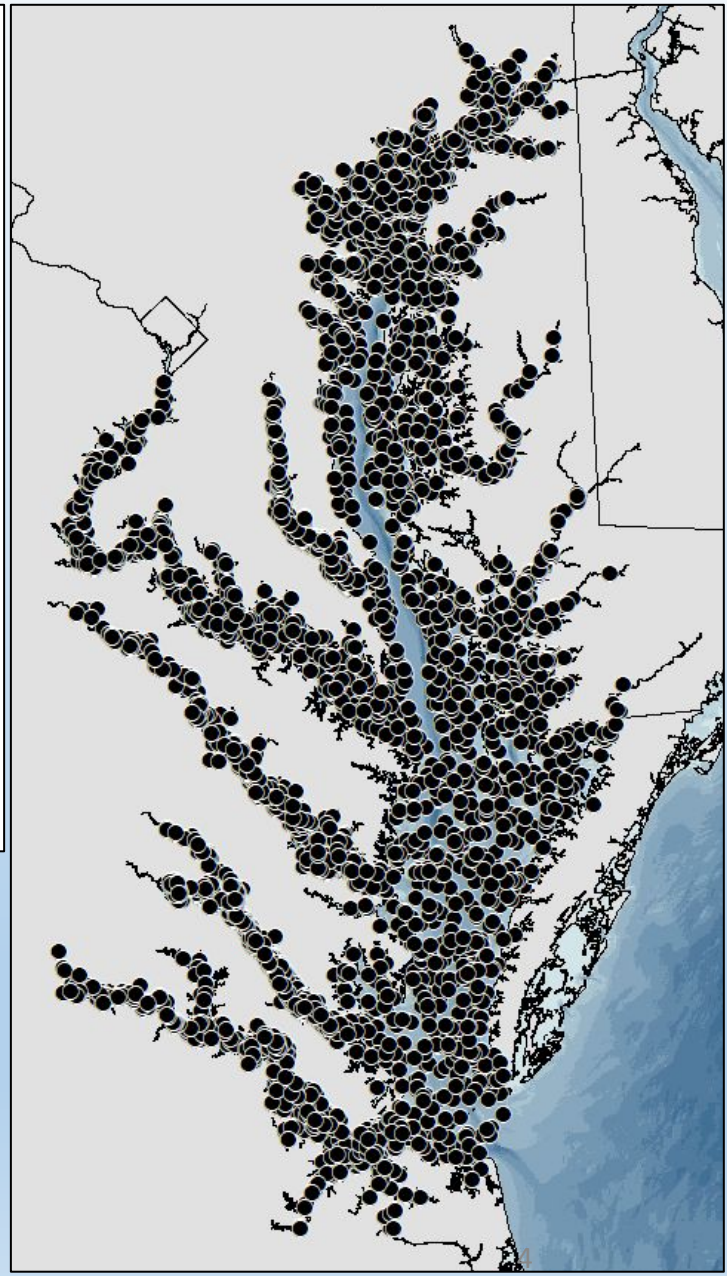
Polychaete Survey: Spatiotemporal extent

- Spatial domain
  - CBP Benthic Survey random sampling component
- Temporal range
  - 1995-2019 (MD)
  - 1996-2019 (VA)
  - July-Oct





Methods: Calculating Polychaete indices

- Modeling approaches
  - General additive model (GAM)
  - Delta-GAM
  - Delta-General linear model (GLM)
  - Random forest (RF)

- Explanatory variables
  - Year
  - Section (spatial unit)
  - Depth*

- Model comparisons
  - 10-fold cross-validation
  - Model performance indicators (MAE, RMSE, R^2)
  - Visual assessment

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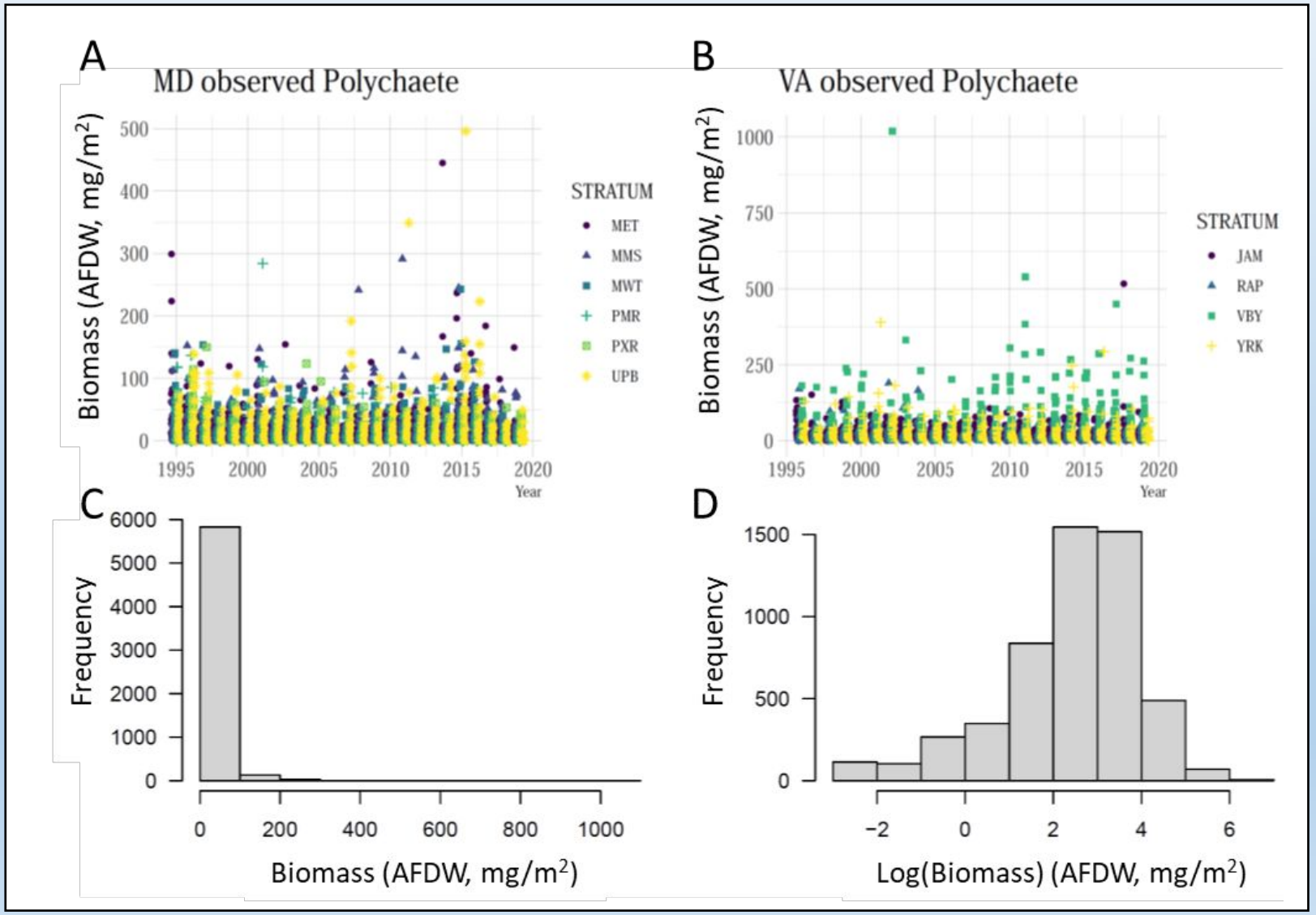
Results: Polychaetes

- Polychaete data
  - CBP observations



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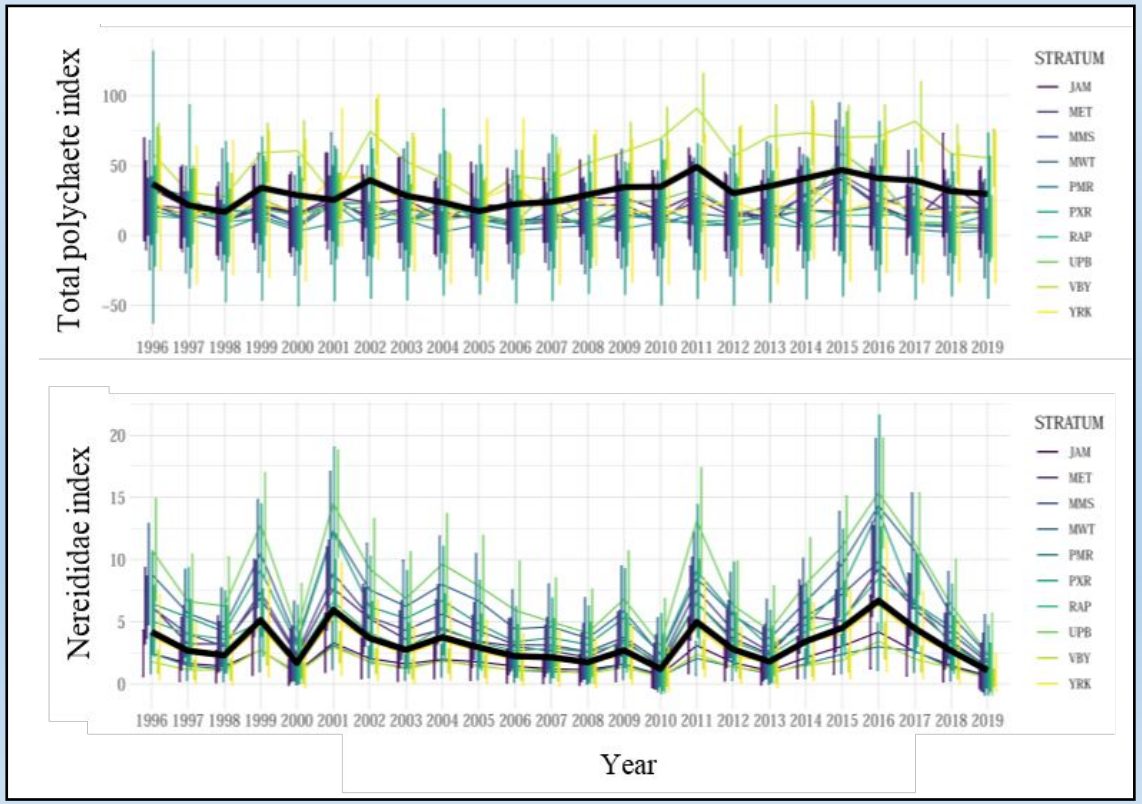
Results: Polychaetes

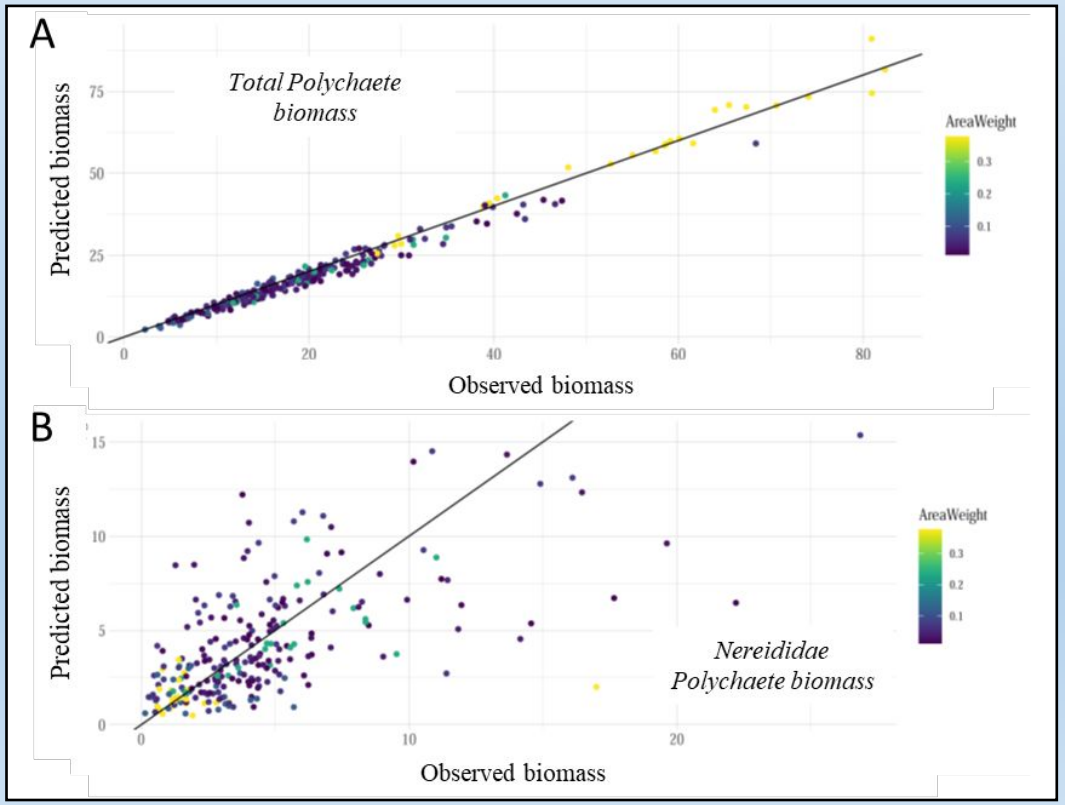
- Polychaete group results
  - Total polychaetes: Delta-GAM
  - Nereididae: GAM

10-fold Cross validation

		MAE	RMSE	R2
Total	GAM	25.54872	47.48895	0.1456766
	Delta-GLM	25.90639	47.95317	0.1301086
	Delta-GAM	25.35281	47.30858	0.1529223
	RF	24.98643	47.17995	0.1621094
Nereididae	GAM	4.672366	12.59160	0.02152202
	Delta-GLM	4.947856	12.96985	-0.06161526
	Delta-GAM	4.775525	12.85549	-0.02221711
	RF	4.713843	12.55976	0.02077619



Training set performance



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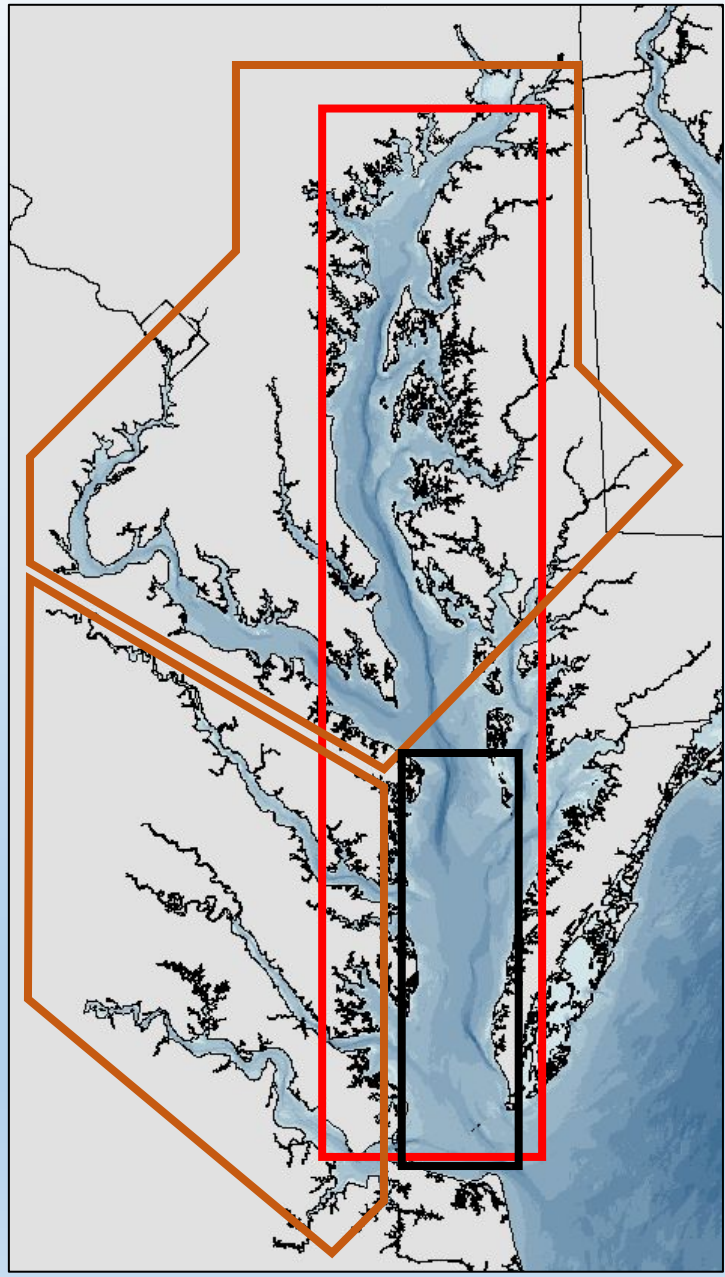
Bay Anchovy Surveys: Spatiotemporal extent

- Spatial domain
  - Mainstem – TIES/ChesFIMS (red)
  - Mainstem – VIMS trawl (black)
  - Tributaries – MD/VIMS seines (Orange)

- Temporal range
  - TIES/ChesFIMS – 1995-2002
  - VIMS trawl – 1988-2019
  - MD seine – 1966-2020
  - VIMS seine – 1988-2020



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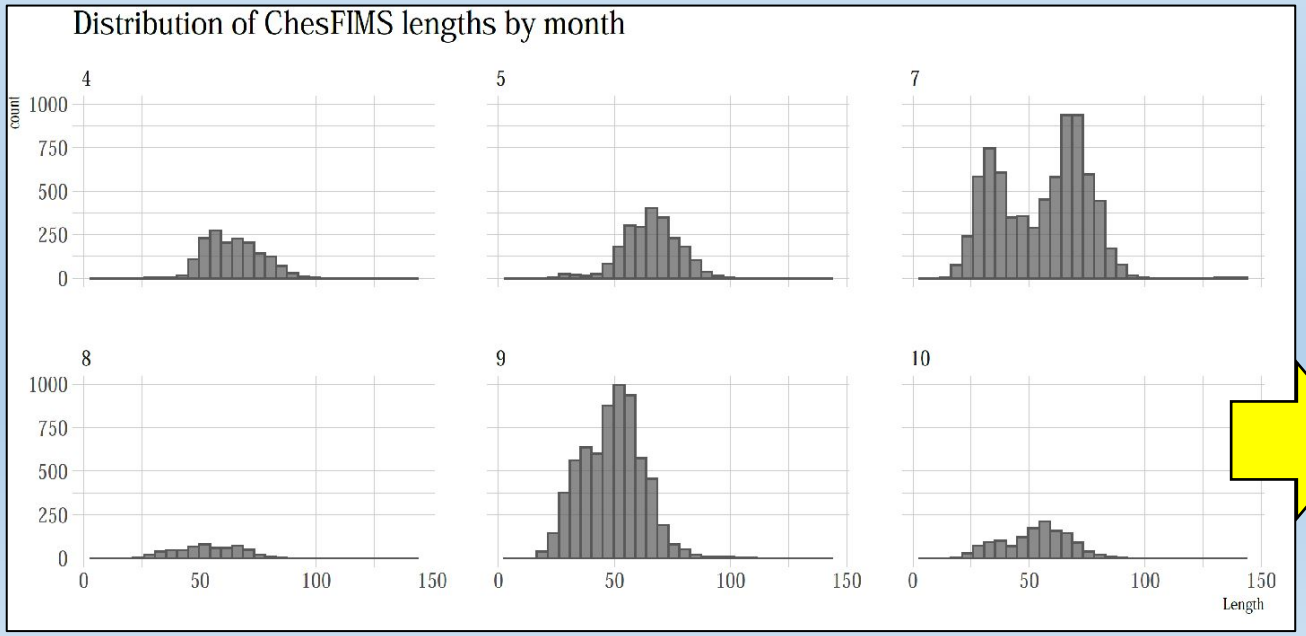
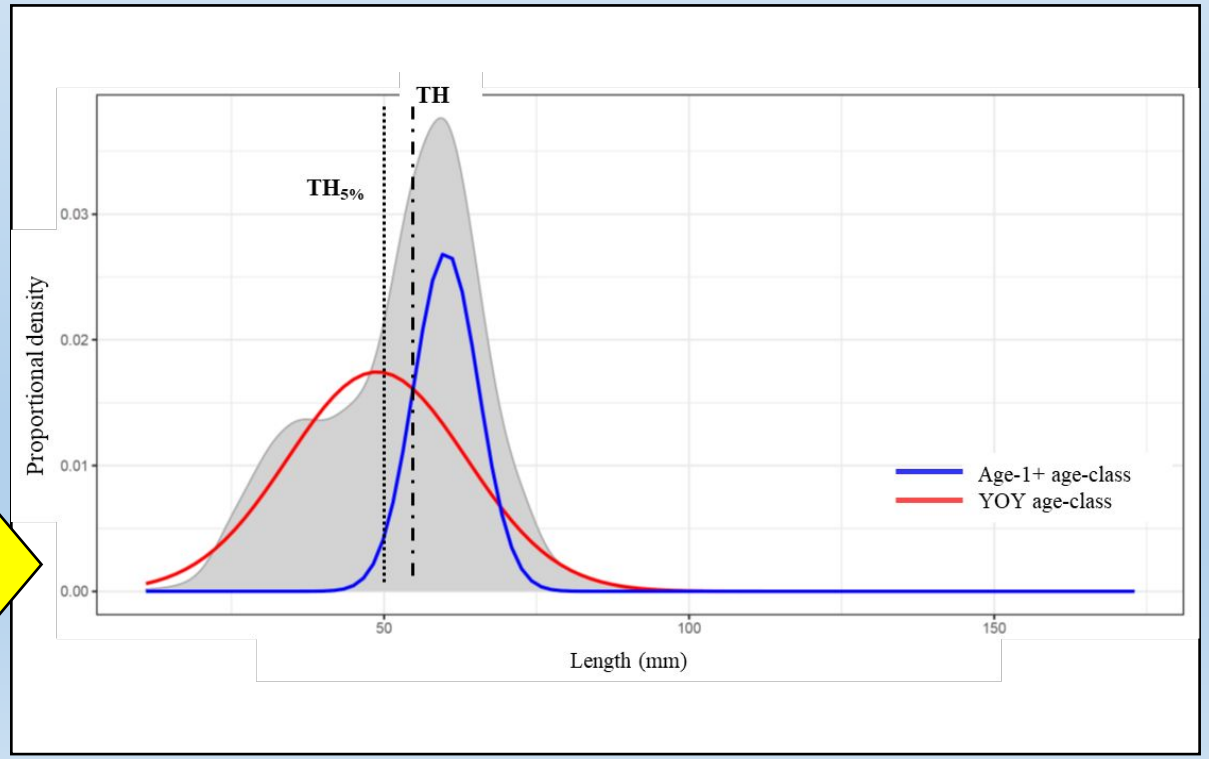
Methods: Calculating Bay Anchovy indices

- VIMS trawl
- Other surveys: Length-based approaches (or timing-based) in development
  - Signal decomposition (TH)
  - 5% quantile of adult mode ($TH_{5\%}$)





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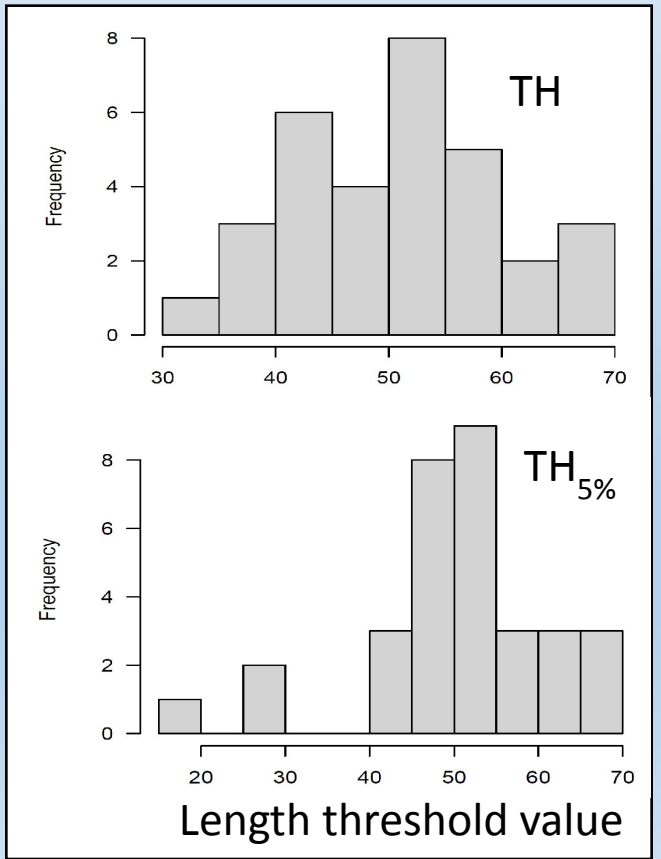
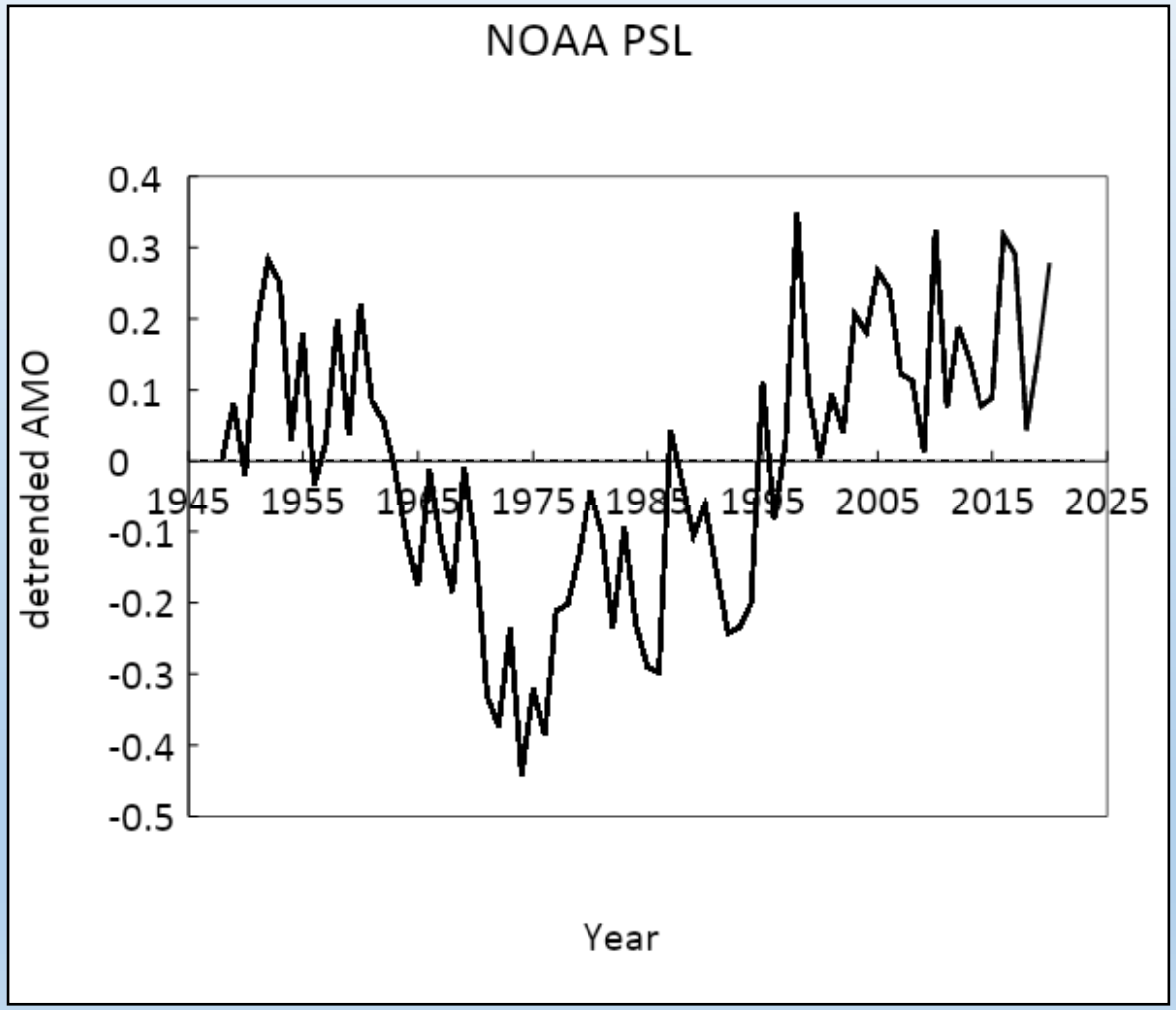
Methods: Calculating Bay Anchovy indices

- VIMS trawl
- Other surveys: Length-based approaches (or timing-based)
  - Signal decomposition (TH)
  - 5% quantile of adult mode ($TH_{5\%}$)
- Continuing work
  - Exploring suitability of length (or timing) cutoffs for other surveys
  - Apply model comparison framework



Methods & Results: Climate indices

- Focus on two climate indices
  - Atlantic Multidecadal Oscillation (AMO)
    - 1948-2020 annual indices available
    - Exploring partial year index values



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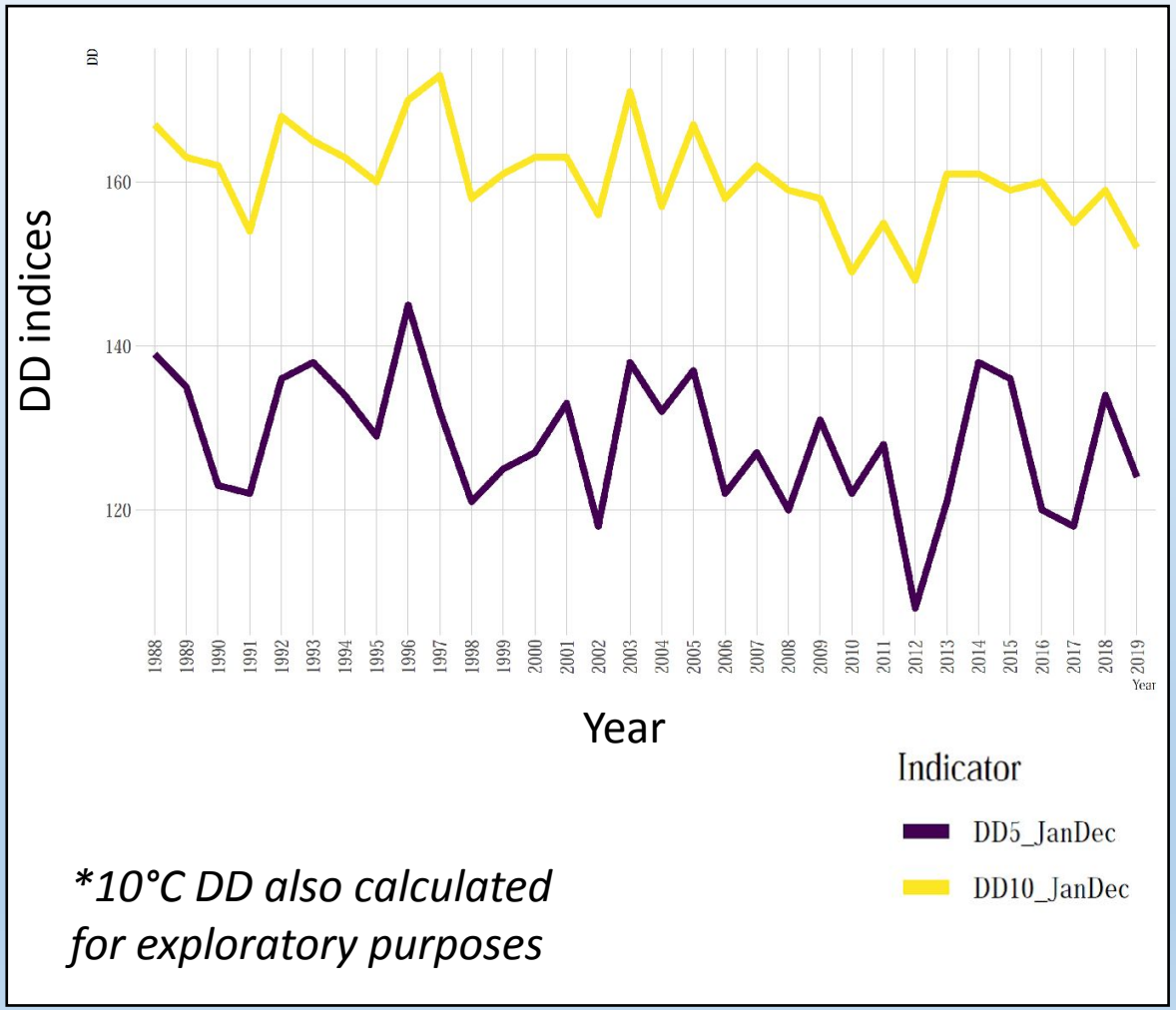
Methods & Results: Climate indices

- Focus on two climate indices
  - Atlantic Multidecadal Oscillation (AMO)
    - 1948-2020 annual indices available
    - Exploring partial year index values
  - 5 °C Degree-Day Index (DD)
    - Mean daily water temperature for 1950-2019
    - Plot here shows 1988-2019 interval
    - Integer day each year at which the cumulative threshold of 500 5°C DD is achieved



**10°C DD also calculated for exploratory purposes*

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Proposed Methods: Relating forage to climate

			Scale	
Tier	**Variable**	**Indicator**	**Spatial**	**Temporal**
1. Abundance	Bay Anchovy	Spawning stock	Mainstem	Spring-Early summer
		Recruits	Mainstem	Late summer-Fall
		Population	Mainstem/Tribs	Spring-Fall
	Polychaetes	Aggregate taxa	Mainstem/Tribs	Summer
		Family (Nereididae)	Mainstem/Tribs	Summer
2. Environmental Factors	Degree day (DD) spring warming index & Atlantic Multidecadal Oscillation (AMO)	Spawning stock	Mainstem	Spring-Early summer
		Recruits	Mainstem	Late summer-Fall
		Population	Mainstem/Tribs	Spring-Fall
		Aggregate taxa	Mainstem/Tribs	Summer
		Family (Nereididae)	Mainstem/Tribs	Summer

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Proposed Methods: Indicator development

Summarize forage indicator values

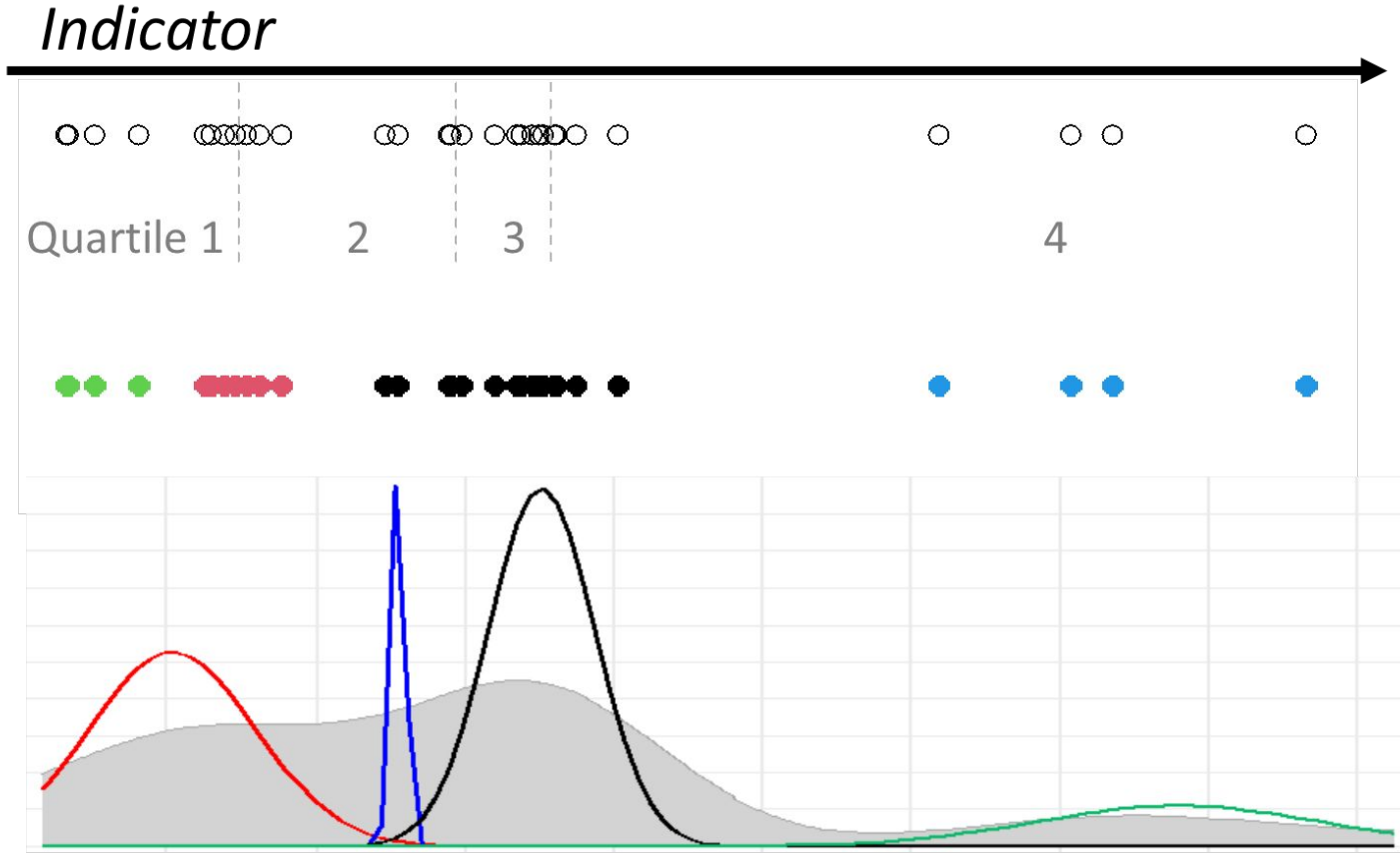
We will assess several methods and select one to group values of indicator into categories, then develop a colorimetric scheme.

Methods:

Quantiles

K-means
(K = 4)

Gaussian
mixture model
(K = 4)



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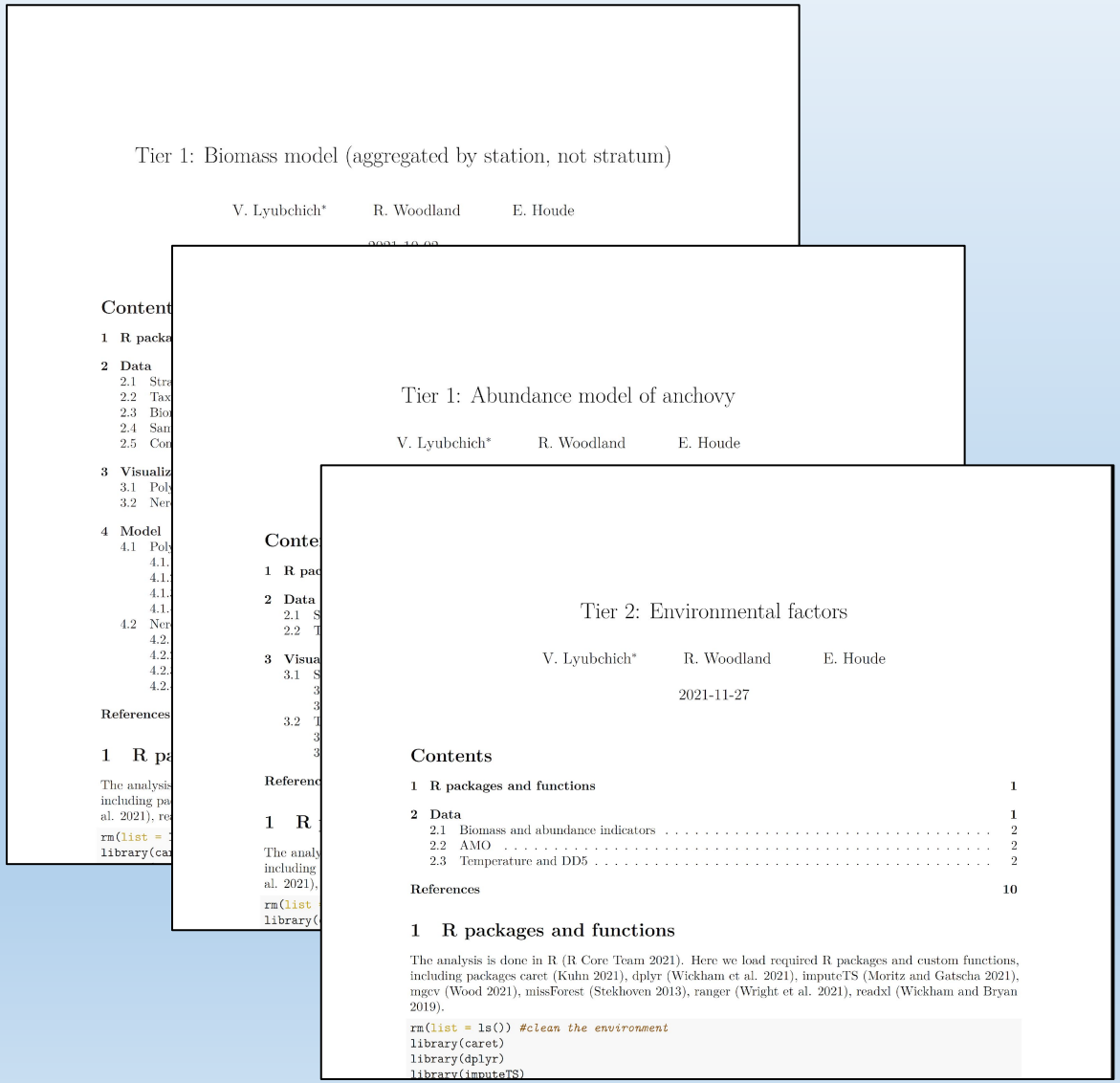
Deliverables and Schedule



- R-code with explanations and interpretation provided for all analyses
- Final report and presentation: April 2022

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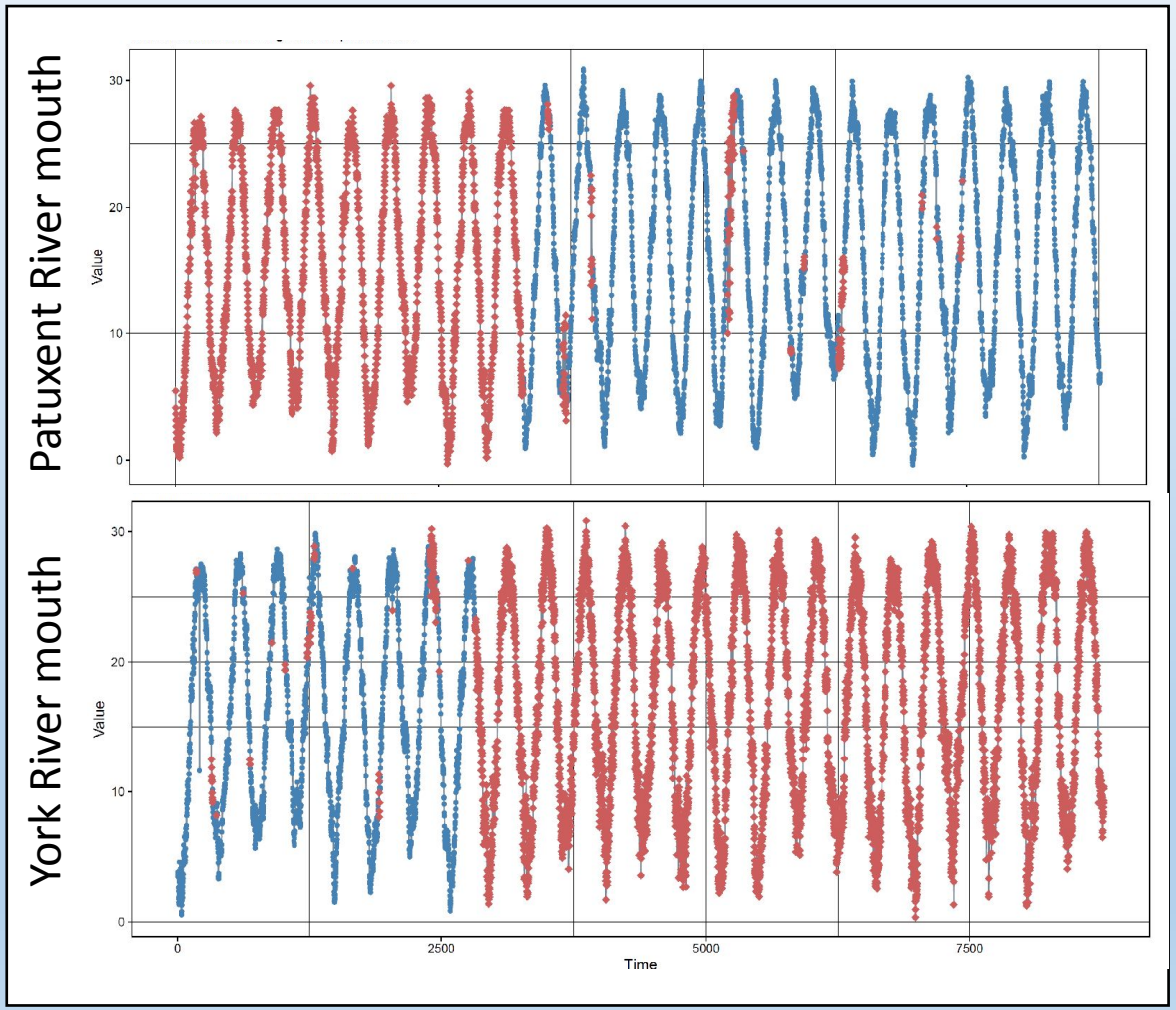
Methods: Climate indices

- Assembling daily water temperature records
  - Use of autoregressive models or random forest models to predict water temperature values



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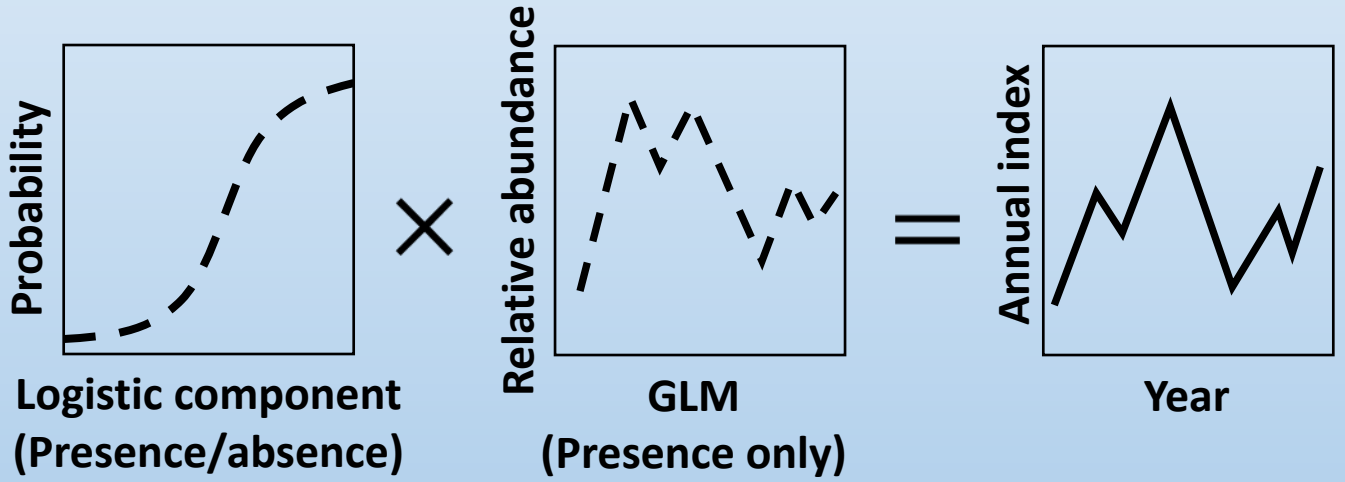
Methods: Calculating forage indices

Annual indices: delta-generalized linear models (Delta-GLMs)



Additional model variables: Year, Section*, Depth

** 'Section' represents the spatial unit for a given calculation*

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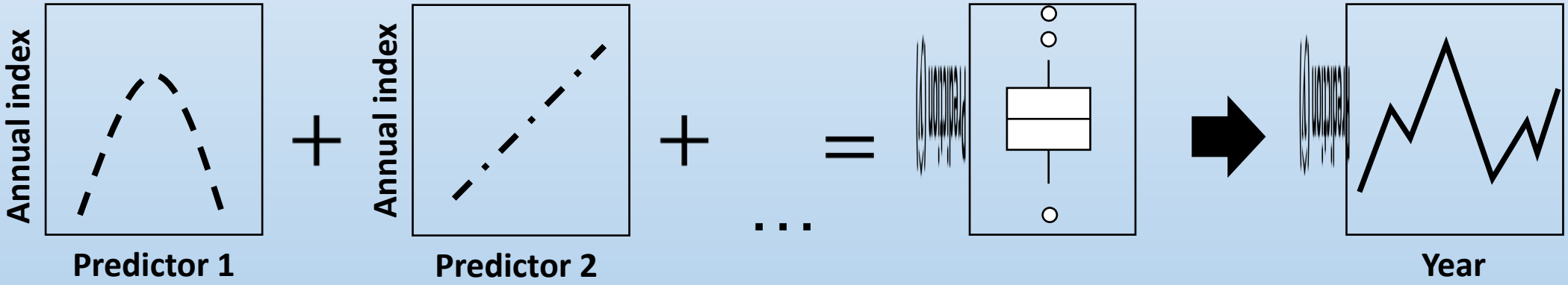
Proposed Methods: Relating forage to climate

Generalized additive (mixed) models (GAMs or GAMMs)



$$\hat{y} = s_1(\text{Predictor 1}) + s_2(\text{Predictor 2}) + \ldots$$

Potential additional model components: Predictor 1 × Predictor 2

Deliverables and Schedule

Report # and Reporting Period	Project Deliverables	Date of Delivery
QAPP deliverable (Reporting Period #1)	• Final (signed) QAPP in PDF format	**5/21/2021**
Report #1 (Reporting Period #1)	• Excel or Access database of all biological and environmental data and sources • Presentation and PDF of the proposed analytical framework • Progress report	**7/14/2021**
Report #2 (Reporting Period #2)	• R modeling/analysis script (code) and model outputs • Progress report	**10/14/2021**
Meeting deliverable (Reporting Period #3)	• Meet with the FAT and other CBP partners and stakeholders to discuss and coordinate indicator development options based on the results of the analyses	**10/15/2021-11/1/2021**
Report #3 (Reporting Period #3)	• R indicator script (code) and visualization outputs • Progress report	**1/14/2022**
Draft Report #4 (Reporting Period #4)	• Editable draft report, submitted to the GIT Lead and the FAT for review and feedback	**3/1/2021**
Report #4 (Reporting Period #4)	• Final report package, including editable database, the R files and PDFs of all R scripts and outputs for modeling/analysis and indicator development, and the final indicator graphics • Presentation of final project results	**4/14/2022**