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WESTERN GROUNDFISH CONFERENCE
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# A Spatially Explicit Stock Assessment for Alaskan Sablefish to Better Understand Spatiotemporal Dynamics

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**NOAA AFSC, Auke Bay Labs, Marine Ecology and Stock Assessment (MESA)**

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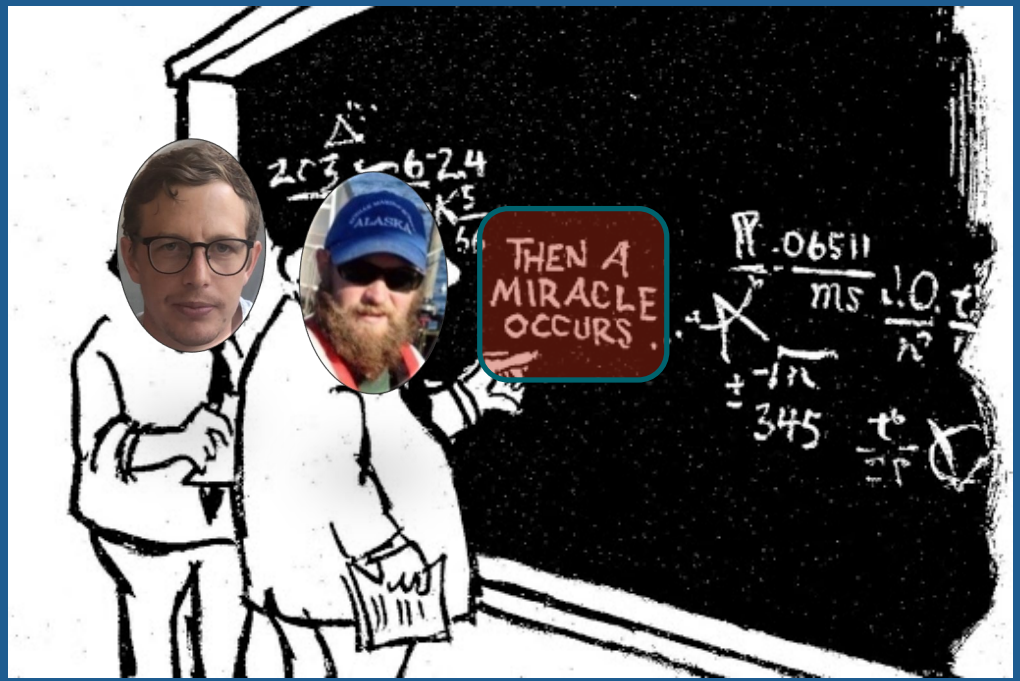
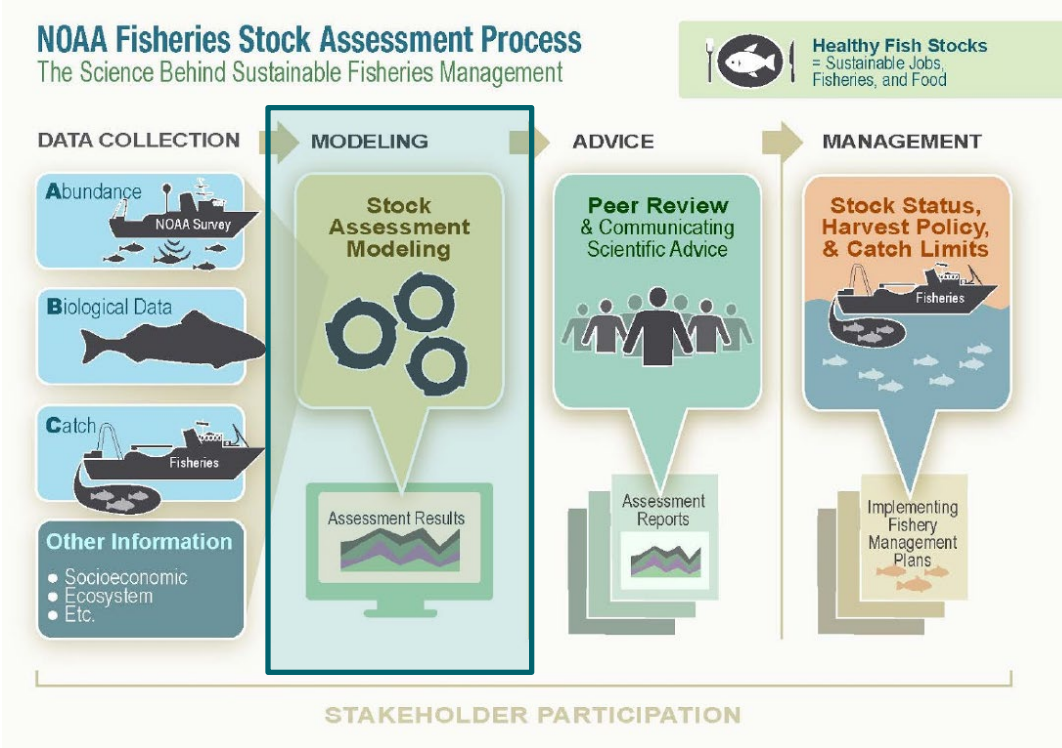
# Insert sexy title

# What is Stock Assessment?



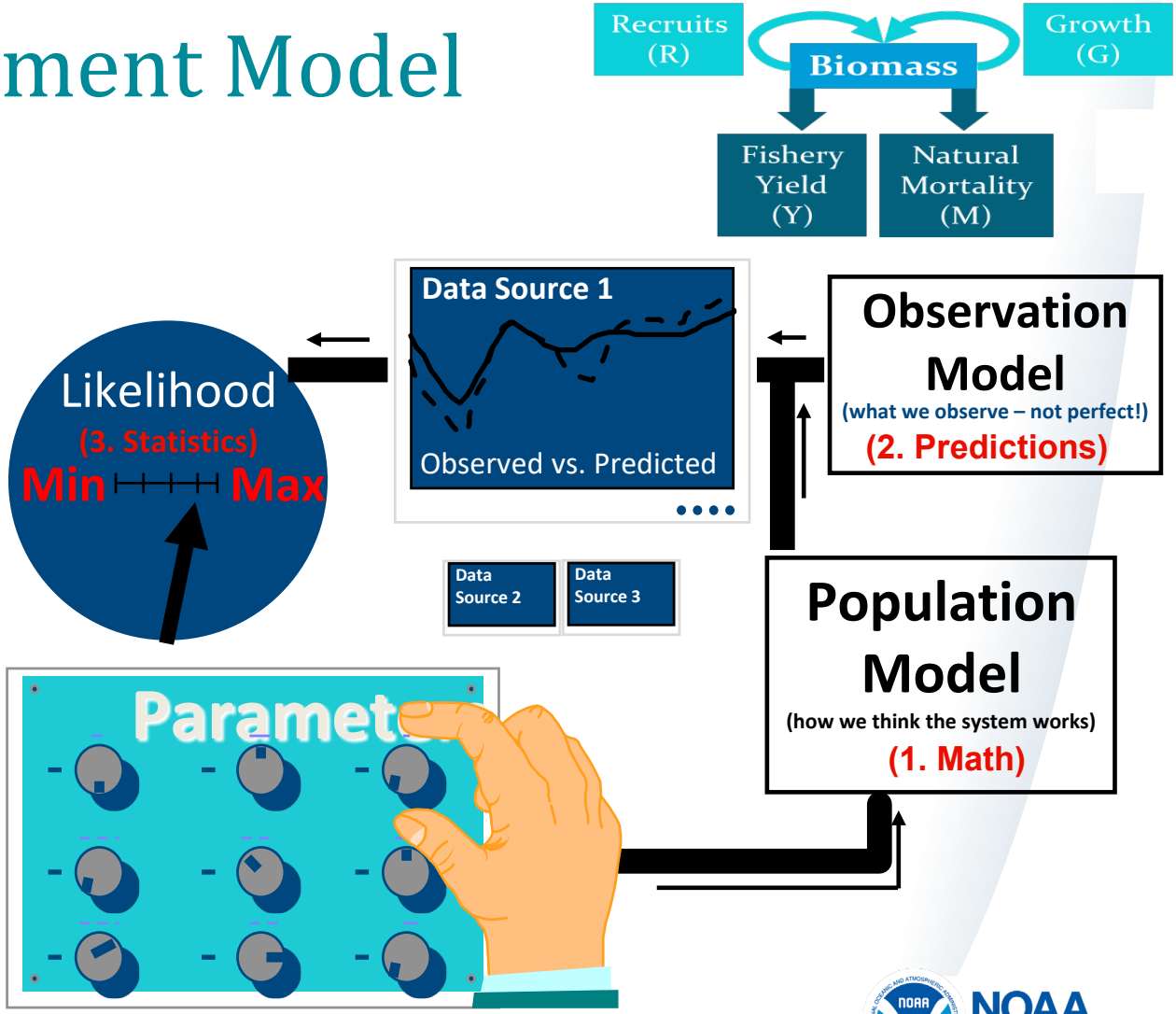
# Purpose of stock assessment

- Characterize stock dynamics and trends
- Determine status relative to target or historical levels
- Describe uncertainty
- Provide scientific advice (catch specifications) for sustainable management



# The Assessment Model

- Most assessment models assume a **unit stock** with homogenous:
  - Vital rates
  - Reproductive dynamics
  - Distribution of abundance and fishing effort
- **No immigration or emigration is allowed**



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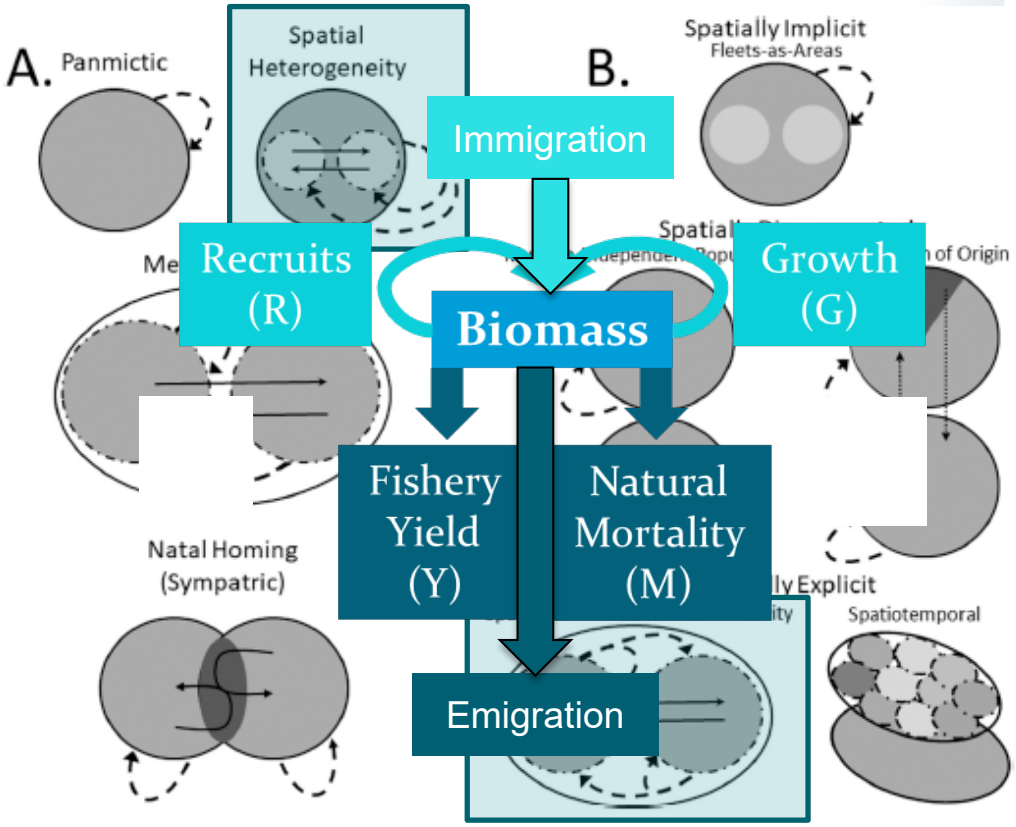
# What About Space?


# Spatially Stratified Models

- Multiple areas, spawning populations, or fleets interacting at various spatiotemporal scales
- Integrate fine-scale dynamics
- Improved information content from data (disaggregate)
- All parameters estimated simultaneously using single objective function
- **Explicitly address assumptions ignored in nonspatial models**



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# Spatial Good Practices

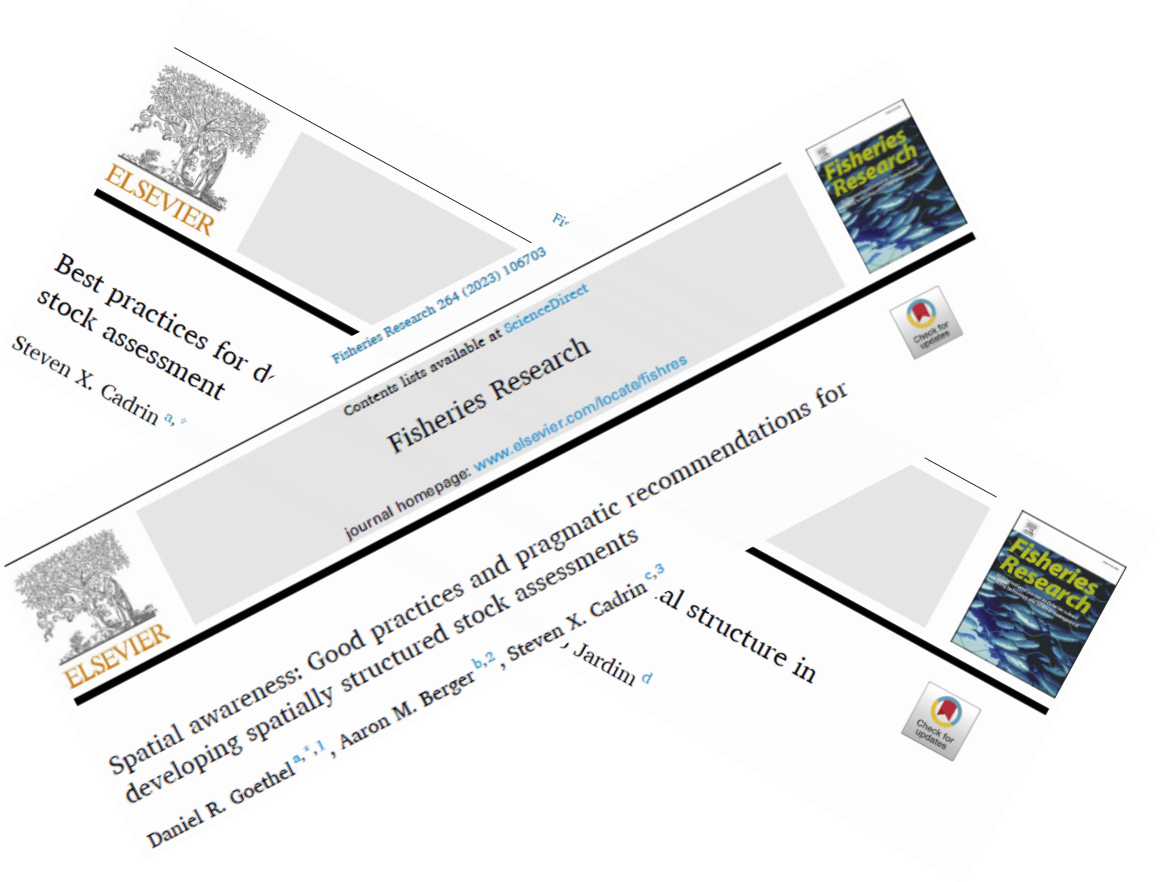
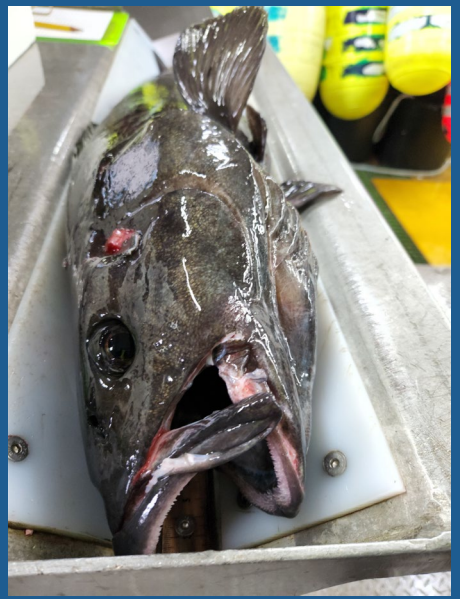



**Table 1**
Analyst decision points to consider when developing spatial stock assessments along with example parameterization options to choose amongst. Provided parameterization options are presented from least to most complex.

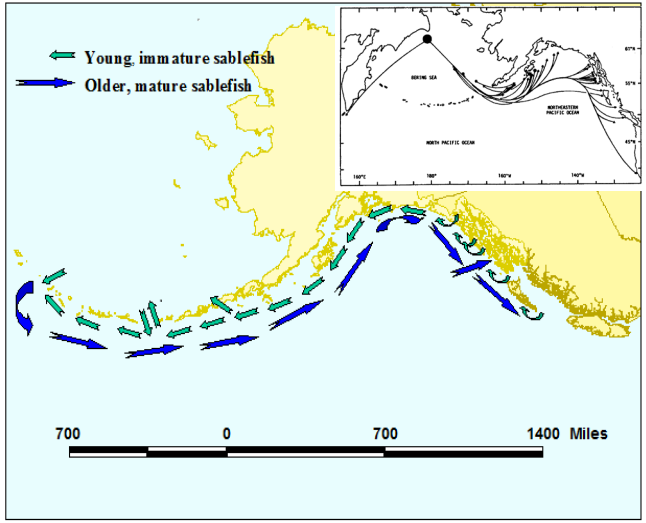
| Decision Point | Parameterization Options |
|---|---|
| Biological Population Structure | Panmictic?<br>Spatial heterogeneity?<br>Natal homing?<br>Metapopulation? |
| Temporal Structure | Yearly?<br>Seasonal? |
| Spatial Resolution | Non-spatial (i.e., spatially aggregated or single population)?<br>Spatially implicit (e.g., fleets-as-areas)?<br>Spatially stratified?<br>Spatiotemporal? |
| Fleet Structure | Use spatial fleets as proxy for availability?<br>Combine fleets with similar characteristics?<br>Share parameters for a given fleet across areas?<br>Incorporate all fleets in all areas? |
| Recruitment Dynamics | Global density-dependence with apportionment (i.e., single stock-recruit function)?<br>Local density-dependence (i.e., single stock-recruit function per population unit)? |
| Initial Distribution and Scaling | Use external data (e.g., CPUE indices) to scale abundance by region?<br>Estimate initial abundance in all areas from all population units? |
| Dispersal | No interactions among populations?<br>Larval dispersal only?<br>Full reproductive mixing among sub-populations (i.e., metapopulations)?<br>No dispersal, but population overlap (i.e., natal homing)? |
| Movement | No movement?<br>Time- and/or age-invariant movement?<br>Gravity-based movement (i.e., estimate residency and make simplifying assumptions regarding emigration)?<br>Random walk?<br>Time periods or age-blocks?<br>Functional forms?<br>Spatial autocorrelation and movement by distance?<br>Habitat preference functions?<br>Seasonal migrations (i.e., feeding/spawning migrations)?<br>Fine-scale advection, diffusion, and taxis models? |
| Demographic Variation | Constant across the model domain?<br>Vary by area using empirically derived values?<br>Vary by population unit (i.e., genetic-based demographics)?<br>Vary by area with current-area traits only (i.e., phenotypic-based demographics)?<br>Vary by area with source-area and current-area traits (i.e., to avoid infeasible transitions)?<br>Vary by area and by population unit? |

# And…Why Do Sablefish Care?

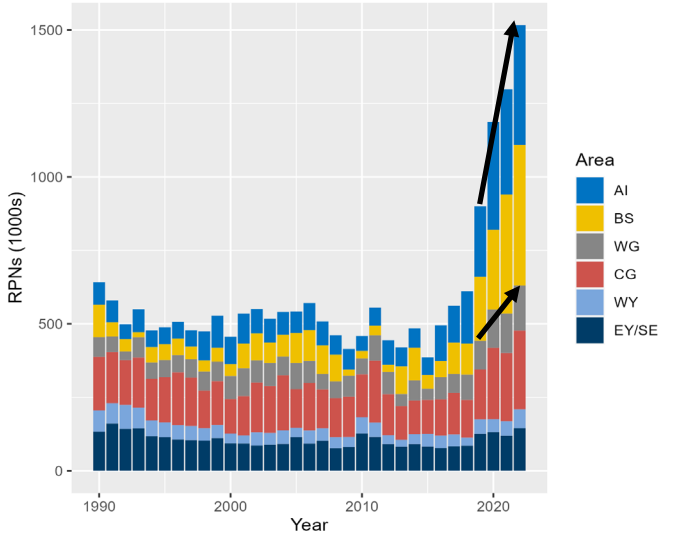


# Sablefish Spatial Structure

- Hypothesized to undergo ontogenetic movement patterns
- Demonstrate large movement potential
- Lack of genetic variation
- Currently assume single panmictic assessment unit across all Alaska
- Catch is apportioned to region using ad hoc survey biomass approach
- Catch and resource distribution vary across management areas

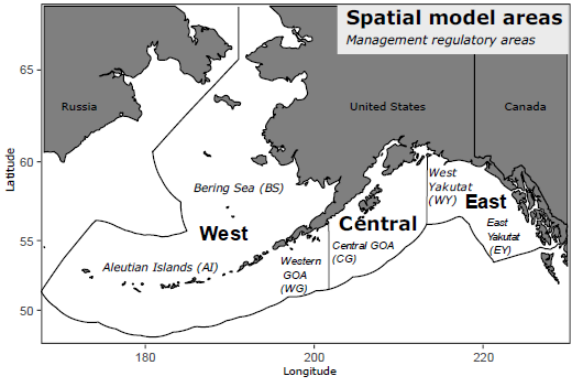



AFSC Longline Survey Relative Population Numbers (RPNs)



# Initial Spatial Model

- 3 area model with movement fixed based on external tag analysis




Spatially stratified, **tag-integrated model** would help understand interactions among fishery, resource, productivity, and data collection spatial structures.

Alternate spatial structures and movement assumptions should be explored!

# Objectives

- Develop and document a case study that follows spatial modeling good practices
- Document the process, decision points and identify good practices
- Develop a tag-integrated spatially explicit model capable of **management advice**
- Identify and investigate key uncertainties
- Compare with panmictic model (status quo)

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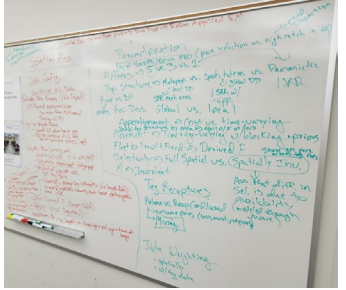
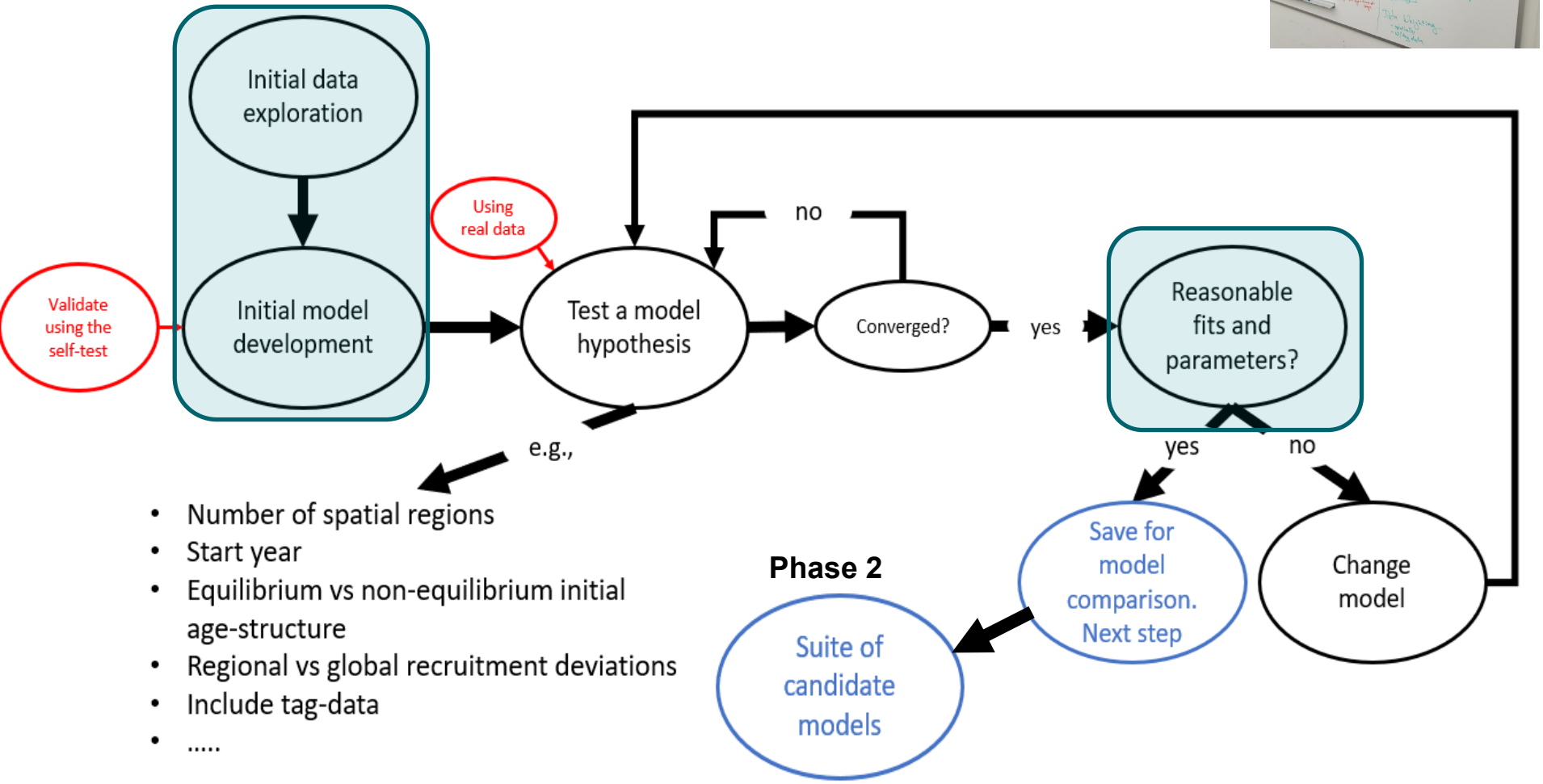
# Methods – Phase 1

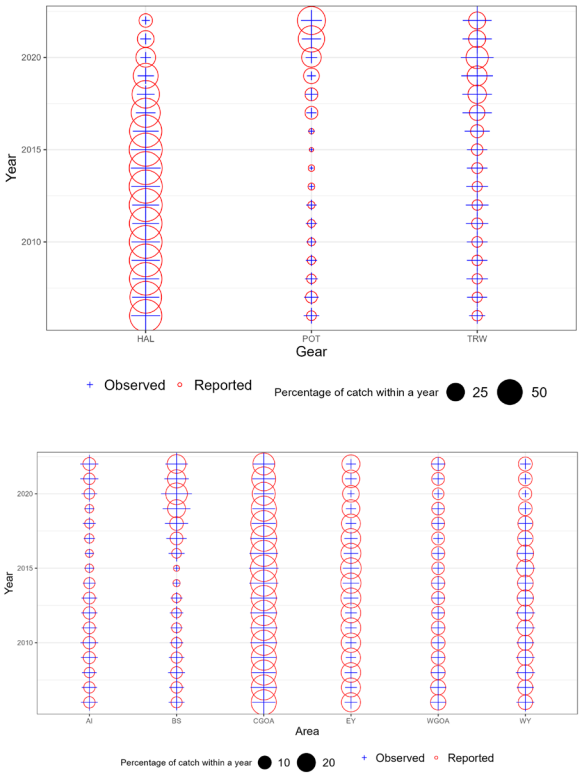




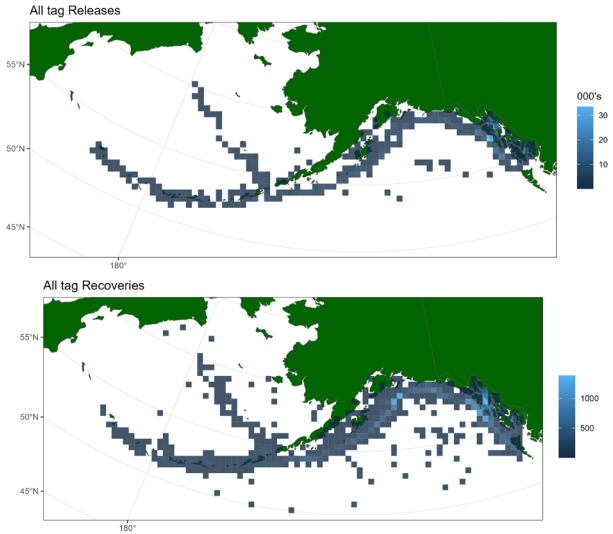
# Data Explorations

- High resolution explorations of all data sources

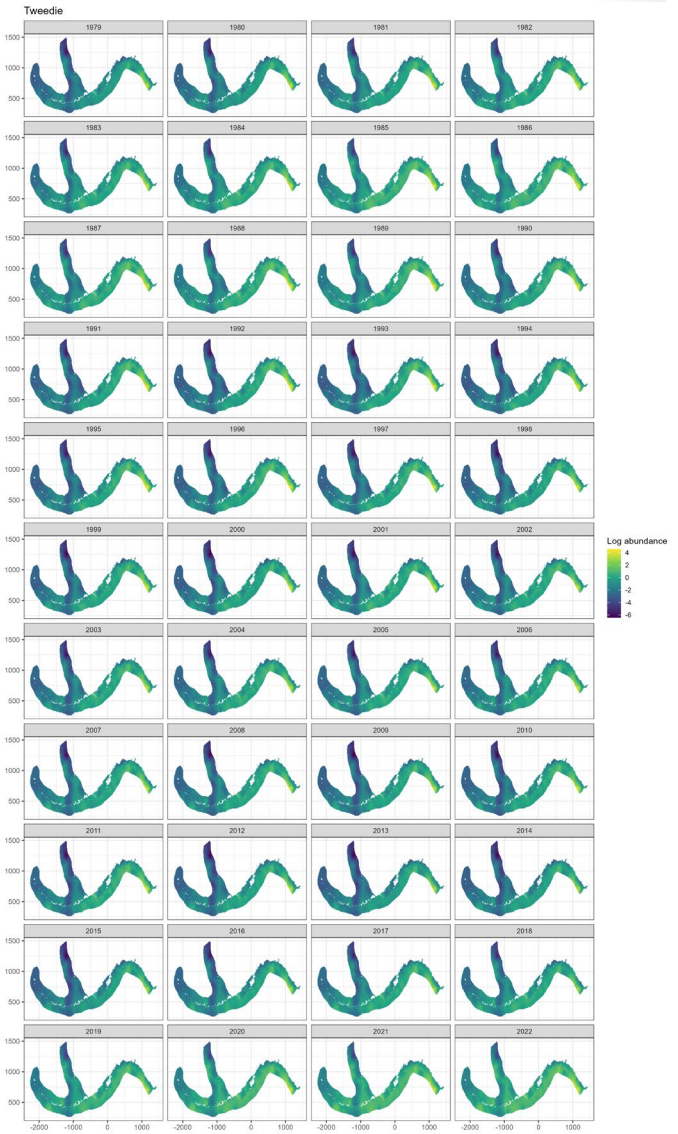
## Catch




## Tagging

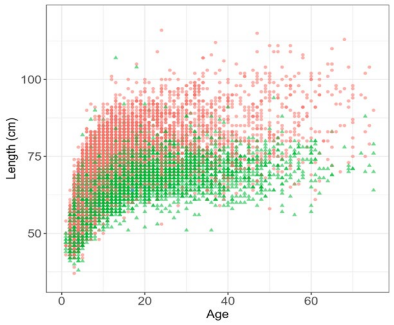


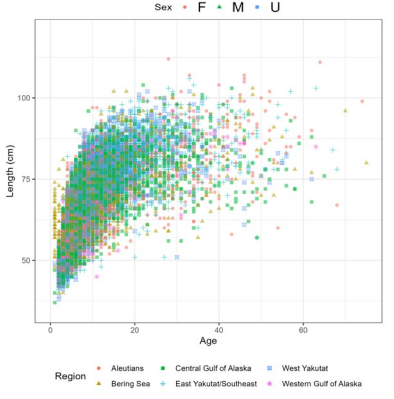

## Survey

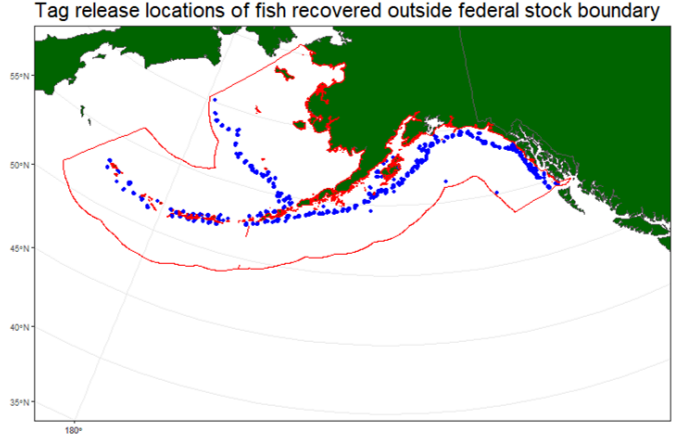


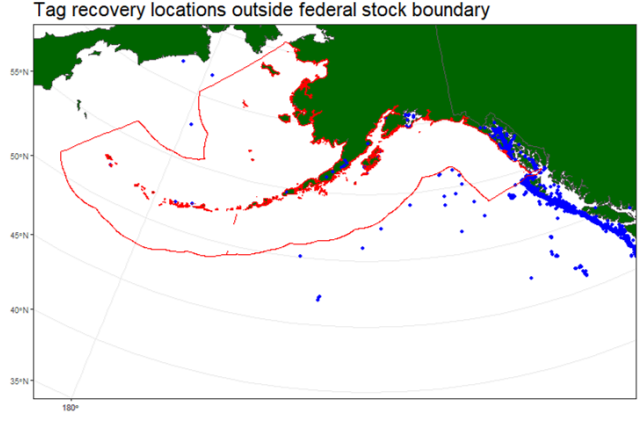
# Data Explorations

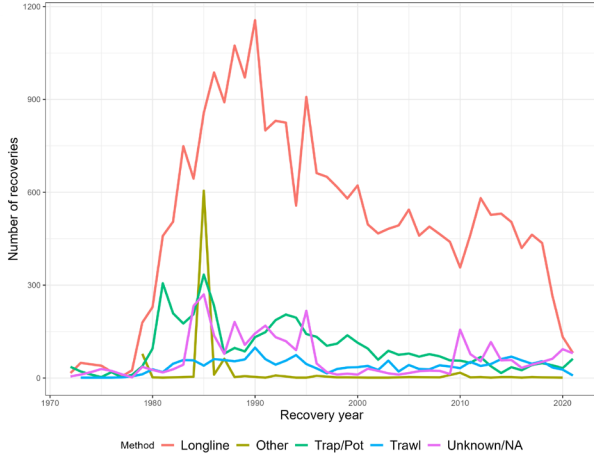
- Can model partitions be reduced?
  - Maintain sex-specific model? **YES**
  - Growth-variation by region? **NO**
- Include tagging data? **YES**
  - Difficult to estimate reporting rate
  - Many tags recovered outside the region
  - But, primary source of information on movement



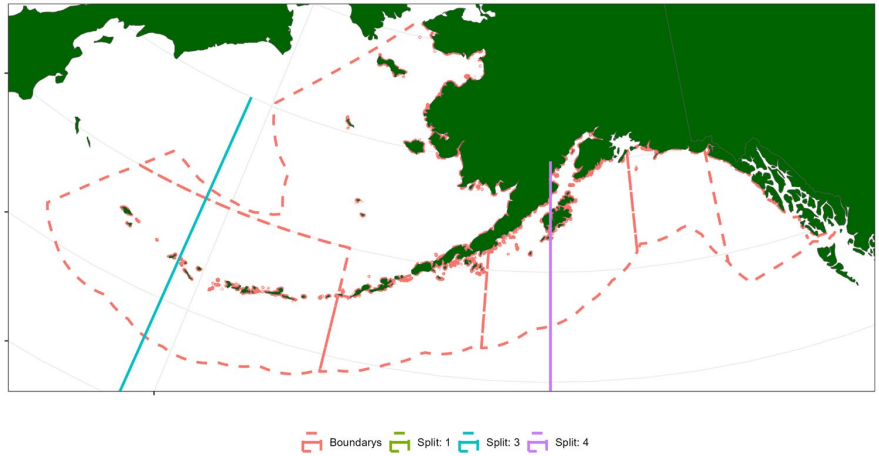



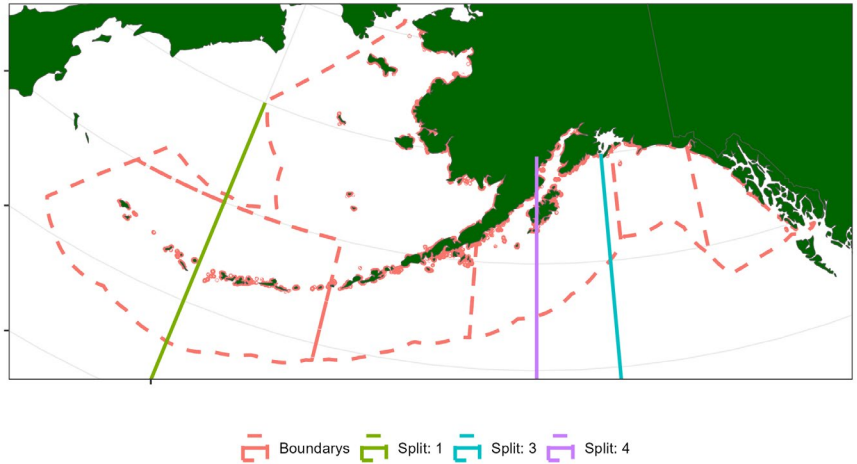
# Data Explorations

- Regression tree analysis on length frequencies
- Can be used to support area aggregation or splitting…or differences in fleet structure (selectivity)
- Should be interpreted cautiously
- Primarily driven by **management boundaries and data reporting resolution**
- Split near Kodiak was similar to that from Kapur et al. 2020 that identified a potential morphometric/growth transition

Survey




Fishery



# Initial Model Parametrization

- Start year: 1977 (limited gear-specific catch by area prior)
- Spatial structure: 5 regions
- Population structure: spatial heterogeneity
- Demographics: sex-specific, spatially-invariant
- Movement: time-varying
- Recruitment: single stock-recruit relationship (SSB pool) with area-specific deviates
- Tagging data directly integrated

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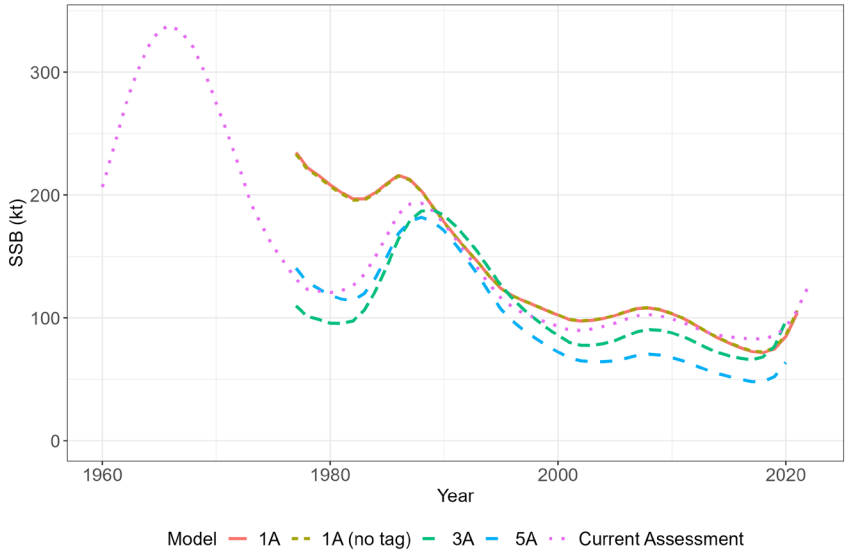
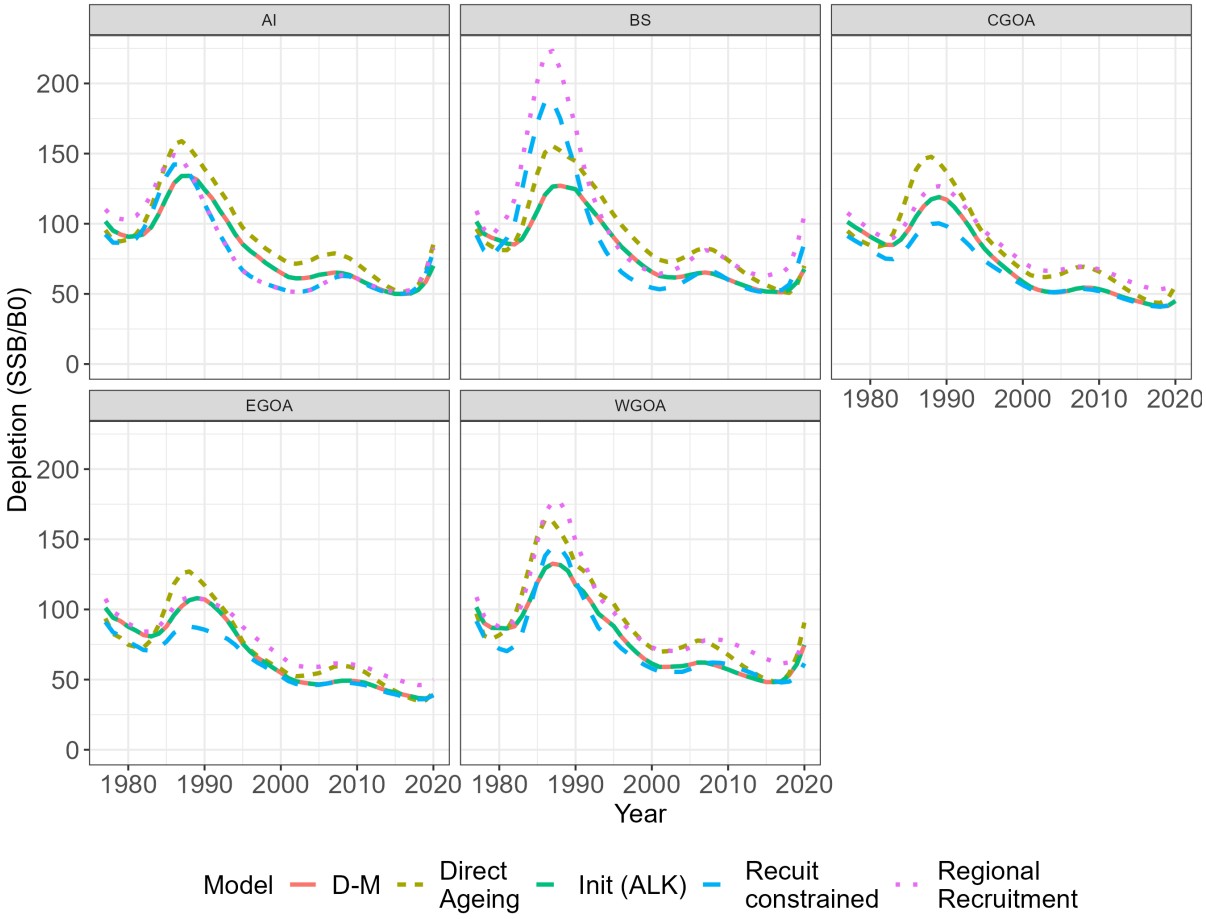
# (Very) Preliminary Results

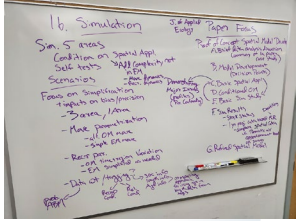
- Validating 1-area model…
- Getting spatial model to converge…
- Alternate spatial configurations…
- Determine preliminary ‘base’ model for basis of simulations (most complex, data conditioned model possible)…Work in progress



# (Very) Preliminary Results



# Methods – Phase 2



- Which models have the best fits? – residuals & AIC
- Which best emulate expected dynamics?
- Which models result in different scientific advice?

Suite of candidate models

Identify Key Model Uncertainties

Suite of models to simulation test

- Test multiple assessment parametrizations against alternate simulation model assumptions
- Identify which parametrizations appear to be most robust

Develop Operating/ Simulation Model

Evaluate Assessment Robustness through Simulations

Identify 'Optimal' Assessment Parametrization

**Phase 3**



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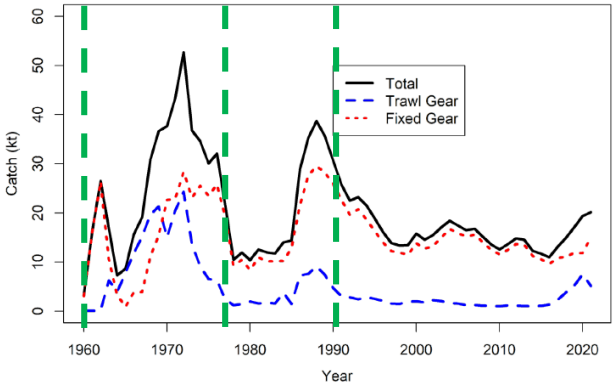
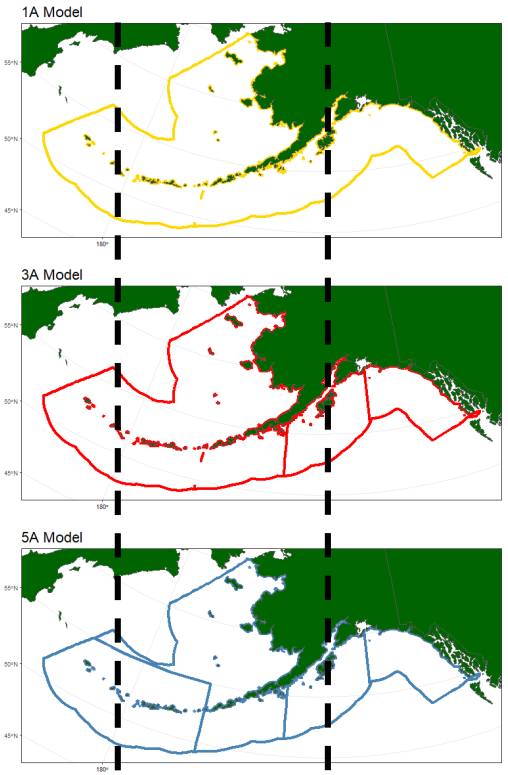
# Key Model Uncertainties

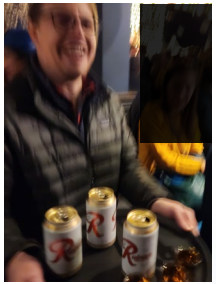
- Start year (equilibrium vs. start of spatial
- Assuming closed population within AK
- Number of spatial units (1 vs. 3 vs. 5)
- Parametrizing movement (age-varying as directly estimated or using ogive)
- Modeling recruitment (and potential confounding with movement) and impact on reference points
- Likelihoods for tagging data (and other comp data)



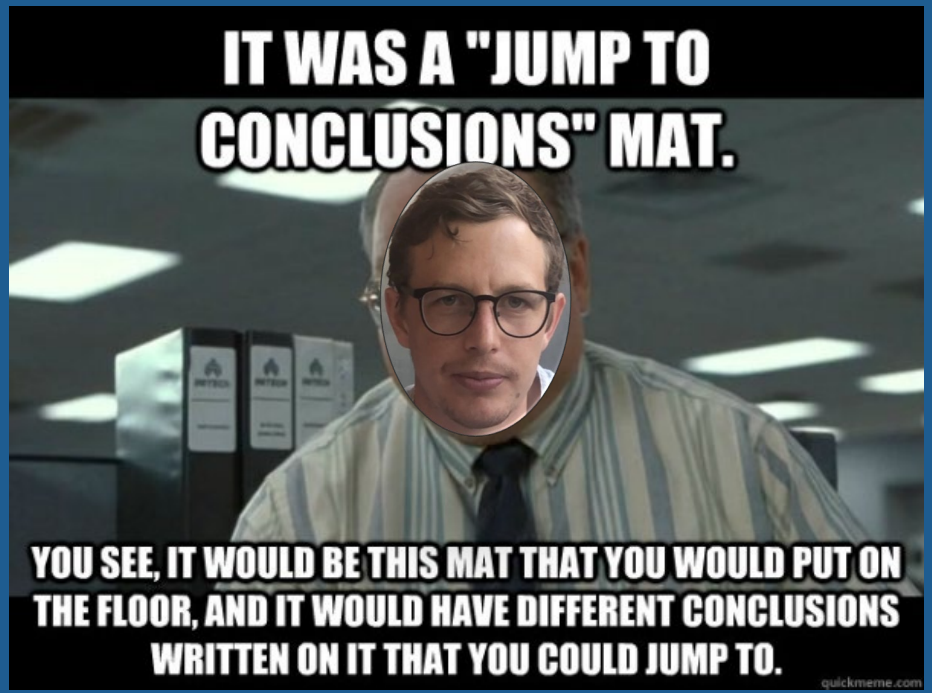



# Methods – Phase 3

- Use results from simulations to refine the spatial model
- Propose a “base-case” spatial model(s) that incorporates simulation results
- Document our process and good practices



# Conclusions

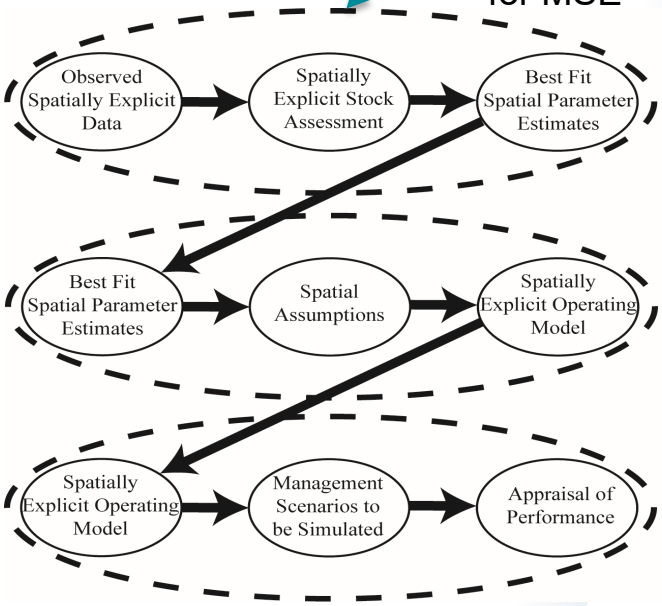


# Conclusions

- Spatial models are hard!
- In-depth data exploration is critical
  - Ability to easily manipulate data aggregation greatly aids analysis and ability to explore alternate model parametrizations
- Appears to be important regional dynamics that warrant monitoring
- Results are preliminary
  - Ongoing simulations are important for elucidating impacts of key uncertainties
- Iteration is key…

Too complicated!!

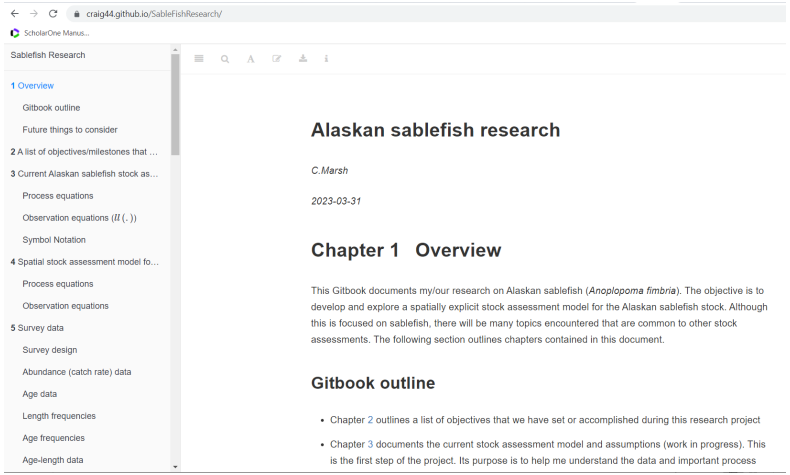
Potential Use as a Conditioned OM for MSE




Goethel et al. (2016)

# Further Information

- Public Gitbook documenting components of our research https://github.com/Craig44/SableFishResearch
- An R package containing the generalized spatial TMB population model (with documentation and unit-tests) https://github.com/Craig44/SpatialSablefishAssessment





# QUESTIONS?