GOA Dover Sole

Movement Model

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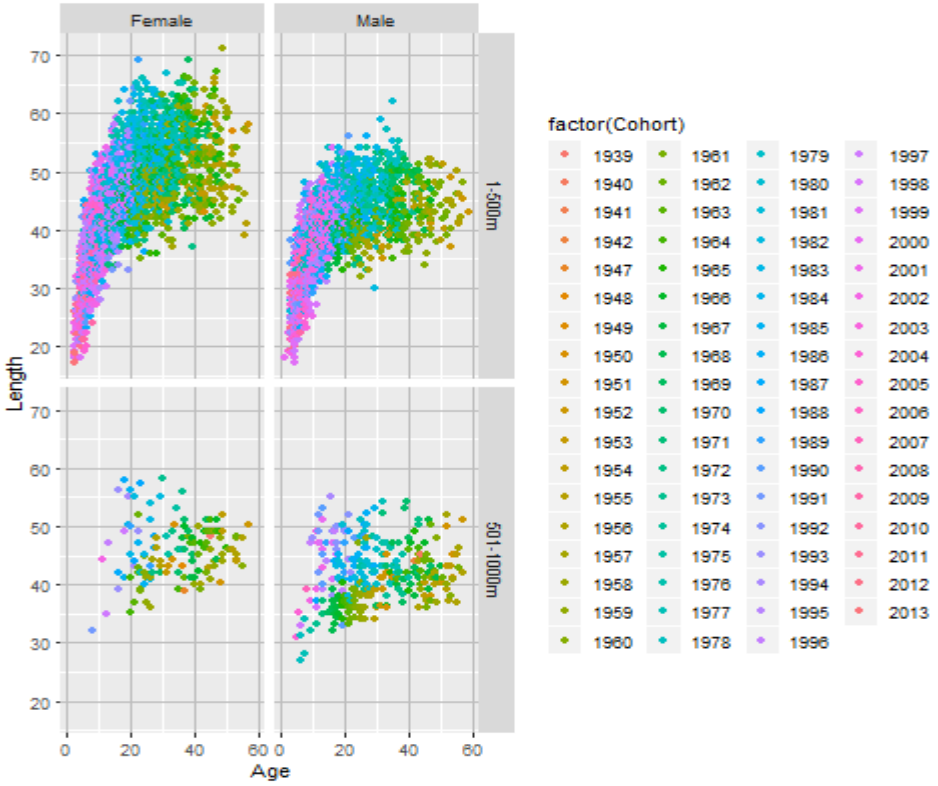
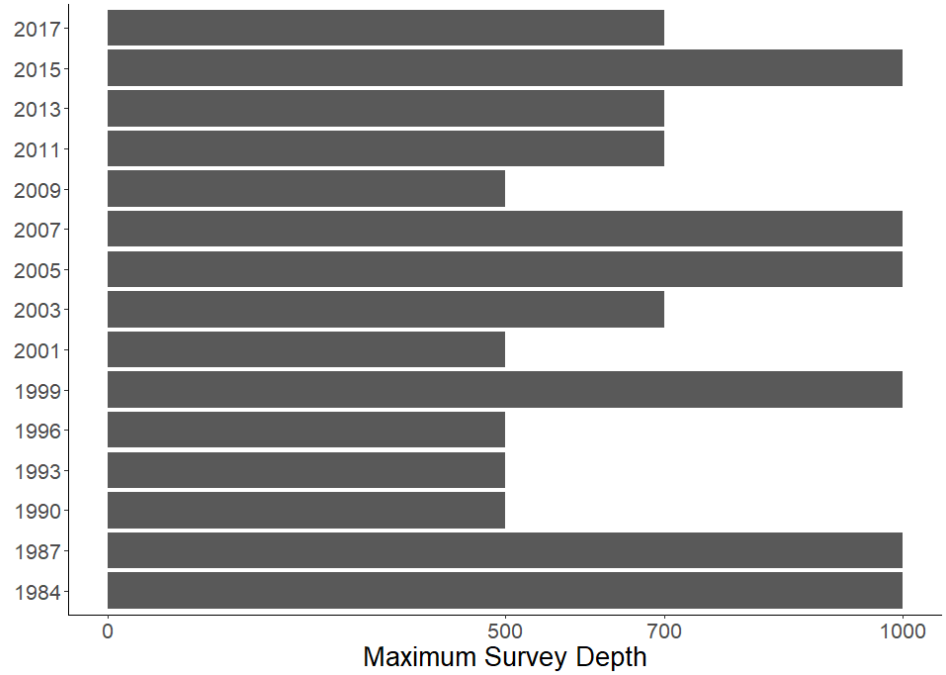
Motivation – Biology

- Ontogenetic movement to depth
- Fish at depth are older
- Older cohorts at depth are smaller



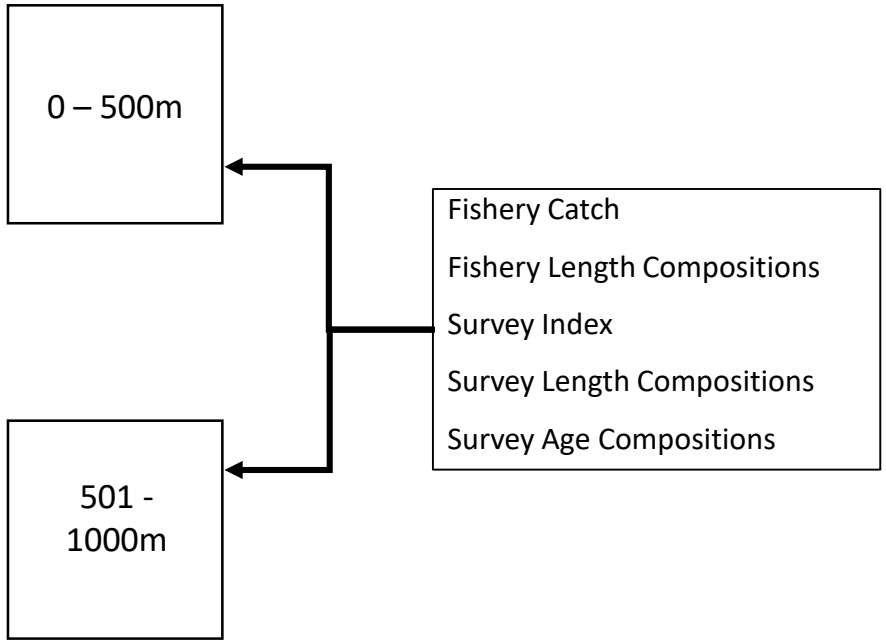
Motivation – Survey Design

- Gaps in surveying depths > 500m
- Most recent assessment:
  - Uses random effects model to fill in data gaps
  - Selectivity is estimated for 0-500m survey years separately than years with deeper coverage



Two Area Box Model

- Shallow: 0-500m
- Deep: 501-1000m



Parameters estimated outside the model

- Female natural mortality (0.085, as for previous assessments)
- Shallow and deep catchability (1, as for previous assessments)
- Weight-length relationship
- Maturity-at-age
- SigmaR = 0.49

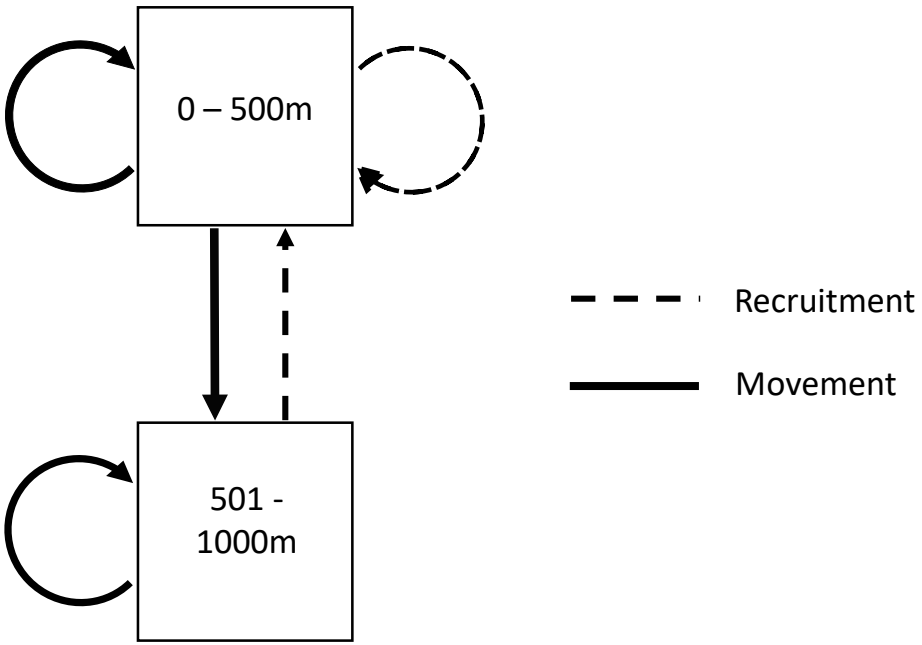
Parameters estimated inside the model

- ln(R0)
- Log-scale recruitment deviations
- Yearly fishing mortality
- Sex-specific parameters of the von Bertalanffy growth curve
- Male natural mortality
- Selectivity parameters
  - Length-based selectivity for fishery
  - Age-based selectivity for survey
  - Asymptotic double normal selectivity
  - Separate selectivity parameters for shallow and deep strata
  - Male selectivity offset of female selectivity

Two Area Box Model

with Movement

- Shallow: 0-500m
- Deep: 501-1000m



Parameters estimated outside the model

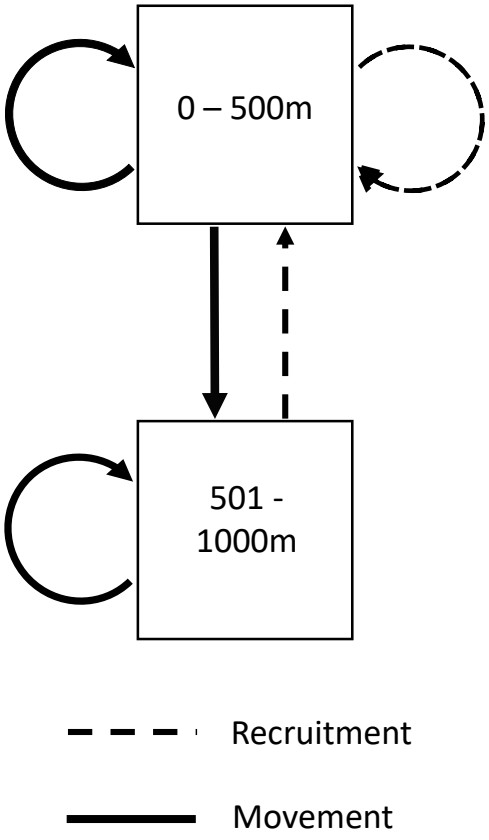
- Recruitment Distribution
  - Probability of shallow recruitment is fixed to 1
- Movement Parameters:
  - Movement from deep to shallow fixed at 0
  - Probability of movement at youngest age fixed to 0

Model Trials

- Model 0
  - One growth pattern
  - Recruitment fixed to shallow
  - Estimate maximum movement probability for age 10 fish
- Model 1
  - Two growth patterns
  - Recruitment fixed to be evenly distributed between two growth patterns in shallow strata
  - Estimate maximum movement probability for age 10 fish
- Model 2
  - Two growth patterns
  - Estimate recruitment to growth patterns in shallow strata
  - Maximum movement probability fixed to 1 for age 10 fish

Model Trials – Model 0

Two area box model with movement



Two Areas
- Shallow (0-500 m)
- Deep (501-1000 m)

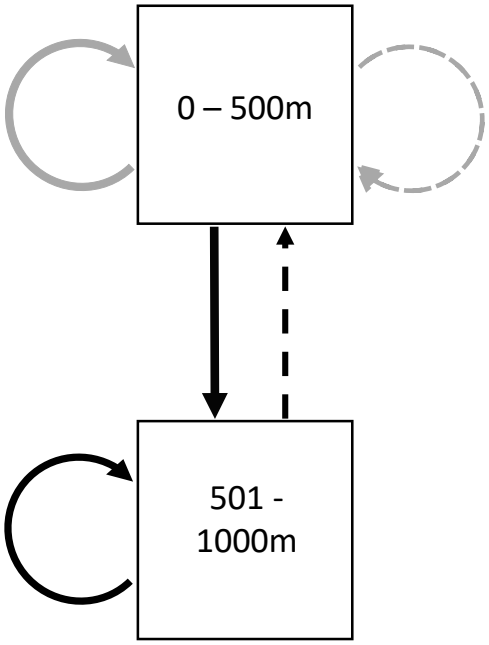
One Growth Patterns for each sex:
- Female
- Male

Recruit to shallow

Movement from shallow to deep
- Minimum age of Movement: 3
- Age of maximum movement rate: 10

Model Trials – Model 1

2 area box model with movement and 2 growth parameters



Growth Pattern 1

Recruitment

Movement

Growth Pattern 2

Recruitment

Movement

Two Areas
- Shallow (0-500 m)
- Deep (501-1000 m)

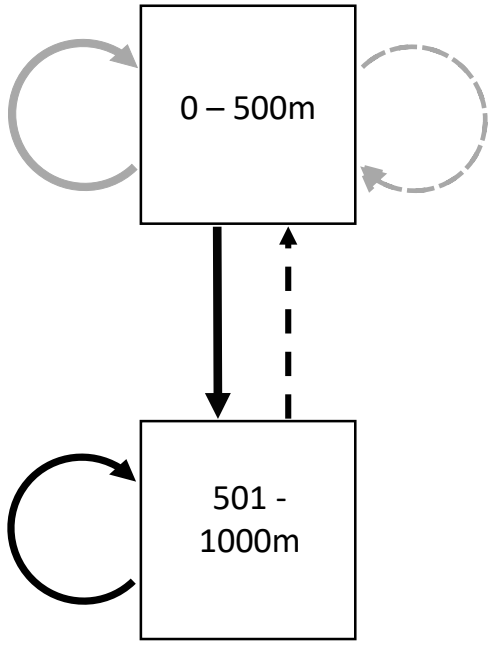
Two Growth Patterns for each sex:
- Female GP_1
- Male GP_1
- Female GP_2
- Male GP_2

Recruit to shallow
- 0.5 R_{GP1}
- 0.5 R_{GP2}

Movement from shallow to deep for GP_2
- Age 3: π_{a3} = 0
- Age 10: Estimate π_{a10}

Two Area Box Model – Model 2

2 area box model with movement and 2 growth parameters



Growth Pattern 1

Recruitment

Movement

Growth Pattern 2

Recruitment

Movement

Two Areas
- Shallow (0-500 m)
- Deep (501-1000 m)

Two Growth Patterns for each sex:
- Female GP_1
- Male GP_1
- Female GP_2
- Male GP_2

Recruit to shallow
- Estimate π^R_{GP1}
- π^R_{GP2} = 1 - π^R_{GP1}

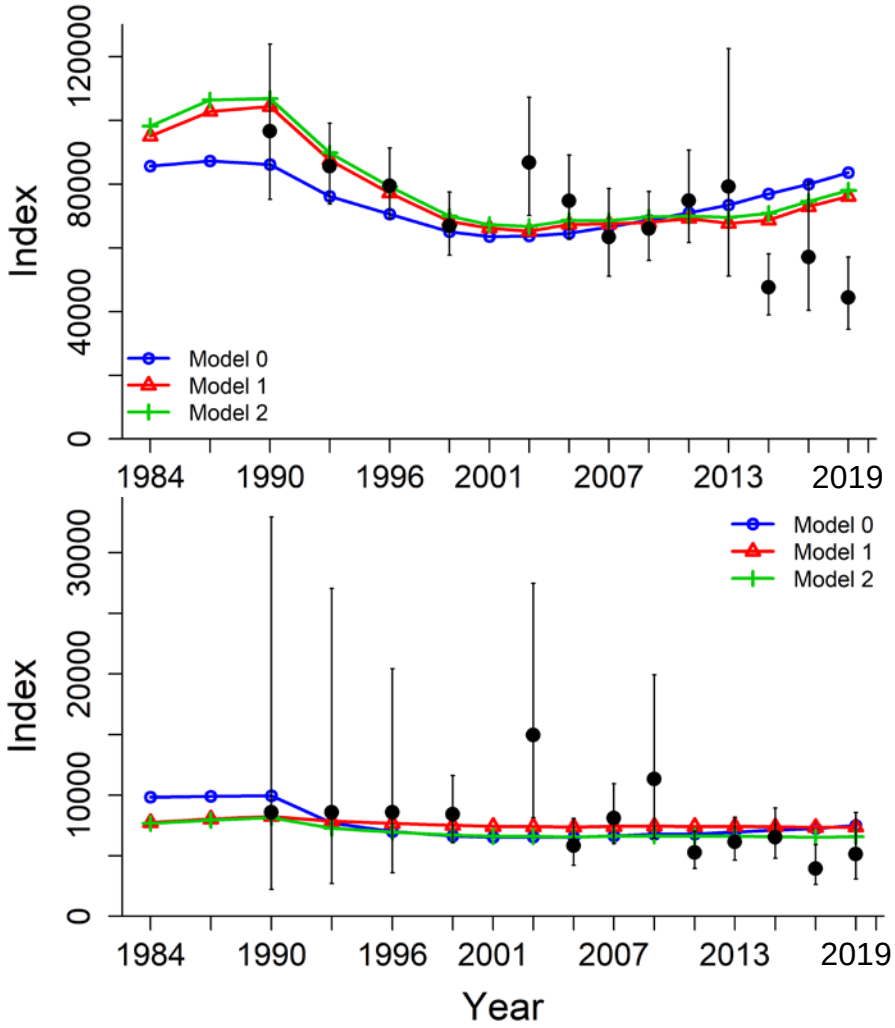
Movement from shallow to deep for GP_2
- Age 3: π^m_{a3}= 0
- Age 10: π^m_{a10} = 1

Model Results

Fits to survey biomass data

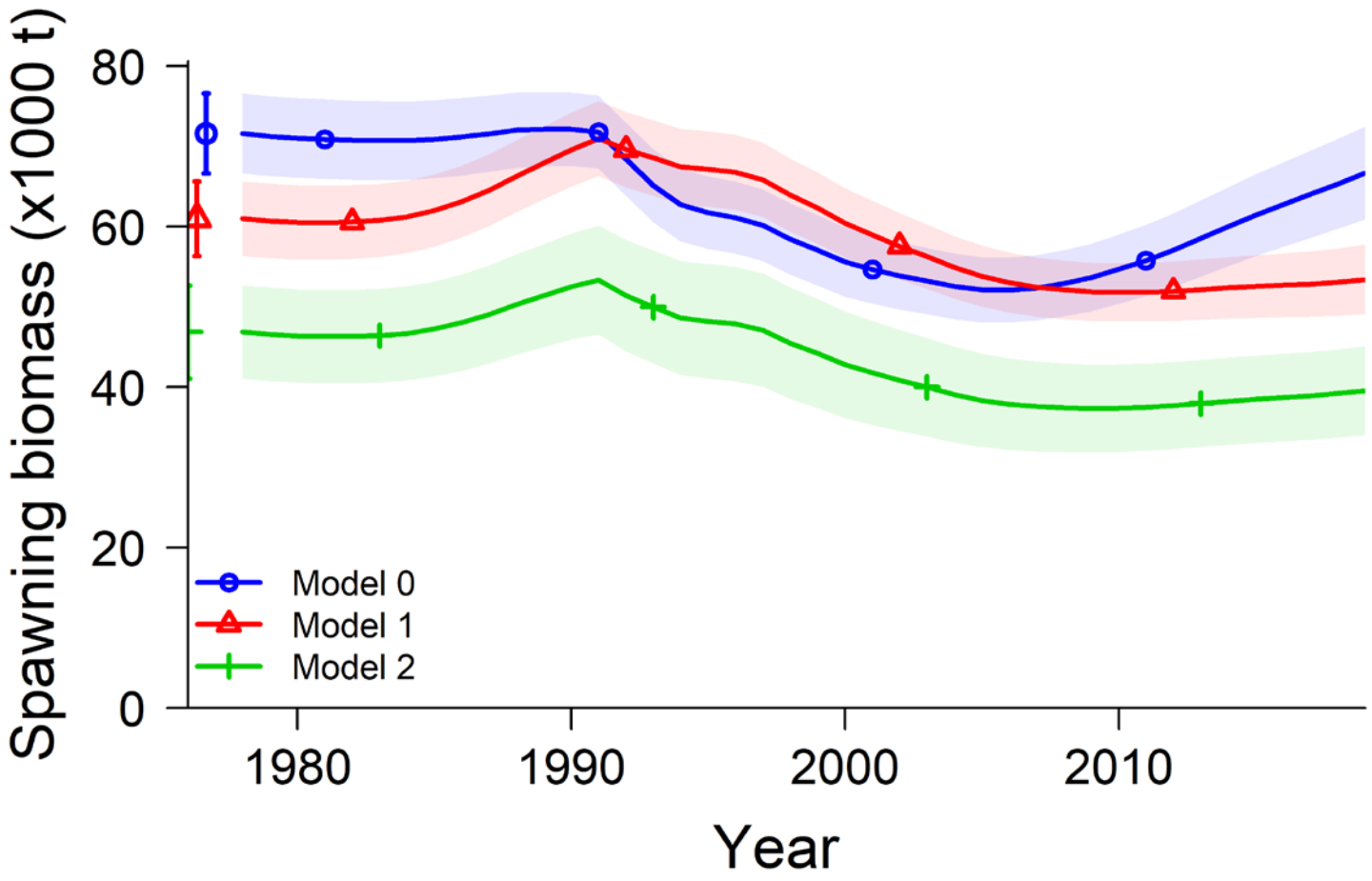
Shallow

Deep



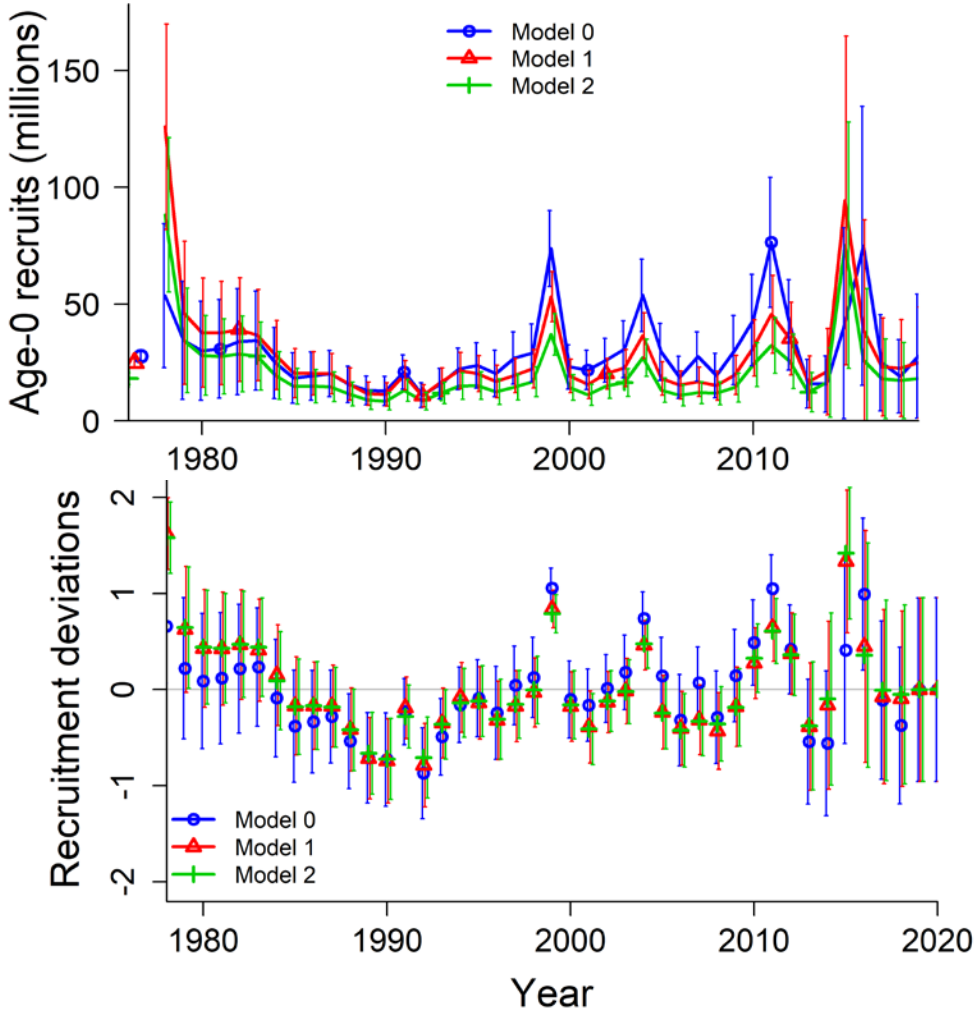
Model Results

Spawning stock biomass



Model Results

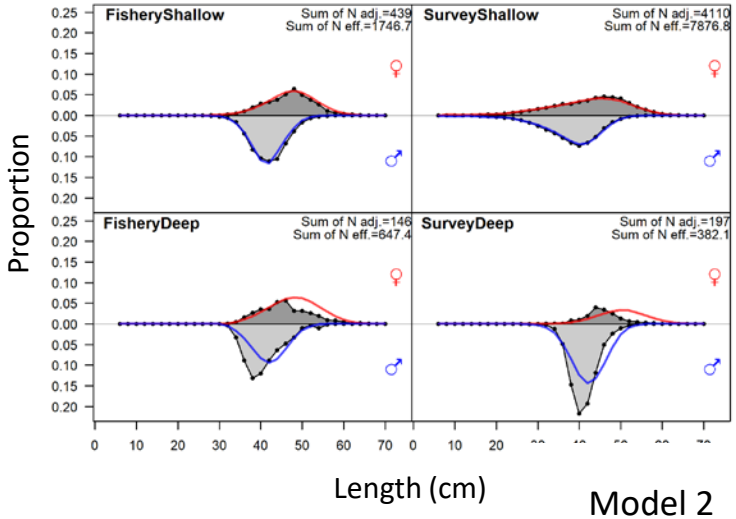
Recruitment and Deviations



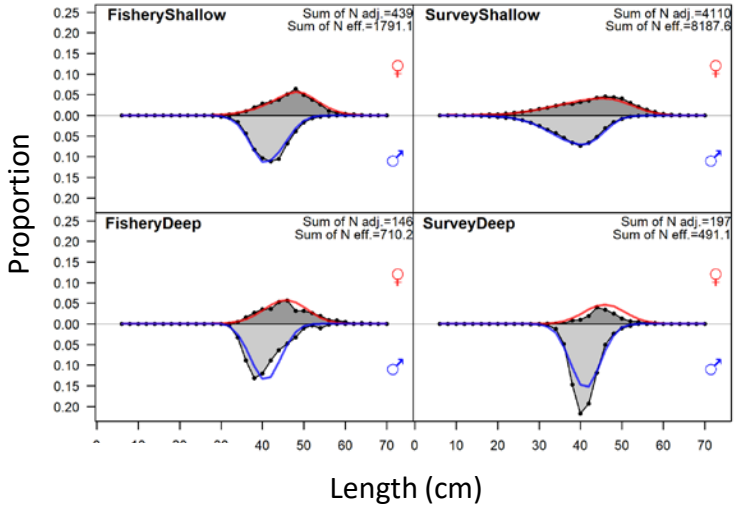
Model Results

Aggregated Length Compositions

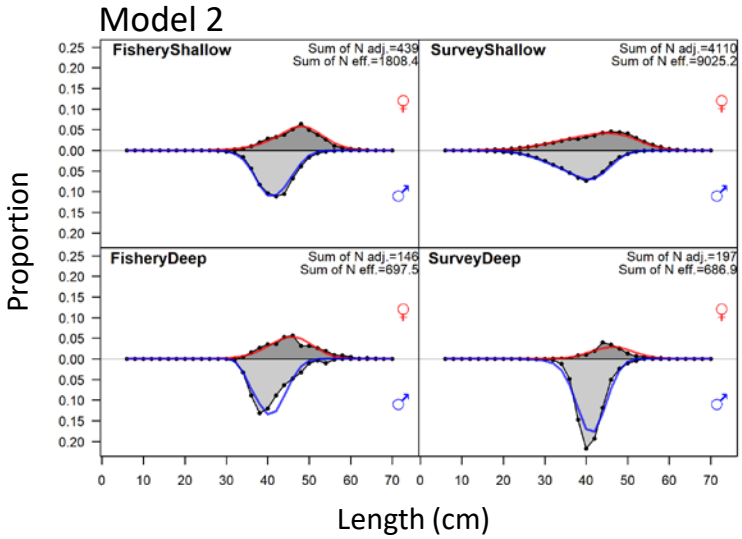
Model 0



Model 1



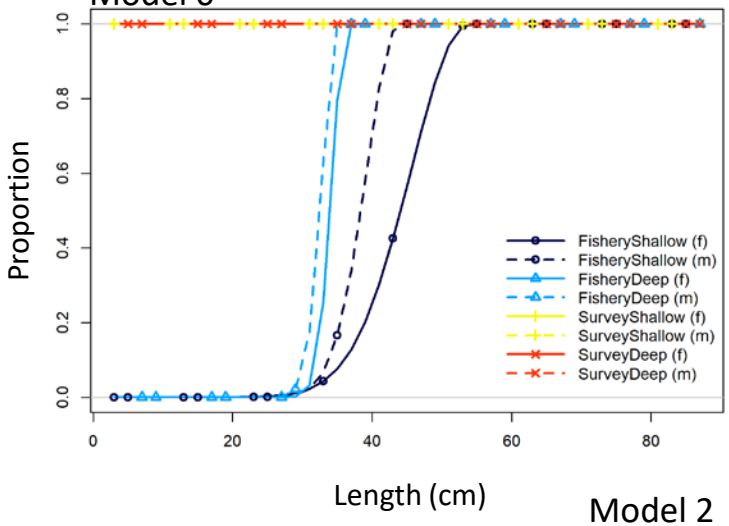
Model 2



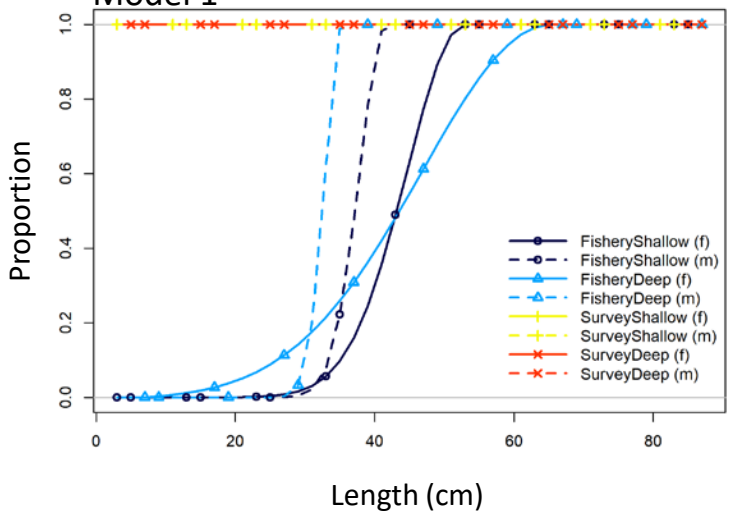
Model Results

Fishery Length Selectivity by fleet

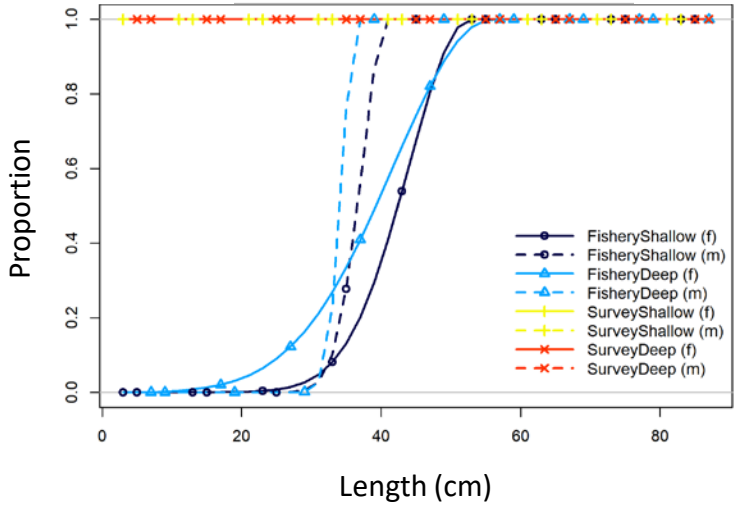
Model 0



Model 1



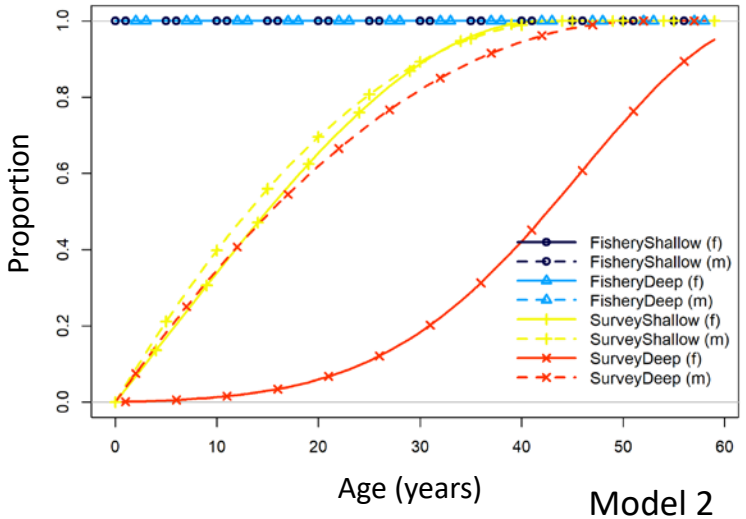
Model 2



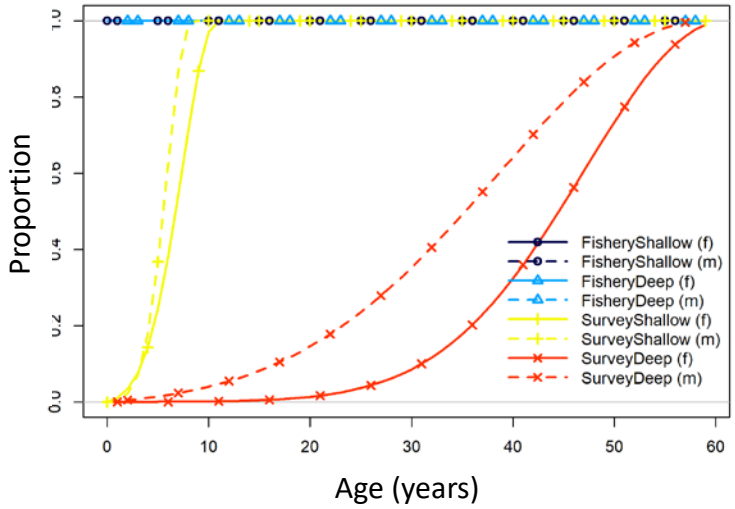
Model Results

Survey Age Selectivity by fleet

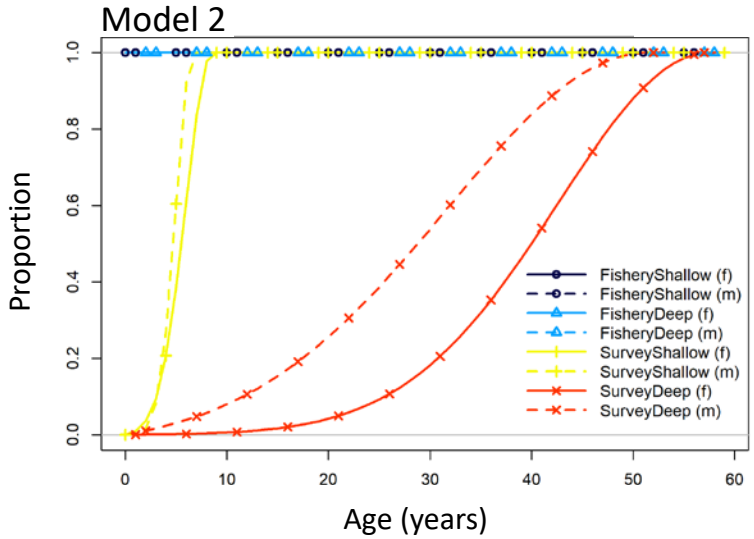
Model 0



Model 1



Model 2



Movement model parameters

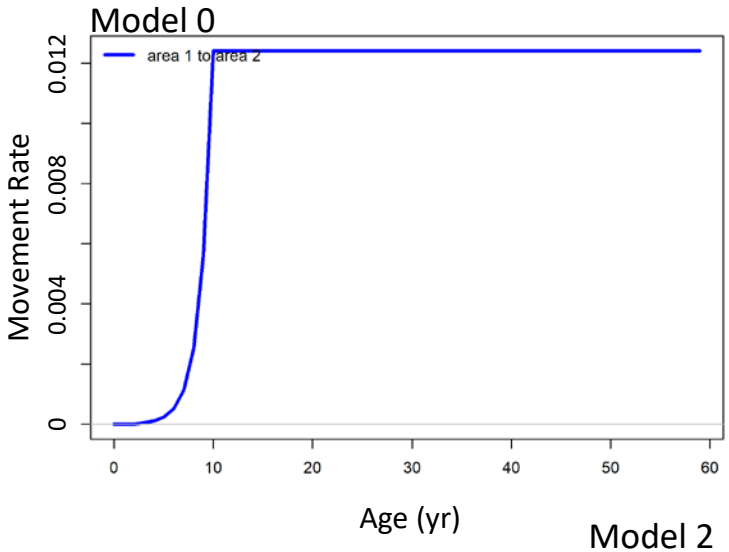
Movement and recruitment probabilities

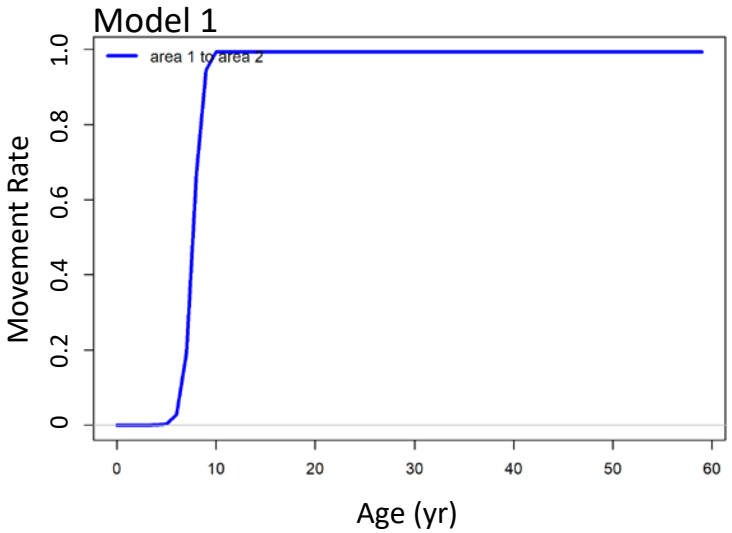
Movement Parameters	Model 0	Model 1	Model2
Probability of movement from Shallow to Deep from Age 0-3	0	0	0
Probability of movement from Shallow to Deep from Age 10+	0.012	1	1
Recruitment Distribution Parameters			
Probability of recruitment into shallow GP1	1	0.5	0.709
Probability of recruitment into shallow GP2	-	0.5	0.291

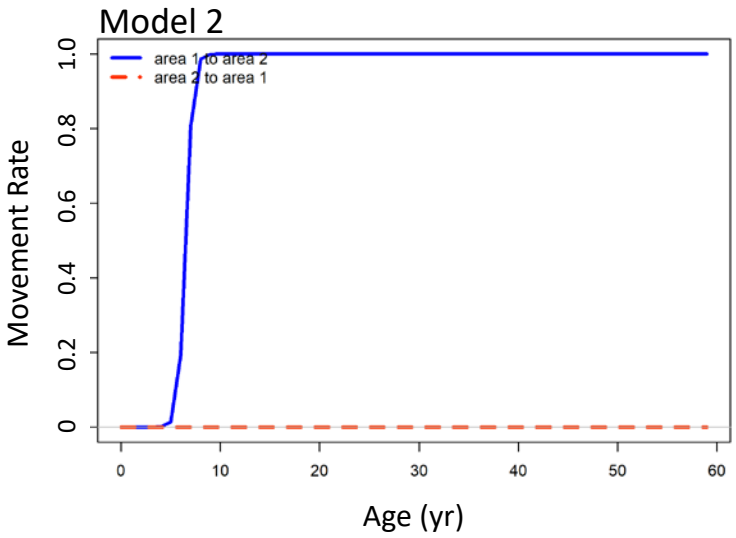
Fixed
Estimated
Estimated on bounds

Model Results

Movement probability







Growth parameters

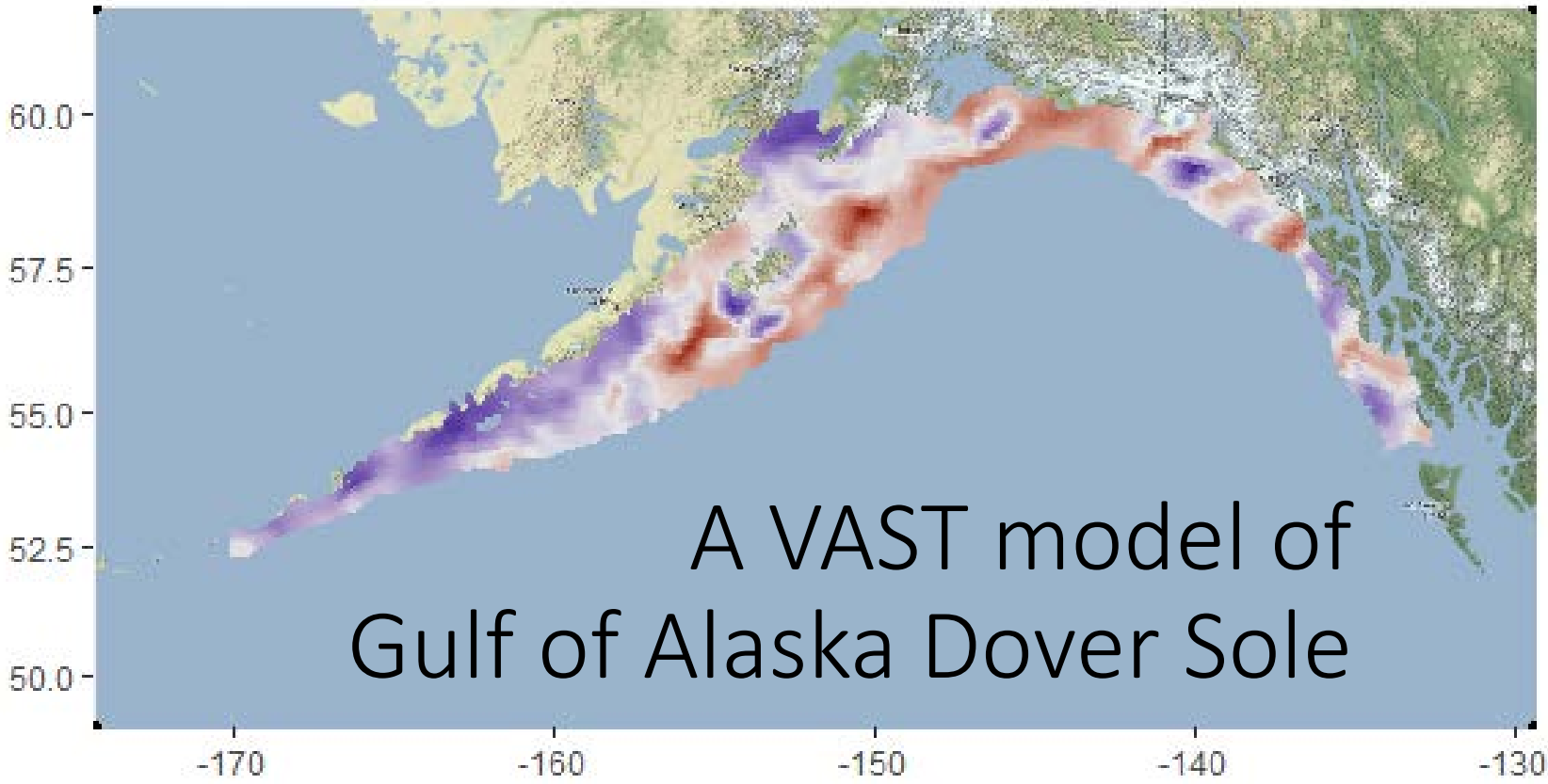
Parameter	GP1						GP2					
	Model 0		Model 1		Model 2		Model 0		Model 1		Model 2	
	Value	StDev	Value	StDev	Value	StDev	Value	StDev	Value	StDev	Value	StDev
Length at min age, F	25.366	-	25.798	0.962	25.596	0.725	25.366	-	22.500	1.251	21.081	1.887
Length at max age, F	52.101	-	52.188	0.287	52.115	0.279	52.101	-	46.903	0.785	47.498	0.760
von Bertalanffy K, F	0.113	-	0.127	0.006	0.129	0.006	0.113	-	0.207	0.028	0.201	0.040
CV young, F	0.150	-	0.133	0.010	0.140	0.008	0.150	-	0.189	0.021	0.207	0.036
CV old, F	0.107	-	0.098	0.003	0.097	0.003	0.107	-	0.104	0.012	0.103	0.012
Length at min age, M	27.110	-	22.064	0.764	25.922	0.922	27.110	-	27.063	0.783	27.020	1.944
Length at max age, M	43.968	-	44.595	0.179	44.614	0.199	43.968	-	42.379	0.240	42.546	0.254
von Bertalanffy K, M	0.158	-	0.186	0.008	0.166	0.010	0.158	-	0.304‡	-	0.199‡	-
CV young, M	0.151	-	0.144	0.010	0.144	0.008	0.151	-	0.100	0.023	0.223	0.031
CV old, M	0.090	-	0.082	0.002	0.081	0.002	0.090	-	0.084	0.004	0.078	0.005
Natural Mortality, M	0.085	-	0.079	0.002	0.079	0.002	0.085	-	0.087	0.003	0.068	0.006

Model Likelihoods

Likelihoods	Model 0	Model 1	Model 2
Total Negative Log Likelihood	5924.34	5712.25	5687.97
Survey Negative Log Likelihood	1.38	-11.40	-11.83
Length comp Negative Log Likelihood	528.23	429.68	415.02
Age comp Negative Log Likelihood	5386.95	5282.69	5273.97

Future Directions

- Estimate sex-specific movement – currently not possible with SS3
- Modify ages of movement probabilities
- GOA specific ageing error
- Time varying natural mortality and catchability

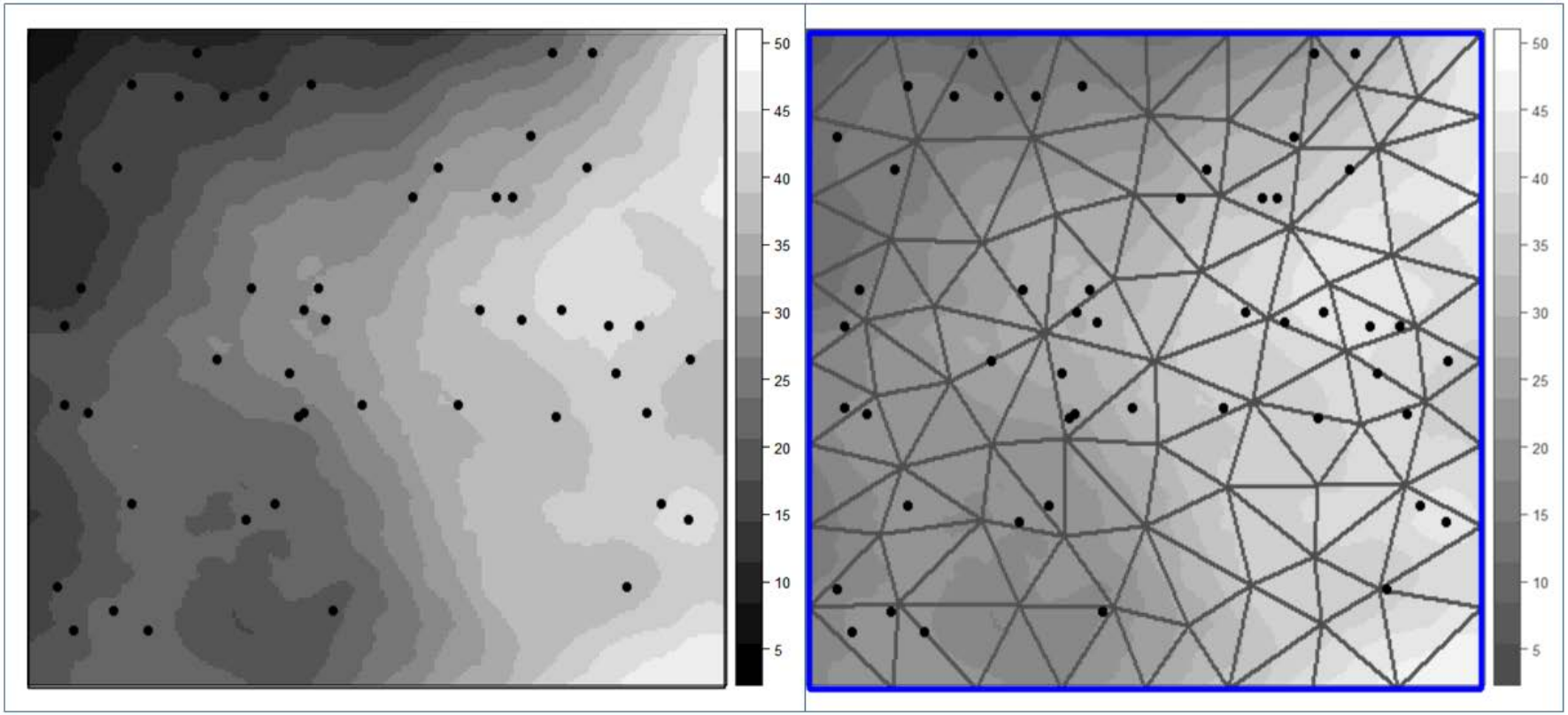


A VAST model of Gulf of Alaska Dover Sole

Andrea Havron, Carey McGilliard

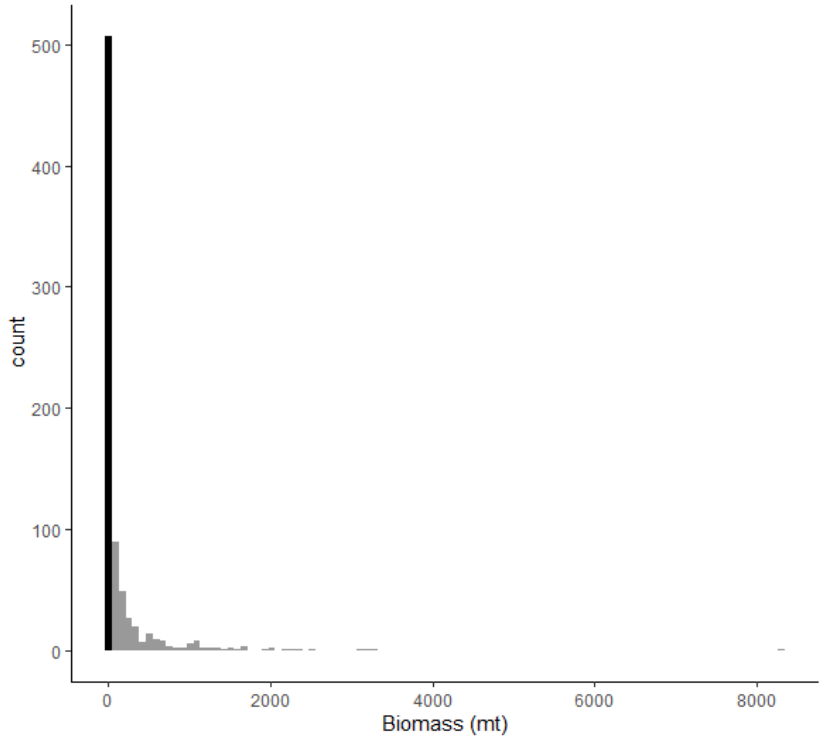
VAST structure

Triangulated Mesh



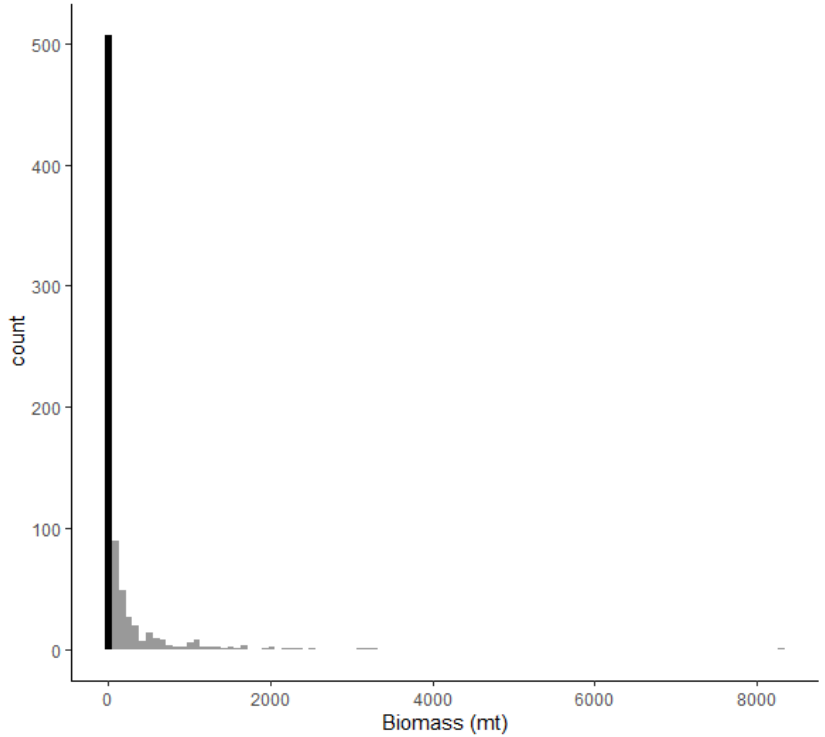
VAST Decisions for Survey Indices

- Observation Model
- Spatial/Spatio-temporal Model
- Additional Random Effects
- Adding Covariates



VAST Decisions for Survey Indices

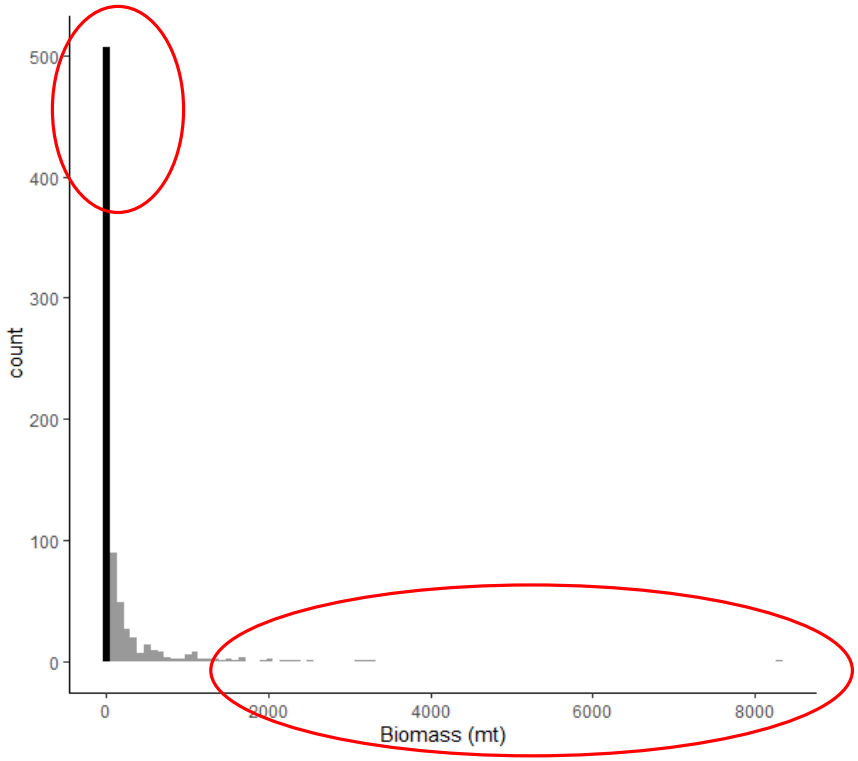
- Observation Model
  - Likelihood Model
  - Probability of Encounter
  - Positive Biomass
- Spatial/Spatio-temporal Model



- Additional Random Effects
- Adding Covariates

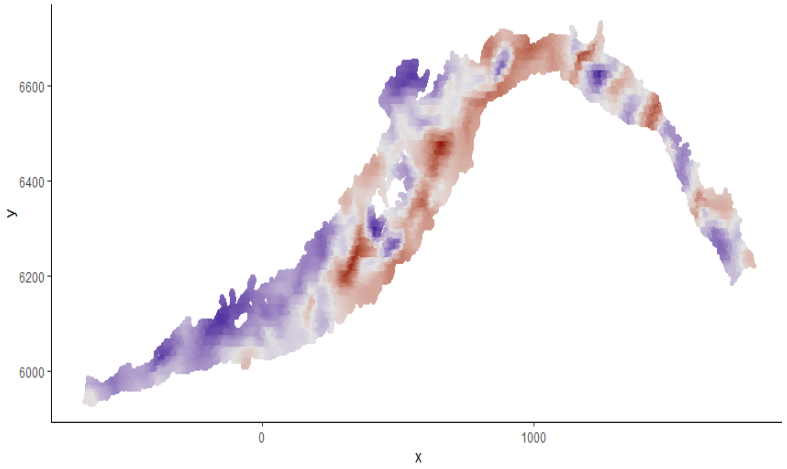
VAST Decisions for Survey Indices

- Observation Model
  - Likelihood Model
  - Probability of Encounter
  - Positive Biomass
- Spatial/Spatio-temporal Model
  - Spatial/Spatio-temporal in Probability of Encounter
  - Spatial/Spatio-temporal in Positive biomass
  - Spatial Structure
    - Mesh
    - Anisotropy
- Additional Random Effects
- Adding Covariates



VAST Spatio-temporal effects

Average Spatial Effect



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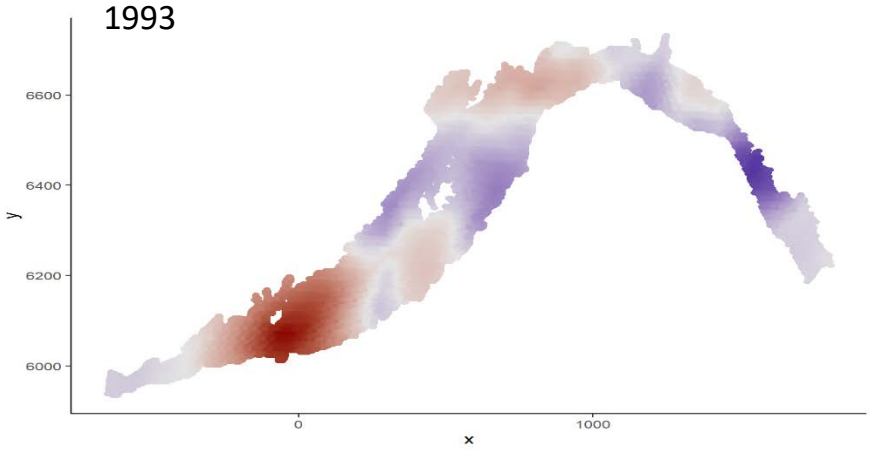
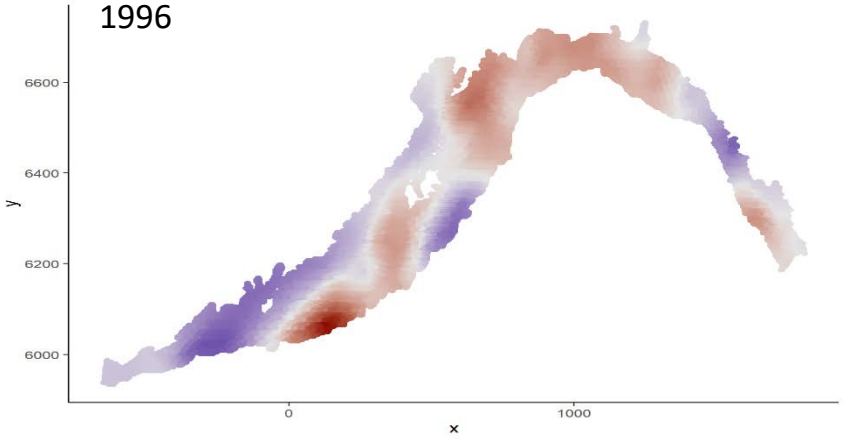
Spatio-temporal Effects

1993

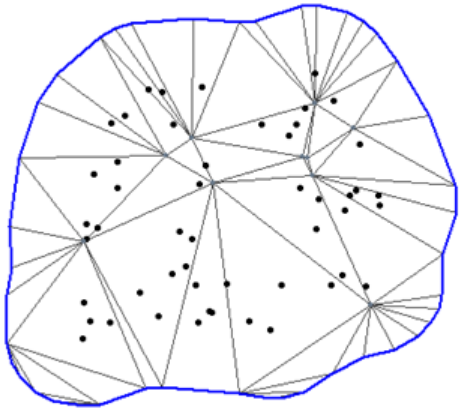


1996



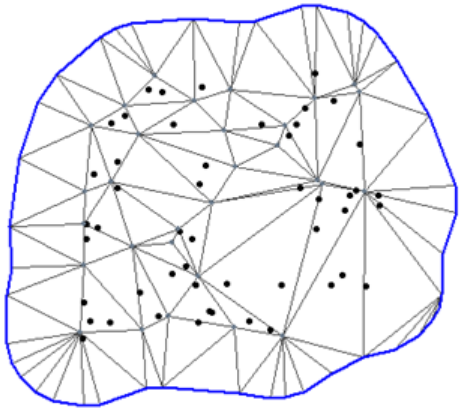
VAST Mesh Settings

Low Resolution

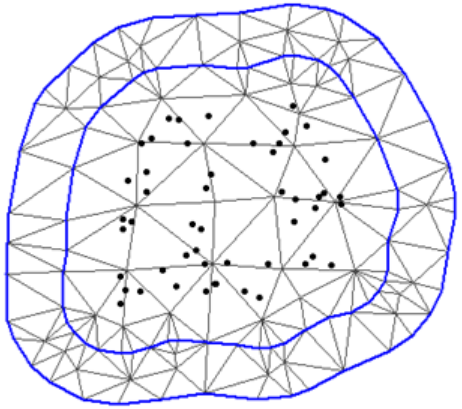


Knots = 10

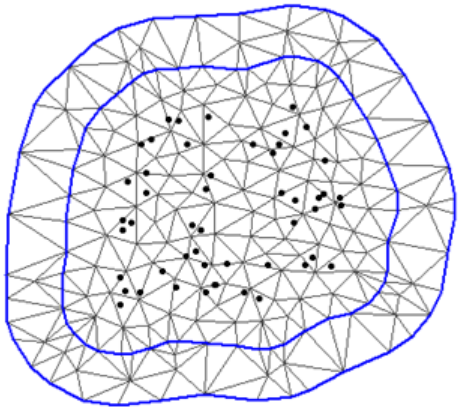
High Resolution



Knots = 30



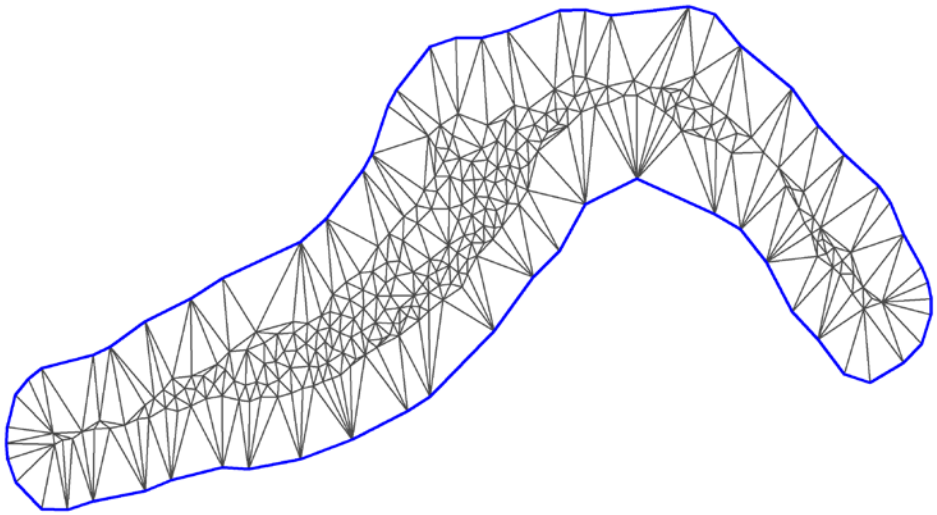
Max Edge = 0.5



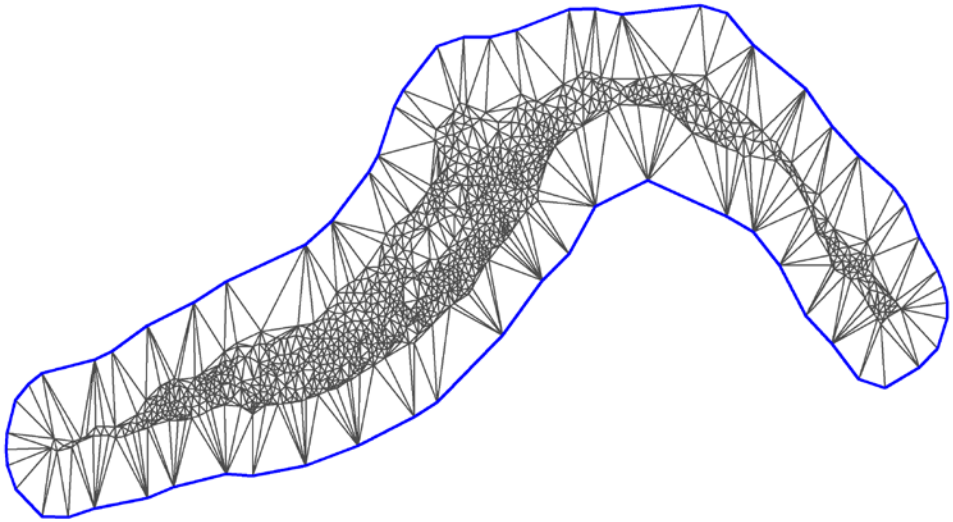
Max Edge = 0.2

GOA mesh settings

250 Knots

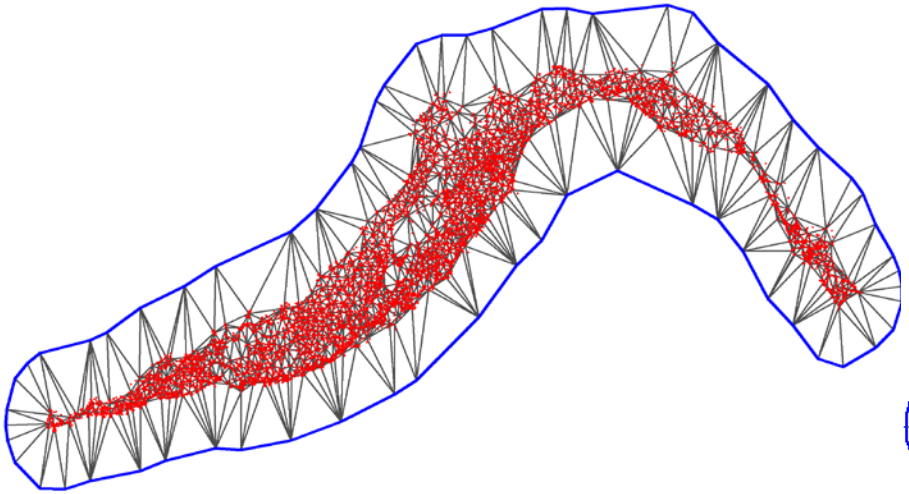


1000 Knots

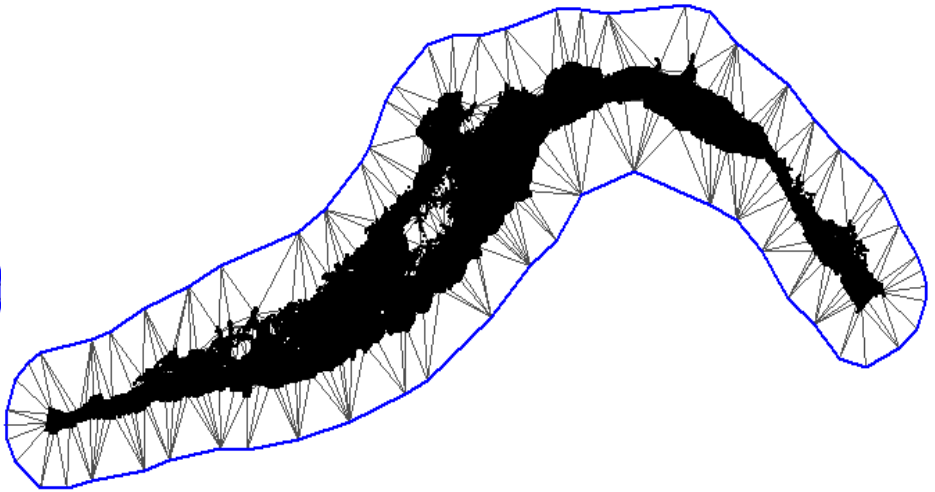


GOA mesh boundary – 1000 knot mesh

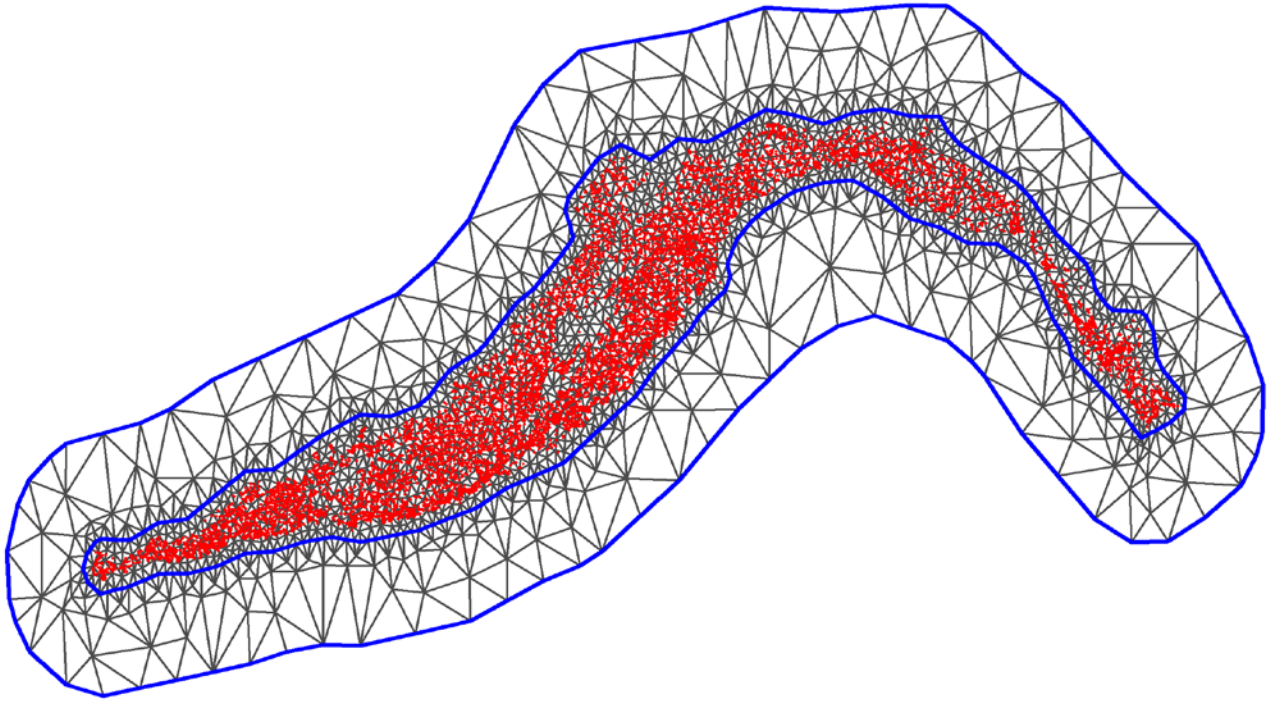
Survey Locations



Prediction Locations



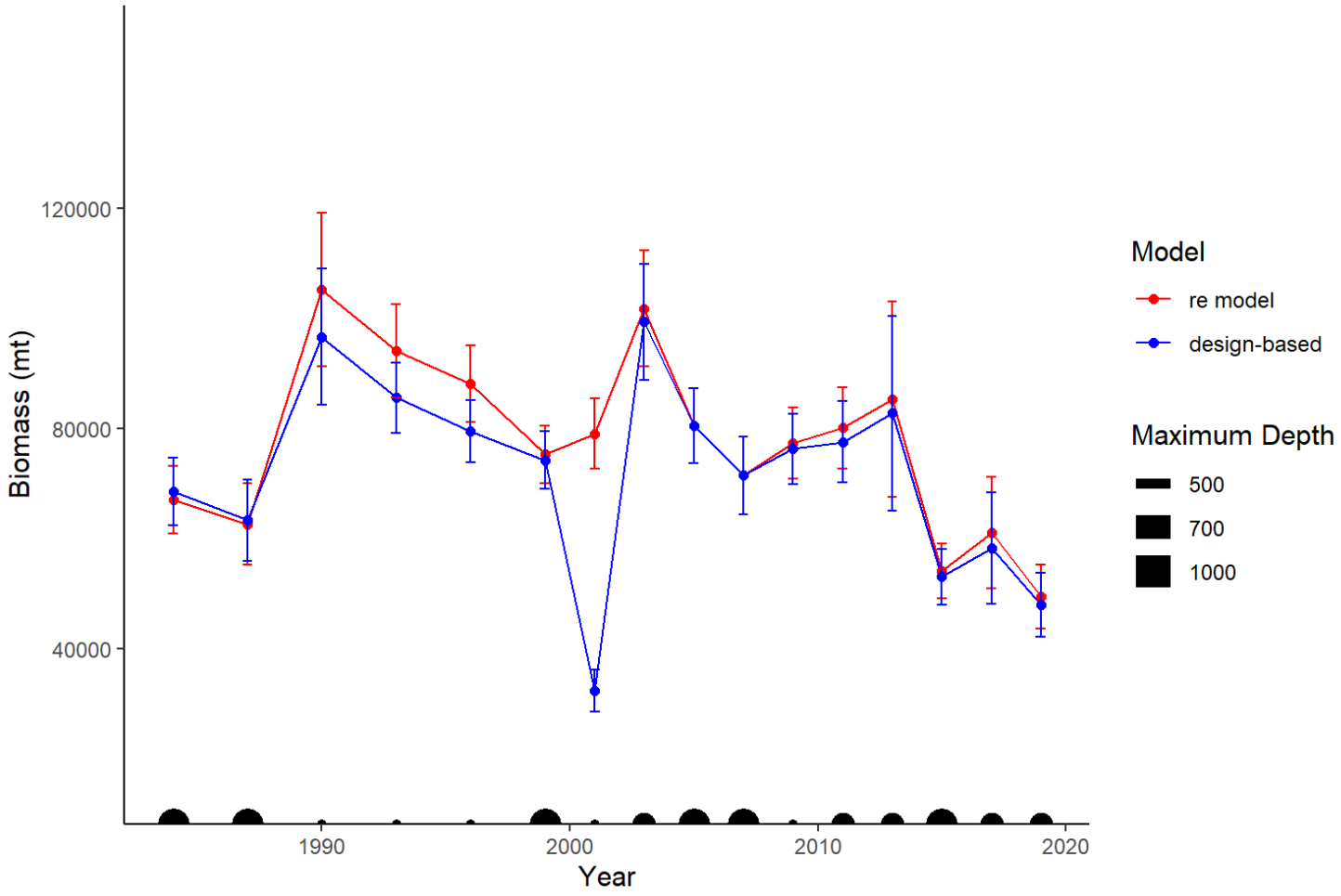
GOA mesh boundary – user defined mesh



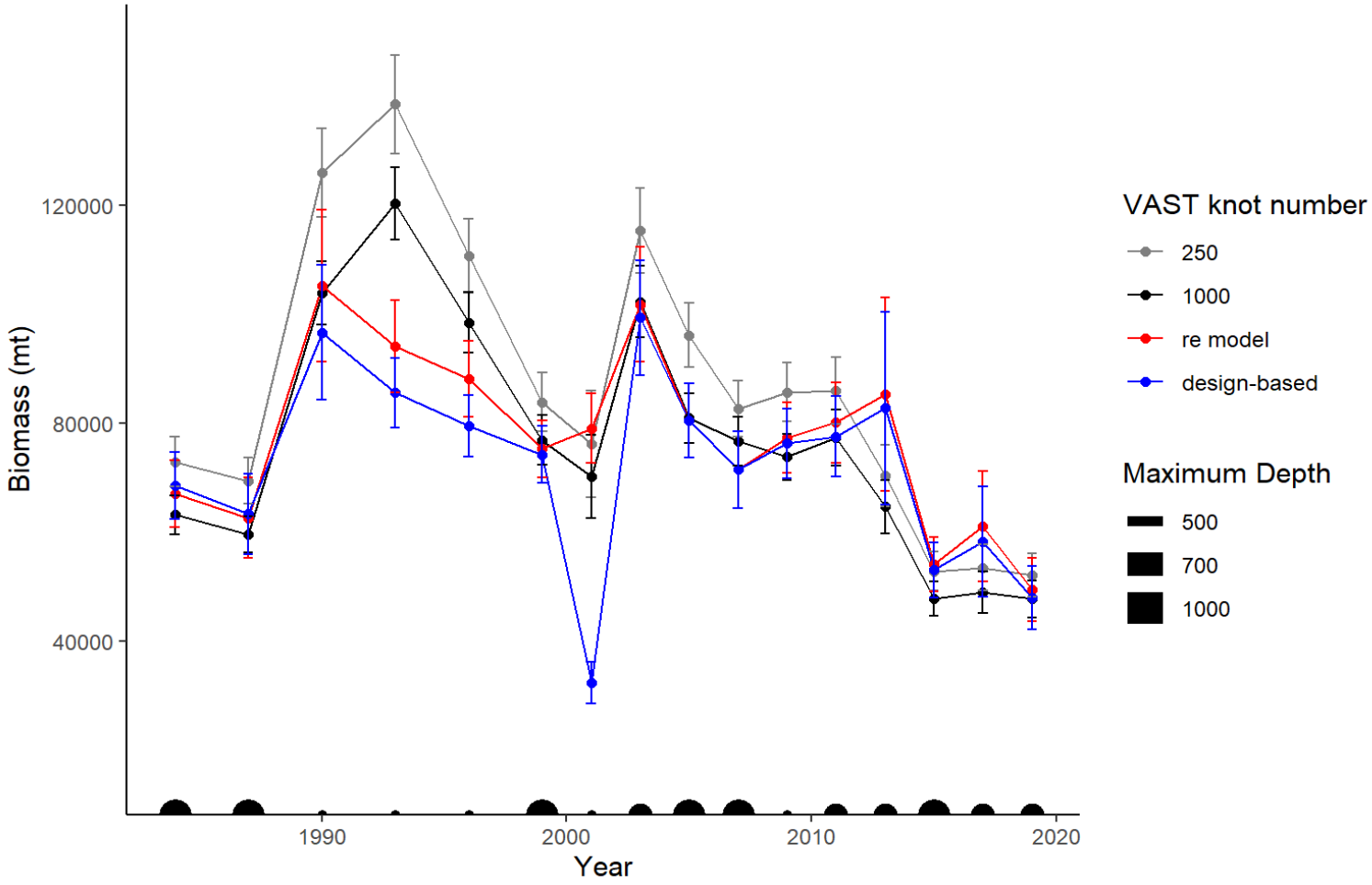
VAST Decisions for Survey Indices

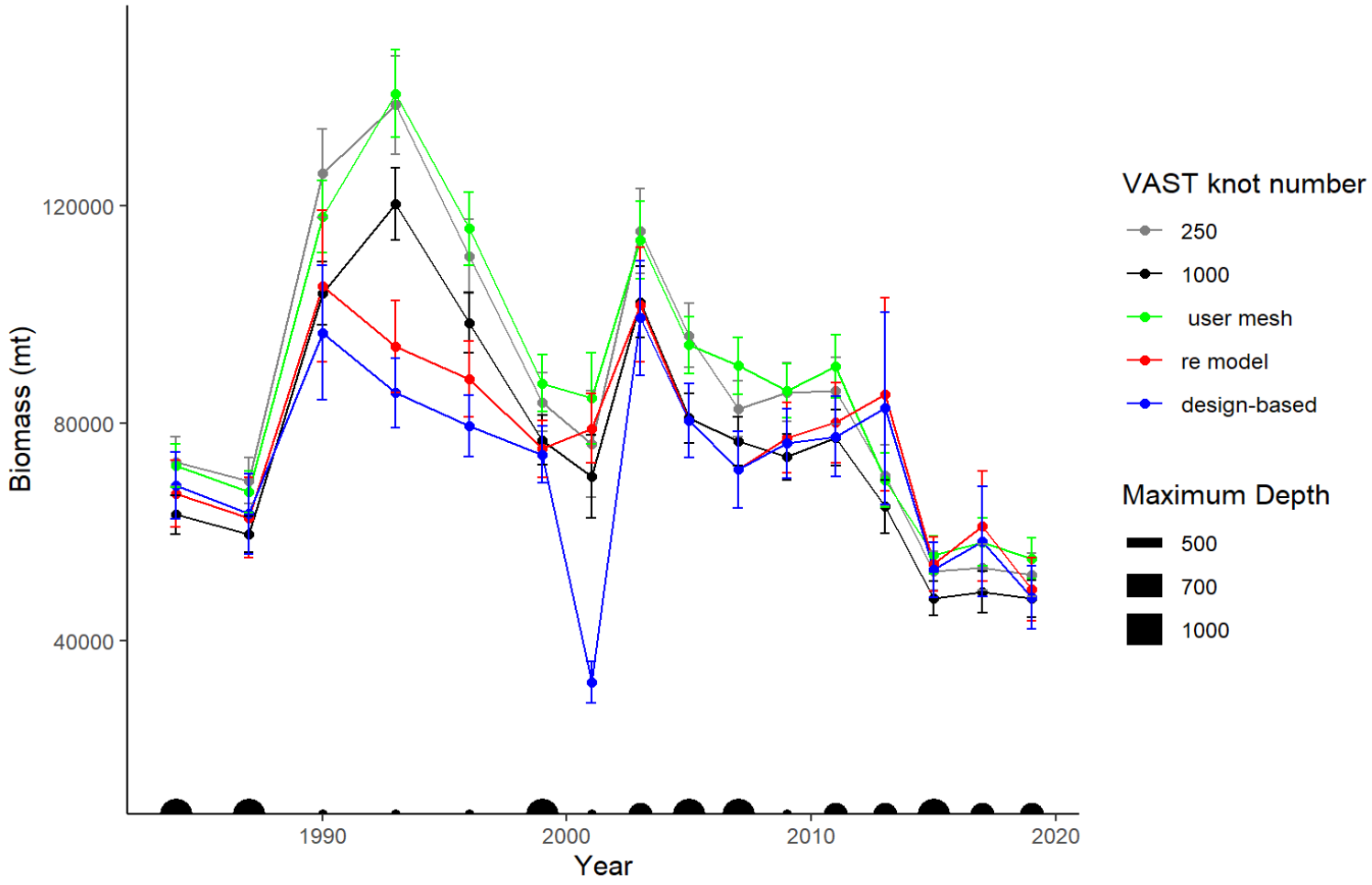
- Models:
  - Design-based
  - RE model
  - VAST using knots:
    - 250
    - 1000
  - VAST with user defined mesh

VAST Model - Review

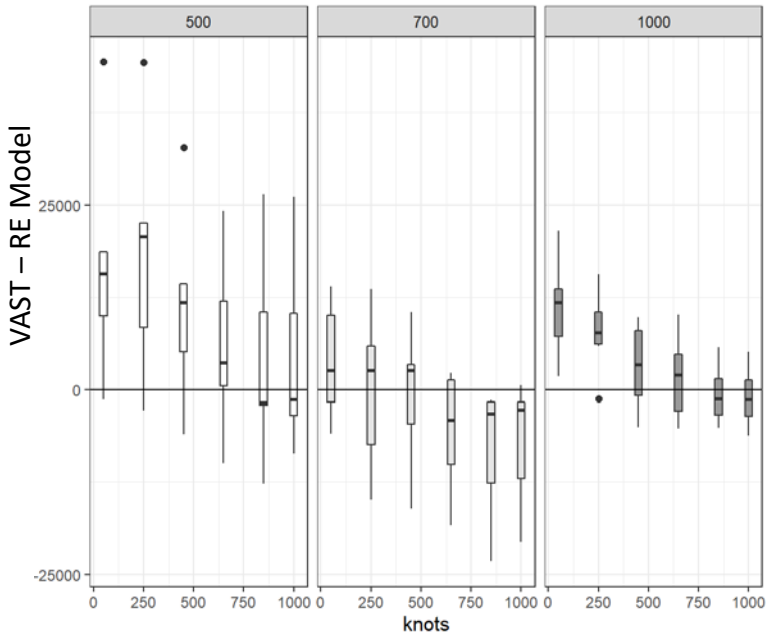


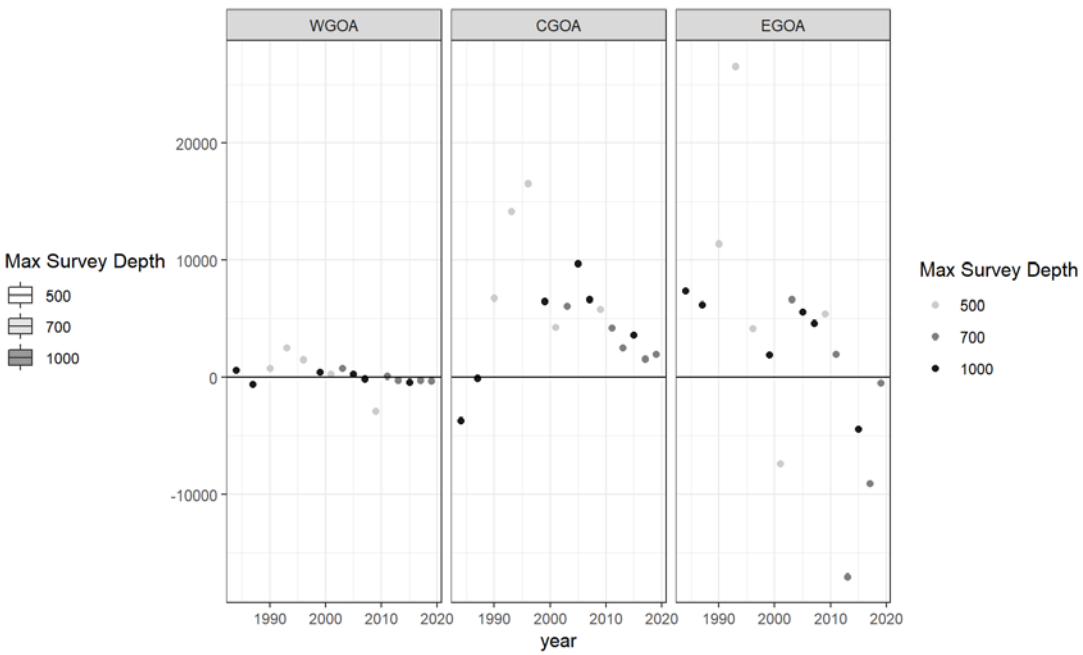
VAST Model - Review




Biomass (mt)
120000
80000
40000
1990
2000
2010
2020
Year
VAST knot number
250
1000
user mesh
re model
design-based
Maximum Depth
500
700
1000

VAST - RE model comparison





VAST Model – Model Validation

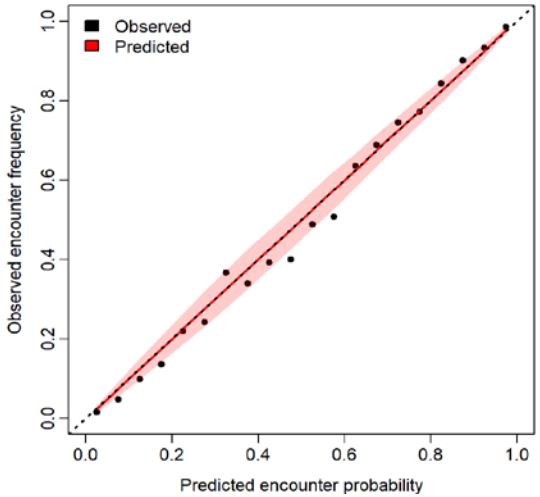
Knots	Max Edge	Lognormal	Gamma
50		0.013	0.006
250		0.01	**0.348**
450		0.003	0.039
650		0	0.003
850		0	0
1000		0	0
	100	0	0.036
	50	0	0.021
	30	0	0

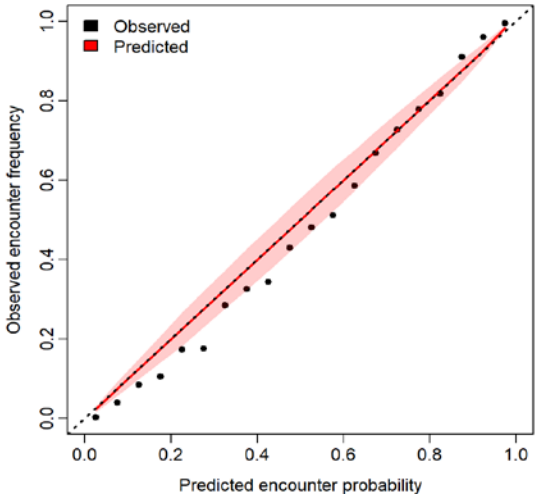
VAST Model – Model Validation

250 Knots

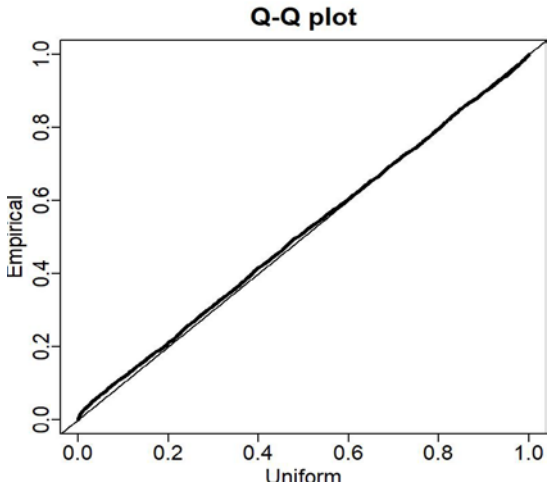
1000 Knots

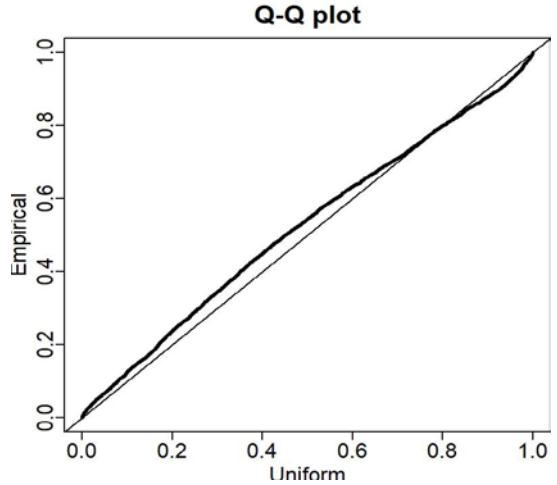
Probability of encounter





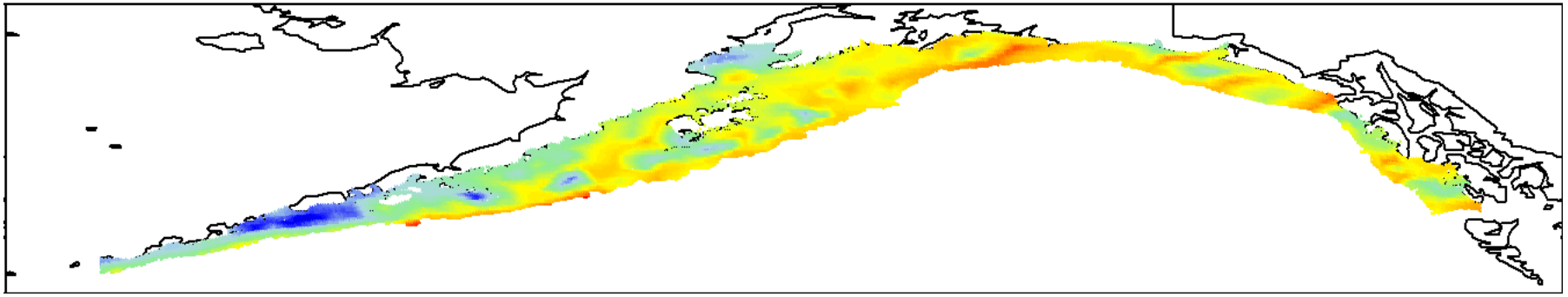
Biomass Density



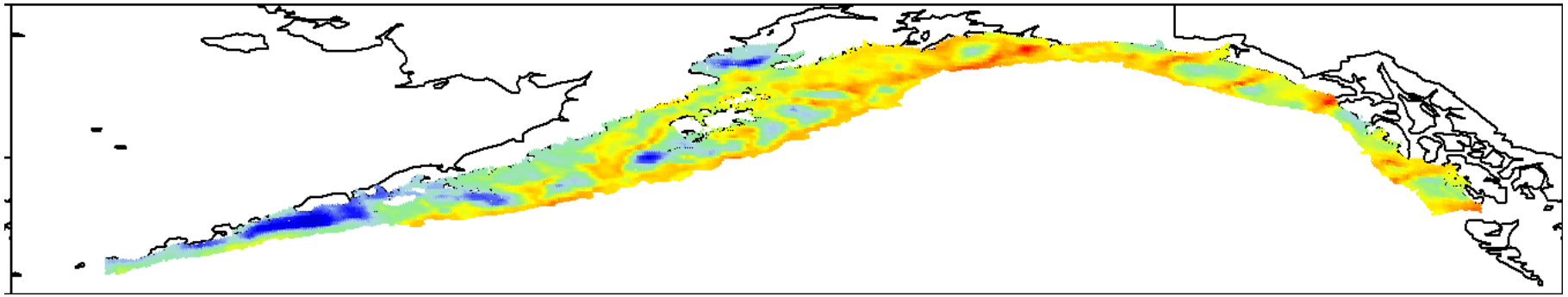


1993 Biomass Density

250 Knots

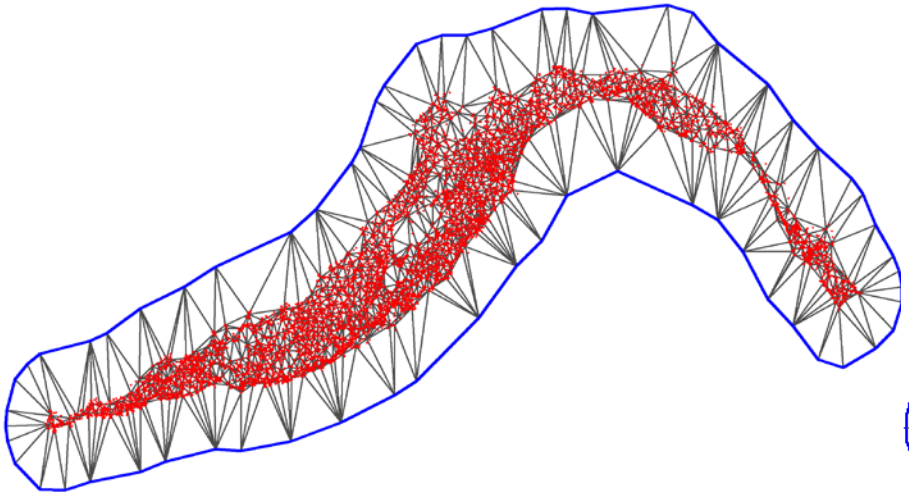


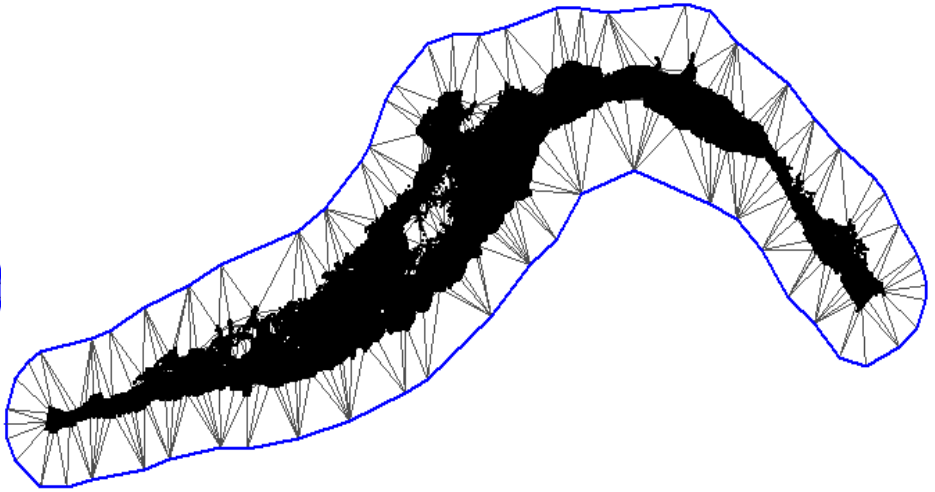
1000 Knots



Issues

- Sensitivity to mesh structure
  - Boundaries
  - Knots





Issues

- Sensitivity to mesh structure
  - Boundaries
  - Knots
- Sensitivity to anisotropy
  - Separate models for Western/Central and Eastern GOA
  - Add Covariates