2024 Maryland Oyster Benchmark Stock Assessment Summary

May 19, 2025
Maryland Oyster Advisory Commission Meeting
Annapolis, MD

Sustainable Oyster Population and Fishery Act of 2016
Statute §4–215

Requires DNR in consultation with University of Maryland Center for Environmental Science (UMCES) to:

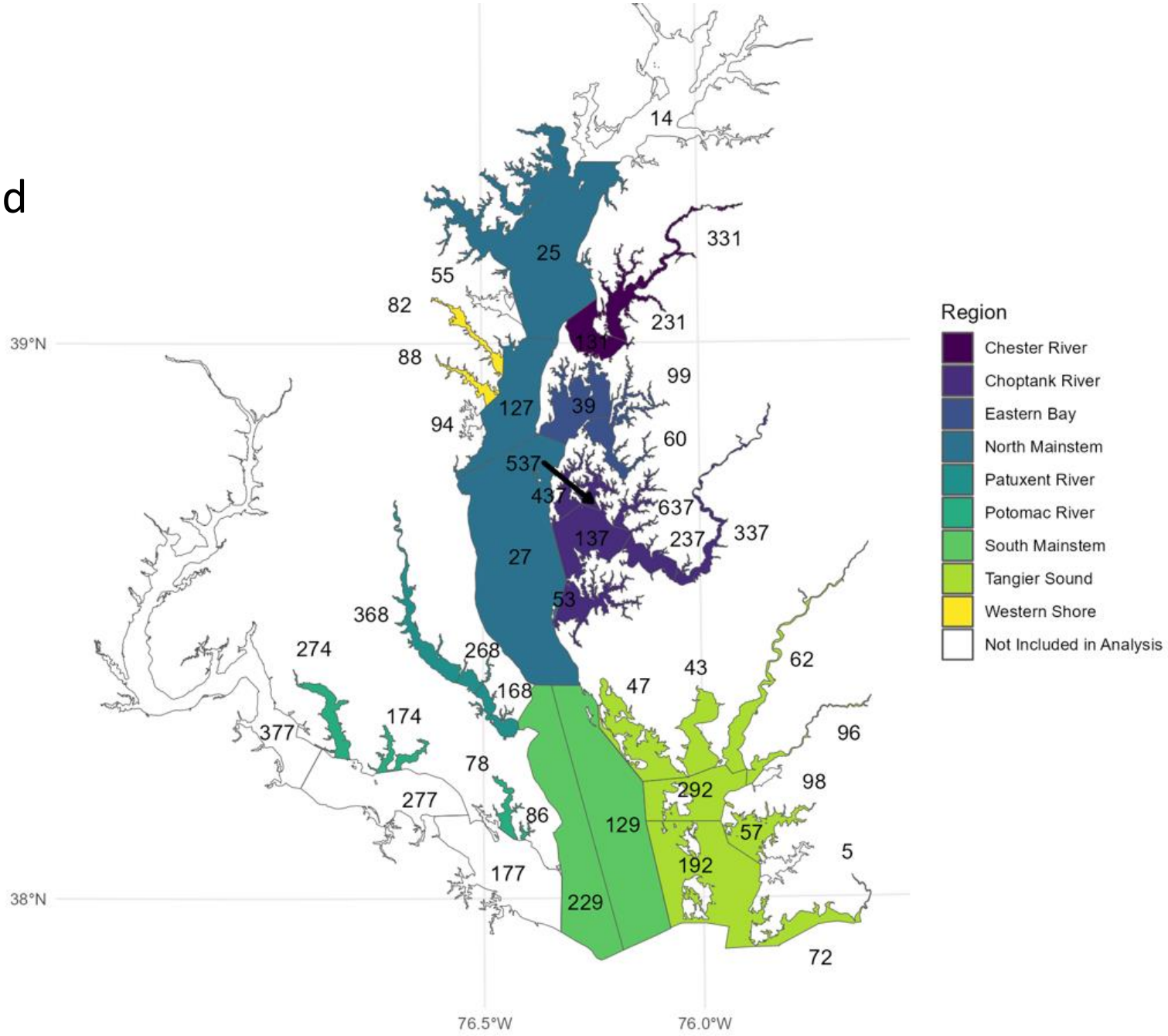
- Conduct an oyster stock assessment
  - Reviewed by an independent panel of fisheries stock assessment experts
- Develop biological reference points to manage the public fishery
- Identify oyster management strategies to achieve a sustainable oyster population and fishery
- Provide opportunity for stakeholder engagement
- Benchmark stock assessment every six years (first one in 2018)

Overview

Assess status of oysters in Maryland portion of Chesapeake Bay

Spatial Scale – NOAA Codes (35)

Timeframe – 2005-2024

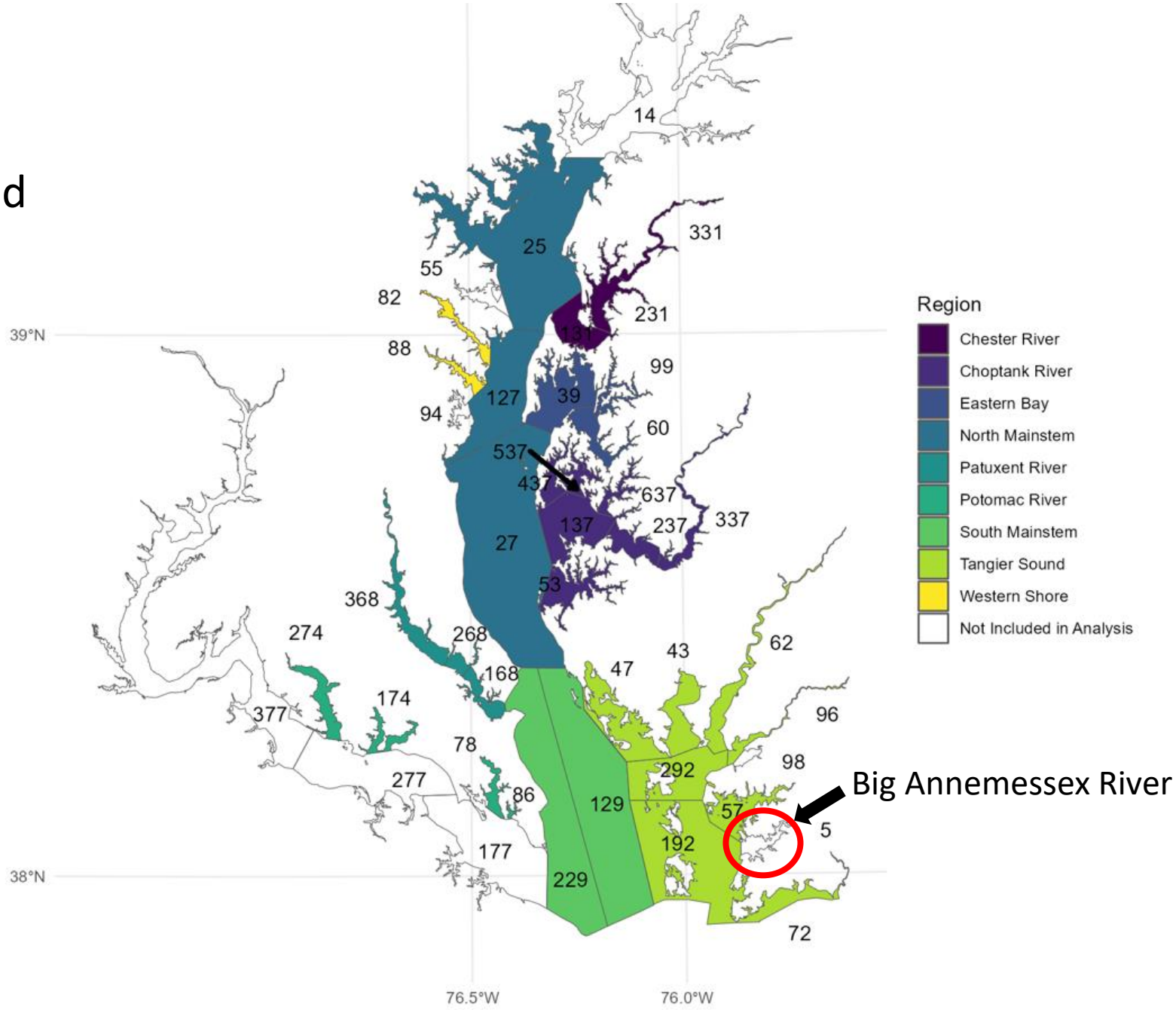


Overview

Assess status of oysters in Maryland portion of Chesapeake Bay

Spatial Scale – NOAA Codes (35)

Timeframe – 2005-2024
To match with the period the Fall Dredge Survey has recorded tow distances



Term of Reference #1

Develop a stock assessment model (or models) that estimates status of the stock relative to biological reference points…

Inventory of Available Data

Terms of Reference #1

Input category	Data Source
Recruitment	Fall dredge survey (√), Hatchery-reared spat (√), Natural seed (√), Patent Tong surveys, Peer reviewed studies
Habitat	Bay Bottom Survey (√), Yates Survey (√), Current sonar surveys, Shell plantings, Artificial substrate plantings, Peer reviewed studies (√)
Harvest	Dealer buy tickets (√), Monthly harvester reports, Bushel tax forms
Natural mortality	Fall dredge survey (√), Peer reviewed studies, DNR and other analyses (√)
Abundance trends	Fall dredge survey (√), Patent Tong surveys
Growth	Peer-reviewed studies(√), Fall dredge survey
Catchability	Peer-reviewed studies(√), other DNR analyses and studies

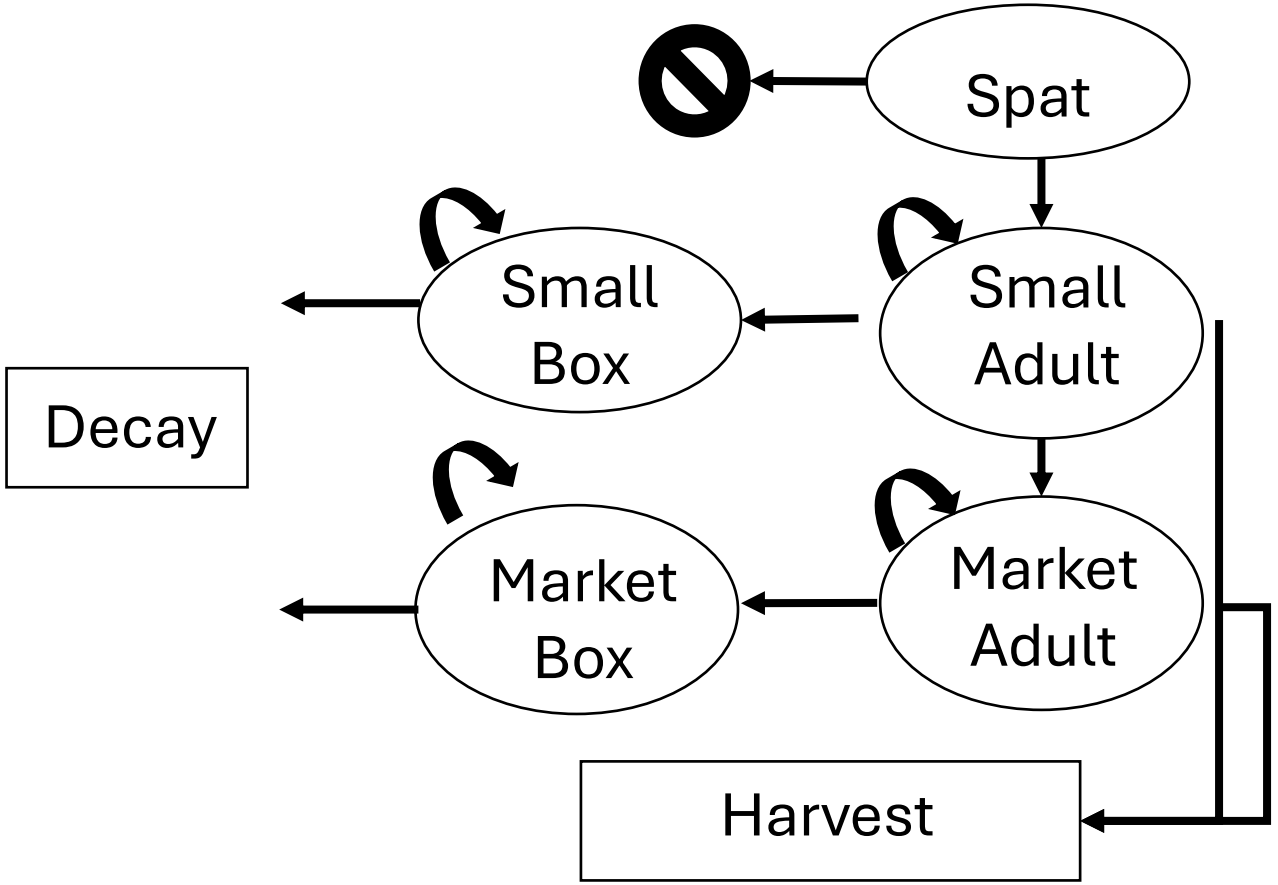
We are using data for 2005-present.

(√) indicates primary role in the analyses
No check mark indicates primarily used for qualitative comparison

Term of Reference #2

Develop a stock assessment model (or models) that estimates status of the stock relative to biological reference points…

Stage-structured Assessment Model



Data for use in model

Fall Dredge Survey (# per area swept)

Harvest Data (Buy Tickets)

- Total bushels by NOAA Code
- Before/after Fall Dredge Survey

Planting data

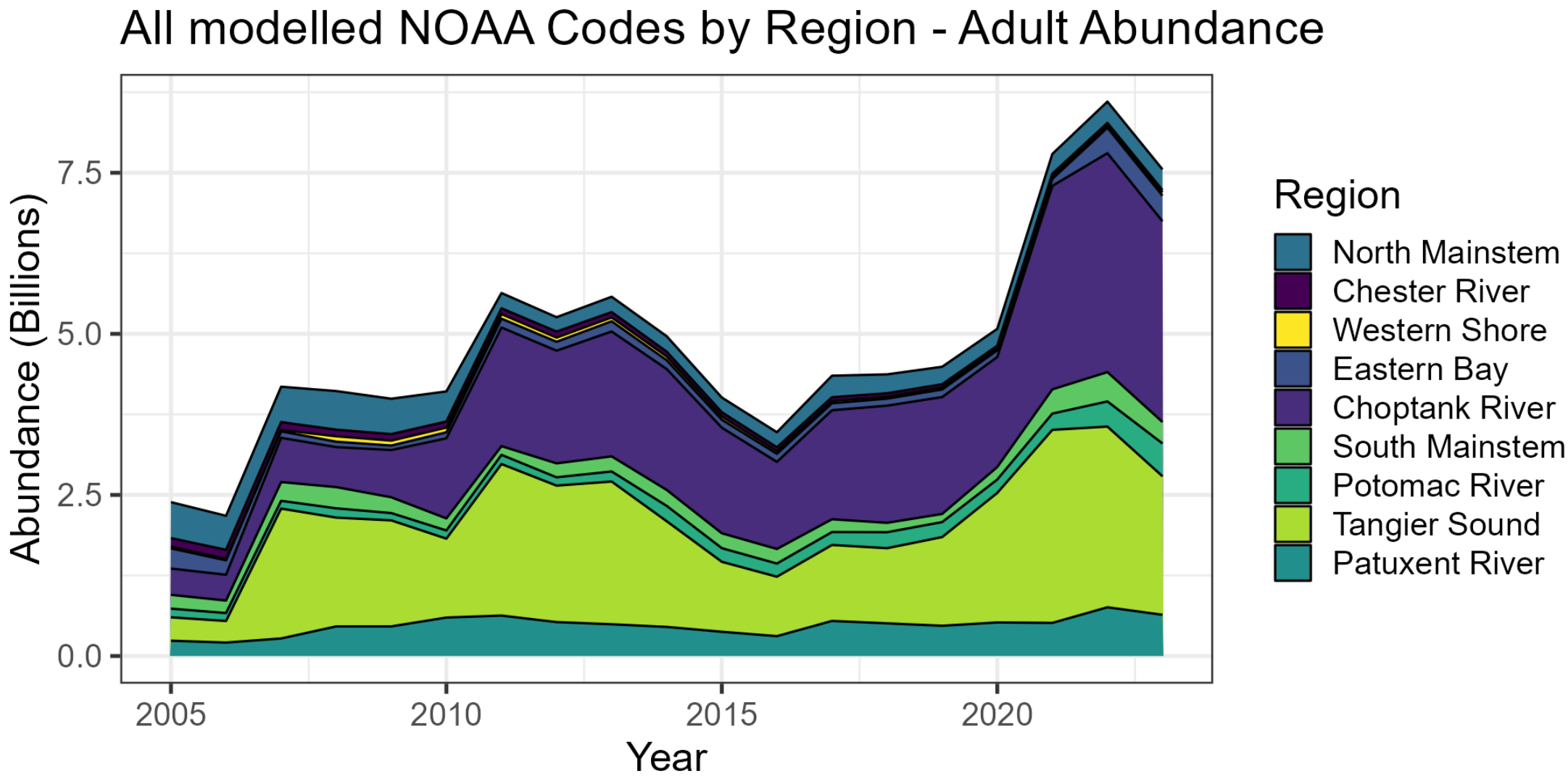
- Spat on shell, Wild Seed

Habitat Area (Bay Bottom Survey*)

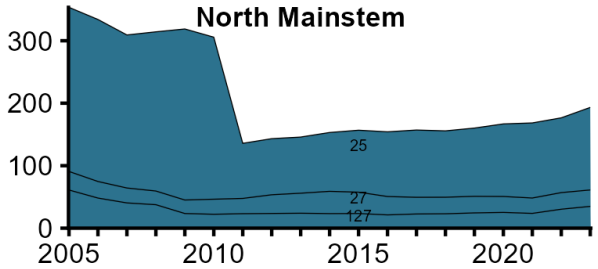
Assessment Model Results

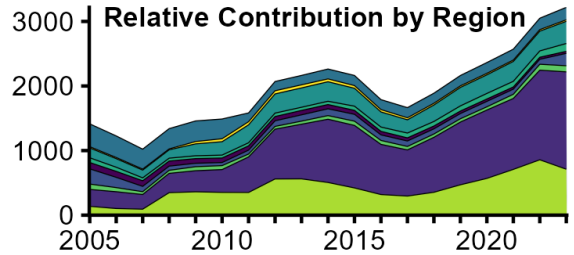
Types of results estimated in model:

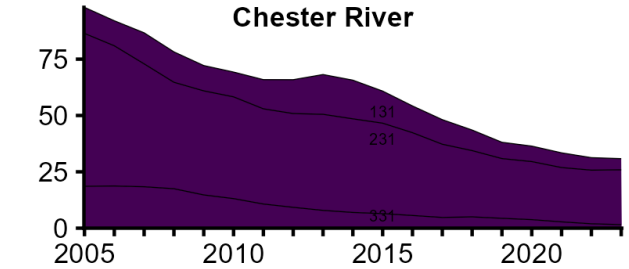
- Number of spat (<1 year old), small (>1 year old, < 3 inches), and market-sized oysters (>3 inches)
- Natural mortality rates (Fraction that die to causes other than harvest)
- Fishing rates (harvest fraction)
- Diagnostics – comparisons with observed data
  - The models generally matched the data well

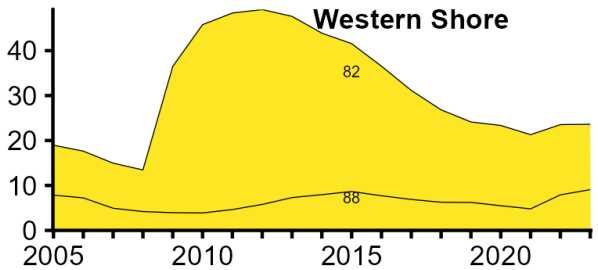

All modelled NOAA Codes by Region - Adult Abundance
Abundance (Billions)
7.5
5.0
2.5
0.0
2005
2010
2015
2020
Year
Region
North Mainstem
Chester River
Western Shore
Eastern Bay
Choptank River
South Mainstem
Potomac River
Tangier Sound
Patuxent River

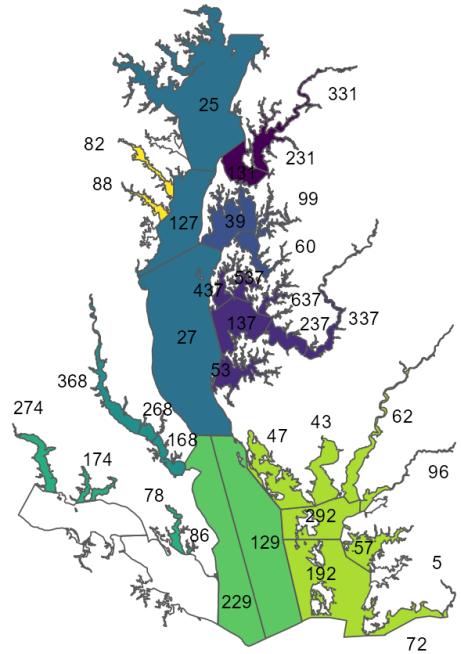
Estimated number of oysters (in millions) by region that are above the minimum size limit (3 inches), 2005-2023

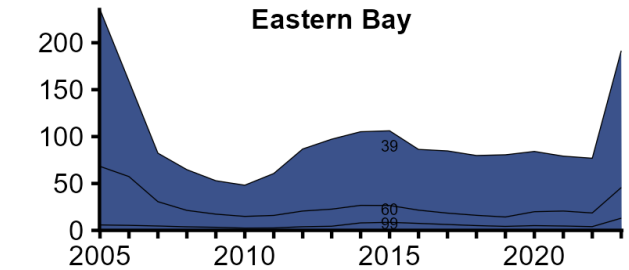


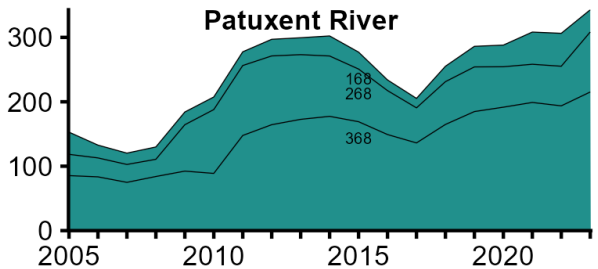


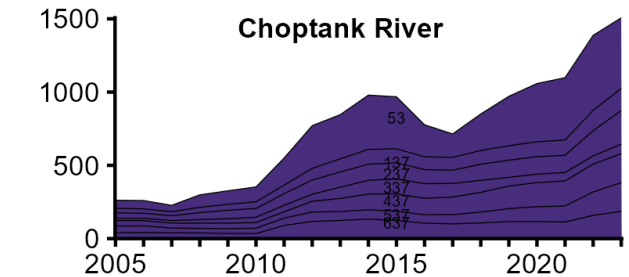


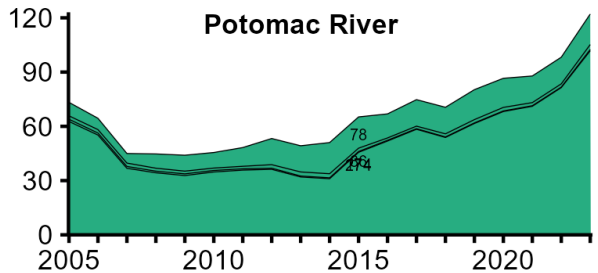


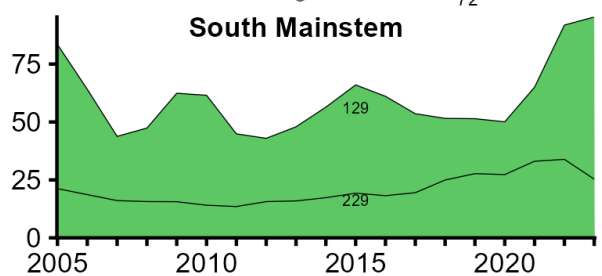


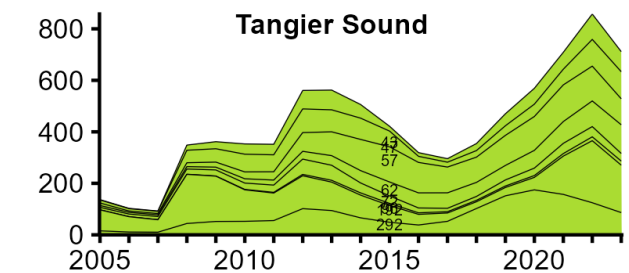




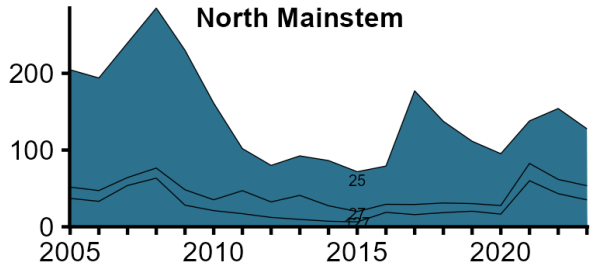


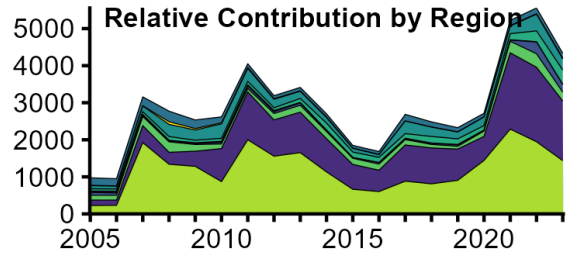


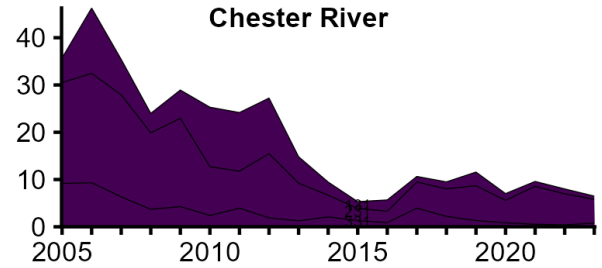


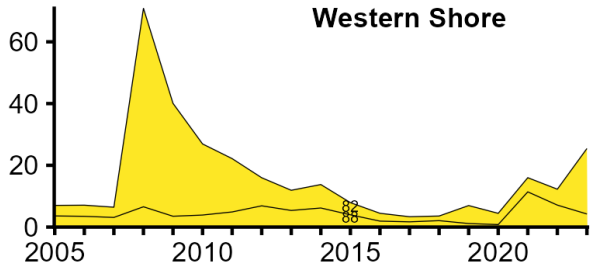


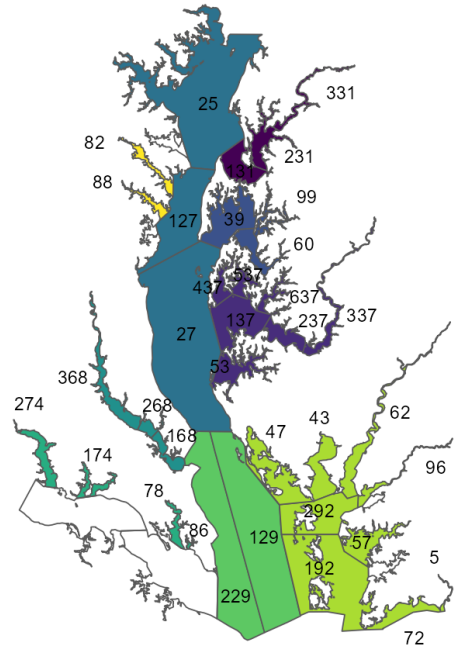
Estimated number of oysters (in millions) by region that are older than one year but below the minimum size limit (3 inches), 2005-2023

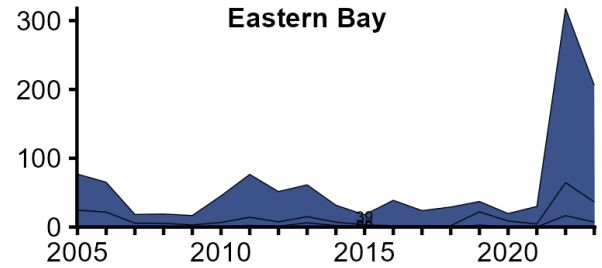


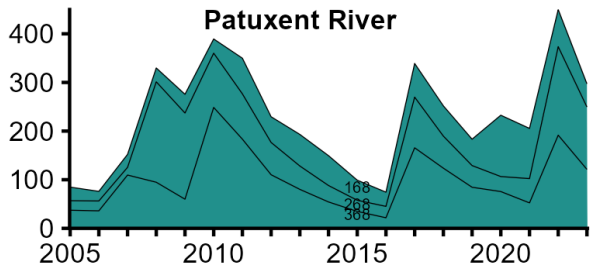


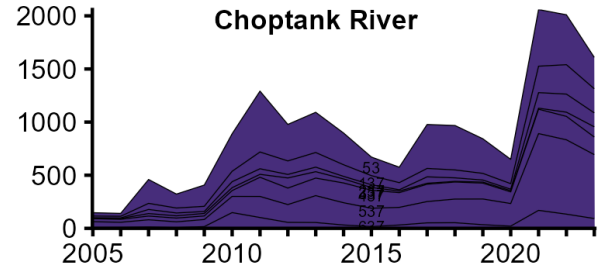


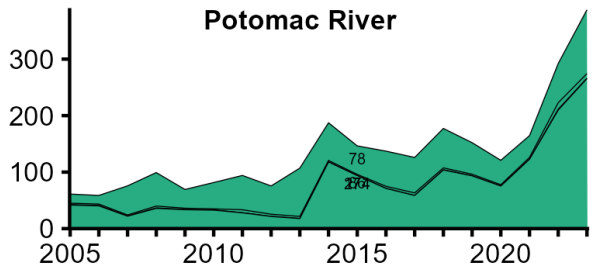


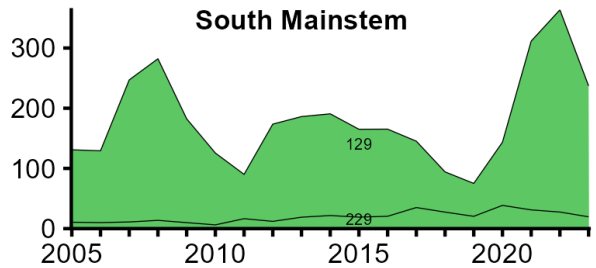


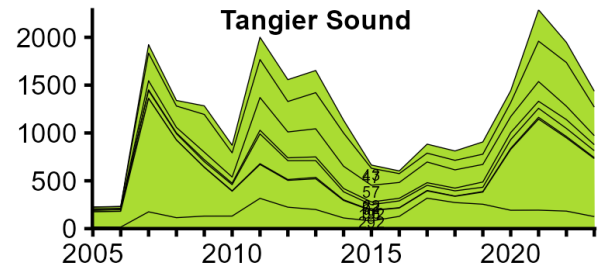




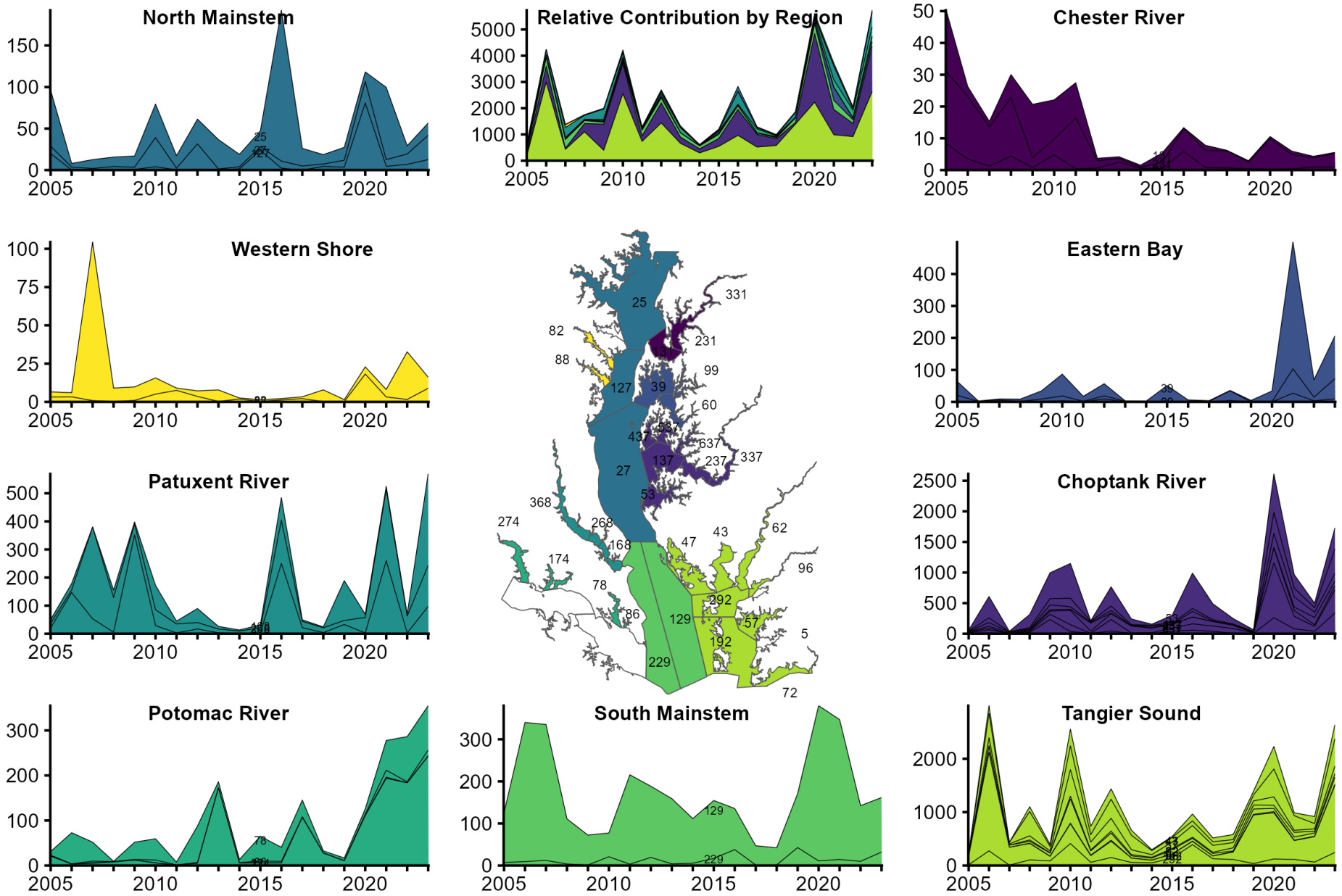








Estimated number of oysters (in millions) by region that are less than one year old, 2005-2023



Stock Assessment Background

What are biological reference points?

- Biological reference points **identify** fishing rate and abundance that will achieve the management objectives.

- Two types of biological reference points:
  1. Target reference point defined by managers through the public process
     Benchmark that identifies our goal
  2. Threshold reference point defined by the stock assessment
     Benchmark that identifies where we do <u>not</u> want to be

Harvest Rate Reference Point

Developed a limit harvest rate reference point based on the harvest rate that was expected to achieve no net loss of oyster shell habitat over time.

Estimated by relating change in cultch from the FDS with the estimated exploitation rate for each NOAA code and year.

Harvest rate limit = 12.6% per year
Harvest rate target = 9.4%

Abundance Reference Points

Estimate a long-term target density (number per m^2) of adult oysters that was common across all NOAA codes to represent a desired level of the oyster population.

Based on density estimates from sanctuaries in Maryland that are achievable for current population.

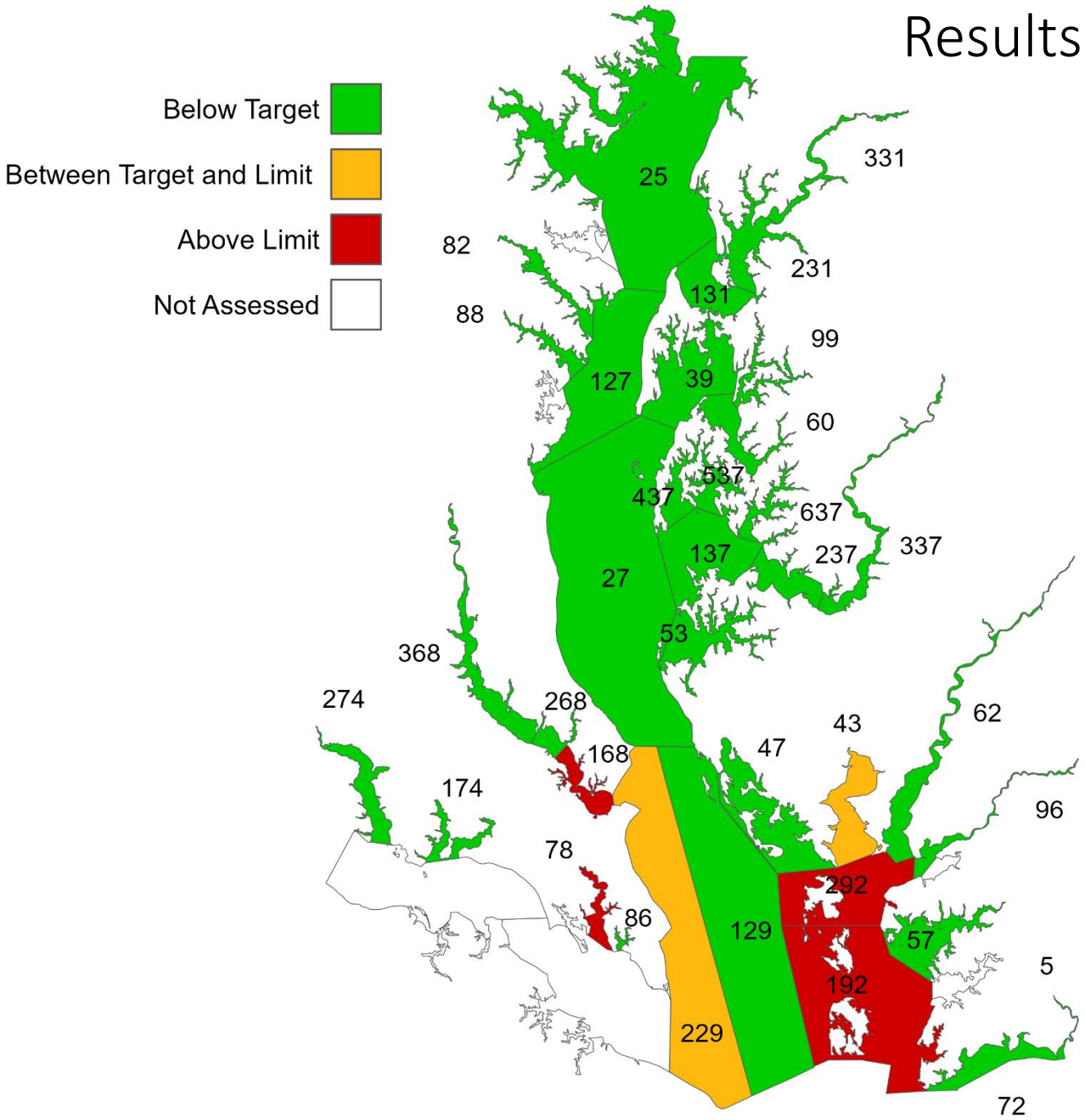
- Lower limit: 4.5 oysters per m^2 (restoration area limit)
- Cautionary level: 9 oysters per m^2 (twice the lower limit)
- **Long-term** target: 94 oysters per m^2 (1/2 the mean density after 6 years on reefs sampled by divers)
  - Long-term may mean **decades** in some areas

Stock Status Evaluation

Used average of last 3 years for comparison to reference points

Used adjusted exploitation rate for comparison to fishing mortality rate reference point. (Adjusted for plantings)

Results – Fishing Mortality Reference Points

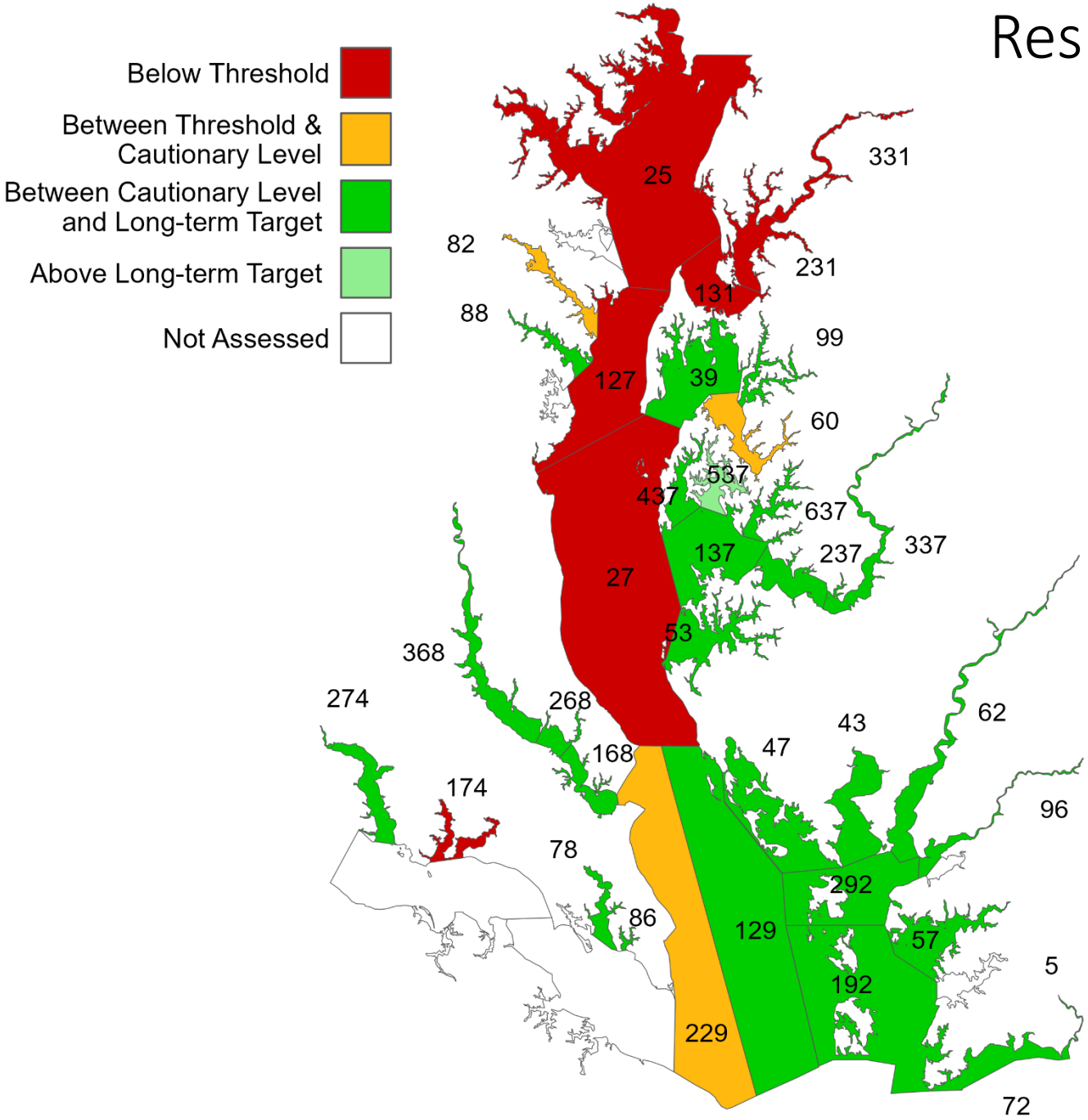


29 NOAA Codes below target

2 NOAA Codes between target and limit

4 NOAA Codes above limit

Results – Abundance Reference Points



One NOAA Code above long-term target

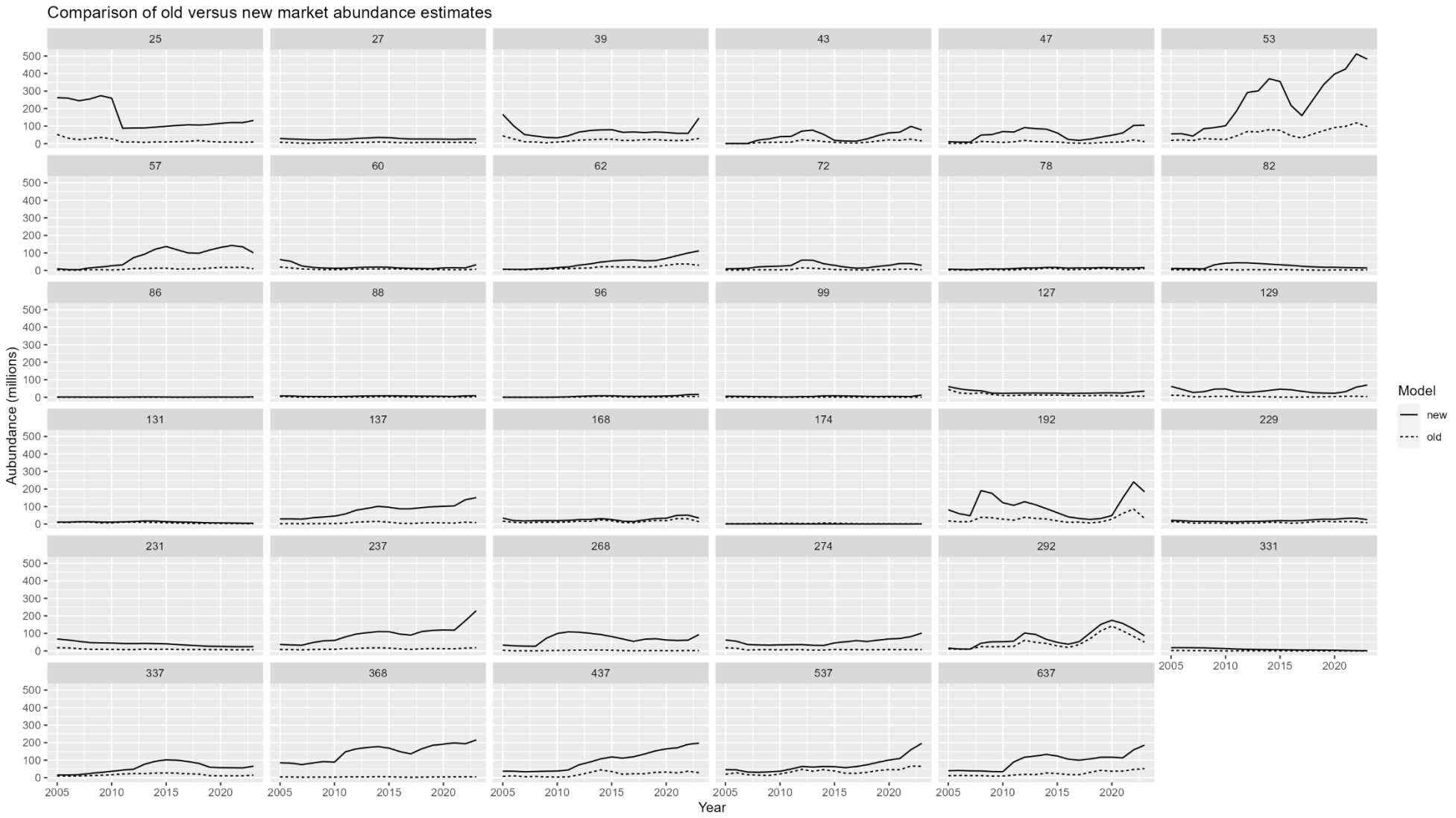
24 NOAA Codes between long-term target and cautionary level

3 NOAA Codes between cautionary level and lower limit

7 NOAA Codes below lower limit

Term of Reference #3

Compare estimates of stock status generated by the previous assessment model with the new model…



Abundance higher in new model compared to previous model

Abundance Reference Points Comparison

	Old Model (abundance)			New Model (density)			
NOAA Code	Limit	Target	2023	Limit	Cautionary level	Target	2023
25	7.0	-	9.9	4.5	9.0	94.2	2.3
27	2.4	-	4.3	4.5	9.0	94.2	1.0
39	4.4	-	29.8	4.5	9.0	94.2	9.1
43	0.3	-	15.4	4.5	9.0	94.2	38.7
47	2.1	-	11.7	4.5	9.0	94.2	30.3
53	1.1	-	97.6	4.5	9.0	94.2	66.9
57	1.4	-	10.1	4.5	9.0	94.2	58.8
60	4.6	-	7.3	4.5	9.0	94.2	7.3
62	2.1	-	29.9	4.5	9.0	94.2	67.0
72	2.0	-	4.0	4.5	9.0	94.2	16.4
78	0.3	-	10.6	4.5	9.0	94.2	46.1
82	2.1	-	3.5	4.5	9.0	94.2	7.8
86	0.1	-	0.9	4.5	9.0	94.2	32.1
88	1.0	-	2.6	4.5	9.0	94.2	18.3
96	0.3	-	3.3	4.5	9.0	94.2	34.4
99	0.3	-	1.2	4.5	9.0	94.2	12.2
127	9.1	-	6.3	4.5	9.0	94.2	3.8
129	1.2	-	3.6	4.5	9.0	94.2	25.5
131	5.5	-	2.3	4.5	9.0	94.2	1.2
137	0.6	-	8.3	4.5	9.0	94.2	15.0
168	3.2	-	13.8	4.5	9.0	94.2	28.8
174	1.3	-	1.1	4.5	9.0	94.2	0.4
192	9.7	-	33.0	4.5	9.0	94.2	22.7
229	2.5	-	7.2	4.5	9.0	94.2	5.3
231	7.5	-	6.6	4.5	9.0	94.2	2.4
237	1.9	-	18.4	4.5	9.0	94.2	26.8
268	0.3	-	2.0	4.5	9.0	94.2	44.1
274	4.5	-	7.6	4.5	9.0	94.2	26.1
292	9.6	-	50.6	4.5	9.0	94.2	24.6
331	0.6	-	0.1	4.5	9.0	94.2	0.7
337	8.7	-	15.1	4.5	9.0	94.2	19.2
368	2.4	-	5.3	4.5	9.0	94.2	22.7
437	2.9	-	28.9	4.5	9.0	94.2	64.6
537	6.5	-	65.2	4.5	9.0	94.2	205.2
637	6.4	-	52.2	4.5	9.0	94.2	62.4

No target in previous model

Most NOAA Codes similar status as previous model (above lower limit)

2 NOAA Codes went from above limit to below limit.

3 NOAA Codes now between lower limit and cautionary level (yellow).

Fishing Mortality Rate Reference Points Comparison

	Old Model			New Model		
NOAA Code	Limit	Target	2023	Limit	Target	2023
25	0.00	0.00	-0.35	0.13	0.09	0.00
27	0.10	0.05	-0.07	0.13	0.09	0.00
39	0.04	0.02	-0.16	0.13	0.09	0.00
43	0.50	0.25	0.48	0.13	0.09	0.12
47	0.36	0.18	0.49	0.13	0.09	0.09
53	0.04	0.02	-0.71	0.13	0.09	0.00
57	0.12	0.06	-0.08	0.13	0.09	0.00
60	0.00	0.00	-0.08	0.13	0.09	0.00
62	0.01	0.00	-0.02	0.13	0.09	0.02
72	0.25	0.12	0.26	0.13	0.09	0.04
78	0.35	0.17	0.42	0.13	0.09	0.19
82	0.00	0.00	-6.50	0.13	0.09	0.00
86	0.24	0.12	0.13	0.13	0.09	0.04
88	0.00	0.00	-0.73	0.13	0.09	0.00
96	0.10	0.05	0.02	0.13	0.09	0.02
99	0.00	0.00	0.00	0.13	0.09	0.00
127	0.00	0.00	-1.01	0.13	0.09	0.00
129	0.24	0.12	0.08	0.13	0.09	0.01
131	0.00	0.00	-0.99	0.13	0.09	0.00
137	0.29	0.14	0.45	0.13	0.09	0.02
168	0.17	0.09	0.29	0.13	0.09	0.20
174	0.00	0.00	-0.99	0.13	0.09	0.00
192	0.28	0.14	0.70	0.13	0.09	0.16
229	0.12	0.06	0.30	0.13	0.09	0.11
231	0.00	0.00	-1.66	0.13	0.09	0.00
237	0.00	0.00	-0.12	0.13	0.09	0.00
268	0.12	0.06	0.02	0.13	0.09	0.00
274	0.00	0.00	-1.23	0.13	0.09	0.00
292	0.00	0.00	0.24	0.13	0.09	0.25
331	0.00	0.00	0.00	0.13	0.09	0.00
337	0.00	0.00	-0.29	0.13	0.09	0.00
368	0.00	0.00	-0.07	0.13	0.09	0.00
437	0.01	0.01	0.02	0.13	0.09	0.00
537	0.19	0.10	0.24	0.13	0.09	0.08
637	0.00	0.00	-1.41	0.13	0.09	0.00

Most NOAA Codes similar status as previous model

5 NOAA Codes went from above limit to below target.

1 NOAA Code went from above limit to between limit and target.

1 NOAA Code went from between limit and target to below target.

Sensitivity analyses – Abundance

	Spat M 0.4	Spat M 0.6	One q per stage	Low N per Bushel	High N per Bushel	No Harvest Before FDS	SOS surv 0.05	Reporting Rate 100%	Reporting Rate 80%	1/2 Adult mean q	Habitat 90%	Habitat 80%	Habitat 70%	Habitat 60%	Habitat 50%	Habitat 37%	2X SD R devs	2X SD Adult q	2X Adult mean q	2X SD Initial Live	2X SD M variation	2X SD G	2X SD Initial Boxes	2X SD Box decay rate	No Full Dredge	30% Boxes Before FDS	10% Boxes Before FDS	Base Model
25	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	4.7	2.3	2.4	2.4	2.5	2.6	2.8	2.4	2.8	1.1	2.3	2.4	2.3	2.3	2.3	4.2	2.3	2.3	2.3
27	1	1	1	1	1	1	1	1	1	1.9	1	1	1	1	1	1	1	1	0.5	1	1	1	1	1	1.3	1	1	1
39	9.2	9	8	9	9.4	9.1	8.4	9.1	9.1	21.6	9.3	9.5	9.9	10.4	11.3	13.5	9.4	17.3	4.2	9	9.3	9	9.1	9.1	11.1	9.1	9.1	9.1
43	39.3	38.1	46.4	39.4	38.2	38.7	38.7	38.8	38.5	73.6	38.5	38.4	38.2	37.9	37.7	37.5	38.9	34.2	19.9	38.7	38.8	38.9	38.7	38.7	50.4	39.3	38.2	38.7
47	30.8	29.8	33.6	30.2	30.3	30.3	30.3	30.3	30.3	59.5	30.3	30.3	30.4	30.4	30.5	30.7	30.4	29.4	15.5	30.4	31	30.5	30.3	30.3	35.5	30.7	29.9	30.3
53	68.1	65.8	59.2	66.9	67	66.9	60.4	66.9	66.9	140.5	68	69.4	71.2	73.6	77	84.6	66.9	96.7	32.3	65.4	69.2	67	66.5	66.9	73.9	66.4	67.4	66.9
57	59.5	58.2	68.7	58.8	58.9	58.8	58.4	58.8	58.8	117	59.1	59.4	59.9	60.7	62	64.9	58.6	59.9	30	59.7	60.6	59.1	59.1	58.8	67.5	58.3	59.5	58.8
62	68.5	65.5	62.1	67.7	66.7	66.9	67	67.1	66.8	133.4	66.8	66.6	66.4	66.3	66.4	67.9	67.6	65.8	32.8	66.2	66.5	67	67.1	67	81.3	66.1	67.7	67
72	16.7	16.2	19.3	16.6	16.3	16.4	16.4	16.5	16.4	31.8	16.4	16.3	16.3	16.2	16	15.8	16.5	15.1	8.4	16.5	16.6	16.5	16.5	16.4	20.7	16.7	16.3	16.4
78	47.2	45	46.6	45.6	46.2	46	46.1	45.9	46.3	92.7	46.2	46.5	46.8	47.2	47.8	49.2	47.1	48.6	23.1	46.2	48.3	47.1	46.2	46.1	58.5	45.9	46.2	46.1
82	7.8	7.7	7.9	7.8	7.8	7.8	7.7	7.8	7.8	16.1	7.8	7.8	7.7	7.8	8.3	9.6	8.9	8.6	4.1	7.7	7.8	7.9	7.8	7.8	9.8	7.7	7.8	7.8
86	32.8	31.5	33.7	31.8	32.5	31.9	32.1	32	32.3	63.3	32.2	32.4	32.6	32.9	33.3	34.2	33.4	32.4	16.4	32.2	31	32.4	32.2	32.1	31.4	32.7	31.7	32.1
88	18.4	18.3	16.4	18.1	18.4	18.3	18.2	18.3	18.4	38.2	18.7	19.1	19.7	20.3	21.4	24.2	19.1	26.3	8.7	18.3	17.4	18	18.3	18.3	26.3	18.7	18	18.3
96	35.2	33.7	33.9	34.8	34.3	34.2	32.8	34.5	34.4	68.6	34.7	35.1	35.7	36.6	37.9	41.2	35	37.4	17.7	34.1	35.3	34.4	34.4	34.4	39	34.6	34.2	34.4
99	12.3	12.1	12.9	12.2	12.2	12.2	12.3	12.2	12.2	24.3	12.2	12.3	12.3	12.3	12.4	12.4	12.7	12	6.2	12.1	12.4	12.1	12.2	12.2	14.6	12.3	12.1	12.2
127	3.8	3.8	3.2	3.8	3.8	3.8	3.6	3.8	3.8	13	3.9	3.9	4	4.5	4.4	5.4	4.6	45.7	1.6	3.8	3.9	3.9	3.8	3.8	4.4	3.8	3.9	3.8
129	25.7	25.3	26.9	25.5	25.5	25.5	25.5	25.5	25.5	50.8	25.5	25.5	25.5	25.5	25.5	25.5	26.9	25.4	12.8	25.5	25.5	27	25.5	25.5	30.5	26.1	25	25.5
131	1.2	1.2	1.1	1.2	1.2	1.2	1.1	1.2	1.2	2.6	1.3	1.3	1.4	1.5	1.6	2.1	1.2	1.9	0.5	1.2	1.2	1.2	1.2	1.2	1.4	1.2	1.3	1.2
137	15.3	14.8	15.2	15.2	15	15	14.6	15.1	15	31.8	15.1	15.1	15.1	15.2	15.2	15.4	15.4	16.6	7.4	15	14.8	15.1	15	15	18.9	15.2	14.9	15
168	28.9	28.6	29.9	26.8	30.5	28.4	28.6	28.2	29.6	49.9	29.4	30.3	31.5	33.3	36.1	42.9	28.7	28.5	16.6	28.8	28.9	29.1	28.8	28.8	29.3	29	28.6	28.8
174	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.2	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4
192	23	22.4	25.6	22.5	22.7	22.6	22.7	22.6	22.7	44.2	22.7	22.8	22.9	23.1	23.4	24	22.8	22.1	11.8	22.7	22.9	22.8	22.7	22.7	25	23	22.4	22.7
229	5.3	5.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	10.9	5.3	5.3	5.4	5.5	5.6	6	5.3	6	2.6	5.2	5.4	5.3	5.3	5.3	6.2	5.3	5.3	5.3
231	2.4	2.3	2.3	2.4	2.4	2.4	2.2	2.4	2.4	4.9	2.4	2.5	2.5	2.6	2.8	3.2	2.4	2.9	1.2	2.4	2.5	2.4	2.4	2.4	4.3	2.4	2.4	2.4
237	27.1	26.4	25	26.6	27.1	26.7	25.4	26.7	26.8	61.9	26.9	27.2	27.4	27.7	28.2	29.1	27.4	39.1	12.7	26.6	26.7	26.7	26.8	26.8	27.5	26.8	26.7	26.8
268	44.6	43.6	47	43.9	44.4	44.1	44.1	44.1	44.2	88.2	44.1	44.2	44.3	44.3	44.4	44.7	48.8	44.4	22.1	43.9	43.4	43.8	44.1	44.1	55.8	45.6	42.8	44.1
274	26.5	25.7	26.4	26.2	26.1	26.1	25.7	26.1	26.1	55.1	26.2	26.4	26.5	26.8	27.2	27.9	28.3	29.9	12.6	26	27	26.4	26.2	26.1	19.6	26	26.2	26.1
292	24.9	24.3	25.6	23.9	25.2	24.5	24.6	24.4	25	46	24.9	25.4	26.1	27.2	29	33.4	24.6	24.5	13.9	24.7	25.1	24.8	24.8	24.6	29.2	24.9	24.4	24.6
331	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1.3	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.3	0.7	0.7	0.6	0.7	0.7	1	0.7	0.6	0.7
337	19.6	18.8	17.7	19.2	19.2	19.2	18.2	19.2	19.2	44	19.4	19.7	20.2	20.9	22.3	26.1	19.7	26.4	9.4	19.2	18.3	19.2	19.2	19.2	23.7	18.9	19.5	19.2
368	22.9	22.6	23.6	22.7	22.7	22.7	22.7	22.7	22.7	45.6	22.7	22.8	22.8	22.8	22.8	22.8	23.4	23	11.3	22.7	24.1	22.7	22.8	22.7	26.8	22.8	22.7	22.7
437	67	62.4	61.5	65	64.4	64.6	55.7	64.7	64.5	124.7	66.6	69.2	72.8	78.2	86.9	109.9	65.2	86.8	31.9	65.4	64.8	65.5	64.5	64.6	74.9	62.5	66.8	64.6
537	207.5	203	223.8	207	206	202.7	205.2	205.5	205.1	386.6	204.8	204.5	204.6	205.4	207.9	217.2	207.6	186.8	104.5	196.6	200.8	208.3	204.1	205.2	259.4	205.9	204.8	205.2
637	64	60.9	52.5	62.4	62.4	62.3	53.6	62.4	62.3	136.2	64.5	67.6	72.2	79.3	90.8	121.3	62.5	108.7	32.9	61.9	62.1	62.2	62.2	62.3	70.9	61.5	63.2	62.4

Sensitivity analyses – harvest rate

	Spat M 0.4	Spat M 0.6	One q per stage	Low N per Bushel	High N per Bushel	No Harvest Before FDS	SOS surv 0.05	Reporting Rate 100%	Reporting Rate 80%	1/2 Adult mean q	Habitat 90%	Habitat 80%	Habitat 70%	Habitat 60%	Habitat 50%	Habitat 37%	2X SD R devs	2X SD Adult q	2X Adult mean q	2X SD Initial Live	2X SD M variation	2X SD G	2X SD Initial Boxes	2X SD Box decay rate	No Full Dredge	30% Boxes Before FDS	10% Boxes Before FDS	Base Model
Reference Point	0.13	0.13	0.12	0.07	0.15	0.13	0.13	0.12	0.14	0.07	0.14	0.16	0.18	0.21	0.25	0.33	0.13	0.13	0.26	0.13	0.13	0.13	0.13	0.13	0.11	0.13	0.13	0.13
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0.004	0	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0.116	0.119	0.094	0.066	0.14	0.118	0.118	0.105	0.134	0.06	0.132	0.151	0.175	0.207	0.255	0.357	0.118	0.134	0.24	0.116	0.114	0.119	0.118	0.118	0.1	0.118	0.117	0.118
47	0.087	0.089	0.079	0.051	0.102	0.088	0.088	0.079	0.099	0.044	0.098	0.11	0.127	0.148	0.179	0.244	0.088	0.091	0.176	0.088	0.078	0.09	0.088	0.088	0.07	0.087	0.089	0.088
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0.001	0.001	0.001	0	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0.001	0.001
62	0.022	0.019	0.023	0	0.031	0.021	0.024	0.014	0.024	0.009	0.021	0.024	0.027	0.032	0.038	0.051	0.019	0.019	0.039	0.019	0.019	0.019	0.019	0.019	0.017	0.022	0.02	0.021
72	0.042	0.043	0.036	0.025	0.05	0.043	0.043	0.038	0.048	0.022	0.048	0.054	0.062	0.072	0.088	0.12	0.043	0.047	0.084	0.042	0.042	0.043	0.042	0.043	0.035	0.043	0.043	0.043
78	0.195	0.194	0.19	0.105	0.231	0.196	0.199	0.173	0.221	0.092	0.217	0.246	0.283	0.332	0.401	0.549	0.194	0.184	0.416	0.192	0.17	0.196	0.192	0.195	0.163	0.195	0.194	0.195
82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0.04	0.041	0.039	0.023	0.048	0.041	0.041	0.037	0.046	0.02	0.046	0.052	0.059	0.069	0.084	0.113	0.041	0.041	0.085	0.04	0.038	0.042	0.041	0.041	0.038	0.041	0.041	0.041
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	0.024	0.016	0.021	0.003	0.034	0.021	0.034	0.016	0.026	0.01	0.023	0.025	0.028	0.032	0.038	0.048	0.02	0.019	0.041	0.021	0.018	0.02	0.02	0.02	0.02	0.021	0.02	0.02
99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129	0.014	0.014	0.013	0.008	0.016	0.014	0.014	0.012	0.015	0.007	0.015	0.017	0.019	0.023	0.027	0.037	0.014	0.014	0.027	0.014	0.01	0.014	0.014	0.014	0.011	0.014	0.014	0.014
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
137	0.021	0.021	0.021	0.011	0.025	0.021	0.022	0.019	0.024	0.01	0.024	0.027	0.031	0.036	0.043	0.06	0.021	0.019	0.045	0.021	0.022	0.021	0.021	0.021	0.017	0.021	0.021	0.021
168	0.2	0.2	0.19	0.114	0.231	0.204	0.205	0.181	0.222	0.115	0.218	0.238	0.262	0.29	0.321	0.365	0.201	0.202	0.35	0.2	0.194	0.2	0.199	0.2	0.188	0.197	0.202	0.2
174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
192	0.154	0.157	0.144	0.091	0.18	0.156	0.156	0.14	0.175	0.079	0.173	0.194	0.221	0.257	0.306	0.406	0.156	0.159	0.304	0.154	0.149	0.157	0.156	0.156	0.125	0.154	0.158	0.156
229	0.107	0.107	0.109	0.035	0.134	0.107	0.108	0.094	0.123	0.05	0.119	0.134	0.153	0.177	0.21	0.274	0.106	0.093	0.228	0.108	0.1	0.107	0.107	0.107	0.09	0.108	0.106	0.107
231	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
268	0.002	0.002	0.002	0	0.003	0.002	0.002	0.001	0.003	0.001	0.002	0.002	0.003	0.003	0.004	0.005	0.002	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
292	0.245	0.246	0.235	0.142	0.281	0.248	0.246	0.221	0.276	0.125	0.273	0.305	0.345	0.394	0.455	0.558	0.245	0.247	0.481	0.244	0.23	0.246	0.245	0.246	0.207	0.243	0.248	0.246
331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
337	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
437	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
537	0.079	0.08	0.074	0.045	0.093	0.082	0.08	0.072	0.09	0.044	0.088	0.099	0.112	0.129	0.153	0.197	0.079	0.087	0.152	0.082	0.079	0.08	0.08	0.08	0.064	0.08	0.08	0.08
637	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Term of Reference #4

Provide research recommendations for improving the stock assessment.

Research Recommendations

(Not arranged in order of priority)

- Conduct fishery-dependent sampling of oyster size distribution to better quantify the number of oysters per bushel and the number of under-sized oysters per bushel among NOAA codes.

- Incorporate a shell budget into stage structured assessment to allow internal estimation of biological reference points.

- Examine updated habitat estimates as they become available from the recent Bay Bottom Survey for inclusion in the assessment model.

- Conduct research to better quantify growth rates that can be incorporated into stock assessment models.

Research Recommendations

(Not arranged in order of priority)

- Measure shell volume (separate from volume of live oysters) in Fall Dredge survey samples to potentially help with modeling changes in habitat volume over time.

- Examine potential for survey samples taken after fishing season to inform estimates of fishing mortality in the assessment model.

- Revisit spatial aspects of the Fall Dredge Survey to determine the area that is represented by samples, especially with respect to the new habitat data from the Bay Bottom Survey that is currently being conducted. Consider including a subset of random sites in the Fall Dredge Survey.

- Conduct experiments to estimate catchability of the Fall Dredge Survey.

Questions?