



**NOAA
FISHERIES**

Atlantic Menhaden: Updated Natural Mortality Estimate

Tuesday, August 12, 2025

Outline

- Background on tagging study
- Tagging data for use as model inputs
 - Differences observed
 - SAS decisions
- Tagging model results
- How estimated M values were used in single species assessment

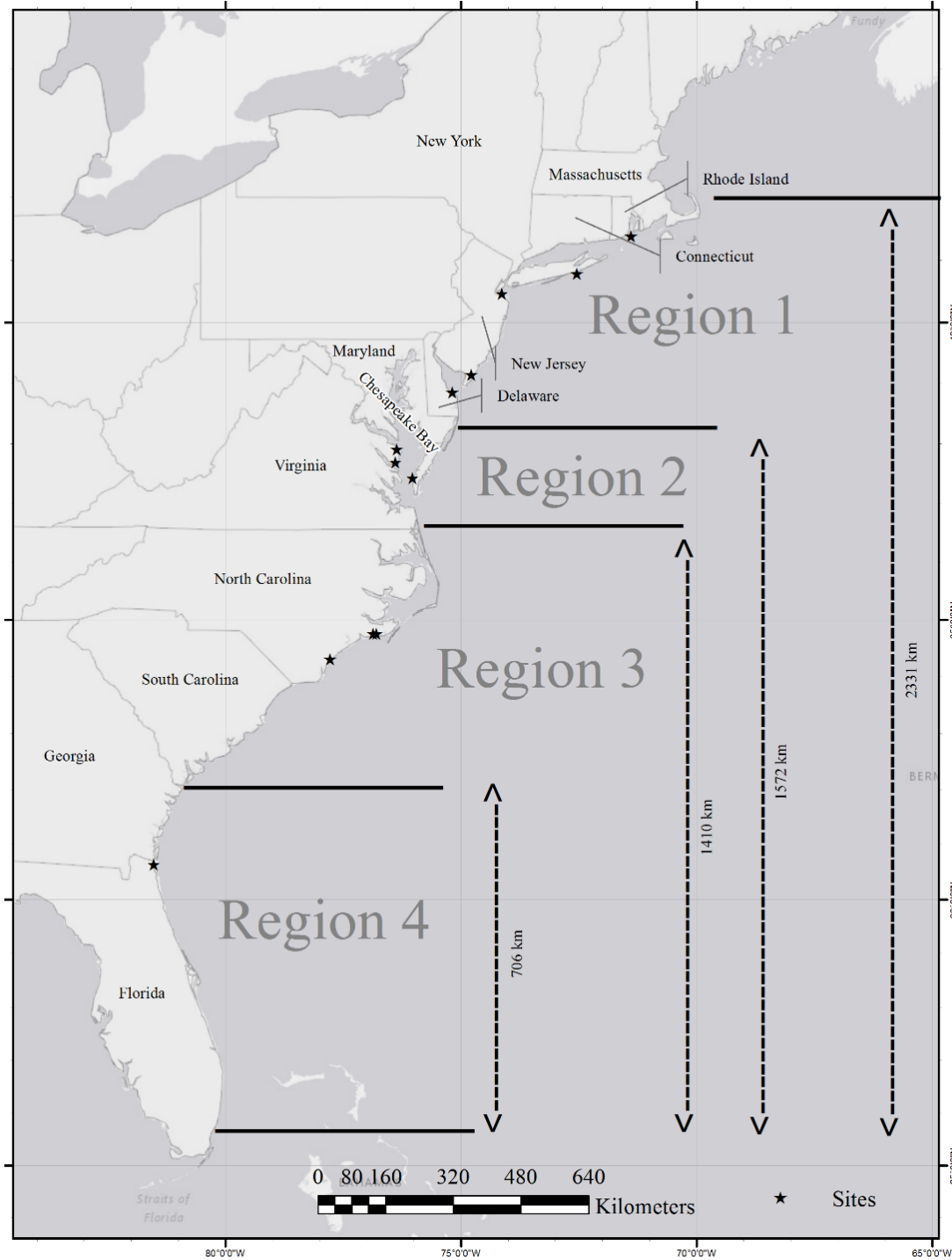
Background

- M in the single-species model is based on a large-scale tagging study that occurred in the late 1960s
 - Ault et al. (2023) reanalysis of the tagging data resulted in a lower estimate of M than the Liljestrand et al. (2019) estimate used in last assessment
- SAS formed a Work Group to review the data and analyses and consult with the authors to understand what was causing the differences and what is the best estimate of M for use in the single-species model

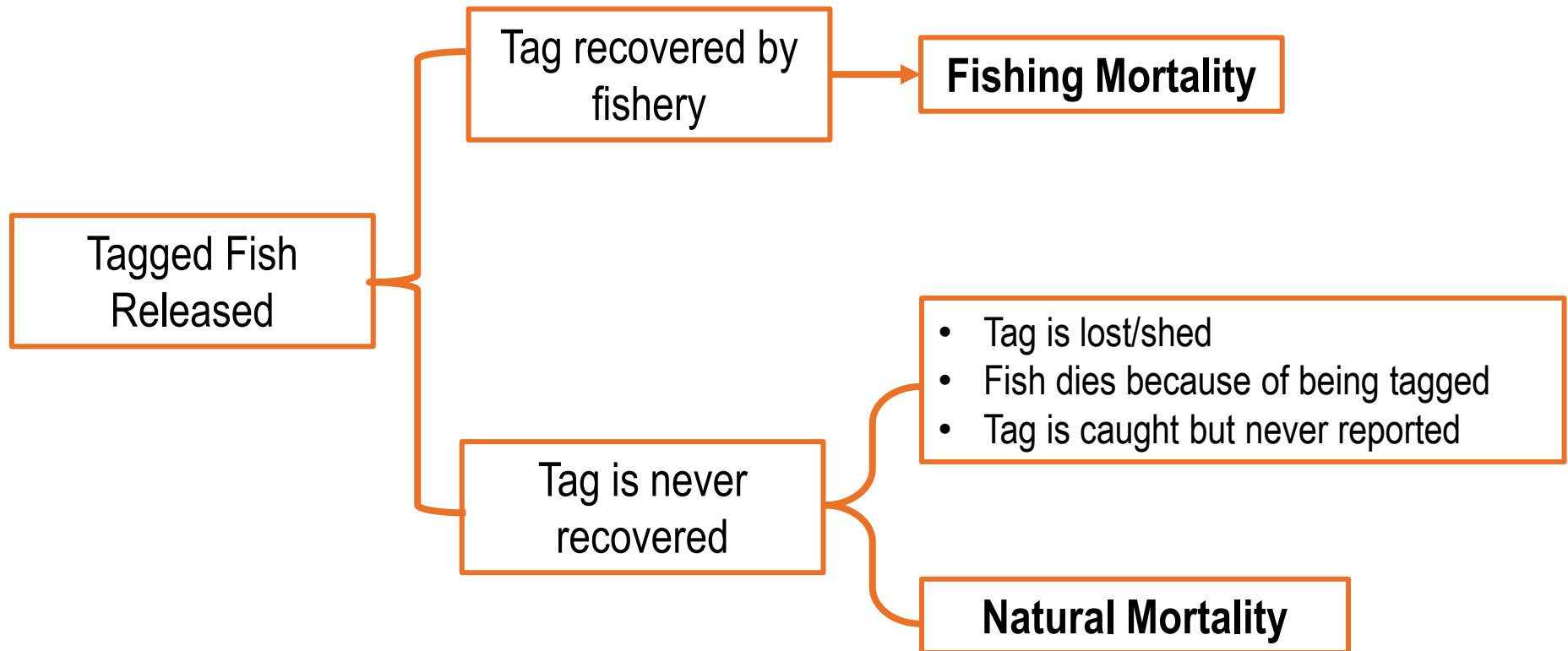
Menhaden Tagging Study

- From 1966-1969, the SEFSC tagged over 1 million menhaden with uniquely identifiable ferromagnetic tags and released them along the Atlantic coast
- The tags were recovered from magnets installed at reduction plants: the fish scrap would pass by magnets and the metal tags would stick to the magnets
- Researchers would clean the magnets regularly to collect the tags





Menhaden Tagging Study



Menhaden Tagging Study

- The SEFSC conducted studies to understand:
 - Tag shedding rates
 - Tag mortality rates
 - Magnet efficiency rates
- Magnet efficiency rate = reporting rate
 - If a tagged fish is caught, how likely is it that the tag will be recovered by a magnet
 - Seeded >96,000 tagged fish into the catch at active plants and counted how many were recovered on the magnets and how long it took

- Tag is lost/shed
- Fish dies because of being tagged
- Tag is caught but never reported

Differences in Data

Liljestrand et al. (2019)

- Coston dataset: tag-recapture information summarized to the month-region level
- 1966-1969
- 1,066,357 tag releases from 1966-1969
- Does not include recoveries after 1969

Ault et al. (2023)

- NMFS re-digitized data set: individual records of tag returns re-entered from original hard copies
- 1966 –1971
- 768,977 releases from 1966-1969
- Missing ~28% of the releases in Coston dataset

Table 1. Spatial breakdown of tag release data from Coston and the re-digitized NMFS records.

	Area 1 MA-NY	Area 2 NJ-DE	Area 3 MD-VA	Area 4 NC-SC	Area 5 GA-FL
Coston: number of months with Release Data 1966-69	8	12	23	36	23
Re-digitized NMFS: number of months with Release Data 1966-69	4	1	22	20	19
Coston: Releases 1966-69	12,931	36,149	308,305	386,171	322,801
Re-digitized NMFS: Releases 1966-69	8,268	700	283,155	199,631	274,417
Re-digitized NMFS: Percent of Coston Releases 1966-69 (by area)	64%	2%	92%	52%	85%
Re-digitized NMFS: Percent of Coston Releases 1966-69	72%				
Coston: number of months with Release Data 1970	0	0	0	0	0
Re-digitized NMFS: number of months with Release Data 1970	0	0	2	2	0
Coston: Releases 1970					
Re-digitized NMFS: Releases 1970			35,789	585	

Differences in Data

Liljestrand et al. (2019)

- Confidential fishing effort & landings data by plant, month, and year

Ault et al. (2023)

- Did not receive permission to access confidential data
- Reconstructed effort by region, month, and year from available non-confidential data

Differences in Methods

Liljestrand et al. (2019)

- Magnet efficiency rates calculated from re-digitized plant test data for each plant
- Efficiency by region, month, & year calculated by taking the average plant efficiency for plants within a region, weighted by the landings of each plant in that region in that month & year

Ault et al. (2023)

- Calculated a regional plant efficiency weighted by the sample size of the plant test data
- Modified those efficiency estimates using a “stepwise” approach to improve the fit of the observed recoveries to the predicted recoveries in the model



Table 2. Batches of tags released in plant-test study by model region, plant, and year. Batches were generally comprised of 100 fish.

Model Region	Plant	1966	1967	1968	1969	1970	1971	TOTAL
1	01			15	14			29
	02		18	24	18	2	7	69
	04		7	5	13			25
	23*						2	2
	25*						4	4
2	07		33	34	23	6	24	120
	09		21					21
	10		35	37	25	25	29	151
	11		30	3		19		52
	29		5	12	1			18
3	12	8	7	1	5	7	3	31
	13	11	17	9	12	10	16	75
	14	5	6	1	7	8	4	31
	15	5	5	2	4			16
	16	5	5	1	7	3	1	22
	17	5	3	7	18	13	18	64
	28	8		11	13	2	15	49
4	19	3	21	28				52
	20	10	15	23	49	18	18	133

*: Plants 23 and 25 were not active from 1966-1969.

SAS Decisions

- Use the Coston dataset
 - More comprehensive spatial coverage (important for movement rates to support spatial models in future)
 - Minimal differences in M estimates between Coston dataset and full time-series of NMFS re-digitized dataset



SAS Decisions

- Use confidential effort and landings data
 - More accurate and rely less on assumptions than the recreated non-confidential time-series

SAS Decisions

- Use empirical estimates of magnet efficiency from the plant test data, but correct the mistake in Liljestrang et al. (2019)
- Liljestrang et al. (2019) used the recoveries on all magnets for each plant to calculate the efficiency rate, but the Coston dataset only included “primary” magnets



SAS Decisions

- Primary vs. Secondary magnets:
 - Primary: recovered tags as the fish scrap was transferred from the reduction plant to the scrap shed
 - Secondary: recovered tags when the scrap was transferred to trucks for transport to buyers
- SAS determined that magnets 1 & 2 were primary magnets and all other magnets were secondary

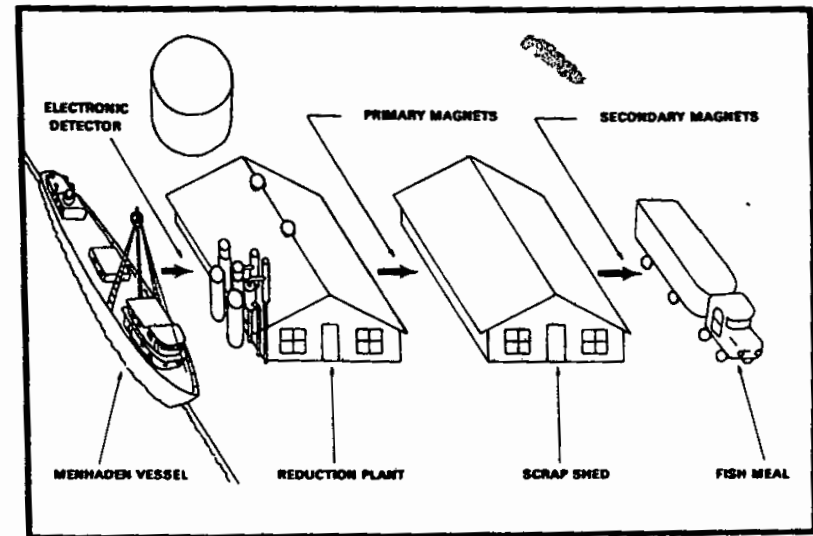
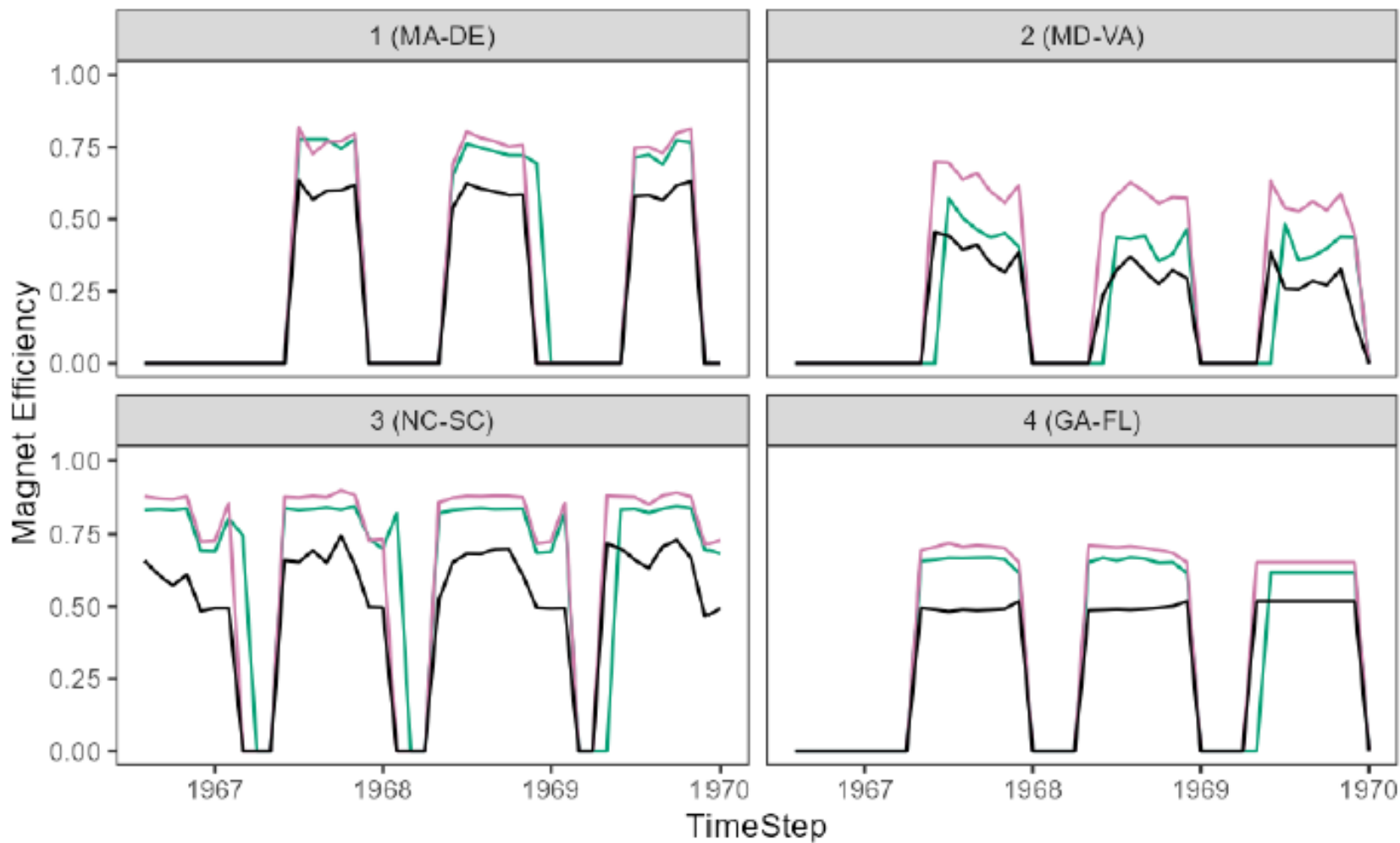


Figure 2.—Tag recovery locations in a typical menhaden reduction plant.

SAS Decisions

- Liljestrand et al. (2019) included both primary and secondary magnets in the efficiency calculations, but Coston only reported recoveries on primary magnets
 - Liljestrand et al. (2019) overestimate the magnet efficiency for the Coston dataset
 - SAS recalculated the magnet efficiencies using only data from magnets 1 & 2 for use with the Coston dataset

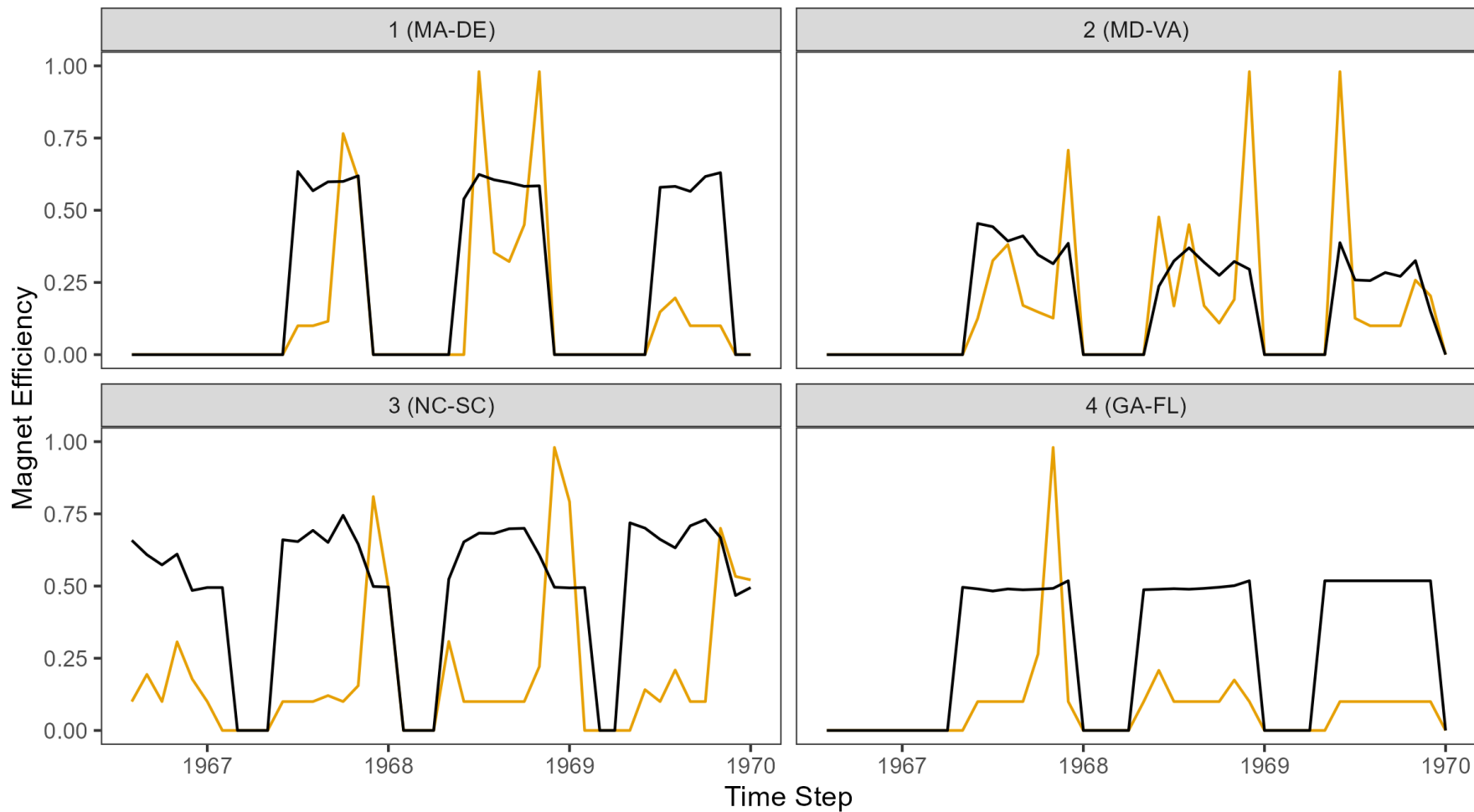


Method — Liljestrand et al. (2019) — M WG (All magnets) — M WG (Magnets 1 & 2)

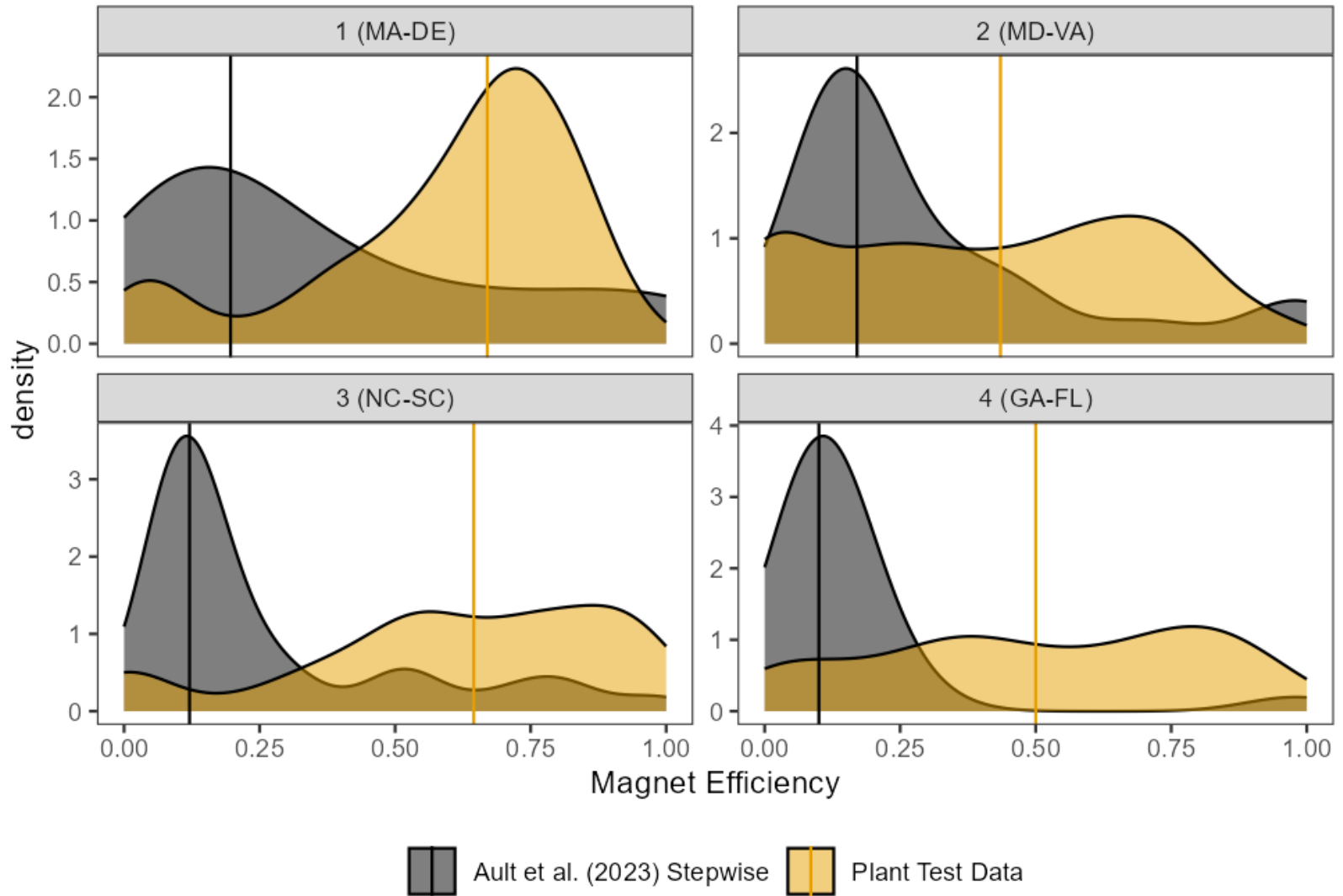
SAS Decisions

- SAS could not come to consensus with Ault et al. on the use of the “stepwise” method to adjust the magnet efficiencies within the tagging model
- Ault et al. improved the likelihood and the fit to the observed recaptures with this approach, but at the expense of the empirical plant efficiency data
- Ault et al. final stepwise magnet efficiencies were much lower than the rates observed in the actual plant test data





Method — Ault et al. (2023) Stepwise — M WG (Magnets 1 & 2)

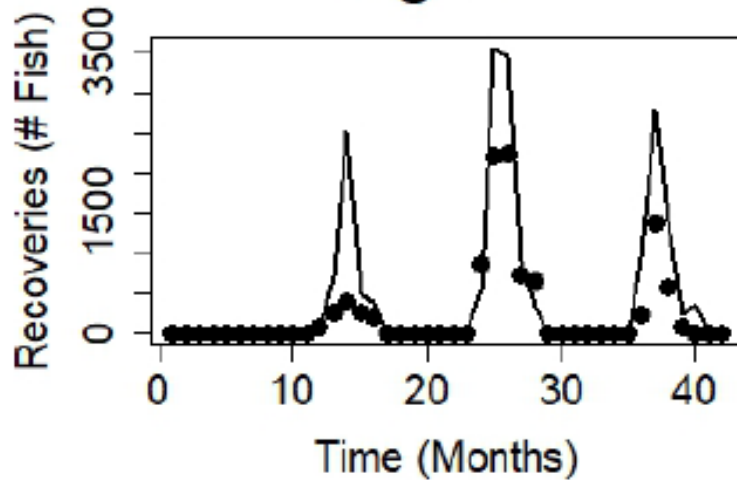


SAS Decisions

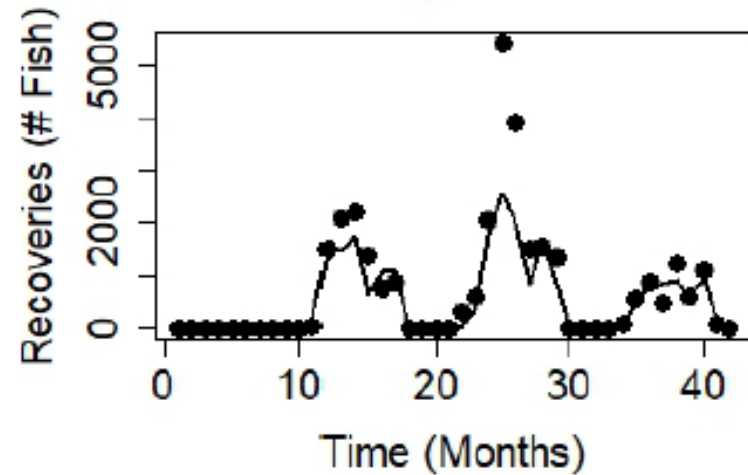
- SAS used the empirical estimates of magnet efficiency as the base run of the tagging model and the stepwise approach as a sensitivity run
 - Used the Coston dataset for both
 - Used the confidential effort for both

Tagging Model Results – Base run

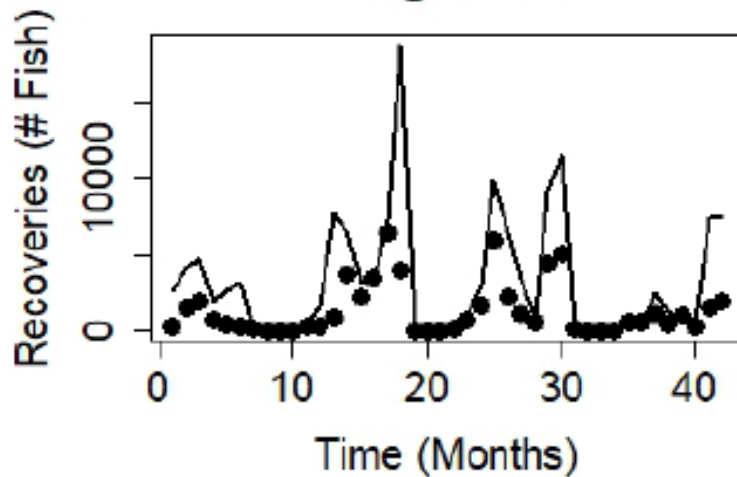
Region 1



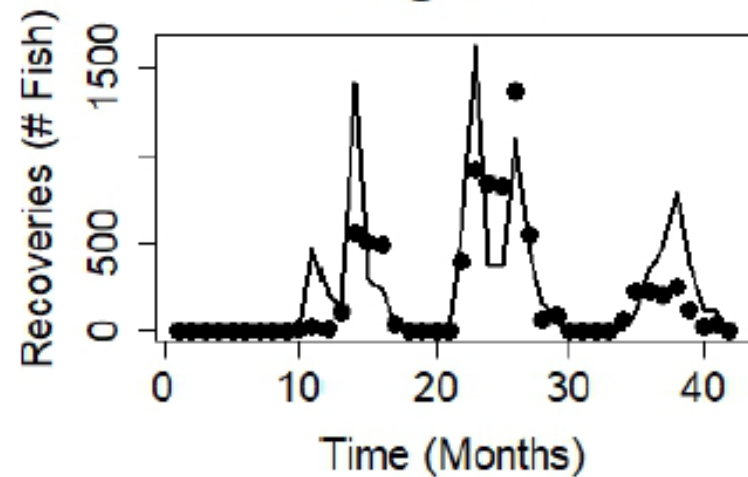
Region 2



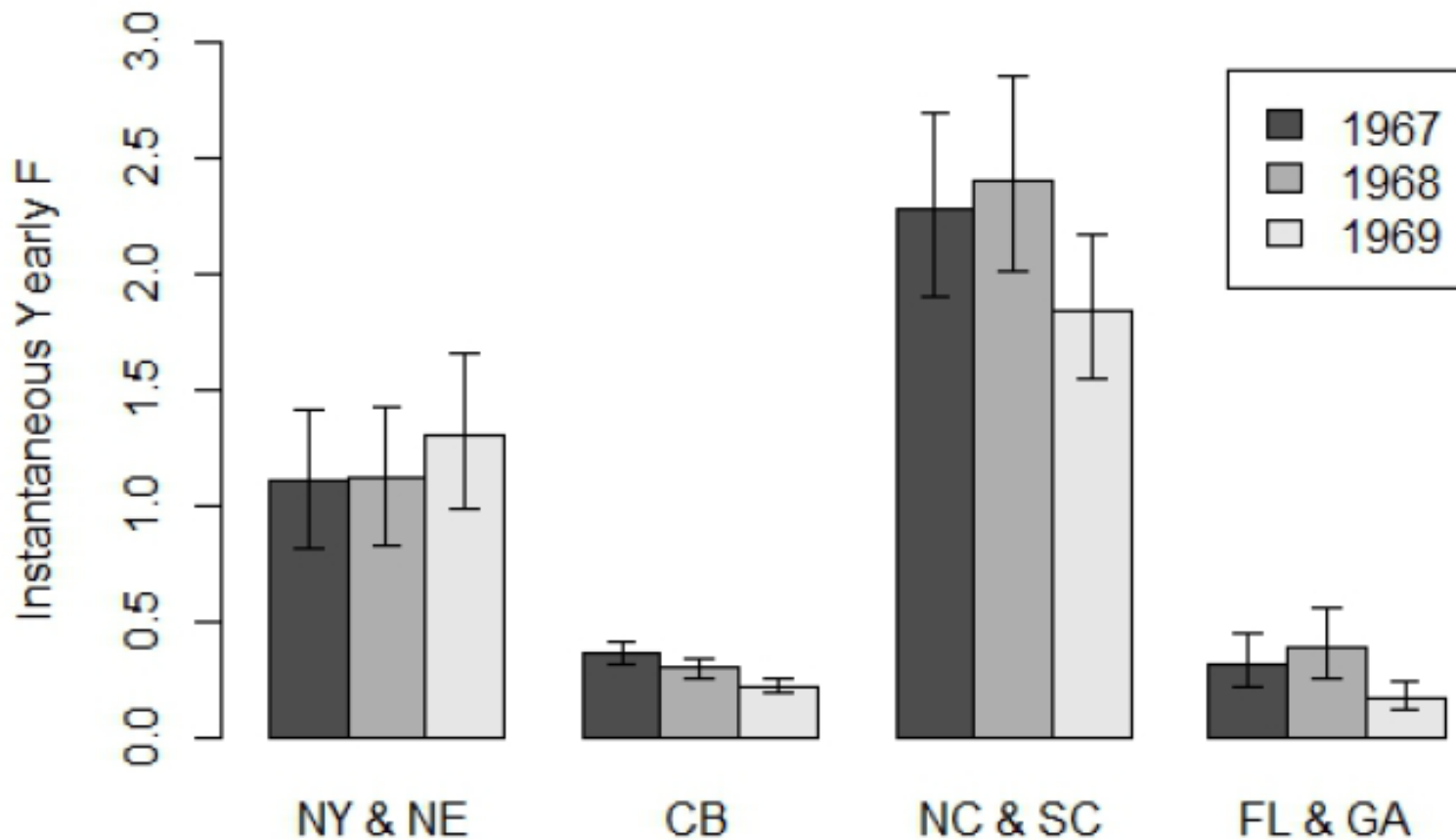
Region 3



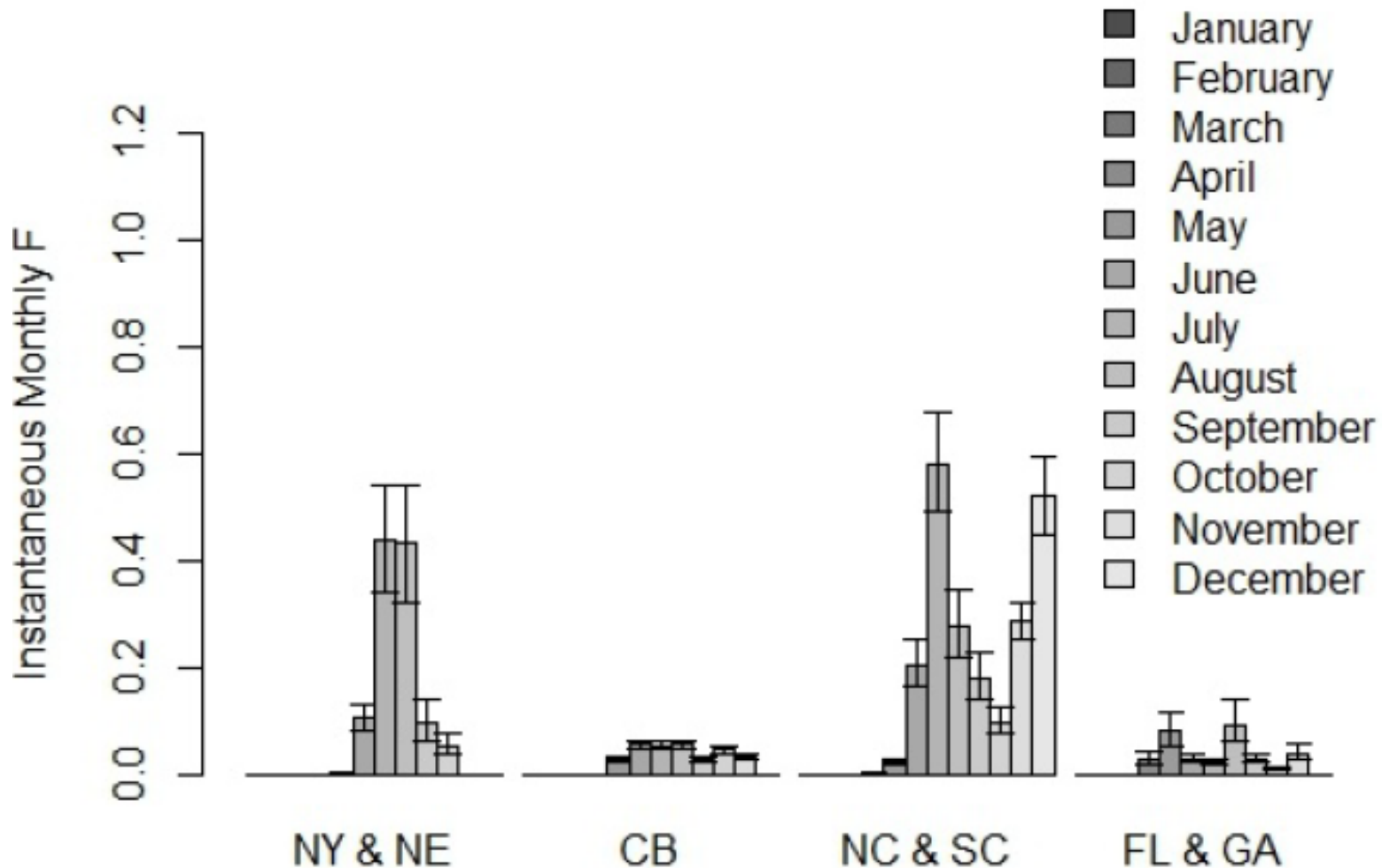
Region 4



Tagging Model Results – Base run



Tagging Model Results – Base run



Tagging Model Results – Base run

May ->
June



June ->
July



July ->
August



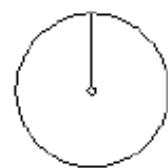
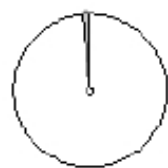
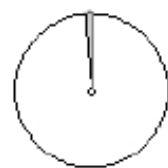
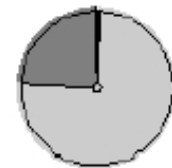
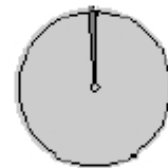
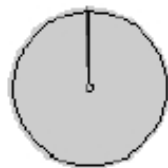
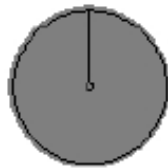
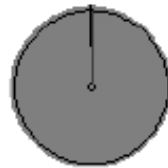
August ->
September



September ->
October



October ->
May



Tagging Model Results

- Liljestrang et al. (2019): $M=1.17$
- M WG revised base run: $M=0.92$
- Sensitivity run: $M=0.47$

Input to BAM

- Revised tagging model M is ~20% lower than Liljestrands et al. (2019)
- Based on the sizes of the tagged fish, most fish in the study were ~1.5 years old, so the SAS developed an age-varying estimate of M to use in the BAM by scaling the Lorenzen curve so that M at age-1.5 was equal to the tagging model M

Input to BAM

