A Bioeconomic Model of the Recreational Gulf of Maine Cod and Haddock Fishery

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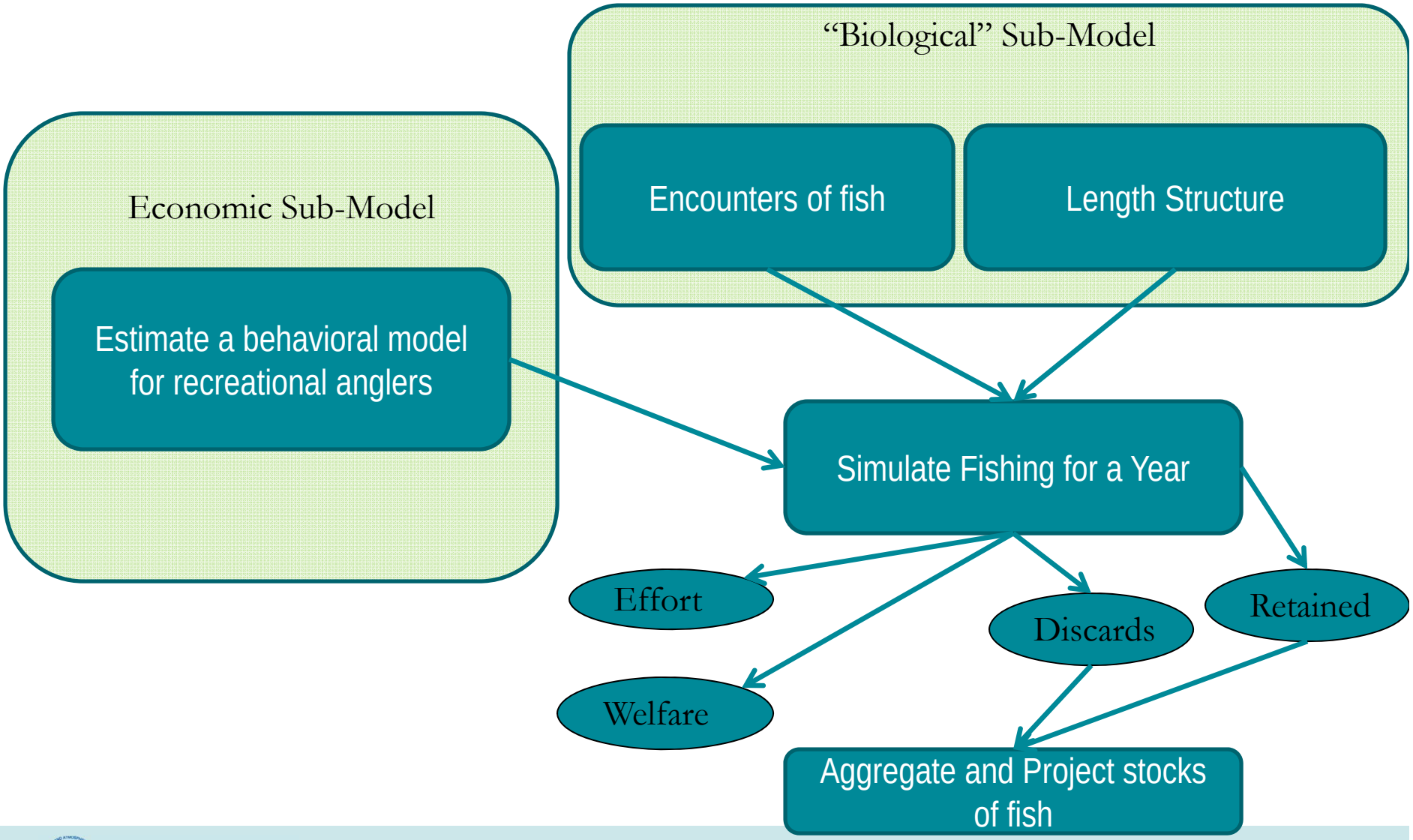
Research/Policy Questions

- How do changes in management measures affect recreational anglers who are targeting cod and haddock in the Gulf of Maine?
  - Size limits
  - Possession limits
- What combination of management measures can achieve conservation objectives?
- How do these changes affect stock sizes?

Outline

- Economic sub-model
  - Behavioral model of anglers
  - 2009 choice experiment survey
- “Biological” sub-model
- Some preliminary results
- Future research

Model Overview



Economic Sub Model

Groundfish Choice Experiment Survey

- Add-on to NMFS' MRFSS Survey in 2009 (ME-NJ)
- Voluntary mail follow-up
- Dillman surveying approach

Groundfish Choice Experiment Survey

Five Components

- Description of study
- A species information page
- Screener questions – familiarity and avidity
- CE questions
- Demographic questions

8x per survey

Vary these attributes

SECTION B: SALTWATER FISHING TRIPS

Please compare Trip A, Trip B, and Trip C in the table below, then answer questions **1** and **2**.
Compare only the trips on this page. Do not compare these trips to trips on other pages in this survey.
Assume that the trips below are identical in every way except for the features listed in the table.
All regulations remain as they are today unless otherwise noted in the table below.

	TRIP FEATURES	TRIP A	TRIP B	TRIP C
REGULATIONS	**DAILY BAG (TAKE) LIMIT** Number of fish you can legally keep per day.	4 Pollock	10 Cod	Do something other than saltwater fishing.
REGULATIONS	**MINIMUM SIZE LIMIT** Smallest fish you can legally keep of this species.	23 inch Pollock	22 inch Cod	
CATCH	**NUMBER OF LEGAL-SIZE FISH YOU CATCH** These fish are at least legal minimum size. Some fish are released if you catch more than the daily bag limit.	10 Pollock	1 Cod	
CATCH	**NUMBER OF UNDERSIZED FISH YOU CATCH** These fish are below the legal minimum size. All of these fish must be released.	1 Pollock	3 Cod	
CATCH	**NUMBER OF OTHER FISH YOU KEEP** Other fish you catch on this trip that can be legally kept.	3 Cod 6 Haddock	1 Haddock 3 Pollock	
TRIP DETAILS	**TRIP LENGTH** Total time purchased for this trip.	8 Hours	12 Hours	
TRIP DETAILS	**TOTAL TRIP COST** YOUR share of the fishing trip cost, including bait, ice, fishing equipment, daily license fees, boat rental fees, boat fuel, and round trip transportation costs associated with traveling to and from the fishing location. Travel costs may include vehicle fuel, car rental, tolls, airfare, and parking. This cost does not include the price of food or drink.	$312	$276	

1 I like this trip best:
(Please mark the **ONE** option **YOU** like best with a ☑ or ☒)

TRIP A ☐ TRIP B ☐ TRIP C ☐

2 Please rate the trips listed in the table above. (Circle the number that reflects your opinion best.)

TRIP A	*DISLIKE*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	*LIKE*
TRIP B	*DISLIKE*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	*LIKE*
TRIP C	*DISLIKE*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	*LIKE*

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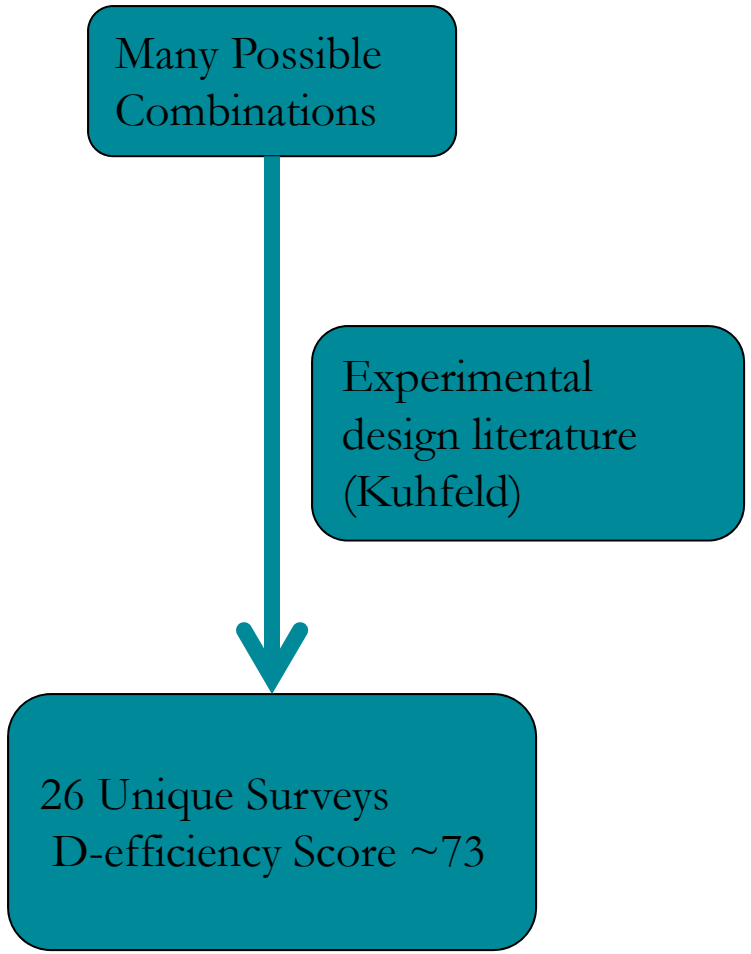
Economic Sub-Model

Attributes and Levels in CE

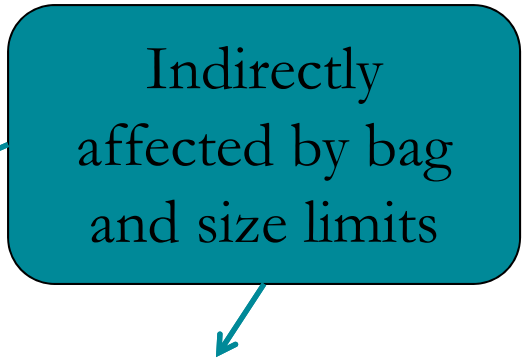
Attribute	Level
Bag limits	2, 4, 8, 10
Size limits:	
Cod	18”, 20”, 22”, 23”, 24”, 26
Haddock	12”, 16”, 17”, 19”, 21”, 22”
Pollock	17”, 19”, 20”, 21”, 23”, 26”
Number of legal sized fish	1, 3, 6, 10
Number of undersized fish	1, 3, 6
Number of other fish	1, 3, 6, 10
Trip length (hours)	2, 4, 6, 8, 10, 12
Shore mode trip cost ($/trip)	$15, $35, $60, $90, $120, $150
All other modes trip cost:	
Hourly trip cost ($/hr.)	$15, $35, $60, $90
Total trip cost ($/trip=$/hr. x # hrs.)	$30-$1080



Response Rates by State and Residency

Intercept State	Mailed	Resident Completed	Non-resident Completed	Total Completed	Completion Rate
Maine	265	67	58	**125**	47%
Massachusetts	1238	272	168	**440**	36%
New Hampshire	536	124	66	**190**	35%
New Jersey	1421	310	124	434	31%
New York	725	157	7	164	23%
Connecticut	34	10	3	13	38%
Rhode Island	358	48	77	125	35%
Total	***4,577***	***988***	***503***	***1,491***	***33%***

Behavioral Model



$$U_{jn} = \beta_1 \sqrt{E[codkept]_{jn}} + \beta_2 \sqrt{E[codreleased]_{jn}} +$$

$$\beta_3 \sqrt{E[haddockkept]_{jn}} + \beta_4 \sqrt{E[haddockreleased]_{jn}} +$$

$$\beta_5[(tr.leng.)_{jn} xfor-hire_n) + \beta_6[(tr.leng.)_{jn} xfor-hire_n]^2$$

$$+ \beta_7 (opt-out)_{jn} + \beta_8 (trip\,cost)_{jn} + \varepsilon_{jn}$$

Behavioral Model Parameters

Parameter	Estimate	Standard Error	t value	Pr > |t|
$\sqrt{cod\ kept}$	0.3243	0.0342	9.48	<0.0001
$\sqrt{cod\ released}$	0.0943	0.0232	4.06	<0.0001
$\sqrt{haddock\ kept}$	0.3195	0.0317	10.08	<0.0001
$\sqrt{haddock\ released}$	0.1063	0.0274	3.88	0.0001
Trip length x For-hire	0.0743	0.0288	2.58	0.0100
(Trip length)^2 x For-hire	-0.003240	0.002035	-1.59	0.1114
Trip cost	-0.005392	0.000209	-25.84	<0.0001
Opt-out	-0.2742	0.1336	-2.05	0.0401
Likelihood Ratio	1,750.1			
No. Obs.	4,308			
No. Cases	14,233			

$$mwtp_{\#codkept} = \frac{\beta_1\left(\frac{1}{2}(\#cod\ kept)^{-\frac{1}{2}}\right)}{\beta_8}$$

Behavioral Model Summary

- Model estimates how changes in expectations (mainly the number of fish kept and released) affects the value of a fishing trip

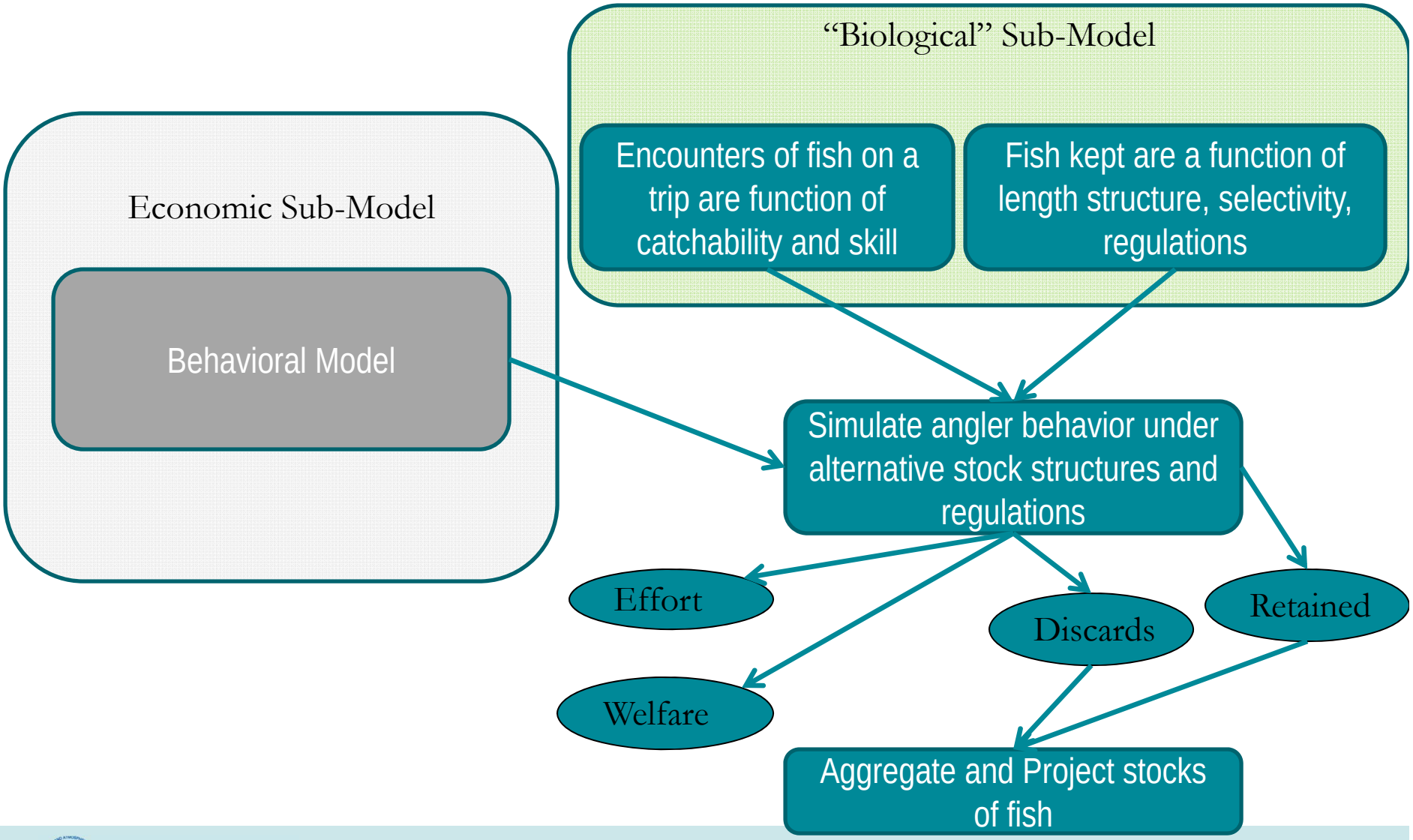
But what changes expectations about kept and released fish?

Regulations, stock composition, other factors

Behavioral Model Limitations

- No explicit link between changes in regulations and expected catch in behavioral model
- No consideration of biological stock structures
- Results are not explicitly linked to changes in numbers of trips per season (i.e., effort shifts)

Model Overview



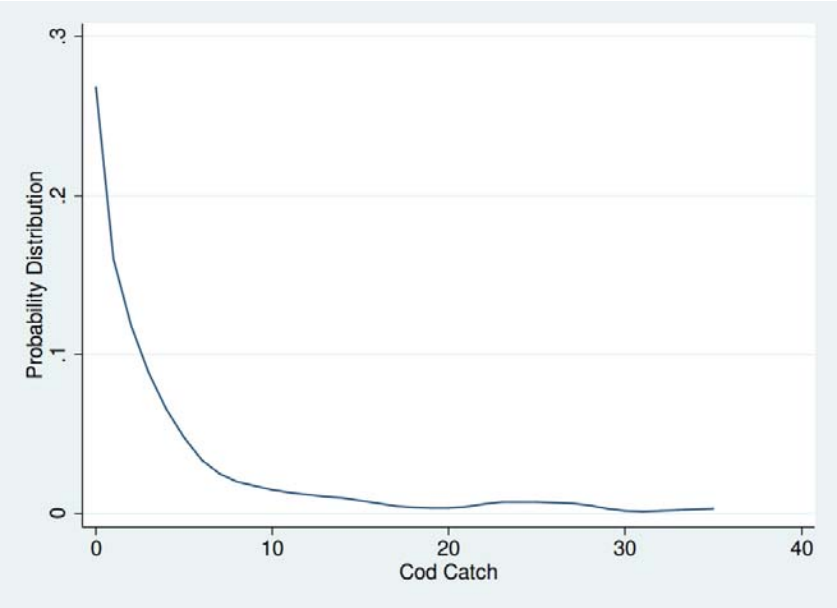
Bioeconomic Model

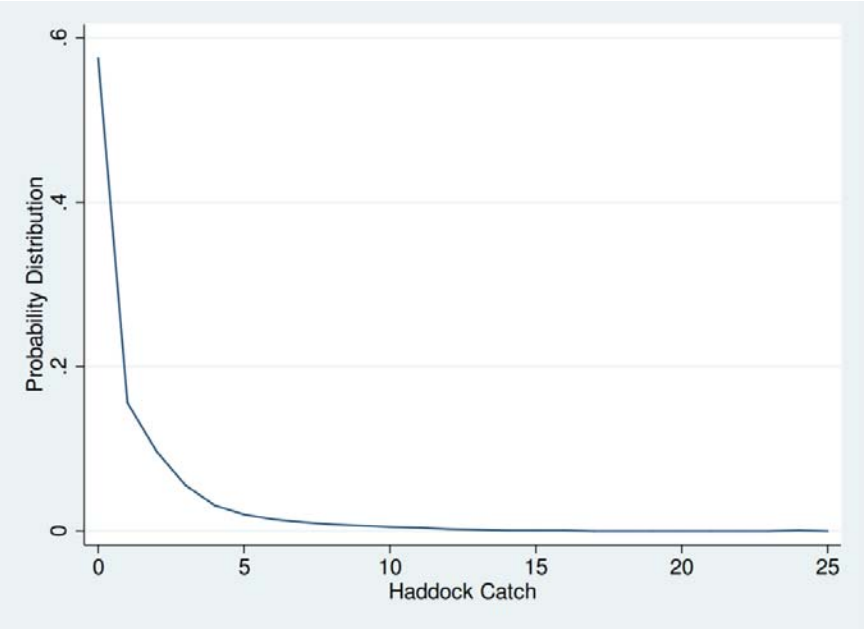
- Simulate a year of fishing effort at the trip level using:
  - The estimated behavioral parameters
  - Historical encounter (catch) rates
  - Stock structures
  - Length-based targeting of fish

Encounters of Fish

- Encounters of fish on a trip are a product of many angler and trip attributes which are not observed.
  - Individual attributes: Skill and familiarity
  - Trip attributes: Mode, location, weather, time spent, time of year, bait, gear
  - Luck
  - Availability of fish

Encounters of Cod and Haddock





- The distribution of Encounters-per-trip derived from MRFSS (2007-2009)
- Encounters=Kept+ Discard
- Lots of zeros
  - Approx 25% of trips do not encounter a cod
  - Nearly 60% of trips do not encounter a haddock

Catch-at-Length

- What is the length-distribution for fish which are caught by recreational anglers?

Pair with bag, size limits to determine how many fish are kept and released.

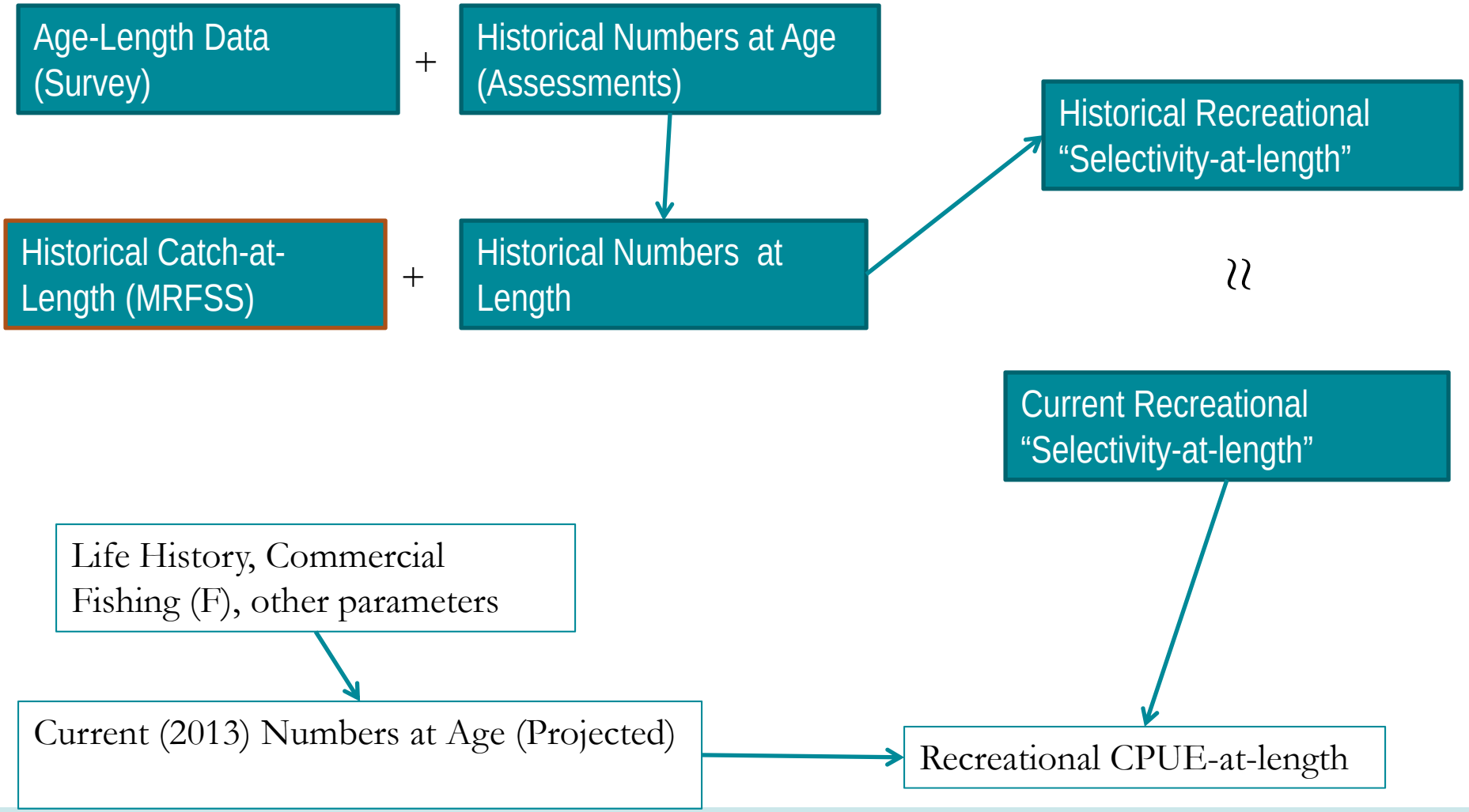
- Not the same as:
  - Length distribution of stock

Doesn't account for targeting behavior

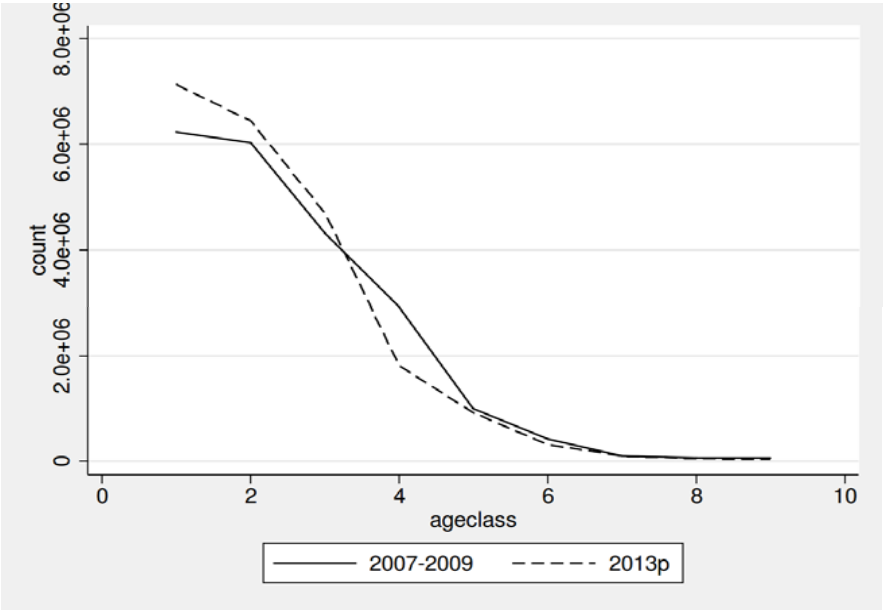
  - Length distribution of historical catch

Doesn't account for changing stock conditions

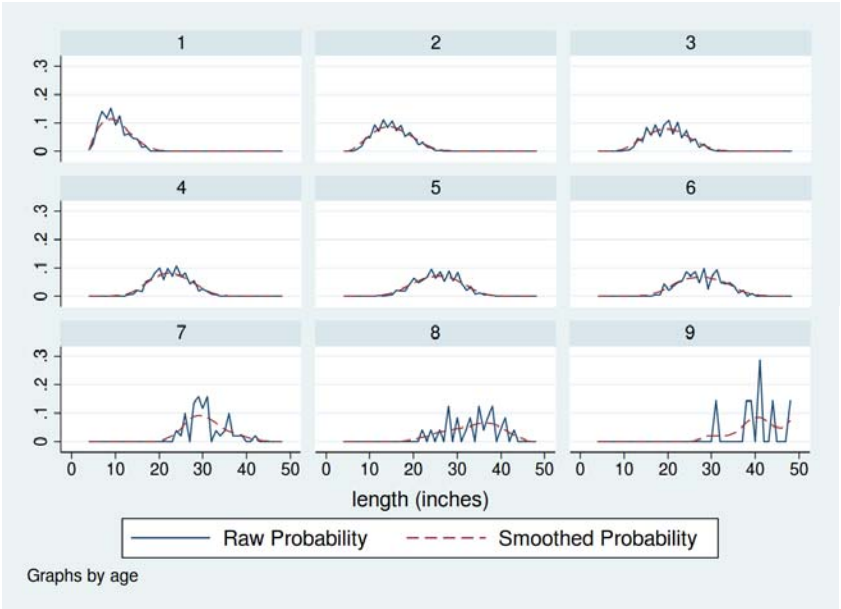
Combining Stock Assessment and Recreational Catch data



Numbers-at-Age and Age-Length

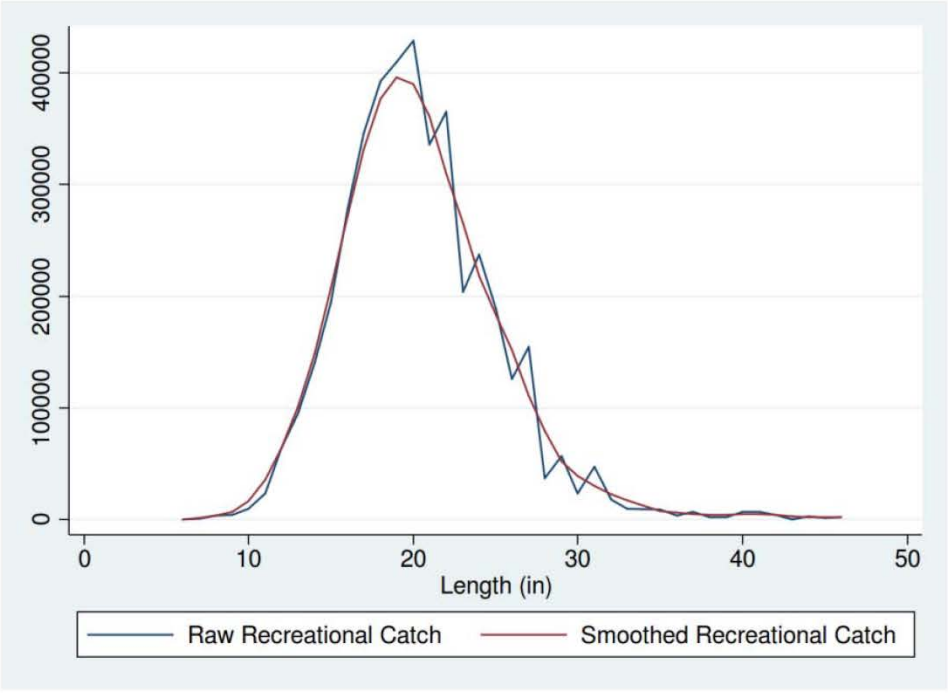


GoM Cod Numbers-at-length

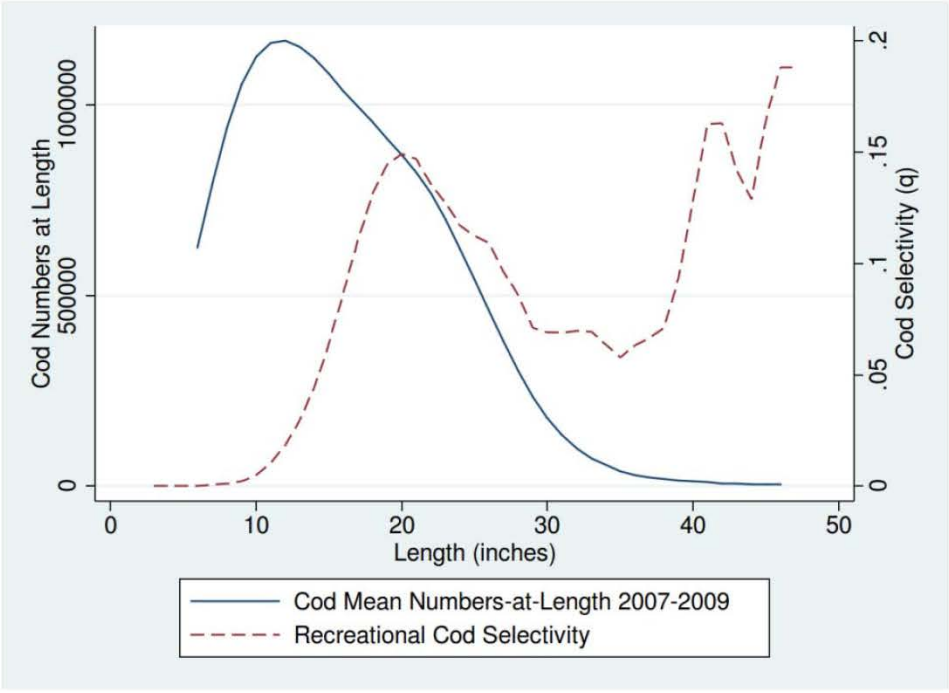


GoM Cod Age-Length Relationship

Cod Recreational Catch



Recreational Selectivity



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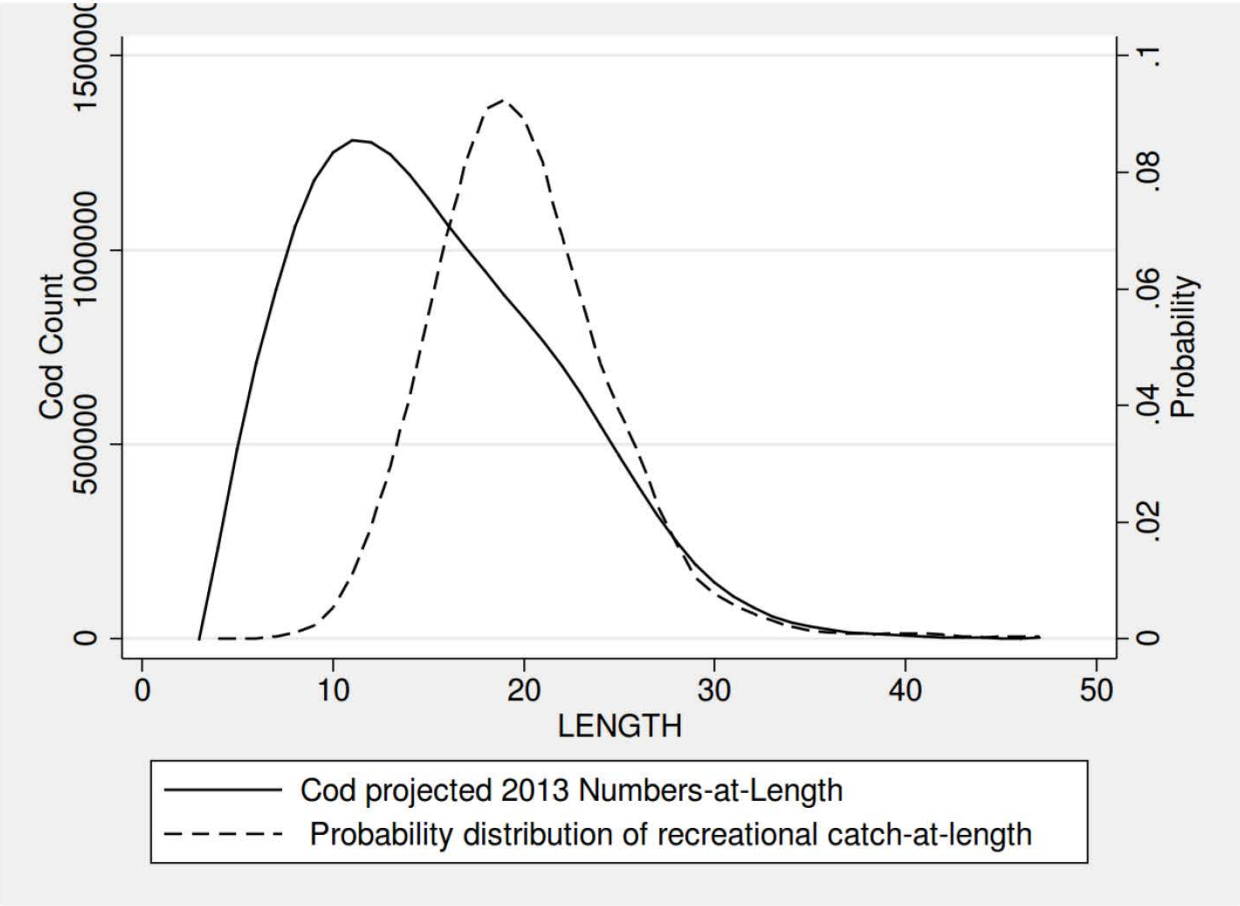
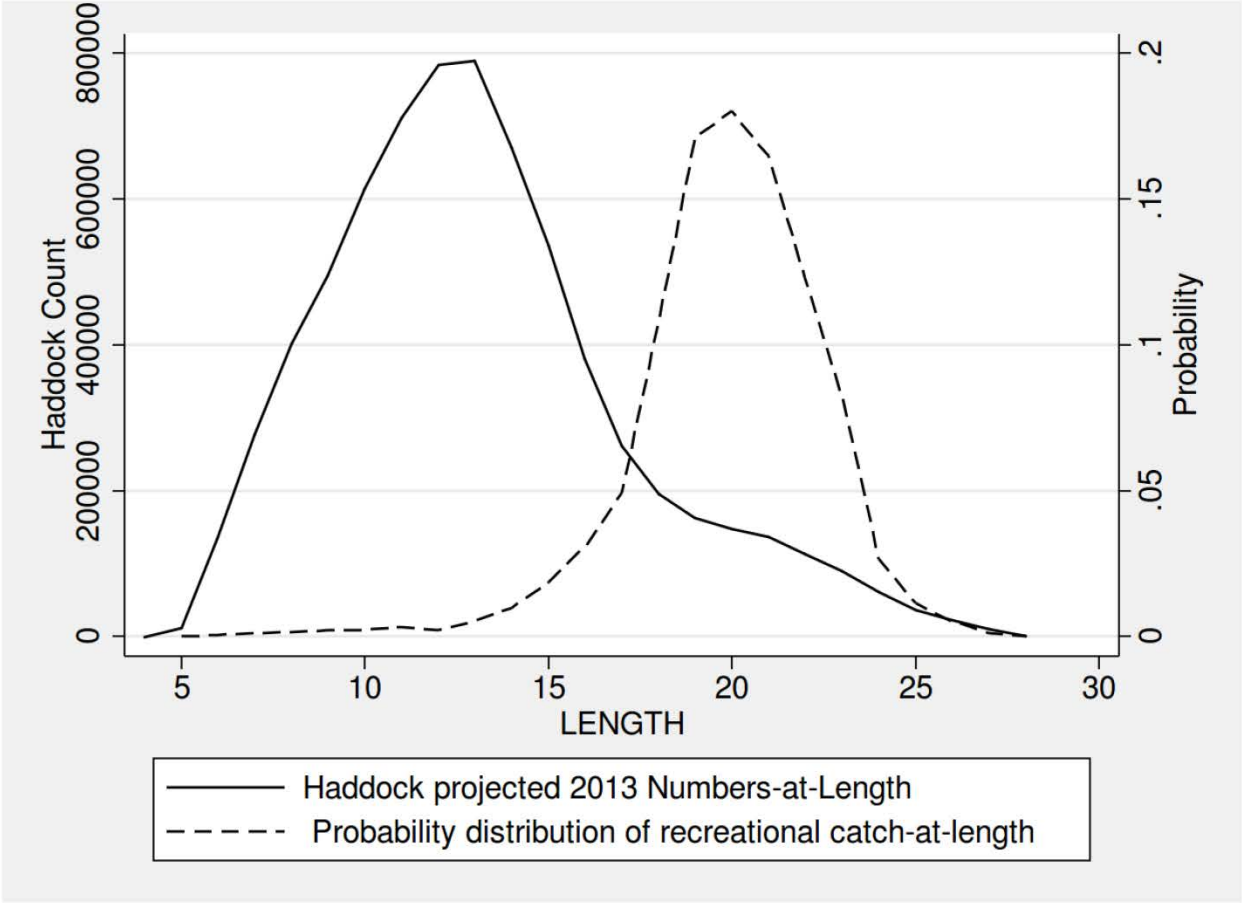
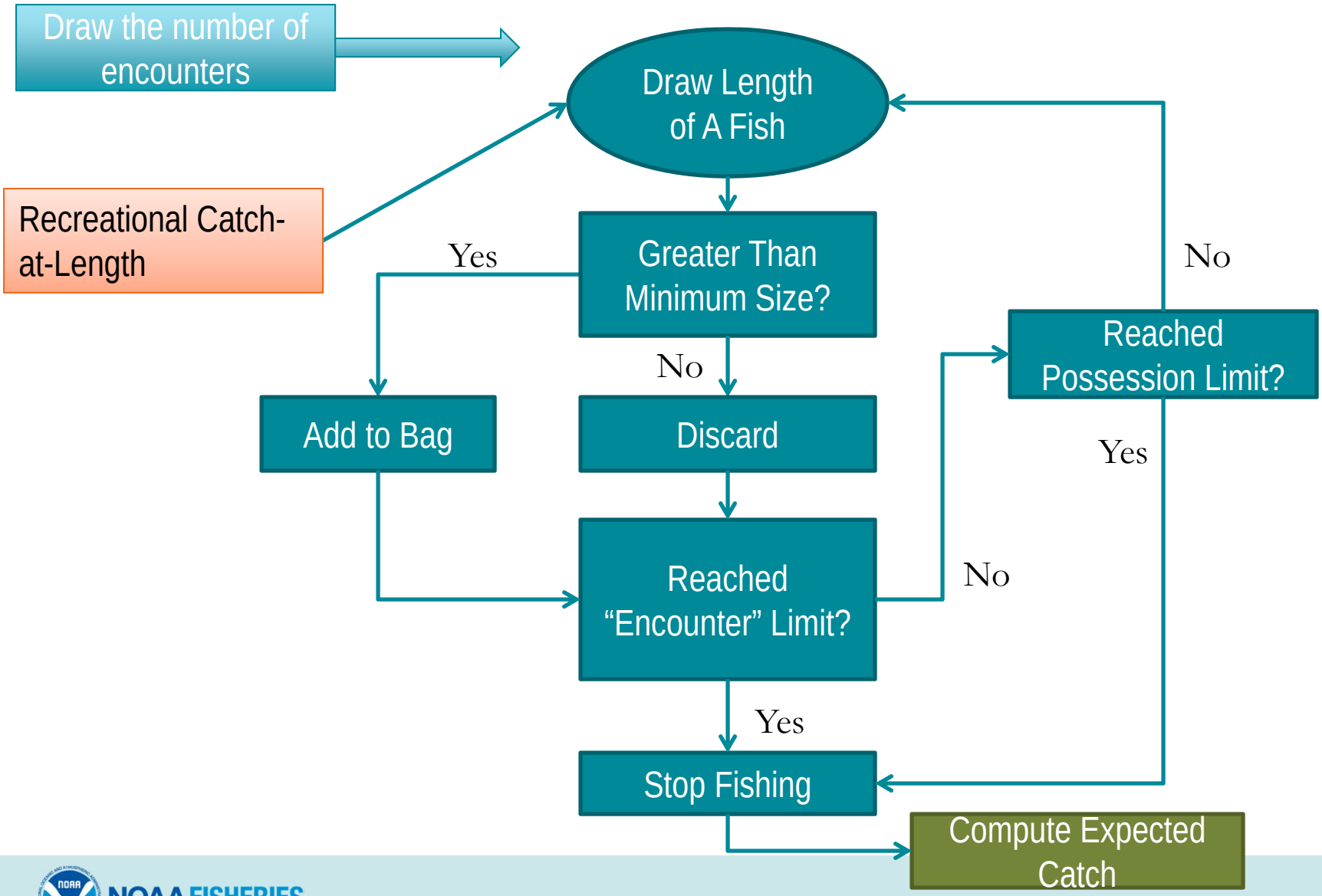
Catch-at-Length for Median 2013 GoM Cod Stock



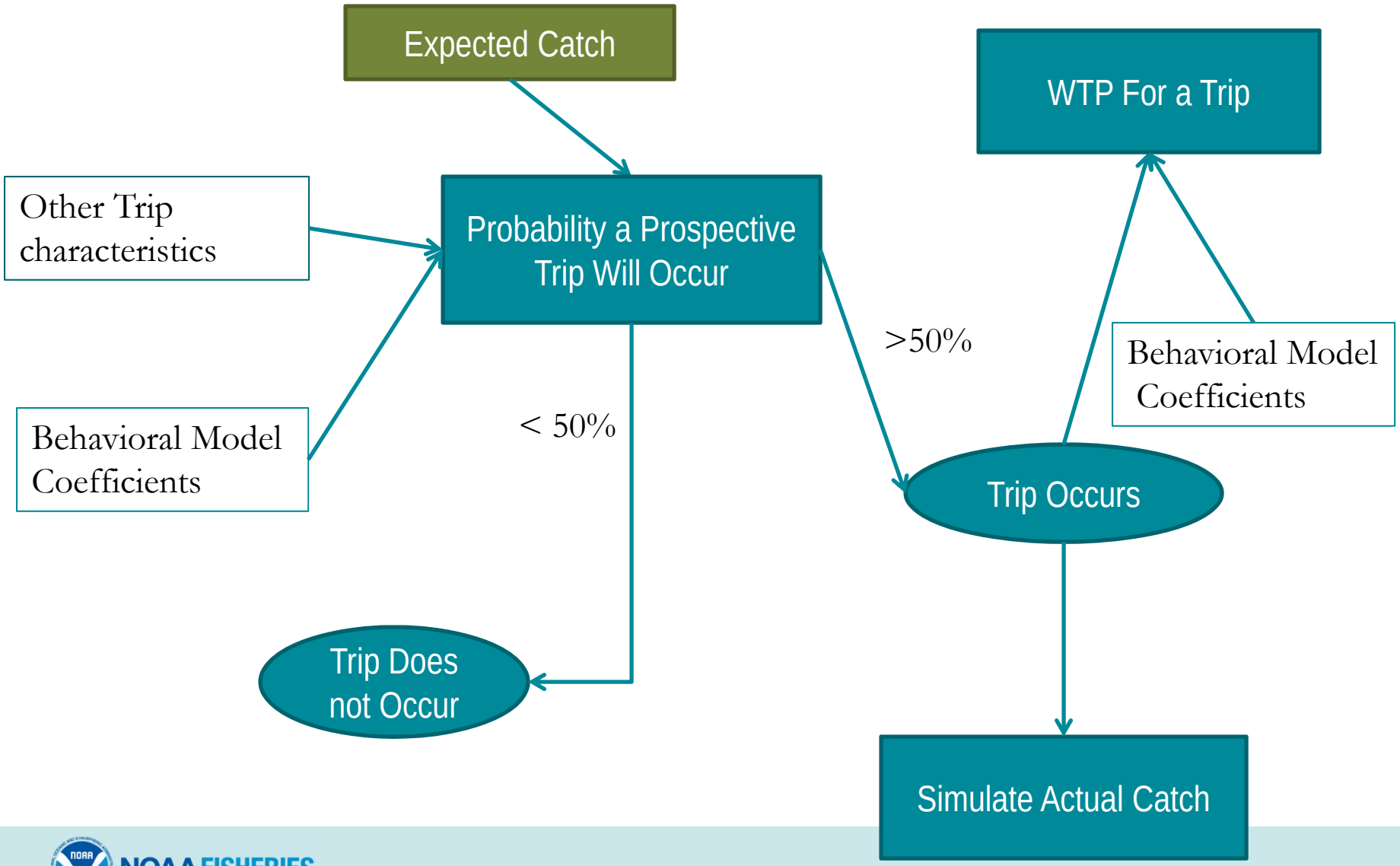
Catch-at-Length for Median 2013 GoM Haddock Stock



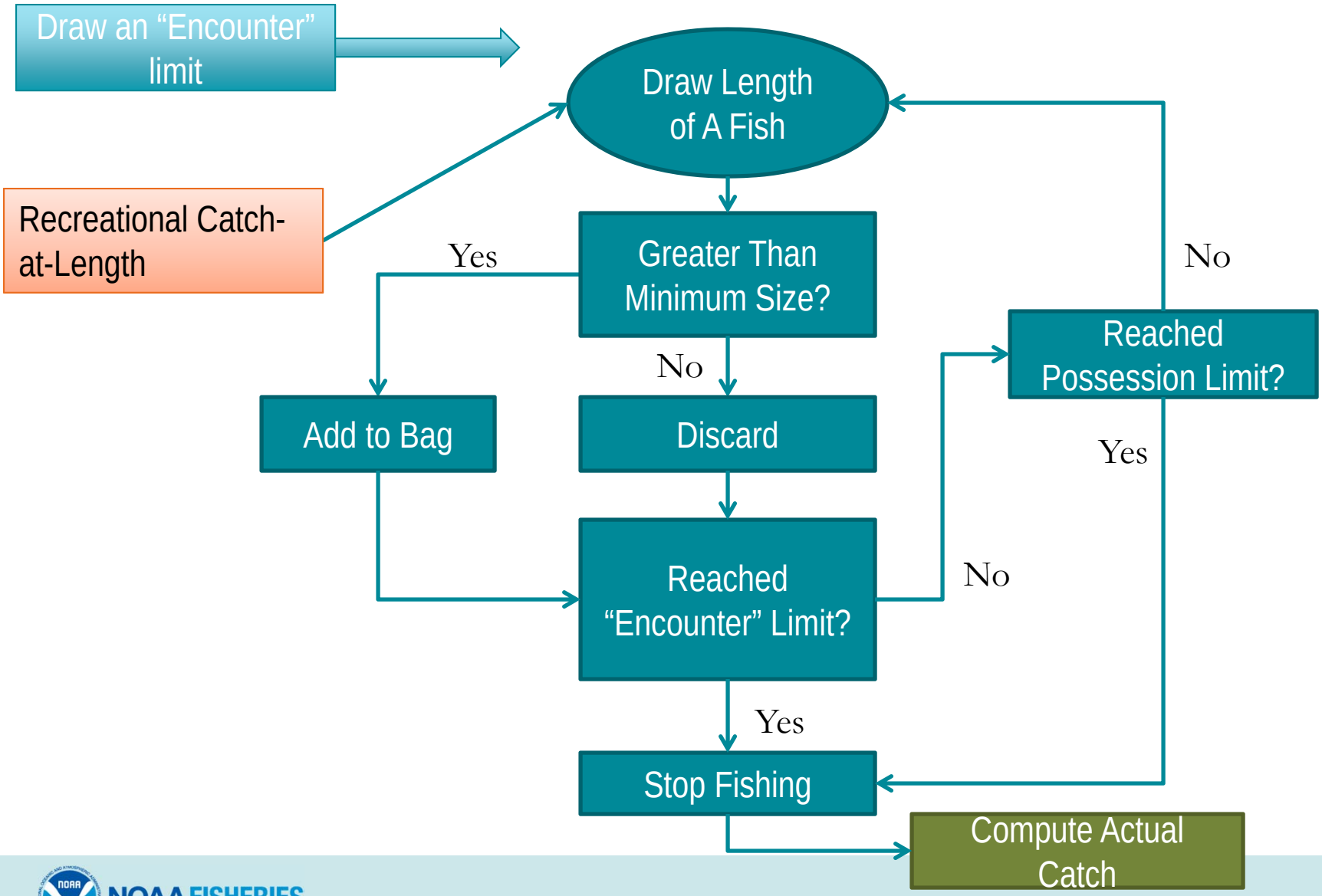
Simulating *Expected Catch* for a Trip



The Participation Decision



Simulating *Actual Catch* for a Trip



Simulating the Entire Recreational Fishery

- How many trips will occur?
  - Set a number for potential trips
    - Large enough so that this number is not binding if the fishery becomes more desirable
  - Cutoff probability from behavioral model (50%)

Calibration

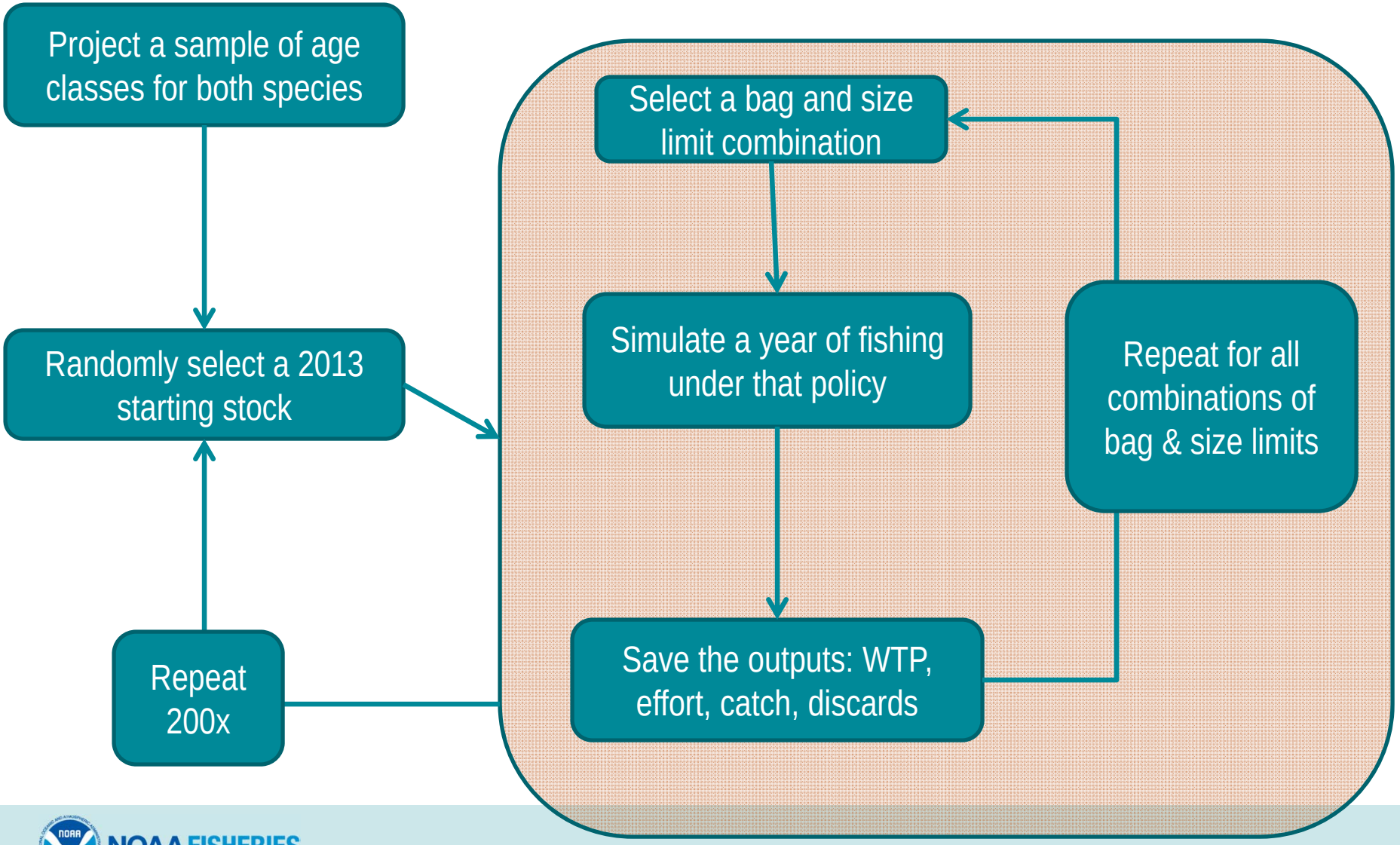
- Use possession and size limits in effect for 2007-2009.
- Set number of "potential trips" so that "Trips" matches actual trips.

	MRFSS 2007-2009 Average	Model Predictions	Error
Potential Trips	N/A	465,000	
Trips	283,401	284,228	0.3%
Cod Kept	419,971	303,854	-27.6%
Cod Released	1,027,738	1,053,829	2.5%
Total Cod	1,447,709	1,357,683	-6.2%
Haddock Kept	356,099	355,284	-0.2%
Haddock Released	96,359	22,350	-76.8%
Total Haddock	452,458	377,634	-16.5%

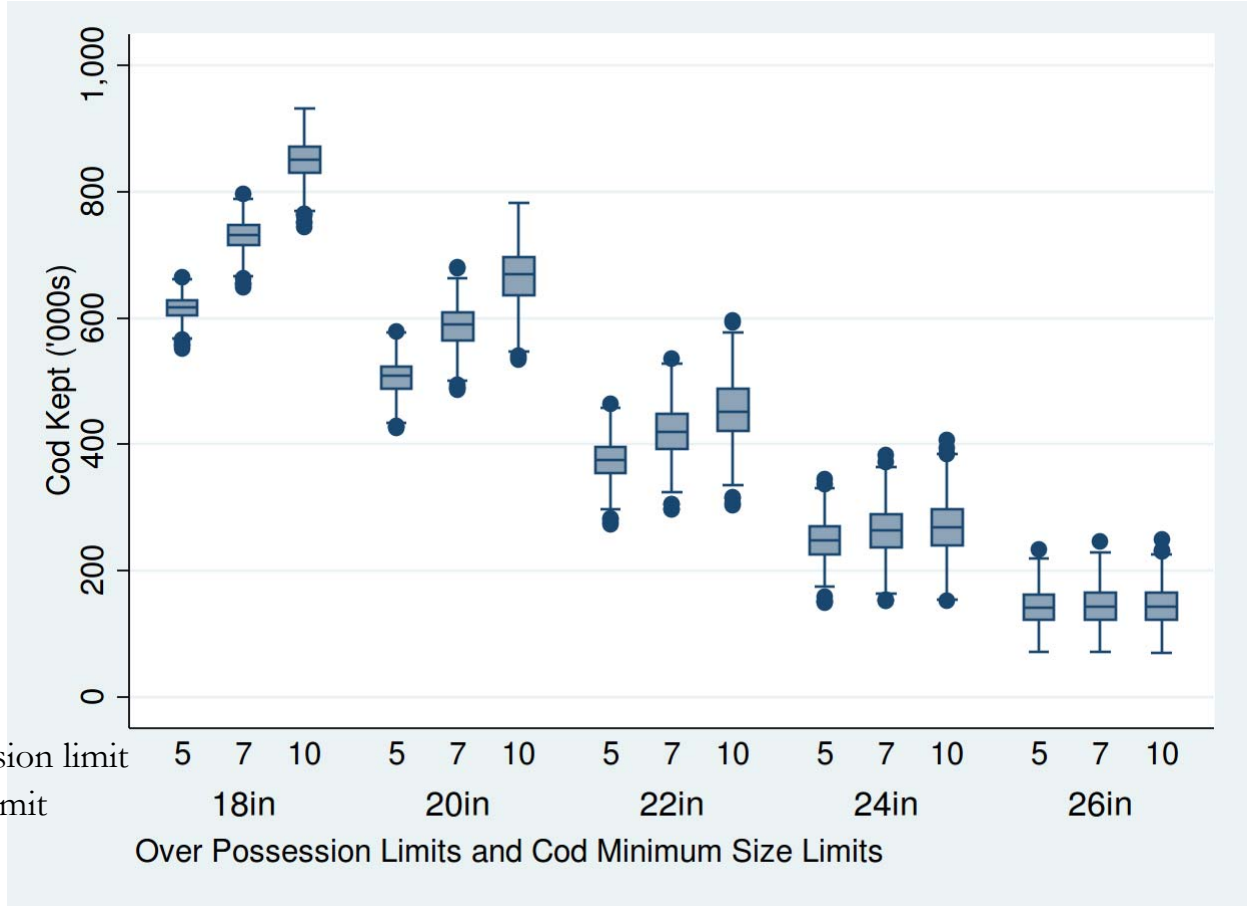
Policy Analysis

- Examine illustrative changes in bag and size limits
  - 5, 7, 10 fish for cod
  - 18, 20, 22, 24, 26 inches for cod
- Incorporate variability regarding stock conditions

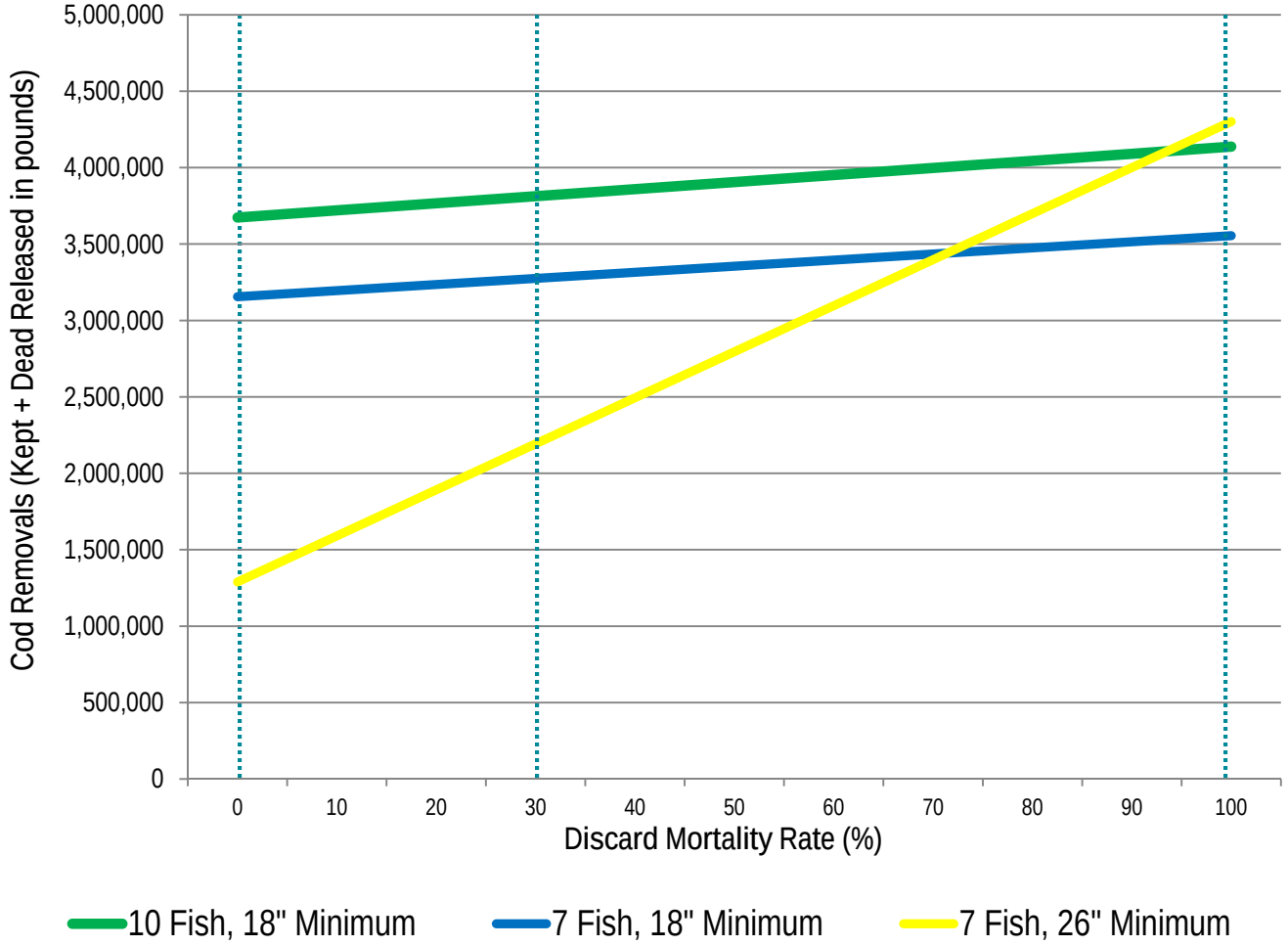
Policy Analysis



Results – numbers of kept cod



Outcomes of some policies are very sensitive to discard mortality



Acknowledgements

- Liz Brooks, Paul Nitschke, Mark Terciero, Chris Legault NEFSC Population Dynamics Branch
- Sonia Jarvis, Doug Lipton, Ted McConnell, University of Maryland
- Dan Georgianna, University of Massachusetts-Dartmouth
- Cynthia Jones, Old Dominion
- Eric Thunberg, NOAA Fisheries Office of Science and Technology

Assumptions

- No changes in catchability/targeting behavior
- Catch-at-length determined by catchability and relative abundances of length classes
- Expectations correctly generated:
  - Anglers generate expected catch based on length of fish in water and catchability.
  - Note: Expected catch for trips which occur is generally higher than actual catch.

Assumptions cont'd

- No heterogeneity in catch rates across fishing modes, time, or space
- No recreational high-grading
- Anglers stop fishing for either species when they hit the "maximum" or the bag limit
- No illegal retention* (too small, over bag limit)