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An Interdisciplinary review of Atlantic cod stock structure in US waters

The Atlantic Cod Stock Structure Working Group (ACSSWG)

Presenter: Richard McBride, NOAA Fisheries

New England Fishery Management Council

Outline – Introduction

Why does stock structure matter?

- Populations vs. monitoring, assessment, or management units

The Atlantic Cod Stock Structure Working Group

- The people, partners and process

Preview the approach and proposal

- Interdisciplinary as complementary not competing perspectives
- A 5 stock hypothesis in US waters

No, not this kind of fish stock



Instead, a biological stock (= population)

What is a biological stock?

Consider a group of individuals where...

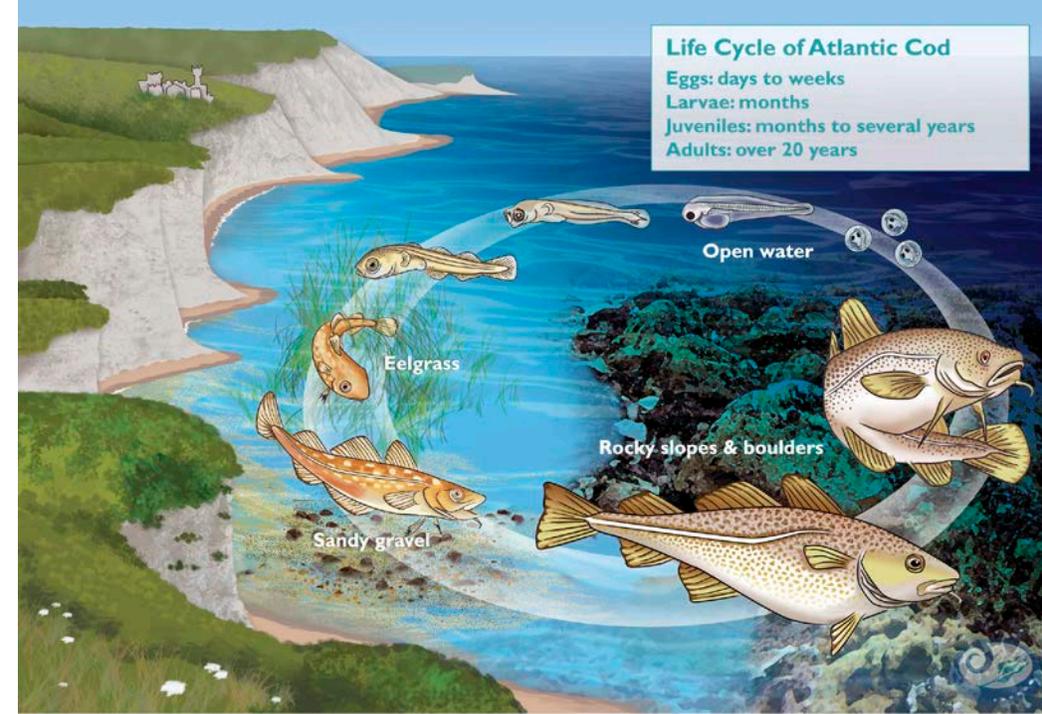
Source of new recruits comes from within

- reproductive isolation

Demographics – growth, mortality, maturity, fecundity –
are similar by age, size, or sex (i.e., dynamic pool)

Abundance estimates are representative of the stock

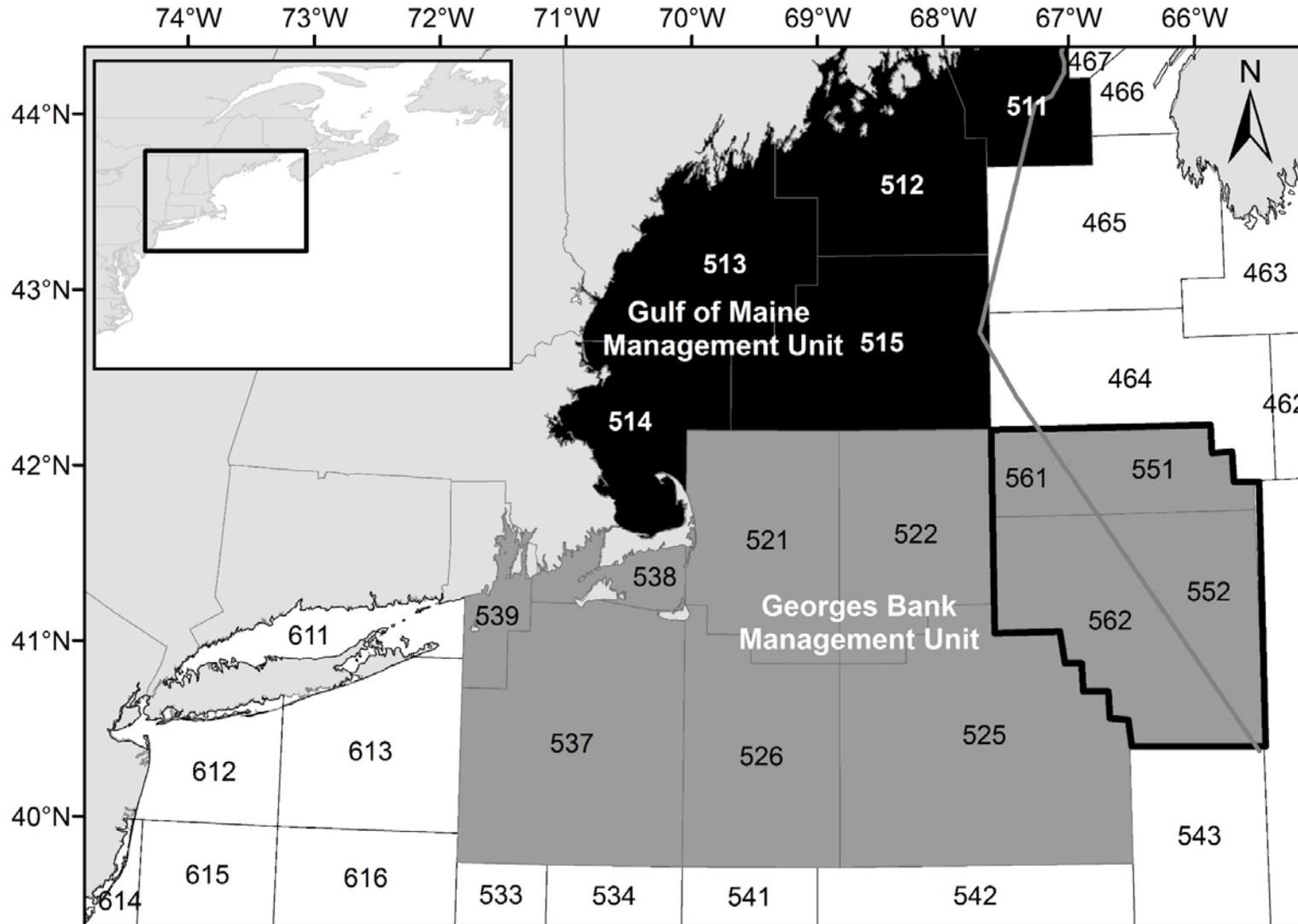
- well mixed



The Atlantic cod uses many habitats throughout its life. Open water, eelgrass beds, sandy and gravel areas, kelp, boulder fields and steep rocky ledges are important for growth and survival during different life stages of this fish.

Art by Molly Thomson

Where are the boundaries of the current US cod management units?



- Since ~ 1970s
(North-South)
- 2 US stock units
 - Transboundary
 - Subunits (areas)

The question:
How do these geographic management units relate to biological stock structure of Atlantic cod?

Wasn't there a stock structure workshop in 2012?

“The Steering Committee recommends ... involving a small group of Canadian and US scientists to consider the results of the Workshop.” - Annala, 2012

Timeline from WG formation (Feb 2018)

Conference Calls

- 1 in 2020
- 7 in 2019
- 3 in 2018

WG workshops (UNH, GMRI)

- Nov 14-15, 2018
- Jun 20-21, 2018

Outreach symposia

- Mar 7, 2020 (MFF)
- Jun 6, 2019 (UNH)
- Jun 19, 2018 (UNH)



Fisheries and Oceans
Canada
Pêches et Océans
Canada



New England
Fishery Management
Council



Gulf of Maine
Research Institute
Science. Education. Community.



University of
New Hampshire



Working Group members



Ames



Andrushchenko



Cadrin



Cournane



Dean



DeCelles



Kerr



Kovach



McBride (co-chair)



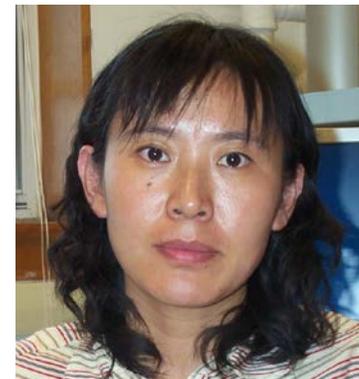
Overgaard
Therkildsen



Puncher



Smedbol (co-chair)



Wang



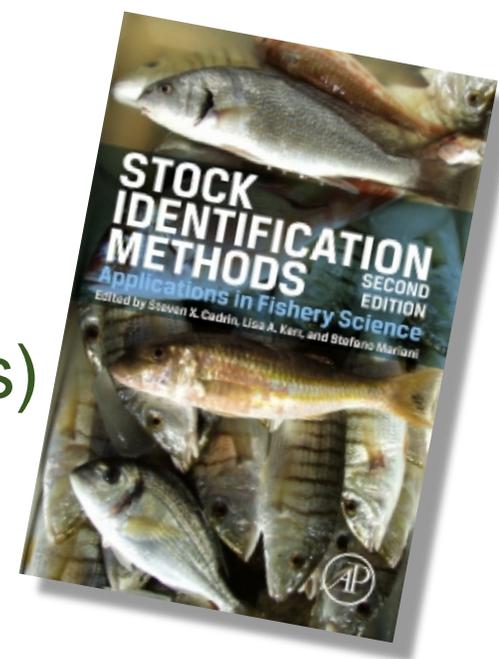
Zemeckis

Why interdisciplinary?

Perspective	Information	Population Inference
Distribution	fishery data fishery-independent surveys	spatial and seasonal fishing patterns by fleet; spawning, feeding and nursery areas distribution at early, juvenile and adult life stages
Dispersal	early life stage dispersal conventional tags archival tags active telemetry passive telemetry	connectivity of spawning and nursery areas movement patterns or rates individual movement trajectories individual movement trajectories movement patterns and spawning dynamics
Geographic Variation	selected genetic characters neutral genetic characters life history traits morphology meristics natural tags abundance trends size or age composition	reproductive isolation or local adaptation reproductive isolation limited mixing and possibly reproductive isolation or local adaptation limited mixing and possibly reproductive isolation or local adaptation limited mixing at early stages and possibly reproductive isolation or local adaptation limited mixing and environmental history demographic independence demographic independence or fishery selectivity

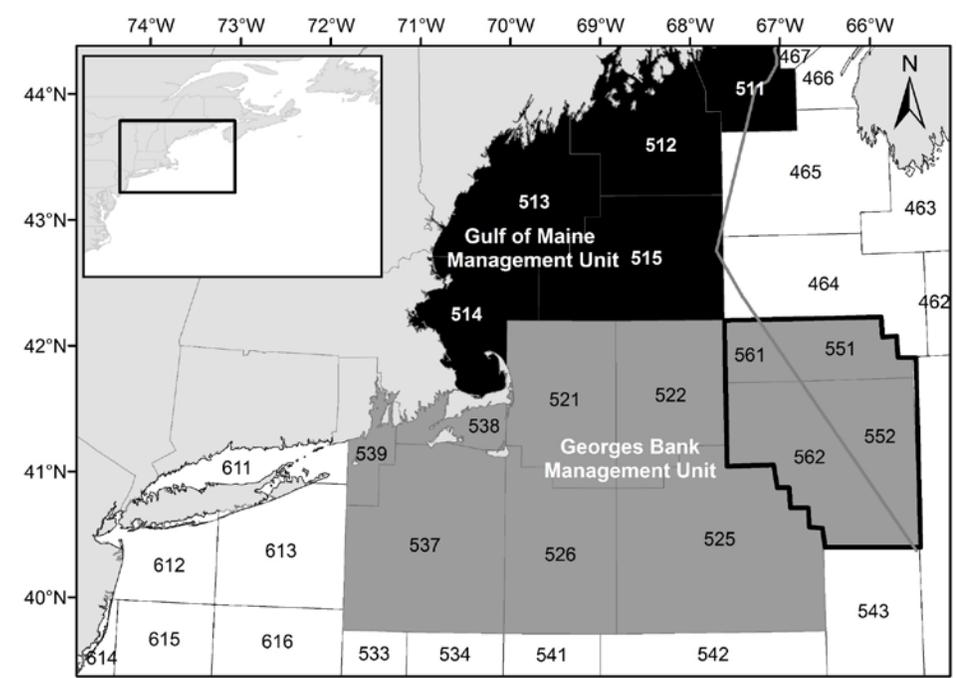
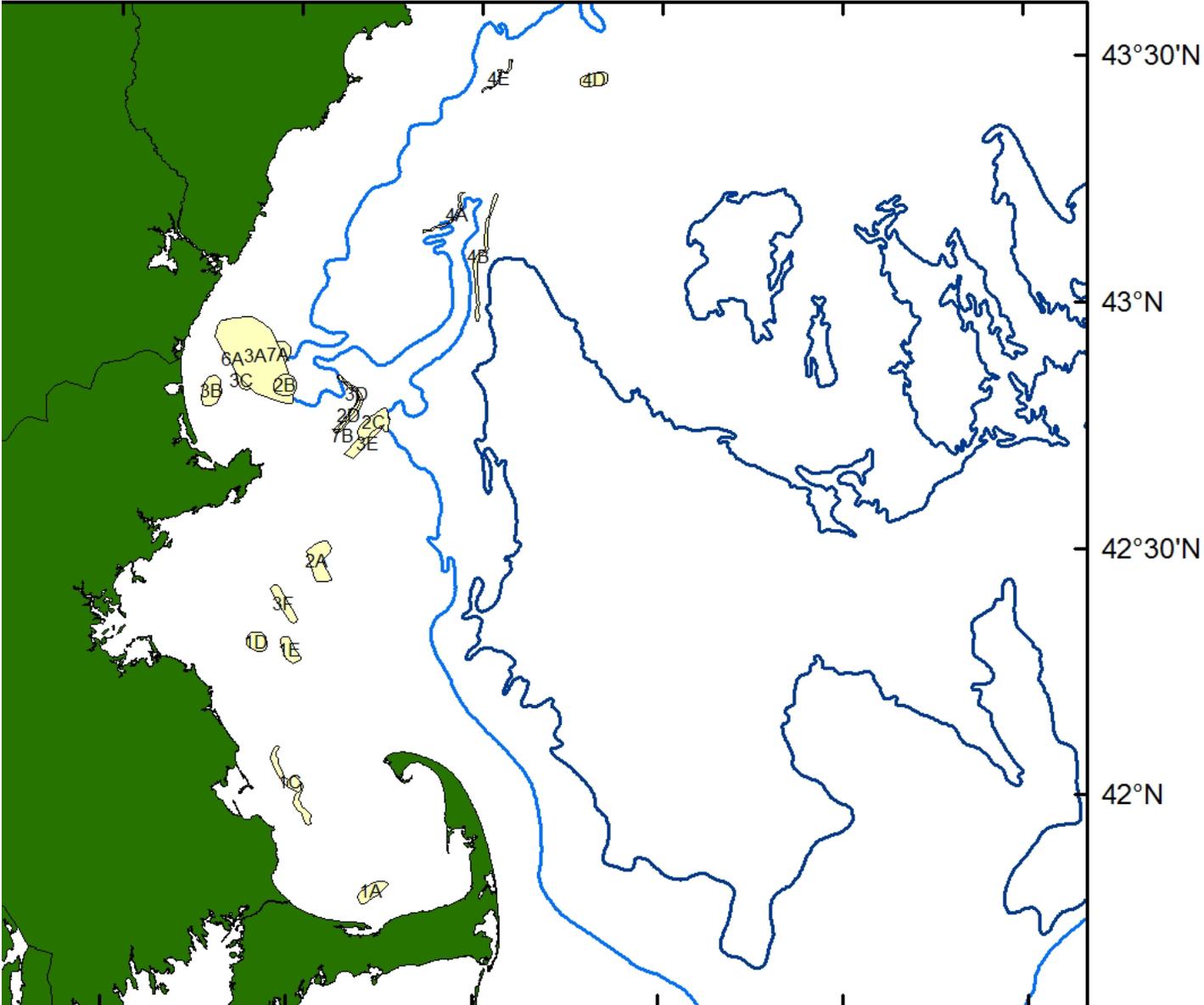
Our interdisciplinary

1. Fishermen's ecological knowledge (structured interviews)
2. Early life history (spawning–settlement)
3. Genetic markers (including adaptive markers and genomics)
4. Life history (48 years of the NEFSC bottom trawl survey)
5. Natural markers (otoliths, parasites, color morphs, etc.)
6. Applied markers (200,000 tagged cod; 12,000 recaptures [1923-2013])

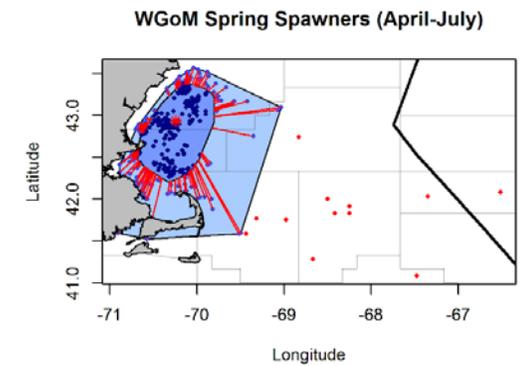
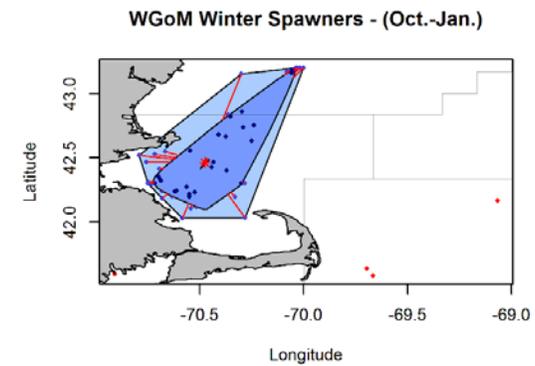


Ecological knowledge

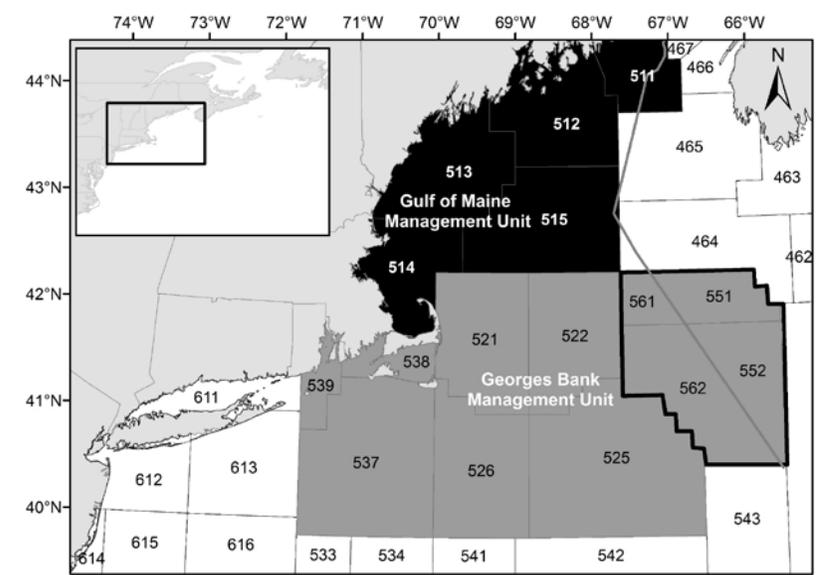
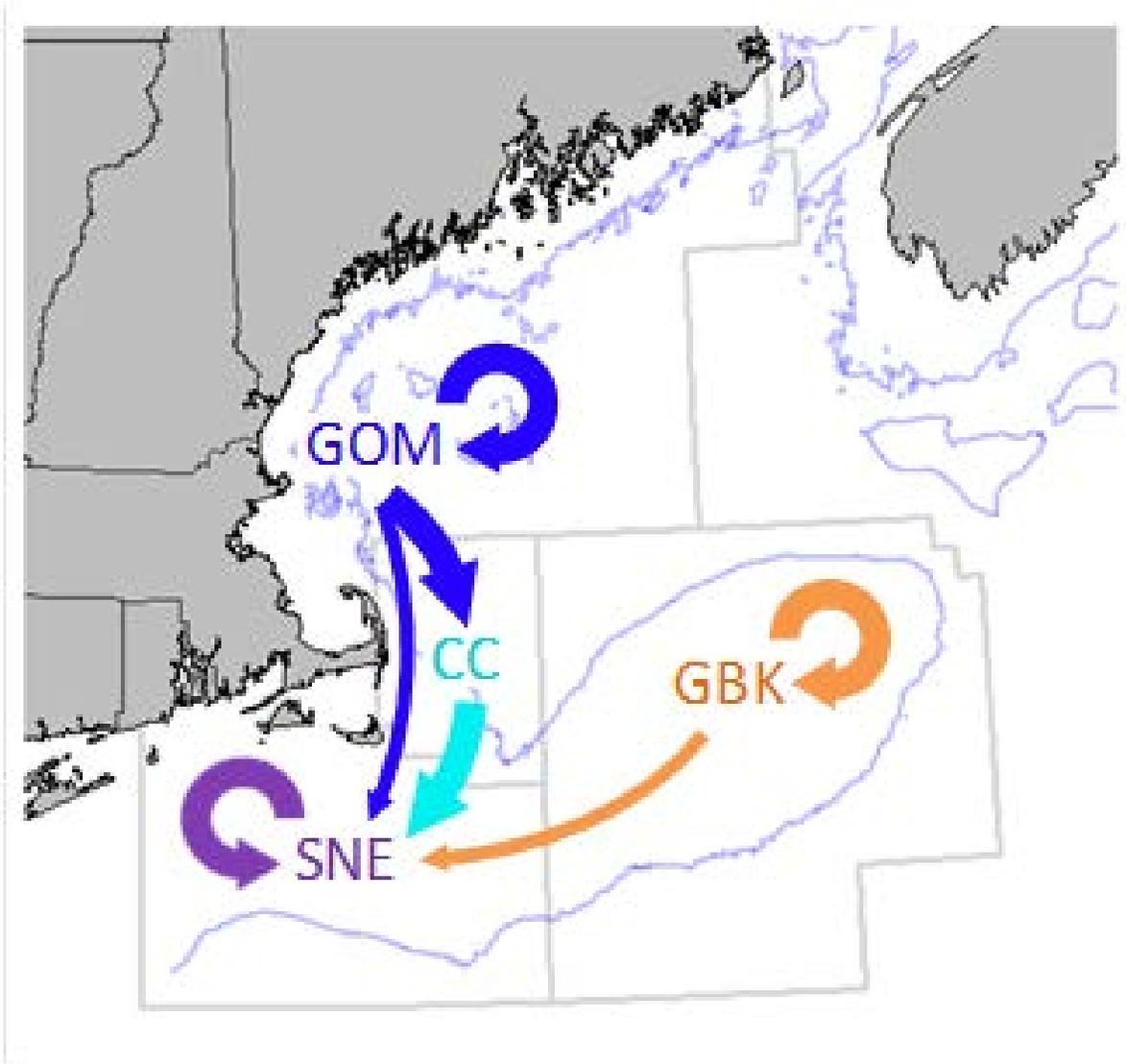
71°W 70°30'W 70°W 69°30'W 69°W 68°30'W



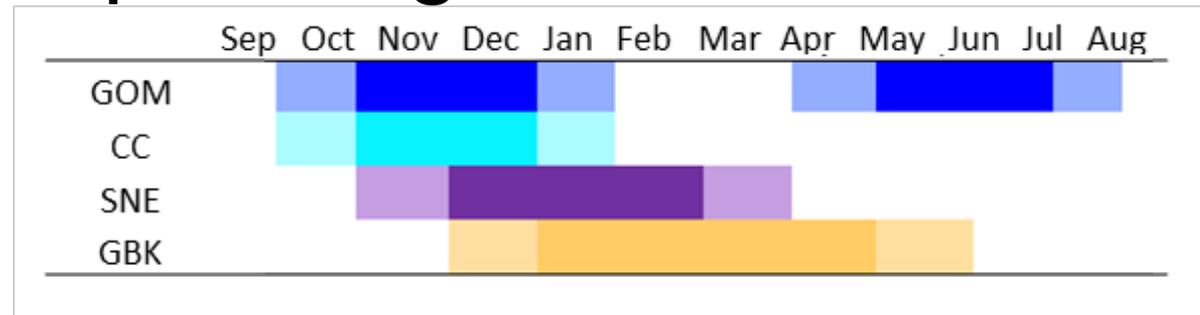
Recaptures of tagged fish show fidelity to spawning grounds



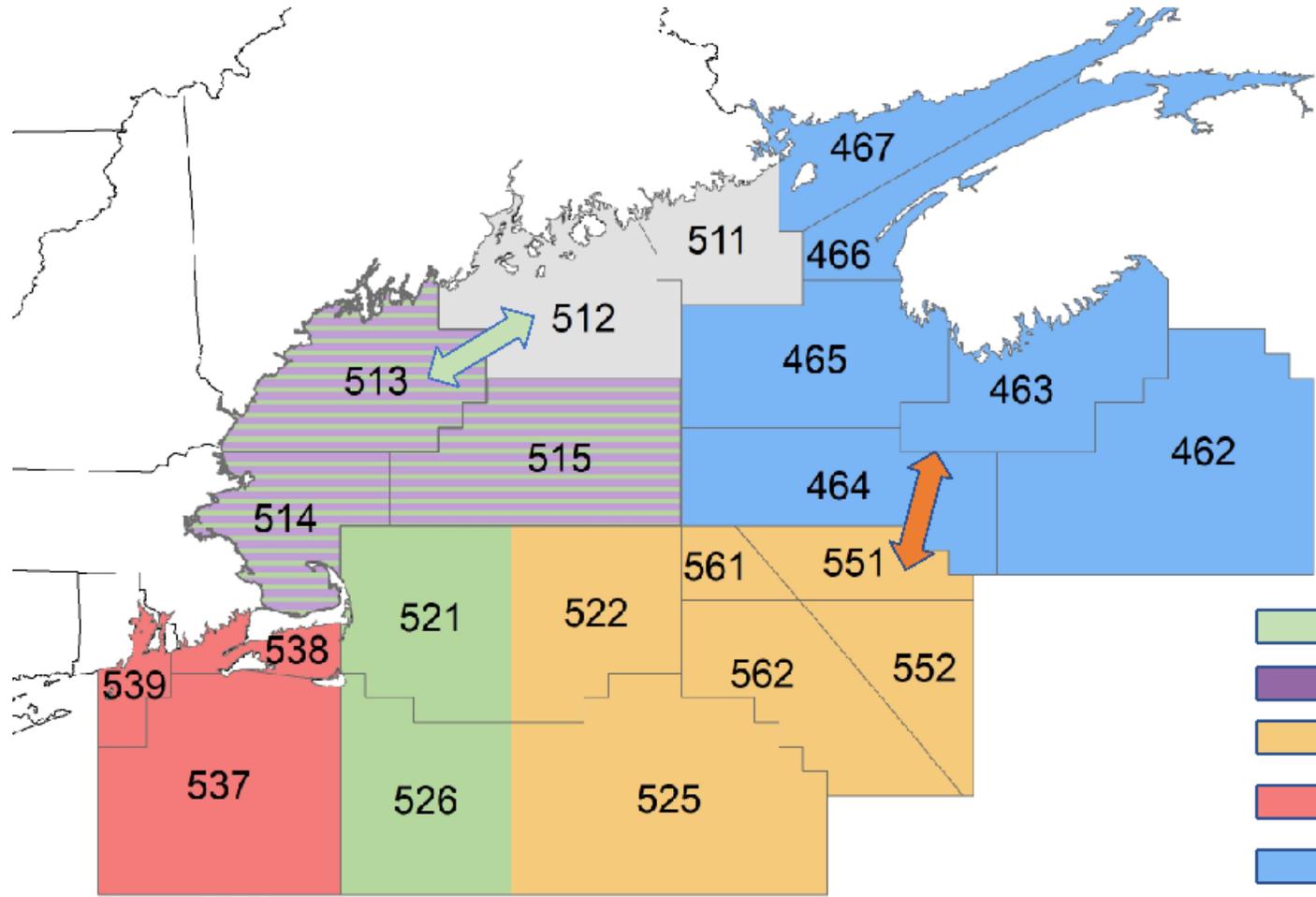
Early life history

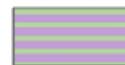


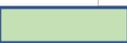
Spawning Seasons

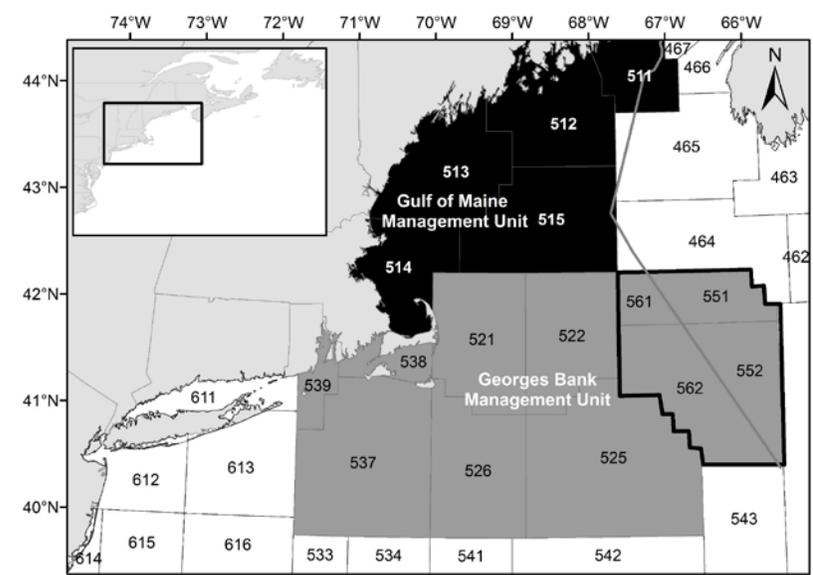


Genetic structure

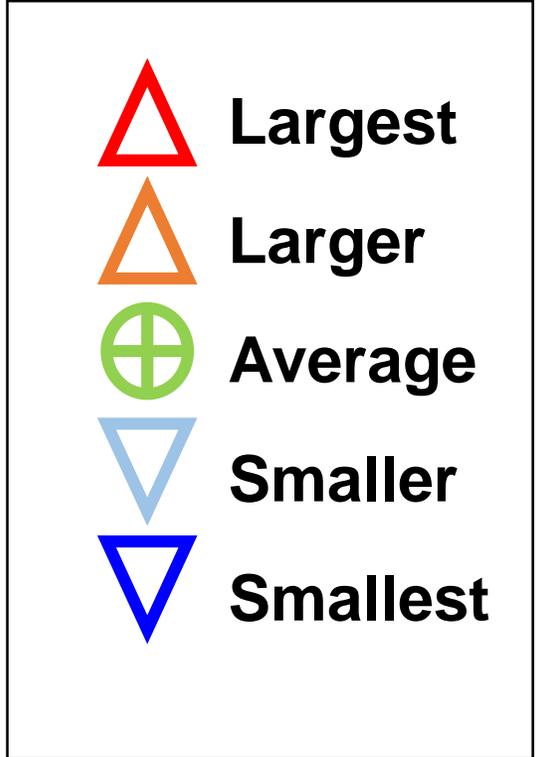
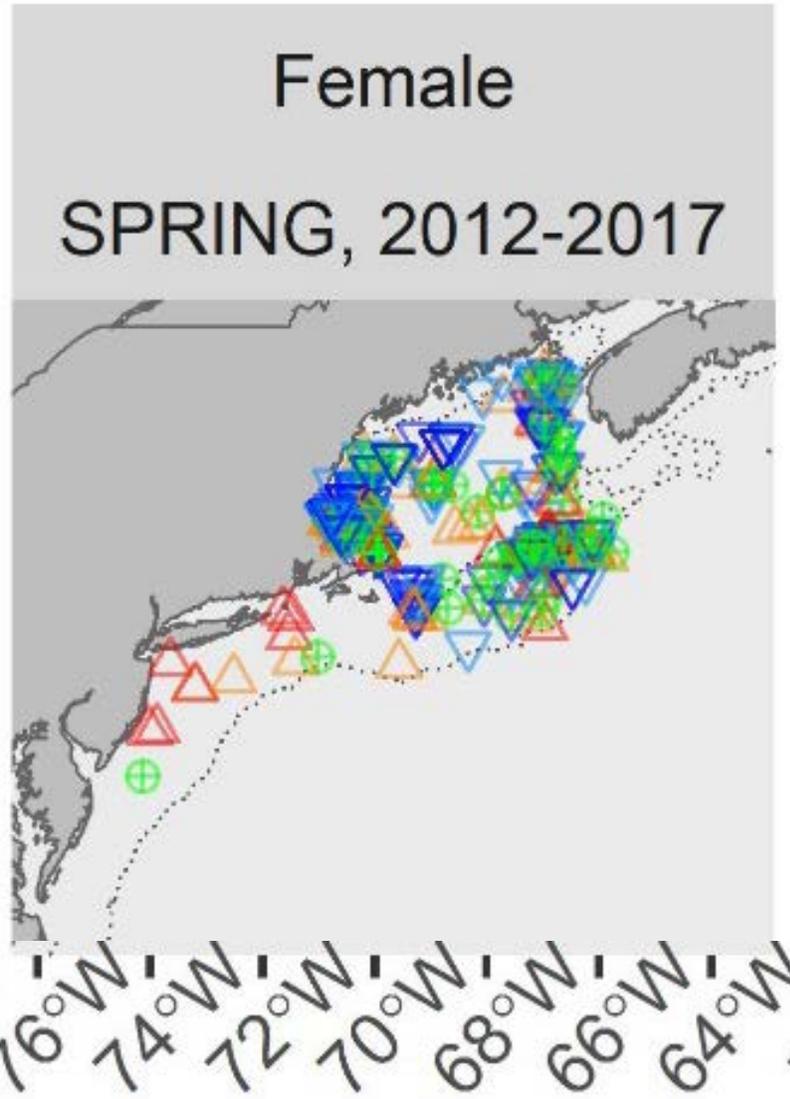
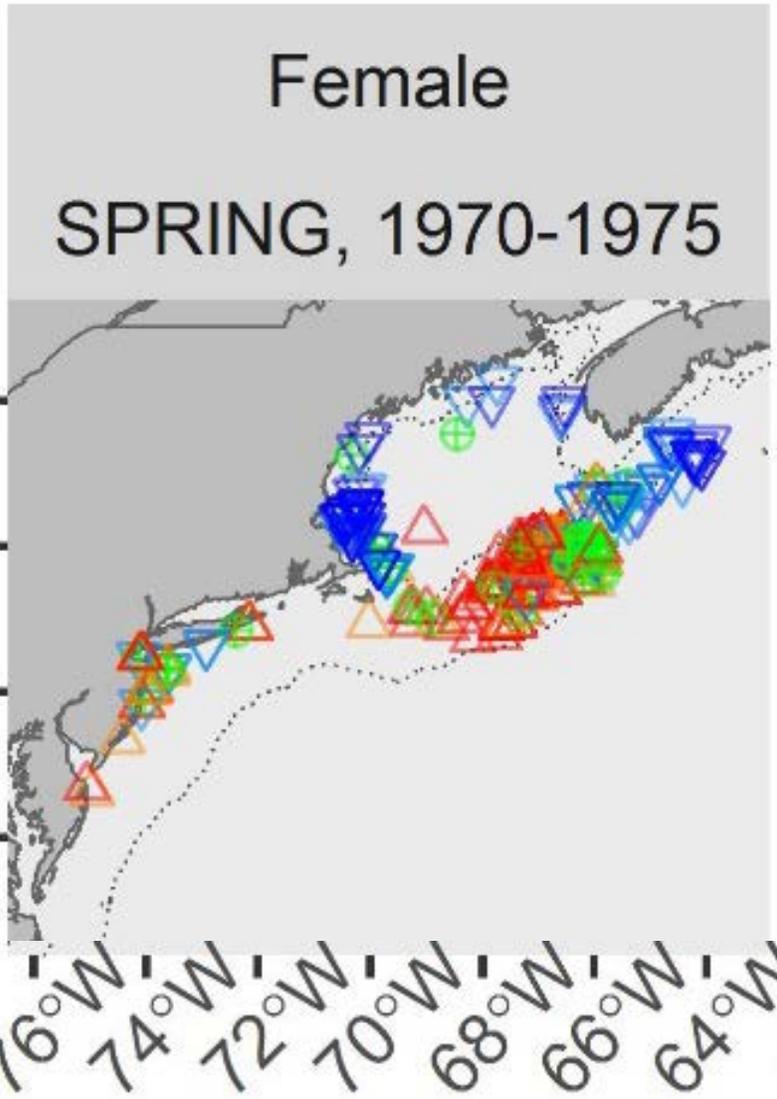
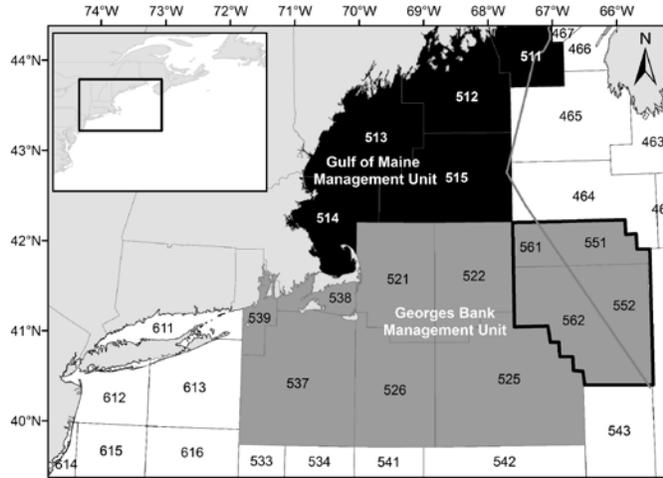


 Winter and Spring Western GoM

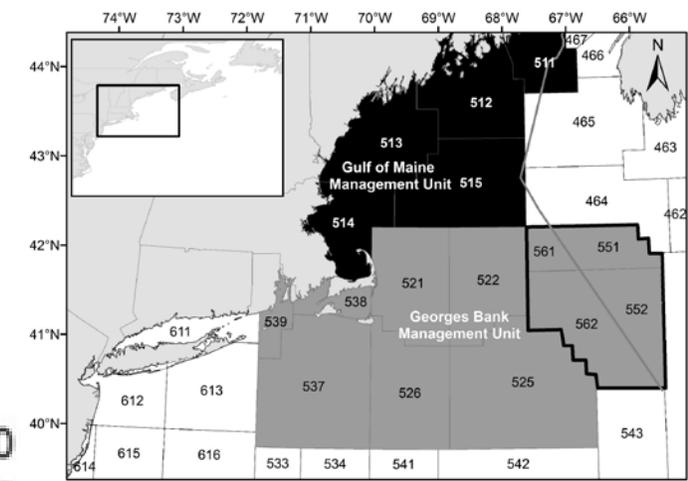
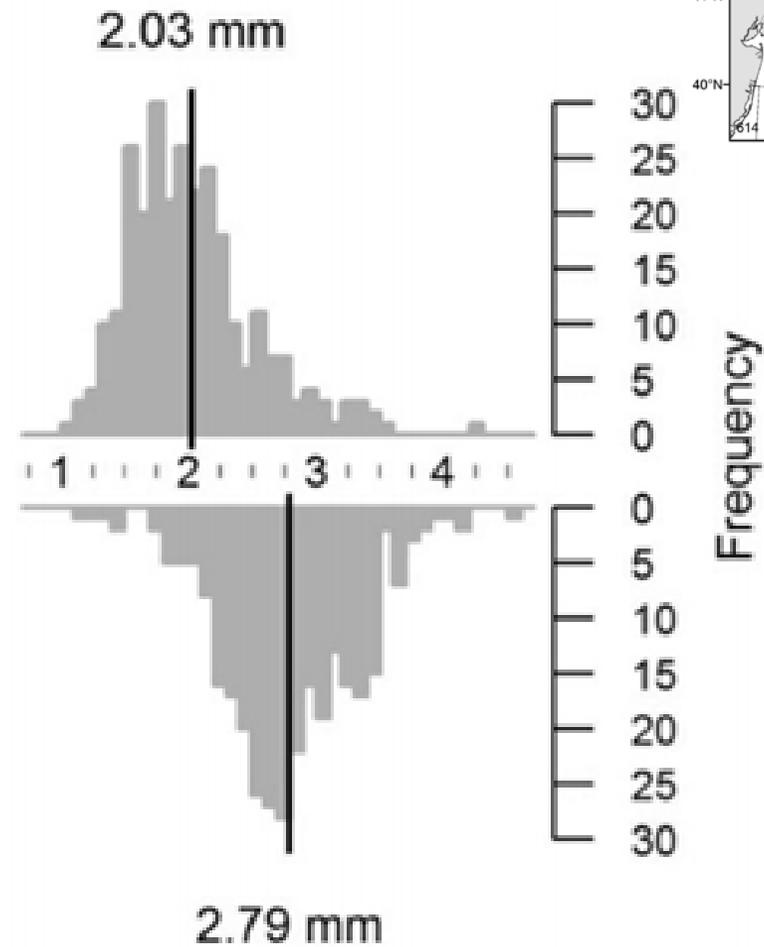
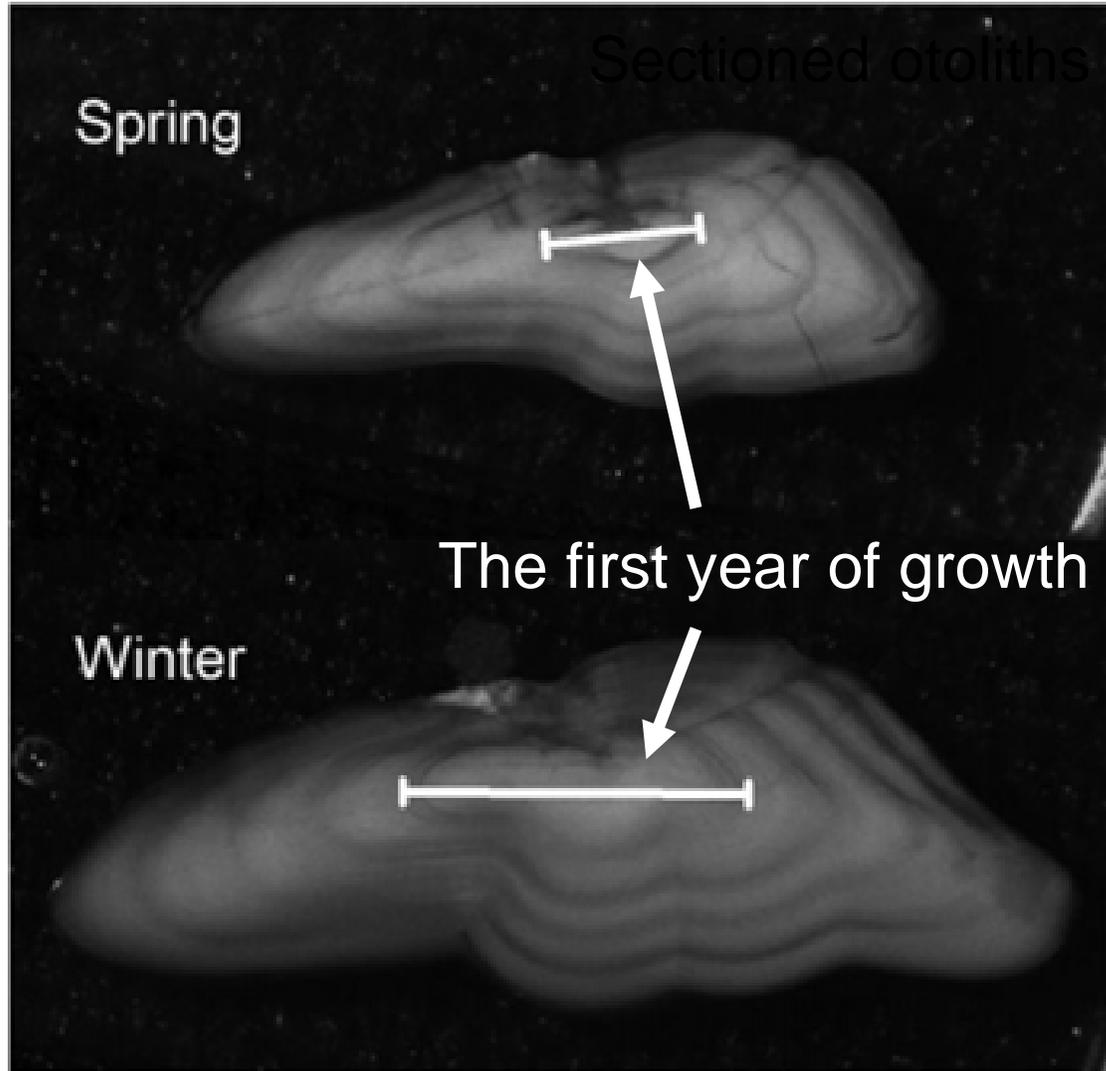
-  Winter Western GoM + Cape Cod
-  Spring Western GoM (overlaps with winter)
-  Georges Bank
-  Southern New England
-  Western Scotian Shelf & Bay of Fundy
-  Eastern GoM (non-spawning)



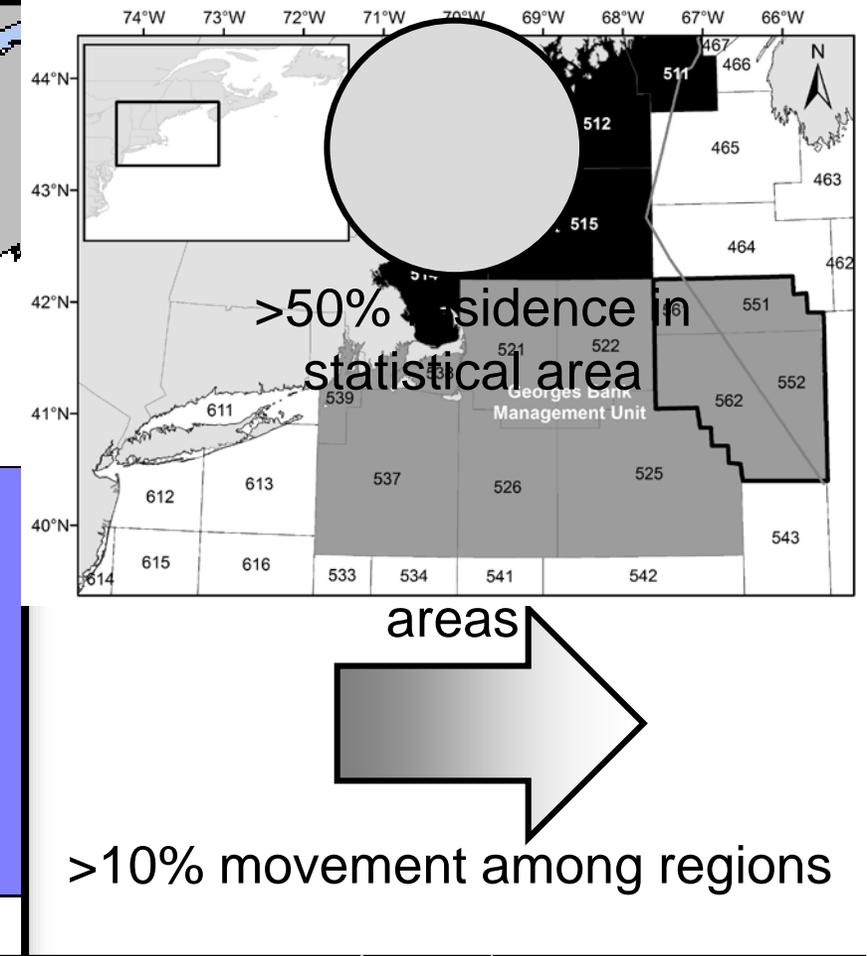
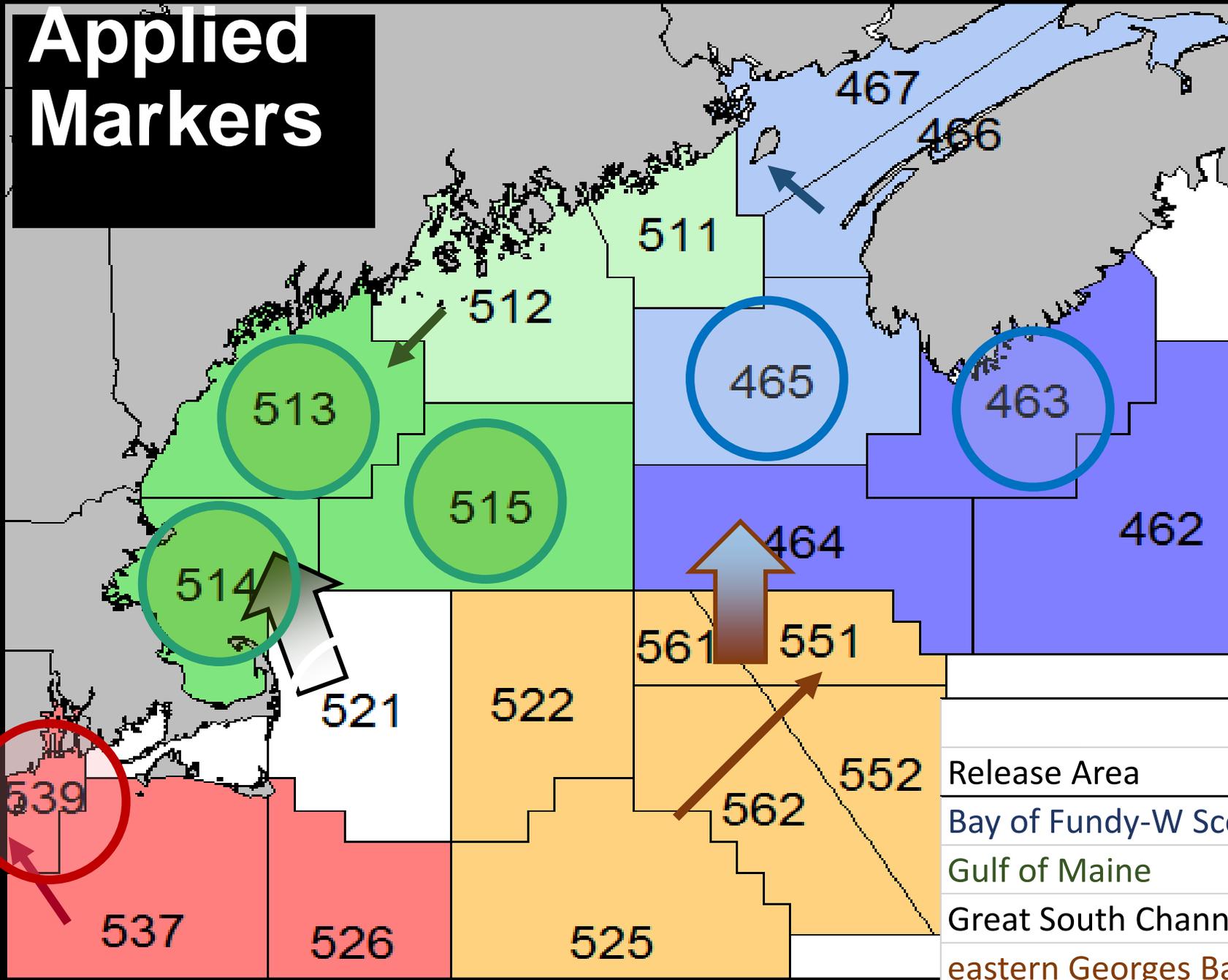
Life history (size @ age-2)



Natural Markers



Applied Markers

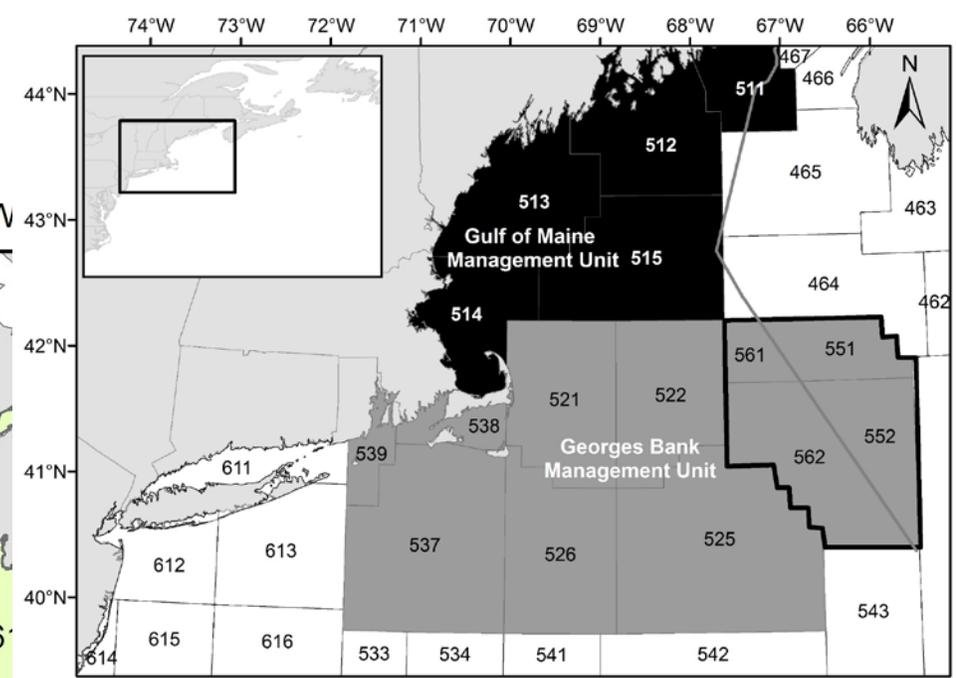
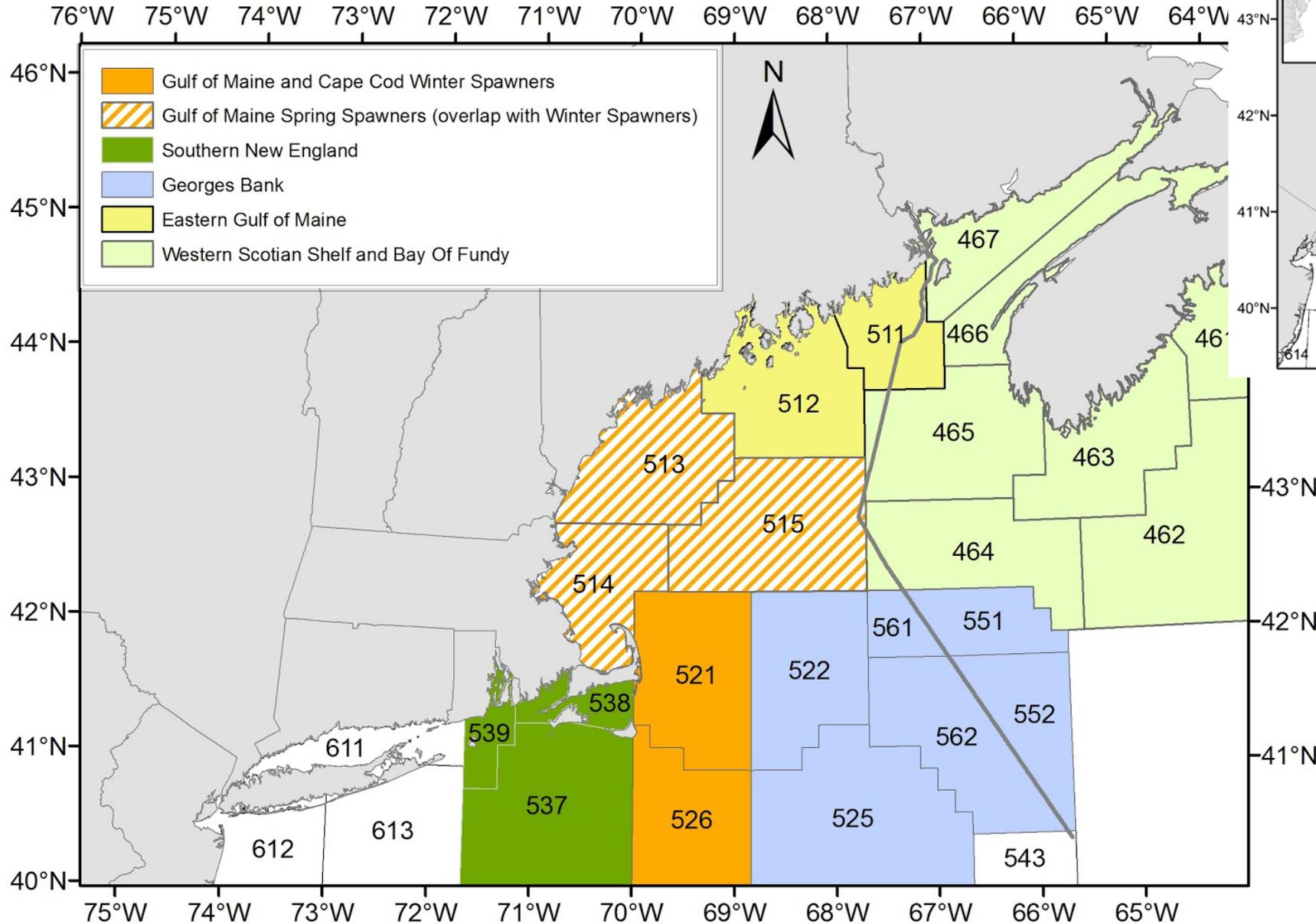


Release Area	Recapture Area				
	BOF	GOM	GSC	EGB	SNMA
Bay of Fundy-W Scotian Shelf	0.93	0.03	0.00	0.04	0.00
Gulf of Maine	0.02	0.92	0.03	0.02	0.01
Great South Channel	0.00	0.17	0.69	0.08	0.04
eastern Georges Bank	0.19	0.02	0.03	0.76	0.00
S. New England-Mid Atlantic	0.00	0.01	0.08	0.01	0.92

Interdisciplinary highlights

- 1) Notable phenotypic and genetic variability among statistical areas
 - Cod not well mixed in either US management unit
- 2) Extensive movements by adults
 - exchange between US-US management units
 - as well as between US-Canada management units
- 3) Larval dispersal around Cape Cod
 - one-way connectivity between US-US management units
- 4) Two sympatric, genetically differentiated stocks in SW Gulf of Maine
 - adaptive differences between winter- and spring-spawning cod

5 US cod stocks proposed



This proposal accounts for:

- Within unit variation
- Between unit connectivity
- Winter/spring sympatry

What is the ACSSWG?

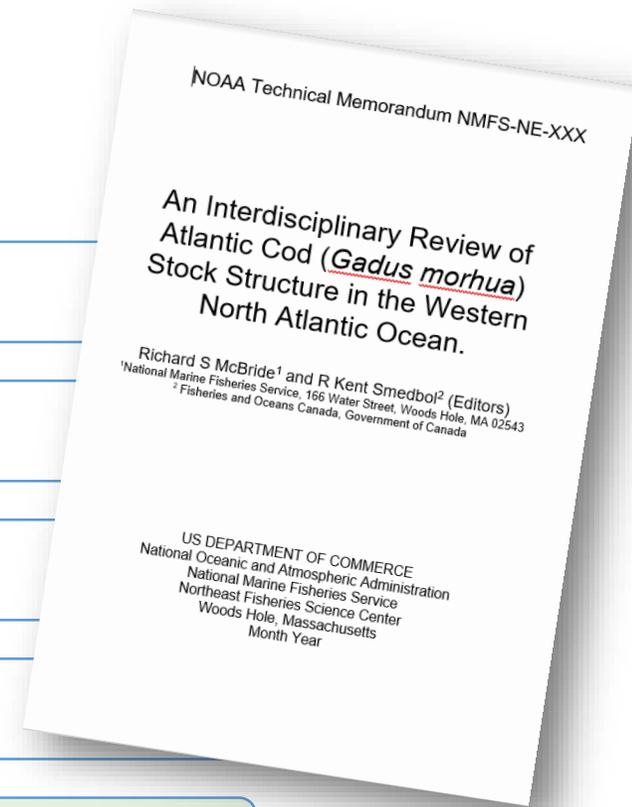
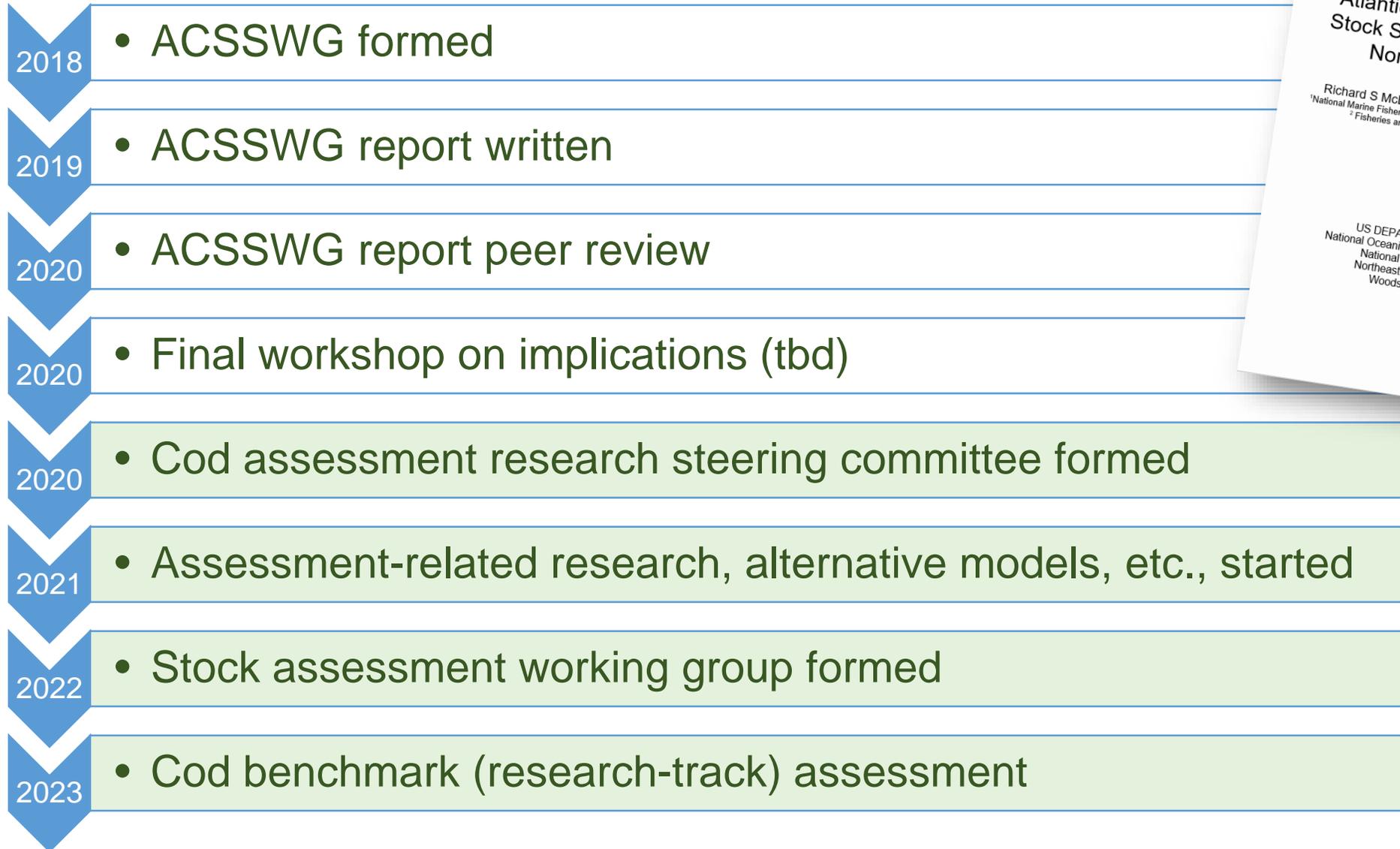


Atlantic cod stock structure working group

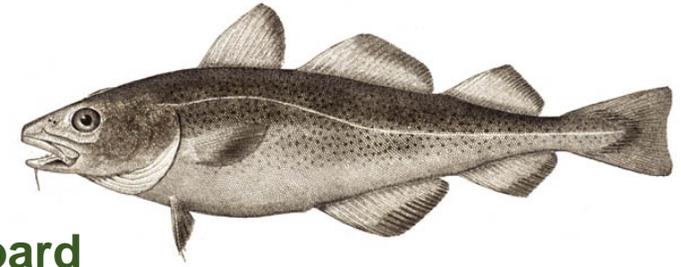
- Experts (members & partners) working collaboratively
- using an interdisciplinary approach
- to characterize the biological stock structure of cod
- for eventual consideration in monitoring, assessment and management of US Atlantic cod

The broader timeline?

You
Are
Here →



Acknowledgements



The working group

Ames, Ted

Andrushchenko, Irene

Cadrin, Steve

Cournane, Jamie

Dean, Micah

DeCelles, Greg

Kerr, Lisa

Kovach, Adrienne

McBride, Rich (co-chair)

Overgaard Therkildsen, Nina

Puncher, Greg

Smedbol, Kent (co-chair)

Wang, Yanjun

Zemeckis, Doug

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