Atlantic cod in southern New England: patterns of abundance and habitat use in a changing climate

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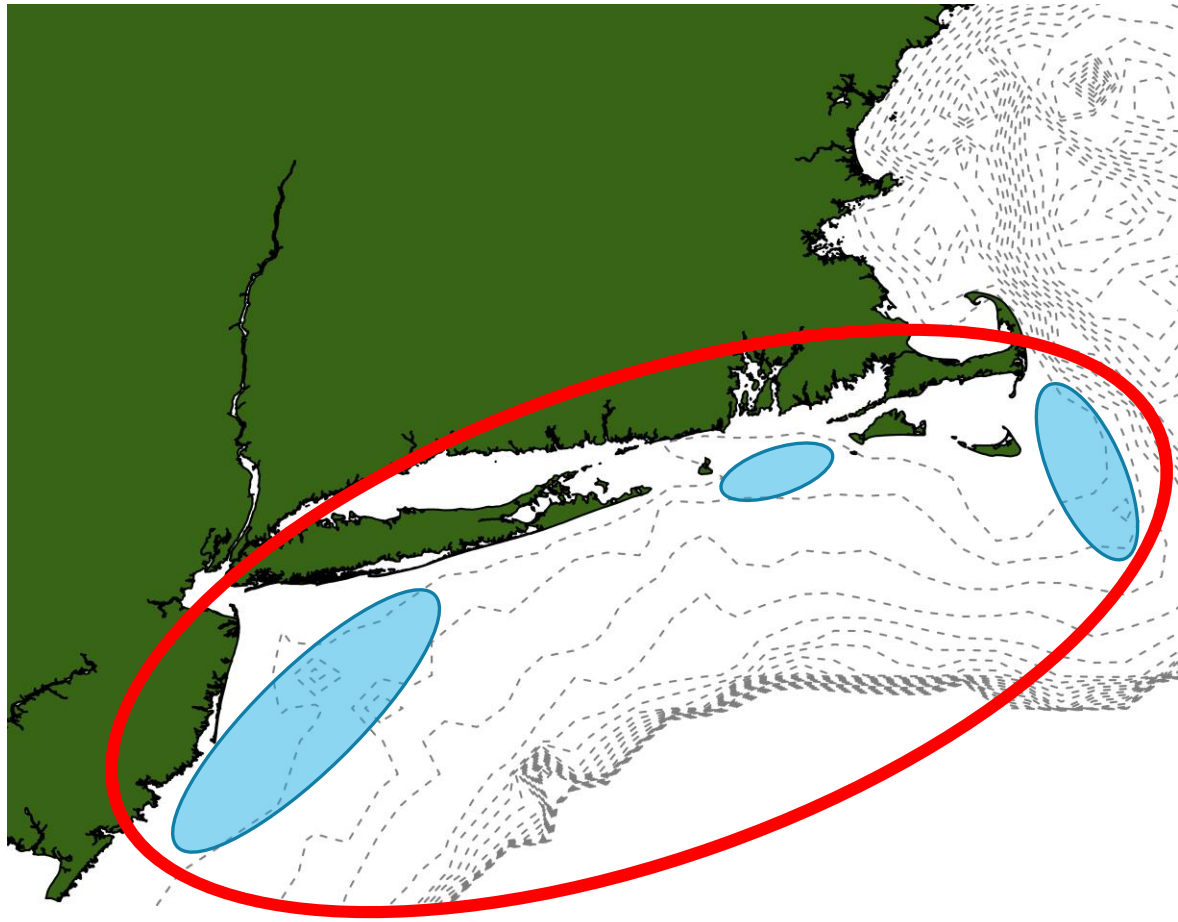
Cod in southern New England (SNE)

Documented spawning activity off RI, MA, & NJ
- World's southernmost contingent of cod
- Spawn November-March

Supported large fisheries in the past
- Still an important winter fishery
- Peak effort from December-February

Infrequently observed in federal trawl surveys

Climate change expected to negatively impact:
- Thermal habitat
- Recruitment
- Productivity/Abundance



Connectivity to Other Spawning Groups?

SNE in Georges Bank Stock unit

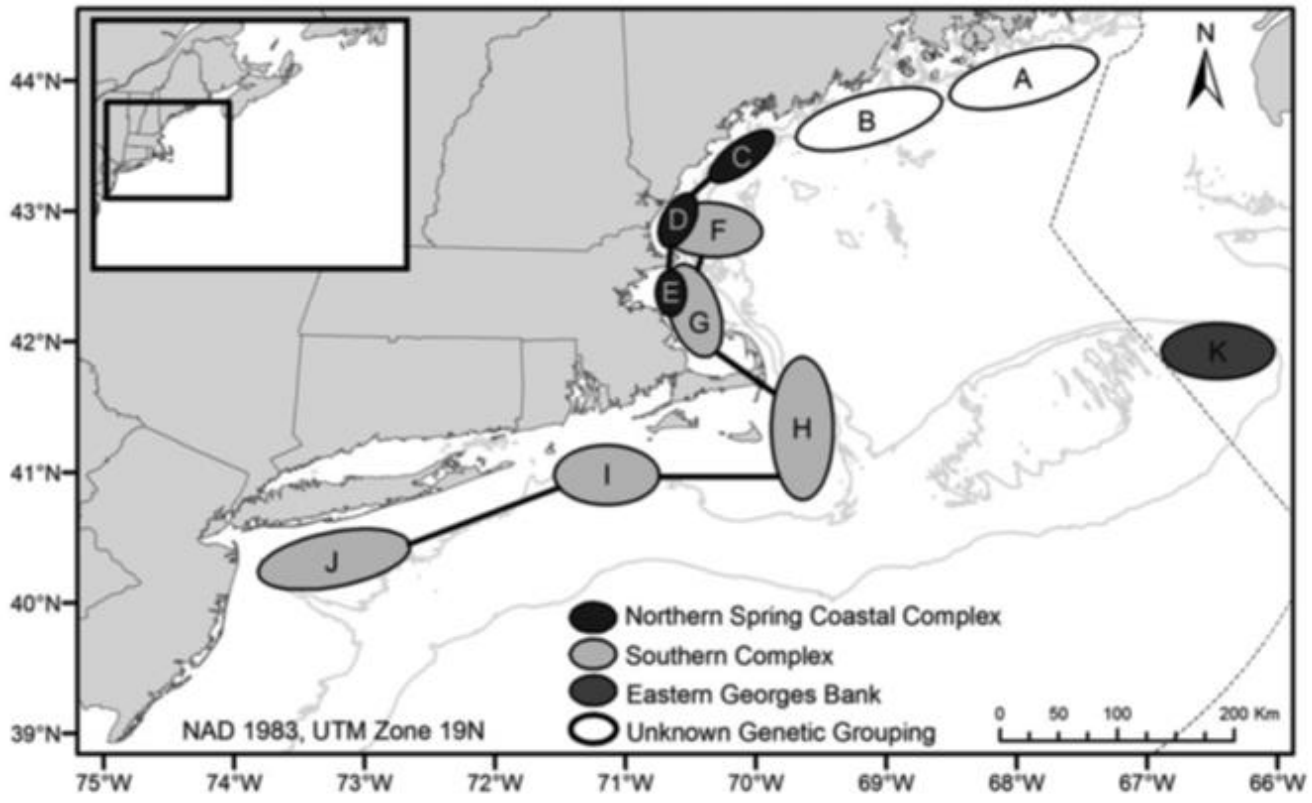
- Based on tagging experiments, landings, surveys
- Juveniles rarely caught south of Cape Cod
- NJ a separate group from MA/RI?

Dispersal models suggest larval injection:

- Possible from western Gulf of Maine
- Unlikely from Georges Bank

Genetic analyses suggest SNE/NJ related to winter spawners in western Gulf of Maine

Is SNE self-sustaining?

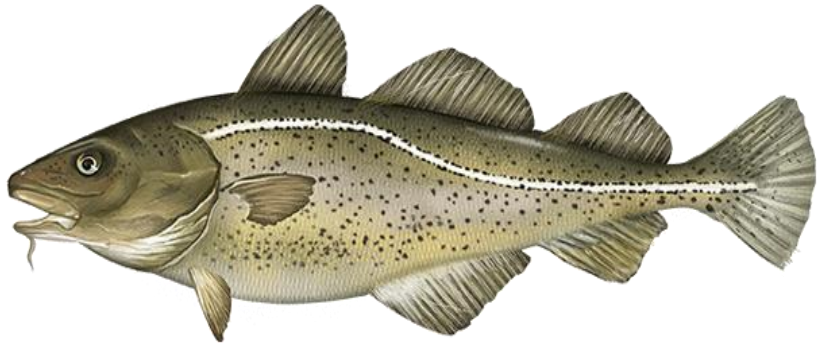


Zemeckis et al. 2014

Are Cod Increasing in southern New England?!?

PC: Frances Fleet

Objectives

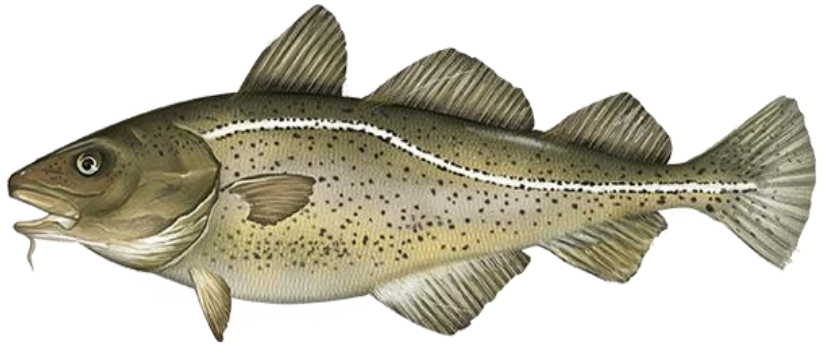


I. Characterize SNE cod distribution and patterns of habitat use throughout the life cycle

II. Evaluate population trends in the region

III. Identify environmental factors that influence cod abundance/variability

Data Sources

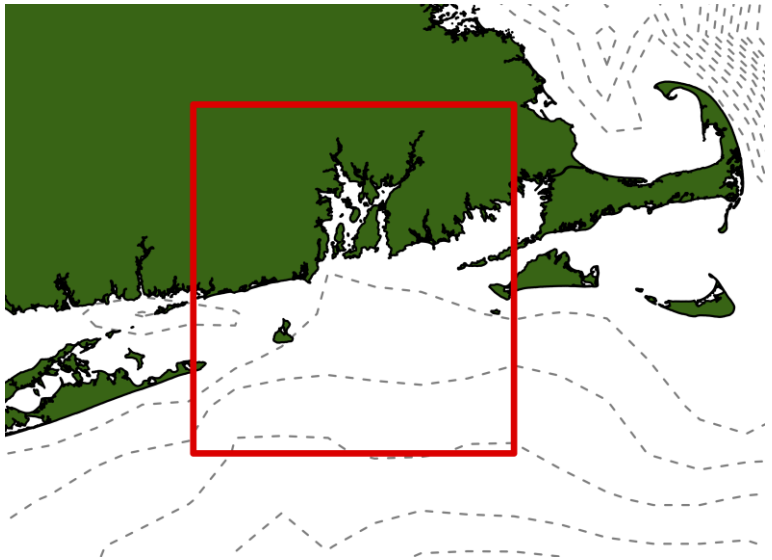


Larvae

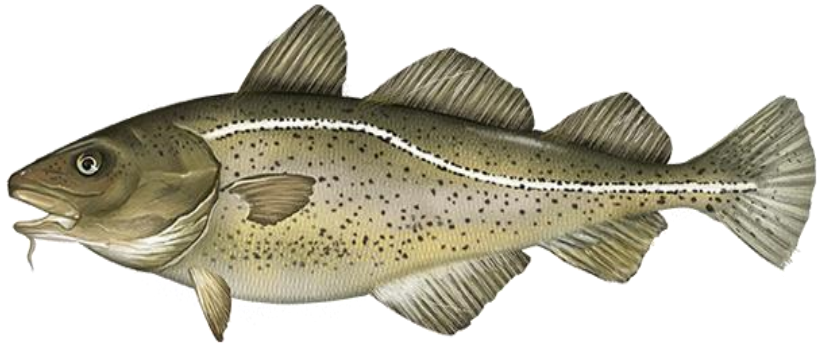
- RIDEM ichthyoplankton survey (biweekly year-round, 2001-2008)
  - 15 stations in Narragansett Bay, recorded larval densities
- URIGSO/RIDEM follow-up survey (weekly mid-February to mid-April, 2016-2017)
  - 15 stations in Narragansett Bay (14 overlapping with 2001-2008), recorded larval counts and total lengths

Young-of-the-year (YOY, <20cm)

- RIDEM monthly trawl survey (1990-2018)
  - 13 fixed stations in Narragansett Bay
- RIDEM seasonal trawl survey (1979-2018)
  - 13 fixed + ~30 random stations throughout RI state waters

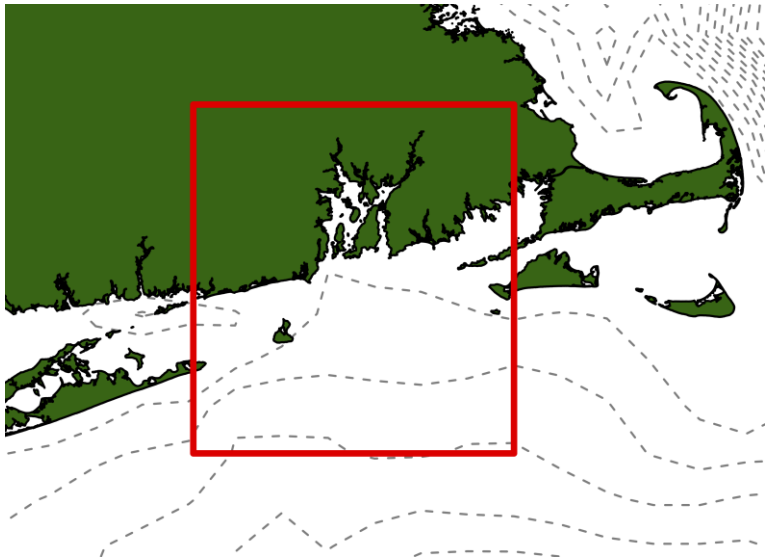


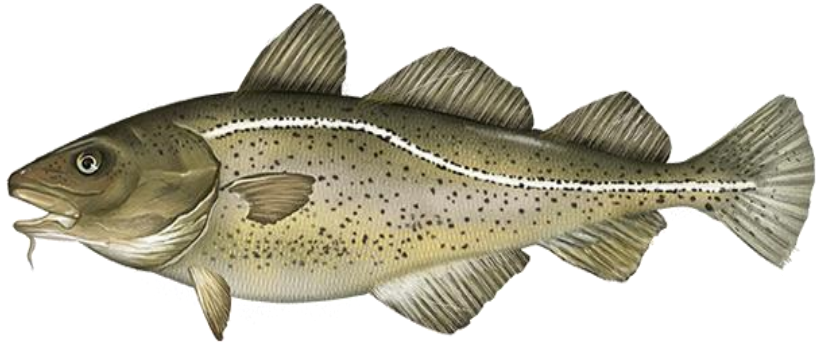
Data Sources



Juveniles (20-37cm) and Adults

- RIDEM monthly and seasonal trawl surveys
- URIGSO weekly trawl survey (1959-2016)***
  - 2 stations in Narragansett Bay
- RI MRIP and VTR (Area 539) landings reports





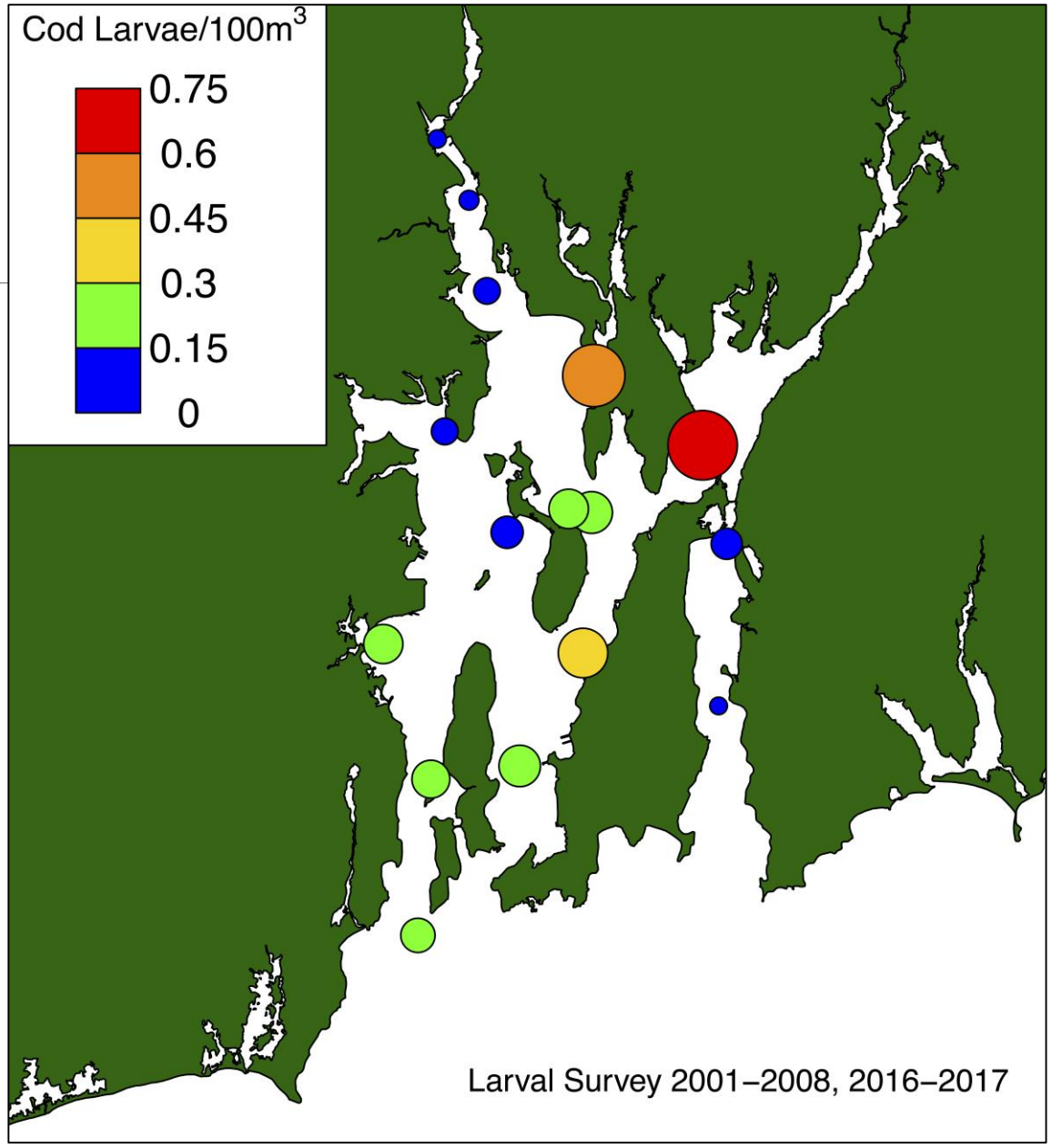
Objective I:
Distribution and patterns of habitat use

Larvae

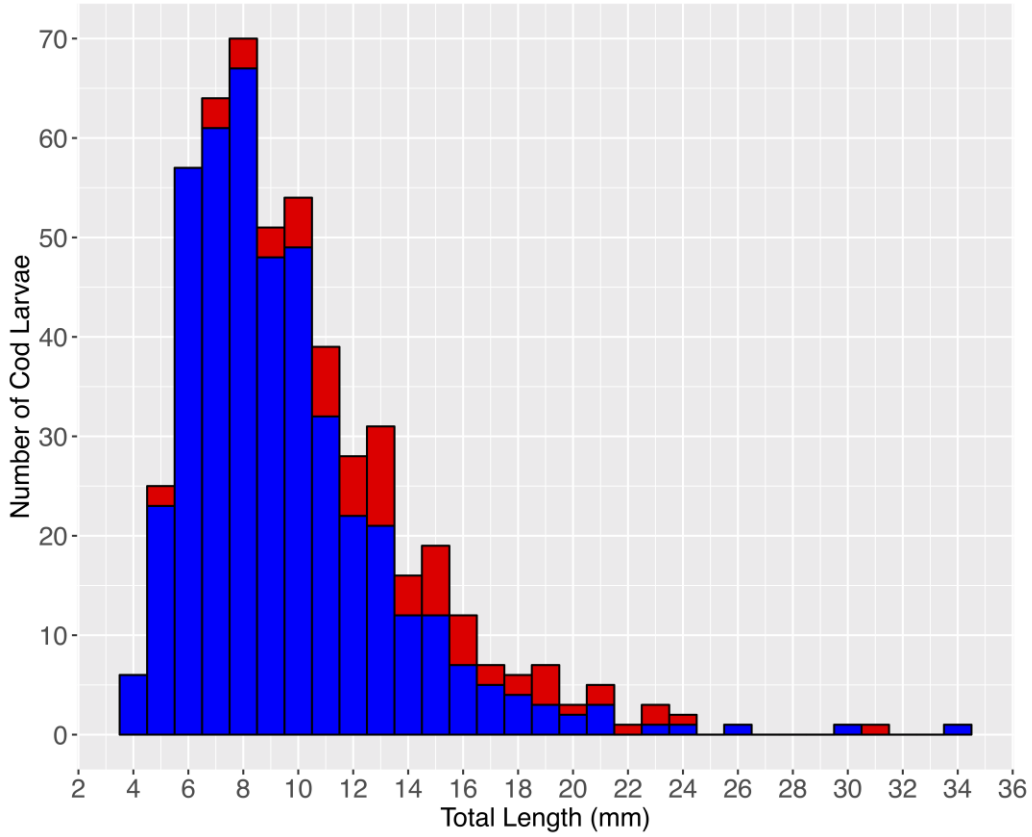
Cod larvae throughout Narragansett Bay

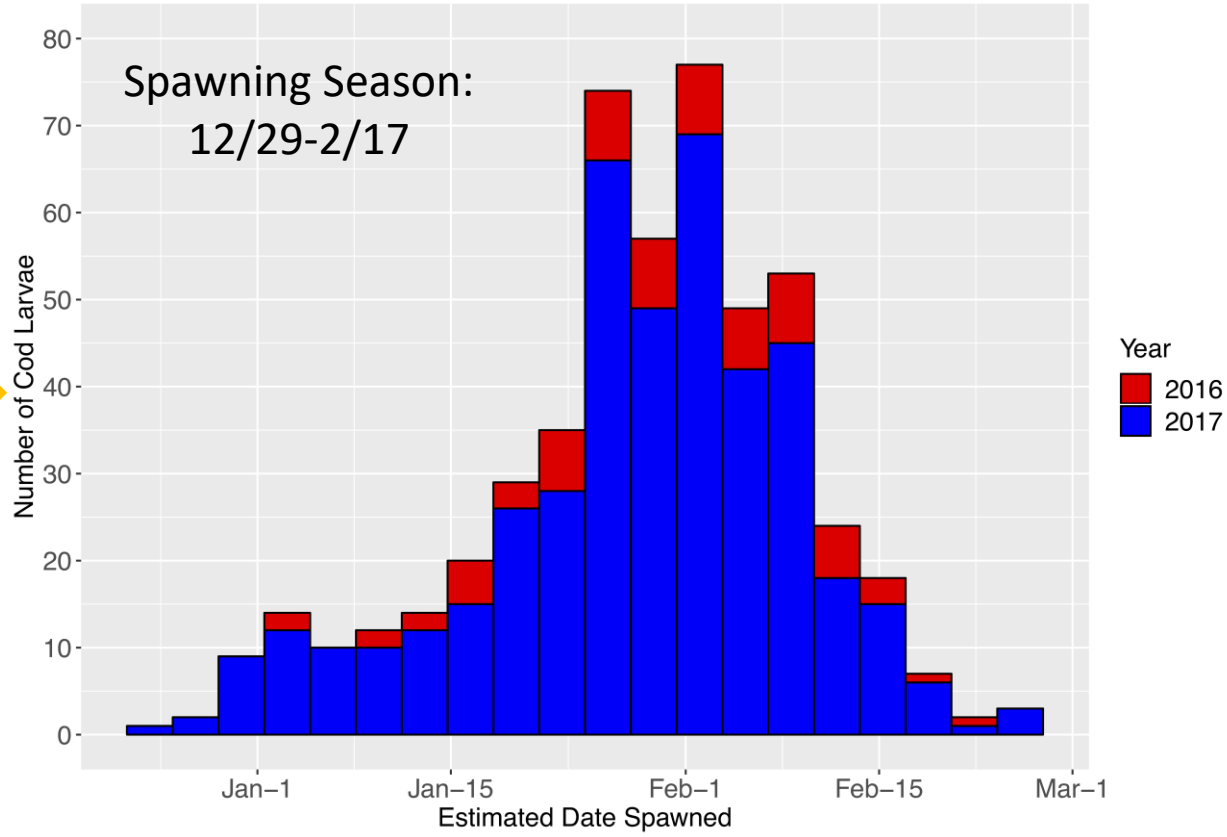
2016-2017 density > 2001-2008 density

High interannual variability



Cod Larvae Length Frequencies





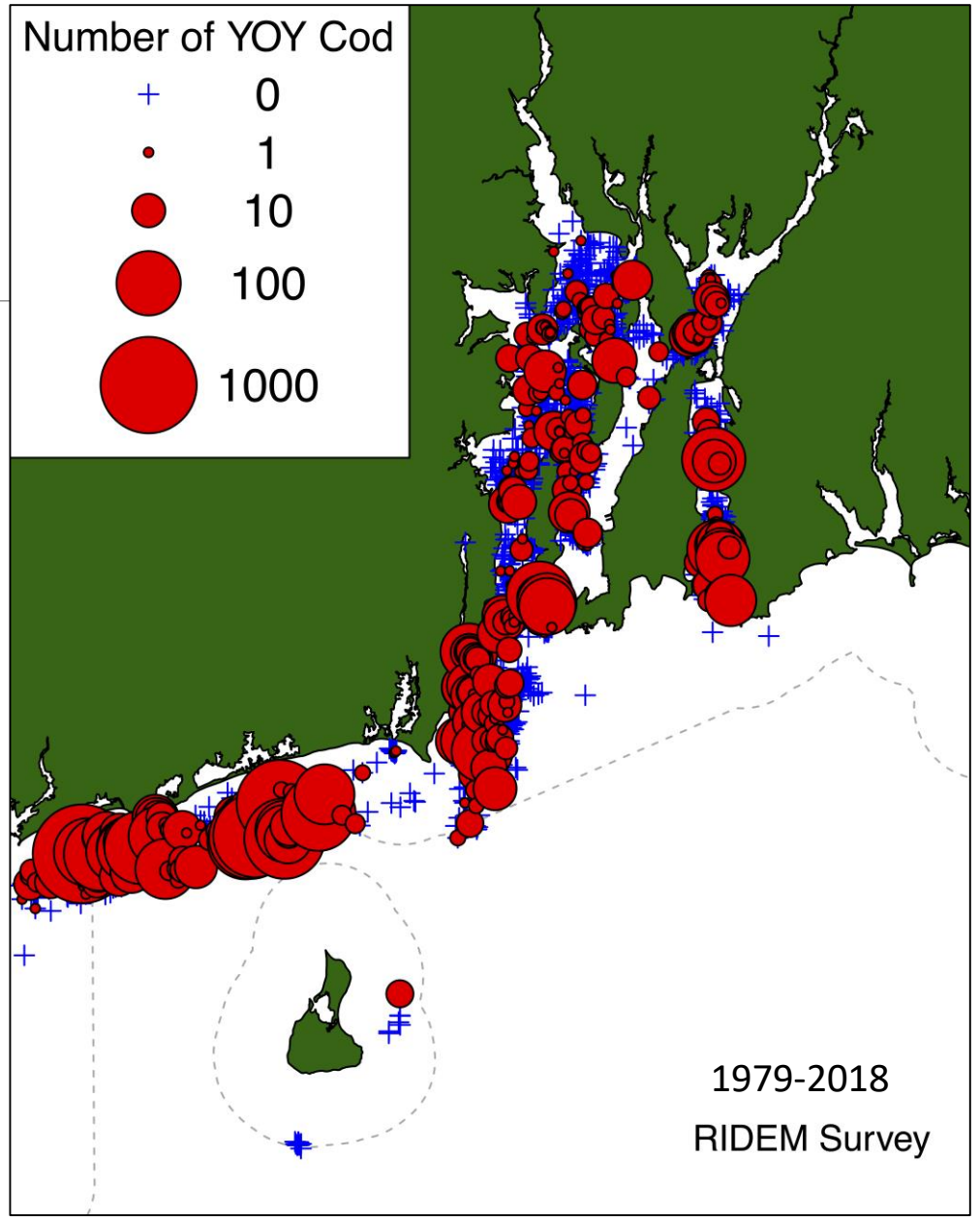
Green et al. 2004

YOY Cod (<20cm)

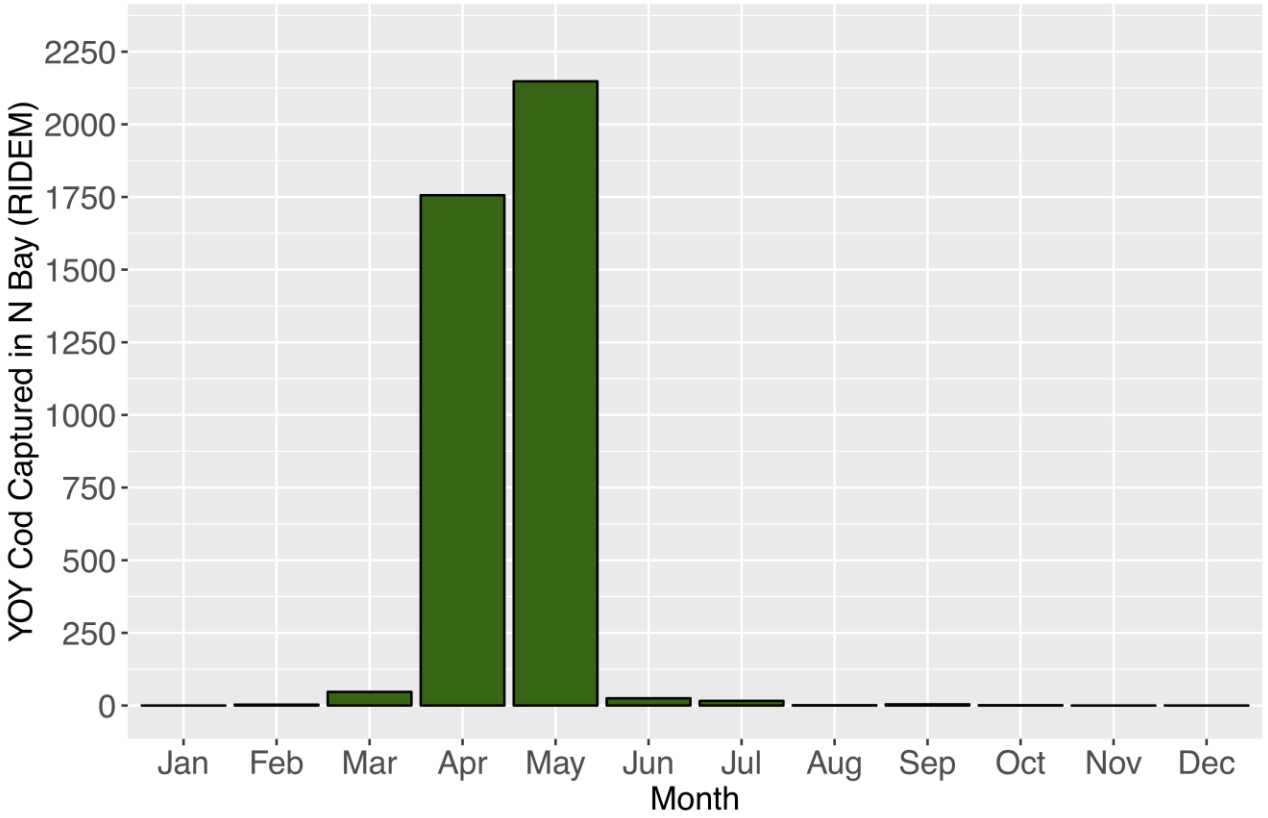
They’re everywhere!

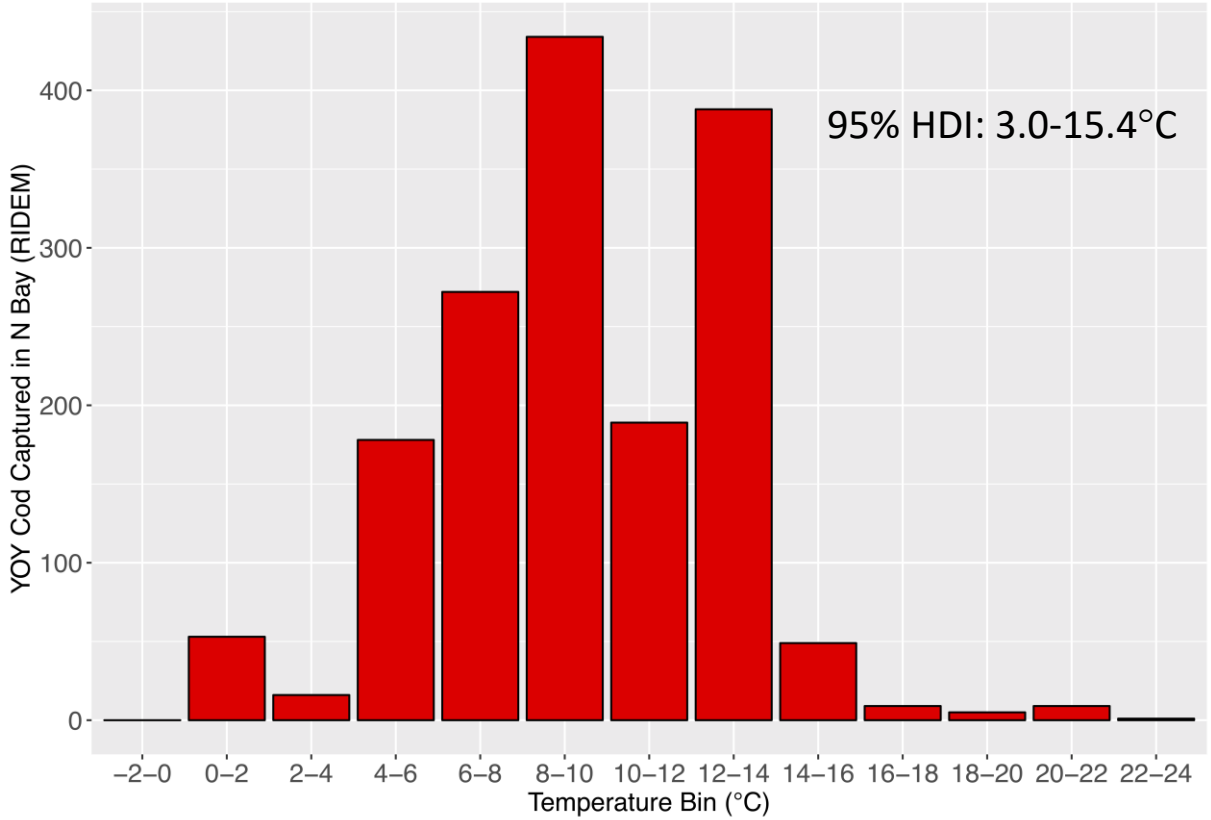
Most abundant outside Narragansett Bay

No clear depth/sediment association



YOY Cod (<20cm)

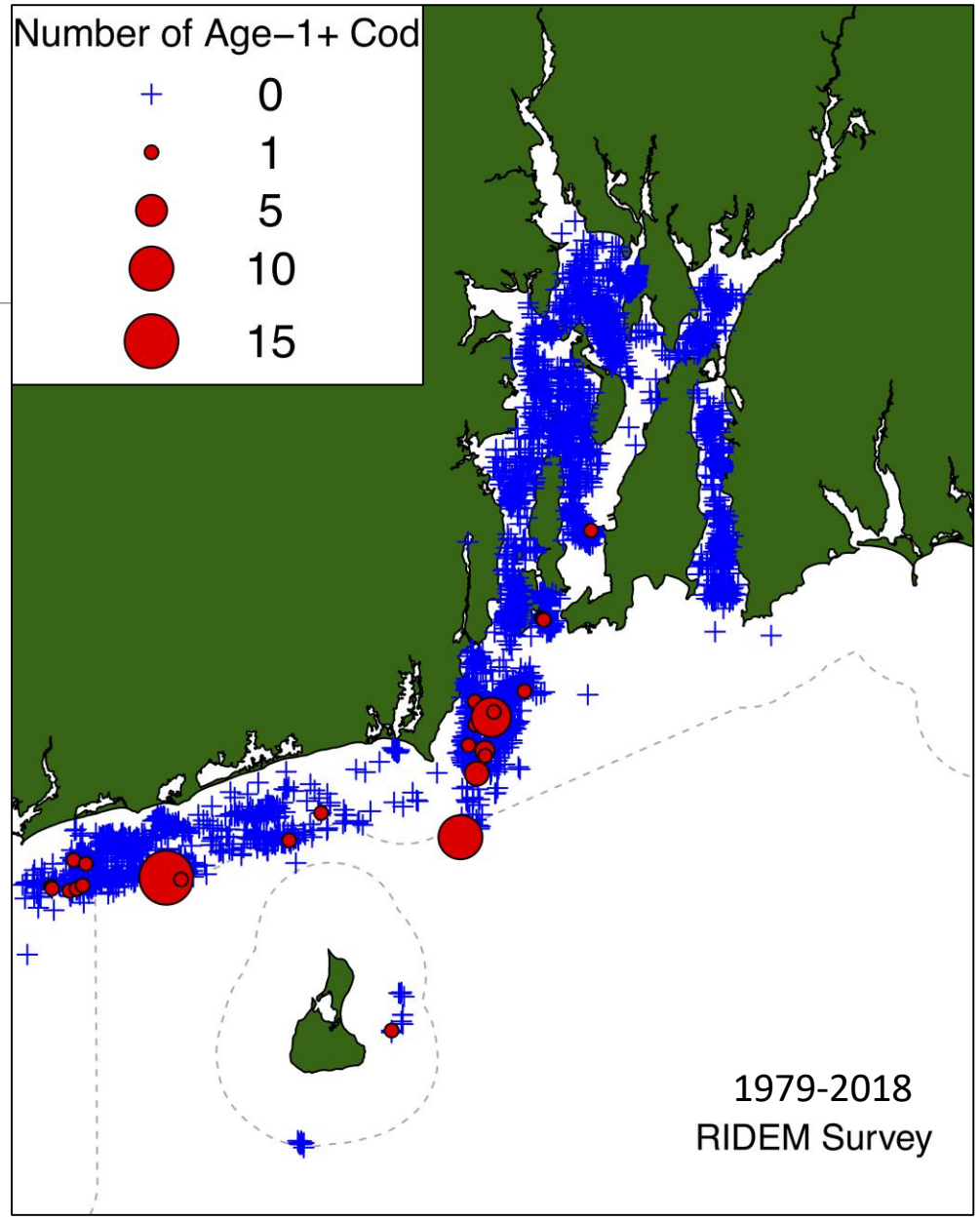

YOY Cod Captured in N Bay (RIDEM)
2250
2000
1750
1500
1250
1000
750
500
250
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


95% HDI: 3.0-15.4°C
YOY Cod Captured in N Bay (RIDEM)
400
300
200
100
0
−2–0
0–2
2–4
4–6
6–8
8–10
10–12
12–14
14–16
16–18
18–20
20–22
22–24
Temperature Bin (°C)

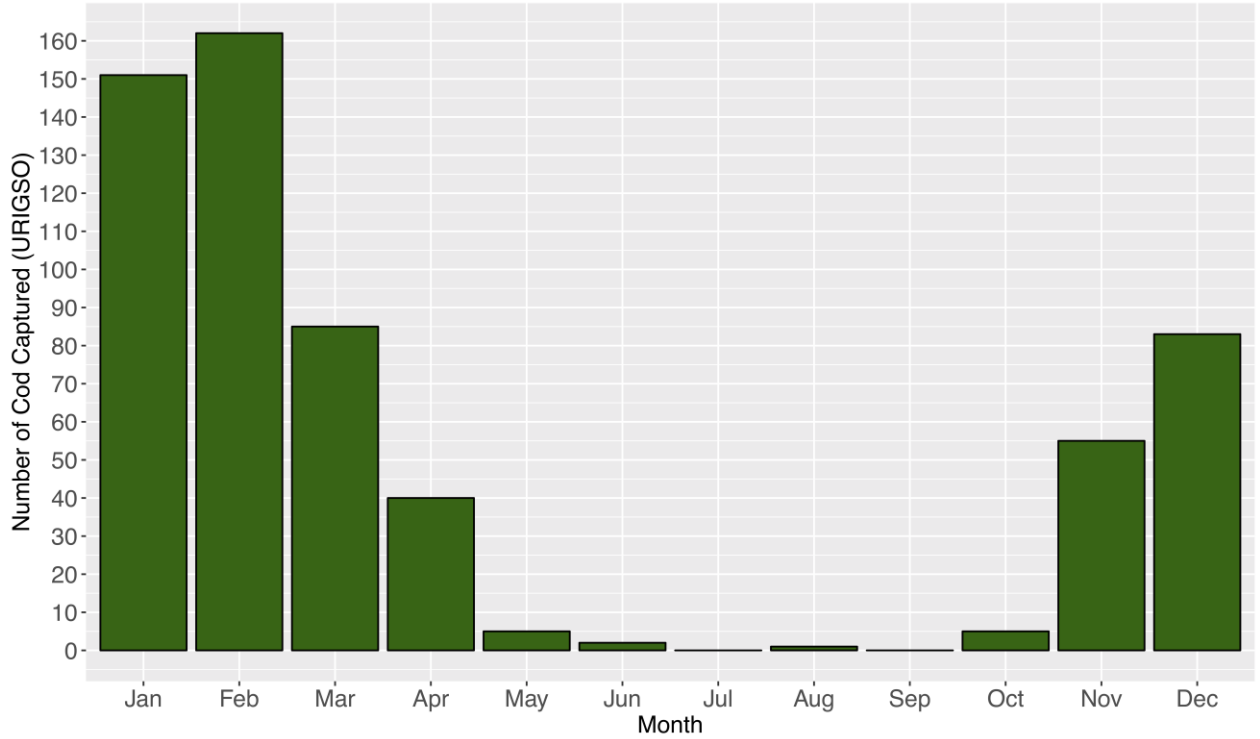
Juveniles and Adults

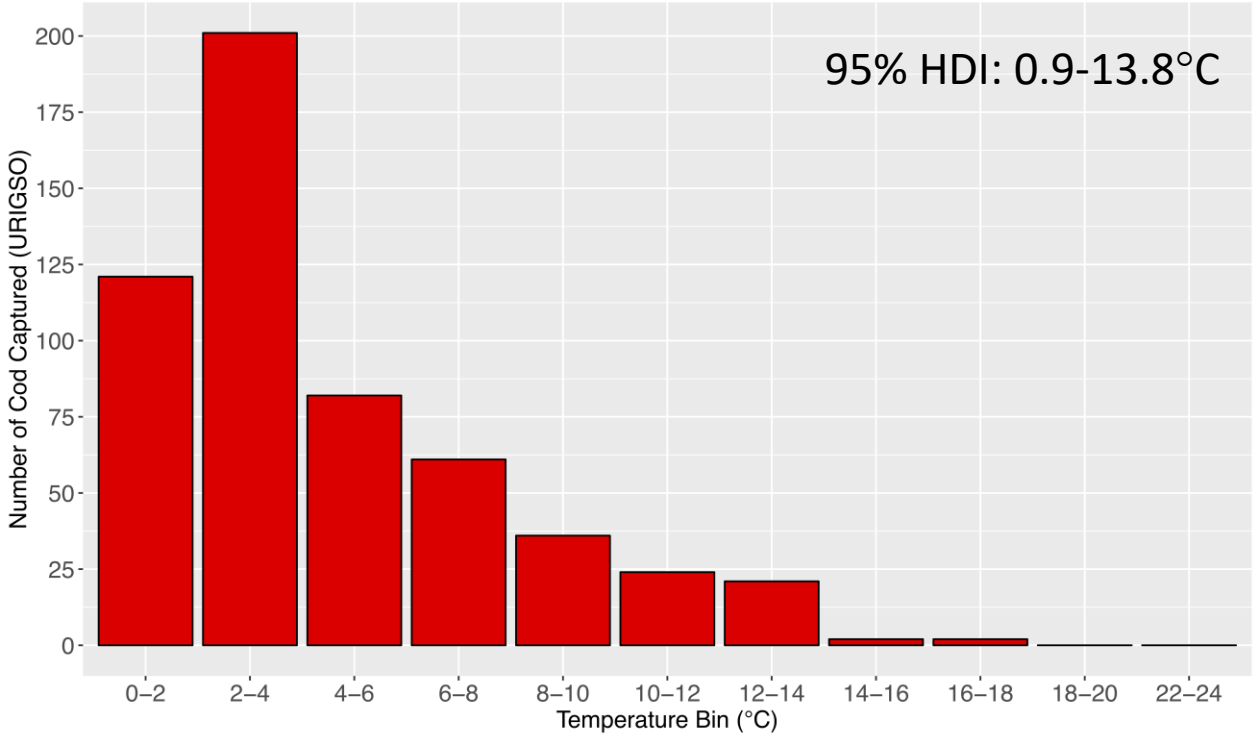
Less frequently observed in state waters

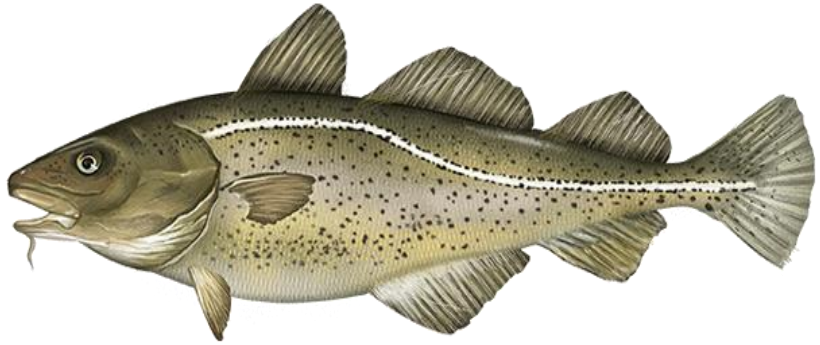
Only captured in deeper areas



Juveniles and Adults (1959-2018)







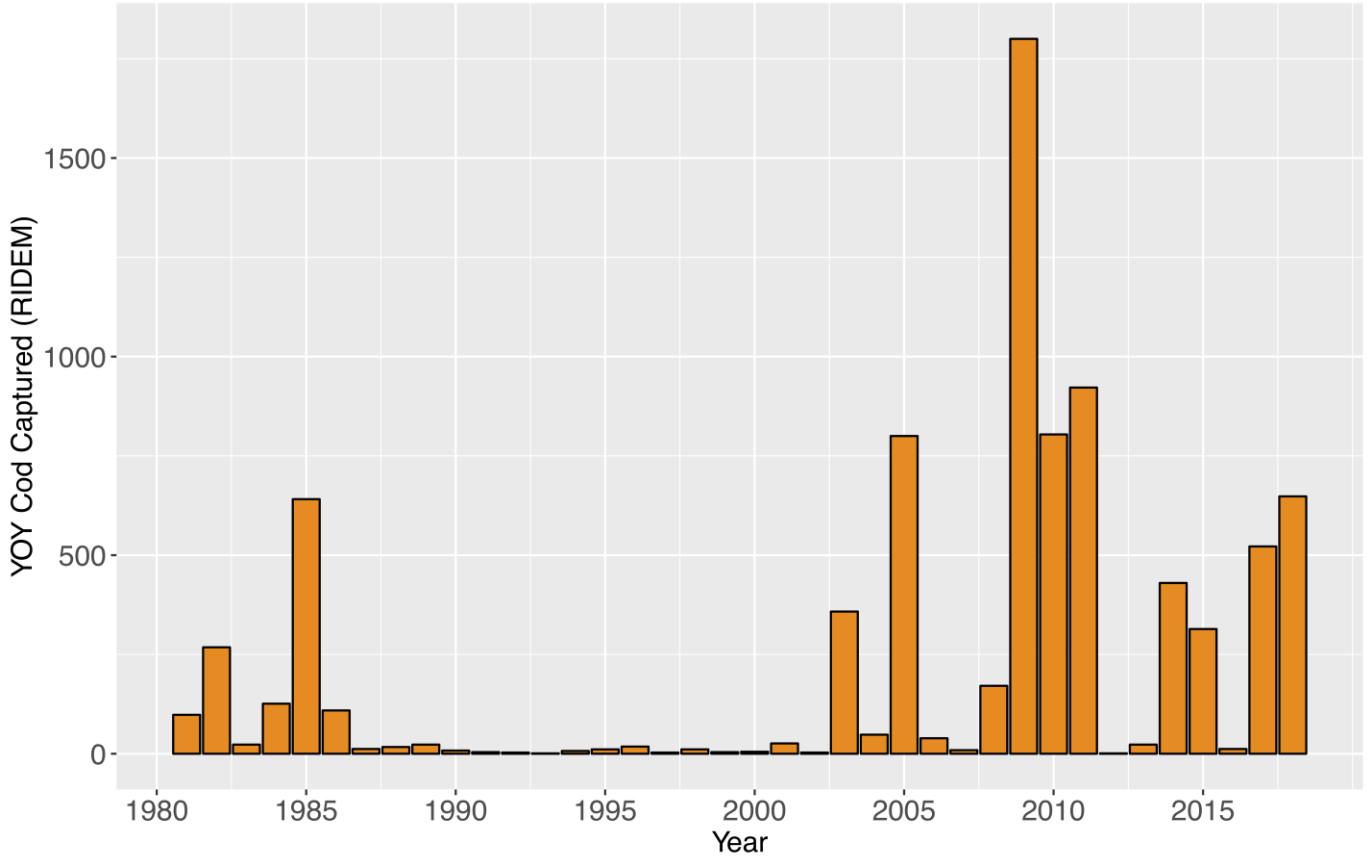
Objective II:
Evaluate Population Trends

YOY Cod

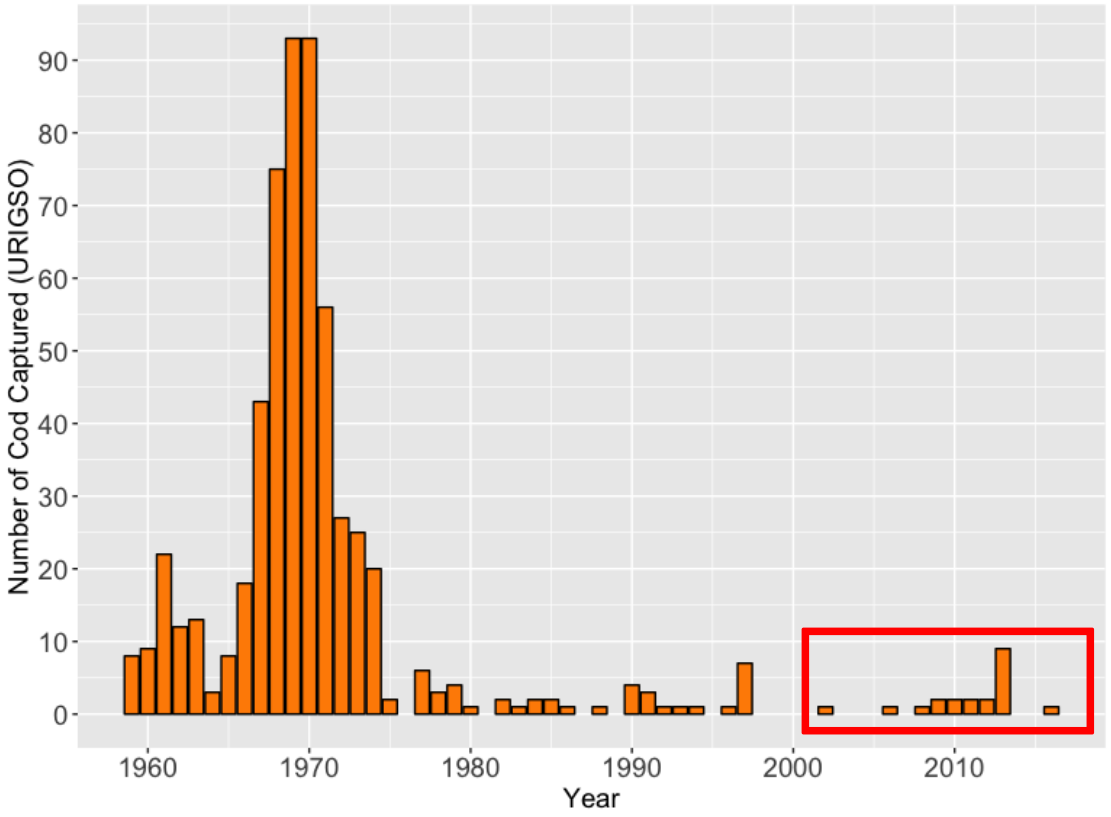
Period of high abundance began ~2000

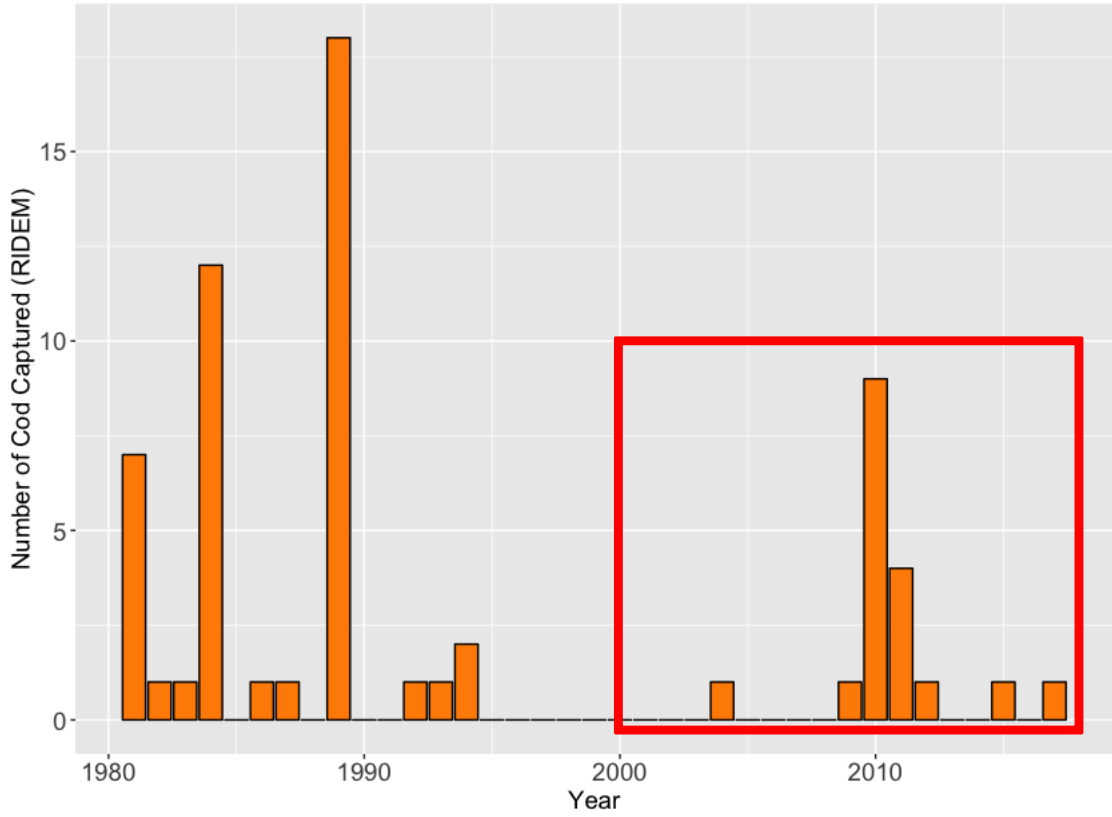
High variance from year to year

Unclear if YOY abundance reflects SSB

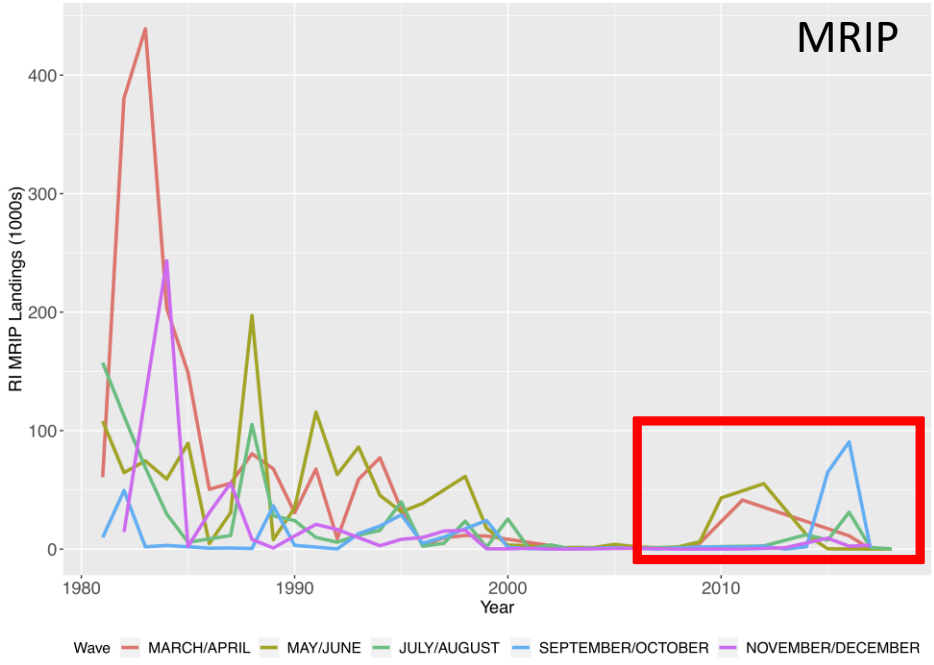


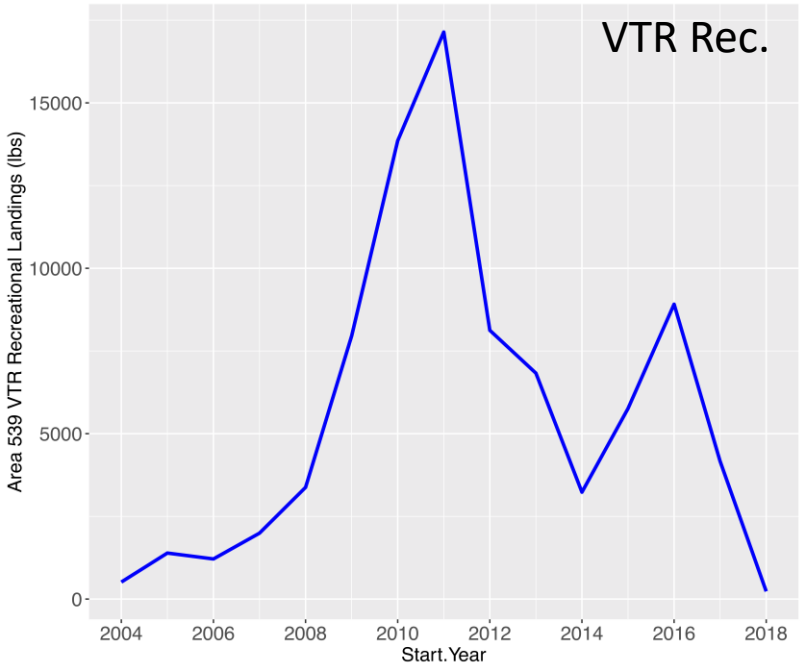
Juveniles and Adults

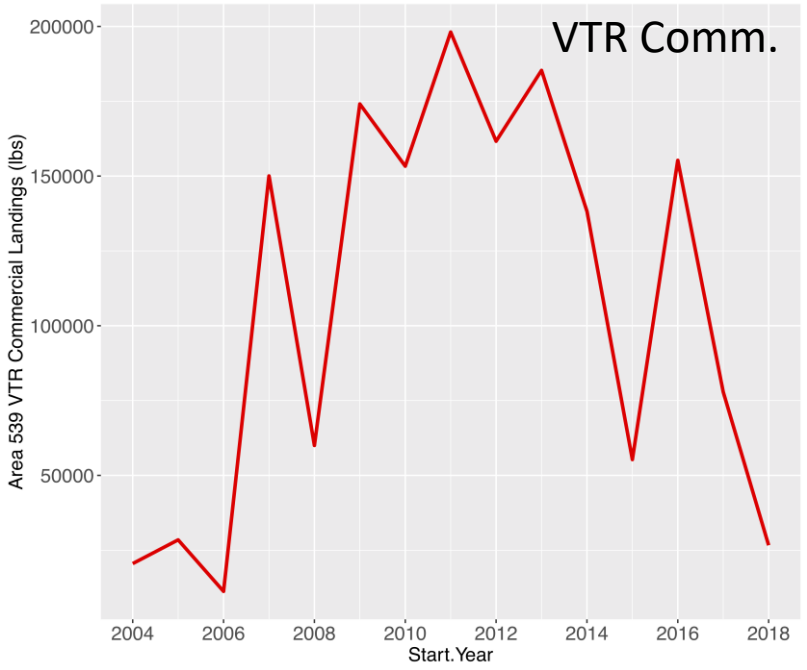


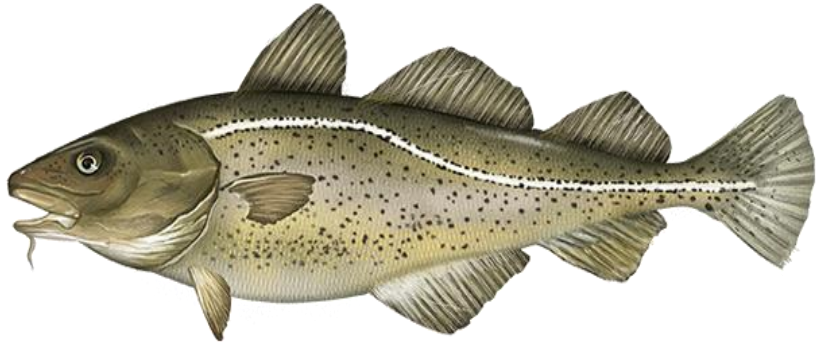


Fisheries-Dependent Data









Objective III:
Impacts of Climate Change

Temperature Preferences

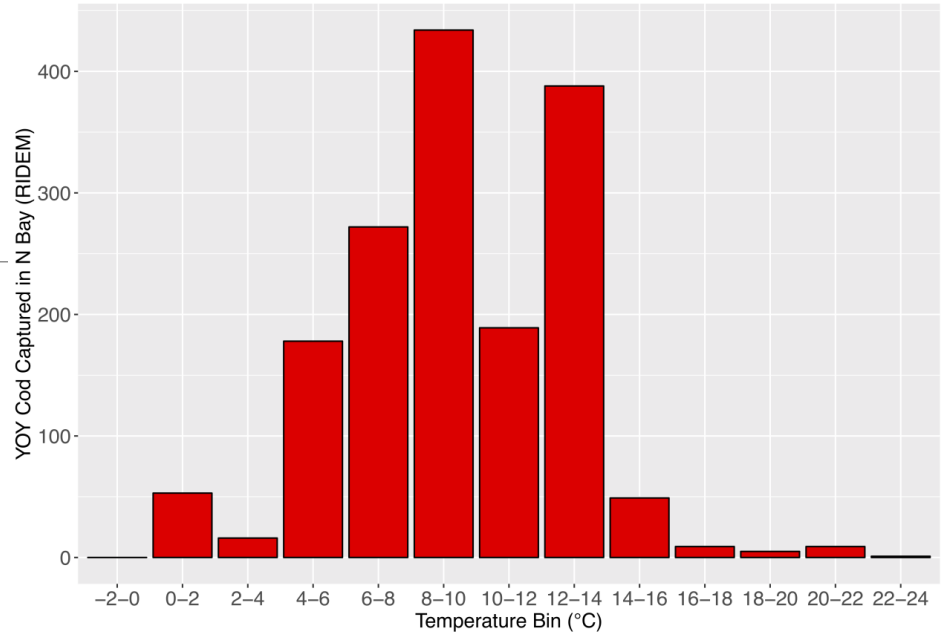
Fahay et al. (1999), Righton et al. (2010)

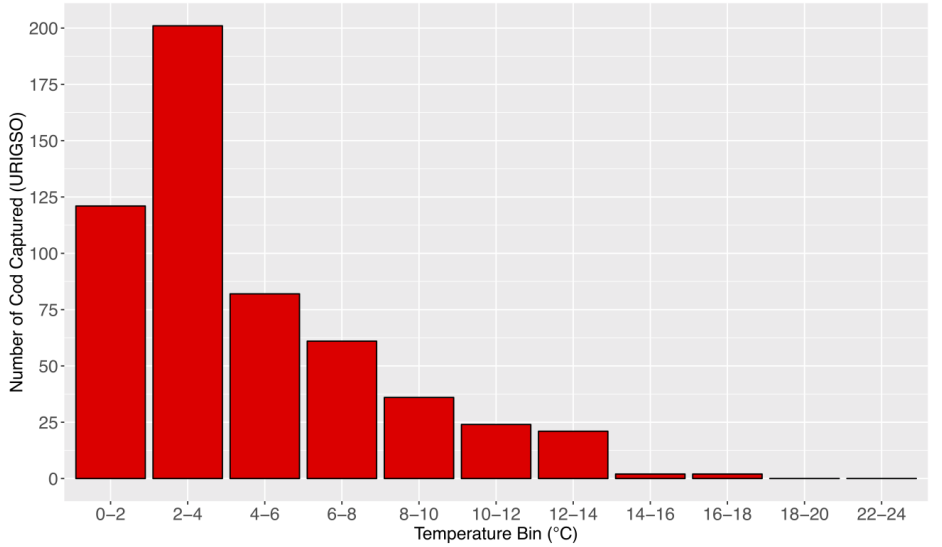
- Juveniles: prefer 7-12°C, can tolerate up to 20°C
- Adults: prefer 7-15°C

Our Data

- YOY 95% HDI: 3.0-15.4°C
- Juveniles & Adults 95% HDI: 0.9-13.8°C

No evidence of increased tolerance of warm temperatures

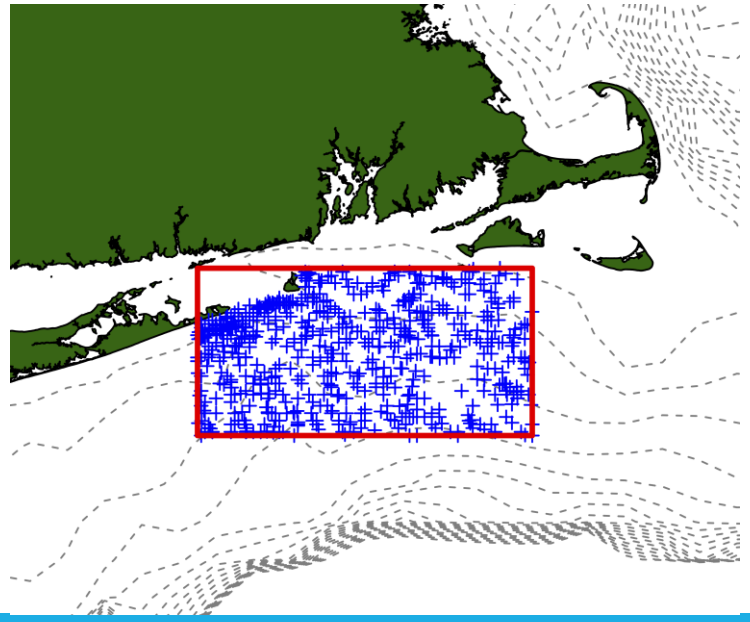


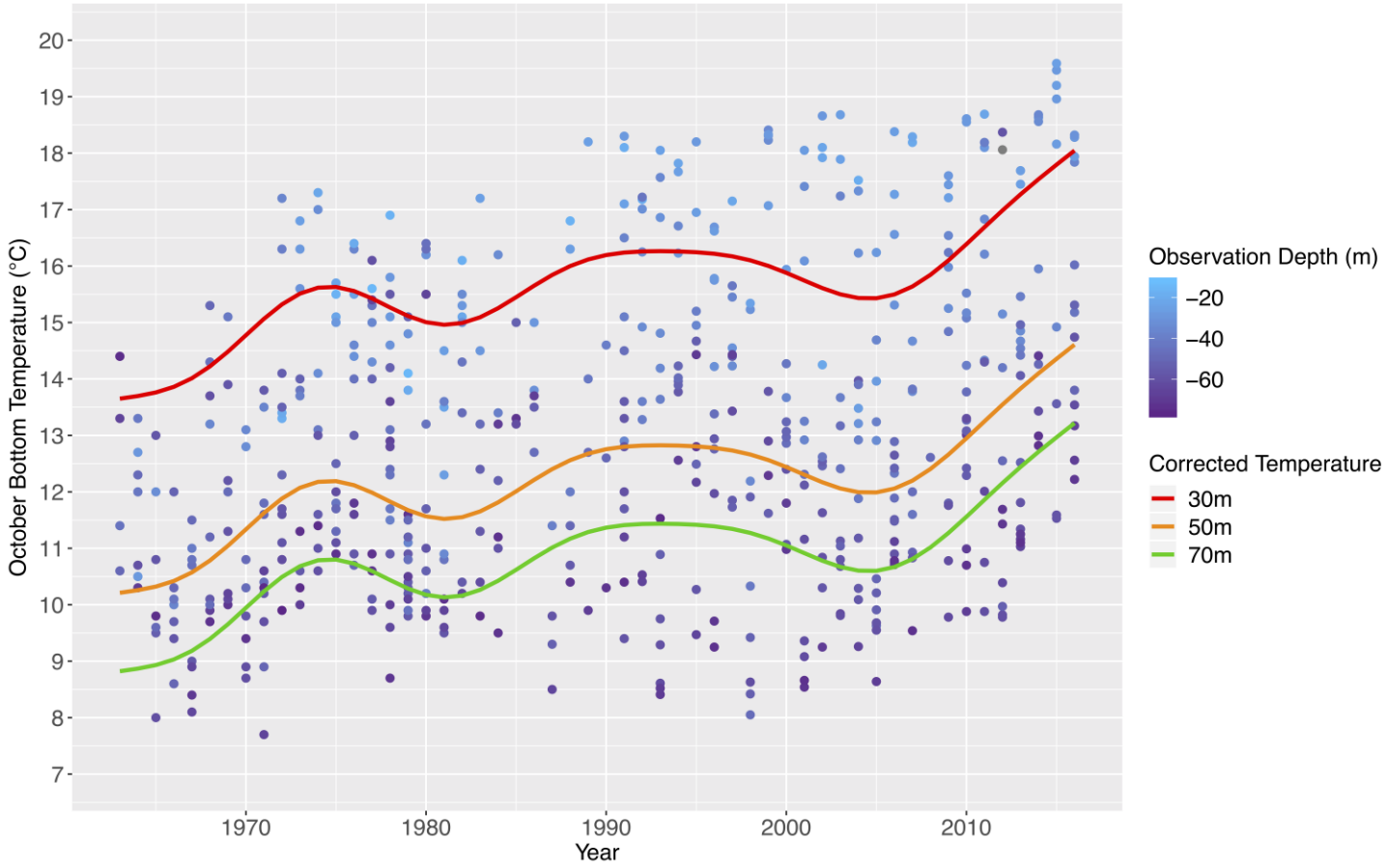


October Shelf Bottom Temperature

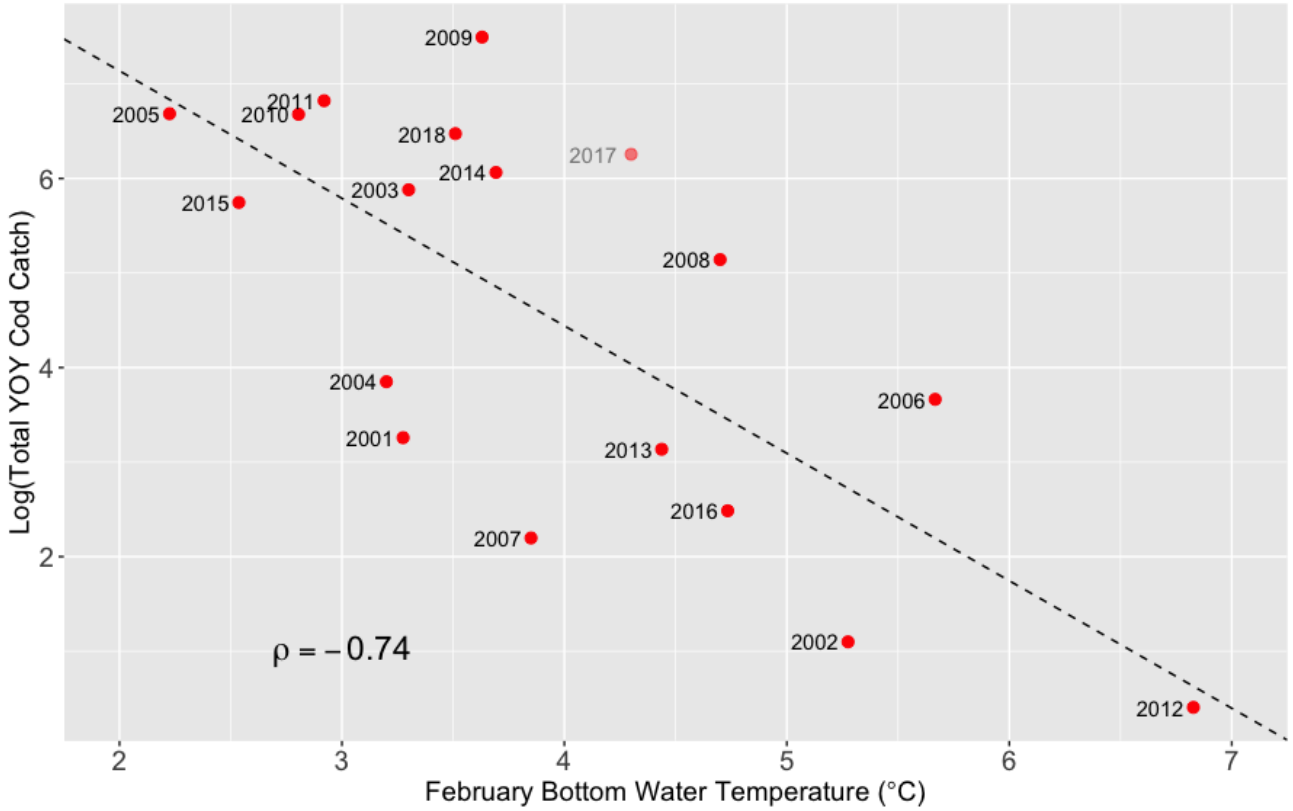
NEFSC Fall Bottom Trawl Survey
40.5-41.25°N, 70.5-72°W
Observations: 12-77m

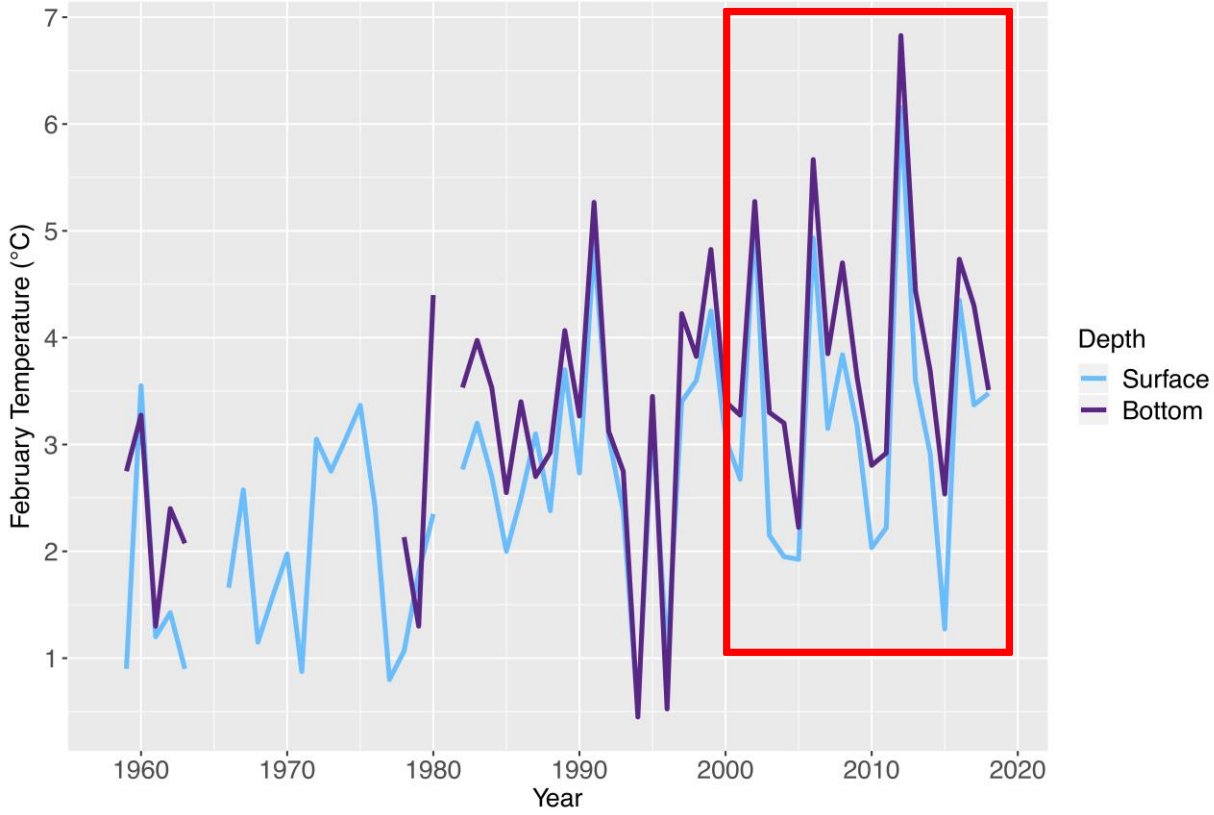
Corrected for day and depth via GAM



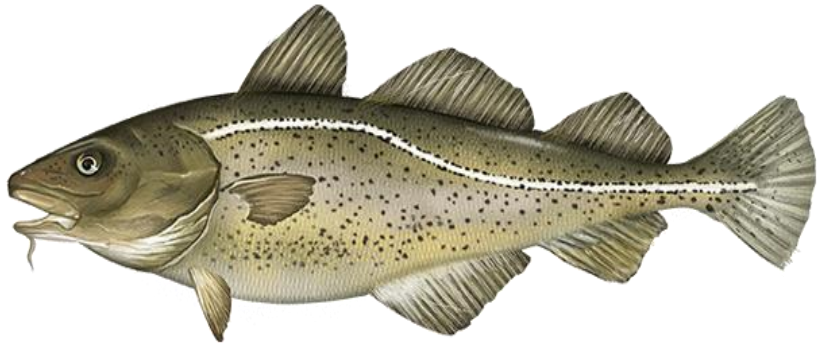


February Temperature vs. YOY Cod Catch





Summary



Cod likely complete their life cycle in SNE waters

Self-sustaining sub-population?

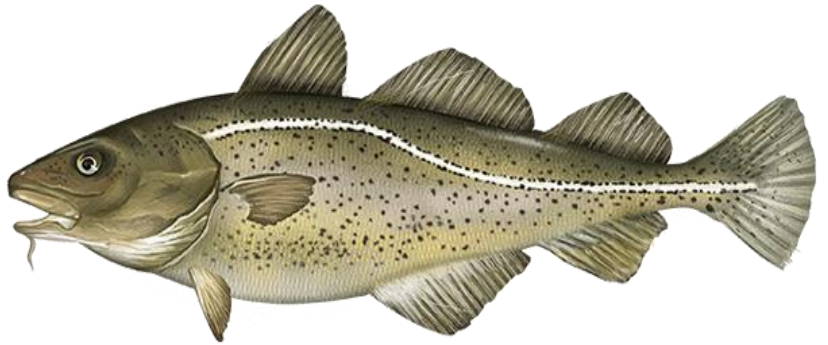
SNE cod have increased since 2000

YOY cod abundance is negatively correlated to February temperature

Observed temperature preferences suggest thermal habitat is constrained in summer

If climate change is having the hypothesized effect, how did the sub-population increase???

Research Needs



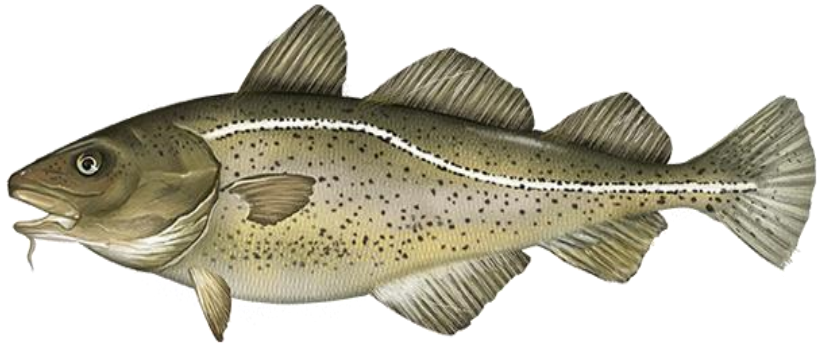
I. Clarify relationship to other spawning groups

II. Characterize abundance and spatial/thermal habitat use patterns

III. Determine role of cod in the SNE food web

IV. Elucidate how SNE cod population dynamics interact with climate change
    i. Is the response of cod to climate change more complicated than originally thought?

Acknowledgements



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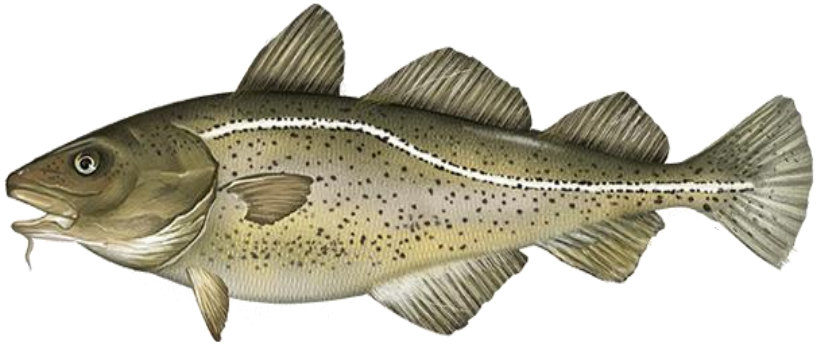
Questions?



RI Landings vs. Trawl Surveys