Atlantic cod stock structure in US waters: Natural Markers

The Atlantic Cod Stock Structure Working Group (ACSSWG)
Presenter: Lisa Kerr, Gulf of Maine Research Institute

New England Fishery Management Council Peer Review

ACSSWG peer review, May 18-19, 2020

Outline

- Background on natural markers.

- Review of natural markers application to Atlantic cod.

- Conclusions on natural markers application to Atlantic cod.

The Team:
L. Kerr, G. DeCelles, G. Puncher, S. Cadrin, R. McBride
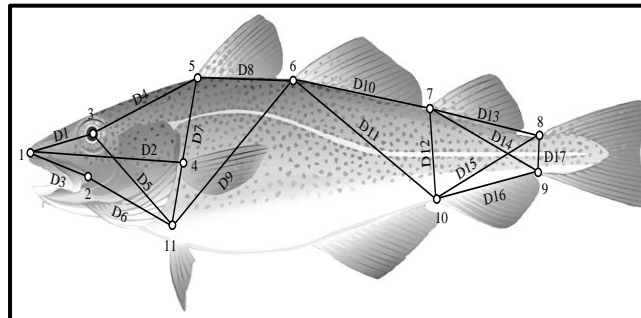
Natural Markers

- Natural markers are naturally-induced characteristics that can be used to identify members of a population or more discrete grouping.

- Phenotypic traits reflect genetic and environmental influences.

- Many different natural makers have been used to identify fish populations.
  - Body characteristics   - Tissue characteristics
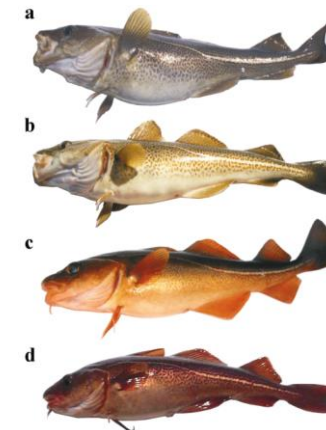 - Otolith characteristics   - Other features, such as parasites.
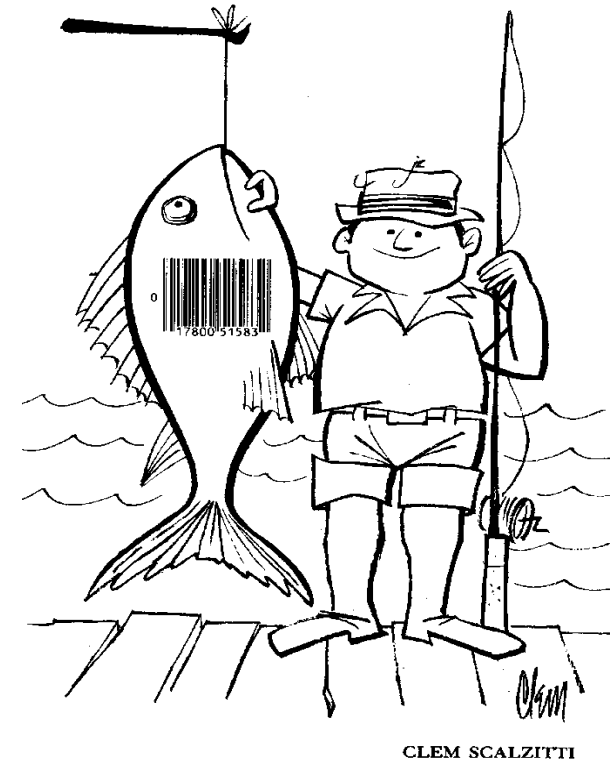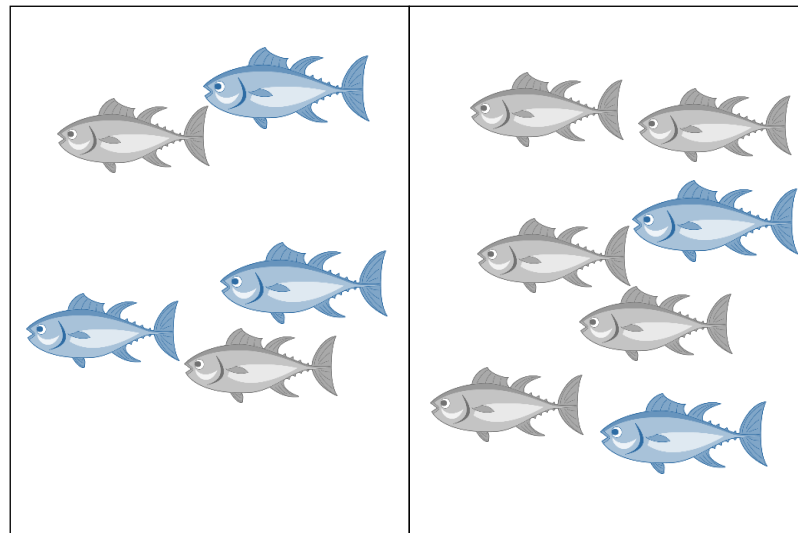
Otoliths
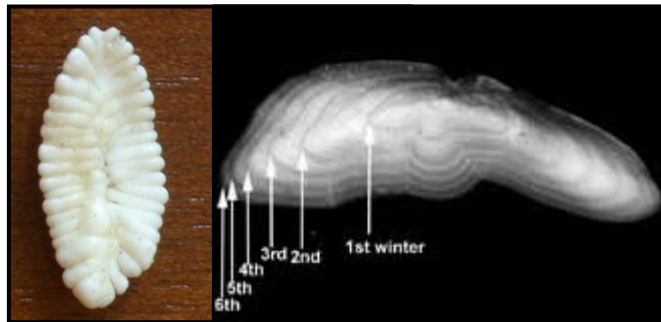
Body Shape

Color Variation

What can we learn from Natural Markers

- Once we establish that a natural marker "works", we can apply the marker in mixed stock analysis.
- Mixed stock analysis: provides estimates of origin of fish in mixed catch.
- This information has been used in

  assessment and management of other species.

CLEM SCALZITTI

Application of Natural Markers to Atlantic Cod

Application of natural markers to the study of Atlantic cod stock structure in the northwest Atlantic.

Otolith characteristics:

Structure

Chemistry

Shape

Body characteristics:

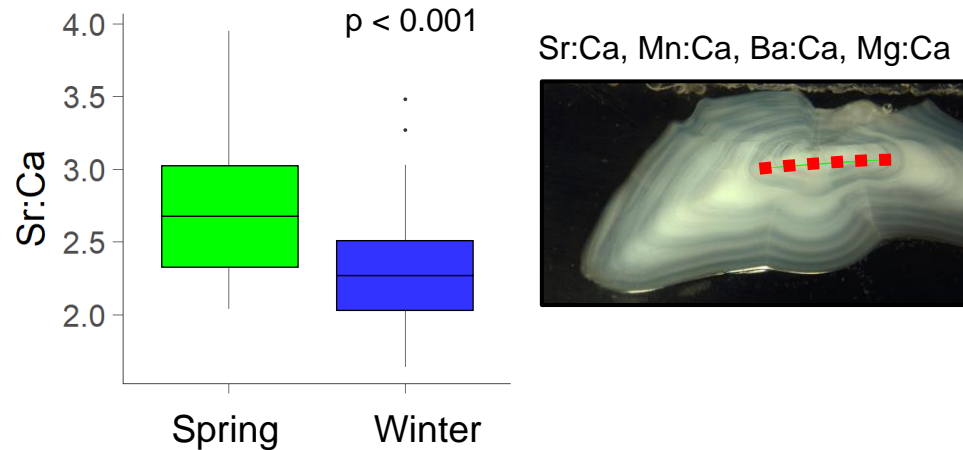Color type

Morphometrics

Meristics

Parasites

**Tissue characteristics:**

Stable isotopes concentrations

Fatty acid profiles

Otolith Chemistry

Chemical composition of
year one otolith growth

Sr:Ca, Mn:Ca, Ba:Ca, Mg:Ca

- Several examples of past applications of otolith chemistry to cod, primarily in Canadian waters, support the utility of this natural marker.

- Recent application indicated significant differences in elemental ratios of winter and spring spawners in western Gulf of Maine (74% accuracy, Kerr et al 2018).

- Mixed stock analysis revealed the recent composition of fish was dominated by winter spawners.
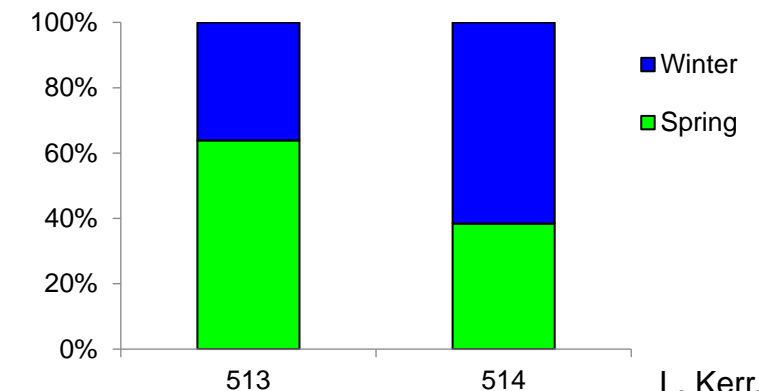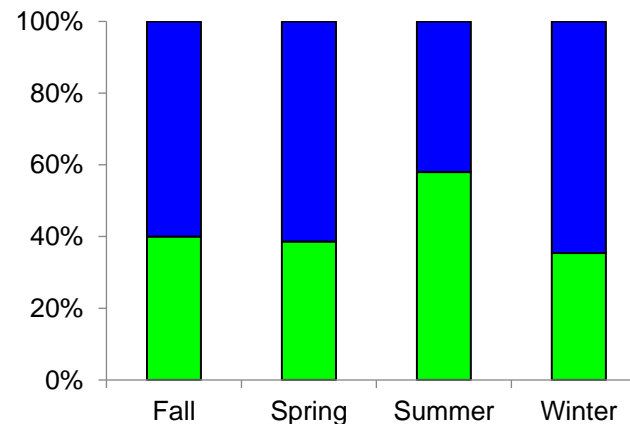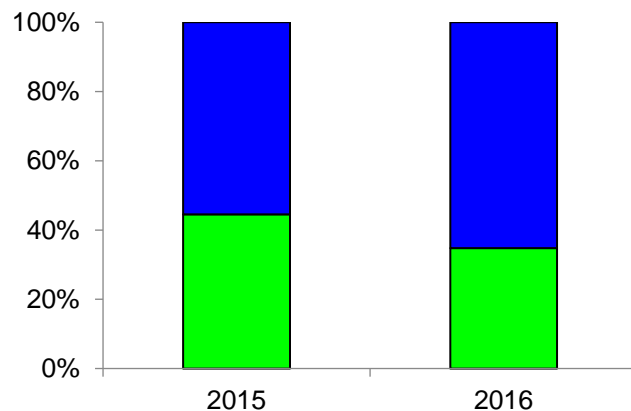
Otolith Structure

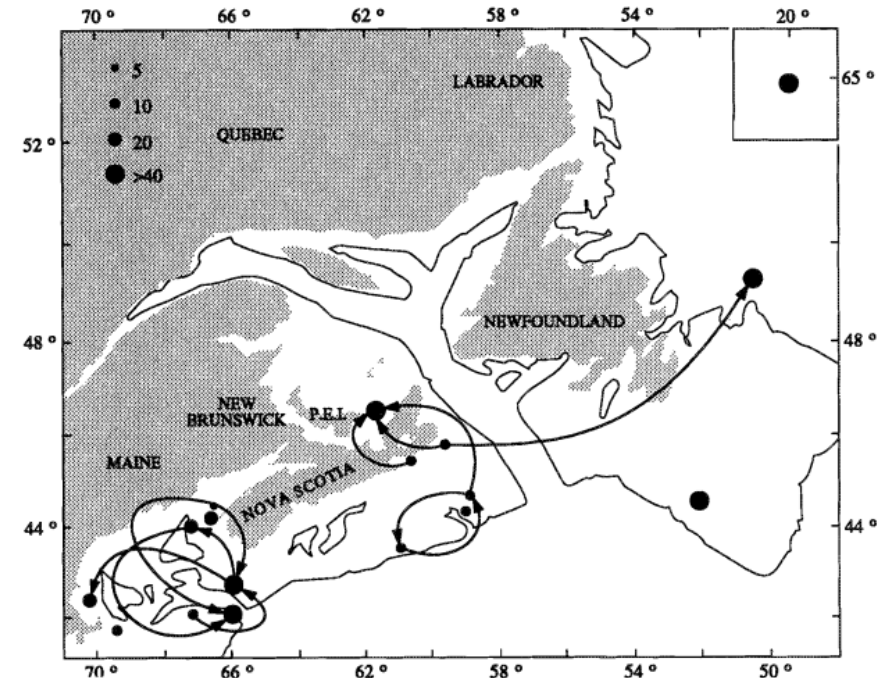- Otoliths "growth signatures" have been established as a powerful tool for stock identification.

- Analysis of otoliths from spring and winter spawning cod in the Gulf of Maine identified distinct early growth patterns between the two spawning populations (81% accuracy; Dean et al. 2019).

- Mixed stock analysis revealed the recent composition of fish was dominated by winter spawners.

Dean et al. 2019
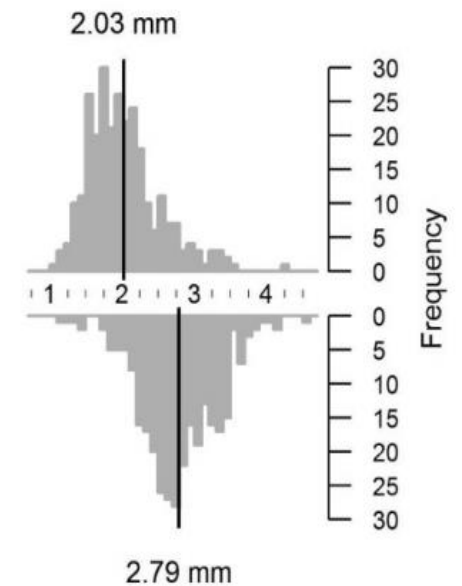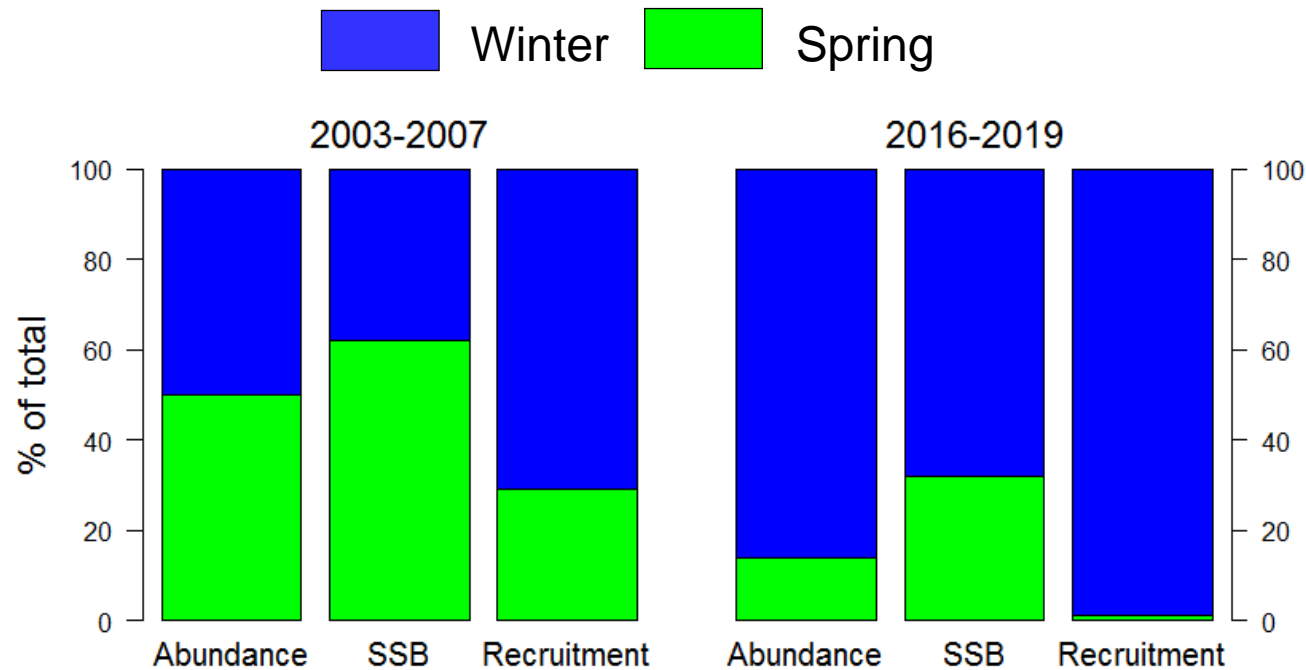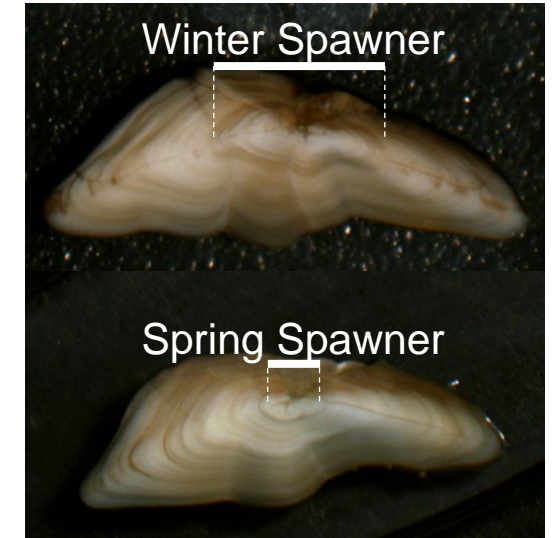
Otolith Shape

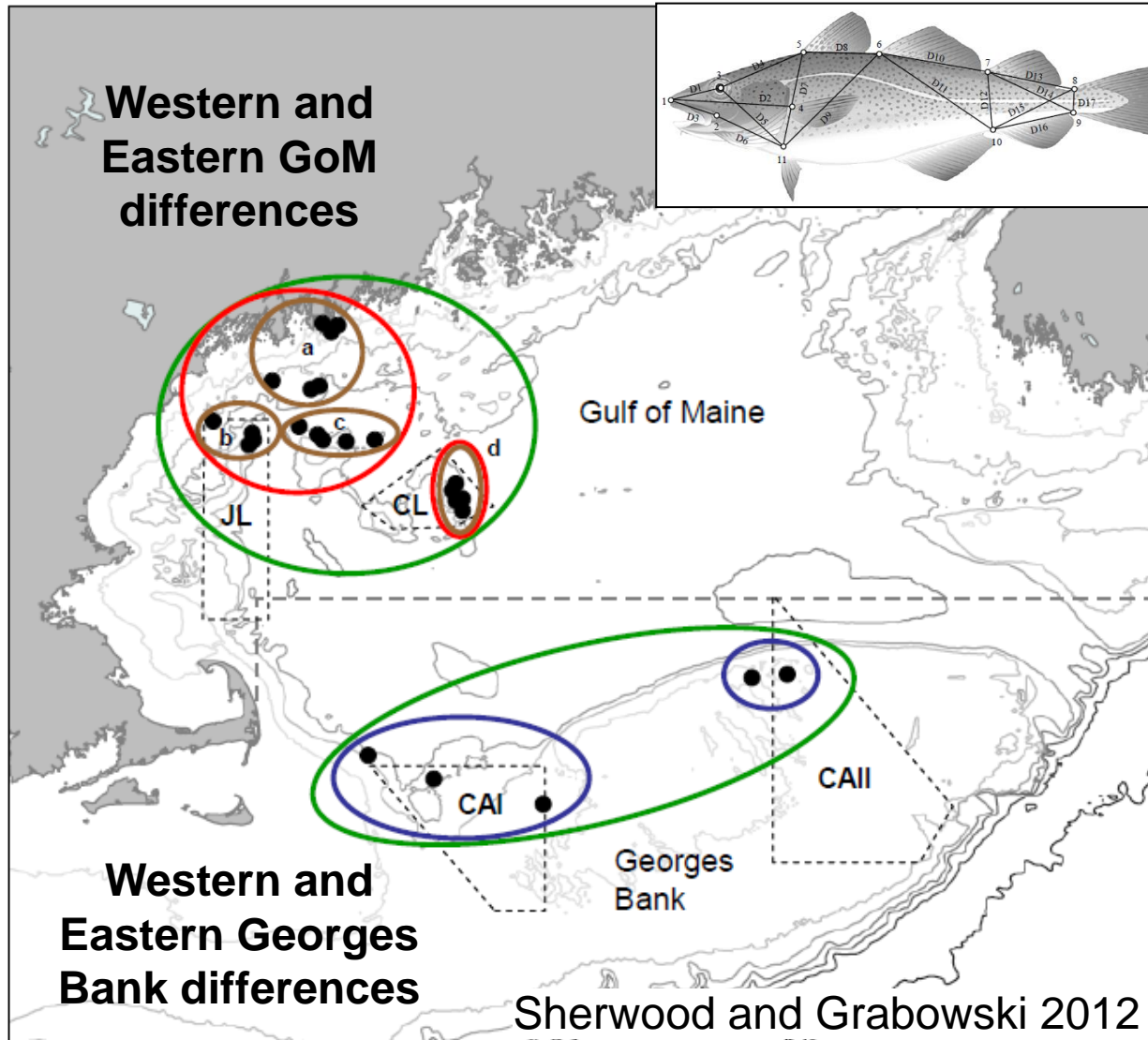- Otolith shape has been shown to have utility in stock discrimination.

- Campana and Casselman 1993 applied otolith shape analysis to classify cod populations in the northwest Atlantic.

- Classification accuracy was wide ranging, with higher classification to Gulf of Maine region.

    1. **Gulf of Maine** (61-80% accuracy)
    2. Eastern Scotian Shelf
    3. St. Lawrence
    4. Newfoundland
    5. Iceland

Morphometrics

Western and Eastern GoM differences

Gulf of Maine

Western and Eastern Georges Bank differences

Sherwood and Grabowski 2012

- Morphometrics (i.e., body shape analysis) has long been used to aid in identification of stock structure in fish.

- Sherwood and Grabowski (2012) examined morphometrics of cod Gulf of Maine and Georges Bank.

  - Identified differences between eastern and western Gulf of Maine (91% accuracy).

  - Identified differences between eastern and western Georges Bank (77% accuracy).

Morphometrics
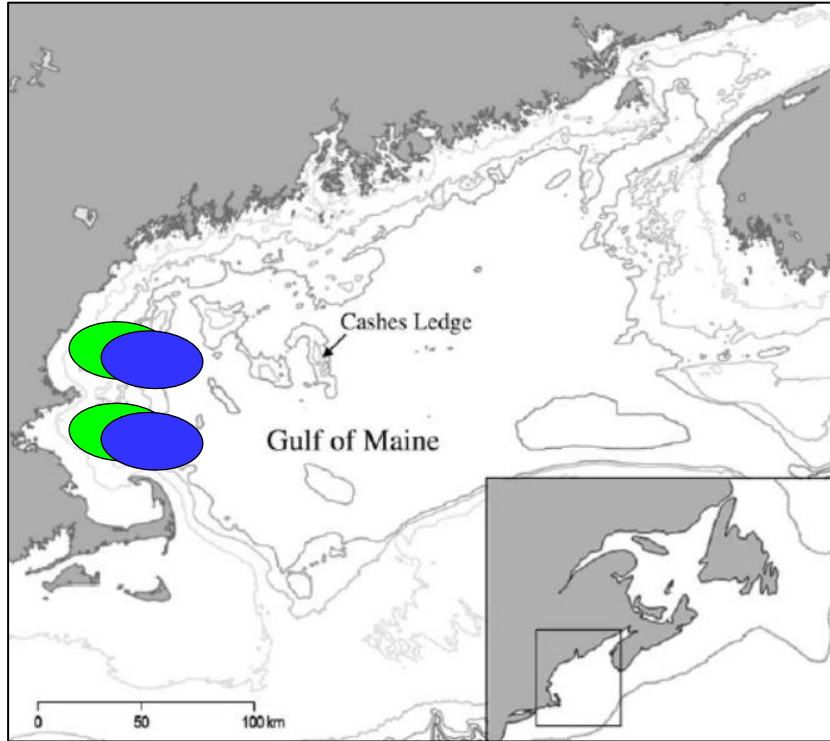
Spring Spawner

Spring spawners: More slender streamlined bodies

**Winter Spawner**

Winter spawners: More robust bodies

- Morphometric methods were applied to winter and spring spawners in the western Gulf of Maine (Ipswich and Mass. Bay).
- Morphometric differences were identified between Massachusetts and Ipswich Bays and between spring and winter spawning groups (82% accuracy).

Sherwood, GMRI

Color Morphs

Red and Olive cod, Cashes Ledge

Sherwood and Grabowski 2010
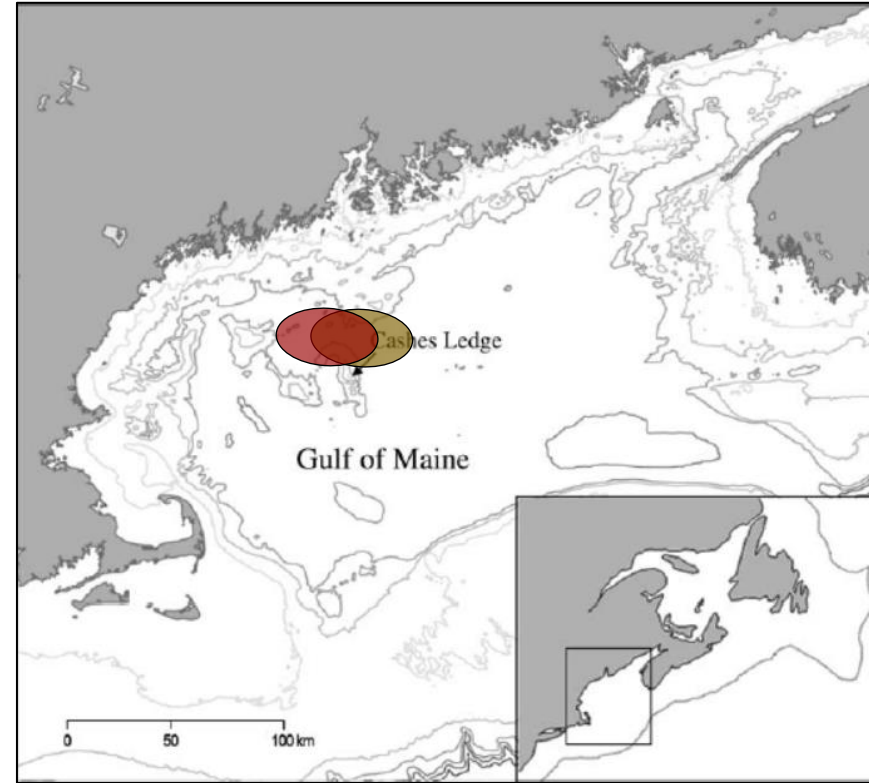
- Coloration in cod is strongly influenced by diet, but can be used as part of interdisciplinary stock composition analysis.
- Sherwood and Grabowski (2010) reported that "red cod" are commonly observed near Cashes Ledge and the presence of red cod in the Gulf of Maine was also noted by Bigelow and Schroeder (1953) and confirmed by Conroy (2016).
- Based on the observed differences in growth, morphometry, habitat, and diet, red cod may exhibit a unique life history strategy in the Gulf of Maine (i.e., more sedentary and shallow-living).

Parasites

- Parasites have been shown to be useful natural tags to identify connectivity and stock structure.

- Atlantic cod are rich in parasites across their range.

- Sherman and Wise (1961) examined infestation rates of the parasitic copepod, *Lernaeocera branchialis*, in Gulf of Maine.

- Infestation rates were interpreted to represent four stocks of cod:
    1) Northern Gulf of Maine (C: heavily infested)
    2) Central and southern Gulf cod (D,E, F: moderately infested)
    3) Georges Bank (G,H, J: lightly infested)
    4) Southern New England (S: free of infestation)
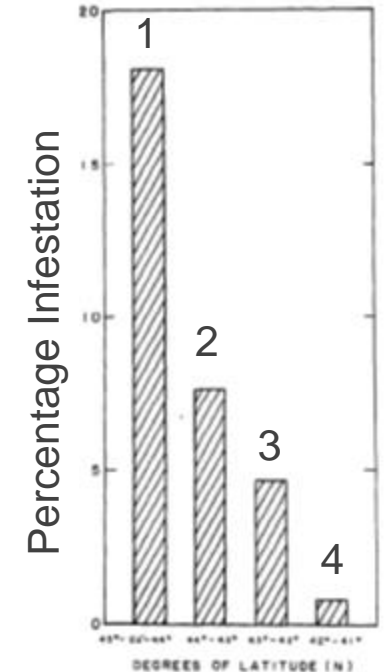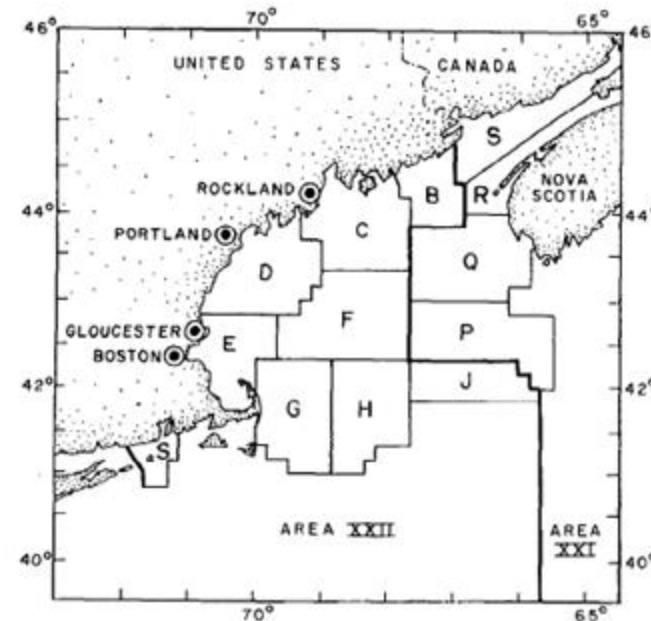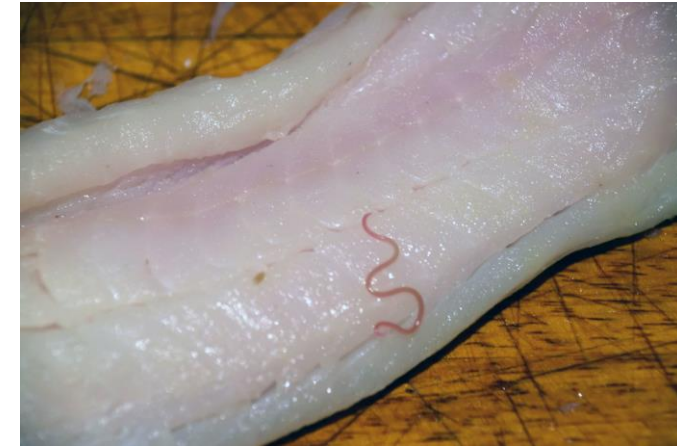
Sherman and Wise (1961)

Multiple Natural Markers

- A combination of genetics, genomics, otolith chemistry, otolith structure, morphometric, and color analysis was applied to winter and spring spawning fish from the two main spawning locations in the Gulf of Maine (Ipswich and Massachusetts Bays).

- Methods provided largely congruent results and support winter and spring spawners as unique groups in the Gulf of Maine.
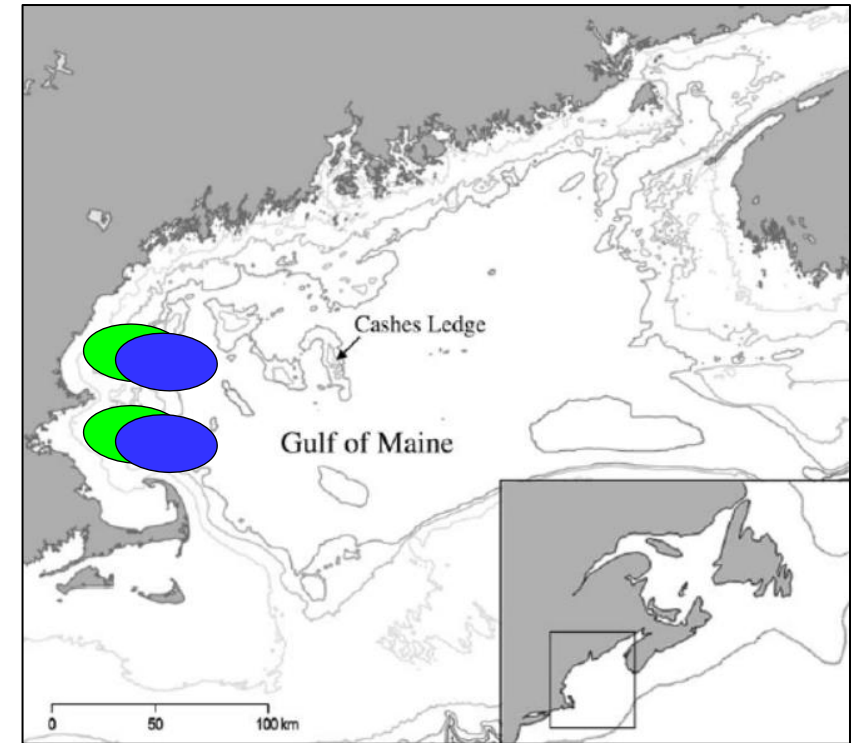
Conclusions on Cod Natural Markers

- Morphometric results(Sherwood and Grabowski 2012) suggest that **cod on eastern and western Georges Bank may comprise unique groups**. These results are in broad agreement with genetics (e.g., Kovach et al. 2010), tagging studies (Wise 1963; Hunt et al. 1999; Tallack 2011), and Fishermen's Ecological Knowledge (Section 7).

- Natural markers (otolith chemistry, structure and morphometrics) support **winter and spring spawners as unique groups**. This finding is supported by otolith chemistry, otolith structure, morphometrics, and genetics (Kovach et al. 2010, Kerr et al 2018, Dean et al 2019, Clucas et al. 2019).

- Parasite infestation rate suggests separation between the northern Gulf of Maine, central Gulf, Georges Bank, and Southern New England cod.

- Natural markers can be useful tools in mixed stock analysis to support future monitoring, assessment and management goals for Atlantic cod in U.S. waters.

Acknowledgements

- The Team: L. Kerr, G. DeCelles, G. Puncher, S. Cadrin, R. McBride

- Reviewers: Graham Sherwood, Zachary Whitener, Micah Dean

Tissue Characteristics

• Fatty acid profiles and stable isotope concentrations have not been routinely applied to investigate cod stock structure in US waters.

• Sherwood and Grabowski (2016) investigated the body shape, condition, diet, age and size structure, and stable isotopes of cod inside and outside of the groundfish closed areas (Closed Areas I and II, Cashes Ledge, and Jeffreys Ledge) in US waters.

• This study was not specifically designed to investigate stock structure, they did find differences in the $\delta^{13}C$ and $\delta^{15}N$ ratios of cod inside and outside of the closed areas, suggesting that cod within closed areas consumed a wider range of prey items.

Meristics

- Despite the utility of meristic characters for investigating the stock identity of Atlantic cod, this technique has not been routinely applied in U.S. waters or the Bay of Fundy.

- In an early study, Schmidt (1930) investigated vertebral counts of cod taken from Nantucket Shoals (mean = 51.9) and Mt. Desert Island (mean = 53.0).

- Later, Templeman (1962) reported similarities in vertebral counts between cod taken from the Northeast Peak of Georges Bank (mean = 52.7) and Browns Bank (means ranged from 52.5 to 53.0), although the sample sizes were not reported.

- Given the utility and cost effectiveness of this approach, meristic characters may be informative for future multidisciplinary stock identification studies in the region.