

## **1. Project title and contract number**

Exploring the potential inadvertent effects of Gulf of Maine and Georges Bank area closures on cod life-history variation

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## **4. Major accomplishments and milestones**

The primary objectives of this project are as follows:

- 1) Demonstrate the existence of life-history variants (i.e. ecotypes or morphotypes) in Atlantic cod from the Gulf of Maine and Georges Bank
- 2) Examine whether Gulf of Maine and Georges Bank closed areas favor sedentary cod types over migrant cod types
- 3) Examine whether closed areas alter cod feeding and growth

Since beginning sampling in summer of 2007, we have made great progress towards achieving these objectives. The following is a list of milestones and accomplishments for this project:

- 1) Sampling for cod has been conducted on a total of 29 days-at-sea aboard 5 industry vessels (see list of participants above) throughout the Gulf of Maine and Georges Bank and in and around 5 of the major closed areas (see Figure 1, Appendix).
- 2) A total of 1,196 cod have been captured and mostly processed for the parameters outlined in the proposal. Specifically we have collected the following data for nearly all of these cod:
  - a. Length, weight, liver weight, gonad weight, gutted weight
  - b. Sex
  - c. Age (from otoliths)
  - d. 13 body shape variables for morphometric analyses
  - e. Color; we have developed a red/green ratio (RGR) measurement from digital images as a robust way of quantifying color in cod
  - f. Stable carbon and nitrogen isotope signatures (subset of 307 cod)
  - g. Diet (from stomach contents)
  - h. Parasite loads

While multivariate analyses of all these variables for all cod is pending completion of sampling (as is submission of data to NEC), preliminary analysis of life-history variables for red cod at Cashes Ledge points to the existence of a distinct life history variant for cod. In particular, red cod (see Figure 2) have more streamlined body shapes, different stable isotope signatures, less parasites, shallower depth of occurrence, lower growth and appear to be more resident (based on stable isotope signatures) than normal colored cod (Figure 3).

## **5. Unexpected difficulties and project alterations**

No major difficulties have been encountered. However, we have had to make some slight alterations to our sampling protocols. These include:

- 1) Dropping Jeffreys Bank closure area as a sampling site (too few cod) and focusing on the four others as well as some more inshore areas for red cod; only Cashes Ledge was found to contain red cod, therefore we needed to add some other open sites for comparison and these tend to be inshore shallower areas (note inshore sampling sites in Casco Bay and Massachusetts on Figure 1).
- 2) Due to timing of sampling, which has been mostly in the summer and fall, we may no longer be able to assess maturity and fecundity as well as we had hoped, although efforts are being made this spring to get out and sample spawning cod (weather allowing).
- 3) Our method for examining red muscle mass (through photos of transverse sections of cod muscle) has proved equivocal and therefore dropped from the analysis.

## **6. Next steps, tasks for next 6 months**

- 1) Complete field sampling; we hope to sample pre- and post-spawning cod this spring and summer (funds remain for roughly 12 charter days to be completed)
- 2) Complete laboratory processing of new samples
- 3) Analyze all data to test for the existence of life-history variants (with a focus on red cod)
- 4) Analyze all data to test for effect of closure status on feeding and growth of cod

## **7. Impacts of the project to fishermen/fishing community, and scientist/science community**

Results for red cod have been presented at numerous forums (e.g., Bowdoin Marine Science Symposium, American Fisheries Society Meeting, Northeast Regional Cod Tagging Workshop) and will be presented at the upcoming NEC Participants meeting along with a poster highlighting preliminary results of cod samples from all the closed areas. The concept of ecotypes and fine-scale movement behavior, drawing on results from this study, will also be presented at an upcoming workshop on “Exploring fine-scale ecology for groundfish in the Gulf of Maine and George Bank” which will be well attended by industry members, scientists and managers.

## **8. Signature and date**



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Graham Sherwood

March 19, 2009

## 8. Appendix

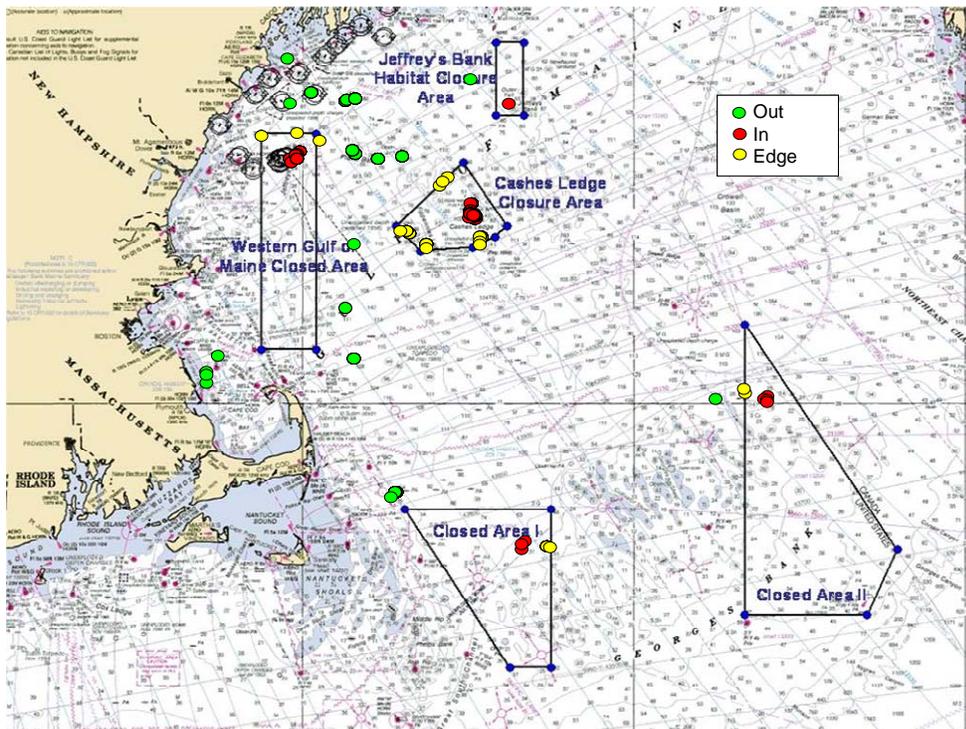


Figure 1. Chart of Gulf of Maine and Georges Bank showing location of closed areas and sampling effort over last two seasons.



Figure 2. Image of color differences being encountered at Cashes Ledge and select inshore sites.

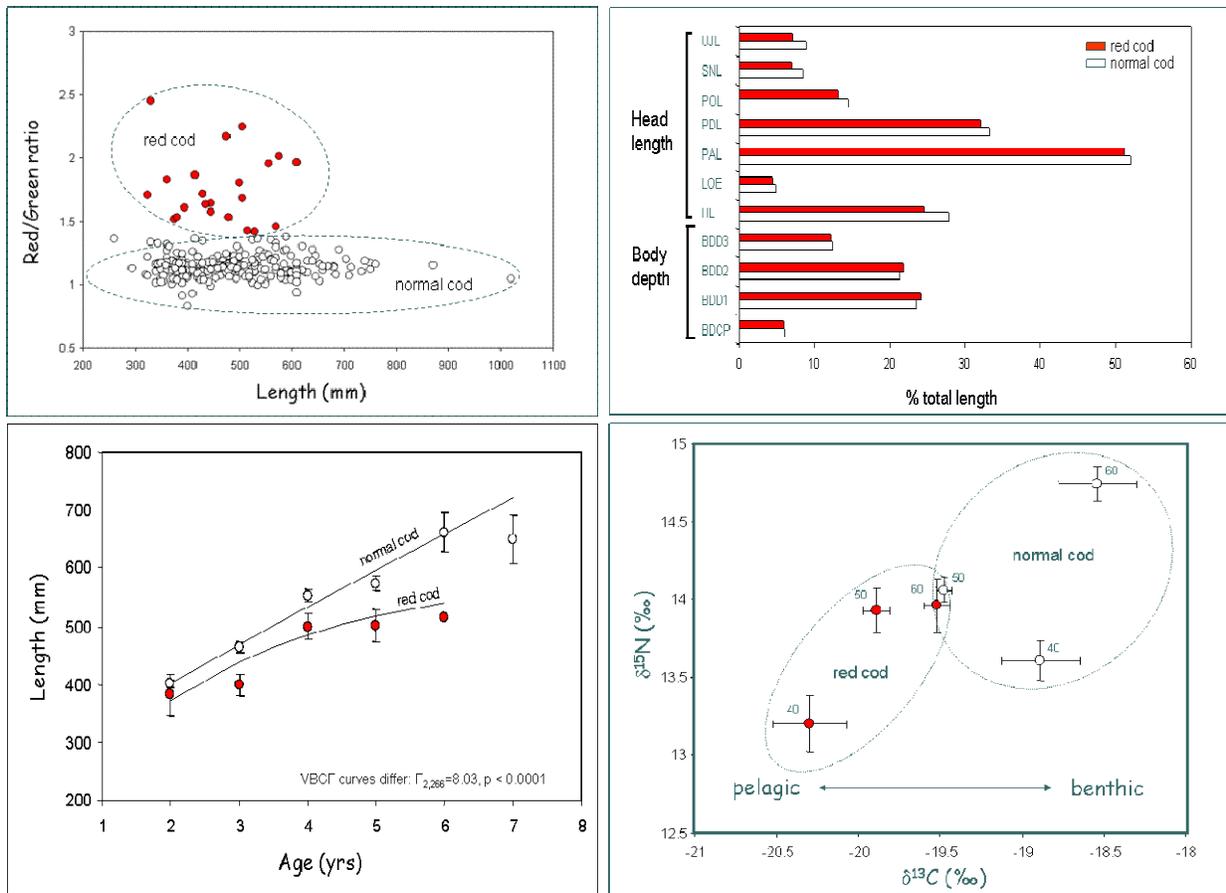


Figure 3. Findings to support designation of Cashes Ledge red cod as a distinct life-history variant (i.e. ecotype) for cod. 1) Top left: size overlap for color types (measured as red/green ratio, RGR) shows that color is not ontogenetic (i.e. a developmental or feeding stage for cod); 2) top right: body shape is more robust and less streamlined for red cod; 3) bottom left: growth is stunted for red cod; 4) stable isotope signatures (particularly carbon,  $\delta^{13}\text{C}$ ) is distinctly more pelagic for red cod. We suspect that this is a reflection of higher residency at shallow depths at Cashes ledge and will be further testing this hypothesis this summer.