Project Title: Defining Atlantic wolffish aggregations in Massachusetts Bay.

Award Number: 111C61
Period of Performance: 7/1/10-6/30/11
Date of Annual Report Submission: June 30, 2011

Principal Investigator:
Elizabeth A. Fairchild, Assistant Research Professor
University of New Hampshire, Dept. of Biological Sciences
Rudman Hall 189, Durham, NH 03824
Ph: 603-862-4475; Fax: 603-862-3784; E-Mail: elizabeth.fairchild@unh.edu

Other Project Participants:
Shelly Tallack, Research Scientist
Gulf of Maine Research Institute
350 Commercial Street, Portland, ME 04101
Ph: 207-228-1639; Fax: 207-772-6855; Email: stallack@gmri.org

Carl Bouchard, Commercial Fisherman
Epping Road, Exeter, NH 03833
Ph: 603-772-5047; Fax: 603-772-5370; Email: cpbouch@aol.com

Jim Ford, Commercial Fisherman
140 Willow Road, Kingston, NH 03827
Ph: 603-642-3318; Email: captainjim1@comcast.net

Michael Armstrong, Program Manager
Recreational and Anadromous Fisheries, Annisquam River Marine Fisheries Station
Massachusetts Division of Marine Fisheries, 30 Emerson Avenue, Gloucester, MA 01930
Ph: (978) 282-0308 ext. 109; E-mail: michael.armstrong@state.ma.us

Project Objectives and Scientific Hypotheses:

Atlantic wolffish (*Anarhichas lupus*) is listed as a Species of Concern in US waters. Full life history information, including biology, migration patterns and seasonal movements, is lacking for Atlantic wolffish populations. Surveys indicate abundance is highest in the Gulf of Maine-Georges Bank region, especially in the southwestern portion at depths of 80 to 120 m. However, groundfish surveys in this "abundant" southwestern area typically are low; scientific survey data may not provide reliable indices for low biomass species like Atlantic wolffish.

Contrary to these data, commercial fishermen report that dense aggregations of Atlantic wolffish are found in very specific locations on Stellwagen Bank Marine Sanctuary in Massachusetts Bay. In these locations, commercial fishing activities are prohibited in April and May so it is unknown when the wolffish arrive, but in early June, catch rates average 200-300 lbs/hr. The overall goal of this project is to document if Atlantic wolffish occur in dense aggregations seasonally in Massachusetts Bay, and if so, why

Hypothesis: In early June on Stellwagen Bank, Atlantic wolffish are not evenly distributed, solitary or paired but instead, occur in very dense concentrations. By the end of June, they disperse.

To test this hypothesis we planned to meet the following objectives:
1. Sample the Atlantic wolffish population in our selected study area in May-June to quantify temporal abundance and distribution.
2. Utilize a proportion of the wolffish catch to:
    a. Calculate age and growth,
    b. Determine the sex ratio and reproductive status, and
    c. Analyze food habits.
3. Externally tag and release all remaining wolffish to understand seasonal dispersal patterns.

Methods and Work Plan:

1) Study Area:
The study area is located on Stellwagen Bank in Massachusetts Bay in statistical area 514 (green rectangle on chart). It is approximately 40 km^2 and ranges from 27- 40 m (15-

22 fathoms) deep, though the majority is 33 m (18 fathoms) deep. Biogeographically it is a very interesting area and was selected because it is the only place identified by fishermen where Atlantic wolffish are highly abundant in the southern Gulf of Maine. Indeed, this is an area where wolffish used to be actually targeted by fishermen in early June. The substrate type is hard sand bottom littered with shells (scallops and mussels). The bottom type is very similar in a 8 km radius around the area, however,
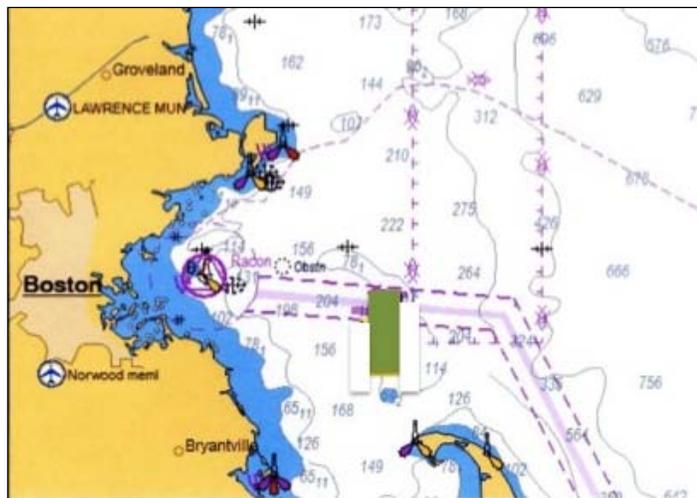
fishermen report that the wolffish are not evenly dispersed throughout. Our hypothesis is that the fish are aggregated in a concentrated zone within the study area. The alternative hypothesis is that the fish are randomly distributed throughout the area.

2) Capture, Tagging, Disposition of Catch:

Atlantic wolffish will be surveyed in the study site by trawl during dedicated sampling trips from late-May through June. A total of ten days will be used to conduct bi-weekly surveys for 5 weeks. To determine if wolffish are evenly distributed or aggregated, sampling will be done throughout the study site in a semi-random fashion in that all towable ground will be surveyed, including the specific area where wolffish are reported to congregate. All fish will be captured in short tows to minimize stress and limit bycatch mortality, using standard legal groundfish nets (6" body, 6.5 " codend mesh size). For each tow, the following information will be collected: date, location, water depth, water temperature and bottom type; additional comments considered relevant (e.g. weather conditions) will also be recorded. Fish will be placed in flowing seawater tanks onboard the vessel. All wolffish will be measured (TL) to the nearest cm, weighed to the nearest 0.1 kg, and tagged. Disposition of wolffish will be either (1) released alive as tagged samples, or (2) sacrificed for life history information.

Released Wolffish: We aim to tag up to 2,500 wolffish with dart tags. A standard tagging protocol will be developed and applied for use during all tagging trips to ensure consistency in tagging methods across taggers. Each released wolffish will be double-tagged. This will enable us both to monitor tag loss and improve the probability that tags will remain evident in recaptured wolffish since even if one tag is shed, the other may remain.

Sacrificed Wolffish: To improve the understanding of wolffish habitat and movements, a goal of 300 fish will be set for life history analyses. This sample size is the appropriate minimum number for age and growth analyses if sampling is random, since even with predominantly large-sized fish expected, 10-12 age classes still may be present (Gary Nelson, pers. comm.). In this, fish will be euthanized by an overdose of MS-222, and then heads, gonads, and entire gastro-intestinal tracts will be bagged separately, and frozen until further analyses.

All bycatch will be identified, enumerated, and immediately released alive.

3) Sample Processing:

Wolffish samples will be thawed and processed to collect data on age and growth, reproductive maturity, and feeding ecology according to the following methods:

Age and growth: Otoliths will be processed at the Massachusetts Division of Marine Fisheries Age and Growth Laboratory at the Annisquam River Marine Fisheries Station in Gloucester, MA for age determination and will follow Nelson and Ross' (1992) methodology. Briefly, for each wolffish head, the sagittal otoliths will be removed, cleaned, and if need be, the region around the nucleus on the convex surface ground with fine grit sandpaper (to expose the innermost annuli). Then the otolith will be submerged in 50% ethyl alcohol on black velvet (to enhance the hyaline zones), and the annuli counted from the nucleus out to the edge. A January 1 birth date will be used. Age (counting) will be determined by three independent viewers to reduce

uncertainty. Growth will be modeled fitting mean lengths-at-age (years) for the Gompertz function. Growth parameters L∞, k, and t_0 will be estimated using non-linear regression.

Reproductive maturity and sex ratio: Fish maturity will be determined by examination of excised gonads. Males will be identified by the presence of testes. Egg size, color, and developmental stage are the primary methods for characterization of female maturity and have been well described (Templeman 1986b; Gunnarsson et al. 2006). Due to the large egg sizes, gross visualization can be used to determine immature from mature females. Ovaries containing no visible eggs to the naked eye are immature as only stage 1 primary ooyctes are present (Gunnarsson et al. 2006). Ovaries containing visible eggs are classified either as cortical alveolus (CA) stage, spawning stage 3 (intend to spawn within the year), or spawning stage 4 (have recently spawned or are recovering; Gunnarsson et al. 2006). Egg size and color as well as condition of the ovaries will be used to classify maturity of female fish. If there are uncertainties, ovarian samples will be processed histologically by the UNH Pathology Laboratory to discern ooycte stages.

Feeding ecology: Gastro-intestinal tracts will be thawed, weighed, dissected, and all prey items identified to the lowest possible taxon. Both frequency of occurrence and volume of dietary items as well as a feeding index will be calculated as:

Frequency of occurrence = no. stomachs containing prey item *i*/total number of examined stomachs x 100.

Volume by species = weight of prey item *i*/total weight of stomach x 100.

Feeding index = weight of total stomach contents/total fish weight x 100.

Due to the crushing nature of wolffish feeding techniques and a fondness for hard-shelled invertebrates like mollusks, crustaceans, and echinoderms, no attempts will be made to quantify prey numerical abundance.

4) Tagging Data Entry and Management:
Tallack and Fairchild will design a database which is appropriate to this small tagging study which can be seamlessly integrated into the NEFSC multi-species tagging database; all data will be error-checked and quality controlled by UNH students. All individuals who report a tagged wolffish will receive a recapture report, a project T-shirt, and will be entered into a semi-annual lottery draw for $500. Information from these recaptures will help identify movements of wolffish in Massachusetts Bay.

Work Completed to Date:

Multiple meetings were held at the beginning of the year to formulate the project timeline and research plan. Tallack designed and produced T-shirts, postcards, and posters, as well as a website for the project (www.wolffishtagging.org).

All 10 sea days were completed during this reporting period and occurred from May 23-June 21, 2011. A total of 53 tows were taken in the study area resulting in the capture of 395 Atlantic wolffish. Of those, 303 were sacrificed for life history analyses, 86 were tagged and released, and 6 were released untagged due to poor condition. A summary of wolffish catch/trip is detailed below:

Date	Captain	Total Tows	Total Wolffish	No. sacrificed	No. tagged	No. not tagged
5/23/11	Ford	3	107	107	0	0
5/26/11	Ford	4	187	187	0	0
6/7/11	Bouchard	6	7	7	0	0
6/8/11	Bouchard	4	3	2	1	0
6/10/11	Bouchard	5	2	0	2	0
6/13/11	Bouchard	7	9	0	9	0
6/16/11	Bouchard	8	6	0	6	0
6/17/11	Bouchard	5	29	0	26	3
6/20/11	Bouchard	5	5	0	5	0
6/21/11	Bouchard	6	40	0	37	3
	TOTAL	**53**	**395**	**303**	**86**	**6**

We were able to document that Atlantic wolffish do aggregate on Stellwagen Bank in a specific area in spring. As the fishing trips have just ended, we have not had a chance to analyze catch data fully but it is apparent that the wolffish are not evenly distributed and are most abundant in late May (compared to the June trips).

The 303 wolffish sacrificed for life history analyses were measured, weighed, and dissected; heads, whole GI tracts, and gonads currently are frozen until further analyses this summer.

While we reached our goal of sacrificing 300 wolffish for life history analyses, we did not come close to meeting our tagging goal. Originally we planned to tag as many as 2,500 fish with t-bar tags. Due to a fairly high t-bar tag shed rate observed in a laboratory experiment at UNH and on the advice of David Hall, owner of Hallprint Lty., we decided to use dart tags for the wolffish. These unfortunately cost more than we had budgeted for so we reduced our tagging goal to 1,500 fish. However, we still did not meet that reduced goal as we only tagged 86 wolffish in the study area. It appears that there is a seasonal distribution shift for Atlantic wolffish on Stellwagen Bank. Wolffish are most concentrated during the last week of May, and possibly the first week of June. Due to other project commitments the industry partners had, we were not able to fish during the first week of June. By the time we could resume wolffish trips on June 7th, the majority of the wolffish had dispersed. In the meantime, the cod had entered the area and were in the exact same area as the remaining wolffish. We attempted to reduce cod bycatch by towing for shorter periods or in nearby areas but this resulted in no wolffish catch. We found that in order to catch wolffish, we had to tow through the cod. It is our hope to find funds to resume tagging efforts next spring during peak wolffish concentration. We have all necessary tagging supplies and outreach infrastructure in place (website, t-shirts, lottery money, database, postcards, posters). In order to understand wolffish movements, we need to tag substantially more fish, and the best time to do this is during peak wolffish concentration and before the cod have moved into the study area (late May, early June).

Results to Date:

We have validated the hypothesis that Atlantic wolffish do aggregate on Stellwagen Bank for a brief period in spring, and then disperse. This is the first scientific documentation of any wolffish species occurring at such a high density. It also shows that previous groundfish surveys have not adequately depicted Atlantic wolffish population structure, at least in Massachusetts Bay. As data analyses continue, we will discover more about this population of wolffish.

Future Work:

During the next 12 months, all 303 wolffish samples will be processed and analyzed. This will involve extracting otoliths from the heads and sending them to the MA DMF Age and Growth Laboratory where they will be sectioned, stained, and age will be determined for each fish. At GMRI and at UNH, stomach contents will be sorted, identified, and weighed to determine the feeding ecology of this group of wolffish. At UNH, gonad samples will be weighed and eggs

(ovaries) staged to determine maturity of the females. In addition, more in-depth analyses of the catch data will occur.

We will continue tagging outreach work to ensure a high probability of reported recapture information. Fishermen who utilize Stellwagen Bank, including charter and party boats, and draggers and gillnetters, will be informed of this wolffish project through posted notices and informational mailings.

This project has proven to be an ideal candidate for testing a new online tagging database that GMRI has been developing. This tagging database utilizes the framework of the online GIS and mapping interface databases designed for the Northeast Regional Cod Tagging Program and the Northeast Consortium Tagging Program. GMRI has been transferring these databases to a new server and rebuilding them in open source software, which will be more reliable and economical for years to come. Wolffish tagging data are being entered into this online database and will be completely uploaded in the next few months. Once the dataset is complete, this tool will offer the following capacities:
- Online storage of data in a password protected database.
- Visualization of tagging data using Google maps technology which can be filtered by a variety of parameters.
- Generation of recapture reports for mailing to individuals who report tags.
- Accessible to the general public with a link to the database provided through the project website.

The URL for the database has not been finalized yet but will be made available to the NEC once completed.

We will seek more funds for follow-up tagging days for spring 2012. Our goal is to find money to fund sea days (industry partners plus technicians/scientists) to fish the study area intensively over a short period of time (2 weeks) when wolffish are most abundant.

Lastly, when all data are analyzed, we will prepare manuscripts for publication and present our results at the NEC PI meeting as well as at another venue.

Impacts and Applications:

This study contributes to a broader understanding of Atlantic wolffish life history and ecology. The research allows us to document ephemeral concentrated aggregations of Atlantic wolffish, a species of concern. Clearly such information will contribute towards an understanding of essential Atlantic wolffish habitat. Age and growth, reproductive status, diet analyses, and movements of these fish will add to the relatively sparse biological information on this species in the southern Gulf of Maine. Finally, the project will forward the goal of the Northeast Consortium to develop partnerships between commercial fishermen and researchers.

Related Projects:

Because one industry partner (Bouchard) also was participating in anther cooperative research project (GEARNET with Tallack/GMRI) and we had extra tags, we took advantage of the opportunity to tag Atlantic wolffish in other areas. At the time of writing this report, at least 2 other wolffish were tagged and released, both in Ipswich Bay in early June. We will continue to take advantage of other opportunities to tag wolffish.

Partnerships:

This project has truly been a partnership between fishermen, scientists, students, and managers. To date, 2 commercial fishermen plus their crews (a total of 3 more fishermen) have actively participated in the research. Two scientists (Fairchild and Tallack), plus GMRI summer interns (Willy Goldsmith and Kristina Thorpe), and 2 UNH lab technicians (Kristin Garabedian and Kim Little) have worked on the wolffish project. On all but one sea day, at least two people from a combination of UNH and/or GMRI have participated. Managers, namely MA DMF, also are active participants in this project. The fishermen have been intricately involved in all aspects of this project. The idea for this project was spawned from discussions Fairchild and Bouchard had over the past years, many of which occurred at sea during other NEC funded projects. Both Capts. Bouchard and Ford were involved with the planning and logistics of this wolffish project, development of sampling strategies (how, where, when tows would occur), fish handling and tagging protocol, and outreach. They have talked regularly and frequently to other fishermen in the study area to inform them of the project and discuss wolffish movements. In addition, their crews have helped with data collection, both in processing wolffish for life history analyses, and tagging and releasing of live wolffish. This project not only has strengthened industry-scientist relationships, but also facilitated new UNH-GMRI partnerships as this is the first project Fairchild and Tallack have worked on together. Finally, unanticipated support from local NH fish companies has been provided. Seaport Fish Market (Rye, NH) and Little Bay Lobster Company (Newington, NH) generously have allowed us to store wolffish samples in their freezers.

Presentations: None yet.

Published Reports and Papers:

- Project website: www.wolffishtagging.org.
- Article written by Willy Goldsmith, an intern at GMRI about the project and posted on Good Morning Gloucester blog: http://goodmorninggloucester.wordpress.com/2011/06/29/tagging-wolffish-on-stellwagen-bank/.

Data:

Data have not been submitted to NEC yet. This will occur at the end of the project. The online tagging database for the wolffish tagging project will be available to anyone who wishes to view the data, and we can download and provide the data to NEC.

Elizabeth A Fairchild

Elizabeth Fairchild
June 30, 2011