*NORTHEAST CONSORTIUM*
**2009 Annual Report**

**Project Title:** Spawning movements and habitat use of winter flounder in the southern Gulf of Maine.

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**Project Objectives and Scientific Hypotheses:**

Little is known about the spawning movements and habitat use of the winter flounder Gulf of Maine (GOM) stock. Seasonal spawning migrations from offshore into shallow embayments and estuaries have been well documented for the Southern New England/Mid-Atlantic (SNE/MA) winter flounder stock; it has been assumed that generally this pattern is true for fish north of Cape Cod, though there have been no studies to support it. However, contrary to what is reported in the scientific literature about the SNE/MA stock, commercial fishermen claim that GOM winter flounder do not spawn in estuaries, but in deeper waters (20-30 m) offshore. There is a paucity of information on this subject in the scientific literature, and further research (as requested in the winter flounder Essential Fish Habitat (EFH) source document by Pereira et al. 1999) is needed for a better understanding and mapping of non-estuarine spawning habitats of winter flounder.

Hypothesis: Winter flounder in the Gulf of Maine spawn in coastal and offshore waters rather than in estuaries.

To test this hypothesis, we proposed the following objectives:

1. Acoustically tag 40 pre-spawning adult winter flounder (20 males, 20 females) in our selected study area in February.
2. Track these fish over the next three months to determine their spatial distribution and movements.
3. Sample the adult population of winter flounder in our study site from February to May to quantify how the reproductive status of these fish changes over time in this offshore area.
4. Determine how the spatial distribution of spawning fish relates to attributes of the spawning habitat.

**Methods and Work Plan:**

We proposed to study winter flounder movements and fine scale distribution within a 35 $km^2$ site in the southwestern GOM during the spawning season by acoustically tagging 40 pre-spawning adult winter flounder (20 males, 20 females) in February. To determine the spatial distribution and movements of the tagged fish, we would use both stationary and hand-held directional hydrophone receivers to locate the fish from February through May. The stationary

hydrophones are submersible, moored single channel receivers capable of identifying and recording multiple coded transmitters (acoustic tags). Each record is time stamped. As many as 75 receivers were to be positioned in a 1 km on center grid design around the area where the tagged fish aggregate. All nearby estuarine inlets were to be gated with these receivers too to determine if adult fish enter the estuaries during spawning season. Because the acoustic tags also record the depth history of each fish, this information is also transmitted to the receivers and recorded. When the position of each acoustic tag (fish) is found using the handheld directional hydrophone, location, depth, substrate type, and notable bathymetric features would be recorded. In addition, we proposed to sample the adult population of winter flounder in the study site biweekly by trawl, and a subsample of 100 adults would be cannulated to quantify how the reproductive status of these fish changes over time in this offshore area.

**Work Completed to Date:**

A series of meetings were conducted between the UNH scientists and other participants prior to the beginning of the field work. These included meetings with: Mike Armstrong in NH to discuss the research plan and time line; Mike Armstrong and Bill Hoffman at MA DMF in Gloucester, MA to discuss hydroacoustic equipment and plan deployment locations and schedules; and industry partners to discuss overall objectives, methods, and schedules.

Estuarine receivers were deployed in March using UNH, industry, and Mass DMF vessels. These receivers were placed from Kittery, Maine to Gloucester, MA, and covered the entrances to Portsmouth Harbor, Little Harbor, Hampton-Seabrook Estuary (HSE), Merrimack River, Plum Island Sound, Ipswich River, Essex River, and the Annisquam River. A total of 27 receivers were used to create "acoustic gates" for these inlets to detect any acoustically tagged fish that enters.

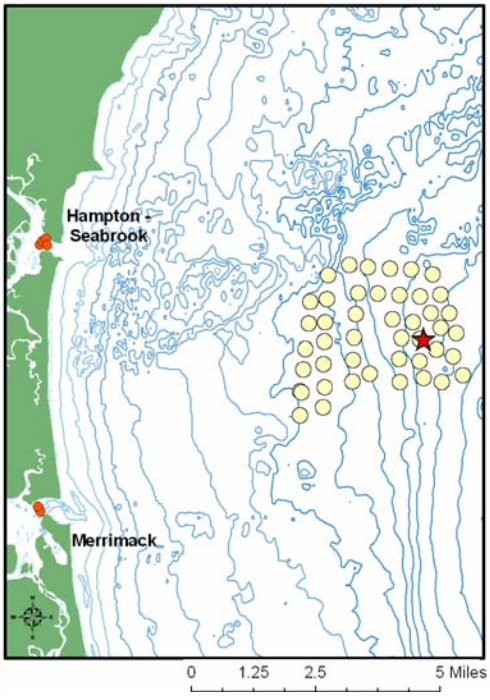

*Figure 1. Offshore receiver array.*

Due to the absence of winter flounder in and near the study area in February and March, the project start was delayed. In both months, we began trawling with industry partners to assess the abundance and distribution of adult pre-spawning winter flounder. However, it wasn't until the beginning of April that a significant amount of winter flounder were caught indicating that their seasonal inshore migration was underway. This was our cue to acoustically tag and release pre-spawning fish which we did over 3 days (April 5-6, 11). A total of 18 males and 22 females were tagged with Vemco V9P1L coded acoustic transmitters with a pressure sensor (more females were present than males,

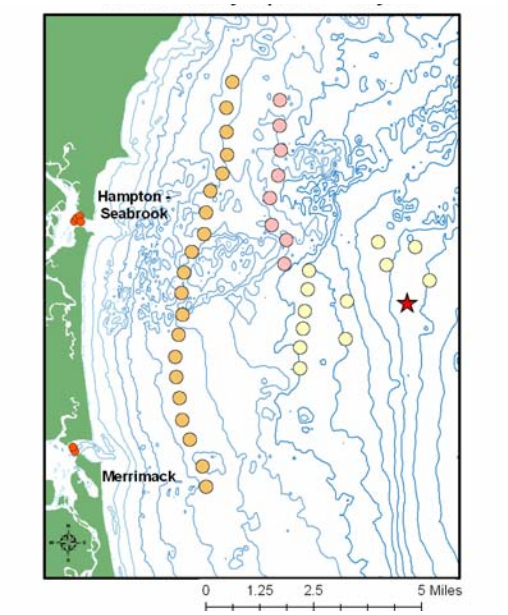


*Figure 2. Receiver array April 29-May 30.*

hence the unequal sex ratio). During those same days, the off-shore receiver array (n= 44) was deployed 800 m on center around the release site in the study area (Fig 1).

Manual tracking with a handheld hydrophone began April 10 and continued several times/week thereafter until the end of June. All receivers were downloaded periodically to validate the direction of fish movements. On April 29, a portion of the receiver grid was moved inshore to maintain contact with the majority of tagged fish (Fig. 2). On May 30, these receivers were hauled out and returned to MA DMF, as they were needed for another project. The 27 estuarine receivers continue to serve as acoustic gates.

Complimentary biweekly trawling continued after the fish were acoustically tagged. Short (30 min.) tows were made in and around the study area and receivers to assess winter flounder abundance and reproductive condition. All catch was identified and enumerated. All winter flounder were measured, tagged (disc), and their sex and reproductive condition determined by external inspection or ovarian biopsy. In the proposal, we were to biopsy only the first 100 females; because we never caught >100 females/tow, we biopsied all pre-spawning females caught.

In addition to our outlined work, we conducted trawling with a small UNH vessel in the HSE when we found one acoustically tagged female had entered the estuary. Though we did not recapture her, we did sample the winter flounder population in the estuary. This included measuring, tagging (disc), and releasing fish, and sacrificing several individuals for gut content analyses and gonadal examination (it is very difficult to differentiate females from males post-spawning, much less get a reliable ovarian biopsy).

**Results to Date:**

As we are still in the midst of the field work portion of this project, we have not begun data analyses in earnest. At this point we can only provide very brief results.

As of 16 June, 42 and 6 days at sea have been completed in collaboration with the industry partners and using UNH vessels, respectively. Fifteen of these days have involved trawling for a total of 85 tows completed (76 offshore and 9 in the HSE). A total of 371 winter flounder have been tagged with disc tags (350 offshore and 21 in the HSE estuary). The offshore tows have ranged in depth from 29 to 91 meters with a mean of 59 m. Mean offshore winter flounder catch/tow has been approximately 5 fish/tow, with a range of 0 to 21 winter flounder.

All acoustically tagged fish were relocated by original array VR2s for at least 2 days immediately post-release. Two fish were presumed mortalities since they never moved noticeably from the release site in April. Within less than one week after the release, 80% of the tagged fish had moved out of the original array, primarily heading North, West, or Southwest from the release site. Thirteen fish left the array < 1 wk after tagging and were never found again. Ten fish that had left the array, crossed back into the array on its western side in mid/late April; eight out of these 10 fish initially left the array going North/NW after release, and crossed the array later in April going North to South. Nineteen fish (48%) have been relocated manually by the VR100 outside of the original array (North, West, or Southwest). Forty-five percent have been relocated one month or more since the release. Thirty percent (n=12) are still being tracked; all were found inshore of the release site, in depths ranging from 7 to 66 m.

No acoustically tagged winter flounder have been recaptured yet. However, 4 disc tagged flounder have been recaptured and reported. So far, one fish was recaptured off Appledore Island, ME (in 5 fm), two fish along the Plum Island shore (5 fm deep), and one fish on Middle Bank /Stellwagen Bank (29fm).

To date, only 2 acoustically tagged fish have entered estuaries. The first fish, #682 (30 cm female), was tracked moving directly west from its release site across the original offshore receiver array from April 5-14, 2009. It continued due west and entered the HSE, where it was detected first by the Hampton Bridge receiver on May 4. It proceeded into the estuary past the bridge and was detected by the 3 receivers west of the bridge beginning that night. It continued to get several detections per day on those receivers throughout May and into June. It has remained within the estuary for at least 44+ days as of June 16, the last download date. Its depths have ranged from 0.5 - 9.5 m in the estuary.

The second fish, #695 (31 cm male), initially moved NW from the release site on April 5 and was gone from the original offshore array by April 7. It was detected by the Merrimack receivers on the morning of April 12 (SW of its release and the original array), and again in the afternoon, <3 m deep. That night it was detected back at the southern border of the original ocean array, and was tracked moving north across the array and release site (57-62 m deep) until it crossed the NE corner of the ocean array @10 pm and was never located again. Its last detection in the Merrimack was at 2:30 pm, and it first reached the ocean array that night at 8 pm, meaning that it traveled ~12 km to the NW in approximately 5.5 hours. That suggests an average speed of 2.18 km/hr, or 2.02 body lengths/second.

Because 38 of the 40 acoustically tagged fish did not enter estuaries during the spawning season, there may be several reproductive strategies that winter flounder use; our study suggests that a large proportion of these fish are spawning outside of estuaries in the southern Gulf of Maine. Further analyses of the movements and habitat occupied by these tagged fish will clarify this behavior.

Though not analyzed yet, the catch data suggests that as time has progressed, the proportion of spawned out females has increased as expected.

**Future Work:**

During the next 12 months, the project will be completed. This includes using remaining days at sea with industry partners to continue tracking tagged fish and trawling, as well as removal of

all gear (receivers and moorings). The majority of the future work will consist of data analyses and manuscript preparation. Analyzing tracking data of acoustically tagged fish will give us the real time position of the fish, while the pressure data from the tag will provide information about the depths occupied by the individual during its time at large. Additional information about the fish's environment (water depth, bathymetric features, substrate type) collected using the vessel's depth sounder each time the sonically tagged fish was located acoustically will be analyzed. These data will allow us to characterize the substrate type used by the fish during their spawning season.

Sequential positions of each individual will provide a record of horizontal movements of these fish during the spawning period. These, combined with temporal records of reproductive status of the group, will allow us to estimate when and where spawning is occurring. These data, combined with the absence of any fish detected by the hydrophone receiver "gates" across each adjacent estuary, will allow us to test our hypothesis that winter flounder in the Gulf of Maine spawn in coastal and offshore waters rather than in estuaries. To study the spawning movements of winter flounder, tracks derived from the positional data will be projected onto a map of the study site using ArcView software. Rate of movement (m/hr), area utilization (home range), habitat use, and spatial randomness will be calculated using the Animal Movement Analyst Extension of the ArcView software (Hooge and Eichenlaub 2000). If possible, kernel utilization distribution (KUD) and minimum convex polygon (MCP) will be calculated for each fish tracked. KUD modeling calculates contours that describe the probability of finding an animal within a given area (habitat) (Seaman and Powell 1996). MCP modeling provides an estimate of area utilized ("home range") by calculated the area within the points traveled (Millspaugh and Marzluff 2001).

The use of a pressure sensor within the acoustic tag will allow us to construct a depth history of each fish (acoustic tag), and relate this depth to horizontal position recorded synoptically during acoustic tracking, and archived on the VR2W receivers. The associations will allow us to determine how horizontal movements, activity (vertical movements), and fine-scale distribution relate to important spawning habitat attributes such as bathymetry and substrate type. Integration of the data from all fish will allow us to broadly characterize the spawning habitat of winter flounder, and to determine how the spatial distribution of spawning fish relates to attributes of the spawning habitat. Depth data from tagged fish may also allow us to locate specific spawning locations and times, because sudden short decreases in depth during nighttime hours that would be recorded on the receivers, may be indicative of winter flounder spawning behavior (Stoner et al. 1999).

**Impacts and applications:**

This study contributes to a broader understanding of winter flounder spawning habitat, especially for those populations north of Cape Cod. Given that the long-term viability of

marine resources depend on protection of their habitat, and that the Sustainable Fisheries Act requires regional fishery management councils to describe, identify, protect, conserve and enhance essential fish habitats (EFH), studies of winter flounder spawning habitat are necessary. Results of the research will be useful to fisheries managers. For example, there is good evidence that southern winter flounder populations return to the same spawning area each year (Saila 1961a; Phelan 1992), and this may be true in the GOM as well. In addition, it appears that the northern populations do not undertake long migrations (Howe and Coates 1975). Therefore localized spawning areas, such as those we are identifying, are probably critical to local populations, and the fishery that depends on them. Clearly it is important to study and understand the essential spawning habitat associated with this area.

State and federal fisheries managers and regulators, who will use the data to identify, conserve and enhance the essential habitat for winter flounder would best benefit by knowing about the project.

**Related Projects:**

Outreach services have been provided by NH Sea Grant through Ken LaValley. These services have included postcard mailings and poster production. In addition, this project builds upon and contributes to complimentary adult winter flounder biotelemetry research in and around Plymouth Harbor, MA conducted by Steve Cadrin and Greg DeCelles (SMAST). In this ongoing southern study, DeCelles and Cadrin tagged and released pre-spawning adult fish right outside of Plymouth Bay in 2007-2009. These fish are being tracked to monitor seasonal movements of adults. Despite historical evidence of spawning inside the harbors, they speculate that the fish may use other locations within the bay for spawning. Both projects seek to clarify misconceptions of the spawning paradigms of the GOM winter flounder stock using identical acoustic equipment. However, because winter flounder spawning aggregates are isolated, different trends may exist between these populations. Because of the similarity of the two projects, scientists from both groups have met on multiple occasions to share ideas and technology. For instance, Fairchild and Howell travelled to SMAST and met with Cadrin and DeCelles to discuss research plans in Nov. 2008. In April 2009, DeCelles visited scientists at UNH to demonstrate the acoustic tagging protocol he had developed.

**Partnerships:**

The collaborative fisherman-scientist partnership has been very strong in this project. A total of 5 scientists and 6 fishermen from 3 commercial vessels have participated. The industry partners (Bouchard, Felch, and Goethel) have been intricately involved in this project as they have helped design the project and methods, create the schedule, and collect the data. In particular, Felch rigged all the hydroacoustic gear required for the project in February. This included

picking up receivers from Mass. DMF in Gloucester, purchasing supplies (rope, anchors, chain, blocks, buoys, etc.), constructing highflyers and anchor systems for the receivers, and deploying and moving the gear as needed. All fishermen have actively participated each week in the trawl sampling and manual tracking of the fish. The many discussions about their knowledge of fish assemblages within the study area have strongly influenced how this project was carried out. Without their expertise, experience, and boats, this project would not have been possible.

**Presentations:**

Fairchild, E. A., W. H. Howell, M. Armstrong, L. Siceloff, B. Hoffman, C. Bouchard, C. Felch, and D. Goethel. "Spawning movements and habitat use of winter flounder in the southern Gulf of Maine." Northeast Consortium PI meeting, 25 March, 2009, Portsmouth, NH. (poster)

Fairchild, E. A. "Spawning movements and habitat use of winter flounder in the southern Gulf of Maine" NH Sea Grant Fisheries Round Table Meeting, 24 June 2009, Urban Forestry Center, Portsmouth, NH.

**Published Reports and Papers:**

To date, the only publications have been informational ones explaining the rationale of the project, who is involved, what to do if a tagged winter flounder is caught, and who to contact for further information. Fishermen have been targeted with the following publications:

1. New Hampshire Coastal Conservation Association June newsletter
2. Mailing to licensed NH fishermen and MA lobstermen
3. Tag-recapture posters at NH and northern MA locations

**Data:**

The data have not been submitted to the Northeast Consortium yet as we are still in the process of collecting information. Data will be available once analyses are completed and manuscripts are published.