Stock-specific Bycatch Mapping for River Herring

**Project Period**
7/01/2014 - 6/30/2016

**Project Location**
Trawl surveys cover US coastal waters from the Gulf of Maine to Cape Hatteras. Genotyping will occur at UCSC (CA District 17). Meetings with collaborators will occur in New Haven, CT (CT District 3).

**Project Description (from Proposal)**
Conduct genetic analysis to determine the genetic stock, or coastal origin, of river herring taken as bycatch in marine fisheries. Project will provide fisheries managers with critical predictions for how proposed bycatch management scenarios will impact the most threatened alewife and blueback herring stocks.

**Summary of Achievements**
Our first genetic analysis of river herring bycatch was recently published (Haselman et al. 2016). This paper is based on funding from this award and from a previous NFWF award. We examined the genetic stock composition of river herring captured as bycatch from 2011-2013. This analysis is the first to reveal the genetic stock composition of river herring bycatch from marine fisheries. In this analysis, we used microsatellite data to assign river herring bycatch to US genetic stocks. Results show that, while all genetic stocks are encountered in bycatch, rates of bycatch are significantly greater for the blueback herring Mid-Atlantic Stock and the alewife Southern New England Stock. We then combined genetic stock proportions to estimates overall bycatch in the Atlantic herring fishery to estimate the number of river herring taken by this fishery in 2012-2013. Results show that about 5 million river herring were taken in this fishery over the two years examined. In 2012, when blueback herring dominated bycatch, the Mid-Atlantic Stock of blueback herring (711,800 fish taken) represented 54.7% of the total river herring mortality. In 2013, when alewife dominated bycatch, the Southern New England Stock of alewife (2.32 million fish taken) represented 64% of the total river herring mortality. Thus, the numbers of fish from these genetic stocks taken as bycatch are sufficient to represent a severe impact on regional populations that may be contributing significantly to failed recovery in these regions. This paper reveals that resolving the bycatch problem will be critical for river herring recovery in Southern New England and the Mid-Atlantic Regions.

The next stage of this project began with the development of a panel of 96 single nucleotide polymorphisms (SNPs) to replace the 15 microsatellites used in prior analyses. SNPs have several advantages over microsatellites, including increased spatial resolution of population genetic structure, faster and more reliable genotyping for larger sample sizes and lower error rates, and more precise genetic stock assignments. Our goal with the new SNPs is to geographically refine our genetic stock identifications to more precisely identify spawning populations being severely impacted by bycatch. However, transitioning to a new marker type requires re-genotyping baseline spawning populations.

This SNP baseline genotyping is complete and expands the range and intensity of geographic sampling beyond that of the Hasselman et al. (2016) study, with 111 anadromous alewife spawning runs (N=8,204) and 66 blueback herring spawning runs (N=2,840) genotyped. Both collections span the entire geographic range of each species (USA and Canada). For most watersheds, we achieved our goal of 48 samples per population. For several rivers, we included multiple years of sampling to examine temporal stability. We expect two products from these data within the next year: (1) a peer-reviewed publication describing the development of the new SNP markers, and (2) a peer-reviewed publication applying these new SNP markers to perform the first true range-wide analysis (USA and Canadian populations) of alewife and blueback herring population genetic structure.

Genotyping of fisheries-independent bottom trawl samples and new bycatch samples (2014-2015) using the newly developed SNP markers has begun. SNP genotypes will be used to assign bycatch and bottom trawl samples to genetic origins to further refine the results of Hasselman et al. (2016) by revealing finer-scale bycatch impacts and including fisheries-independent data, which can reveal the consequences of shifting fishing into new areas for threatened genetic stocks.

Members of this project have been active in communicating results to scientists, managers, and the public. Dan Hasselman and Eric Palkovacs both serve as members of the ASMFC-NMFS River Herring Technical Expert Working Group (TEWG). Dr. Hasselman chairs the TEWG genetics subgroup and...
serves as scientific advisor to the Mid-Atlantic Fishery Management Council, providing specific advice on shad and river herring management. Dr. Palkovacs has discussed this work at invited seminars (McGill University, UC Berkeley, University of Michigan) and to the public (Seymour Marine Discovery Center). Dr. Palkovacs has discussed this work on BBC Radio and Martha's Vineyard Magazine. Dr. Hasselman presented the bycatch work to the TEWG on September 26, 2016. Dr. Palkovacs testified about this bycatch work at the October 5, 2016 meeting of the Mid-Atlantic Fishery Management Council where the Council ultimately voted against including river herring as stocks in the fishery.

**Lessons Learned**

We learned that the most depleted river herring spawning runs (Southern New England and Mid-Atlantic Regions) are suffering the greatest mortality due to bycatch. We also learned that there is strong resistance against taking further action to reduce river herring bycatch from fishery managers in these regions.
### Activities and Outcomes

#### Funding Strategy
Activity / Outcome | Description |
--- | --- |
Herring - Research - # studies used to inform mgmt | Enter the number of studies completed whose findings are used to adapt management/ inform mgmt decisions |

| # studies used to inform mgmt - Current | 2.00 |
| # studies used to inform mgmt - Grant Completion | 5.00 |

**Notes**
- Peer-reviewed publications in top journals will make our results available to the broad scientific and management communities within 3 years of the onset of the project. Our prior NFWF proposal, funded in 2010, has yielded papers in several top journals in the field, including Evolutionary Applications and Molecular Ecology, with three more papers that will be submitted for publication this year.

UPDATE: We currently have 1 paper in review (Baetscher et al.), 1 paper nearing submission (Reed et al., utility of SNP markers for genetic stock identification), and 1 paper in development (application of SNP markers to recent bycatch).

#### Funding Strategy
Activity / Outcome | Description |
--- | --- |
Herring - Reduction in by-catch - # of individuals saved | Enter the number of individuals saved through use of safer gear or practices |

| # of individuals saved - Current | 0.00 |
| # of individuals saved - Grant Completion | 640000 |

**Notes**
- If the recommendations from our proposed research are implemented, we expect this information to yield significant reductions in the impacts of marine bycatch. As a goal, we estimate that it could yield a bycatch reduction of perhaps 10% (representing about 640,000 fish saved). Information from our proposed research will allow managers to focus bycatch mitigation strategies on the most threatened stocks (Southern New England and Mid-Atlantic Stocks). If river herring migrate as single-stock groups, even a small percentage reduction in overall bycatch could save the majority of a spawning run and the unique genetic diversity contained therein.

UPDATE: This is a longer term outcome that is dependent on fishery managers using the information provided to enact regulations aimed at reducing bycatch. Unfortunately, recent proposals to tighten management regulations in ways that would reduce bycatch have been rejected by the fishery management councils. This is despite lengthy discussion of our bycatch studies and the attendance and testimony of Eric Palkovacs to describe results and address questions about our bycatch studies. We are making an impact on the conversation, but the management actions are still needed to yield results for this metric.

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Final Programmatic Report Narrative

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1. Summary of Accomplishments

We examined the genetic stock composition of river herring captured as bycatch. This analysis is the first to reveal the genetic stock composition of river herring bycatch from marine fisheries. We developed a new set of SNP markers and genotyped river herring populations in the US and Canada using this new set of markers. We have begun deploying these new markers to assess bycatch in 2014-2015.

2. Project Activities & Outcomes

Activities

- We have published the main findings from bycatch work using microsatellites (Hasselman et al. 2016). We have a paper in review describing the development and utility of the new SNP markers (Baetscher et al. in review). We have papers in preparation describing rangewide population genetic structure of river herring using the new SNP markers (Hasselman et al., in prep) and new bycatch results from 2014-2015 using the SNPs (Reid et al. in prep). It is difficult to determine what management difference our work is making in terms of the numbers of fish saved. This work is getting attention from fishery managers and was a main topic of conversation at the October Mid-Atlantic Fishery Management Council Meeting, where adding river herring as stocks in the fishery was being voted on. Ultimately, this action was not taken by the Council. However, this work was continuously referenced at this meeting. The Council voiced continued support of ongoing catch caps as a means to reduce bycatch.
- We had hoped to complete work examining marine population genetic structure using fishery independent samples collected by various bottom trawl surveys. This work is still in progress.

Outcomes

- We examined the genetic stock composition of river herring captured as bycatch from 2011-2013. This analysis is the first to reveal the genetic stock composition of river herring bycatch from marine fisheries. In this analysis, we used microsatellite data to assign river herring bycatch to US genetic stocks. Results show that, while all genetic stocks are encountered in bycatch, rates of bycatch are significantly greater for the blueback herring Mid-Atlantic Stock and the alewife Southern New England Stock. We then combined genetic stock proportions to estimates overall bycatch in the Atlantic herring fishery to estimate the number of river herring taken by this fishery in 2012-2013. Results show that about 5 million river herring were taken in this fishery over the two years examined. In 2012, when blueback herring dominated bycatch, the Mid-Atlantic Stock of blueback herring (711,800 fish taken) represented 54.7% of the total river herring mortality. In 2013, when alewife dominated bycatch, the Southern New England Stock of alewife (2.32 million fish taken) represented 64% of the total river herring mortality. Thus, the numbers of fish from these genetic stocks taken as bycatch are sufficient to represent a severe impact on regional populations that may be contributing significantly to failed recovery in these regions. This paper reveals that resolving the bycatch problem will be critical for river herring recovery in Southern New England and the Mid-Atlantic Regions
- The next stage of this project began with the development of a panel of 96 single nucleotide polymorphisms (SNPs) to replace the 15 microsatellites used in prior analyses. SNPs have several advantages over microsatellites, including increased spatial resolution of population genetic structure, faster and more reliable genotyping for larger sample sizes and lower error rates, and more precise genetic stock assignments. Our goal with the new SNPs is to geographically refine our genetic stock identifications to more precisely identify spawning populations being severely impacted by bycatch. Transitioning to a new marker type requires re-genotyping baseline spawning populations. This step is now complete.
- Genotyping of fisheries-independent bottom trawl samples and new bycatch samples (2014-2015) using the newly developed SNP markers has begun. SNP genotypes will be used to assign bycatch and bottom trawl

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samples to genetic origins to further refine the results of Hasselman et al. (2016) by revealing finer-scale bycatch impacts and including fisheries-independent data, which can reveal the consequences of shifting fishing into new areas for threatened genetic stocks.

3. Lessons Learned
We learned that the most depleted river herring spawning runs (Southern New England and Mid-Atlantic Regions) are suffering the greatest mortality due to bycatch. We also learned that there is strong resistance against taking further action to reduce river herring bycatch from fishery managers in these regions. This may be due to the feeling that additional action will limit commercial harvest of several targeted species. Indeed, there has been a strong negative reaction to our published work from commercial fishing interests and those opposing additional restrictions on river herring bycatch. At the same time, our work is getting positive attention from conservation groups and fishery managers who are genuinely interested in solving the bycatch problem and restoring river herring populations. In light of the recent failure of the Mid-Atlantic Council to vote to manage river herring under Federal regulations, it seems likely that one or more lawsuits will be filed in the near future. The out come of these lawsuits may hinge on whether current actions, such as catch caps, are actually working to reduce bycatch of the most depleted river herring populations. Our work will help inform these issues as this management situation continues to develop.

4. Dissemination
In addition to the four peer-reviewed papers described above, members of this project have been active in communicating results to scientists, managers, and the public. Dan Hasselman and Eric Palkovacs both serve as members of the ASMF-NMFS River Herring Technical Expert Working Group (TEWG). Dr. Hasselman chairs the TEWG genetics subgroup and serves as scientific advisor to the Mid-Atlantic Fishery Management Council, providing specific advice on shad and river herring management. Dr. Palkovacs has discussed this work at invited seminars (McGill University, UC Berkeley, University of Michigan) and to the public (Seymour Marine Discovery Center). Dr. Palkovacs has discussed this work on BBC Radio and Martha's Vineyard Magazine. Dr. Hasselman presented the bycatch work to the TEWG on September 26, 2016. Dr. Palkovacs testified about this bycatch work at the October 5, 2016 meeting of the Mid-Atlantic Fishery Management Council where the Council ultimately voted against including river herring as stocks in the fishery.

5. Project Documents
Identify the origins and impacts of river herring bycatch in marine fisheries (Hasselman et al. 2016)
Bycatch of mid-trophic level anadromous fishes that connect marine and freshwater ecosystems is a growing conservation concern. Anadromous alewife (Alosa pseudoharengus) and blueback herring (A. aestivalis) are important components of coastal freshwater and marine food webs, but have experienced dramatic declines in the abundances of spawning adults. Freshwater-focused restoration efforts have yielded few consistent signs of recovery; raising concerns that bycatch in northwest Atlantic commercial fisheries may be negating these conservation actions. Using data from 15 microsatellites genotyped for baseline populations and bycatch, we conducted genetic stock identification to understand how bycatch was partitioned among previously identified regional genetic stocks. We then combined this information with fishery observer data to estimate genetic stock-specific bycatch mortality for the southern New England Atlantic herring fishery (2012-2013). Bycatch overall, but especially in the Atlantic herring fishery, was disproportionately assigned to the most severely depleted genetic stocks (i.e., alewife Southern New England stock – 69.5% of assignments; blueback herring Mid-Atlantic stock – 78.2% of assignments). These genetic stocks overlap in the region surrounding Long Island Sound, suggesting that bycatch taken from these genetic stocks by the southern New England Atlantic herring fishery in recent years may be negatively impacting recovery efforts in this region. Our study suggests that mitigating bycatch on the southern New England fishing grounds may benefit recovery efforts for alewife and blueback herring genetic stocks that have experienced the greatest declines in spawning adult abundances.

Management Implications: A major question in river herring conservation has been the effects of bycatch in marine fisheries in driving declines and preventing recovery. This study is the first to use genetic stock identification to assess the spawning origins of river herring caught as bycatch in marine fisheries. Results show that the most depleted genetic stocks in Southern New England and the Mid-Atlantic Regions are also being the most heavily impacted by bycatch. The magnitude of bycatch and its pattern of geographic concentration in the region surrounding Long Island Sound suggest that bycatch may be a particular threat to these populations. We recommend immediate action to limit river herring bycatch in this region, especially in the Atlantic herring fishery operating off the coast of Southern New England.

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Both freshwater habitat alteration and marine fisheries can affect anadromous fish species, and fluctuating populations elicit conservation concern and coordinated management. We describe the development and characterization of two panels of 96 single nucleotide polymorphism (SNP) assays for two species of anadromous alosine fishes, alewife and blueback herring (collectively known as river herring), that are native to the Atlantic coast of North America. We used data from high-throughput DNA sequencing to discover SNPs and then developed molecular genetic assays for genotyping sets of 96 individual loci in each species. The two sets of assays were validated with multiple populations that encompass both the geographic range and the known regional genetic stocks of both species.

The SNP panels developed herein accurately resolved the genetic stock structure for alewife and blueback herring that was previously identified using microsatellites and assigned individuals to regional stock of origin with high accuracy. These genetic markers, which generate data that is easily shared and combined, will greatly facilitate ongoing conservation and management of river herring including genetic assignment of marine caught individuals to stock of origin.

Management Implications: The development of new SNP markers allow for faster genotyping and more reliable genetic stock identification compared to microsatellites. Genotyping of riverine baseline populations with these new SNP markers is complete, and genotyping of bycatch samples from 2014-2015 is nearing completion. This new round of bycatch genotyping will provide increased precision and accuracy for identifying the origins of river herring bycatch in marine fisheries. This information can be used to guide management actions aimed at reducing bycatch for the most depleted river herring populations.


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