Estimates of River Herring Bycatch in the Directed Atlantic Herring Fishery

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Introduction

Atlantic herring (*Clupea harengus*) is an economically and ecologically important species with a fishery that ranges seasonally from Cape May NJ to Maine. The fishery is prosecuted for bait and food using single and paired midwater trawls, purse seines, and bottom trawls. It is a high volume fishery, averaging 100,000 mt of landings since 1995. In recent years, a majority of landings have come from the midwater gears, especially outside the Gulf of Maine. Unlike many fisheries, the high volume nature of operations means catch events (or individual net hauls) are generally pumped directly from net to hold with little sorting of species.

The spatial distribution of Atlantic herring overlaps with the spatial distributions of two other important herring species: blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengu*s). These two species (known colloquially as "river herring") have a rich social and economic history in fisheries management. (ASMFC, 1999), and are currently listed as a species of concern by the National Marine Fisheries Service because in-river catches and individual spawning populations have decline recently (http://www.nmfs.noaa.gov/pr/species/concern/).

Due to the spatial overlap among these herring species, river herring are encountered as bycatch in the Atlantic herring fishery. Managers, stakeholders, and the public have expressed concern over bycatch of river herring due to the Atlantic herring fishery's high volume nature and the current status of river herring populations. This report provides estimates of river herring bycatch in the directed Atlantic herring fishery for years 2005-2007. Data come from two sources: the NMFS at sea observer program and the Maine Department of Marine resources portside bycatch project funded by the Atlantic Coastal Cooperative Statistics Program.

Methods

Observer Program

The full methodologies associated with NMFS at sea observer program can be found else where (NMFS, 2008). Generally, this program places observers on vessels to monitor and quantify bycatch and discards of non-target species during normal fishing operations on a haul by haul basis. Dedicated sampling protocols for trips taken on Atlantic herring vessels have been in place, mostly in response to haddock bycatch concerns (NEFMC, 2006). Since 2005, efforts have focused on directed Atlantic herring trips (NEFMC, 2006).

On Atlantic herring trips, observers subsample river herring and other smaller sized fishes during the pumping phase from net to hold. This is in response to the high volume nature of Atlantic herring operations, making it impossible to observe all the bycatch on a haul by haul basis. Sub-sampling protocols require that 10 baskets per haul are taken from an area of the pumping process prior to separation of the catch, and are taken at regular intervals during the pumping process. Species composition and weight, size and other biological information are collected from all baskets. In essence the observer is sub-sampling the catch stream for later expansion to the entire haul, and then to the trip. After recording haul duration, location, discards, and retained

non-target species the data are then housed in a centralized database and are available for further analysis.

Portside project

Since 2005, Maine Department of Marine Resources (DMR) has quantify bycatch in the directed Atlantic herring and Atlantic mackerel fisheries from funding received through the ACCSP Sampling takes place at processing plants and bait dealers in Maine, New Hampshire, Massachusetts, Rhode Island, and New Jersey. (Figure 1) . The program takes advantage of normal processing plant operations by measuring bycatch that enters a food or bait processing facility. Samplers collect and quantify all bycatch from individual "lots" of fish (transported by trucks or vessels) that enter the processing facilities. Lots range in size from 10,000 to 40,000 lbs and many lots enter the facility from a particular landing vessel, or multiple vessels, either from direct pumping or by truck. Plants process one lot (fish caught by one vessel on a particular trip, delivered by truck or boat) at a time and then reset the plant in preparation for the next lot. Therefore, each lot is a subsample of an individual landing event, and the bycatch removed can be documented and assigned to a catch location, gear type, date and a total lot amount. However each lot may not represent the entire landing for a trip from a particular vessel, and as such maybe viewed as a subsample.

Samplers position themselves at the point of entry into the facility along an assembly line or at the base of the hoppers where the fish are unloaded. Sampling is conducted before grading or sorting of the catch occurs. All bycatch is removed from the assembly line or hopper and is placed in bushel baskets or buckets specific to each species. The total weight of any observed bycatch is recorded along with species identification, total species weight, an individual lengths, and weights of all fish according to a NMFS and ACCSP specified protocol. If there is a large amount of one species, the total weight is recorded and then length frequencies and weight are gathered from a sub sample of n = 50. The information collected is recorded on data sheets and entered into the DMR biological database. However, due to data confidentiality issues, only vessel gear type, month, and port of landing, are recorded for bycatch sampling trips.

Estimation of River Herring Bycatch

For this analysis blueback herring and alewives are combined because species identification is difficult and the portside project did not distinguish between species until 2006.

Directed Atlantic herring trips were defined as those that kept or landed in excess of 2,000 lbs of Atlantic herring. In total, 502 directed Atlantic herring trips were observed by portside or observer projects from 2005 to 2007. Eighteen trips had both observer and portside estimates of river herring bycatch. A paired Wilcox signed rank test was used to compare these individual estimates of the ratio of river herring caught to Atlantic herring kept. No significant difference between these two projects was observed ($P = 0.29$), suggesting that observations from portside and observer projects can be pooled. However, because of the low sample size the power to detect a significant difference was likely low, and so this should be considered a preliminary result. Observer estimates of these paired observations were removed from further analysis.

For this analysis, trip data from the observer and portside projects were grouped into year, quarter, area, and gear type (single midwater trawl, paired midwater trawl, purse seine, and bottom trawl) strata Areas were defined as Western Gulf of Maine (WGOM), Eastern Gulf of Maine (EGOM), Georges Bank/Cape Cod (GB/CC), and Southern New England (SNE). These areas represent the major locations where the directed Atlantic herring fishery occurs and loosely follow the management area boundaries for Atlantic herring (Figure 2).

Following Lohr (1999), the ratio estimate (R) for stratum S was calculated using the form:

$$\hat{R}_S = \frac{\sum_i r_{S,i}}{\sum_i A_{S,i}}$$

where $r_{S,i}$ is the observed river herring bycatch (pounds) from trip *i* in stratum *S* and $A_{S,i}$ is the Atlantic herring landings (pounds) for trip *i* in stratum *S*. Its variance is estimated by:

$$\mathrm{var}(\hat{R}_S) = \frac{1}{n_S \bar{A}_S^2} \frac{\sum_i (r_{S,i} - \hat{R}_S A_{S,i})^2}{n-1}$$

where n_S is the number of observer/portside observations and A_S bar is the mean of Atlantic herring observer landings for stratum S.

Total river herring bycatch (B) for each stratum was calculated as

$$\hat{B}_S = \hat{R}_S \cdot L_S$$

where L_S is the total Atlantic herring catch/landings from stratum S (year, quarter, area, and gear type), The standard error of B_S was estimated by:

$$SE(\hat{B}_S) = \sqrt{\mathrm{var}(\hat{R}_S) \cdot L_S^2}$$

The annual total estimate of bycatch and its variance were derived by summing B_s and SE^2 over all strata within a given year.

Landings and catch data were generated by querying the NMFS Vessel Trip Report Database (VTR) for targeted trips (landed more then 2,000 lbs of Atlantic herring). This database gives precise location, date, time, and gear type used. Generally catch and landings are interchangeable for Atlantic herring as the reports of discards in the VTRs are small. Some strata had no observer or portside samples because fishing activity for Atlantic herring in these particular locations/times was minimal.

Results and Conclusions

Proportion of trips sampled by year, quarter, area, and gear stratum are given in Table 1, while coverage for all strata is given in Table 2. Proportion covered in strata ranged between 0.08-0.26 by trip and 0.09-0.25 by weight, however many strata have little or no coverage particularly with regards to certain gear types (Table 1). Overall coverage was highest in 2005 (0.26) and lowest in 2007 (0.08)(Figure 2). It should be noted that in 2006 the observer project concentrated on only single and paired midwater trawls, and had no observations of purse seine gear in that year.

Percent occurrence of trips categorized by river herring bycatch expressed as a percentage of Atlantic herring landings is shown in Figure 3. Nearly 70 % of the observed trips had zero river herring bycatch. About 97% of the trips had $\leq$ 2.5% bycatch of river herring, while $\leq$1% of the trips had bycatch >10%. This suggests that while incidents of river herring bycatch are low, they can be substantial given the high volume nature of the Atlantic herring fishery.

Most bycatch occurred near Cape Cod (GB/CC) and SNE in the late fall through spring periods (Figure 4). Specifically, large bycatch of river herring was observed in the areas of Cape Cod and Cape Ann, MA (WGOM), Nantucket (SNE) and the area around Block Island (SNE) (Figure 5-8). Bycatch was also observed near Cape Ann (WGOM) in the fall (Quarter 3). Highest bycatch of river herring occurred in the SNE area, particularly in 2007 near NJ (Figures 4).

Estimates of river herring bycatch were highest in the late fall and winter periods (Quarters 1 and 4: Figure 9). During this time, Atlantic herring, Atlantic mackerel, and river herring can be found together in mixed aggregations during their fall migration around Cape Cod, as well as during the overwintering period from Block Island south.

Overall, bycatch was highest in both single and paired midwater trawl gears, while it was lowest in purse seines. Surprisingly, bycatch was high in bottom trawls in 2007 (Figure 10). Catch of Atlantic herring are usually only 3-7,000 mt for bottom trawls compared to 50-60,000 mt for single and paired midwater trawls; thus, the high bycatch possibly indicates a higher encounter rate of river herring for bottom trawls.

It is important to note that the lack of large bycatch estimates for purse seines may not reflect the gears' inability to catch river herring. Rather, purse seines are not currently operating in areas and seasons where the vast majority of estimated river herring removals occur (Figure 8).

Variation among yearly estimates of bycatch was high. The estimate of bycatch in 2007 (1.7 million pounds) was about an order of magnitude higher than the estimates of bycatch in 2005 (0.28 million fish) and 2006 (0.17 million fish)(Table 2). The increase was due mostly to high estimates during quarter 1 of 2007 across most gear types and areas (Figures 9 and 10). This suggests that the increase may be due to availability rather then a sampling artifact. The coefficients of variation (CV) of the bycatch estimates were also high and were not reduced with more intensive sampling (Table 2).

Estimates total yearly bycatch of river herring in the Atlantic herring fishery are similar to the levels of landings observed in the directed river herring fishery (ASMFC, 2008). However

further analysis is need to determine if other small mesh fisheries (i.e. scup, squid, mackerel, and others) contribute as much or more to the estimates carried out in this analysis. This study suggests that any small mesh fishery operating in the SNE and GB/CC area in the late fall to early spring may also have significant river herring bycatch

The use of both observer and portside data allowed for the estimation of total bycatch of river herring in the directed Atlantic herring fishery. Further analysis is needed to determine if purse seine operations would encounter river herring should they start fishing in areas or seasons where river herring may occur. Also, the directed Atlantic herring fishery is under going profound management changes (e.g., available quotas by management area, allowable gear types, etc.) and they should be made with some consideration of the impact on river herring bycatch.

Funding for both sampling programs should continue and the coverage of the directed Atlantic herring fishery should increase to continue to provide precise estimates of river herring bycatch for management use. Additionally data from both projects can also be used to examine bycatch issues for other small bodied fishes (i.e. shad, dogfish, haddock, and whiting).

Literature Cited

ASMFC (1999) Fishery Management Plan for Shad and River herring. Atlantic States Marine Fisheries Commission 1444 'Eye' Street, Northwest Washington, D.C. 20005

ASMFC (2008) Review of the Fishery Management Plan for Shad and River herring. Atlantic States Marine Fisheries Commission 1444 'Eye' Street, Northwest Washington, D.C. 20005

Lohr, S. L. 1999. Sampling: Design and Analysis. Brooks/Cole Publishing Company, Pacific Grove, California. 494 p.

NEFMC (2006) Framework 43 to the Northeast Multispecies (Groundfish) Fishery Management Plan (FMP) New England Fishery Management Council. 50 Water Street, Mill 2 Newburyport, MA 01950

NMFS (2008) Fisheries Observer Program Manual. National Marine Fisheries Service Fisheries Sampling Branch 166 Water Street Woods Hole MA 02543

Table 1. Proportion coverage by trip and strata. EGOM is Eastern Gulf of Maine, WGOM is Western Gulf of Maine, GB is Georges Bank/Cape Cod), SNE is Southern New England, BT is Bottom trawl, PS is purse seine, SMT is single midwater trawl, PMT is paired midwater trawl, N/A is no landings. Cells in bold have ≥33% coverage by trip

Year	Quarter	EGOM BT	EGOM PS	EGOM SMT	EGOM PMT	GB BT	GB PS	GB SMT	GB PMT	SNE BT	SNE PS	SNE SMT	SNE PMT	WGOM BT	WGOM PS	WGOM SMT	WGOM PMT	Average
2005	1	0.00	N/A	N/A	N/A	N/A	N/A	0.00	0.00	0.00	N/A	0.23	0.13	N/A	N/A	N/A	N/A	0.19
2005	2	0.00	0.10	0.00	N/A	N/A	N/A	0.00	0.00	0.00	N/A	0.20	**0.33**	N/A	0.13	0.28	0.21	0.22
2005	3	0.00	0.15	0.22	0.09	N/A	N/A	**0.39**	0.28	N/A	N/A	N/A	N/A	0.08	**0.53**	0.27	0.13	0.25
2005	4	0.00	0.24	0.00	0.00	0.00	N/A	**0.72**	**0.36**	0.00	N/A	**1.00**	**0.75**	0.14	0.17	**0.37**	0.20	**0.33**
2006	1	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.08	N/A	0.24	0.25	N/A	N/A	N/A	0.00	0.19
2006	2	0.00	**1.00**	0.22	0.00	N/A	0.00	0.14	**0.33**	0.00	N/A	**0.44**	0.00	N/A	0.04	0.06	0.10	0.10
2006	3	0.00	0.08	0.13	0.00	N/A	N/A	0.21	0.00	N/A	N/A	0.00	N/A	0.00	0.11	0.14	0.22	0.12
2006	4	0.00	**0.44**	N/A	N/A	0.20	N/A	0.15	0.27	0.00	N/A	**0.43**	**0.50**	N/A	**0.33**	0.10	**0.50**	0.20
2007	1	0.00	N/A	0.00	N/A	N/A	N/A	0.21	0.25	0.04	N/A	0.11	0.07	N/A	N/A	0.17	0.00	0.08
2007	2	0.00	0.14	N/A	N/A	N/A	N/A	0.11	0.17	0.00	N/A	0.10	0.18	N/A	0.00	0.08	0.19	0.11
2007	3	0.00	0.13	0.00	0.00	N/A	0.00	N/A	N/A	N/A	N/A	N/A	N/A	0.00	0.08	N/A	N/A	0.07
2007	4	0.00	0.06	0.10	**0.50**	0.00	N/A	0.11	0.30	0.05	N/A	0.13	N/A	N/A	0.00	0.00	0.00	0.10

Table 2. Proportion covered by trip and weight, and estimates of yearly removals of river herring from the directed Atlantic herring fishery.

Year	# trips observed	Proportion coverage (trip)	Proportion coverage (weight)	Discards (lbs)	CV
2005	267	0.26	0.25	285,833	0.6
2006	145	0.14	0.08	171,973	0.6
2007	90	0.08	0.09	1,686,617	0.5
average	167	0.16	0.14	714,808	0.56

Figure 1. Location of Portside bycatch sampling

Figure 2. Map of areas used for analysis and expansion of river herring removals

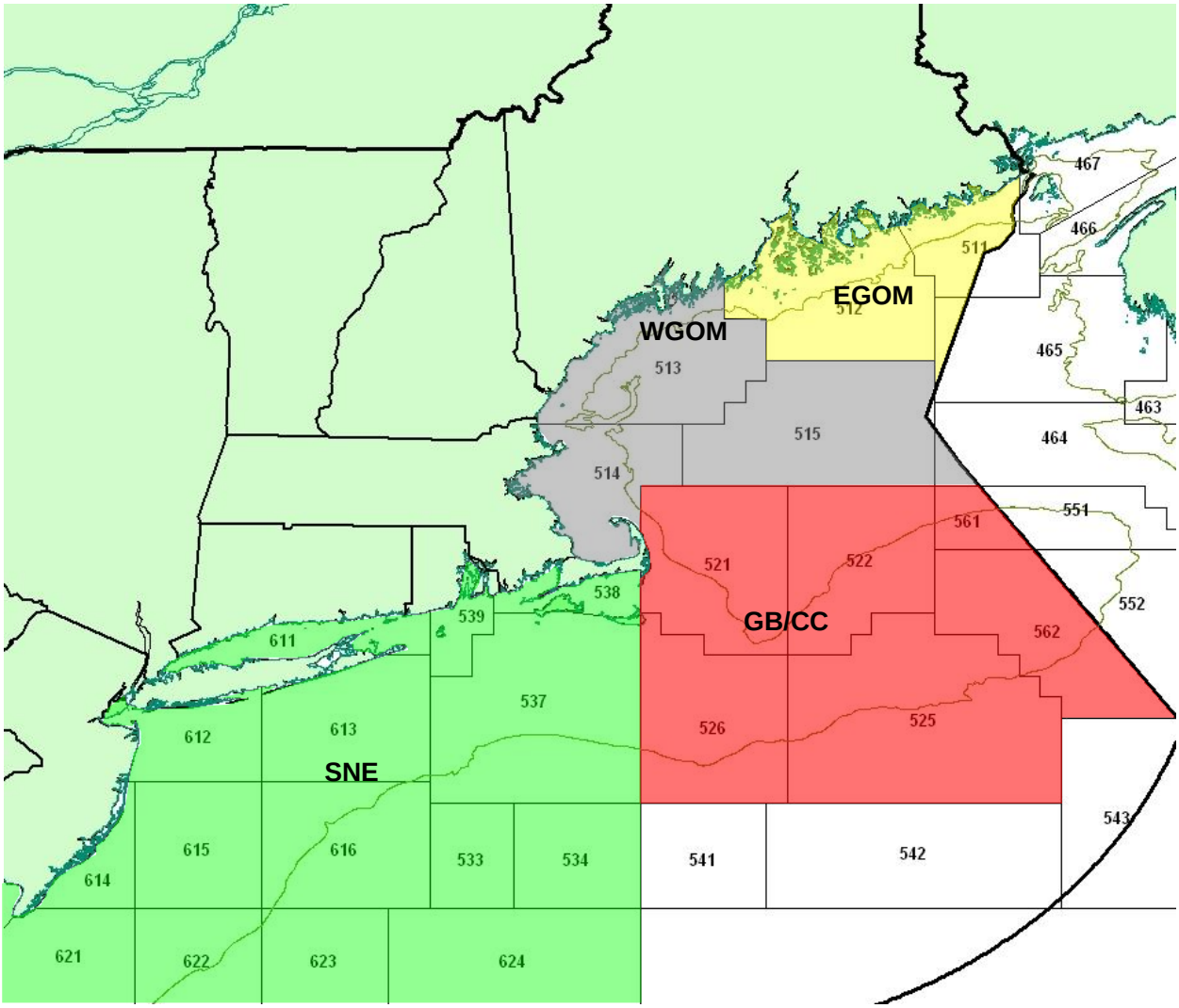

Figure 3. Percent occurrence of trips categorized by the amount of river herring bycatch expressed as a percentage of Atlantic herring landings

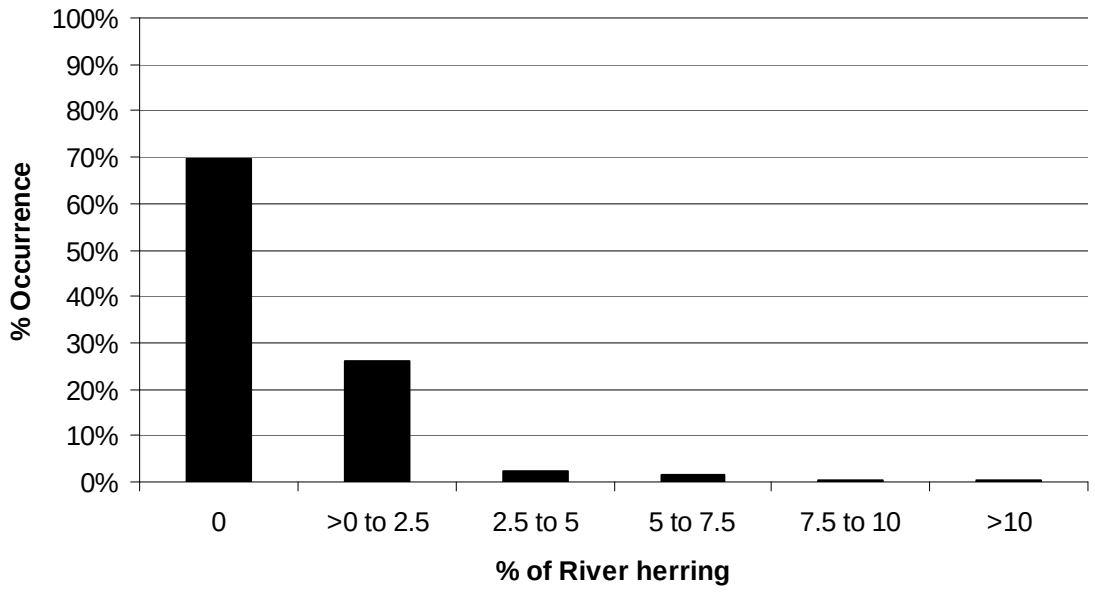

Figure 4. Estimated river herring bycatch by area.

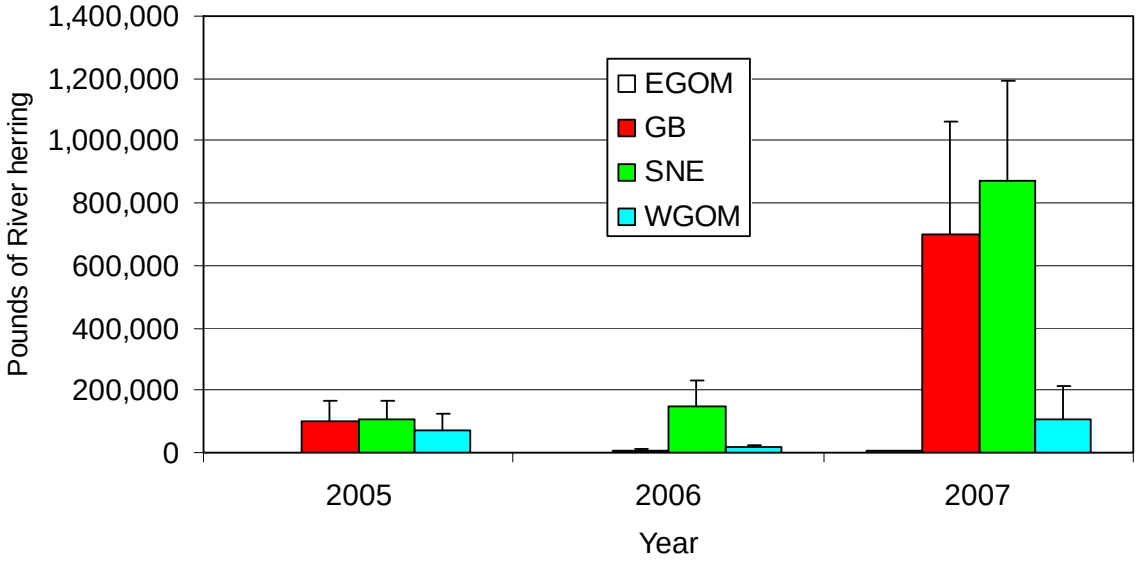

Figure 5. River herring bycatch by gear type 2005-2007 in Quarter 1 (Jan-Mar). From observer data only.

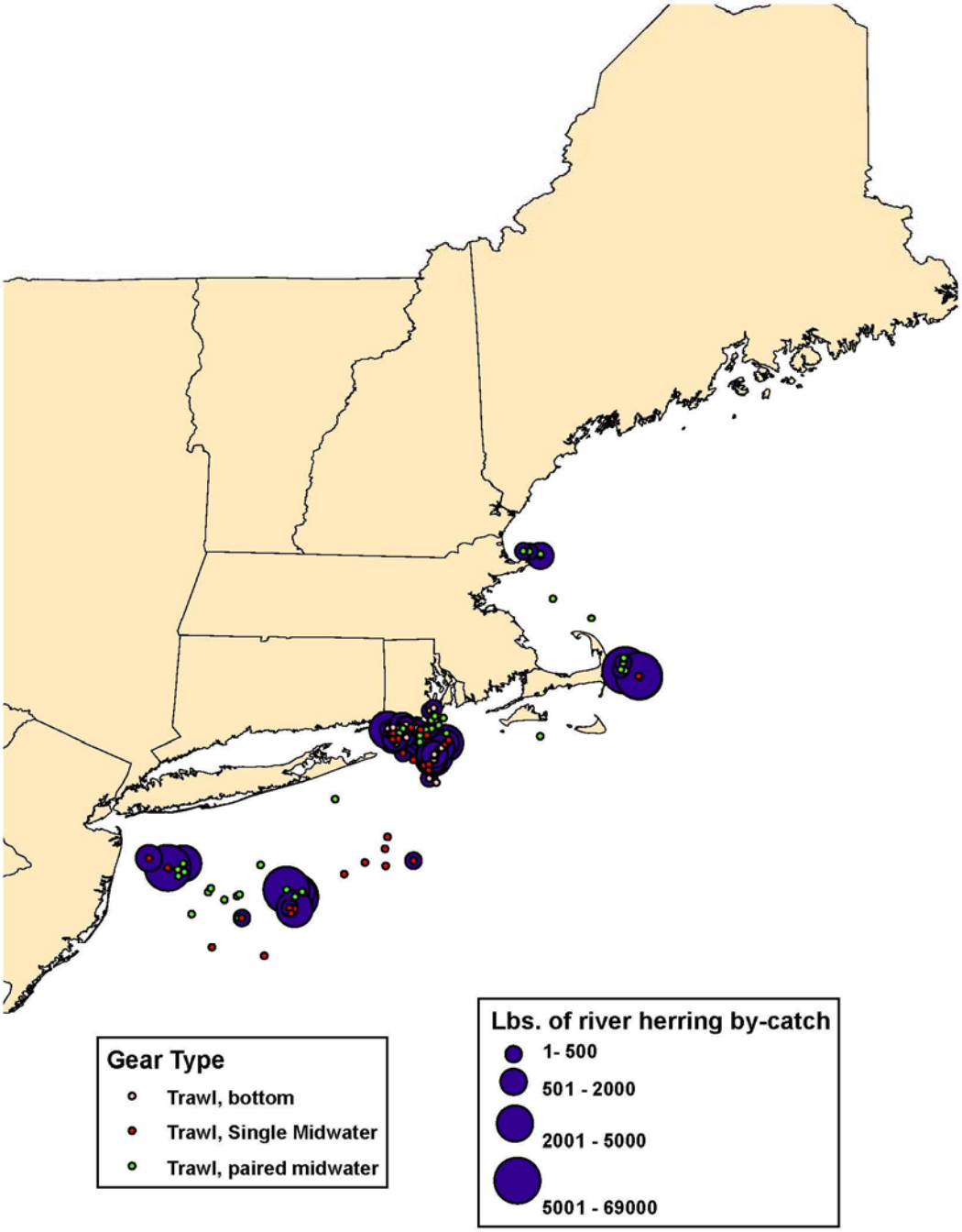

Figure 6. River herring bycatch by gear type 2005-2007 in Quarter 2 (Apr-Jun). From observer data only.

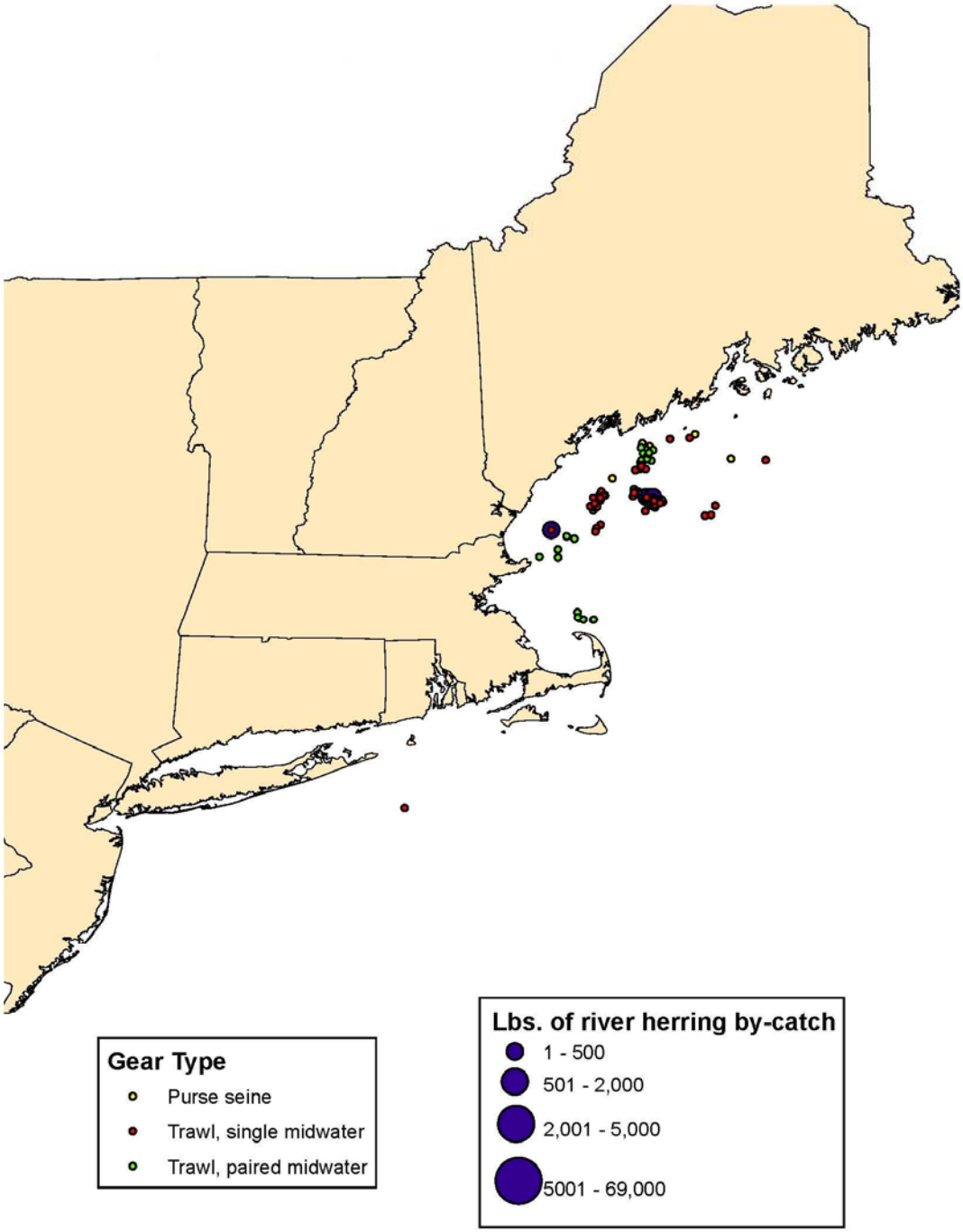

Figure 7. River herring bycatch by gear type 2005-2007 in Quarter 3 (Jul – Sep). From observer data only.

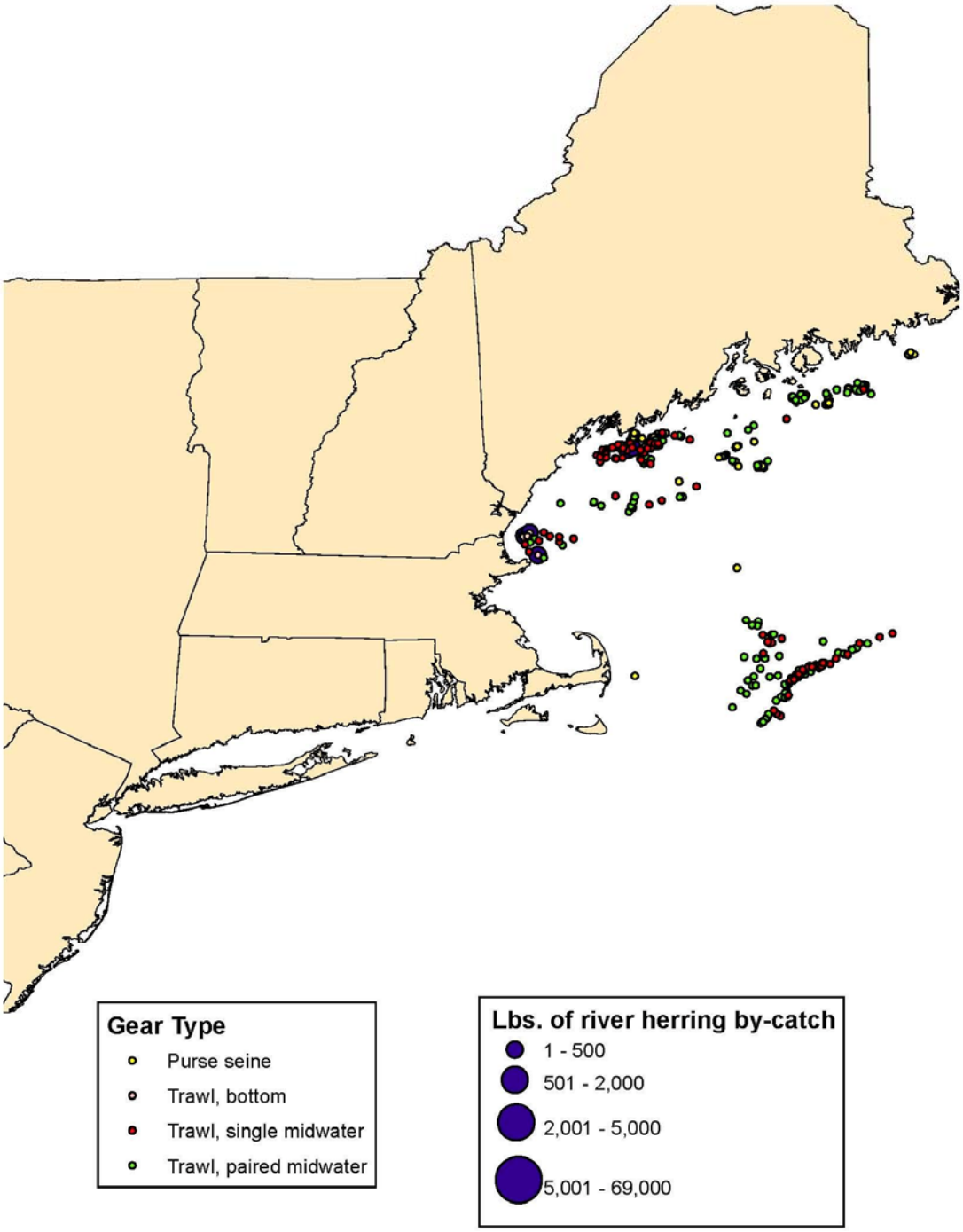

Figure 8. River herring bycatch by gear type 2005-2007 in Quarter 4 (Oct - Dec). From observer data only.

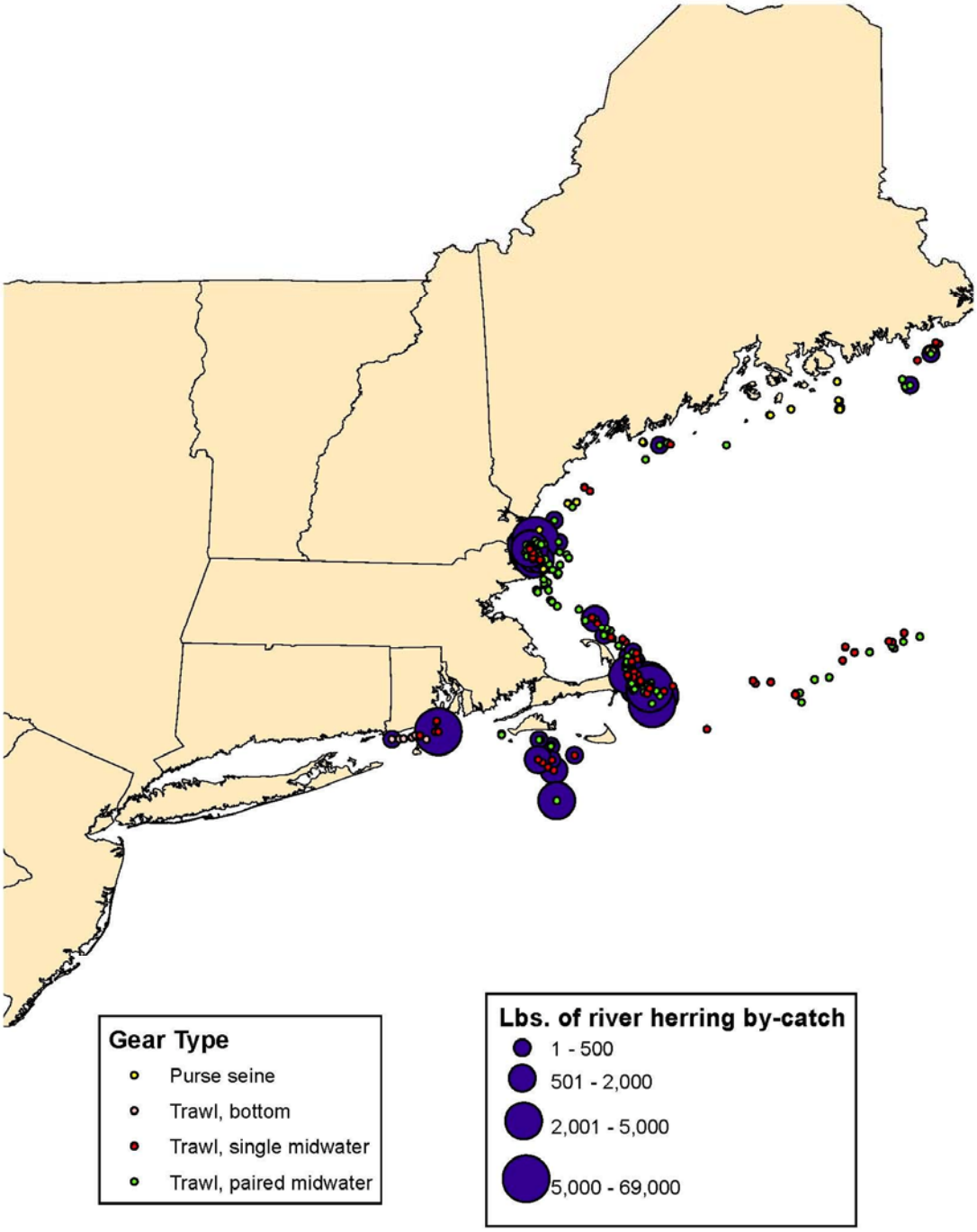

Figure 9. Estimated river herring bycatch by quarter.

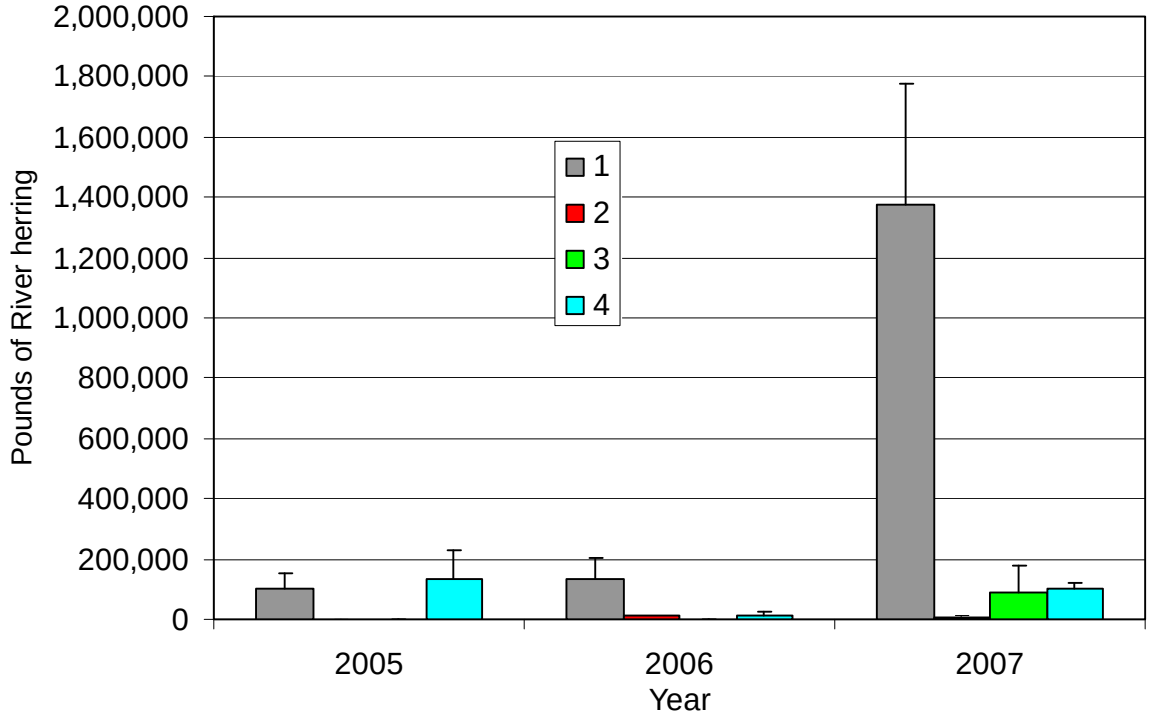

Figure 10. Estimated river herring bycatch by gear type.