13.
Chapter 5: Commercial and Recreational Fisheries

APPENDIX A

BASELINE CHARACTERIZATION: DATA SOURCES, METHODS, AND RESULTS

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1. Overview

The purpose of the baseline characterization was to provide baseline information on the current state of fisheries resources in the Ocean SAMP area based on existing survey data. It is not an assessment of individual fish stocks, nor is it an analysis of longer-term trends in Rhode Island's offshore fisheries resources. Data were obtained from multiple bottom trawl surveys occurring in and around the Ocean SAMP area. Ten years of data were used in this analysis as this provides enough data to smooth out interannual variability while retaining a focus on the current state of resources in the study area. Data included in this analysis were collected at survey stations within a polygon delineated by the following coordinates:

41° 30' N, 071° 50.5'W
40°50' N, 071° 50.5'W
41° 30' N, 070° 50'W
40°50' N, 070° 50'W

Survey stations that occur adjacent to but just outside the SAMP area were included in this analysis in order to allow for a comprehensive analysis of fisheries resources in and around the planning area. See Figure 1 for a map showing the location of each of the survey stations included in this analysis.

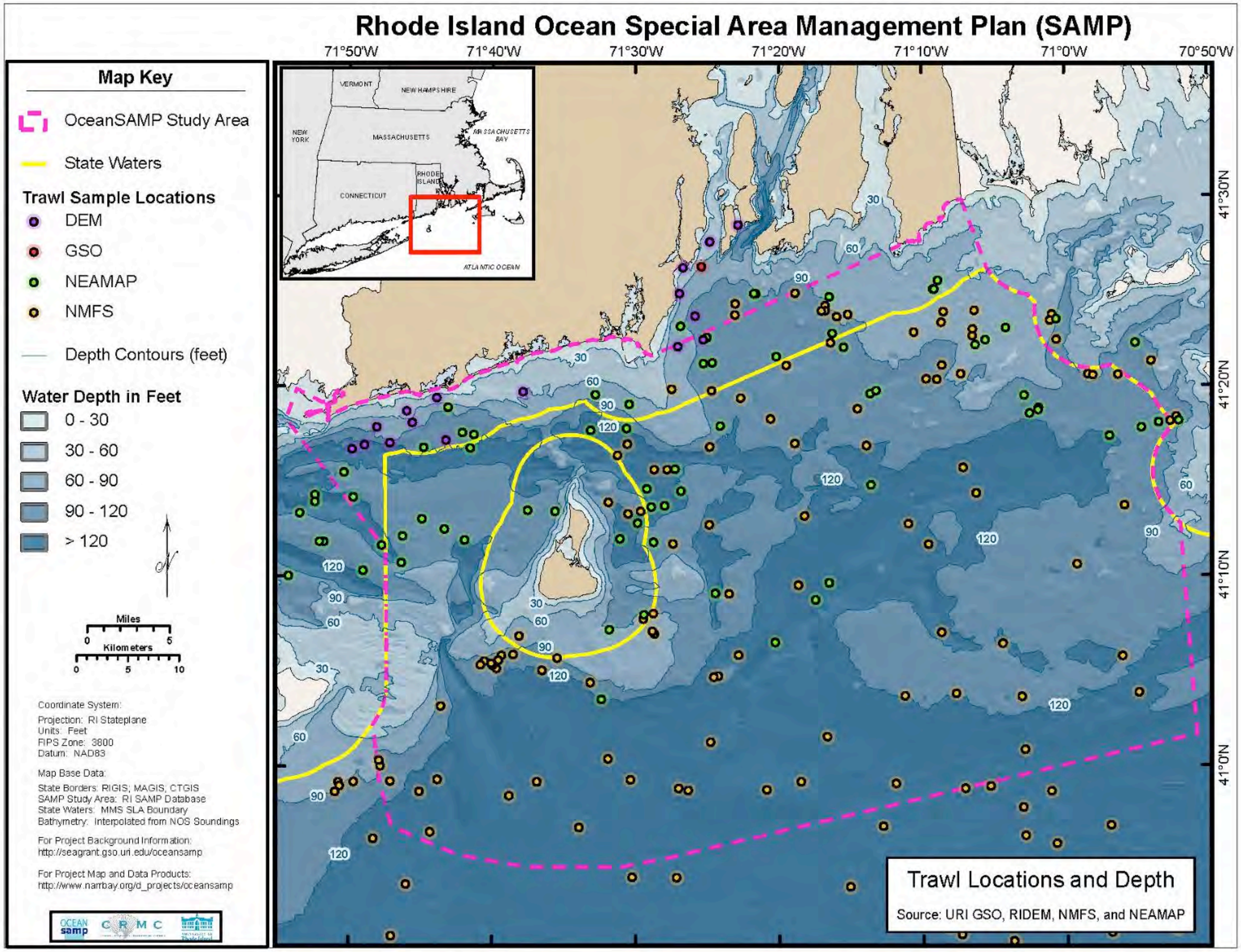

Figure 1. **Locations of Survey Stations Included in Baseline Characterization Analysis**

The following datasets are included in the data analyses:

- Rhode Island Department of Environmental Management (DEM): DEM data includes seasonal and monthly fixed stations along the southern Rhode Island coast (Block Island Sound) and the mouth of Narragansett Bay, 1999-2008. Biomass at monthly stations was converted to seasonal data each year by averaging April, May, and June tows to obtain a spring biomass and September, October, and November tows to obtain a fall biomass.
- University of Rhode Island Graduate School of Oceanography (GSO): GSO data includes one weekly fixed station in the mouth of Narragansett Bay, 1999-2008. Weekly biomass was converted to seasonal data each year by averaging April, May, and June tows to obtain a spring biomass and September, October, and November tows to obtain a fall biomass.
- Northeast Area Monitoring and Assessment Program (NEAMAP): NEAMAP data includes random stations throughout the nearshore waters off Rhode Island. The NEAMAP survey data analyzed include sampling in fall 2007, spring 2008, and fall 2008.
- National Marine Fisheries Service (NMFS): NMFS data includes random stations throughout the waters off Rhode Island, generally not inside Block Island Sound. Sampling occurred during spring and fall from 1999 through 2008.

The survey catch weight (biomass) was calculated for each survey by dividing the catch per tow (weight) by the area of each tow. Survey biomass units are milligrams per square meter (mg / m2). Tow area is the calculated area swept using the length of the tow and the distance between the net's wings, or wingspread:

$$\text{Length of tow (m) x width of net (m) = area towed (m}^2\text{).}$$

For the NMFS and NEAMAP surveys, the length of the tow and the wingspread were recorded by GPS and net sensors and used to calculate area swept. For the DEM and GSO surveys, area swept was estimated using the length of the tow, which is consistent, and gear specialists' estimates of wingspread based on net configuration. The purpose of these calculations was to allow for comparison between the surveys. However, these calculations do not account for all differences between the surveys, and results show that relative biomass estimates nonetheless vary significantly between the individual surveys. For this reason, all figures and map based on this analysis show the results for each individual survey.

2. Analysis of Total Catch

A. Methods

For analyses of total catch data, biomass was summed over all species listed in Table 1. Species in Table 1 were selected by the Ocean SAMP team and include commercially and recreationally targeted species as well as "Species of Concern", except for those (i.e. large pelagics) which cannot be adequately sampled through bottom trawl surveys. When noted, biomass values were transformed for some analyses by taking the natural logarithm (Ln) to reduce violation of the assumption of normally distributed residuals.

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American lobster	*Homarus americanus*
American shad	*Alosa sapidissima*
Atlantic cod	*Gadus morhua*
Atlantic herring	*Clupea harengus*
Atlantic mackerel	*Scomber scombrus*
Atlantic sea scallop	*Placopectin magellanicus*
Barndoor skate	*Dipturus laevis*
Black sea bass	*Centropristis striata*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Butterfish	*Peprilus triacanthus*
Cusk	*Brosme brosme*
Dusky shark	*Carcharhinus obscurus*
Goosefish	*Lophius americanus*
Little skate	*Leucoraja erinacea*
Longfin squid	*Loligo peali*
Rainbow smelt	*Osmerus mordax*
Scup	*Stenotomus chrysops*
Silver hake	*Merluccius bilinearis*
Smooth dogfish	*Mustelus canis*
Spiny dogfish	*Squalus acanthias*
Striped bass	*Morone saxatilis*
Summer flounder	*Paralichthys dentatus*
Tautog	*Tautoga onitis*
Thorny skate	*Amblyraja radiate*
Winter flounder	*Pseudopleuronectes americanus*
Winter skate	*Leucoraja ocellata*
Yellowtail flounder	*Limanda ferruginea*

Table 1. Species considered in total biomass analyses

B. Results

Multi-way analysis of variance (ANOVA) based on Ln transformed biomass data indicate that the primary factors accounting for variation in total biomass are season, survey, and depth. Season was the most important factor effecting total biomass (Figure 2). Catch biomass is higher in fall and lower in spring. Survey is the second most important factor (Figure 3); the NMFS survey biomass is lowest and the NEAMAP survey biomass is highest. Even when accounting for differences in biomass caused by season and survey, there is a statistically significant trend in depth where survey sites at deeper depth are characterized by the highest biomass. Tukey's pair-wise means difference test based on Ln transformed biomass shows that the deep depth strata (60 to 90 ft and 90+ ft) have higher total biomass than either of the shallow depth strata (20 to 40 ft and 40 to 60 ft). Other factors that were investigated and found not to have a significant effect on biomass include region (Figure 5), year, and combined depth/region.

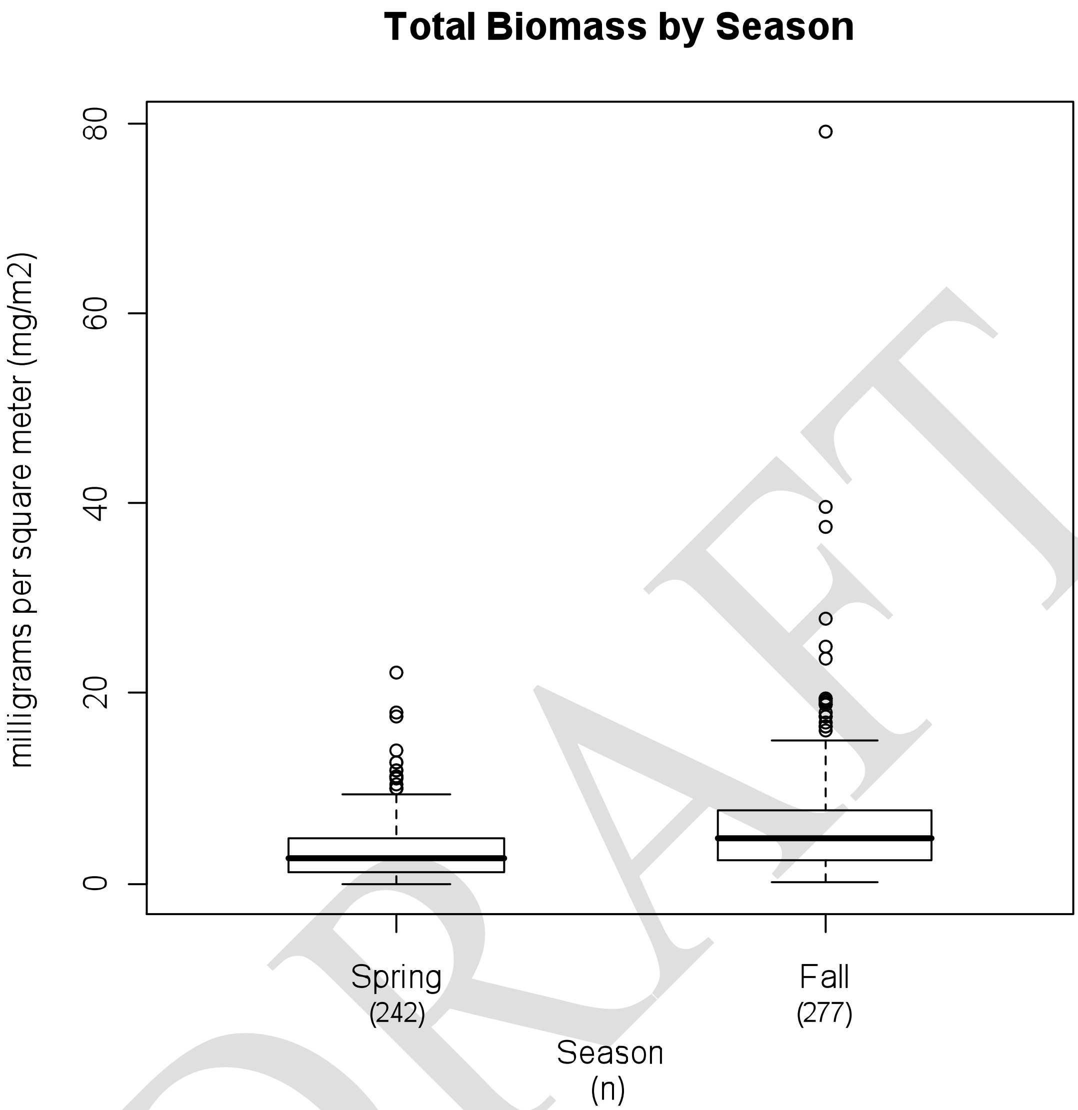

Figure 2. The mean, interquartile, range, and outliers of the biomass (mg/m2) summed by species. Multiple ANOVA based on Ln transformed biomass indicates that season differences are statistically significant at the 95% confidence level (actual p-value < 0.001). N = sample size for this analysis.

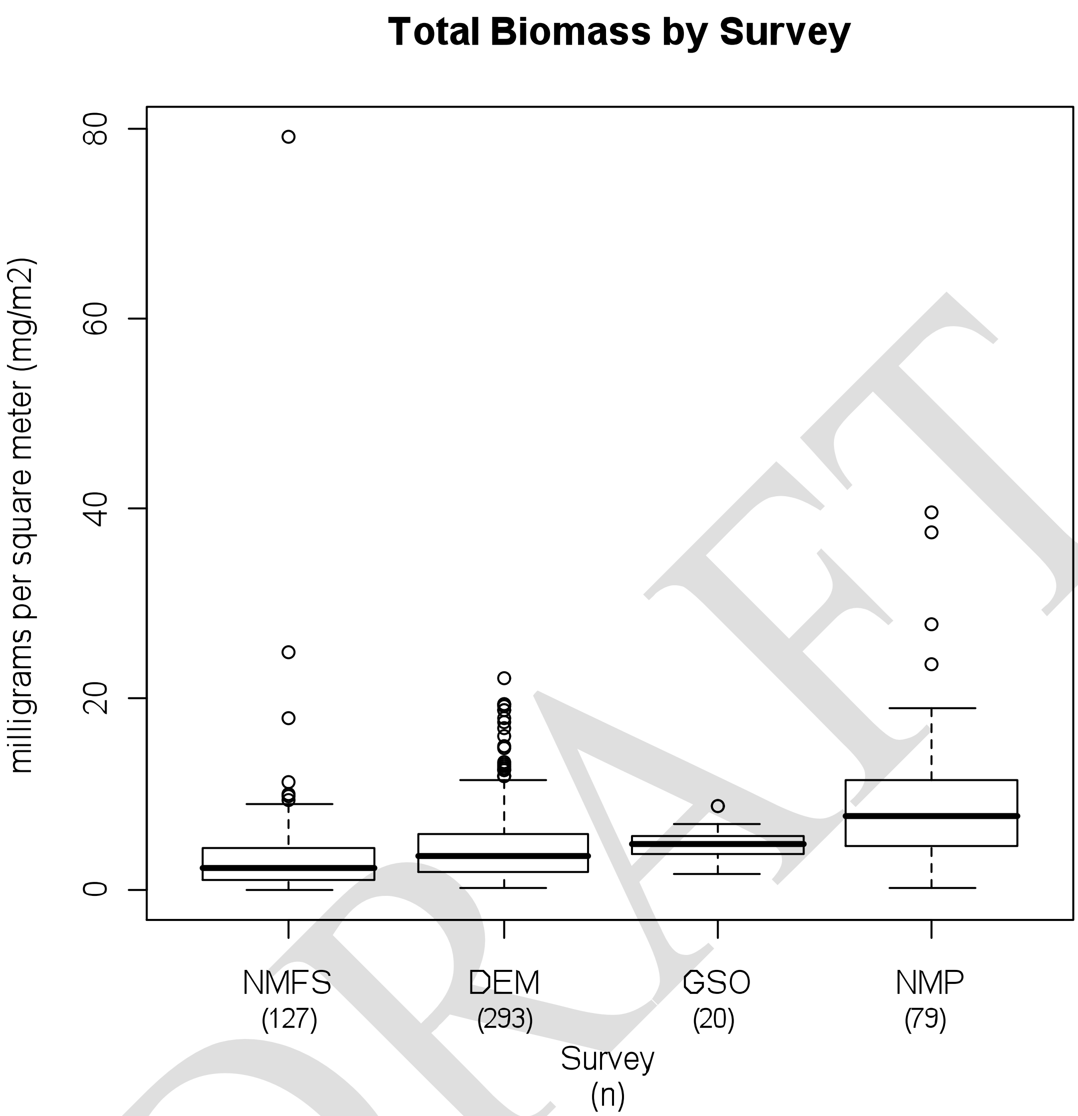

Figure 3. The mean, interquartile, range, and outliers of the biomass (mg per m2) summed by species. Multiple ANOVA based on Ln transformed biomass indicates that survey differences are statistically significant at the 95% confidence level (actual p-value < 0.001). N = sample size used in this analysis.

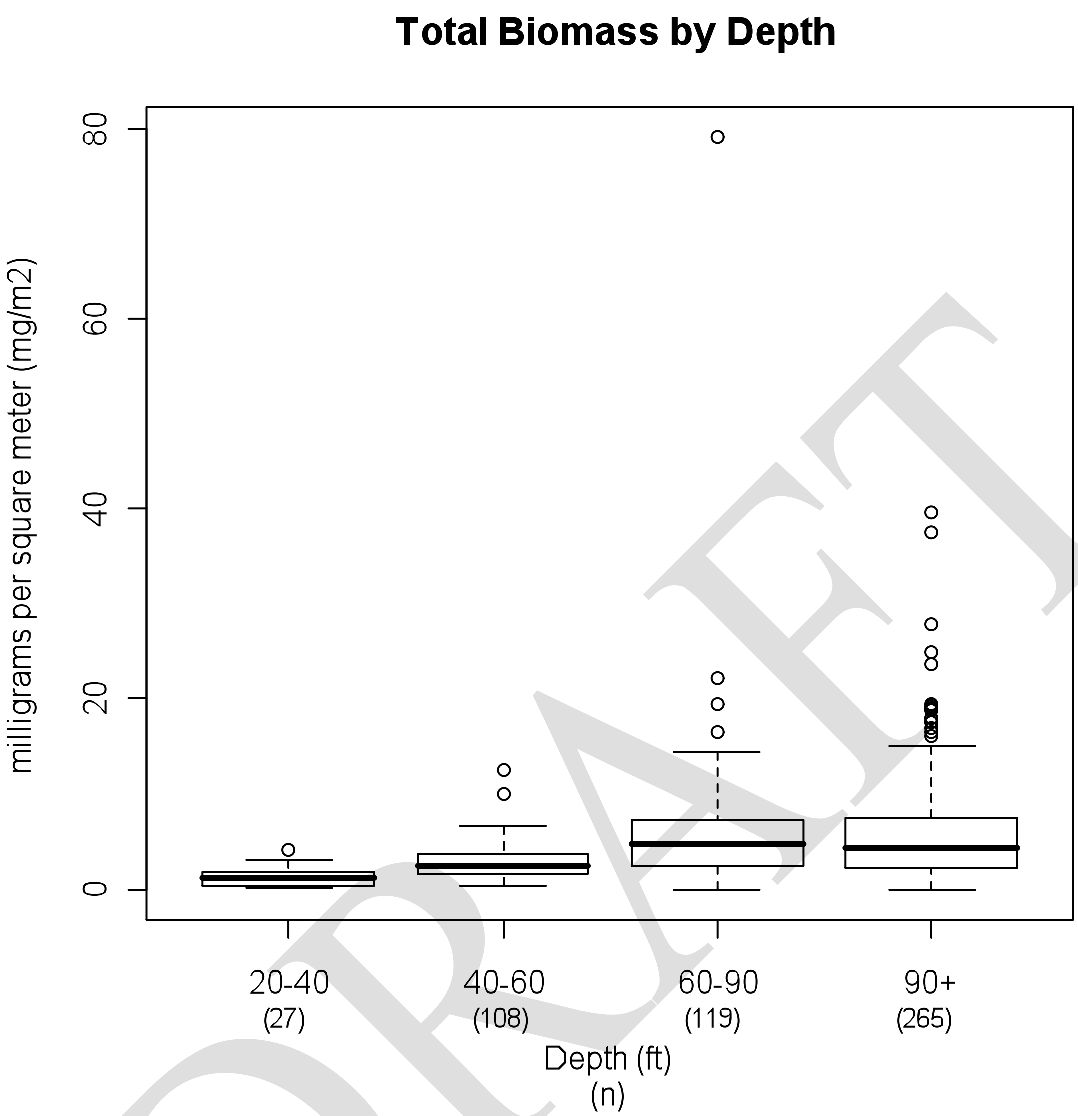

Figure 4. The mean, interquartile, range, and outliers of the biomass (mg per m2) summed by species. Multiple ANOVA based on Ln transformed biomass indicates that depth stratum is statistically significant at the 95% confidence level (actual p-value < 0.001). Tukey's pair-wise means difference test based on Ln transformed biomass shows that the deep depth strata (60 to 90 ft and 90+ ft) have higher total biomass than either of the shallow depth strata (20 to 40 ft and 40 to 60 ft). N = sample size used in this analysis.

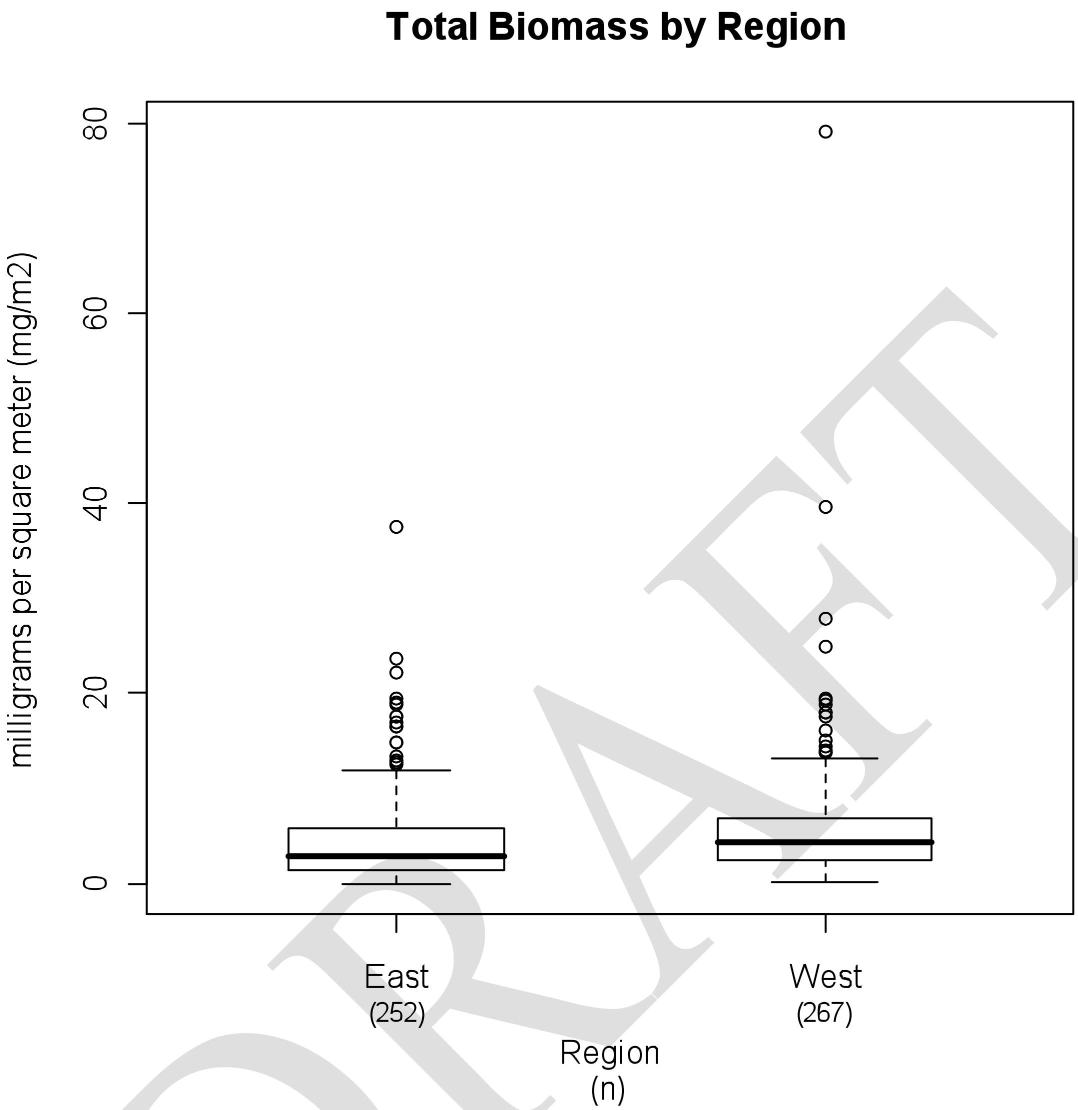

Figure 5. The mean, interquartile, range, and outliers of the biomass (mg per m2) summed by species. Multiple ANOVA based on Ln transformed biomass indicates that region (as defined by survey stations east or west of -71.38° (west) longitude) is not statistically significant (actual p-value = 0.29). N = sample size used in this analysis.

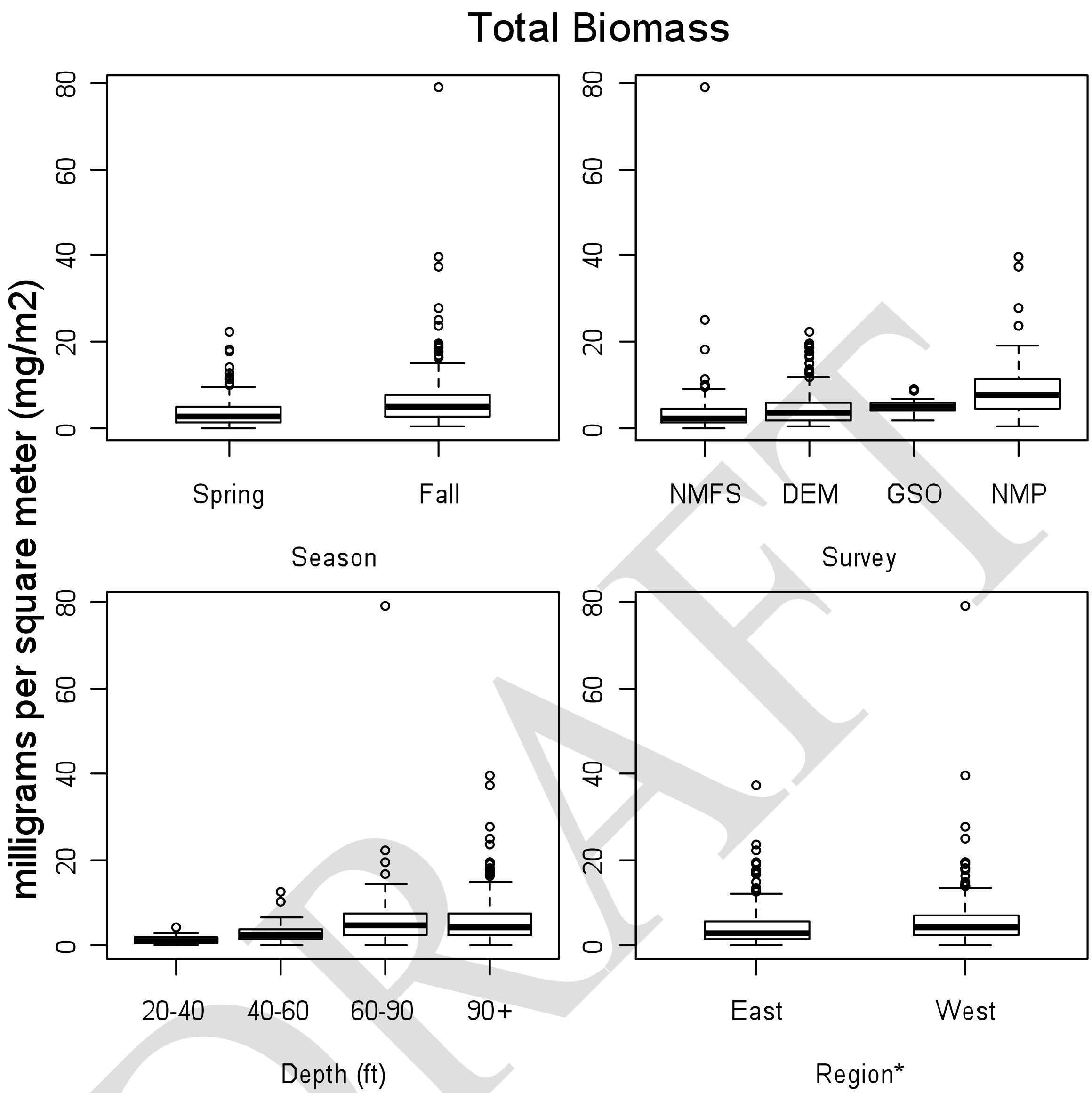

Figure 6. Summary results of multivariate analysis of total biomass. Region is defined as survey stations east or west of -71.38° (west) longitude. Sample size for each analysis is indicated in the individual figures (2-5).

3. Analysis of Catch by Species

A. Summary Data

Catch biomass data from the four trawl surveys were also used to assess individual species catch biomass for key species for which data were available. Figure 4 below shows a simple sum of individual species biomass within the study area based on RIDEM, GSO, and NMFS survey data from 1999-2008. NEAMAP data were not included in this figure as only two years of data are available. Figure 4 below illustrates that in the fall surveys, little skate, scup, and longfin squid were among the species with the highest relative biomass in the study area, whereas in the spring surveys, little skate, scup, and winter flounder were among the species with the highest relative biomass in the study area. Figures 5-8 below show the individual species biomass reflected in each individual survey. Note that all figures represent the total biomass on a logarithmic scale to allow for comparison between the figures.

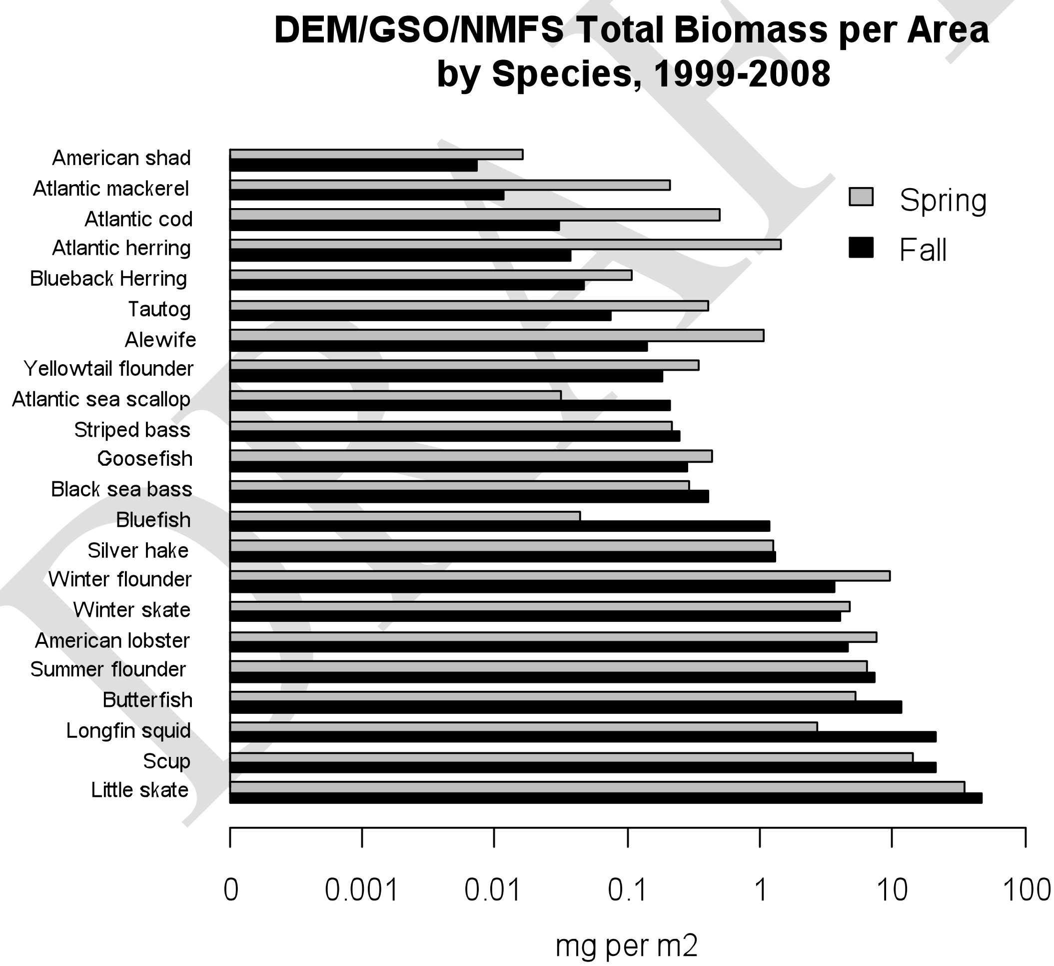

Figure 7. Total biomass per area by species, 1999-2008. Based on RIDEM, URI GSO, and NMFS trawl surveys. Includes all commercially and recreationally targeted species as well as those identified as drivers of demersal fish and invertebrate community composition (see BVStep analysis below).

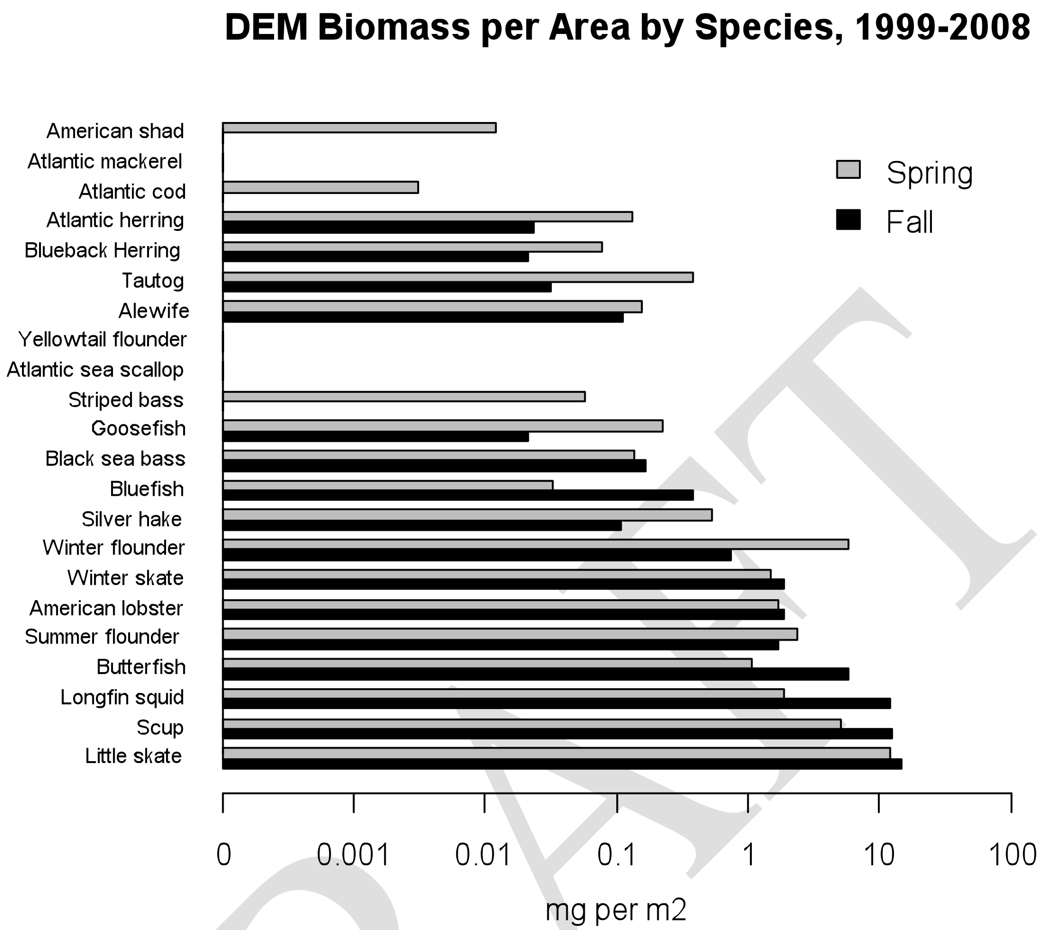

Figure 8. DEM trawl survey biomass per area by species. Includes all commercially and recreationally targeted species as well as those identified as drivers of demersal fish and invertebrate community composition (see BVStep analysis below).

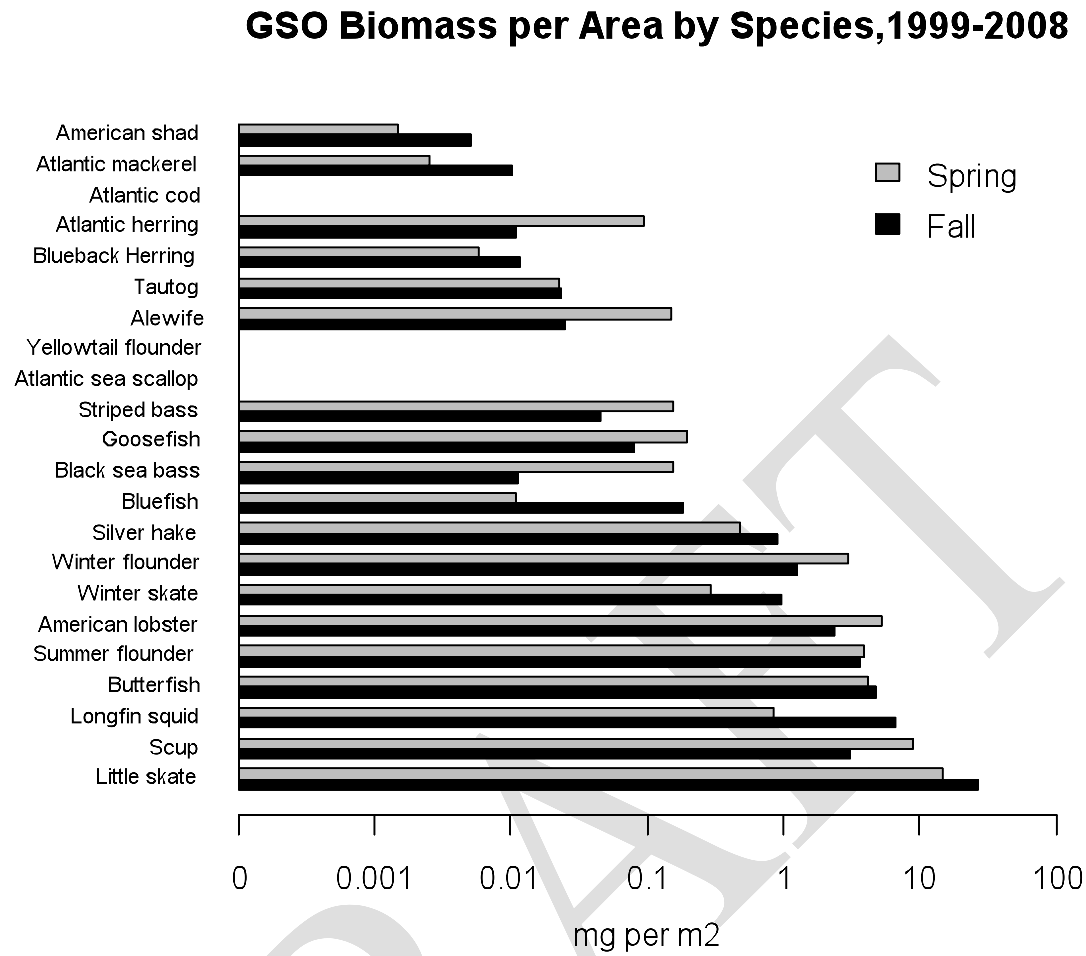

Figure 9. GSO trawl survey biomass per area by species. Includes all commercially and recreationally targeted species as well as those identified as drivers of demersal fish and invertebrate community composition (see BVStep analysis below).

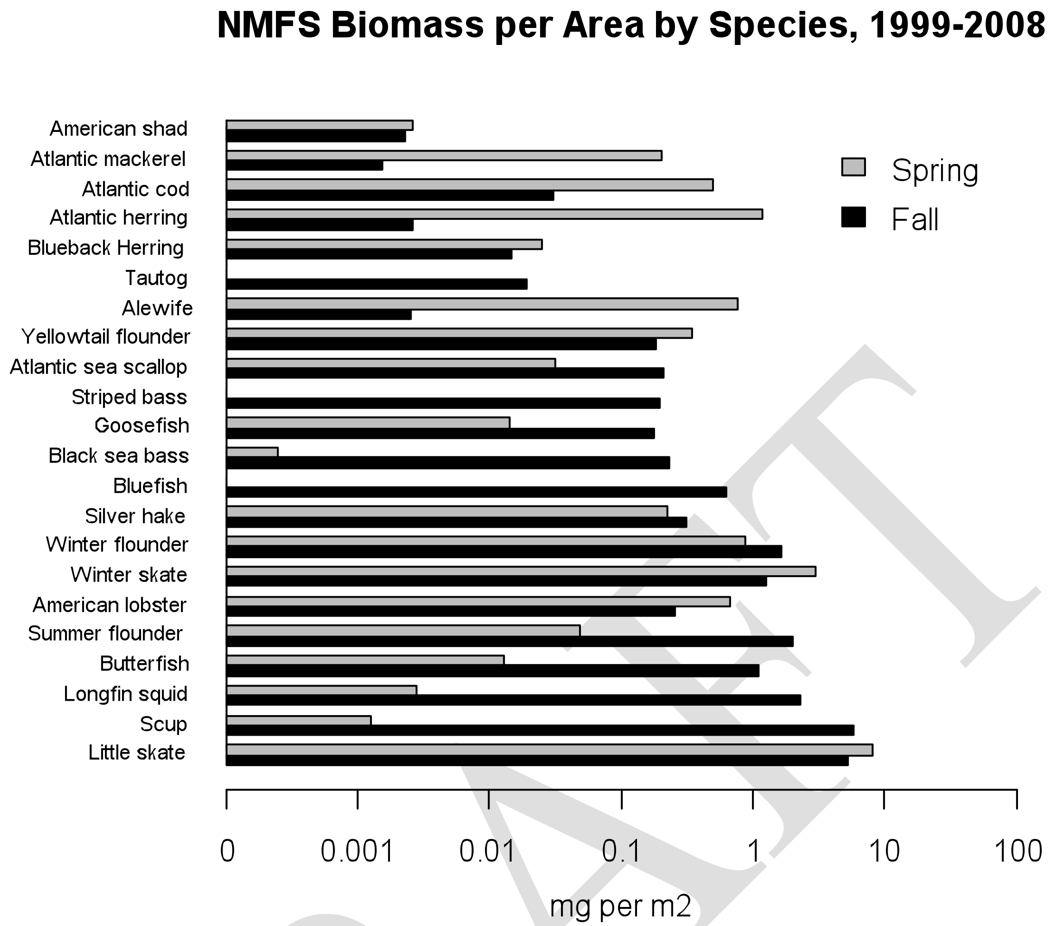

Figure 10. NMFS trawl survey biomass per area by species. Includes all commercially and recreationally targeted species as well as those identified as drivers of demersal fish and invertebrate community composition (see BVStep analysis below).

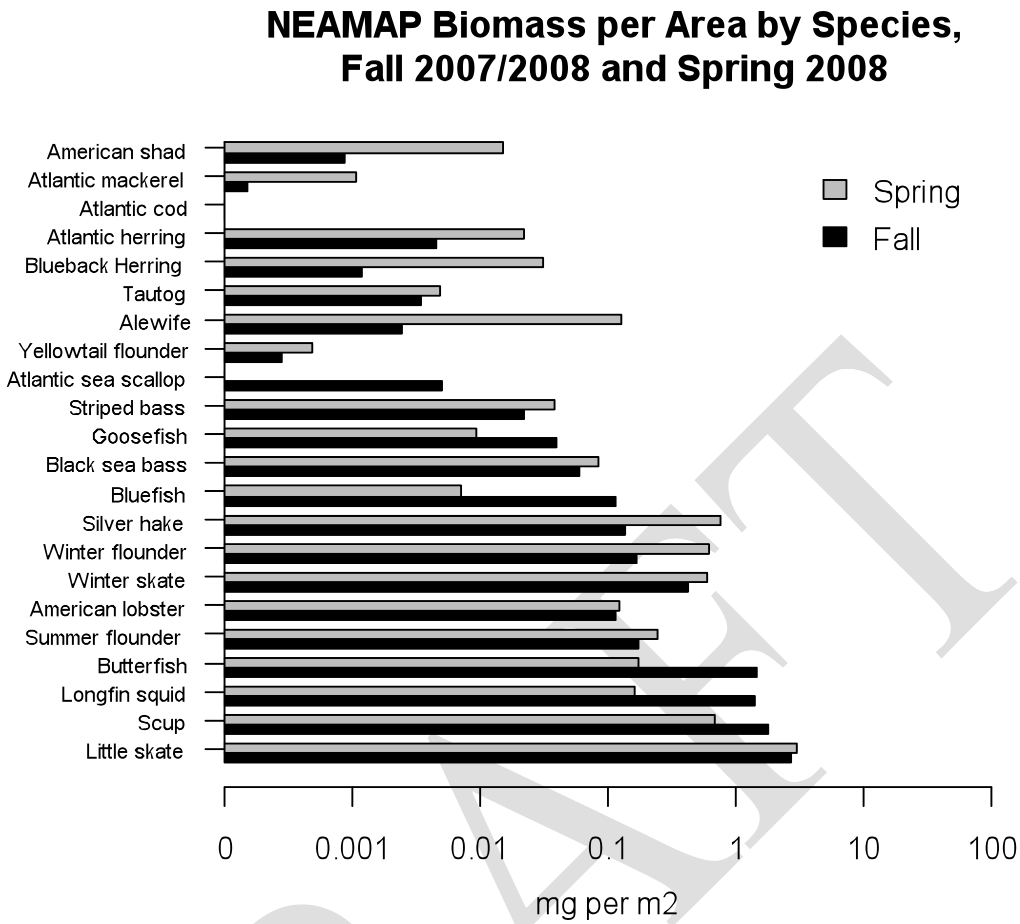

Figure 11. NEAMAP trawl survey biomass per area by species. Includes all commercially and recreationally targeted species as well as those identified as drivers of demersal fish and invertebrate community composition (see BVStep analysis below).

B. Multivariate Analysis Methods

All multivariate analysis was performed in Primer 6.0. Fisheries survey data from National Marine Fisheries Service (NMFS), Northeast Monitoring and Assessment Program (NEAMAP), Rhode Island Department of Environmental Management (DEM) and the Graduate School of Oceanography (GSO) were combined to identify patterns in fish an invertebrate species composition throughout Block Island Sound and Rhode Island Sound. All data was standardized to units of biomass (mg) per meter squared prior to multivariate analysis to account for differences in gear and sampling methods. Due to the omission of cancer crabs during DEM sampling, cancer crabs were excluded from these analyses.

Multidimentional scaling plots (MDS) were created as a visual representation of the unique species compositions within Block Island Sound and Rhode Island Sound as identified by the aforementioned surveys. Each point on the MDS plot represents one tow. Points that are closer together have more similar species composition than distant points. ANOSIM analyses were used to identify factors that affect species composition in the SAMP area as depicted in the MDS plot. The following five factors were tested: Survey agency, Year, Season, Depth strata and SAMP region. A BVStep analysis was performed to identify the individual species that are most responsible for the pattern in demersal fish and invertebrate community composition within Block Island Sound and Rhode Island Sound.

C. Results

Of the five factors tested in the ANOSIM analysis (Survey agency, Year, Season, Depth strata and SAMP region), season and survey agency were shown to significantly affect fish and invertebrate species composition in the SAMP area (R=0.236 and R=0.266,respectively) . These results suggest that seasonal movement of demersal fish species influences the structure of local marine communities (Figure 5). Such seasonal variations in species composition should be considered when predicting the impacts of offshore development and resource exploitation. The ANOSIM results further indicate that a distinct composition of species is caught by each survey agency (Figure 6). This finding may be an artifact of slight differences in sampling methods and gear that were not fully corrected for during initial data processing. Such inconsistencies must be considered in further studies that combine data from various survey agencies. The ANOSIM results indicate that neither SAMP region or depth strata affect demersal fish and invertebrate species composition within Block Island Sound and Rhode Island Sound (R=0.043 and R=0.032, respectively). Despite differences in chemical and physical properties within the SAMP area, the species composition of the demersal community is not significantly different in the East and West sectors. More precise delineation of SAMP Area and depth strata, however, many reveal fine-scale patterns in species composition that were not detected in this analysis.

The BVStep analysis identified 17 species that most affect the demersal fish and invertebrate community composition within the SAMP area (Table 2, Figure 7). Although these species may not be the most abundant within the SAMP area, they are of immense ecological importance to the stability and resiliency of the local marine community. When attempting to predict the effects of development and exploitation on the demersal fish assemblage of the SAMP area, it is essential to consider these community-shaping species. Many of these species vary in abundance from fall to spring (Figure 7). Such seasonal community dynamics should also be considered when planning offshore construction and directed exploitation.

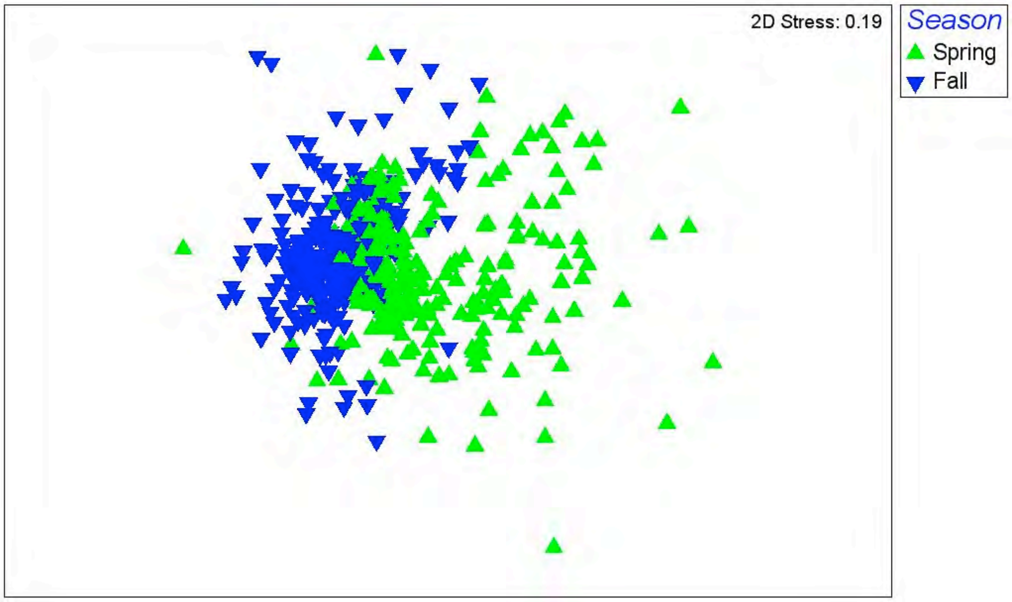

Figure 12. Ordination of the biomasses of SAMP species within Block Island Sound and Rhode Island Sound. This nonmetric multidimensional scaling plot (MDS) depicts the pattern in demersal fish and invertebrate species composition, with similar species compositions close together. Each point represents one tow. The green triangles represent spring tows and the blue inverted triangles represent fall tows. This shows that species composition within Rhode Island Sound and Block Island Sound is seasonally distinct (R=0.236).

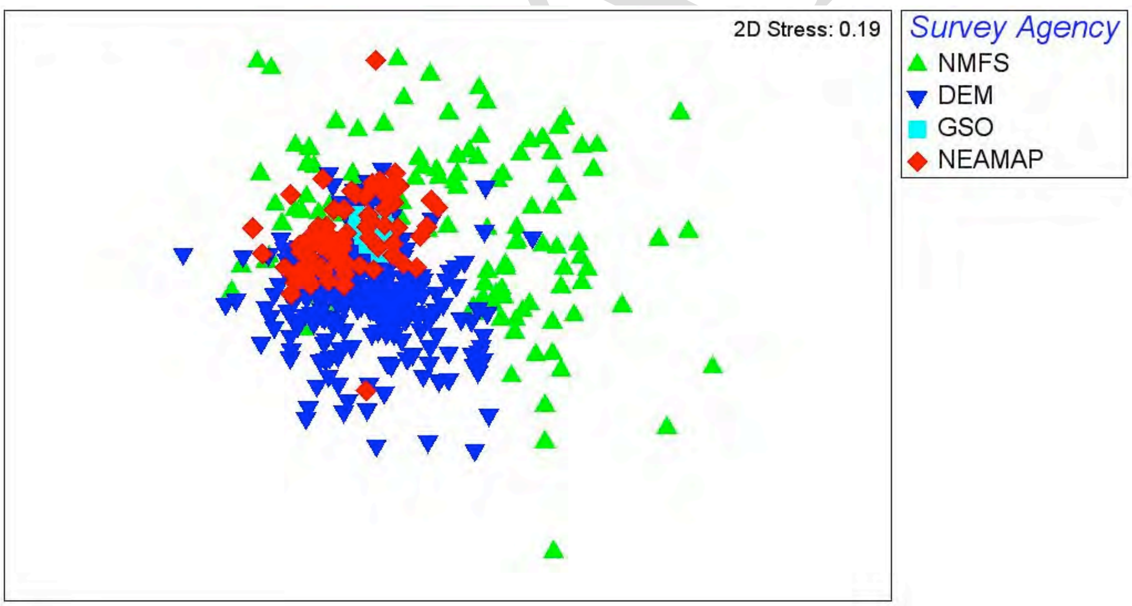

Figure 13. Ordination of the biomasses of SAMP species within Block Island Sound and Rhode Island Sound. This nonmetric multidimensional scaling plot (MDS) depicts the pattern in demersal fish and invertebrate species composition, with similar species compositions close together. Each point represents one tow. The green triangles represent NMFS tows and the blue inverted triangles represent DEM tows, the light blue squares represent GSO tows and the red diamonds represent NEAMAP tows. This plot shows that each survey agency catches a distinct composition of demersal fish species, which may be a source of bias (R=0.266).

	Biomass (mg m^{-2})	
Species	**Spring**	**Fall**
Alewife	0.109	0.059
American Lobster	0.315	0.309
American Shad	0.019	0.004
Atlantic Cod	0.042	0.014
Atlantic Herring	0.143	0.021
Atlantic Sea Scallop	0.008	0.046
Black Sea Bass	0.076	0.053
Blueback Herring	0.031	0.034
Bluefish	0.074	0.141
Butterfish	0.405	0.825
Longfin Squid	0.242	1.091
Scup	0.888	1.316
Silver Hake	0.243	0.118
Summer Flounder	0.360	0.243
Winter Flounder	0.508	0.190
Winter Skate	0.304	0.260
Yellowtail Flounder	0.071	0.052

Table 2. BVStep Results. The spring and fall biomass of each species identified as a driver of the pattern in demersal fish and invertebrate community composition within Block Island Sound and Rhode Island Sound. R=0.940.

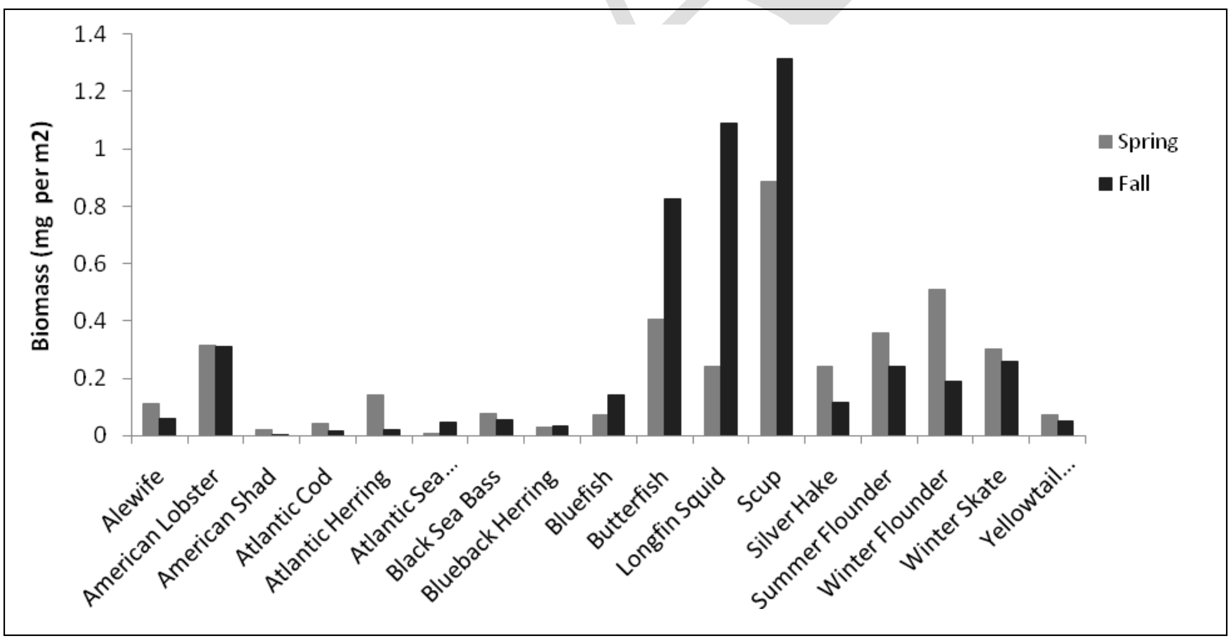

Figure 14. Spring and fall biomass of each species identified as a driver of the pattern in demersal fish and invertebrate community composition within Block Island Sound and Rhode Island Sound (Primer 6.0, BVStep, R=0.940).

D. Individual Species Trends

Individual species data were also used to plot recent trends in biomass caught sampled through these trawl surveys. Trends figures include only DEM, GSO, and NMFS trawl survey data as only two years of data are available through the NEAMAP program.

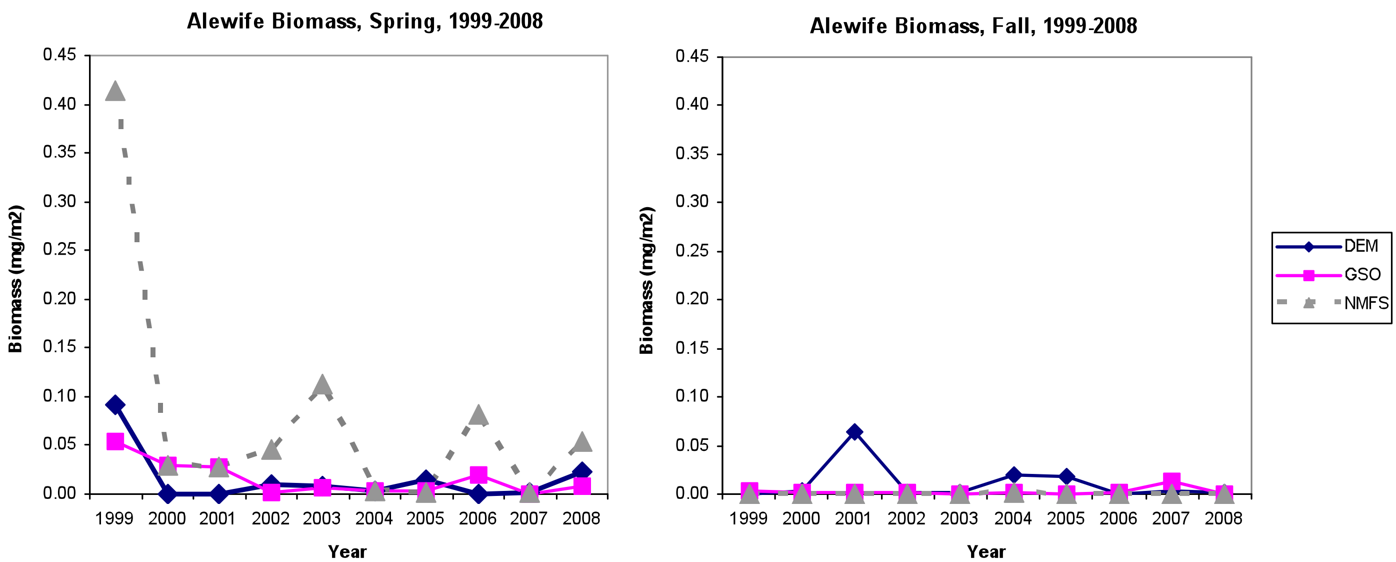

Figure 15. Alewife biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

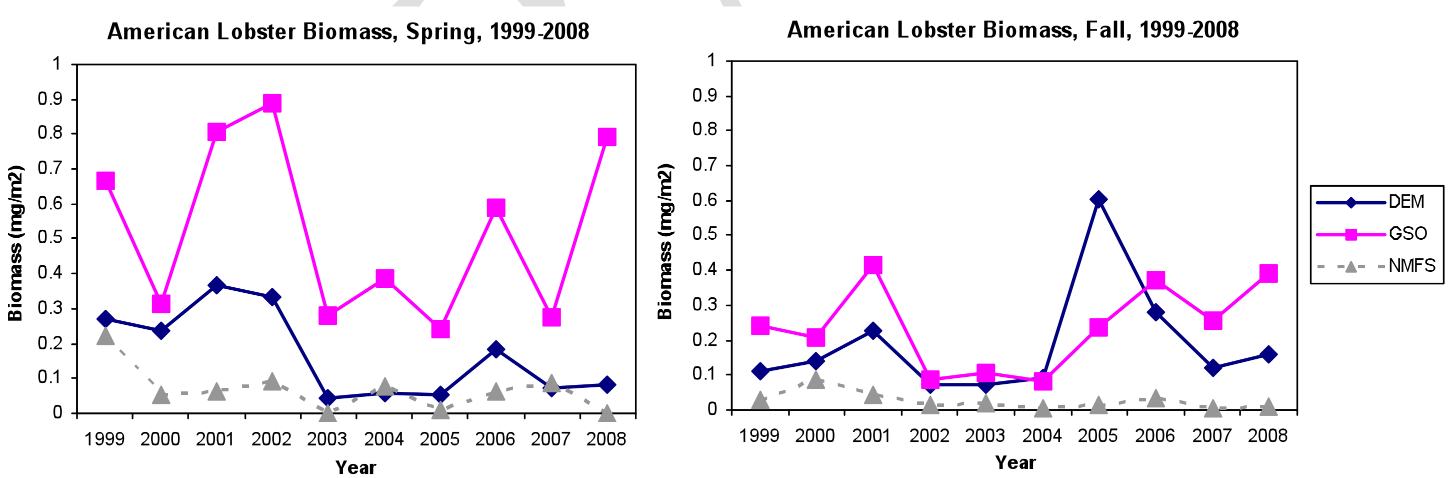

Figure 16. American lobster biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

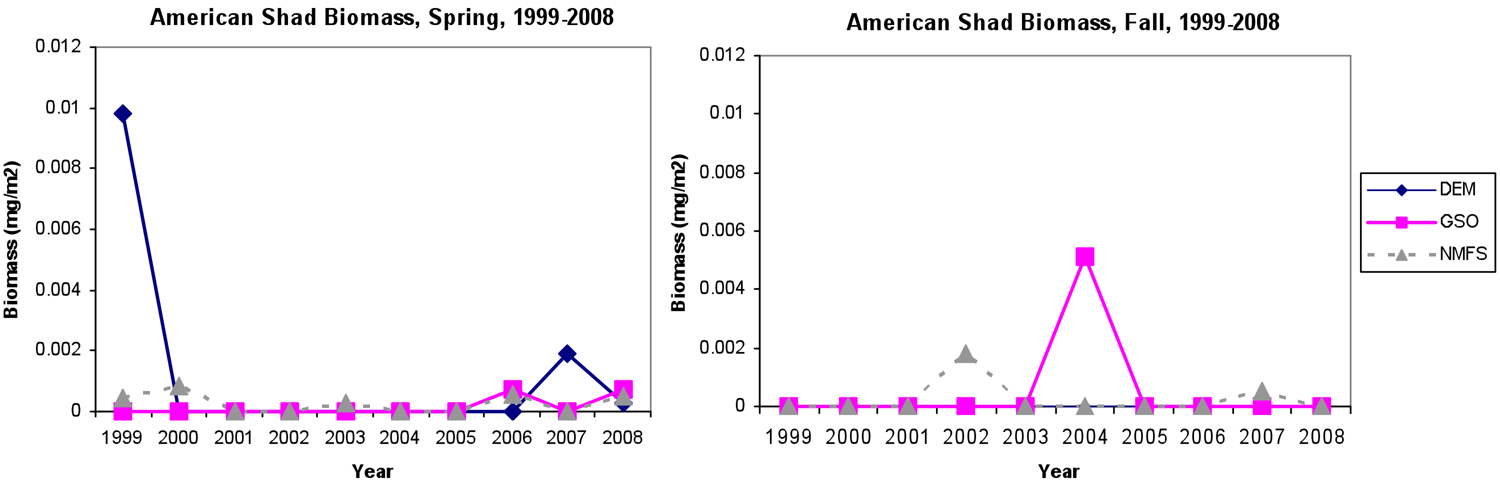

Figure 17. American shad biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

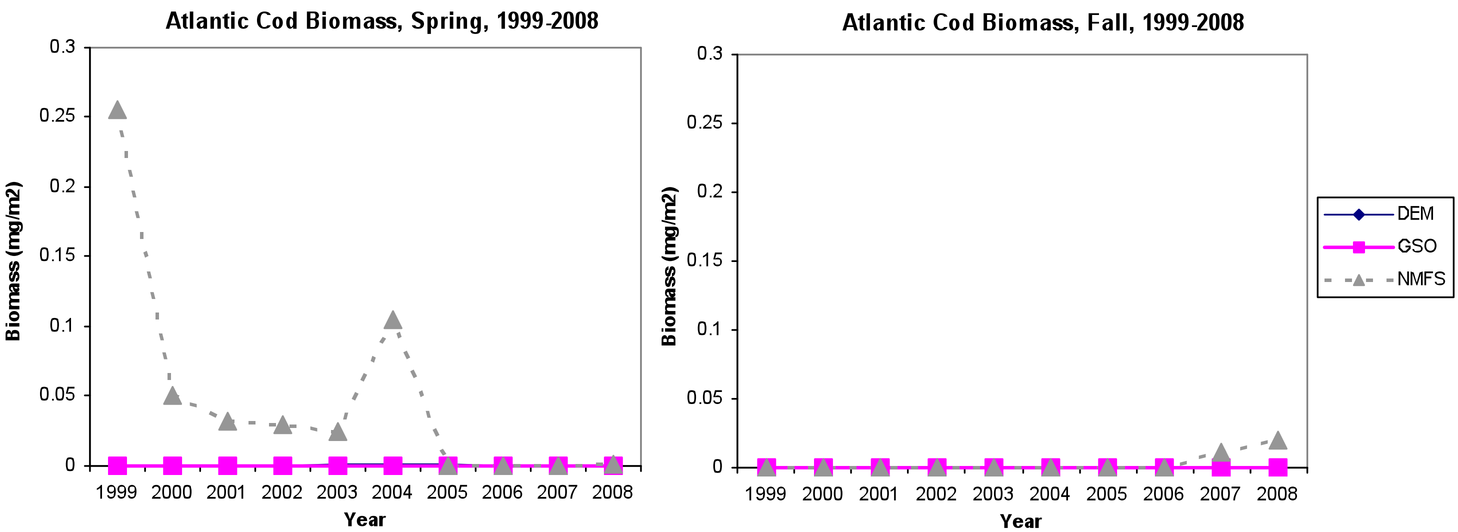

Figure 18. Atlantic cod biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

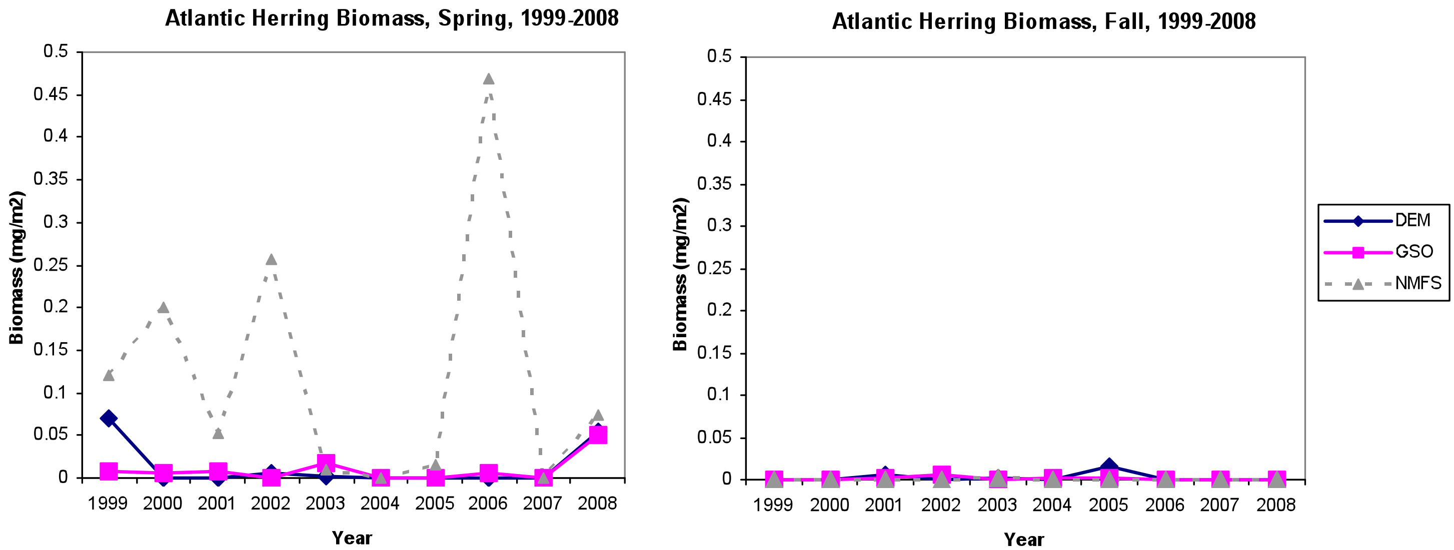

Figure 19. Atlantic herring biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

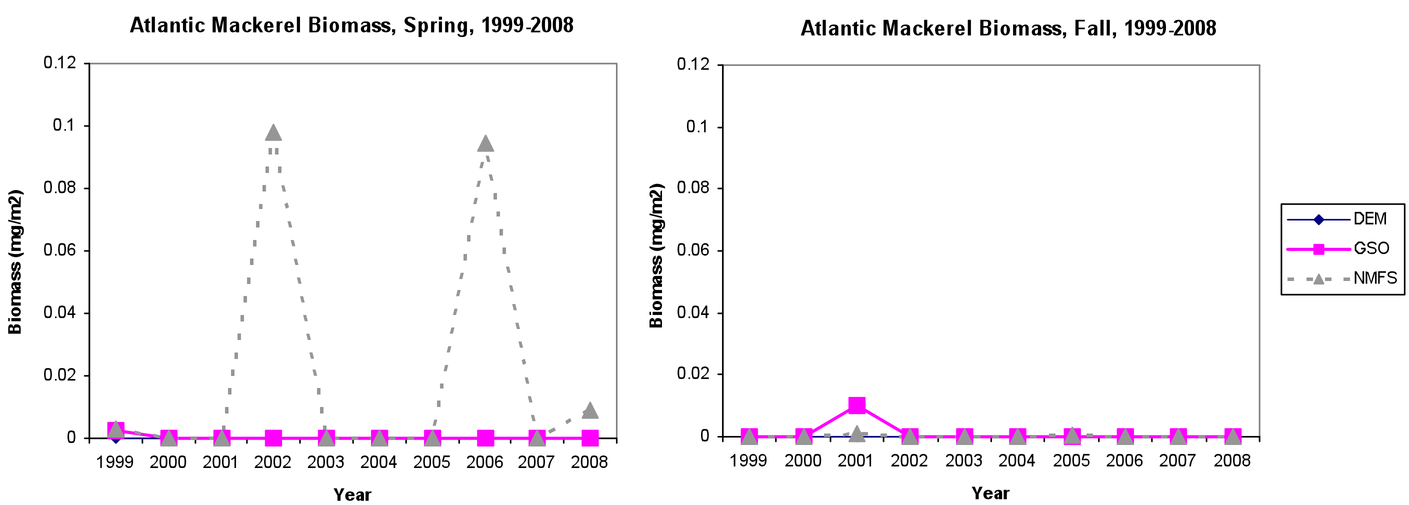

Figure 20. Atlantic mackerel biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

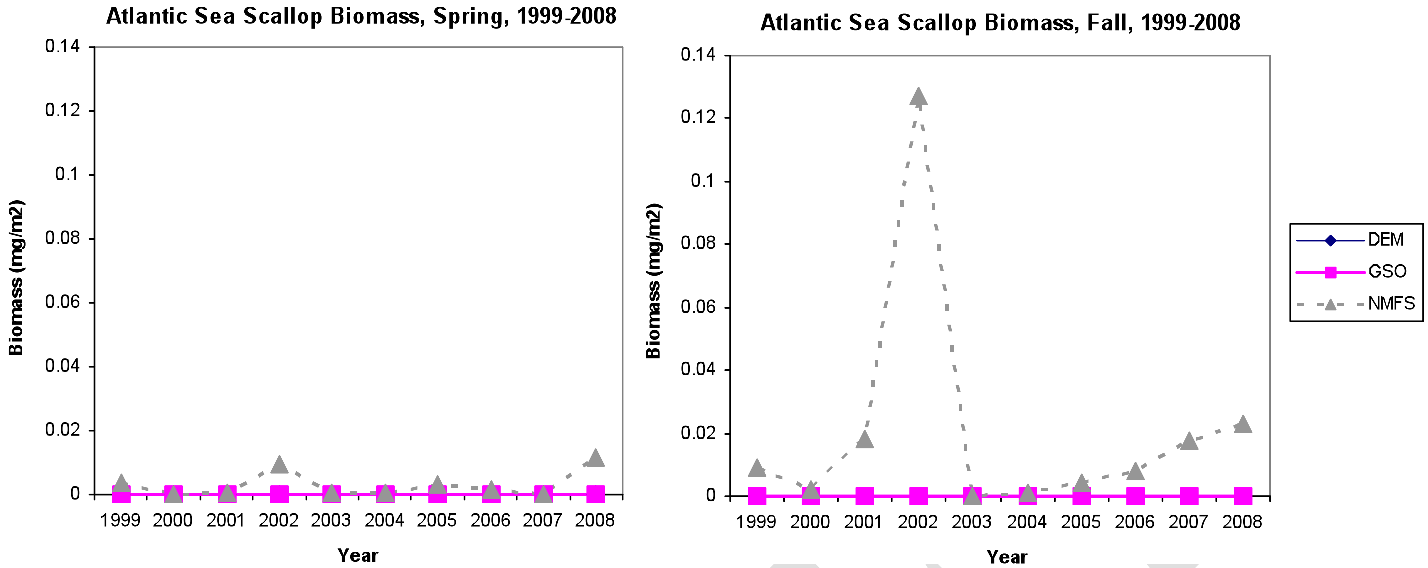

Figure 21. Atlantic sea scallop biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

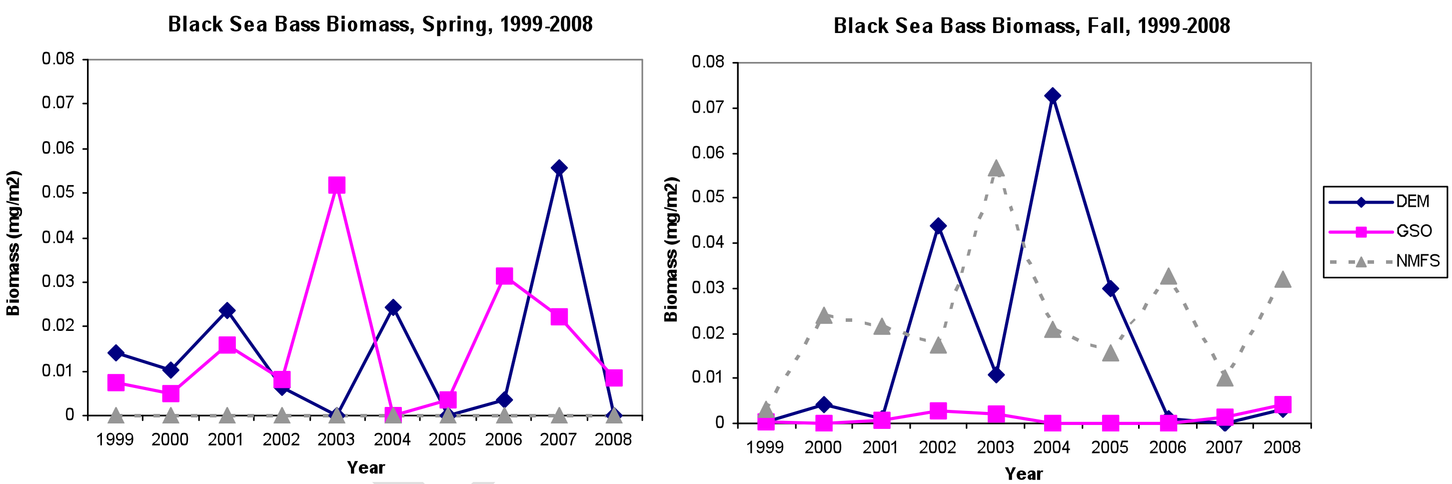

Figure 22. Black sea bass biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

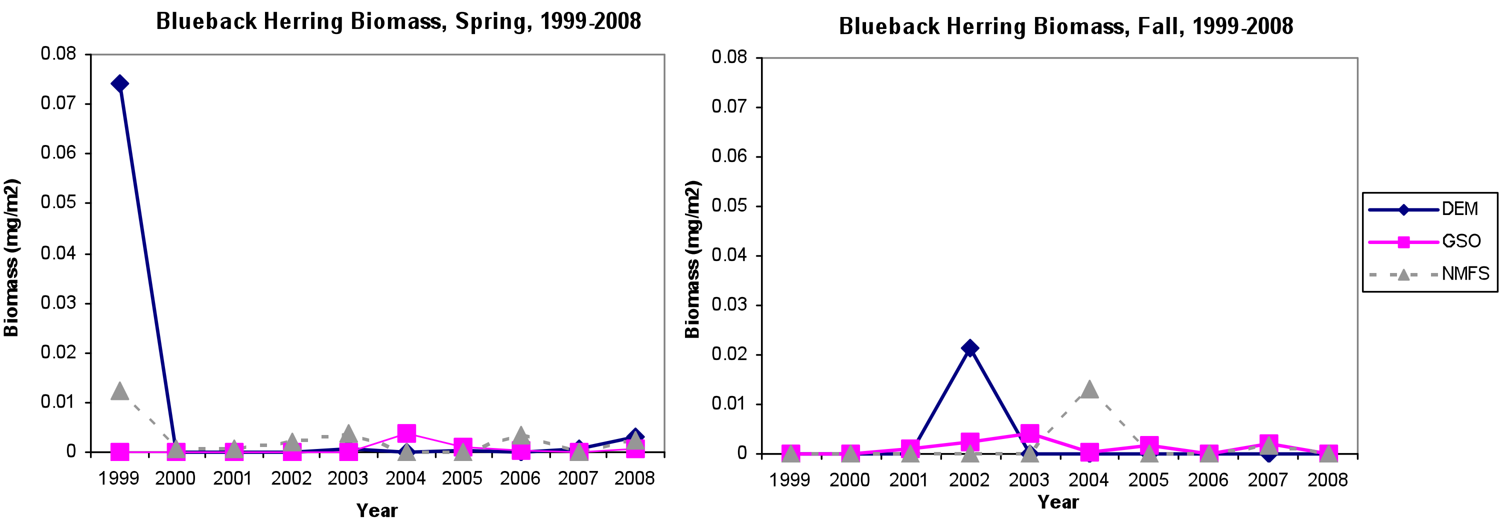

Figure 23. Blueback herring biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

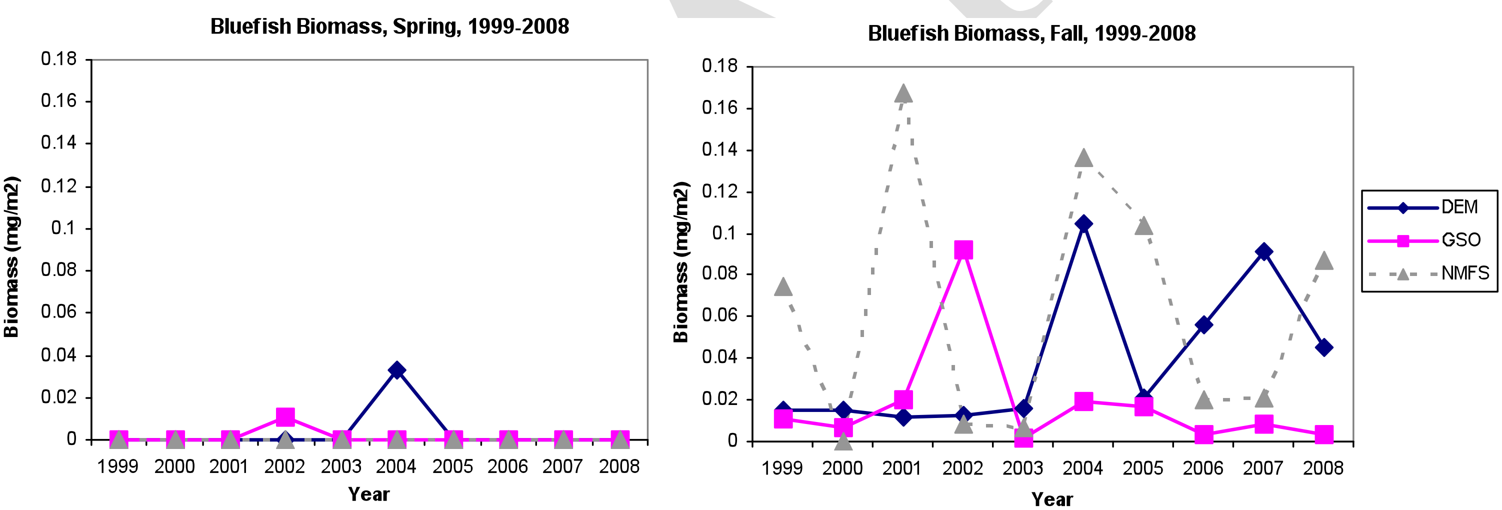

Figure 24. Bluefish biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

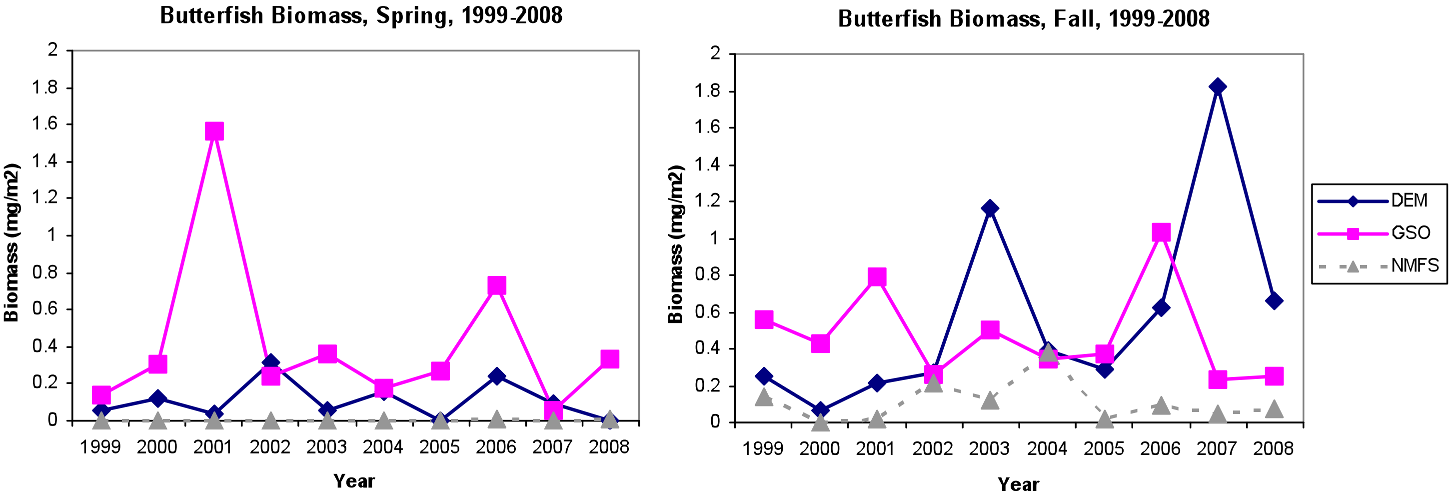

Figure 25. Butterfish biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

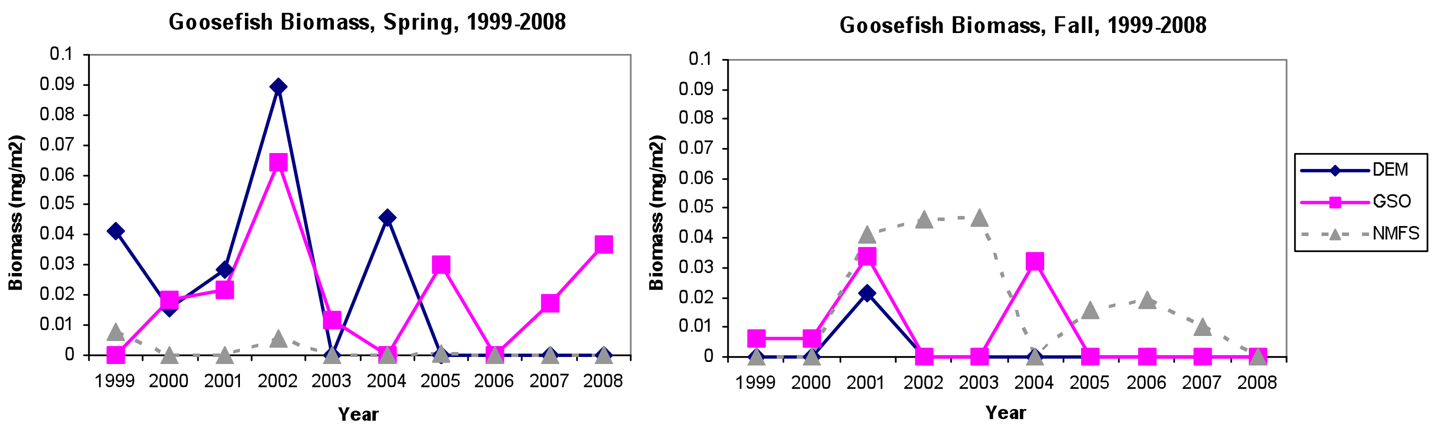

Figure 26. Goosefish (monkfish) biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

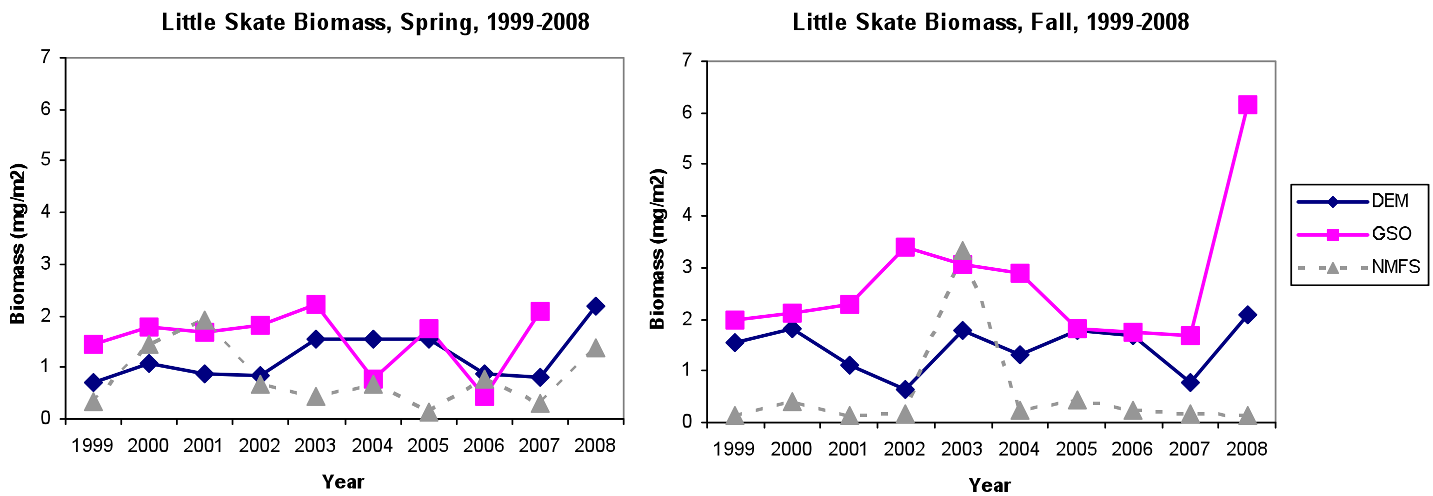

Figure 27. Little skate biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

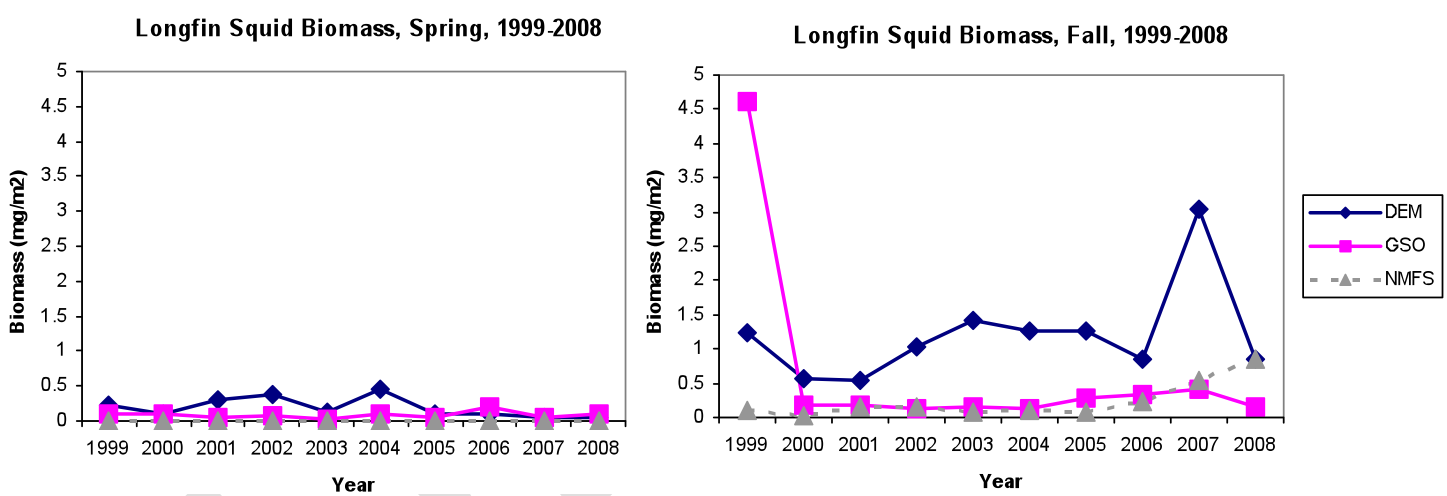

Figure 28. Longfin squid biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

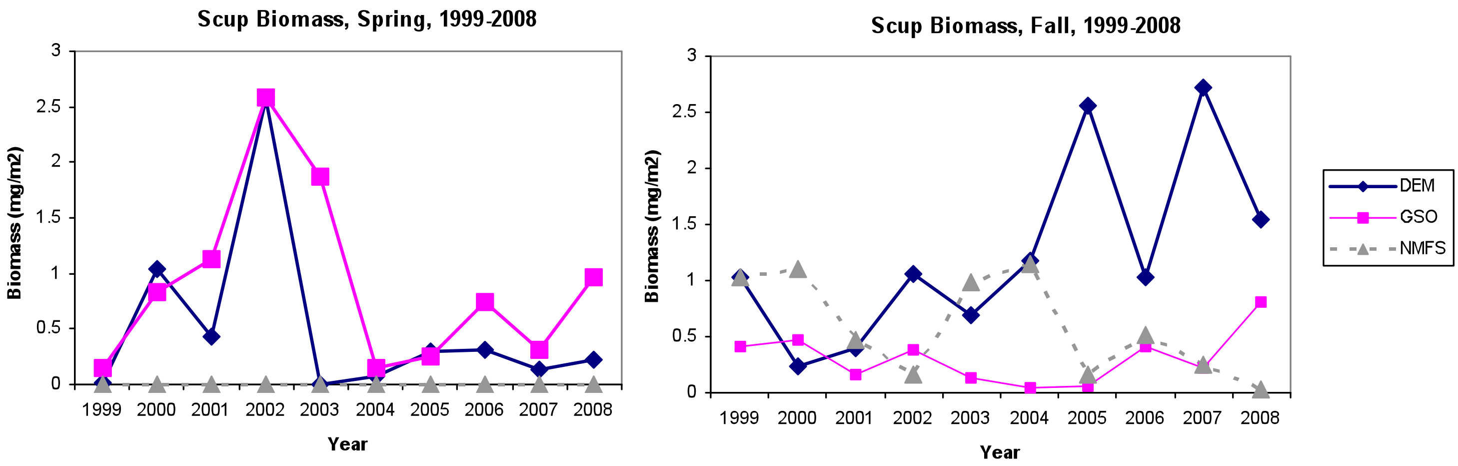

Figure 29. Scup biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

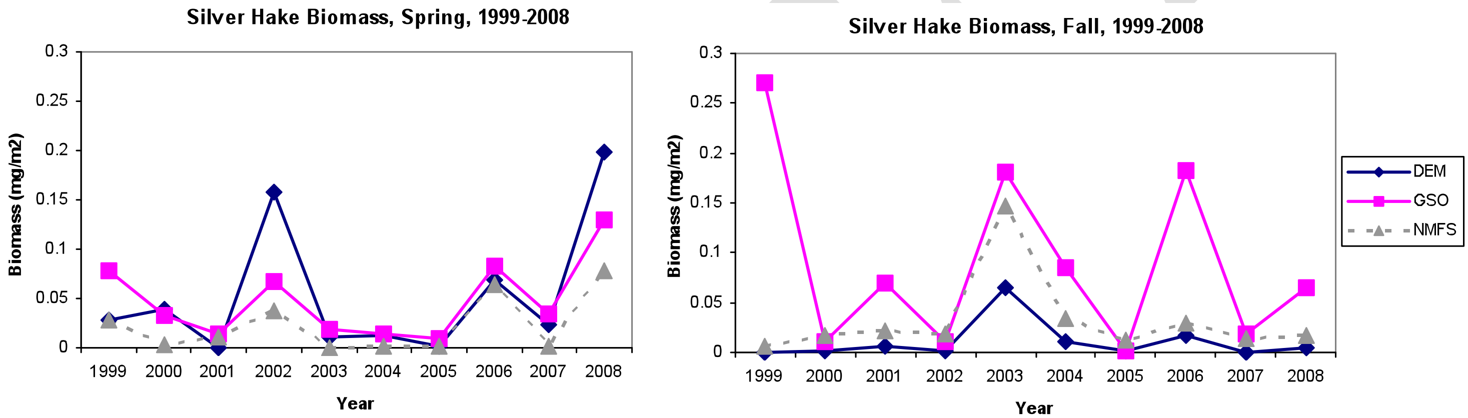

Figure 30. Silver hake biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

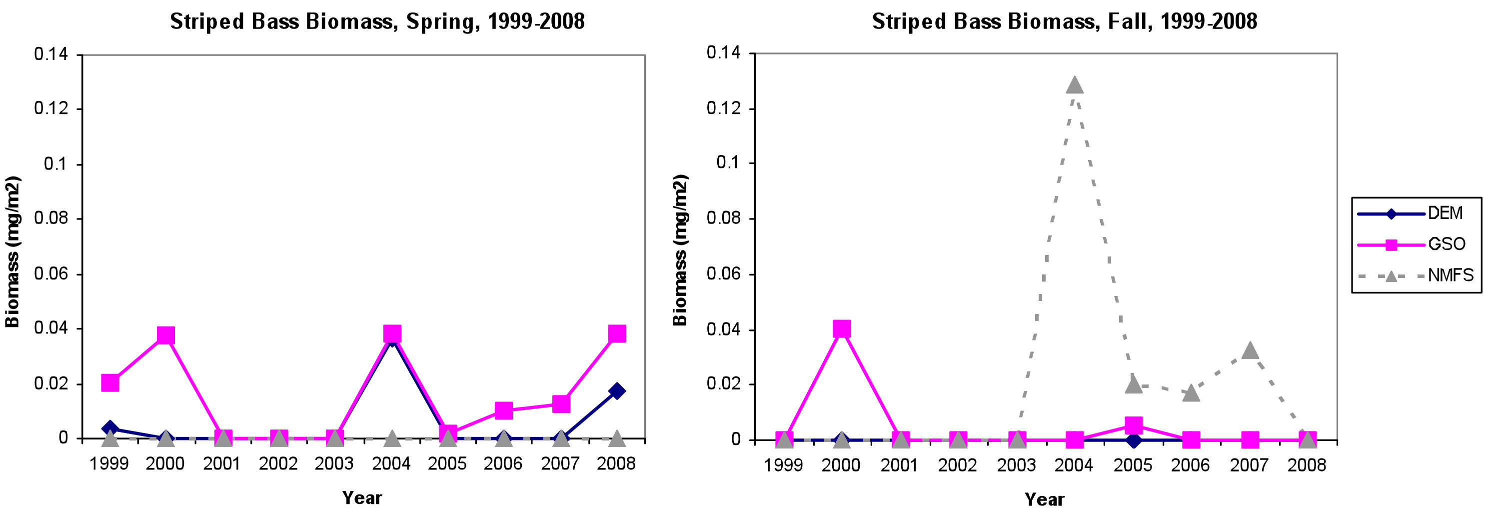

Figure 31. Striped bass biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

Figure C-25. Summer Flounder Biomass

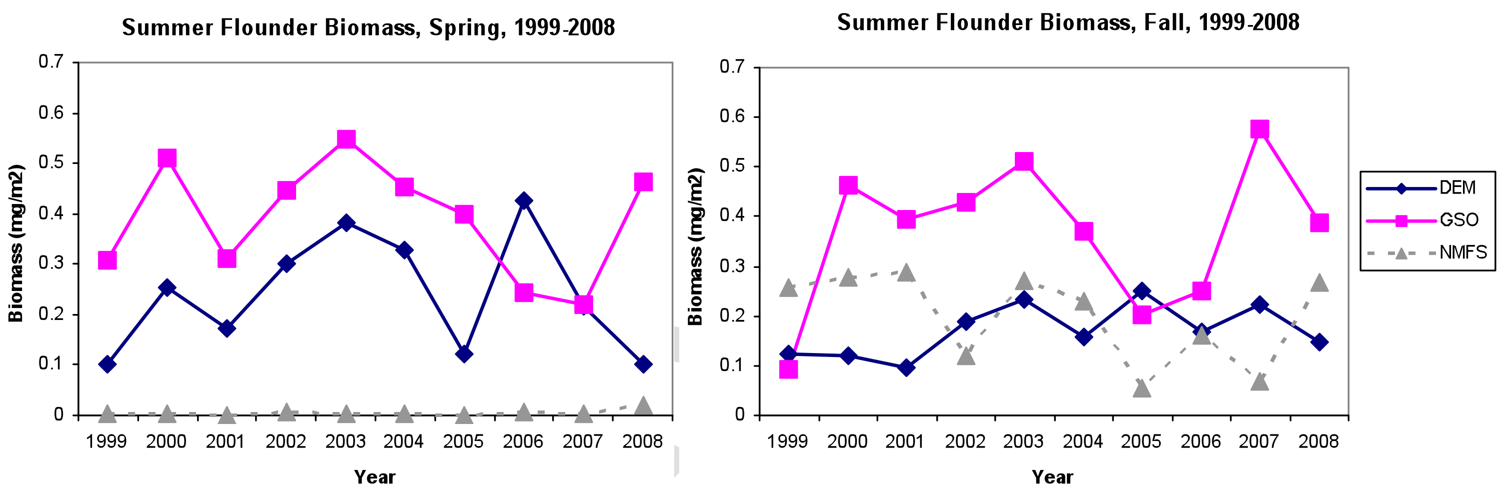

Figure 32. Summer flounder biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

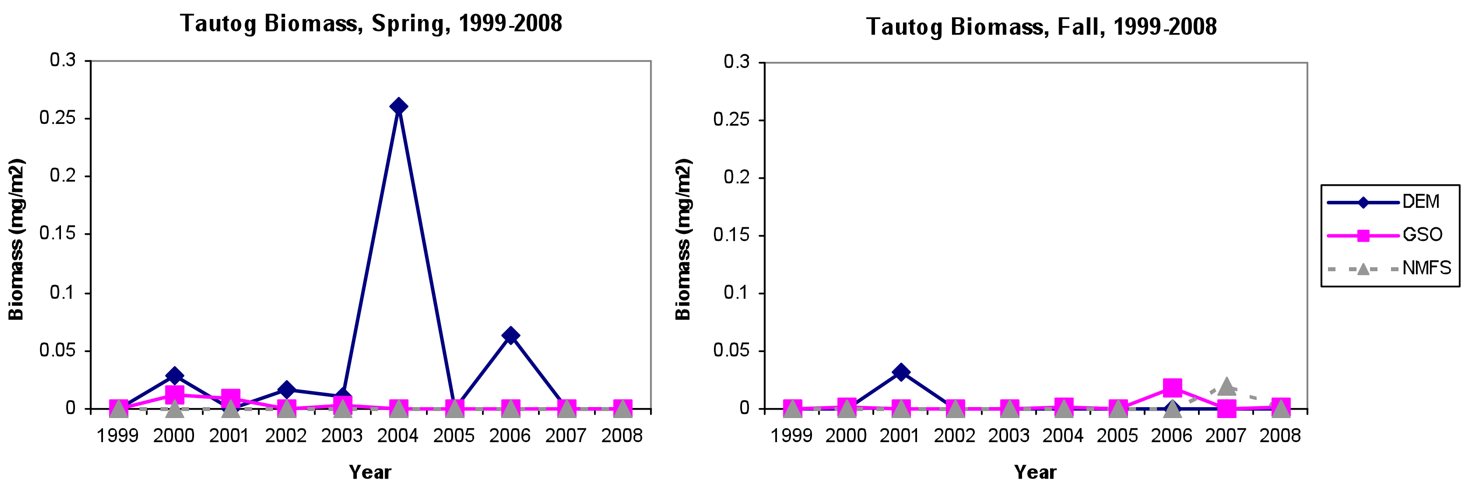

Figure 33. Tautog biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

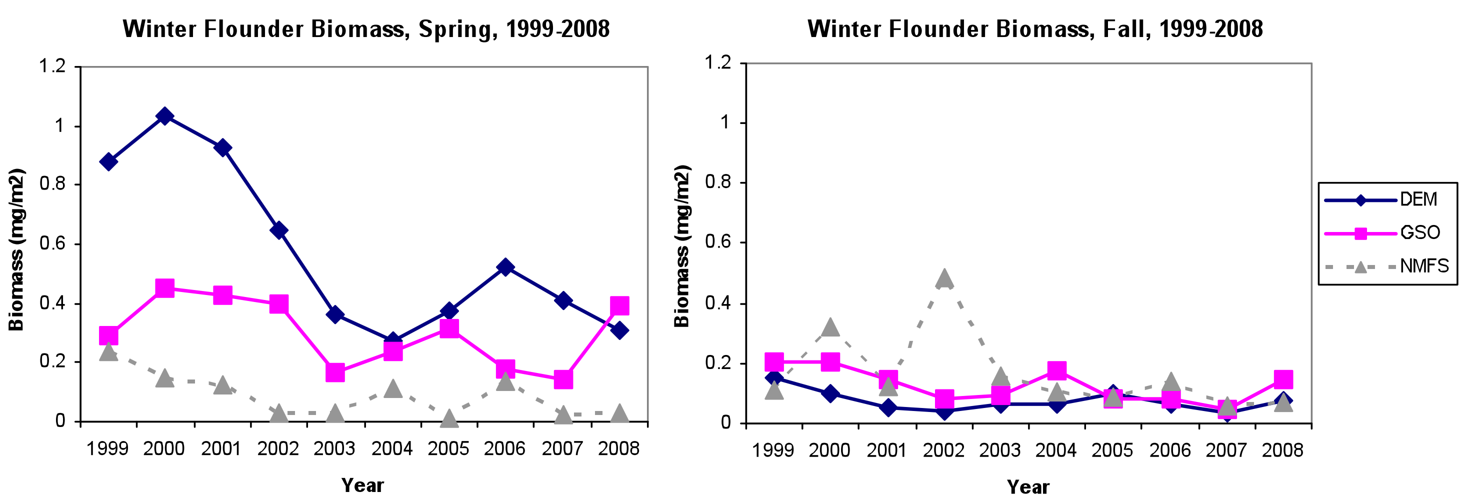

Figure 34. Winter flounder biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

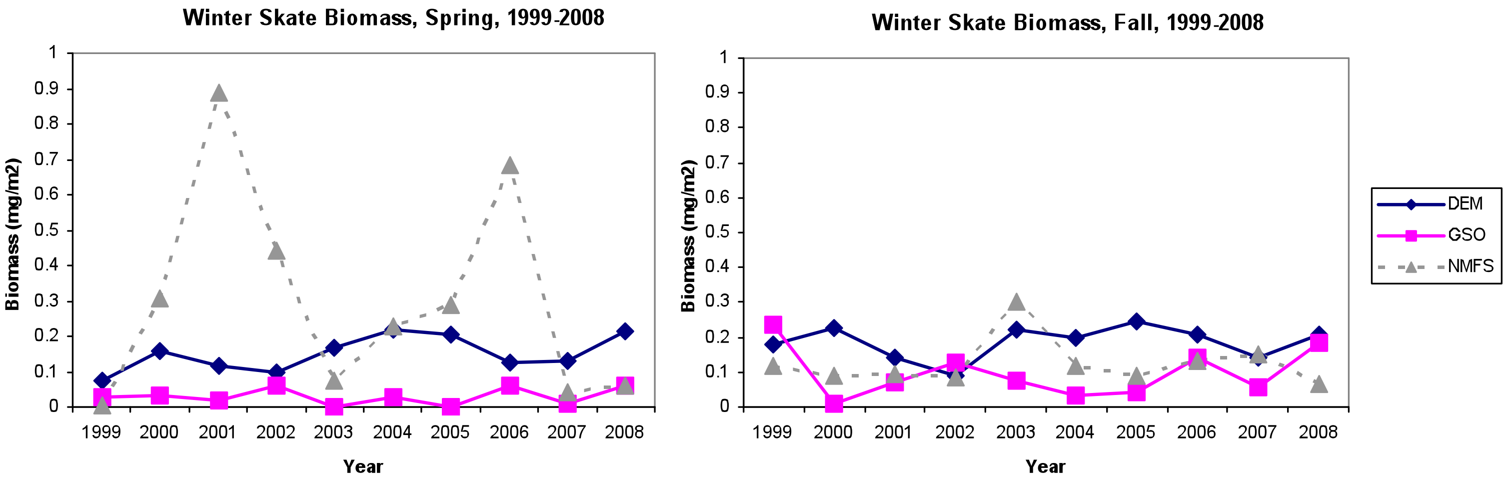

Figure 35. Winter skate biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

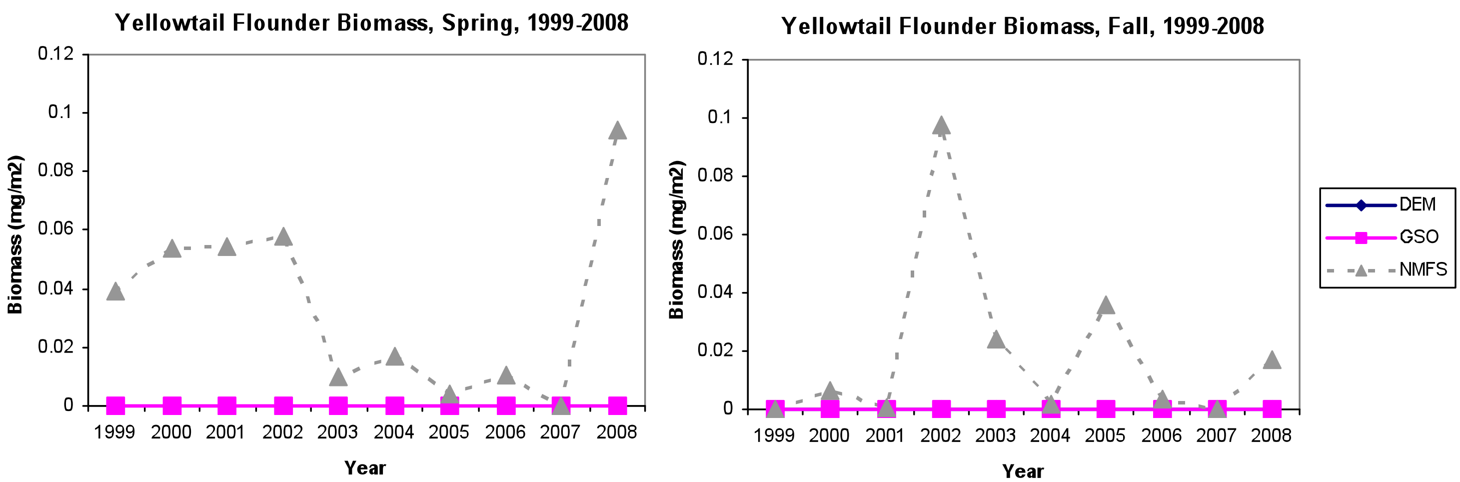

Figure 36. Yellowtail flounder biomass 1999-2008 based on DEM, GSO, and NMFS survey data.

5. Maps of Individual Species Biomass, Spring and Fall

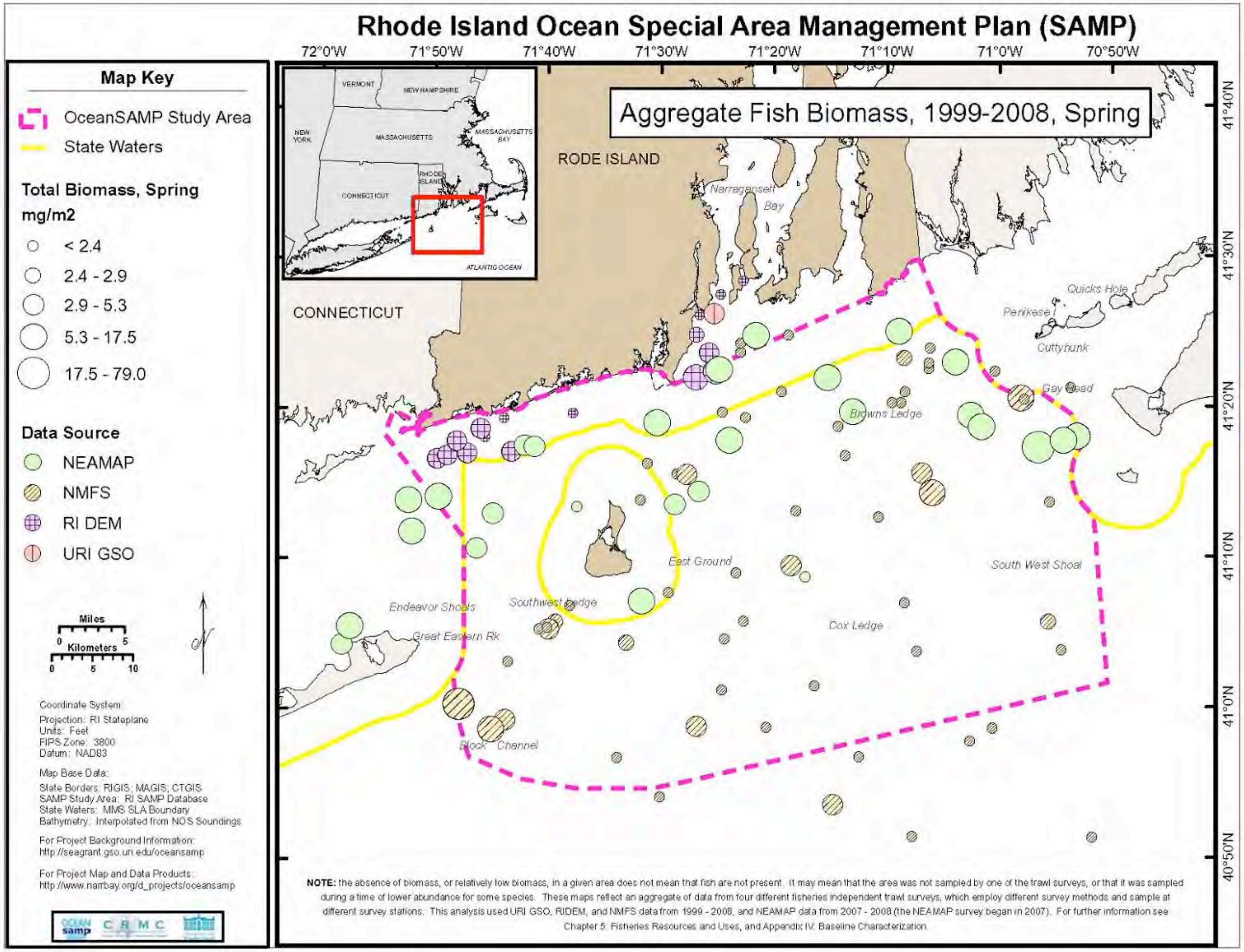

Figure 37. Aggregate Fish Biomass, 1999-2008, Spring

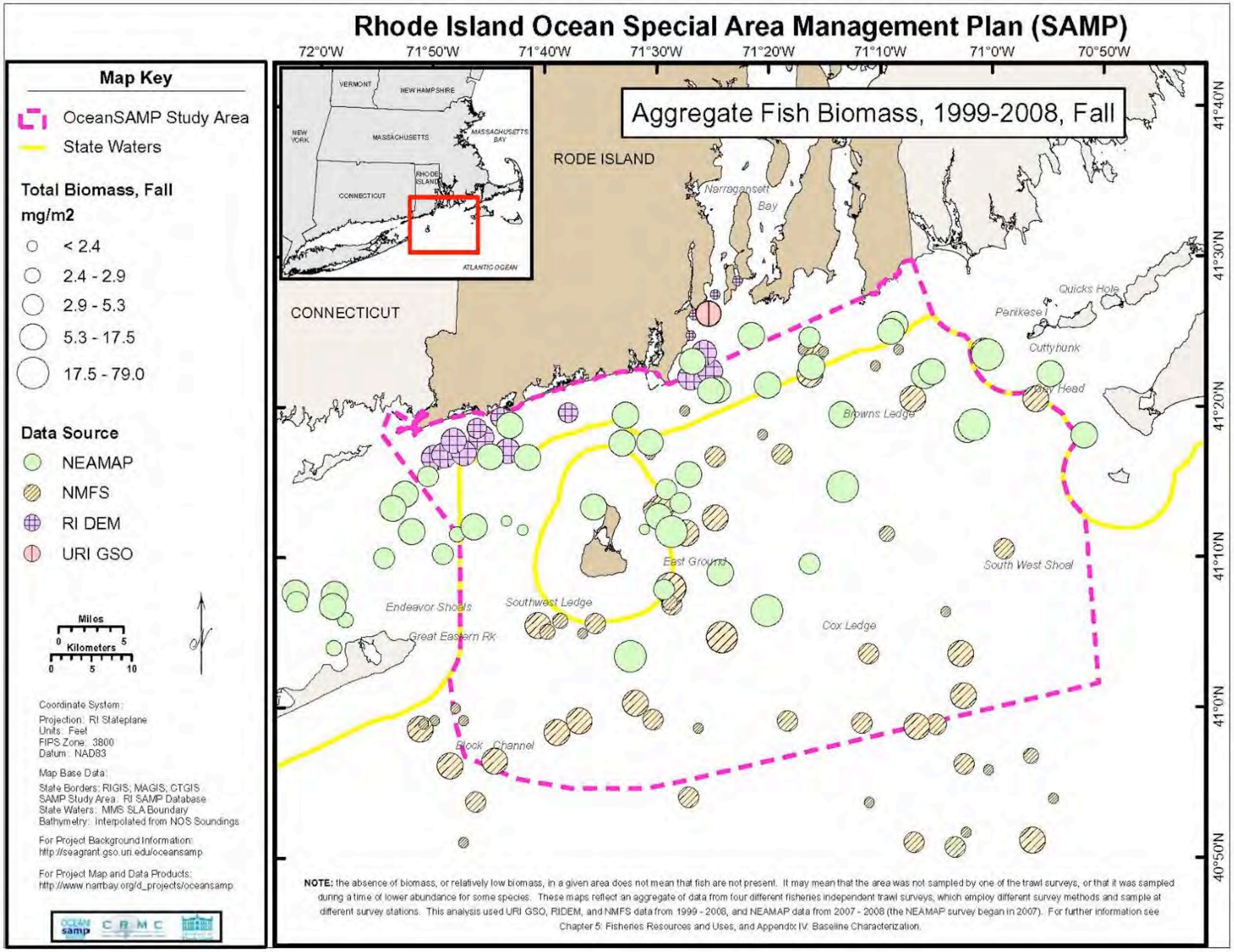

Figure 38. Aggregate Fish Biomass, 1999-2008, Fall

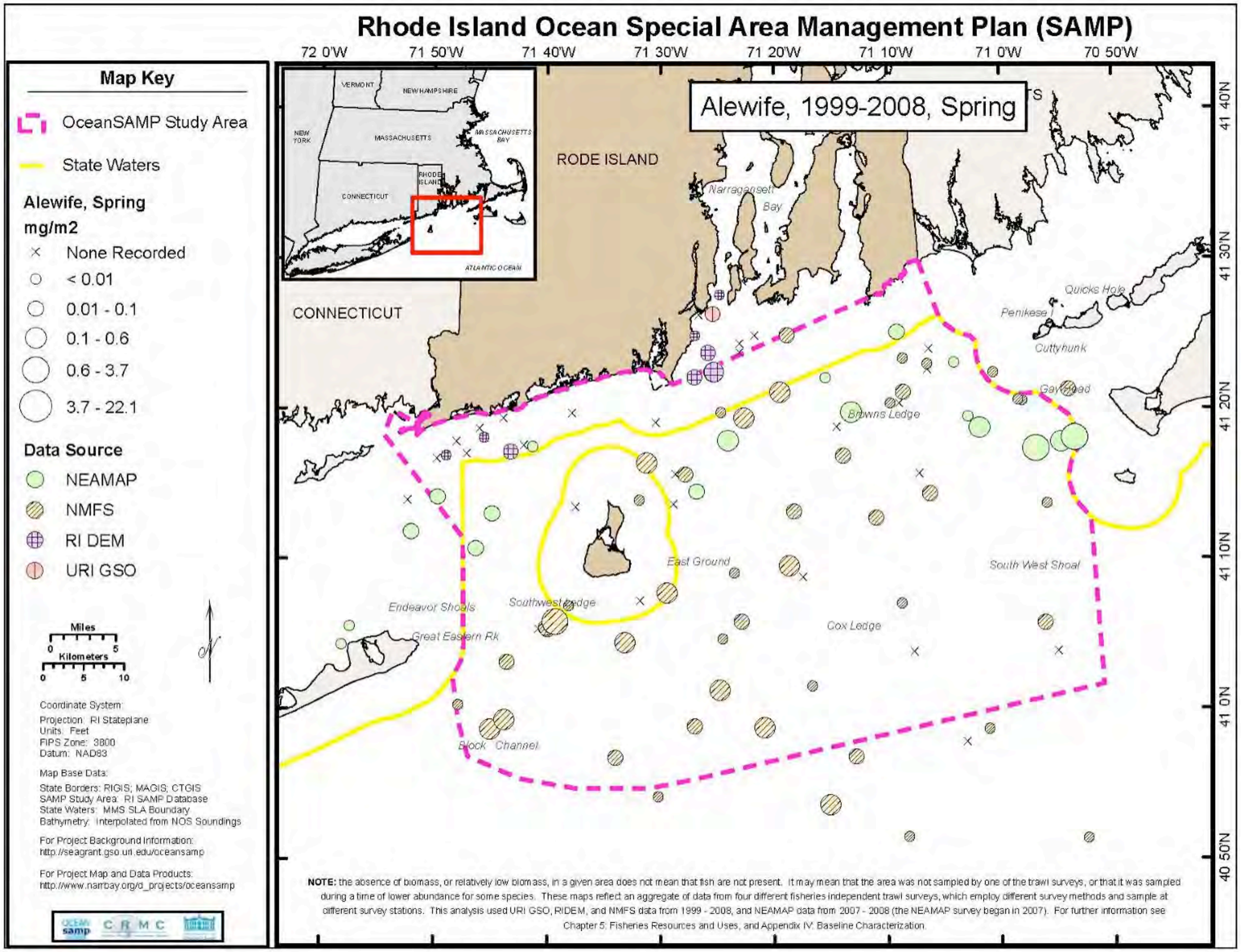

Figure 39. Alewife Biomass, Spring

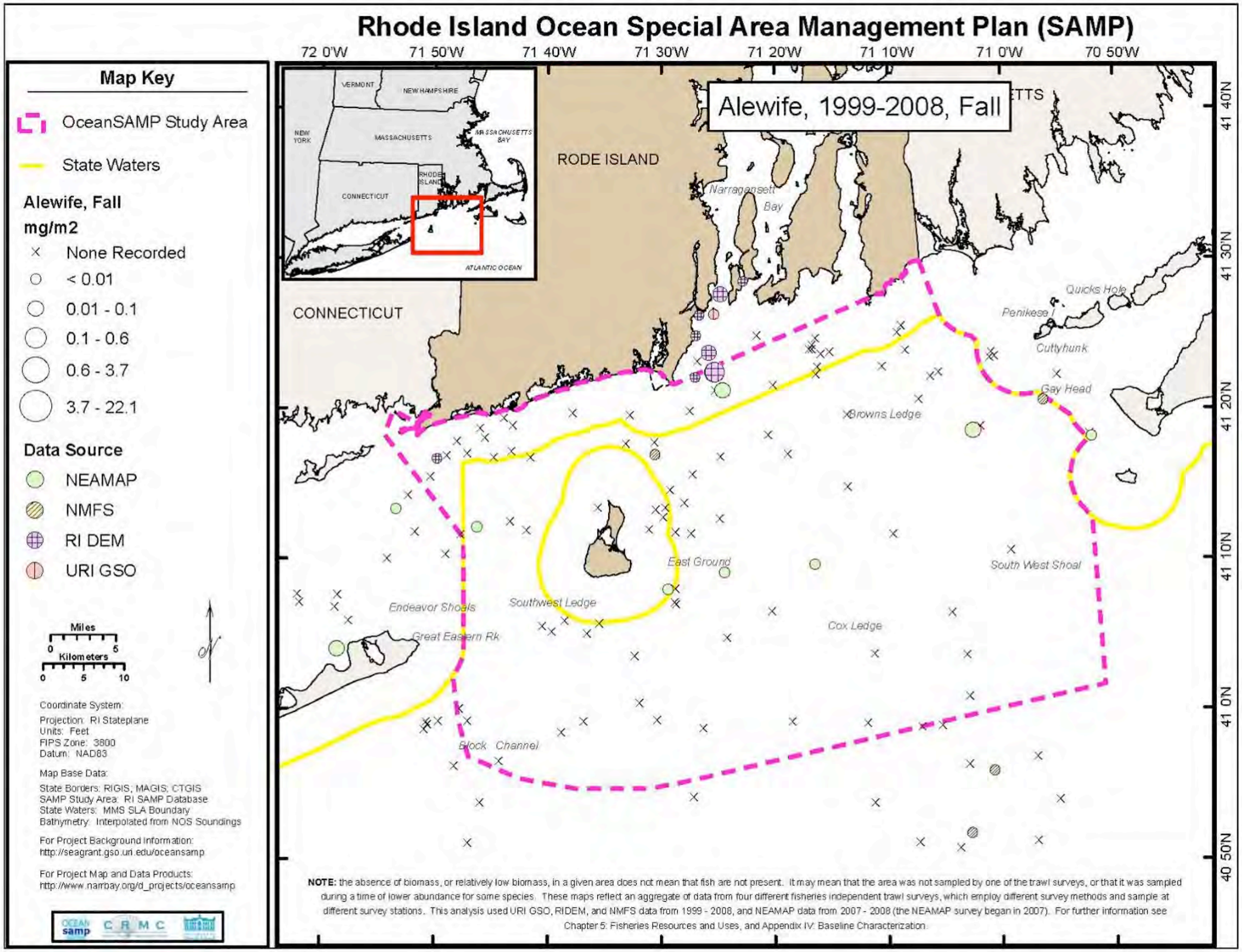

Figure 40. Alewife Biomass, Fall

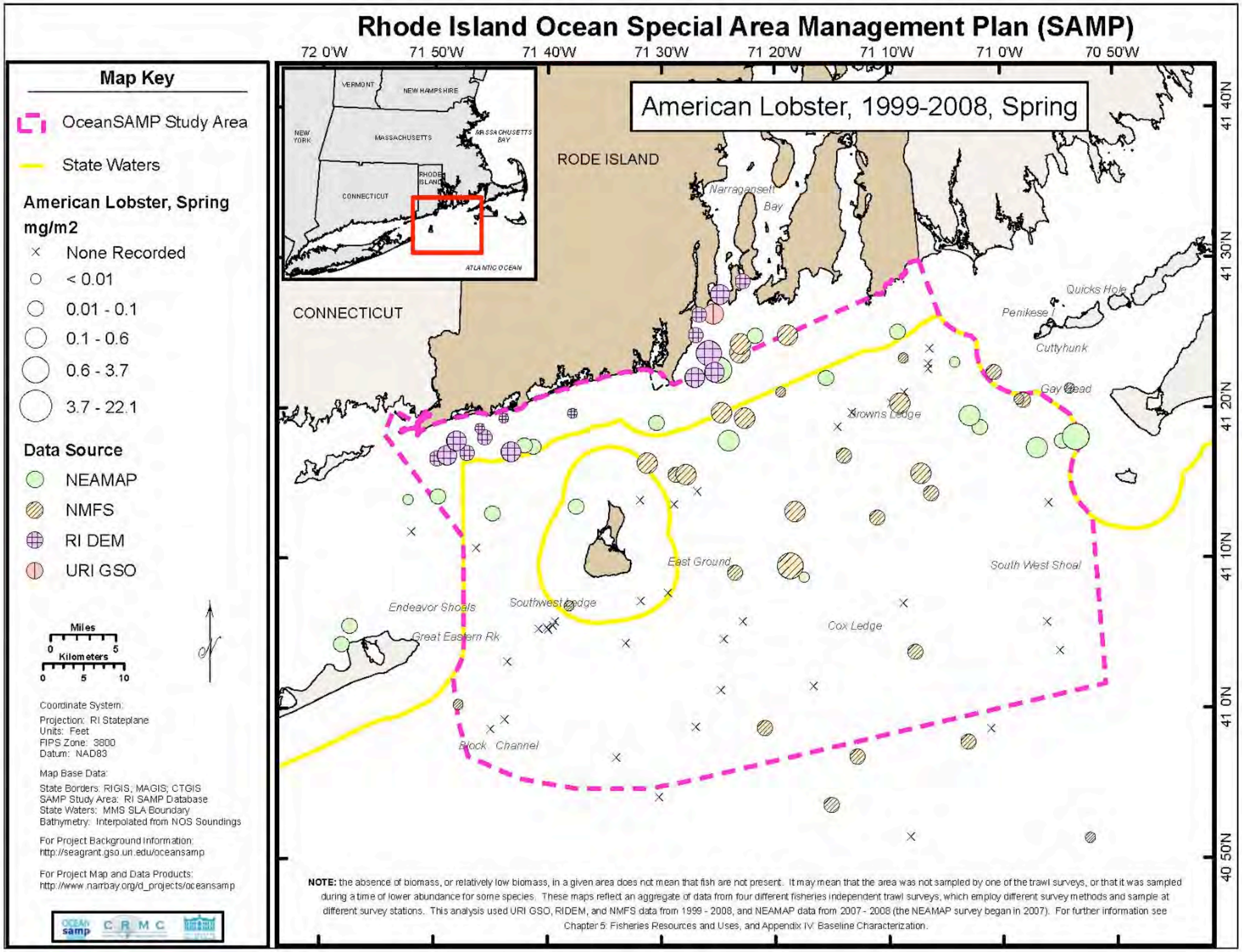

Figure 41. American Lobster Biomass, Spring

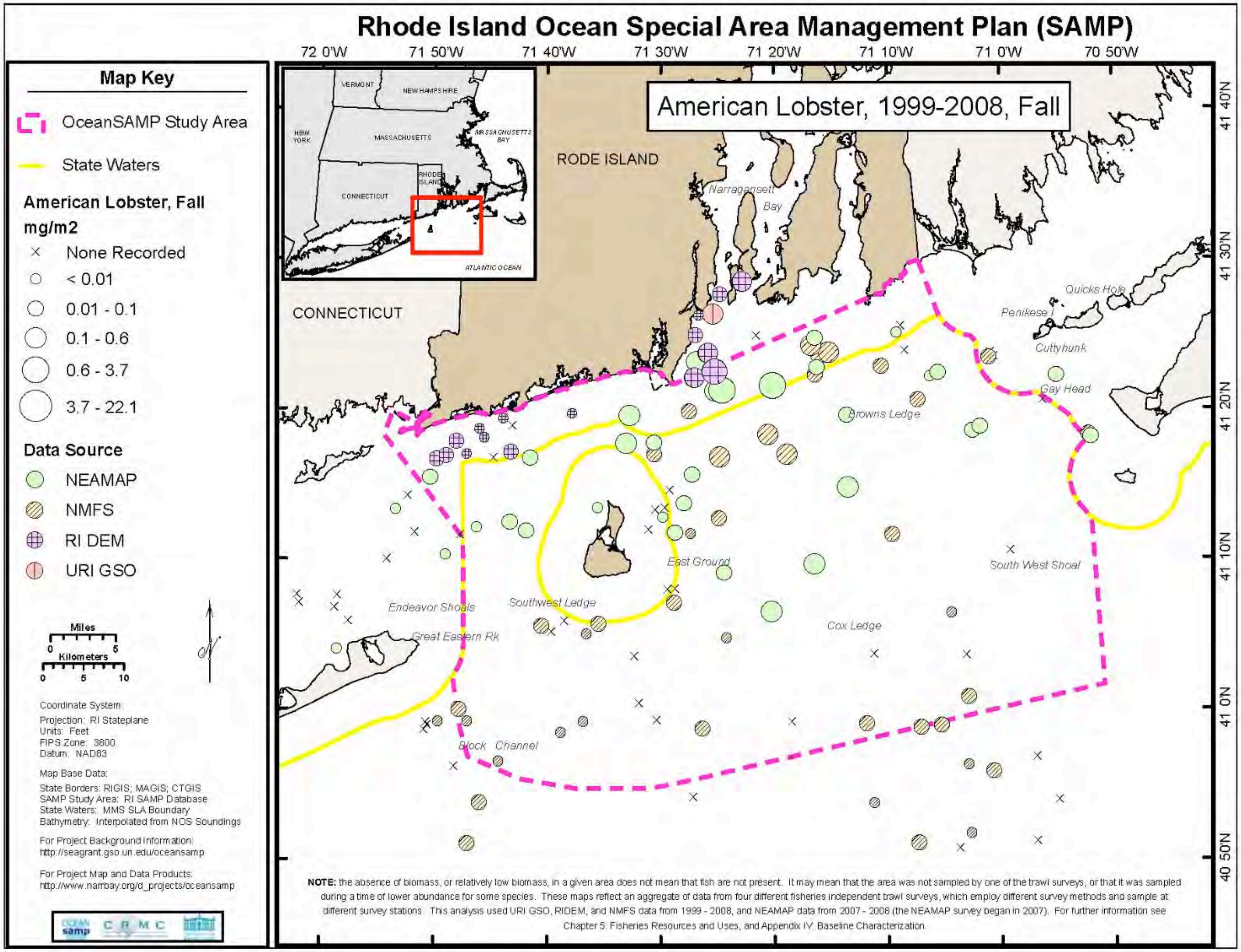

Figure 42. American Lobster Biomass, Fall

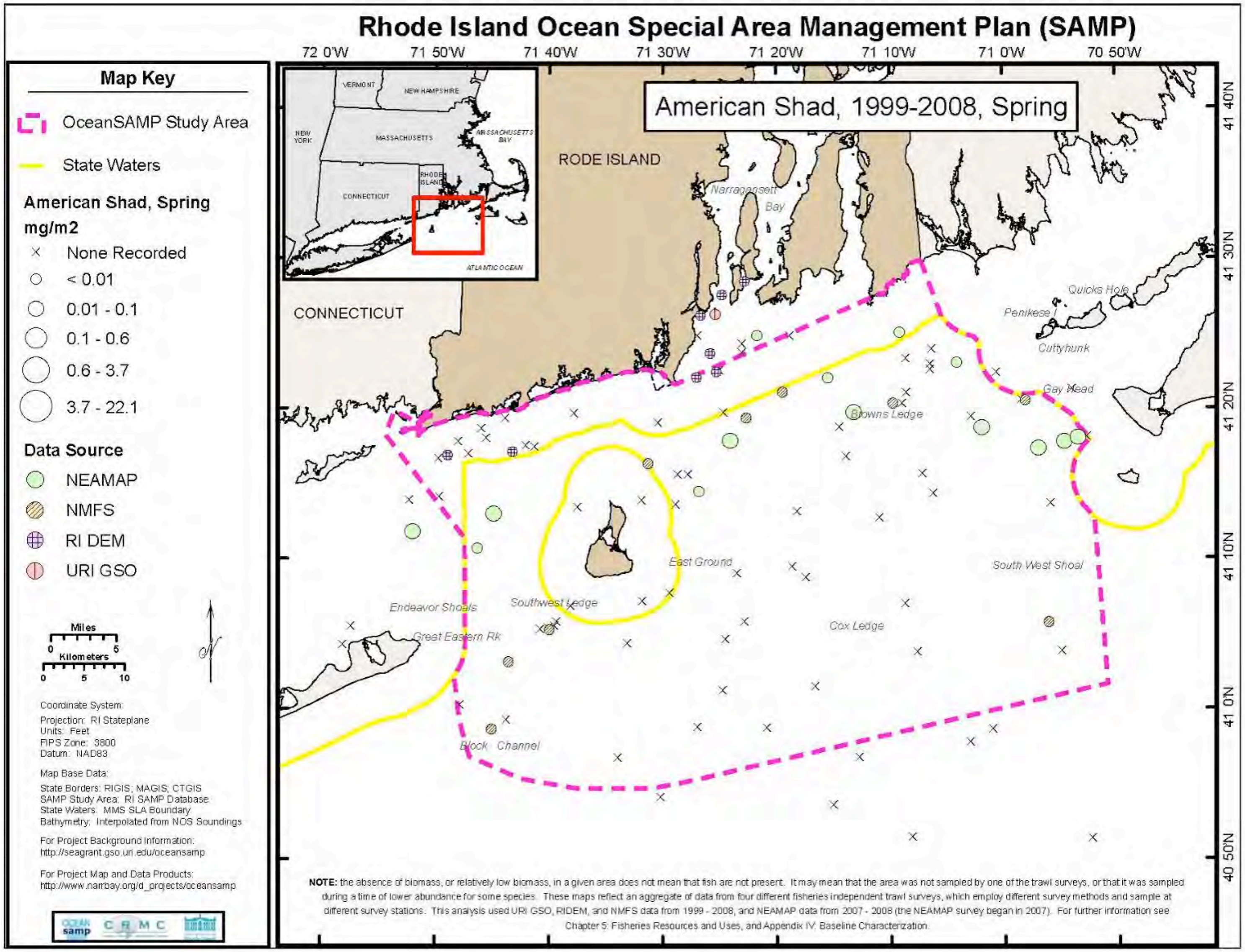

Figure 43. American Shad Biomass, Spring

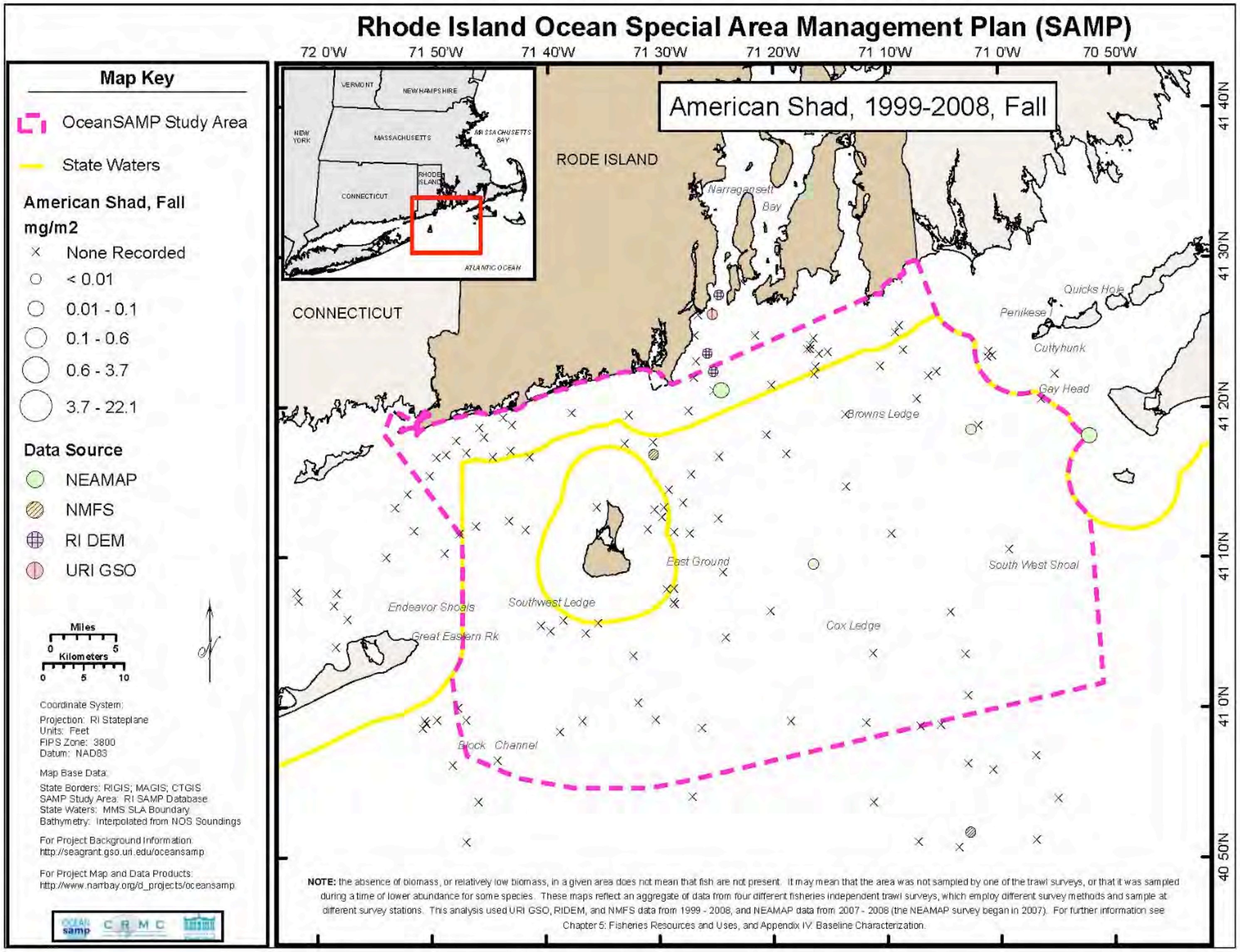

Figure 44. American Shad Biomass, Fall

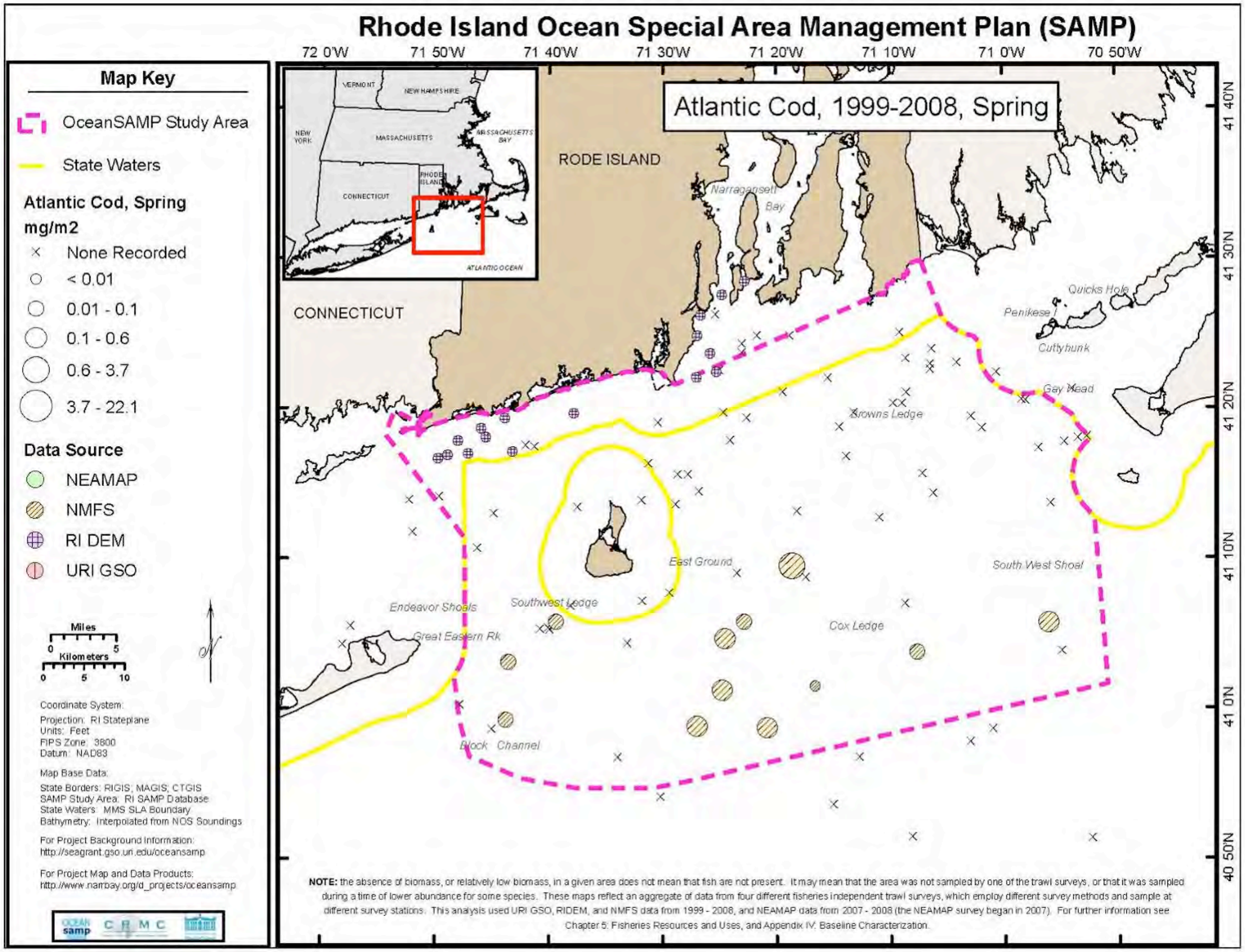

Figure 45. Atlantic Cod Biomass, Spring

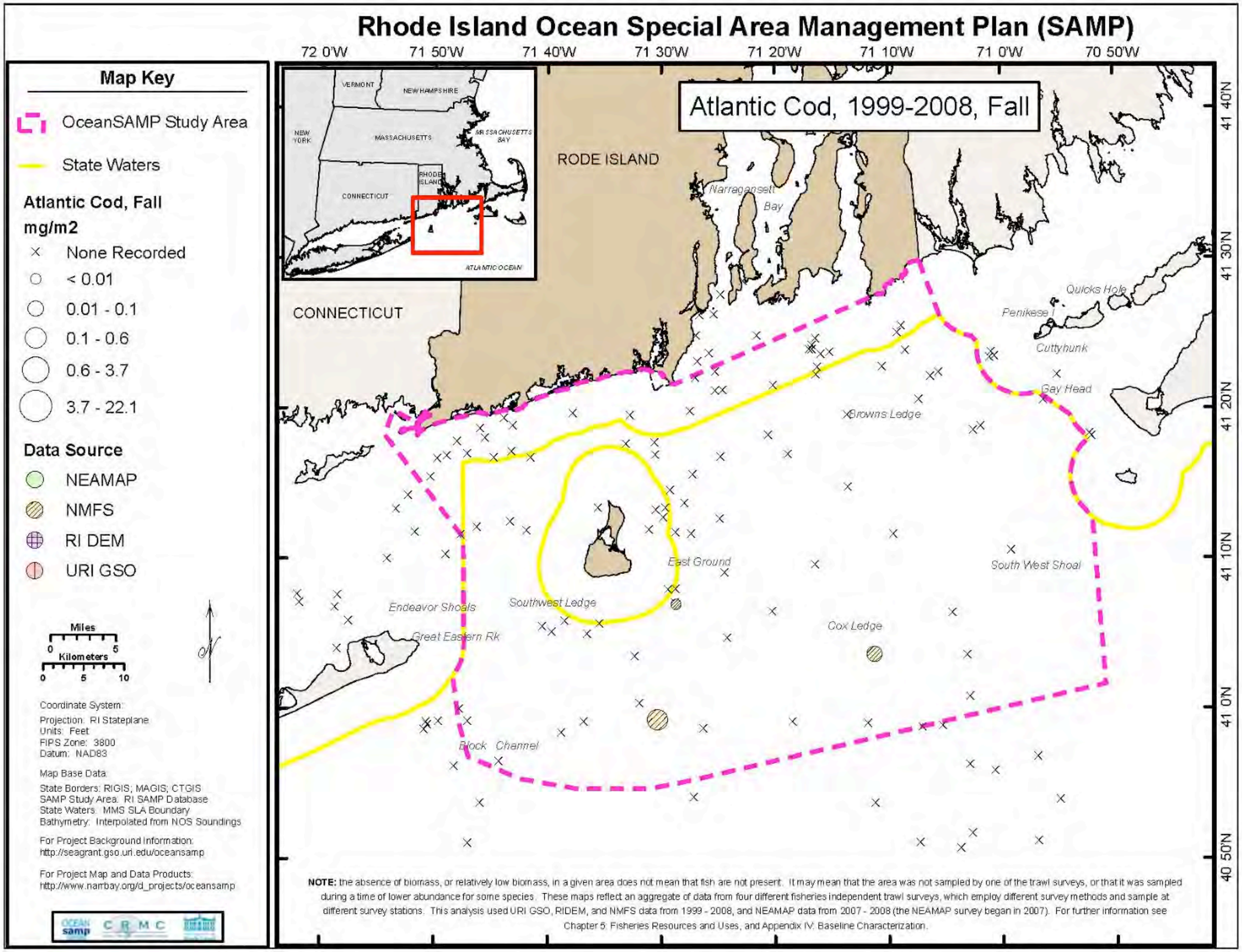

Figure 46. Atlantic Cod Biomass, Fall

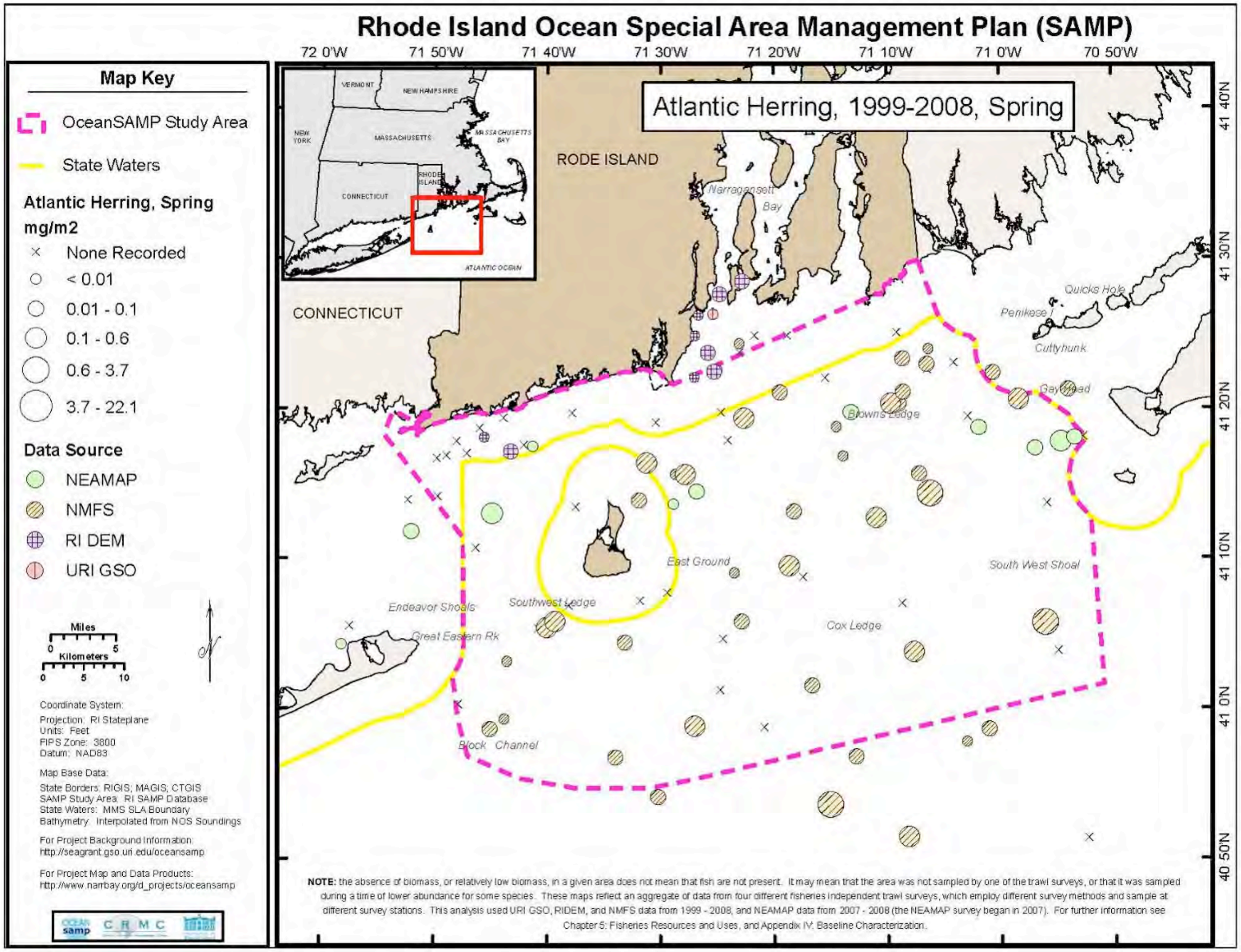

Figure 47. Atlantic Herring Biomass, Spring

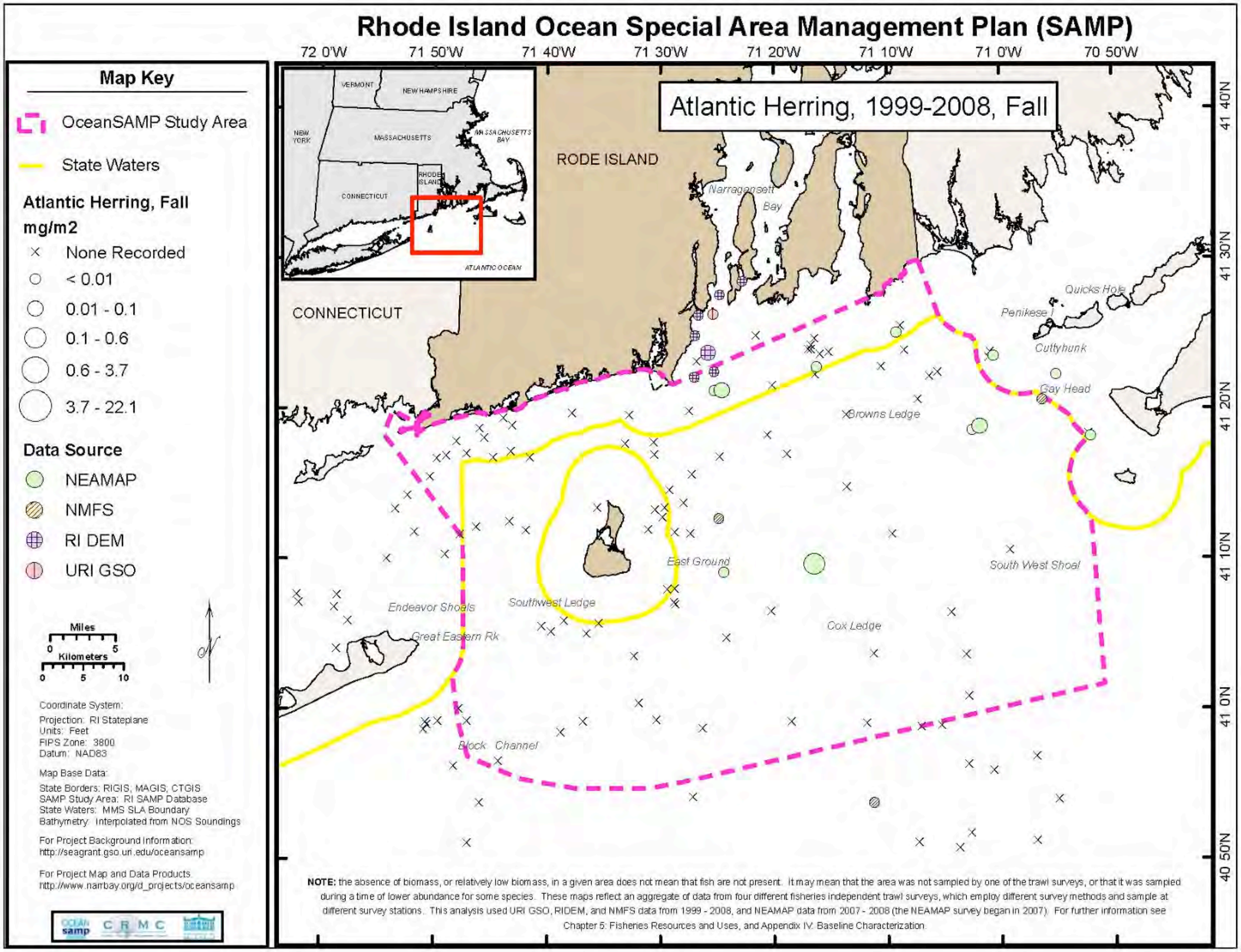

Figure 48. Atlantic Herring Biomass, Fall

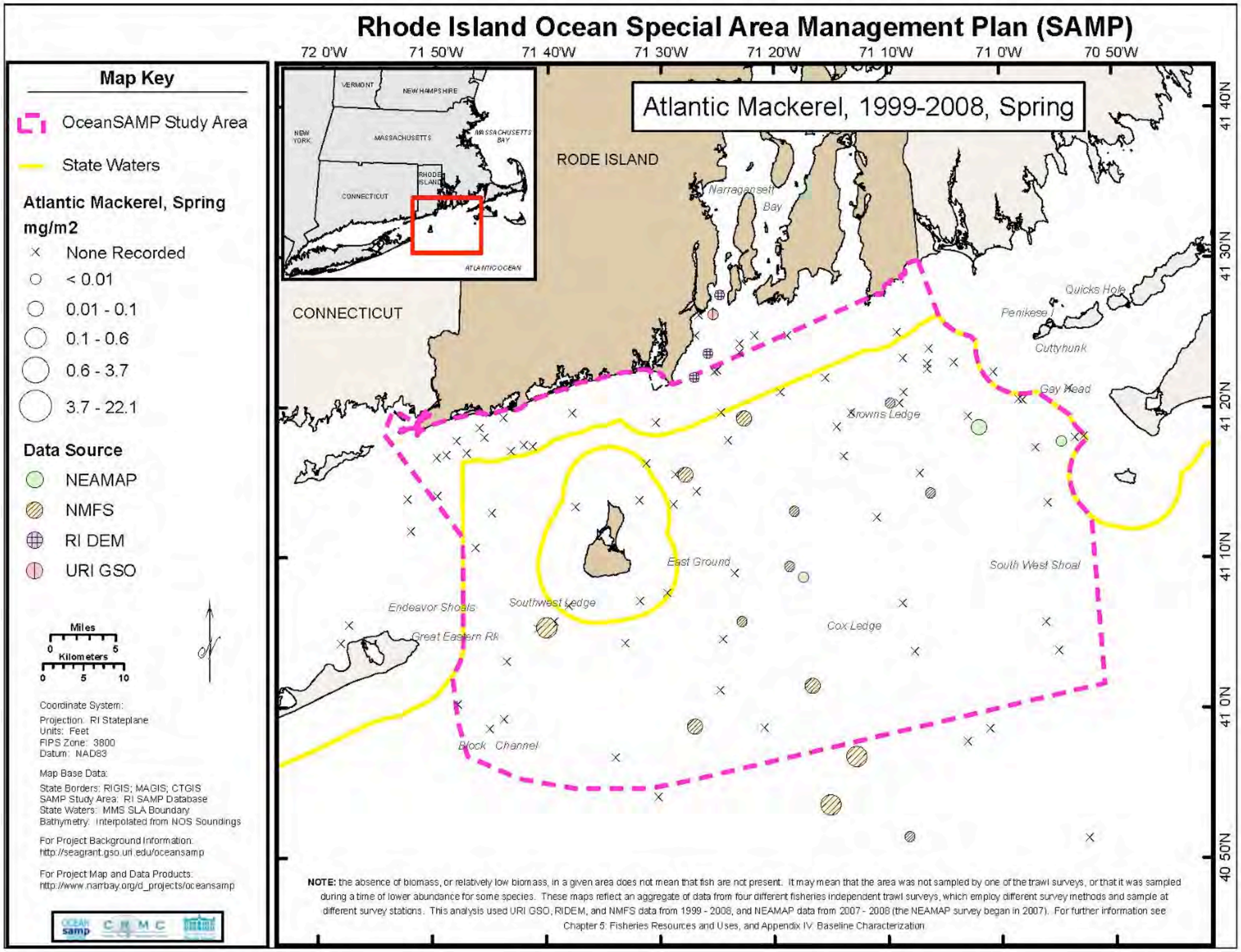

Figure 49. Atlantic Mackerel Biomass, Spring

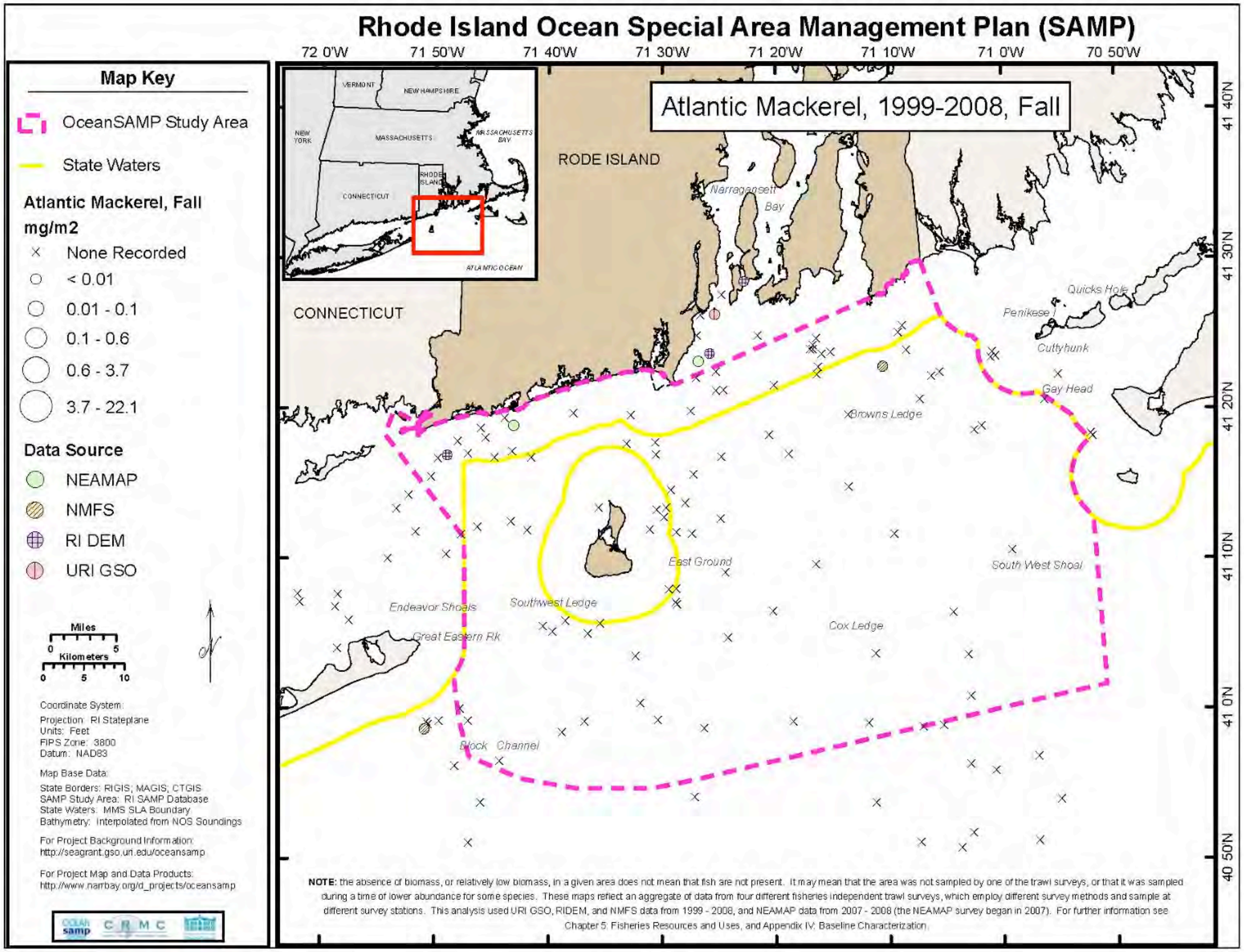

Figure 50. Atlantic Mackerel Biomass, Fall

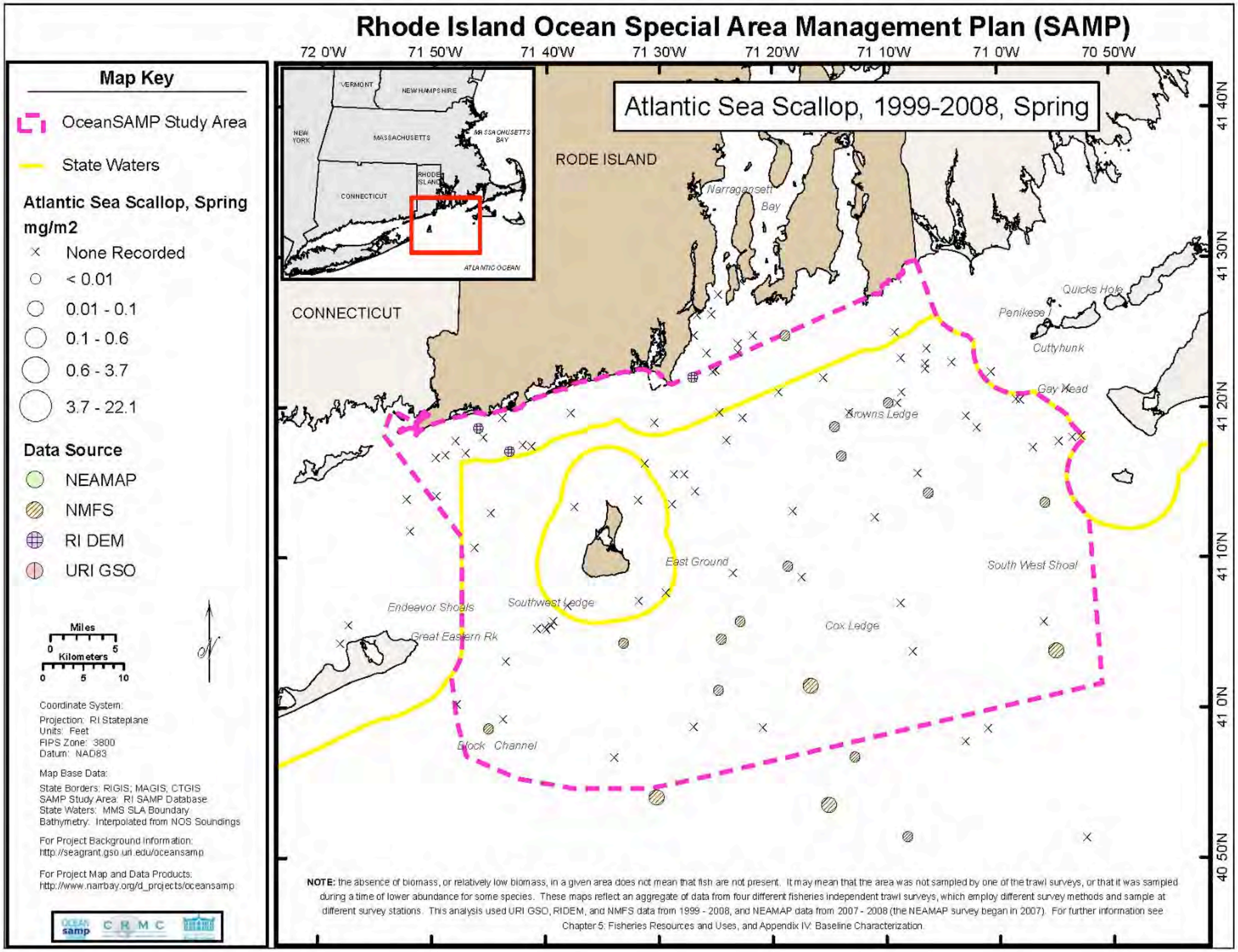

Figure 51. Atlantic Sea Scallop Biomass, Spring

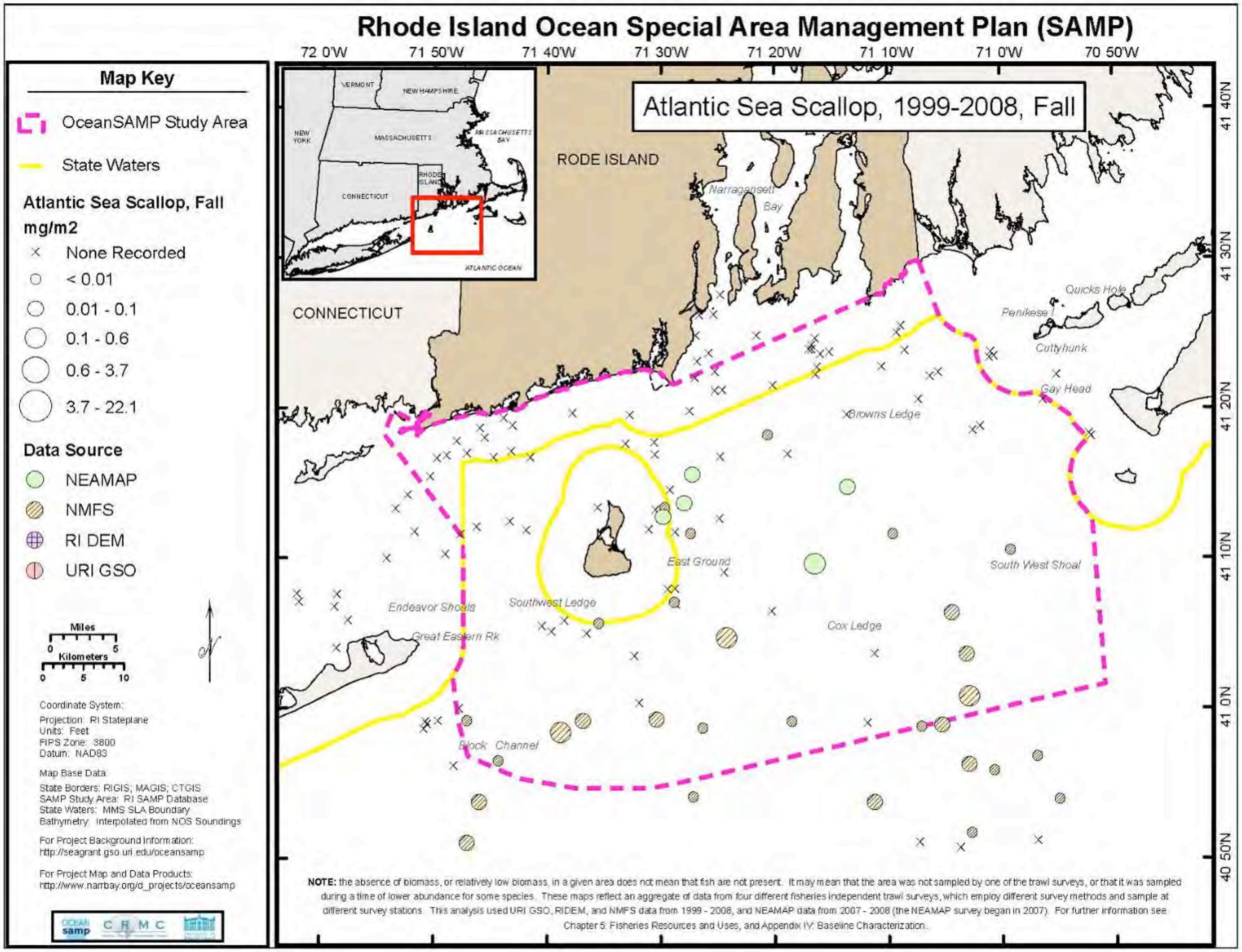

Figure 52. Atlantic Sea Scallop Biomass, Fall

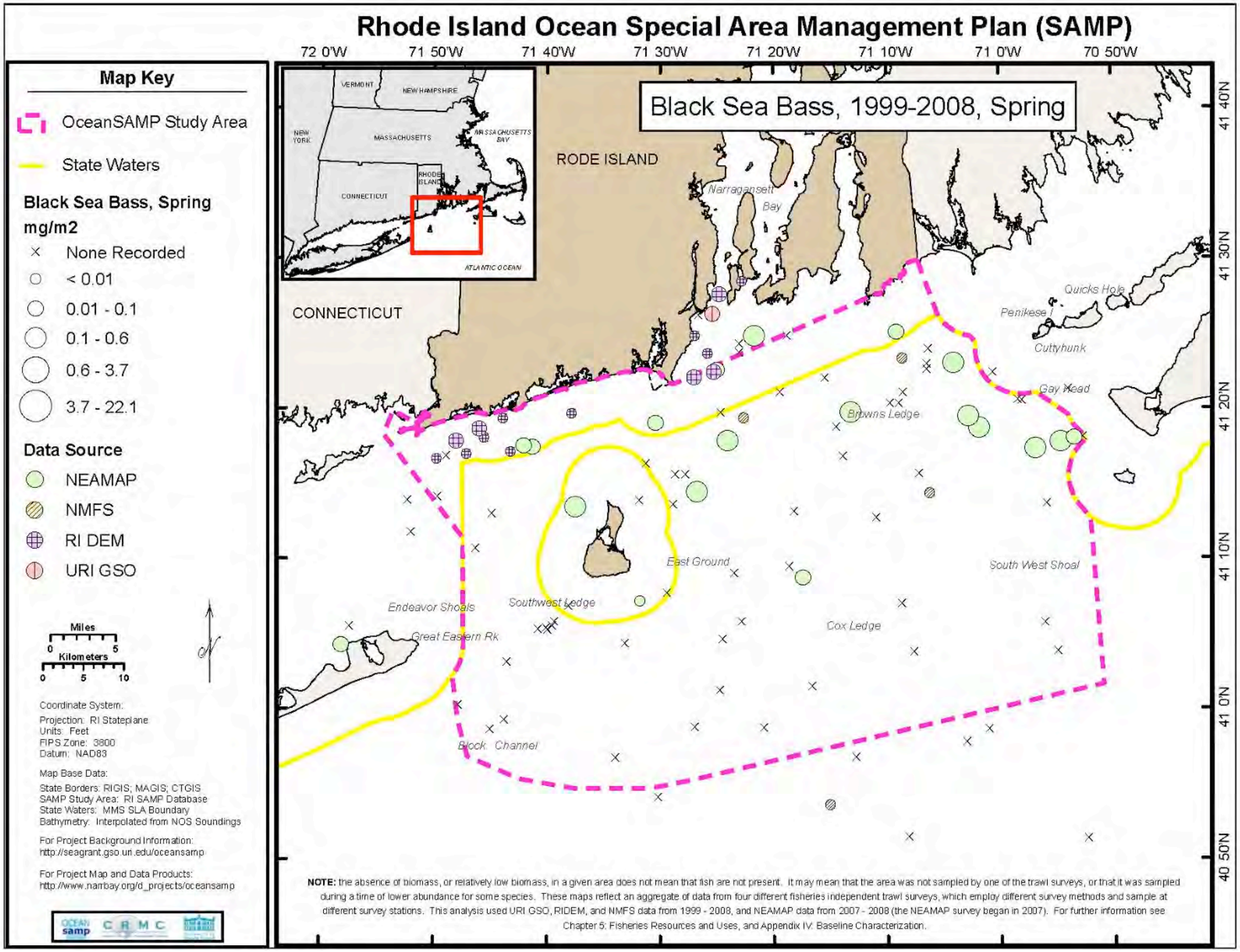

Figure 53. Black Sea Bass Biomass, Spring

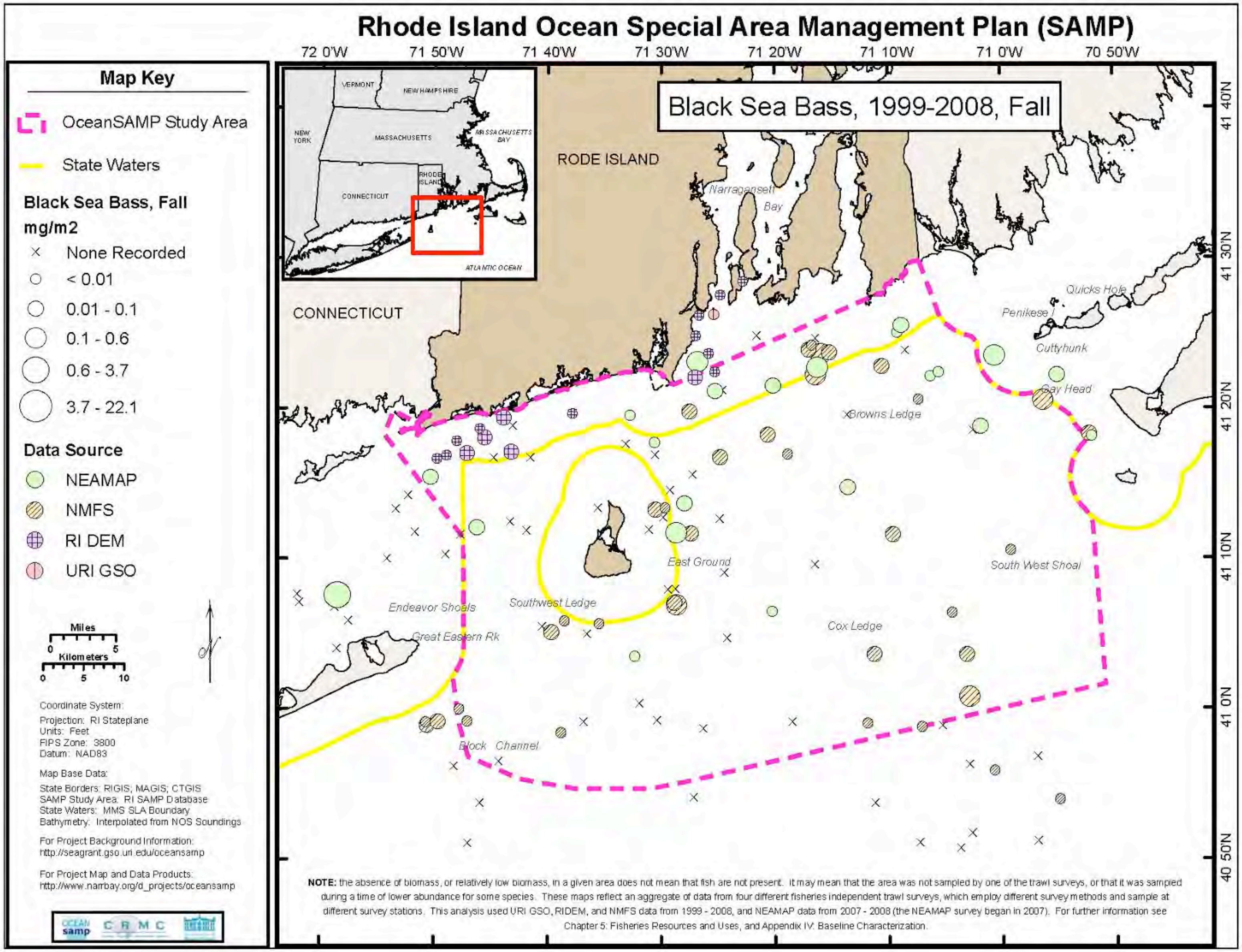

Figure 54. Black Sea Bass Biomass, Fall

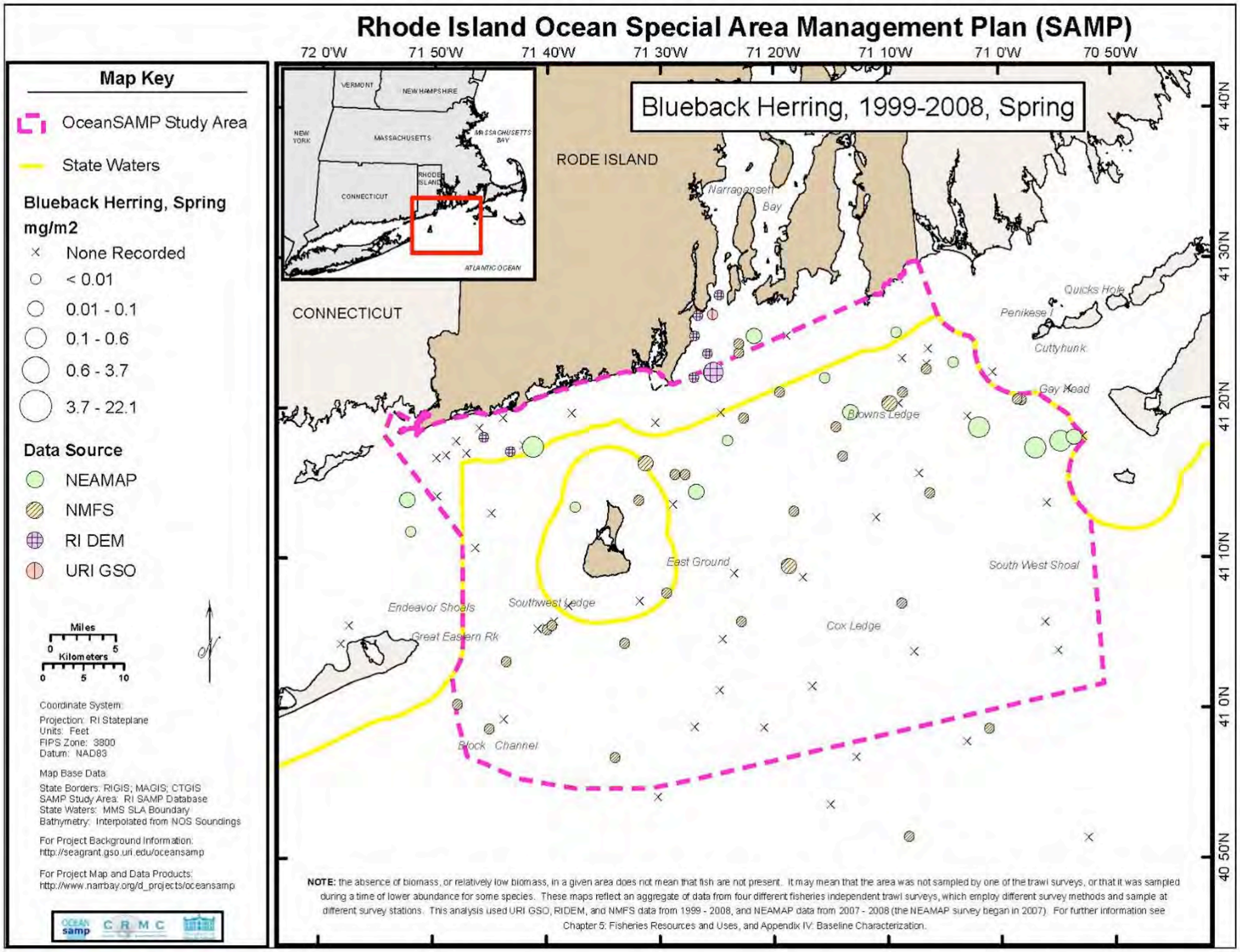

Figure 55. Blueback Herring Biomass, Spring

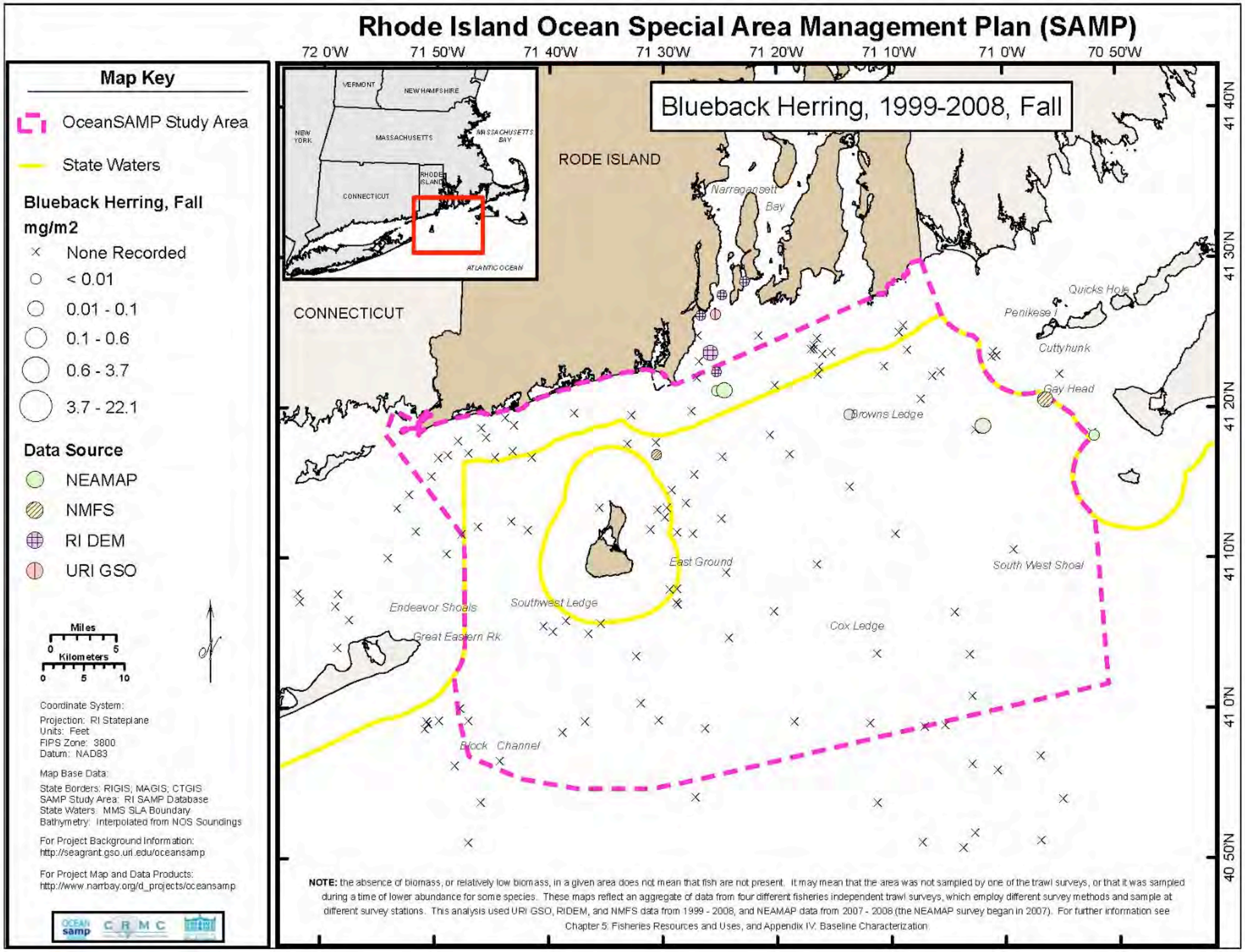

Figure 56. Blueback Herring Biomass, Fall

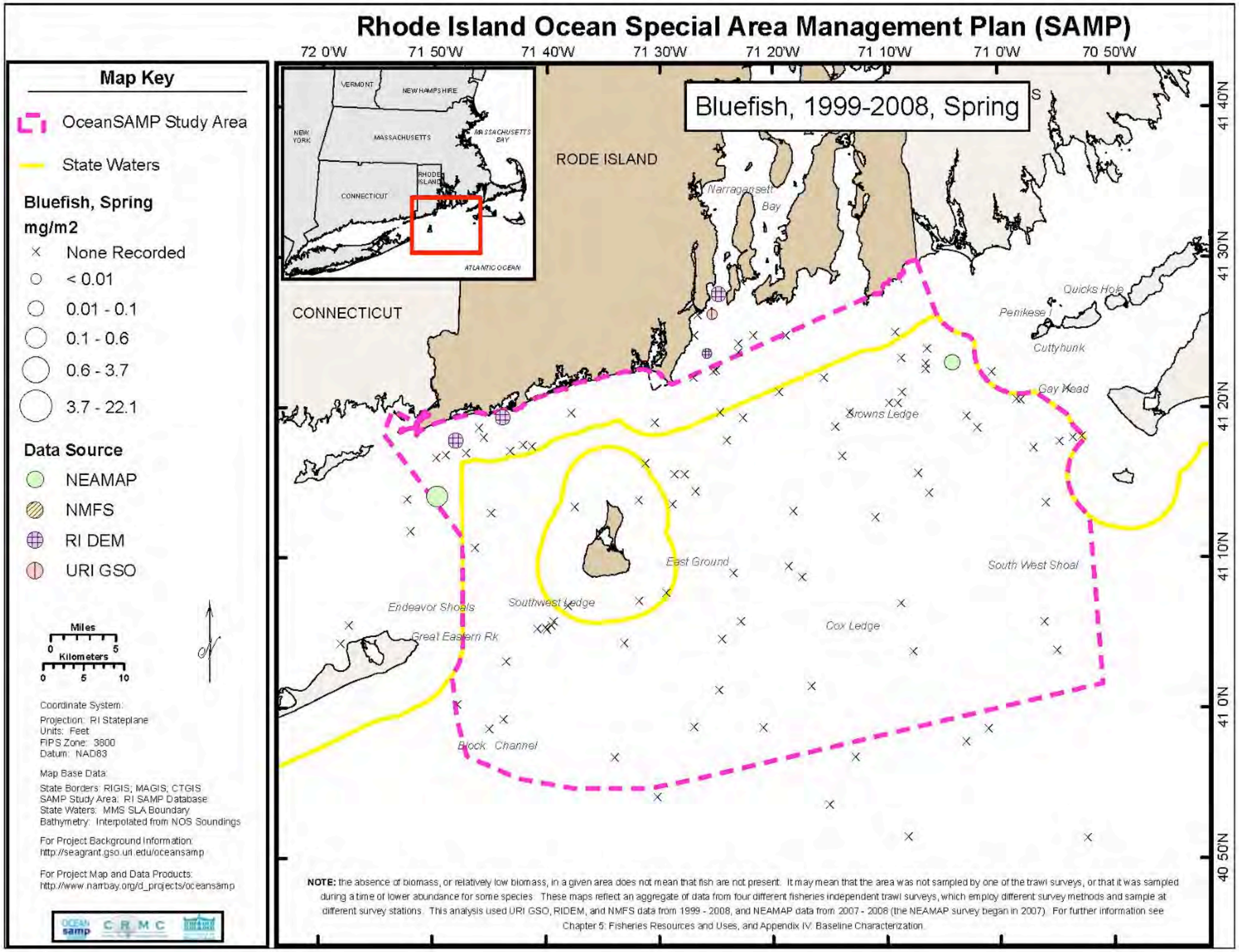

Figure 57. Bluefish Biomass, Spring

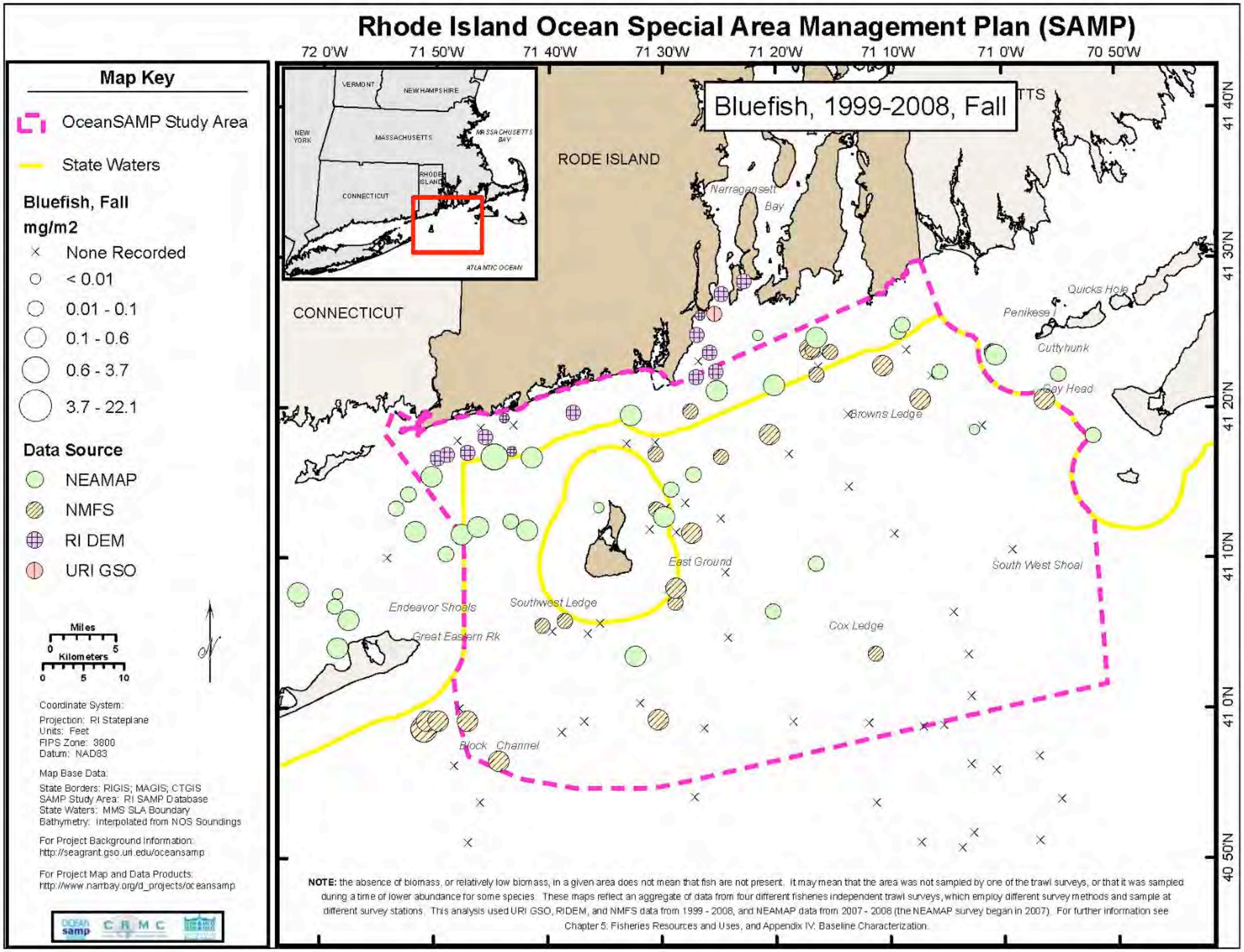

Figure 58. Bluefish Biomass, Fall

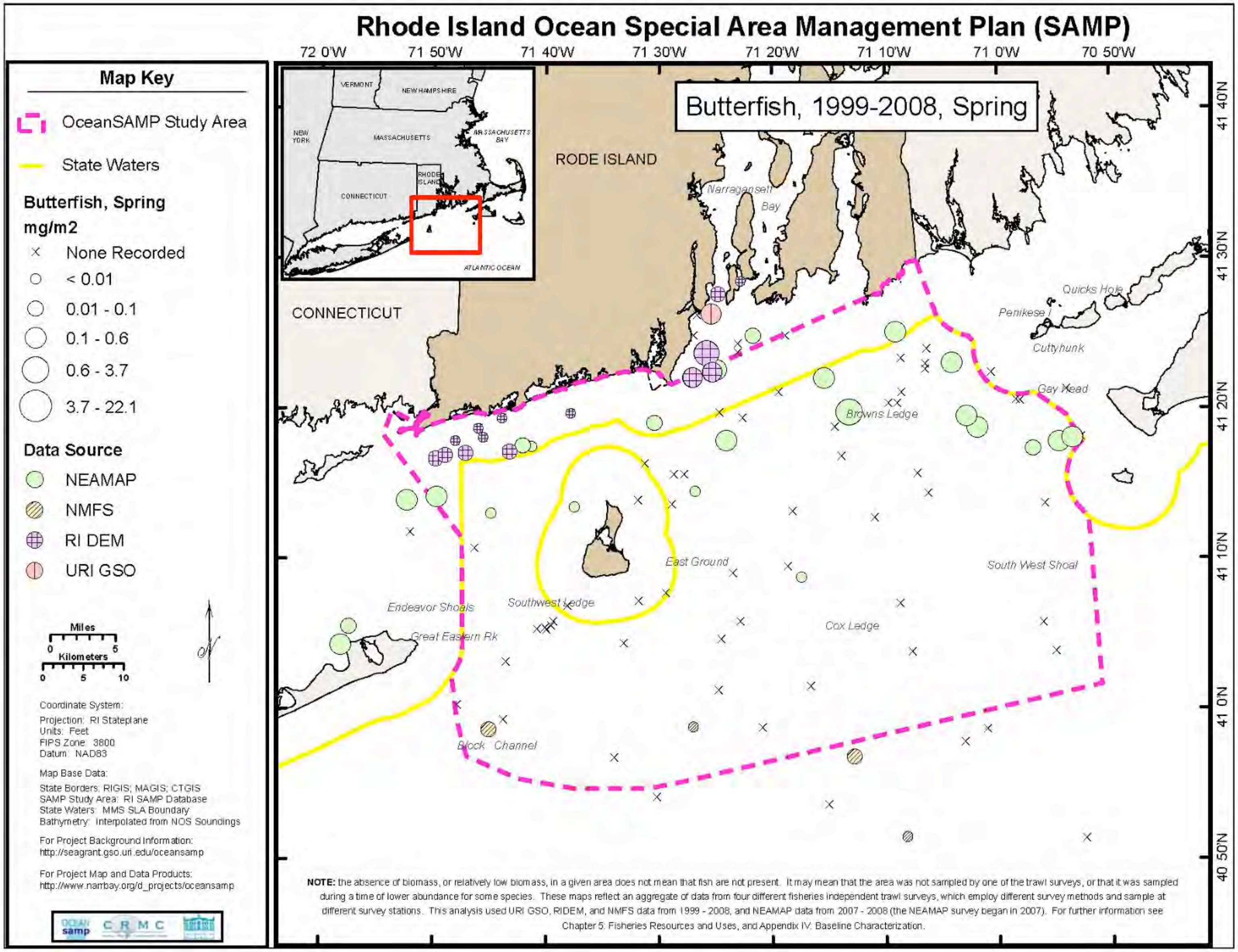

Figure 59. Butterfish Biomass, Spring

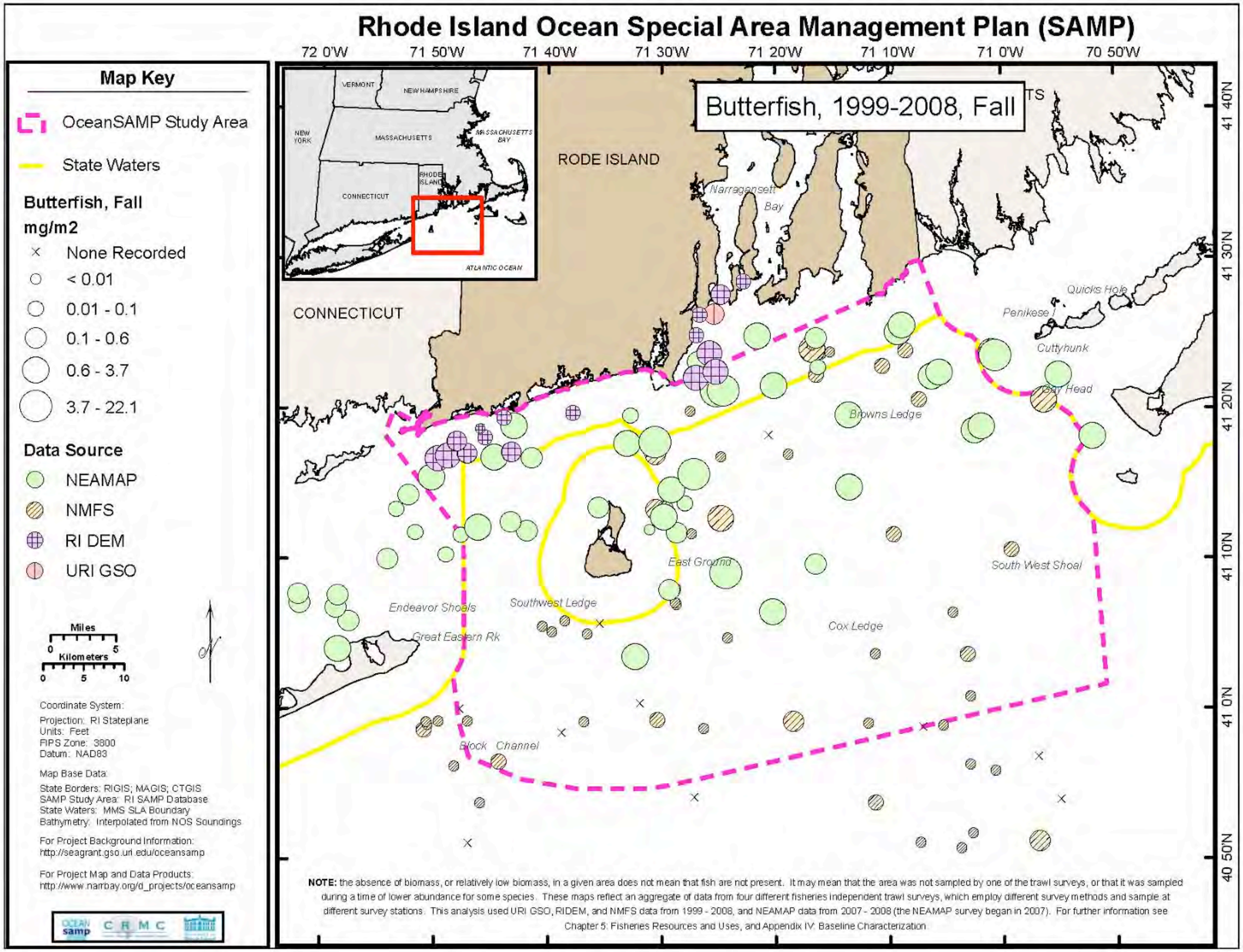

Figure 60. Butterfish Biomass, Fall

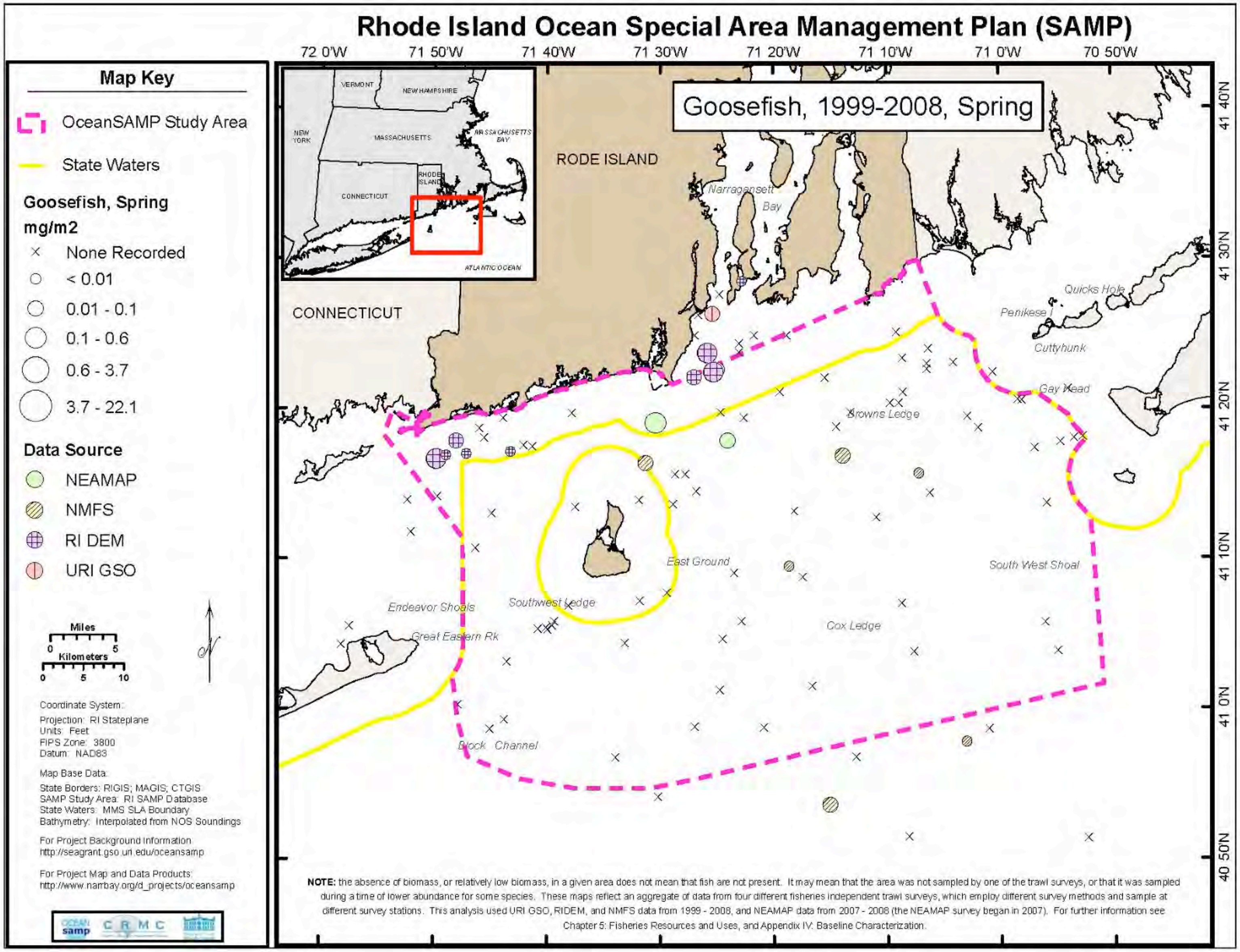

Figure 61. Goosefish Biomass, Spring

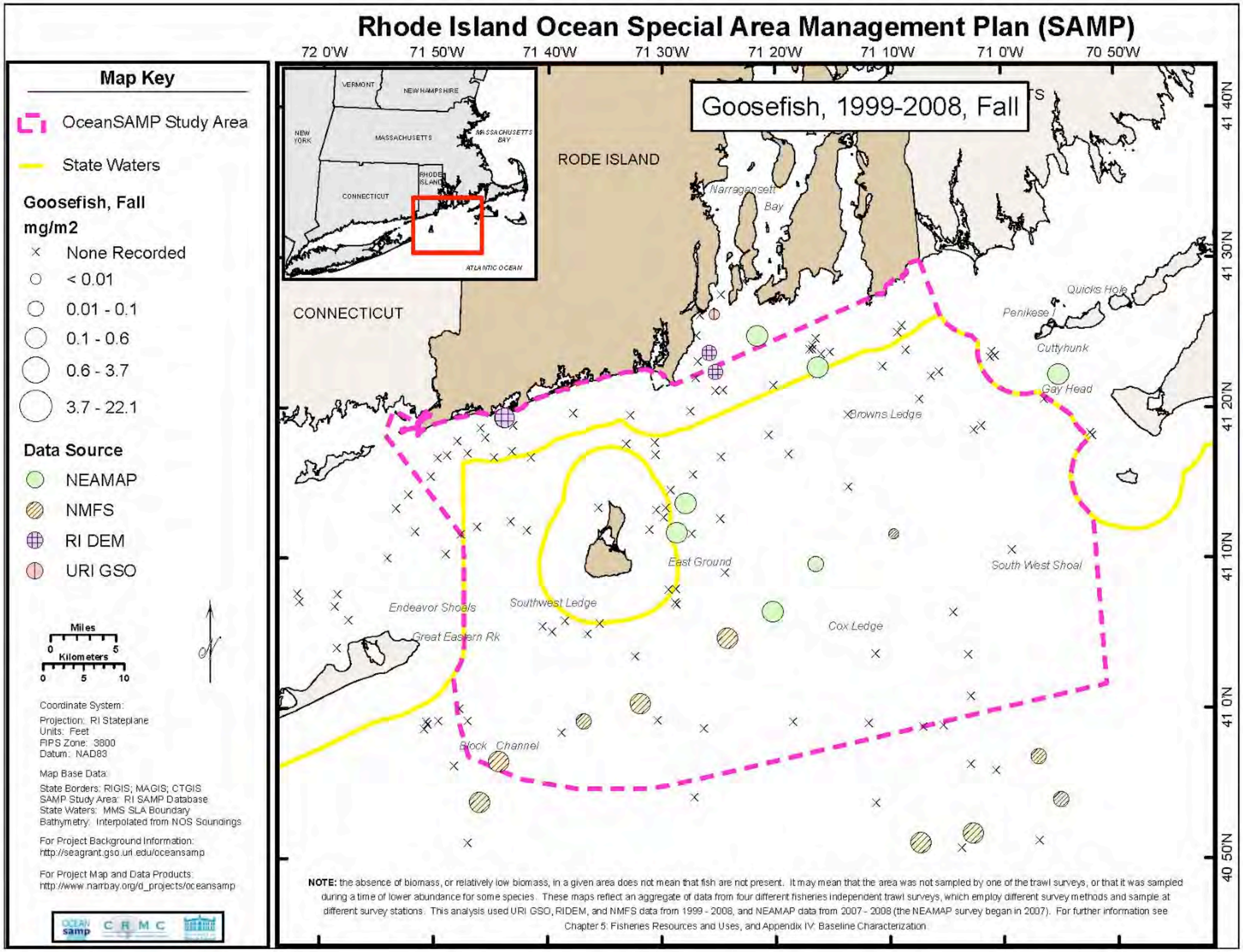

Figure 62. Goosefish Biomass, Fall

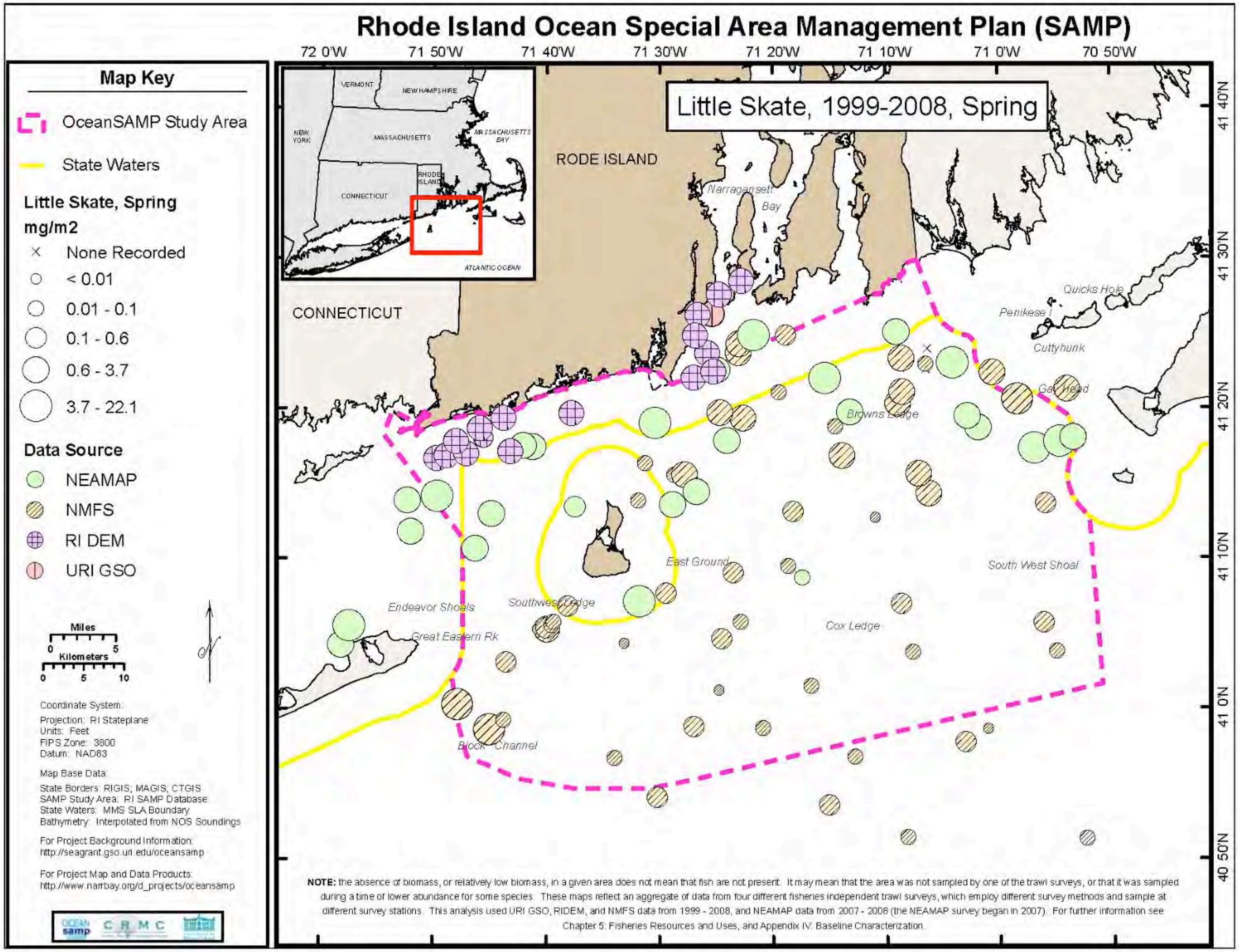

Figure 63. Little Skate Biomass, Spring

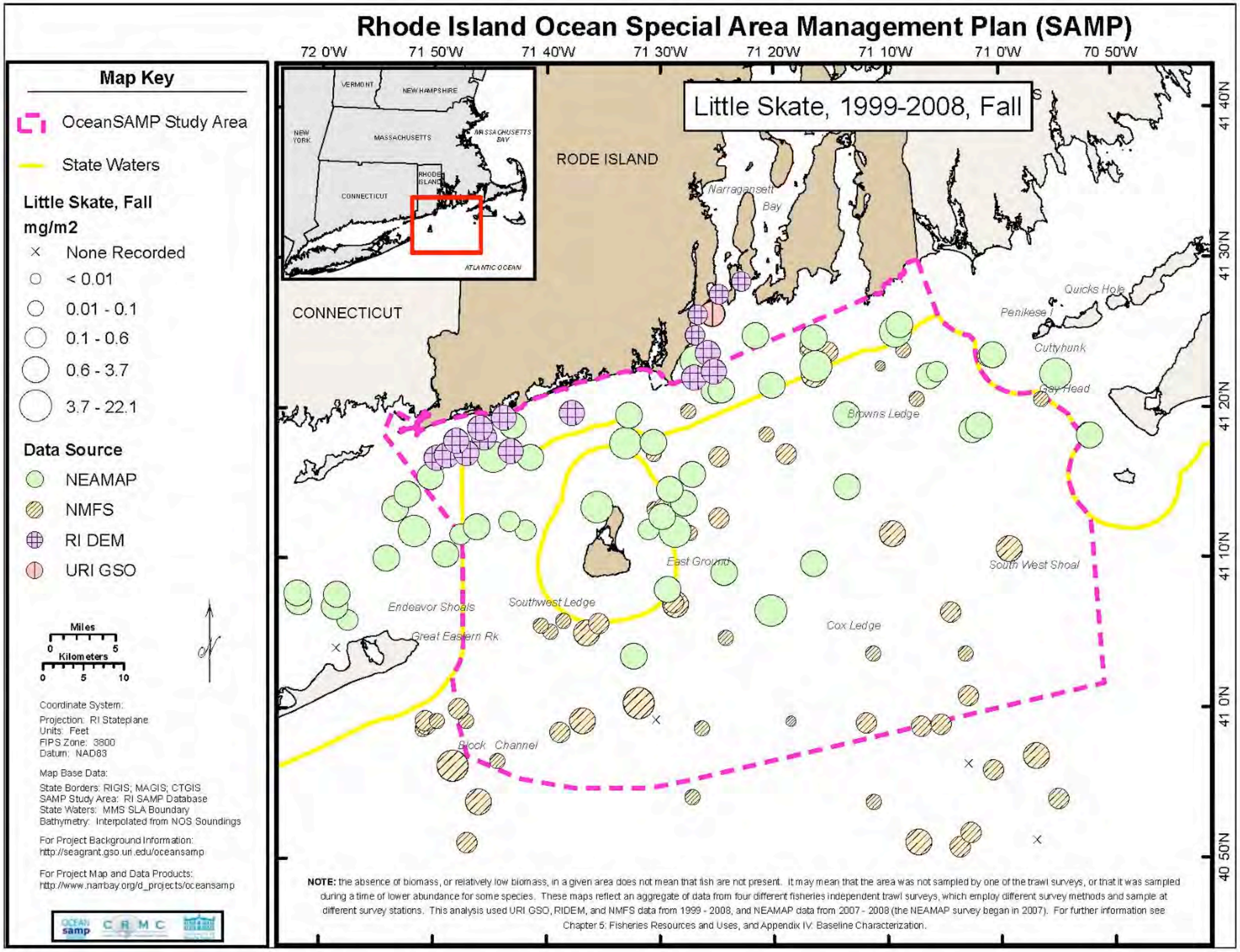

Figure 64. Little Skate Biomass, Fall

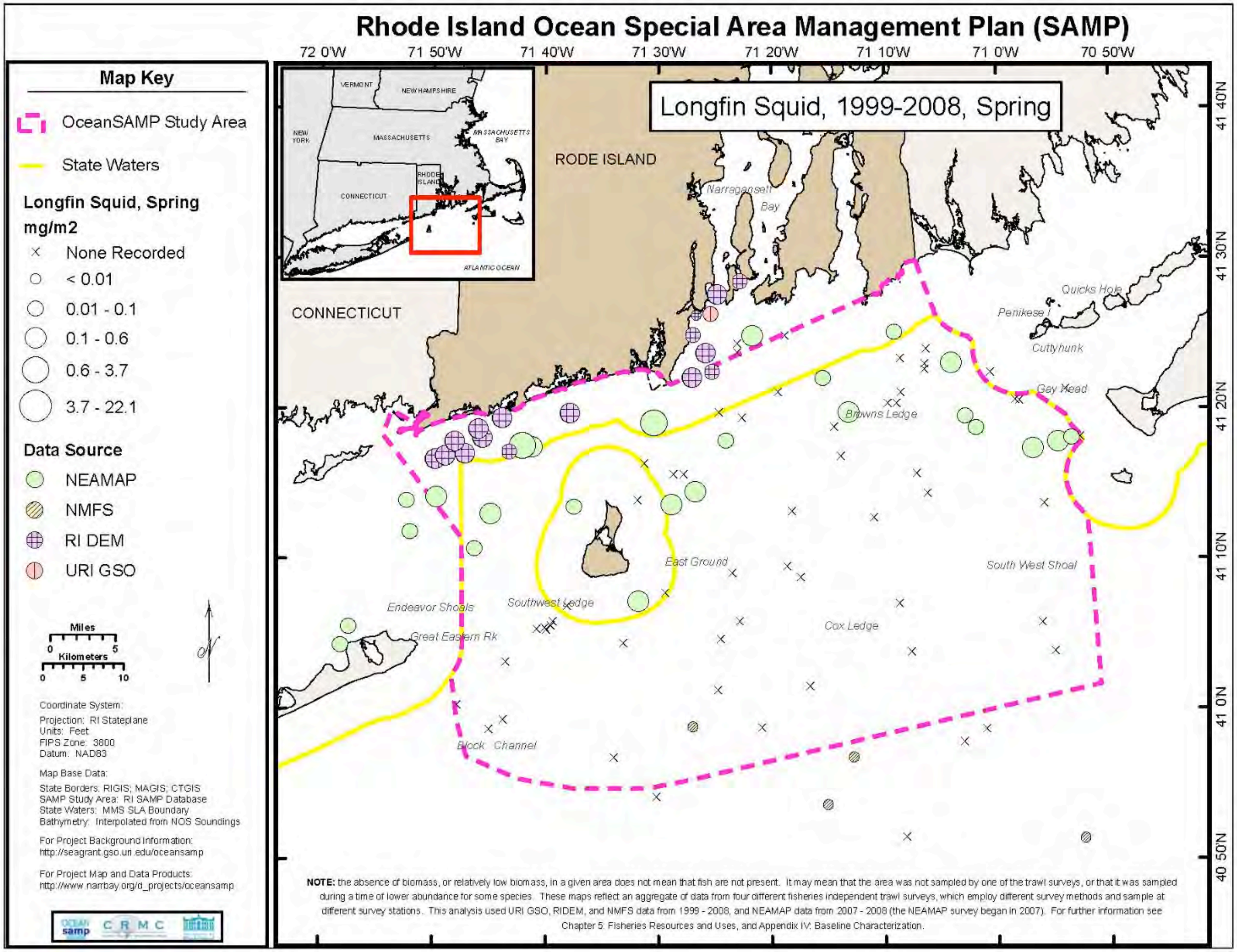

Figure 65. Longfin Squid Biomass, Spring

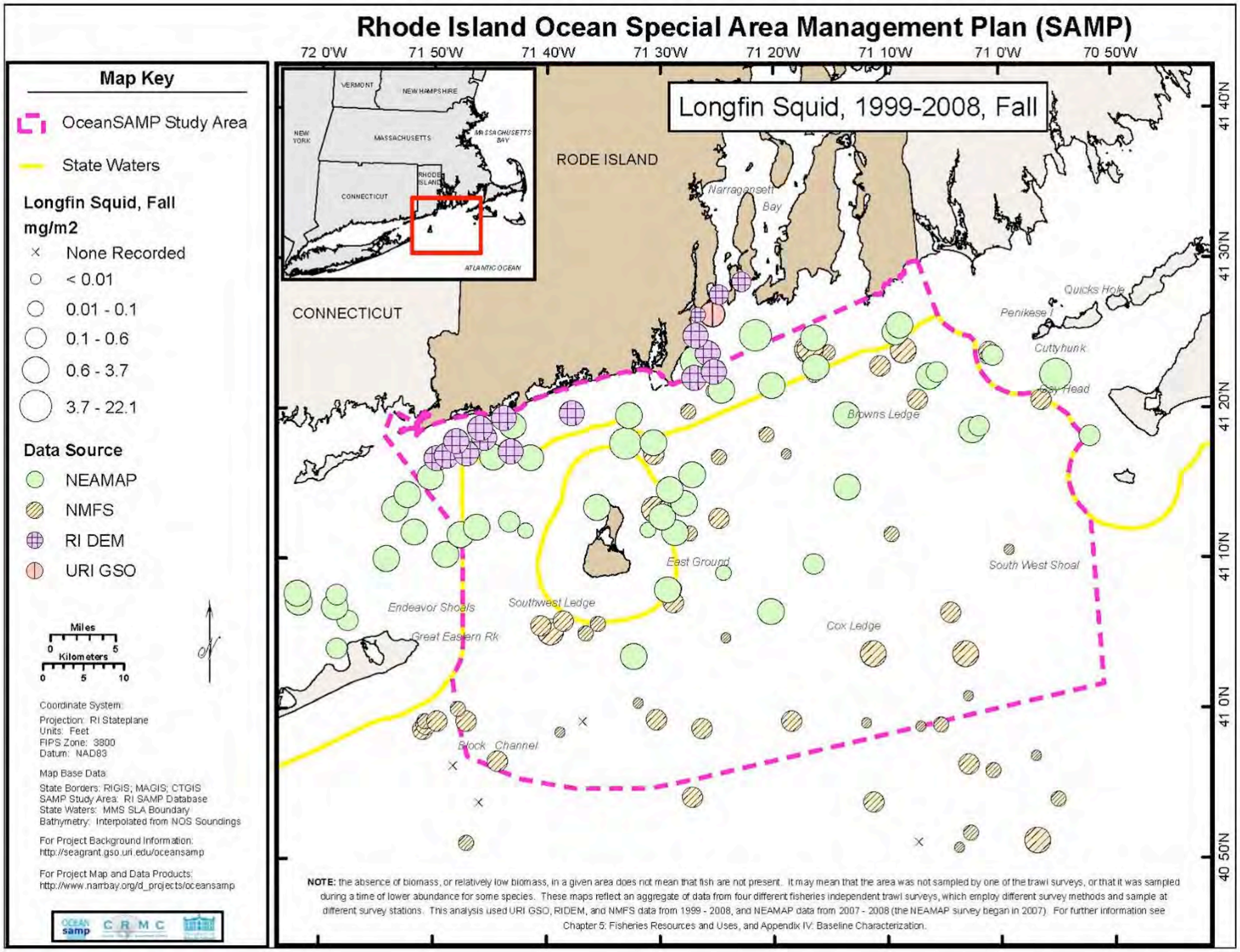

Figure 66. Longfin Squid Biomass, Fall

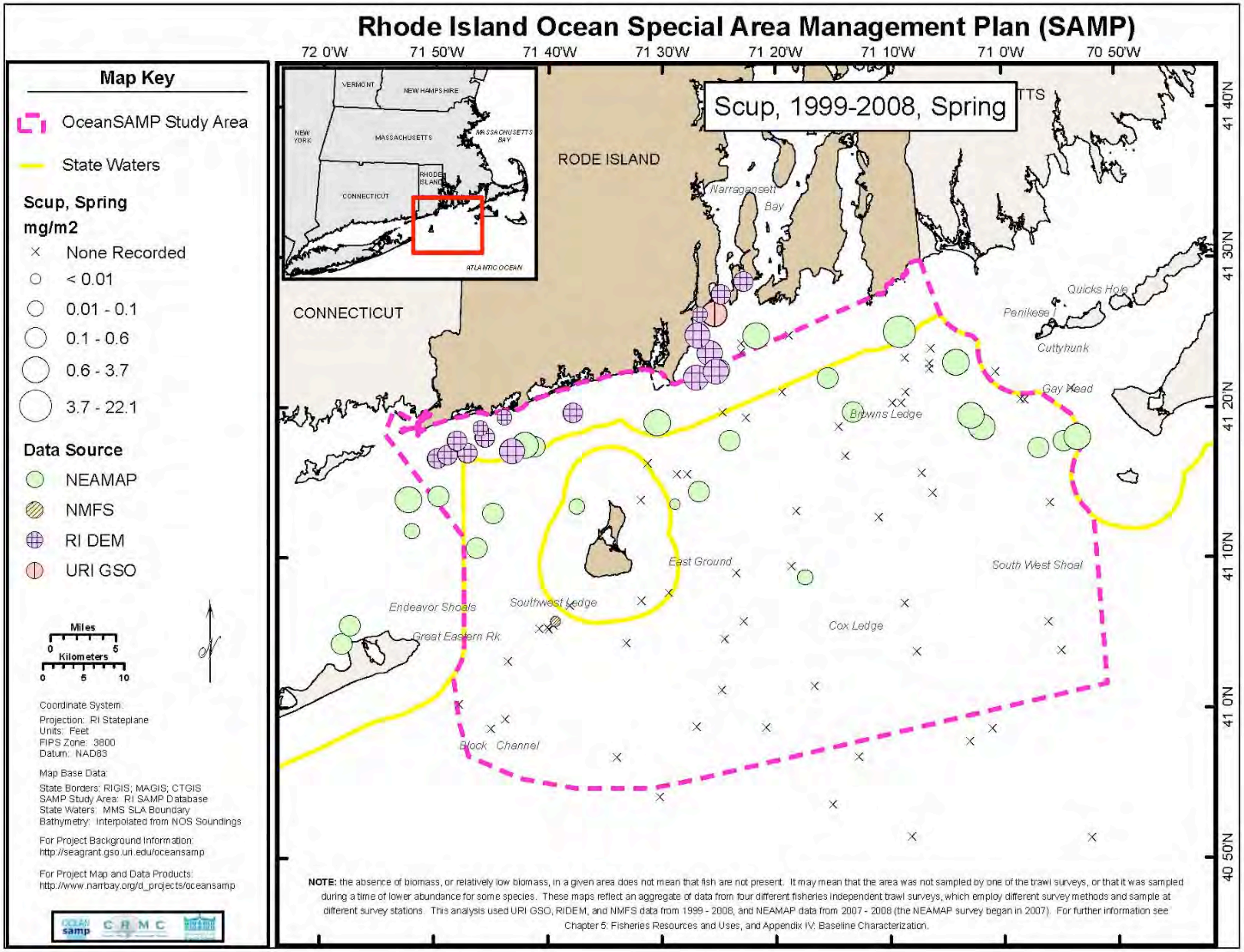

Figure 67. Scup Biomass, Spring

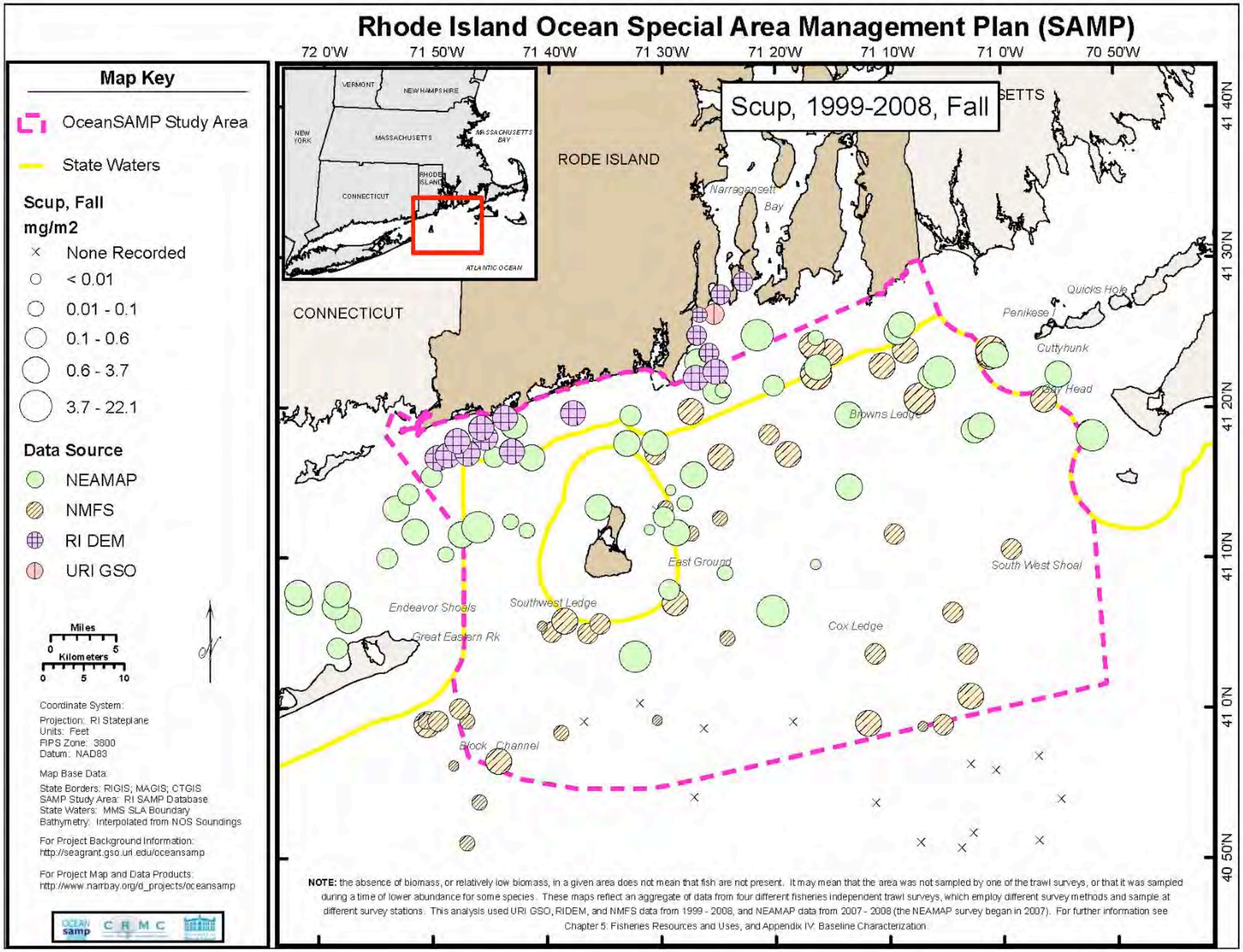

Figure 68. Scup Biomass, Fall

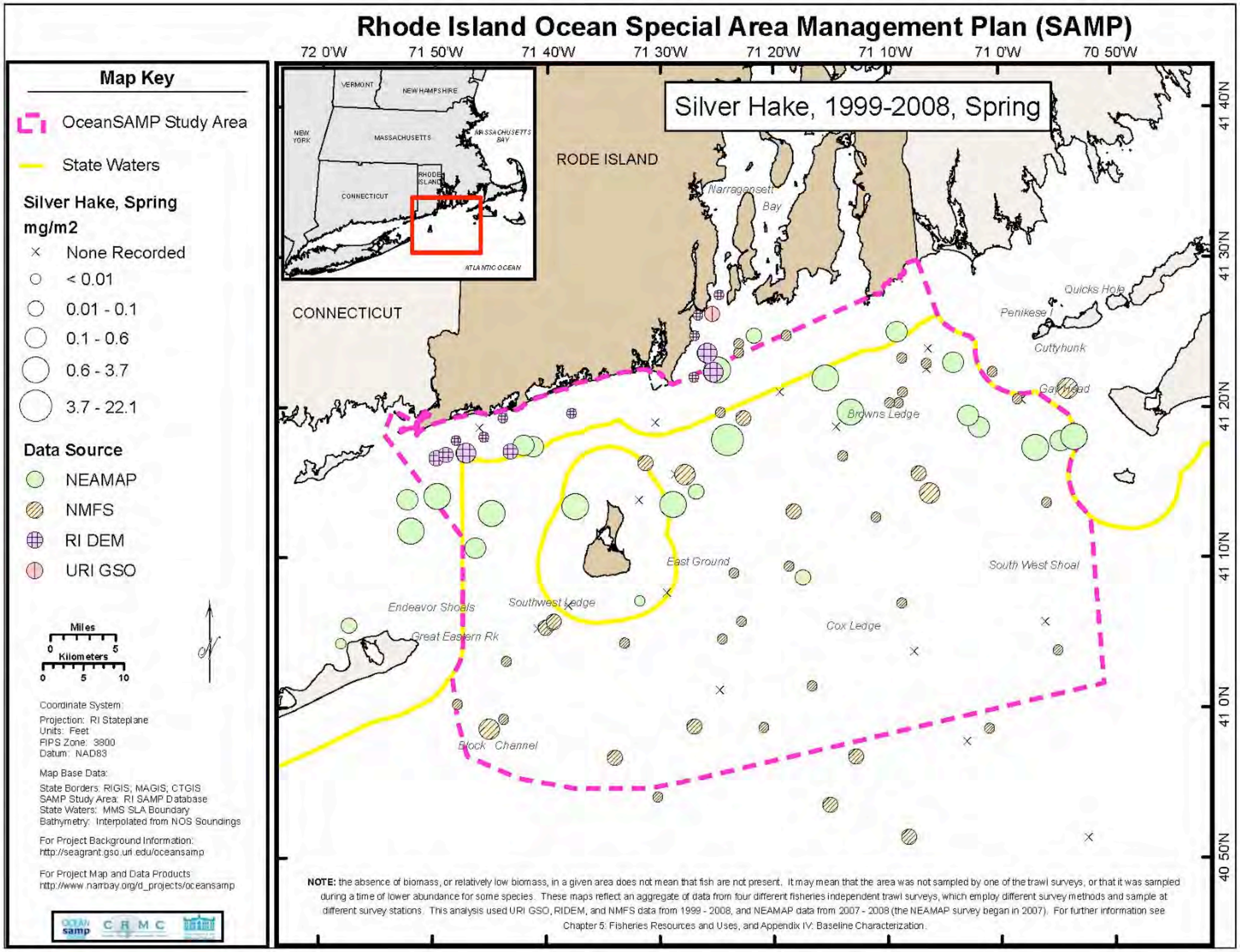

Figure 69. Silver Hake Biomass, Spring

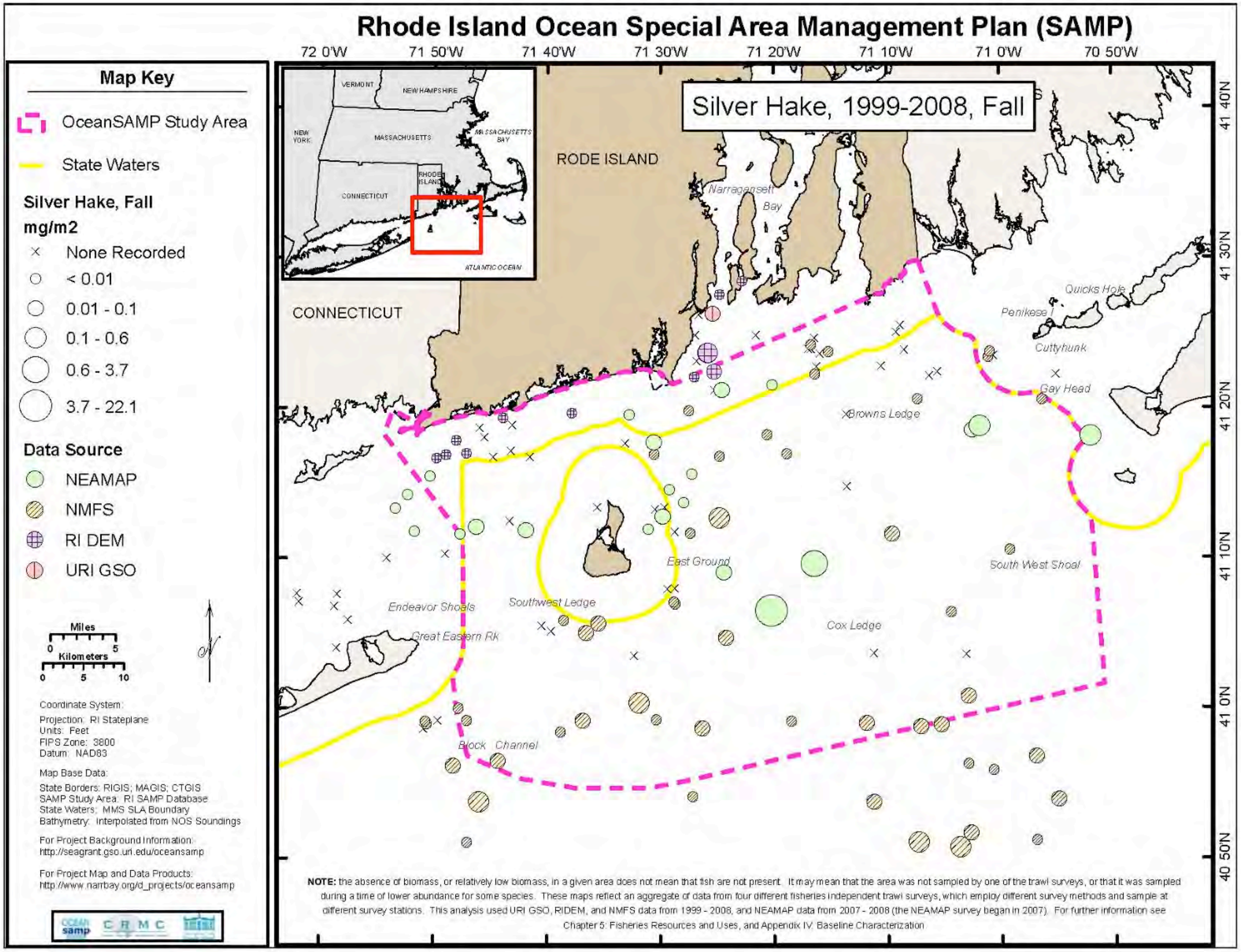

Figure 70. Silver Hake Biomass, Fall

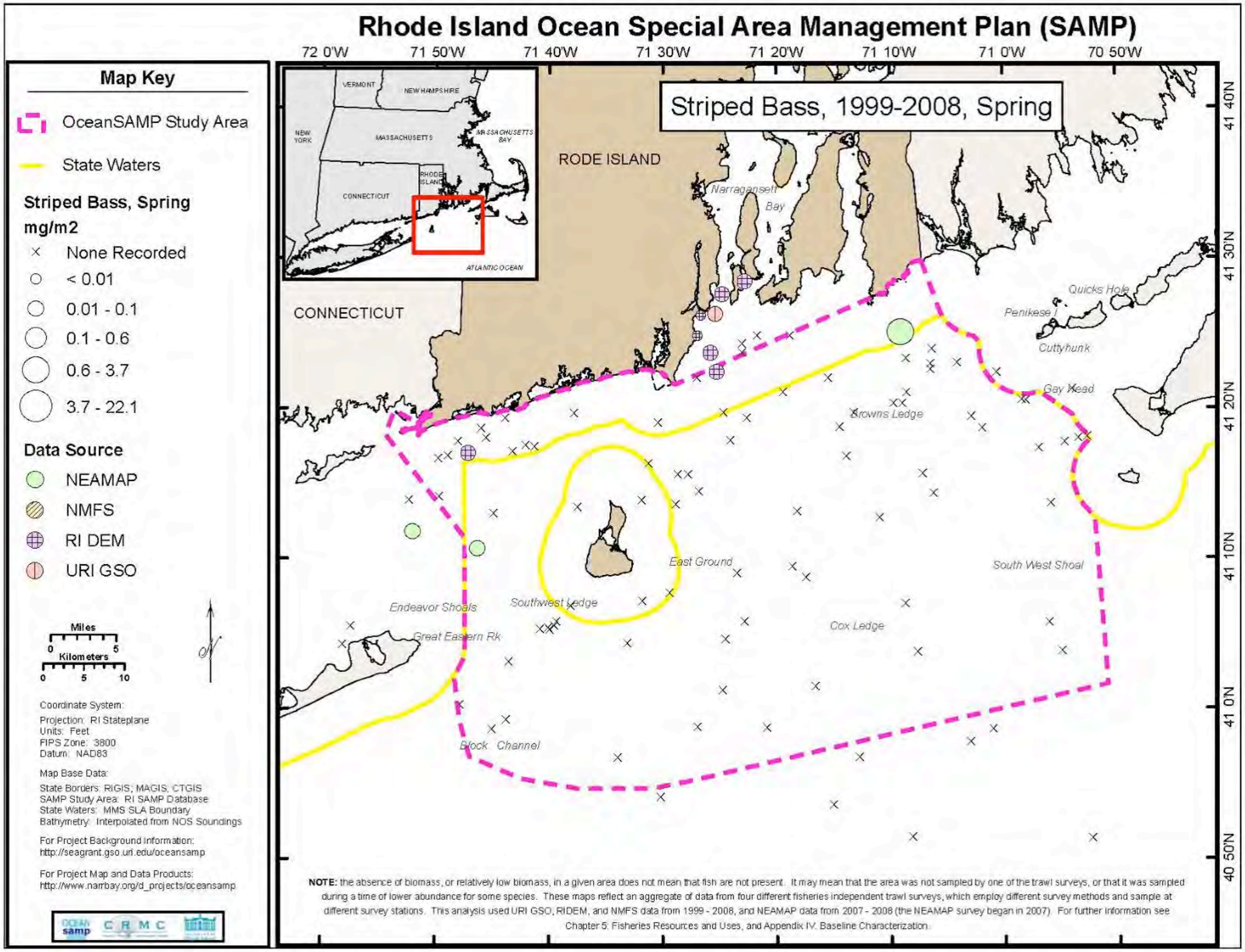

Figure 71. Striped Bass Biomass, Spring

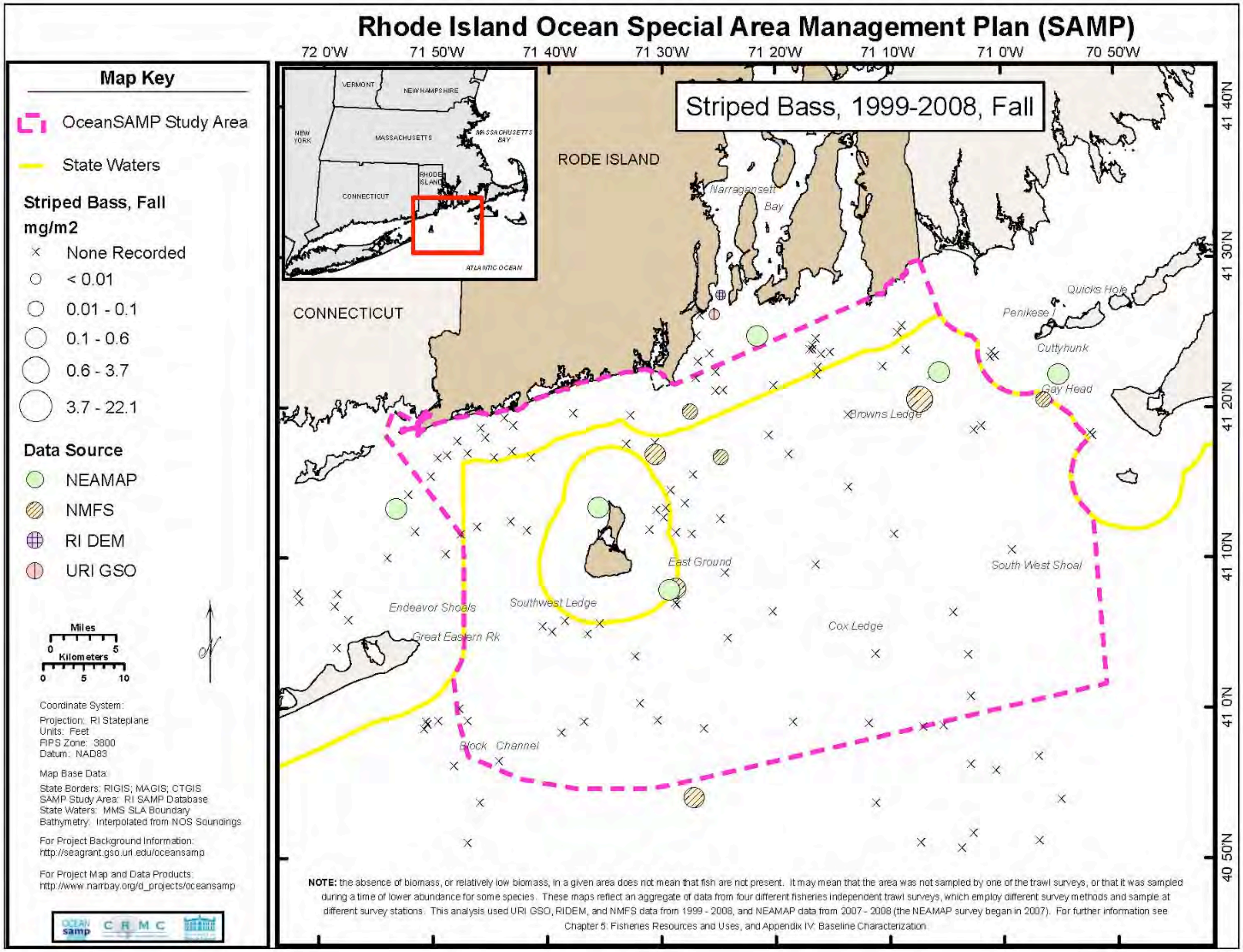

Figure 72. Striped Bass Biomass, Fall

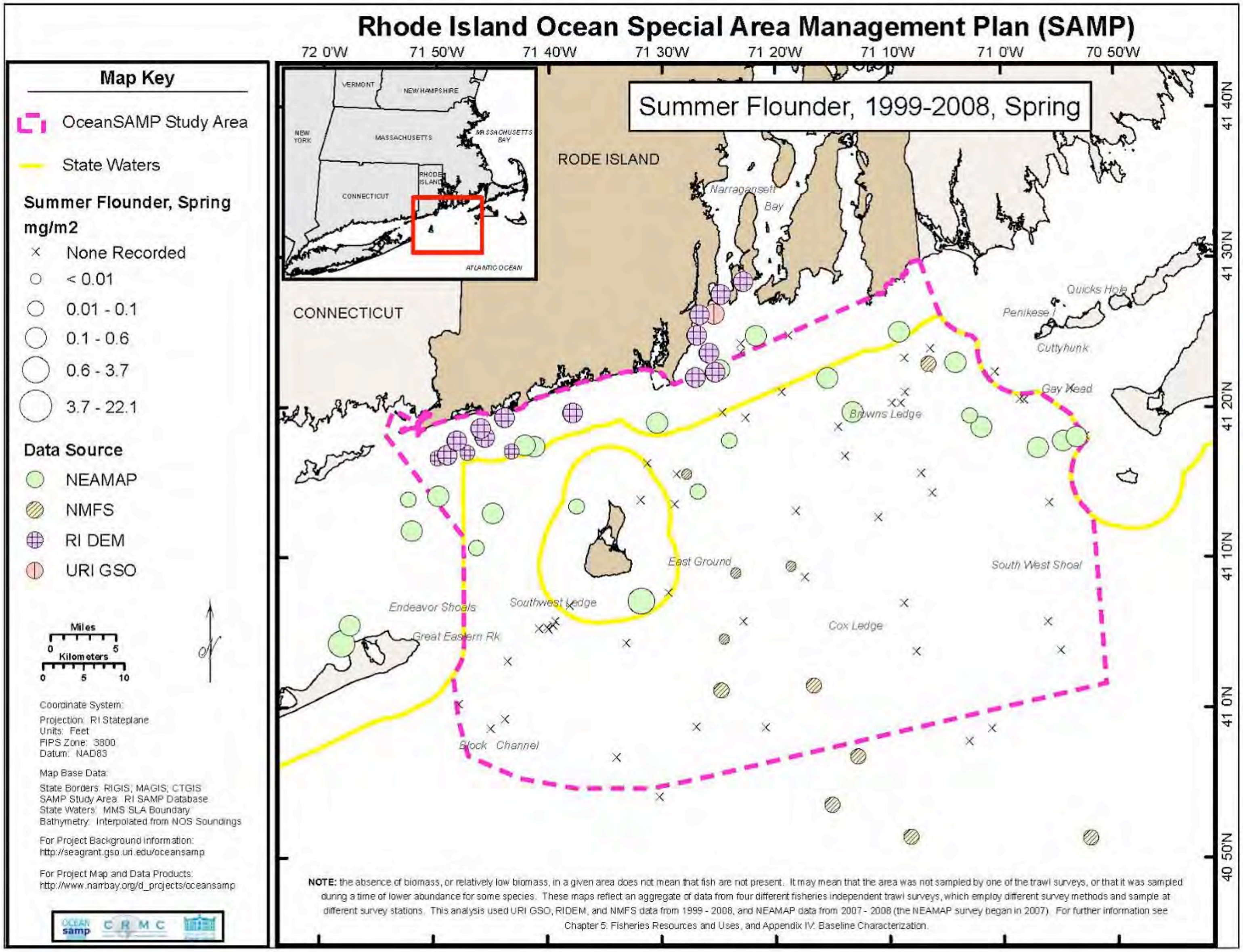

Figure 73. Summer Flounder Biomass, Spring

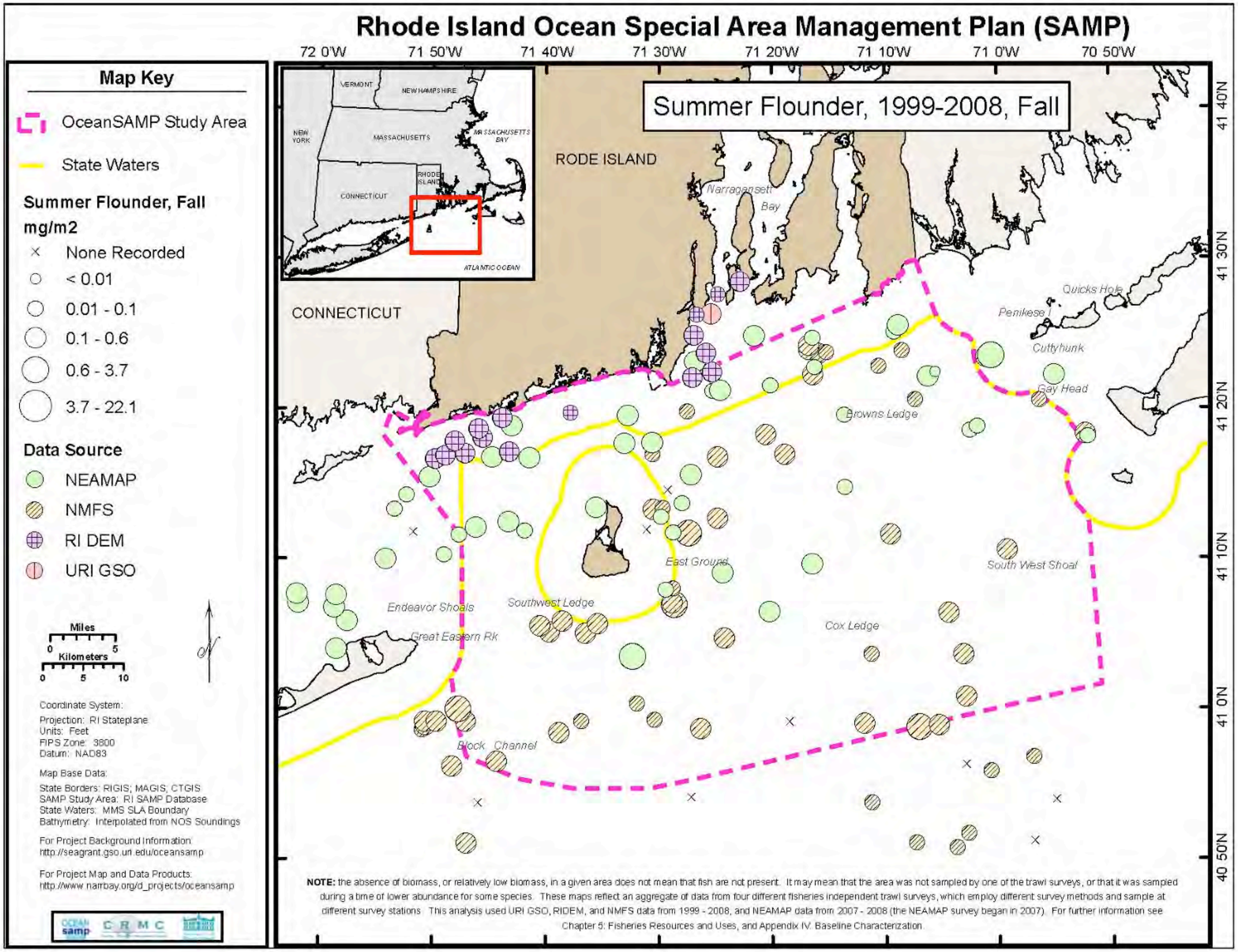

Figure 74. Summer Flounder Biomass, Fall

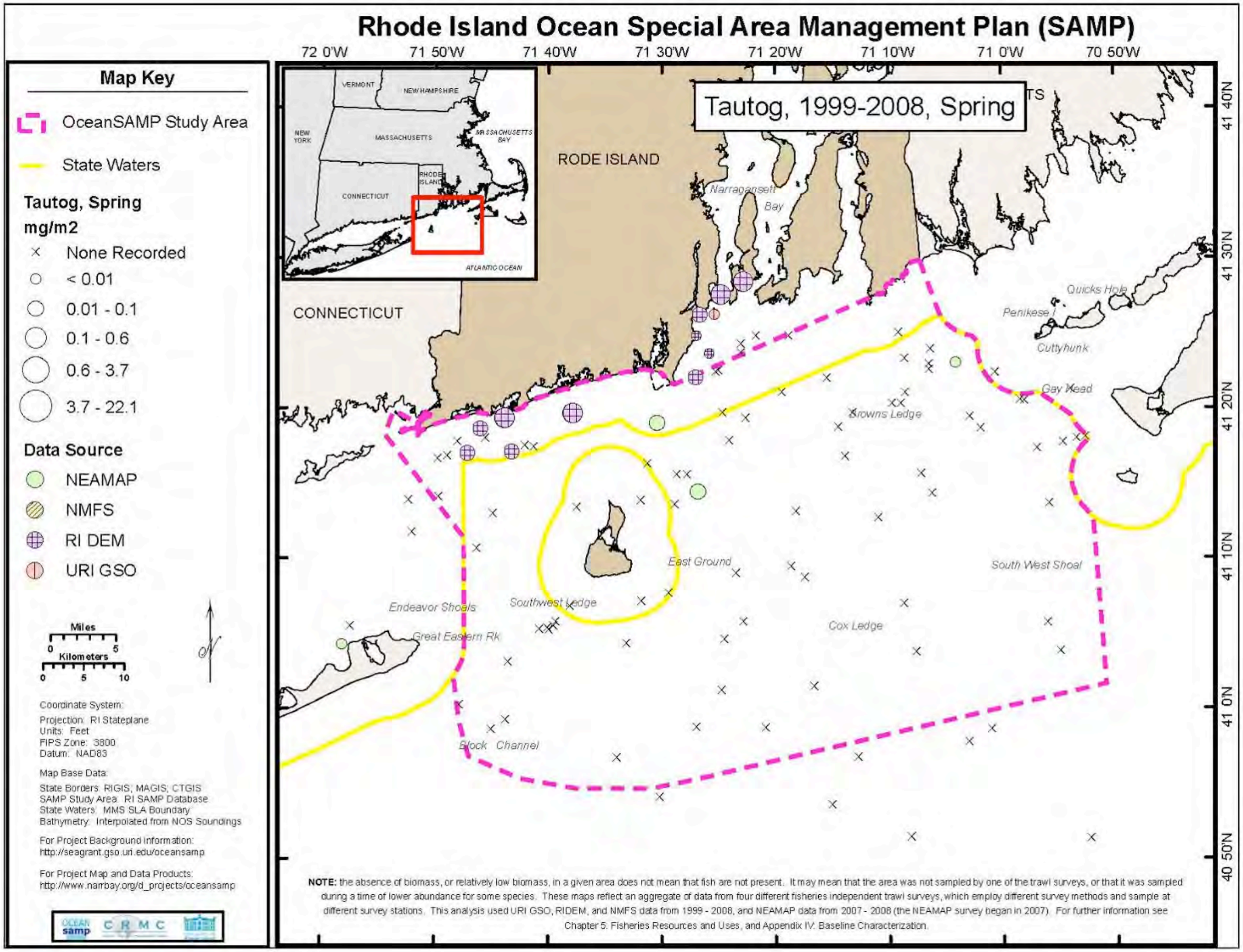

Figure 75. Tautog Biomass, Spring

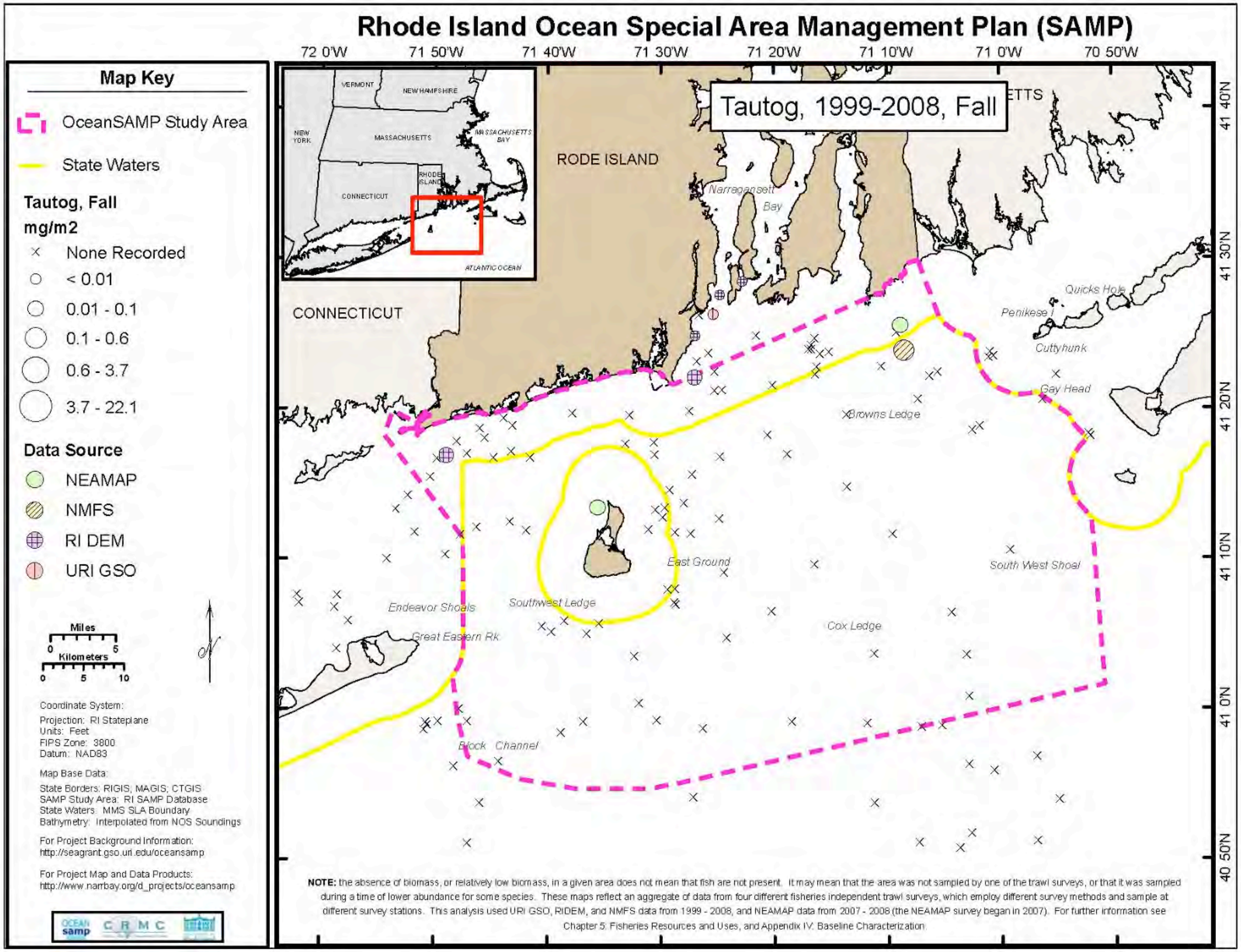

Figure 76. Tautog Biomass, Fall

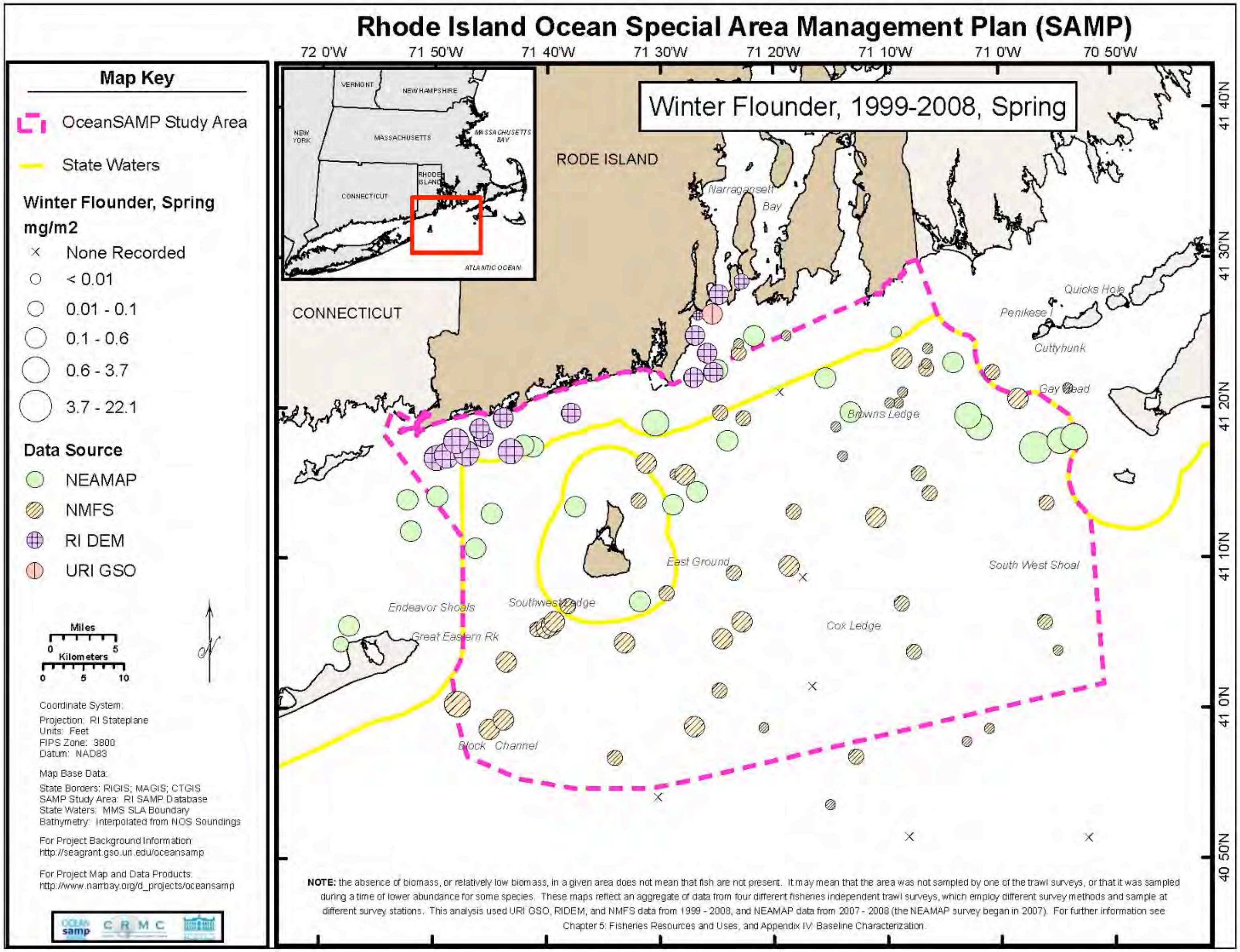

Figure 77. Winter Flounder Biomass, Spring

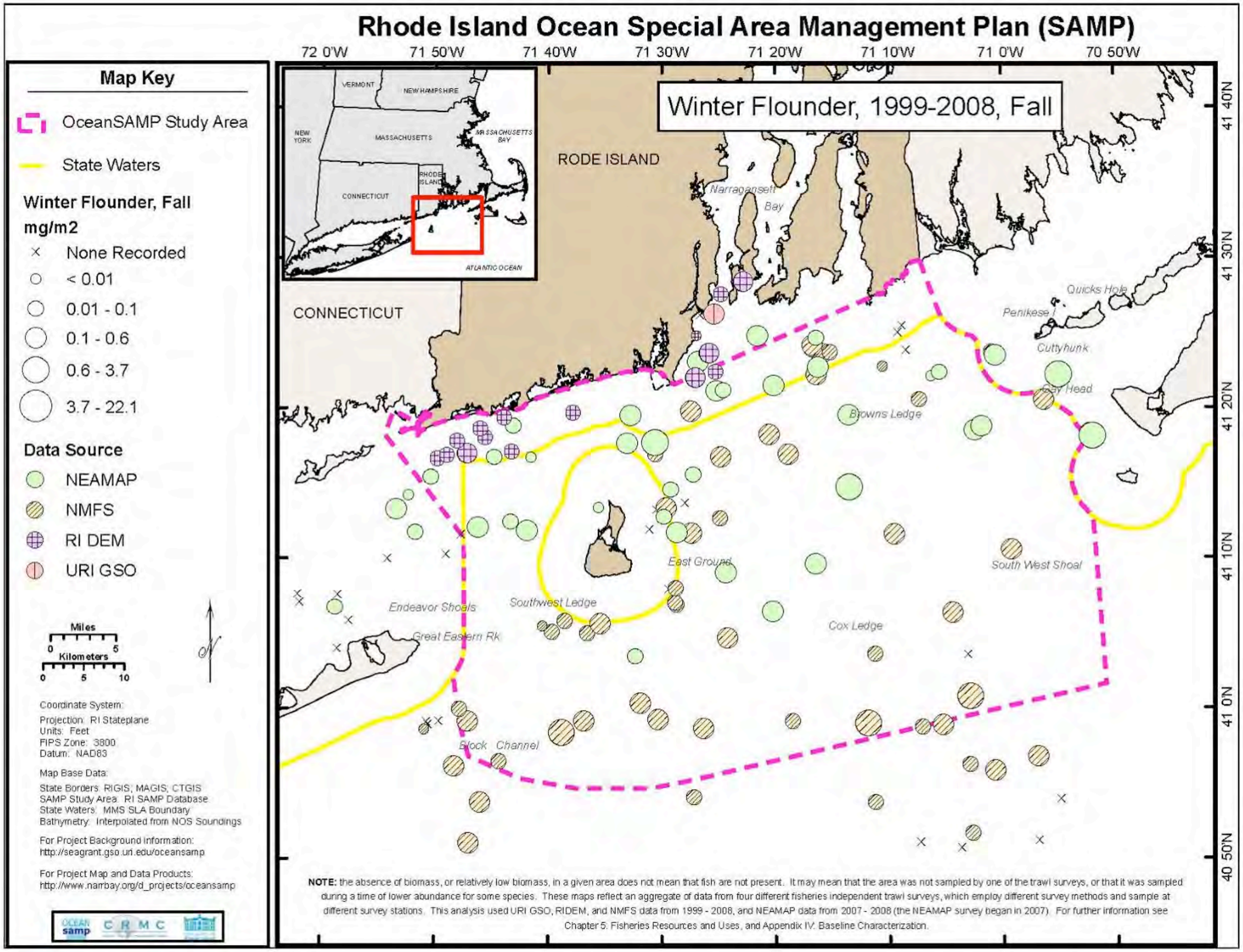

Figure 78. Winter Flounder Biomass, Fall

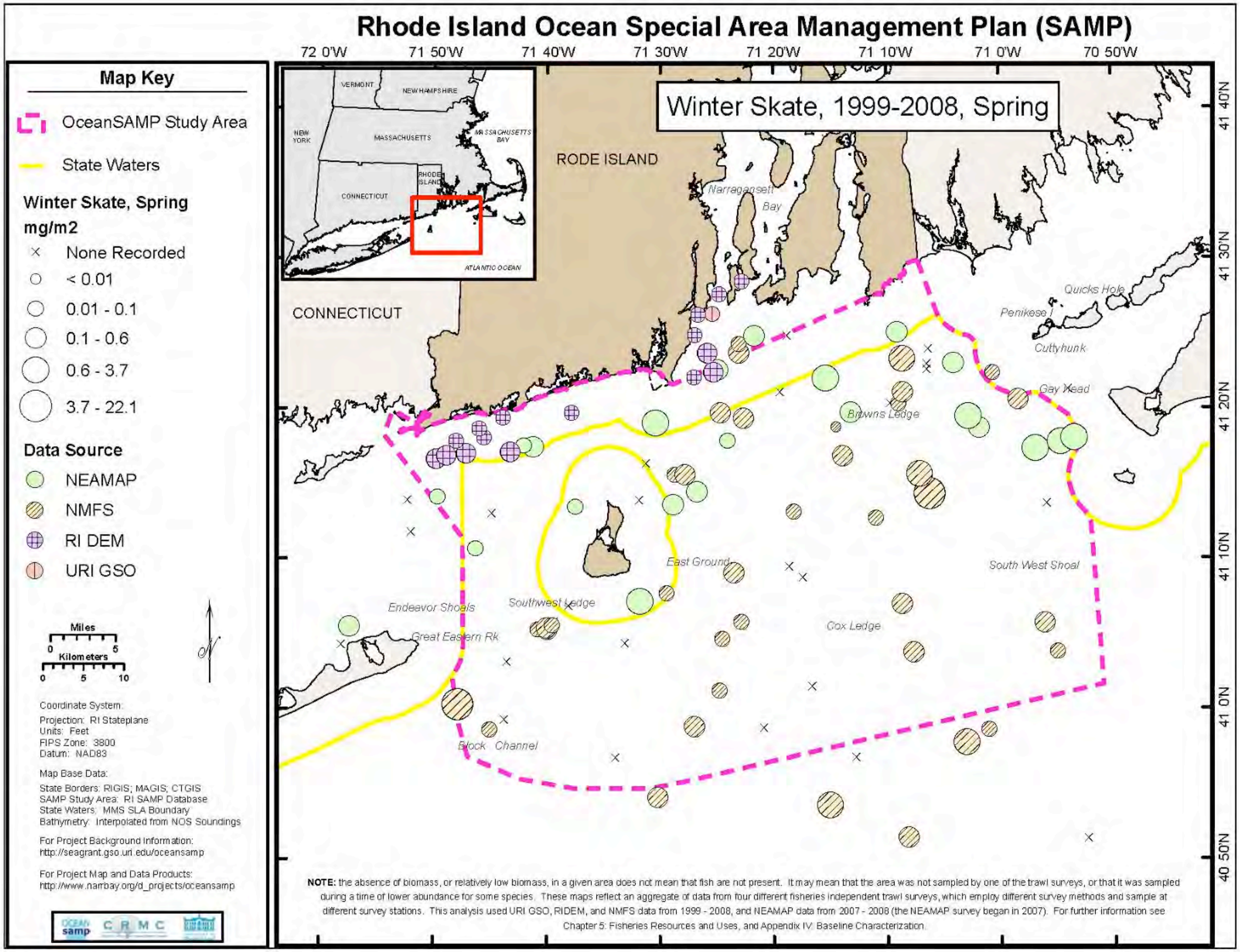

Figure 79. Winter Skate Biomass, Spring

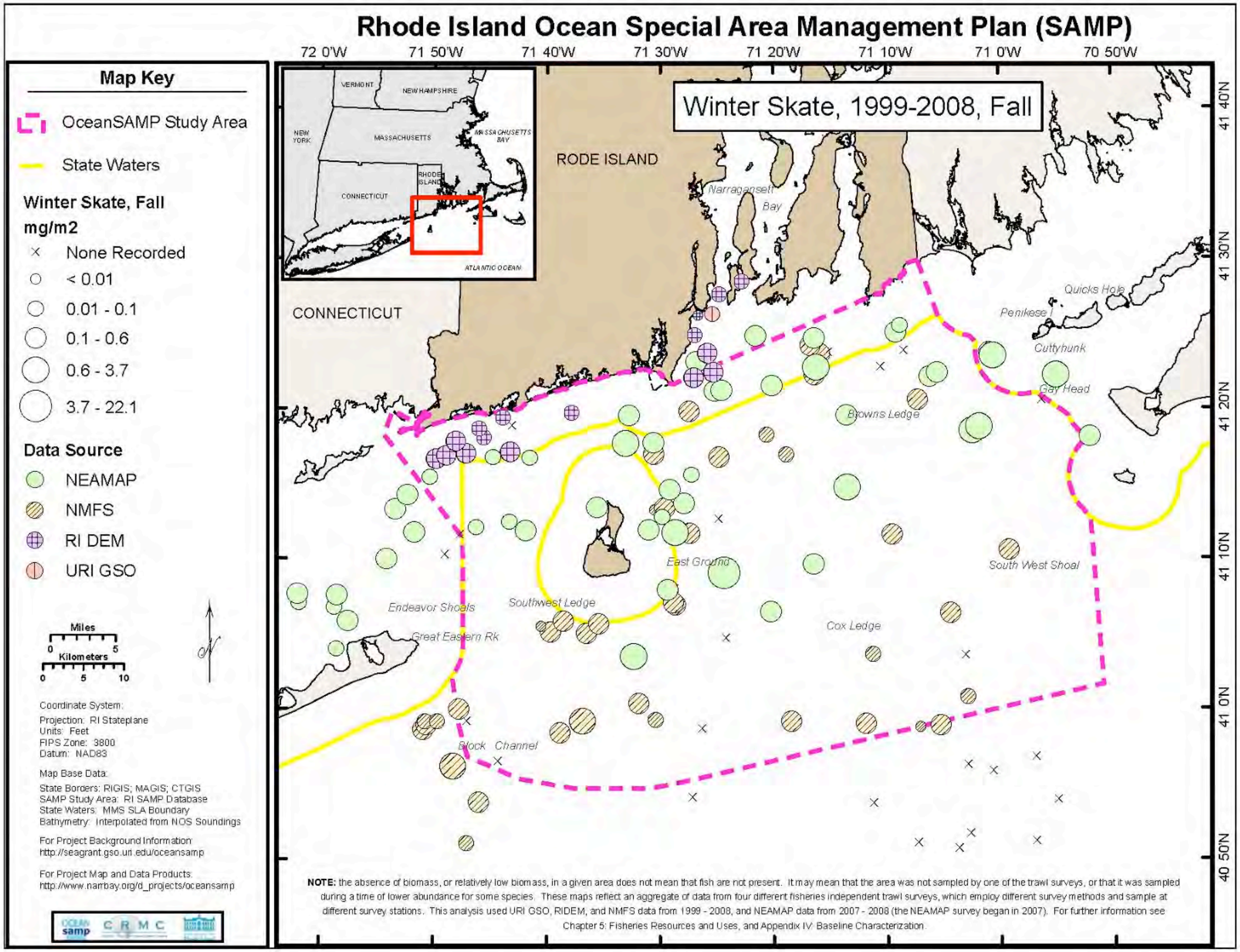

Figure 80. Winter Skate Biomass, Fall

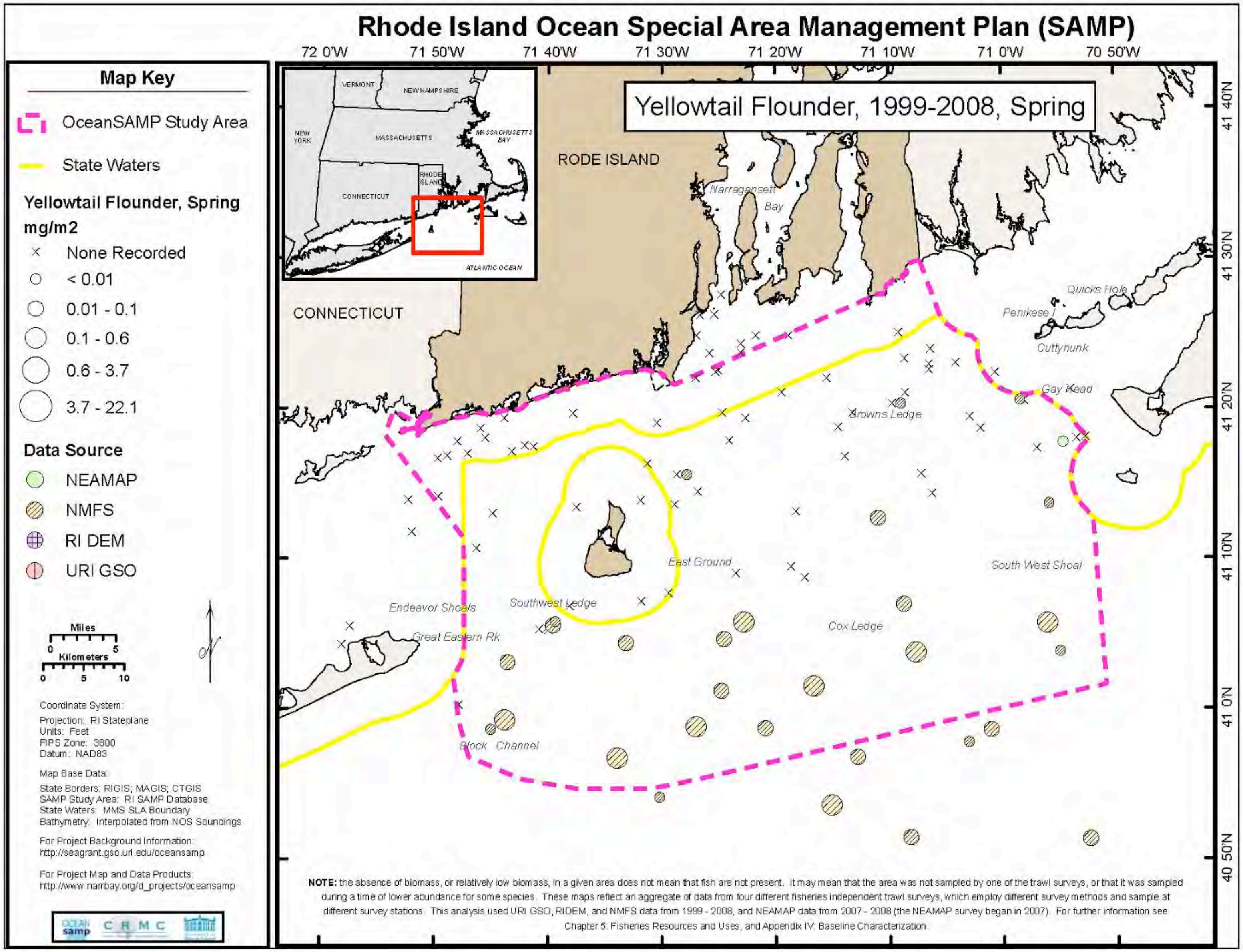

Figure 81. Yellowtail Flounder Biomass, Spring

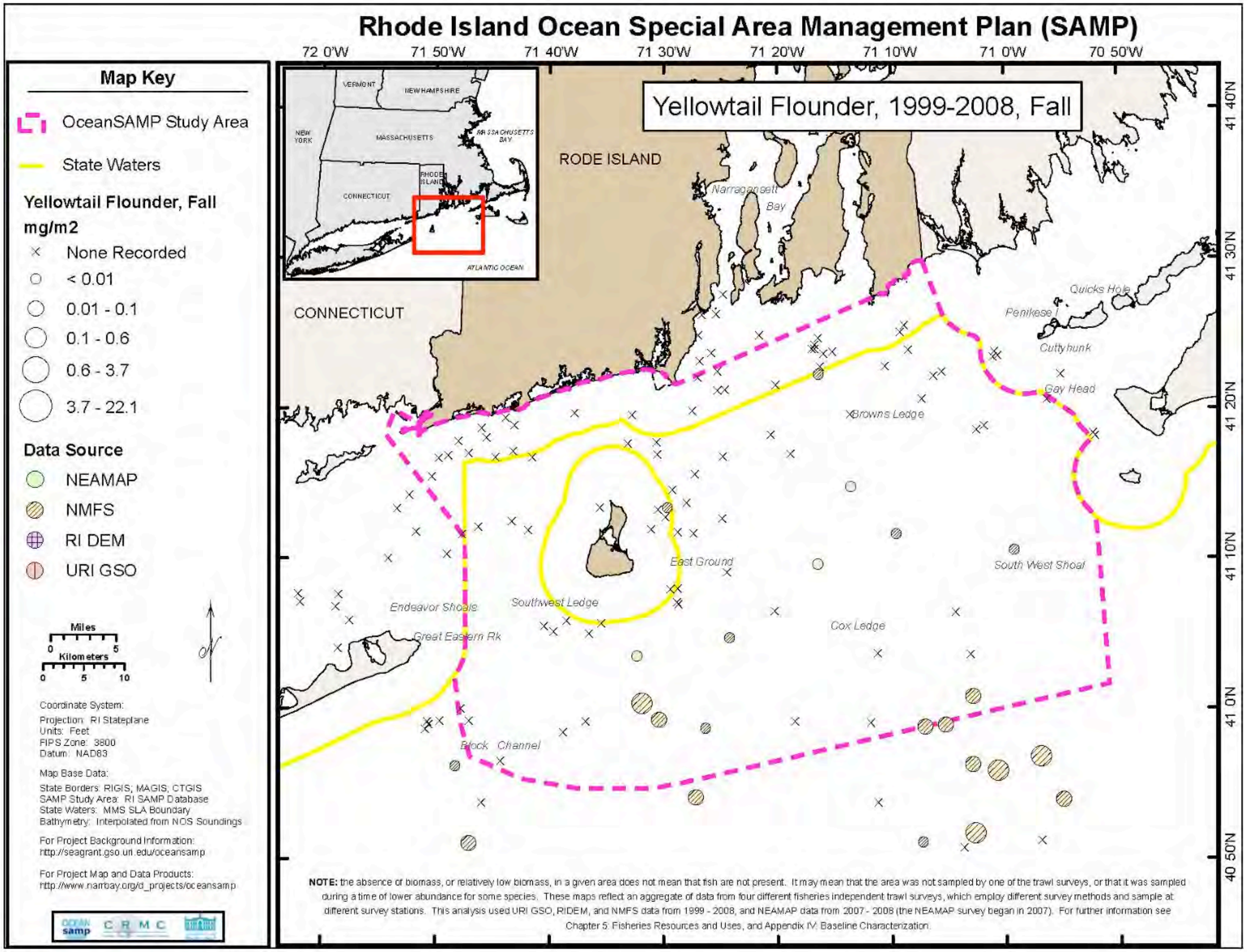

Figure 82. Yellowtail Biomass, Fall