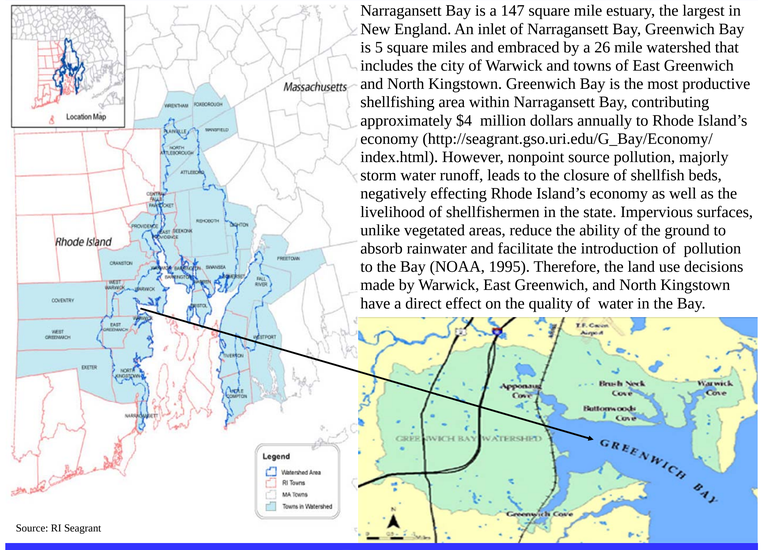

# Shellfishing Closure Areas and Impervious Surfaces: Greenwich Bay, Rhode Island

## Introduction




Source: RI Seagrant

Narragansett Bay is a 147 square mile estuary, the largest in New England. An inlet of Narragansett Bay, Greenwich Bay is 5 square miles and embraced by a 26 mile watershed that includes the city of Warwick and towns of East Greenwich and North Kingstown. Greenwich Bay is the most productive shellfishing area within Narragansett Bay, contributing approximately $4 million dollars annually to Rhode Island's economy (http://seagrant.gso.uri.edu/G_Bay/Economy/index.html). However, nonpoint source pollution, majorly storm water runoff, leads to the closure of shellfish beds, negatively effecting Rhode Island's economy as well as the livelihood of shellfishermen in the state. Impervious surfaces, unlike vegetated areas, reduce the ability of the ground to absorb rainwater and facilitate the introduction of pollution to the Bay (NOAA, 1995). Therefore, the land use decisions made by Warwick, East Greenwich, and North Kingstown have a direct effect on the quality of water in the Bay.

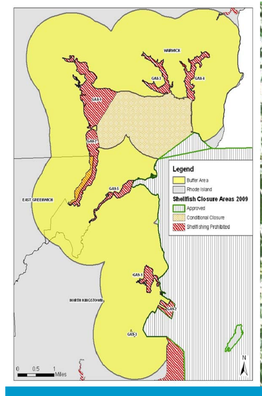
## Purpose

The purpose of this project is to determine if impervious surfaces, classified in this study as urban area, in the Greenwich Bay watershed have increased or decreased over the past 20 years (1989-2009). Between these years, organizations such as Save the Bay, the Rhode Island Coastal Resources Management Council, and the Greenwich Bay Initiative studied the contamination in Greenwich Bay and advocated to city officials to change land use and zoning policies for areas surrounding the Bay. New coastal management policies were implemented in the late 1990's. Thus, another facet of this project is to examine if the new management practices have started to make an impact on the land use in the watershed.

## Methodology

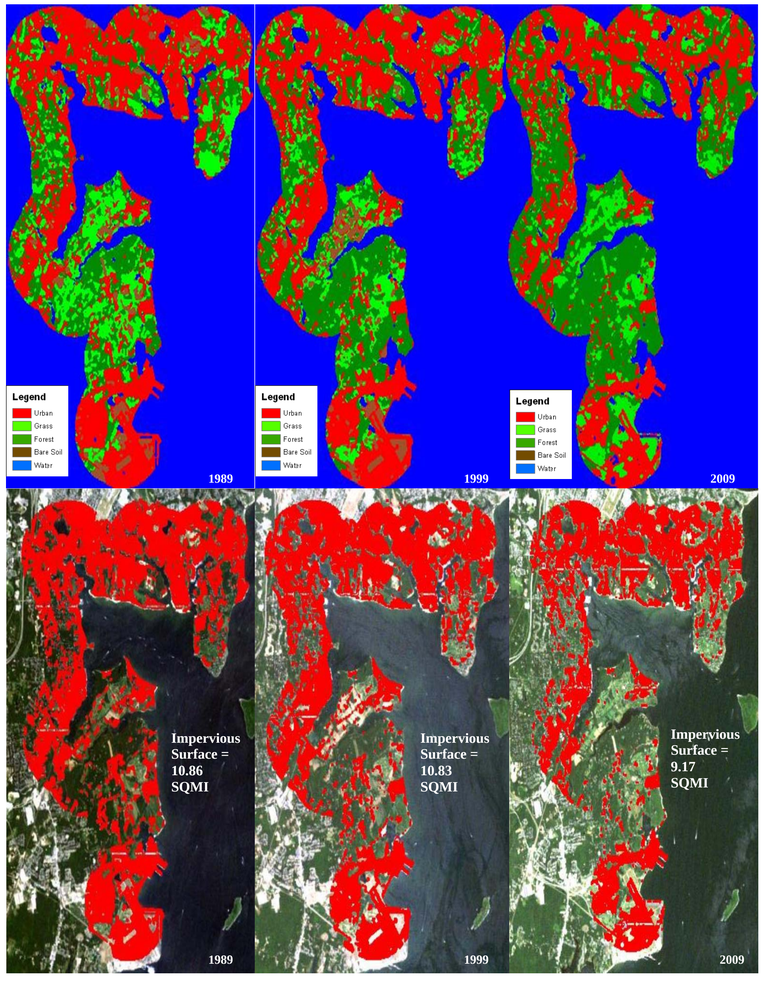
### Images and Study Area:

The images used to perform this study are Landsat TM 4-5 with 30 meter spatial resolution, from USGS Glovis using Bands 1-5 and 7. The images are from July 1989, 1999, and 2009. In order to define the study area, a 1 mile inland buffer was generated in ArcMap around shellfish prohibition areas in Greenwich Bay Growing Area (Area 8) and West Middle Bay Growing Area (Area 9). This buffer area was used to clip the 3 images. An initial buffer was created that included the Greenwich Bay sandy, beach coastline; however, this buffer needed to be manipulated in ArcMap by using the Erase tool so that the beaches were no longer part of the study area. The reason the beaches were excluded from this study is because during a test unsupervised classification run, it was determined that the beach sand was being classified as urban area due to the high reflectance of both land features. This would have skewed the results of the study and it was determined to shrink the buffer inside the beach coastline. Another technique that could have been implemented in order to reduce error would have been to run supervised classification instead of unsupervised classification, which was used in this study. The process of creating the buffer in ArcMap, overlaying it in ENVI, and the final clipped image can be seen below.




### Classification:

Prior to classification, a Principal Component Analysis using the Minimum Noise Fraction method was used in order to reduce the redundancy of the data and enhance the information content of the image. This was performed to increase the accuracy of classification. With this processed image, unsupervised classification using the K-Means method was used to distinguish land cover types. The classification began with 12 classes and 20 iterations and was later combined to 5 classes: Urban, Forest, Grass, Bare Soil, and Water. Regions of Interests (ROIs) were created in order to generate a Confusion Matrix to determine the overall accuracy of the classification and the accuracy of each class. The overall accuracy of each image was above 98%. However, the user and producer accuracy for the 1989 and 2009 images were affected by a runway on an air force base in the lower portion of the image that was classified as water because of the similar reflectance of the pavement that makes up the runway. The ROIs for the urban class were purposely placed on this feature to reduce the user and producer accuracy for the water and urban classes and to record the issue with this part of the image. This was the main issue with the classification in all three images. Again, if supervised classification had been used, this issue may have been avoided. The three classified images can be seen below.




The classification results show that the square mileage of impervious surface around Greenwich Bay is decreasing.

### Change Detection:

The change of impervious area between 1989 and 1999 was 0.03 SQMI. Though this change is not significant, it still shows a trend in the decrease of impervious surfaces surrounding Greenwich Bay.

| 1989-1999 | Bare Soil | Urban | Water | Vegetation | Row Total | Class Total |
|---|---|---|---|---|---|---|
| Bare Soil | 0.8 | 0.39 | 0 | 0.3 | 1.48 | 1.48 |
| Urban | 0.27 | 8.93 | 0.08 | 1.55 | 10.83 | 10.83 |
| Water | 0 | 0.09 | 27.94 | 0.1 | 28.12 | 28.12 |
| Vegetation | 0.46 | 1.46 | 0.05 | 9.42 | 11.38 | 11.38 |
| Class Total | 1.53 | 10.86 | 28.06 | 11.37 | | |
| Class Changes | 0.73 | 1.93 | 0.12 | 1.95 | | |
| Image Difference | -0.05 | -0.03 | 0.06 | 0.01 | | |

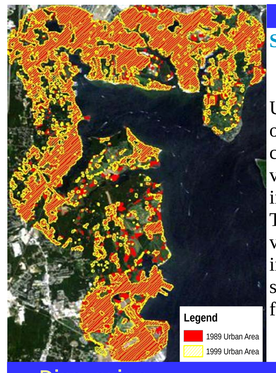
- **10.86 SQMI** was the total urban area in 1989
- **10.83 SQMI** was the total urban area in 1999
- **-0.03** means that between 1989 and 1999 the total urban area has decreased
- **8.93 SQMI** is the amount of urban area that has not changed from 1989-1999
- **1.55 SQMI** is the initial vegetation area that is changed to urban
- **1.46 SQMI** is the initial urban area that is changed to vegetation
- **1.93 SQMI** is the total area that was converted from urban to other classes

The change of impervious area between 1999 and 2009 was 1.66 SQMI. This is more significant than the change from 1989 to 1999. Also, it is important to note that 3.23 SQMI of initial urban area was converted to vegetation, while only 1.81 SQMI of initial vegetation was converted to urban.

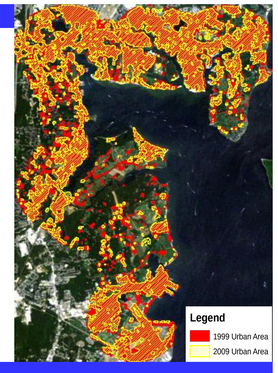
| 1999-2009 | Water | Bare Soil | Vegetation | Urban | Row Total | Class Total |
|---|---|---|---|---|---|---|
| Water | 27.6 | 0.01 | 0.13 | 0.31 | 28.06 | 28.06 |
| Bare Soil | 0.06 | 0.03 | 0.13 | 0.37 | 0.58 | 0.58 |
| Vegetation | 0.34 | 1.13 | 9.31 | 3.23 | 14 | 14 |
| Urban | 0.12 | 0.31 | 1.81 | 6.93 | 9.17 | 9.17 |
| Class Total | 28.12 | 1.48 | 11.38 | 10.83 | | |
| Class Changes | 0.52 | 1.45 | 2.08 | 3.91 | | |
| Image Difference | -0.06 | -0.9 | 2.62 | -1.66 | | |

- **10.83 SQMI** was the total urban area in 1999
- **9.17 SQMI** was the total urban area in 2009
- **-1.66** means that between 1999 and 2009 the total urban area has decreased
- **6.93 SQMI** is the amount of urban area that has not changed from 199-2009
- **1.81 SQMI** is the initial vegetation area that is changed to urban
- **3.23 SQMI** is the initial urban area that is changed to vegetation
- **3.91 SQMI** is the total area that was converted from urban to other classes

### Summary of Results:




Urban area has decreased over the 20 years. The change from urban area to vegetation cover has increased over the 20 years. The change from urban to vegetation has also increased, but not as significantly as the change from urban to vegetation.




## Discussion

Possible reasons for a decrease in urban area in the Greenwich Bay watershed include the passage of the Greenwich Bay Management plan by the RI Coastal Resources Management Council in 2003. This plan includes numerous strategies cities can use in regulating development around Greenwich Bay. Also, the RI Coastal Zone Buffer Program, which requires the creation of a 50 foot vegetated buffer between a residential or commercial building and the coastline, was passed in 1994. There has also been a trend in Warwick, East Greenwich, and North Kingstown to buy vacant land to preserve as open space. One example is a 40 acre abandoned amusement park, Rocky Point, that sits on the coast of Greenwich Bay and has partially been converted to a blueberry farm. However, it is important to note that the issue of development in the Greenwich Bay watershed is complicated and cannot be explained by any one factor. Land is a finite resource and that can also explain the drop off in development because as less land becomes available the residual is typically property that has more constraints to development. Another factor is the desire for larger waterfront homes. There are many cases where several small cottages will be consolidated, demolished and rebuilt as a single large home.

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***References***
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