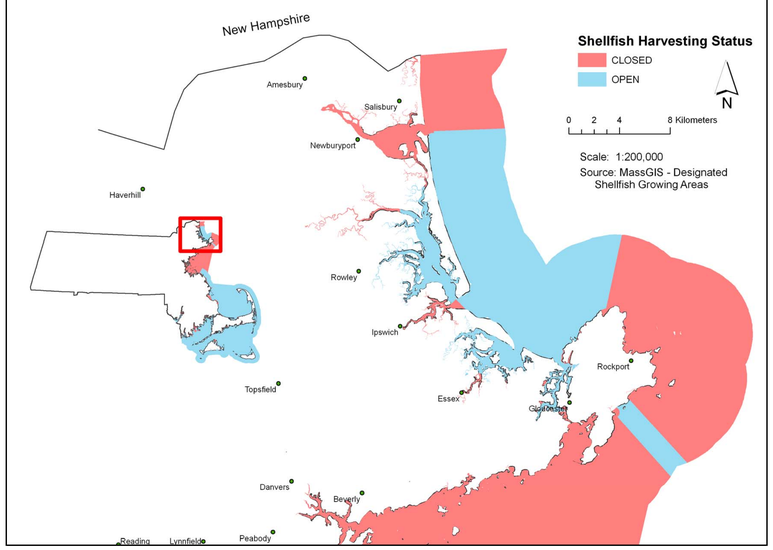
Watersheds Tributary to Closed Shellfish Harvesting Areas on Massachusetts' Clam Coast

Introduction

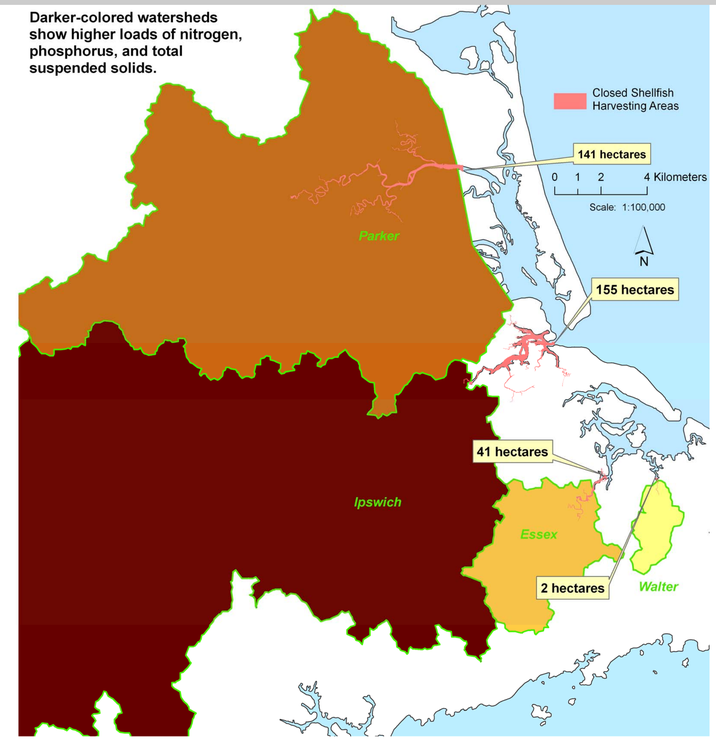
Famous across the country as "Ipswich Clams", deep-fried whole-bellied clams are summer delicacy beloved by natives and visitors to the North Shore of Massachusetts. The clams dug in the tidal flats in Newbury, Rowley, Ipswich, Essex, and Gloucester are susceptible to the buildup of toxic substances produced by algal blooms in over enriched waters. Compared to the surrounding areas in Massachusetts and New Hampshire, the Clam Coast is generally less developed, as indicated by a lower density of impervious surfaces. There are, however, areas in the estuaries of rivers that are closed to shellfish harvesting. This study seeks to explore what are the watershed characteristics most highly correlated with the size of these shellfish harvesting area closures.



Results

The table below and the figure to the right summarize the calculated characteristics of the Ipswich, Parker, Essex, and Walter Rivers. We see that the largest rivers have the largest shellfish bed closure areas. Coincidentally, the level of development in the watersheds (indicated by percentage of impervious area and total flux of pollutants) also decreases with size of watershed. It is therefore difficult to determine whether large shellfish bed closures are occurring in estuaries connected to large river systems simply because there is more potential harvesting area to be depleted, or if the amount of nitrogen, phosphorus, and total suspended solids can be tied be to shellfish bed closures. Pearson's correlation coefficients were calculated between the areas of shellfish bed closures and the other watershed statistics. Although the significance levels of this test are low due to the low sample size, it was determined that watershed size is the strongest indicator of shellfish bed closing size. The nitrogen flux (which weights Spectator Recreation and Residential multi-family uses most heavily) is the most highly correlated of the development indicators. No weighting scheme was used to produce the shading shown in the figure, as the rating system used would not make a difference for this case.

Summary of Watershed Statistics						
Watershed	Area of Closed Shellfishing Beds (hectares)	% Impervious	Total Watershed Area (km²)	Flux of Nitrogen (1,000 kg/ year)	Flux of Phosphorus (1,000 kg/ year)	Flux of Total Suspended Solids (1,000 kg/ year)
Ipswich	155	12%	37,600	190	24.9	6,400
Parker	141	8%	19,600	84	9.5	2,500
Essex	41	7%	2,600	10	1.1	260
Walter	2	6%	540	2	0.2	51
Correlation of Area of Closed Shellfishing Beds with Potential Causal Factors						
Correlation Coefficient (r)		0.81	0.92	0.90	0.86	0.87
Significance (P-value)		0.19	0.08	0.11	0.14	0.13

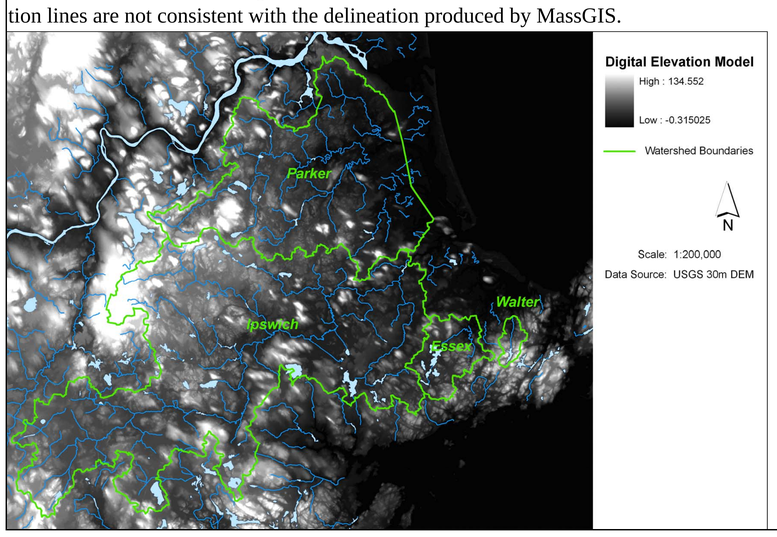


Cartography by Jack Melcher for UEP-232, Spring 2010

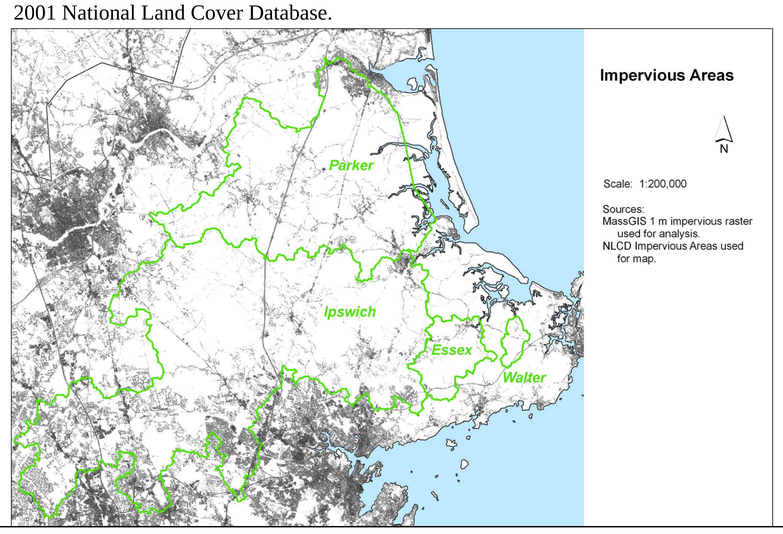
Nitrogen, Phosphorus, and Total Suspended Solids loading coefficients from "AQUALAND: The Massachusetts Aquatic Landscape Characterization Tool" by The Landscape Ecology Program at the University of Massachusetts.

Methodology

Watershed Delineation: ArcGIS tools were used to delineate the watersheds tributary to the closed shellfish harvesting areas of interest. Manmade drainage features and a "burned in" network of natural streams were not available for a highly accurate delineation, so a lower-resolution digital elevation model was used. As a result, some delineation lines are not consistent with the delineation produced by MassGIS.



Impervious Area: Zonal analysis tools were used to calculate percentage impervious area based on the 1-meter resolution raster available from MassGIS. Because of limitations on data storage for this project, these files were discarded after the analysis was complete. The image shown below is the 30-meter impervious surface raster from the 2001 National Land Cover Database.



Pollutant Load Calculations: Expected non-point source pollutant loads (in terms of kilograms of nitrogen, phosphorus, or total suspended solids per hectare, per year) for Massachusetts land uses were obtained from the manual of AQUALAND modeling program. These values can be used to get a picture of where the areas that have highly-polluting runoff are located. Non-point nitrogen loads are plotted below.