1 Background

Under the Clean Water Act, state environmental agencies are charged with monitoring and assessment of streams and rivers in all areas of southern New England. Currently, the Massachusetts Department of Environmental Protection (MassDEP) and the Rhode Island Department of Environmental Management (RIDEM) collect water chemistry data and sample biological communities to characterize the condition of streams. Where available, these data are compared against water quality standards and biological criteria that have been developed to quantify water quality conditions. Monitoring biological communities, especially macroinvertebrates, in low gradient streams along the coast of southeast New England provides important information about the water quality and the health of aquatic ecosystems.

The MassDEP and RI DEM biomonitoring programs have collected macroinvertebrates from riffle habitats in moderate to high gradient, rocky-bottom streams for many years. Both states have developed riffle habitat multimetric indices to assess the effects of anthropogenic stress on macroinvertebrate assemblages (Jessup et al. 2012, Jessup and Stamp 2020). Multimetric indices (also referred to as Indices of Biotic Integrity (IBIs)) are numeric representations of biological condition based on the combined signals of several different assemblage measurements (Karr 1981). The raw measurements are recalculated or standardized as biological metrics, or numerical expressions of attributes of the biological assemblage (based on sample data) that respond to human disturbance in a predictable fashion. The index scores provide a measure of how far conditions at a site have deviated from the expected state of the macroinvertebrate community.

In southern Massachusetts (MA) and Rhode Island (RI), low gradient, slow-moving streams that either lack or have infrequent riffle habitat are fairly prevalent. Because there are natural differences in the structure and function of macroinvertebrate assemblages in low gradient versus faster-moving, rocky-bottom streams, the collection methods and bioassessment indices that were developed for riffle habitats cannot be effectively applied in these streams. To address this, MassDEP developed a multihabitat collection method for macroinvertebrates in low gradient, slow-moving streams in 2013. The multihabitat method allowed for effective sampling of snags, root wads, leaf packs, aquatic macrophytes, undercut banks, overhanging vegetation, fine sediments, and hard substrates. In 2019, with funding from the U.S. Environmental Protection Agency (U.S. EPA) Southern New England program (SNEP), the multihabitat collection method was used to sample over 50 sites in low gradient, non-tidal, wadeable streams in MA and RI. The sites were located in the SNEP region, which consists of watersheds draining into Narragansett Bay and Buzzards Bay and south from Cape Cod , including the Islands. The intent of collecting these data was to obtain a dataset that could be used to calibrate a low gradient IBI for macroinvertebrate assemblages in the SNEP region.

In this report, we describe the development of a low gradient IBI for macroinvertebrate assemblages in non-tidal, wadeable streams in the SNEP region. Data collection and index development was done concurrently with the development of a statewide low gradient IBI for MassDEP. Data collected by MassDEP using multihabitat methods in the SNEP region were included in the SNEP analysis. Data from an additional 69 low gradient sites located in Massachusetts and outside the SNEP region were used in certain steps of the SNEP analysis, and are described at those steps.

Steps in the IBI development process included data compilation and preparation, definition of site disturbance categories and criteria, classification analyses, metric selection and scoring, index compilations, performance evaluation, selection of the final IBI, and IBI validation. The report concludes with an evaluation of potential IBI thresholds for four levels of biological condition and a

discussion on potential applications. The creation of an IBI for coastal low gradient streams in the SNEP region will improve resource managers' ability to identify degradation in biological integrity and water quality and help inform prioritization of streams for protection and restoration.

2 Data Compilation and Preparation

IBI development began with the assembly and analysis of macroinvertebrate and environmental data, including habitat, water quality data, and GIS-derived landscape-level data such as land cover. The data were compiled into a Microsoft (MS) Access relational database.

2.1 Macroinvertebrates

2.1.1 Dataset

The low gradient IBI dataset spanned seven years (2013-2019) and included a total of 114 samples from 109 unique sites in the SNEP study area in RI and MA. Twenty-two sites were located in RI and 87 in MA (Figure 1, Table 1). MassDEP collected 60 of the samples over the seven year period and Tetra Tech (under contract to SNEP) collected 54 samples in 2019. The distribution of sites across Level 4 ecoregions is summarized in Table 1. Most sites were located in the Narragansett/Bristol Lowland and Southern New England Coastal Plains and Hills (SNECPAH) Level 4 ecoregions. Seven were located in the Cape Cod Level 4 ecoregion. For some analyses, we utilized low gradient data from an additional 69 low gradient sites in MA that were located outside the SNEP region (Figure 1).

Table 1. Distribution of the 109 sites across states and Level 3 and 4 ecoregions (U.S. EPA 2011).

L3 ecoregion	Level 4 ecoregion name	Level 4 code	Number of sites	
			MA	RI
Atlantic Coastal Pine Barrens	Cape Cod/Long Island	84a	7	0
Northeastern Coastal Zone	Gulf of Maine Coastal Plain	59h	2	0
	Long Island Sound Coastal Lowland	59g	0	3
	Narragansett/Bristol Lowland	59e	66	5
	Southern New England Coastal Plains and Hills	59c	12	14
		Total	***87***	**22**