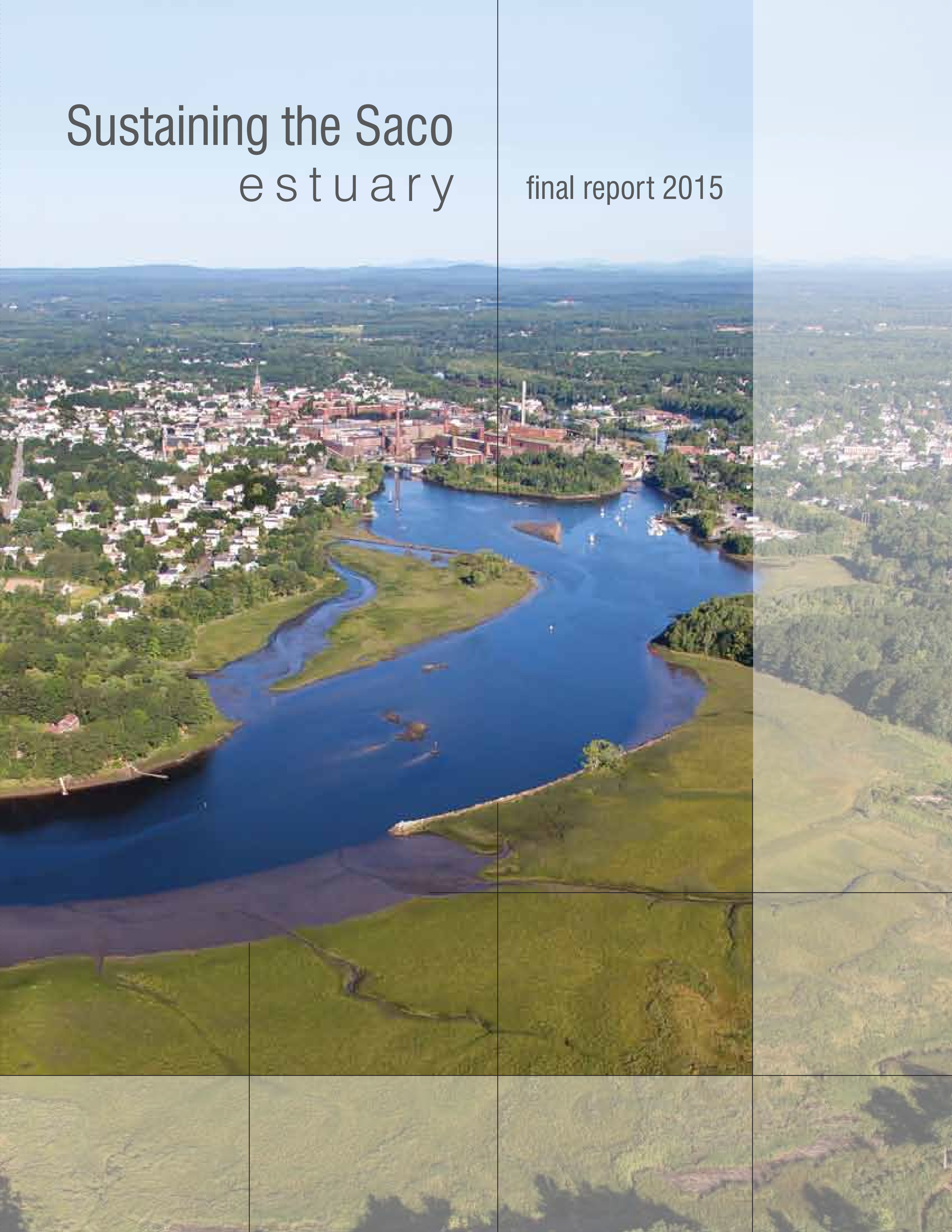
# Sustaining the Saco
# estuary

final report 2015



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Report Editing and Design: Waterview Consulting

# CONTENTS

Saco River Corridor Commission · Biddeford-Saco Chamber of Commerce and Industry

Town of Biddeford: Planning Board, Open Space Committee, Conservation Commission, Shellfish Conservation Committee


## About the Stewardship Network

Many people care for the Saco Estuary. Together they form a Stewardship Network protecting water, wildlife and habitats. Residents, visitors and businesses benefit from the efforts of the Stewardship Network. The surprisingly diverse collection of plants, birds and fish discovered by UNE and Wells Reserve researchers is a consequence of the cumulative actions taken by these people to sustain the Saco Estuary and the values most important to the people who live work and play in the region.

### 360 Acres of Tidal Marsh

Three types of tidal marshes --salt, brackish, and freshwater-- occur here. These marshes improve water quality and provide habitat for many kinds of wildlife.

### 10 Rare Plants

A surprising diversity of plants live in these marshes, including ten species that are rare in Maine and/or nationally.

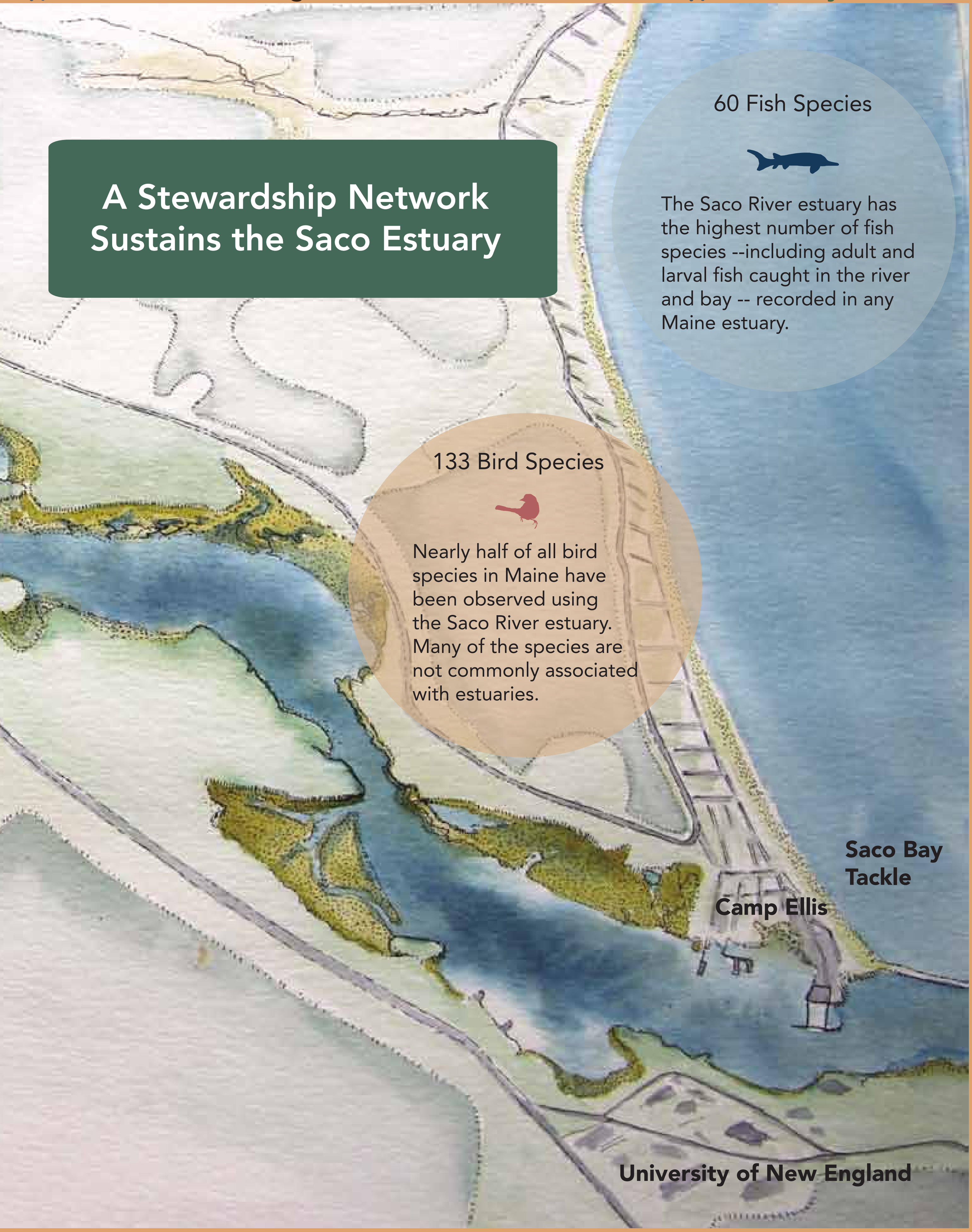
MollyMaps 2014

This research is part of Maine's Sustainability Solutions Initiative, a program of the Senator George J. Mitchell Center, which is supported by National Science Foundation award EPS-0904155 to Maine EPSCoR at the University of Maine.

State of Maine: DEP, DMR, DIFW · Wells National Estuarine Research Reserve

Town of Saco: Planning Board, Conservation Commission · Saco Valley Land Trust · Saco River Salmon Club · Biddeford Saco Water · Coastal Waters Commission · Biddeford Pool Land Trust

# A Stewardship Network Sustains the Saco Estuary




## 60 Fish Species

The Saco River estuary has the highest number of fish species --including adult and larval fish caught in the river and bay -- recorded in any Maine estuary.

## 133 Bird Species

Nearly half of all bird species in Maine have been observed using the Saco River estuary. Many of the species are not commonly associated with estuaries.

Rachel Carson National Wildlife Refuge · Friends of Wood Island Lighthouse

CHAPTER 4

# BENTHIC MACROINVERTEBRATES OF THE SACO ESTUARY

## TIDAL FLATS AND LOW MARSH HABITATS

BY ANNA L. BASS

## INTRODUCTION

### Why study invertebrates?

Invertebrates are an important food source for many birds and fish that live in estuaries. Common estuarine invertebrates include amphipods (*Gammarus*), bivalves (*Pisidium*), gastropods (Hydrobiidae), and polychaetes (*Hediste diversicolor*). Information on benthic invertebrate community composition in an estuary's marshes and mudflats can be used to indicate the healthy functioning of an estuary and its marshes.

Invertebrates, with their varying levels of tolerance to disturbance and pollution, have long been used as biological indicators of marsh health (Pearson & Rosenberg, 1978; Diaz, 1989; Warren et al. 2002; Hering et al. 2006). Land use and associated activities can significantly shape benthic invertebrate communities (Lerberg et al. 2000; Canedo-Arguelles et al. 2014). While human activities can significantly affect the abundance and types of invertebrates present, environmental factors also play a key role in structuring invertebrate communities. However, distinguishing between human and environmental impacts can be a challenge. Environmental factors that regulate the distribution and abundance of invertebrates in estuaries include (but are not limited to) sediment characteristics, salinity gradients, biomass of emergent vegetation, and predator presence (Chester et al. 1983; Ysebaert et al. 1998; Kang and King 2012; Yozzo and Osgood, 2013).

As one moves from the mouth of the Saco River to the Cataract Dam, the tidal marshes exhibit a salinity transition from polyhaline (18-30 ppt) to mesohaline (5–18 ppt) to oligohaline (0.5-5 ppt) and tidal freshwater conditions. In general, benthic invertebrate community composition shifts with polyhaline conditions, supporting communities dominated by polychaetes and crustaceans, and mesohaline conditions resulting in oligochaete and insect larvae-dominated communities (Yozzo and Osgood 2013).

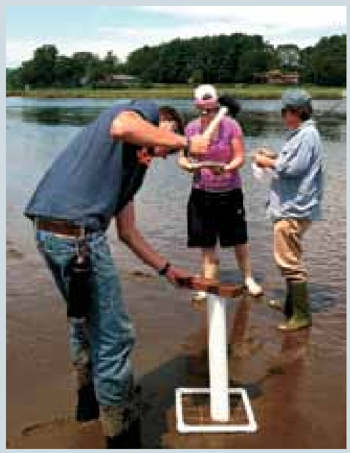
Hydrobiidae

*Hediste diversicolor*

Oligochaete

Ceratopogonidae

*Note: Organisms are stained with Rose Bengal to aid in recovery from the original core sample. Photos by Anna Bass.*



Sampling invertebrates in the Saco Estuary's tidal marshes and mudflats.

*Photos by Carrie Byron.*

## What is known about the invertebrates of the Saco Estuary?

This is the first study of its kind to document the invertebrate species in the estuary's tidal marshes and mudflats. Little to no information has been available on the types and numbers of infaunal (i.e., within the sediment) invertebrates that inhabit the tidal marshes of the Saco Estuary. Most studies that have included invertebrates have concentrated on areas near the mouth of the river that are dredging sites for the U.S. Army Corps of Engineers (USACoE 2013) or on highly mobile macrofauna (Reynolds and Casterlin 1985). The areas surveyed near the mouth of the river are affected by the inflow of salty water from Saco Bay and, consequently, are dominated by marine invertebrates (USACoE 2013).

## STUDY OBJECTIVES—MACROINVERTEBRATES

The objectives of this macroinvertebrate study were to answer the following questions:

1. What types of invertebrates inhabit the tidal flats and low marsh habitats of the Saco Estuary?
2. How diverse are the invertebrate communities in the tidal flats and low marsh habitats?
3. Do invertebrate communities change as one moves down the Saco Estuary to the bay?

## RESEARCH DESIGN AND METHODS

To answer these questions, multiple core samples were taken from areas located relatively close to the low tide line ($\leq$100 m). These core samples facilitated the collection of the top 4 cm of sediment in areas with plants such as *Spartina alterniflora* and the adjacent tidal flats. All sites were sampled within $\pm$1.5 hr of low tide. Six marshes were sampled once per month from May to August during 2013. The six marshes span the area from the Cataract Dam (N2 and S1) to the mouth of the river (N10 and S11), with two sites (N4 and S6) located in the middle reaches of the river (see Figure 1 for site locations). These sites were selected to capture the range of salinities observed along the river and to sample a broad range of invertebrate communities.

In addition to the core samples, we collected salinity data for the core samples, allowing us to document the salinity of the water present in the flats and in the vegetation.

## RESULTS AND DISCUSSION

Salinity in the upper estuary sites (N2, S1, N4, and S6) ranged from 3.4–10.6 ppt for the tidal flat habitats and 3.4–10.6 ppt for the low marsh habitats. Salinity in the lower estuary sites (N10, S11) ranged from 16.3-26.2 ppt for the tidal flat habitats and 10.3–20.9 ppt for the low marsh habitats. N4 and S6 exhibited the higher end of the salinity ranges for both habitats during the May sampling periods; otherwise, the salinity values were more closely related to those found in all months for the N2 and S1 sites.


FIGURE 1 Tidal marsh study sites along the Saco Estuary.

TABLE 1 List of invertebrate species identified from May to August 2013 sampling events of both tidal flats and low marsh habitats of the Saco Estuary.

| Annelida | Arthropoda | Mollusca | Nematoda | Nemertea |
|---|---|---|---|---|
| Hirudinida | Arachnida | Bivalvia | | Anopla |
| Erpobdellidae | Acariformes | Sphaeriidae | | Lineidae |
| *Erpobdella* sp. | Insecta | *Pisidium* sp. | | *Lineus ruber* |
| Glossiphoniidae | Chironomidae | Tellinidae | | |
| *Gloiobdella elongata* | *Bezzia/Palpomyia* sp. | *Macoma balthica* | | |
| Polychaeta | Ceratopogonidae | Gastropoda | | |
| Ampharetidae | *Forcipomyia* sp. | Hydrobiidae | | |
| *Hobsonia florida* | *Procladius* sp. | Lymnaeidae | | |
| Nereididae | *Tanytarsus* sp. | *Fossaria* sp. | | |
| *Hediste diversicolor* | Limnephilidae | | | |
| Sabellidae | Thaumaleidae | | | |
| *Manayunkia* sp. | Tipulidae | | | |
| Spionidae | *Tipula* sp. | | | |
| *Polydora sp* | Malacostraca | | | |
| Oligochaeta | Anthuridae | | | |
| Enchytraeidae | *Cyathura polita* | | | |
| Naididae | Gammaridae | | | |
| | *Gammarus mucronatus* | | | |
| | Melitidae | | | |
| | *Maera danae* | | | |
| | Talitridae | | | |
| | Leptocheliidae | | | |
| | *Hageria rapax* | | | |

## What types of invertebrates inhabit the tidal flats and low marsh habitats of the Saco Estuary?

A minimum of 19 species were positively identified during the four months that sampling was conducted, and a minimum of 24 families were represented during our survey (Table 1).[1] For the oligochaetes, a minimum of two families, Enchytraeidae and Naididae, are present in the estuary (samples identified by professional taxonomists with EcoAnalysts, Inc.). It is highly likely that other oligochaete families are also present, but they await further discovery. Consequently, all oligochaete individuals were lumped into one group, the Oligochaeta. All dipterans were identified to family for this study, with some specimens identified to genera by professional taxonomists.

The most abundant members of the communities were the oligochaete worms, chironomid fly larvae, nereid worms, hydrobid snails, and ceratopogonid fly larvae, respectively (Table 2). Invertebrate abundance increased from lower salinity sites to higher salinity sites (west to east or down the estuary toward Saco Bay).

[1] The invertebrate data give a preliminary picture of the species present in the estuary and are limited in three ways. First, only a fraction of the marsh was sampled, i.e., the low marsh and tidal flats. Second, not all specimens were identified to species; therefore, all diversity and community level analyses were based on the family level. Third, this report includes data for only one year; therefore, yearly trend analysis is not possible.

TABLE 2 Mean abundance of invertebrates (no. individuals/m²) for the habitats within the six sites sampled. The abundance of three replicates in each of the two habitats was used to generate a mean over the four sampling periods: May, June, July, and August.

| | | N2 | | S1 | | N4 | | S6 | | N10 | | S11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flat | Low | Flat | Low | Flat | Low | Flat | Low | Flat | Low | Flat | Low |
| Annelida | | | | | | | | | | | | | |
| Hirudinida | | | | | | | | | 1 | | | | |
| | Erpobdellidae | | 3 | | | | | | | | | | |
| | Glossiphoniidae | | 15 | | | | | | | | | | |
| Polychaeta | Ampharetidae | | | | | 3 | | 13 | | | | | |
| | Nereididae | | | | | | | 15 | 3 | 72 | 111 | 261 | |
| | Sabellidae | | | | | | | 4 | | | | | 28 |
| | Spionidae | | | | | | | | | 11 | 11 | 1 | |
| Oligochaeta | | 32 | 215 | 160 | 89 | 59 | 265 | 127 | 823 | 484 | 736 | 41 | 1776 |
| Arthropoda | | | | | | | | | | | | | |
| Arachnida | Acariformes | | | | | | | | | | | | 1 |
| Insecta | Ceratopogonidae | 1 | 1 | 5 | 32 | 1 | 8 | 15 | 94 | | 7 | | 75 |
| | Chironomidae | 62 | 39 | 33 | 16 | 177 | 51 | 36 | 29 | | | | |
| | Limnephilidae | 1 | | | | | | | | | | | |
| | Siphloneuridae | | | | | 1 | | | | | | | |
| | Thaumaleidae | | | | | 12 | | | | | 1 | | |
| | Tipulidae | | | | | | 1 | | | | | | |
| Malacostraca | Anthuridae | | | | | 32 | 9 | 48 | | | | | |
| | Gammaridae | 1 | 11 | | | | | 1 | | | | | |
| | Melitidae | | | | | 3 | 1 | | | | 5 | | 1 |
| | Talitridae | | | | | | | | | | 3 | | |
| | Leptocheliidae | | | | | | | | | | 9 | | |
| Mollusca | | | | | | | | | | | | | |
| Bivalvia | Sphaeriidae | | 41 | 3 | 1 | | | | | | | | |
| | Tellinidae | | | | | | | | | 3 | | | |
| Gastropoda | Hydrobiidae | 7 | 44 | 12 | 29 | 17 | 237 | | 3 | | | | |
| | Lymnaeidae | | 1 | | | 1 | 7 | | | | | | |
| Nematoda | | | | 3 | 8 | 3 | 1 | 1 | 3 | 3 | 7 | | 5 |
| Nemertea | Lineidae | | | | | | | | | 1 | 1 | | |
| | Totals by Habitat | 104 | 370 | 216 | 175 | 309 | 580 | 260 | 956 | 574 | 891 | 303 | 1886 |
| | Totals by Site | 474 | | 391 | | 889 | | 1216 | | 1465 | | 2189 | |

## How diverse are the invertebrate communities in the tidal flats and low marsh habitats?

To estimate the diversity of invertebrates for the various habitats and sites, Shannon-Wiener diversity indices based on family-level diversity were calculated (Figure 2). Diversity estimates were similar in both habitats, with tidal flats exhibiting a range of 0.9–2.0 and the low marsh habitats ranging from 1.1–2.1. Site N4 had the highest diversity value for the tidal flats, and N10 for the low marsh habitat.

## Do invertebrate communities change as one moves down the Saco Estuary to the bay?

Many factors can influence where estuarine invertebrates live, including sediment characteristics and salinity. To determine whether the invertebrate communities differed according to where they were found in the Saco Estuary, we analyzed the data in two different ways. First, a nested permutational MANOVA (PERMANOVA) was applied to the community abundance data to assess whether multiple variables were significantly associated with the invertebrate communities at each site. Each habitat type was analyzed separately because tidal flats and low marsh habitats differ from each other. Variables included in the tidal flat analysis included the position (i.e., Biddeford or Saco side), porewater salinity, and sediment grain size, with the month sampling occurred nested. Neither position nor grain size had a significant effect on the community composition, but porewater salinity did (Pr>F=0.001, p=0.001).

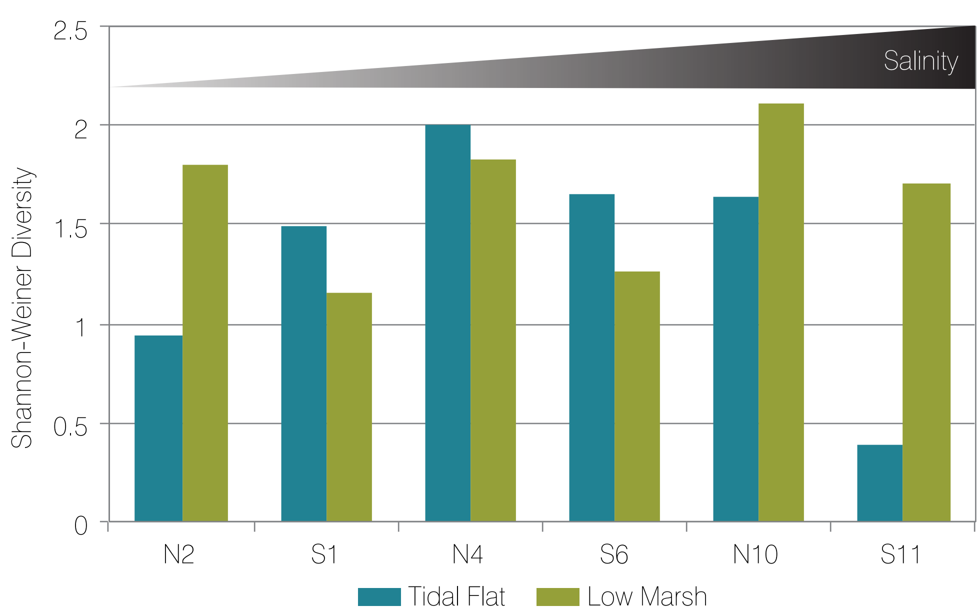



FIGURE 2 Invertebrate diversity by site and habitat as measured by the Shannon-Wiener Diversity Index. Abundance data for all months were averaged and standardized, and overall family-level diversity estimates were generated.

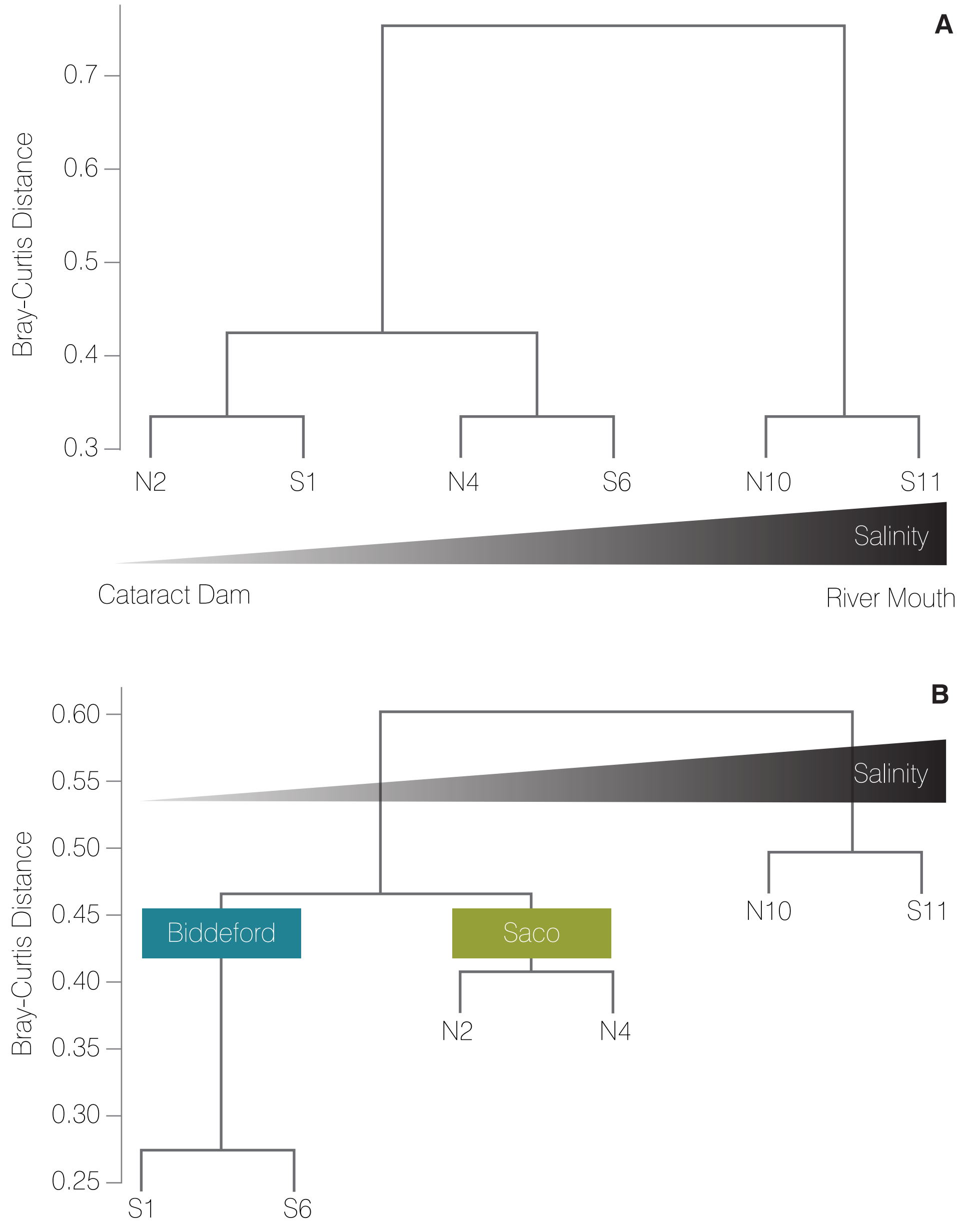



FIGURE 3 Cluster dendrogram for the tidal flat (A) and low marsh (B) invertebrate community data. Mean abundance data were converted to presence/absence data, and Bray-Curtis distances between each site were generated. Clustering was based on average distances among sites. (A) The impact of salinity is visible in the clustering of tidal flat communities with lower to intermediate salinity values (N2 & S1, N4 & S6, respectively) versus the higher salinity sites (N10 & S11). The transition from low salinity (near Cataract Dam) to high salinity (near the mouth of the river) is indicated by the blue triangle below the dendrogram. (B) Both the positional and salinity effects are recovered in the cluster analysis with Biddeford sites (S1 & S6) and Saco sites (N2 & N4) grouping together and the higher salinity sites (N10 & S11) forming a separate cluster. The level at which salinity is a significant factor is indicated by the blue bars and within the lower salinity sites, position as a significant factor is indicated by the clustering of the two Biddeford sites versus the Saco sites.

For the low marsh habitats, grain size of sediment was not available; therefore, the variables used in the model were position and salinity with month nested. The data analysis indicated that both position and salinity had significant effects on community composition (Pr>F=0.002 and p=0.01; Pr>F=0.007 and p=0.01, respectively), but no significant interactions between the two variables were indicated (Pr>F=0.130).

To determine whether there were clusters of sites based on community composition or types of invertebrates found at each site and within each habitat, a second approach, hierarchical clustering analysis with Bray-Curtis distances, was employed. For this analysis, the individual count data per site and habitats were standardized to presence/absence counts. Examination of the clustering analysis supports the nested PERMANOVA results, which indicated that salinity is a significant factor in the determination of the community composition of the tidal flats and both position and salinity are significant factors in the low marsh habitats.

## CONCLUSIONS

Although more surveys are needed, and future identification of invertebrates in the Saco Estuary to the species level is necessary, the patterns we observed are consistent with what is known about the community ecology of benthic invertebrates in tidal marshes.

1. Different factors are important in determining the community composition of invertebrates in tidal flats versus the low marsh habitats. In the tidal flats, porewater salinity appears to play a significant role in community composition. In the low marsh habitats, multiple influences shape community composition including site location (Biddeford or Saco side) and porewater salinity. The significant effect of site location on low marsh communities may be tied to land use patterns or hydrodynamics of the river.
2. Other variables, such as land use patterns, contaminants, and plant community composition, likely play a significant role in structuring the invertebrate communities in both habitats and should be investigated.

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## LITERATURE CITED

Chester, AJ, RL Ferguson, and G.W. Thayer. 1983. Environmental gradients and benthic macroinvertebrate distributions in a shallow North Carolina estuary. Bulletin of Marine Science 33:282–295.

Diaz, RJ. 1989. Pollution and tidal benthic communities of the James River Estuary, Virginia. *Hydrobiologia* 180:195–211.

Hering, D, RK Johnson, S. Kramm, S. Schmutz, K. Szoszkiewicz, and PFM Verdonschot. 2006. Assessment of European streams with diatoms, macrophytes, macroinvertebrates and fish: a comparative metric-based analysis of organism response to stress. *Freshwater Biology* 51:1757–1785.

Kang, S-R and SL King. 2012. Influence of salinity and prey presence on the survival of aquatic macroinvertebrates of a freshwater marsh. *Aquatic Ecology* 46:411–420.

Lerberg, SB, AF Holland, and DM Sanger. 2000. Responses of tidal creek macrobenthic communities to the effects of watershed development. *Estuaries* 23:838–853.

Pearson, TH and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology, An Annual Review 16:229–311.

Reynolds, WW and ME Casterlin. 1985. Vagile macrofauna and the hydrographic environment of the Saco River Estuary and adjacent waters of the Gulf of Maine. *Hydrobiologia* 128:207–215.

USACoE. 2013. Camp Ellis Beach, Saco, Maine shore damage mitigation project. Environmental Assessment and Clean Water Act Section 404 (B) (1) Analysis. Available at http://www.nae.usace.army.mil/Missions/ProjectsTopics/CampEllis.aspx.

Warren, RS, PE Fell, R Rozsa, AH Brawley AC Orsted ET Olson, V Swamy, and WA Niering 2002. Salt marsh restoration in Connecticut: 20 years of science and management. *Restoration Ecology* 10:497–513.

Yozzo, DJ and DT Osgood. 2013. Invertebrate communities of low-salinity wetlands: overview and comparison between *Phragmites* and *Typha* marshes within the Hudson River Estuary. *Estuaries and Coasts* 36:575–584.

Ysebaert, T, P. Meire, J. Coosen, and K Essink. 1998. Zonation of intertidal macrobenthos in the estuaries of Schelde and Ems. *Aquatic Ecology* 32: 53–71.