Fringing Marshes of the Saco River Estuary Support High Nekton Diversity

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Fish of the Saco

*images not to scale; artwork by Jim Doctorman

Furey & Sulikowski, 2011. Northeastern Naturalist 18: 37-44.

Table 2. Overall mean total lengths (TL) and standard deviations (SD) for all 24 fish species observed in the study. Also given are average and maximum adult TL (or standard length, SL, when noted) cited in scientific literature for each species. Asterisk (*) denotes source is as cited in Collette and Klein-MacPhee 2002. An "X" in "Present" indicates the species was previously observed within the estuarine portion of the river that matches the current study's extent (Stations 4 and 5, Reynods and Casterlin 1985).

24 species; 20 new

		Seine (mm)		Otter trawl (mm)		Beam trawl (mm)		Literature value (mm)		
Common name	Present	Mean	SD	Mean	SD	Mean	SD	Average	Max	Source*
Bluefish		66.21	5.88	113	NA	NA	NA	NA	1150	Collette and Klein-MacPhee 2002
Largemouth Bass		61.00	40.22	NA	NA	NA	NA	NA	970	Page and Burr 1991
Striped Mullet		55.27	17.42	NA	NA	NA	NA	NA	600	McDonough and Wenner 2003*
Red Hake		75.50	10.29	NA	NA	NA	NA	NA	500	Musick 1967*
Atlantic Sturgeon		NA	NA	1132.50	95.46	NA	NA	800–2000	NA	Damon-Randall et al. 2010
American Eel	X	52.00	0.82	NA	NA	85	4.84	NA	1200	Bigelow and Shroeder 1953*
Atlantic Herring		48.50	5.74	52.12	6.96	38	3.46	NA	430	Collette and Klein-MacPhee 2002
Alewife		56.27	8.26	NA	NA	46.63	10.65	NA	300	Ross 1991*
Cunner		11.50	NA	NA	NA	NA	NA	150–250	NA	Bigelow and Shroeder 1953*
Winter Flounder	X	71.35	55.19	131.47	52.12	134.75	29.47	NA	580	Fields 1988*
Yellow Perch		25.00	NA	NA	NA	NA	NA	NA	400	Page and Burr 1991
Blueback Herring		43.38	14.73	66.14	6.4	NA	NA	NA	300	Ross 1991*
Windowpane		56.58	19.34	123.55	48.3	NA	NA	250–305	NA	Bigelow and Shroeder 1953*
Pumpkinseed		49.00	NA	NA	NA	NA	NA	NA	400	Page and Burr 1991*
Rainbow Smelt		49.68	13.18	49.21	6.45	NA	NA	180–230	NA	Collette and Klein-MacPhee 2002
Atlantic Tomcod	X	41.87	9.49	NA	NA	33.35	21.57	228–300	NA	Collette and Klein-MacPhee 2002
Northern Pipefish		102.64	51.28	NA	NA	148.33	28.04	NA	305	Nichols and Breder 1927*
Sand Lance	X	68.26	27.67	60.00	27.5	51	0.48	NA	190	Nazinski et al. 1990*
Atlantic Silverside		68.56	20.30	44.62	4.4	NA	NA	115	NA	Conover and Ross 1982*
Mummichog		46.76	13.11	NA	NA	NA	NA	NA	10	1990*
Threespine Stickleback		31.03	16.46	NA	NA	NA	NA	40–70	NA	Collette and Klein-MacPhee 2002
Banded Killifish		44.03	8.78	NA	NA	NA	NA	152–178	NA	Clemmer and Schwartz 1964
Ninespine Stickleback		33.22	4.18	NA	NA	NA	NA	35–55 SL	76	Scott and Scott 1988*; Ayvazian and Krueger 1992*
Fourspine Stickleback		30.50	7.51	NA	NA	53.50	3.53	23–44	NA	Blouw and Hagen 1984*

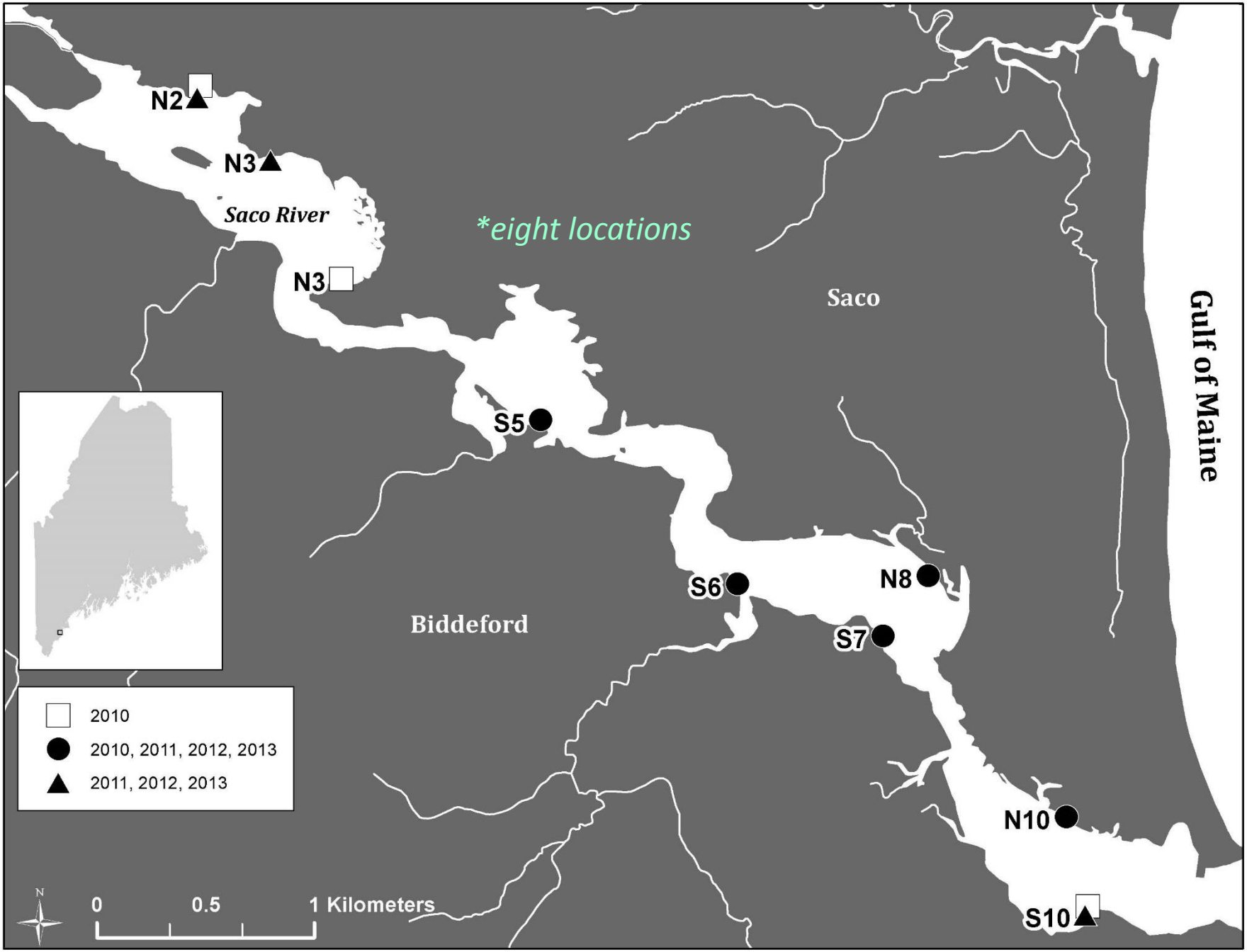
Channel-Focused Sampling

economically valuable and threatened species

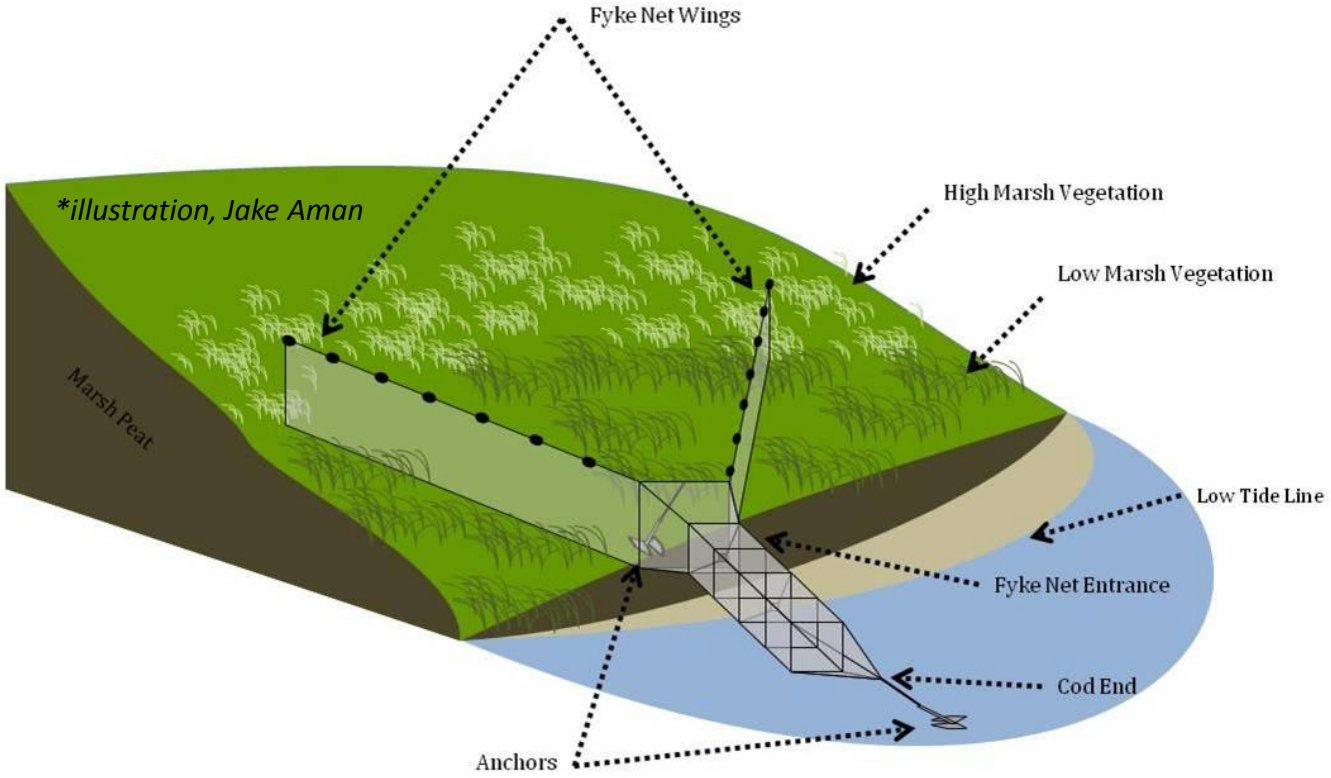
nearly all juvenile lengths (important nursery ground)


Fringing
Marshes

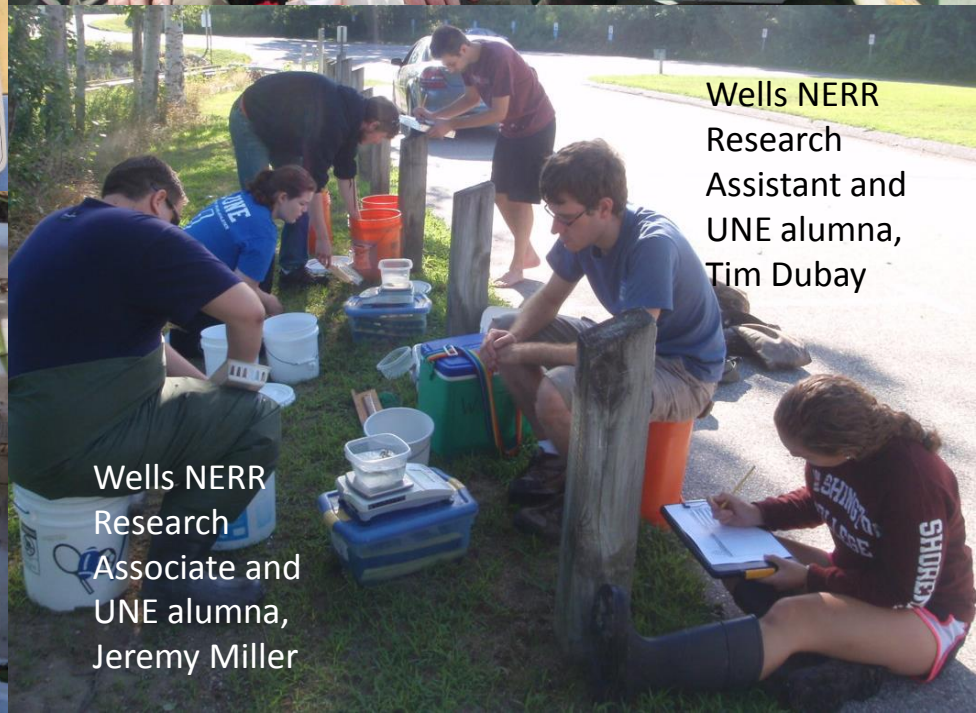
"…few studies have considered fringing salt marshes as unique habitats, distinct from larger, meadow salt marshes. In many New England estuaries, fringing salt marshes are the dominant marsh type, and yet regional efforts aimed at marsh conservation and restoration still focus on larger meadow marshes." -Morgan *et al.* 2009. Estuaries & Coasts 32:483-495.


N2
N3
Saco River
N3
*eight locations
Saco
Gulf of Maine
S5
S6
N8
Biddeford
S7
N10
S10
2010
2010, 2011, 2012, 2013
2011, 2012, 2013
N
0
0.5
1 Kilometers

Year	BV Marsh (N10)	STP (N2)	Cemetary (N3)	Ferry (N8)	UNE (S10)	Notre Dame (S5)	Salmon Club (S6)	Twin Island (S7)
2010	21-Jun night 22-Jun day 19-Jul day 20-Jul night	24-Jun day, night 28-Jul day, night	24-Jun day, night 28-Jul day, night	21-Jun night 22-Jun day 19-Jul day 20-Jul night	21-Jun night 22-Jun day 19-Jul day 20-Jul night	24-Jun day, night 28-Jul day, night	24-Jun day, night 28-Jul day, night	22-Jun day, night 19-Jul day 20-Jul night
2011	1-Aug day 2-Aug night	3-Aug day 4-Aug night	3-Aug day 4-Aug night	1-Aug day 2-Aug night	1-Aug day 2-Aug night	3-Aug day 4-Aug night	4-Aug night	3-Aug day 4-Aug night
2012	6-Aug day 7-Aug night	8-Aug day 9-Aug night	8-Aug day 9-Aug night	6-Aug day 7-Aug night	6-Aug day 7-Aug night	8-Aug day 9-Aug night	8-Aug day 9-Aug night	6-Aug day 7-Aug night
2013	12-Aug day 13-Aug night	14-Aug day 15-Aug night	14-Aug day 15-Aug night	12-Aug day 13-Aug night	12-Aug day 13-Aug night	14-Aug day 15-Aug night	14-Aug day 15-Aug night	12-Aug day 13-Aug night



Wells NERR Research Associate, Jake Aman



Wells NERR Research Assistant and UNE alumna, Tim Dubay

Wells NERR Research Associate and UNE alumna, Jeremy Miller

4,167 individuals

dam

ocean

		2010	2011	2012	2013	Avg #nekton/m^2
STP	N2	0.09	0.05	0.08	0.03	0.06
Cemetary	N3	0.00	1.08	0.25	0.05	0.34
Notre Dame	S5	0.20	0.32	0.01	0.09	0.15
Salmon Club	S6	0.13	0.02	0.01	0.06	0.06
Ferry	N8	0.17	0.07	0.17	0.12	0.13
Twin Island	S7	0.66	0.19	0.52	0.08	0.36
BV Marsh	N10	0.87	0.10	0.53	0.38	0.47
UNE	S10	1.14	0.09	0.01	0.05	0.32

29 species total;
27 fish, 2 crustaceans

http://fishbio.com/wp-content/uploads/2011/09/Pumpkinseed-Sunfish.jpg
http://restorerainbowsmelt.com/wp-content/uploads/2011/10/slider-basic-biology-w-credit.jpg
http://ny.cf.er.usgs.gov/nyprojectsearch/projects/projectImages/2457-A3J-1_image003.jpg
http://3.bp.blogspot.com/-3tQPvSDtNgY/ToE0vaFbuqI/AAAAAAAABjY/jbUfhCOczhw/s1600/IMG_0255.JPG

Scientific Name	Common Name
Alosa pseudoharengus	alewife
Anguilla rostrata	American eel
Clupea harengus	Atlantic herring
Menidia menidia	Atlantic silverside
Microgadus tomcod	Atlantic tomcod
Fundulus diaphanus	banded killifish
Alosa aestivalis	blueback herring
Pomatomus saltatrix	bluefish
Lepomis macrochirus	bluegill
Esox niger	chain pickerel
Carcinus maenas	European green crab
Apeltes quadracus	fourspine stickleback
Notemigonus crysoleucas	golden shiner
Couesius plumbeus	lake chub
Micropterus salmoides	large mouth bass
Fundulus heteroclitis	mummichog
Syngnathus fuscus	northern pipefish
Pollachius virens	pollock
Lepomis gibbosus	pumpkinseed
Osmerus mordax	rainbow smelt
Urophysis chuss	red hake
Crangon septemspinosa	sand shrimp
Notropis hudsonius	spot tail shiner
Fundulus majalis	striped killifish
Lepomis sp.	sunfish
Gasterosteus aculeatus	threespine stickleback
Morone americana	white perch
Catostomus commersonii	white sucker
Pseudopleuronectes americanus	winter flounder
Perca flavescens	yellow perch

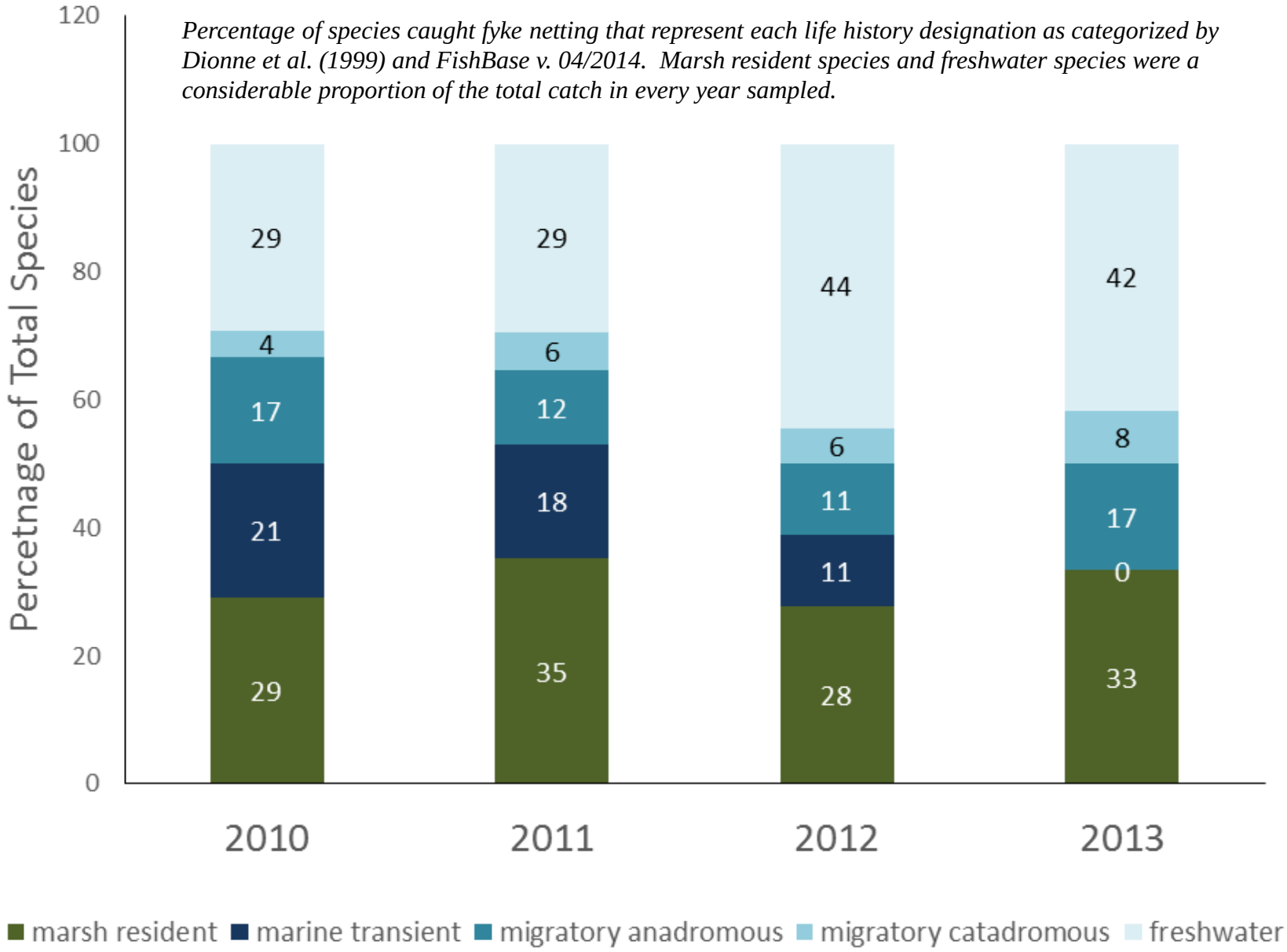
Cosmopolitan Species

Compiled species (all sites combined). An X reveals the presence of that species within the Saco River Estuary in that year. Grayed species indicate species that were found in all years. Life history categories include r = marsh resident, f = freshwater, m = migratory, c = catadromous, a = anadromous, and t = marine transient (from Dionne et al. 1999 and FishBase v. 04/2014).

Species		Life History	Presence/Absence 2010	2011	2012	2013
Alosa pseudoharengus	alewife	m(a)	X			
Anguilla rostrata	American eel	r or m(c)	X	X	X	X
Clupea harengus	Atlantic herring	t	X			
Menidia menidia	Atlantic silverside	r	X	X		
Microgadus tomcod	Atlantic tomcod	t	X	X		
Fundulus diaphanus	banded killifish	f	X		X	X
Alosa aestivalis	blueback herring	m(a)	X	X	X	X
Pomatomus saltatrix	bluefish	t	X	X	X	
Lepomis macrochirus	bluegill	f	X		X	
Esox niger	chain pickerel	f		X	X	
Carcinus maenas	European green crab	r	X	X	X	X
Apeltes quadracus	fourspine stickleback	r	X	X	X	
Notemigonus crysoleucas	golden shiner	f			X	X
Couesius plumbeus	lake chub	f	X	X		X
Micropterus salmoides	largemouth bass	f	X	X	X	X
Fundulus heteroclitis	mummichog	r	X	X	X	X
Syngnathus fuscus	northern pipefish	t	X			
Pollachius virens	pollock	t		X		
Lepomis gibbosus	pumpkinseed	f	X		X	
Osmerus mordax	rainbow smelt	m(a)	X			
Urophysis chuss	red hake	t	X			
Crangon septemspinosa	sand shrimp	r	X	X	X	X
Notropis hudsonius	spottail shiner	f			X	
Fundulus majalis	striped killifish	r	X	X	X	X
Gasterosteus aculeatus	threespine stickleback	r	X			
Morone americana	white perch	m(a)	X	X	X	X
Catostomus commersonii	white sucker	f	X	X		X
Pseudopleuronectes americanus	winter flounder	t			X	
Perca flavescens	yellow perch	f	X	X	X	

http://vitalsignsme.org/sites/default/files/species_photos/crangon_septemspinosa.jpg http://upload.wikimedia.org/wikipedia/commons/6/66/White_Perch.jpg
http://www.dnr.state.md.us/fisheries/fishfacts/image/eel.gif http://vertebrates.si.edu/fishes/hudson_highlight/P00986Fundulus_majalis.jpg http://www2.dnr.cornell.edu/cek7/nyfish/Cyprinodontidae/mummichog.jpg
http://www.maineboats.com/files/u2/blueback-herring-wide.jpg http://www.maine.gov/ifw/fishing/species/identification/images/largemouthbass.jpg www.qc.edu/biology/Waldman/Images/Green-crab_SG.gif

Percentage of species caught fyke netting that represent each life history designation as categorized by Dionne et al. (1999) and FishBase v. 04/2014. Marsh resident species and freshwater species were a considerable proportion of the total catch in every year sampled.



Important Species

**River-wide, all sites combined*

Number of Individuals (#, relative abundance in that year)

2010
alewife (961, 44%)
sand shrimp (401, 18%)
Atlantic tomcod (328, 15%)

2011
blueback herring (660, 73%)
striped killifish (63, 7%)
sand shrimp (59, 7%)

2012
blueback herring (504, 68%)
sand shrimp (57, 8%)
banded killifish (50, 7%)

2013
blueback herring (189, 57%)
lake chub (42, 13%)
European green crab (29, 9%)

Biomass (g, % biomass in that year)

2010
American eel (1566, 24%)
white sucker (1206, 18%)
Atlantic tomcod (642, 10%)

2011
American eel (3734, 66%)
European green crab (617, 11%)
blueback herring (308, 5%)

2012
American eel (1259, 32%)
blueback herring (964, 25%)
largemouth bass (763, 20%)

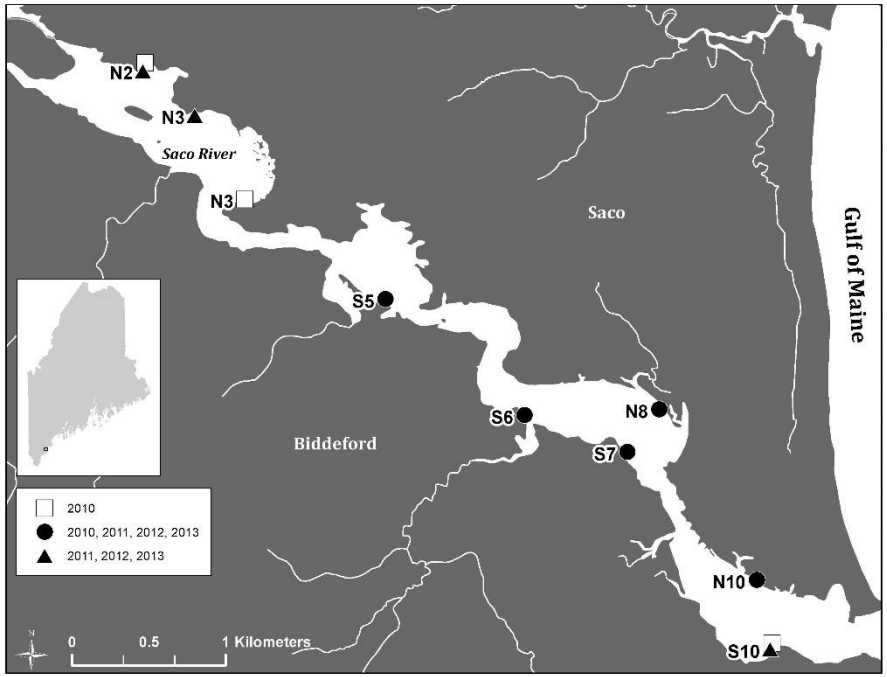
2013
American eel (1926, 49%)
European green crab (538, 14%)
blueback herring (506, 13%)

Species Richness

Species Richness (S)

Day/Night Combined

		Year						
		2010	2011	2012	2013	All Years:	# Freshwater Species	% Freshwater Species
UNE	S10	8	5	1	3	10	0	0
BV Marsh	N10	7	6	7	4	12	0	0
Twin Island	S7	8	8	7	5	14	2	14
Ferry	N8	11	8	4	4	13	1	8
Salmon Club	S6	8	3	2	5	11	0	0
Notre Dame	S5	10	7	3	5	12	3	25
Cemetary	N3	7	9	7	4	14	6	43
STP	N2	10	5	8	7	15	9	60



		Avg #fish/m^2
STP	N2	0.06
Cemetary	N3	0.34
Notre Dame	S5	0.15
Salmon Club	S6	0.06
Ferry	N8	0.13
Twin Island	S7	0.36
BV Marsh	N10	0.47
UNE	S10	0.32

N2 = most species rich despite having low catches

Species Diversity

Shannon-Weiner Diversity Index (H')

Day/Night Combined

red = most diverse site in that year; blue = least diverse site in that year

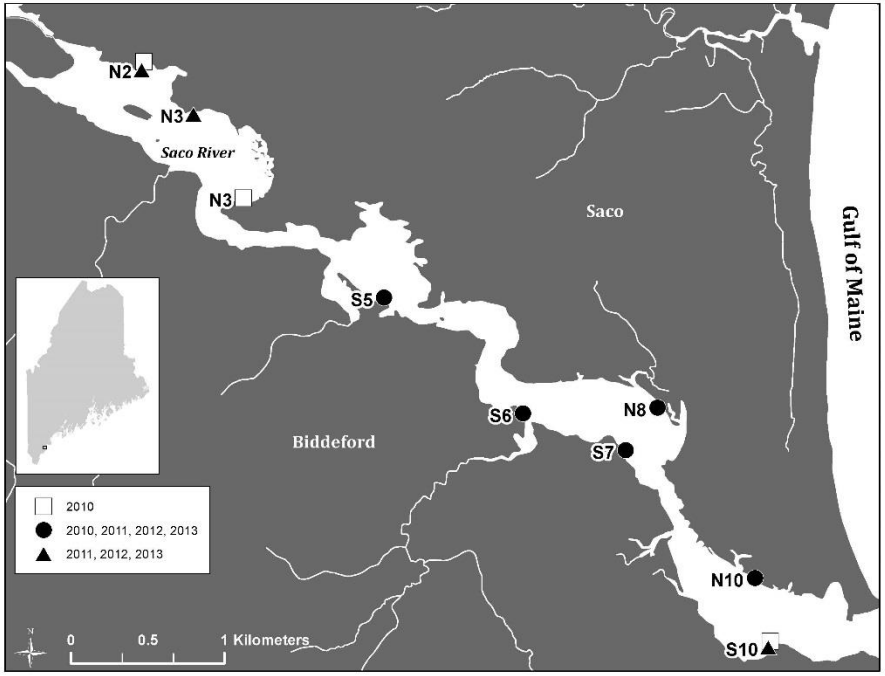
		Year			
		2010	2011	2012	2013
UNE	S10	1.13	1.29	0.00	1.05
BV Marsh	N10	1.42	1.32	1.44	0.73
Twin Island	S7	1.20	1.62	0.52	1.29
Ferry	N8	1.48	1.24	0.14	0.62
Salmon Club	S6	1.32	1.03	0.64	0.59
Notre Dame	S5	1.51	1.15	1.04	0.97
Cemetary	N3	1.46	0.46	1.29	1.17
STP	N2	2.03	1.51	1.45	1.62

Simpson's Index of Diversity (λ)

Day/Night Combined

red = most diverse site in that year; blue = least diverse site in that year

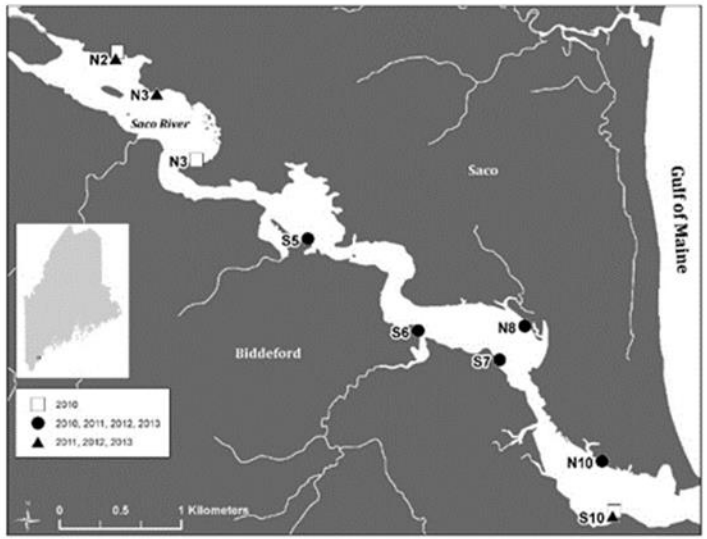
		Year			
		2010	2011	2012	2013
UNE	S10	0.59	0.64	0.00	0.64
BV Marsh	N10	0.72	0.65	0.72	0.41
Twin Island	S7	0.64	0.75	0.23	0.67
Ferry	N8	0.71	0.59	0.05	0.30
Salmon Club	S6	0.62	0.62	0.44	0.25
Notre Dame	S5	0.69	0.52	0.63	0.49
Cemetary	N3	0.70	0.20	0.64	0.65
STP	N2	0.85	0.77	0.64	0.74

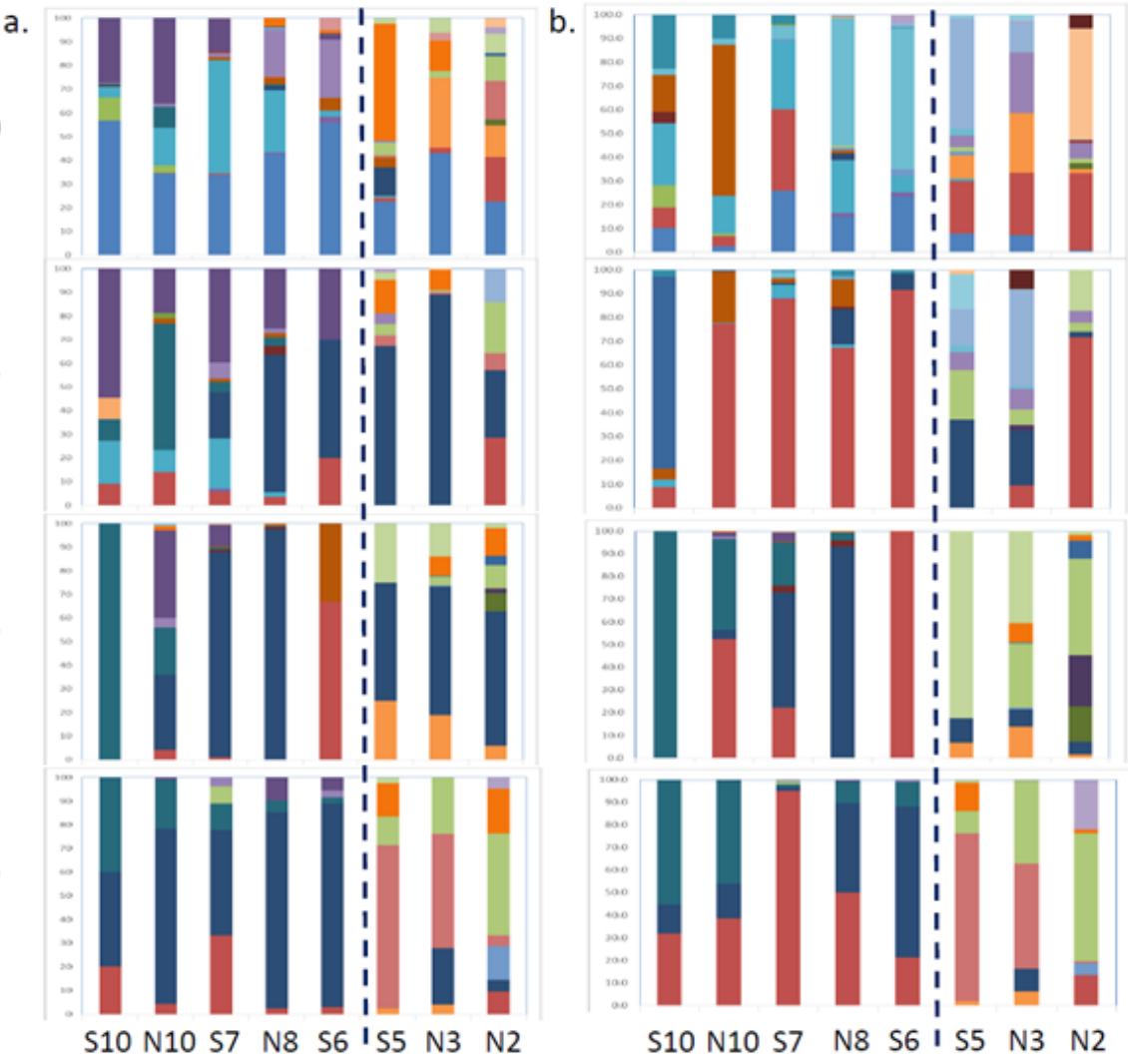


		Avg #fish/m^2
STP	N2	0.06
Cemetary	N3	0.34
Notre Dame	S5	0.15
Salmon Club	S6	0.06
Ferry	N8	0.13
Twin Island	S7	0.36
BV Marsh	N10	0.47
UNE	S10	0.32

N2 = most diverse despite having low catches

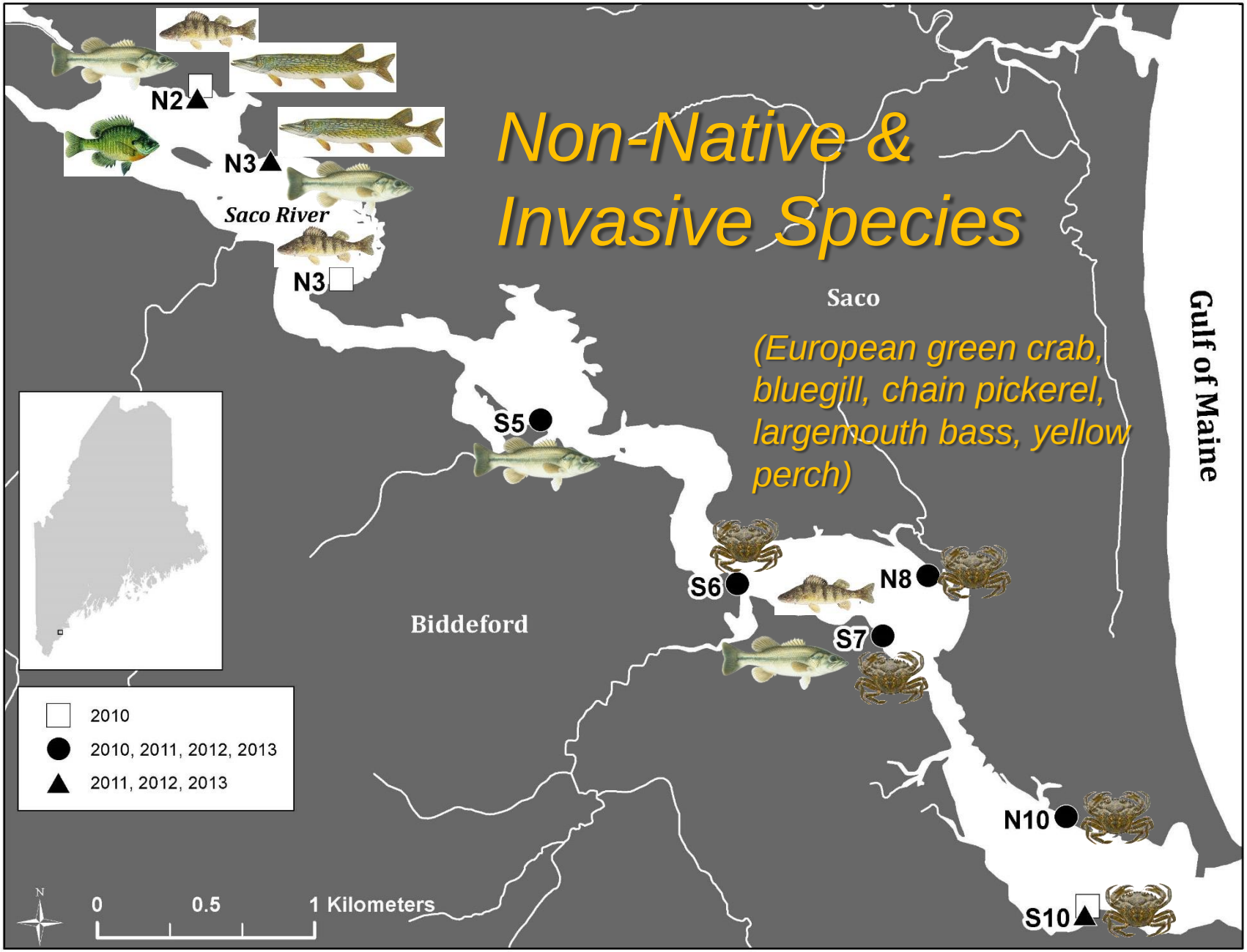
Species Composition





Percent species composition by site and year as determined by (a) number of individuals and (b) biomass.

Considerable within and across site variation across years.


Non-Native & Invasive Species
(European green crab, bluegill, chain pickerel, largemouth bass, yellow perch)
N2
N3
N3
Saco River
S5
Saco
Biddeford
S6
N8
S7
N10
S10
Gulf of Maine
2010
2010, 2011, 2012, 2013
2011, 2012, 2013
N
0
0.5
1 Kilometers

Community Similarity

Sørenson's Similarity Index (β)

Sørenson's Similarity Index (β) measures the degree of similarity or overlap of species between ecological communities. Values range from 0 (no species overlap) to 1 (complete overlap).

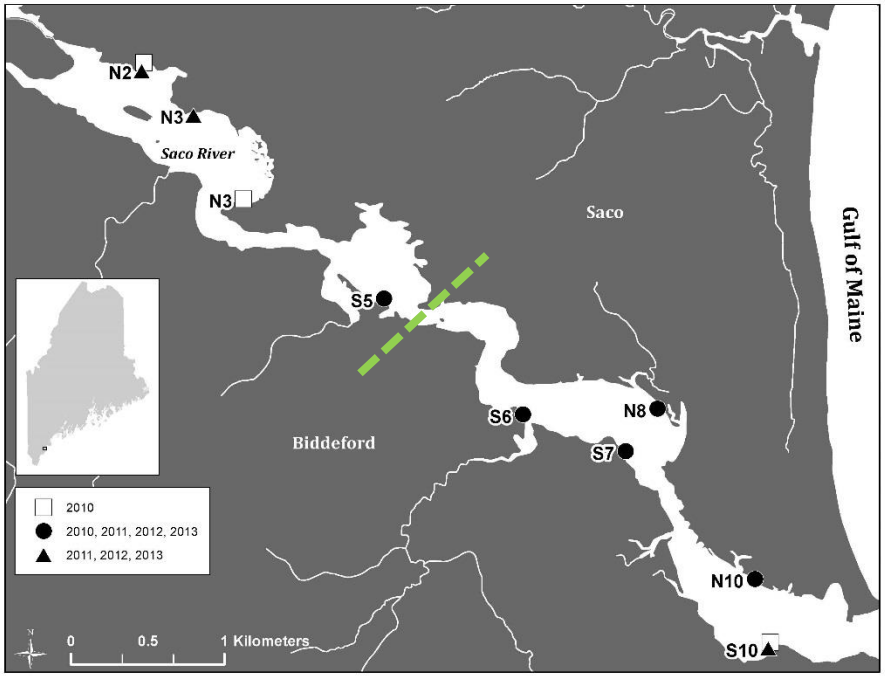
The index is calculated using the formula below:

$$\text{Sørenson's Similarity Index } (\beta) = 2c/(S_1 + S_2)$$

where, S_1 = number of species in community 1

S_2 = number of species in community 2

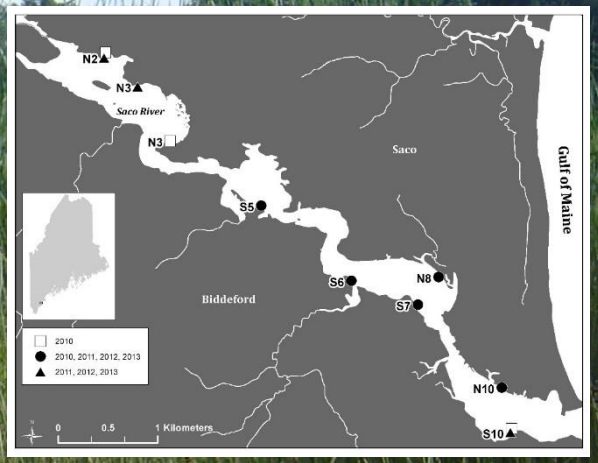
c = number of species common to both communities

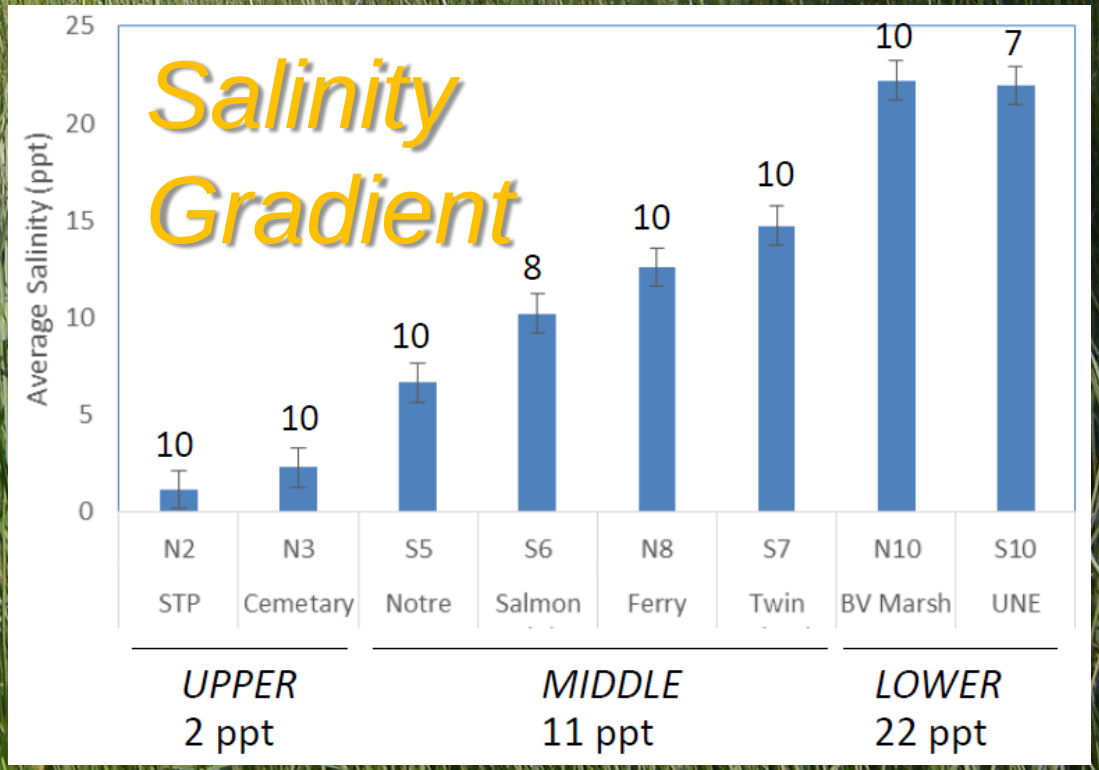


**Compared N2 to every other site; all years combined*

Site		β	Species in Common:
UNE	S10	0.24	alewife, American eel, blueback herring
BV Marsh	N10	0.30	alewife, American eel, blueback herring, striped killifish
Twin Island	S7	0.34	alewife, American eel, blueback herring, largemouth bass, yellow perch
Ferry	N8	0.36	alewife, American eel, blueback herring, lake chub, striped killifish
Salmon Club	S6	0.31	alewife, American eel, blueback herring, striped killifish
Notre Dame	S5	0.67	alewife, American eel, banded killifish, blueback herring, lake chub, largemouth bass, striped killifish, white perch, white sucker
Cemetary	N3	0.76	alewife, American eel, banded killifish, blueback herring, chain pickerel, golden shiner, lake chub, largemouth bass, striped killifish, white perch, yellow perch

N2 had more species in common with near sites compared to those located further downriver.


N2
N3
Saco River
N3
S5
Saco
Gulf of Maine
Biddeford
S6
N8
S7
N10
S10
2010
2010, 2011, 2012, 2013
2011, 2012, 2013
0
0.5
1 Kilometers


Salinity Gradient
Average Salinity (ppt)
25
20
15
10
5
0
10
10
10
8
10
10
10
7
N2
STP
N3
Cemetary
S5
Notre
S6
Salmon
N8
Ferry
S7
Twin
N10
BV Marsh
S10
UNE
UPPER
2 ppt
MIDDLE
11 ppt
LOWER
22 ppt

Summary Points

- Fringing marshes of the Saco River Estuary support diverse nekton communities (4,167 individuals, 27 fish species, and 2 crustaceans) that are variable in space and time.
- In general, species richness increased with distance from the river mouth, mostly through the addition of freshwater species and tracking an observed salinity gradient.
- In terms of fish community composition, sites closer to the dam were more similar to each other than sites near the mouth, with a break occurring at S5…what will happen with SLR?

Changes in Fish Condition Factor through Time

Linking to other measured ecological components

Complimentary methods yield different, valuable ecological data about fish-use of the Saco.

Scientific Name	Common Name	River Channel Sampling		Tidal Marsh Sampling
		Beach Seine	Gill net	Fyke net
Alosa pseudoharengus	alewife	X	X	X
Anguilla rostrata	American eel	X	X	X
Ammodytes americanus	American sand lance	X		
Alosa sapidissima	American shad		X	
Clupea harengus	Atlantic herring	X	X	X
Brevoortia tyrannus	Atlantic menhaden	X	X	
Menidia menidia	Atlantic silverside	X		X
Acipenser oxyrinchus	Atlantic sturgeon		X	
Microgadus tomcod	Atlantic tomcod	X	X	X
Fundulus diaphanus	banded killifish	X		X
Alosa aestivalis	blueback herring	X	X	X
Pomatomus saltatrix	bluefish	X	X	X
Lepomis macrochirus	bluegill			X
Esox niger	chain pickerel			X
Apeltes quadracus	four spine stickleback	X		X
Notemigonus crysoleucas	golden shiner			X
Couesius plumbeus	lake chub			X
Micropterus salmoides	largemouth bass	X		X
Fundulus heteroclitus	mummichog	X		X
Pungitius pungitius	nine spine stickleback	X		
Syngnathus fuscus	northern pipefish	X		X
Pollachius virens	pollock			X
Lepomis gibbosus	pumpkinseed	X		X
Osmersus mordax	rainbow smelt	X		X
Urophycis chuss	red hake	X		X
Myoxocephalus octodecimspinosus	longhorn sculpin	X		
Acipenser brevirostrum	shortnose sturgeon		X	
Micropterus dolomieu	smallmouth bass	X		
Notropis hudsonius	spottail shiner	X	X	X
Fundulus majalis	striped bass	X	X	
Fundulus majalis	striped killifish	X		X
Mugil cephalus	striped mullet	X		
Paralichthys dentatus	summer flounder	X		
Gasterosteus aculeatus	three spine stickleback	X		X
Morone americana	white perch		X	X
Catostomus commersonii	white sucker			X
Scophthalmus aquosus	windowpane flounder	X		
Psuedopleuronectes americanus	winter flounder	X		X
Perca flavescens	yellow perch			X
		32		27


Questions?
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