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Abundance and distribution of diadromous fish in an unimpacted large river: a case study from the Miramichi

Presentor:

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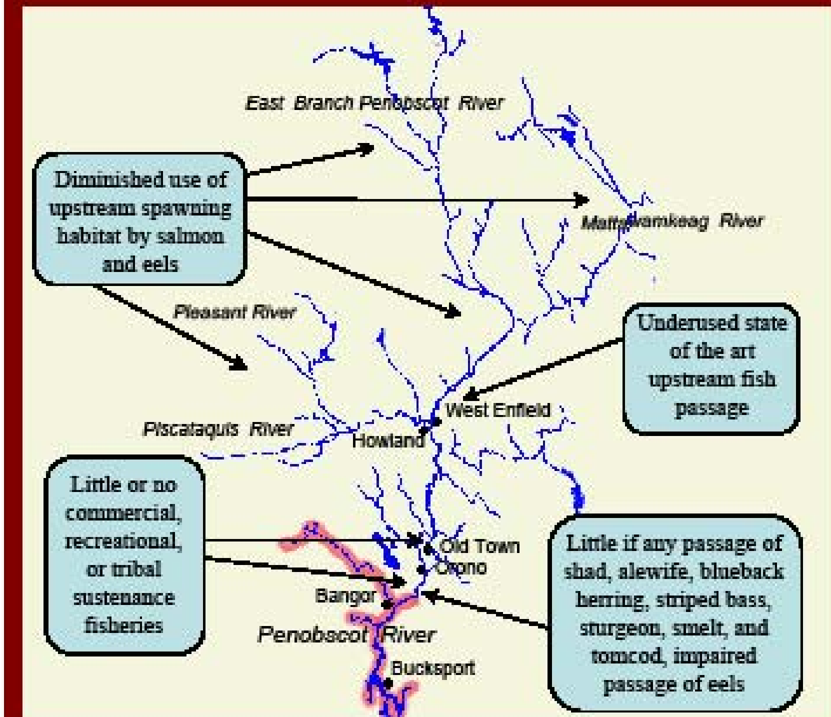
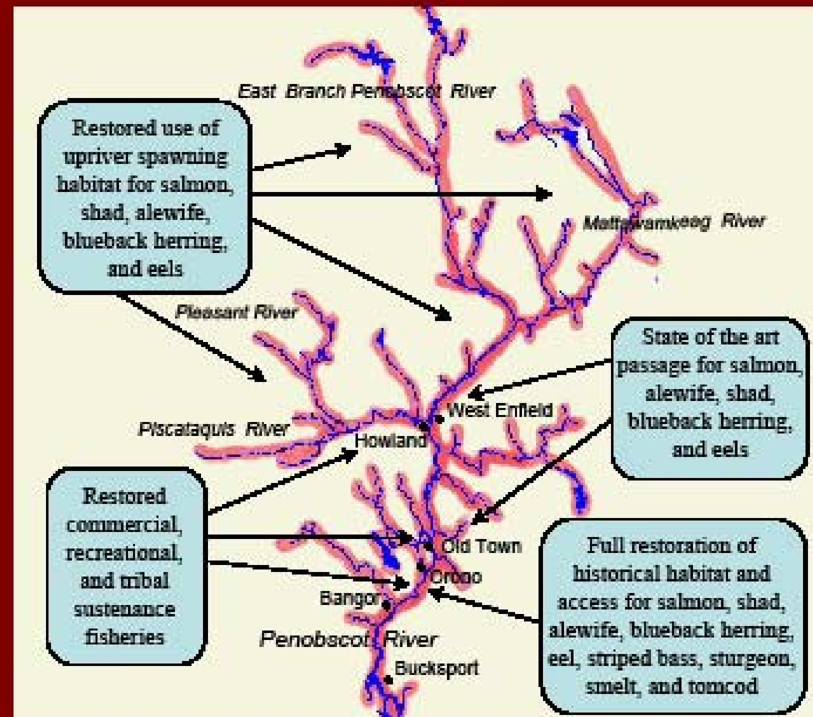
Penobscot River Restoration Project

Before and After Habitat Access



Existing Access for Sea-Run Fish



Significantly Improved Access for Sea-Run Fish to Nearly 1,000 Miles

Abundance and distribution of diadromous fish in an unimpacted large river: a case study from the Miramichi

When we embark on a restoration project, what can we expect?

Can we learn anything about what runs could be like in the absence of dams on the Penobscott River from a neighbouring large river that has had the good “luck” of not being impacted by main stem dams?

Abundance and distribution of diadromous fish in an unimpacted large river: a case study from the Miramichi

Presentation plan:

1 – description / comparison of Penobscot and Miramichi watersheds

- physical characteristics and fish fauna

2 – relative abundance of diadromous fishes in Miramichi

3 – spatial distribution of diadromous fish (upstream penetration)

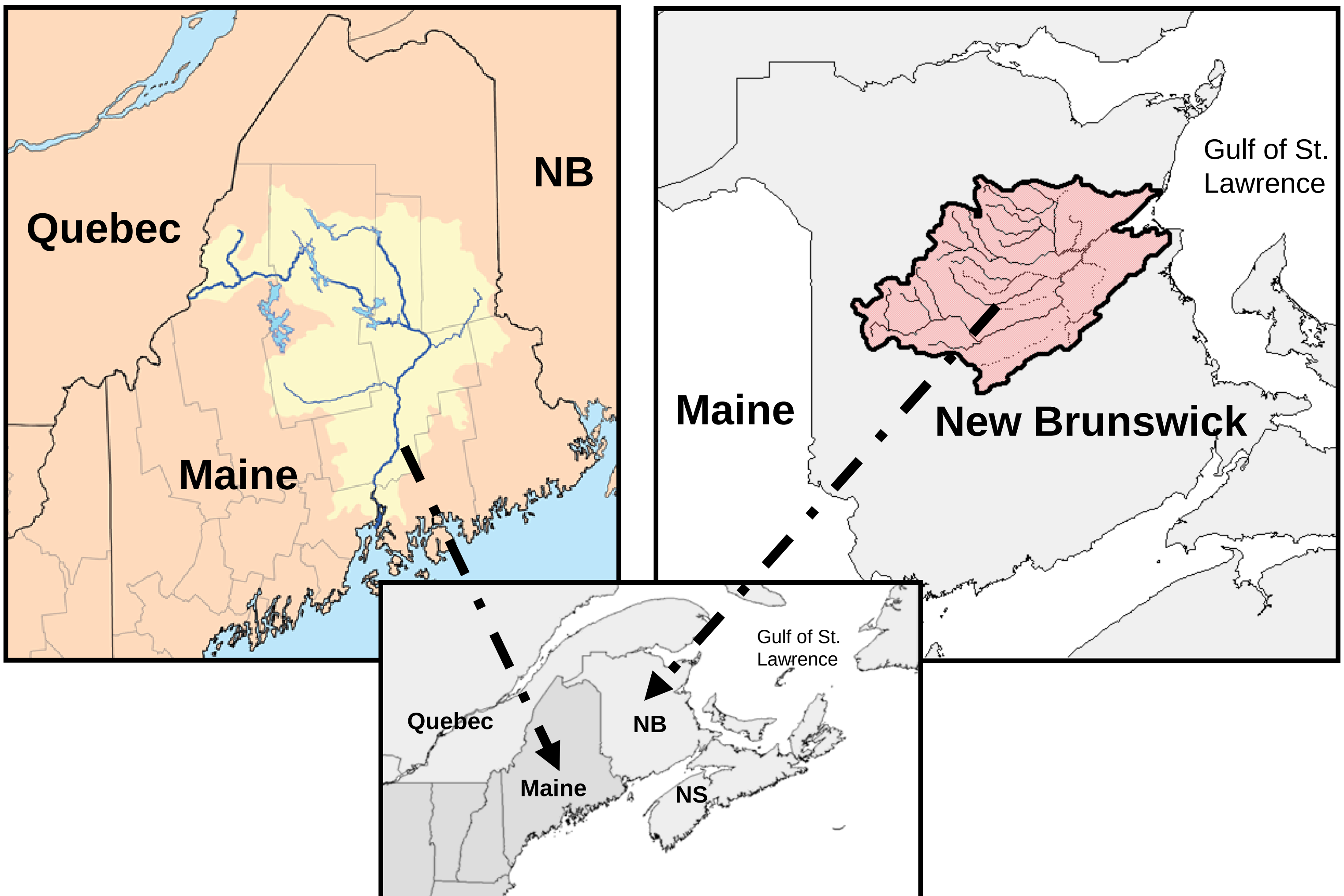
4 – temporal variability

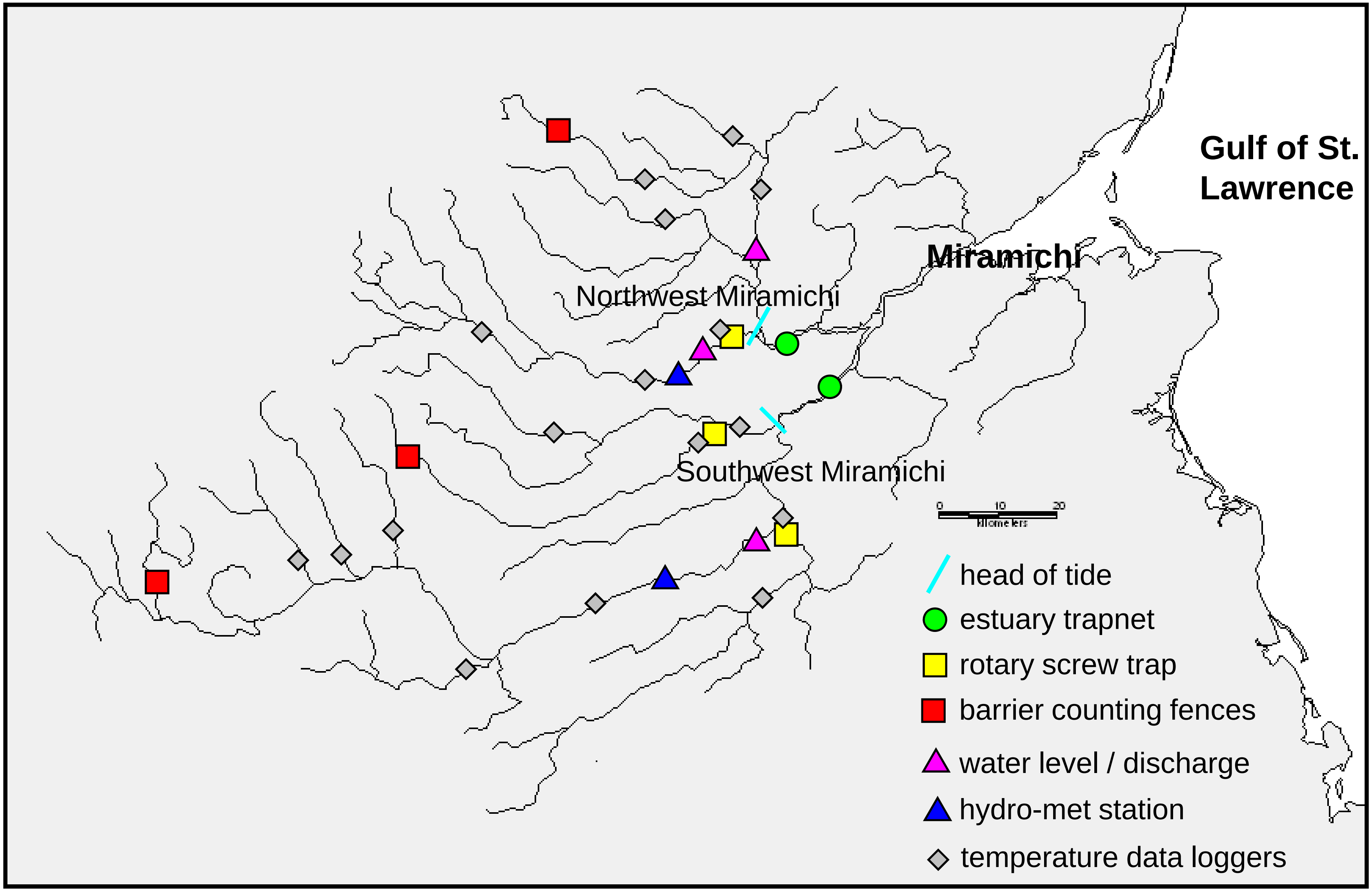
- relative abundance
- spatial distribution
- biological characteristics (run-timing, age structure, size at age)

5 – value of control site to guide restoration assessment

Penobscot and Miramichi

Miramichi River is geographically close to Penobscot





Miramichi: dendritic large watershed with limited but diverse monitoring initiatives

Physical Characteristics of Penobscot and Miramichi

	Penobscot	Miramichi
Latitude (range)	~44º30’ to ~46º30’	46º10’ to 47º20’
General direction of flow	north to south into Atlantic Ocean	west to east into Gulf of St. Lawrence
Basin area	2.22 million ha (8,570 mi^2)	1.36 million ha
Max. elevation	490 m (1,602 ft west branch)	470 m
Longest distance from the sea	320 km	250 km
Mean annual discharge (m^3 s^{-1})	402	322

Physical Characteristics of Penobscot and Miramichi

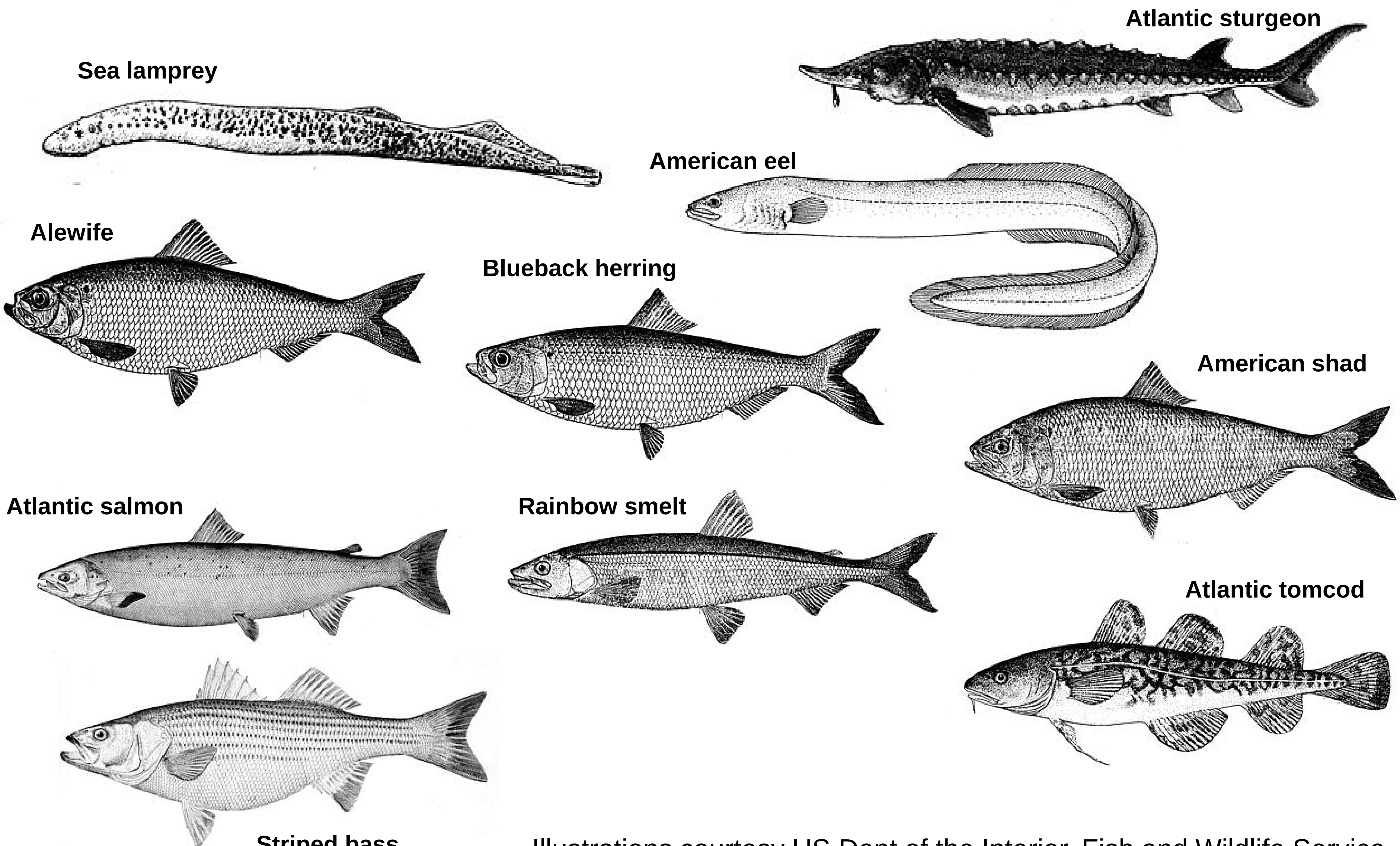
	Penobscot	Miramichi
Number of days with ice cover	Late December to March	December to April 100 to 170 days (1961 – 2002)
Mean air temperature	-10.1ºC in January +19.6ºC in July	-11ºC in January +19ºC in July
River order	6	7 (8)
Habitat area for salmon production	1,250 ha	5,500 ha
Artificial barriers to fish migration	116 dams 20 hydro-generating	<u>None</u> (few small dams in small streams)

Freshwater fish

Both rivers share a common diversity of freshwater fish species

	Penobscot	Miramichi
Brown bullhead, shiner (golden, common), chub (creek, lake, fallfish), dace (northern redbelly, blacknose, finescale, pearl), perch (white, yellow), lake trout, slimy sculpin, stickleback (3-spine, 9-spine, brook), white sucker (18 common)		
Specific to the river (may be due to incomplete documentation)	<u>*cusk (burbot)*</u>, shiner (blackchin, blacknose, spottail), fathead minnow, longnose dace, <u>*arctic char*</u>, <u>*lake whitefish*</u>, <u>*landlocked salmon*</u>, 4-spine stickleback, longnose sucker, redbreast sunfish, pumpkinseed (13)	Banded killifish, mummichog (2)
Non-native species	Brown trout, rainbow trout, splake, central mudminnow, chain pickerel, northern pike, green sunfish, smallmouth bass, largemouth bass, black crappie (10)	Brown trout, rainbow trout, tiger trout, chain pickerel*, smallmouth bass** * eradicated in single known lake ** first report in a lake Sept. 2008

Diadromous fish



Illustrations courtesy US Dept of the Interior, Fish and Wildlife Service

Diadromous fish

Miramichi River accommodates a similarly diverse diadromous fish community which the Penobscot had historically. Spawning populations are present unless noted.

	Penobscot	Miramichi
Sea lamprey (*Petromyzon marinus*)	? No upstream passage	Common
Atlantic sturgeon (*Acipenser oxyrhynchus*)	Rare	Rare No spawning
Shortnose sturgeon (*Acipenser brevirostrum*)	?	Absent
Alewife (*Alosa pseudoharengus*) Blueback herring (*Alosa aestivalis*) American shad (*Alosa sapidissima*)	Present Limited upstream passage	Abundant Commercial fishery on all three species

Diadromous fish

	Penobscot	Miramichi
Atlantic salmon (*Salmo salar*)	Maintained Upstream passage assured	Abundant Aboriginal and recreational fisheries
Rainbow smelt (*Osmerus mordax*)	Present	Abundant Commercial fishery
Atlantic tomcod (*Microgadus tomcod*)	Present	Abundant Commercial fishery
Striped bass (*Morone saxatilis*)	Present No spawning ?	Abundant All directed fisheries closed
Speckled trout* (*Salvelinus fontinalis*) * sea run trout	Abundant	Abundant Aboriginal and recreational fisheries
American eel (*Anguilla rostrata*)	Present limited upstream passage	Abundant Commercial fishery

Abundance and distribution of diadromous fish in Miramichi

Information comes from several sources:

1) fisheries

2) directed research

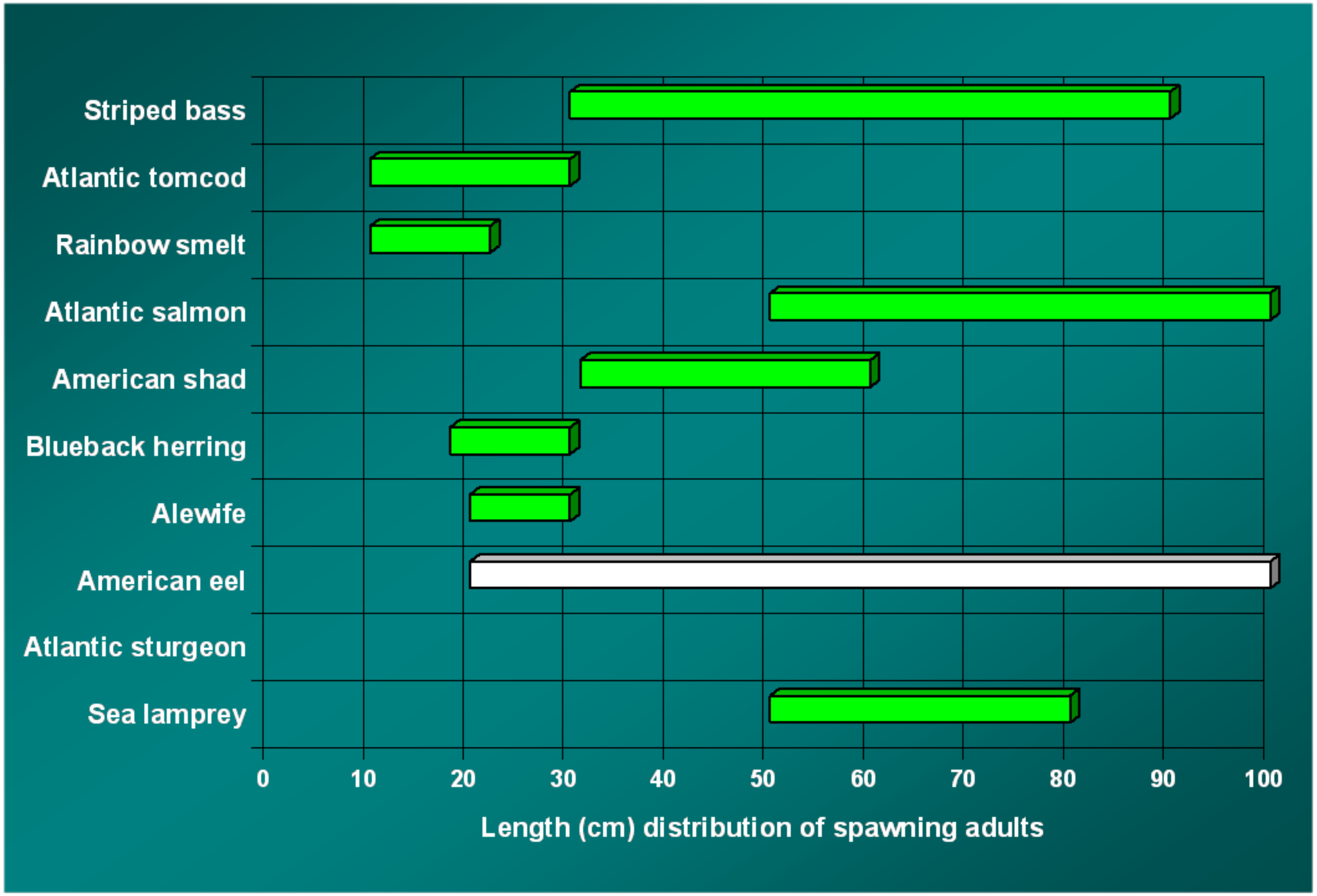
3) monitoring facilities in estuary and inriver,

4) electrofishing surveys,

5) local knowledge

Diadromous fish in Miramichi

Size of spawning adults



iteroparous, 13+ years

iteroparous, ? years

iteroparous, 7 years

iteroparous, 11 years

iteroparous, 11 years

iteroparous, 12 years

iteroparous, 11 years

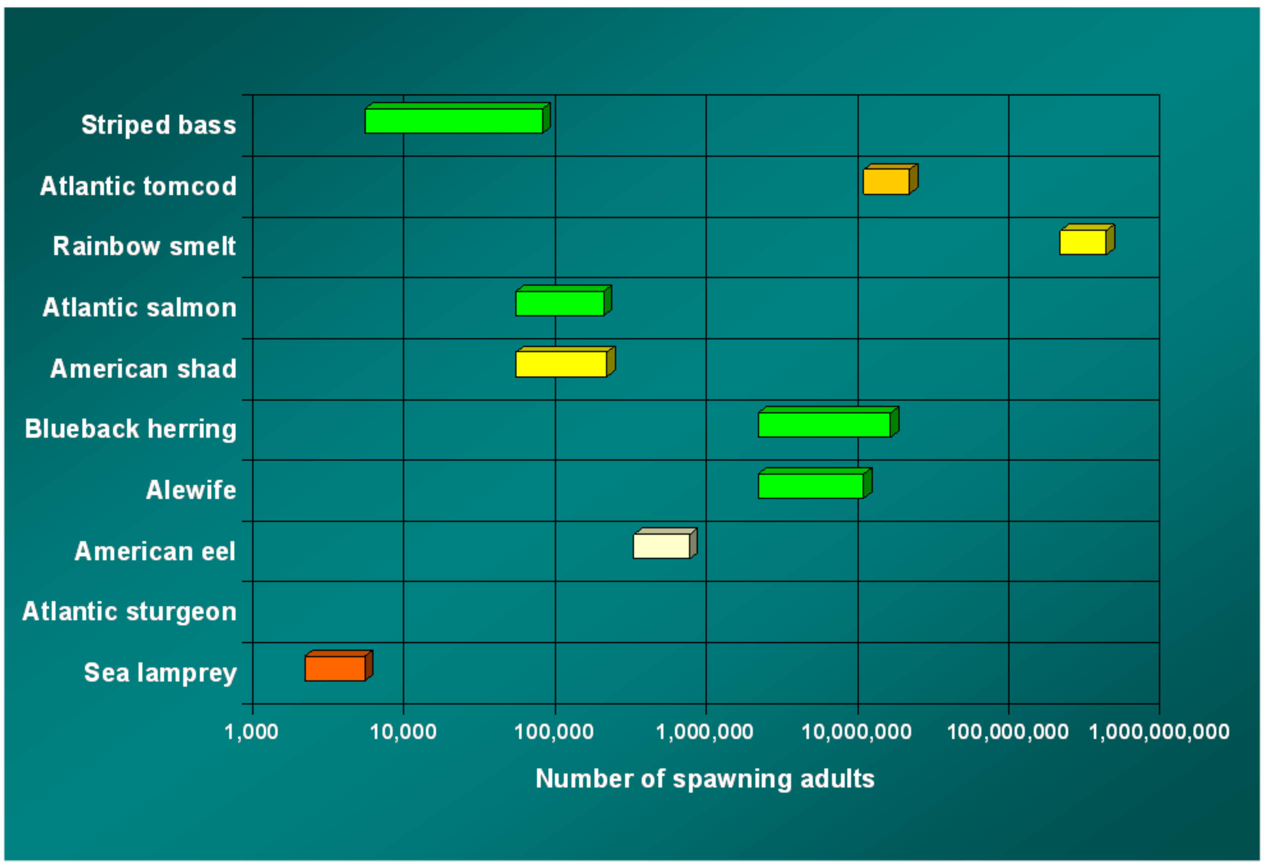
semelparous, catadromous, 20+yrs

semelparous, 10+ years

eel – freshwater samples

Relative abundance of diadromous fish in Miramichi

Abundance estimates of adult spawning stock size are based on species specific assessments, from fisheries landings with assumptions on exploitation rates, or based from monitoring facilities and relative habitat areas.



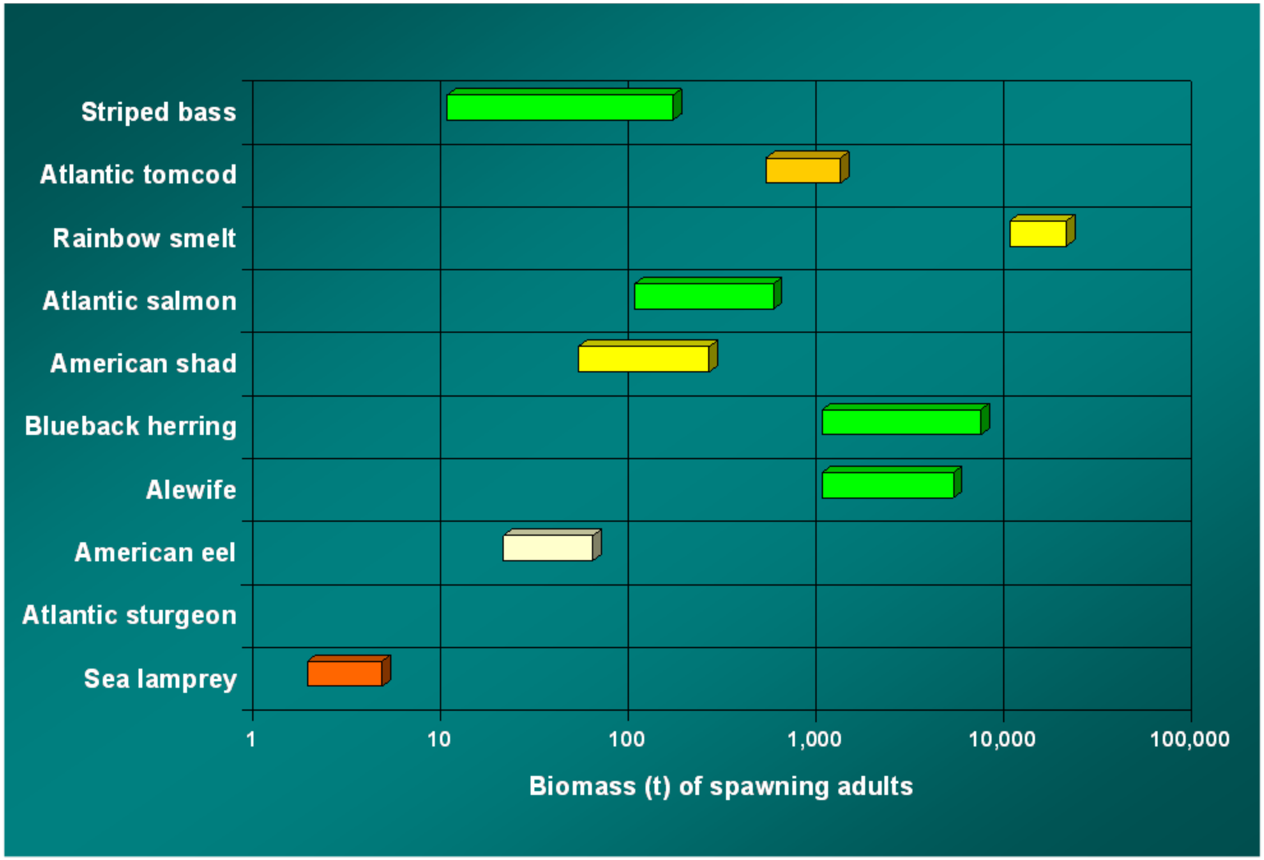
Reliability

- assessed
- landings & ER
- qualitative

- eel – abundance in freshwater, all sizes

Relative abundance of diadromous fish in Miramichi

Biomass estimates based on numerical abundance and mean weight.
Biomass of spawning anadromous fish ~ ***15,000 to 25,000 t*** annually



Reliability

- assessed
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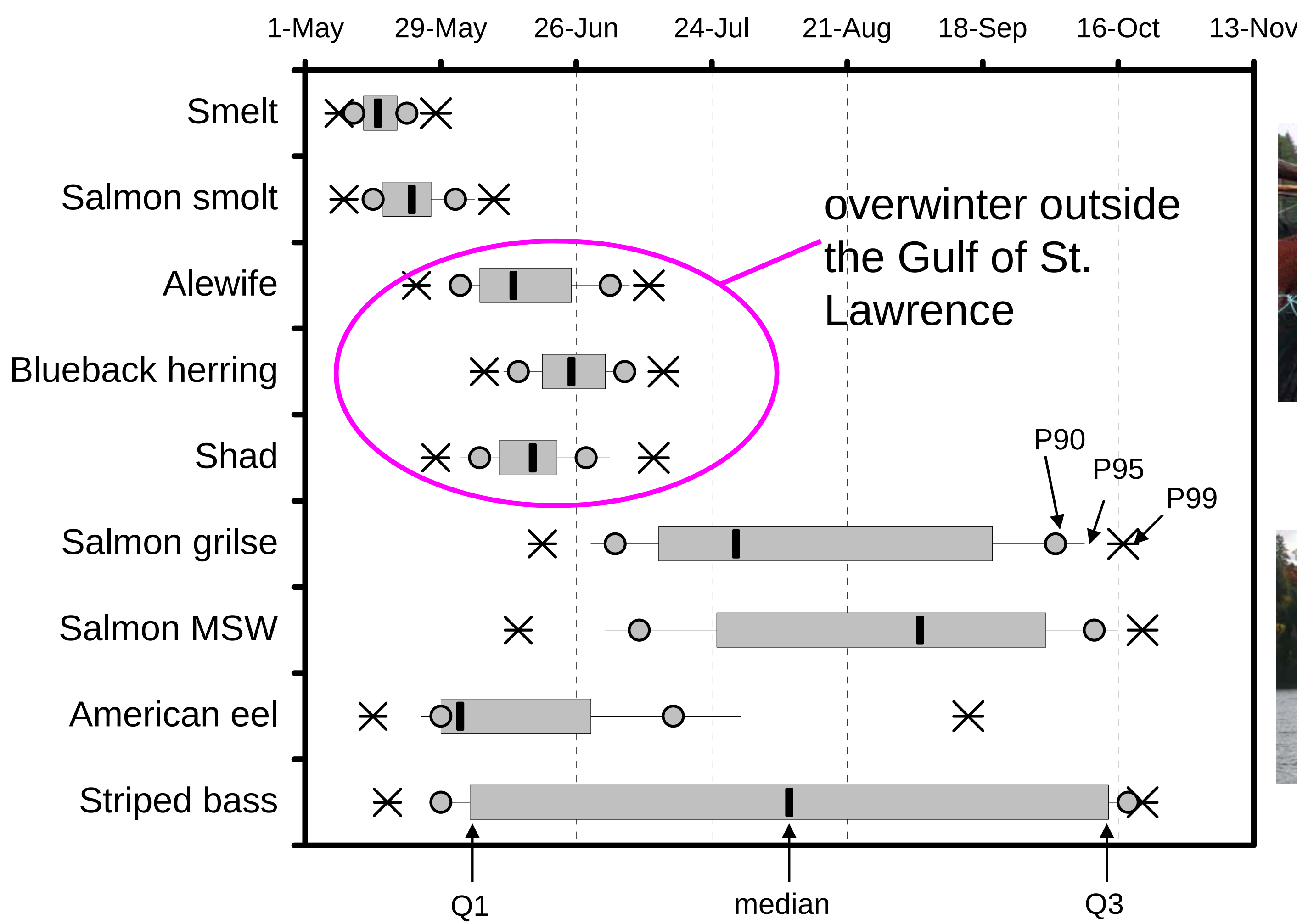
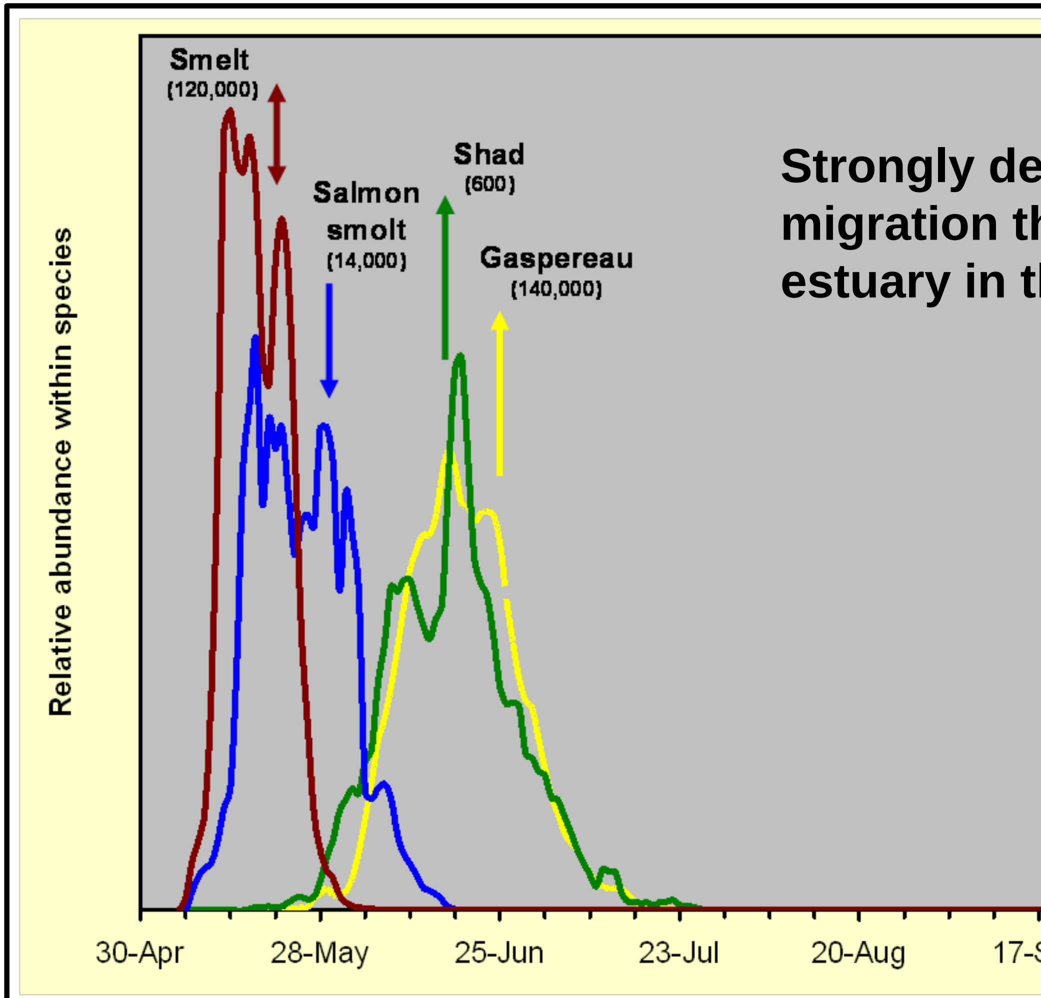
Inseason timing of catches at the estuary trapnets in the Miramichi River (1998 to 2007)

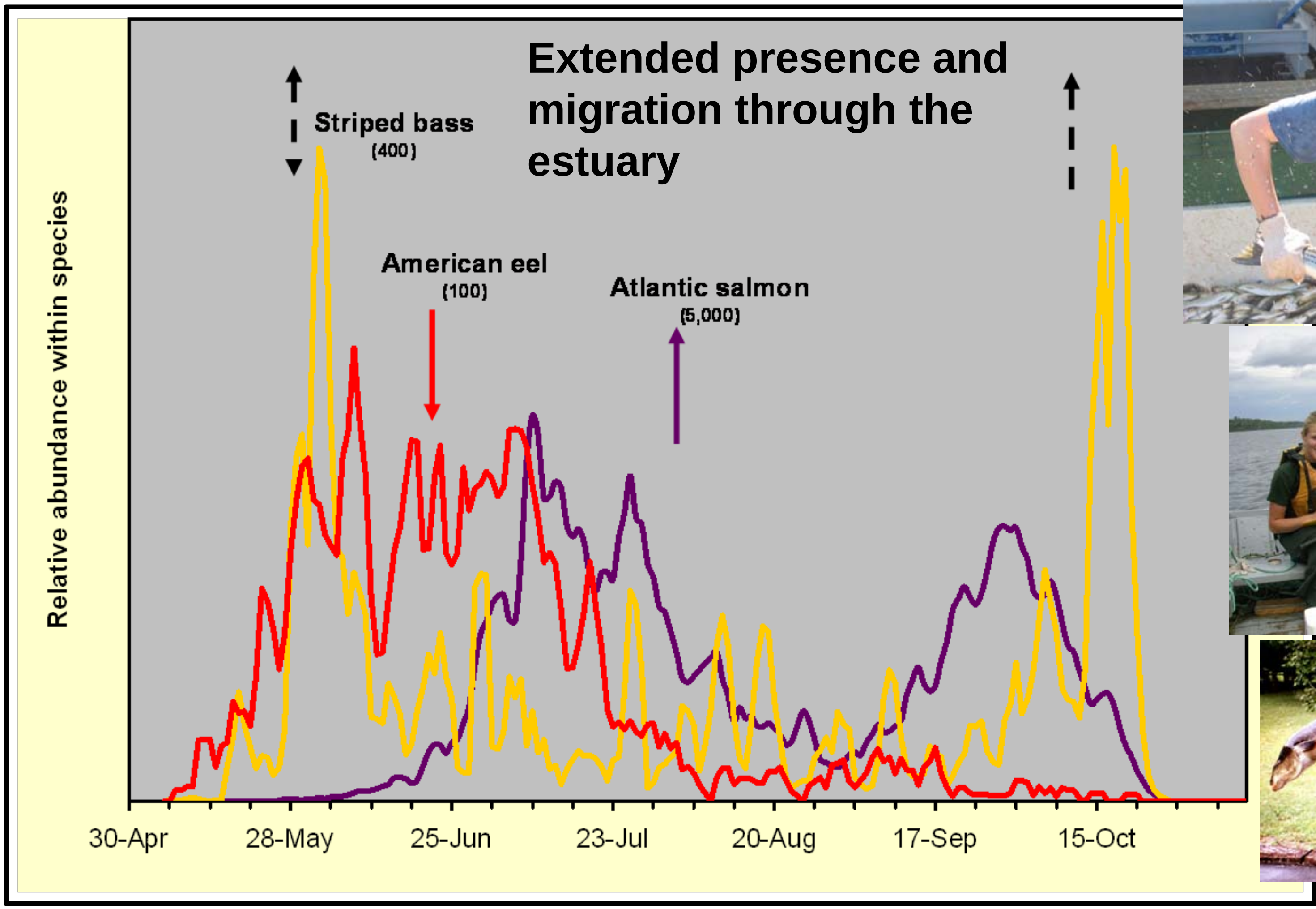


Inseason timing of catches at the estuary trapnets in the Miramichi River (1998 to 2007)



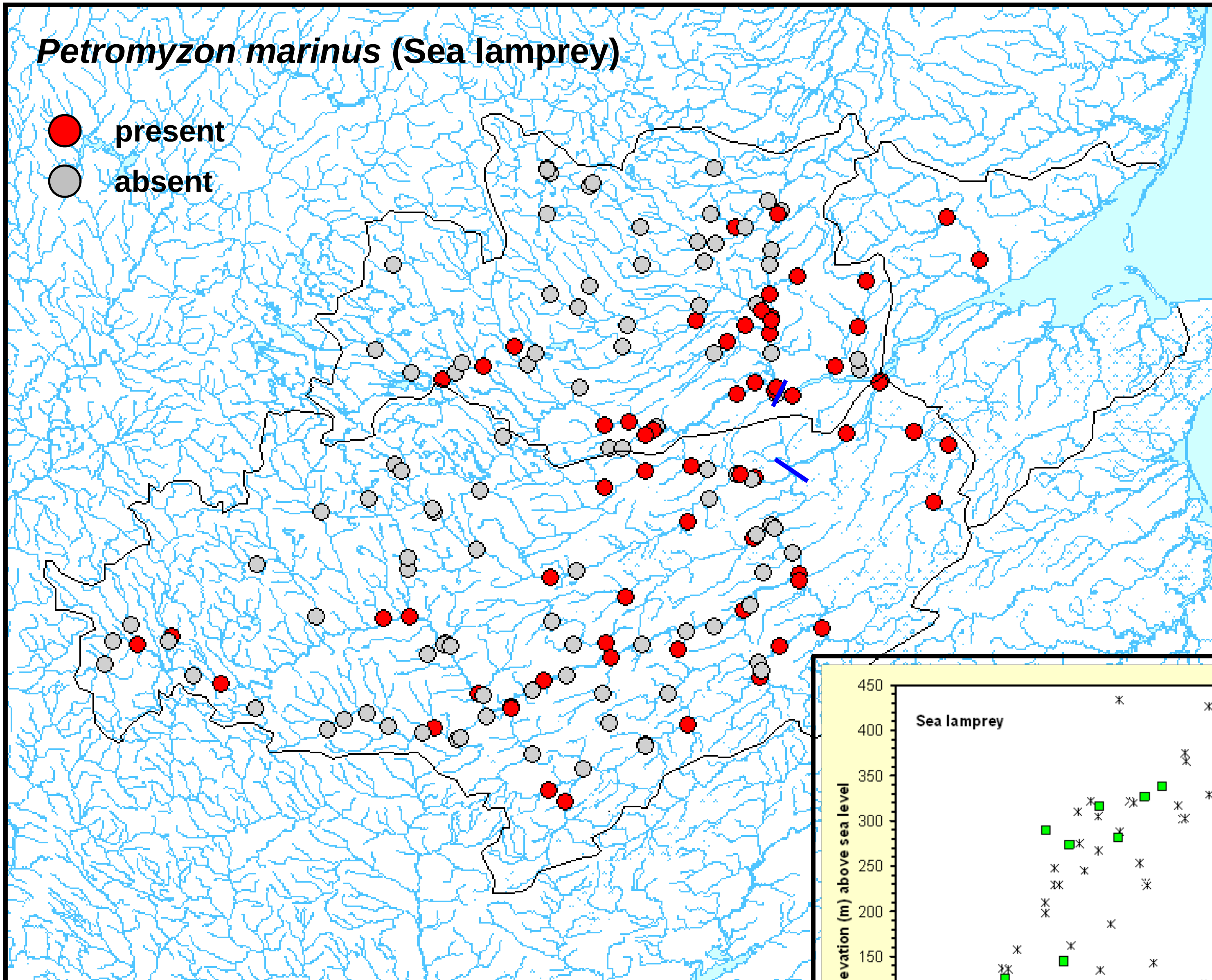
Strongly defined migration through the estuary in the spring

Inseason timing of catches at the estuary trapnets in the Miramichi River (1998 to 2007)

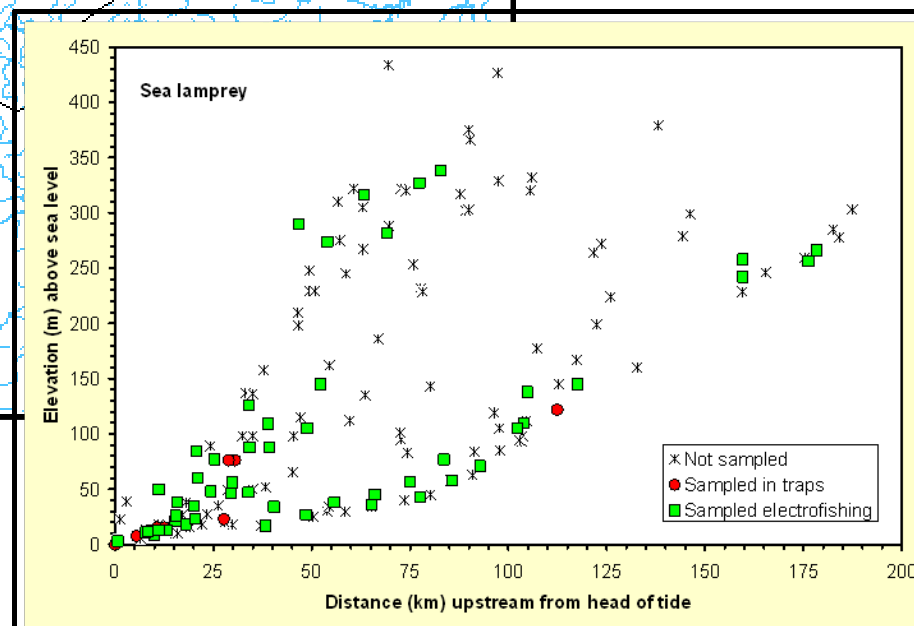


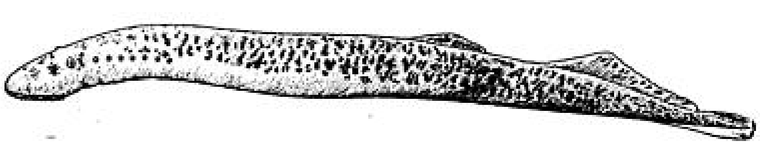
Spatial distribution (upstream penetration) of diadromous fish in Miramichi

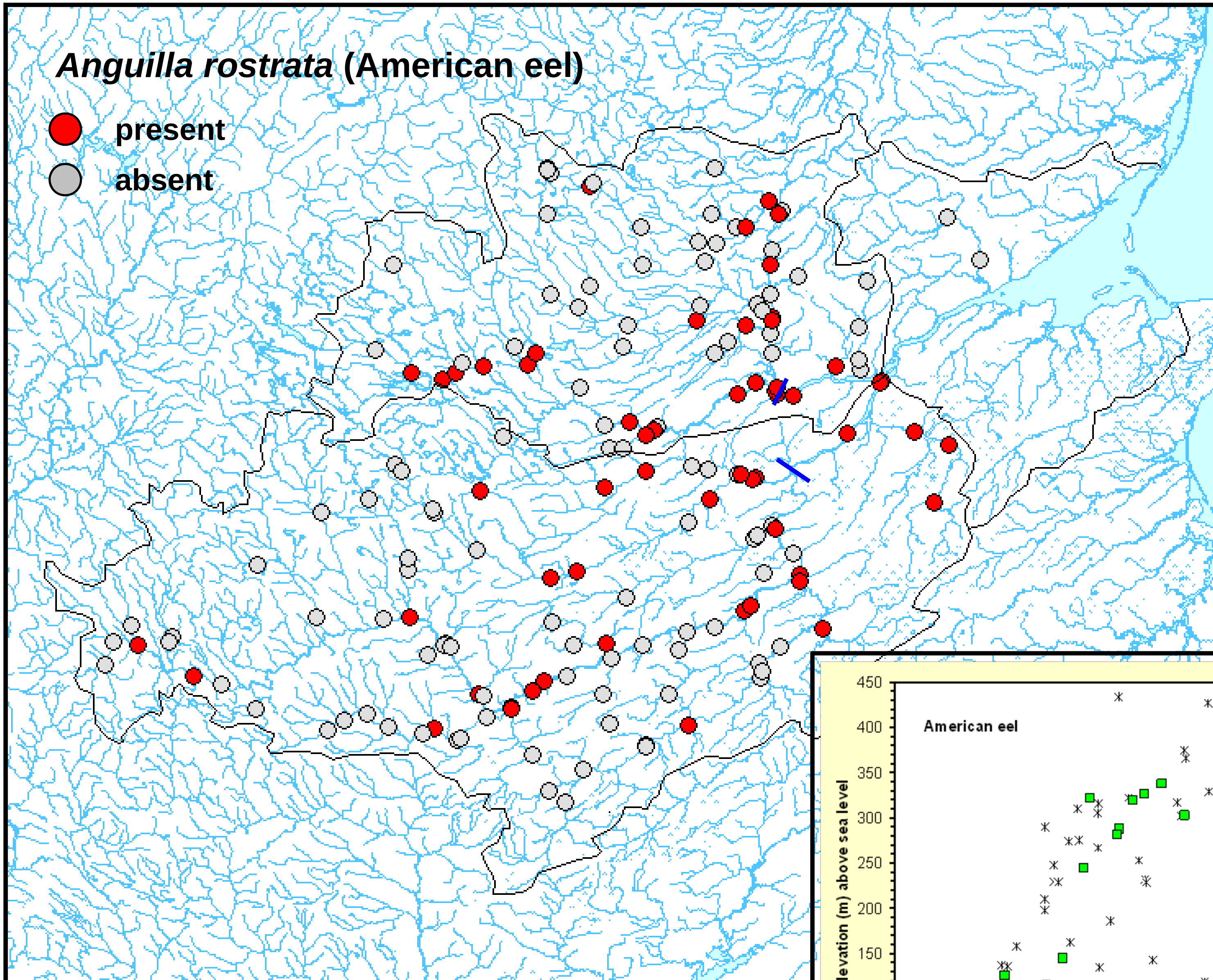
- Distance above head of tide
- Elevation (above sea level)



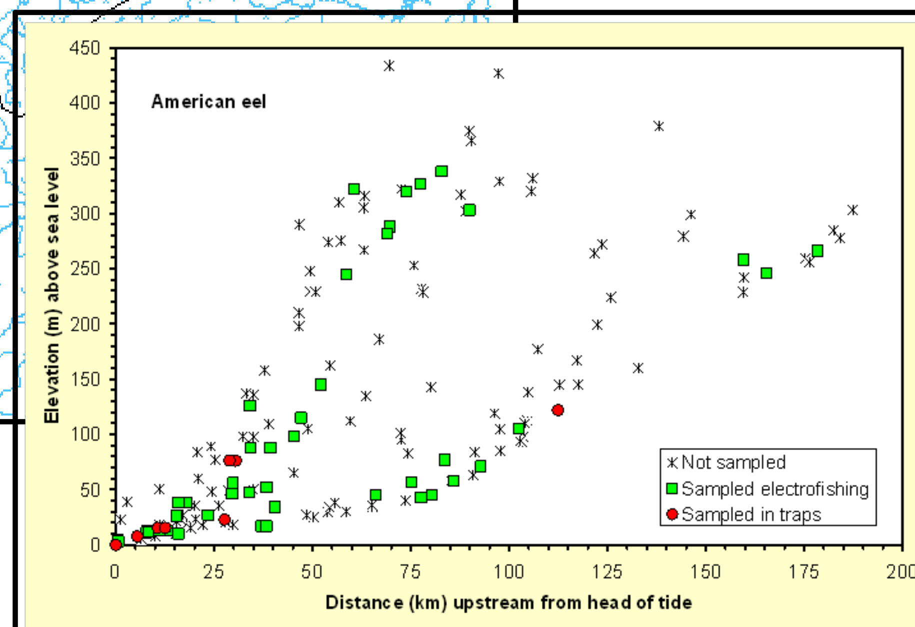
Broad distribution
- **to 178 km**
- **to 338 m (asl)**

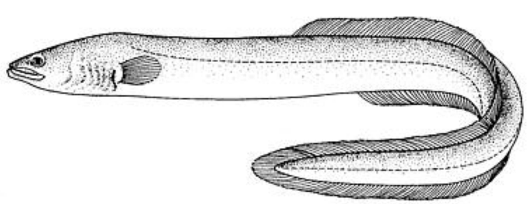


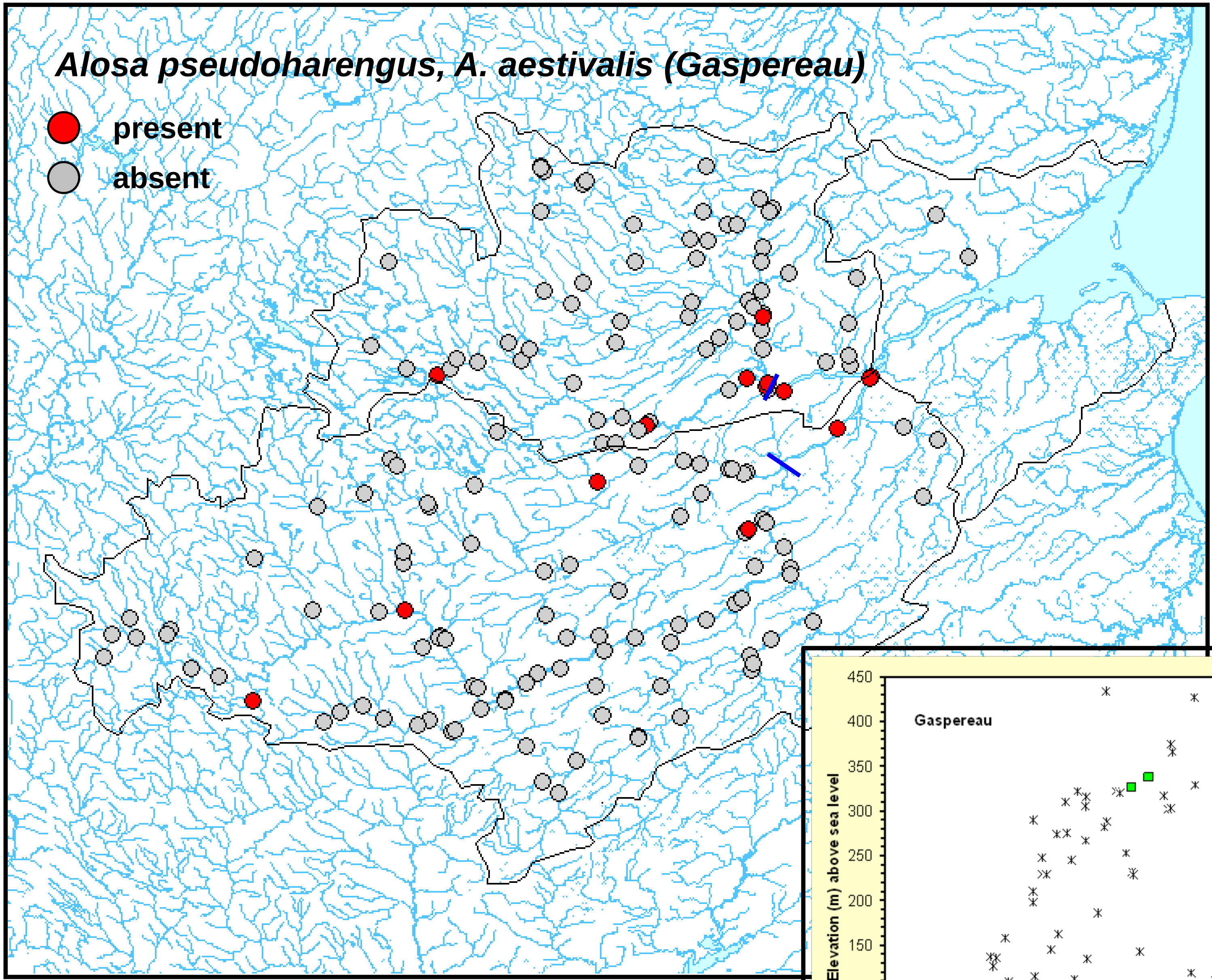




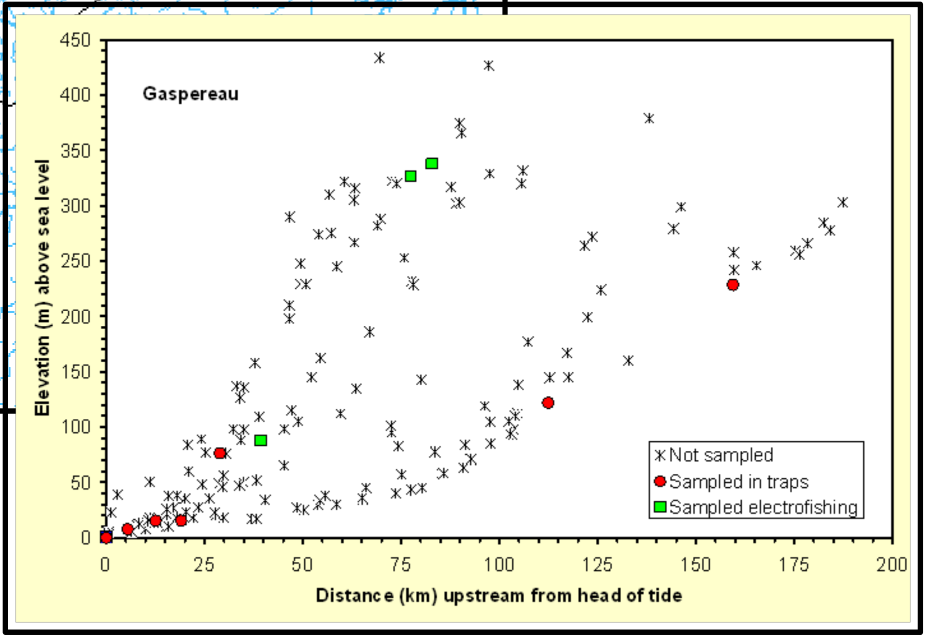
Broad distribution
- **to 178 km**
- **to 338 m (asl)**

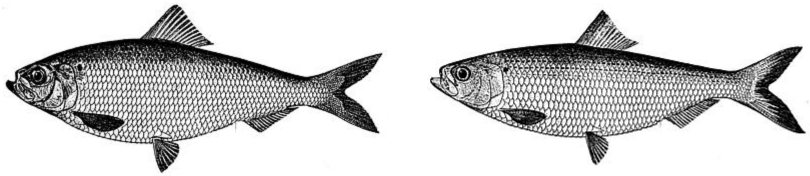


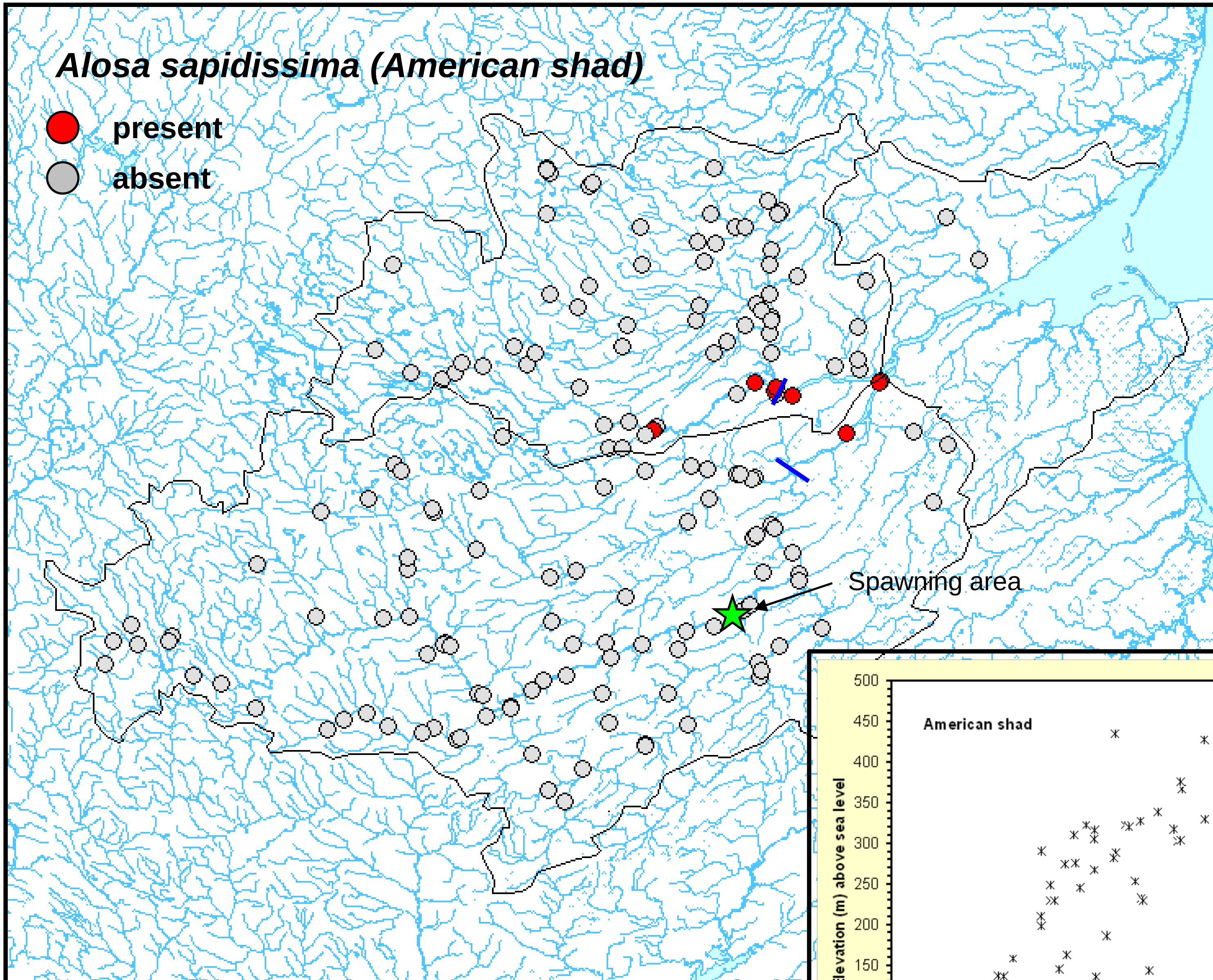




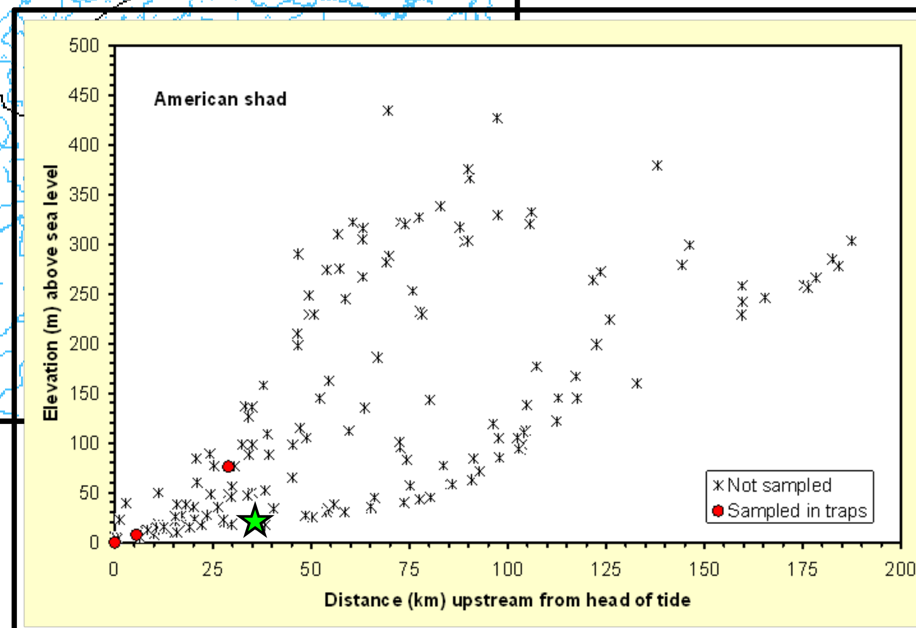
Broad distribution
- **to 159 km**
- **to 338 m (asl)**

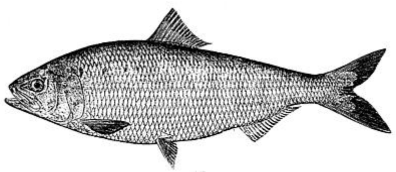


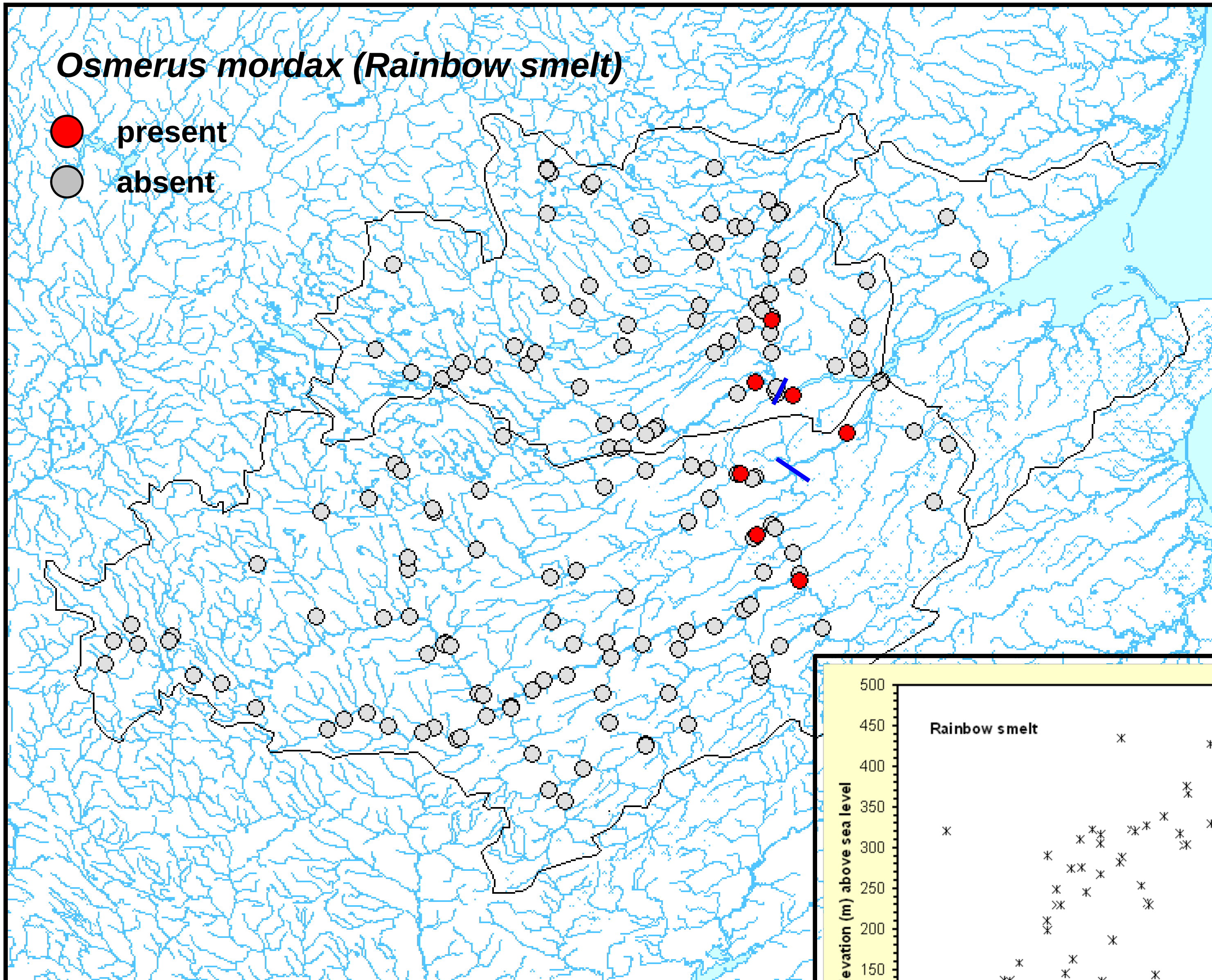




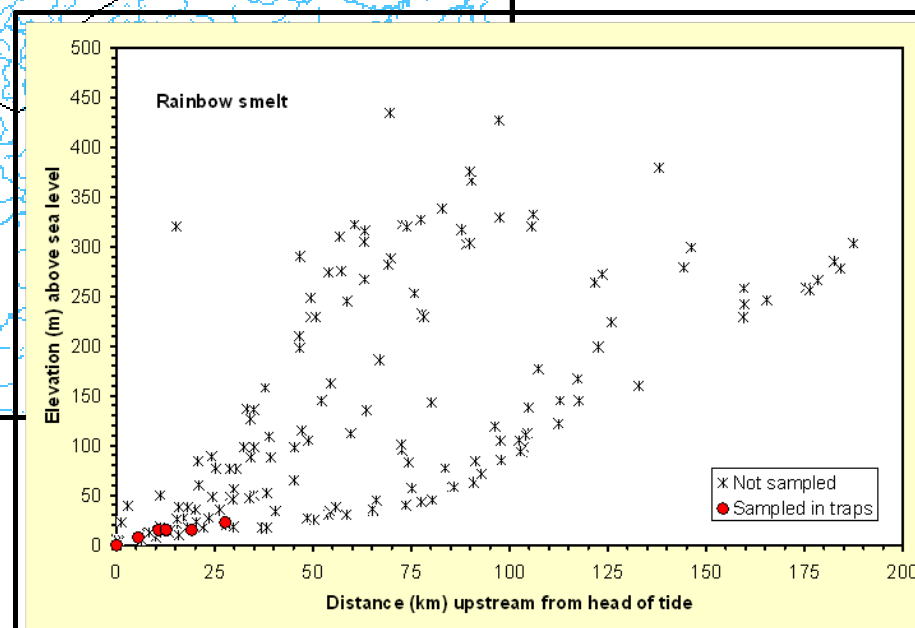
Limited distribution
- **to 40 km**
- **to 76 m (asl)**

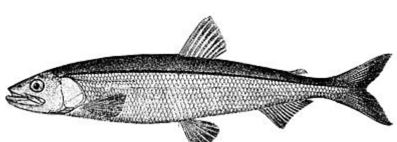


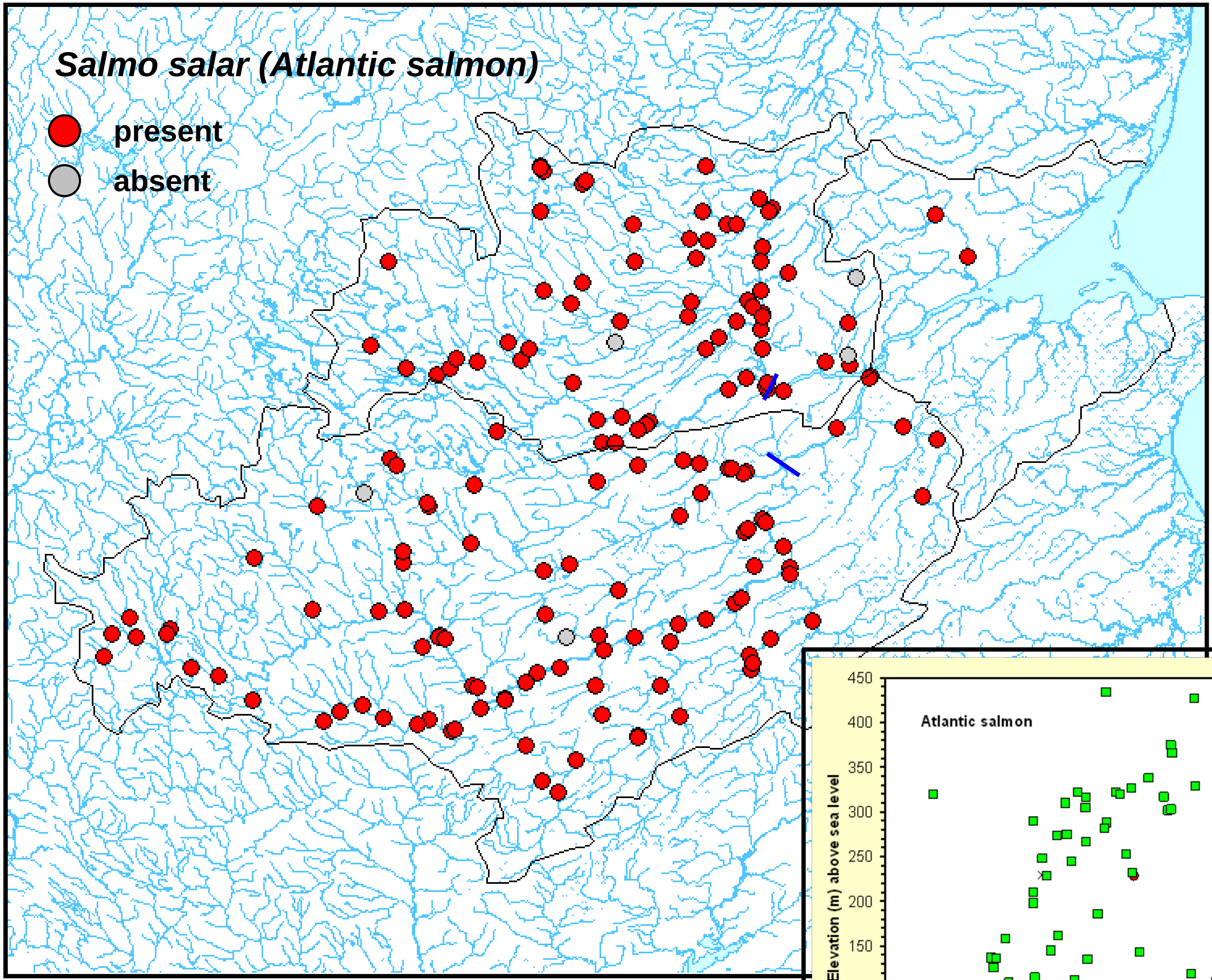




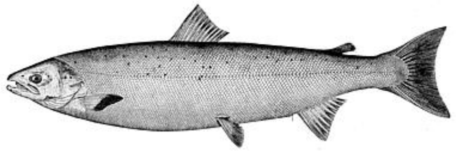
Limited distribution
- to 30 km
- to 25 m (asl)

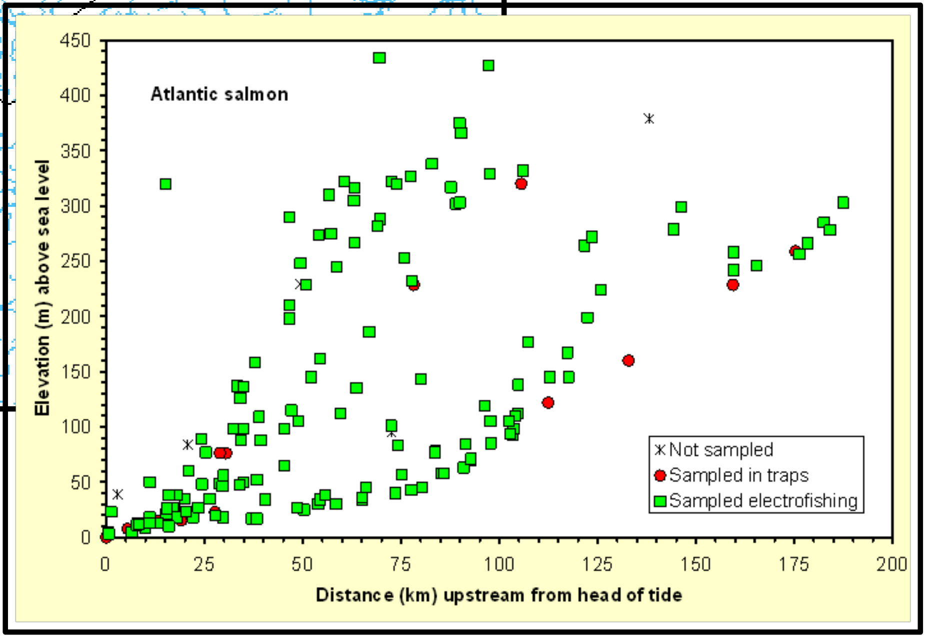


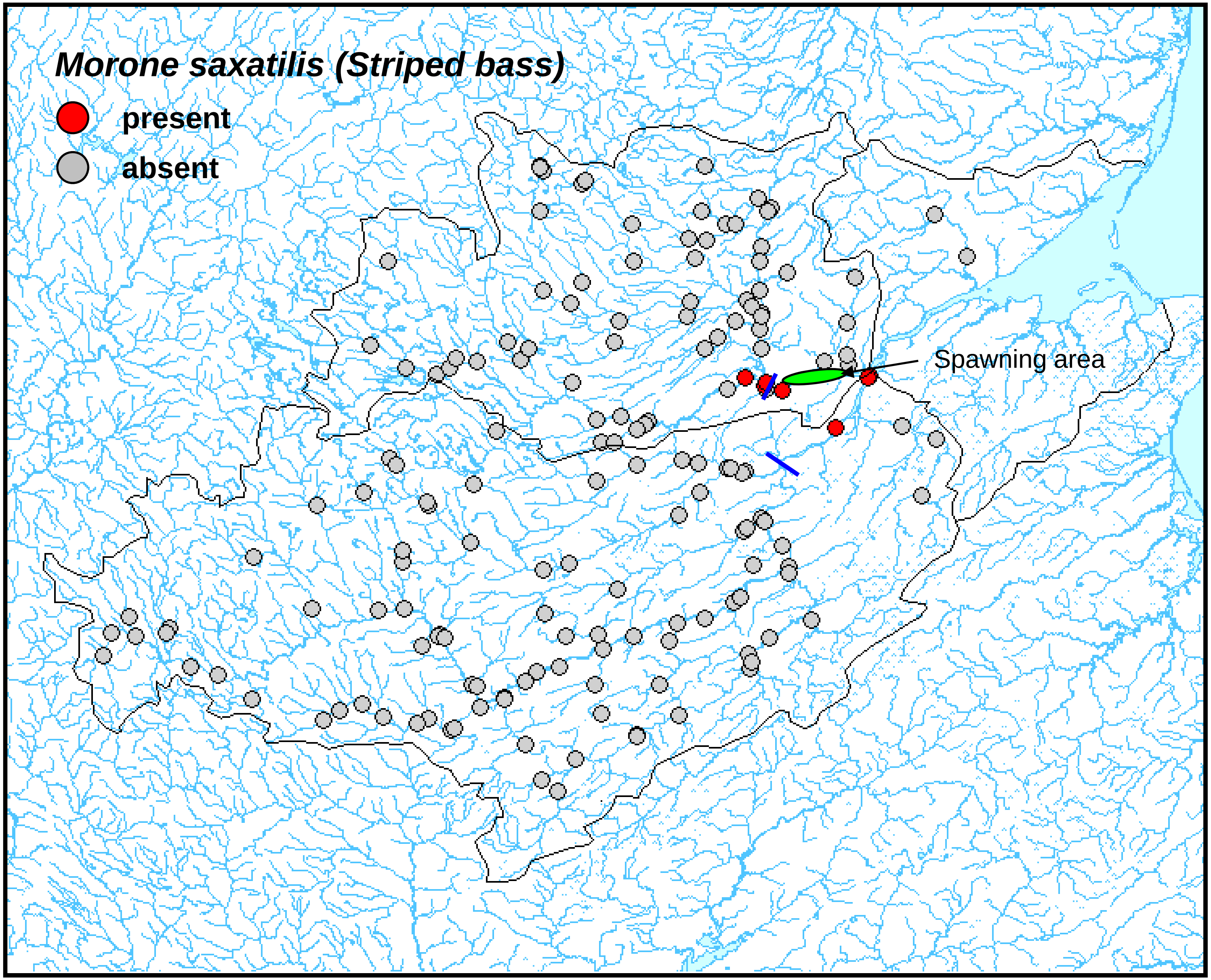


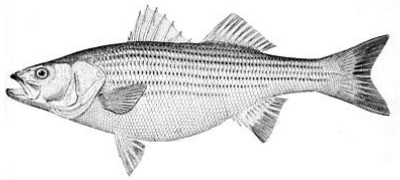


Broad distribution
- **to 187 km**
- **to 434 m (asl)**

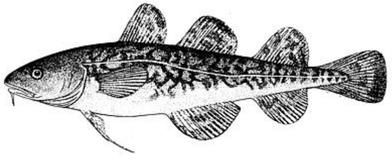






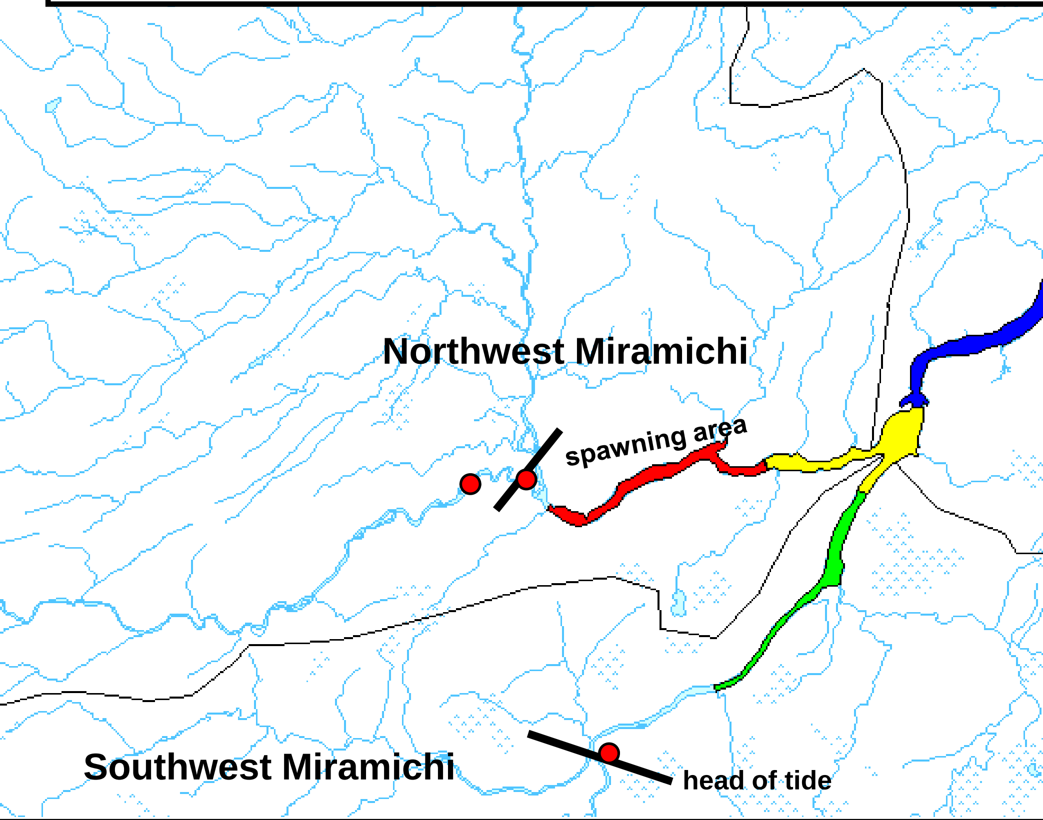


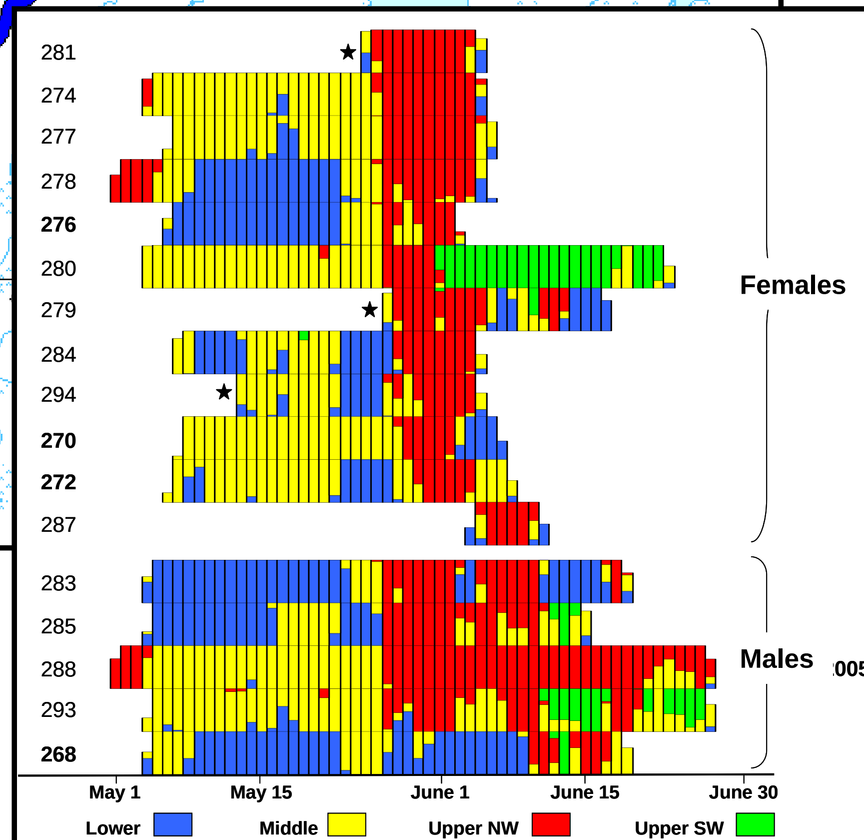
Striped bass and Atlantic tomcod
- **limited to tidal water**

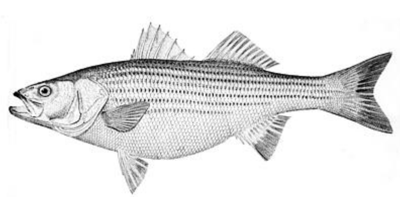


Morone saxatilis ***(Striped bass)***

- ***occupation of tidal water areas by spawners in the Miramichi River***
- ***May and June***
- ***based on acoustic telemetry (Douglas et al. 2009)***







Upstream penetration

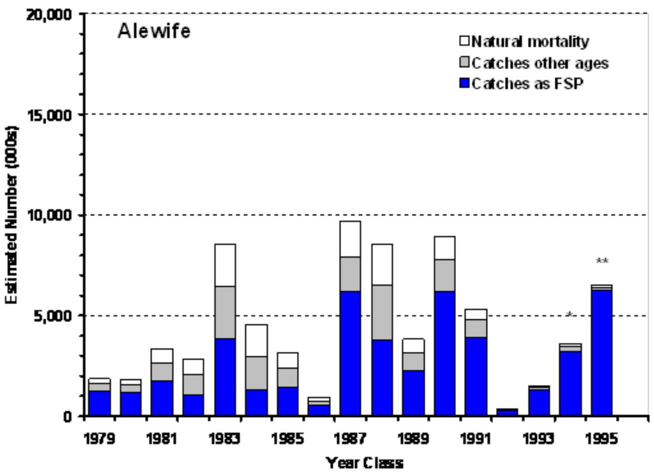
	Observed	Potential
Atlantic tomcod	Tidal water	Tidal water
Striped bass	Tidal water	Tidal water
Rainbow smelt	30 km 25 m (asl)	< 30 m (asl)
American shad	40 km 76 m (asl)	< 50 km < 100 m (asl)
Alewife	159 km; 338 m (asl) Not distinguished for species	Alewife: > 160 km, > 300 m (asl) Blueback: ?
Blueback herring		
Sea lamprey	178 km 338 m (asl)	Entire basin
American eel	178 km 338 m (asl)	Entire basin
Atlantic salmon	187 km 434 m (asl)	Entire basin

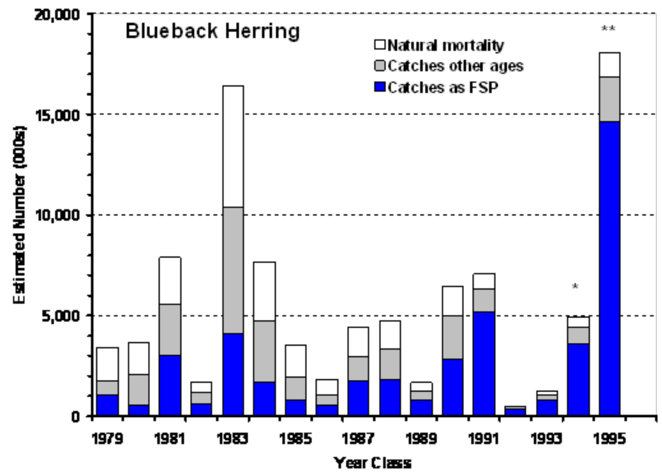
Temporal variation of diadromous fish in Miramichi

1. relative abundance
2. spatial distribution
3. biological characteristics

Temporal variation in abundance

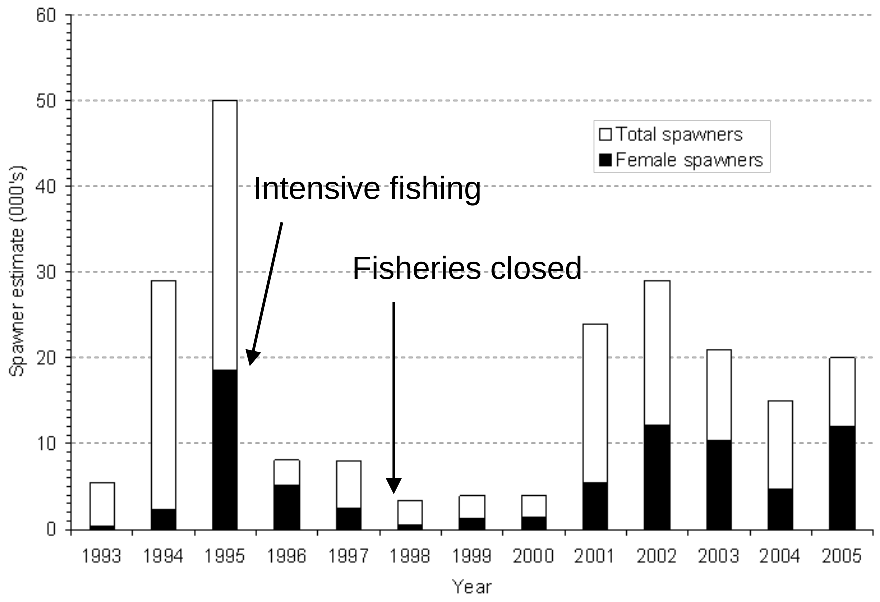
Annual CV over time period (mean number)	Assessment 1982 to 1999	Estuary trapnet catches (2 sites) 1998 to 2007	Rotary screw trap catches (2 sites) 1999 to 2007
Alewife	46% (5.8 million)		
Blueback herring	49% (8.2 million)		
Gaspereau	37% (14.0 million)	46% to 57% (38,000 to 93,000)	63% to 194% (73 to 147)





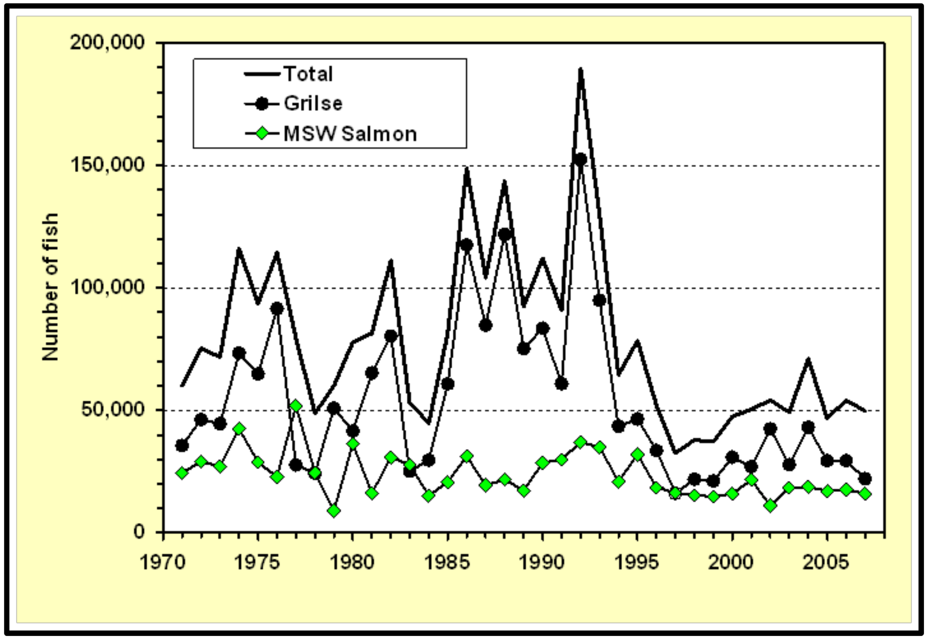
Temporal variation in relative abundance

Annual CV (%) over time period (mean)	Spawning population assessment 1993 to 2005	Catches at estuary trapnets (2) 1994 to 2007
Striped bass	81% (17,000)	79% to 100% (139 to 229)



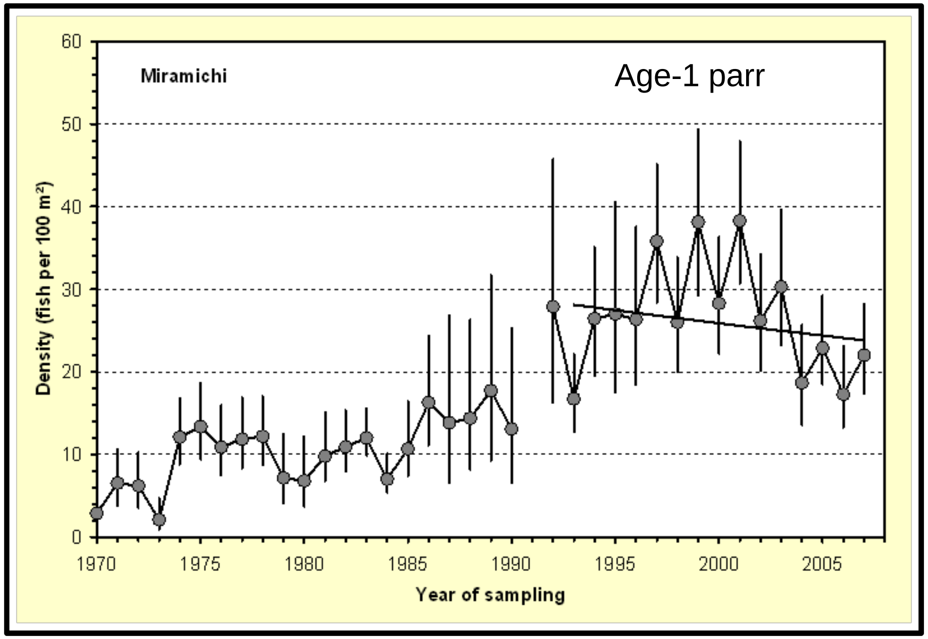
Temporal variation in relative abundance

Annual CV over time period (mean)			
Atlantic salmon adults	Assessment 1984 to 2007	Estuary trapnet catches (2 sites) 1998 to 2007	Headwater counting fences (3 sites) 1998 to 2007
	56% (76,200)	28% to 36% (1,474 to 3,046)	14% to 30% (562 to 1,732)



Temporal variation in relative abundance

Annual CV over time period (mean)			
Atlantic salmon juveniles	Fry density fish 100 m^{-2}	Parr density fish 100 m^{-2}	Biomass g 100 m^{-2}
Four main rivers 1984 to 2007	31% to 46% (45 to 95)	49% to 83% (18 to 29)	31% to 53% (215 to 399)



Temporal variation in spatial distribution

Interpretation of extent of upstream penetration depends on:

1) areas sampled

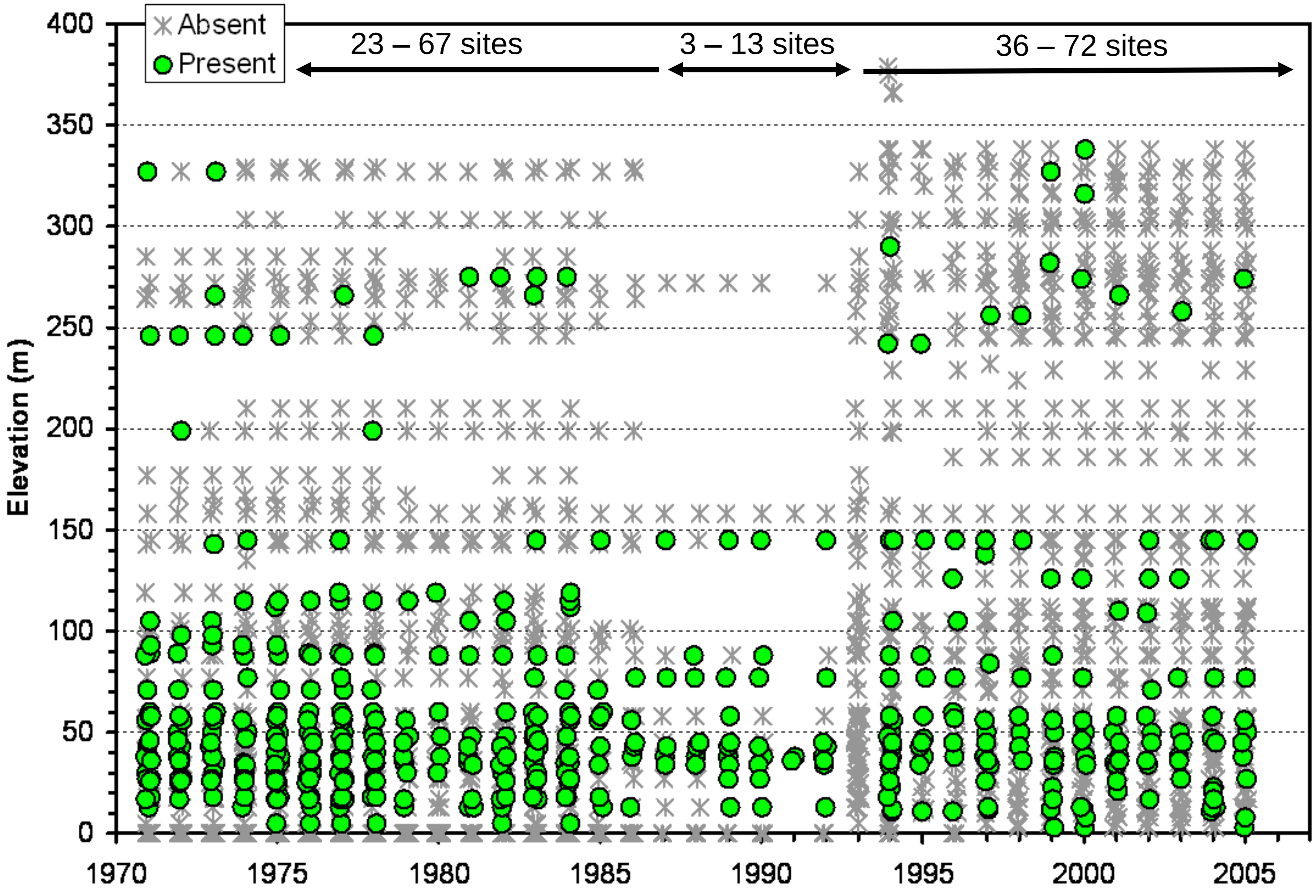
2) ability to observe/catch the animal with the sampling gear

3) abundance of the animal

Examples of variation in interpretation of extent of upstream penetration based on juvenile electrofishing surveys

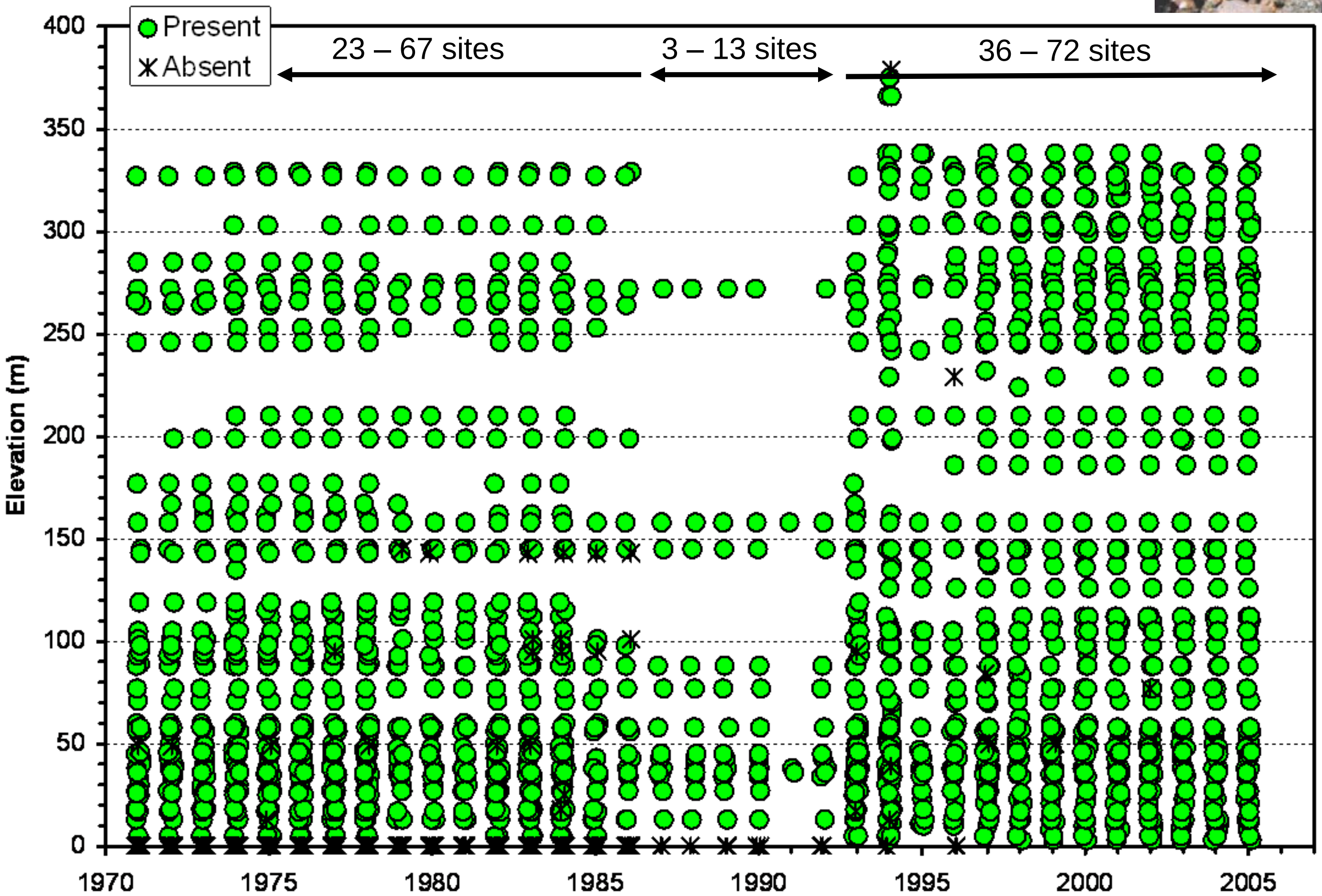
Interpretation of upstream penetration – sea lamprey

Upstream penetration based on catches in electrofishing surveys



Interpretation of upstream penetration – Atlantic salmon

Upstream penetration based on catches in electrofishing surveys



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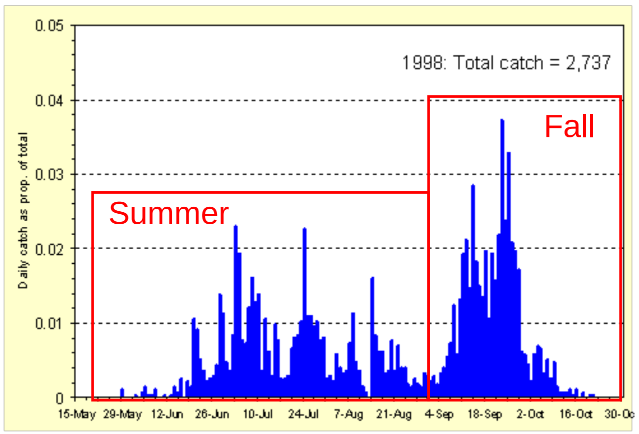
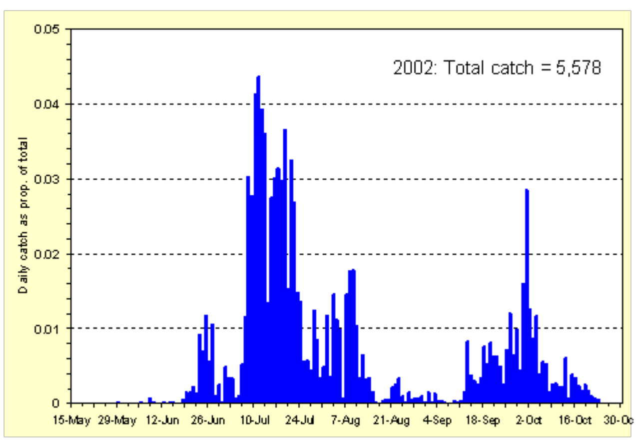
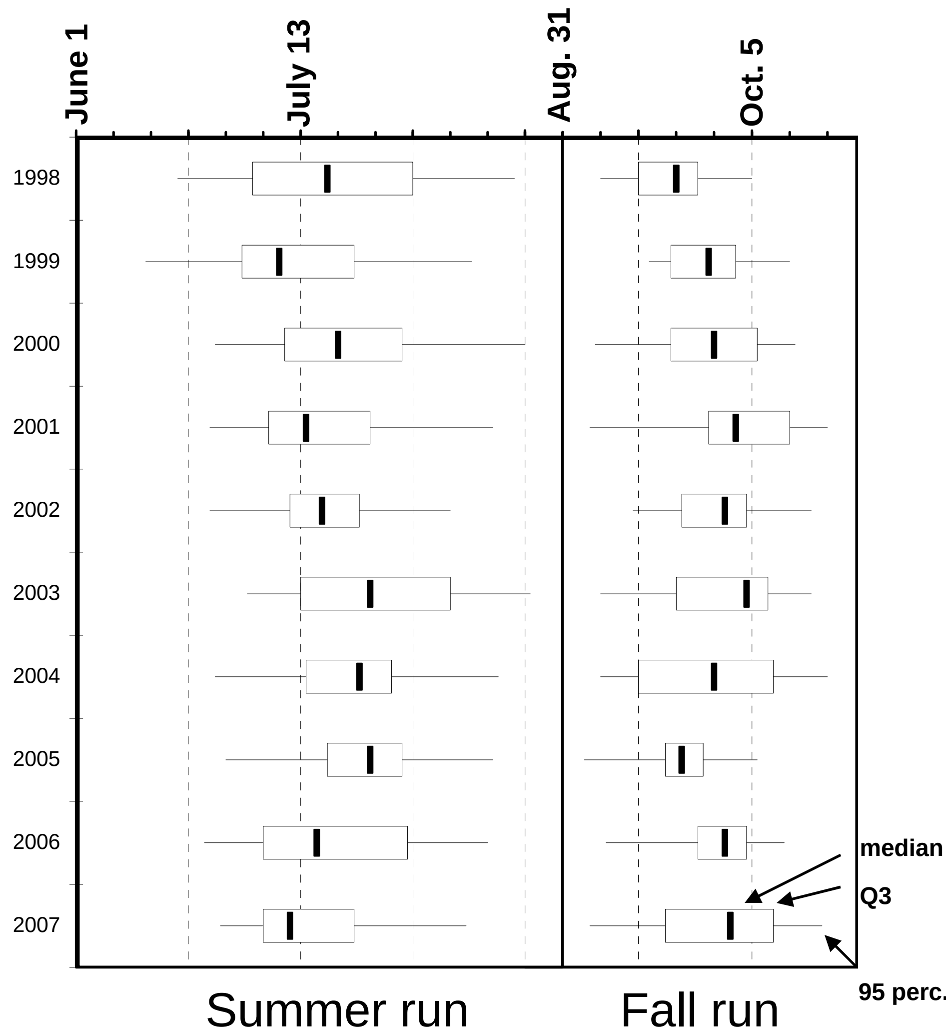
Temporal variation in characteristics

Timing of Atlantic salmon catches in estuary trapnets

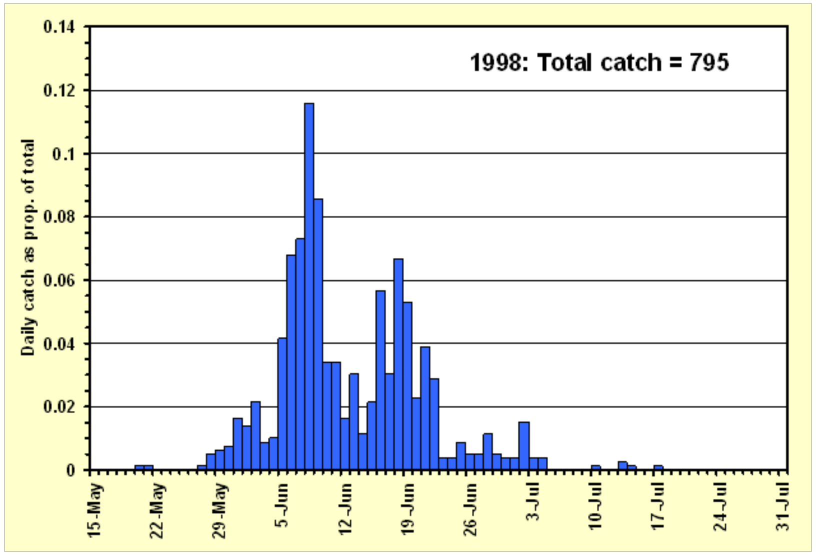


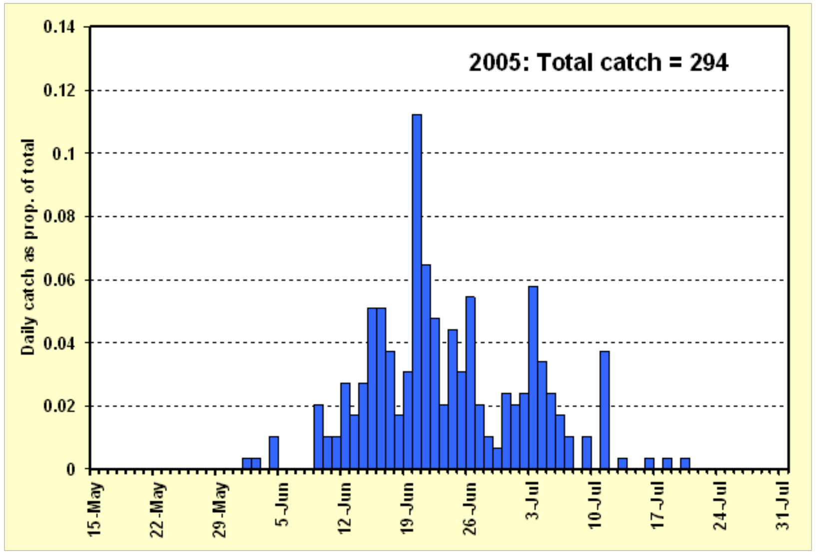


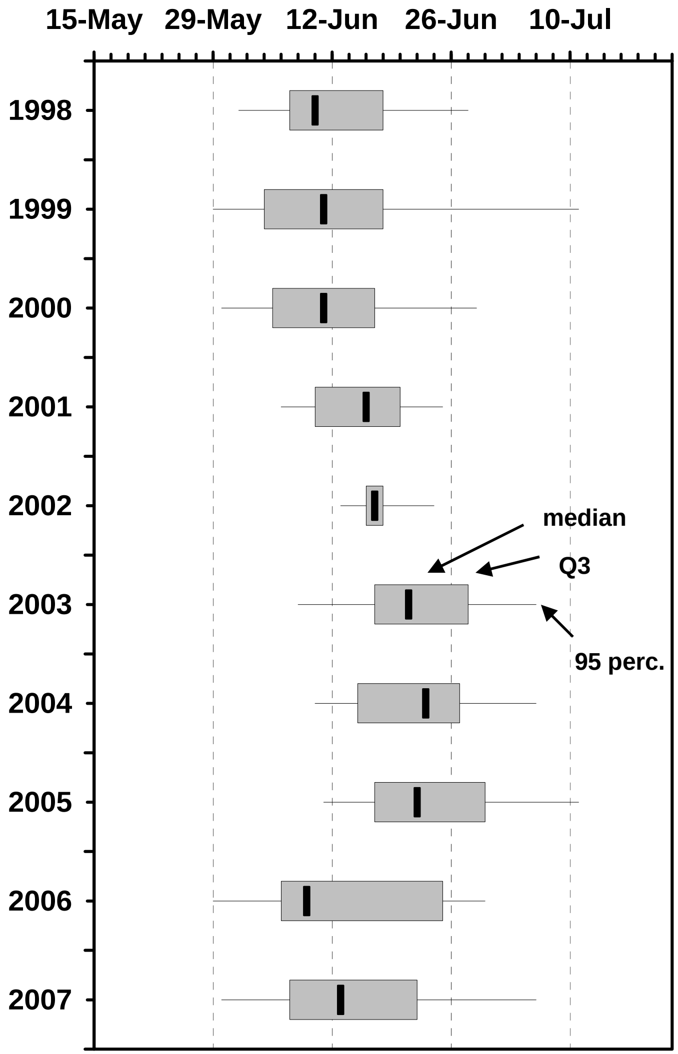
Total catch	% summer
2,737	51%
3,069	71%
3,558	61%
6,312	42%
5,578	76%
4,675	63%
6,125	61%
5,013	60%
5,110	60%
3,458	70%



Temporal variation in timing of American shad catches in estuary trapnets







Repeat spawning is maintained (smelt, gaspereau, shad, salmon, bass)

Species	Age at first spawning (years)	Oldest observed age (years)	Number of spawnings
Alewife	2 to 5	11	6 to 7
Blueback herring	2 to 7	12	6 to 7
Shad	3 to 6	11	7
Striped bass	2 to 4 (males) 3 to 5 (females)	13	
Atlantic salmon	3 to 7 (1 to 3 sea years)	11	up to 7

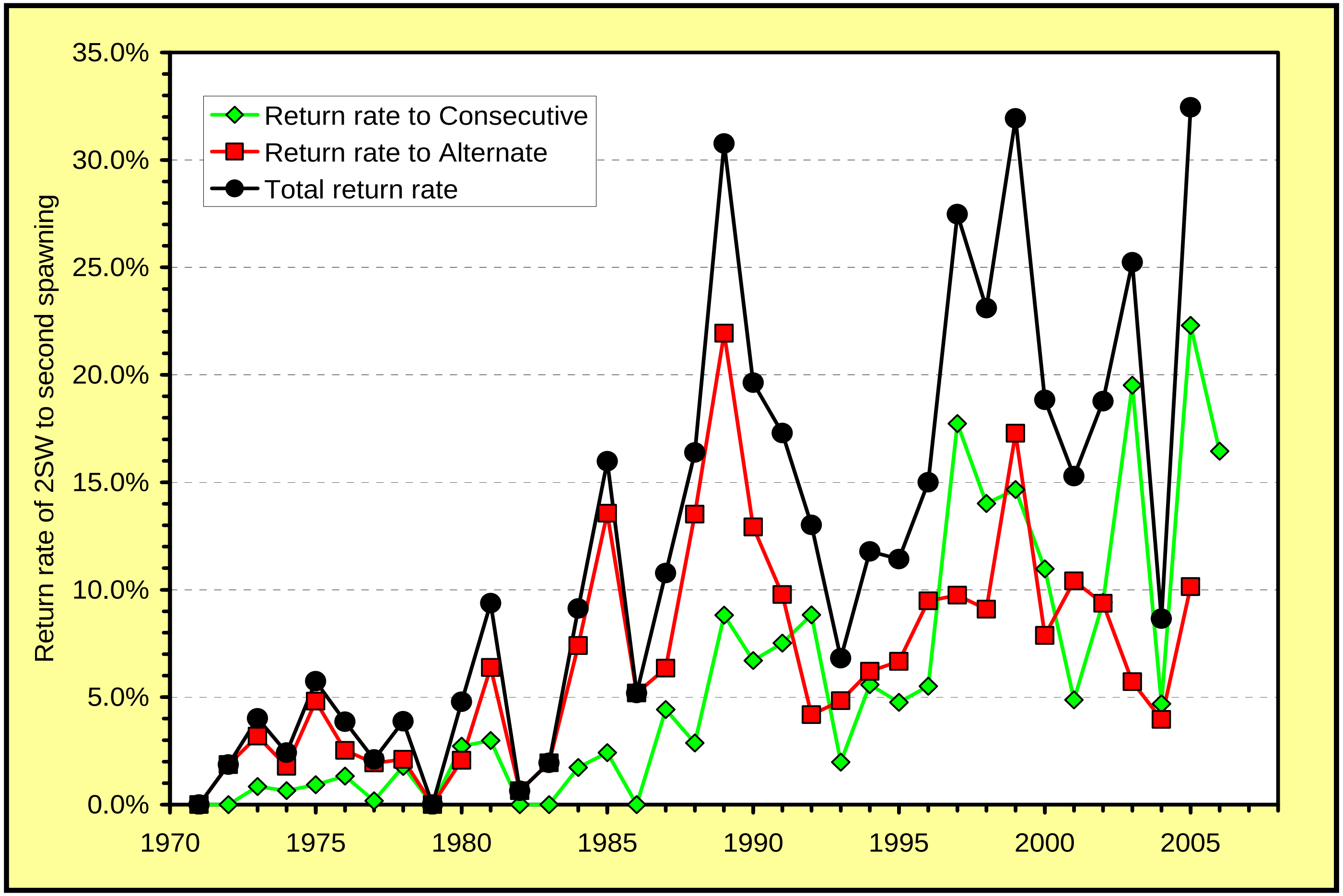
Atlantic salmon increasing survival to repeat spawnings

Number of samples by spawning migration

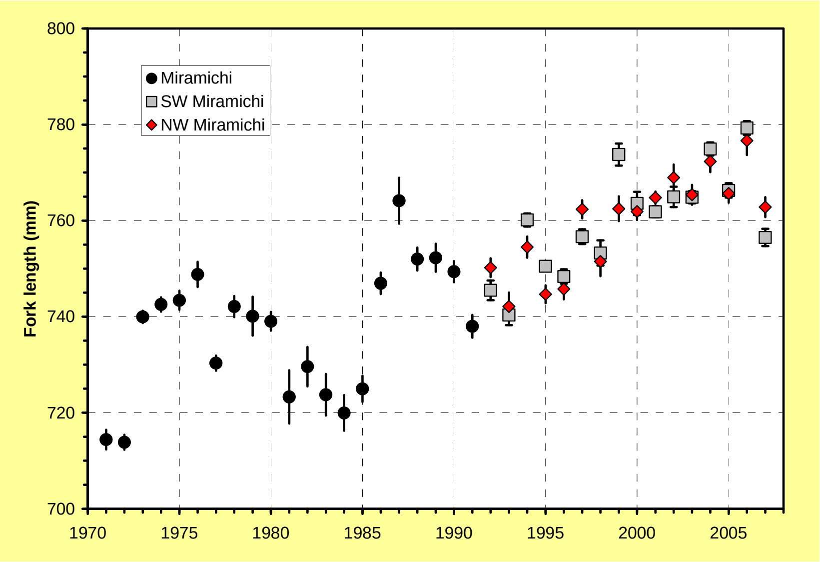
	Spawning migration						
Year	1	2	3	4	5	6	7
1971	550	17	1	.	.	.	.
1972	1180	17	.	.	.	.	.
1973	1451	15	.	.	.	.	.
1974	1904	39	3	.	.	.	.
1975	1317	40	2	.	.	.	.
1976	1159	21	1	.	.	.	.
1977	902	30	3	.	.	.	.
1978	638	38	.	.	.	.	.
1979	803	22	4	.	.	.	.
1980	851	14	5	.	.	.	.
1981	643	12	4	.	.	.	.
1982	594	17	2	.	.	.	.
1983	277	11	.	.	.	.	.
1984	323	9	.	1	.	.	.
1985	357	16	5	.	.	.	.
1986	667	38	3	.	.	.	.
1987	360	11	1	.	.	.	.
1988	530	37	6	2	.	.	.
1989	421	65	6	1	.	.	.
1990	494	109	33	7	.	.	.
1991	332	81	39	12	.	.	.
1992	1030	128	86	41	9	2	.
1993	636	79	47	24	3	.	.
1994	1728	127	34	19	4	3	.
1995	2068	172	40	19	3	2	1
1996	1275	211	61	20	2	3	.
1997	1292	308	123	51	6	2	1
1998	1339	210	91	36	5	1	1
1999	1261	168	76	36	9	2	.
2000	1837	274	108	61	21	2	1
2001	2805	499	125	66	31	6	2
2002	2669	208	71	31	27	4	1
2003	2366	293	73	31	8	7	1
2004	2539	320	94	32	8	1	1
2005	2057	193	52	18	5	.	.
2006	3240	459	64	15	6	.	.
2007	2409	247	95	24	5	.	1

Fisheries and Oceans Canada / Pêches et Océans Canada

Survival of Atlantic salmon to a second spawning remains highly variable but has increased to highest levels since 1984 when retention fisheries for large salmon were prohibited and commercial sea fisheries reduced or closed.

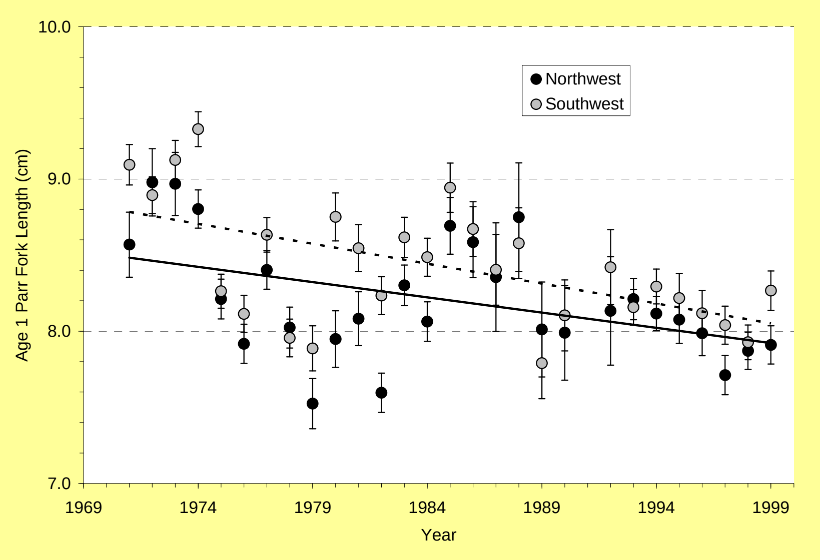


Variation in size of juvenile and adult salmon



Atlantic salmon adult (2SW) size has increased over the period 1971 to 2007

- corresponds in part to closures of size-selective fisheries
- larger size post 1998 correspond to period of lower abundance



Atlantic salmon parr (age 1) fork lengths (mean +/- 2 std err)

- adjusted for density and date of sampling
- lengths have declined and are weakly associated with increasing water temperatures (Swansburg et al. 2004)

Challenges to monitoring diadromous fish

Miramichi monitoring is intensive but incomplete

- estuarine monitoring covers the period of migration for most diadromous fish but is restricted to openwater period (miss Atlantic tomcod and some smelt dynamics)

- inriver monitoring is appropriate for species with resident stages in freshwater but fails to characterize and monitor alewife / blueback herring / shad spawning and juvenile production.

- high profile species (Atlantic salmon) receives the most attention and effort

- not possible to obtain total counts of any species and alternate methods (ex. mark and recapture experiments) are used for assessment

- watershed is large and complex and monitoring of physical features has improved in the past decade (real-time hydro-met stations, year-round temperature recorders)

Need a control site to interpret restoration assessment

Failures and successes should be evaluated relative to factors external to the restoration actions.

Numerous factors outside the watershed can condition abundance, survival and biological characteristics of the species of interest

- sea fisheries, ocean climate, ecosystem variations (prey, predators)

Factors within the watershed not associated with fish passage also affect diadromous fishes

- climate variation, water cycle dynamics, land use

The Miramichi River is a suitable control site for the Penobscot River restoration experiment.


16.09.2008
STRIPED BASS
Tommi Linnansaari