DEVELOPMENT OF AN INTERIM FISH ASSEMBLAGE ASSESSMENT INDEX FOR NON-WADEBALE RIVERS IN MAINE & NEW ENGLAND: 2002 - 2007

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Major River Basins in New England

S
D
a Sufficient Regional
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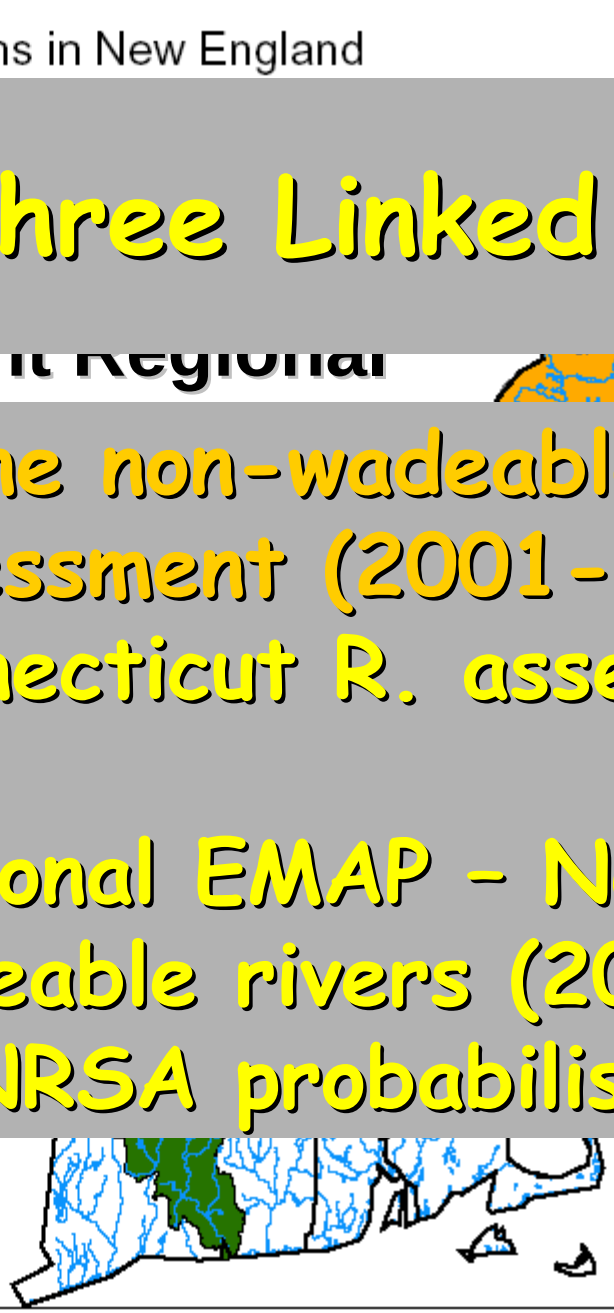
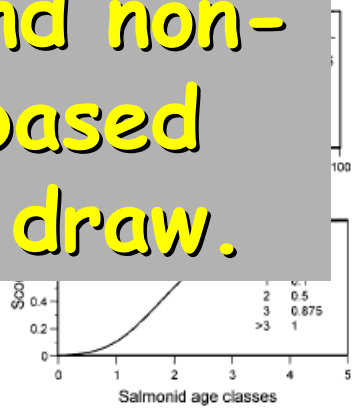
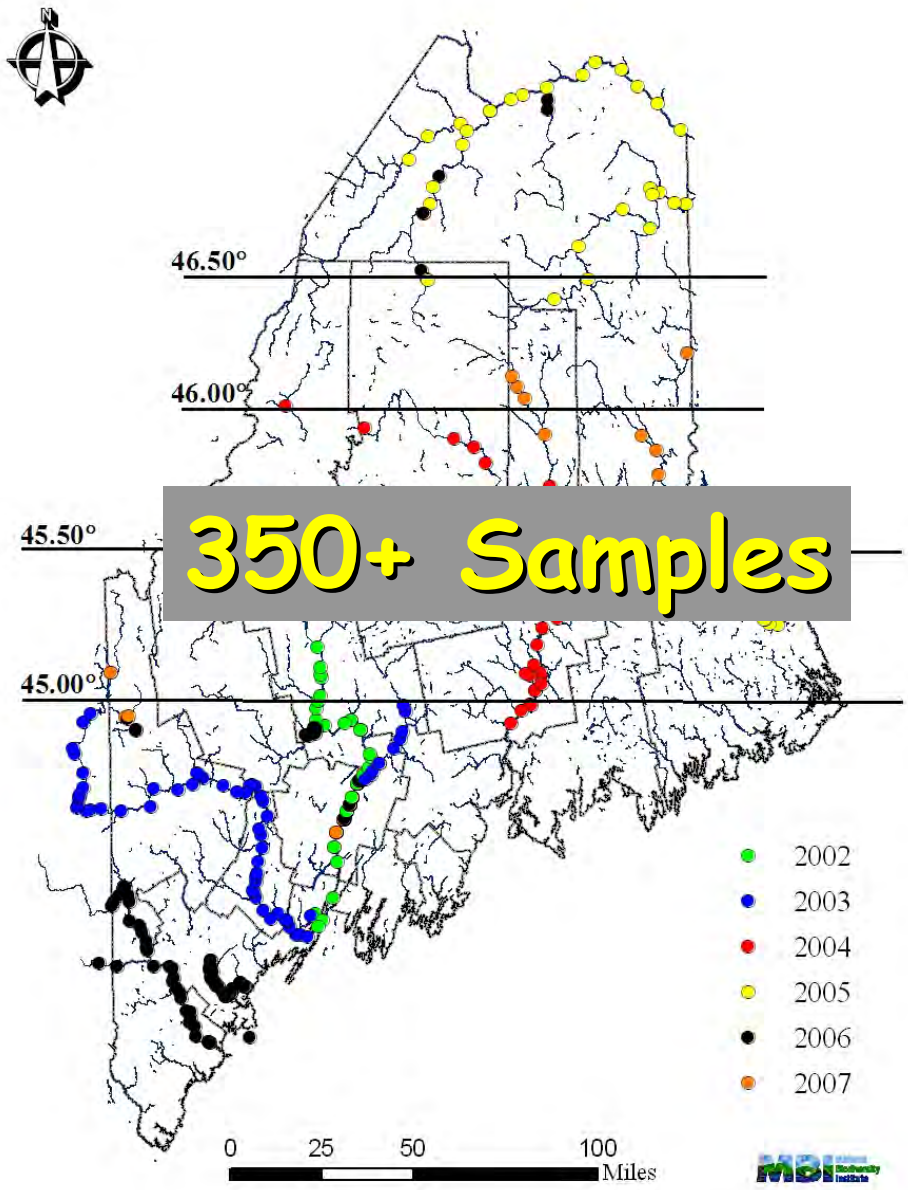
Three Linked Projects:

1. Maine non-wadeable rivers assessment (2001-2007)
2. Connecticut R. assessment (2008-9).
3. Regional EMAP – New England non-wadeable rivers (2008-9); based on NRSA probabilistic sites draw.







Kennebec River (2002-6)

- Wyman Dam to Merrymeeting Bay (30 sites, 2 test areas)
- Follow-up Waterville to Augusta (2002-6)

Androscoggin River (2003)

- Errol, NH to Merrymeeting Bay (51 sites)

Sebasticook River (2003)

- Douglas Pond to Winslow (9 sites)

Penobscot River (2004)

- N. Br. To Hamden (40 sites); included W. Br., E. Br., 5 additional tributaries

Northern Maine Rivers (2005-6)

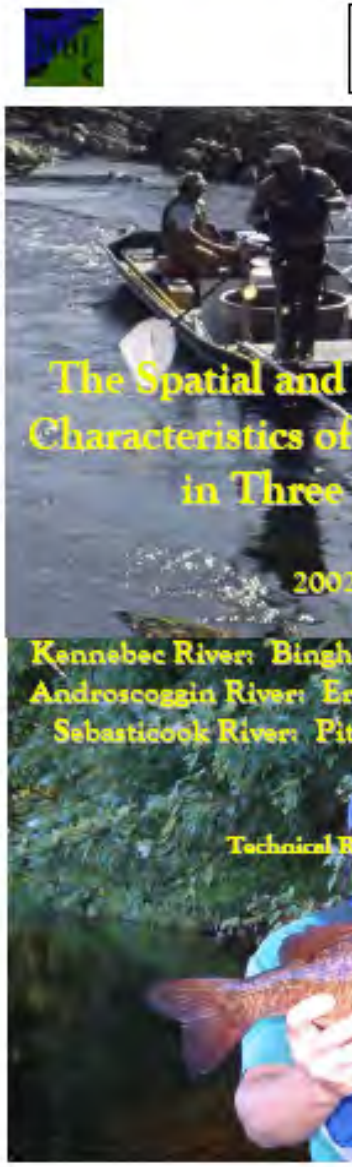
- St. John (14 sites), Allagash (8 sites), Aroostook (10 sites), St. Croix (12 sites)

Southern Maine Rivers (2006)

- Presumpscot R., Saco R. (32 sites)

Miscellaneous Maine Rivers (2007)

- Mattawamkeag R., Rapid R., Moose R., Moosehead Outlets, Dead R., E. Br. Penobscot (22 sites)



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Maine Rivers Fish Assemblage Assessment: Development of an Index of Biotic Integrity for Non-wadeable Rivers

MBI Technical Report MBI/2008-11–2

March 8, 2009

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lage Assessment:

s Results
e to Allagash
Ft. Fairfield
o to Calais
New Brunswick border

istribution Atlas

Assemblage Index for

06-1

& Biocriteria
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561

John M. Audet
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Checklist of Fish Assemblage Development Tasks

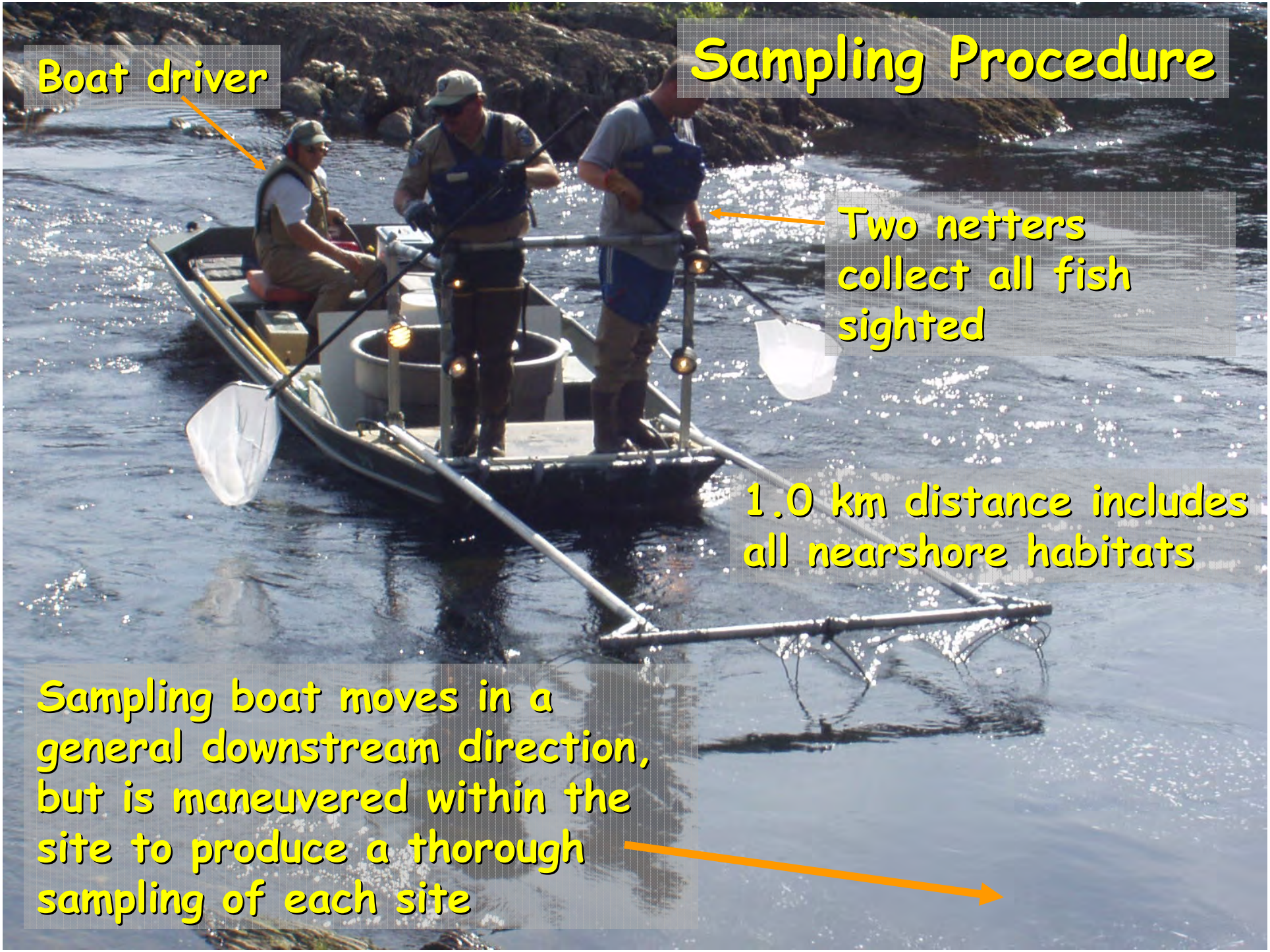
- Develop an effective & systematic sampling method (2001-3)
- Develop a sufficient spatial & temporal database (2002-6)
- Autecology of extant fauna & metric development (2005-6)
- Classify riverine ecotypes (2006-7)
- Establish "reference condition" – BCG (2007-8)
- Derive and test IBIs with reference and independent test sites (2008)

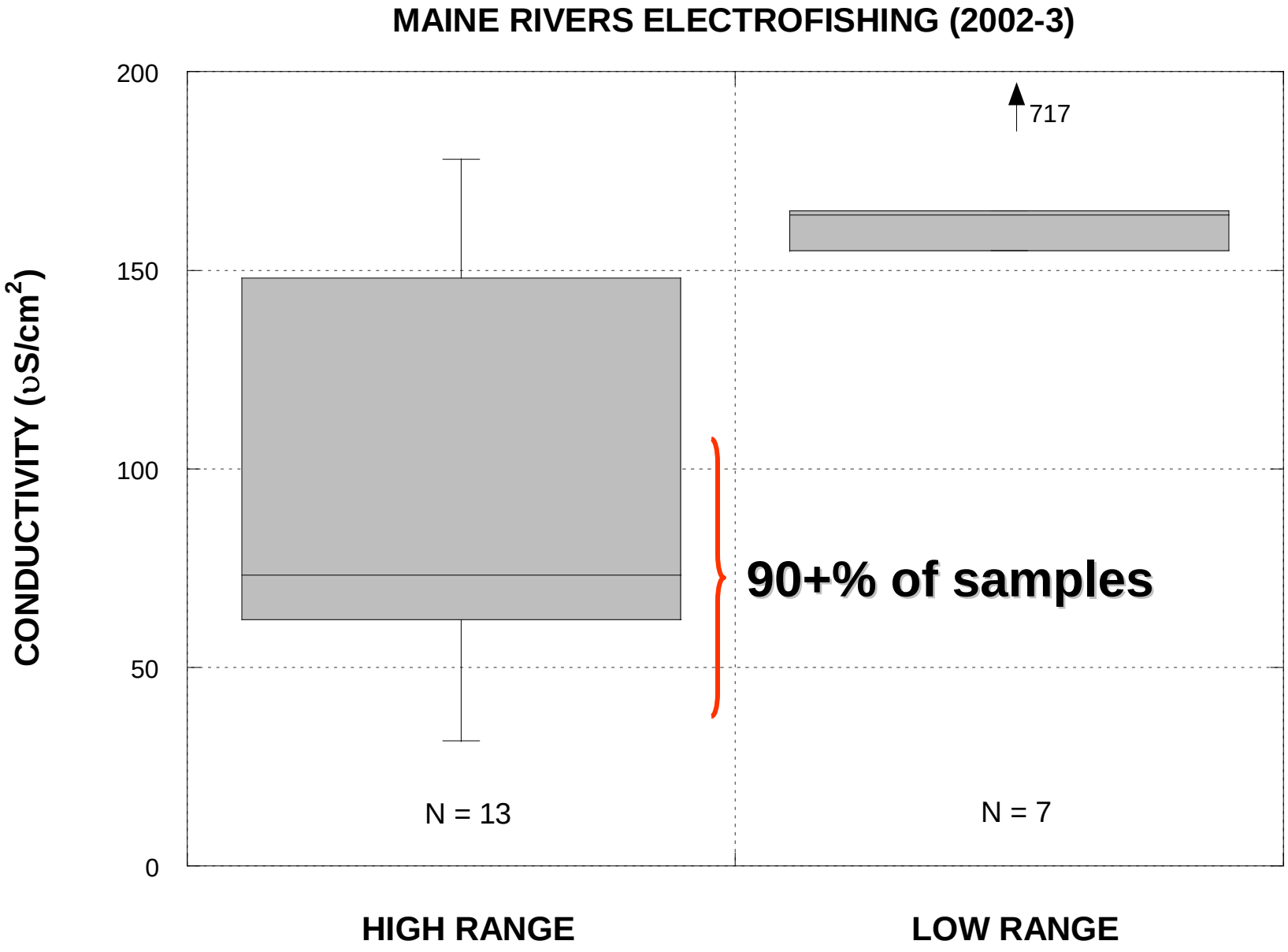
Sampling Methods

Standardized Approach:

- Pulsed D.C. boat electrofishing – effort indexed to distance
- Electrode array customized for Maine river conditions
- Intensive survey design – mainstem & non-wadeable tribs.
- Field water quality and habitat data
- July 1 – September 30 index period

Sampling Procedure





Electrofishing Unit Settings

Developed in 2005 to Access Medium Sized and Shallower Rivers

Launching & Retrieving

Smith-Root 2.5 GPP Unit

Qualitative Habitat Evaluation Index Field Sheet

Midwest Biodiversity Institute

QHEI Score: ____

River Code: ____ *RM:* ____ *Stream:* ____

Site Code: ____ *Project Code:* ____ *Location:* ____

Date: ____ *Scorer:* ____ *Latitude:* ____ *Longitude:* ____

1.) SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % percent

TYPE	POOL	RIFFLE		POOL	RIFFLE
☐☐ -BLDR/SLBS [10]			☐☐ -GRAVEL [7]		
☐☐ -Lg BOULD [10]			☐☐ -SAND [6]		
☐☐ -BOULDER [9]			☐☐ -BEDROCK [5]		
☐☐ -COBBLE [8]			☐☐ -DETRITUS [3]		
☐☐ -HARDPAN [4]			☐☐ -ARTIFICIAL [0]		
☐☐ -MUCK [2]			☐☐ -SILT [2]		

NUMBER OF SUBSTRATE TYPES: ☐ -4 or More [2]

(High Quality Only, Score 5 or >) ☐ -3 or Less [0]

SUBSTRATE ORIGIN — Check ONE (OR 2 & AVERAGE)

☐ -LIMESTONE [1]
☐ -TILLS [1]
☐ -WETLANDS [0]
☐ -HARDPAN [0]
☐ -SANDSTONE [0]
☐ -RIP / RAP [0]
☐ -LACUSTRINE [0]
☐ -SHALE [-1]
☐ -COAL FINES [-2]

SUBSTRATE QUALITY — Check ONE (OR 2 & AVERAGE)

SILT:
☐ -SILT HEAVY [-2]
☐ -SILT MODERATE [-1]
☐ -SILT NORMAL [0]
☐ -SILT FREE [1]

EMBEDDEDNESS:
☐ -EXTENSIVE [-2]
☐ -MODERATE [-1]
☐ -NORMAL [0]
☐ -NONE [1]

Substrate ____ Max 20

COMMENTS: ____

2.) INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)

(Structure)
____ UNDERCUT BANKS [1]
____ OVERHANGING VEGETATION [1]
____ SHALLOWS (IN SLOW WATER) [1]
____ ROOTMATS [1]

TYPE: Score All That Occur
____ POOLS > 70 cm [2]
____ ROOTWADS [1]
____ BOULDERS [1]

____ OXBOWS, BACKWATERS [1]
____ AQUATIC MACROPHYTES [1]
____ LOGS OR WOODY DEBRIS [1]

AMOUNT: (Check ONLY one or check 2 and AVERAGE)
☐ -EXTENSIVE > 75% [11]
☐ -MODERATE 25 - 75% [7]
☐ -SPARSE 5 - 25% [3]
☐ -NEARLY ABSENT < 5% [1]

Cover ____ Max 20

COMMENTS: ____

3.) CHANNEL MORPHOLOGY: (Check ONLY one PER Category OR check 2 and AVERAGE)

SINUOSITY
☐ -HIGH [4]
☐ -MODERATE [3]
☐ -LOW [2]
☐ -NONE [1]

DEVELOPMENT
☐ -EXCELLENT [7]
☐ -GOOD [5]
☐ -FAIR [3]
☐ -POOR [1]

CHANNELIZATION
☐ -NONE [6]
☐ -RECOVERED [4]
☐ -RECOVERING [3]
☐ -RECENT OR NO RECOVERY [1]
☐ -IMPOUNDED [-1]

STABILTIY
☐ -HIGH [3]
☐ -MODERATE [2]
☐ -LOW [1]

MODIFICATIONS / OTHER
☐ -SNAGGING
☐ -RELOCATION
☐ -CANOPY REMOVAL
☐ -DREDGING
☐ -ONE SIDE CHANNEL MODIFICATIONS
☐ -IMPOUNDMENT
☐ -ISLAND
☐ -LEVEED
☐ -BANK SHAPING

Channel ____ Max 20

COMMENTS: ____

4.) RIPARIAN ZONE AND BANK EROSION (check ONE box PER bank or check 2 and AVERAGE per bank)

River Right Looking Downstream

RIPARIAN WIDTH

L	R	(Per Bank)
☐	☐	-VERY WIDE > 100m [5]
☐	☐	-WIDE > 50m [4]
☐	☐	-MODERATE 10 - 50m [3]
☐	☐	-NARROW 5 - 10m [2]
☐	☐	-VERY NARROW < 5m [1]
☐	☐	-NONE [0]

FLOOD PLAIN QUALITY (*PAST 100 Meter RIPARIAN*)

L	R	(Most Predominant Per Bank)
☐	☐	-FOREST, SWAMP [3]
☐	☐	-SHRUB OR OLD FIELD [2]
☐	☐	-RESIDENTIAL, PARK, NEW FIELD [1]
☐	☐	-FENCED PASTURE [1]

L	R	
☐	☐	-CONSERVATION TILLAGE [1]
☐	☐	-URBAN OR INDUSTRIAL [0]
☐	☐	-OPEN PASTURE, ROWCROP [0]
☐	☐	-MINING / CONSTRUCTION [0]

BANK EROSION

L	R	(Per Bank)
☐	☐	-NONE / LITTLE [3]
☐	☐	-MODERATE [2]
☐	☐	-HEAVY / SEVERE [1]

Riparian ____ Max 10

COMMENTS: ____

Is Sampling Reach Representative of the Stream (Y/N) Y If Not, Explain:

Lat/Long (Beg):	
Lat/Long (Mid):	
Lat/Long (End):	
Lat/Long(X-Loc):	

Major Suspected Sources of Impacts (Check All That Apply):
- None ☐
- Industrial ☐
- WWTP ☐
- Ag ☒
- Livestock ☐
- Silviculture ☒
- Construction ☐
- Urban Runoff ☐
- CSOs ☐
- Suburban Impacts ☐
- Mining ☐
- Channelization ☐
- Riparian Removal ☐
- Landfills ☐
- Natural ☐
- Dams ☐
- Other Flow Alteration ☐
- Other:

	Gear:	Distance:	Water Clarity:	Water Stage:	Canopy -% Open
First Sampling Pass	A	1.0	clear	low	100

Subjective Rating (1-10): 7

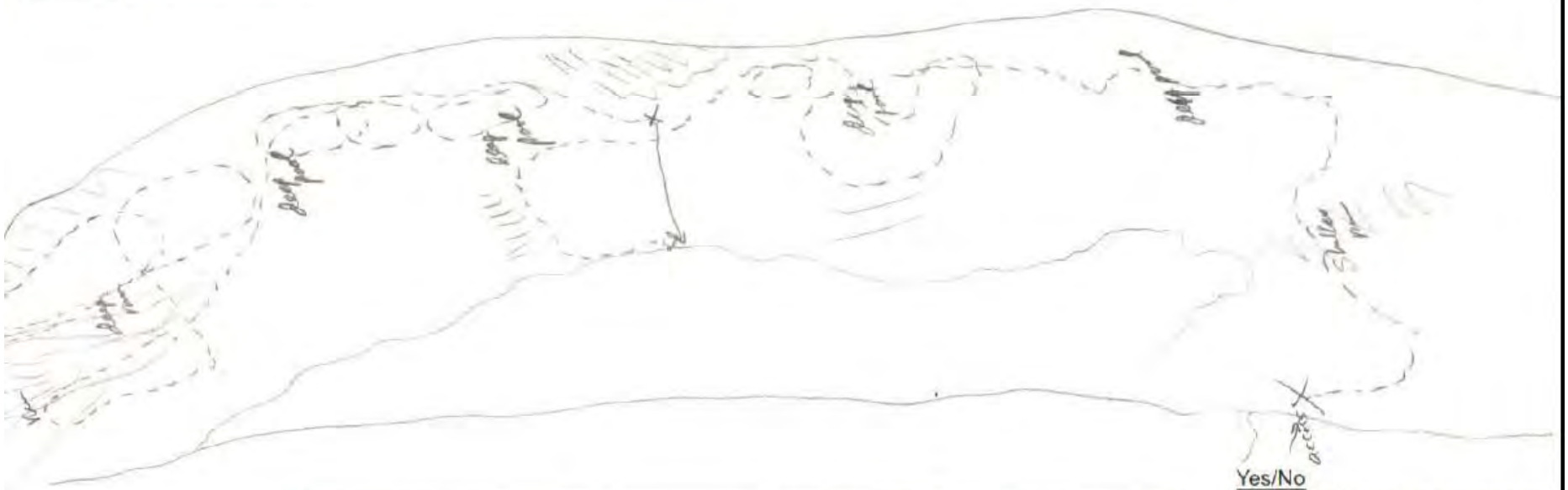
Aesthetic Rating (1-10): 7

Gradient: ☐ - Low, ☒ - Moderate, ☐ -High

Stream Measurements:

Average Width	Average Depth	Maximum Depth	Av. Bankfull Width	Bankfull Mean Depth	W/D Ratio	Bankfull Max Depth	Floodprone Area Width	Entrench. Ratio

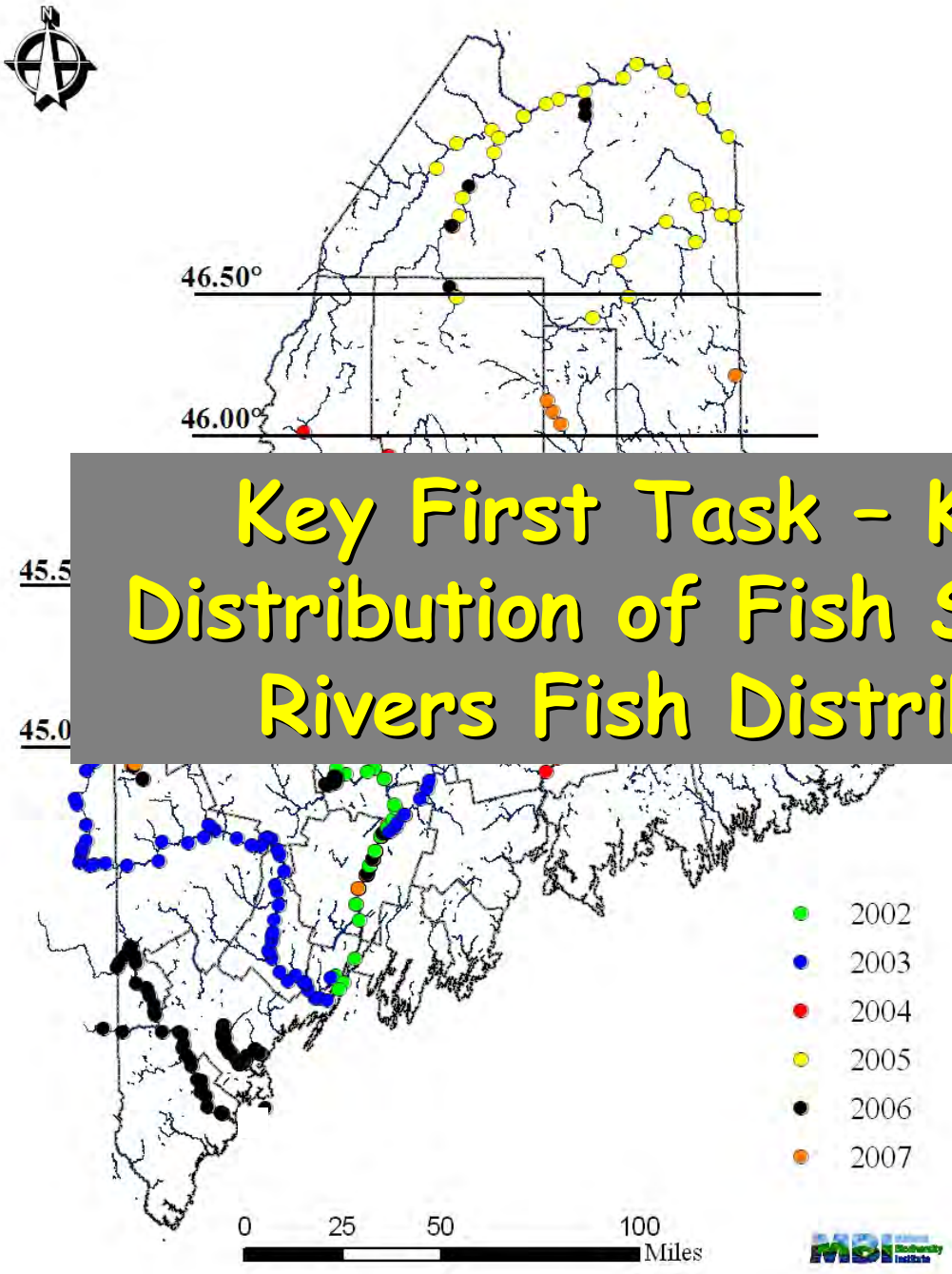
Stream Drawing:



Instructions for scoring the alternate cover metric: Each cover type should receive a score of between 0 and 3, Where: 0 - Cover type absent; 1 - Cover type present in very small amounts or if more common of marginal quality; 2 - Cover type present in moderate amounts, but not of highest quality or in small amounts of highest quality; 3 - Cover type of highest quality in moderate or greater amounts. Examples of highest quality include very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

Yes/No	
☐ ☐	Is Stream Ephemeral (no pools totally dry or only damp spots)?
☐ ☐	Is there water upstream? How Far:_____
☐ ☐	Is There Water Close Downstre How Far:_____
☐ ☐	Is Dry Channel Mostly Natural?

Maine Rivers Fish Assemblage Assessment: 2002-7



Key First Task – Know Current Distribution of Fish Species: Maine Rivers Fish Distribution Atlas

Table 1. Native, tolerance, habitat, foraging, and reproductive guild designations and other notes on the distribution and occurrence of 60 fish species documented or suspected to occur in Maine' non-wadeable rivers. Sources for guild and metric assignments appear in the footnotes (scientific nomenclature adheres to Nelson et al. 2004).

Species	Native Status[1]	Environmental Tolerance[2]	Target Fish Classification[3]	Common Habitat(s)[4]	Spatial Occurrence[5]	Thermal Guild[6]	Foraging Guild[7]	Reproductive Guild[8]	Habitat Guild[9]	Notes
Petromyzondi										
Sea lamprey (*P*										nocoetes.
Acipenseridae										
Shortnose sturg										R. 2006.
Atlantic sturge										2005 and.
Anguillidae										
American eel (*A*										
Clupeidae										
Blueback herri										d.
Alewife (*Alosa*										lected.
American shad (*Alosa sapidissima*)	N	M	A	R1,T1-2	C	M	P	PS	W	Mostly y-o-y, few adults collected.
Gizzard shad (*D*										in 2000.
Cyprinidae										
Lake chub (*Co*										
Common carp										er Kennebec R.
Common shine										
Golden shiner										
Bridle shiner (*N*										tion only.
Spottail shiner										
E. Blacknose dace (*Rhinichthys atratulus*)	N	S	FS	R1	N	M	BI	NGL	B	
Longnose dace (*Rhinichthys cataractae*)	N	M	FS	R1	S	M	BI	NGL	B	Collected only in upper Androscoggin R.

Detailed autecology of known and potential species – 60 recorded thus far in Maine's rivers

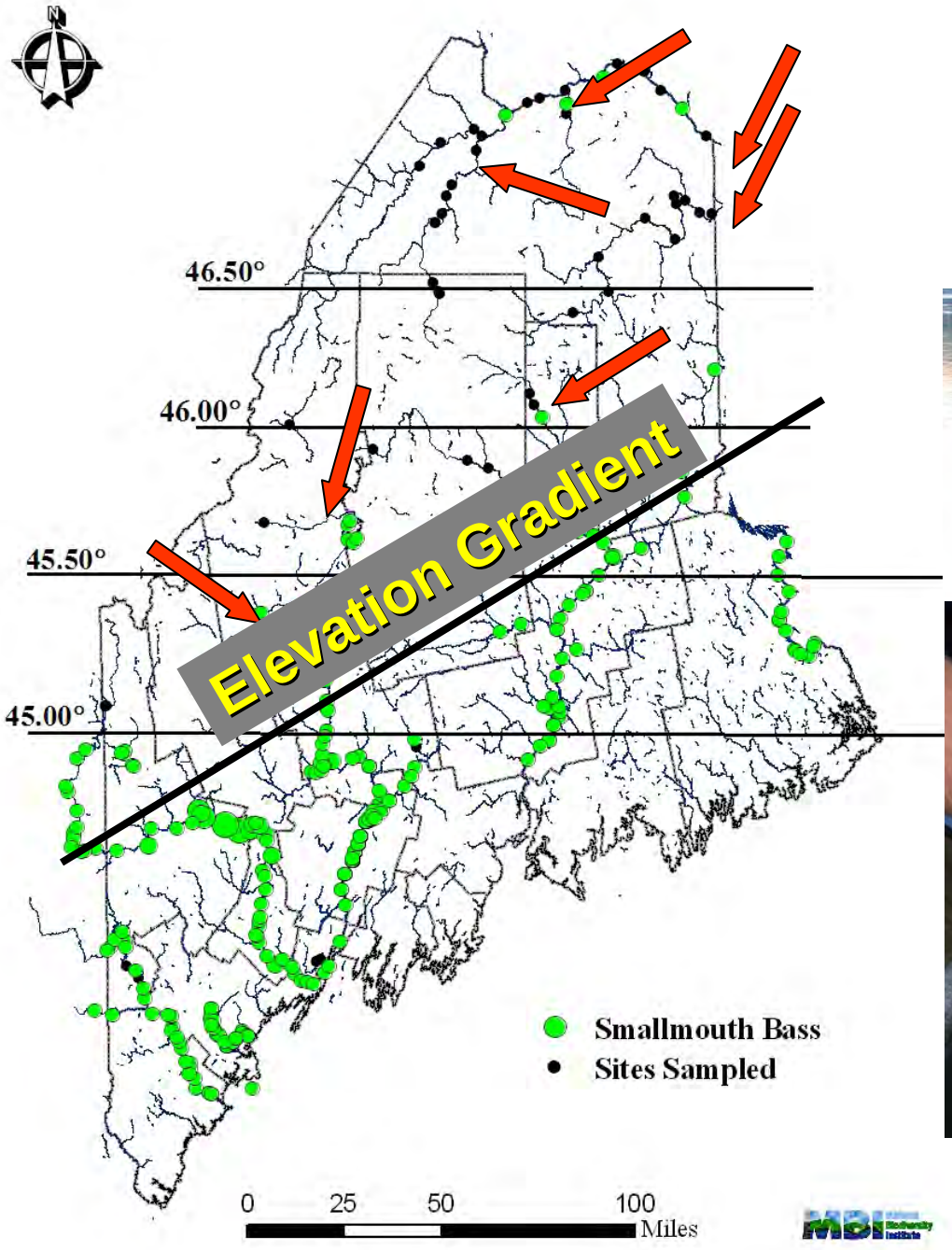
Update as new species are added via New England REMAP project

[1] After Halliwell (2005): N – native; E – exotic of inter-continental origin; IC – introduced of intracontinental origin; IS – introduced of interstate origin; IM – introduced and managed; U – undetermined origin.
[2] I – highly intolerant; S – sensitive (moderately intolerant); M – intermediate; P – moderately tolerant; T – highly tolerant.; sources used include Ohio EPA (1987), Whittier and Hughes (1998), Halliwell et al. (1999), Langdon (2001)
[3] After Bain and Meixler (2000) : FS – fluvial specialist; FD – fluvial dependent; MG – macrohabitat generalist; A – anadromous; [ ] - designations in brackets were not classified by Bain and Meixler (2000).
[4] R1 – high gradient riverine; R2 – low gradient riverine; I1 – impounded riverine; T1 – tidal riverine freshwater, T2 – tidal embayment brackish
[5] Spatial distribution within the state: C – primarily coastal rivers; S – primarily south of 46.000° latitude; N – primarily north of 45.500° latitude; U – ubiquitous statewide occurrence.
[6] After Hokanson (1977); S – temperate stenotherm; M – temperate mesotherm; E – temperate eurytherm.
[7] After Goldstein and Simon (1999); H – herbivore, D – detritivore, I – invertivore, BI – benthic insectivore, C – top carnivore, P – piscivore, G – generalist, O – omnivore, P – planktivore.
[8] After Ohio EPA (1987) and Hughes et al. (1998),; NGL – non-guarding lithophil [simple lithophil], LN – lithophilic nester, L – lithophil, V – vegetation, P – psammophil [sand-fine gravel], CN – cavity nester, VN – vegetation nester, PN – psammophil nester.
[9] After Hughes et al. (1998): W – water column, B – benthic, E – edge, H – hider, G – generalist

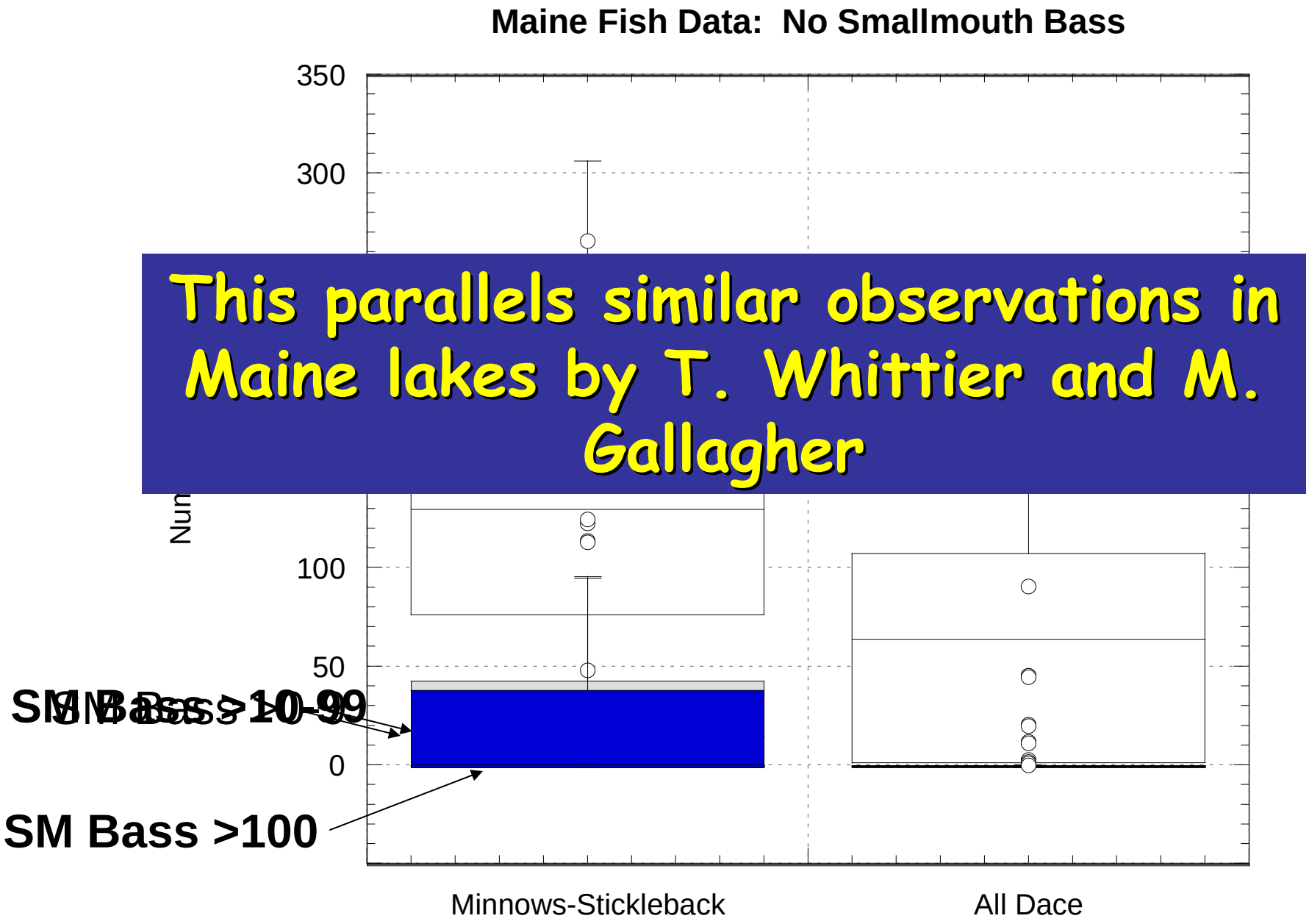
Warmwater Species

Smallmouth bass (adult life stage)
(Introduced Naturalized c. 1870)

Maine Rivers Fish Assemblage Assessment: 2002-7



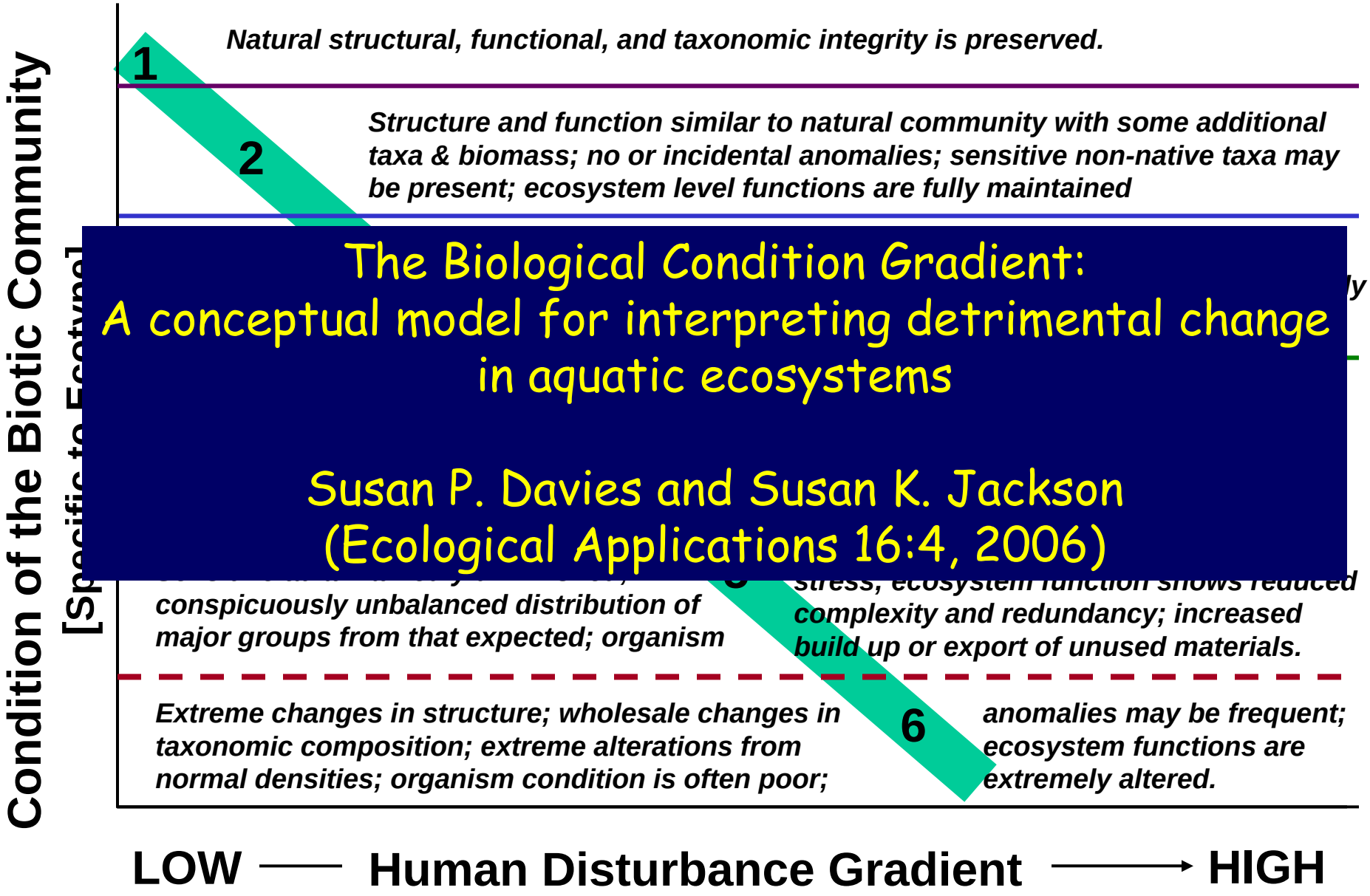
← Physical barriers



This parallels similar observations in Maine lakes by T. Whittier and M. Gallagher

Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers

(10/22 draft)



Cold Water Assemblages

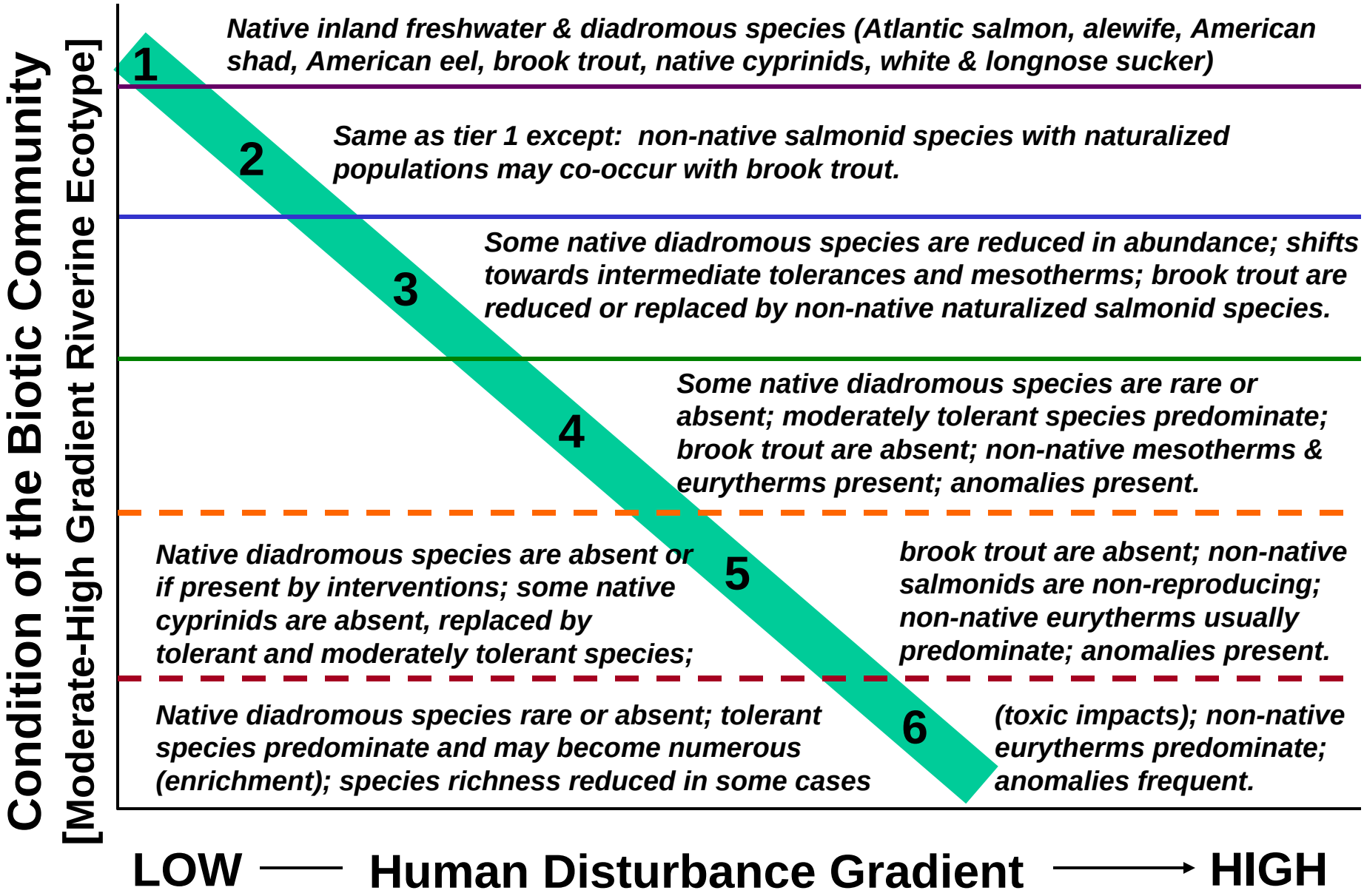
The "assumed baseline" for the Biological Condition Gradient applicable to Maine's large rivers

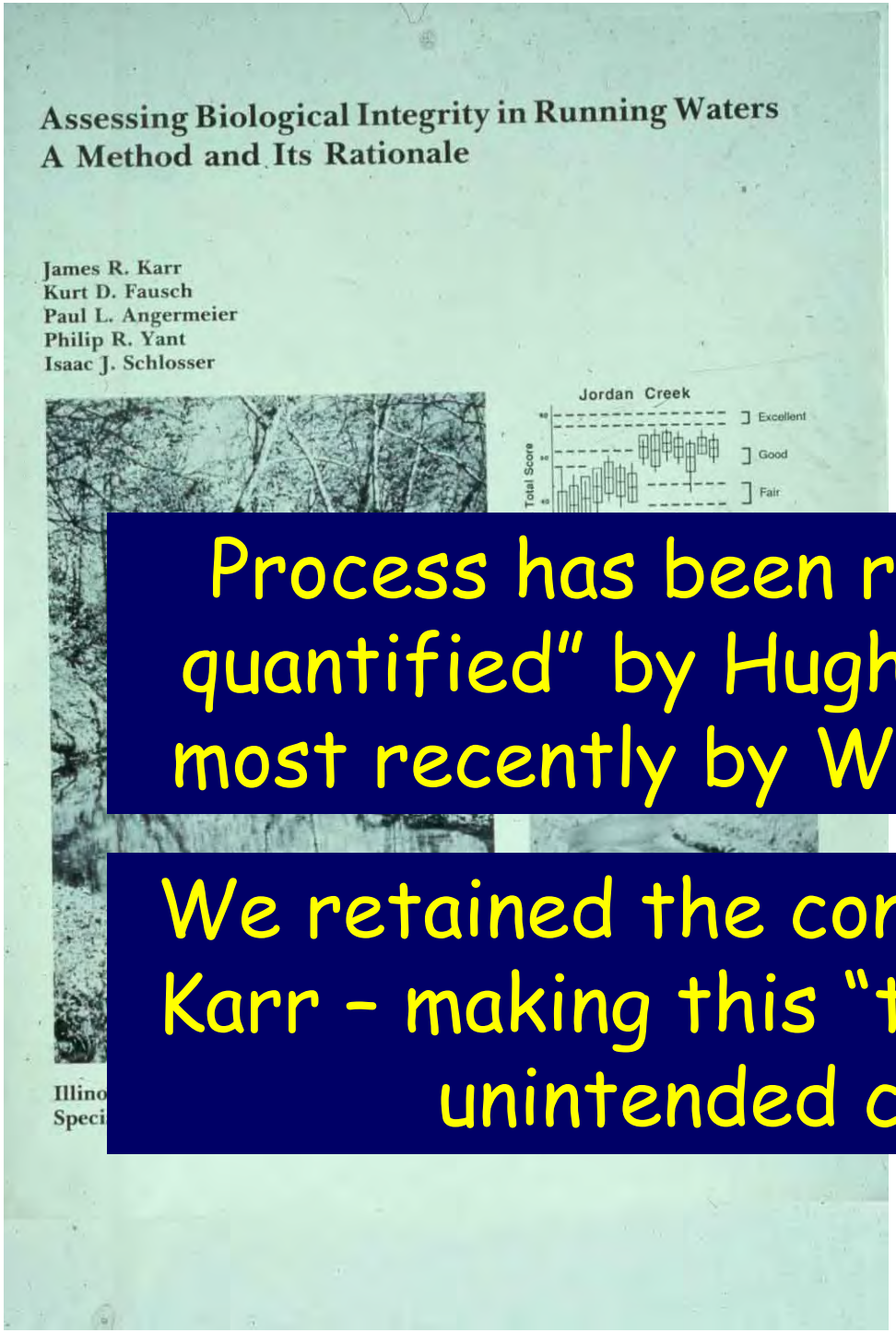
Will this "hold" for southern NE?

"Unique" Character of the Riverine Fish Fauna of Maine

- Post-glacial ingress resulted in "baseline" fauna
- Maine Rivers "constrained" to Gulf of Maine.
- One brief connection to St. Lawrence & none to Connecticut & western river basins.
- Curry (2007): Late glacial impacts on dispersal and colonization of Atlantic Canada and Maine by freshwater fishes. Quaternary Research 67(2): 225-233.
- Several "warmwater" species common to this latitude in other regions are not indigenous (blackbass, pike, muskellunge, crappie).

Biological Condition Gradient Conceptual Model: Maine Rivers





Guidelines for Deriving Regionally Relevant "IBI Type" Assessment Tools

- Karr et al. (1986) provides guidance for metric development, substitution, [illegible] natural history.

Process has been refined and "better quantified" by Hughes et al. (1998) and most recently by Whittier et al. (2007)

We retained the conceptual approach of Karr – making this "too mechanical" have unintended consequences

candidate metrics and aggregate indices.

Candidate IBI Metrics

Table 6. Candidate metrics for further evaluation and possible inclusion in fish assemblage IBIs applicable to non-wadeable rivers of Maine.

Candidate Metric	Expressed As[1]	Intent	Origin[2]
Taxonomic			
Sucker species	N	Long lived species	Original IBI metric
Cyprinid species	B	Important faunal component	Whittier et al. (2000)
Sunfish species	N	Water column inhabitant	Original IBI metric
Clupeid species	%	Diadromous component	None
Adult suckers	%	Riverine run habitat	None
Ecological Role			
Stenothermic species	B	Cold water habitat specialists	Coldwater IBI metric
Steno + Mesothermic sp.	B	Cold & cool water habitat	None
Eurythermic species	B	Signal shift from cold water	None
Fluvial specialists	%	Riverine habitat dependency	Bain and Meixler (2000)
Fluvial dependents	%	Riverine habitat dependency	Bain and Meixler (2000)
Macrohabitat generalists	%	Reflect loss of riverine habitat	Bain and Meixler (2000)
Diadromous species	B	Original component of fauna	None
Native tidal species	B	Reflect tidal habitats	None
Reproduction and Recruitment			
Age classes across all species	N	Reproduction/recruitment	None
Salmonid age classes	B	Reproduction/recruitment	Mebane et al. (2002)
Non-guarding Lithophils	B	Sensitive to substrate quality	Hughes et al. (1998)

Metric values can be expressed as # species, individuals, biomass, or proportion of sample.

Candidate Metric Selection and Testing

- 148 candidate metrics identified
- Pared to 40 metrics in step one
- PCA revealed 4 "clusters"
- "specialist" and cold water metrics
- "general" assemblage metrics
- "disturbance" indicative metrics
- "non-distinct" clusters, but ecologically relevant (e.g., DELT anomalies)
- Reduced to final 12 metrics for the Interim IBI

"Traditional" IBI vs. Interim Maine IBI

"Traditional IBI Metrics:

1. Native species richness
2. Darter Species
3. Sucker Species
4. Sunfish Species
5. %Intolerant species
6. %Tolerant species
7. %Omnivores
8. %Insectivores
9. %Top carnivores
10. %Hybrids
11. %Diseased individuals
12. Number of individuals

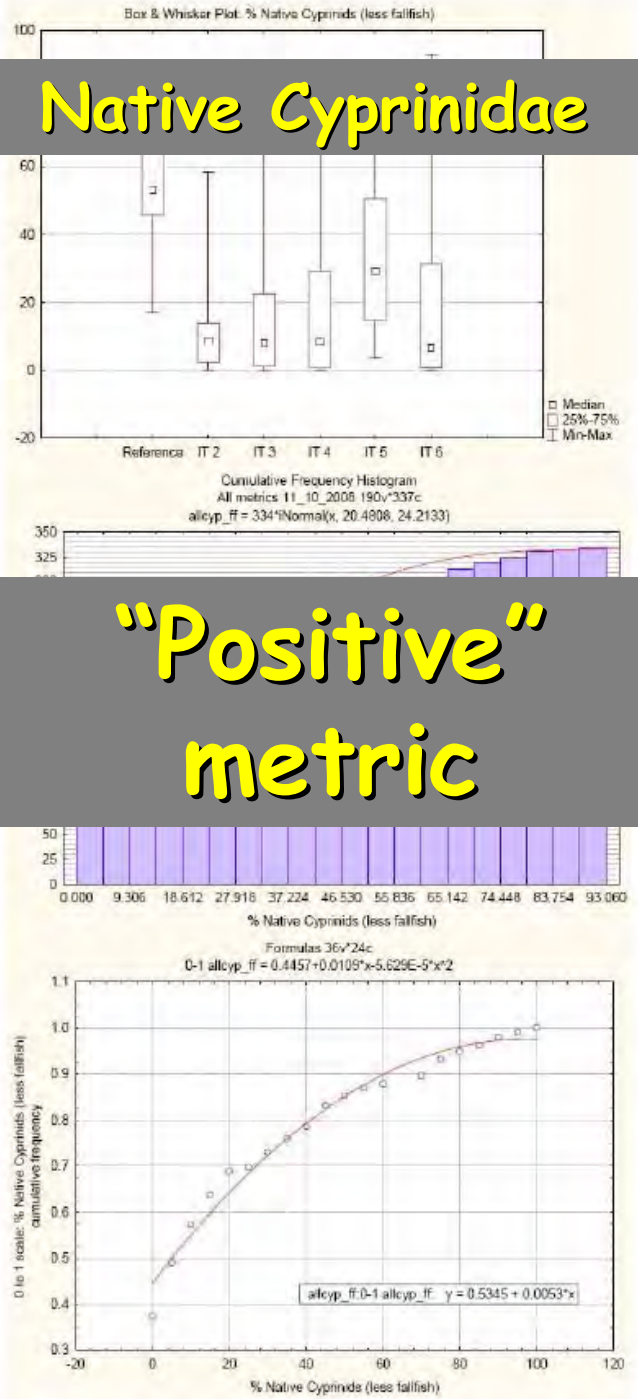
Interim Maine IBI Metrics:

1. Indigenous species richness
2. Native cyprinids (less fallfish)
3. %Adult white/longnose biomass
4. %Blackbass
5. %Fluvial specialist/dependent
6. %Macrohabitat generalists
7. %Benthic insectivores
8. Temperate stenotherms
9. %Native salmonids
10. Non-guarding lithophils
11. %DELT anomalies
12. Non-indigenous species

Metric Calibration Process

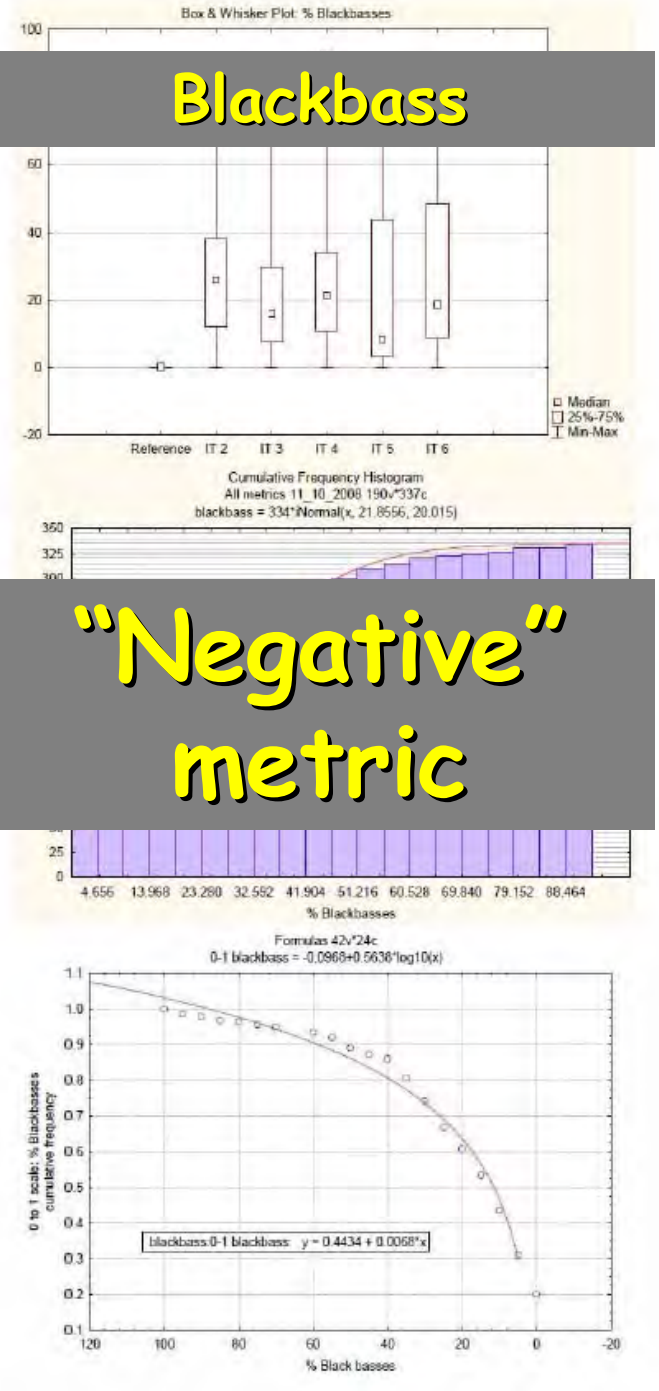
- Followed Mebane et al. (2003) methodology.
- Box plots: reference vs. non-reference sites.
- Non-ref: four ranges of QHEI + conductivity >100 $\mu S/cm^2$.
- Extracted scoring "curves" from cumulative histograms of each metric.
- Used "best fit" of linear, polynomial, and logarithmic plots.
- Final scoring criteria were adjusted to fit Y_1 and Y_2 insertions (and to preclude "ecological nonsense").

Native Cyprinidae



"Positive" metric

Blackbass

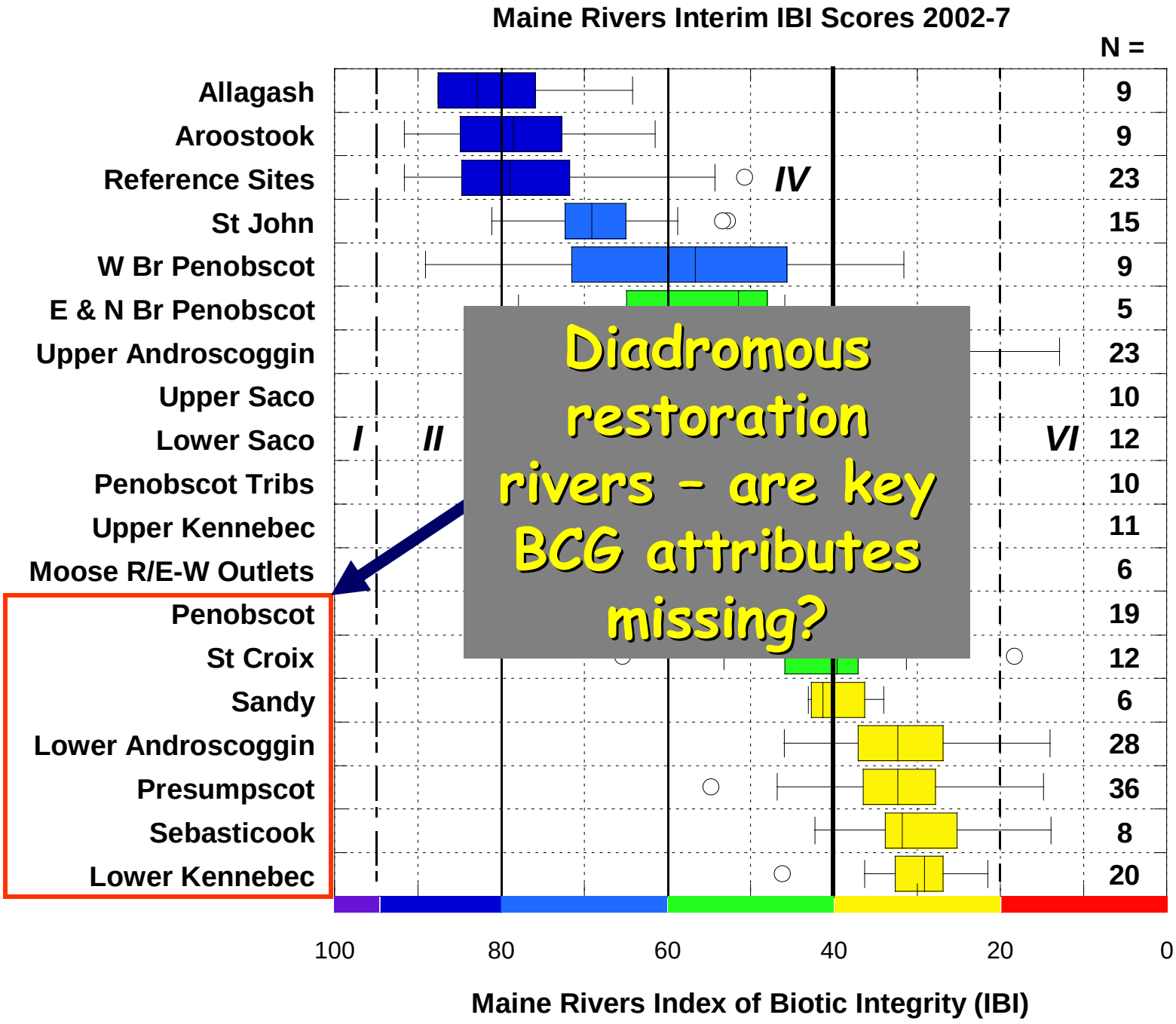


"Negative" metric

Interim Maine Rivers IBI Metrics & Scoring

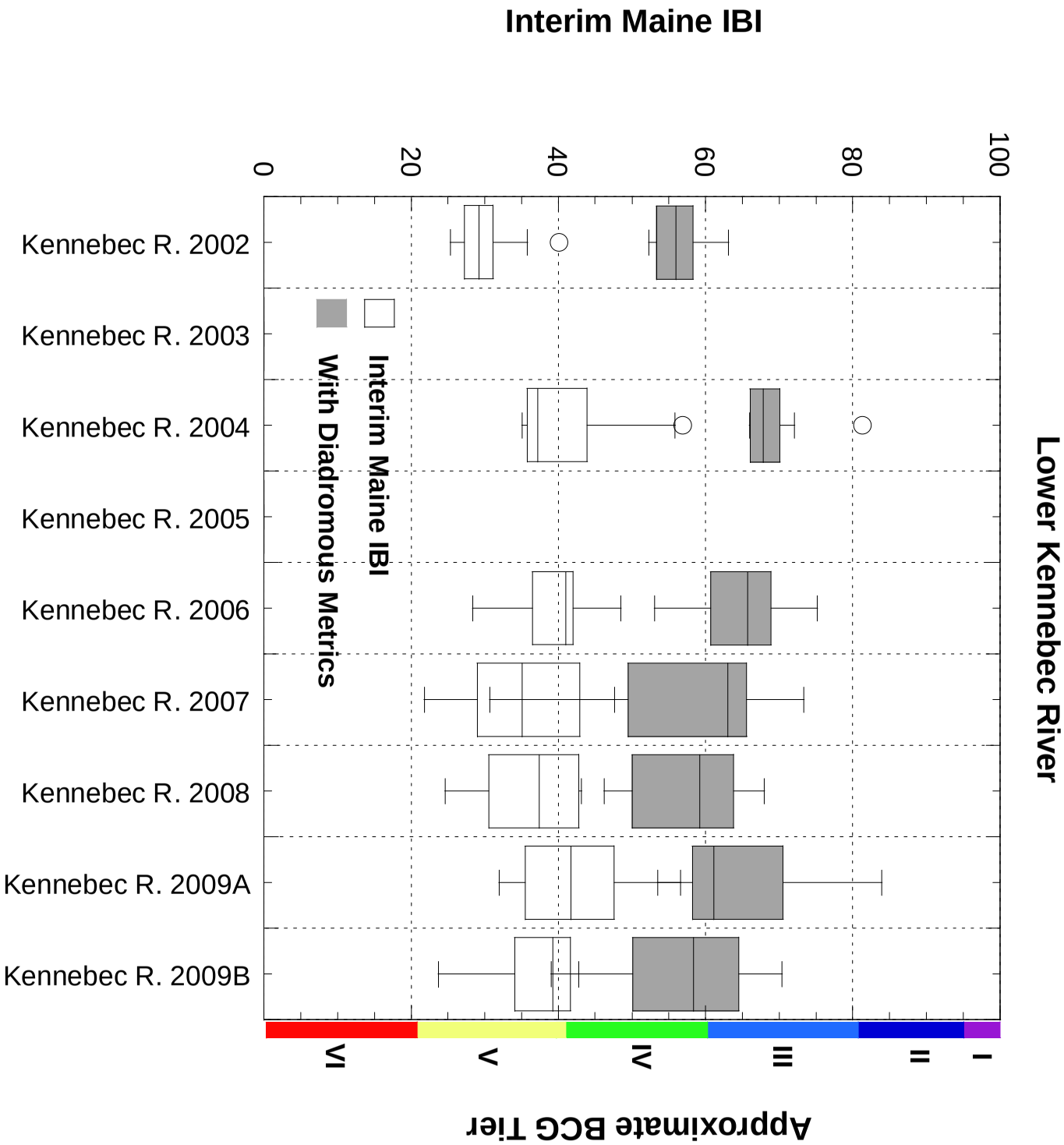
Metric	Scoring Equation	Scoring Adjustments	
		Score = 0	Score = 10
Native Species Richness	10 * (-0.2462 + (0.0828*numspec2)))	<3 sp.	≥15 sp.
Native Cyprinid Species (excluding fallfish)	(10 * (0.4457 + (0.0109*allcyp_ff) - (0.00005629 * (allcyp_ff ^{2}))))	Eq[1]	Eq
Adult white & longnose sucker biomass	(10 * (0.3667 + (0.008*ws_lns_pb) - (0.000023592 * (ws_lns_pb^2))))	0	≥128 kg/km
%Native Salmonids	(10 * (0.9537 + (0.00000000039*nat_salm) - (0.000078892 * (nat_salm^2))))	0	≥20%
%Benthic Insectivores	10 * (0.010966*benth_pc_n)	0	≥91.2%
%Blackbass	10 - (10 * (-0.09684 + (0.5638*log10(blackbass))))	Eq	0
%Fluvial Specialist/Dependent	(10 * (0.2775 + (0.0073*fluv_pc_n)))	0%	Eq
%Macrohabitat Generalists	10 - (10 * (0.1017 + (0.0096*macro_gen)))	>90%	Eq
Temperate Stenothermic Species	(10 * (0.7154 + (0.4047*(log10(steno)))))	0 sp.	>5 sp.
Non-guarding Lithophilic Species	(10 * (0.2979 + (0.8975*log10(lith_ng))))	<1	>10
Non-indigenous Species	10 - (10 * (0.1063 + (0.3271*Non-indigenous_sp) - (0.029*(Non-indigenous_sp^2))))	≥5	0
%DELT Anomalies	10 - (10 * (0.8965 + (0.1074*log10(delta))))	Eq	0

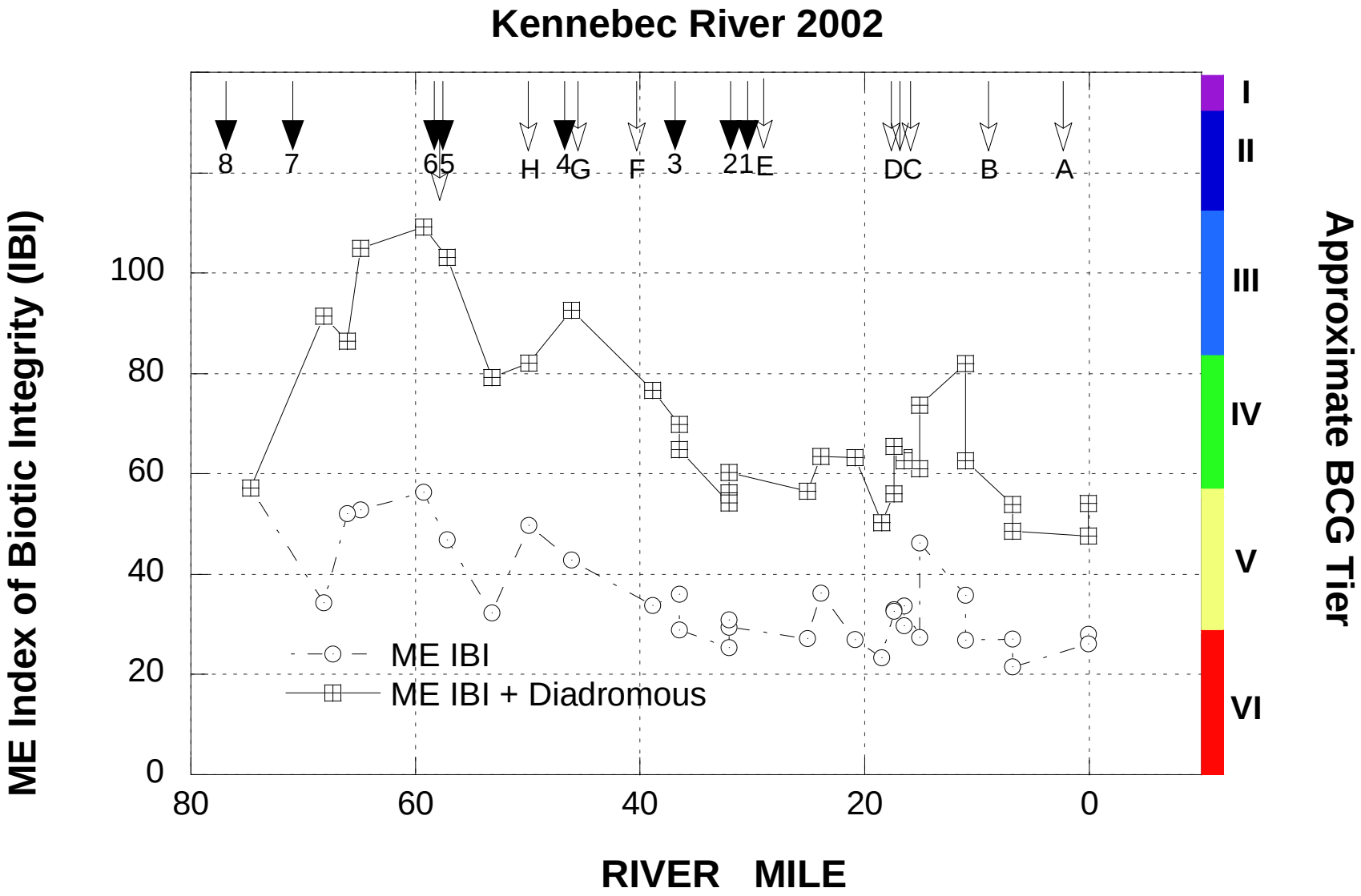
[1] No scoring adjustments are necessary; scoring determined by equation (Eq) across entire metric scoring range of 0-10.

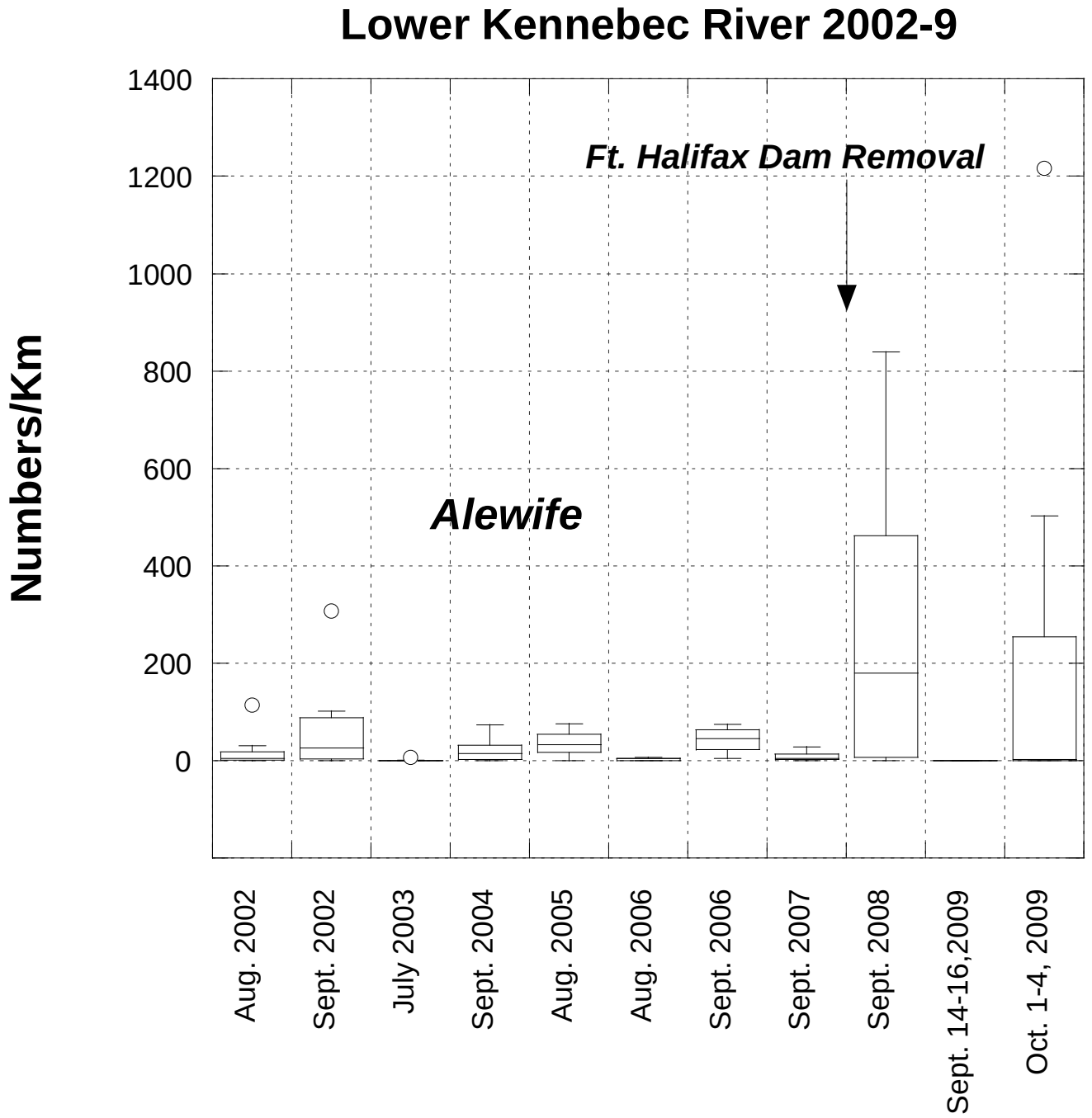


Current Improvements to the Interim Maine Rivers IBI

- Diadromous species are not included except indirectly via other metrics
- IBI scores do not seem to fit BCG expectations
- Developed a set of diadromous metrics that include: #diadromous species; log rel. no. American eel; log rel. no. Clupeidae; log rel. no. Diadromous fish.
- Additive to "core" IBI – does not "penalize" rivers that do not have diadromous fish.







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- Maine DMR – technical support
- Maine DOC – North Woods housing
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- US F&WS
- Penobscot Indian Nation – permits, tech. asst.
- Casco Bay Estuary Partnership - funding
- Harvard MCZ – fish vouchers
- Maine North Woods - access
- Private Land Owners - access
- And many, many others!