Ecosystem response model for use on Maine diadromous rivers

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The Nature Conservancy
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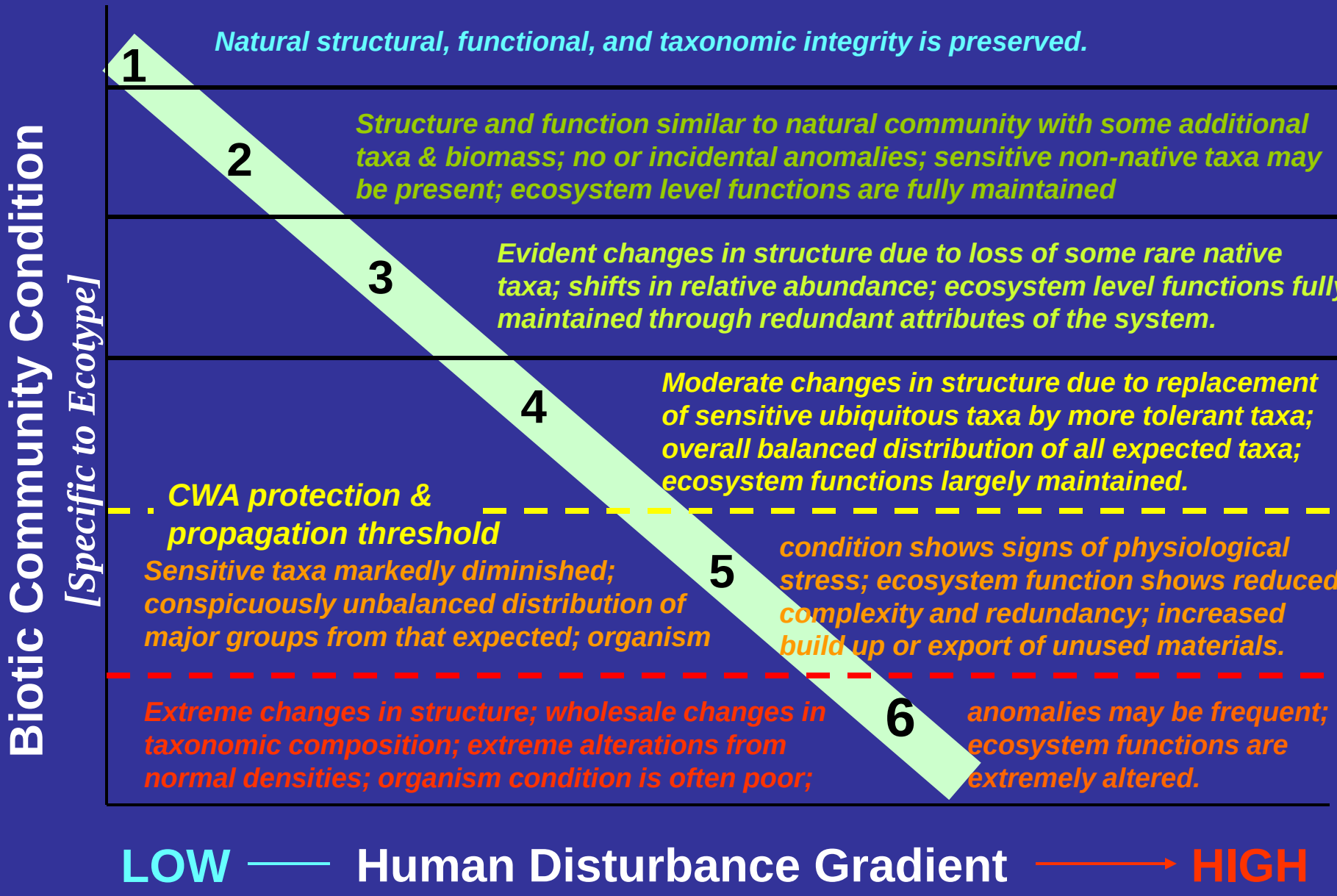
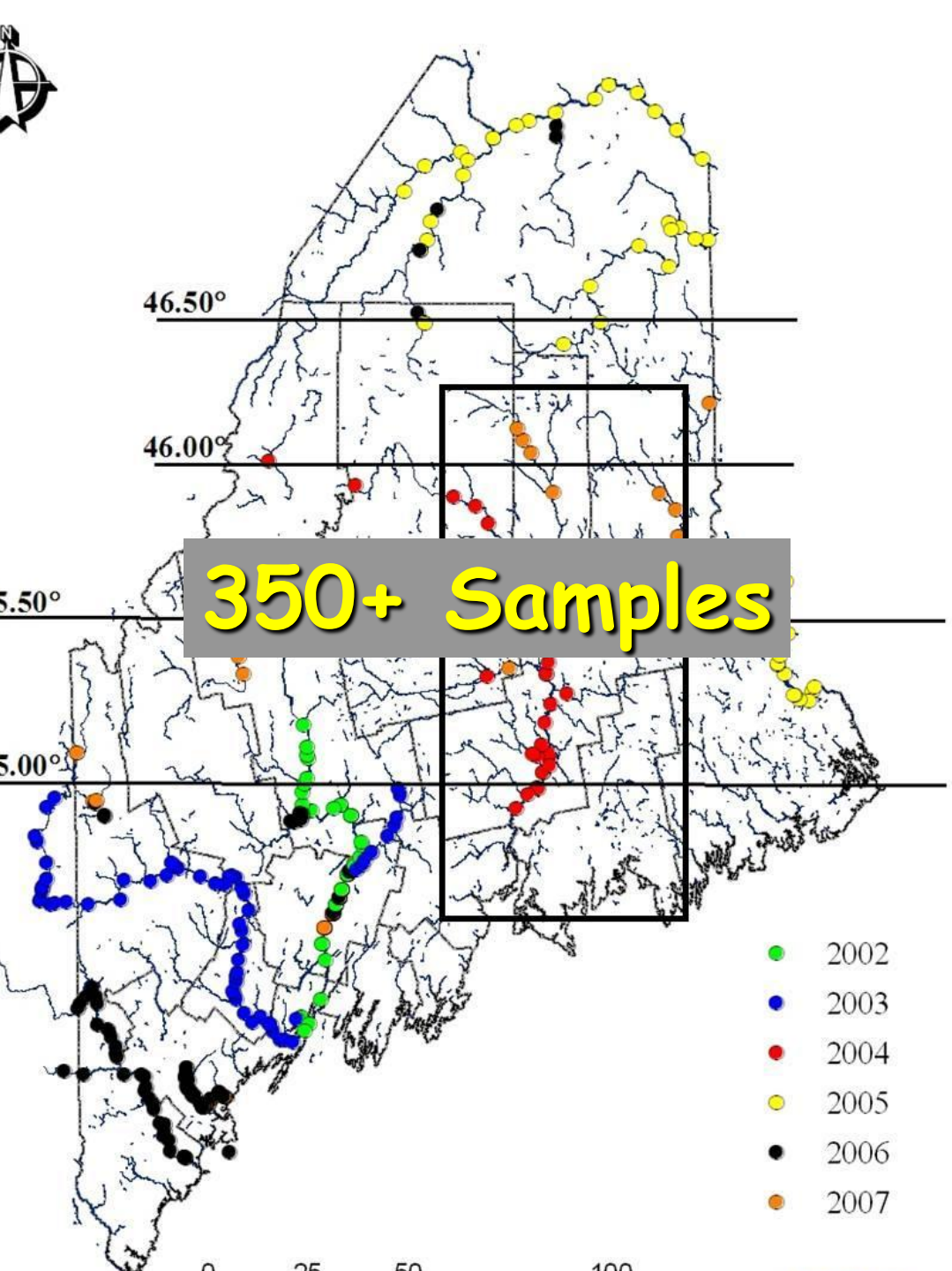
PENOBSCOT RIVER RESTORATION TRUST
AMERICAN RIVERS ~ ATLANTIC SALMON FEDERATION ~ MAINE AUDUBON ~ NATURAL RESOURCES COUNCIL OF MAINE ~ PENOBSCOT NATION ~ THE NATURE CONSERVANCY ~ TROUT UNLIMITED

Kleinschmidt
Energy & Water Resource Consultants

Bio-Condition Gradient Conceptual Model

(Davies and Jackson, 2006)



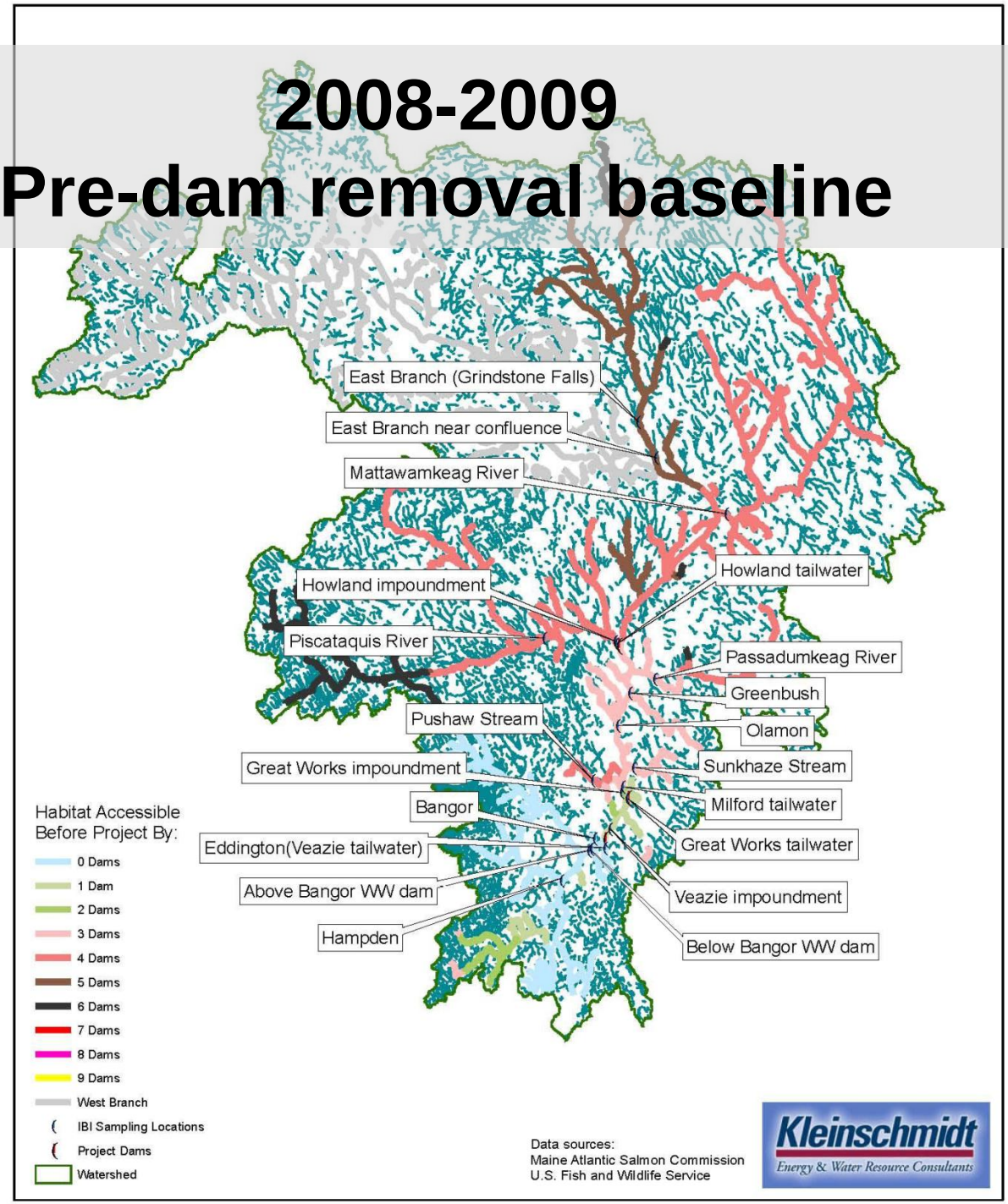


Maine-wide IBI Program
2002-2007

Major watersheds:

- **Penobscot 2004 & 2007**
- *Kennebec*
- *Androscoggin*
- *Saco*
- *St Croix*
- *St John/Allagash*
- *Presumpscot*

2008-2009
Pre-dam removal baseline



Model Development

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).

Detailed autecology of known and potential species

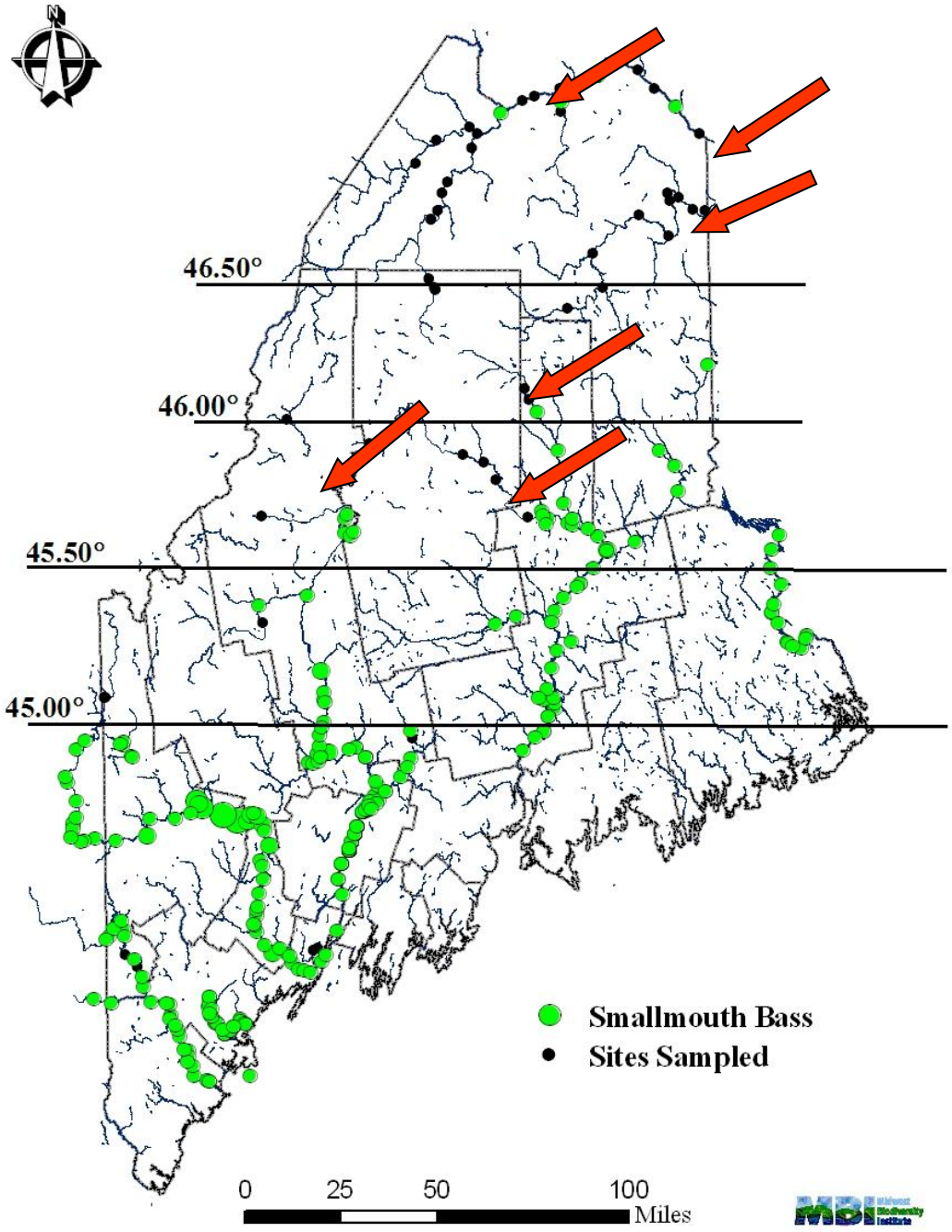
Species	Native Status[1]	Environmental Tolerance[2]	Target Fish Classification[3]	Common Habitat(s)[4]	Spatial Occurrence[5]	Thermal Guild[6]	Foraging Guild[7]	Reproductive Guild[8]	Habitat Guild[9]	Notes
Petromyzondi										
Sea lamprey *(P*										nocoetes.
Acipenseridae										
Shortnose sturg										R. 2006.
Atlantic sturge										2005 and.
Anguillidae										
American eel *(*										
Clupeidae										
Blueback herring *(Alosa aestivalis)*	N	M	A	T1,T2	C	M	P	NGL	W	All y-o-y, no adults collected.
Alewife *(Alosa pseudoharengus)*	N	M	A	T1-R2	C	M	P	PS	W	Mostly y-o-y, few adults collected.
American shad *(Alosa sapidissima)*	N	M	A	R1,T1-2	C	M	P	PS	W	Mostly y-o-y, few adults collected.
Gizzard shad *(Dorosoma cepedianum)*	IC	T	[MG]	na	na	E	D	L	W	Collected in Kennebec R. in 2000.
Cyprinidae										
Lake chub *(Couesius plumbeus)*	N	I	[FD]	R1	N	S	BI	NGL	B	
Common carp *(Cyprinus carpio)*	E	T	MG	T1-2	C	E	O	V	W	Merrymeeting Bay and lower Kennebec R.
Common shiner *(Luxilis cornutus)*	N	M	FD	R1-T1	All	E	I	NGL	W	
Golden shiner *(Notemigonus crysoleucas)*	N,IS	T	MG	R2,I1	All	E	G	L	W	
Bridle shiner *(Notropis bifrenatus)*	N	I	MG	R2	S	E	I	L	W	Presumpscot R. – one location only.
Spottail shiner *(Notropis hudsonius)*	U	M	MG	T1,I1	C	E	I	L	W	
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.

[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

Gulf of St. Lawrence
Baie des Chaleurs
Campbellton
Bathurst
Îsles-de-la-Madeleine
Rivière-du-Loup
Fleuve
Saint-Maurice
Rivière
Québec
Trois-Rivières
Rivière Chaudière
Saint-Georges
Saint-François
Sherbrooke
Lac Memphrémagog
Lac Témiscouata
Fort Kent
Restigouche
Nepisiguit River
Saint John River
Chatham
Miramichi
Tobique River
Aroostook
Allagash River
Prince Edward Island
Charlottetown
Northumberland Strait
Woodstock
Fredericton
Grand Lake
Moncton
Petitcodiac R.
New Glasgow
Penobscot River
Moosehead Lake
Mattawamkeag River
Piscataquis River
Lincoln
St. Croix River
Dikdeguash R.
Saint John
Chignecto Bay
Truro
Minas Basin
West St. Mary's River
Bay of Fundy
Calais
Kennebec River
Passamaquoddy Bay
Machias R.
Bangor
Skowhegan
Androscoggin River
Rumford
Union River
Annapolis River
Shubenacadie River
Halifax
Digby
Grand Manan Island
LaHave R.
Mersey R.
Liverpool
Mt. Desert Island
St. Mary's Bay
Saco River
Bath
Penobscot Bay
Portland
Monhegan Island
Yarmouth
Clyde River
Jordan Basin
Cape Sable
Lake Winnipesaukee
Merrimack River
Concord
Great Bay
Portsmouth
Gulf of Maine
Cashes Ledge
Brown Bank
Cape Ann
Connecticut River
Massachusetts Bay
Boston
Charles
Wilkinson Basin
Georges Basin
Northeast Channel
Stellwagen Bank
Cape Cod
Hartford
Providence
48°
46°
44°
42°

"Unique" Character of Maine Riverine Fish Assemblages

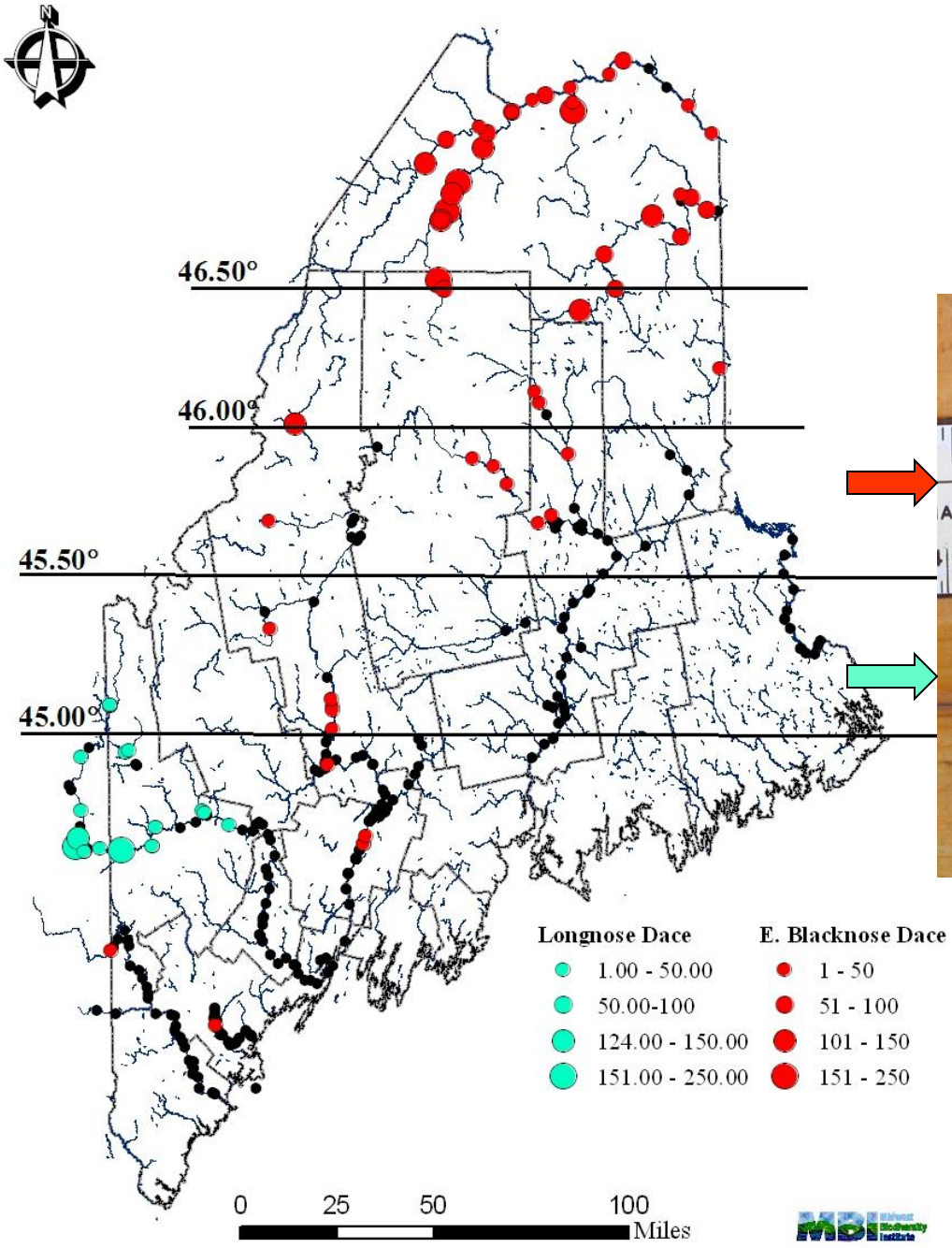
- Post-glacial recruitment defines "baseline" fauna (*Curry 2007*)
- No connection to St. Lawrence, southern New England, or western river basins
- "coolwater" species common to this latitude in other regions are ***not*** indigenous (black bass, pike, walleye, muskellunge, crappie)



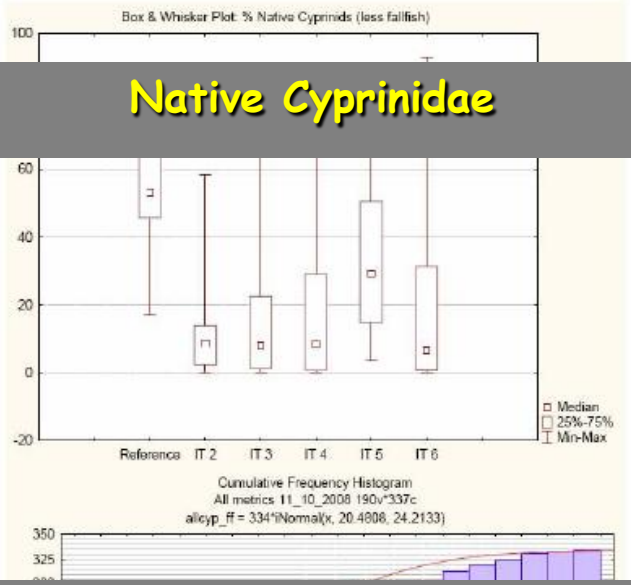
Physical barriers

Non-indigenous species distribution

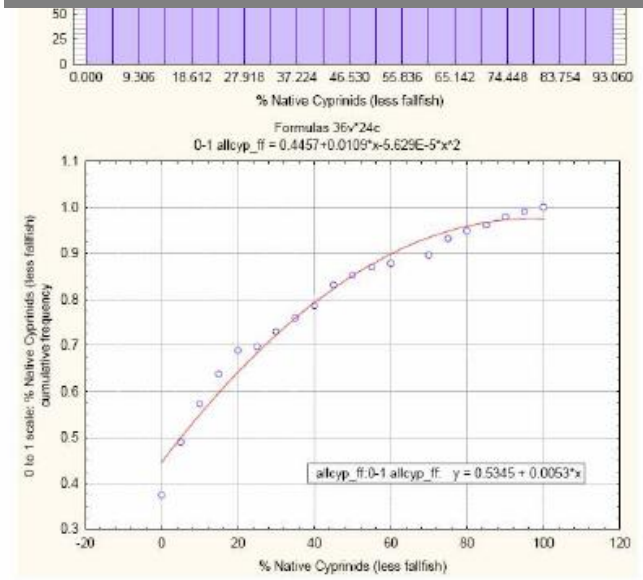
Indigenous species distribution



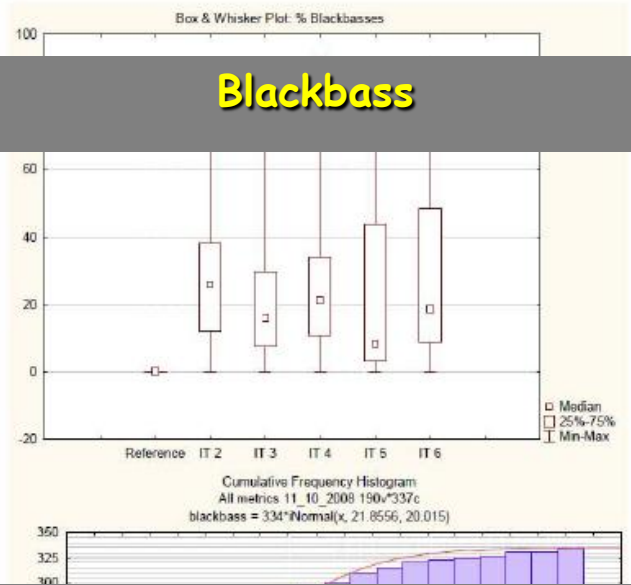
Native Cyprinidae



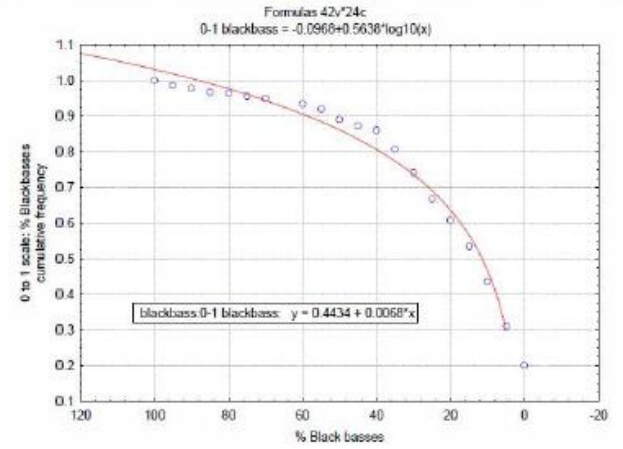
"Positive" metric



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.

"Traditional" IBI vs. Interim Maine IBI

"standard" 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

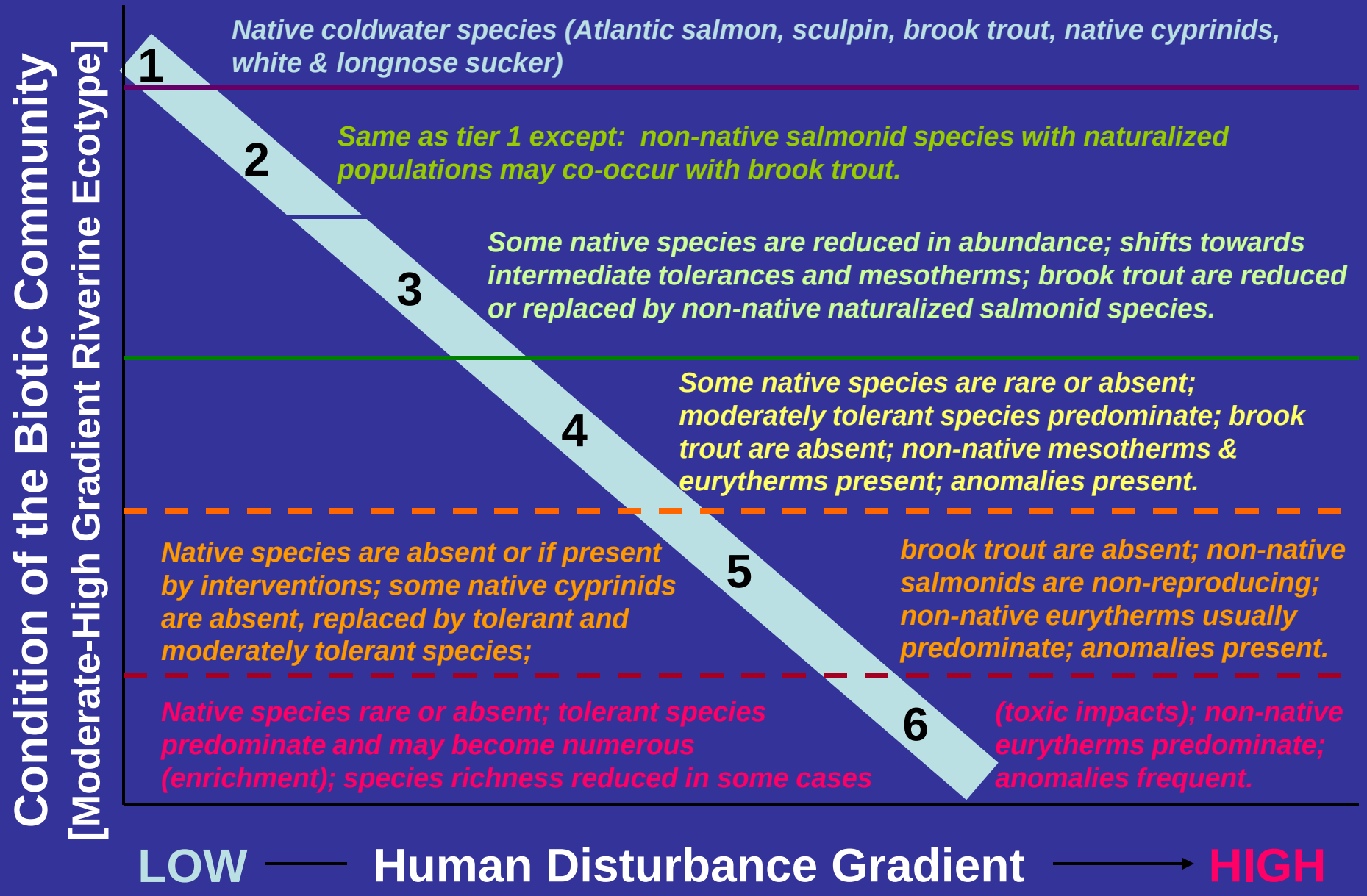
Interim Maine IBI Metrics:

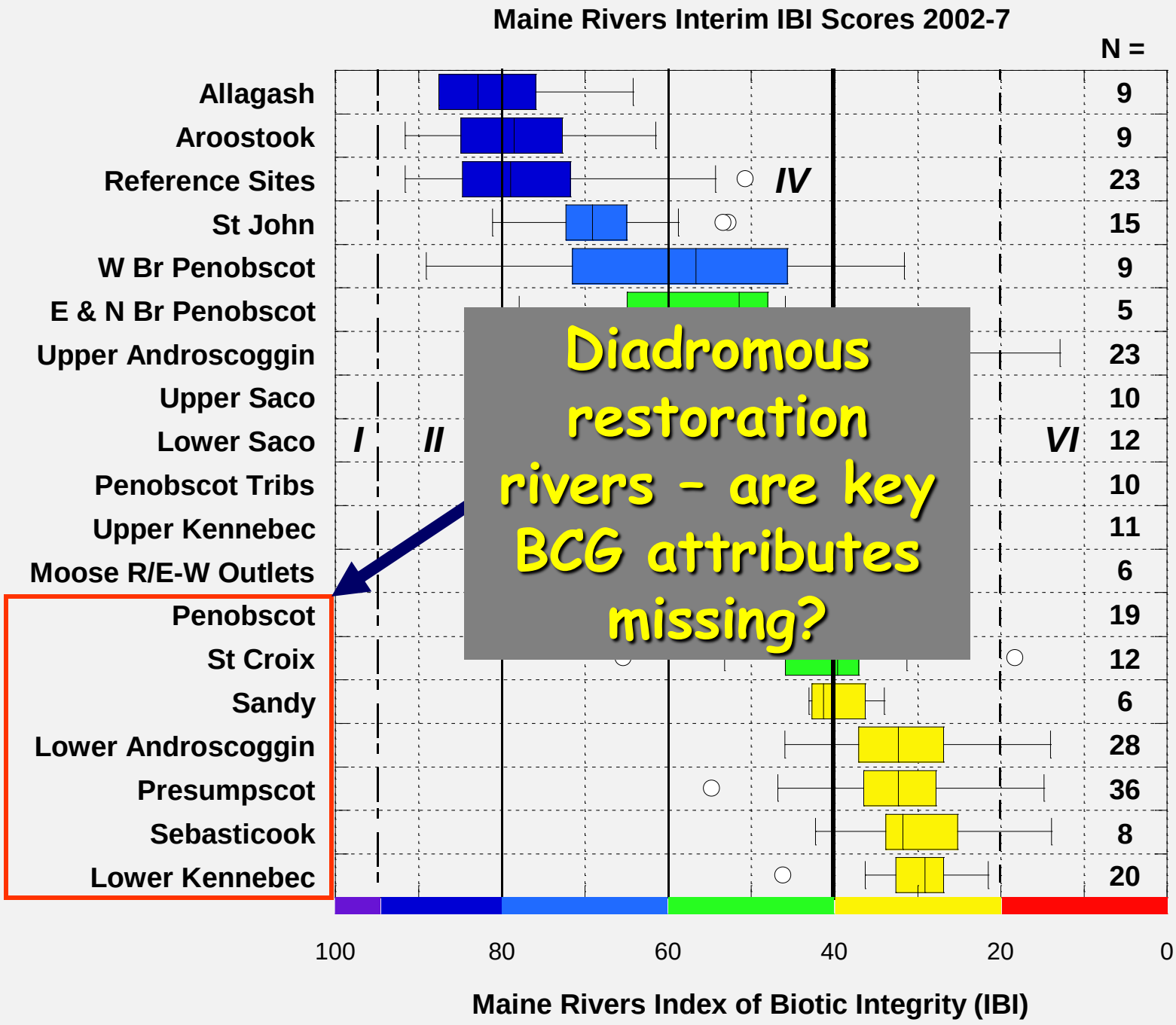
1. Native species richness
2. Native cyprinids (less fallfish)
3. % Adult white/longnose biomass
4. % Black bass
5. % Fluvial specialist/dependent
6. % Macrohabitat generalists
7. %Benthic insectivores
8. Temperate stenotherms
9. % Native salmonids
10. Non-guarding lithophils
11. % DELT anomalies
12.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

Cold Water Assemblages

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

Conceptual Model: Maine Coldwater Rivers




Maine Rivers Interim IBI Scores 2002-7
N =
Allagash
Aroostook
Reference Sites
St John
W Br Penobscot
E & N Br Penobscot
Upper Androscoggin
Upper Saco
Lower Saco
Penobscot Tribs
Upper Kennebec
Moose R/E-W Outlets
Penobscot
St Croix
Sandy
Lower Androscoggin
Presumpscot
Sebasticook
Lower Kennebec
9
9
23
15
9
5
23
10
12
10
11
6
19
12
6
28
36
8
20
I
II
IV
VI
Diadromous restoration rivers – are key BCG attributes missing?
100
80
60
40
20
0
Maine Rivers Index of Biotic Integrity (IBI)

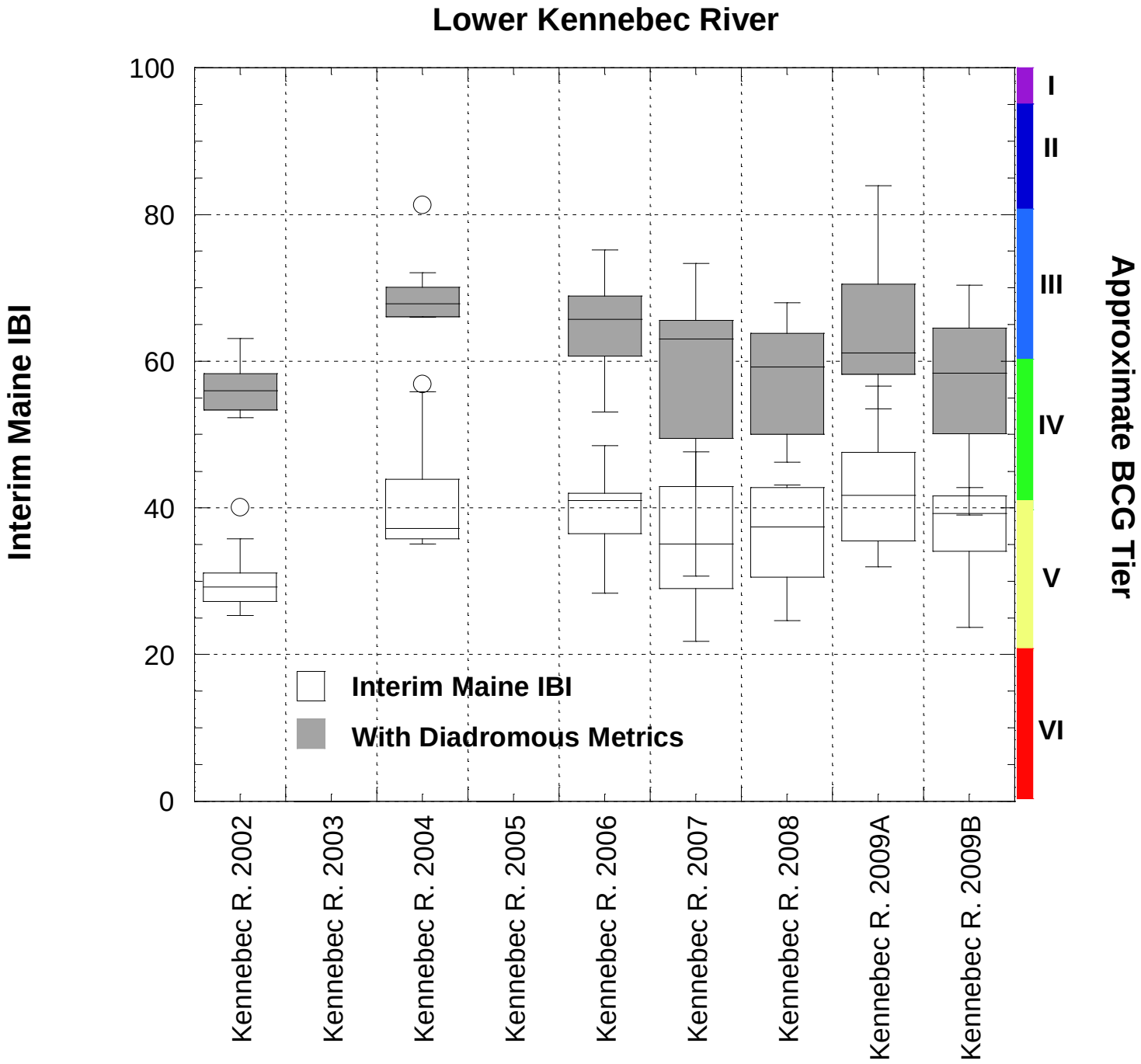
Warm water and tidal freshwater assemblages

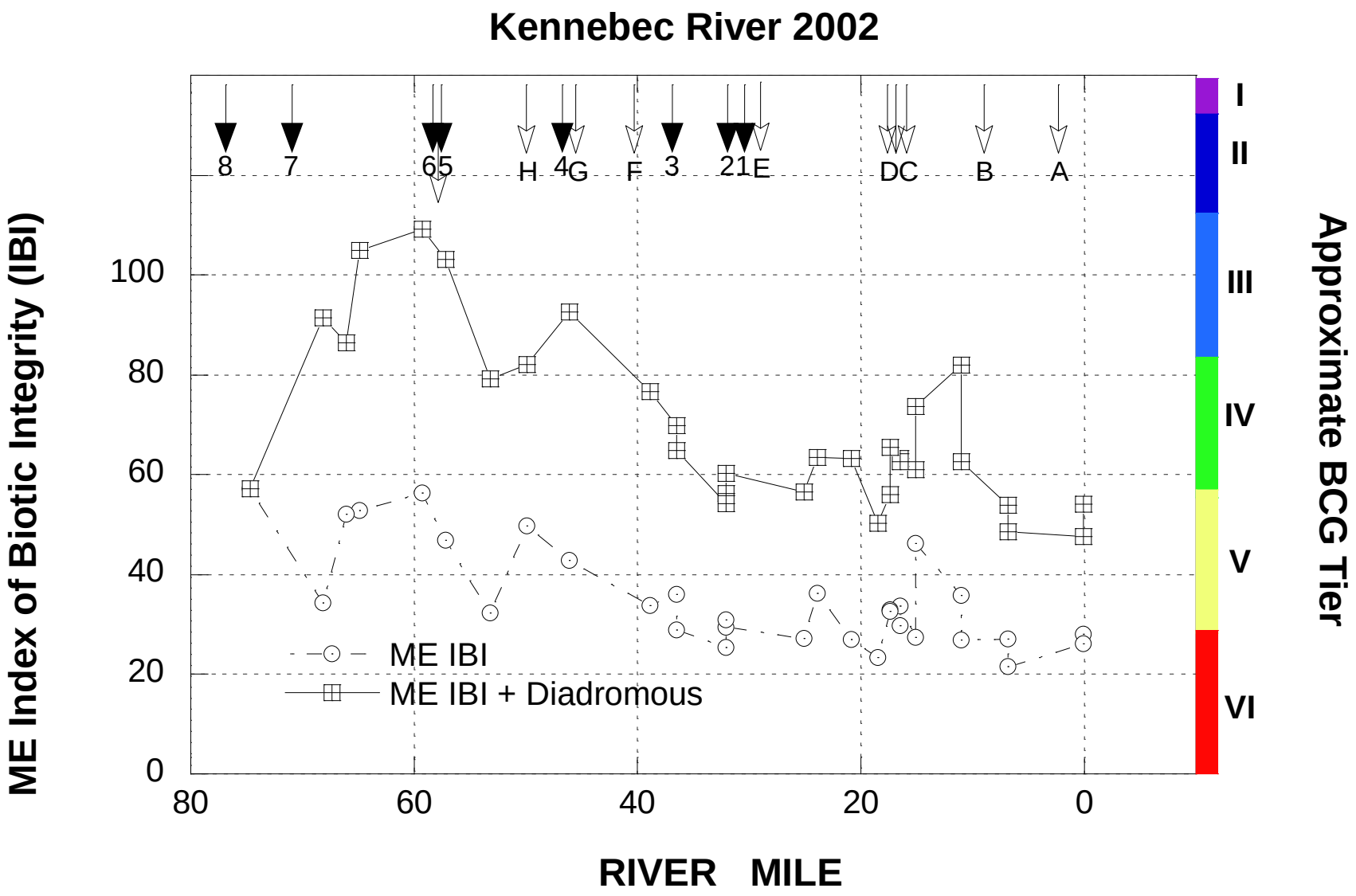
Still require further Biological Condition Gradient calibration

Refinements to account for diadromy

- Lower mainstem river scores do not fit expectations due to lack of coldwater spp.
- Provisional diadromous metrics
  - #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.


Lower Kennebec River
Interim Maine IBI
Approximate BCG Tier
100
80
60
40
20
0
I
II
III
IV
V
VI
Interim Maine IBI
With Diadromous Metrics
Kennebec R. 2002
Kennebec R. 2003
Kennebec R. 2004
Kennebec R. 2005
Kennebec R. 2006
Kennebec R. 2007
Kennebec R. 2008
Kennebec R. 2009A
Kennebec R. 2009B


Kennebec River 2002
ME Index of Biotic Integrity (IBI)
Approximate BCG Tier
RIVER MILE
8
7
65
H
4
G
F
3
21
E
DC
B
A
I
II
III
IV
V
VI
ME IBI
ME IBI + Diadromous
0
20
40
60
80
100
80
60
40
20
0

Penobscot River IBI Status

- 2010-11 additional pre-project data
- Refine IBI metrics for diadromy *(TBD).*
- 2011 – dam removal & restoration process starts
- 2012 ? Begin collecting post-project data

Acknowledgements

FUNDING

- U.S. EPA, Region I – statewide IBI surveys and analysis
- NOAA Fisheries
- The Nature Conservancy
- ARRA (via the Penobscot River Restoration Trust)
- Casco Bay Estuary Partnership - southern Maine surveys

SUPPORT

- Maine DEP – in-kind support
- Maine IF&W – technical support
- Maine DMR – technical support
- Maine DOC – remote area lodging & Allagash wilderness access
- Penobscot Indian Nation – permits, tech. assist.
- Harvard MCZ – fish vouchers
- Maine North Woods - access