Development and refinement of benthic indices to assess coastal waters for U.S. EPA's National Coastal Condition Assessment.

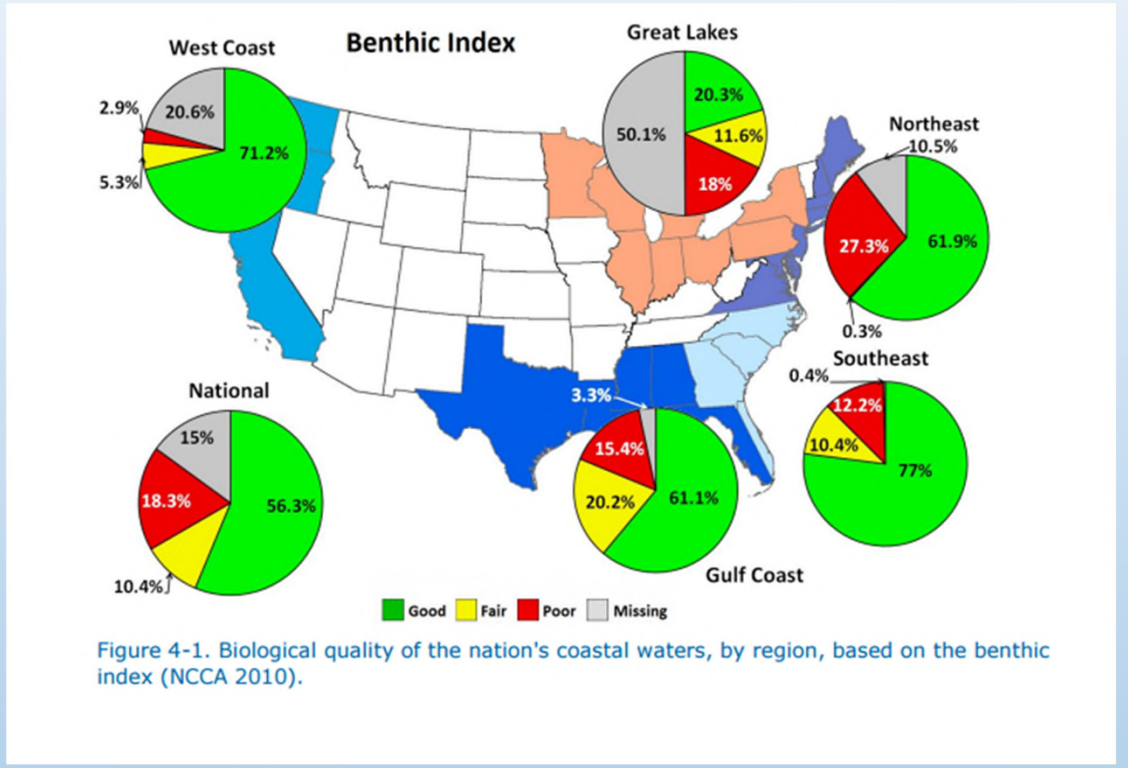
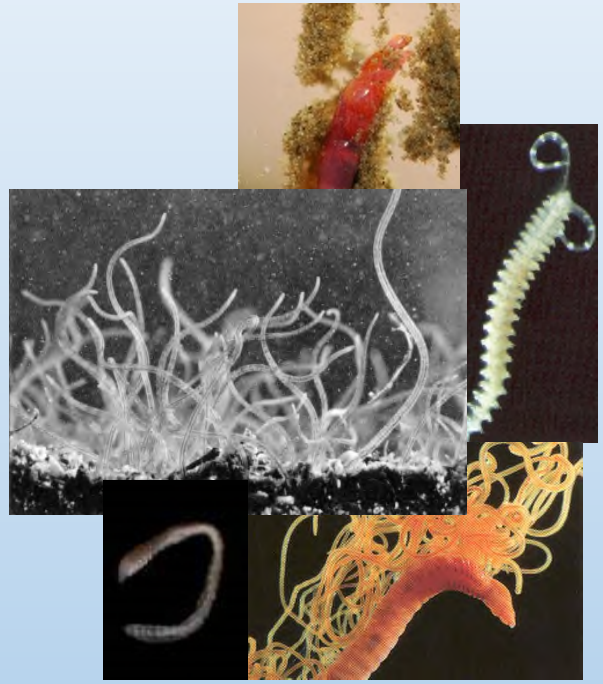
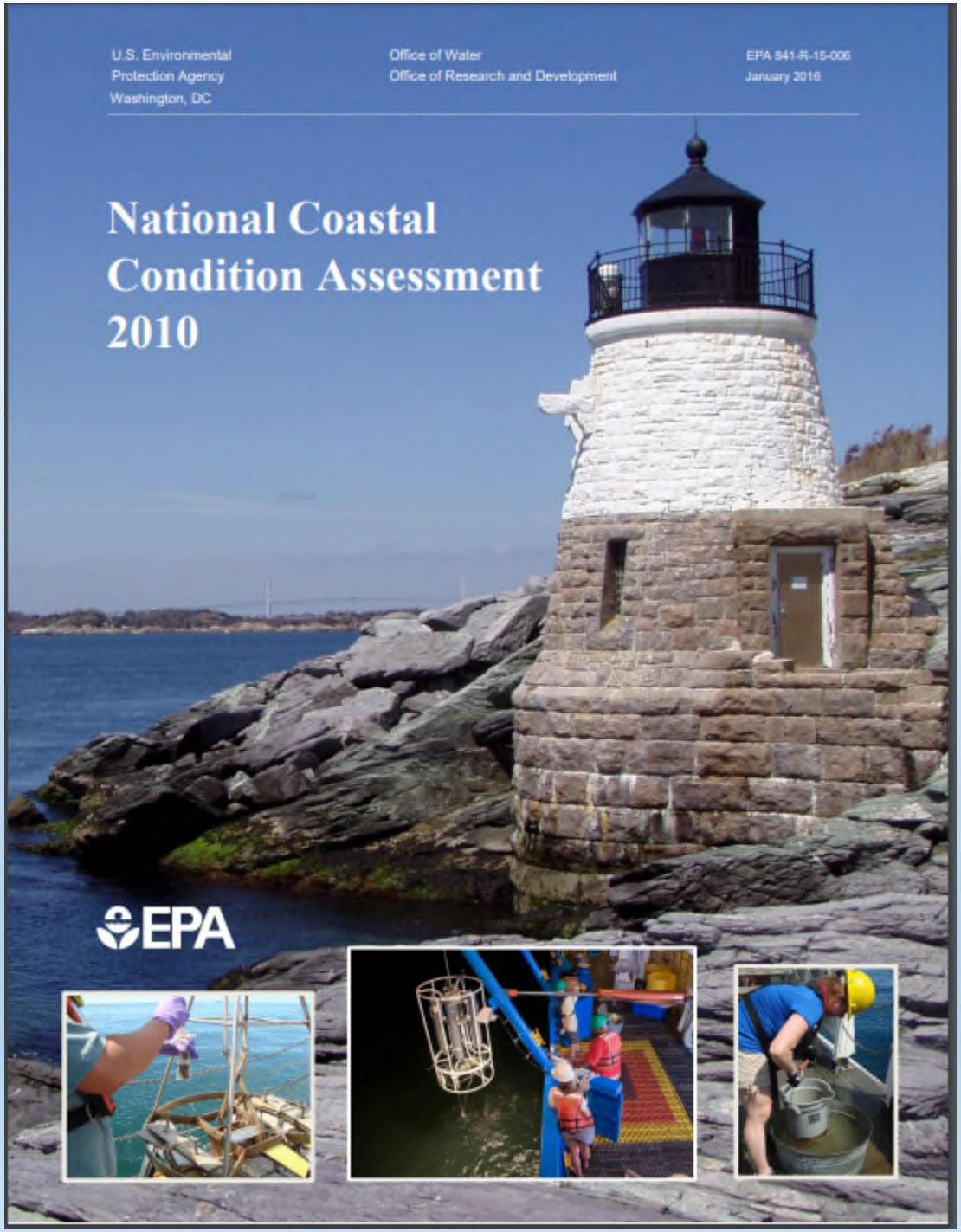


Figure 4-1. Biological quality of the nation's coastal waters, by region, based on the benthic index (NCCA 2010).



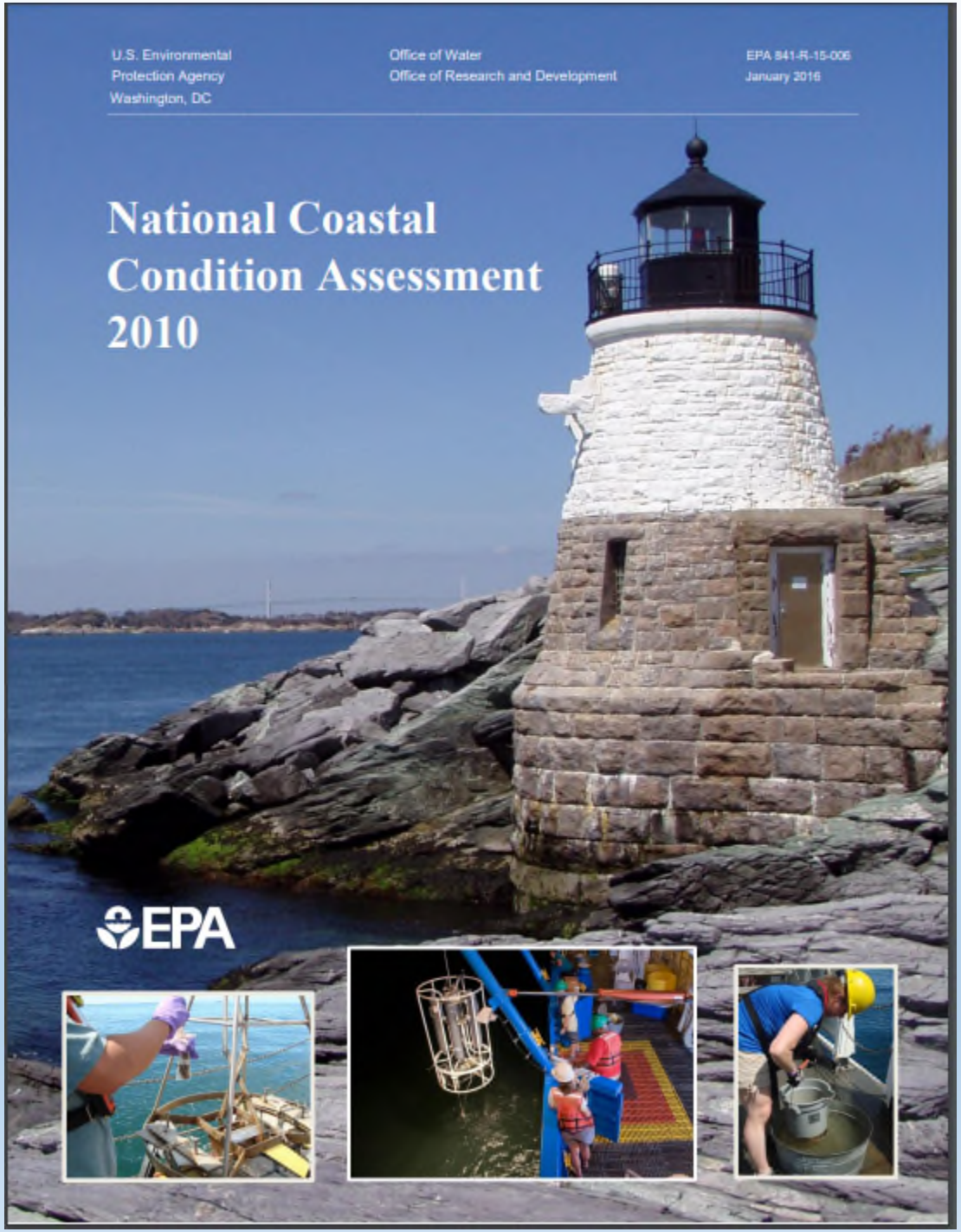
M.C. Pelletier[1], D.J. Gillett[2], A. Hamilton[3], T. Grayson[4], V. Hansen[1], E.W. Leppo[3], S.B. Weisberg[2], A. Borja[5], T. Angradi[1], B. Hinchey-Malloy[6], L.E. Burlakova[7], H. Sullivan[4]

[1]U.S. EPA Office of Research and Development, [2]SCCWRP, [3]TetraTech, [4]U.S. EPA Office of Water, [5]AZTI – Tecnalia, [6]U.S. EPA Great Lakes National Program Office, [7]Buffalo State



2010 National Coastal Condition Assessment

- Extension of previous EPA marine and estuarine monitoring programs from 1990-2006
- Included near-shore Great Lakes monitoring for the first time
- Biological monitoring based on benthic invertebrates, assessed using benthic indices
  - Estuaries – 5 different indices for different parts of the country
  - Great Lakes – Oligochaete Trophic Index used to assess deep potions of Great Lakes by SOLEC



This talk:

Improvements to benthic assessment for 2015 & 2020 National Coastal Condition Assessment

<u>Estuaries</u>

Development of single index for use in all continental US estuaries

<u>Great Lakes</u>

Initial efforts to assess/improve the benthic index for nearshore Great Lakes waters

Coastal Indices used for National Coastal Assessment and NCCA 2010 Reporting

Region/ Province	Data Source	Statistical Method	Component Metrics	Index Condition Scale		
				Good	Fair	Poor
Northeast/ Acadian	NCA 2000-2001	Logistic Regression Analysis	Diversity (Shannon *H'*) Pollution Tolerant Taxa Proportion Capitellids	> 5	4 – 5	< 4
Northeast/ Virginian	EMAP 1990-1993	Discriminant Analysis	Diversity (Gleason *D*) Abundance Tubificids Abundance Spionids	> 0	n/a	≤ 0
Southeast/ Carolinian	EMAP 1993-1994	Cluster Analysis	Abundance Species Richness Dominance Pollution Sensitive Taxa	> 2.5	2 – 2.5	< 2
Gulf/ Louisianan	EMAP 1991-1992	Discriminant Analysis	Diversity (Shannon *H'*) Abundance Tubificids Proportion Capitellids Proportion Bivalves Proportion Amphipods	> 5	3 – 5	< 3

- Benthic Indices developed and calibrated separately for each Region
- Concerns about cross-region comparability

West Coast Salinity-adjusted expected number of species

Region	Good	Fair	Poor
West	Observed species richness is more than 90% of the lower 95% confidence interval of expected species richness for a specific salinity.	Observed species richness is between 75% and 90% of the lower 95% confidence interval of expected species richness for a specific salinity.	Observed species richness is less than 75% of the lower 95% confidence interval of expected species richness for a specific salinity.

Need for New National Benthic Index for Application to US Estuaries

Multivariate (discriminant analysis, logistic regression)

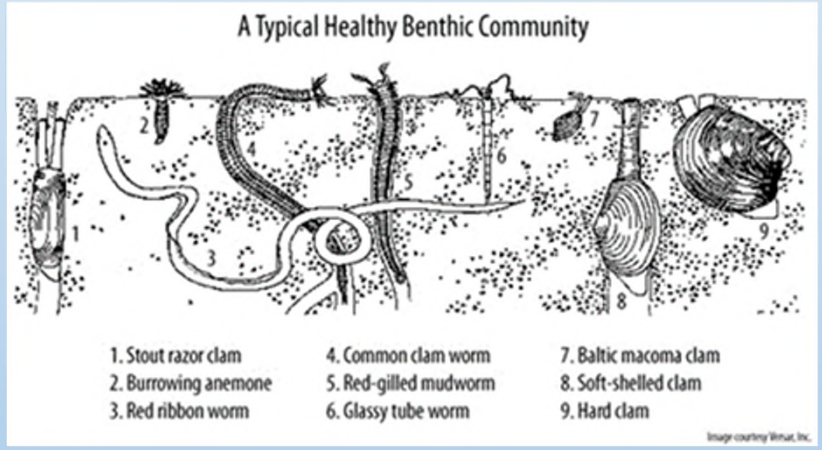
- Need reference and impaired sites
- Select from multiple potential metrics
- Combine metrics to develop index

B-IBI (multimetric)

- Need reference and impaired sites
- Select from multiple potential metrics
- Combine metrics to develop index

AMBI (abundance-weighted tolerance index)

- Do Not Need reference and impaired sites
- Need to categorize tolerance values of benthic taxa



What is AMBI (AZTI Marine Biotic Index)?

Pergamon

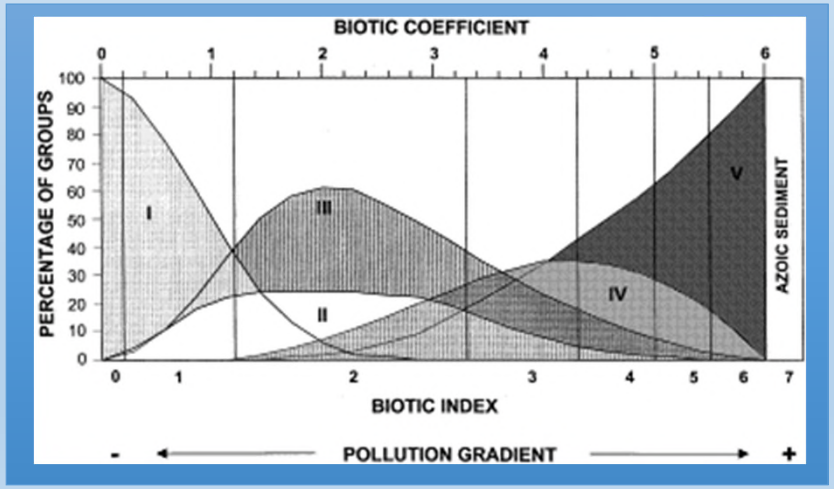
Marine Pollution Bulletin Vol. 40, No. 12, pp. 1100–1114, 2000

Printed in Great Britain
0025-326X/00 $ - see front matter

PII: S0025-326X(00)00061-8

A Marine Biotic Index to Establish the Ecological Quality of Soft-Bottom Benthos Within European Estuarine and Coastal Environments

A. BORJA*, J. FRANCO and V. PÉREZ
Department of Oceanography and Marine Environment, Technological Institute for Fisheries and Food (AZTI), Av. Satrústegui 8, 20008 San Sebastián, Spain



$$BI = \frac{0 * \%EG\ I + 1.5 * \%EG\ II + 3 * \%EG\ III + 4.5 * EG\ IV + 6 * EG\ V}{}$$

Range =

0 (unimpacted) to 6 (heavily impacted) or 7 (azoic)

- Previous Case Studies in FL, SoCal, Chesapeake Bay, Northwest

AMBI – Adaptation to US estuaries

- 3 Day workshop in Cosa Mesa, CA (Sept 2011)
  - Decision to explore development of AMBI for US estuaries
  - Decision to compare 'new' index to existing local indices from around the country
  - NCCA species categorized by EG group (tolerance value)

- Creation of working group with larger group meetings at CERF (2011-2015)
  - 3 regional Datasets assembled – compare local index to AMBI
  - Workshop EG list augmented with existing European EG list
  - Published results in 2015


Ecological Indicators 50 (2015) 99–107

Contents lists available at ScienceDirect

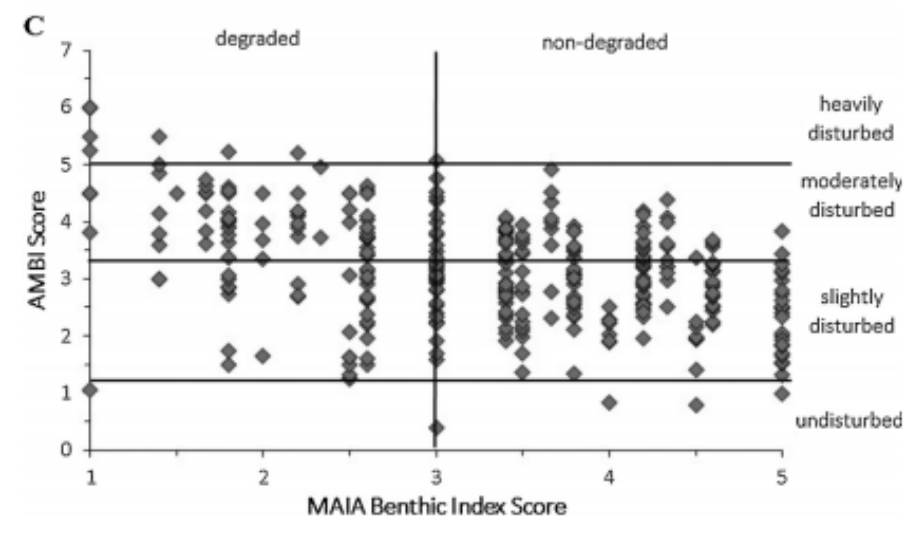
Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

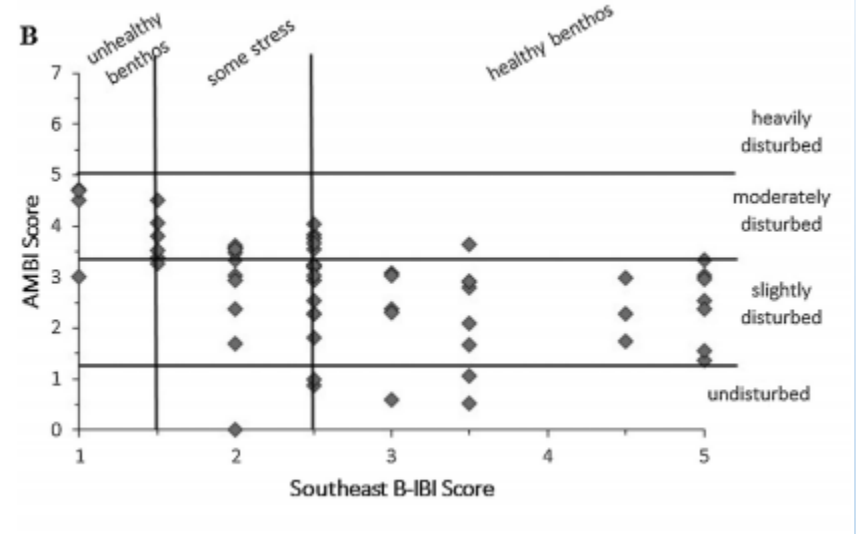
Effect of ecological group classification schemes on performance of the AMBI benthic index in US coastal waters

David J. Gillett [a,*], Stephan B. Weisberg [a], Treda Grayson [b], Anna Hamilton [c], Virginia Hansen [d], Erik W. Leppo [c], Marguerite C. Pelletier [e], Angel Borja [f], Donald Cadien [g], Daniel Dauer [h], Robert Diaz [i], Margaret Dutch [j], Jeffrey L. Hyland [k], Michael Kellogg [l], Peter F. Larsen [m], Jeffrey S. Levinton [n], Roberto Llansó [o], Lawrence L. Lovell [g], Paul A. Montagna [p], Dean Pasko [q], Charles A. Phillips [r], Chet Rakocinski [s], J. Ananda Ranasinghe [a], Denise M. Sanger [t], Heliana Teixeira [u], Robert F. Van Dolah [t], Ronald G. Velarde [v], Kathy I. Welch [j]

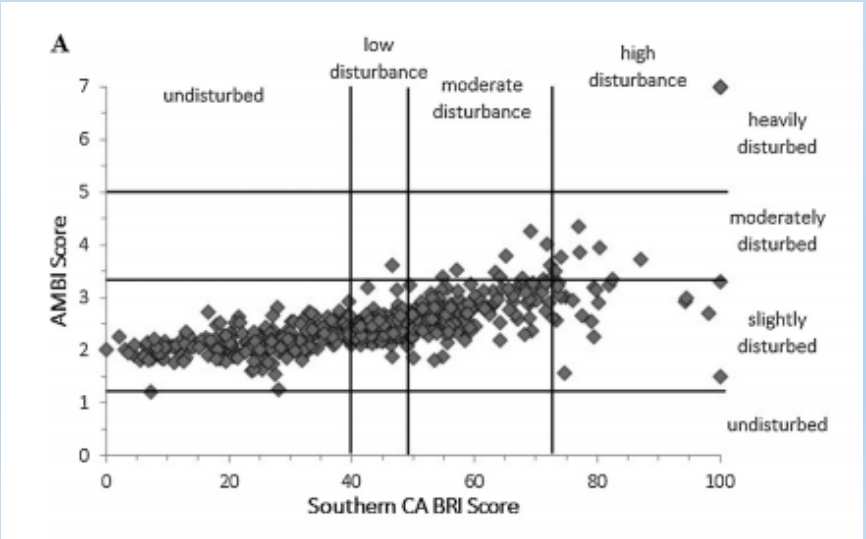
AMBI – Adaptation to US estuaries



R = 0.437, p<0.0001

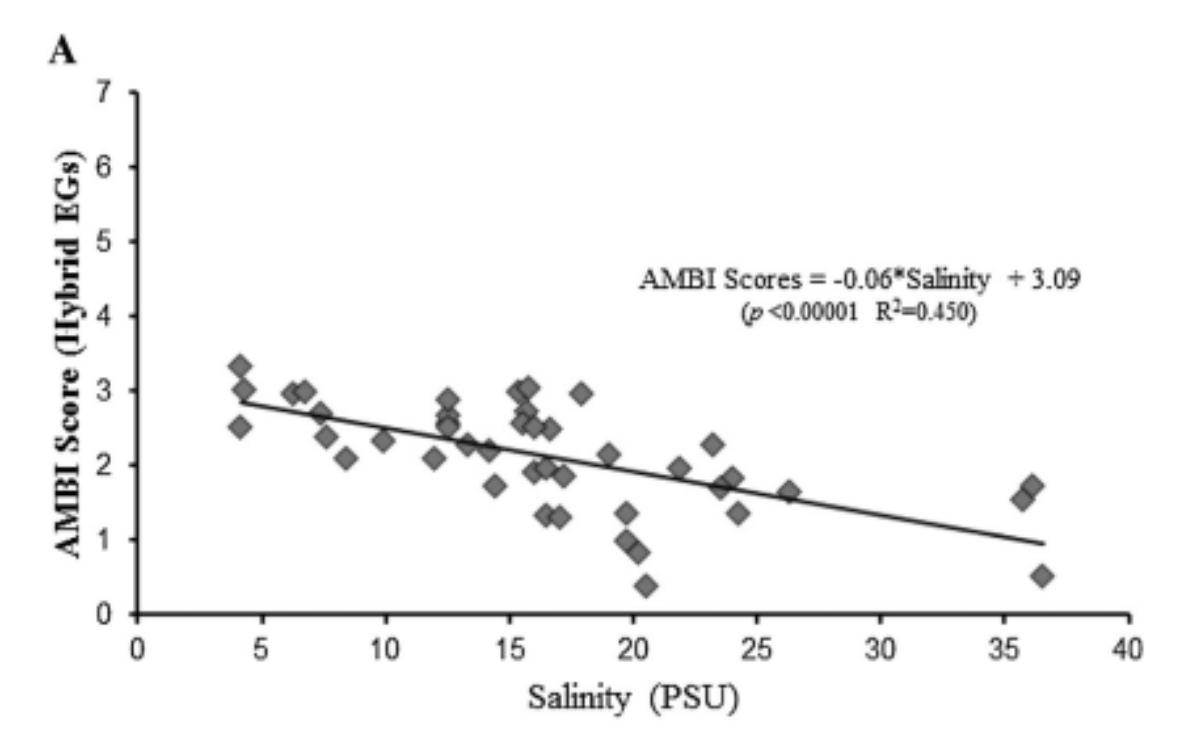


R = 0.525, p<0.0001



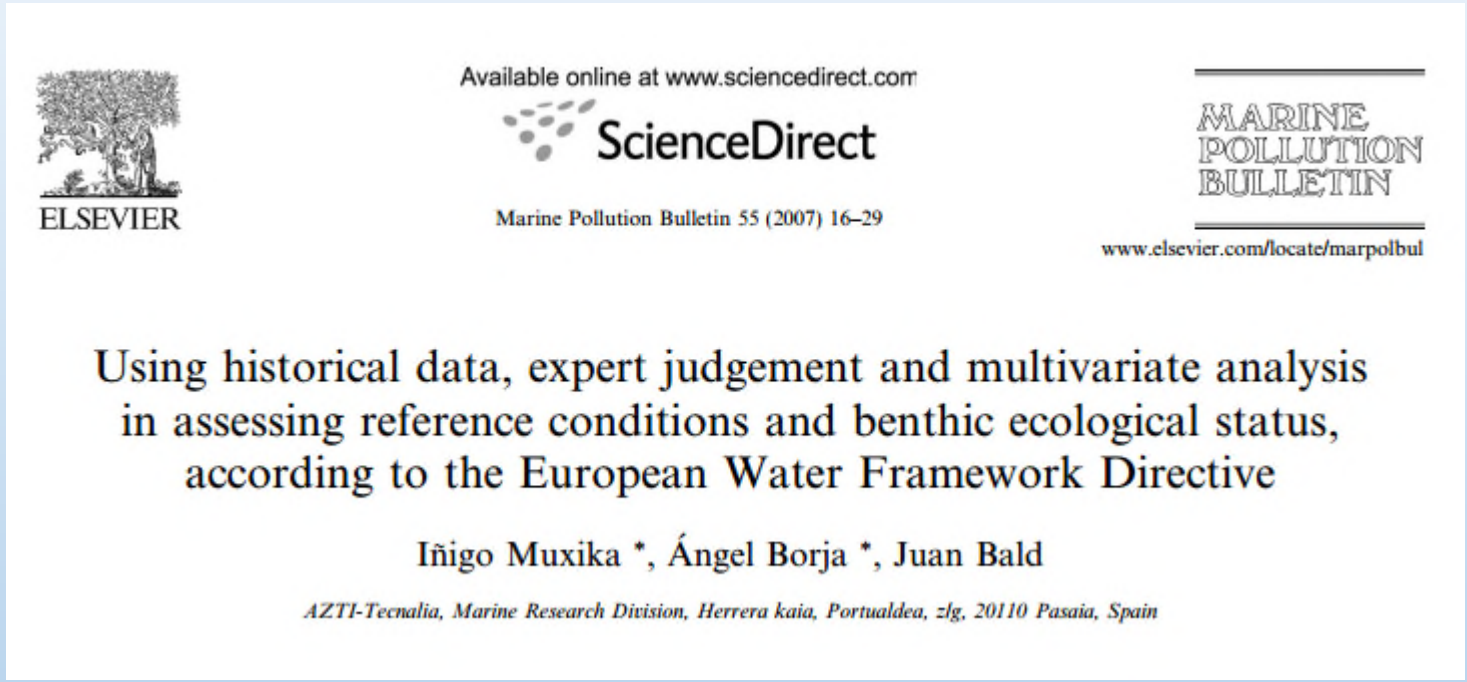
R = 0.736, p<0.0001

AMBI – Adaptation to US estuaries



- Strong salinity bias seen in unimpacted station in the southeast and mid-Atlantic (SoCal is primarily high salinity sites so a salinity bias would not be expected)

Expansion of AMBI to M-AMBI (multivariate AMBI)



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ScienceDirect
Marine Pollution Bulletin 55 (2007) 16–29

MARINE POLLUTION BULLETIN
www.elsevier.com/locate/marpolbul

Using historical data, expert judgement and multivariate analysis in assessing reference conditions and benthic ecological status, according to the European Water Framework Directive

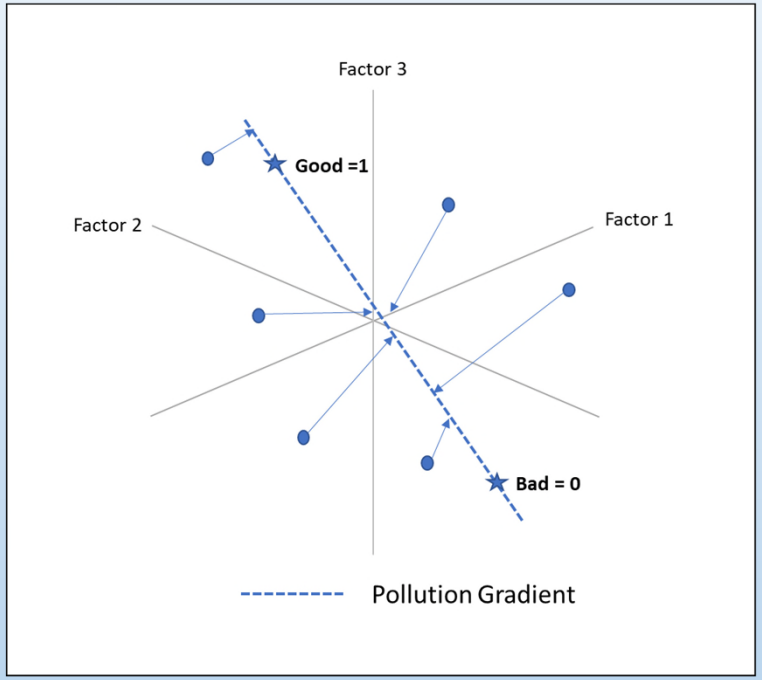
Iñigo Muxika *, Ángel Borja *, Juan Bald

AZTI-Tecnalia, Marine Research Division, Herrera kaia, Portualdea, z/g, 20110 Pasaia, Spain

- Combines AMBI, diversity (H') and species richness into a new index
- Helps to deal with issues of salinity bias
- Allows discrimination of sites with low species richness

How does M-AMBI work?

- Uses Factor Analysis to combine AMBI, diversity (H') and species richness into a new index
- Good and Bad endpoints ('reference' & 'impaired' derived for each metric)
  - Used to set up a pollution gradient
  - Station values from factor analysis projected onto the pollution gradient
- Classified by habitat (salinity and location (estuarine v. coastal))
- Range = 0 (Bad) to 1 (High)



Stretches
Oligo/mesohaline
Polyhaline
Euhaline (estuarine)
Euhaline (coastal)

M-AMBI – Adaptation to US estuaries

Ecological Indicators 89 (2018) 818–827

Contents lists available at ScienceDirect

Ecological Indicators

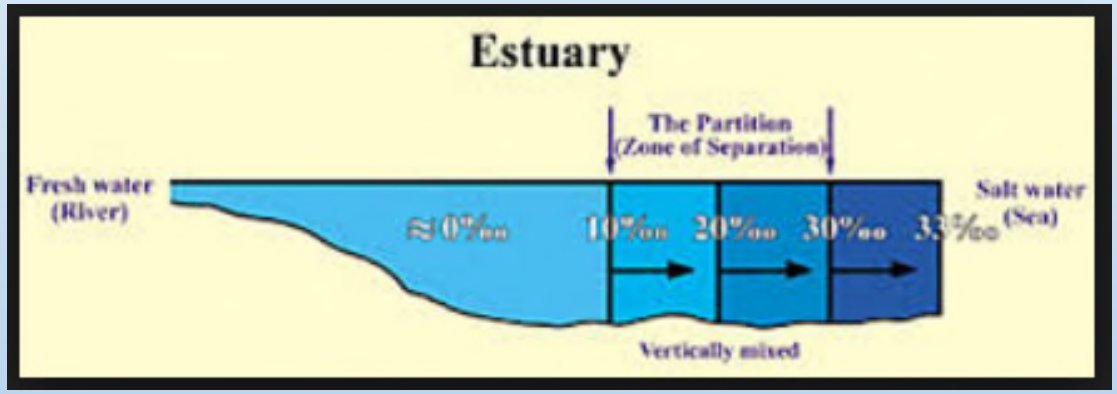
journal homepage: www.elsevier.com/locate/ecolind

Research paper

Adaptation and application of multivariate AMBI (M-AMBI) in US coastal waters

Marguerite C. Pelletier[a,*], David J. Gillett[b], Anna Hamilton[c], Treda Grayson[d], Virginia Hansen[e], Erik W. Leppo[c], Stephan B. Weisberg[b], Angel Borja[f]

- Venice salinity classification to identify habitats



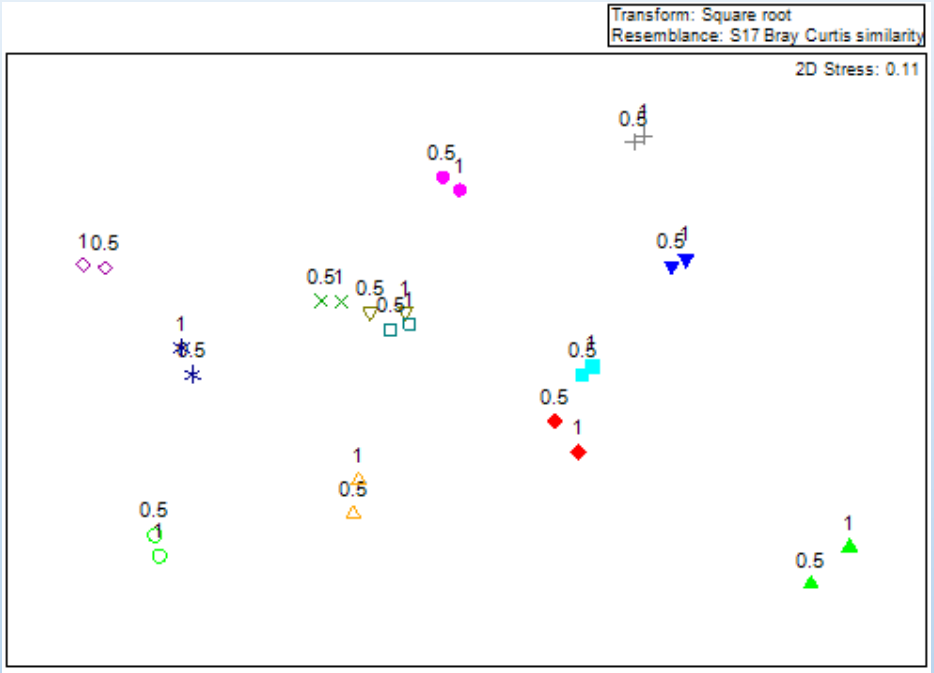
Habitat	Salinity (psu)		
Tidal Freshwater	<0.5		
Oligohaline	0.5	to	<5
Mesohaline	5	to	<18
Polyhaline	18	to	<30
Euhaline	30	to	<40
Hyperhaline	>=40		

- Needed to develop expectations for each habitat, but West Coast data used larger grab (0.1 m^2 grab vs 0.04 m^2 grab or equivalent) and sieve (1.0 mm vs. 0.5 mm)

M-AMBI Development – West Coast gear differences

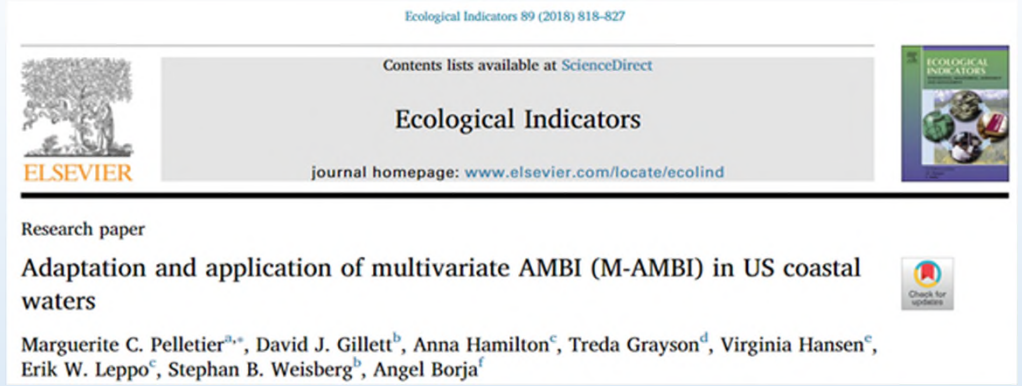
- Sieve size differences did not appear to be significant based on subset of stations using both sieves

- Grab size impacted the total number of species



95th percentile	Rest of US		WEST	
	S	H'	S	H'
Tidal Freshwater	16	2.06	15	1.80
Oligohaline	16	2.14	14	1.82
Mesohaline	26	2.50	17	1.97
Polyhaline	43	2.93	77	3.30
Euhaline	59	3.29	92	3.60

M-AMBI –
Adaptation to US estuaries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Marguerite C. Pelletier[a,*], David J. Gillett[b], Anna Hamilton[c], Treda Grayson[d], Virginia Hansen[e], Erik W. Leppo[c], Stephan B. Weisberg[b], Angel Borja[f]

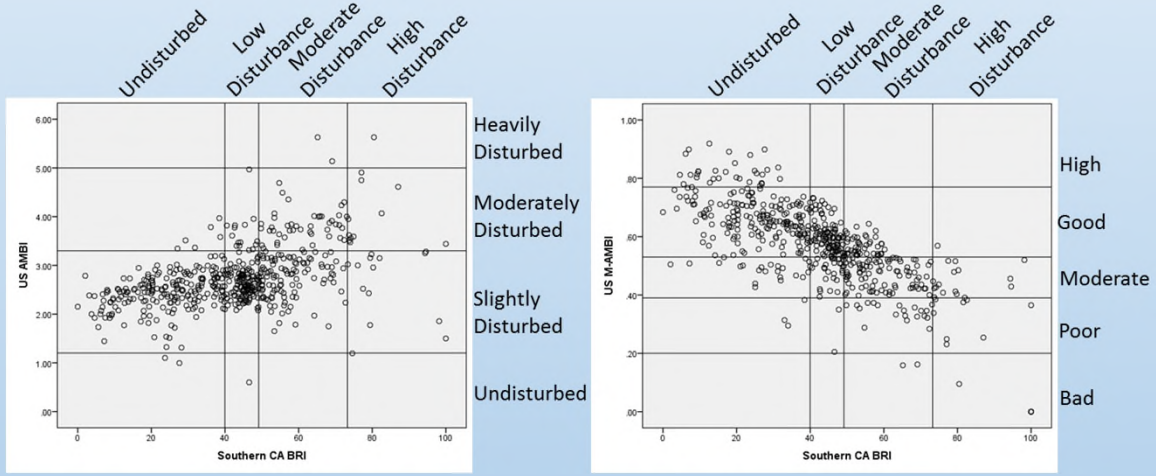
- Bad endpoints were same for all habitats (S, H' = 0, AMBI =6)
- High endpoints based on 95th percentile of 1999-2006 NCA data, based on habitat
  - TF, O, M, H calculated for entire US
  - P and E – calculated for West and Rest of US
- Using 1999-2006 NCA data, explored use of metrics other than S and H' (i.e., % oligochaetes for tidal freshwater habitat)
- Calculating M-AMBI for 3 validation datasets
  - Compare to local indices
  - Look at calibration accuracy vs. apriori Good/Bad sites
  - Look to see if salinity correlation has been reduced or eliminated

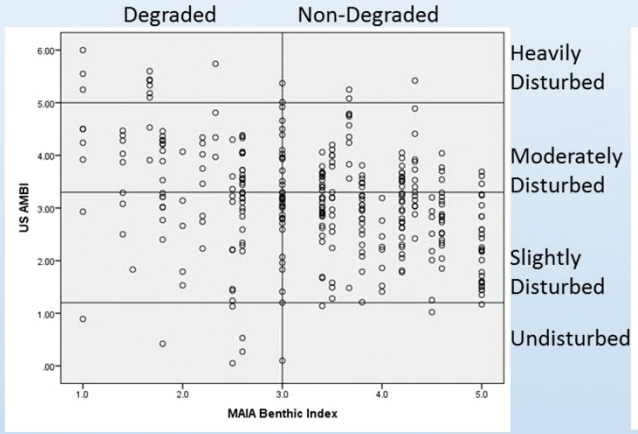
M-AMBI – Good Classification Accuracy

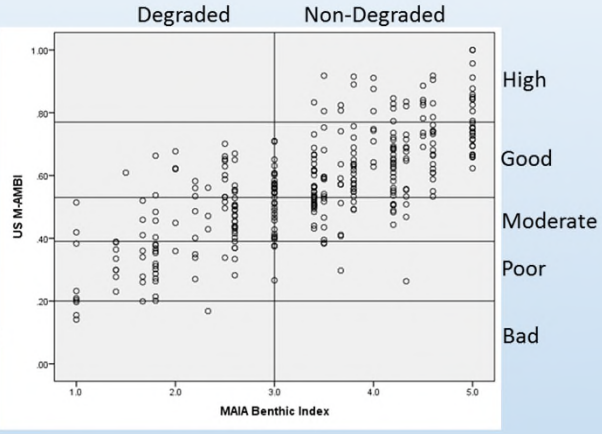
	M-AMBI vs Local Index			M-AMBI accuracy compared to apriori Good-Bad sites	
Dataset	Correlation (Spearman's ρ)	Overall Classification Accuracy (%)	Kappa	Overall Classification Accuracy (%)	Kappa
Mid-Atlantic	r = 0.715 (p<0.0005)	87.3	0.65 (substantial)	83.2	0.57 (moderate)
Southeast	r = 0.829 (p<0.0005)	97.4	0.95 (almost perfect)	90.3	0.81 (almost perfect)
Southern California	r = - 0.746 (p<0.0005)	86.3	0.49 (moderate)	100	1.00 (almost perfect)

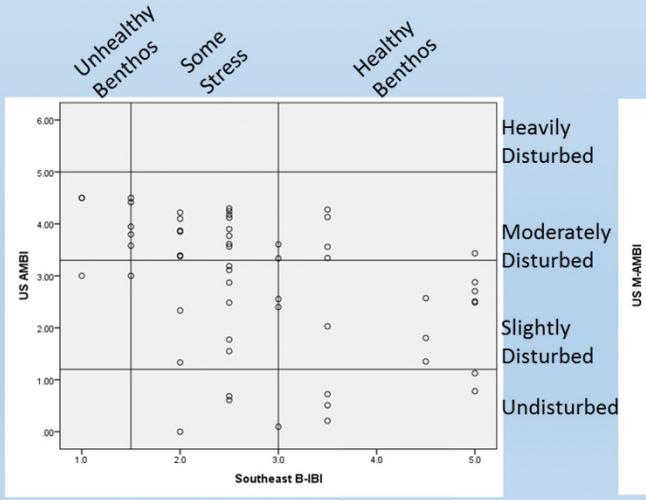
- Good correspondence with local indices
- Good correspondence with a-priori Good/Bad sites from local datasets

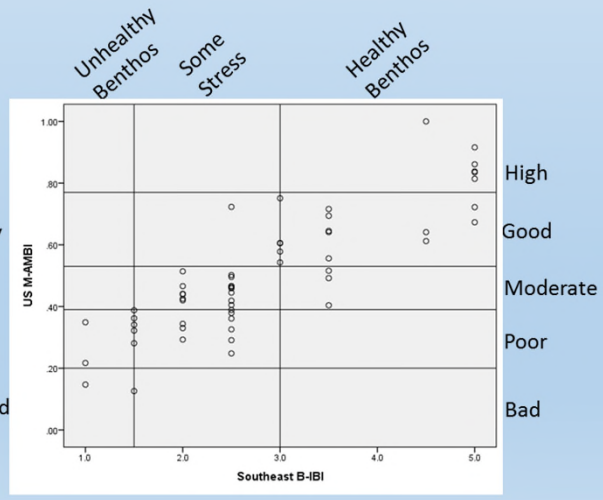
M-AMBI – Tighter correspondence to local indices



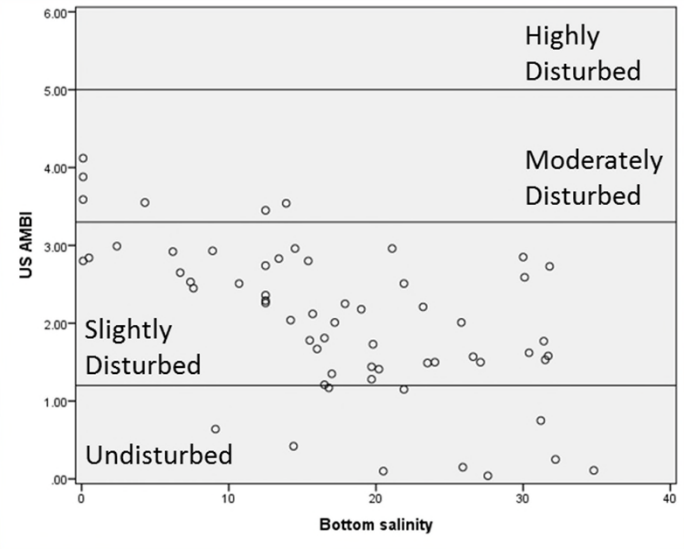


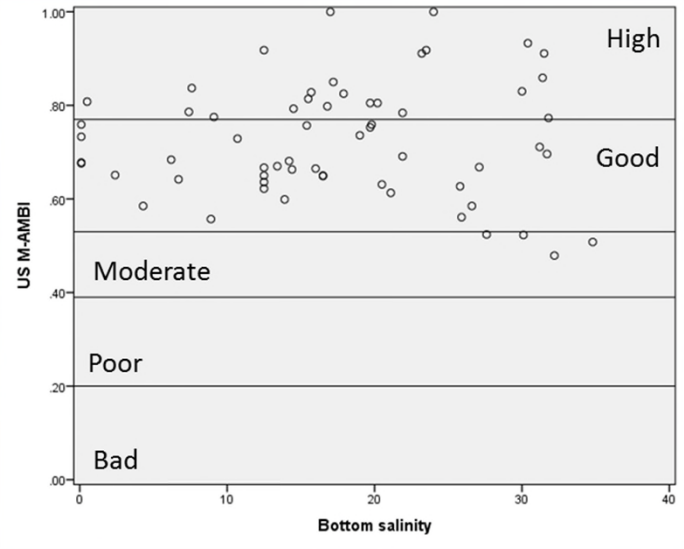






M-AMBI – Removal of Salinity Bias seen with AMBI



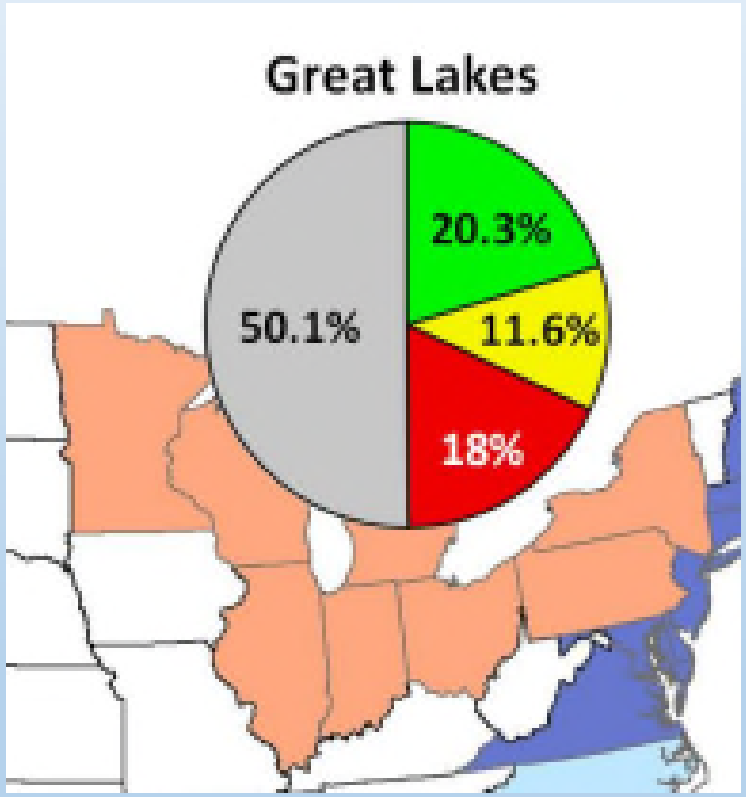


Dataset		US M-AMBI	US AMBI	MAIA BI
Mid-Atlantic	Spearman	0.043	**-0.613****	0.017
	p-value	0.742	**<0.0005**	0.933
	N	61	**61**	26
Southeast	Spearman	-0.410	**-0.900***	-0.671
	p-value	0.493	**0.037**	0.215
	N	5	**5**	5
Southern California	Spearman	-0.008	-0.132	-0.156
	p-value	0.973	0.568	0.499
	N	21	21	21

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Used M-AMBI to assess all estuaries in the 2015 NCCA Report

Great Lakes Index assessment/improvement



$$\mathbf{OTI} = c \times \frac{\frac{1}{2}\sum n_0 + \sum n_1 + \mathbf{2}\sum \boldsymbol{n_2} + \mathbf{3}\sum \boldsymbol{n_3}}{\sum n_0 + \sum n_1 + \sum n_2 + \sum n_3}$$

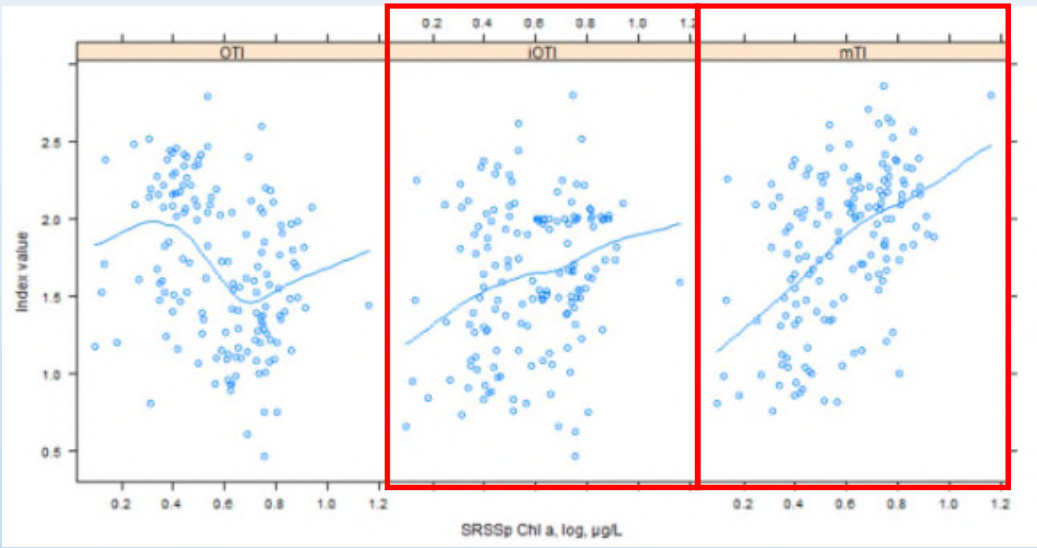
$c = 1$	if	$n > 3{,}600$
$c = 0.75$	if	$1{,}200 < n < 3{,}600$
$c = 0.5$	if	$400 < n < 1{,}200$
$c = 0.25$	if	$130 < n < 400$
$c = 0$	if	$n < 130$

>50% of samples classified as ‘missing’

- ~1/2 were sites that were not sampled – hard bottom or grab ‘blowout’
- ~1/2 were sites with no oligochaetes, or unclassified oligochaetes

Potential modification of Great Lakes Index

- 3 day workshop in Chicago, IL (Oct 2016)
  - L. Burlakova presented 2 new indices;
    - Improved OTI (iOTI)
    - Modified TI (mTI)
  - Group classified additional taxa into OTI groups
  - Group agreed to assemble additional validation datasets



Journal of Great Lakes Research 44 (2017) 618–628

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

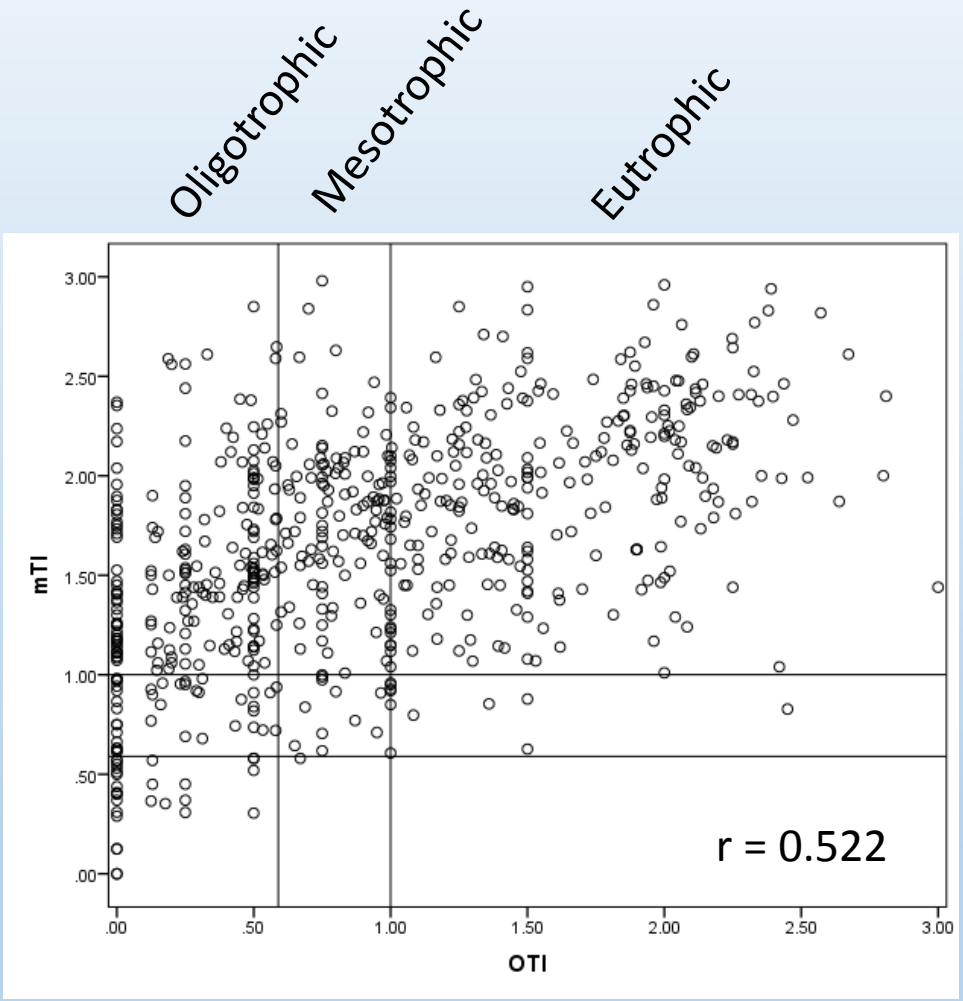
Development of new indices of Great Lakes water quality based on profundal benthic communities

Lyubov E. Burlakova [a,*], Katya E. Kovalenko [b], Kurt L. Schmude [c], Richard P. Barbiero [d], Alexander Y. Karatayev [a], Barry M. Lesht [d,e]

[a] Great Lakes Center, Buffalo State College, 1300 Elmwood Ave., Buffalo, NY 14222, USA
[b] Natural Resources Research Institute, University of Minnesota-Duluth, 5013 Miller Trunk Highway, Duluth, MN 55811, USA
[c] Department of Natural Sciences, Lake Superior Research Institute, University of Wisconsin-Superior, 801 N. 28th St., Superior, WI 54880-5400, USA
[d] CSRA, 1359 W. Elmdale Ave. Suite 2, Chicago, IL 60660, USA
[e] Department of Earth and Environmental Sciences, University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL 60607, USA

For deeper water sites in Lake Erie, both the iOTI and mTI had a better relationship with surface remote-sensed chlorophyll than the 'original' OTI

Potential modification of Great Lakes Index



2010 & 2015 NCCA data

- mTI tends towards more eutrophic conditions than the OTI
  - mTI - used coding from the Burlakova paper + additional coding from workshop
  - OTI calculated using original coding
- For most sites, most taxa are not coded
  - OTI median: 20% of abundance consists of coded oligochaetes
  - mTI median: 30% of taxa abundance coded

Next steps for Great Lakes Index

- Code additional taxa
- Relate OTI and mTI to stressor gradients to validate indices
- May need to develop new index that uses OTI (or mTI) as a metric within a larger index to encompass more of the benthic community

Summary

- M-AMBI is multivariate AMBI
  - Accounts for naturally structuring parameters (e.g., salinity)
  - Improves index performance by adding additional metrics
  - Good correspondence with well-calibrated local indices
  - Appropriate for assessing condition at a national scale

- Great Lakes Index
  - Additional validation needed to relate index to stressors
  - May need to add additional metrics to mTI to better characterize the benthic community