AN INDEX OF ENVIRONMENTAL INTEGRITY APPROACH FOR THE U.S. MID-ATLANTIC REGION

John F. Paul

National Health and Environmental Effects Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

EMAP Symposium
4-6 May 2004

Intent of Today's Presentation

- proposed procedure for an aggregated index of environmental integrity (IEI)
- initial application of IEI for the mid-Atlantic region

Topics to Cover Today

Background for need of IEI

Proposed procedure for IEI

Illustration of IEI for estuaries

Issues associated with IEI

Summary and next steps

Background

Environmental managers - require information in a form they can understand and use in decision making

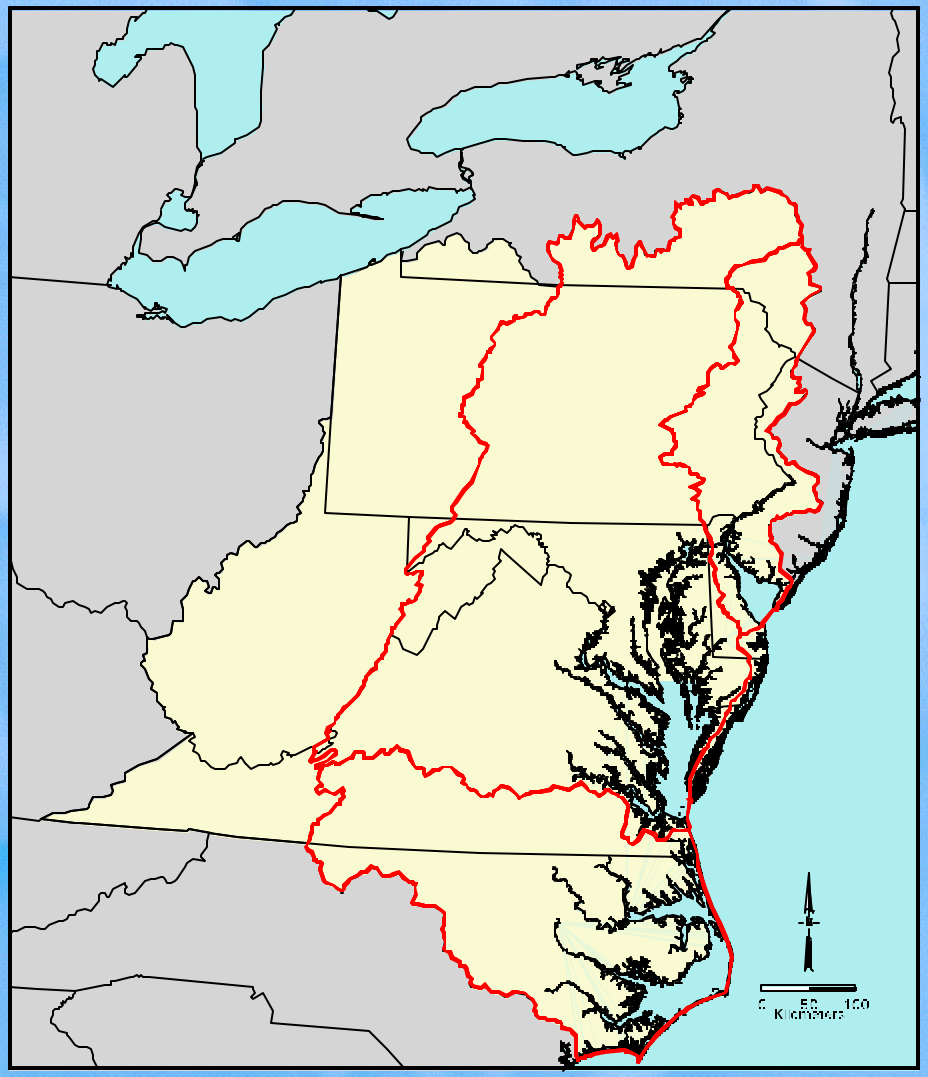
Scientists - challenge is to distill vast complexity of environment into something useful for managers

Multimetric approaches - intended to make it easier for managers to use ecological data in their decision making

Mid-Atlantic Integrated Assessment (MAIA)

Began in 1994 as joint partnership between USEPA ORD and Region III

- **provide managers with sound information on resource condition**
- **testing ground to refine EMAP design and assessment methods**



MAIA Purpose

- Develop Acceptable and Useful Environmental Indicators for Biology, Habitat and Land Activities
- Merge with Physical and Chemical Information with Biology into Dynamic and Useful Assessments
- Have Data Influence and Drive Management Decisions and Influence Public Perception and Opinion
- Translate to Relative Risk

Major MAIA Products

- State-of-Estuaries
- State-of Streams/Rivers
- State-of-Forests
- Landuse / Landcover
- Landscape Atlas
- State-of-Ground Water
- Integrated Regional Report Card
- Pesticides Profile
- Inventory of Environmental Monitoring
- Integrated Field Monitoring
  - Estuaries
  - Streams

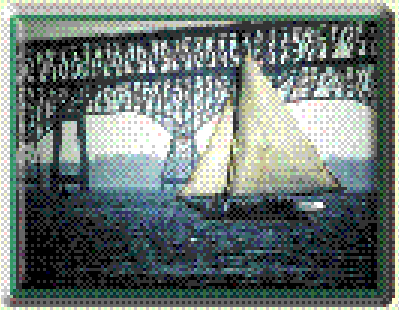
United States
Environmental Protection
Agency

Office of Research and
Development
Washington, DC 20460

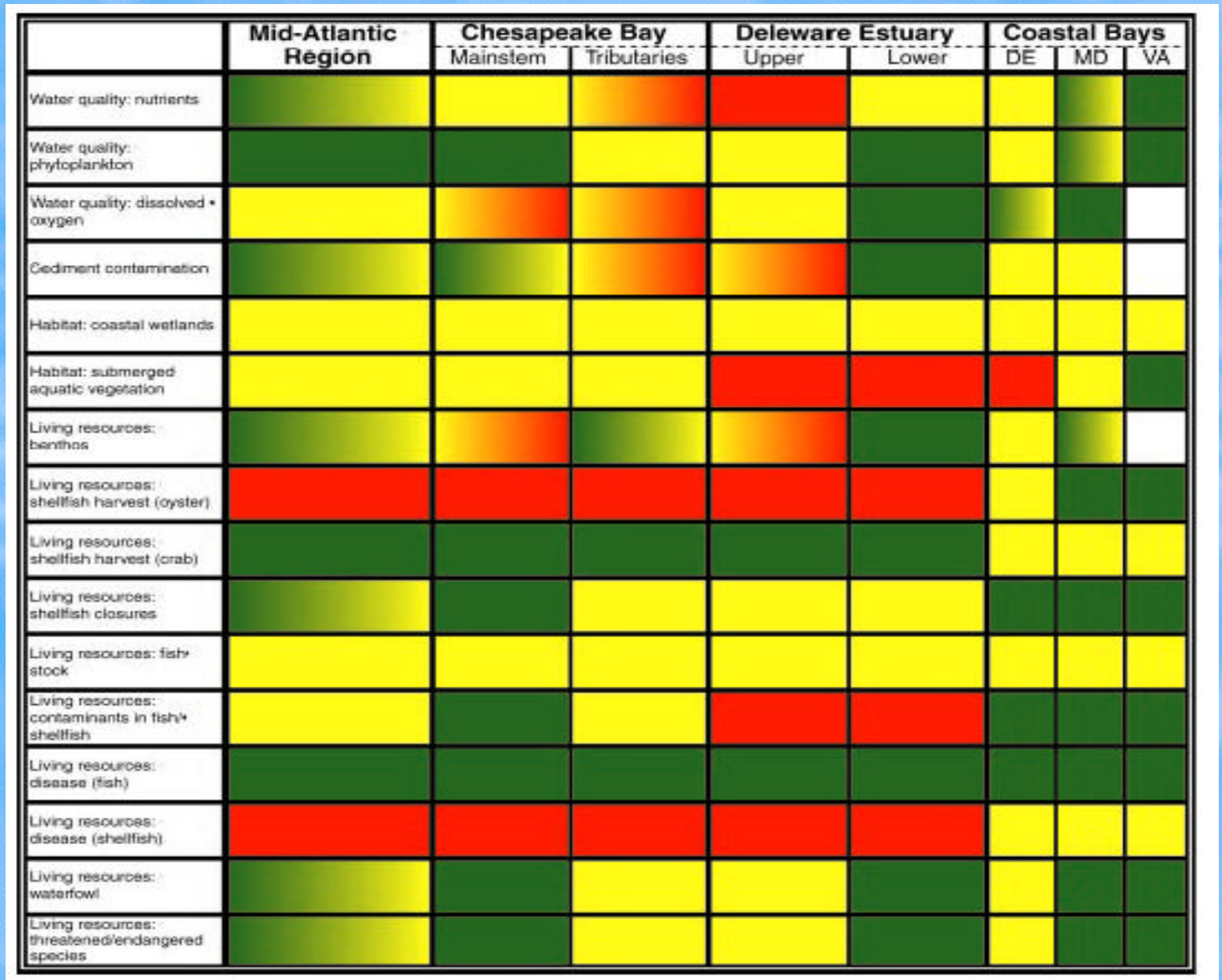
EPA 600-R-98-148
November 1998
www.epa.gov

EPA

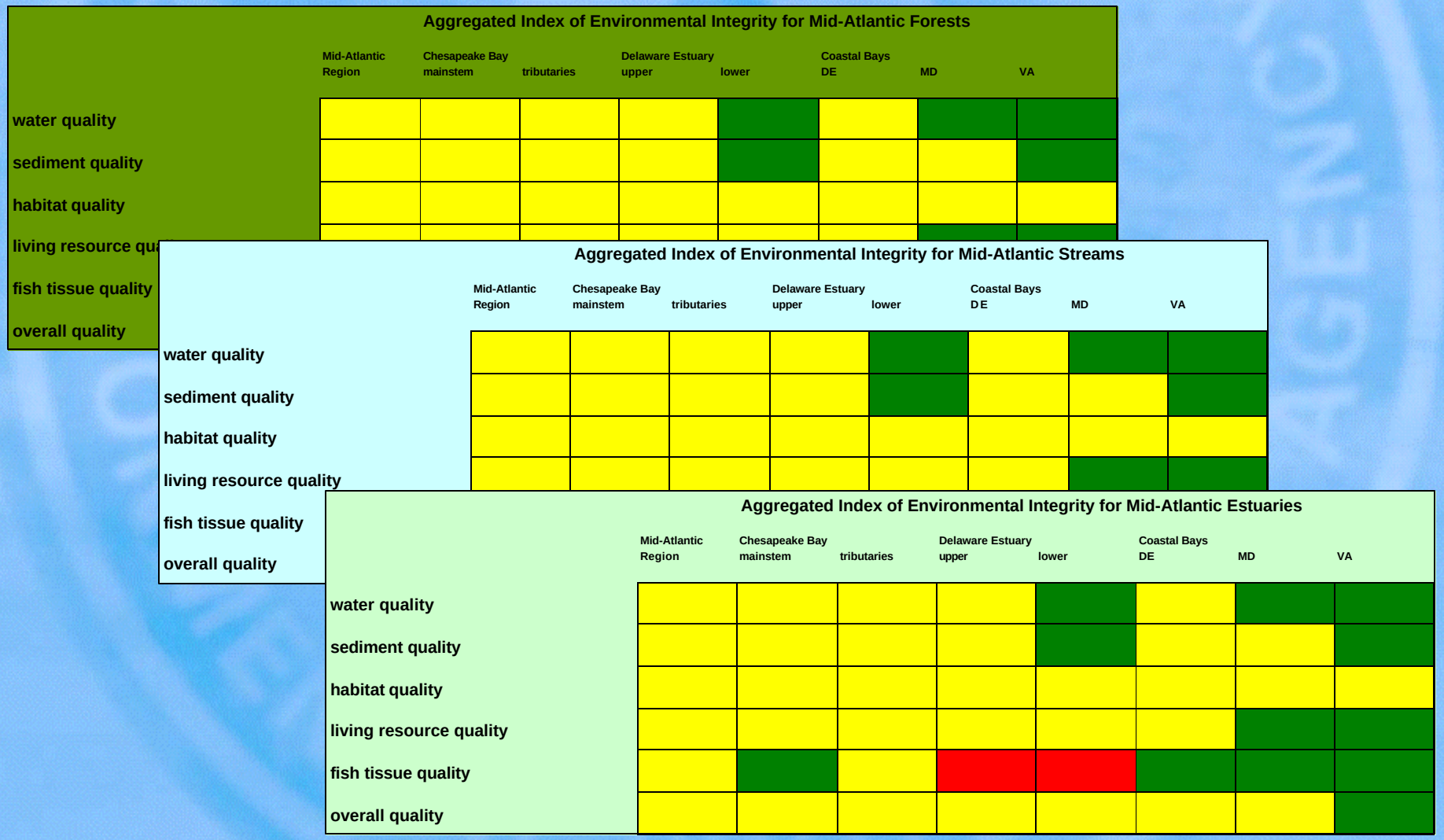
Condition of the Mid-Atlantic Estuaries



Environmental Report Card for Estuaries



MAIA Multiresource Assessments



Impetus/Challenges for Aggregated Index

Managers would like information across resources

- **comparative assessments**
- **geographic region condition**

Different indicators for each resource

Ability to look at what makes up overall conditions

Aggregated Index of Environmental Integrity

Start with environmental report cards for individual resources

Aggregates across indicators, spatial scales, and resources

Hierarchical multimetric approach

- **individual metrics respond to stress**
- **uniform scaling for metrics**
- **simple summation of individual metrics**

Based upon basic tenets of IBI approach - some differences

Information on biological systems, environs in which they reside, and human uses

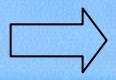
Application doesn’t lose information on individual metrics

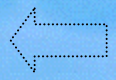
- **diagnostic mode**

Simple Example - Streams in a Region

Environmental Report Card for Streams in Region

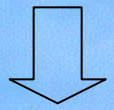
	Watershed A	Watershed B	Watershed C	Watershed D
Water Quality: total nitrogen	3.0	5.0	1.0	3.0
Water Quality: total phosphorus	4.0	1.0	2.0	1.0
Water Quality: acid rain	5.0	3.0	4.0	1.0
Habitat: riparian, streambank	1.0	4.0	2.0	2.0
Habitat: channel sedimentation	3.0	1.0	1.0	2.0
Living Resource: fish	4.0	3.0	2.0	2.0
Living Resource: macrobenthos	4.0	2.0	2.0	3.0
Living Resource: aquatic insects	2.0	1.0	5.0	3.0
Living Resource: nonnative species	2.0	5.0	4.0	4.0





Index of Environmental Integrity for Streams

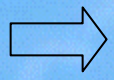
	Region
Water Quality: total nitrogen	1.0
Water Quality: total phosphorus	2.6
Water Quality: acid rain	2.5
Habitat: riparian, streambank	3.2
Habitat: channel sedimentation	3.6
Living Resource: fish	3.9
Living Resource: macrobenthos	3.6
Living Resource: aquatic insects	2.8
Living Resource: nonnative species	2.9



Index of Environmental Integrity for Streams

	Watershed A	Watershed B	Watershed C	Watershed D
Overall Water Quality	1.3	2.0	3.7	2.7
Overall Habitat	4.0	3.0	2.0	3.0
Overall Living Resource	3.5	3.3	2.8	3.0

aggregation



diagnostic

IEI Applied to Mid-Atlantic Estuaries

Scores for Indicators for Estuaries in Mid-Atlantic

	Mid-Atlantic Region	Chesapeake Bay		Delaware Estuary		Coastal Bays		
		mainstem	tributaries	upper	lower	DE	MD	VA
water quality: nutrients	4	3	2	1	3	3	4	5
water quality: phytoplankton	5	5	3	3	5	3	4	5
water quality: dissolved oxygen	3	2	2	3	5	4	5	
sediment contamination	4	4	2	2	5	3	3	
habitat: coastal wetlands	3	3	3	3	3	3	3	3
habitat: submerged aquaticvegetation	3	3	3	1	1	1	3	5
living resources: benthos	4	2	4	2	5	3	4	
Living resources: shellfishharvest (oyster)	1	1	1	1	1	3	5	5
living resources: shellfishharvest (crab)	5	5	5	5	5	3	3	3
living resources: shellfishclosures	4	5	3	3	3	5	5	5
living resources: fish stock	3	3	3	3	3	3	3	3
living resources:contaminants in fish/shellfish	3	5	3	1	1	5	5	5
living resources: disease(fish)	5	5	5	5	5	5	5	5
living resources: disease(shellfish)	1	1	1	1	1	3	3	3
living resources: waterfowl	4	5	3	3	5	3	5	5
living resources: threatened/endangered species	4	5	3	3	5	3	5	5

IEI Applied to Mid-Atlantic Estuaries

Aggregated Index of Environmental Integrity for Mid-Atlantic Estuaries

	Chesapeake Bay	Delaware Estuary	Coastal Bays
water quality: nutrients	2.6	2.8	3.9
water quality: phytoplankton	4.2	4.8	3.9
water quality: dissolved oxygen	2.0	4.8	4.6
sediment contamination	3.2	4.6	3.0
habitat: coastal wetlands	3.0	3.0	3.0
habitat: submerged aquaticvegetation	3.0	1.0	2.7
living resources: benthos	2.8	4.6	3.6
living resources: shellfishharvest (oyster)	1.0	1.0	4.3
living resources: shellfishharvest (crab)	5.0	5.0	3.0
living resources: shellfishclosures	4.2	3.0	5.0
living resources: fish stock	3.0	3.0	3.0
living resources:contaminants in fish/shellfish	4.2	1.0	5.0
living resources: disease(fish)	5.0	5.0	5.0
living resources: disease(shellfish)	1.0	1.0	3.0
living resources: waterfowl	4.2	4.8	4.3
living resources:threatened/endangered species	4.2	4.8	4.3

Index of Environmental Integrity for Mid-Atlantic Estuaries

	Mid-Atlantic Region
water quality: nutrients	2.8
water quality: phytoplankton	3.9
water quality: dissolved oxygen	2.2
sediment contamination	3.2
habitat: coastal wetlands	3.0
habitat: submerged aquaticvegetation	2.9
living resources: benthos	2.6
living resources: shellfishharvest (oyster)	1.7
living resources: shellfishharvest (crab)	4.8
living resources: shellfishclosures	4.1
living resources: fish stock	3.3
living resources:contaminants in fish/shellfish	4.2
living resources: disease(fish)	4.4
living resources: disease(shellfish)	1.6
living resources: waterfowl	4.1
living resources:threatened/endangered species	3.4

Index of Environmental Integrity for Mid-Atlantic Estuaries

	Chesapeake Bay	Delaware Estuary	Coastal Bays
overall water quality	3.0	4.1	4.1
overall sediment quality	3.2	4.6	3.0
overall habitat quality	3.0	2.0	2.9
overall living resources quality	3.4	3.6	4.0
overall fish tissue quality	4.2	1.0	5.0

Issues - Discussion

Differences with approach for IBI

- start with environmental report cards
  - no explicit development of metric dose-response
  - assume validity of indicators and thresholds
- response to stress - anthropogenic and natural
- environmental index

Averaging of individual metrics with equal weighting

- IEI approach not dependent on equal weighting

Limited interrelationships among metrics (indicators)

Missing information for indicators or geographic areas

Overlook low value for “significant” metric - diagnostic mode

Aggregation across resources within geographic area - weighting

Level of aggregation depends upon question posed

Significance of different IEI values

Significance of Different IEI Values

Illustration with MAHA Streams - Monte Carlo Simulations

Assume 5% CI about Percent Impacted Stream Miles

(mean and 90% CI)

	Mid-Atlantic Highlands	Ecoregions			
		Valley	Ridge & Blue Ridge	NC & Central Appalachians	Western Appalachians
Water Quality	3.5 (3-4)	4 (4-4)	4.5 (4-4.5)	3.5 (2.5-3.5)	3.5 (3-4)
Habitat Quality	3 (2-3)	2 (1-2)	5 (4-5)	2 (2-3)	1 (1-2)
Biological Condition	1.67 (1-1.67)	1 (1-1)	1.67 (1.67-2.33)	1.67 (1-1.67)	2.33(1.67-2.33)
Fish Contaminants	3 (2-4)	3 (2-3)	4 (3-5)	2 (1-3)	3 (2-5)

Summary and Next Steps

- Desire to aggregate across indicators, spatial scales, and resources
- Proposed a procedure for aggregated index of environmental integrity (IEI)
- Hierarchical multimetric approach
- Builds upon IBI work but has major differences
- IEI starts with environmental report cards
- Response to anthropogenic and natural stress
- Environmental index