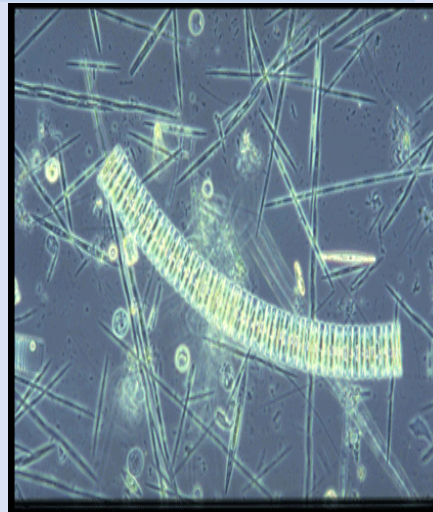
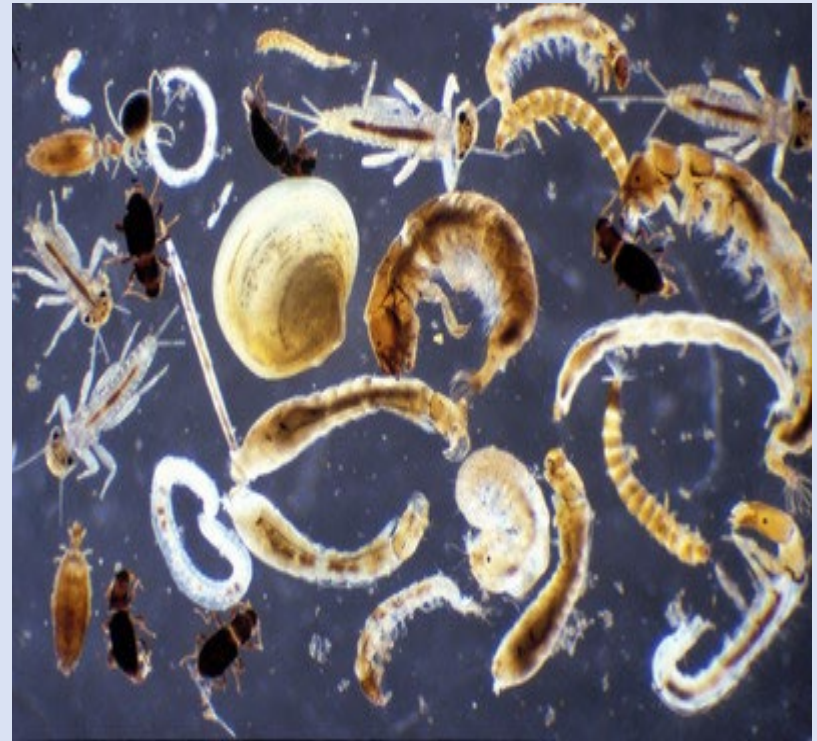


The Biological Condition Gradient

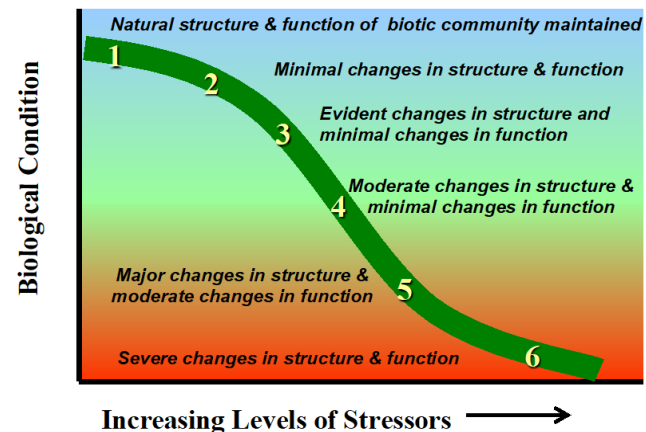
EPA/ELI Learning Exchange

July 14, 2022

Susan Jackson
USEPA



The Biological Condition Gradient (BCG)



Susan Jackson...

Susan Jackson USEPA ...



Greg Johnson

Steve Epting (U... Pamela Toshner...

Steve Epting (US EPA)

Pamela Toshner, Wisc...



BCG – a tool in a large protection and restoration toolbox

Protecting lake water quality is a **multi-dimensional** effort requiring protection of **complex natural systems** and administration of many **inter-related programs** (federal, state, local, non-profit) within watersheds.

If well-integrated and managed as a whole, these efforts have the potential to protect the complex nature of our vulnerable and pristine resources.

BCG CONCEPTUAL MODEL

Levels of Biological Condition

Natural structural, functional, and taxonomic integrity is preserved.

Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

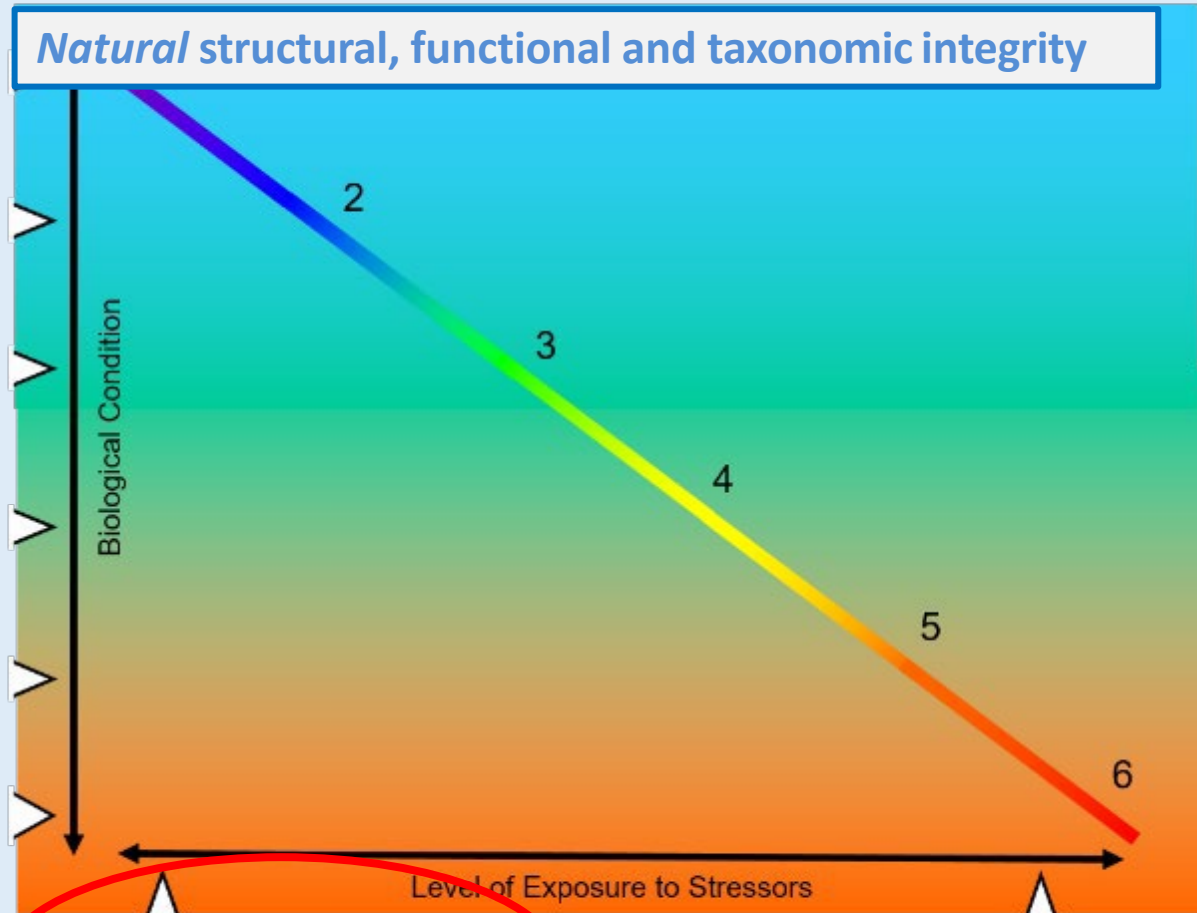
Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.

Natural structural, functional and taxonomic integrity



Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.

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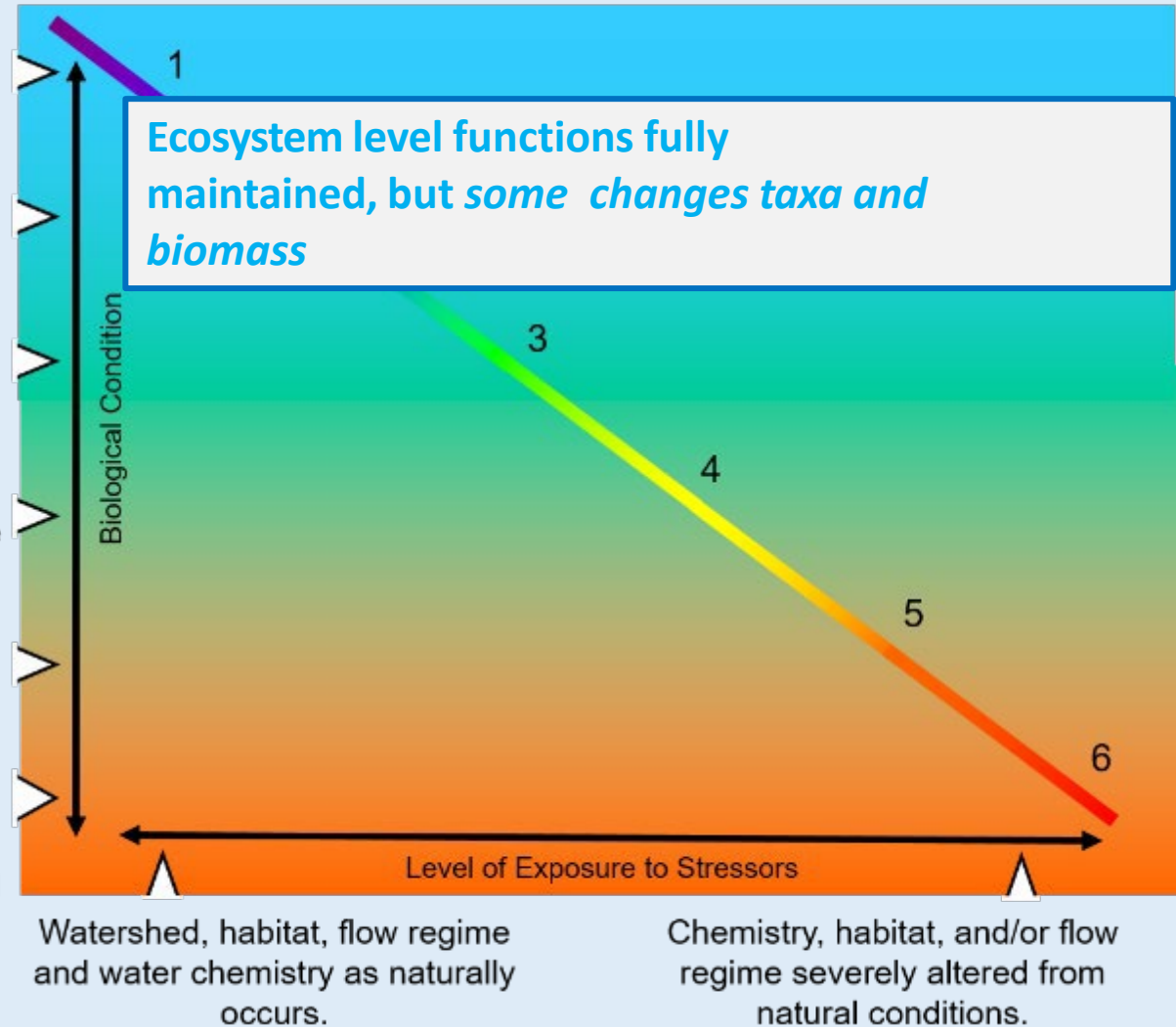
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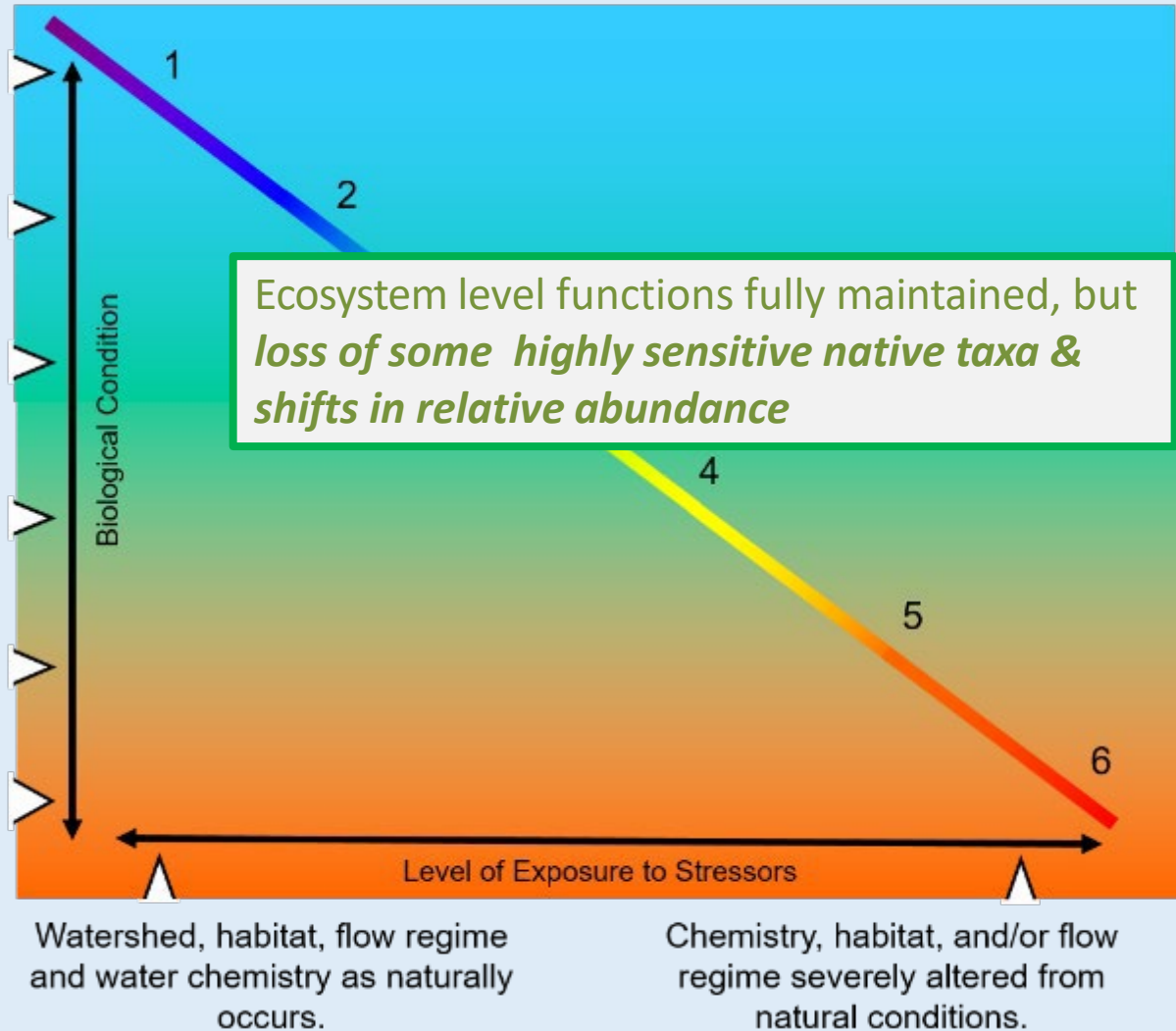
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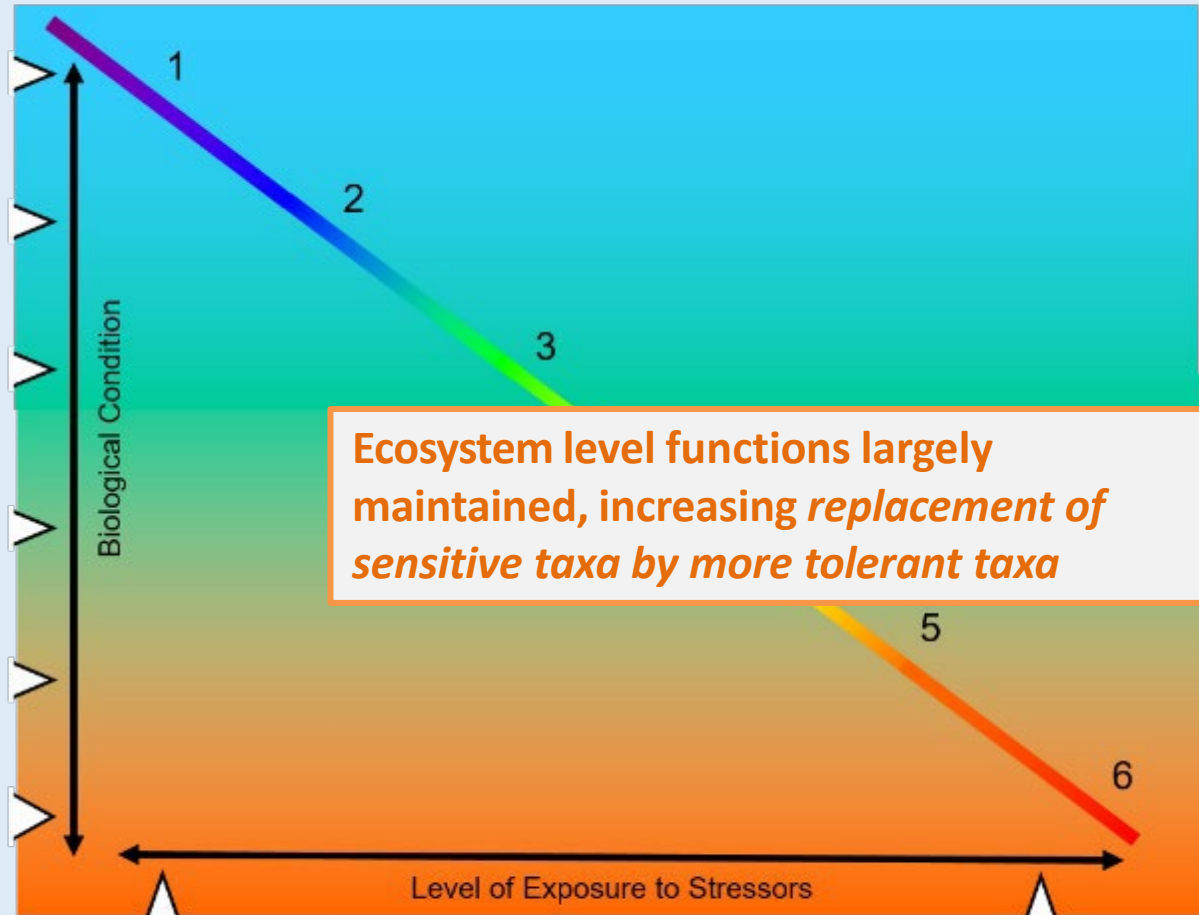
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Ecosystem level functions largely maintained, increasing replacement of sensitive taxa by more tolerant taxa

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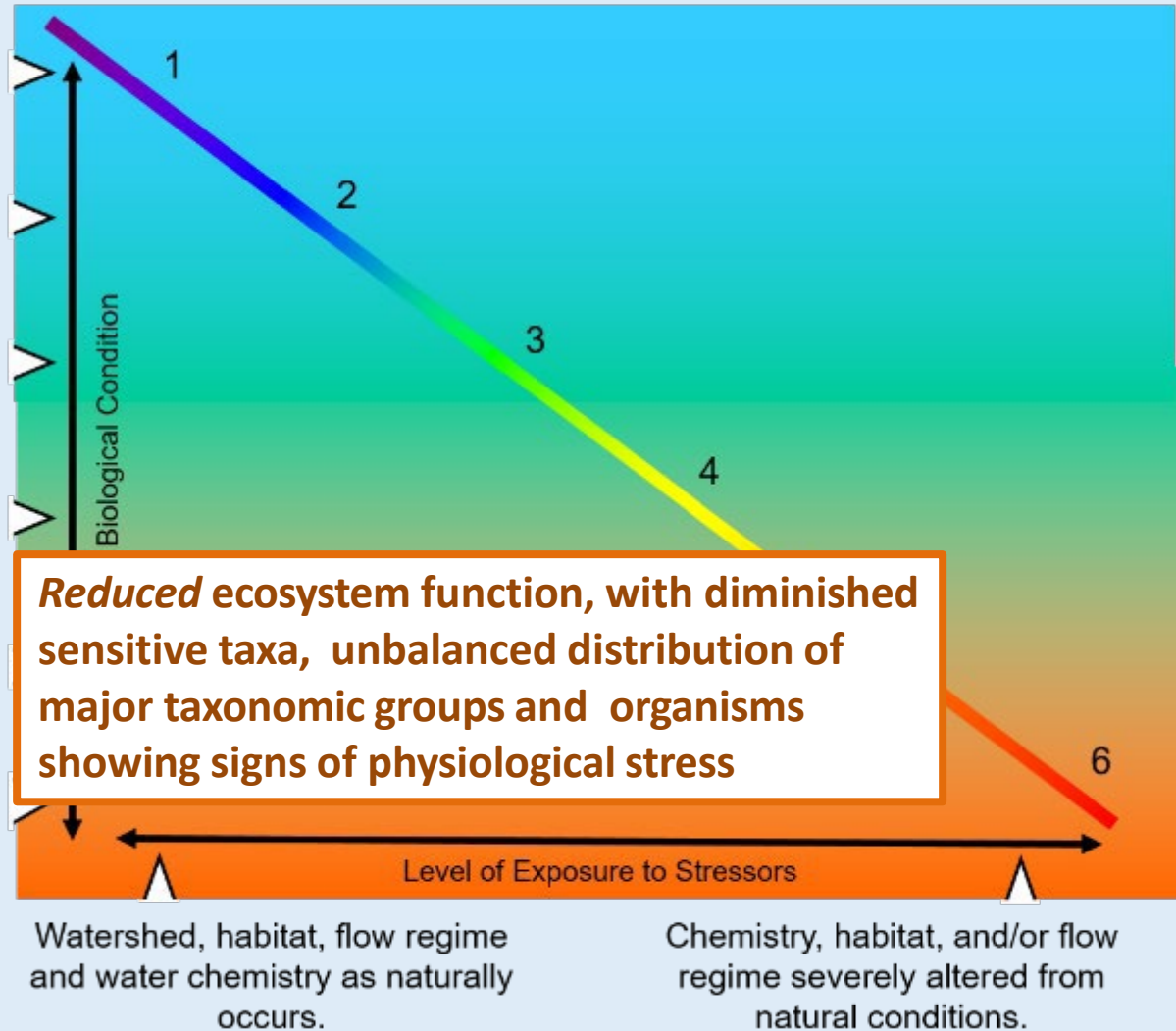
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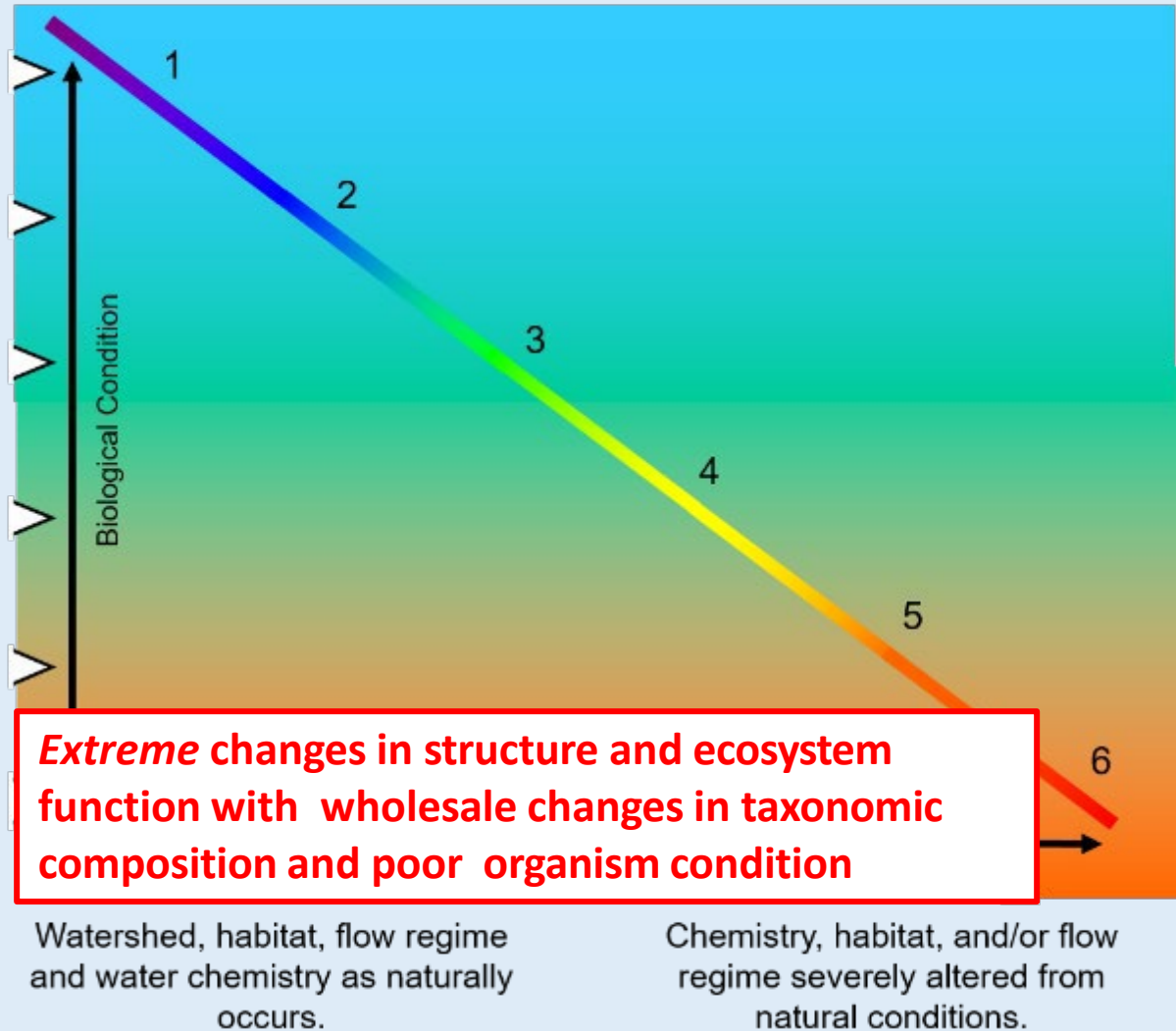
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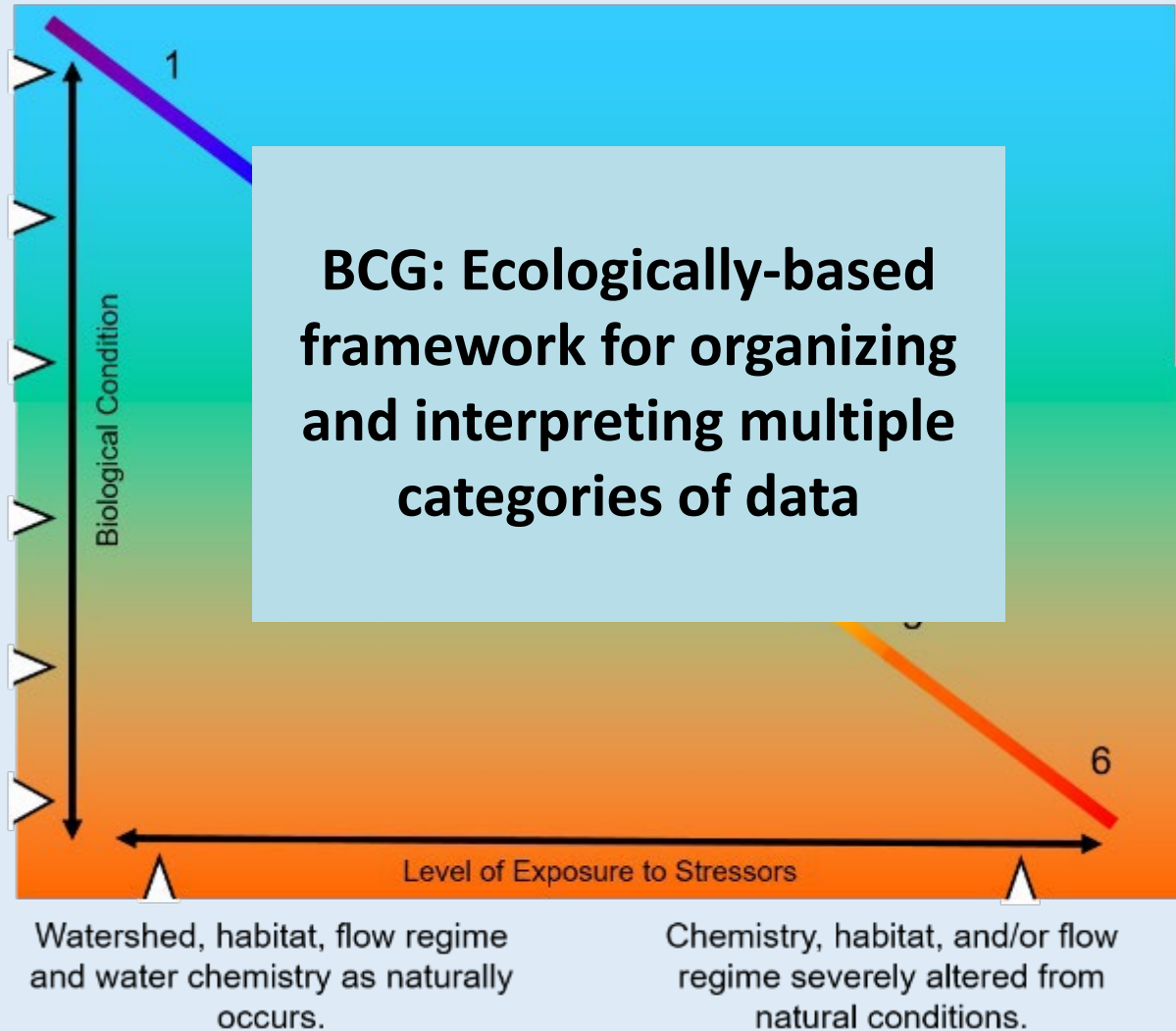
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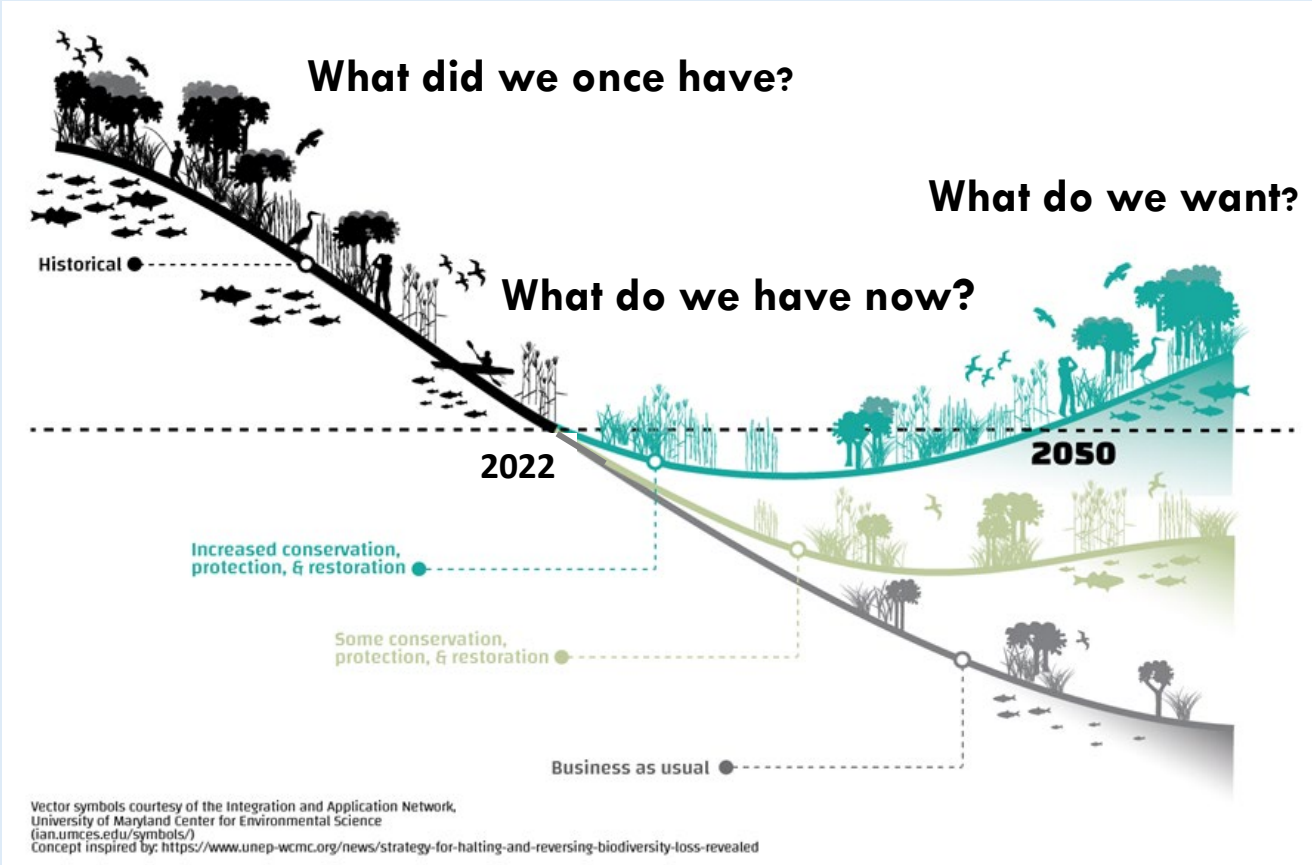
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BCG helps answer basic questions



Experts look at site data (taxa present), assign BCG level and provide rationale

“This sample has a lot of sensitive taxa, some specialists, smaller proportions of the most tolerant taxa, most native taxa present, small increase in expected biomass, and a balance of functional types”



“This is a BCG Level 2”

BCG Level 2: Minimal changes in structure of the biotic community and minimal changes in ecosystem function—virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.



EPA 842-R-16-001

A Practitioner's Guide to the Biological Condition Gradient: A Framework to Describe Incremental Change in Aquatic Ecosystems

February 2016



A Practitioner's Guide to the Biological Condition Gradient [EPA 842-R-16-001](#)

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“This sample has a lot of sensitive taxa, some specialists, smaller proportions of the most tolerant taxa, most native taxa present, small increase in expected biomass, and a balance of functional types”



“This is a BCG Level 2”

Narrative

Richness of sensitive taxa is high

Specialists are present

Individuals of tolerant taxa are not dominant

Most native taxa present

Predators and herbivores are in proper proportions

Quantitative

Sensitive Taxa are > 50 – 60 % of taxa

of highly specialized, taxa > 0

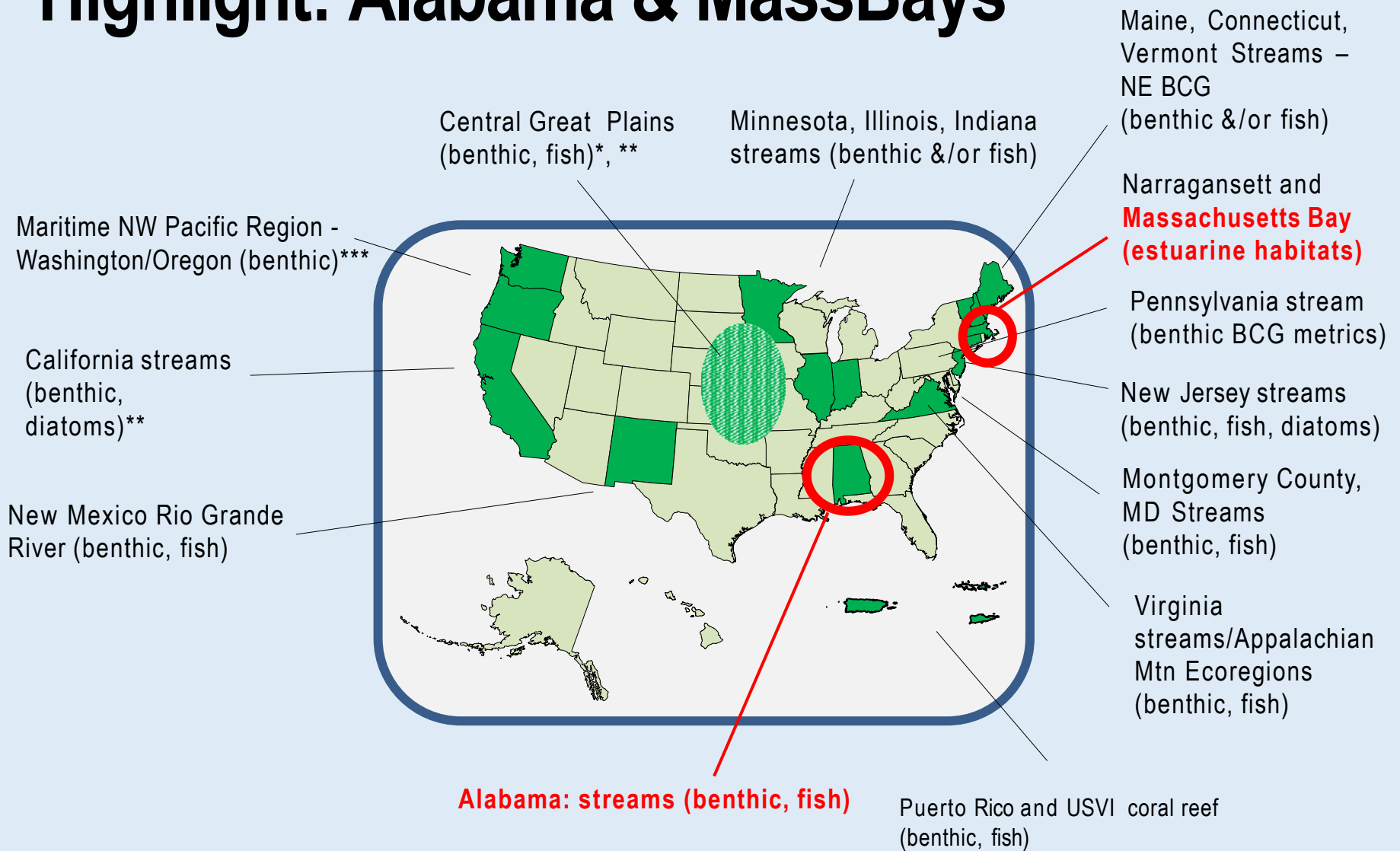
< 20 – 30 % tolerant individuals

Observed/Expected > 7

% predators > 5 – 15 % of % herbivores



Highlight: Alabama & MassBays



* BCG in progress.
 ** Exploring model application to meet Tribal program purposes
 *** Testing climate sensitive indicators

ALABAMA'S BIOLOGICAL CONDITION GRADIENTS

Identifying high quality waters,

Prioritizing restoration and protection, and

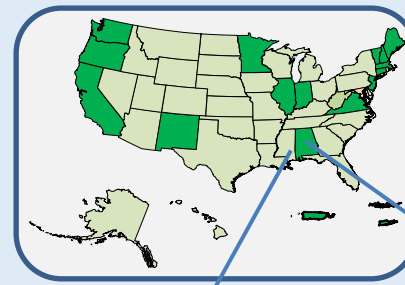
Communicating the need for these changes

Lisa Huff-ADEM, Pat O'Neil-Geological Survey of Alabama, Susan Jackson-USEPA
Ben Jessup, Jeroen Gerritsen and Jen Stamp-Tetra Tech, Inc.
and many, many more

Bioassessment and Criteria Webinar Series
16 December 2020



Alabama: The River State



1. The River State - Lots of water

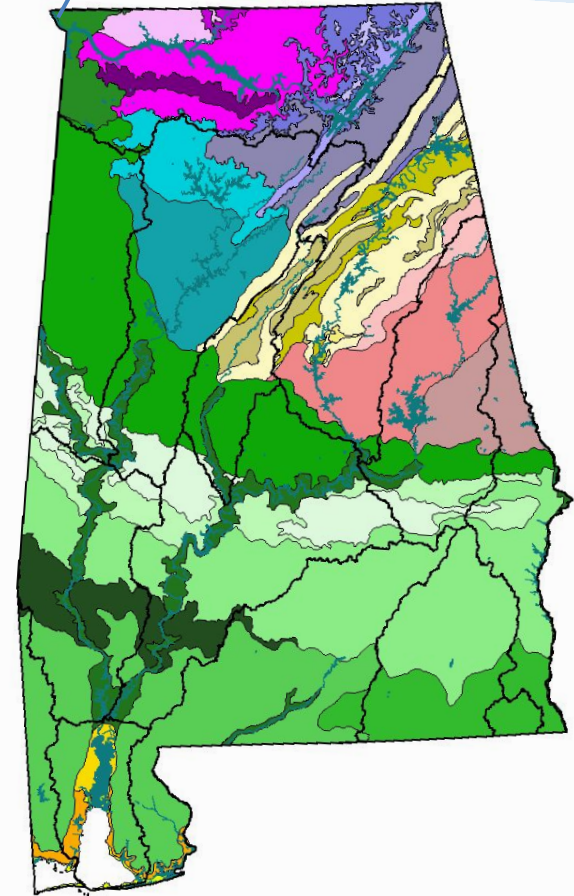
- 14 Basins draining 51,609 mi²
- 59,000 perennial stream miles
- 70,700 intermittent stream miles

2. Lots of variability – Defining “Expected” and “Natural”

- Multiple Ecoregions (climate, soils, geology, morphology)

3. Biodiversity Hotspot

- #1 Freshwater fish diversity: 332 species
- #1 Freshwater mussels: 180 species
- #1 Aquatic snails: 202 species
- #1 Crayfish: 83 species



29 Sub-ecoregions of Alabama

Alabama's Monitoring Strategy: Using BCG to interpret ecological condition and associate with stressors

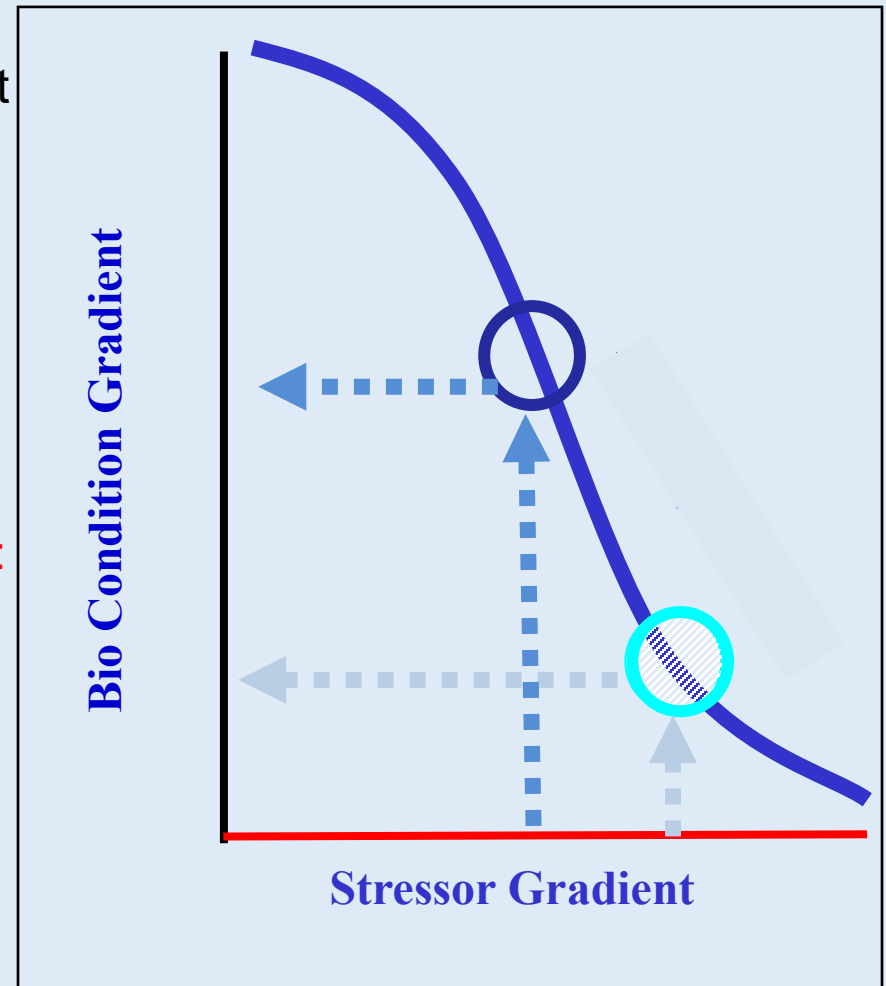
Link biological data with stressor gradient

Numeric Measures used:

- Biological indices, metrics
- Stressor specific tolerance
- Stressor levels and gradient

Use BCG as an interpretative framework:

- assess condition
- set targets
- monitor progress
- detect early change



Alabama's Designated Use Classes: Two Levels of Aquatic Life Use

High quality waters that constitute an outstanding Alabama resource

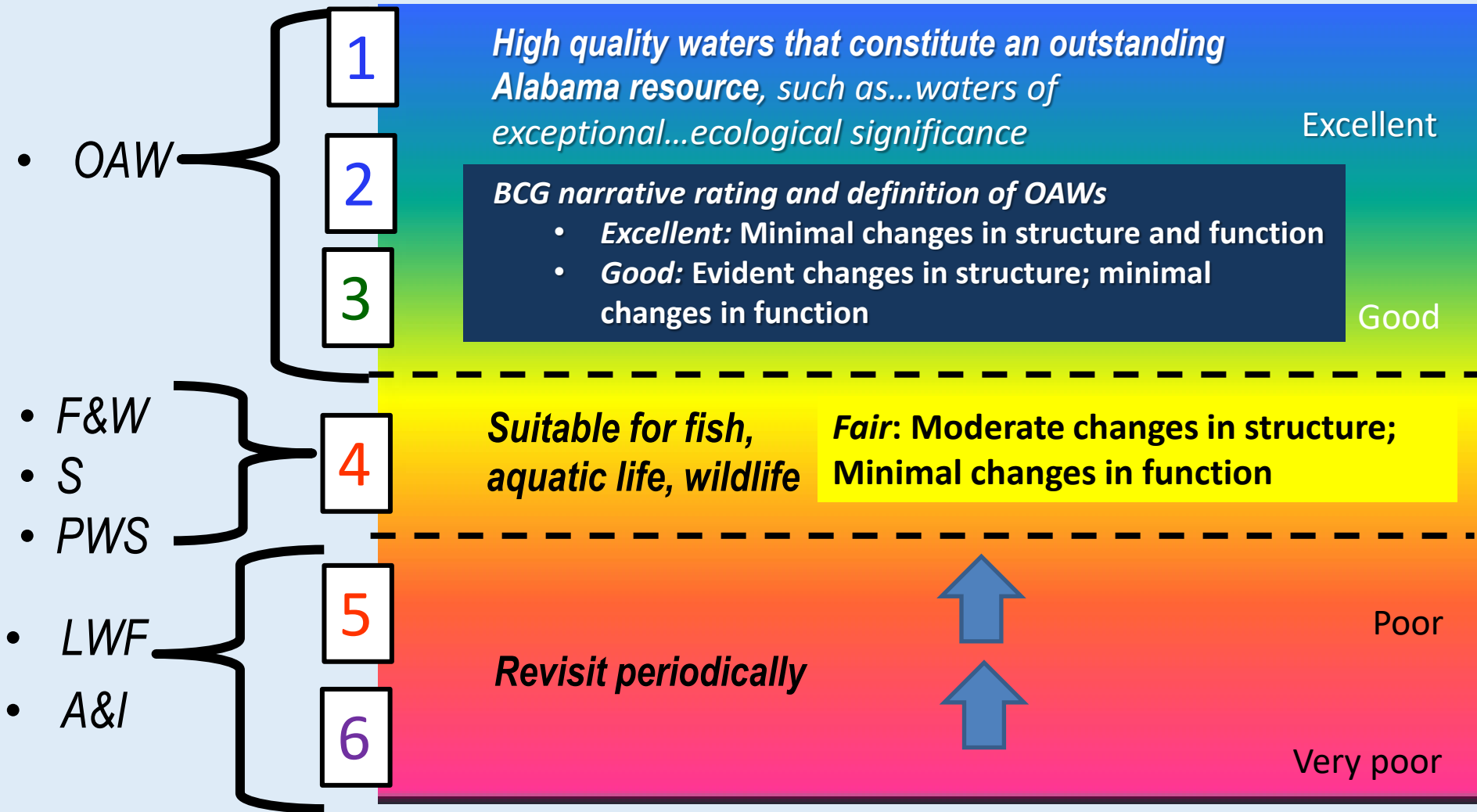
- *Outstanding Alabama Water (OAW): Excellent or Good*

CWA §101[a][2] goal of fishable/swimmable

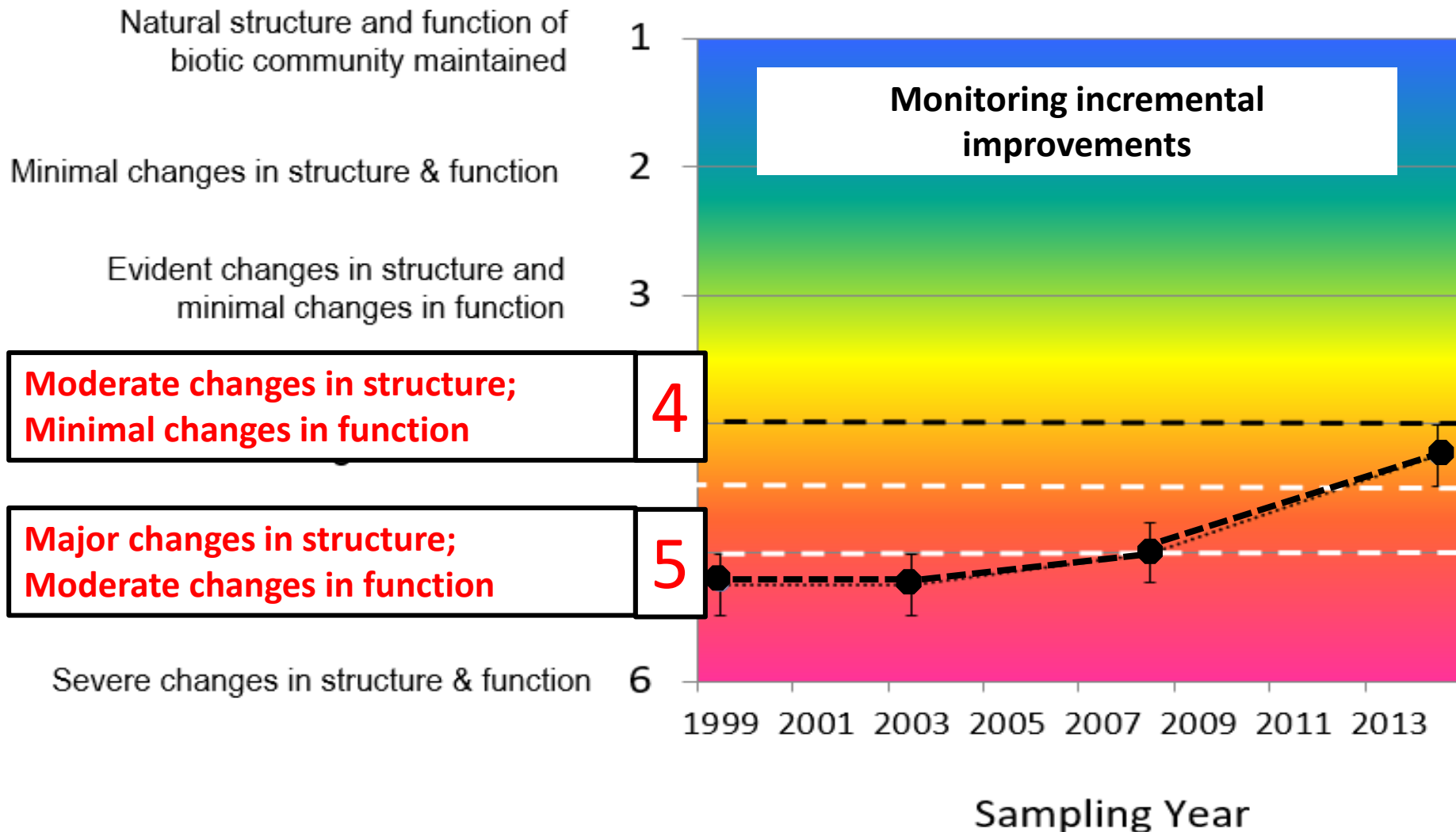
- *Fish & Wildlife (F&W): Suitable for fish, aquatic life, wildlife: Fair*
- *Swimming (S)*
- *Public Water Supply (PWS)*
 - Supporting: *Excellent, Good, or Fair*



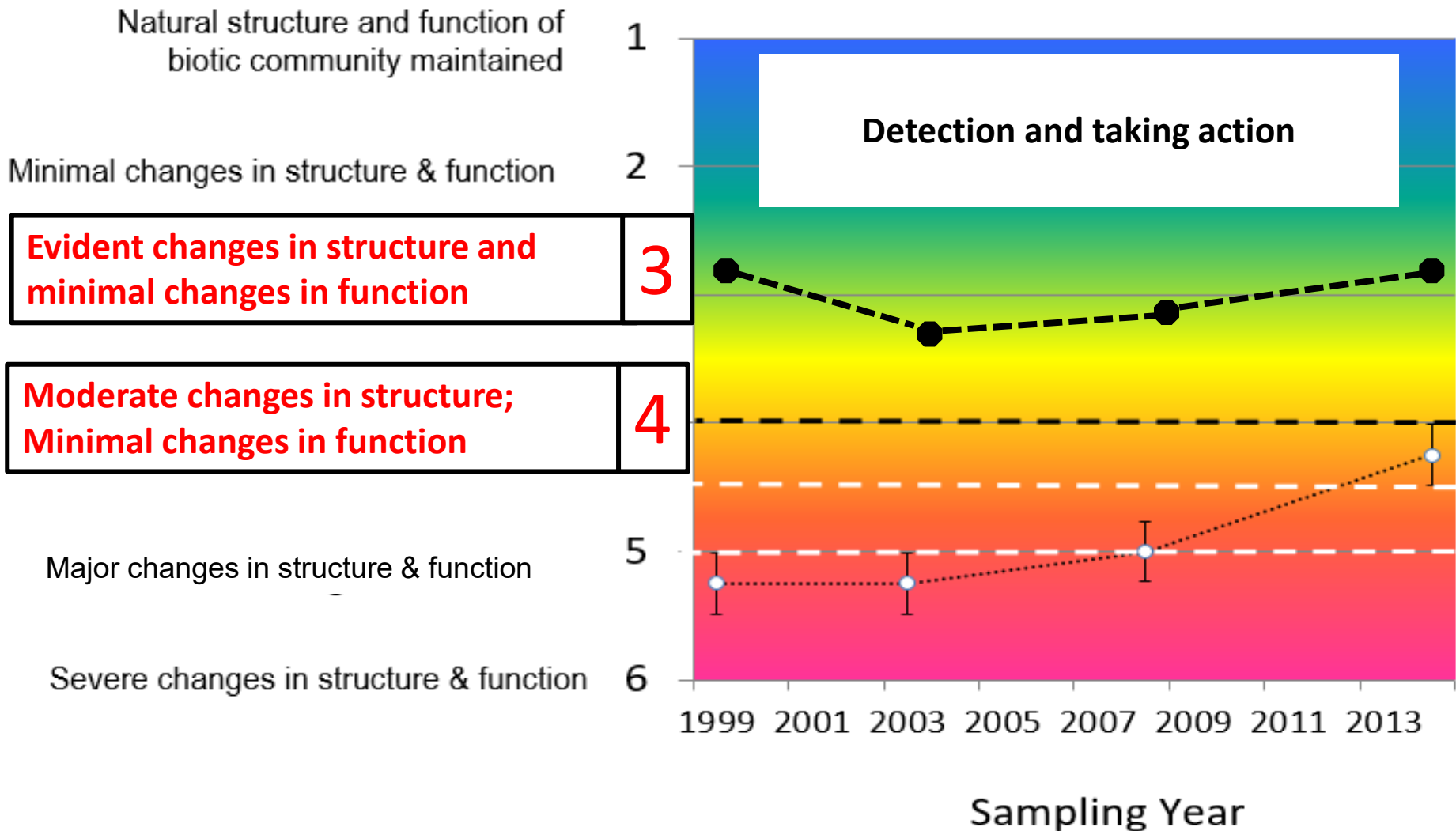
EX: Describe ALU goals



EX: Demonstrating incremental progress towards goals



EX: Detecting early signal of degradation



The BCG for setting habitat protection & restoration targets in MassBays

The MassBays National Estuary Partnership:

Executive Director: Pam DiBona

Staff Scientist: **Prassede Vella**

EPA Regional Program Coordinator: **Margherita Pryor**

Five **Regional Coordinators** aka Regional Service Providers
Science and Technical Advisory Committee (**STAC**)

EPA ORD : Giancarlo Cicchetti, Susan Yee, Leah Sharpe, Ken Rocha

An aerial photograph of a coastal bay. The water is a mix of light blue and green, indicating varying depths and possibly sediment or vegetation. A prominent river channel flows from the bottom left towards the center. The shoreline is visible, with some marshland and trees on the right side. The sky is not visible, as the image is focused on the water and land.

MassBays NEP Program Goal

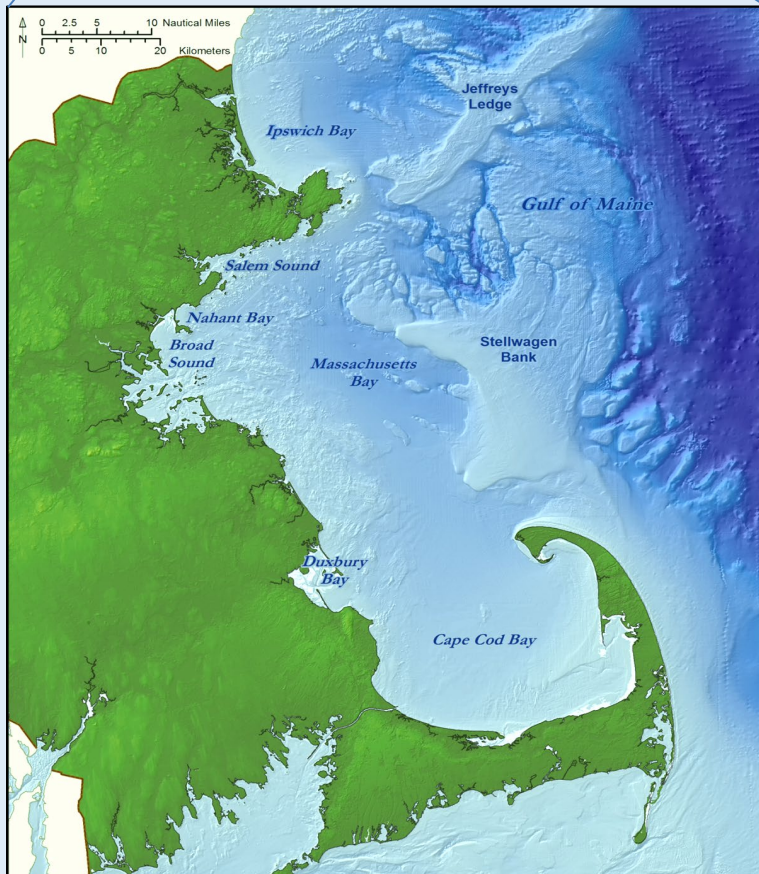
Set targets for **bay wide restoration and protection**

Current: numeric targets for **eelgrass, salt marsh, and tidal flats**

In development: **andromodous fish**



Massachusetts Bays (MassBays) is large



1100 miles from end-to-end

Outer edge defined by
Stellwagen Bank

Receives input from 7000
 mi^2 watershed area
1.7 million people in 50
coastal communities



Massachusetts Bays (MassBays) is large



**How define expectations for a functioning,
healthy estuary in a region that has
experience extensive development over past
300 years?**

receives input from 7,500
mi² watershed area
1.7 million people in 50
coastal communities

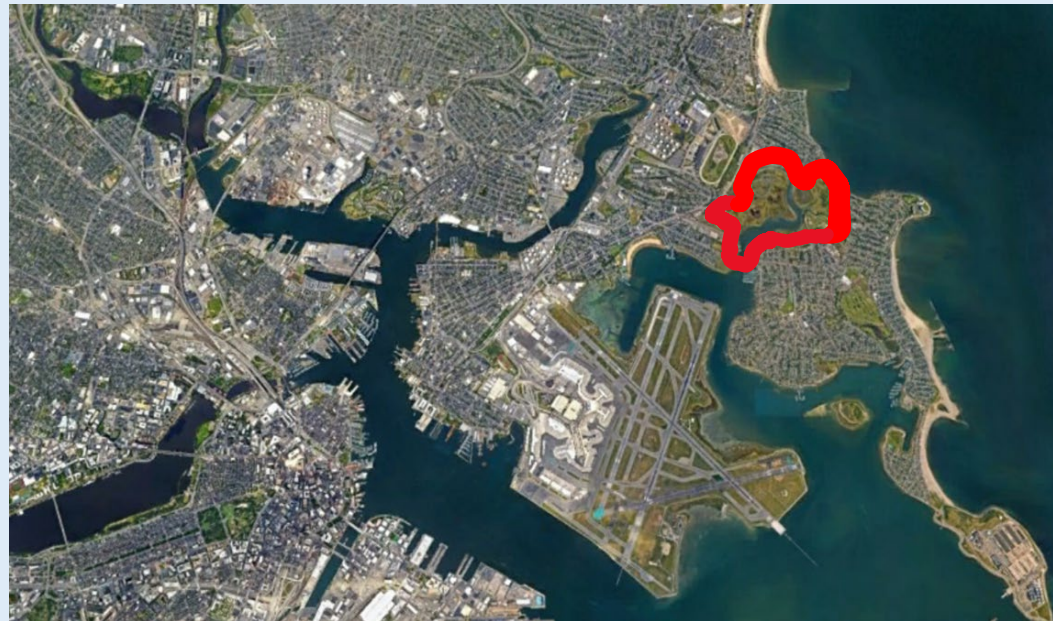


What did we once have?

Des Barres
1777

What do we have now?

**Belle Isle
Marsh**



Google Earth 2022 image

What do we want to protect or restore?



Des Barres 1777



Google Earth 2022 image

Here is the challenge: ecological drivers, program management, and on-site actions at different scales

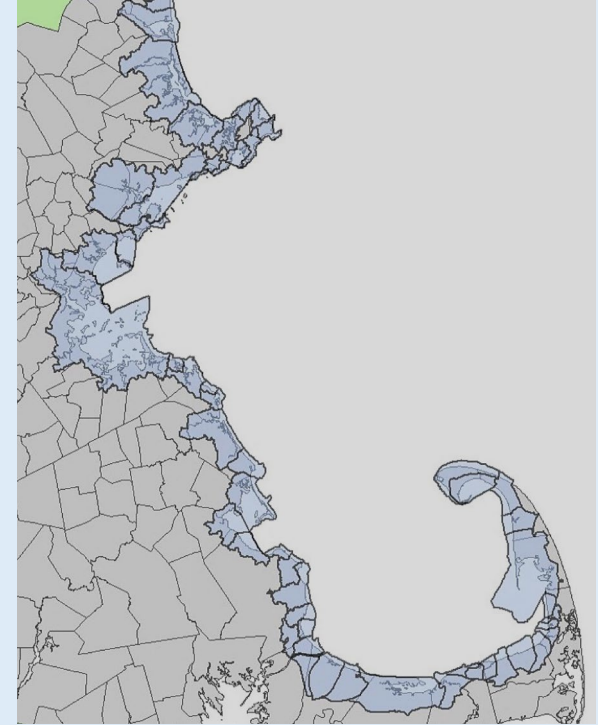


Four Ecotypes: predict habitat from energy levels and sediment abundance

Habitat BCGs: salt marsh, eelgrass, tidal flats



Five Management Regions, each with a Regional Coordinator



Action implemented at embayment scale

Last but not least: Multitude of data sets and sources of information



Here is the challenge: ecological drivers, program management, and on-site actions at different scales


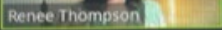


MassBay NEP Work in Progress:

Build query-based mapping tool to access, sort and present multiple categories of data needed to inform decisions at multiple spatial levels.

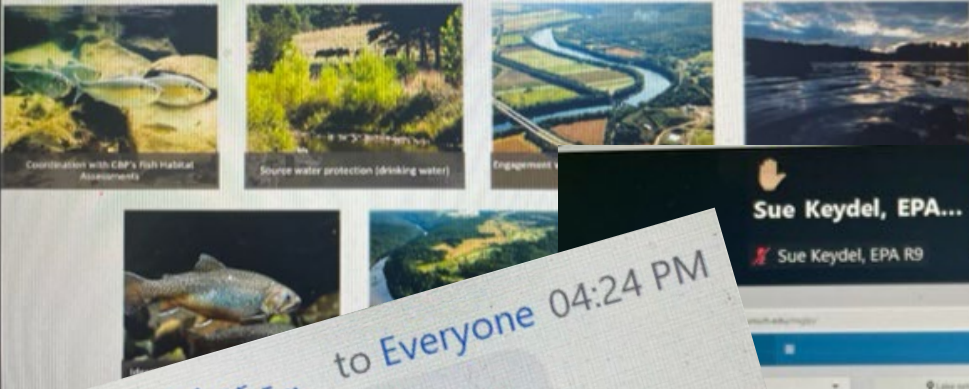
Current: Annual Protection/Restoration Workplans

**Users: MassBays Program and Regional Coordinators
Basic Unit: Embayment**

Susan Jackson...  Adam Schempp Steve Epting (U... 

 Susan Jackson USEPA ...  Renee Thompson  Adam Schempp  Steve Epting (US EPA)

MANAGEMENT APPLICATIONS AND ADDITIONAL STAKEHOLDERS OF THE CHESAPEAKE AND MARYLAND HWS INCLUDE:

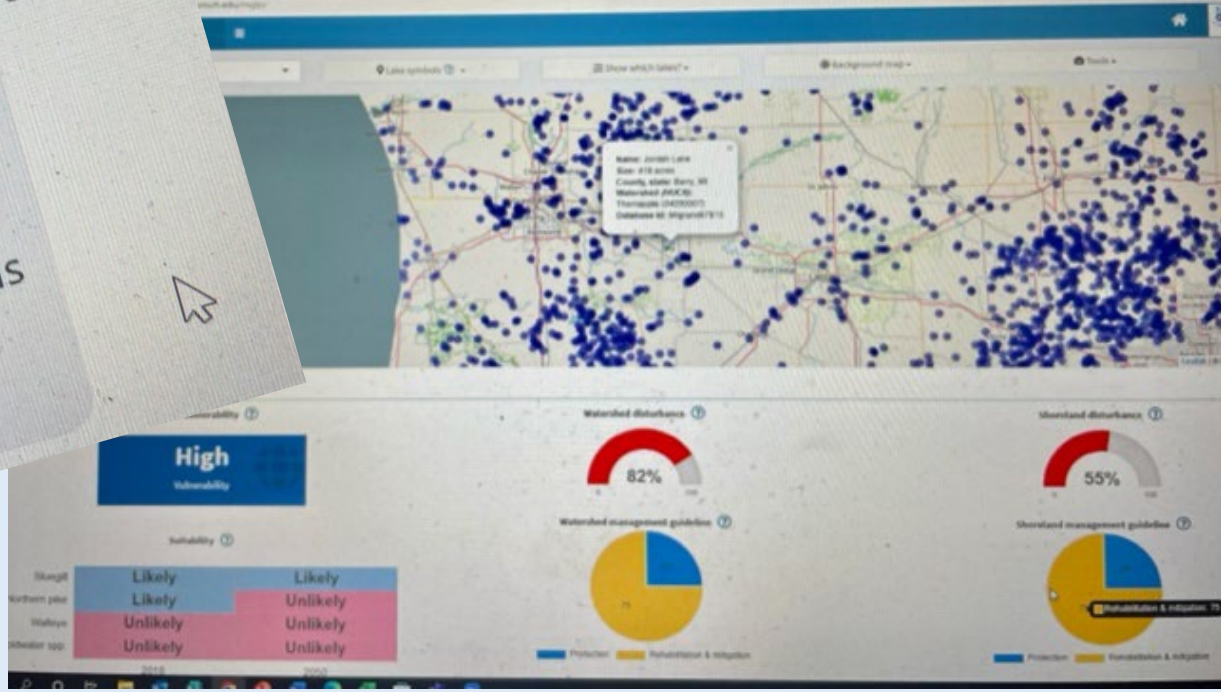


 Sue Keydel, EPA...  SFANCIEU 

 Sue Keydel, EPA R9  SFANCIEU  Julia Kirkwood MI EGLE  Susan Jackson USEPA ...

KS Kathy Stecker -... to Everyone 04:24 PM

Tailor messages to the audience. Try to relate your message to something you know is important to your audience.



Data Exploration & Visualization Tool_Vetting Underway

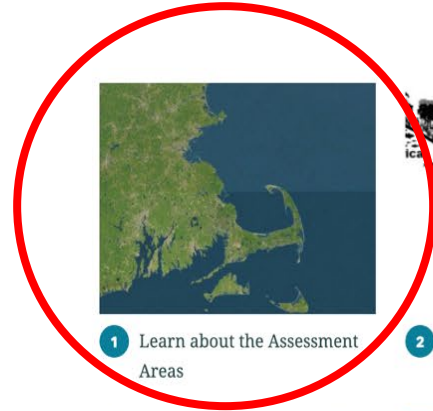


Collection

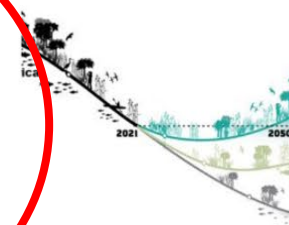
MassBays National Estuary Partnership Data Exploration Tool

Follow these steps to understand historical and current habitat condition, current stressors, and impacts to ecosystem services.

You will be able to revisit any previous or future step using the tabs at the top of the next page.



1 Learn about the Assessment Areas



2 Explore Baywide Ecotypes



3 Embayment Level Habitat Data



4 Embayment Level Stressor Data



5 [DRAFT] Ecosystem Services Data



6 MassBays Community Profiles Data

Get started

General information re MassBays and the NEP program

Data Exploration & Visualization Tool_Vetting Underway



Collection

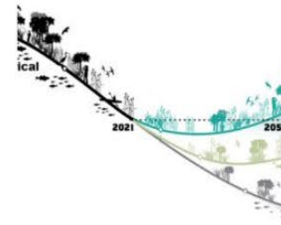
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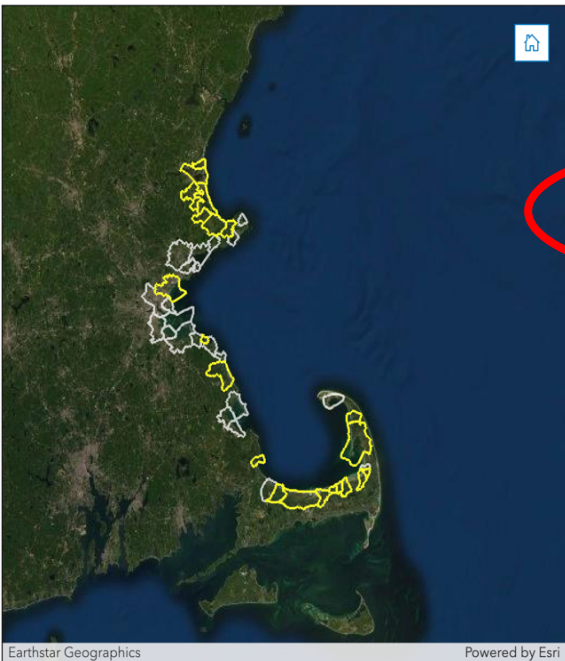


6 MassBays Community Profiles

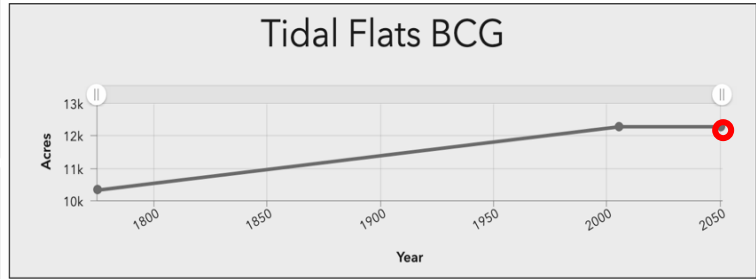
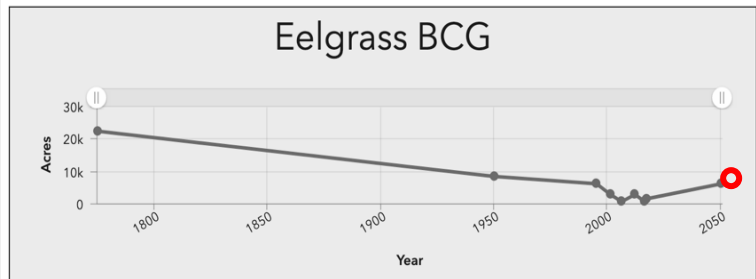
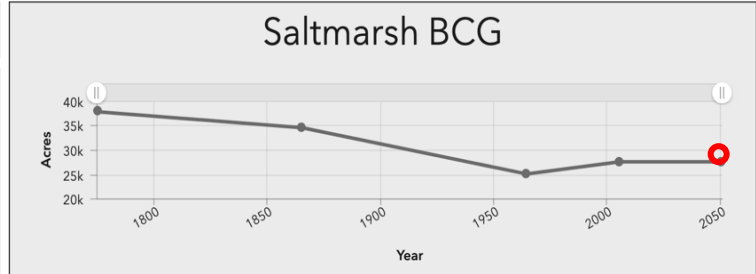
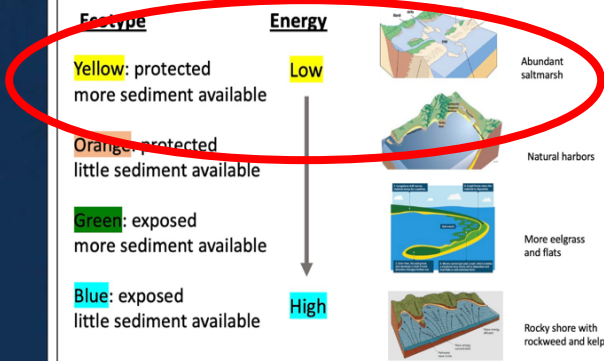
Get started

Baywide BCGs and Targets

How does historical habitat data inform protection and restoration targets?



Ecotypes group embayments based on physical conditions: exposure, depth, relative sediment abundance. This helps assess the types of habitats they could support in the absence of anthropogenic stressors.



Habitat Targets

Salt marsh: protect

Eelgrass: restore

Tidal flats: protect

Data Exploration & Visualization Tool_Vetting Underway

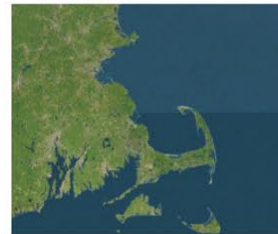


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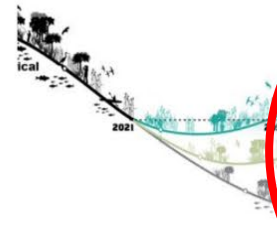
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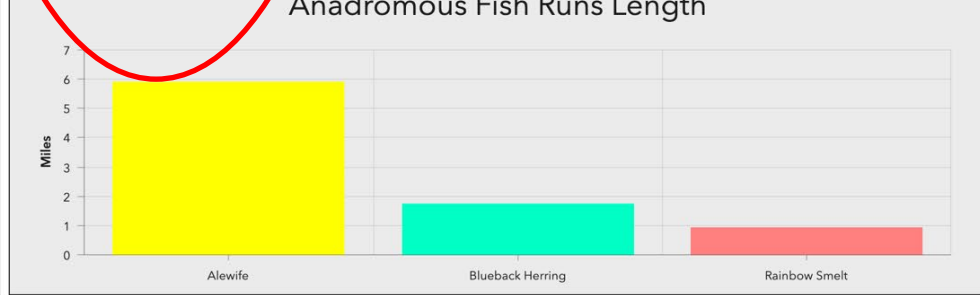
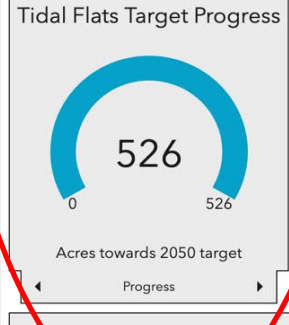
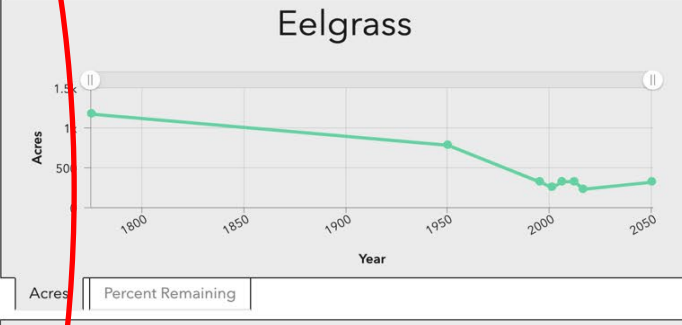
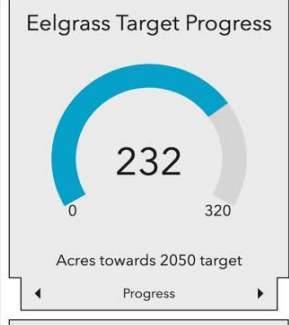
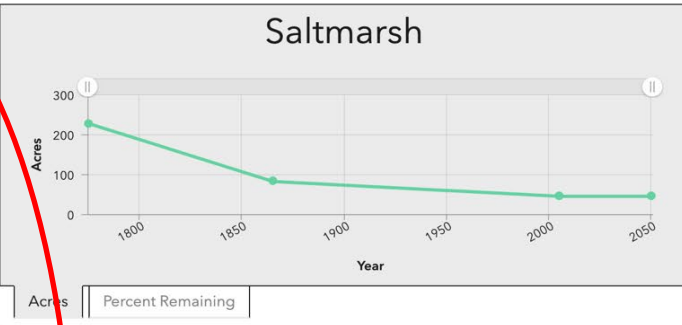
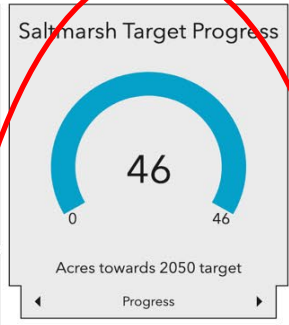
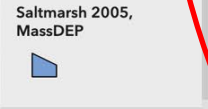
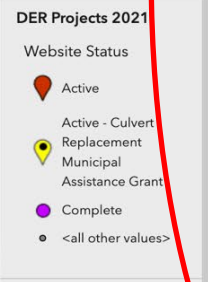
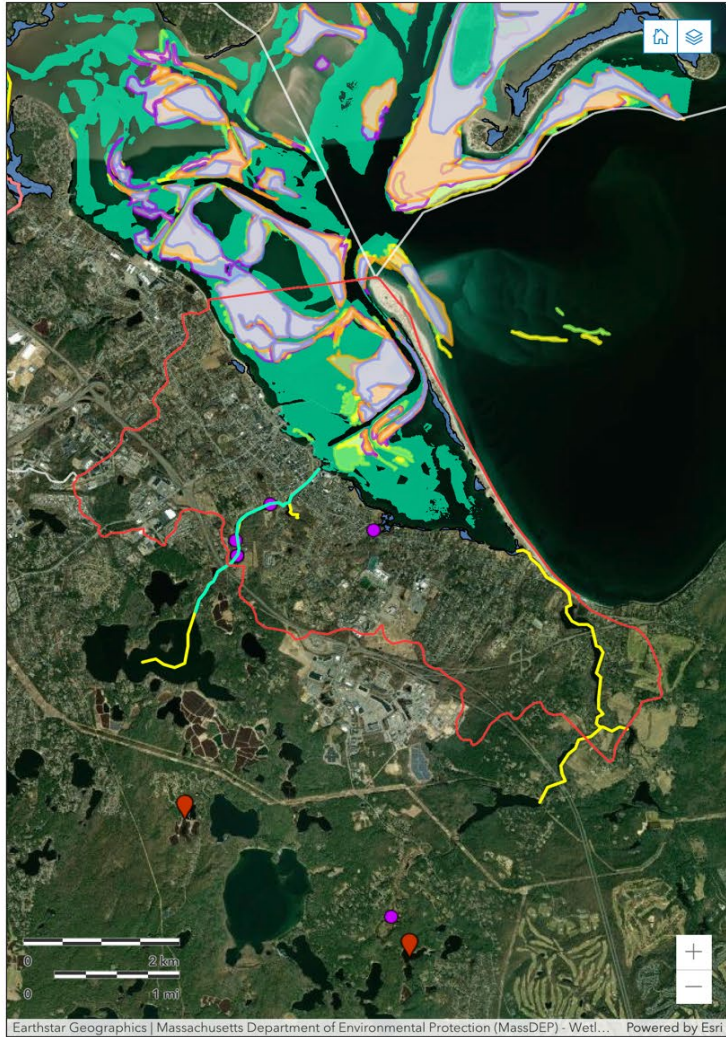
Embayment Information: target, status,



Explore each embayment's historical condition, current condition, and progress towards 2050 target condition.

The graphs on the right show embayment habitat change over time, including a proposed trajectory toward each habitat's 2050 target.

EEL RIVER / PLYMOUTH HARBOR	
NAME	EEL RIVER / PLYMOUTH HARBOR
Ecotype	exposed more sediment available
MassBays Region	South Shore
Stressor-Resource Category	1



Data Exploration & Visualization Tool_Vetting Underway



Collection

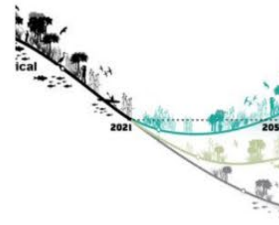
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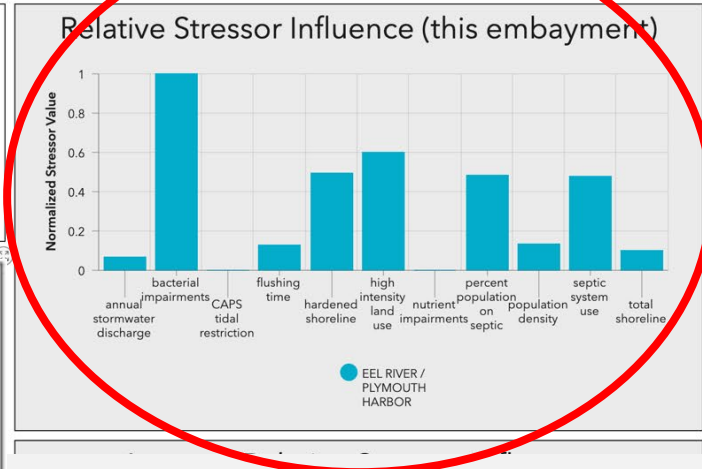
Get started

Stressor data for each embayment



Explore stressor profiles in each embayment

The graphs on the right show the relative ecosystem stressor for a suite of stressors reported in the MassBays NEP stressor database. Direct link between each bar in the stressor profile and its data source in progress.



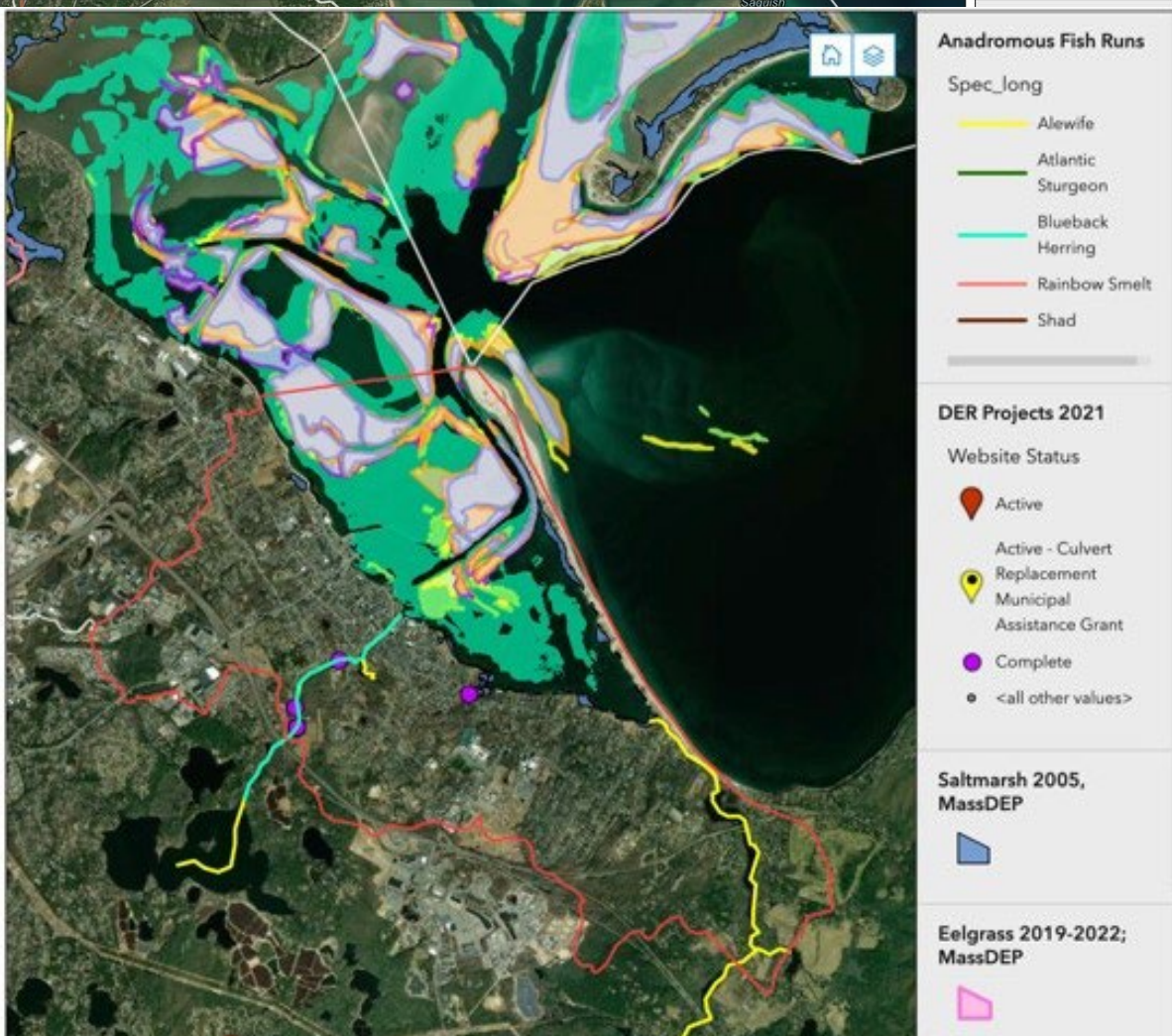
For this embayment, priority stressors:

Bacteria

Hardened Shoreline

High Intensity Land Use

Septic Systems (% population on septic, septic use)



Data Exploration & Visualization Tool_Vetting Underway

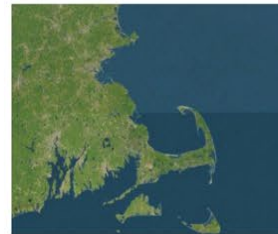


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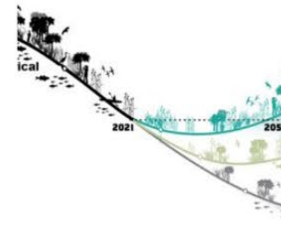
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2 Explore Baywide Ecotypes



3 Embayment Level Habitat Data



4 Embayment Level Stressor Data



5 [DRAFT] Ecosystem Services Data



6 MassBays Community Profiles

Get started

Ecosystem Services and Community Profiles for each embayment – in development



EEL RIVER / PLYMOUTH HARBOR

NAME	EEL RIVER / PLYMOUTH HARBOR
Ecotype	exposed more sediment available
MassBays Region	South Shore
Stressor-Resource Category	1



Anadromous Fish Run

Spec_Long

- Alewife
- Atlantic Sturgeon
- Blueback Herring
- Rainbow Smelt
- Shad

DER Projects 2021

- Website Status
- Active
 - Active - Covert
 - Replacement Municipal Assistance Grant
 - Complete
 - <all other values>

Saltmarsh 2005, MassDEP

Eelgrass 2019-2022, MassDEP

Eelgrass 2015-2017, MassDEP

Eelgrass 2010-2013, MassDEP

Ecosystem Services

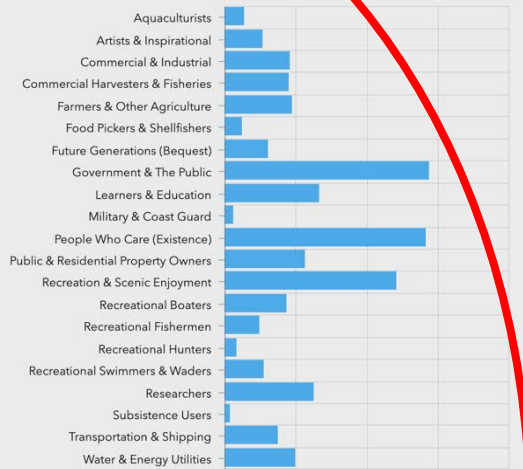
Who benefits?



What are the benefits?



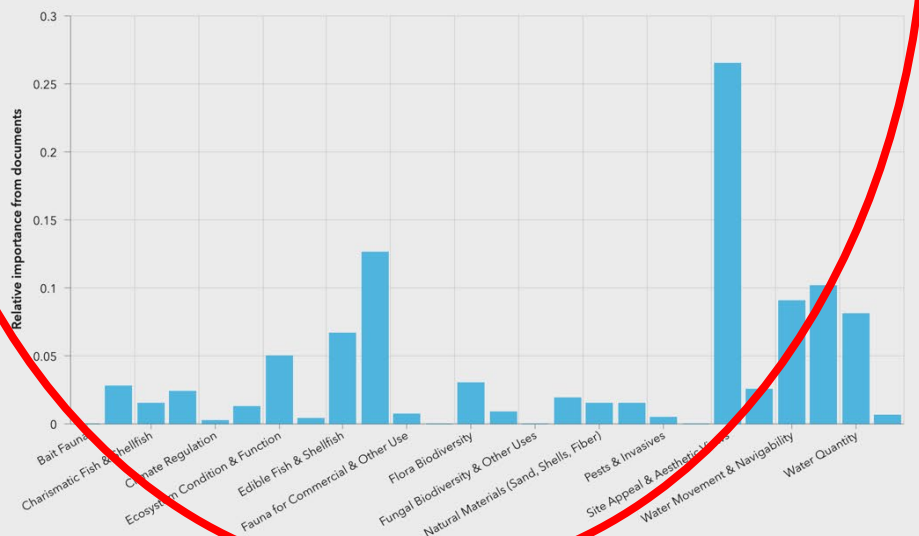
Who Benefits from Coastal Resources?



Relative Frequency User Groups Mentioned in Documents

All Coastal Habitats | Salt Marsh | Seagrass | Tidal Flats

What are the most important Ecosystem Services?



All Coastal Habitats | Salt Marsh | Seagrass | Tidal Flats

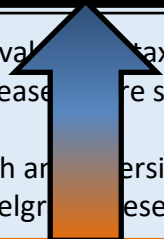
EX: Eelgrass Beds (hypothetical)

BCG y-axis numeric decision rules

Beneficiaries: Property Owners and Recreational Fishing Population

BCG y-axis attributes

BCG Level	Ecological attributes (narrative)	Ecological measures (quantitative)	Ecosystem Services
<p>1</p> <p>Target Condition</p>	<p>Abundant, dense, and healthy eelgrass beds in many places</p>	<p>Eel grass bed extent: between A and B acres eelgrass per km shoreline</p>	<p>Coastal property values and tax revenue: High in all areas</p> <p>Recreational catch and diversity: High in all areas</p>
<p>3</p>	<p>Abundant, dense, and healthy eelgrass beds in most places; thin and/or poor quality eelgrass beds in other places</p>	<p>Eel grass bed extent: between B and C acres eelgrass per km shoreline</p>	<p>Coastal property values and tax revenue: High where healthy eel grass present</p> <p>Recreational catch and diversity: High where healthy eelgrass present</p>
<p>Existing Condition</p>	<p>Thin and/or poor quality eelgrass beds in many places</p>	<p>Eel grass bed extent: limited acres of eelgrass per km shoreline</p>	<p>Coastal property values and tax revenue: Incremental increase where saltmarsh present</p> <p>Recreational catch and diversity: incremental increase where eelgrass present</p>
<p>5</p>	<p>Sparse eelgrass beds</p>	<p>Eelgrass bed extent: almost no eel grass per km shoreline</p>	<p>Coastal property value and tax revenue: Low</p> <p>Recreational catch and diversity: low</p>
<p>6</p>	<p>No eelgrass bed</p>	<p>Eelgrass bed extent: zero eel grass per km shoreline</p>	<p>Coastal property value and tax revenue: Coastal properties are a liability</p> <p>Recreational catch and diversity: zero</p>



EX: Eeelgrass Beds (hypothetical)

BCG y-axis attributes

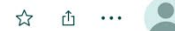
BCG y-axis numeric decision rules

Beneficiaries: Property Owners and Recreational Fishing Population

BCG Level	Ecological attributes (narrative)	Ecological measures (quantitative)	Ecosystem Services
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Working on: Link multiple, measurable metrics such as habitat acreage (BCG levels), fish catch and diversity, property values, tax revenue, priority stressors

		km shoreline	Recreational catch and diversity: zero
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EEL RIVER / PLYMOUTH HARBOR

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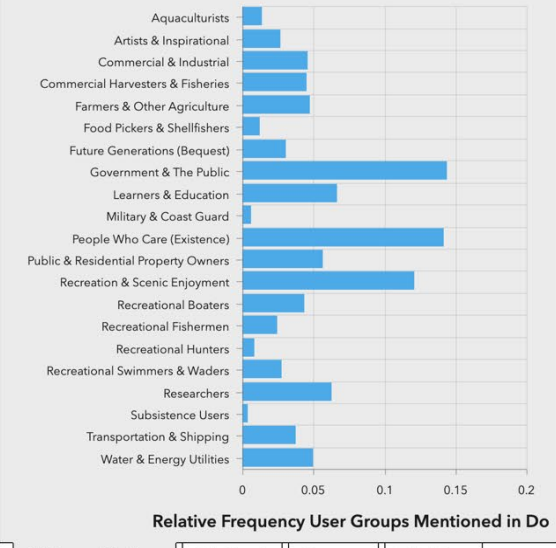


EJ profiles and criteria

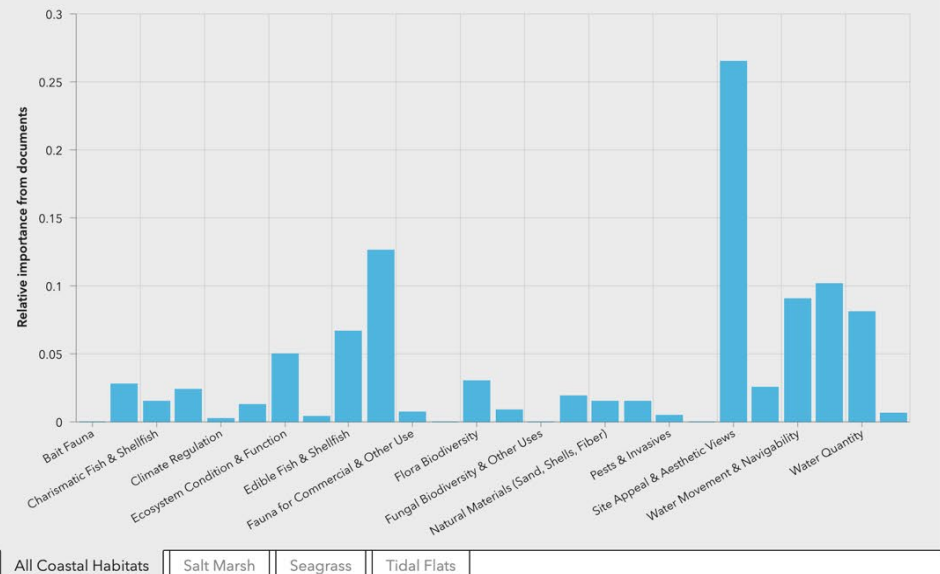
Coming

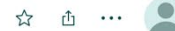
Source: Massachusetts criteria and data

Who Benefits from Coastal Resources?



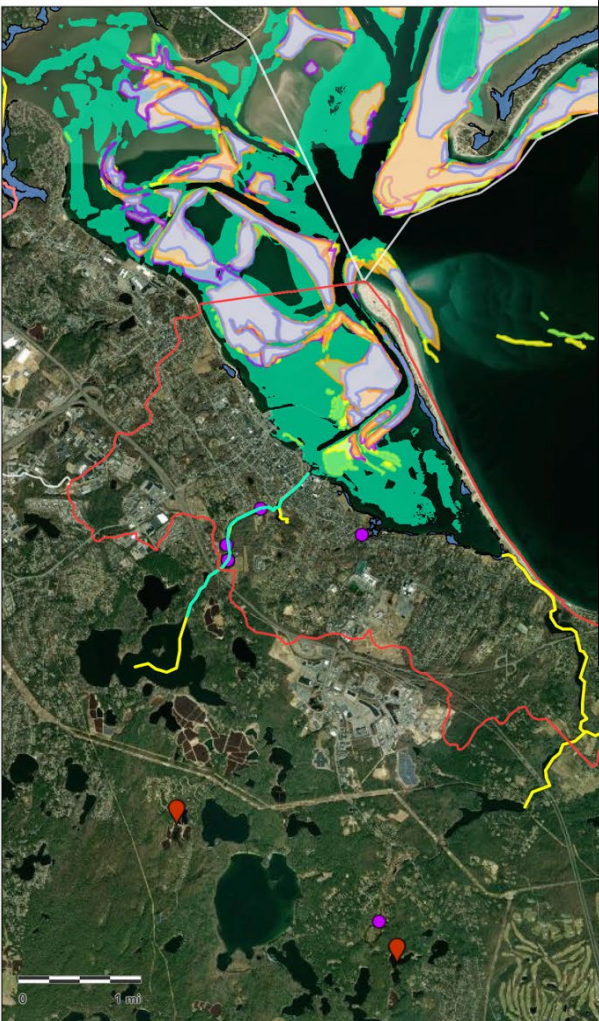
What are the most important Ecosystem Services?





EEL RIVER / PLYMOUTH HARBOUR

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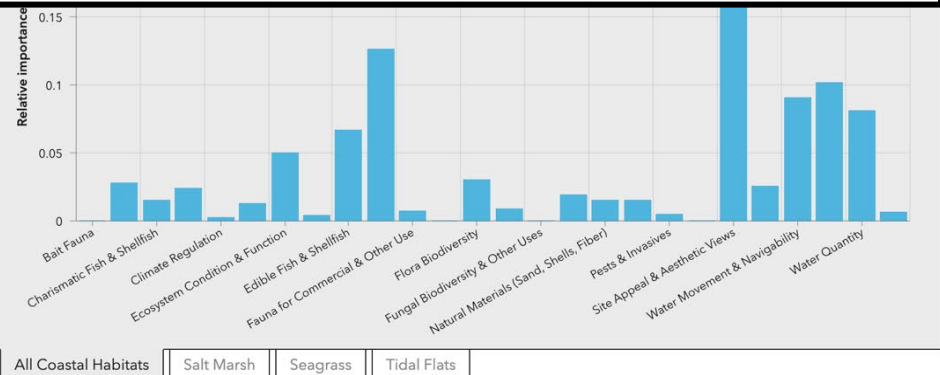


EJ data and info to be mapped for each embayment including population density, income, ethnic/race, poverty & health.

EJ Index for eleven environmental indicators:

- Particulate Matter (PM2.5)
- Ozone
- National Scale Air Toxics Assessment Diesel PM (DPM)
- National Scale Air Toxics Assessment Air Toxics Cancer Risk
- National Scale Air Toxics Assessment Respiratory Hazard Index
- Traffic Proximity and Volume
- Lead Paint Indicator
- Proximity to Risk Management Plan Sites
- Proximity to Superfund Sites
- Proximity to Hazardous Waste Facilities
- Proximity to Major Direct Water Dischargers

Data source: Massachusetts



Both Alabama & MassBays NEP using BCG to help:

- Set protection and restoration goals and targets
- Monitor and track progress
- Communicate and engage the public

“Take Homes”

BCG provides ecological framework that reflects the underlying geophysical features supporting aquatic biota and key habitats

Knowledge of those features promotes credible protection and restoration targets and facilitates association with stressor levels, watershed condition, and ecosystem services.

User and public facing scalable data mapping, visualization and exploration tools provide managers and the public information that they can understand and use

Thank You!

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