

# **A Framework for Categorizing Biological Indicators According to their Sensitivity to Climate Change**

**Britta Bierwagen**

Global Change Research Program  
National Center for Environmental Assessment  
Office of Research & Development  
U.S. Environmental Protection Agency

**Climate Change Effects on Biocriteria Workshop**  
March 27-29, 2007  
Baltimore, MD

# Key Messages

**Biological indicators may be affected by climate change**

**Categorizing indicators according to climate sensitivity is one step in controlling for or detecting climate change effects**



# Outline

- A very brief overview of biocriteria
- How climate change affects biological indicators
- Categories of indicators
- Indicator classes
- Implementation of framework



# *Biocriteria*

- **Targets define desired biological condition of waterbody**
    - Assess ecosystem health
    - Element of water quality standards
- 
- EPA biocriteria guidance documents exist for:
    - Rivers & Streams, Lakes, Wetlands, Estuaries & Coastal Areas
  - Biocriteria guidance is under development for:
    - Coral Reefs

# State Biocriteria Program Goals

- Stressor identification
- Monitor BMP effectiveness
- TMDL assessment & monitoring
- Status & trends in water quality & condition
  - Baselines
  - Water quality standards
- Aquatic life uses determination



# Climate Change & Biocriteria Programs

- Additional stressor on ecosystem
- Affects both reference & non-reference sites
- Current indicators may be confounded by climate change effects on ecosystems
- Biocriteria program management goals
  - Difficult to establish goal if baseline is changing
  - Or goals may be impossible to meet



Overview - *Climate Change Effects* - Categories of Indicators - Indicator Classes - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Climate Change & Biocriteria Programs

- Additional stressor on ecosystem
- Affects both reference & non-reference sites
- Current indicators may be confounded by climate change effects on ecosystems
- Biocriteria program management goals
  - Difficult to establish goal if baseline is changing
  - Or goals may be impossible to meet



Overview - *Climate Change Effects* - Categories of Indicators - Indicator Classes - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Climate Change & Biocriteria Programs

- Additional stressor on ecosystem
- Affects both reference & non-reference sites
- Current indicators may be confounded by climate change effects on ecosystems
- Biocriteria program management goals
  - Difficult to establish goal if baseline is changing
  - Or goals may be impossible to meet



Overview - *Climate Change Effects* - Categories of Indicators - Indicator Classes - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*



# Climate Change & Biocriteria Programs

- Additional stressor on ecosystem
- Affects both reference & non-reference sites
- Current indicators may be confounded by climate change effects on ecosystems
- **Biocriteria program management goals**
  - Difficult to establish goal if baseline is changing
  - Or goals may be impossible to meet



Overview - *Climate Change Effects* - Categories of Indicators - Indicator Classes - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# *How do existing biological indicators respond to climate change?*



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Categories of Indicators

	<b><i>Insensitive to Climate Change</i></b>	<b><i>Sensitive to Climate Change</i></b>	<b><i>Sensitive to Climate Change and Other Stressors</i></b>
<b><i>Indicator</i></b>	Warmwater fish	Fish community composition	Salmon egg to fry survival
<b><i>Response</i></b>	No change in majority of range	Cold- and coolwater fish species decline, warmwater fish species increase	Decreased survival due to increased turbidity from sediment input due to increased precipitation and/or land use change

# *What Defines Climate-Insensitive?*

- Ecological events not cued to temperature
- Species is tolerant of broad temperature range
- Tolerant of wide range of hydrologic conditions
  - High flows or low flows
  - High variability in flow
  - Variation in salinity

# What Defines Climate-Sensitive?

- Ecological events cued to temperature
- Species exists in narrow temperature range
- Intolerant of certain hydrologic conditions
  - High flows or low flows
  - Saltwater intrusion



M.Wenger, USFWS

Overview - Climate Change Effects - **Categories of Indicators** - Indicator Classes - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Climate-Sensitive Indicator Classes

- Phenology (timing of emergence, reproduction, flowering, etc.)
- Number of reproductive periods
- Vulnerable life stage to climate variable
- Thermal tolerance
- Hydrological tolerance



Overview - Climate Change Effects - Categories of Indicators - **Indicator Classes** - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Examples of Sensitive Indicators

## Phenology

- Earlier emergence of stoneflies and mayflies with warmer temperatures
- Earlier trout spawning in warmer water



Overview - Climate Change Effects - Categories of Indicators - *Indicator Classes* - Implementation of Framework

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Examples of Sensitive Indicators

Longer growing season leads to an increase in the number of reproductive periods

- Increase in algal productivity
- Additional reproductive periods of amphipod species





# Examples of Sensitive Indicators

## Life stage vulnerable to climate variable

- Decrease in salmon egg to fry survival from increased turbidity from erosion



# Examples of Sensitive Indicators

## Thermal tolerance

- Increase in peak abundance of thermophilic copepod species
- Shift from cold- and coolwater to warmwater fish species



# Examples of Sensitive Indicators

## Hydrological tolerance

- Decline of drought intolerant mussel spp.
- Decrease in autumn spawning salmonid species
- Decrease in salt intolerant wetland plants



# *What are the next steps?*



**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Using the Framework

- Evaluate and understand how current indicators respond to climate change
- Evaluate novel indicators to detect climate change
- Determine how indicator responses affect a Biological Condition Gradient and biocriteria in standards



[Overview](#) - [Climate Change Effects](#) - [Categories of Indicators](#) - [Indicator Classes](#) - [Implementation of Framework](#)

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Using the Framework

- Evaluate and understand how current indicators respond to climate change
- Evaluate novel indicators to detect climate change
- Determine how indicator responses affect a Biological Condition Gradient and biocriteria in standards



[Overview](#) - [Climate Change Effects](#) - [Categories of Indicators](#) - [Indicator Classes](#) - [Implementation of Framework](#)

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Using the Framework

- Evaluate and understand how current indicators respond to climate change
- Evaluate novel indicators to detect climate change
- Determine how indicator responses affect a Biological Condition Gradient and biocriteria in standards



*Overview - Climate Change Effects - Categories of Indicators - Indicator Classes - Implementation of Framework*

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*

# Extending the framework

- Alter design of sampling and monitoring programs (Case Study 1)
- Monitor reference and non-reference sites for similar changes (Case Study 2)



*Overview - Climate Change Effects - Categories of Indicators - Indicator Classes - Implementation of Framework*

**RESEARCH & DEVELOPMENT**

*Building a scientific foundation for sound environmental decisions*



**Thank You!**

**Questions?**

