# The Biological Condition Gradient

Portland

4 April, 2012

# Biological Integrity: Operational Definition

"The ability of an aquatic ecosystem to support and maintain a balanced, integrated and adaptive community of organisms having a species composition, diversity and functional performance comparable to the natural habitats of a region."

As modified from Karr and Dudley (1981)

# The Biological Condition Gradient

- Conceptual model of aggregated biological knowledge to describe changes with increasing stress
- Based on combination of ecological theory and empirical knowledge
- Regional calibration
  - Conceptual model
  - Quantitative decision model

# Schematic of the Biological Condition Gradient

**Levels of Biological Condition**

Natural structural, functional, and taxonomic integrity is preserved.

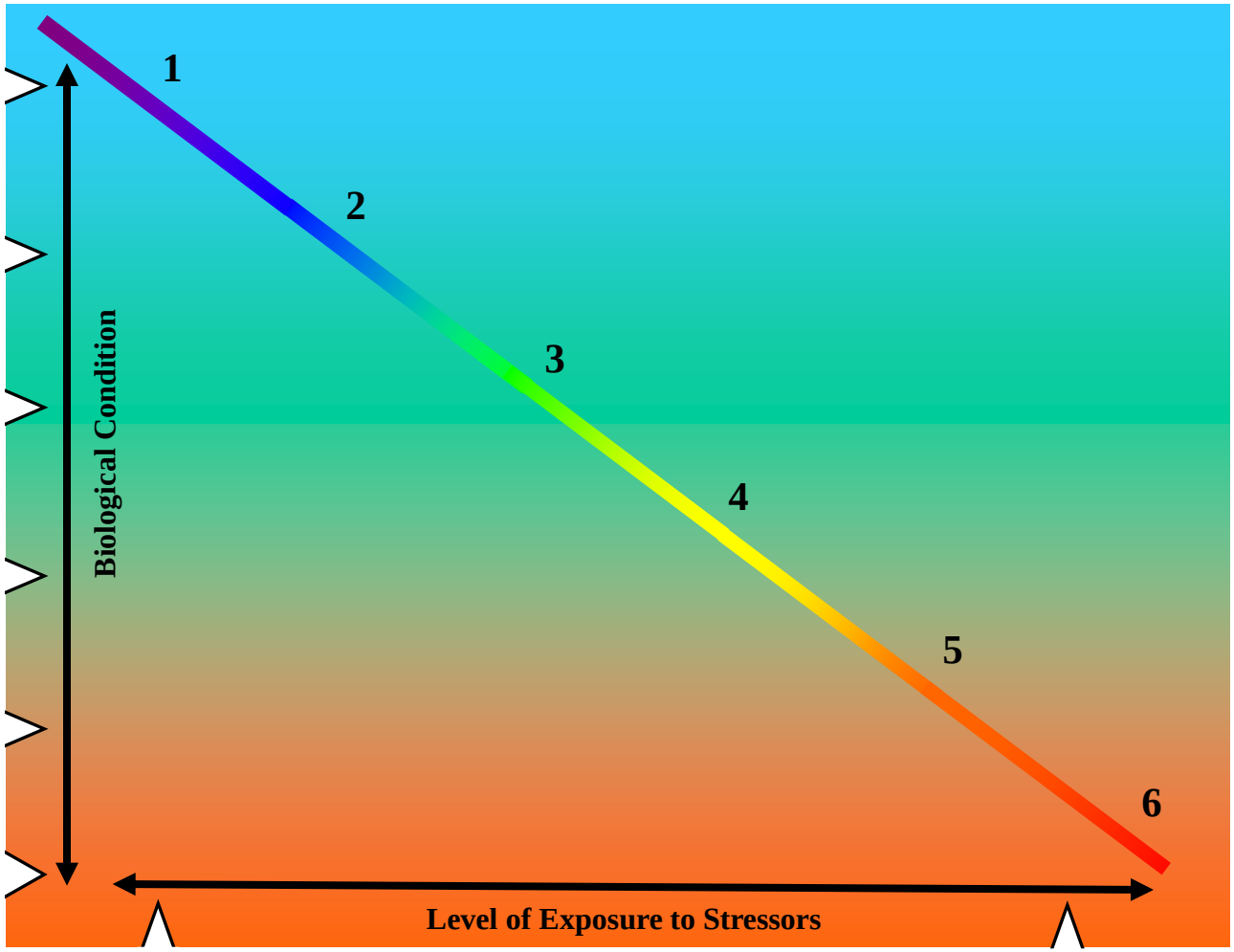
Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

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 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.




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

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

# Basic idea

- What do we expect to see?
  - Species, abundances
  - Habitats
  - Biotopes
  - Interactions
- What do we **not** expect to see?
  - What is missing?
  - What is present that shouldn't be?

# Biological Integrity

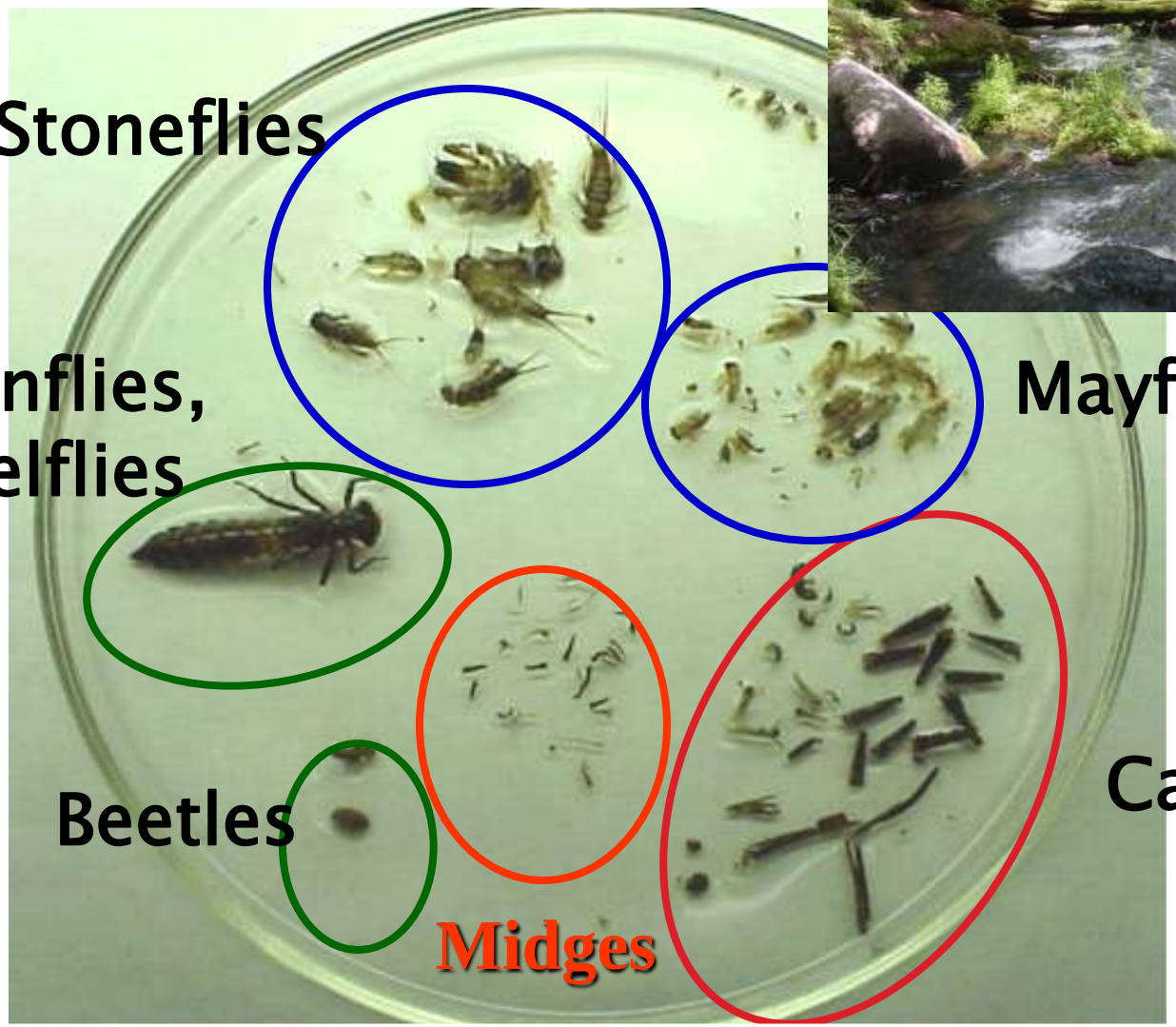
QUANTITATIVE MEASURES

The ability of an aquatic ecosystem to support and maintain a balanced, integrated and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region

REFERENCE

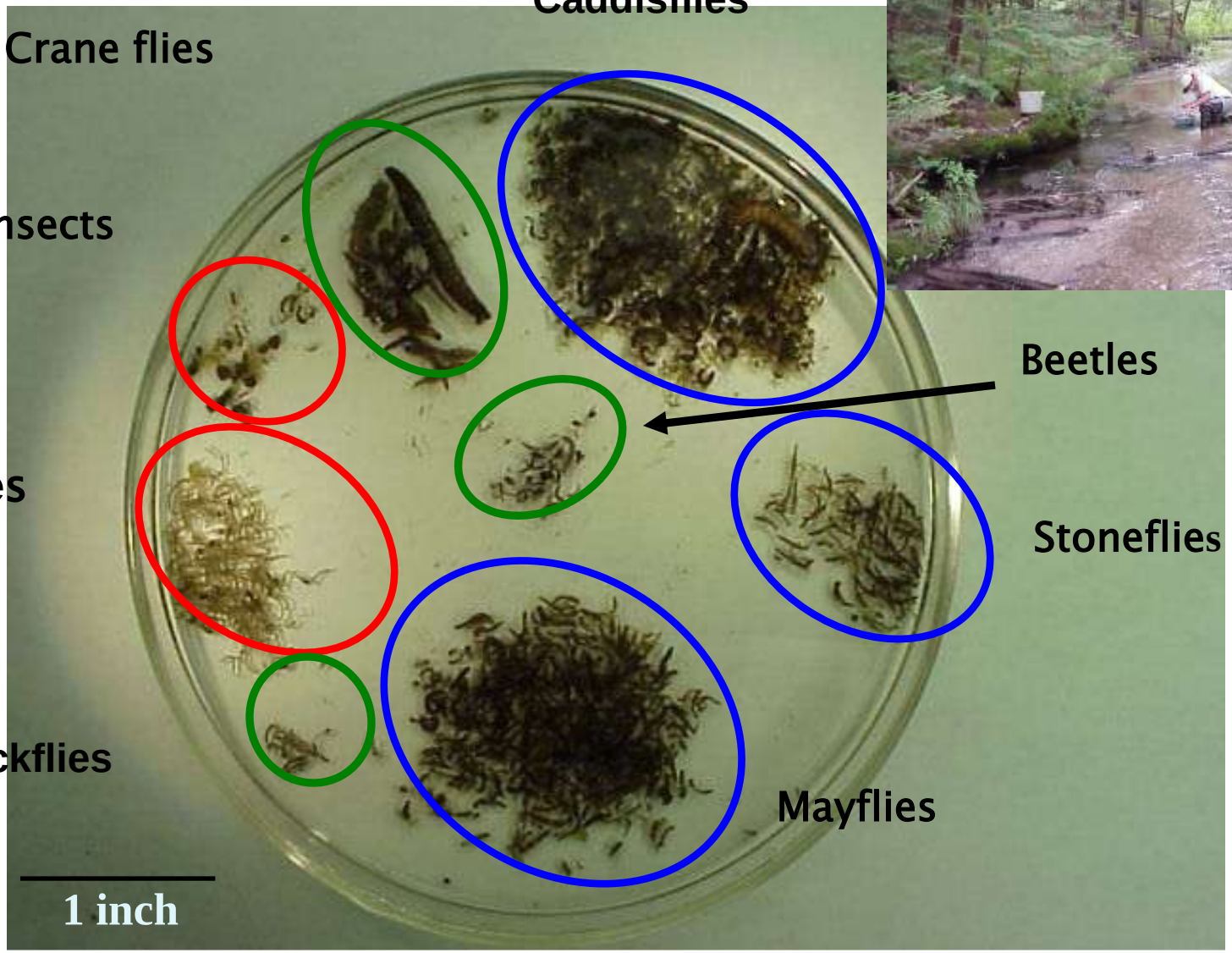
CLASSIFICATION

# Undisturbed/Minimally Disturbed Stream


Courtesy of Susan Davies, ME DEP

# Nutrient Enriched Stream

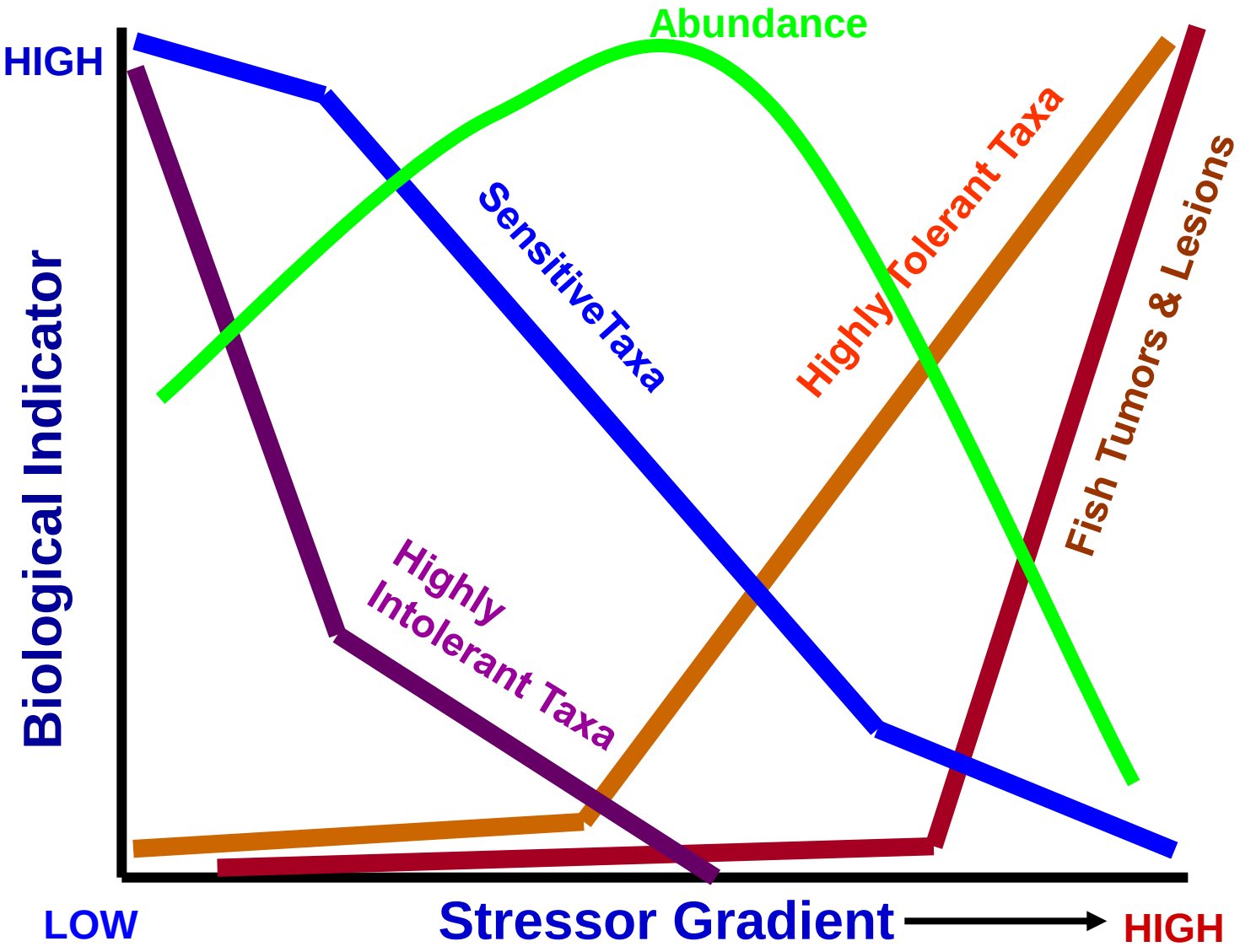



Courtesy of Susan Davies, ME DEP

# Drainage from a Shopping Mall Parking Lot


Courtesy of Susan Davies, ME DEP

# Biological Indicators: Behavior Along the Stressor Gradient




Modified from Original Courtesy of Chris Yoder, CABB

# Attributes

I. **Historically documented, sensitive, long-lived, regionally endemic taxa**

II. **Highly sensitive or specialist taxa**

III. **Sensitive and common taxa**

IV. **Taxa of intermediate tolerance**

V. **Tolerant taxa**

VI. **Non-native taxa**

VII. **Organism condition**

VIII. **Ecosystem Function**

IX. **Spatial and temporal extent of detrimental effects**

X. **Ecosystem connectance**

# BCG Calibration

- Classification
- Identify stressor gradient
- Workshop:
  - Define expectations
  - Identify attributes and their metrics
  - Assign sites to levels of BCG
  - Develop rules for assigning sites (decision criteria)
- Develop model(s) for automated replication of panel decisions
- Test and iterate

# Classification

- Identify groups of sites that under natural conditions would have comparable biological communities

- Rely on those characteristics of sites that are intrinsic, or natural, and not the result of human activities

# Identify Stressor Gradient

- Gradient of least stressed to most stressed in context of ecoregion
- Identify example sites in classes of stress

# Identify attributes and metrics
## New England fish

## Sensitive taxa

| N | Common Name |
|---|---|
| 19 | American Brook lamprey |
| 5 | Banded Sunfish |
| 3 | Bridled shiner |
| 29 | Burbot |
| 15 | Creek chubsucker |
| 2194 | Slimy sculpin |
| 21 | Swamp darter |
| 8221 | Brook trout, wild |

**Attribute 2 taxa: most sensitive; the first to disappear**

**Slimy sculpin**

**Burbot**

**Attribute 3 taxa: moderately sensitive**

**Wild brook trout**

# New England fish

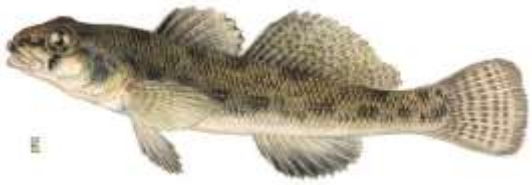
## Attribute 4 taxa: broadly tolerant of many conditions

| N | Common Name |
|---|---|
| 521 | Chain pickerel |
| 9046 | Common shiner |
| 2552 | Cutlips minnow |
| 10020 | Fallfish |
| 118 | Fourspine stickleback |
| 15499 | Longnose dace |
| 1764 | Pumpkinseed |
| 4485 | Redbreast sunfish |
| 612 | Redfin pickerel |
| 1344 | Spottail shiner |
| 8832 | Tesselated darter |
| 2 | White perch |

**Longnose dace**

**Redbreast sunfish**

**Fallfish**

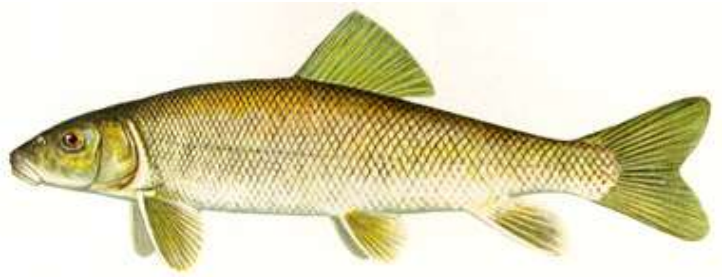


**Tesselated darter**

# New England fish

**Attribute 5 taxa: Highly tolerant; increased abundance in stressed sites**

| N | Common Name |
|---|---|
| 259 | Banded killifish |
| 55137 | Blacknose dace |
| 479 | Brown bullhead |
| 4974 | Creek chub |
| 595 | Golden shiner |
| 23426 | White sucker |
| 187 | Yellow bullhead |



**White sucker**

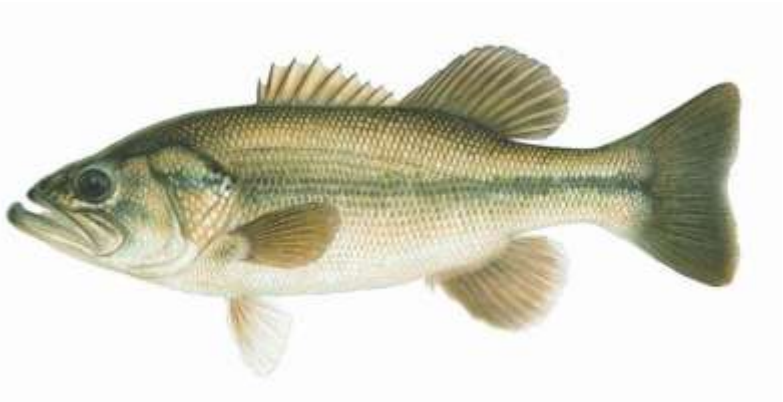
**Blacknose dace**

# New England fish

## Attribute 6a taxa: Highly tolerant, nonnative

| N | Common Name |
|---|---|
| 11 | Bluntnose minnow |
| 13 | Carp |
| 32 | Central mudminnow |
| 45 | Fathead minnow |
| 3 | Goldfish |
| 364 | Green sunfish |
| 1648 | Largemouth Bass |

**Fathead minnow**



**Largemouth bass**

# Assign sites to BCG levels

- Panel members assign sites to BCG levels using species composition information
- Best sites (reference) are not necessarily Level 1!
- Capture critical information for decisions

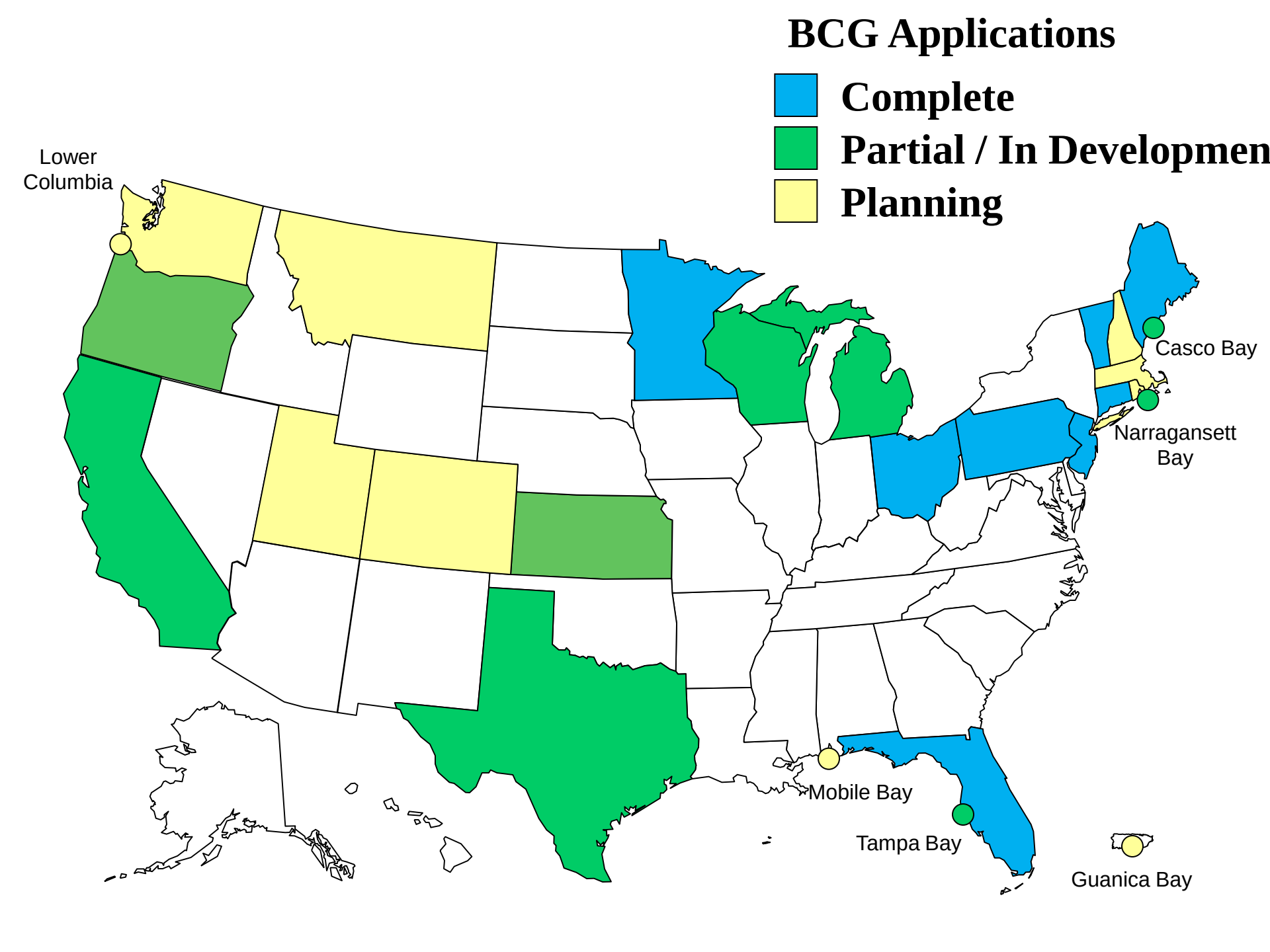
# New England (Maine) best: Level 1

# Connecticut, New Jersey best:  Level 2

# Wisconsin Driftless Area best:  Level 2-3

# Develop decision rules

- During site assessment, record reasons why, e.g., “not enough sensitive taxa”
  - How many is enough for Level 4?  Level 3?
  - How sensitive?
- Build up sets of decision rules for assigning sites to BCG levels
- Tend to use strength of evidence, using multiple attributes for decisions


BCG Applications
Complete
Partial / In Developmen
Planning
Lower Columbia
Casco Bay
Narragansett Bay
Mobile Bay
Tampa Bay
Guanica Bay

# Lessons Learned

- Classification
  - Catchment area
  - Stream gradient (high, low)
  - Wetlands influenced (= very low gradient?)
  - Cold water / cool water / warm water
- Reference sites to identify expectations
- Applicability of assemblages
  - eg., fish n.a. in smallest headwaters
  - Assemblage response to stressors

# Considerations for estuaries

- Legacies of overexploitation
  - Cod
  - Salmon
  - Turtles
  - Lobster
  - Kelp
- Ocean changes
- Watershed changes
  - Hydrology
  - Nutrients
  - Sediment
- Direct habitat disruption
  - Habitat mosaic
- Secondary effects on other keystone components
  - Habitat mosaic
  - Trophic cascades

# Evidence for “best”

- Present-day conditions
- Historical reconstruction
  - Historical documents (descriptions, journals, charts, aerial images)
  - Fish/shellfish landings records
  - Museum collections
  - Archeological evidence (middens, other digs)
  - Paleo evidence (diatoms, forams, pollen)

# Advantages

- Based on ecological considerations, not a particular data set
- Universal attributes from species to biotopes
- Conceptually tied to least stressed, but **not** dependent on statistical comparison to specific reference
  - Requires projection/extrapolation to pristine conditions
  - Allows development of entire scale of system response
- Remarkable congruence of rules
  - Follows original description of BCG