Incorporating fish monitoring into your project

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Before we get started

- What is your objective/goal?
  - To improve or protect water quality – duh.
- Why is the water quality bad or in need of protection?
  - Because of that stressor – over there.
- What stressor?
  - The impervious surface, the agriculture, the deforestation, urban sprawl, etc.
- How is that affecting the water quality?
  - It's causing increased sedimentation, flashiness, temperature fluctuations, changes in the water chemistry
  - Abiotic changes are causing changes in the biota
- What are you going to do about it?
  - We have a project!
Tell me more

• How is that project going to improve or protect the water quality?
  – It will........

• How fast will the ABIOTIC response be?
  – May be immediate for somethings, longer for others (i.e., years)

• How large of an area or much of a stream will this project effect?
  – That depends.

• How will you know if your project worked?
  – We will monitor stuff?

• Like what? Why?
Fish measures that may respond to your project

Depending on the stressor(s) addressed, the following may be useful for monitoring:

- Relative density - Catch Per Unit Effort (CPUE), proportions
- Density/Population size - abundance; #/100m
- Community/assemblage structure
- Indices of biotic integrity (IBIs)
- Length-Frequency
- Age-Frequency
- Growth rate - daily or annual growth
- Condition - relative weight, relative condition
- DELTs - Deformities, Lesions, and Tumors
- I’m sure I’m forgetting some
When to use fish?

• After you determine what stressor(s) your project will address
  • How will the physiochemical and biotic environments change in response?
• Choose the best monitoring tool(s) for the job
  – No silver bullet
  – Prioritize monitoring options by the measures that are most likely to respond to the stressors your project will address
• Use fish measures when aspects of their biology and ecology are:
  – the most likely parameter to respond to a change in the identified stressor (as caused by your project)
  – See Day 2 fish presentation on the biological characteristics of watersheds
  – Consult a fisheries professional
2 ways of looking at fish responses

(**These are not mutually exclusive)

1) Assemblage/Community
   - Shifts in amounts of species, groups, or guilds
   - Changes in community structure, groupings (tolerance), or guild, etc.
   - E.g., Assemblage similarity (ANOSIM)

2) Species specific
   - Indicator species, species of concern
   - Changes in number, growth, condition, length, age, biomass, or reproduction
   - E.g., Mean condition of trout; # of Sea Lamprey redds or carcasses
Assemblage Response

- Canonical Correspondence Analysis (CCA)

- Each ellipse surrounds a group of samples

- How similar is each group? (e.g., US/DS; Before/After; Reference/Impaired)

- Have groups become more similar over time (in response to your project)?
Species Specific Responses

Keller 2011
Types of fish responses and associated monitoring

• Electrofishing can be used to assess both assemblage and species specific responses
• Single pass electrofishing
  – Assessing relative densities (i.e., CPUE, proportions), condition, length-frequencies, biomass, growth rates (collecting material for age determination), reproduction
• Multi-pass electrofishing
  – Used to assess all of the above, plus abundance estimate (i.e., density per unit reach length or area)
  – Not sensitive to differences in crew size between visits
  – Assumptions: no emigration or immigration, consistent collection effort among passes, constant capture probability, descending removal pattern
  – Method used for the DRWI
Types of fish responses and associated monitoring

• Other techniques may be used for species specific responses
  – angling, seining, trapping, observation
  • To collect fish tissues or observe fish for signs of disease, deformities, lesions, tumors or growths.
  • Observation/counting nests, redds, or carcasses
  • Seining may be used to determine CPUE

• DRWI uses standardized electrofishing protocols for comparability across the basin
Examples of other techniques

Catch rates from trapping (Keller 2011)

Centrarchid (bass and sunfish) nests
Habitat matters

• Habitat template model
  – If you build it they will come; the physiochemical environment dictates the assemblage found

• Therefore it is important to account for
  • Physical structure (e.g., woody debris, cobble)
  • Water conditions/quality (pH, DO, conductivity)
  • Flow and temperature regime
  • Other physiochemical aspects that influence fish assemblages

• The DRWI has standard protocols for assessing reach level habitat
  – Finer resolution habitat monitoring may be appropriate depending on your project
Disturbance

• Other models of community assembly also apply
  – E.g., Disturbance model - Disturbances shape communities
  – An altered flow regime (e.g., periodic flashiness or drought) can shape an assemblage

• Interactions with other species are also important
Urban and Ag Syndromes

• While single causes may be present in some cases
• Many disturbances affect many stream processes and stream assemblages in different ways
• Urban Syndrome (well known, i.e., I didn’t make it up)
• Agricultural Syndrome (Made this up, but others probably have too)
Stressors: The Urban Syndrome

• Contaminants
• Eutrophication
• Low Dissolved Oxygen
• Habitat loss
• Loss of riparian/floodplain function
• Flashy Hydrology
• Erosion
• Sedimentation-Embeddedness
• Poor habitat
• Shortened, reduced food base
• Higher temperatures
• Passage blocks
Flashy discharge downstream of two main storm sewers
Response: Urban Syndrome

- Fewer cold water species
- Fewer intolerant species
- More tolerant species
- More omnivores
Response at high urbanization

Increase in:

• Estuarine (Mummichog)
• Arid/Great Plains (Green sunfish, Fathead minnow, Western Mosquitofish)
• Large river species (Spottail Shiner)
Stressors: Ag Syndrome

• High nutrient loading
• Channel simplification (channelization, etc.)
• Loss or reduction of forested riparian zone
• Bank and channel disturbance (livestock)
• Low summer flows (intermittency of some small head water tributaries)
Response: Ag Syndrome

• Many of those measured by IBIs
  – IBIs originally developed for agricultural landscapes
• Possibly higher abundance due to nutrient enrichment, but unclear which taxa are benefitted
• Increase in early colonizer species that are able to move out and in drying and newly wetted streams
  – E.g., Creek Chub
Species or guild specific responses

- Fish dispersal limited mostly by:
  - Reproductive capabilities (Balon 1975)
  - Affinities for different substrates during spawning, egg, or larval development (Balon 1975)
    - Possible stressors
      » altered pH, DO, conductivity, temperature and flow regime
      » Substrate impacts/decreased pore space: siltation, embeddedness
    - Possible response (assuming negative but opposite could be true – species dependent)
      » Absence from the local area
      » Reduced abundance
      » Age structure/Reproduction – few or no young fish
      - E.g., adult trout present but not reproducing
Species or guild specific responses

- Weight-length relationships can indicate fatness, gonad development, and provide a measure of overall well-being (Le Cren 1951)
  - O/E approach
  - Condition determined by:
    - Physical and biological factors related to ingestion, digestion, and metabolism (Anderson and Neumann 1996 p.458)
    - Possible stressors
      » altered pH, DO, conductivity, nutrients, turbidity, temperature and flow regime
      » Substrate impacts as they relate to foraging: siltation, embeddedness
  - Possible response
    » Decreased or increased condition – species/guild dependent
Assemblage Recovery

- Not well established for projects
- Depends on regional species pool
  - Physiochemical environment may change due to restoration but regional species pool may no longer include sensitive species to recolonize restored habitat
- May not be well described by IBI or metric approach
- Finer scale species, group or guild specific responses may be of use
  - Using tolerance groups or expected species specific changes
  - Testing hypothesized guild responses to restoration
    - E.g., decreases in herbivores in response to reduced nutrients
- Aspects of the Target Fish Community approach may be applicable (Bain and Meixler 2008)
Accounting for scale

• Need to understand the influence of variables at higher and lower scales, and temporally for your project
• Identify the scale(s) on which your project is operating/influencing the stream
  – Regional
    • Climate, geology, current land use and landscape factors (dams, slopes), nutrients, chemistry, etc.
  – Local
    • Reach – 100, 200, 300m length of stream
    • Channel Unit/Mesohabitat – riffle, run, pool
    • Microhabitat – depth, velocity, substrate of individual
  – Historical
    • Land use change, species introductions, past industry
Environmental Filtering Model: Food for thought

Poff 1997

Tonn et al. 1990
Hypothetical approach: Project/study design example 1

• Problem: Channelized stream resulting in 1) flashiness, 2) erosion DS, 3) poor structural complexity

• Solution/hypothesis: Reconnecting stream to floodplain will reduce 1-2 and improve 3

• BACI; Monitor before and after, include a control and impact if possible

• Physiochemical monitoring may consist of:
  – discharge monitoring (link to flashiness)
  – bank erosion pins (link to erosion DS)
  – amount of woody debris (link to structural complexity)
Hypothetical approach: Project/study design example 1

• Fish hypothesized to respond to changes in physiochemical environment.

• Potential fish response/monitoring may consist of:
  – Assemblage monitoring of restored and downstream reaches (link to stressors via generalized stressor gradient)
  – Expect assemblage shift away from most tolerant fishes
  – Expect decrease in DELTs with overall decreased disturbance
  – Expect improved IBI score
  – Expect increased Trout and/or pool species (link to woody debris/structural complexity)
  – Expect increased richness with increased structural complexity
  – Expect changes in growth rates or condition of some species
  – Expect more stable age and length frequency structures
  – Expect species previously absent to colonize area if present in regional species pool - depends on species’ proximity to the restored reach
Hypothetical approach: Project study design example 2

• Problem: Eutrophication of headwater stream
• Solution/hypothesis: Implementing ag BMP will reduce nutrient input to a more natural state.
• BACI; Monitor before and after, include a control and impact if possible
• Physiochemical monitoring may consist of:
  – nutrient monitoring (link to eutrophication)
• Potential fish monitoring (depends on local species):
  • Fish hypothesized to respond to changes in physiochemical environment (nutrients).
  • Assume only tolerant fishes are present due to history; IBIs and metrics of limited use
  • Recommend monitoring guild or fish biomass, fish condition, and fish growth rates which should decrease in response to decreasing nutrients
Hypothetical approach: Project study design example 3

• Problem: Flashy hydrology due to large amounts of impervious surface
• Solution/hypothesis: Installing rain gardens will reduce runoff and decrease flashiness
• BACI; Monitor before and after, include a control and impact if possible
• Physiochemical monitoring may consist of:
  – discharge monitoring (link to flashiness)
• Fish monitoring (depends on local species):
  – Annual assemblage monitoring
  – Or identify a species or guild specific response to flashiness
Available Data

• Available fish data (and potential partners!)
  – NJDEP, NJDFW, USGS, EPA
  – The Academy of Natural Sciences/Delaware River Watershed Initiative

• Consult/collaborate with fisheries professionals
Questions?

Feel free to contact when considering monitoring options.

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