Considerations for implementing an integrated Hg monitoring network

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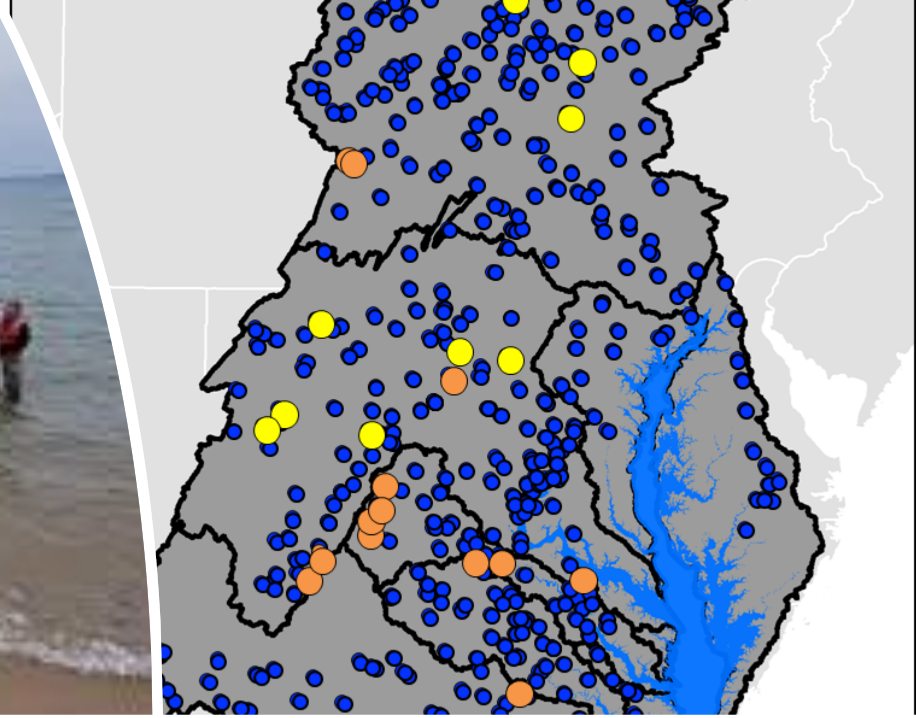
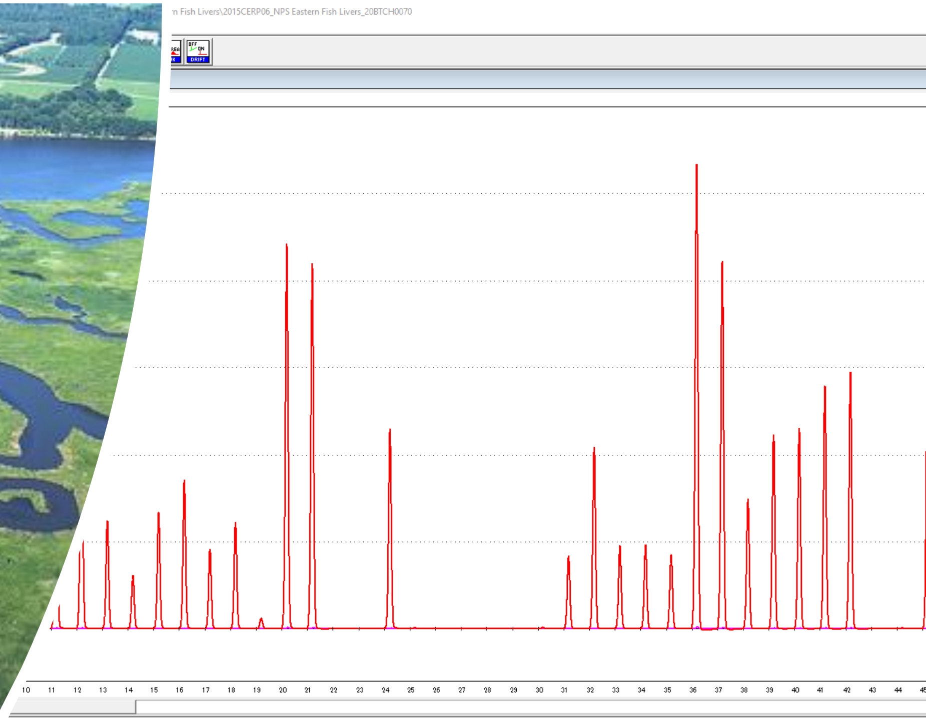
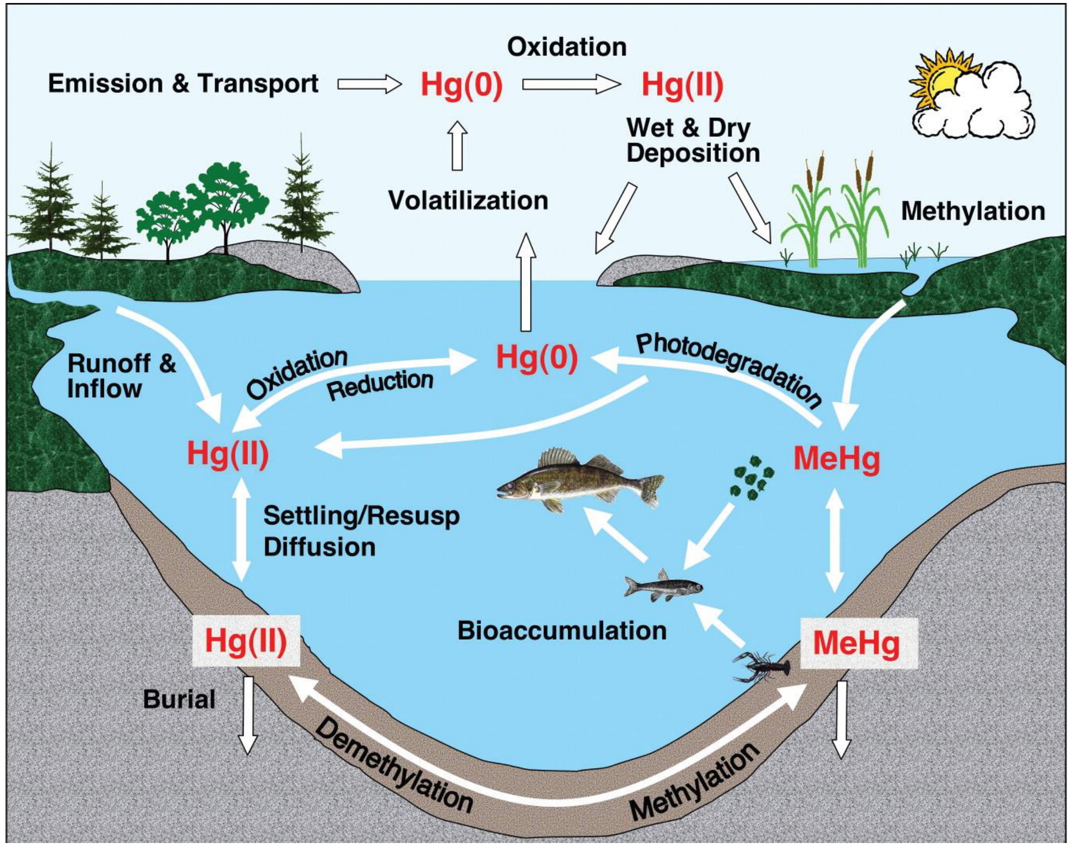
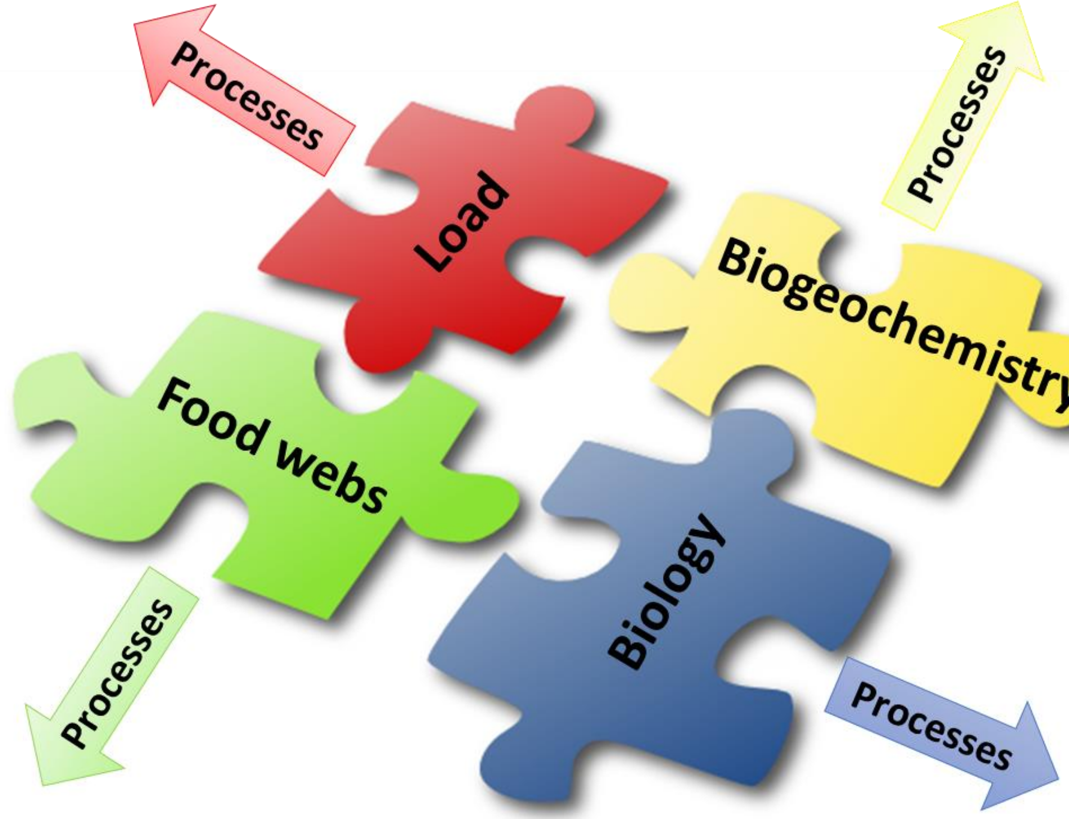




Hg monitoring is complicated by biogeochemical and ecological processes





Monitoring considerations

- Objectives
- Target Species
- Tissue Types
- Sample Types
- Size Classes
- Sample Replication
- Site Selection
- Sampling Frequency
- Program Duration
- Sample Analysis

*these goals are not mutually exclusive, but each imparts its own unique data needs

Common Monitoring Objectives

- Inform health risks (human or wildlife)
- Identify sources
- Track temporal changes
- Assess response to mitigation/disturbance
- Understand processes; identify potential mitigation actions
- Support model development

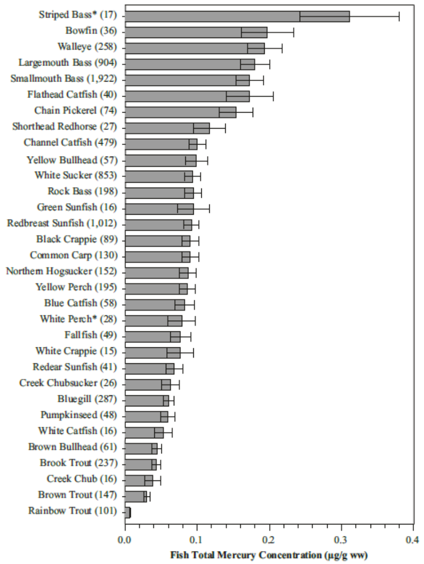
Fish Species

Selection

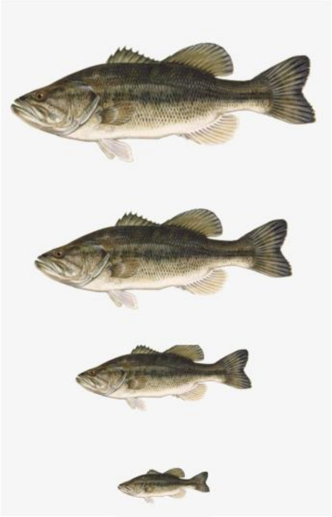
- Human or wildlife health
- Hg varies by trophic position and habitat
    - Diet plasticity
- Temporal variability and age/size
    - Tissue turnover times
- Site fidelity and migration
    - Tissue Hg represents integrated dietary Hg over time
- Abundance and distribution

Multi- or single species

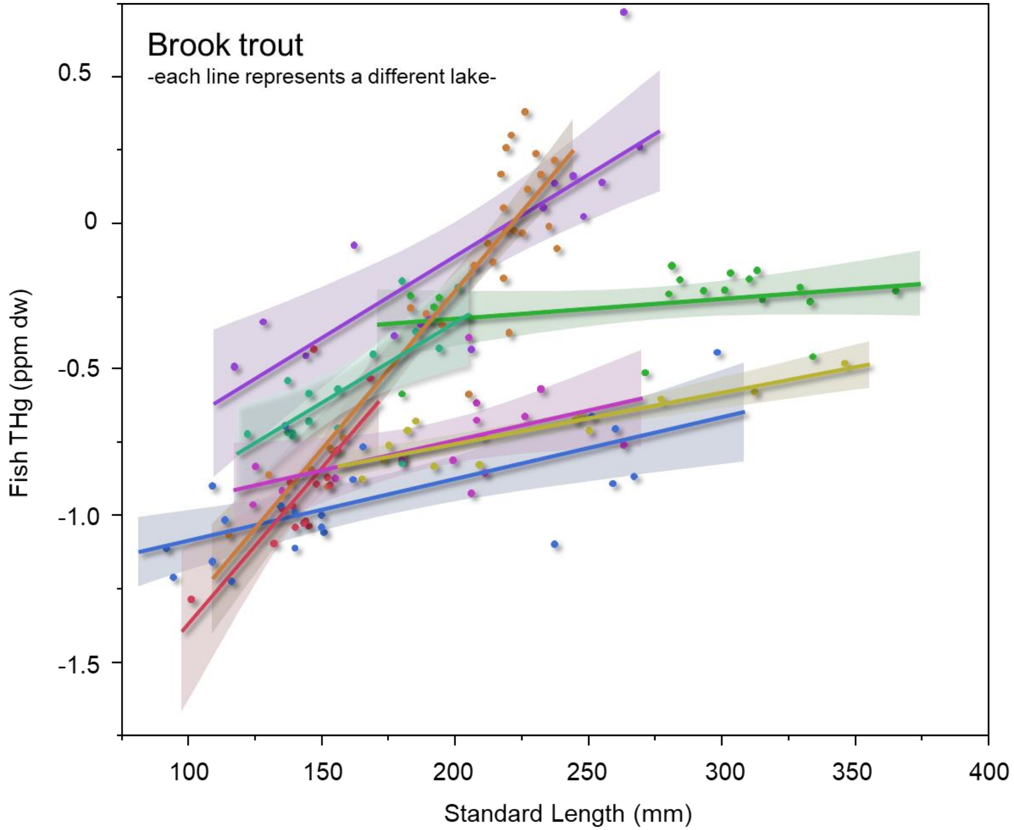
- Commonly co-occur
- Variable temporal and spatial trends



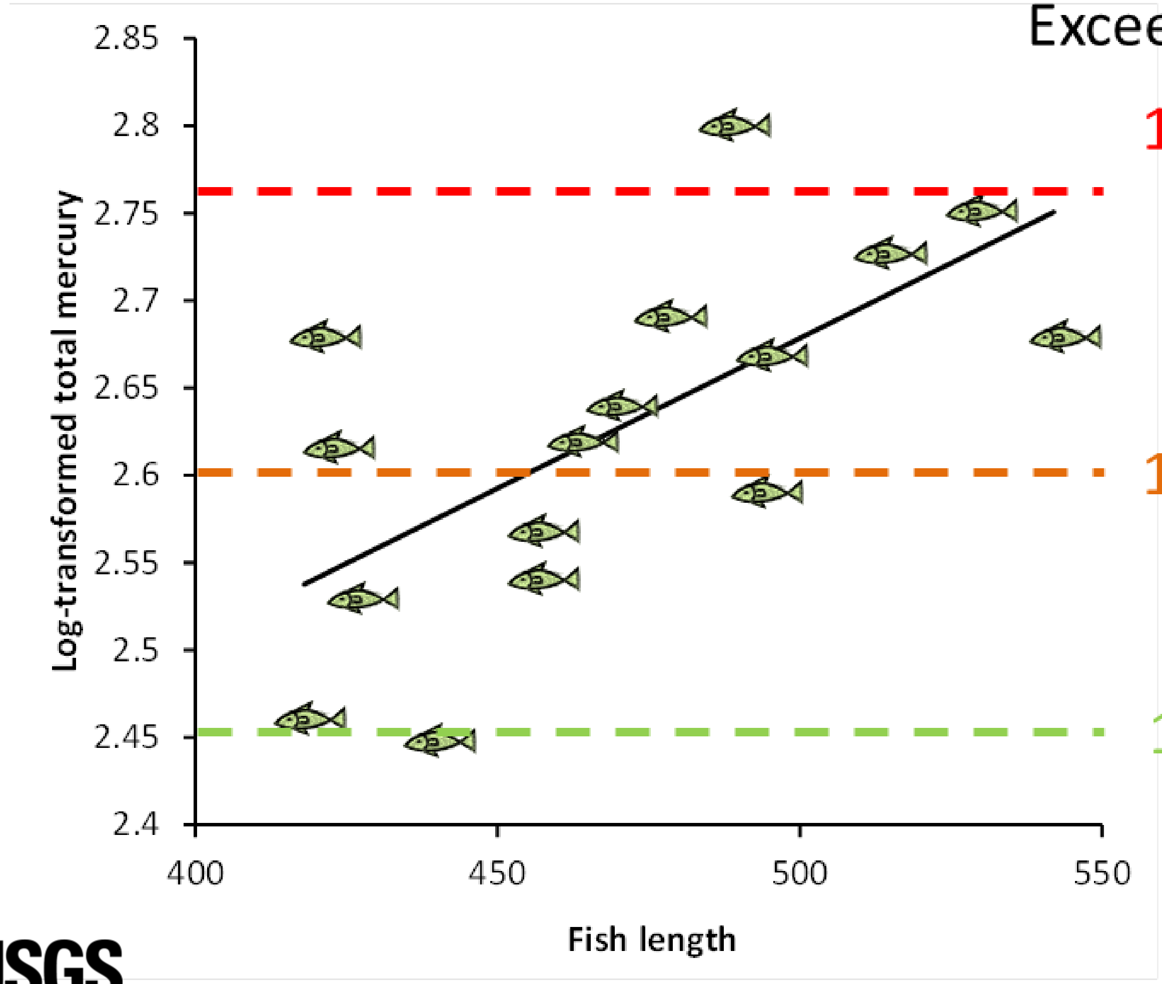
Fish size



- Available size range
  - Overlap across sites
- Single target size range
  - Reduce variation
  - Limited spatial coverage?
- Fixed range of sizes
  - Maximize comparability
- Largest individuals
  - Human health nexus
- Unspecified



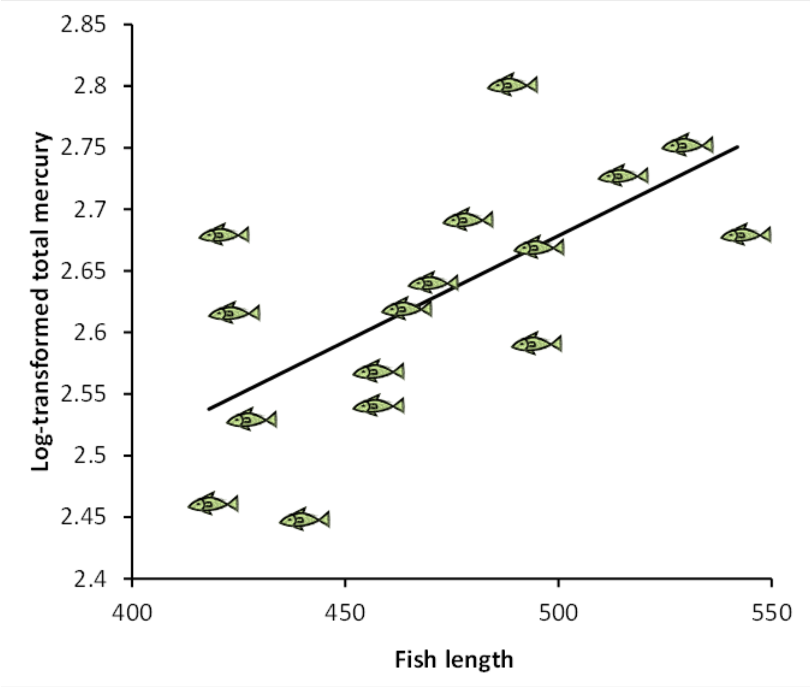
Estimating Risk – “raw estimates”



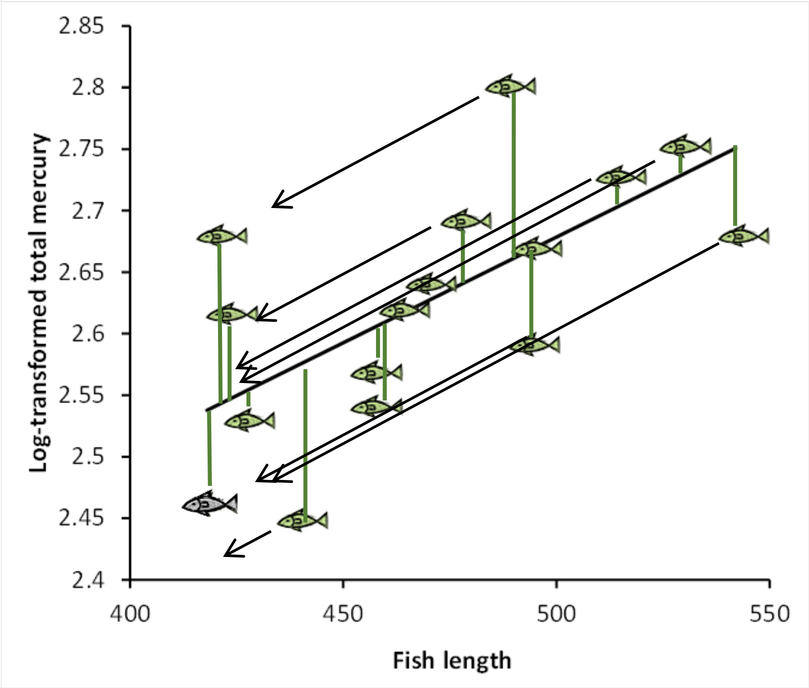
Number Exceeding	Percent Exceeding
1	6
10	59
16	94

Risk – Accounting for Size: How its done

Size – Mercury Relationship

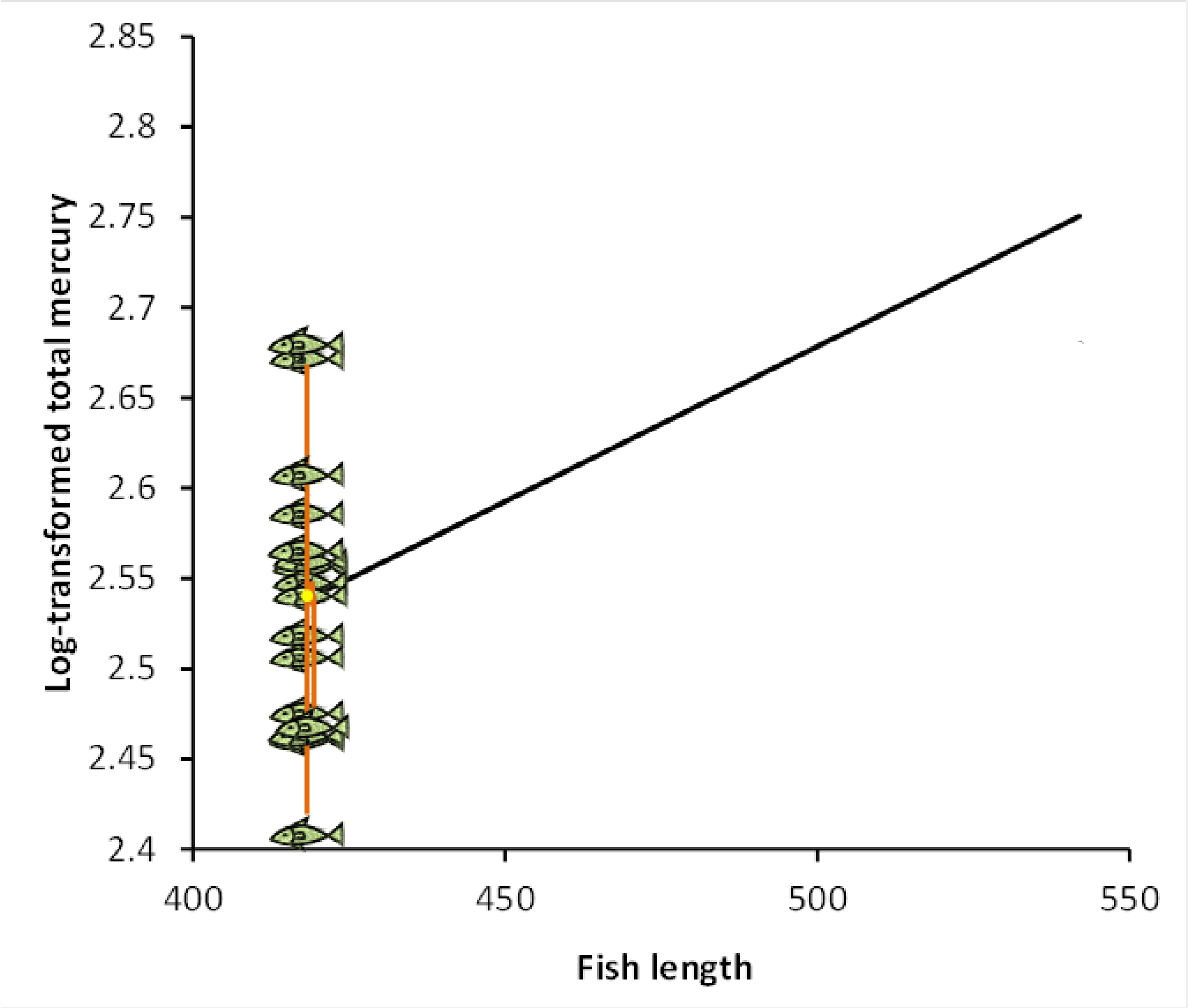


Residual Variation



Risk – Accounting for Size: How its done

Model Fish at Smallest Size Observed



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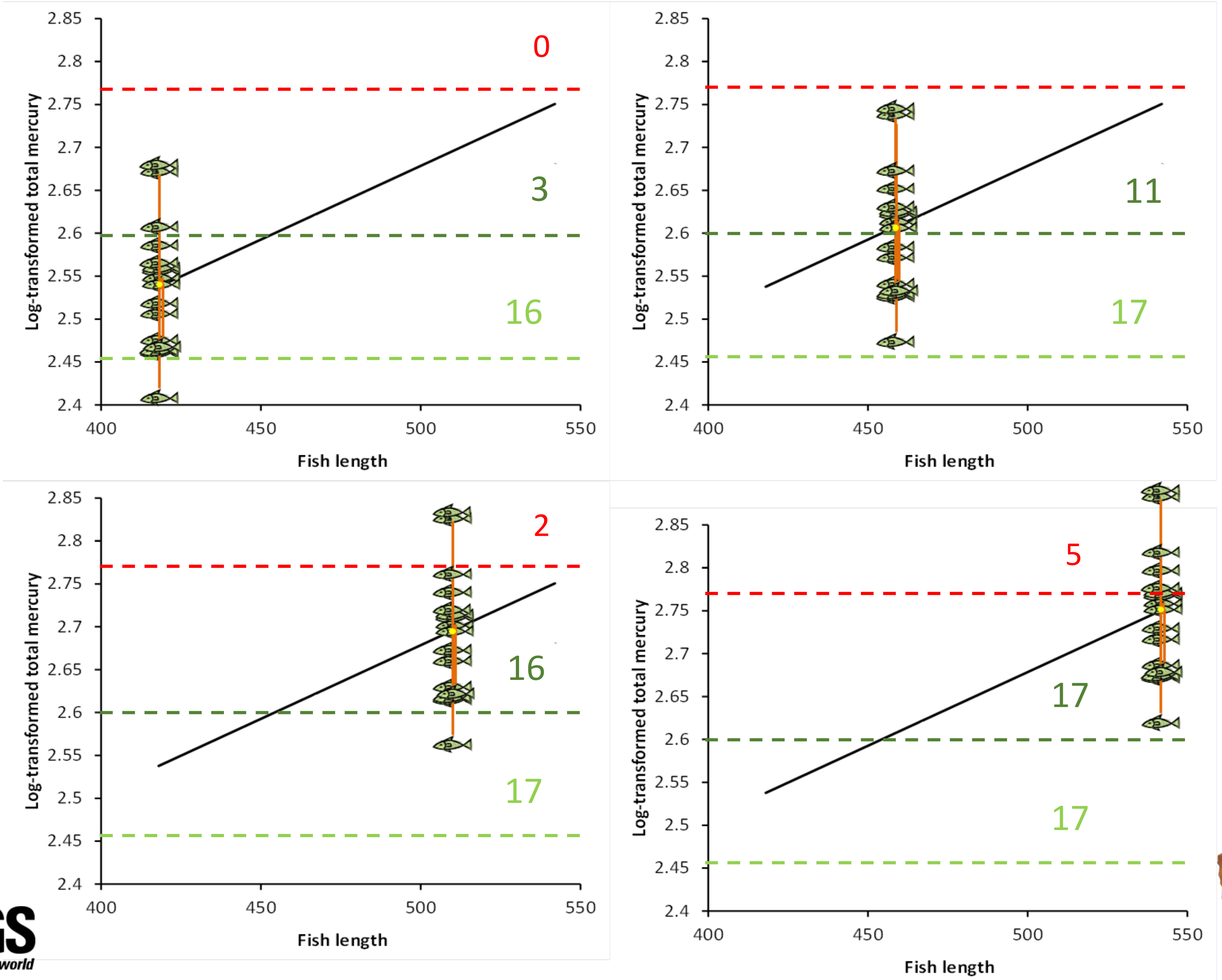
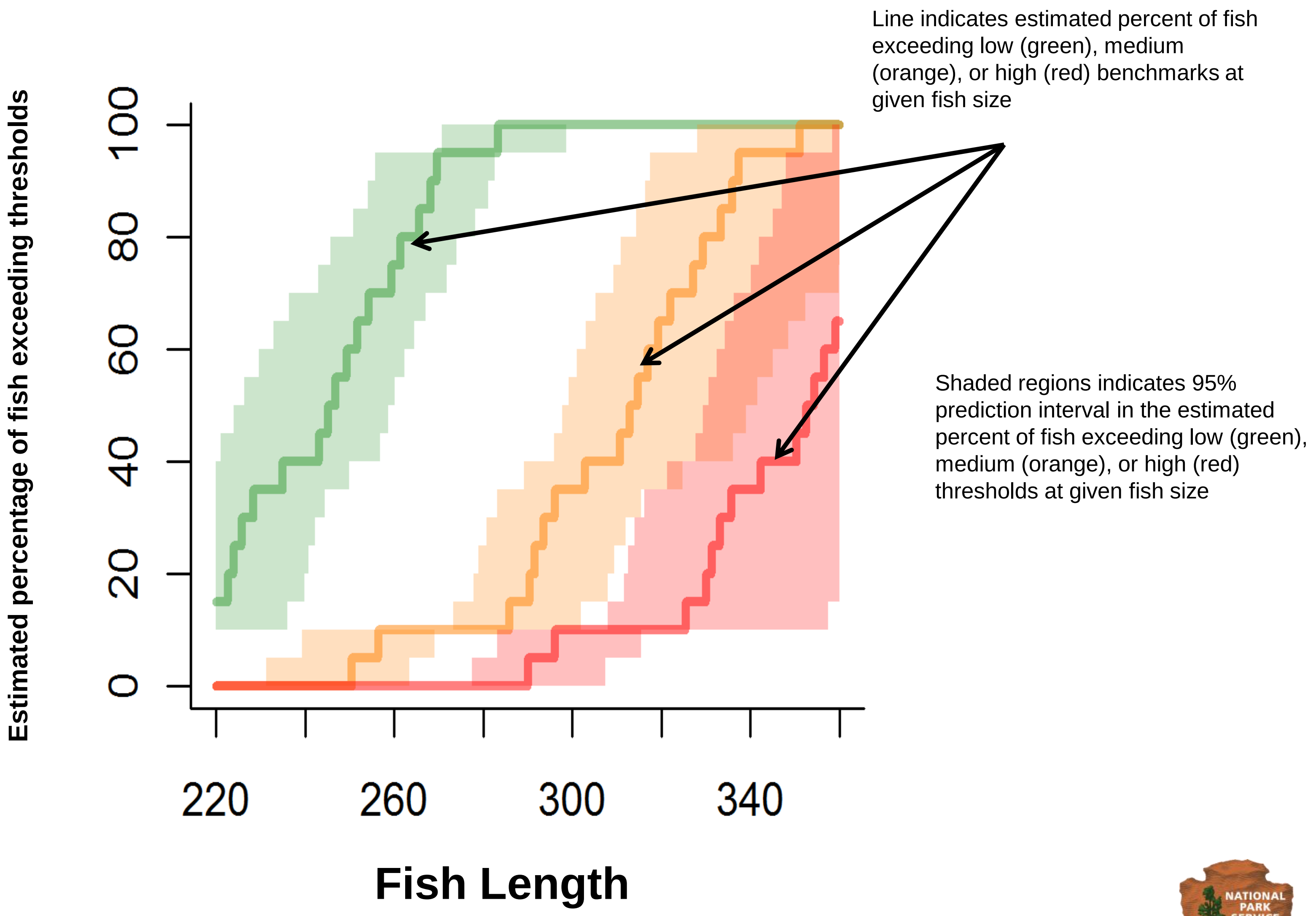
Risk – Accounting for Size: How its done

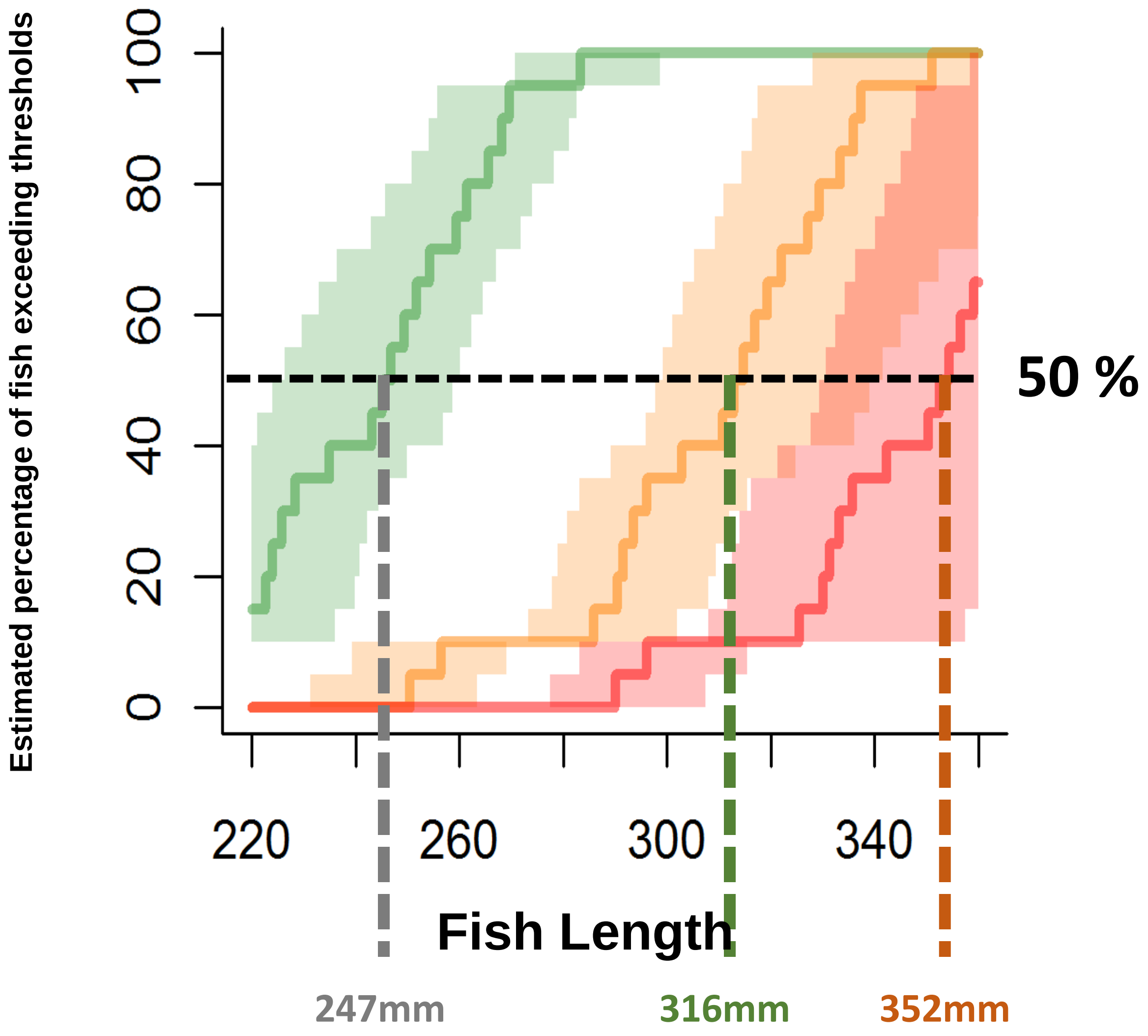
Repeat at Intervals up to Largest Size Observed



Size-specific risk example



Size-specific risk example



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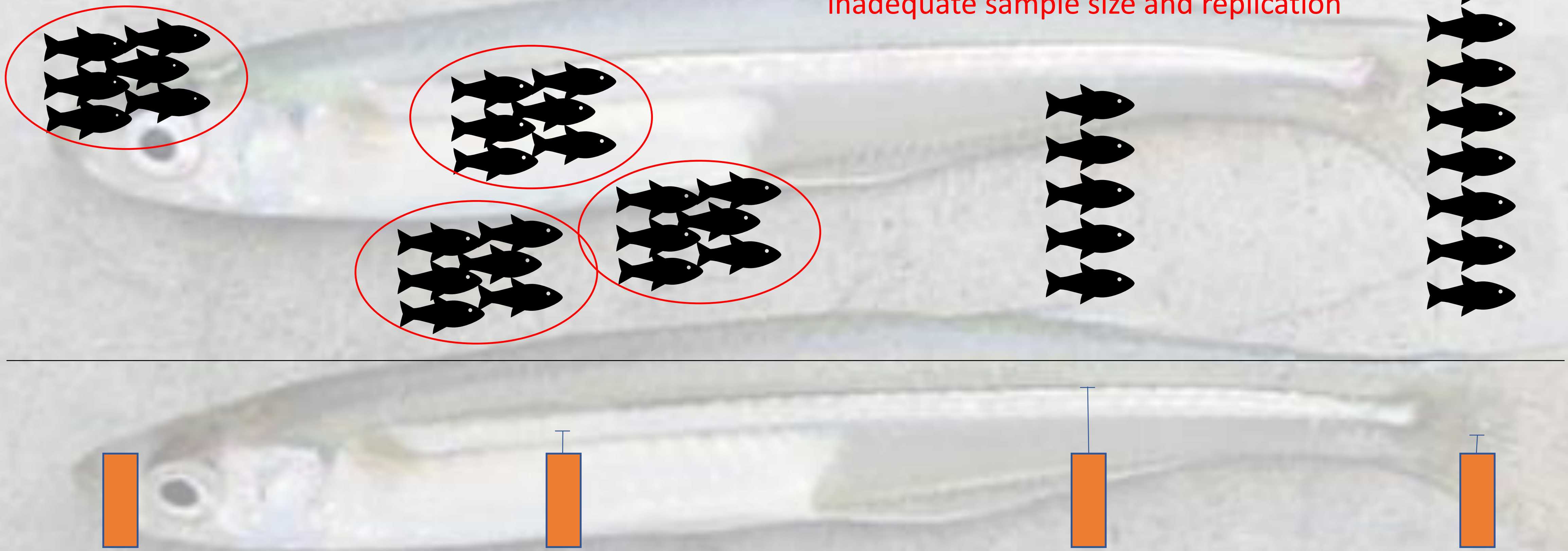
Composite vs individual and replication

A common issue when patching together disparate monitoring data is inadequate sample size and replication



- Low cost
- Estimate mean
- No variance
- No size adjustment

- Lower cost
- Estimate mean
- Pseudo variance
- Poor size adjustment

- Moderate cost
- Estimate mean
- Higher variance
- Poor size adjustment

- Higher cost
- Estimate mean
- Lower variance
- Best size adjustment

Skinless muscle

- Human consumption nexus
- Reduced variability

Whole body

- Wildlife health nexus
- Higher variability

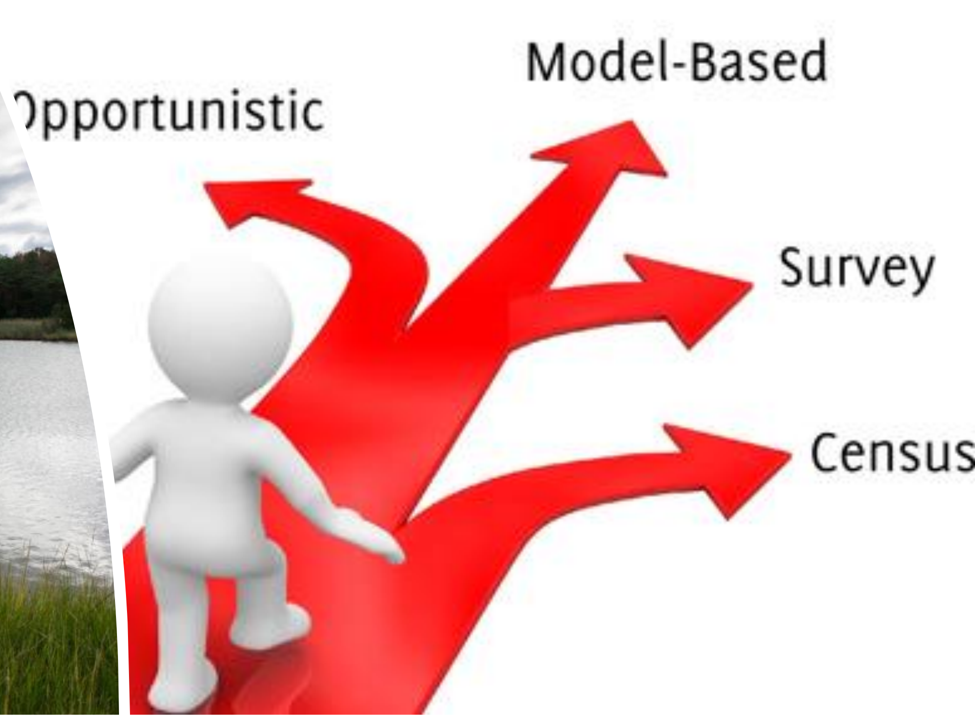
Skin-on fillet

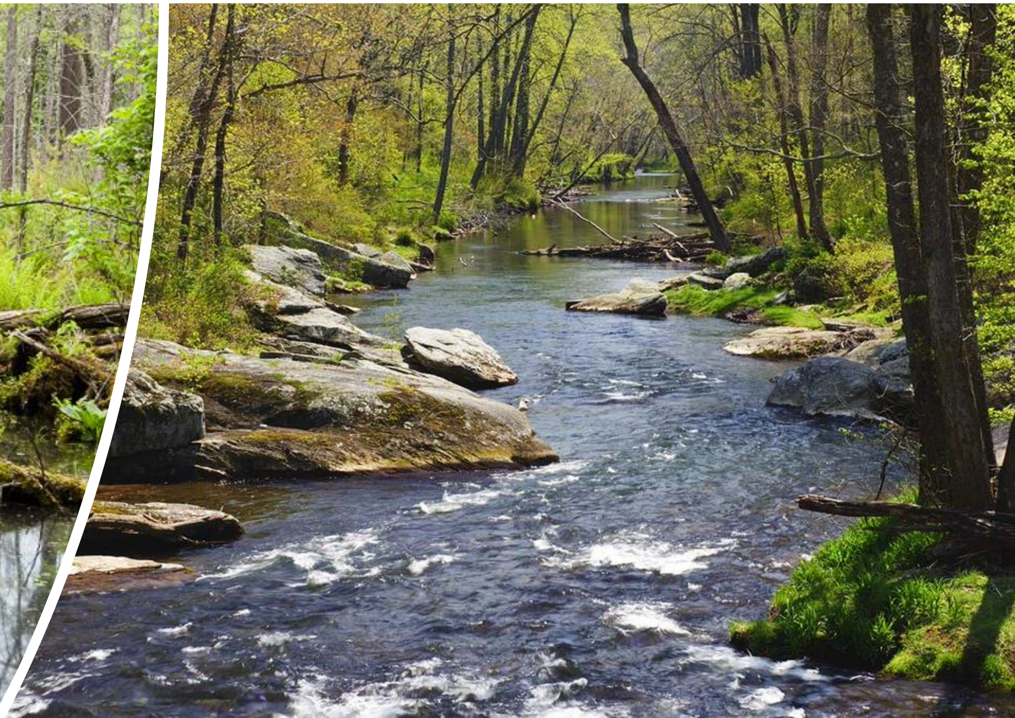
- More common for other contaminants

Tissue type

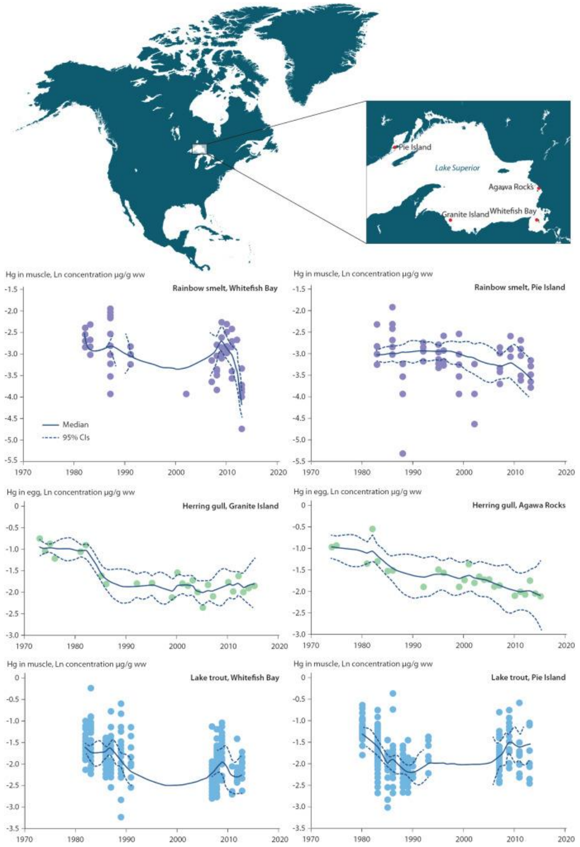
Site selection and sampling design

- Stratified across habitats and watersheds
  - **Context dependence**
  - Examine drivers of variation
- Opportunistic
  - Can be effective in some circumstances, but lacks applicability to many goals
- Temporal vs spatial focus
- Targeted
  - Specific locations of interest (e.g. population fishing)
  - Probability of impairment
  - Limited inference elsewhere

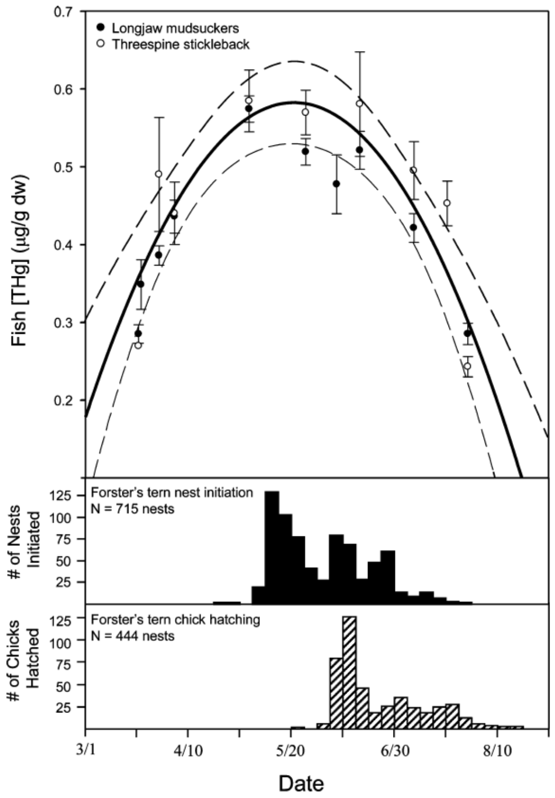




Frequency of Monitoring



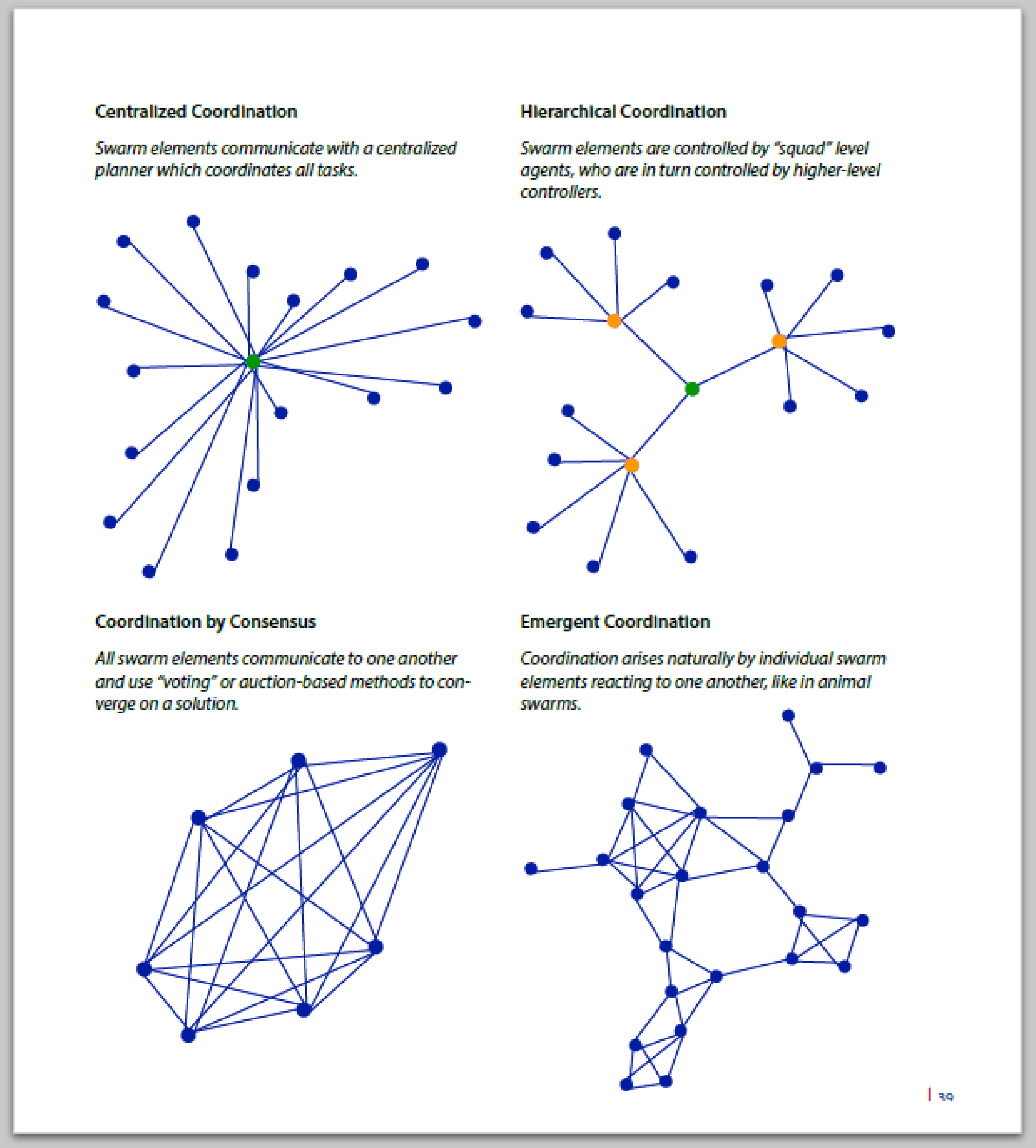
Interannual



Intra-annual

Analysis & Coordination

- Decentralized monitoring can limit broader utility of data and result in unbalanced efforts
- Some form of centralizing coordination better ensures comparability and integration
  - Bottlenecks can slow data availability
- Hierarchical coordination can maintain engagement and inclusion while better ensuring comparability



Centralized Coordination

Swarm elements communicate with a centralized planner which coordinates all tasks.

Hierarchical Coordination

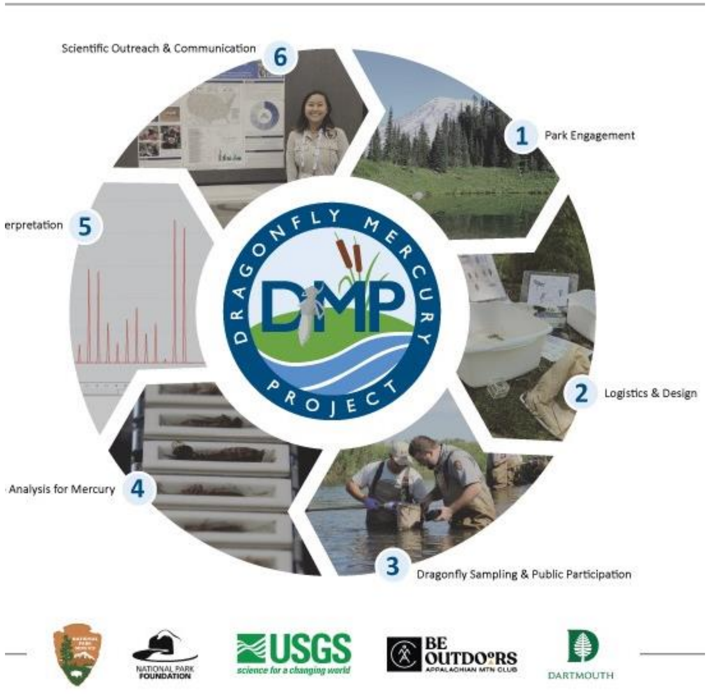
Swarm elements are controlled by "squad" level agents, who are in turn controlled by higher-level controllers.

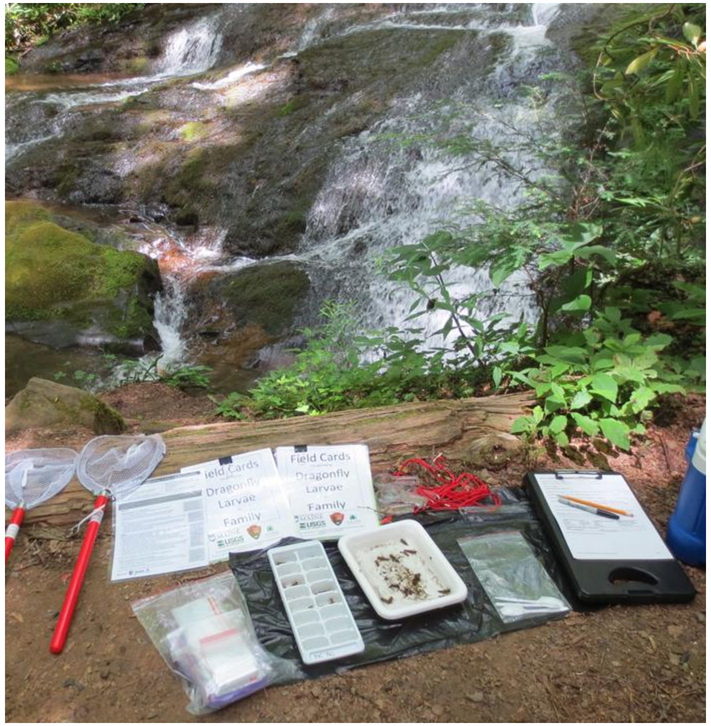
Coordination by Consensus

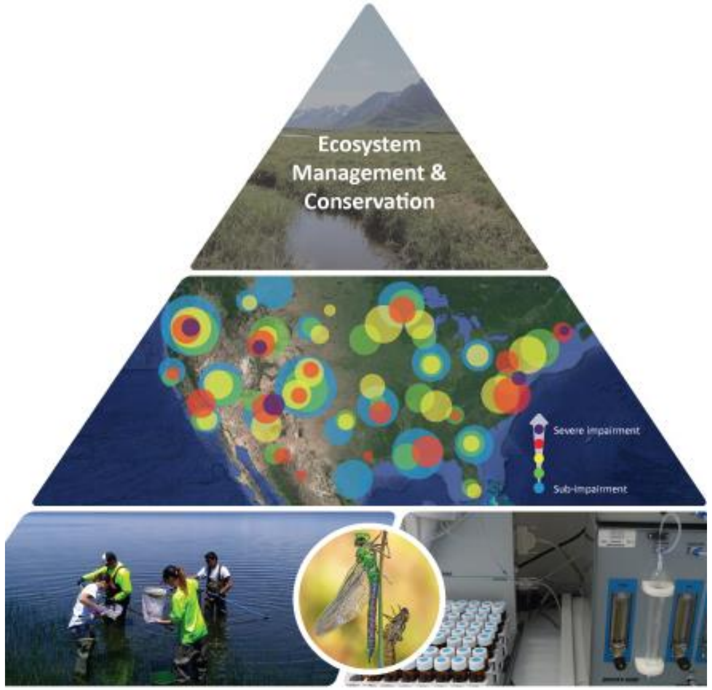
All swarm elements communicate to one another and use "voting" or auction-based methods to converge on a solution.

Emergent Coordination

Coordination arises naturally by individual swarm elements reacting to one another, like in animal swarms.







The Dragonfly Mercury Project – a national-scale network example

- A hierarchical coordinated network design
- National in scope
- Centralized coordination and modular implementation

Questions?

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