DRAFT Ecosystem Monitoring Program Design Framework

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Steps to designing a monitoring program (Adapted from USEPA 2000):

1. Determine goal, objective, actions and assessment questions of interest to be addressed by Program (*see below*)
2. Determine relevance of indicators to both assessment questions and to ecological structure/function (*see below*)
3. Determine which are core indicators and provide rationale for each (*SWG and April workshop*)
    a. Does it help answer multiple questions?
    b. Is there a known natural variability (preferred low variability) for the indicator (in order to distinguish extraneous factors from a true environmental signal)? Variability includes measurement error, temporal variability-within the field season, temporal variability-across years, spatial variability and diagnostic capability. Do we need to sample disturbed sites to determine variability?
    c. Long term dataset exist for trends and assess variability/ status
4. Determine population of interest (using Classification) for each core indicator and minimum number of sites (*post workshop*)
5. Determine what specifically we measure (metrics), frequency of sampling and sampling period (*post workshop*)
6. Establish analysis methods, quality control and data management (*post workshop*)
7. Match available funding and projects to list of core indicators (*post workshop*)
8. Test each indicator for variability (temporal- within season and year, inter-annual, spatial) (*post workshop*)
9. Determine thresholds for indicators (*post workshop*)

Ecosystem Monitoring Program Goal: The goal of the Program is to track the status and trends of ecosystem condition* to inform decisions for the purpose of conserving and restoring the lower Columbia River and estuary.

*We define ecosystem condition as the biota, habitat structure and function and biophysical processes

Ecosystem Monitoring Program Objective: Use estuarine quality and condition index to track changes in LCRE; provide context for results of other RME efforts.

Ecosystem Monitoring Program Actions:

1. Develop an estuarine quality and condition index for the LCRE.
    - Determine questions of interest
    - Determine users and purpose (e.g., different indices for different audiences/purposes).
        - *Do we incorporate the current Estuary Partnership indicators (from report card, with water quality, land use, stewardship, habitat and Endangered Species as indicators)?*
    - Determine which indicators are relevant to assessment questions and ecological structure and function
    - Define analytical methods, quality control and data management

- Assess the variability of the indicator (temporal and spatial variability, diagnostic capability) and test relative performance of each indicator
- Determine sampling period, metrics, number of sites and frequency
- Report on uncertainties; recognize limitations in data collection, analyses and results
- Track key issues for region (salmon recovery [CPUE, growth, genetics, contaminants], climate change [pH in Estuary, temperature, water level in the mainstem], contaminants)
- Incorporate results from other estuary RME into index as relevant

2. Define Population of Interest.
   - Define questions, indicators, metrics and broad category of habitats
   - Use one classification scheme that encapsulates the categories of interest
   - Track other RME locations and fill in spatial gaps, such as tributaries, impacted sites
3. Report recommendations on how best to conserve and restore the lower Columbia River and estuary.
4. Based on results, provide recommendations for diagnostic /BACI studies to better understand uncertainties and reasons behind trends/results and refine good versus bad quality or relative performance for indicators.
5. Provide data management and central clearinghouse to ensure data accessible to managers and other RME efforts.
6. Strive for full implementation of the larger program by matching and scaling up/down aspects of design to funding programs available.

DRAFT Questions to be addressed by Estuarine Quality and Condition Index:

1. What is the biological integrity of the LCRE and is it improving or declining? (Estuary Partnership, 1999a, b; NPCC, 2010 "*Are Columbia River Basin ecosystems healthy?*")
   "Biological Integrity / USEPA definition: capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization that is comparable to representative natural habitat in the region"
   Original Index of Biotic Integrity (IBI Metrics / Karr 1981):
   1. Species Richness and Composition Metrics; 2. Indicator Species Metrics; 3. Trophic Function Metrics; 4. Reproductive Function Metrics; 5. Abundance and Condition Metrics
   - Indices of biological integrity
   - Indicator species – what are key indicator species and are their populations increasing or decreasing? (Estuary Partnership, 1999a, b; *"Are Endangered species recovering?"*; NPCC, 2010 "*Are Columbia River Basin fish and wildlife abundant, diverse, productive, spatially distributed, and sustainable?")*
     - Candidate Indicators:
       - *Possible examples: resident fish, amphibians, bats, birds, ESA listed species (*Estuary Partnership 1999a; *Columbia white-tailed deer, bald eagle, Chinook were used in the past)*
       - Presence/absence of species
       - Abundance of individual species
       - Species richness and composition
       - ESA listed species recovering
       - Predators
       - vegetation diversity and cover (Estuary Partnership, 1999b)
       - invasive species presence and extent (Estuary Partnership, 1999b)
   - Salmon performance - What is juvenile salmon performance (i.e., life history strategy diversity, spatial structure, growth, foraging success) in lower river, and is it improving or declining? (NMFS, 2011a, b)
     - Candidate Indicators:
       - fish density
       - genetics
       - growth
       - timing of habitat use
       - foraging success (stomach contents?)
       - fish/salmon species community composition
       - condition
   - Salmon performance limiting factors - What are the limiting factors that affect the status of a population or ESU within the estuary and are they improving or declining? (NMFS, 2011a, b)
     - Candidate Indicators:
       - habitat capacity
         - cover that provides refugia
         - prey availability - macroinvertebrate composition and density
         - salmon diet
         - provides base of food web (Estuary Partnership, 1999b)
       - habitat opportunity

        - Habitat Suitability Index Model annual results
        - annual hydrograph (magnitude, duration, frequency of inundation, timing and rate of change)
        - water temperature, pH, dissolved oxygen levels (Estuary Partnership, 1999b)
    - realized function –
        - salmon condition
        - growth
        - lipid content
        - mortality
        - foraging success (stomach contents?)
        - contaminants (Estuary Partnership, 1999b)

2. What are the pollutants of concern, and are their concentrations increasing or decreasing? (from Estuary Partnership 1999a, b, "Are pollutant levels increasing or decreasing, "Are concentrations of toxics in sediment and biota impair native species?"; LCREP LTMP)
    - Candidate Indicators:
        - nutrients, pathogens, HABs, prioritized pollutants of concern (TBD by EPA Toxic Reduction Working Group) (Estuary Partnership, 1999b, updated 2011)
        - Benthic macroinvertebrates (Benthic Index of Biotic Integrity) (Estuary Partnership, 1999b)

3. What are the ecosystem (biological, chemical and physical) processes and are those processes improving or degrading? (NMFS, 2011b)
        - Net ecosystem metabolism
        - Carbon sequestration
        - Habitat forming processes
        - Sediment transport
        - Habitat structure and function – what is habitat quality and coverage and is it improving or declining? (Estuary Partnership, 2011 a, b)
            - habitat coverage (e.g., landcover) (Estuary Partnership, 1999b; "*Are we gaining or losing habitat*")
            - complexity (large woody debris, channel cross-sections, micro-topography)
            - Carbon, nutrient flux (Estuary Partnership, 1999b)
            - Primary and secondary production (Estuary Partnership, 1999b)
            - invasive species presence and extent (Estuary Partnership, 1999b)
            - Sediment grain size
            - Macrodetrital inputs (NMFS, 2011b)
            - Flood attenuation
            - Sediment supply and trapping
            - Water storage
            - Refugia
            - Connectivity/patchiness
            - Annual hydrograph (magnitude, duration, frequency, timing and rate of change of inundation [Poff et al., 1997])

- Water quality (water temperature, pH, dissolved oxygen levels, salinity)

4. What are the effects of climate change on estuary ecosystem condition and are they increasing or decreasing? How are the components adapting to stressors of climate change and how resilient are the components? (Estuary Partnership, 1999 a, b; NPCC, 2010 "*Is climate change affecting fish and wildlife in the Columbia River Basin?*")
    - Candidate Indicators:
        - Indicators of resilience
        - Salmon performance (i.e., life history strategy diversity, spatial structure, growth, foraging success) (NMFS, 2011a, b)
        - pH (in estuary), dissolved oxygen (in estuary), water temperature (throughout) (Estuary Partnership, 1999b)
        - Annual hydrograph (magnitude, duration, frequency of inundation, timing and rate of change) in estuary and effect on opportunity and capacity (NMFS, 2011b)
        - Primary, secondary and other macroinvertebrate composition (prey) in estuary (Estuary Partnership, 1999b)
        - Tidal freshwater contributions of nutrients, carbon to estuary (Estuary Partnership, 1999b)

Indicators should be relevant, applicable and responsive (Adapted from USEPA 2000)

1. Relevance to societal concerns about ecological condition
2. Pertain to one or more assessment questions
3. Provide information useful for management decisions
4. Clearly relate to ecological components or processes deemed important in ecological condition
5. Ability for the indicator to complement indicators at other scales and levels of biological organization
6. Feasibility and practicality of implementation-methods, logistics, cost
7. An indicator should exhibit significantly different responses at distinct points along a condition gradient and be stable (i.e. low spatial and temporal variability) (EPA, 2000)

Is the indicator a **direct measurement** (dissolved oxygen concentration), or an **index** (benthic condition)?

DRAFT Indicators of Ecosystem Condition:

I. **Biota:**

Represented by:

a) Juvenile salmon performance (i.e., life history strategy diversity, spatial structure, growth, foraging success)
    - fish density, growth, genetics, timing of habitat use, prey selectivity, fish/salmon species community composition

b) Juvenile salmon performance limiting factors
    - Habitat opportunity (magnitude, duration, frequency, timing and rate of change of inundation; water temperature; pH; dissolved oxygen levels; Habitat Suitability Index Model)

- Habitat capacity (prey availability - macroinvertebrate composition and density; refuge from predators; provides base of food web, salmon diet)
- Realized function (salmon condition, growth, lipid content, mortality, foraging success)

c) Invasive species
d) Other species (bats, birds, amphibians, resident fish, etc.)

II. **Habitat Structure:**

Represented by:

a) Habitat coverage (e.g. landcover)
b) Annual hydrograph (magnitude, duration, frequency, timing and rate of change of inundation [Poff et al., 1997])
c) Water quality (water temperature, pH, dissolved oxygen levels)
d) Channel complexity (LWD, channel cross-sections, micro- topography)
e) Vegetation (diversity and cover)
f) Invasive species (presence and extent)
g) Sediment grain size

III. **Habitat Function:**

Represented by:

a) Carbon, nutrient flux
b) Primary and secondary production
c) Macrodetrital inputs
d) Flood attenuation
e) Sediment supply and trapping
f) Water storage
g) Refugia

IV. **Biophysical Processes:**

Represented by:

a) Net ecosystem metabolism
b) Sediment transport
c) Habitat forming processes
d) Carbon sequestration

References

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- Questions from MERR relevant to the estuary:

5. Are Columbia River Basin fish and wildlife abundant, diverse, productive, spatially distributed, and sustainable?
6. Are Columbia River Basin ecosystems healthy?
7. Is climate change affecting fish and wildlife in the Columbia River Basin?

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