

# High Level Indicators for Watershed Health and Salmon

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Prepared by the Pacific Northwest Aquatic Monitoring Partnership

In recent years, there has been heightened interest at the executive level in improving our collective ability to track and communicate changes in environmental conditions and salmon in easily understood terms. Doing so fosters accountability, encourages consensus, supports priority-setting and budgeting, and can engender support.

The purpose of this report is to briefly summarize the ongoing efforts of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) to recommend a core set of high level indicators (HLI) of common interest to governments, tribes, and others in the Pacific Northwest (PNW). HLIs by definition, communicate complex information in easily understood terms for use in reports to Congress, legislatures, governors, and the public. This report specifically pertains to watershed health and salmon<sup>1</sup>. Other categories of HLIs (e.g., implementation, nearshore/estuary indicators) will be addressed in future reports.

HLIs are constructed to convey summarized information at broad scales, to address the following kinds of questions posed by decision-makers:

- *What is the status of biological (salmon) and physical (habitat) conditions at identified scales (e.g., region-wide, statewide)?*
- *How are those conditions changing over time?*
- *Are freshwater and estuarine habitats healthy and productive?*

In September 2008, PNAMP provided a report to the Northwest Environmental Information Sharing (NWEIS) executive summit that included: high level biological, physical, and implementation indicators currently in use in the PNW; who is using the indicators; and to the extent possible, metrics being used to support the indicators. This current report builds upon that earlier work, substantively advancing and providing recommendations for watershed health and salmon indicators. PNAMP's work has continued to benefit considerably from coordination with a number of ongoing HLI reporting efforts focused on watershed health and salmon (Appendix 1), which were utilized in completing this report.

## A Conceptual Framework

Information associated with HLIs can best be viewed in a hierarchical context. Typically, HLIs are reported at broad geographic scales, drawing upon data that are compatible across multiple scales. For instance, HLIs may use data that are rolled-up from local to larger (e.g., watershed) scales, or perhaps even further rolled-up to regional or broader scales (e.g., statewide or multi-state). The reverse can also be the case, wherein HLI data obtained at larger scales may be disaggregated to be locally relevant. Regardless, agreeing on HLIs for watershed health and salmon is a key step for efforts to improve coordination of monitoring programs.

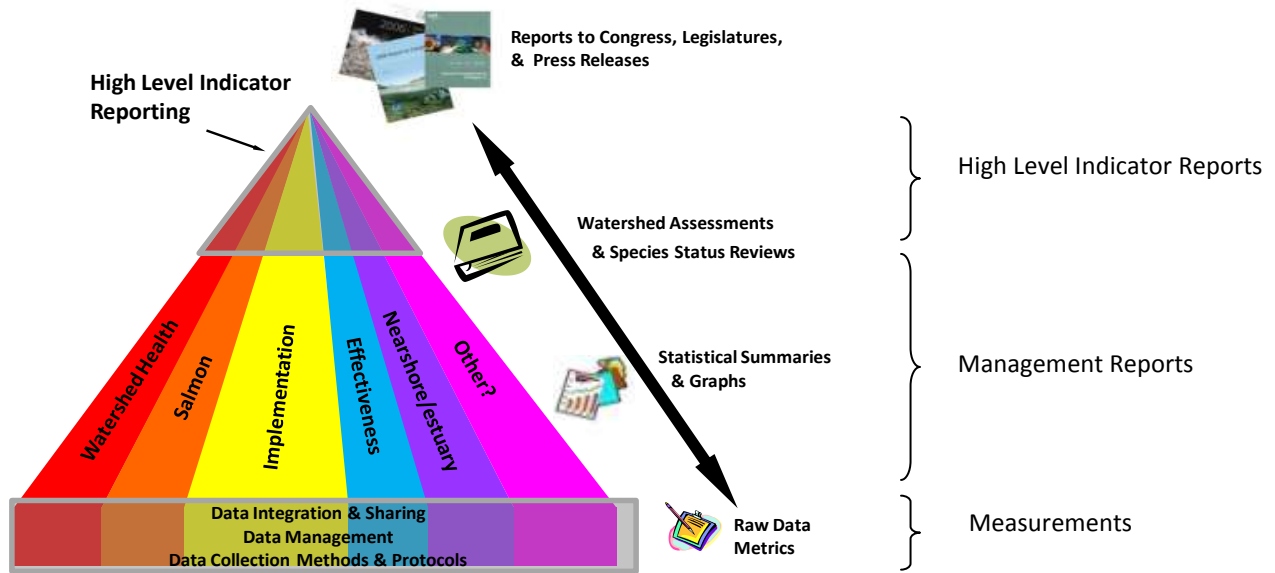
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<sup>1</sup> Includes steelhead.

To reach agreement on common HLIs, it is useful to clarify concepts and terminology. We applied the following three inter-related levels of organization and terminology:

1. high level indicators – categories of data that are measured and compiled,
2. reporting measures – the way indicators are reported, and
3. metrics – what is actually measured.

These are illustrated in Figure 1 below, wherein the color-coded sections represent different categories of HLIs. Within those categories, metrics associated with raw data collected in the field are summarized and compiled from the local to broader scales, and are rolled-up and illustrated in reporting measures in management and high level indicator reports.



**Figure 1.** Information pyramid showing the alignment between HLI categories, reports, and raw data (metrics).

High level indicators are the focus of this report. They may be derived from one or more individual metrics (described below), generally at broad geographic scales. An HLI derived from multiple metrics or even other HLIs might be expressed as an index. Once HLIs are identified and agreed upon, progress on metrics and how to share data to meet multiple reporting needs can accelerate.

Reporting measures are how HLIs are compiled and illustrated in reports. The drivers for reporting HLIs vary widely (e.g., statutes, rules, legal agreements, contract obligations). That wide diversity means that the ways in which HLIs are summarized or combined to meet reporting needs will also vary. For example, depending on the reporting driver, the status or trend in an HLI or group of HLIs may need to be reported in quantitative (numeric) terms or may need to be reported in more qualitative terms (such as high-medium-low, or green-yellow-red). It would be very desirable to explore the extent of executive agreement on reporting measures. However, such agreement is not as critical to making immediate progress as are the core HLIs and metrics themselves, to be able to reap the benefits from HLI coordination and timely information sharing for upcoming reporting cycles.

Metrics define data in standard units of measurement. They are typically associated with specific data collection and/or analysis protocols. Metrics differ from indicators in the sense that they are directly measured and used in deriving the HLIs. Once core HLIs are agreed upon, more work will be needed to identify the most common and meaningful metrics for deriving the HLIs.

## **Core Indicators**

The HLIs for watershed health and salmon outlined below were synthesized from those already being reported on or strongly desired for reporting by the largest number of involved entities. As “core” HLIs they reflect the categories of greatest alignment across current agency initiatives, reports, and associated policy interests, as well the areas of greatest alignment among management questions, issues of scale, existing information, and desired new data needs. They are consistent with the general criteria outlined in Appendix 2. As presented here, the core HLIs may be revised to some extent following discussions related to the monitoring guidance for salmon that NOAA Fisheries is now in the process of completing.

The watershed health indicators included here are narrower in scope but complementary to broader indicators of “ecosystem health” (e.g., that might include marine conditions, terrestrial habitat quality) or general biodiversity (e.g., other animal, plant, and insect species). The draft core salmon indicators are associated with interests in species listed under the ESA as well as species that have not been listed. In addition to brief descriptions of the core indicators, illustrative examples of related reporting measures are shown, along with metrics that could provide data for the indicator. A significant next step is to clearly describe the units of measure for each HLI and identify the specific metrics needed. As noted earlier in this report, more work is needed to explore commonality in reporting measures.

### **Core Indicators for Watershed Health**

The six watershed health HLIs below are recommended for consideration. Depending on the reporting need, the indicators could be depicted individually or in combination to reflect the health of watersheds across multiple scales (e.g., watershed, Evolutionarily Significant Unit (ESU), statewide, Columbia basin). Some are derived from single metrics and others are from multiple metrics. Outlined below are brief descriptions of each indicator along with examples of reporting measures and metrics that could be used. An example is provided in Appendix 3.

- A. Water Quality Index
- B. Stream Flow
- C. Sediment Quality Index
- D. Habitat Quality (in-stream and riparian) Index
- E. Biological Health (in-stream) Index
- F. Land Use / Land Cover

**A. Water Quality Index** – represents the biological and chemical aspects of water quality in index values.

- Example reporting measure: annual index values organized into good, fair, poor categories based on extent water quality meets expectations.
- Example metrics: temperature, pH, fecal coliform bacteria, dissolved oxygen, nutrients, and sediments. May also include values for pharmaceuticals, pesticide, industrial pollutants, heavy metals and other contaminants. A spatially distributed randomized sampling design applied to common sampling frames is assumed, but is not currently being implemented broadly.

**B. Stream Flow** – represents the quantity and patterns of water movement.

- Example reporting measures: percentage of time minimum instream flows (as established in state rule) are met during the salmon critical period (August 1 – September 30), or times flows exceed mean annual peak flow
- Example metric: streamflow in cubic feet per second

- C. Sediment Quality Index** – represents the condition of sediment and stream bed stability, which strongly influences the quality of streams and their biota. Relative Bed Stability is a relatively new index with high potential.
- Example reporting measure: annual index values organized into good, fair, poor categories
  - Example metrics: substrate size, embeddedness
- D. Habitat Quality (in-stream and riparian habitat)** – represents the quality and quantity of physical riparian and instream habitat. It would be highly desirable to agree on a Habitat Quality Index (HQI); however, such agreement does not yet exist. In lieu of a widely-accepted HQI, a starting point is to identify a short-list of core sub-indicators that would be informative on their own and could eventually feed into an HQI.
- Example reporting measure: annual index values organized into good, fair, poor categories
  - Example sub-indicators and metrics:
    - Stream physical character - example metrics channel morphology, sinuosity
    - Riparian vegetation – example metrics canopy density, vegetation type and height
    - In-stream habitat – example metrics large woody material, pool ratio, pool residual depth
- E. Macro-invertebrate Index (in-stream)** – tracks ecological health in watersheds. The index aggregates macro-invertebrates, plant and invasive species composition into index values.
- Example reporting measure: annual index values organized into good, fair, poor categories
  - Example metrics: macro-invertebrates, and possibly periphyton and invasive species
- F. Land Use / Land Cover** – represents habitat condition at a landscape scale, as determined from remote sensing methods.
- Example reporting measures: status organized into good, fair, poor categories, or change organized into high, medium, low categories
  - Example metrics: general attributes include percent impervious surface; change in land use in terms of agriculture/forest/urban areas

In addition to using the above indicators on an individual basis, it may be desirable to integrate them into a new high level indicator or **watershed health reporting measure**. Such an indicator or measure would be a derived index. More work would be needed to develop such an indicator.

- Example reporting measures: good-fair-poor, or a ranking system based on identified criteria associated with human health, and/or on associations with limiting factors or threats for salmon.
- Example indicators for the index: water quality, stream flow, sediment quality, habitat quality (in-stream and riparian), biological health (in-stream), and land use / land cover.

### **Core Indicators for Salmon**

The four HLIs below focus on salmon abundance and are recommended for initial consideration. These HLIs will be revisited after the NOAA Fisheries’ monitoring guidance is completed. It is possible that additional salmon HLIs may be recommended that more fully orient to salmon recovery (e.g., indices that integrate not only abundance, but productivity, spatial structure, diversity, viability level, threat or risk level).

In addition to the draft HLIs outlined below, examples of reporting measures and metrics are also included. Depending on the reporting need these HLIs can be used either individually or in combination, across scales in space (e.g., population, ESU/DPS (Distinct Population Segment)) and time (e.g., annually, 5 or 10-year averages). The basic level of information to inform these indicators is at the population scale. An example is provided in Appendix 3.

- A. Abundance of wild spawners

- B. Abundance of adults harvested
  - C. Abundance of juveniles
  - D. Abundance of hatchery spawners
- A. **Abundance of wild spawners** – represents the number of wild or natural-origin spawning adults of an identified type (e.g., ESU) or in a specified area (e.g., dam count). Abundance of wild spawners can be combined with abundance of wild adults harvested (below) to derive total wild run size, and estimates of adult-to-adult productivity, viability, and risk level. Again, the basic level of information for this indicator is the population.
- Example reporting measures: annual number, percent change over specified time intervals, or status compared to a goal in terms of good, fair, poor
  - Example metrics: spawner count or estimate
- B. **Abundance of adults harvested** – represents the number of wild, natural-origin, or hatchery-origin adults harvested in fisheries for identified groups (e.g., ESU) or in a specified area (e.g., ocean, tributary). Abundance of wild adults harvested can be combined with abundance of wild spawners (above) to derive total wild run size.
- Example reporting measures: annual total harvest, percent change in harvest over specified time intervals, or number harvested or harvest rate compared to a goal
  - Example metrics: number harvested, harvest rate
- C. **Abundance of juveniles** – the number of wild juveniles for identified groups (e.g., population) or areas (e.g., watershed), representing stream habitat productivity or carrying capacity.
- Example reporting measures: individual or composite annual number of smolts, percent change over specified time intervals
  - Example metrics: number of smolt outmigrants, juvenile density in rearing areas
- D. **Abundance of hatchery spawners** – represents the number of hatchery-origin spawning adults of an identified type or in a specified area (e.g., dam count). Abundance of hatchery spawners can be combined with abundance of wild spawners (above) to derive hatchery: wild spawner ratios or the percentage of hatchery spawners on the spawning grounds at the scale of listed populations.
- Example reporting measures: annual number, percent change over specified time intervals, or status compared to a goal in terms of good, fair, poor
  - Example metrics: spawner count or estimate

## Data Gaps

Of the 10 watershed health and salmon HLIs outlined above, the lack of habitat-related watershed health data forms the largest gap. There is more comprehensive coverage of data and metrics for the four draft salmon indicators, though many gaps still exist across the Pacific Northwest. More work is underway and needed to better describe the type and extent of existing data coverage and gaps, and existing data management systems and access for all indicator categories.

## Recommendations

1. Endorse the six high level indicators for watershed health and the draft list of four salmon indicators. Commit to the additional work needed to flesh out remaining details (i.e., reviewing associated reporting measures, identifying indices, derivations, and refining metrics) for existing and new indicators, and determine data availability.
2. Commit to exploring the challenges associated with obtaining existing and new data in support of the indicators, and identifying impediments and solutions to improve access and sharing.

## Additional Indicator Work

Beyond the needs already mentioned in this report, the following categories of HLIs merit additional attention:

- **Watershed health and ecosystem indicators:**
  - Nearshore/estuary condition
  - Toxics
  - Pollutant loads
  - Fecals
  
- **Implementation indicators** - Progress has been made in recent years on identifying and reporting common indicators and metrics to track implementation of actions (e.g., number of fish barriers improved, number of miles/acres restored or treated). However, much room for improvement remains, especially with regard to access and efficient sharing of existing data across agencies.
  
- **Effectiveness indicators** - Identification and selection of core indicators pertaining to questions about the effectiveness of actions on high level outcomes is lagging; thus this category of HLIs is currently not reflected in HLI reports. Effectiveness questions include – “are our actions responsible for producing more fish and/or better habitat?” “Did our actions have the outcome we wanted?”

## Summary

1. A list of six watershed health and four draft salmon high level indicators is recommended.
2. The recommended indicators are truly “high-level.” Depending on the reporting requirement, they can be reported directly, or can be used in reporting measures derived from specific metrics, multiple component data, or in indices.
3. They are aligned with and responsive to a broad range of policy interests (watershed health and salmon recovery), but are narrower in scope and complementary to broader indicators of “ecosystem health” or general biodiversity.
4. They are consistent with several efforts to develop indicators to address the same or similar questions and reporting purposes (e.g., Washington’s “*State of Salmon in Watersheds*” “*Environmental Indicators for the Oregon Plan for Salmon and Watersheds*,” and the “*Status of the Resources*” report for the Columbia Basin), providing credibility and the potential for broad consistency.
5. Several of the recommended indicators are essentially “ready to go,” (e.g., water quality and flow, land use and land cover) pending a relatively modest investment in further development and agreement among implementing agencies.
6. Reporting efforts would benefit from clearly identifying the specific metrics required and improving the data management and data transfer steps needed to roll-up and share data for the indicators. Some indicators will require improved sampling designs.

## Appendix 1

### Sources examined for this report on high level indicators

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- Columbia Basin Fish and Wildlife Authority Status of Fish and Wildlife Resources in the Columbia River Basin project report
- Federal Columbia River Power System BiOp Annual and Comprehensive (3 yr) Progress Reports
- NOAA Fisheries ESA Biennial report to Congress on ESA Recovery Actions
- NOAA Fisheries Pacific Coastal Salmon Recovery Fund Report to Congress
- Northwest Power and Conservation Council proposed high level indicators report
- Oregon Department of Environmental Quality Air Quality Index
- Oregon Department of Environmental Quality Water Quality Index
- Oregon Plan for Salmon and Watersheds Biennial Report
- Oregon Watershed Enhancement Board Key Performance Measure Report
- Puget Sound Action Team, State of the Sound 2007
- U.S. Forest Service; Northwest Forest Plan – the first 10 years (1994-2003): preliminary assessment of the condition of watersheds
- U.S. Forest Service; PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program, 2001-2007 Annual Summary Report
- Washington State of Salmon in Watersheds biennial reports

## Appendix 2

### Examples of Indicator Sorting Criteria/Questions

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#### Criteria:

Quantifiable – Can be described numerically and objectively

Relevant – Is biologically and socially germane to the question(s) being asked

Responsive – Will be sensitive to the stressors of concern

Understandable – Can be summarized in intuitively meaningful ways to a wide range of audiences and is pertinent to decision makers

Reliable – Will be supported by science; statistical properties understood

Accessible – Data exist or collection of necessary data is feasible, in terms of cost, time, skills

*Adapted from Dent et al. (2005). Environmental indicators for the Oregon Plan for Salmon and Watersheds. Institute for Natural Resources, Oregon State University. Prepared for the Oregon Watershed Enhancement Board*

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#### Evaluation questions

Is the indicator conceptually valid?

Do data exist?

Can the indicator feasibly be implemented?

Are the statistical properties understood and sufficient?

Does the indicator fulfill management and reporting needs?

*From O'Neil et al. (2008) A regional effort to select environmental indicators for the Puget Sound. Abstract at the 2<sup>nd</sup> Annual NWFSC Science Symposium*

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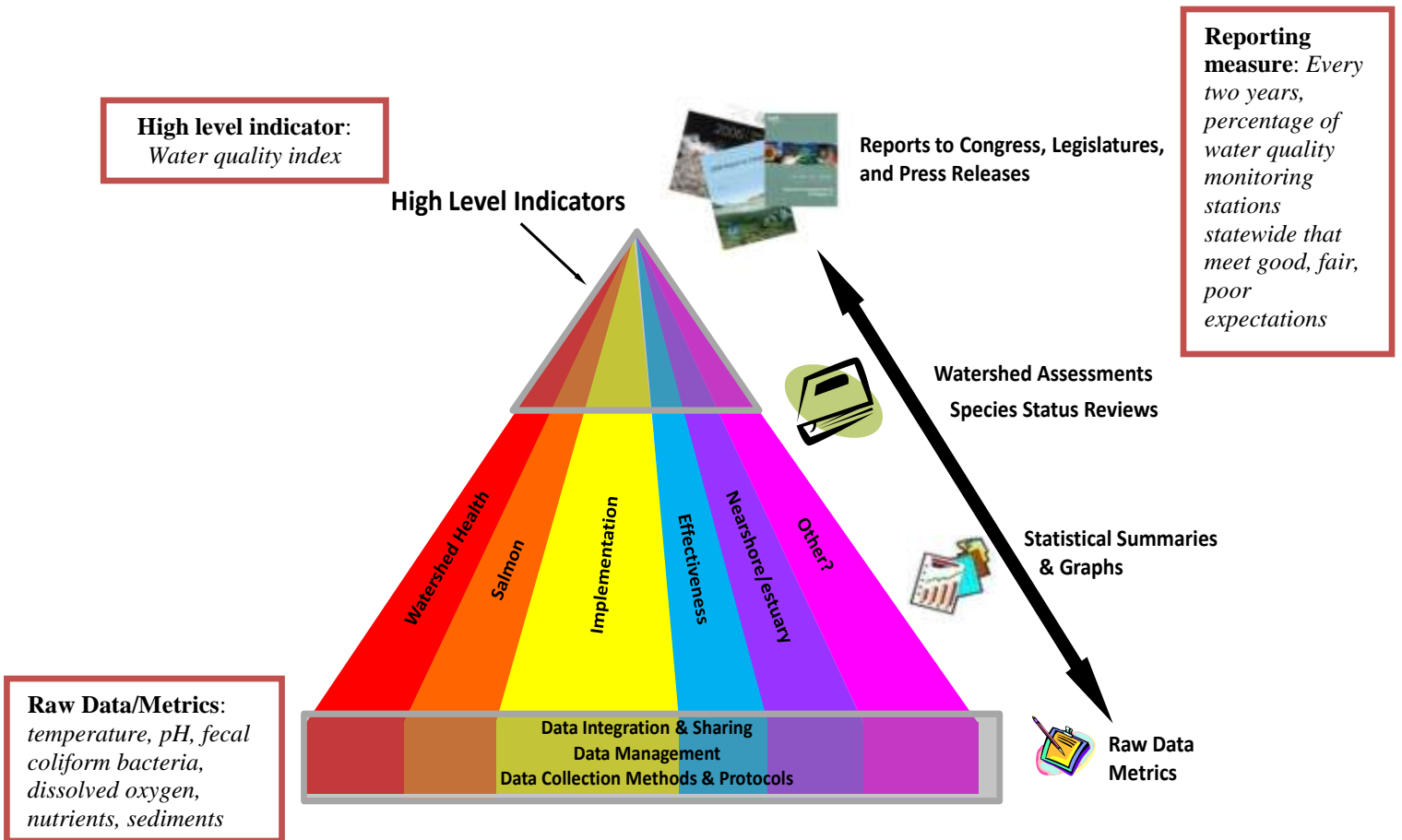
# Appendix 3

## Examples illustrating high level indicators, reporting measures, and metrics

This appendix illustrates the relationships between high level indicators and measures depicted in reports, and underlying metrics associated with raw data collected in the field, using an example for watershed health and another for salmon.

### Watershed health example

#### High Level Indicator: Water Quality Index



# Salmon example

## High Level Indicator: Abundance of Wild Spawners

