DRAFT

High Level Indicators for Watershed Health and Salmon and Steelhead Recovery

A Draft White Paper by
Pacific Northwest Aquatic Monitoring Partnership

Acknowledgement

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I. Introduction

Many Programs, Similar Mandates, Different Reporting Metrics

In the Pacific Northwest, natural resource management entities collect and analyze many types of information for answering management questions that address the objectives for which they are responsible**.** The Pacific Northwest Aquatic Monitoring Partnership, or PNAMP, is working to develop standardized protocols and methods for field data collection, data management, and analytical processes, which, in widespread use, would change this data into a common currency. This would enable data collected for an initial primary purpose to maintain value for use by multiple stakeholders seeking to analyze aggregate data by "rolling-up" the data. This paper provides the context and outlines the necessary steps for the development and coordination of technical and administrative activities to support the evaluation of data at higher-level geographic scales.

While there are many potential applications for such aggregate data, this paper identifies the need to coordinate the collection of data in a manner that can support evaluation and decision-making at higher-level spatial scales for example subbasin plans, Evolutionary Significant Units, and provincial scale objectives. This increases the potential for technical, policy and public organizations to communicate using consistent language and processes. PNAMP is supporting this work so that in the future it can be possible to conduct basic assessment and evaluation work at watershed as well as a regional scale. Enabling operational adaptive management and well-informed decision-making will be the principal by-products of this initiative (*see* Appendix A.). Providing accurate and unambiguous information to the public, NGO's, governments and their branches, is the goal.

Why Are High Level Indicators Important?

The practical requirements for implementing adaptive management include analyses that can support and guide the evaluation and re-direct activities at a programmatic scale as pertinent data become available. Resource management agencies need high-level indicators that flow explicitly from on-the-ground monitoring programs to provide information on whether progress towards meeting biological objectives has been made. Communicating the results of such evaluations, and the rationale they may provide for changing the direction of management activities, will require high-level indicators that can be easily understood by all interested parties in terms of every day definitions and experiences.

Interest by the public in the environment remains high. Through the coordinated use of high-level indicators, a uniform message about the health of watersheds and aquatic resources can be communicated to the public with a common language, using the same terms, and conducting analyses that allow comparison of findings, and ultimately, to similar conclusions. Scientific jargon, acronyms, and complex metrics fail to convey important information to the decision makers who provide the funding that enable monitoring programs to function at a cost-effective and reliable level (*see* Appendix B.

Definitions of Monitoring Terms). For these reasons, PNAMP is developing a set of high-level indicators for endorsement by its Charter member agencies for use within the Pacific Northwest region. PNAMP members will be able to draw from those indicators appropriate for their own reporting needs. For example, high-level indicators could be used as the basis for developing provincial scale objectives that the agencies and tribes of the Pacific Northwest region can endorse and implement. The PNAMP document "Strategy For Coordinating Monitoring of Aquatic Environments in The Pacific Northwest," and derivative work plans have previously recognized the need for high-level indicators.

Defining High-Level Indicators

For the purpose of this paper, we define high-level indicators accordingly:

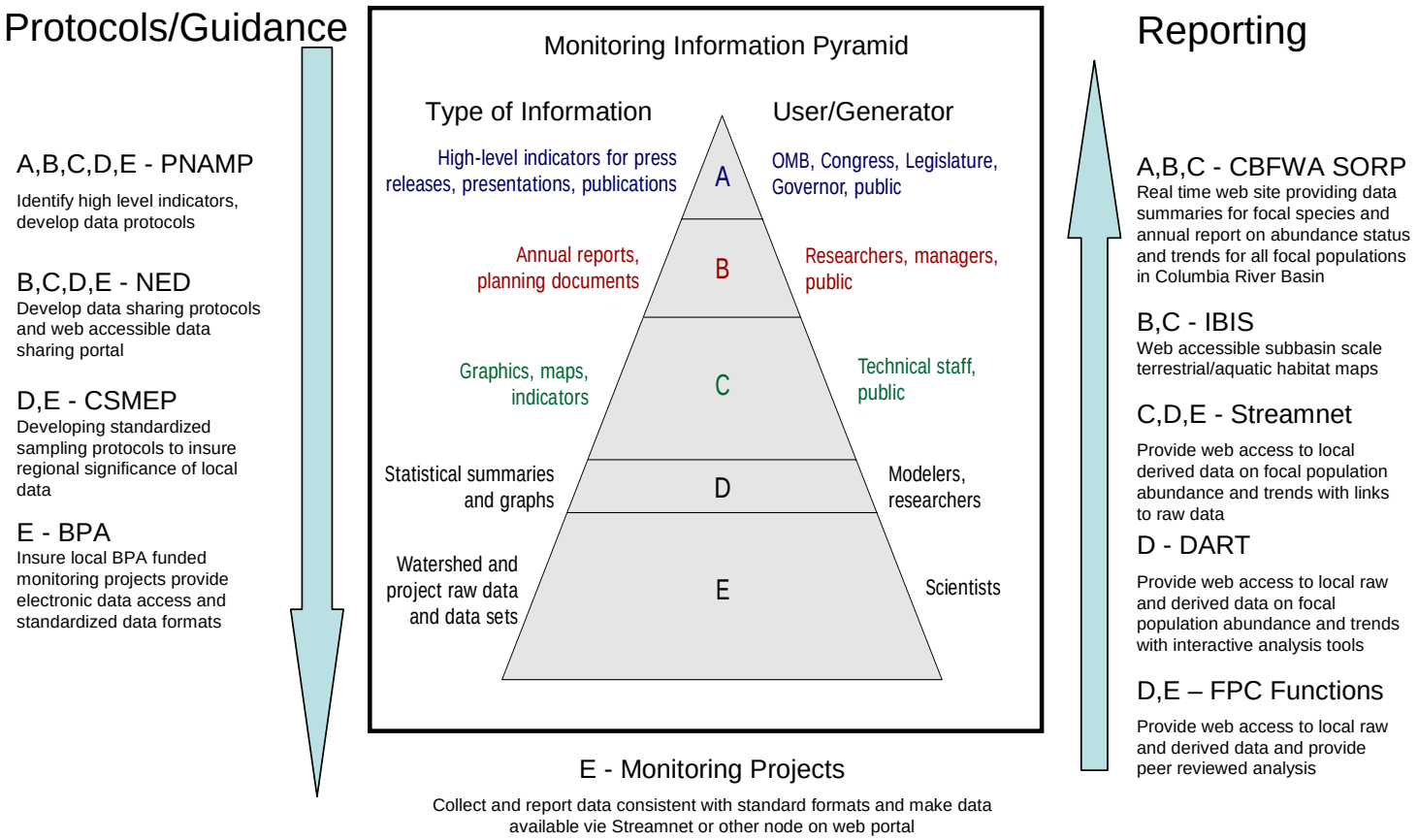
> *Variables that are monitored for the purpose of biological and physical habitat change analysis and evaluated at a watershed and regional scale. These may be broad-spectrum environmental variables (e.g. water quality or sediment load) because of varied ecotypes and landscapes. They may also be discrete factors such as numbers of fish that are sampled over a broad geographic scale. Thus, the use of the term "high level" is intend to describe activity that occurs at or across a broad scale and is not intended to describe a high degree of importance.*

Thus, high-level indicators are comprised of, and provide an aggregate value for, data collected at lower scales and are intended to report derivative results and summary findings, conclusions, and ultimately, management recommendations. Many types of data are of interest to the members of PNAMP and are collected to meet a primary mandate of the collecting entity, especially when varied ecotypes and species' life-history differences are concerned.

The challenge and the promise of high-level indicators is that they bring focus to the organization of the data collection efforts on the ground, by requiring uniformity and consistency in data collection, management, analysis, protocols and methods. When such consistency has been achieved, then like data, from different areas and sources can be aggregated into a specific number with confidence, for a broader geographic area. Similarly, related but unlike data can be aggregated into a composite value, for example indices for water quality. To achieve a regional approach to monitoring that is scientifically credible will require the coordination of lower and mid-level data collection efforts to ensure the consistency necessary to support secondary, yet higher scale use of the data. Thus, finer scale data is important both for its intended original application and because it constitutes the building blocks from which scale broader evaluations can be constructed.

The data pyramid portrayed in Figure 1. demonstrates the relationship between types of information and how they can support decision-making. For example, the status of high-level indicators compels the activities at the bottom of the pyramid, e.g. on the ground methods, protocols, and logistical implementation requirements. They also can help

Figure 1. Data Pyramid



direct decisions and recommendations about the analytical processes and statistical designs in the middle of the pyramid.

Caveats

The high level indicators described in Chapter II are a synthesis of monitoring and evaluation efforts from around the country and the world. This is not intended to be a complete list of all of the monitoring and evaluation efforts taking place in the world, but rather a partial list of high-level indicators that are relevant to the Pacific Northwest.

Because this paper is focused on indicators, it does not address monitoring/statistical design issues, for example the types of monitoring design that would be appropriate to answer a particular question such as upstream/downstream, before/after project implementation, probabilistic, or index sites.

Finally, while rolling-up data to support reporting on the ESU level is a service high-level indicators could provide, it is important to note that some management questions will need to be answered at the population level. For example, if one only shows fish status at the ESU level, the actual requirements at the population level may be obscured.

II. Current Use of High-Level Indicators

Within the Pacific Northwest and beyond, several ongoing initiatives have identified and are applying high-level indicators. These efforts are driven either by separate statutory requirements or by calls from Congress or state Legislatures for increased accountability. For example, state statutes in Oregon and Washington set forth clear requirements for comprehensive reporting that includes high-level indicators. However, a regional comparability gap persists.

The indicators in this document will be divided into three sections: regional, national, and international efforts. Every example of an indicator includes a brief history about the data set and its development and an explanation about why these indicators and not others are a good set of indicators for the region.

Regional Experience with High-Level Indicators

(1) Washington State Salmon Recovery

The Washington State Salmon Recovery Reports are published by the Governor's Salmon Recovery Office. The office was established by the Washington State Legislature through the Salmon Recovery Planning Act (Engrossed Substitute House Bill 2496). The Salmon Office's role is to coordinate and produce a statewide salmon strategy; assist in the development of regional recovery plans; secure current and future funding for local, regional, and state recovery efforts; and provide the Biennial State of Salmon report to the Legislature (Washington State Governor's Homepage). The indicators mentioned in the recovery reports are created, consistent with the 2002 Comprehensive Monitoring Strategy and Action Plan for Watershed Health and Salmon Recovery, by Executive Order 04-03 . The Governor's Forum on Monitoring is a multi-agency venue for coordinating technical and policy issues and actions related to monitoring salmon recovery and watershed health.

Washington has taken a broad approach to high-level indicators, applying a set of mixed variables that include socioeconomic and environmental indicators, to a narrower purpose, the assessment of progress towards recovery planning. The salmon recovery plan for the State of Washington is divided into five regions: the Lower Columbia, Mid Columbia, Upper Columbia, Puget Sound, and the Snake River. Each region monitors the same set of high-level indicators. High-Level Indicators in use in Washington (*see* Appendix C. for WA. Statute 77.85.020) for the purpose of measuring progress towards the recovery of salmon include the following 12 indicators that are monitored by each region are:

1. Water quality in watersheds
2. Fish passage barriers corrected and stream miles opened
3. Acre-feet of water restored to streams
4. Endangered Species Act compliant harvest goals
5. Salmon recovery plan status

6. Acres acquired for salmon restoration (Proposed)
7. Average compliance rate for salmon and steelhead fishers
8. Hatchery management plans meeting Endangered Species Act
9. Volunteer hours in watershed and salmon recovery activities
10. Salmon Recovery Funding Board grants
11. Fish status summary
12. Trends in wild juvenile salmon production

The Washington State Salmon Recovery Plan is a good model for the Pacific Northwest because it includes significant parts of the Columbia River Basin, is regionally focused, includes economic, environmental, and social indicators, and has a few years of hard data for each indicator. The recovery plan is also a collaborative effort between several agencies including the Washington State Department of Ecology, Washington Department of Wildlife, United States Fish and Wildlife Service, and the Environmental Protection Agency (EPA). There is data from each region and combined data for the whole state.

The Washington State Salmon Recovery effort uses a panel of independent scientists. In 1998 the Washington State Legislature passed Engrossed Substitute House Bill 2496 creating a five-member "Independent Science Panel" (ISP), whose purpose is to provide scientific review and oversight of the state's recovery efforts and to review recovery plans at the request of the Governor's Salmon Recovery Office. In addition, the 1999 and 2001 Legislatures directed the Panel to work on scientific issues pertaining to monitoring salmon recovery and watershed health (The Governors Salmon Recovery Office, Science and the ISP Website).

A few of the indicators are now showing significant improvement. The number of fish passage barriers that are corrected continues to climb. The number of hatchery plans that are in compliance with the ESA is improving. And it appears the overall trends for wild juvenile salmon stocks are also improving. These indicators are all tailored to track salmon recovery and, to a lesser extent, habitat recovery.

(2) The Oregon Plan for Salmon and Watersheds

The Oregon Plan for Salmon and Watersheds (Oregon Plan) initiated in 1997 is a state led initiative to restore watersheds and recover fish and wildlife populations to productive and sustainable levels while providing substantial environmental, cultural, and economic benefits. A process to describe existing social and economic indicators has been initiated by the Oregon Progress Board. The Oregon Watershed Enhancement Board (OWEB) partnered with the Institute for Natural Resources to develop and institutionalize a system for tracking a small set of environmental indicators, designed to answer the following management questions:

- Are Oregon's environmental conditions stable, declining, or improving over time?

- Are environmental conditions improving under current land management and restoration practices?

While the work of the Oregon Progress Board continues, Oregon has developed an ecosystem approach in their use of high-level indicators. The planning document "Environmental Indicators for the Oregon Plan for Salmon and Watersheds," specifies 15 environmental indicators of basin condition under the domains of Aquatic and Riparian Ecosystems; Terrestrial Ecosystems; Estuarine Ecosystems; and the topic of Ecosystem Biodiversity (Dent et al., 2005).

Aquatic and Riparian Ecosystems

- Anadromous fish abundance, distribution, and life histories
- Coldwater Index of Biotic Integrity (IBI) for fish and for macroinvertebrates (With the same data, we can report native and nonnative species numbers and distributions for Indicator 15.)
- Water Quality Index (WQI) (miles or percent of streams with rating of poor, fair, or good WQI)
- Area, distribution, and types of riparian and wetland vegetation
- Riparian function index based on vegetation and site capability (e.g., large wood recruitment, shade, and nutrient input) and wetland function index based on hydrogeomorphic (HGM) typing
- Physical aquatic habitat and estuarine habitat condition
- Access to freshwater and estuarine habitat (miles of habitat accessible or limited; further analyze by habitat quality)
- Frequency of meeting instream water rights

Terrestrial Ecosystems

- Area, distribution, configuration, and types of cover for established ecological classes
- Change in land use and land cover

Estuarine Ecosystems

- Area, distribution, type, and change in area of tidal and submerged wetlands
- Index of Biotic Integrity for estuaries

Ecosystem Biodiversity

- Number of native plant and animal species and distribution over time (departure from potential)

- At-risk species (aquatic, estuarine, and terrestrial; plant and animal)

- Percent of nonnative invasive species (focus on subset of known species)

This report is published by OWEB on a biennial basis. This report has at least five years of data from which to draw. The data and information contained in the report is then provided to the Oregon Watershed Restoration Inventory and used to report on Oregon Plan progress, to support effectiveness monitoring of restoration activities, and to support watershed assessments and future restoration project planning and prioritization. The information is then summarized and put into the Oregon Plan for Salmon and Watersheds.

The Oregon Plan is organized by basin rather than by region. The report is divided into 15 basins. The report has a description of each basin, which is followed by pertinent data. Each basin has a list of the recovery issues that are impacting that basin. The indicators that are reported for each basin include economic, environmental, and social impacts, specifically:

- Social impacts including comprehensive information on land cover and ownership

- Economic information on investments by agency

- Environmental impacts data on ESA listings and water quality concerns including: Water Quality Total Maximum Daily Load (TMDL) and Agricultural Water Quality Management Areas

This report has good indicators for water quality, but not for fish and wildlife. The only indicator that mentions fish and wildlife in the Oregon plan is the number of completed and reported restoration projects. There is no mention of stream recovery, habitat enhancement or overall improvement in salmon and wildlife abundance. The individual basin sections also mention what accomplishments and challenges have taken place in that basin.

In Oregon, several requirements are stipulated by OR. Statute 541.429 (see Appendix C.) for the purpose of measuring progress towards improving the health of watersheds include:

- A status report on watershed and key habitat conditions in the drainage basin based on available information

- An assessment of data and information needs deemed critical to monitoring and evaluating watershed and habitat enhancement programs and efforts

- An overview of state agency programs addressing watershed conditions

- An overview of voluntary restoration activities addressing watershed conditions

- A summary of investments made by the board from funds received under section 4b, Article XV of the Oregon Constitution, and all other sources

- The recommendations of the board for enhancing the effectiveness of Oregon Plan implementation in each drainage basin

Thus, Oregon has presently identified a set of environmental high-level indicators, which will be supplemented with social and economic indicators in the future. These indicators will be used statewide to evaluate progress towards sustainability

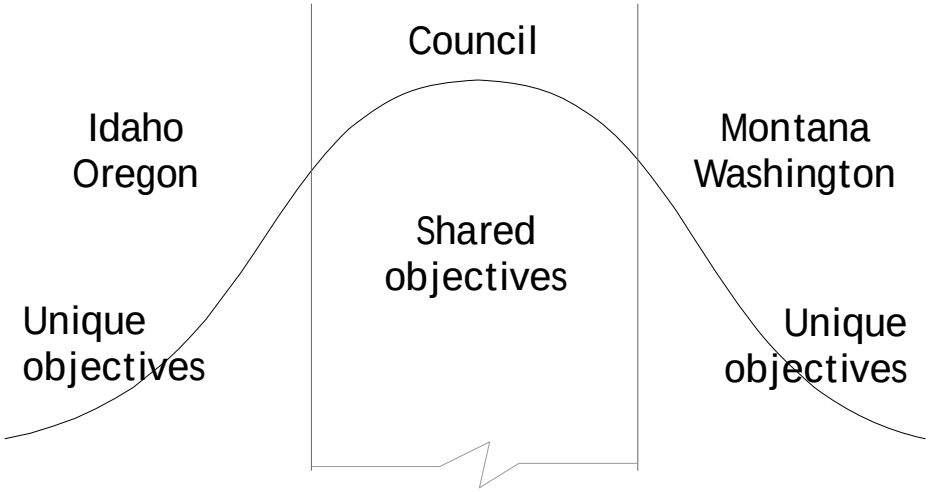
(3) Northwest Power and Conservation Council (NPCC)

In 2006 Council staff proposed a process for developing provincial scale objectives. The proposed approach is currently undergoing public comment. Depending on the outcome, the NPCC's Fish and Wildlife Program may host a regional dialogue in the future about developing provincial scale objectives.

To distinguish them from indicators, provincial objectives would be comprised of the "amount" of an indicator variable (numbers of fish) to be obtained or achieved. To the extent possible, these objectives would be quantified, yet would vary in magnitude between provinces as appropriate. The provincial scale objectives of the Fish and Wildlife Program could encompass a set of shared objectives common to the four states, while respecting additional reporting needs of individual states, as depicted in Figure 2.

One potential scenario for implementing provincial objectives in a way that could foster comparability with other entities within the Columbia River Basin would be to draw them from a larger set of high-level indicators that would be endorsed by PNAMP in the future. The process of developing, negotiating, and gaining regional acceptance of high-level indicators for the Pacific Northwest has yet to be accomplished, but may follow the examples established by the on-going efforts of Washington and Oregon, as modified to incorporate additional tribal and federal requirements.

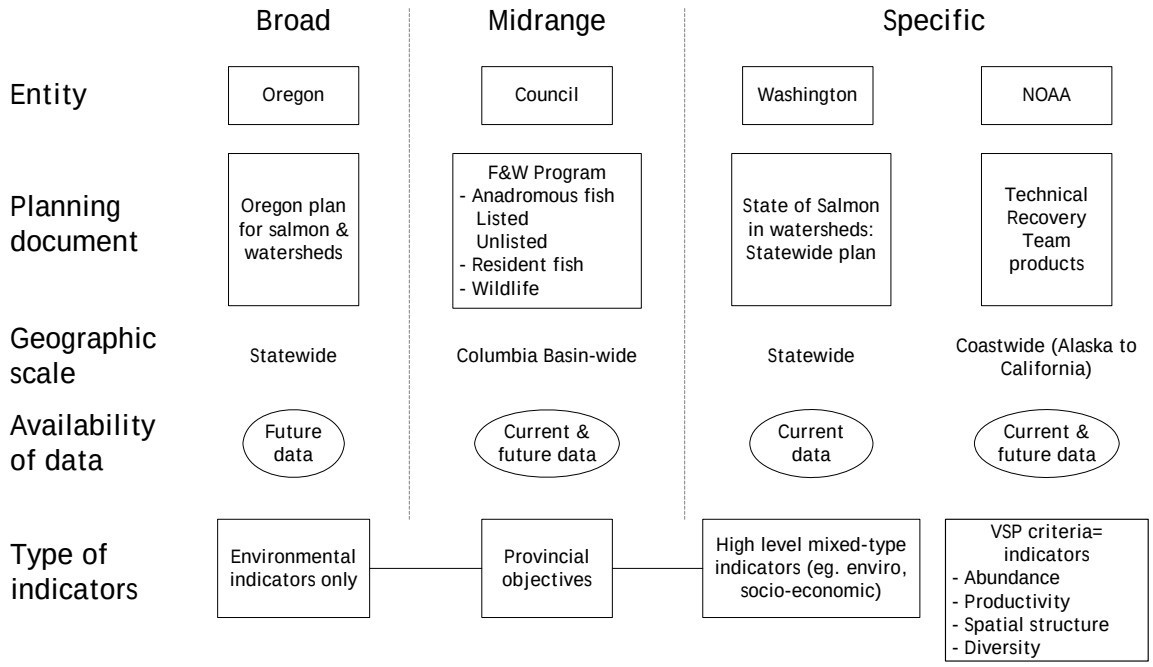
Programmatic scale evaluations of the Fish and Wildlife Program could provide a means to measure progress towards Program objectives, provincial scale objectives, and sub-basin plan objectives. The individual sub-basins may use any additional relevant indicators to their recovery plans.



The NPCC currently uses two planning tools as a part of their sub-basin planning efforts; the Ecosystem and Diagnosis Treatment (EDT) and the Interactive Biodiversity Information System (IBIS). The EDT is a practical, science-based approach for developing and implementing watershed plans and a means of providing decision makers with the technical information needed to achieve their program goals and objectives. The IBIS is an interactive map/data query tool that is used to reveal and analyze the relationships among Pacific Northwest fish and wildlife species and their habitats.

High level indicators could be used in conjunction with these planning tools and other information databases like Streamnet which tracks, among other things, fish populations within the Columbia River Basin. Thus, the EDT and the IBIS could be used to gather some of the required data to measure the high level indicators.

Figure 3. A comparison of the high-level indicators developed by the Washington Governor's Salmon Recovery Office in cooperation with the Washington Salmon Recovery Funding Board; the Oregon Watershed Enhancement Board; and the NOAA, and the NWPPC.



(4) The California Bay Delta Authority (CALFED)

The CALFED Bay-Delta Program is a unique collaboration among 25 state and federal agencies that came together in the early 1990's with a mission to improve water supplies in California and the health of the San Francisco Bay/Sacrament-San Joaquin River Delta (CALFED website). CALFED is currently working on developing indicators and performance measures to monitor the progress of their Ecosystem Recovery Plan. CALFED is also currently developing a salmon recovery plan for the State of California. The CALFED program is a good example of a collaborative effort between agencies to solve complex social and environmental problems, but to date no measurement indicators have been developed.

(5) PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program

The PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) is funded by the US Forest Service (FS) and U.S. Bureau of Land Management (BLM). The program was initiated in 2001 and monitors on FS and BLM lands within the interior Columbia River Basin. The primary goal of PIBO is to evaluate whether PACFISH/INFISH management practices are effective in maintaining or improving the structure and function of upslope, riparian, and aquatic conditions at multiple spatial scales.

Approximately 250 watersheds are selected each year for sampling. These watersheds are then repeated on a five-year rotation to address the study questions (Kershner et. al. 2004). This data will be analyzed by examining changes in distribution of the data, as well statistical analyses to evaluate trends through time at the reach as well as the sub-

watershed scale. This data will then be reported at multiple scales from the Forest/Resource Area to the entire Columbia River Basin.

(6) Pacific Coastal Salmon Recovery Fund

The Office of Management and Budget (OMB) and Congress have required stringent reporting of results of Pacific Coastal Salmon Recovery Funds (PCSRF). OMB has asked for:

- Performance goals that demonstrate progress toward achieving salmon recovery
- Independent and quality evaluations to determine program effectiveness in achieving salmon recovery
- Demonstrated cost effective and efficient programs
- Progress reporting by NOAA Fisheries for PCSRF funds has become the surrogate measure of salmon recovery success along the Pacific coast.

The relationships of the indicators, metrics, and scale of application used by the several of the foregoing entities is reported in Appendix D.

(7) Federal Columbia River Power System Plan

The 2005-07 Implementation Plan for the Federal Columbia River Power System identified performance measures and targets that will be tracked annually to help determine priorities for management actions and to adaptively manage restoration efforts for affected ESUs.

National Experience with High-Level Indicators

(1) The State of the Great Lakes

The State of the Great Lakes report is published every two years. The report is a result of the Great Lakes Water Quality Agreement signed in 1972 between the United States and Canada. The EPA and Environment Canada are the two primary partners in this agreement. Environmental indicators are evaluated on a biennial basis at the State of the Great Lakes Ecosystem Conference.

There are indicators for water, sediments, air, biology, fish and beaches. There is at least 10 years of data for each indicator in addition to goals, objectives and targets. Some of the indicators that pertain to the Pacific Northwest include:

- Measuring trophic levels and dissolved oxygen in the water

- Measuring the concentration of chemicals in the sediments and air including PCB

- Monitoring biological indicators including benthic health

The Great Lakes indicators for fish and beaches are not relevant to the Pacific Northwest. The fish indicators measure the toxicity of the fish for human and wildlife consumption and not the overall abundance or fitness levels. The beach indicators only measure whether or not the beaches are safe for swimming.

(2) Lake Superior Bi-National Program

The Lake Superior Lakewide Management is an on going bi-national agreement between the United States, Canada, and several U.S. States and Canadian Provinces. Lake Superior is a unique, vast resource of fresh water that has not experienced the same levels of development, urbanization and pollution as the other Great Lakes. Because of its uniqueness, the International Joint Commission recommended in 1990 that Lake Superior be designated as a demonstration area where discharges and emissions of toxic substances that are long-lived in the environment and build up in human and animal populations, would not be permitted (U.S. EPA Lake Superior Bi National Program Web page).

This program was designed to focus on the entire ecosystem of Lake Superior: its air, land, water and human/wildlife. In contrast, the State of the Great Lakes Report does not focus on the entire ecosystem because wildlife and humans are not included in the monitoring efforts.

Some of the pertinent indicators from the Lake Superior Bi-National Program include indicators for aquatic communities, terrestrial wildlife, habitat, and sustainability. These indicators also have at least 15 years of data with goals, objectives, and targets.

Aquatic Indicators for Abundance and Contamination

- Tributary community

- Harbor Embayments

- Estuaries Community

Terrestrial Wildlife Indicators

- Wildlife Abundance and contamination- the wildlife communities are different in the Pacific Northwest.

Habitat indicators

- Streamflow/Sedimentation

- Benthic Communities
- Forest or Riparian Fragmentation

Sustainability Indicators

- Status of Basin Diversity
- Landscape Patterns
- Human Impacts

(3) Chesapeake Bay Program

The Chesapeake Bay Program (CBP) is a unique regional partnership that has led and directed the restoration of the Chesapeake Bay since 1983. Some of the partners include the Chesapeake Bay Program partners, which include the states of Maryland, Pennsylvania and Virginia; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; and the Environmental Protection Agency, representing the federal government; and participating citizen advisory groups.

The indicators that have been developed and adopted by the CBP area good representation of the issues affecting the Bay. Most of the indicators measure strategies that have been fairly successful at reducing the negative impacts to the Bay. The indicators include data from at least the early 1980's, so the data set is quite extensive. There are indicators for fish and wildlife. Some of the pertinent indicators from the CBP include:

- The abundance of various fish populations
- The Benthic Index of Biotic Integrity
- Water quality, chemical contaminants, chlorophyll, dissolved oxygen, and water clarity
- Wetlands restoration
- Riparian forest buffers planted
- Wetland enhancement
- Agricultural pollution controls on nitrogen, phosphorous, and sediment
- Fishery and hatchery management
- Load levels on nitrogen, phosphorous and sediment

- River flow levels

(4) Long Island Sound Study

The Long Island Sound Study (LISS) formed in 1985, is a bi-state partnership consisting of federal and state agencies, user groups, concerned organizations, and individuals dedicated to restoring and protecting the Sound. Some of the partners include the EPA and the States of New York and Connecticut. The first Comprehensive Conservation and Management Plan was completed in 1994 and identified several key issues that needed to be addressed by LISS. The indicators have contributed to the significant improvement of the Long Island Sound in the 10 plus years that data has been collected and monitored. The relevant indicators include:

Water Quality Indicator

- Water clarity
- Chlorophyll-A concentrations
- Dissolved oxygen
- Reducing nitrogen loads

Fish and Habitat Indicators

- Fish abundance
- River miles restored

Land Use and Public Involvement

- Historic trends of the extent of forested land in the watershed
- Data on land coverage
- Participation and creativity in grant programs

International Experience with High-Level Indicators

(1) Environmental Sustainability Index (ESI) - 2005

This index is a method to benchmark environmental stewardship. The ESI is broken down into components and indicators. There are components for environmental systems,

reducing environmental stresses, reducing human vulnerability, social and institutional capacity, and global stewardship. The EIS has indicators for:

- Air quality
- Water quality
- Water quantity
- Biodiversity
- Land
- Natural resource management
- Environmental governance
- Eco-efficiency

The ESI is a composite index tracking with a diverse set of socioeconomic, environmental, and institutional indicators that characterize and influence environmental sustainability at the national scale. The ESI also serves as a database of comparison between participating countries. The index is currently striving to create a more complete set of indicators that will positively influence the state of a country's environment. The ESI is not particularly useful for the Pacific Northwest at this time, because indicators for fish and wildlife are still under development.

(2) Countdown 2010

Countdown 2010 is an international agreement among most of the European countries and numerous environmental organizations whose goal is to curb the decline of biodiversity by 2010. Most of the work to date consists of elaborate commitments to change current environmental policies and implement existing ones. While a number of agreements have been implemented, little action to curb biodiversity decline has taken place. Countdown 2010 has a long way to go before they can achieve their goal. This international agreement is also not useful for the Pacific Northwest because they have not developed indicators at this time.

(3) State of the Environment for British Columbia

The report, State of the Environment, is an important to promoting shared stewardship. It provides a way to measure progress on delivering the government's goals of clean and safe water, land and air, and healthy and diverse native species and ecosystems (Government of British Columbia, Strategic Policy Division). The indicators included in the State of the Environment, Environmental Trend reports have data back to the early 1990's. The report is published every few years, with the next report to be published in

2007. The report has several notable indicators that are relevant to the Pacific Northwest including:

Habitat Indicators

- Road density by watershed group
- Percentage lost of selected habitat types
- Number of endangered, threatened and special concern vertebrate animals and vascular
- plant species dependent upon selected habitat types
- Percentage of eco-section not influenced by roads or seismic lines in British Columbia
- Area under license for use or managed for conservation in 51 coastal estuaries

Fish Indicators

- Conservation risk to steelhead stocks
- Age distribution of white sturgeon
- Conservation risk to bull trout in British Columbia

Wildlife Indicators

- Percentage of historic range in which selected species are extirpated or declining

III. Developing High-Level Indicators Within the Regional Framework for Monitoring

Bio-indicators: A Holistic Approach to Monitoring

Although the initiatives described in the prior section on "Regional Experience with High-Level Indicators" were not intended or designed to fit together into a broader regional initiative, they do form important components for a regional approach to the implementation of high-level indicators. Various reports of the NPCC Independent Scientific Advisory Board and the Independent Scientific Review Panel have admonished the Pacific Northwest to embrace an ecosystem approach to monitoring that addresses such dynamics as trophic levels, feeding assemblages, energy flow, and issues of scale.

One approach would be to identify bio-indicators on a staggered temporal axis, so evaluations of activity on different trophic levels could generate trend information over the near, mid and long terms. For example, the use of macro invertebrates not only gives insight to water quality but also provides information on biodiversity. In their book, "Life in Running Waters," Karr and Chu (1999) set forth the elements necessary for a multi-metric approach to biological monitoring:

- Biological monitoring is essential to protect biological resources
- Health and integrity are meaningful for environmental management
- Biological monitoring detects natural fluctuations and biological changes caused by humans
- Ecological risk assessment and risk management depend on biological monitoring
- Understanding biological responses requires measuring across degrees of human influence
- Only a few biological attributes provide reliable signals about biological conditions

Near-term Indicators - Aquatic and streamside insects

Mid-term Indicators - Avian species that are piscivorous like osprey or grebes

Long-term Indicators - Long lived species such as freshwater mussels

Next Steps for PNAMP

PNAMP can assist the region by identifying and recommending a set of high-level indicators that provide a shared basis for evaluation and reporting, to the extent possible given statutory constraints.

Step 1. Identify a set of shared management questions.

Relevant management questions were identified for agencies and programs in the Pacific Northwest and are presented in Appendix A: RM&E Management Questions, Information Needs, and Cost Sharing Agencies (BPA 11/14/05).

These were developed through a survey of regional examples and reviewed at the PNAMP/CSMEP Workshop, March 16-17, 2006.

Step 2. Identify the high-level indicators necessary to answer the management questions.

Identification of current indicators used by federal, state, and tribal governments to report progress to the public and senior executives. Identification of common reporting elements and reporting scale.

The pool of indicators can be relatively small but diverse, so that the viability of habitat, wildlife, resident fish, and listed and unlisted anadromous fish can be evaluated. Some individual indicators should also be broad spectrum in nature, for example water quality, so they can provide information useful to a number of management questions.

Step 3. Identify the types of monitoring necessary to gather the data on the high-level indicators.

Determine the extent of the geographic area from which the data would be gathered, and recommend how to implement the work, such as stand-alone projects, or via a shared network.

Step 4. Determine the extent to which data is already being collected on those high-level indicators.

Determine the extent of the geographic area from which the data is being gathered. Identify data repositories for the information and determine how it can be compiled from various data sources. This could be addressed as part of the inventory projects that both PNAMP and CSMEP are developing. The CSMEP approach is to work bottom up and then integrate the data. The PNAMP approach is top down to an appropriate level to answer the management questions.

Step 5. Gap Analysis

Juxtapose the set of management questions with the types of data currently being collected and conduct a gap analysis. Assess the approach EcoTrust is using.

Step 6.

Development of simple value ratings (red, yellow, green) based upon common scoring procedures for habitat, water, and fish measurements

Provisional List of High-Level Indicators

The following draft list of high-level indicators was derived from the work of Washington, Oregon, UCSRP, Streamnet and others. It has been incorporated by the NPCC staff as a provisional set of "core indicators" in their document "Draft Guidance for Developing Monitoring and Evaluation as a Program Element of the Columbia River Basin Fish and Wildlife Program" and proposed as basis for evaluating the program's progress towards provincial objectives. Evaluation of the NPCC Fish and Wildlife Program based on the monitoring of a core set of physical and biological indicators would signal a shift towards a more ecological approach to management.

Physical

- Water temperature
- Sedimentation
- Passage, flow
- Large woody debris
- Upland use
- Habitat categorization
- Stream morphology
- Ecological attributes important to resident fish

Biological

- Benthic macro-invertebrate assemblages (this may be a good example of an indicator that should be used locally and not at a basin scale)
- Species abundance for juvenile, smolt, and adult life stages and distribution
- Fish survival or ocean productivity indicators
- Annual population growth rates
- Hatchery releases and return rates
- Harvest rates
- Adult and juvenile passage survival through the mainstem dams

Further Development of the Indicators

One method for the design and implementation of high-level indicators has been developed by the Ecosystem Management Initiative and is entitled “A Resource for Ecosystem and Community Based Projects.” This document will be useful as the monitoring and evaluation efforts in the Pacific Northwest continue to evolve. The document explains how to develop indicators for ecological priorities including regionally significant communities such as the Columbia River Basin, critical habitat, ecologically sensitive zones, and ecosystem drivers.

There are indicators for land acquisition, diversity, water quality, and social indicators. The document also mentions how to develop indicators to address the threats to the project area including invasive species, predation, habitat loss and degradation, water pollution/ contamination, soil composition, and new development. As an organization is developing indicators it is also useful to mention the assets to the organization and the monitoring and evaluation plan. Examples of assets are high quality ecosystems, political support, social assets, and organizational strengths.

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Appendix A. Adaptive Management

In practice, adaptive management is a method for taking action in the absence of information, or when only limited information is available. This may occur when the information is so unique that it does not exist; there is no basis in prior experience from which to extrapolate; or, when prior experience occurred at such a different scale as to be irrelevant. Adaptive management provides a valuable tool for ensuring that timely feedback from such diverse activities informs the re-direction of future research to increase effectiveness. In their seminal work applying adaptive management in a hydropower context, Professor Kai Lee and the late Jody Lawrence wrote:

> *Adaptive management is learning by doing... Adaptive management is both a conceptual approach and a strategy for implementation. As a conceptual approach, it sets a scientifically sound course that does not make action dependent on extensive studies. As a strategy for implementation, adaptive management provides a framework within which measures can be evaluated systematically as they are carried out. Adaptive management encourages deliberate design of measures. This assures that both success and failures are detected early and interpreted properly as guidance for future action. Information from these evaluations should enable planners to estimate the effectiveness of protection and enhancement measures on a systemwide basis. Measures should be formulated as hypotheses. Measures should make an observable difference. Monitoring must be designed at the outset. Biological confirmation is the fundamental measure of effectiveness*. (Emphasis added.)

(From *Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, Environmental Law Vol.16:431-460, 1986.)

The National Research Council (NRC) related several lessons learned about the practicability of adaptive management and the institutional conditions that affect how experiments on the scale of an ecosystem can be conducted (NRC, 1996). These lessons are:

1. Learning takes from decades to as long as a century. Patience is both necessary and difficult, particularly in institutional settings such as government that work in faster cycles.

2. Systematic record keeping and monitoring are essential if learning is to be possible. But collecting information is expensive and often hard to justify at the outset and during times of budget stringency because the benefits of learning are hard to estimate quantitatively.

3. Cooperative management in the design and execution of experiments is indispensable. Experimentation within the context of resource use depends on the collaboration of resource users.

4. Adaptive management does not eliminate political conflict but can affect its character in important, if indirect, ways.

Although "adaptive management" has been the foundation underlying numerous conservation plans and strategies for restoring aquatic habitat conditions and native species, good science is still very limited in this area. Long-term commitments to science-based evaluations of management actions will be needed to address this gap. Future research efforts should be integrated, along the lines of projects supported by the NSF bio-complexity program such as integrating physical, biological, economic, and social sciences, as appropriate. A stronger connection between management actions and research is a common theme that is frequently identified, but on-the-ground it is rarely implemented due to the additional costs.

One key element to an adaptive management experiment is providing a large enough perturbation to a system so a detectable change in a response variable can be measured. For example, by measuring responses to a limited range of spill and flow levels in the Columbia River hydrosystem, it will be difficult to assess detectable changes over the salmon and steelhead life-cycle and to contrast those changes in life-cycle survivals to those for transported juvenile fish. This is a key question that needs to be addressed in order to evaluate the future of transportation, spill, and flow measures in restoring salmon, steelhead, and other aquatic populations that use the mainstem Columbia River.

Appendix B. Definitions of Monitoring Terms

In the Columbia River Basin several large-scale planning documents have categorized three types of monitoring in a hierarchical sequence such as the All-H Paper, the 2000 FCRPS Biological Opinion, and the Retrospective Report of the Independent Scientific Review Panel (ISRP). The three types of monitoring differ in terms of their application, and along spatial and temporal scales. The ISRP and ISAB recognized the "inconsistent terminology concerning research, monitoring, and evaluation among the various fields of science such as fisheries, hydrology, wildlife, genetics" and in particular with the scientific basis for "effectiveness monitoring" of management actions (ISRP 2005-14). The ISRP and ISAB have used the words "Tier 1, Tier 2, and Tier 3" in a slightly different manner in past reports referring more to the way data are collected such as census versus sample, than to the scale of the study. To eliminate potential confusion in the future, they have dropped the use of the word "Tier" when referring to the way data are collected. The relationship of the ISRP's definitions of census and statistical monitoring to Action Agency (2002) Tier 1, 2 and 3 monitoring is shown below (*see* ISRP's Retrospective Report 1997-2005). In addition to monitoring for biological, environmental and physical data, there is compliance and implementation monitoring associated with monitoring of restoration projects.

	Census Monitoring	Statistical Monitoring
Large Scale Tier 1 Monitoring	Usually census monitoring is most appropriate (e.g., remote sensing to create GIS data layers).	Statistical monitoring could be useful in special cases (e.g., in monitoring range condition on BLM land in Oregon)
Small Scale Tier 2 Monitoring	Usually census monitoring is not appropriate because of high costs of large number of experimental units and/or on-the-ground labor intensive methods.	Statistical monitoring with known precision and confidence based on a sample of units is usually most appropriate (e.g., juvenile Chinook salmon abundance in a sample of reaches of the John Day River).
Effectiveness Tier 3 Monitoring	Usually census monitoring is not appropriate because of high costs of large number of experimental units and/or on-the-ground labor intensive methods. *** Note:** Not always true. e.g., spawning ground / redd surveys where all spawning area in a watershed is surveyed = census, not survey. Call Pete Hahn, WDFW, for examples	Statistical monitoring with known precision and confidence based on a sample of units is usually most appropriate. Rigorous experimental design is required (e.g., evaluation of survival of juvenile salmonids past John Day Dam with different levels of spill).

Appendix C. State Initiatives

Washington statute 77.85.020 - *Beginning in December 2000, the governor shall submit a biennial state of the salmon report to the legislature during the first week of December. The report may include the following:*

(1) A description of the amount of in-kind and financial contributions, including volunteer, private, and state, federal, tribal as available, and local government money directly spent on salmon recovery in response to actual, proposed, or expected endangered species act listings;

(2) A summary of habitat projects including but not limited to:

(a) A summary of accomplishments in removing barriers to salmon passage and an identification of existing barriers;

(b) A summary of salmon restoration efforts undertaken in the past two years;

(c) A summary of the role which private volunteer initiatives contribute in salmon habitat restoration efforts; and

(d) A summary of efforts taken to protect salmon habitat;

(3) A summary of collaborative efforts undertaken with adjoining states or Canada;

(4) A summary of harvest and hatchery management activities affecting salmon recovery;

(5) A summary of information regarding impediments to successful salmon recovery efforts;

(6) A summary of the number and types of violations of existing laws pertaining to: (a) Water quality; and (b) salmon. The summary shall include information about the types of sanctions imposed for these violations;

(7) Information on the estimated carrying capacity of new habitat created pursuant to chapter 246, Laws of 1998; and

(8) Recommendations to the legislature that would further the success of salmon recovery. The recommendations may include:

(a) The need to expand or improve non-regulatory programs and activities; and

(b) The need to expand or improve state and local laws and regulations.

Oregon statute 541.420 - *"The Oregon Watershed Enhancement Board shall, by January of each odd-numbered year, submit a report to the Governor and to the appropriate committee or committees of the Legislative Assembly that assesses the implementation and effectiveness of the Oregon Plan in the state. The report shall address each drainage basin in the state and shall include, but need not be limited to:*

(a) A status report on watershed and key habitat conditions in the drainage basin based on available information;

(b) An assessment of data and information needs deemed critical to monitoring and evaluating watershed and habitat enhancement programs and efforts;

(c) An overview of state agency programs addressing watershed conditions;

(d) An overview of voluntary restoration activities addressing watershed conditions;

(e) A summary of investments made by the board from funds received under section 4b, Article XV of the Oregon Constitution, and all other sources; and

(f) The recommendations of the board for enhancing the effectiveness of Oregon Plan implementation in each drainage basin.

(2) In order to provide the board with the information necessary to complete the report described in subsection (1) of this section, each natural resources agency shall provide information requested by the board in the format and at the times determined by the board.

(3) For purposes of this section, "natural resources agency" includes:

(a) Department of Environmental Quality;

(b) State Department of Agriculture;

(c) State Department of Fish and Wildlife;

(d) State Forestry Department;

(e) Department of State Lands;

(f) Water Resources Department;

(g) Department of Land Conservation and Development;

(h) State Department of Geology and Mineral Industries;

(i) Oregon Watershed Enhancement Board;

(j) Fish and Wildlife Division of the Department of State Police;

(k) Department of Transportation;

(L) State Parks and Recreation Department;

(m) Economic and Community Development Department;

(n) State Marine Board; and

(o) Any other state agency that is required to manage, allocate or protect natural resources, either as the primary responsibility of the agency or in conjunction with the primary responsibilities of the agency.

(4) In addition to the report specified under subsection (1) of this section, the Oregon Watershed Enhancement Board shall report regularly during the interim on the implementation of the Oregon Plan to the joint legislative committee created under ORS".

Appendix D. Comparison of Indicators of Pacific Northwest Entities			
Indicator	**Organization**	**Metric**	**Scale**
Spawner Abundance	WA	• Composite number of Spawners per year per ESU for all stocks of the species of concern within the ESU. • % fish stocks healthy	ESU (SRR), Statewide
	OR	• The trend in monitored native fish populations in key OWEB investment areas. • % of listed areas where monitoring is adequate • % of federal ESA species de-listed in the last year • % of Oregon ESA listed species de-listed I the last year.	ESU
	FCRPS	• Adult abundance and trends for each listed ESU • Adult survival estimates through the hydro-system	Mainstem Columbia and Snake Rivers. ESU estimates based on models
	USFS	• none	
Juvenile migrant Abundance	WA	• Composite index of migrants trapped at trap sites within the ESU for the species of concern within the ESU • % increasing	ESU (SRR), statewide
	OR	Not specified	
	USFS	None	
Riparian and Instream Habitat	WA	• Composite score yet to be developed for EMAP indicators of riparian and instream conditions • Acres of habitat acquired for salmon recovery	WRIA (HUC 5), ESU, statewide
	OR	Trend in native riparian communities in OWEB investment areas	Not specified

Riparian and Instream Habitat	FCRPS	• Numbers of acres protected, restored or enhanced • Cubic feet of water conserved • Diversion screens restored • Miles of riparian habitat protected, or enhanced in pilot watersheds	
	USFS	This assessment consisted of aggregating road, vegetation, and in-channel data to assess the condition of 6th-field watersheds in an effort to describe the distribution of the condition of watersheds in the Northwest Forest Plan area.	Coastal WA, OR, and CA
Water Quality Index	WA	WQI--An index developed by the Washington Department of Ecology that utilizes dissolved oxygen, pH, temperature, nitrate nitrogen, phosphorus, and turbidity. Data depends upon existing non-random ambient monitoring sites.	WRIA (HUC 5), ESU, statewide
Water Quality Index	OR	• % of stream miles monitored with improved water quality • An index developed by the Oregon Department of Environmental Quality that utilizes dissolved oxygen, pH, temperature, nitrate nitrogen, phosphorus, and turbidity. Data depends upon existing non-random ambient monitoring sites except on the Oregon coast where sites are random.	HUC 5, ESU, statewide
Water Quantity	WA	Acre-feet or water restored to streams.	Statewide and SRR
Fish Passage Barriers	WA	Inventory not complete, but major barriers are identified and tracked in GIS database. Compilation from state agencies and USFS. # of barriers and miles of habitat opened.	WRIA (HUC 5), ESU, statewide
	FCRPS	Miles of stream accessed	
Predation	FCRPS	Annual predation rates and impact on juvenile salmonid survival	
	UCSRP	Evaluate effectiveness of predator control programs.	SRR
Hatchery	FCPS	Hatchery operation reports	

	WA	% hatchery management plans meeting ESA criteria	• Statewide
Harvest	WA	• Number of ESA listed stocks meeting NOAA approved harvest goals • % compliance rate with harvest rules	• Statewide • Statewide
Volunteers	WA	Hours contributed by volunteers	
Restoration Actions	WA	• Amount and kinds of grants awarded by SRFB • Forest Service projects	Statewide and by SRR
	OR	• % of matching funding from grants • % of restoration actions that address restoration priorities	

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