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November 1, 2007

DECISION MEMORANDUM

TO: Council members

FROM: Peter Paquet, Manager, Wildlife & Resident Fish

SUBJECT: Data Management Workplan

PROPOSED ACTION

No action is required at this time.

BACKGROUND

Attached is a draft document entitled "A Coordinating Strategy for Managing Fish, Wildlife, and Habitat Data: Columbia River Basin Framework". This document represents a coordinated effort by the Northwest Environmental Data-Network (NED) and the Columbia Basin Fish and Wildlife Authority Joint Committee to provide a framework for data management in the Columbia River Basin as called for by the Council in 2007-2009 project selection process. At this time, the authors are seeking input and comment from the Council on the adequacy of the proposal to meet the Council's expectations. Once this step is completed we will develop a budget and funding options for implementation of the strategy for presentation to the Council at its December 11-12, 2007 meeting.

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A Coordinating Strategy for Managing Fish, Wildlife, and Habitat Data
Columbia River Basin Framework

A report to
Northwest Power and Conservation Council

By
Northwest Environmental Data-Network & Columbia Basin Fish and Wildlife Authority
Joint Committee

November 13, 2007

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A. Example of How Existing Fish and Wildlife Program Data Project Align to Answer Management Questions

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VISION STATEMENT

Imagine crossing geographic and administrative boundaries to efficiently make policy decisions for regional fish, wildlife, and their habitats. By accessing multiple organization's current and future data and information we can begin to successfully manage the regions dynamic natural systems and their inhabiting fish and wildlife. With effort and organization, we can adopt a common data management strategy that incorporates core data elements, data standards and protocols to enhance information transferability. A data management system connecting numerous entities in the Pacific Northwest would create a powerful tool for effective management planning and scientific monitoring.

Executive Summary

Natural systems are complex, interrelated, and ever-changing. Data and information about natural systems mirror these same properties. Currently ecosystem information is collected across multiple programs and efforts, using many different methods and is maintained in many different technical systems. The result is that it is difficult, and in some cases practically impossible to assemble the data into ecosystem level views that cross geographic, administrative, and political boundaries. This underscores the need for a regional Coordinated Data Management Strategy.

Resource managers and scientists understand that consistent use of data standards and protocols improve the quality of data, enhance its usability, and clarify its purpose. These practices also extend the useful life of the data well into the future. Most data are collected to support specific decision making processes. For the Northwest Power and Conservation Council's Fish and Wildlife Program, data are used from a wide variety of sources to support regional decision making by a wide array of decision makers. Without common understanding and shared standards and protocols, resource managers have "disparate" data sets and fragmented information to answer more and more complex questions at multiple geographic scales (e.g., site, watershed, sub-basin and basin, and regional levels). A strategy that addresses field data collection and storage and a design of regional data structures to move information from collection to reporting is needed to inform decision making. The building of a coordinated strategy will help build a common understanding among the many entities responsible for management of fish, wildlife and their habitats in the Pacific Northwest.

The purpose of the strategy is to meet the need for easier access to important information to inform natural resource management decisions and practices. Steady progress is being made on regional information management. This is especially true since the voluntary formation of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), Northwest Environmental Data-network (NED) and the Pacific North West Regional Geographic Information Council collaborative efforts. That is, there is converging agreement on regional data needs & priorities with consensus building around the NOAA-Technical Review Team Viable Salmon Populations metrics, the High Level Habitat Indicators, Wildlife-Habitat Relationships, and restoration project descriptions as core sets of information critical for the region. Also, to help address this issue, regional coordinating groups convened an Executive Summit (October 2, 2007) to obtain agency commitments towards common core information management practices. The Summit was the first step on a path towards a more systematic and common approach for regional data management.

With effort, organization and the adoption of information system standards and protocols it is possible to create information systems that can "connect the dots" across disparate systems from the local level all the way to the regional level. With numerous entities in the Pacific Northwest involved with various portions of resource management, managing data is a daunting task. Coordination and collaboration are critical targeted functions of a comprehensive data management strategy that starts by establishing partnerships among networks. These partnerships can vary in formality, from requiring binding commitments to simple agreements to collaborate, and are critical for successful data management across the region. The potential of connected systems to inform and improve regional decision making and outreach is very high for subbasin plans, project planning, salmonid recovery, scientific monitoring, water allocation and power generation and many other purposes.

1.0 Introduction

Natural systems including fish, wildlife and habitat[1] are complex, interrelated, and ever-changing. Data and information about natural systems are also complex, used and shared by many, and new data are constantly generated. This underscores the need for a coordinated data management strategy both within the Fish and Wildlife Program and, more broadly, among all entities in the region dealing with these natural systems.

The data management needs and challenges faced by the Northwest Power and Conservation Council (Council) and Bonneville Power Administration (BPA) in planning and implementing the Columbia River Basin Fish and Wildlife Program are often the same problems facing other resource management agencies with data-dependent decision making responsibilities. Therefore, we can look across many different types of data management efforts to find workable solutions.

Resource managers and scientists understand that consistent use of data standards and protocols help refine the quality of data being collected, enhance its usability, as well as clarify its purpose. These practices also extend the useful life of the data collected well into the future. Most data are collected to support specific decision making processes. However, for the Council's Fish and Wildlife Program, data are used from a wide variety of sources to support regional decision making by a wide array of decision makers. Without shared standards and protocols, resource managers have disparate data sets with fragmented information upon which to answer increasingly more complex questions at multiple geographic scales (e.g., site, watershed, sub-basin and basin, regional, state, national, and international levels).

The need for information for the Fish and Wildlife Program goes well beyond the responsibility of individual data collectors. Therefore, a coordinated data management strategy that addresses field data collection and storage and a design of regional data structures that are capable of moving information from collection to reporting to inform decision making is a critical need. In building a coordinated data management strategy, we will help build a common understanding among the multitudes responsible for management of the Columbia Basin's fish, wildlife and their habitats. While focusing on Columbia River Basin (CRB) issues, this strategy is also intended to be consistent with other efforts as well as transferable to the Pacific Northwest region.

In a review of the Council's Fish and Wildlife Program, the Independent Scientific Review Panel (ISRP) has consistently recommended standardized approaches that also allow for the integration of fish, wildlife and habitat goals and information[2,3]. The Council, working with NOAA-Fisheries, conducted a detailed study of information needs for the Fish and Wildlife Program which outlined necessary steps to improve information management[4,5]. The ISRP also

[1] Habitat includes water, air, land and other areas that species occupy
[2] ISRP Database Review, Report No. 2000-3
[3] ISRP Preliminary Review of 2007-09 Proposals, Report No. 2006-4
[4] Science Applications International Corporation, May 2003. Recommendations for a Comprehensive and Cooperative Columbia River Information System. Report to the North West Power and Conservation Council.

recommended that the fish and wildlife elements be fully integrated in the development of Subbasin Plans when they emphasized "coordination, subbasin-scale planning that integrates habitat, wildlife, fish goals, and that incorporates explicit consideration of ecological relationships, including linkages amongst multiple populations of fish, wildlife and their habitat"[6]. Lastly, the StreamNet project reviewed the fish and wildlife data management programs[7], and recommended increased support for information management systems along with developing more efficient information management tools. The ISRP also provided their recommendations on increasing the ability to find share and use the subject data, focusing on metadata and access. "It is critical that metadata (the methods by which the data were collected) be archived in a database structure that maintains the association between primary data and their pertinent metadata. Monitoring data are intended to have a long shelf life (e.g., 50-100 years) and, if the methods are not available, the usefulness of monitoring data is severely limited. We have recommended adoption of a policy requiring that the reporting requirements for projects funded by the program include requirements for delivery of primary data, and their associated metadata, in a standard machine-readable format, within a specified period of time. Compliance with this policy should be a condition for continued funding. The Council has been supportive of this policy."[5]

1.1 Data Management Challenges

The history of information system development in the Pacific Northwest region is, for the most part, ad-hoc. Typically, as different agencies, institutions or projects needed to manage information they mostly went about it independently, creating for example, their own databases, collection methods and reports. While there have been some efforts at consolidation or standardization they have not succeeded or been sustained across the basin as a whole. These individual information systems are called disparate systems because they often don't share the same operating system or language, don't collect data of uniform quality or description and usually cannot "talk" directly to each other.

Over the last 15 years the Internet, geographical information systems, geographical positioning systems and advances in database technology have created better technologies to knit information from these disparate databases into common systems. Today's challenge is to evolve existing systems and processes in a coordinated manner to make better use of these new capabilities

Many agencies and organizations legal responsibilities require decision making based on good science and in many other areas our work depends on environmental data that is: verifiable, highly defined, of high quality, accessible via internet technologies and is based on consistent or comparable methodologies and standards. Many of these needs are not being adequately met.

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[5] NPCC May 2006 *White Papers and Recommendations from the May 25th and 26th, 2005 Intergovernmental Workshop. Beyond Ad-Hoc: Organizing, Administering, and Funding a Northwest Environmental Data-Network. NPCC, Portland Oregon.*

[6] ISRP Retrospective Report, Report No. 2005-14

[7] *Data Management in Support of the Fish and Wildlife Program;, Schmidt, B., J. Anderson, B. Butterfield, C. Cooney, and P. Roger. 2002*

The Northwest Environmental Data Network (NED) is working cooperatively on actions and joint activities to improve the collection, management and sharing of environmental data and information in the Pacific Northwest region. For example NED goals include supporting and coordinating production of a regional data dictionary, the common use of query tools to metadata, development of a regional information Portal tied to the national system, and the development of a data networking and maintenance plan. NED is interested in supporting or helping to develop agreements, standards and protocols and the technology necessary to improve data sharing and discovery across multiple regional partners, and in identifying and promoting administrative, organizational and funding arrangements needed to support regional data management. NED does not intend to be a provider or a manager of data.

The region has three general options for future data management decisions – status quo, a classical systems analysis approach, or a segmented approach. The features of each can be summarized as follows (adapted from the Chief Information Officers Council [8](CIOC) report 1999).

- Status quo – Represents business as usual resulting in continued failure to share information and cope with the rapidly changing environment. This approach would result in business rework, decreased productivity, and lost and missed opportunities. This is the default strategy if programs are not implemented for new ways of managing information.

- Conventional approach – Requires a substantial initial investment in time and dollars. First, a framework must be developed that shows how to prepare an architecture description. Second, the current baseline must be described. Finally, a targeted architecture must be described. Only after these activities are completed, implementing needed architecture changes through design, development, and acquisition of systems can begin. Although this approach appears to be sound, it may result in "paralysis by analysis," because of the complexity of the effort.

- Segmented approach – Promotes the incremental development of architecture segments within a structured enterprise architecture framework. This approach focuses on major business areas (e.g., grants or common financial systems) and is more likely to succeed because the effort is limited to common functions or specific enterprises.

1.2 Précis

The region is already moving with a segmented approach, but these efforts need policy support for continued development and implementation. The purpose of this data management strategy is to unite these efforts in a common framework to improve information sharing needed for regional scale decision making.

With effort, organization and the adoption of information system standards and protocols it is possible to create information systems that can “connect the dots” across disparate systems from the local level all the way to the national level. The potential of connected systems to inform and improve regional decision making and outreach is very high for (at least): subbasin plans, project

planning, salmonid recovery, scientific monitoring, water allocation and power generation and many other purposes. NED and Columbia Basin Fish and Wildlife Authority (CBFWA) have created a Fish and Wildlife Program workgroup to attempt to connect the dots for Columbia River fish, wildlife and habitat data to support the Fish and Wildlife Program. The workgroup has adapted the Federal Enterprise Architecture Framework (FEA-Framework)[8] as an approach for improving practices in the design, modernization, use, sharing, and coordination of information resources in the context of the Council's Fish and Wildlife Program.

The Strategy for Managing Fish, Wildlife and Habitat Data for the Columbia River Basin's Fish and Wildlife Program is a subset of data and information needs of interest to the Northwest Environmental Data network (NED), Pacific Northwest Aquatic Monitoring Partnership (PNAMP), NOAA Fisheries recovery planning, and other coordination efforts that are scoped at a broader regional scale than the CRB. There are other important regional processes where the types of data needs are similar to, and overlap with the CRB. For example, the States of Oregon and Washington and their Federal and Tribal Partners have wildlife and watershed management programs in areas outside of the CRB. There is also an important salmonid recovery initiative for Puget Sound coordinated by effort of the Puget Sound Partnership. Our preferred solution is to support efforts that are transferable at a broader state, regional or even in some cases national and international needs for consistency in data collection and reporting.

The purpose of this strategy is to offer an approach to meet the need for easier access to data-rich information to inform natural resource management decisions and practices. To do this we must first understand the basic information management approaches presently used by the various agencies and the challenges existing to more open information sharing. Secondly, as existing systems evolve, we have a need for a common framework and terminology for coordinating and implementing changes. We propose adapting the Federal Enterprise Architecture Framework as a useful model for achieving the needed level of coordination. Finally, we offer short-term recommendations to address the most pressing needs to sharing information.

2.0 Regional Information Needs

Regional decisions concerning fish and wildlife resources should be based upon sound scientific principles and biological objectives. At the same time, these decisions often affect multiple stakeholder groups, concerned about not only the target natural resource issue at hand, but also about the secondary effects of decisions on other natural resources, on local economies, and even on personal life styles. For instance, during the last round of subbasin planning, local groups were asked to evaluate the biological status and limiting factors for numerous fish and wildlife focal species and develop restoration plans that accounted for anticipated changes in human population, climate change, and local economies. These issues are complex, multidisciplinary in nature, and cross political and bureaucratic boundaries.

The information needed to inform these decisions is equally complex, multidisciplinary, and inter-jurisdictional. A brief review of the information needed to support regional discussions and

[8] Federal Enterprise Architecture Framework. Version 1.1. September 1999. Developed by the Chief Information Officers Council. http://www.cio.gov/Documents/fedarch1.pdf

decisions is needed before we can evaluate present information management practices relative to regional needs.

Currently, there are three major activities around which Columbia Basin regional data needs can be organized. They are 1) implementing the NPCC Fish and Wildlife Program, in particular through development and implementation of subbasin plans; 2) adoption and implementation of recovery plans for those focal populations listed under the Endangered Species Act; and 3) the restoration actions and monitoring and evaluation required under the Federal Columbia River Power System (FCRPS) Biological Opinion. The *Status of the Resource Report* and web site is an example of a monitoring process that tracks and reports the changes in the status of populations and habitats over time.

For purposes of this strategy, regional data sharing needs are described relative to the data content areas, the level of detail, and the needed functionality of the system.

2.1 Data content areas

The data needed to inform natural resource decisions usually comes from three broad areas: the individual populations level of the various focal species, the habitats and habitat conditions level within which the populations reside, and the human impacts level which those populations and habitats respond both positive and negative. A basic premise is that by effecting changes in habitat conditions, society can affect the performance of the fish and wildlife populations to realize desired goals and objectives.

Finally, there is an additional data content area that impacts on natural resources decisions and outcomes. These are catastrophic or significant natural events like flooding, fires, or avalanches. These data types represent uncertainty if natural events in the form of risks and hazards that have direct impacts on natural and human populations.

2.1.1 Populations

Metrics are needed that describe changes in focal fish and wildlife populations over time. For instance, there is a consensus that the NOAA-Technical Recovery Team (TRT) attributes describing Viable Salmonid Populations are the appropriate population-level metrics (abundance, productivity, diversity, and spatial structure). For other threatened and endangered populations recovery plans state the specific metrics required for delisting. Additionally, similar metrics or indices are probably appropriate for other populations like hatchery runs, and other fish and wildlife species of concern or of interest. But, consensus has not been reached on many of these species as to what specific metrics need to be evaluated.

Measures of abundance and productivity (which represents a species survival) are key information to assessing populations. In the case of anadromous populations there are seven life stages: pre-spawning, spawning and incubation, freshwater growth, smolting, ocean entry, ocean growth, upstream migration. These measures would help inform decisions at the various spatial scales through out the CRB. These life stage data would help evaluate critical limiting factors and can be aggregated over the entire life cycle of a population.

2.1.2 Habitats

Habitat conditions should be described at various hierarchical scales so that focal species life histories could be evaluated in context with their habitat components, as well as to evaluate landscape changes. A hierarchical approach can include at one level "high level" indicators and at another wildlife-habitat mapping at a site. Establishing habitat matrices at various levels of scale (i.e. region, basin, ecoprovince, subbasin, watershed and site) would allow overall health of a watershed to be assessed as well as put habitat mitigation at a site in context to a watershed, subbasin or ecoprovince needs. Habitat is a focus of many recovery actions and enhancement efforts because it is tangible, accessible, easier to study than populations, and readily manipulated to achieve desired conditions that can affect a species or population use of an area. Invasive species can also be tracked and monitored.

2.1.3 Human activities

As humans we alter our landscapes which inadvertently changes natural conditions that in turn can cause changes in the performance of our focal species populations. Habitat restoration is a major strategy for restoring and enhancing the performance of many fish and wildlife populations. What we need to know, therefore, is the extent and type of these habitat restoration projects as well as changes in the broader scale patterns of habitat use and populations response that might be occurring.

2.1.4 Catastrophic or Natural Events

Everyone would like predictability, but the reality is we live in a world of uncertainty when it comes to the potential location, frequency, and occurrences of natural events. To address uncertainty, we need to acquire data on the frequency, location, and size of these natural events which allow us to assess risk and hazard influences to habitats and the populations they support.

2.1.5 Basic Framework Data Sets

To operate a functional information framework, basic information data sets need to be developed or adopted and made available. These data sets address key areas which are considered basic and form a foundation from which to build upon and allow comparisons. The data sets allow consistency and comparability between and among other data and represent information that is mostly static, like hydrology units, elevation, major road networks, political boundaries, and state shorelines. As these data sets improve in detail and resolution, then a process is needed to allow older versions to be either renewed or updated. The Pacific Northwest Regional Geographic Information Council is taking a lead role in coordinating the development of these data sets.

2.2 Levels of detail

Another way to characterize the data and information needs in the CRB is according to the level of analysis or spatial extent involved. Regional information sharing needs are broader than just raw data as collected by field projects (Figure 1). Equally important is the sharing of the information created from raw data. This information ranges from data derived from raw data (e.g. survival and productivity rates or summary statistics), through targeted analyses and planning assessments (e.g. hydrosystem survival, watershed assessment or hatchery reform plans) to high level syntheses and integration (e.g. potential impacts of global warming, effects of production hatcheries on natural production, etc.). Most management decisions and communication are based upon this derived and interpreted data and information.

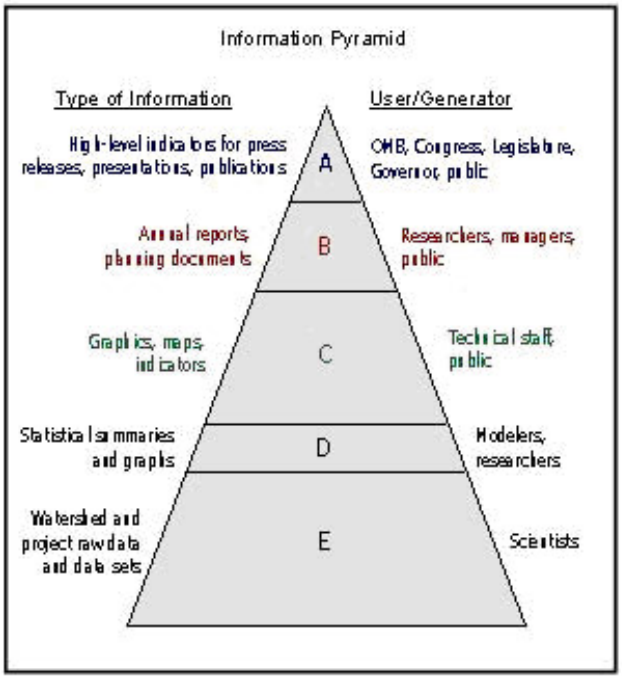

Figure 1. Examples of the types of information required for natural resource management versus how the information is generated in the Columbia River Basin.

2.2.1 Observational (primary or raw) data

Data are created at specific temporal and spatial locations by direct observations, habitat inventories, bird surveys, spawning ground counts, daily fish passage counts past dams, stream temperature are examples of these types of data. These data are typically managed and used at

the local level, often as spreadsheets or single databases. Data management practices at this level vary widely.

Often these data reside on single computers and are not forward to regional databases. The inconsistencies in distributing local data and the often disconnect to allow access to regional databases is a key hurdle to achieving effective regional data sharing.

2.2.2 Summary and derived data

Most management decisions are based upon metrics calculated from observational data. For instance, fishing openings and closures are often based upon an estimate of run size, a desired level of spawners and the proportion of the allowable catch caught to date, not directly on dam counts or landings. Survival and productivity estimates are calculated from estimates of abundance at successive life stages. Reports at the provincial or Evolutionarily Significant Units (ESU) level are often expressed as the percentage of all populations in an area that meet certain performance levels.

Unlike observational data, derived metrics are presented in reports, figures, and tables more often than they are incorporated into databases and maintained over time. If the derived metrics are created by an interagency team, these data can be lost when the team or project is discontinued. Managing for these orphan or homeless data sets is also an important gap in regional information management.

2.2.3 Synthesized data and information

At the upper levels of the information pyramid, data are integrated, synthesized, and interpreted to address broad policy questions (e.g. potential impacts of global warming, effects of production hatcheries on natural production, progress toward delisting populations under the Endangered Species Act). The information at this level is most often distributed in various reports and publications, often in hardcopy format. This information is best captured, maintained and shared using library practices rather than as databases, and however, the underlying data must be maintained and accessible to allow for future discovery and referencing.

2.3 Information Management Functions

Reports on regional information sharing problems consistently cite problems in the areas of data collection, data sharing, and data usage (SAIC[4], ISRP[2,3,6], NPPC[5]). This section briefly describes features that, if regionally implemented by the natural resource management agencies, would address the most frequently cited information problems. We believe this can be done economically and systematically, without requiring wholesale changes to existing information management approaches (see Section 4).

2.3.1 Data collection

Consistent application of a few core practices at the data collection stage would largely eliminate criticism that similar data are collected inconsistently and is of varying quality across areas

within the Basin and across agencies. Development and implementation of the following practices would alleviate these problems.

- Identify core data elements – Standardizing all data elements that resource managers collect is not needed. The first step is to identify those data elements that are used to create regionally-meaningful information at the higher levels of the data pyramid (Figure 1). These data elements are used to create broader scale measures of resource status and trends and track progress toward delisting and restoration goals and objectives. Much of this work has been accomplished, in different forums, for example by the NOAA-TRTs, PNAMP, and CBFWA, however a single Columbia or regional summary of this work and agreement on a core set of data elements is needed.

  For anadromous fish populations, the viable salmon population (VSP) parameters provide a good start for the types of data that should be standardized. Analogous metrics are likely appropriate for resident fish and wildlife populations.

  For habitat conditions, an initial list of core data elements can be derived from the High Level Watershed Indicators reports of PNAMP (2007, in draft) and the NPCC (2007, in draft) or for habitat components at multiple scale the Wildlife-Habitat Relationships in Oregon and Washington (Johnson & O'Neil, 2001).

  For human activities, the most important data elements should describe land use practices, the level of development and actions undertaken to preserve or restore habitat quality (e.g. PISCES, Pacific Coastal Recovery Fund, Oregon Watershed Enhancement Board, and Salmon Recovery Fund Board).

- Develop a common data dictionary for the core data elements – A common data language will avoid misunderstanding and confusion and reduce errors when data sets are rolled up to larger spatial or temporal scales. The NOAA-TRTs, PNAMP, and Northwest Habitat Institute have already contributed many of the data elements likely to be included in a core data set. Further work is needed, however, and care must be taken to develop appropriate "translations" between legacy definitions and a new standard core set of definitions.

- Describe and adopt a set of data collection protocols – The way observations are made and data are collected is equally important to improve data comparability and quality at larger spatial scales. Two notable developments have moved the region closer to more standardized data collection protocols. First, the EPA EMAP statistical sampling framework has gained acceptance among agencies as a robust and statistically defensible method for taking samples of some types of data. Second, PNAMP is working toward developing recommended field protocols for many aquatic monitoring practices. Physical, logistical, and financial constraints will probably preclude complete standardization of methods, but much progress is being made and past criticisms will be greatly reduced as this effort proceeds. These protocols must be published and accessible in common data (or protocol) dictionary, which will need to be maintained to protect the usefulness of legacy data, collected using various collection protocols.

- Use a core set of data QA/QC practices – Well understood data quality is crucial to their use and interpretation, especially as data are shared beyond the original data owner. The NED is proposing work to develop a recommended set of sound QA/QC practices. As these are adopted and implemented problems and confusion about data would be substantially reduced. Portions of these practices can also be automated in data entry and reporting programs, requiring little additional manual effort, but involving programming and other deployment costs

- Timely reporting – The timely capture and reporting of data is a further hurdle to improving regional data sharing. There are many reasons contributing to this problem, but continually improving digital technology provides opportunities to improve data handling at the local level without imposing unreasonable burdens on field staffs. Where local data is essential for periodic regional reporting, agencies should work to develop data production schedules.

2.3.2 Data sharing and management

A regional information management system should include all or most of the relevant publicly-funded data collected, should make that data and information easily discoverable and available quickly through the Internet.

- Develop procedures to capture regional derived and orphan or homeless data sets that can result of emerging issues. As described above, these data are important to developing regional and other inter-jurisdictional management decisions, but they are often at high risk of being lost over time. Procedures must be developed to identify these data and assure its integration and long-term safekeeping. Because these data sets are often developed according to *ad hoc* and irregular schedules, management methods should be flexible and able to respond to unanticipated situations. A budget placeholder would be one appropriate way to provide needed flexibility.
- Use and support the NED Portal to provide easy access to published data sources and spatial products.

2.3.3 Data usage

Biologists, researchers and other scientists who collect and use the available data directly are all involved in its use and interpretation. Data usage would be much improved if the following three problems could be overcome.

- Reports and tools are adopted or created to synthesize and better understand data and communicate this information to stakeholders and policy makers. The State of the Resource Report (SOTR) has made substantial progress in summarizing and communicating data, but other reports and tools will be needed to address other issues.
- Provide better data support to regional and inter-agency efforts (e.g. subbasin planning, hatchery reform).
- Identify data gaps and develop strategies to address them.

2.3.4 Data Storage

A regional information management system will include a data storage infrastructure as part of its maintenance and retrieval protocols. Data storage procedures provide off-site robust and routine data backup solutions along with scheduled updates. Keeping redundant copies of data archived allows a safe guard against unforeseen mishaps as well as preservation of historic versions.

- Once individual projects have been completed within the region, data providers should archive with a repository generated data and information to insure its protection.
- Projects that extend over a year or more should periodically backup raw and derived data with a date and version included in the file title.

3.0 Present Information Management Approaches

Most of the observational data relevant to the Fish and Wildlife Program comes from outside funding sources (Figure 2) while 47% of the data is funded directly or in part from the Program. In the future, the fish and wildlife program percentage is likely to drop dramatically as more information on climate change, human population growth, and economics are incorporated into Program assessments. These and other additional data sources, e.g. Framework data like Light Detection and Ranging (LIDAR) will require increase costs for data management, its analysis and interpretation on the Program and its participants, and therefore will require cost sharing approaches to implement and maintain them.

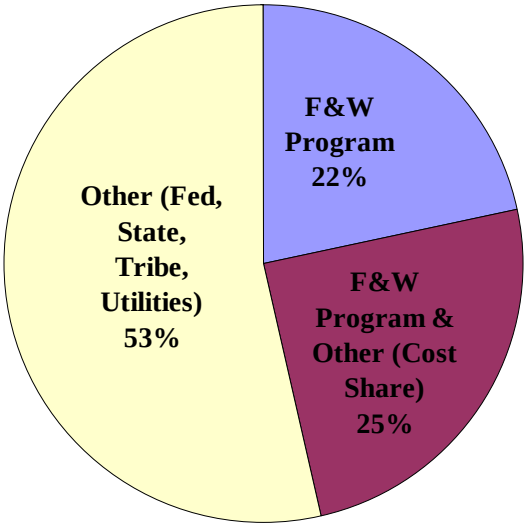

Figure 2. Funding sources for Focal Fish Species Data in All Provinces (2005 Status of Fish and Wildlife Resources in the Columbia River Basin – Summary Report, November 2006).

3.1 Characteristics and key constraints of existing data management approaches

Because of the desire to achieve viable regional data sharing, it is pertinent to understand some of the current constraints. Some of these constraints are institutionalized while others can be addressed administratively. The institutional constraints would be better addressed in an executive collaborative forum. To begin to address these and other information sharing issues, an Executive Summit was held on October 2, 2007 in Portland, Oregon.

3.1.1 Agency-funded data collection

Present information management procedures have evolved over decades to meet specific agency mandates or needs. There are few agency-wide procedures, partly because these were originally costly and difficult to implement, and they tended to focus on functions that involved the public directly and economically (e.g. fishing and hunting licenses, commercial catch reporting) or that legislative bodies examined during the appropriations cycle (e.g. hatchery programs).

Most other data were handled in a decentralized manner by regional offices and individual projects. Standard methods of data collection, quality control, management, and sharing depended upon local skills, experience, and need. Changes and adoption of new technology depended more upon peer-to-peer contacts and discussion than upon agency-wide decisions.

Even though these data may be useful to regional processes, these uses are not part of the routine agency operations and priorities. Consequently, there has been little incentive for local biologists and managers to undertake the extra work of changing data management procedures to accommodate regional needs.

3.1.2 Data collected with Fish & Wildlife Program (FWP) funding.

Nearly half of the focal fish species data collected in the Columbia River basin today is funded, at least in part, under the Fish and Wildlife Program (Figure 2). There has been little guidance to these projects on how they should handle and share these data, other than general statements asking data be reported electronically to a regional repository. Some of the data do make their way into regional databases like DART or StreamNet, but most of it is “reported” electronically in project reports (usually as MS Word or Adobe Acrobat files) maintained by BPA and/or the StreamNet Library.

The NED is working with BPA to develop draft data management guidelines that can be referenced in BPA project contract language.

3.2 Present regional data management efforts

The recent completion of the Council’s subbasin planning effort highlighted the need for consistency and uniformity in fish, wildlife, and habitat data management for use in monitoring

and evaluation at multiple scales within the Columbia River Basin. Several independent efforts to accumulate information from the subbasin assessments have been incorporated into coordinated efforts to develop standardized protocols for collection and management of data for larger regional efforts. Although the subbasin plans were useful for planning purposes at the subbasin scale, they currently do not guide basin-wide decision making (budget allocation and species prioritization) or provide opportunities for the "roll-up" of population specific information (comprehensive benefits). In addition there are frequent reports, for example by StreamNet, of challenges inherent in more consistent use of standards and protocols by states, tribes, and others.

Projects currently exist in the Columbia River Basin, funded by FWP, which provide data collection, data management, and information dissemination services. These projects address the data management issue from a standpoint of fish and wildlife status, trends, and goals standpoint. First, a series of projects have been recently initiated to provide guidance and develop protocols for data collection to support broader monitoring and evaluation efforts within the Columbia River basin and across the Pacific Northwest. These projects were initiated, partially, in response to reviews by the Independent Science Review Panel (ISRP) and the NPCC's 2000 Fish and Wildlife Program and the 2003 Mainstem Amendment. The FWP is currently funding portions of four projects that are coordinating and addressing the issue of common data collection and data sharing protocols. A second group of projects focus on collecting and accumulating fish and wildlife monitoring data. These projects range from on-the-ground data collection, to data management, up to reporting basin-wide efforts.

3.2.1 Existing Common Data Collection Coordination Projects

<u>Pacific Northwest Aquatic Monitoring Partnership (PNAMP)</u>

- Forming a formal organization that includes a Charter signed by 19 state, federal, tribal and regional entities in 2004
- Drafting "Considerations for Monitoring in Sub-basin Plans" for the Fish and Wildlife Program and completed a strategic plan (PNAMP Strategy for Coordinating Monitoring of Aquatic Environments in the Pacific Northwest) in 2005
- Implementing monitoring protocol comparison projects and served as a forum for coordination of monitoring across programs
- Conducting current aquatic monitoring inventories within Columbia River subbasins
- Continuing to facilitate discussions among technical experts and between scientists, managers, and liaison groups for the collective evaluation and interpretation of current and new knowledge regarding issues in need of management or research attention to insure data standards and integrity among and between various monitoring programs.

Collaborative Systemwide Monitoring and Evaluation Project (CSMEP)

- Conducted metadata inventories and identified strengths and weaknesses of fish population data for 13 Columbia River subbasins by working collaboratively with StreamNet and has developed a web accessible database for these data (this effort continues in additional subbasins)
- Developed preliminary monitoring and evaluation study designs for status and trends of fish populations and effectiveness of habitat, harvest, hydro and hatchery actions currently being implemented in the Salmon River Pilot Project
- Planning to continue to collaboratively design improved monitoring and evaluation study designs that will fill information gaps and provide better answers to key management questions in the future through multi-agency collaboration and pilot testing of study designs. CSMEP is implementing the Columbia River Basin portion of the fish monitoring strategy for PNAMP.

Integrated Status and Effectiveness Monitoring Program (ISEMP)

This project is an ongoing collaborative effort to design, test, implement and evaluate status and trends monitoring for salmon and steelhead populations and their habitat, and watershed-scale effectiveness monitoring for management actions affecting salmon and steelhead populations and habitat, in the interior Columbia River Basin. ISEMP takes a pilot-project approach to the research and development of monitoring by implementing experimental programs in several major subbasins of the interior Columbia: the Wenatchee, Entiat, John Day, South Fork Salmon and Lemhi River basins. The overall goal of the project is to provide regional salmon management agencies with the data, information and tools necessary to design efficient and effective monitoring programs.

The PNAMP, CSMEP, and ISEMP projects address issues related to what data are needed, how they should be collected, and what data gaps exist that should be filled by additional sampling programs - key aspects that are most appropriate for biologic specialists. Members of these projects are well positioned to work with data management specialists to develop and agree on data definitions, formats and sharing arrangements across the region.

3.2.2 Existing Data Management, Sharing, and Coordinating Projects

Northwest Environmental Data Network (NED)

NED is a state, federal, tribal and non-profit consortium of 13 entities with an interest and commitment to developing plans and agreements and where necessary promoting technologies needed to improve the quality, quantity and timeliness of data for monitoring and other environmental programs. Development of standards for reporting and exchanging information is a part of the NED mission. NED has launched its web portal to disseminate metadata describing and locating monitoring data sets, completed a set of Best Practices for Reporting Location and Time Related Data, developed a solution for collecting disparate subbasin planning data and successfully completed workshops which

helped bring various groups together to discuss how to share data once it is acquired. The CBFWA Status of the Resource Project intends to work closely with NED to establish web access protocols for the data used to generate annual reports.

The NED project, with collaboration from data collection and reporting projects, can help to facilitate the efficient transfer and sharing of data between regional programs and the discovery of data via the NED Portal.

StreamNet

StreamNet is a data development and dissemination project that provides data related services to the Fish and Wildlife Program and the region's fish and wildlife agencies. StreamNet exists specifically to facilitate transfer of data from multiple agencies for regional use in research, monitoring, management, public education, policy and decision-making. Data are obtained from field agencies and FWP funded projects. The primary data sets are standardized to a consistent format across agencies, quality assessed, and geo-referenced. The data are made available publicly through an on-line data query system and through interactive map interfaces, accessible through the internet and metadata will be available through the NED portal. This makes data available from many agencies that are not able to make data available via the web themselves. The project has also developed an online searchable archive capable of housing data from a wide variety of sources, including BPA funded projects, and making them available over the internet. StreamNet provides indirect support to a variety of management, restoration and monitoring efforts that are designed to protect, enhance, and restore fish populations, and is an active participant in both PNAMP and NED. StreamNet performs the task of posting monitoring data from the management agencies on the internet in regionally consistent format, a function the agencies are currently not structured or tasked to do. Posting data on the internet is a prerequisite for the data to be available through any anticipated distributed database system or portal.

Interactive Habitat and Biodiversity Information System for the Columbia Basin (IBIS)

This Northwest Habitat Institute project operates and maintains an internet website to: 1) disseminate habitat and biodiversity information for eco-provinces and subbasins, and 2) create performance tools to support subbasin and basinwide decision making. The project supports data management for fish, wildlife, and their habitats with information generated from the Interactive Habitat and Biodiversity Information System (IBIS) for the Columbia River Basin. IBIS consists of terrestrial, resident and marine fish information. It is comprised of over 150,000 records on over 1,000 fish and wildlife species and addresses species habitat needs, habitat mapping, species ranges, life histories, management activity influences, biotic functions, ecosystem services and allows geospatial depictions. The IBIS information was developed with the support of over 40 resource agencies and organizations. In 1995, the effort to collect and compile

fish and wildlife information began, and in 1997 the first major milestone was reached with the publication of the book, Atlas of Oregon Wildlife; in 2001 a second major milestone was reached with the publication of the book, Wildlife-Habitat Relationships in Oregon and Washington and the publication of an updated edition of the Atlas of Oregon Wildlife. So far, over 700 people have participated in developing IBIS information.

A principal focus of IBIS is to support a common understanding of fish and wildlife information to allow for better management of our natural resources. IBIS is currently funded for maintenance and operation as a principal informational source for the Columbia River Basin, and is recognized as a "Core Program" for the Columbia River Basin by the Columbia Basin Fish and Wildlife Authority as a "Key Informational Source" for the Northwest by National Biological Information Infrastructure, as "Best Available Science" by the Office of Community Development in Washington State, and as "Best Practices" by the Ash Institute-Harvard University. This project primarily addresses the wildlife portion of basinwide data needs by providing: maps, GIS data and species information for ecoprovinces and subbasins online; it also can support project or site level habitat mapping and evaluations.

Fish Passage Center

The Fish Passage Center provides Columbia River mainstem fish passage data collection, data management, and internet accessibility. The project also collects and stores data for the Smolt Monitoring Program and the Gas Bubble Trauma project and other historical data sets including resident fish data. The data is available via the internet, and the program includes monitoring and evaluation to assess the progress in accomplishing the biological objectives of the program at a basin-wide level. The primary purpose of the Fish Passage Center is defined in the Program to provide technical assistance and information to fish and wildlife agencies and tribes in particular and the public in general on matters related to juvenile and adult salmon and steelhead passage through the mainstem hydrosystem. Specifically, the Program establishes that the Fish Passage Center (FPC) shall: 1) Plan and implement the annual smolt monitoring program; 2) Gather, organize, analyze, house, and make widely available monitoring and research information related to juvenile and adult passage, and to the implementation of the water management and passage measures that are part of the Council's program; 3) Provide technical information necessary to assist the agencies and tribes in formulating in-season flow and spill requests that implement the water management measures in the Council's Program, while also assisting the agencies and tribes in making sure that operating criteria for storage reservoirs are satisfied; and 4) In general, provide the technical assistance necessary to coordinate recommendations for storage reservoir and river operations that, to the extent possible, avoid potential conflicts between anadromous and resident fish.

Data Access in Real Time (DART)

The project provides single-point, internet-based access to a subset of Columbia Basin mainstem information to guide and support BPA's independent decisions pertaining to its responsibilities under the Power Act and Endangered Species Act, as well as tools for data analysis. DART is a second tier data management project that acquires data from other data projects for display and analysis through its online tools. DART provides direct and timely public access to integrated Columbia Basin environmental, operational, fishery, riverine, ocean and climactic data resources for sound management of the Columbia Basin resources and hydrosystem by federal, state, public and private entities.

Routine reporting and analysis by DART provides information on the impacts of the hydrosystem on fish passage. Historical, real-time, and predictive passage statistics provide informative data for managing the hydrosystem in relation to migrating and resident stocks. The real-time analysis and modeling tools facilitate adaptive management for fish passage. In addition, the program presents a comprehensive description of fish passage including pre-season analyses of the impacts of potential hydrosystem operations on migrants; real-time in-season analysis and predictions of smolt migration rate and survival and adult upstream migration; and post-season assessment of the performance of the pre-season and in-season predictions.

PIT Tag Information System (PITAGIS)

PTAGIS is the central repository for all PIT tag information for the Fish and Wildlife Program. This information is available to all entities through the internet. The PTAGIS project provides computer software that facilitates the standard data collection of mark, release and recovery information for PIT tagged fish. The Columbia Basin PIT Tag Steering Committee establishes the data collection standards and methods employed by the PTAGIS project. The Coded-Wire Tag (CWT) Recovery Project is an on-going data collection and data management program conducted by ODFW, WDFW, and PSMFC that supports a coast-wide stock identification system for coded-wire tagged salmonid fish. Within the Columbia Basin, the CWT is used extensively for identification of hatchery and wild anadromous salmonid stocks. In particular, the tag recovery data are used to monitor the status of both threatened and endangered stocks. In addition, the recovery data are used to assess a wide variety of studies designed to improve survival of hatchery-produced salmonids. CWT recovery information also provides critical data for evaluating stock rebuilding programs sponsored by the Fish and Wildlife Program.

Regional Mark Information System (RMIS)

The Pacific States Marine Fisheries Commission hosts the Regional Mark Processing Center (RMPC). This office maintains the on-line Regional Mark Information System (RMIS) to facilitate exchange of Coded Wire Tag (CWT) data among release agencies, sampling & recovery agencies, and other data users. The RMPC also serves as the U.S. site for exchanging U.S. CWT data with

Canada for Pacific Salmon Treaty purposes. Canada houses a second complete copy of Pacific Coast wide CWT data sets. The CWT database houses information relating to the release, sample, and recovery of coded wire tagged salmonids throughout the Pacific region. These data flow to the RMPC in the form of files sent by electronic transfer, and must meet stringent validation criteria for inclusion in the permanent database.

3.2.3 Existing Reporting and Analysis Projects

Status of the Resource Project – CBFWA

The CBFWA Status of the Resource Project is an interactive web based interface to fish and wildlife status, trends, and goals data, and it will address specific responsibilities such as identifying data gaps, coordinating data reporting, and making data available via the internet. The state, Tribal, and federal fish and wildlife managers will, through CBFWA, be responsible for ensuring that the important data are available, reliable and adequately documented. The project will develop, produce, and distribute an annual resource status and trends report of focal species (fish and wildlife) relative to biological objectives in subbasin plans. In addition, the project will develop (i.e., summarize existing data and analyses from existing reports and personal interviews), produce, and distribute a project implementation report that tracks and assesses the implementation and success of fish and wildlife projects funded through Fish and Wildlife Program. The primary responsibility that CBFWA brings to regional data management is a commitment by its Members to assist in developing a regional level report of fish and wildlife data in a consistent and transparent manner through a web site and annual report. A significant portion of the fish and wildlife status and trends data necessary to provide a comprehensive data package for the basin is not funded through BPA but is the responsibility of the Tribes, and state and federal fish and wildlife management entities.

3.2.4 Existing Management Reporting Project

Pisces - BPA

Pisces is a project management software tool developed by BPA for managing the funded projects within the Fish and Wildlife Program. BPA created Pisces to help manage fish and wildlife projects throughout the Columbia River Basin. Pisces provides a collaborative environment, where Contractors and BPA project managers can create and manage Statements of Work based on work elements. Program partners will be able to access reports on all aspects of the program's activity. Pisces is a web-enabled software tool.

Data protocols developed by the CSMEP NED, and PNAMP, and approved by regional executive will be used by data collection projects in data collection programs. It is then anticipated that BPA will be tasked by the NPCC to enforce, through project contracting, the implementation of regionally developed data collection and reporting protocols. The data management projects should then be provided clear guidance on which data are most important

to have in a uniform format, and tasked to work with NED to insure that data are accessible and available. These requirements should be met and maintained to feed into the regional reporting required to support the CBFWA Status of the Resource Project and other regional data portals available on the web.

Data management projects should focus on development, quality assurance, and maintenance of priority databases and insure that data continues to be readily accessible via the internet. This strategy supports the recommendations from the recent ISRP review that called for clear direction to StreamNet on their data management activities. There is a particular interest in improving both the quality and timeliness of data from StreamNet. It is anticipated that in the near future NPCC will ask BPA to require all Fish and Wildlife Program monitoring projects to make their data accessible electronically through the internet, via StreamNet, IBIS, or other web based data projects. Lastly, all project metadata should also be made available from all FWP funded projects to the NED portal.

3.3 Progress to date

The desired outcome described above identifies very significant changes that must occur both within and outside the Fish and Wildlife Program before we can achieve the information sharing goals described in the NPPC Data Center white paper[9]. While much remains to be done, those tasks should be viewed within the context of very substantial progress made over the last two decades. In 1988 data were closely held by all agencies and sometimes required legal action or tedious negotiations before they were shared with others. Benefits of developing a set of common principles and practices for data management however, were not well understood by the agencies at that time.

Today, advances in data handling technology, a greater degree of trust among resource managers, a recognition that they all share similar data management problems, and very limited resources have led agencies to greater cooperation in addressing common data management issues. The CSMEP project brought agencies together to coordinate approaches to a number of persistent monitoring questions. The voluntary creation of PNAMP to share monitoring resources and NED to share data management resources for all these groups to develop common solutions is a significant step forward.

3.3.1 Guiding principles based on lessons learned

With progress has come sometimes with setbacks and frustrating experience. Yet these lessons guide our efforts to move forward. The following conclusions from efforts to date are incorporated into our strategies and recommendations for moving forward.

- Consistent data management practices (not just technology) require policy-level support. The existing systems cannot evolve and incorporate core regional standards without support from relevant policy levels.
- Data have value beyond their initial purpose – The whole **IS** greater than the sum of the parts. The synergistic benefits from being able to use data in expanded and more

[9] NPCC, 2006. *Columbia Basin Data Center Proposal* http://www.nwcouncil.org/library/2006/2006-7.pdf

integrated analyses and applications adds additional value to all the prior data collection and management efforts.

- Coordinating and planning ahead for data sharing is cheaper, faster, and provides higher quality data than acting after the fact. Information management must always be a proactive endeavor. Some flexibility, for example through a "data placeholder" account, is necessary to react to unexpected activities as they arise.
- Effective information management is an ongoing effort, not an episodic task. A sound data management strategy should be part of core funding considerations during project funding cycles.
- Most of the regional information sharing needs involve summarized, derived, or other analyzed and synthesized data, rather than the original observational data from which the derived metrics are calculated.
- Derived data and analyses created during inter-agency technical projects (orphan or homeless data sets) are at particularly high risk of being lost over time, if they are not captured and integrated into the regional network.
- Connecting local data sets to shareable agency or regional databases is an important need for improving data sharing. Developing efficient methods to move data from field collection will yield the large benefits. Solutions should focus on improving data management at the local level, not simply transcribing these data into standardized regional formats.
- Effective regional information sharing will require hybrid solutions. A combination of database technology and library technology will be needed to handle information at all levels of the information pyramid (Figure 1). Data management schema may require both distributed and warehouse approaches.

3.3.2 Summary of accomplishments to date

Steady progress is being made on many of the problems underlying an effective information sharing approach for the Columbia Basin. This is especially true since the voluntary formation of the PNAMP and NED collaborating groups. In particular, the following accomplishments over the last few years are forming the foundation for continuing significant progress over the next several years.

- Converging agreement on regional data needs and priorities – consensus is building around the NOAA-TRT VSP metrics, the High Level Habitat Indicators, and restoration project descriptions as a core set information critical for the region to move forward.

- Useful tools and procedures are available to build upon so that we will not have to start anew. Many of the logistical problems on how to manage data efficiently and effectively are being addressed by the following efforts.
    - EPA Water Quality Exchange
    - ISEMP data capture applications
    - IDFG Fish and Wildlife Information System
    - Commercial software

Agencies can evaluate, adopt or modify these tools to fit specific local needs. There is probably no need to develop new solutions independently and from the ground up as has often been necessary in the past.

- A draft "Best Practices for Regional Data Collection, Sharing, and Exchange" (NED) document is being developed. This represents a technical consensus on achievable practices and procedures that can be implemented across agencies. The challenge will be to reach consensus on standards and deployment and to educate and train staff in their application.
    - Metadata
    - QA/QC procedures
    - Data dictionary
    - Publishing to the Internet

- Recommendations on data collection protocols (CSMEP and PNAMP) – the CSMEP and PNAMP groups are developing recommended methods to improve standardization and comparability of field data collection. These efforts are also coordinating with NED and the existing data projects to incorporate sound data management practices as part of data collection efforts[10].

- Location and time data standards – Consistent recording of time and locational data along with field observations allows traditional field observations to use a host of Geographic Information System applications for expanded data analysis and communication with stakeholders. NED has developed Best Practices that can now be deployed

- NED Portal – As problems are solved at the collection and management levels, Internet portal technology will allow a wide variety of data users to find and examine those data. This ability is crucial for, among other things, developing interdisciplinary collaboration to address complex future issues.

- New data layers (e.g. limiting factors, global warming, subbasin plans, PNW RGIC, population growth) – are continually being developed. Increasingly, they are incorporating regional recommendations for standards that will improve integration and analysis of this information.

- New tools, such as the Pacific Northwest Habitat Classification System (PHaCS) an inventory of the current habitat classifications being used within the region. The PHaCS recorded over 60 classifications, lists each habitat classification components, and crosswalks each component to IBIS hierarchical classification. This is the beginning of developing a common language for habitat classifications within the region.

[10] Northwest Environmental Data Network. 2007. *Best Practices for Reporting Location and Time Related Data* http://www.nwcouncil.org/ned/time.pdf

4.0 A Regional Strategy for Moving Forward

4.1 Inter-agency agreements and commitments

Developing a coordinated data management strategy depends on the adoption of administrative and business practices, agreements, and standardized protocols. To effectively develop these elements, executive coordination and consent are needed. The targeted architecture represents an end-to-end approach to data collection, reporting, management (or handling), discovery and sharing. This approach includes: more consistent use of best practices and standards by content groups (e.g. PNAMP), systematic attention to data quality throughout data management, use of regional-scale tools to making published data discoverable through metadata, migration towards distributed database management technologies (e.g. within NED), and the development and use of data sharing agreements and practices to make data available

4.2 Shared principles

• Data should be owned and managed "at or near to the source", when possible, the goal is not to duplicate multiple copies of the data but rather efficiently access, service and maintain these data. This is not to say that data sets can not be housed redundantly in a central warehouse as a means to assist in access, serving and establishing an off-site backup of the data. This does not necessarily eliminate the need for NED or other organizations to compile and host some data (e.g., where a particular data collector has bandwidth issues, complex security issues, or can be put into a regional context), but it does minimize this requirement.

• Data will be accessed via a small number of industry-standard interfaces. For our example there are currently four standards interfaces from the Open GIS Consortium (OGC) are used: the Web Mapping Service (WMS, map-like views of information), the Web Features Service (WFS, retrieve and update geospatial data), Web Coverage Service (WCS, geospatiial coverages) and the Web Processing Service (WPS, pre-programmed calculations and/or computation models).

• Data will be exchanged using self-describing technology like eXtensible Markup Language (XML).

Principles Adapted from the FEA Framework report will be used to develop and incorporate these ideas into NED Best Practices documents.

- Standards: Develop and adopt a core set of technology standards. The region should adopt open system standards in which the interrelationships of components are fully defined by interface standards available to the public and maintained by group consensus. An open-system architecture is the goal; however, initially only partially open systems will be attained. This principle could lead to use of JAVA and future JAVA-like protocols, which give a high priority to platform independence.

- Data Collection: Minimize the burden on data collectors. Data standardization, including a common vocabulary and data definition, will take time to achieve but is critical. A common approach eliminates redundancy and helps ensures data consistency. To ensure

success, business units as well as IT personnel should be involved. Each data element should have a trustee accountable for data quality.

- Functionality: Take advantage of standardization based on common functions and customers. Agencies should develop or design reusable components or purchase architecture components, recognizing that these items are designed to obtain a particular functionality. Standardization on common functions and customers will help resource managers implement future changes in a timely manner.

- Information Access: The region should develop a diversity of public and private access methods for information, including multiple access points, the separation of primary or "raw" from analytical and derived data, and data warehousing/distributed data management system architecture(s). Information access and display must be sufficiently adaptable to a wide range of users and access methods, including formats accessible to those with sensory disabilities.

- Proven Technologies: Select and implement proven market technologies to facilitate efficiency across the region. Incorporating proven technologies in a timely manner will help to keep the region up to date and on the forefront of evolving systems. These technologies should also be based on accepted industry data standards and processes to ensure compatibility between systems. Systems should be decoupled to allow maximum flexibility for incorporating new technologies.

4.3 A conceptual approach

With hundreds of entities in the Pacific Northwest involved with various portions of resource management, managing regional and cross jurisdictional data is a daunting task. Consequently, coordination and collaboration are critical targeted functions of a comprehensive data management strategy that starts by establishing partnerships among Networks (Figure 3). These partnerships can vary in formality, from requiring binding commitments to simple agreements to collaborate, and are critical for successful data management across the region. Formal agreements are preferred because they define the responsibilities for management of the information resource.

Networks are defined as a broad collection of organizations, entities, agencies, or Nodes (referred to collectively as "communities of interest") that share similar roles in the overall data management schema. For example, Northwest Environmental Data Network (NED) was developed to improve the quality, quantity, and availability of regional data and related information on fish, wildlife & their aquatic and terrestrial habitats from multiple organizations and agencies using a publicly supported approach to information systems management. Natural Resource Information System (NRIS) and National Biological Information Infrastructure (NBII) are also data sharing networks.

Nodes are a collection of applications and projects that are provided by organizations or agencies that have made an agreement to serve as the centralized location for different types of

information. Nodes would therefore be required to follow guidelines, standards, and protocols set forth in a shared Framework (described in subsequent sections). Some examples of regional nodes include; StreamNet, Northwest Habitat Institute (NHI), Fish Passage Center (FPC), and Pacific Northwest Aquatic Monitoring Partnership (PNAMP).

Portals refer to an information discovery and sharing application that is designed to facilitate communication and sharing of geographic data and resources to enhance government efficiency and improve citizen services. This tool usually includes 1) a centralized metadata database and search engine to discover and download any type of data (e.g., spatial, tabular, publications); 2) a metadata development template, manual upload service, and automatic harvesting tools; 3) indexes and organizes tabular data, spatial data, and other electronic products such as publications; and 4) provides a current inventory of all data published in the standard format. Additionally, portals can also have: 1) a map viewer to allow viewing and overlay of spatial data; 2) a gazetteer of standard place names; and 3) a web service compliant to allow connection to and use of web-based industry standard services in a distributed environment. An example is the NED portal.

The conceptual approach includes three overlapping communities or networks; note some groups can operate in several communities (Figure 4).

Each community is described below:

1) A Data Provider Community, comprised of Data-Generating Nodes (such as a Monitoring Node), and other projects that generate raw data or facilitate providing access to raw data via the Internet;
2) A Data Systems Community, comprised of Data- and Information-Distribution Nodes, Portals and projects. Groups working within this community provide data, information (derived data, analyses, and reports), as well as information tools and services; and
3) A Data User Community, comprised of Client Data Users (which are sometimes Nodes, but often projects or individual entities).

Nodes within the communities use the Internet to facilitate collaboration via information exchange. Each Node follows appropriate (i.e. Network-specific) components, standards and protocols consistent with the framework. A broad conceptual example within the Pacific Northwest of how several Protocols interact and collaborate, including data creation, flow and coordination is illustrated in Figure 5.

Nodes currently funded by the Fish and Wildlife Program include Fish Passage Center, StreamNet, Northwest Habitat Institute (IBIS), Data Access in Real Time, and the NED Portal. These nodes would become more connected via the Internet and to other substantial data sharing nodes funded through additional projects, State, Federal and Tribal agencies, and others.

In a recent analysis of the first annual Status of the Resource report, in which a population abundance indicator was provided (where available) for every focal population identified within the Council's Subbasin Plans, it was determined that BPA (the Fish and Wildlife Program) directly funds less than 22% of the data required to create the report (Figure 2), and cost shares on another 25% of the data. Other tribal, state, federal, utilities, and NGOs, not affiliated with

the Fish and Wildlife Program provide over 50% of the data necessary for regional fish and wildlife management decision making.

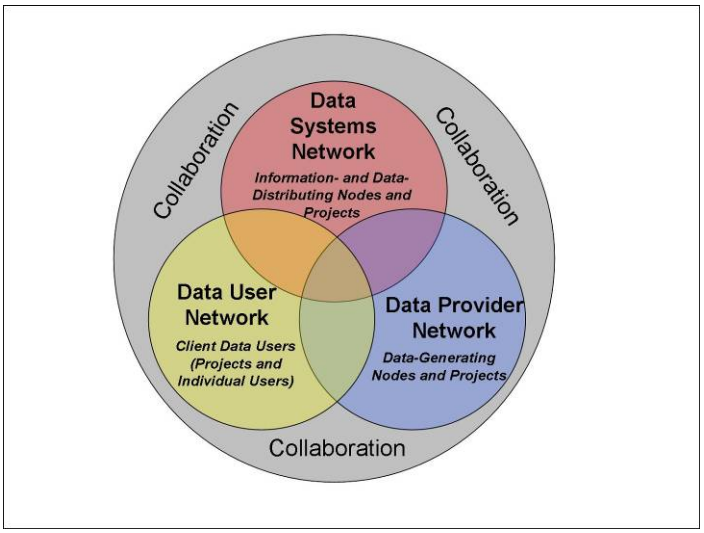

Figure 3. Example of Types of Networks: Data Systems, Data Providers, and Data Users.

Error! Objects cannot be created from editing field codes.

Figure 4. Example of Networks as communities of interest accessible through the Internet.

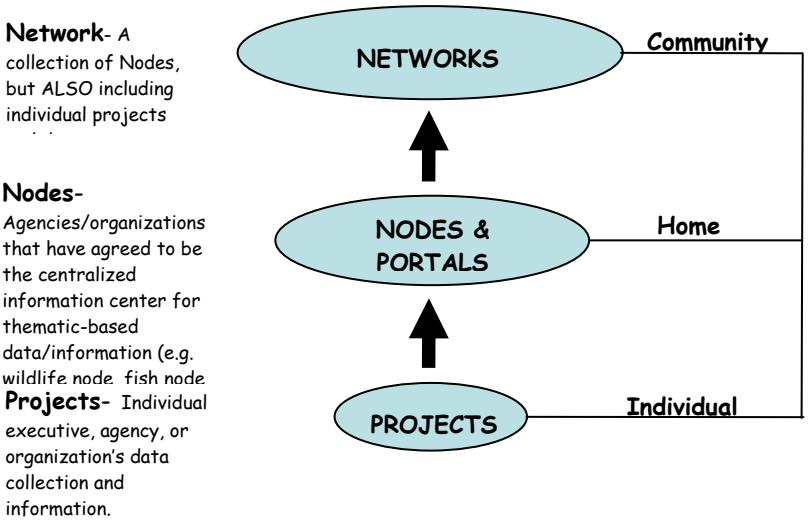

Figure 5. Pathway for individual projects to reach data sharing networks.

4.3.1 Building off the FEA Framework

The FEA framework is a conceptual model to define and document a coordinated structure for cross-cutting businesses and design developments by government and with partners. The framework can be applied where a structure is needed among multiple State and Federal agencies.

The FEA Framework can guide the Fish and Wildlife Program, the Council, BPA and partners in building a shared development for common data management processes, interoperability, and information sharing. This is appropriate, as the FEA Framework is recommended for use whenever Federal business areas and substantial Federal investments are involved with international, State, or local governments. This shared framework allows individual organizations to work their architecture issues within the broader context of the FEA to reap benefits of resource sharing and interoperability.

This goal of greater openness and sharing between today's natural resource data repositories is shared in the data provider, data user, and data systems communities. The present data networks and nodes have each developed using internally consistent principles and frameworks. However, the individual frameworks have focused on meeting internal agency or program needs and communication across diverse nodes and datasets was not a major consideration in the designs. Consequently, today we are faced with data systems that have difficulty communicating with each other.

We propose to be guided by the FEA as the organizing framework for moving toward more collaborative regional data efforts (Figure 6). This framework was developed specifically "to promote shared development for common . . . processes, interoperability, and sharing of information among" diverse information systems. Other reasons for organizing efforts with a FEA Framework include:

- The approach is robust and flexible. It was created by some of the leading systems architects in the world. It is unlikely we can do better, locally.
- It can be adapted to individual needs and is nonrestrictive.
- It is, or will be, already being used by federal resource managers as they review and modify their own information management programs.
- The conceptual approach is extensible to state, tribal, and NGO data management efforts.
- It provides a common language to address common problems.
- It integrates both business models and technical models for information management.
- We would not be recreating the wheel - Pacific Northwest natural resource data coordination problems are similar to the problems faced by federal agencies and addressed in the CIOC report (1999).

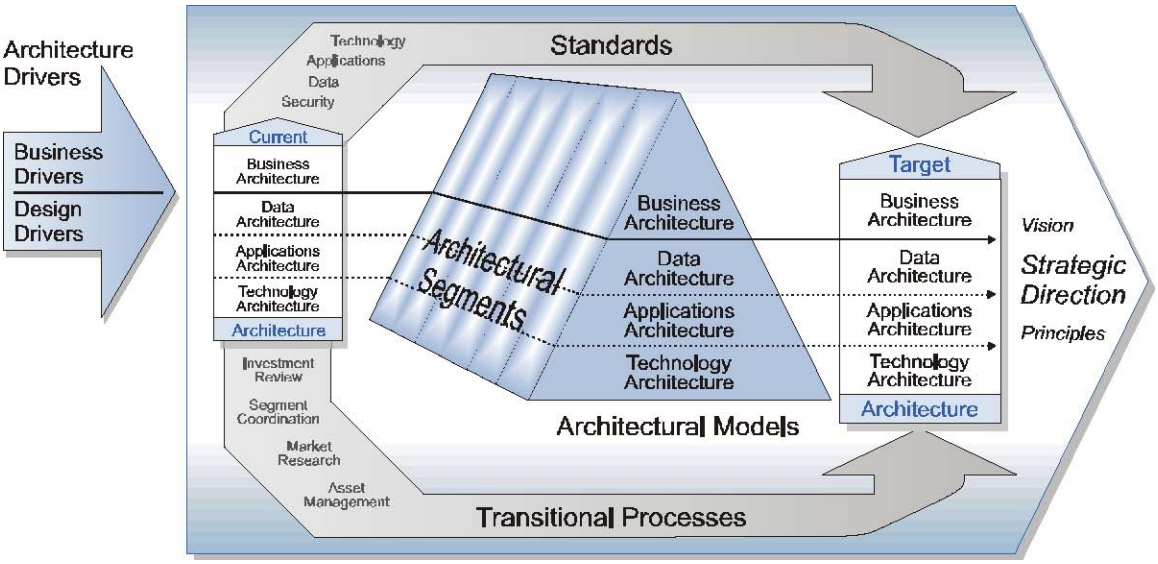

Figure 6. Federal Enterprise Architecture Framework.

This strategy is an end-to-end approach to data collection, reporting, management (or handling), discovery and sharing and includes: 1) more consistent use of best practices and standards by content groups, (e.g. within PNAMP for collection of aquatic data), 2) for systematic attention to data quality throughout data management, 3) regional scale tools for making published data discoverable through metadata, 4) migration to distributed database management technologies, and 5) the development and use of data sharing agreements and practices to make data available that has either been unavailable at all or unavailable in a time to be used for needed.

When applying the FEA framework to the Columbia River Basin scale (Level II, Figure 7), the primary data needs support the Northwest Power Act, the Endangered Species Act as it applies to the Federal Columbia River Power System and recovery planning for other anthropogenic influences on fish and wildlife management (like hatchery runs, water releases, and fishing harvest) . These data consist primarily of population, habitat and project information.

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Figure 7. FEA framework applied at the Columbia River Basin scale.

The strategy recognizes the value of data being collected by others (states, tribes, etc.) that help to support Fish and Wildlife Program implementation and effectiveness efforts including actions required under the various FCRPS Biological Opinions.

The desired state of regional network data/information for populations, habitats, and human actions is a network of data networks that would provide decision makers, researchers and the public with access to comprehensive data/information they trust. Standardized regional data collection, quality assurance and storage protocols would be implemented and used by all data gathering and processing entities and priority legacy data would be brought into conformance with standard storage schemas.

Data gathered within any basin by any project on any topic (such as juvenile Spring Chinook out migration), could be included in queries, summary statistics or trend analyses encompassing other basins or projects in a timely and meaningful way. Processed data (information), in the form of interpretive reports would be indexed and easily accessible through search engine functionality. All data and information would be geo-referenced with common parameters to allow spatial analysis and presentation. Metadata and data dictionaries would be complete, concise, available via the web, and inclusive of the regional information spectrum. Most of the forgoing depends on a clear understanding of data content and the adoption and use of data standards/protocols for network participants.

4.3.2 Coordination and cooperation

Regional coordination and cooperation requires the development of core standards and practices that promote inter-agency information sharing while maintaining individual agency flexibility. A coordinating strategy based on cooperation will provide a forum for organizing regional programs. That in turn will improve communication, shared resources and data and create solutions that add value to the efforts of cooperating partners.

4.3.3 Building a common language

Because of disparate data sets and habitat classifications, it is preferred to adopt a common data management approach that incorporates a common language built upon core data elements, data standards, and protocols that will enhance information access and transferability. To illustrate the need for a common language some 67 terrestrial and aquatic habitat classification systems that are in use within the CRB were compiled in varying detail, organization, and content. Cross-walks were then established between the various habitat system categories and the Interactive Habitat and Biodiversity Information System (IBIS) because it provides detailed descriptions of three category levels (Habitat Types, Structural Conditions, and Key Environmental Correlates), and applies to terrestrial, aquatic, wetland, and marine environments. The results show many categories could not be cross-walked and many of these categories were not even habitat elements. So our ability to have a clear understanding of at least core data elements is a needed first step towards efficiently and effectively using other data. A connected

data management system with numerous entities in the Pacific Northwest will create a powerful tool for effective management planning and scientific monitoring of our natural resources.

4.3.4 Efficiency

The development of a coordinated regional strategy for managing fish, wildlife, and habitat data will improve efficiency of management and policy based on shared expertise and past viable solutions (e.g. sharing of lessons learned through decades of fish and wildlife management). A coordinated strategy and framework will make it easier to automate tasks and procedures to reduce overall work load. Greater data compatibility will also increased scientific credibility and cost-effectiveness of limited funds.

4.3.5 Shared goals

Sharing common goals means developing a comprehensive data management strategy that ensures efficient use of fish and wildlife information, research, and monitoring data. Similar goals also will provide long-term support to implement the data management strategy. Identifying key components that can improve data-gathering and analysis at various scales will become easier with shared goals and a unified vision for regional data management.

4.3.6 Work within a common process

To begin to coordinate a management strategy agencies and organizations will use the FEA Framework architecture as a tool to coordinate the expertise, elements, and projects needed to improve information sharing. And to the extent possible, use standard commercial technology along with adapting to “Open Source” concepts and practices to share information. Organizations and agencies will then work through a common process, the “wedding cake” which is a seven-step process to improve regional information sharing based on the FEA Framework (Figure 8).

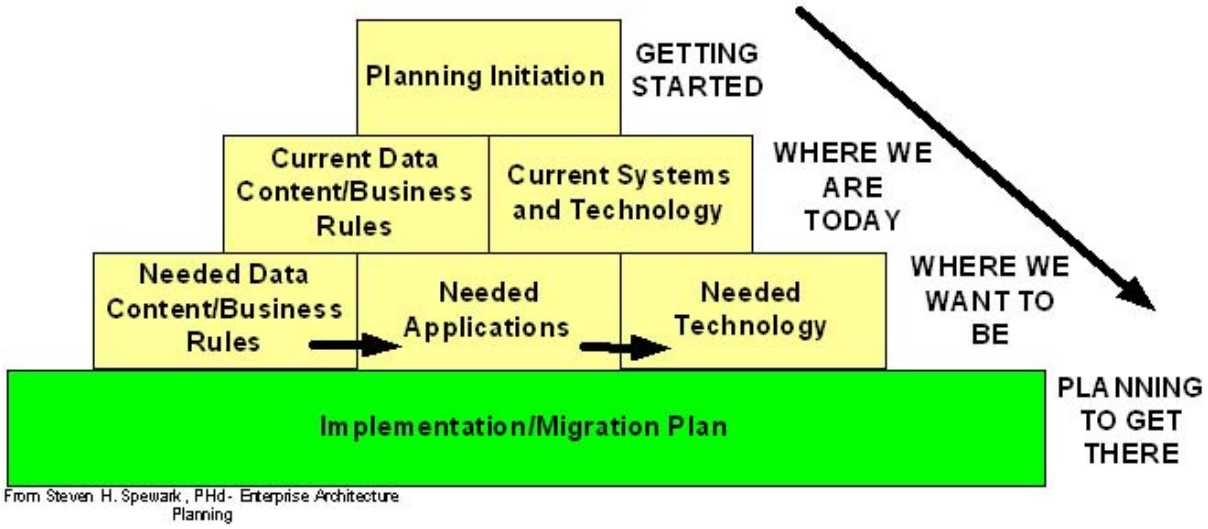


Figure 8. The "Wedding Cake" process is a step-by-step way to systematically identify, design and deploy the FEA Framework.

4.3.7 Share responsibility for implementation

In order to develop a coordinated data strategy organizations and agencies need to share responsibility for its implementation. Responsibilities includes: Organizations and agencies incorporating Best Practices, sharing technology and applications (pool resources), developing cost-share arrangements, evaluating alternative technologies (e.g. PNWWQX, ISEMP, NED Portal, IDFG, etc.) and where appropriate start with small scale pilot and prototype solutions.

5.0 Recommendations

Three short term actions are needed to progress toward more effective information management and sharing needed to manage the Fish and Wildlife Program. First, at a broad scale, resource management agencies and others need to develop a common set of core information management practices and guidelines. These should take advantage of ongoing technological advances and reduce the present cost of converting data from disparate systems into common formats and delivery methods. Second, critical data gaps should be filled. Particularly important is the potential loss of orphan data sets and data that are not organized into database formats. Finally, use incentives where possible to encourage agencies to adopt more effective information management practices. For instance, common data management tools and applications needed to be implemented in a manner that does not significantly increase the workload for data providers.

Sharing existing resources (principally staff expertise and time) can also reduce the development and deployment costs for each agency.

A critical need is to design and test important missing pieces and practices to achieve the data system functionality called for by the ISRP and recommended by the SAIC report and NPCC "Data Center" proposal. While the focus should be on the Columbia Basin, NED could also proceed with broader (regional) geographic data issues. Some uses of this pilot period may only be applicable to the Columbia Basin, and careful consideration has been given to avoid approaches that may directly conflict with data management needs of participating agencies working outside of the Columbia Basin. Appendix A and B depict how the current data projects are setup to answer questions and outline the existing entities and how they would align with the key functional components of the FEA Framework.

. Specific actions include:

- Realign existing projects within this framework
- Create pilot efforts to address gaps
- Identify the priority data that needs to move from collection to reporting to provide the most cost effective and accurate information to support decision making. This may include data format, metrics, and general best practices for data collection to support management needs.

5.1 Develop strategies and guidelines to facilitate regional information management and exchange

Standards and/or best practices are being developed, documented and distributed for comment. A regional dialog is needed to complete development of Best Practices and adopt deployment strategies. Depending on the needs of regional decision-makers these may be made mandatory or voluntary. All of the standards and best practices should be designed and focused on promoting interoperability and to support the data sharing architecture.

NED is currently working on Best Practices recommendations and an implementation strategy for policy support. The following issues are being addressed:

- Metadata and metadata tools. Metadata is essential for exchanging, sharing and using data. For distributed architectures they provide the basis for searchable indices of information

- Geographic data guidelines: latitude and longitude, map coordinate datum and map coordinate projection.

- Data management guidelines: for example common calendar/data policy, methods codes, regional data dictionary, common monitoring methods, codes and station names

- Quality assurance and quality control practices: Procedures and consistent approaches to complete quality assurance and quality checking. Users of data must be able to understand the quality of the data

- Documentation guidelines for derived data: Written material that explains how the product was generated and what assumptions were used. Much is maintained in a metadata record however it is important that detailed descriptions of data derivation be maintained.

- System security protocols: It is necessary to define security protocols and chain of custody, for certain shared data sets, for example: who has ability to create, update, delete or edit data files. Users also need to know that the data is backed up and/or mirrored data sets are available.

5.2 Address critical data gaps

The Data Management Workshop sponsored by CBFWA, the SOTR project, NED discussions and other forums have identified critical short term data gaps. These gaps are to be addressed by the following actions in FY08-09 [also see Data Coordination Project Needs Report FY 08 & 09 (10-25-07)].

1. The StreamNet project will address salmon abundance and productivity gaps identified by SOTR and CSMEP by:
    - Maintaining the functionality of the present system
    - Reprioritizing data efforts as requested by NED/CBFWA DMFS work group to
        - Update and expand SOTR abundance data
        - Develop pilot efforts to obtain productivity metrics
        - Provide services as needed for the CSMEP project
    - Develop a plan to address internal agency data flow bottlenecks

2. The Northwest Habitat Institute will address data gaps by:
    - Maintain IBIS and other existing data sets
    - Update and refine wildlife basin, ecoprovince, and sub-basin habitat maps, including a hierarchical approach for habitat mapping (coarse-scale to fine-scale).
    - Develop wildlife, habitat, and GIS tools and services. Including developing and maintaining map services, a wildlife data collection tool on the Internet, a regional GIS Repository for wildlife and habitat data, and provide GIS support to state agencies and tribal organizations.
    - Work with wildlife managers to develop, implement and support new Habitat Assessment protocols to evaluate mitigation and impact sites.
    - Work with wildlife managers to develop a database for support of operational loss assessments (e.g. how operational changes affect wildlife populations and functional relationships) c.f. Scott Soltz (wildlife M&E white paper).

3. Provide one-time additional funds through StreamNet to capture orphan data from the Hatchery Reform project.

4. Identify tribal data management and sharing options and evaluate potential solutions through StreamNet.

5. Deploy the NED Internet Data Portal.

5.3 Use incentives/ business rules to implement change

There are five ways to provide incentives for implementing new information management practices – increase functionality and value, reducing overall cost of change, and increasing the available resources.

- Increasing functionality and value – by providing access to more information; new reporting and decision support tools

- Reducing cost – no single entity bears full cost of developing new practices; local costs are minimized by greater automation of procedures

- Increasing resources – through collaborative efforts and shared staff expertise and applications

- Add language to contracts requiring data management practices consistent with the NED Best Practices Guidelines and publishing to the Internet.

- Developing policies and procedures that support the above practices

6.0 DEFINITION OF TERMS

CIOC – The Chief Information Officers Council serves as the principal interagency forum for improving practices in the design, modernization, use, sharing, and performance of Federal Government agency information resources. The Council's role includes developing recommendations for information technology management policies, procedures, and standards; identifying opportunities to share information resources; and assessing and addressing the needs of the Federal Government's IT workforce.

Columbia Basin Fish and Wildlife Authority (CBFWA) - coordinates and promotes effective protection and restoration of fish, wildlife, and their habitat in the Columbia River Basin.

Community- a collection of Nodes, but ALSO including individual projects and data users

Data Dictionary- is a set of metadata that contains definitions and representations of data elements.

Independent Scientific Review Panel (ISRP) - reviews individual fish and wildlife projects funded by Bonneville Power Administration and makes recommendations on matters related to those projects.

Light Detection and Ranging (LIDAR) - is a remote sensing system used to collect topographic data. This technology is currently being used by NOAA to document topographic changes along shorelines.

Metadata- is data about data. An item of metadata may describe an individual datum, or content item, or a collection of data including multiple content items.

Open Source - is a development method for software that harnesses the power of distributed peer review and transparency of process.

Pacific Northwest Geographic Information Council (PNW-RGIC)- council developed to strategically optimize the coordination of cost-effective acquisition, development, use, exchange and management of geospatial data focused on Oregon, Washington, northern California and Idaho

Portal- is a catalog of geospatial information containing thousands of metadata records and links to live maps, features, and catalog services, downloadable data sets, images, clearinghouses, map files, and more. Metadata records found with in portals were submitted by government agencies, individuals, and companies, or by harvesting data from geospatial clearinghouses.

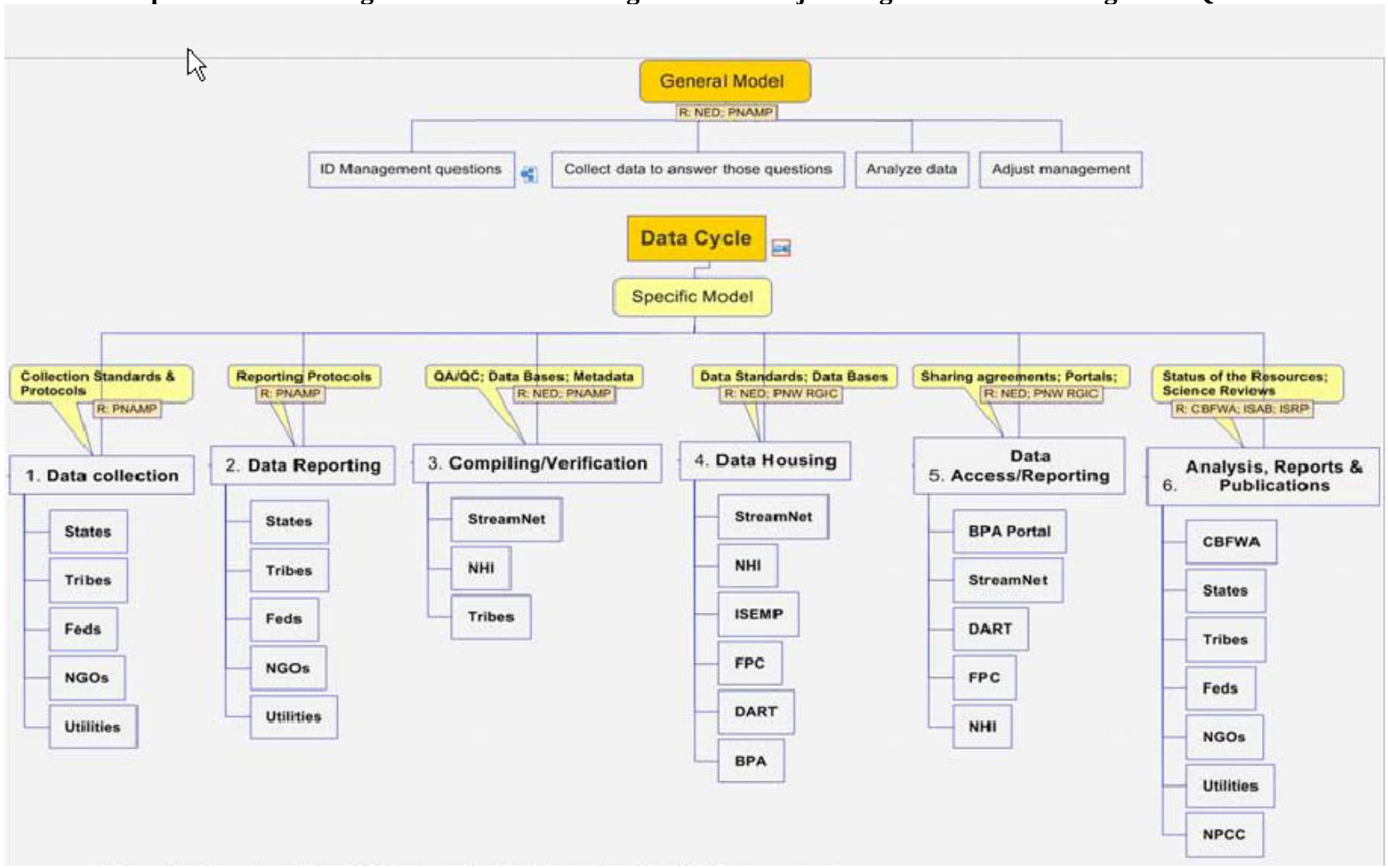
Protocols- network-specific “best practices”, standards, procedures

Science Applications International Corporation (SAIC) - a leading systems, solutions and technical services company, offers a broad range of expertise in defense modernization efforts, intelligence, homeland security, logistics and product support, health and life sciences, space and earth sciences and global commercial services.

8.0 Appendices

Appendix A

Example of How Existing Fish and Wildlife Program Data Project Align to Answer Management Questions



Appendix B.
Key Functional Components Related To The FEA Framework.

Key Tasks	Lead Group(s)	Others Needed for Implementation	Type of Architectural Model	Cost Share	New Component to Build	Assign to NED or RGIC Work Group	Currently Being Worked On	Agreement Needed
Data Sharing Agreements	NED, RGIC	FR, AA, LU, EPA, ST, T, NBII, USGS, NWPCC & CBFWA	Business			YES	YES	Regional MOA
Developing Metadata Standards – Tabular and Spatial Data	NBII, NED, RGIC	FR, AA, LU, EPA, ST, & T	Data			YES	YES	Regional MOA
Develop Standards – Data Collection, Exchange, Archiving, and Reporting	NED, RGIC, PNAMP	NBII, FR, AA, LU, EPA, ST, & T	Data			YES	YES-Few	Regional MOA
Develop Protocols – Data Collection, Tabular & Spatial	NED, RGIC PNAMP	NBII, FR, AA, LU, EPA, ST, & T	Data			YES	YES-Few	Regional MOA
Develop Data Dictionary Template	NED, RGIC, PNAMP	NBII, FR, AA, LU, EPA, ST, & T	Data			YES	YES	Regional MOA
Create Geospatial and Tabular Data Node(s)	FPC, Dart, NHI, Streamnet, NOAA, BPA,	RGIC, FR, AA, LU, ST, T, & CBFWA	Technology	YES	YES		YES-Few	Regional MOA

Key Tasks	Lead Group(s)	Others Needed for Implementation	Type of Architectural Model	Cost Share	New Component to Build	Assign to NED or RGIC Work Group	Currently Being Worked On	Agreement Needed
Create Geospatial and Tabular Data Warehouses/Repositories [component of above Node]	FPC, Dart, NHI, Streamnet, NOAA, BPA	RGIC, FR, AA, LU, ST, T, & CBFWA	Technology	YES	YES		YES-Few	Regional MOA
Develop Implementation Plan and Coordination	NED, RGIC, CBFWA	RGIC, FR, AA, LU, ST, & T	Business		YES	YES		Regional MOA
Portal Development and Cataloging	NED, NBII & ST	FR, AA, LU, ST, & CBFWA	Technology	YES		YES	YES	YES
Project Tracking	BPA, NED	NED, RGIC, ST T, & USGS	Data	YES	YES		YES-Few	
Independent Advisors & Evaluations – QA/QC and Progress on Implementation and Performance Tracking	VT-CMI, PCSRF, PISCES, Others	NED, RGIC, CBFWA, FR, & AA	Business		YES			

Key Tasks	Lead Group(s)	Others Needed for Implementation	Type of Architectural Model	Cost Share	New Component to Build	Assign to NED or RGIC Work Group	Currently Being Worked On	Agreement Needed
Create Tools and Services [part of Nodes]	NED, RGIC	RGIC, FR, AA, LU, ST, T, NHI, Streamnet, NBII, USGS, EPA	Technology	YES	YES	YES	YES-Few	
Develop Business Rules	NED, RGIC	RGIC, FR, AA, LU, ST, T, NHI, Streamnet, NBII, USGS, EPA	Business	YES		YES	YES-Few	YES
Identify Core Data Node	NWPPC, CBFWA, NOAA	FR, AA. LU, ST, & T	Technology	YES			YES-Several	Regional MOA
Identify Master/Core Data Sets (Hydrology, Roads, Priority Habitats)	NWPPC, CBFWA, NOAA	FR, AA. LU, ST, & T	Data		YES	YES		Regional MOA
Developing Partnerships & Cost Sharing Agreements	NED, RGIC	RGIC, FR, AA, LU, ST, T, CBFWA, NHI, Streamnet, NBII, USGS, EPA	Business				YES-Few	Regional MOA

Agencies:
FR=Fish Regulatory Agencies (NOAA , USFWS); AA=Action Agencies (BPA, COE, BOR); LU=Land Management Agencies (USFS, BLM, NRCS); EPA=Environmental Protection Agency; ST=State (Natural Resource, Fish and Wildlife, Land or Ecology Departments); T=Tribes; NWPCC=Northwest Power and Conservation Council; CBFWA=Columbia Basin Fish and Wildlife Authority; S=Streamnet; NHI=Northwest Habitat Institute; UW=University of Washington; NED= Northwest Data-Network; RGIC=Regional Geographic Information Committee; VT-CMI=Virginia Tech, Conservation Management Institute [Develop and Operate USFWS Multi-State Project and Fish and Wildlife Information Exchange]; NBII=National Biological Information Infrastructure; USGS=U.S. Geological Service.