Habitat Restoration in the Columbia River Estuary: A Strategy for Implementing Standard Monitoring Protocols

By

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Research Report

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Executive Summary

This project, to propose an implementation strategy for standard monitoring protocols, builds on my Pacific Northwest National Laboratory Fellowship to support a study entitled *Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary* (Diefenderfer et al. 2005). The major objective of the study was to develop a minimum set of standard monitoring protocols to be used within each restoration project in the Columbia River estuary (CRE).

The Biological Opinion, developed by the National Marine Fisheries Service in 2000, has encouraged the CRE research and management community to focus efforts on restoring impacted habitats for threatened or endangered salmon. A current concern is that the estuary-wide restoration effort lacks a uniform framework in which to evaluate the effectiveness of individual projects as well as the cumulative effects of multiple restoration projects.

This report provides an overview of monitoring in general as context for this study; describes the background and restoration framework for the CRE; documents the development of standard protocols conducted during the larger study of cumulative effects of multiple restoration projects; proposes a technical and institutional implementation strategy, proposes a CRE-specific database and concludes with long-term implementation considerations.

Chapter one outlines the context for standard monitoring protocols. It begins with a description of monitoring as a component of large-scale ecosystem restoration and describes universal objectives that apply to monitoring and evaluation programs. Second, it describes estuary restoration strategies common within the CRE and describes technical and institutional considerations for monitoring protocols. It concludes with examples of research programs across the country that use standard monitoring protocols.

Chapter two explains the background for a restoration framework for the CRE. Currently there is no comprehensive, coordinated restoration, monitoring and evaluation program in place, but this has been recognized as an unmet need. Restoration is being conducted in a piecemeal fashion and only local and regional programs are in place, not a CRE-wide program. This chapter illustrates the institutional responsibilities for aquatic habitat restoration and the progress toward an integrated monitoring framework, describes restoration goals and strategies, provides examples of ongoing restoration projects, discusses management implications and concludes with the potential of standardized protocols to restoration projects in the CRE.

The contents of chapter three highlight my role in working in a collaborative group effort to develop a minimum set of standard monitoring protocols. It describes my role in collecting relevant restoration literature, helping to design the protocol layout, taking minutes from a restoration managers' meeting, and highlighting my recommendations for future versions of the protocol manual.

Chapter four is the main focus of this report. It describes a strategy I propose for implementing standard monitoring protocols. The basic components of this strategy are a proposed restoration taskforce, designed as the central hub of restoration efforts. It also describes technical and institutional implementation activities to consider when developing and implementing standard monitoring protocols.

Chapter 5 describes and illustrates a proposed CRE-specific restoration project database in detail. It provides specific tools for different user groups and is intended to be user friendly and easily accessible. It is designed to be updated and maintained by the central taskforce described in chapter 4.

Finally, the report concludes with long-term implementation considerations. These include reviewing the performance of restoration actions, implementing an adaptive management approach and contingency planning.

The contents of this report may be useful to those entities that ultimately will be chosen to lead a CRE-wide restoration, monitoring and evaluation program. The implementation strategy outlined in this report could be used as a first step in moving towards an integrated program that is structured around the use of standard monitoring protocols. Also, the proposed database could be used as a template for a restoration project database within the CRE.

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Abbreviations and Acronyms

AA	Action Agencies
BiOp	Biological Opinion
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CLT	Columbia Land Trust
Corps	U.S. Army Corps of Engineers
CREST	Columbia River Estuary Study Taskforce
DU	Ducks Unlimited
EOS	Estuary/Ocean Subgroup
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
IWWR	Interagency Workgroup on Wetland Restoration
LCREP	Lower Columbia River Estuary Partnership
LCRFRB	Lower Columbia River Fish Recovery Board
LTRMP	Long-term Resource Monitoring Project
NEP	National Estuary Program
NCR	National Research Council
NRCS	Natural Resources Conservation Service
NOAA	National Oceanic and Atmospheric Administration
OWEB	Oregon Watershed Enhancement Board
PNNL	Pacific Northwest National Laboratory
RM&E	Restoration, Monitoring and Evaluation
RVMP	Regional Volunteer Monitoring Program
RPA	Reasonable and Prudent Alternative
SER	Society for Ecological Restoration
SR	Sea Resources
SRFB	Salmon Recovery Funding Board
UMESC	Upper Midwest Environmental Sciences Center

Abbreviations and Acronyms Cont'd

USFWS	United States Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resources Development Act

1.0 THE CONTEXT FOR STANDARDIZED MONITORING PROTOCOLS

1.1 Introduction

The goal of this Master's Project for the Marine Resource Management Program is twofold: 1) to address the status of restoration monitoring efforts and 2) propose an implementation strategy for standard monitoring protocols for salmon habitat restoration projects in the Lower Columbia River estuary. This project builds on my Pacific Northwest National Laboratory Fellowship to support a study entitled *Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary* (Diefenderfer et al. 2005). This report provides an overview of monitoring in general as context for this study; describes the restoration framework for the Columbia River estuary; documents the development of standard protocols conducted during the larger study of cumulative effects of multiple restoration projects; proposes a technical and institutional implementation strategy; and concludes with long-term implementation considerations.

Monitoring is a critical component of large-scale ecosystem restoration. Monitoring as defined by Thayer et al. (2003) is, *"the systematic collection and analysis of data that provides information useful for measuring project performance at a variety of scales (locally, regionally, and nationally), determining when modification of efforts is necessary, and building long-term public support for habitat protection and restoration efforts."* The purpose of monitoring programs is to study the status and trends of processes and components of ecosystems in response to disturbance, while being conscious of the impact monitoring may have on the environment (Thayer et al. 2003). Currently, many agencies and organizations use different monitoring techniques that are intended to address a corresponding variety of objectives. Bisbal (2001) has identified a set of common universal objectives that apply to monitoring and evaluation programs:

- to measure attributes of environmental conditions and biological resources in the system of interest within relevant temporal and spatial scales,
- to conduct ecological research at landscape scales and to better understand the distribution and abundance of ecological variables at those scales,

- to improve integration, coordination and sharing of monitoring efforts across organizations, geographic scales, and relevant elements of the ecosystem,
- to ensure that management decisions are based on the best and most current information and,
- to predict future conditions and suggest hypotheses for subsequent scientific testing.

Monitoring of restoration projects is essential for understanding whether or not project goals and objectives are being met (Borde et al. 2004). It can also be used to identify gaps in scientific knowledge, improve future project designs and decision making, and offer information for use in an adaptive management framework (Thayer et al. 2003, Borde et al. 2004, Neckles et al. 2000).

Restoration projects go through many phases: planning, design, construction, and (in some cases) monitoring. Monitoring of a restoration project should be considered at the first step (or planning phase) of a restoration project. Thom and Wellman (1996) have defined seven steps in developing a monitoring program: *1) define restoration vision, goals and objectives, 2) develop the conceptual model, 3) choose performance criteria, 4) choose monitoring parameters and methods, 5) estimate cost, 6) categorize the types of data and 7) determine the level of effort and duration.* The cornerstone of a successful monitoring program is found in step 4, the development of standard monitoring protocols.

Currently, there is a push for a formal restoration, monitoring and evaluation program in the Columbia River estuary (CRE) and agencies are tasked with answering natural resource questions based on the big picture (the large-scale landscape view) (PNAMP 2004). In order to gain answers to these questions, data from each restoration project needs to be collected using standardized monitoring protocols. However, some instances may require the use of customized, not standardized protocols. Protocol flexibility should be maintained due to varying restoration purposes, budgets and users. Oakley et al. (2003) in *Guidelines for Long-Term Monitoring Protocols* describe the importance of monitoring protocols, "*monitoring protocols are 1) a key component of quality assurance for monitoring programs to ensure that data meet defined standards of quality with a known level of confidence, 2) necessary for the program to be credible so* *that data stand up to external review, 3) necessary to detect changes over time and with changes in personnel, and 4) necessary to compare data among places and agencies."*

1.2 Standardized Monitoring Protocols: Pros and Cons

A manual of minimum monitoring protocols is the key piece to providing information necessary to sustain a large-scale monitoring program in the CRE. The manual might serve as the common link between numerous agencies conducing habitat restoration projects. Monitoring conducted using standard protocols will bring attention and scientific credibility to the CRE to obtain funding for future restoration efforts and will help to create conditions to make a better case for receiving funding. Data provided from each restoration project will be contributed to the overall program, allowing funding agencies to gain a better understanding of the big picture.

A second benefit of using standard monitoring protocols is that they provide a framework for collecting repeatable scientifically and statistically valid data at each restoration site. The protocols provide the foundation for the collection of baseline data that is needed for comparison after restoration has occurred. This allows for site comparisons over the long-term among numerous restoration sites on varying spatial and temporal scales. It also provides the basis for adaptive management over time as datasets accumulate.

A third benefit is facilitating collection and sharing of data among multiple restoration entities and leveraging multiple monitoring programs for mutual and collective benefits. Collaboration among restoration entities can benefit the entire monitoring program on many levels; restoration costs can be shared between agencies, managers can meet to help discuss important decisions, training can be provided for new users of the monitoring protocols, data can be shared and used for multiple analyses, and contacts can be made to help direct expertise where needed.

A fourth benefit would be to increase the credibility of the data for regulatory and other purposes and provide a basis for more standardized modeling, assessment, and decision support systems. Using standard monitoring protocols throughout a program will help to increase the credibility of the data being collected at each restoration site.

The collected data must be converted into a form that provides information that can be used for management decisions.

Even though standardized protocols provide many benefits to users they may not be appropriate for all situations. Standardized monitoring protocols that are overly prescriptive may stifle the ability of managers to respond to changing conditions. As project restoration sites proceed and as new information is collected, an overly strict set of procedures does not allow managers flexibility to adapt to unforeseen changes or uncertainties.

The study of different habitats within an ecosystem may be a second example of why complete standardization may not be appropriate. The CRE is comprised of many different systems: mud flats, backwater sloughs, tidal channels, and tidal marshes. A set of protocols that may be suitable for one system, may not be appropriate for another. In such cases, it may be more appropriate for protocols to be customized to a particular habitat type rather than standardized across habitats.

1.3 Definitions

A review of estuary and wetland restoration literature discloses a broad spectrum of estuary and wetland restoration definitions. The majority of the definitions are all-encompassing for a wide range of restoration actions, but some are specific to habitat and restoration actions. The following restoration strategies define the range of restoration projects within the CRE and are in concert with those described in the attached draft Monitoring Protocols for Columbia River Estuary Habitat Restoration Projects in Appendix A. Individual projects may use one or a combination of the following approaches depending on the goals of the project, project site conditions and the funding.

Restoration

Habitat restoration as defined by the NRC (1992) is "*return of an ecosystem to a close approximation of its condition prior to disturbance*," (NOAA Restoration Center 2005, IWWR 2003, SER 2004).

Conservation

Conservation as defined by Meffe et al. (1994) is the maintenance of biodiversity. It also includes preventing the loss of or damage to inhabitants or processes of the environment. The most common activity associated with this strategy is the purchase of land rather than physical modification activities as required under restoration.

Creation

Creation is defined as the building of a wetland in an area that was not inundated by water in the recent past (Gwin et al 1999, IWWR 2003). It is an effort to reproduce the conditions of an undamaged, functioning ecosystem.

Enhancement

Gwin et al. (1999) define enhancement as "*the modification of specific structural features of an existing wetland to increase one or more functions based on management objectives*." LCREP (2005) defines it as, "*improvement of a targeted ecological attribute and/or process.*" It can also be defined as "*increasing one or more of the functions performed by an existing wetland beyond what currently or previously existed in the wetland*," (IWWR 2003).

Protection

Protection can be defined as maintaining the integrity of the habitat in question and to shield it from disturbance (Burlin 2004).

The successful implementation of a set of standardized monitoring protocols to guide restoration projects require careful consideration of restoration approaches and both *technical* and *institutional* considerations. Technical considerations include: data collection, data formats, data storage and organization, data analysis, data quality, and metadata requirements. Institutional parameters include: funding for monitoring programs, training and capacity building for sustaining monitoring programs, data ownership/ responsibility for data quality and updates, access to data/data sharing, use of data for planning, assessment and regulatory purposes, and decision making. The consideration of both sets of parameters within a comprehensive monitoring program will likely increase the probability of meeting program goals while also providing benefits to end users, those who obtain a direct benefit from interacting in some way with the estuary.

1.4 Technical Considerations for Monitoring Protocols

Data collection is very important to a successful monitoring program. The selection of parameters for assessing environmental variables must correspond to relevant ecosystem function(s) and must be tied directly to the goals and objectives of the project (Diefenderfer et al 2005). In terms of a standardized monitoring effort, it is critical to collect data in the same way to facilitate comparison within and among sites from one time period to the next. The collection of data in a standardized fashion should be feasible in terms of funding, and effort needed to complete each data collection protocol. Standardizing data collection efforts can also help to reduce overlap of studies and reduce project costs.

When designing and implementing a set of standardized monitoring protocols, it is important to consider data formats. Each standardized monitoring protocol for assessing a particular environmental parameter has specified metrics that need to be collected. Standardizing the format in which the data are collected is essential to eventually analyzing, comparing, and aggregating data. If the data are in a common format, then the data can be shared between users and used in multiple data analysis techniques.

Eventually a standardized set of monitoring protocols will provide numerous sets of data that will need to be stored and organized. It is essential to store the data in a format that can be accessed by multiple users and organized in terms of the metrics collected through each of the standard monitoring protocols in a regional database. Each entity using the standardized protocols will become familiar with their contents and will be able to query and access the database easier and with more precision as data is stored and organized.

Data analysis is the process of converting raw data into information that can be used to explain components of the ecosystem being studied (San Francisco Estuary Project 1992). Data analysis must be considered when implementing and designing a set of standardized monitoring protocols. If the data being analyzed are not helping to answer the questions being addressed in the study area, then there is an opportunity to revise the standardized protocol metrics so that appropriate parameters are being measured.

Data quality is an essential element for consideration when designing and implementing a set of standardized monitoring protocols. Collected data must be statistically robust and of a high enough quality for use by multiple entities. It also must be of a caliber that can be relied upon by managers who are tasked with making important decisions about estuarine habitat and resources. The caliber or quality of data must be decided upon by scientists, users and statisticians.

An important technical component is the need for metadata. Metadata is a description of the collected data. It describes why and how the data were collected, and explains the quality, content and attributes of the data. Metadata must be considered in the design and implementation of a set of standardized monitoring protocols because the information provided by the metadata helps managers to understand the purpose for the collected data. It also allows entities working on similar projects to determine if the data are directly usable for their study needs. The technical considerations described above are important for successfully implementing standard monitoring protocols, but institutional parameters should also be considered.

1.5 Institutional Considerations for Monitoring Protocols

Institutional parameters include: funding for monitoring programs, training and capacity building for sustaining monitoring programs, data ownership/responsibility for data quality and updates, access to data/data sharing, use of data for planning, assessment and regulatory purposes, and decision making.

Funding is typically a major issue within monitoring programs. When developing and implementing standardized protocols it is essential to consider the cost of conducting each protocol. Managers must make decisions about what parameters to collect based on the funding available. Standardizing data collection efforts through standard protocols can facilitate cost-sharing among projects. Projects collecting similar data (e.g. landscape feature data) could split the cost of a data collection campaign (e.g., aerial surveys), and each entity would benefit from the collaborative effort. Implementation of a set of standard monitoring protocols should consider funding to make data collection feasible for all to achieve.

A second institutional parameter to consider is training and capacity building for sustaining monitoring programs. A set of standardized monitoring protocols must be feasible for all to use. After protocols have been developed and adopted, the monitoring program should sponsor a training program to show individuals how to properly use the protocols. This training can be carried to each individual project that chooses to monitor using the standard protocols. In addition to the training, maintaining collaboration and support from numerous agencies will greatly help to sustain a long-term monitoring program. Collaborative efforts can also help to find flaws in the protocols and suggest better techniques for their use.

Data ownership/ responsibility for data quality and updates is another important institutional parameter. Each entity participating in a monitoring program may choose to remain responsible for the data they collect, preferring to control their own data and perform their own QA/QC procedures. The metrics contained in the standardized protocols would ensure the data were of the necessary quality, since each entity would be using the same protocols. It would be the responsibility of the entity collecting the data to provide updates to a central database. When designing and implementing a set of standardized protocols it is important to provide a data collection sheet at the end of each protocol so that data can be easily recorded and entered into a central database.

Along with the standard monitoring protocols, a central database will facilitate common access and data sharing. Not only is it important to understand how an individual restoration project is functioning, it is also important to understand how all restoration projects collectively are affecting the estuary and its resources. Those entities contributing information to a common database will have access to high quality data to allow comparisons among sites, technical topics and/or other factors. The use of standardized data collection procedures will also help to facilitate sharing of data among multiple projects to begin to assess the cumulative effects of multiple restoration projects within the estuary.

Use of data for planning, assessment and regulatory purposes is another benefit of using standardized monitoring protocols. The conversion of data into information allows managers to make important decisions: to plan future restoration actions, assess the condition of an existing monitoring site, and comply with governmental regulations and policies.

The process of data analysis can be described in a series of four steps: data, information, knowledge and wisdom which are depicted in Figure 1. Data in raw form are out of context and do not have a defined relationship to other things. Once relationships between data are established, information is gained. The comprehension of patterns between data and other information constitute knowledge once they are understood. Finally, wisdom is achieved when it is recognized that patterns in knowledge arise from principles and understanding what the basis for the principles are (Bellenger 2004). Designing and implementing monitoring protocols with these processes in mind will help to make better decisions in the long run.

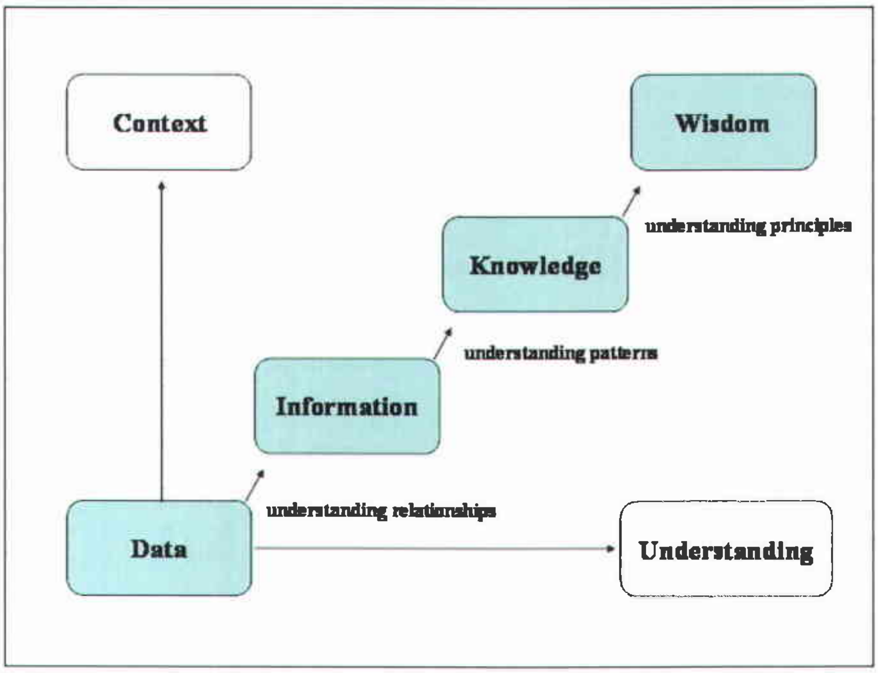

Figure 1. The Process of Knowledge Management. (modified from Bellenger 2004)

Monitoring is a very important piece of decision making because it can ultimately affect future uses of the habitat and can affect the way end users interact with the estuary. Decisions are made at many different levels and it is important to base those decisions on data that are collected in a standardized way.

Technical and institutional parameters come together within the concept of adaptive management. Restoration, monitoring and evaluation within the CRE is one component of an adaptive management approach for salmon enhancement and might be partly guided by experimentation (Lee 1993). An adaptive management approach as defined by Lee (1993), "*is one that is designed from the outset to test clearly formulated hypotheses about the behavior of the ecosystem being changed by human use.*" Most of the time the hypotheses are predictions about how a species (e.g. ESA listed salmon) or a group of species will respond to a management decision. This framework is particularly attractive to restorationists because there is a constant "learning by doing" process that occurs which enables managers to make and change decisions as the monitoring project progress, with new updated information. This is particularly appealing to managers conducting habitat restoration projects because they must deal with restoration uncertainty. An adaptive management framework allows them to make decisions over time to steadily reduce scientific uncertainty.

The technical and institutional considerations described above are not mutually exclusive, but rather they exist in tandem. The list described above is not exhaustive, but demonstrates some components useful to implementing a set of standardized monitoring protocols.

1.6 Examples of Research Programs & Standardized Monitoring Protocols

The following examples illustrate existing programs, consisting of multiple agencies that have developed and/or use standard monitoring protocols within a given region. As described in a paper by Becker and Armstrong (1988), only a small number of standardized protocols exist for environmental field studies. Even fewer exist in comprehensive regional monitoring programs that involve multiple agencies.

Washington

The Washington State Salmon Recovery Funding Board (SRFB) was created by the Washington State Legislature in 1999. It provides funds for entities conducting work related to protection or restoration of salmon habitat. The board has developed a suite of standard monitoring protocols that are currently being used by many restoration entities in the Pacific Northwest (SRFB 2005_1). Some protocols are being used by the Puget Sound Ambient Monitoring program while others are used in the long-term freshwater and stream ambient monitoring program.

Puget Sound, Washington

In 1987 the U.S. Environmental Protection Agency added Puget Sound to the National Estuary Program (NEP) to help protect water quality and the habitat for plants and animals living within it (U.S. EPA 2004). In 1991, the Estuarine Habitat Assessment Protocol was developed for the program "*to (1) assess the function to support fish and wildlife and (2) to monitor the comparative performance of the site after restoration or of a mitigation site designed to replace the development site*" (Simenstad et al. 1991). This set of standardized protocols has been used widely by many agencies in the Pacific Northwest (Johnson et al 2004).

Oregon

To date, no standardized protocol for monitoring of estuaries or estuarine restoration projects has been available in Oregon. However, multiple agencies in 2002 funded the development of such a protocol for tidal marshes excluding those of the Columbia Estuary. This was recently published (Adamus 2005) and is likely to be used in agency programs. Components of this protocol may be applicable to the Columbia but have not been tested there. In addition, the USEPA research facility in Newport, Oregon, has developed standardized protocols (quality assurance plans) for sampling of mudflat and eelgrass habitats (e.g., xxx – ask Tony for citations). A standardized protocol for prioritizing formerly-tidal habitats for restoration was supported by the Oregon Department of Land Conservation and Development and was recently published (Brophy 2005).

California

The Wetlands Regional Monitoring Program (WRMP), part of the San Francisco Bay Area Wetlands Restoration program, has developed many protocols specific to monitoring attributes of San Francisco Bay and the surrounding area (Wetlands Regional

Monitoring Program 2005). Also, volunteer organizations within the state have collected data in the Bay area using standardized protocols under the Regional Volunteer Monitoring Program (RVMP) that is sponsored by EPA Region 9, San Francisco Estuary Institute and the San Francisquito Watershed Council (RVMP 2004).

The Southern California Comprehensive Coastal Water Quality Monitoring Program uses standard monitoring protocols and a standard format for reporting monitoring results. These were developed within their Quality Assurance Project Plan. These monitoring activities are conducted with the state's watersheds, bays, estuaries and coastal waters. The ultimate goal under the program is to maintain and improve coastal water quality (SCCWRP 2001).

The California CoastKeeper Alliance has developed a regional kelp restoration and monitoring protocol for the regional kelp restoration project. The goal of the program is to restore kelp beds from Santa Barbara to San Diego by biologists and community participants. It is a project that will span multiple years and requires collaboration between state and federal governments, CoastKeepers and the volunteering public. (Reed et al. 2002).

New York State

The New York State Salt Marsh Restoration and Monitoring Guidelines prepared by Niedowski (2001) were developed to help local governments create and monitor salt marsh restoration projects. They are intended to be used by projects sponsored by municipalities and contain standardized protocols for reed control and salt marsh restoration.

Chesapeake Bay

The Chesapeake Bay Monitoring program uses standardized protocols to monitor pollutant inputs, water quality, living resources and habitat. Most of the restoration occurs within the bay itself and the adjacent tributaries. The monitoring program incorporates historical monitoring efforts with the collaboration of state and federal agencies (Chesapeake Bay 2005).

Upper Mississippi River System (Upper Mississippi River, Illinois River and tributaries)

The U.S. Geological Survey's Upper Midwest Environmental Sciences Center (UMESC) administers the Long Term Resource Monitoring Project (LTRMP) with the goal to maintain the Upper Mississippi River Systems' multiple uses. The project is funded by the U.S. Army Corps of Engineers and works in collaboration with five states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). Standard protocols were developed and used for field and laboratory work under the LTRMP to monitor water quality, vegetation, and benthic macro-invertebrates. Standardized protocols were used to provide managers with a tool to compare samples spatially among multiple sampling locations (Pegg 2004).

Gulf of Maine

The monitoring protocol for tidal wetlands is a minimum standardized set that the authors believed was needed to evaluate structural and functional responses of tidal wetlands to restoration. The protocols include assessments for hydrology, soils and sediments, vegetation, nekton and birds and are to be used at all restoration sites within the region. Included within the report are inventory data sheets for projects being conducted in the region and a list of regional inventory coordinators (Neckles and Dionne 2000).

Louisiana

The Louisiana Legislature passed an Act in 1989 that created a state coastal wetland restoration program and the State's Wetlands Conservation and Restoration Fund. The purpose is to protect coastal marshes. The Coastal Wetlands Planning, Protection and Restoration Program apply seven standard monitoring protocols to all restoration projects within the coastal zone to collect important physical and biological data (CWPPRP 2005).

Cape Cod

Monitoring protocols have been developed for the Long-Term Coastal Ecosystem Monitoring Program. The protocols cover the following habitats: estuaries and salt marshes, barrier islands, spits, dunes, ponds and freshwater wetlands and coastal uplands. The protocols are interconnected; information from one protocol may be used to interpret analysis and trends of another protocol (Roman et al. 2001).

2. 0 THE COLUMBIA RIVER ESTUARY: BACKGROUND AND RESTORATION FRAMEWORK

The CRE is defined as the tidally-influenced portion of the river from the mouth to Bonneville Dam, a distance of 146 miles. Over the past 150 years the lower CRE habitat has been altered significantly. It has been channelized, dammed, diked, and dredged. Because of these actions, islands have been built, wetlands and pastures have vanished, and exotic species of plants and animals have exploited the estuary's resources (Garono et al. 2004). Today, the estuary is one of the most heavily impacted portions of the Columbia River basin (Thomas 1983). This is mainly due to shoreline development, river flow regulations, and habitat alteration and modification (Simenstad et al. 1992). Most of the research to date has focused on dams and their negative impacts to habitat and as barriers to salmon migration, but now there is a large research focus on available habitats within the estuary (Fresh et al. 2004). Many of the impacted habitats are used by salmonid populations that have been listed as threatened or endangered under the Endangered Species Act (ESA) (Fresh et al. 2004). The majority of current restoration work is aimed at reuniting previously detached wetland areas to the CRE tidal regime though various methods such as dike breaching and tide gate modification.

2.1 Institutional Responsibilities for Aquatic Habitat Restoration

No coordinated or integrated monitoring program yet exists within the CRE, but there are some regional monitoring programs in progress. They include:

- *Monitoring Strategy for the Oregon Plan for Salmon and Watersheds* by the Oregon Watershed Enhancement Board (OWEB 2005_1),
- The *Aquatic Ecosystem Monitoring Strategy* by the Lower Columbia River Estuary Partnership (Sutherland 1998),
- *The Monitoring and Evaluation Strategy for Habitat Restoration and Acquisition Projects* by the Washington Salmon Recovery Funding Board (SRFB 2005_2),
- The Northwest Power Planning Council Fish and Wildlife Protection, Enhancement and Mitigation Program (Vigmostad et al. 2005), and
- The Pacific Northwest Aquatic Monitoring Partnership coordination and monitoring efforts (PNAMP 2004).
- USEPA Environmental Monitoring and Assessment Program (EMAP), West Coast Initiative, conducted jointly with Oregon Department of Environmental Quality.

Separate monitoring efforts are being conducted with support from federal, state, tribal and local entities, local governments, academic organizations, and public and private groups. Each entity has jurisdiction over certain CRE resources, but due to differing institutional bureaucracies, congressional mandates, scientific expertise, funding cycles and project scales, a large burden has been placed on establishing a coordinated CRE-specific monitoring program (Bisbal 2001).

CRE habitat restoration is conducted and funded by numerous agencies. The major funding agencies for CRE habitat restoration are NOAA Fisheries, U.S. Fish and Wildlife Service (USFWS), the Federal Columbia River Power System Action Agencies (AA), Bonneville Power Administration (BPA), U.S. Army Corps of Engineers (Corps), Bureau of Reclamation, Environmental Protection Agency (EPA), and the Oregon and Washington Departments of Fish and Wildlife. The primary responsibility of NOAA Fisheries and the USFWS is to provide jurisdiction over ESA listed anadromous fish while the USFWS regulates other fish not covered by NOAA. The BPA directs funds to the Northwest Power and Conservation Council's Fish and Wildlife program for the protection, enhancement and mitigation of fish and wildlife in the Columbia River Basin. The Corps and the Bureau of Reclamation operate the federal dams in the system. They are provided funding for habitat restoration projects from Congress, but the appropriations are not steady, resulting in an unequal allowance to those requesting funding for habitat restoration. The Corps is mainly involved with estuary habitat improvement restoration projects and the EPA enforces the Clean Water Act (Northeast Midwest Institute 2005, Federal Caucus 2003).

Other forms of funding for habitat restoration come from the Water Resources Development Act (WRDA), under which the Corps can develop habitat restoration projects, and the Pacific Coastal Salmon Recovery Fund. The WRDA, "*is a comprehensive legislative package that provides for the conservation and development of water and related resources. It authorizes the Secretary of the Army, through the Chief of Engineers, to conduct studies and to construct projects and research the various activities that lead to improvements of rivers and harbors of the United States*" (U.S. Army Corps of Engineers 2005_1). The Pacific Coast Salmon Recovery Fund provides funds for state, tribal, and local salmon conservation and recovery efforts. The fund obtains its monies from Congressional appropriations.

The federal agencies listed above funnel monies to entities conducting salmon habitat restoration within the CRE. For example, NOAA Fisheries and EPA provide funding to the Lower Columbia River Estuary Partnership (LCREP). Agencies submit proposals for habitat restoration projects to LCREP and if they meet LCREP guidelines, funding will be provided to the agency. All funding agencies within the CRE require that managers of individual restoration projects must make decisions based on data collected from each project and report back to the funding agency on project progress.

2.2 Progress Toward an Integrated Monitoring Framework

The Biological Opinion (BiOp) developed by the National Marine Fisheries Service in 2000 compelled the estuary research and management community to focus attention on restoring impacted salmon habitats. The current concern is that restoration efforts lack a uniform framework in which to evaluate individual project effectiveness, and in addition, the cumulative impacts of multiple restoration projects in the estuary. Many restoration projects are in progress and many have been completed. Since there is no official restoration, monitoring and evaluation (RM&E) program in the CRE, restoration projects are being conducted in a piecemeal fashion and have not been guided by standard protocols. The concern in the CRE parallels what has already been addressed in the Upper Columbia River basin. Hillman (2003), in *Monitoring Strategy for the Upper Columbia Basin* states, "*Within the Upper Columbia Basin, Washington, several different organizations, including federal, state, tribal, local and private entities currently implement tributary actions and conduct monitoring studies. Because of different goals and objectives, different entities are using different monitoring approaches and protocols. In some cases, different entities are measuring the same (or similar) things in the same streams with little coordination or awareness of each others efforts.*" Therefore, there is a need to standardize metric collection so that data can be compared among projects at varying spatial and temporal scales within the estuary.

To address the current concern, a project titled "*Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary*" was developed (Johnson et al. 2004). The project presents a framework to assess the value of individual projects throughout the estuary. The framework provided by the project is necessary for addressing the central resource management issue in the CRE: the restoration of estuarine salmon habitat. The overarching goal from a resource management perspective is to enhance ecosystem function through carefully designed projects to eventually increase the abundance of ESA listed salmon stocks (Diefenderfer et al. 2005). The main focus of the project to date was the development of a minimum set of standardized monitoring protocols for use by multiple entities.

2.3 Minimum Monitoring Protocols

The creation of the minimum set of standard monitoring protocols to assess restoration of salmon habitat was developed using a collaborative group process. Individuals from NOAA, CREST, and PNNL worked to draft components of the protocol manual. The final draft protocols, attached in Appendix A, have undergone many iterations and refinements. They will be peer reviewed and tested in the field to determine their feasibility and to also determine what other metrics, not included in the manual, need to be considered for future inclusion.

Standardized monitoring protocols were developed under this project to assess the condition of salmon habitat before and after restoration. The reason for developing the protocols was to help fulfill an unmet need within the estuary and aid in the regional movement to standardize data collection efforts, allowing for project comparison and assessment of cumulative effects of multiple restoration projects. The protocols were tailored to assess changes from tidal reconnection, a common restoration activity within the CRE, intended to increase habitat for rearing and migrating ESA listed salmonids. In addition, they were also designed to assess physical and biological features within each habitat (Diefenderfer et al. 2005).

The goal of many estuary restoration projects is to reconnect historical wetlands to tidal inundation to allow for connectivity with backwater channels and sloughs and provide suitable habitat for listed salmon. Standardized monitoring protocols will help to achieve this goal by providing relevant metrics that are tailored to fit different habitats within the CRE. Eventually, the use of standard protocols by numerous agencies will facilitate the collection of statistically valid data sets that can be used to compare among habitats on different temporal and spatial scales. This standardized data collection as described by Diefenderfer et al. (2005) "*will require the means to 1) evaluate the effectiveness of individual restoration activities (Roni et al. 2002), 2) allow comparison between projects (Neckles et al. 2002, Williams and Orr 2002) and 3) determine the long-term and cumulative effects of habitat restoration on the overall ecosystem (Steyer et al. 2003).*"

Contained within the minimum monitoring manual are seven protocols. They include: 1) protocol for assessing hydrology (water elevation), 2) protocol for assessing water quality (temperature, salinity and dissolved oxygen), 3) protocol for assessing bathymetry and topography, 4) protocol for assessing landscape features, 5) protocol for assessing vegetation changes resulting from tidal reconnection, 6) protocol for assessing success rate of vegetation plantings, and 7) protocol for assessing fish temporal presence, size/age-structure and species composition. All seven are intended to be used at each restoration site, provided that time and funds are sufficient.

This report includes a discussion of my participation in developing the standard protocols in (chapter 3) and a proposal for their implementation (chapter 4) and a web-based data management system (chapter 5). The draft set of minimum monitoring protocols can be found in a current draft report titled, *Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary, First Annual Report 2004* (Diefenderfer et al. 2005) and the chapter within this report containing the draft monitoring protocols has been attached in Appendix A.

2.4 Restoration Goals

Currently there is no estuary wide integrated research, monitoring, and evaluation (RM&E) program in operation in the CRE, although some restoration and monitoring projects have already begun or have been completed (Johnson et al. 2004, LCREP 2004). In 2000, a Biological Opinion (BiOp) was developed by the National Marine Fisheries Service to determine whether or not the Federal Columbia River Power System (FCRPS) would harm the 12 existing salmonid species in the Columbia River (Johnson et al. 2004). Contained within the opinion are RPA actions. RPA actions are "*alternative* *actions identified by services during formal consultation to avoid jeopardy or adverse modification of critical habitat,* (USFWS 2004)." In total, 199 RPA actions were described in the BiOp. Numbers 158-162 and 179-199 are explicit to restoration, monitoring and evaluation. In particular RPA action 161 states, "*Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the Lower Columbia River Estuary Partnership (LCREP) monitoring and research efforts (Management Plan action 28) to address the estuary objectives of the Biological Opinion,* (BPA & Corps 2003)."

In 2001, the AA, for the FCRPS, worked with NOAA Fisheries, and other federal, state, local and tribal fisheries agencies to develop an all-encompassing RM&E plan for the Columbia River Basin (called the basin-wide plan) (RME Plan 2003). The draft basin-wide RM&E plan is structured so that research, monitoring and evaluation actions are centered around listed salmon and steelhead species and are ordered hierarchically in the context of ecosystems, sub basins and habitats supporting salmonid populations. During the development of the basin-wide plan, six workgroups were tasked to draft the principal RM&E components and sub-components (RME Plan 2003). One group in particular was the estuary/ocean subgroup (EOS). Established in 2002, the EOS was tasked to complete a RM&E plan by September 30, 2003 that included draft performance standards, a needs assessment, and an implementation plan for the RM&E actions related to the estuary and plume (a layer of Columbia River water in the adjacent Pacific Ocean). The EOS is comprised of representatives from NOAA Fisheries, Corps, BPA, and the Pacific Northwest National Laboratory (PNNL) (BPA & Corps 2003).

In August 2004, the EOS completed a final draft of the RM&E plan for the Columbia River estuary titled, "*Plan for Research, Monitoring and Evaluation of Salmon in the Columbia River Estuary.*" The plan describes overall goals and objectives, provides a framework on which to conduct an estuary RM&E program, monitoring methods and referenced protocols, and lists current RM&E projects within the CRE (Johnson et al. 2004). It is prescribed that the plan will pave the way for a formal estuary program in the future.

The overall goal from the perspective of NOAA and the Action Agencies as described by Johnson et al. (2004) is to, "*conserve and restore estuary habitats to* *improve the viability of endangered and threatened salmonid populations*." The goal of the estuary RM&E plan is divided into three sections: status monitoring, action effectiveness research and uncertainties research. The Action Agencies fund studies under these three categories and are responsible for constructing and implementing a plan for estuary RM&E actions. Table 1 below provides definitions for three RM&E goals.

Goal	Definition
Status Monitoring$_1$	Activities to monitor trends in the status of the ecosystem and fish populations and the conditions in the habitats they use.
Action Effectiveness Research$_1$	Evaluation of how effectively actions specifically designed to aid listed salmonids produce the desired biological and physical response.
Uncertainties Research$_2$	Research to address uncertainties in the analytical assessments used in the Biological Opinion (NMFS 2000) and subsequent planned check-in evaluations.

Table 1. RM&E goals and definitions. (Definitions from Johnson et al 2003$_1$ and Johnson et al 2004).

The AA have recently completed an implementation plan describing actions they intend to apply to avoid jeopardy for ESA listed salmoids and any unfavorable alteration of critical habitat. Within the implementation plan the AA have established the actions that will be implemented within the estuary to protect and improve estuary habitat. They also have outlined specific actions applicable to the goals of the estuary RM&E plan (U.S. Army Corps of Engineers et al. 2005$_1$). The standardized monitoring protocols objective within the project titled, "*Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary*" fits within the action effectiveness research goal. The AA under the three RM&E goals are conducting habitat restoration projects.

2.5 Restoration Strategies

There are five main restoration strategies used in the CRE: restoration, conservation, creation, enhancement, and/or protection. The term restoration can be used to encompass all terms, but as described below, has a separate definition (National

Research Council 1992). Table 2 describes each restoration strategy and provides examples of typical CRE projects associated with each strategy.

Strategy	Project Type
Restoration	Tide gate removal Dike Breaching Culvert upgrades/culvert installation Elevation adjustment
Conservation	Land conservation Easements Riparian fencing Manure management
Creation	Material Placement Tidal channel modification
Enhancement	Riparian plantings Tide gate/culvert replacement Invasive species removal Bioengineered streambank stabilization Riparian fencing
Protection	Land acquisition Land use regulations

Table 2. Restoration strategies and examples of project types.
(Modified from Johnson et al. 2003_1).

A single, or combination of these strategies, are used for each restoration site depending on the goals of the project and the status of the area in question. The majority of the restoration work in the CRE is centered around reconnecting historical wetlands to tidal inundation. Wetland restoration can be conducted in two ways: passively and actively. Passive restoration allows time and natural processes within the wetland to restore it to a new condition. Active restoration requires physical exploitation of the land in question to reach a desired outcome while still allowing for time and natural processes to continue to shape and restore the wetland (Gupta 2000).

2.6 Ongoing Restoration Projects

The restoration strategies described above are currently being integrated into many projects in the estuary. The Lower Columbia River Estuary Partnership (LCREP) has created an inventory of all known restoration projects titled "*Columbia River Estuary: Restoration Projects in the Floodplain and Tidally Influenced Areas-1999 to*

Present" that includes descriptions of the fifty-two restoration projects in the CRE (LCREP 2004). This spreadsheet contains details from each restoration project and a record of the restoration strategy or strategies being used to complete each project. All projects listed are in different phases; some have already been completed, some are in the monitoring stage and some are in the planning/permitting stage. Of the 52 projects, the following six are a selection of major projects within the estuary that represent restoration and enhancement projects, or a combination of the two.

Blind Slough

The Columbia River Estuary Study Taskforce, Clatsop Diking Improvement Company No. 7 with assistance from the Army Corps of Engineers, Portland District, have implemented restoration actions to re-establish tidal connection between Blind Slough and the CRE. Over two years of baseline monitoring was built into the project prior to engaging restoration actions to monitor water quality and fish populations. The project team intends to bridge the connection of the two waterways through various means such as dike breaching, culvert installation, and removal of soil material (CREST 2005_1).

Crims Island

The restoration and enhancement of tidal channel, marsh and riparian habitats is being conducted by a suite of partners: U.S. Army Corps of Engineers, Portland District, Columbia Land Trust (CLT), American Rivers, BPA, LCREP and United States Geological Survey (USGS) - Biological Resources Division and many others. The goal of the project is to restore 92 acres of tidal wetland and adjacent tidal channels, and 115 acres of riparian forest habitat. Within the scope of work they intend to connect the CRE tidal regime to emergent and marsh habitats. Marsh habitat and interconnecting tidal channels will be cleared of excess sediment to allow passage of juvenile salmon that use the habitat on their migration through the estuary. Work began during the summer of 2004 and will carry on through 2006 (USACE, 2005_2).

Chinook River

The major restoration effort within this watershed is to modify an existing tidegate that is hindering fish passage. The work requires the use of restoration and enhancement strategies to complete the tidegate improvement insert a culvert and restore the CRE tidal regime to the Chinook River estuary. The work is being sponsored by the Washington Department of Fish and Wildlife (WDFW) and in connection with the Natural Resources Conservation Service (NRCS), CLT, Sea Resources (SR), Ducks Unlimited (DU), Washington Department of Transportation (WASHDOT), and Lower Columbia River Fish Recovery Board (LCRFRB) (USACE, 2005_2).

Youngs Bay/Klaskanine River

A 50 acre restoration project will be conducted by the Youngs Bay Watershed Council, DU, NRCS and landowner Sharnelle Fee. Historically a levee was built to convert wetland area into agricultural land, but currently the levee is preventing tidal inundation in parts of the wetland area and does not allow juvenile salmon access to rearing habitat. One levee will be removed to allow historical areas to flood during daily tidal cycles, and one will be constructed so that neighboring areas do not suffer from flooding caused by the removal of the first levee. Project monitoring will occur for 5 years to record salmon abundance and diversity (YBWC 2005). In addition, an ongoing study by The Wetlands Conservancy, The Nature Conservancy, and several local groups is intended to prioritize areas in the Youngs Bay area for restoration or conservation, using existing spatial data, new field data, and contacts with landowners (P. Adamus, Oregon State University, pers. comm.).

Anunde Island

This restoration project will allow the Lower Columbia Watershed Council to remove a dike along the Clatskanie River which links Anunde Island with the mainland. This restoration action will allow water to move in and out of a historic side channel. Bank stabilization and revegetation of bare surfaces will also take place (OWEB 2005).

Brownsmead

This restoration effort is centered on restoring juvenile salmon habitat. CREST will take the lead along with the engineering skills of the U.S. Army Corps of Engineers in restoring tidal flow to approximately 9.2 miles of slough habitat. The sloughs are concentrated within an area encompassing 2,068 acres of floodplain that was originally diked (NOAA 2005).

The six projects described above depict the current status of restoration efforts within the CRE; while each project may be working to accomplish individual goals, numerous projects are undertaking similar restoration actions, but are conducting those actions using different protocols. The disadvantage with inconsistent methodologies is that results cannot be compared among projects from one time period to the next (Becker and Armstrong 1988). Agencies within the estuary have begun to recognize the deficiencies in the overall CRE restoration effort and have pinpointed three basic needs within the estuary; 1) a formal estuary *program*, 2) standardized monitoring protocols embedded within a formal *program,* and 3) a centralized data management system for access, storage and querying of individual project data. (Diefenderfer et al. 2005, Johnson et al. 2004 PNAMP 2004, PNAMP 2005, LCREP 2005). Many agencies are devoting resources to help fulfill these unmet needs, and it is the intent of chapter 4 to propose an implementation strategy that will address needs 2 and 3.

2.7 Management Implications

The large-scale restoration effort is a significant marine resource management issue because it requires collaboration among stakeholders, state-of-the-science techniques for data collection and protocol implementation, an interdisciplinary and adaptive management approach, and the ability to understand and prioritize monitoring work to fit within a fixed budget. It also requires an existing knowledge (accomplished through literature searches, meetings, workshops and field work) of existing monitoring frameworks, protocols, fishery life history information, habitat information and monitoring, and sampling attribute information, in order to apply these topics to the estuary.

The task of creating standardized monitoring protocols has direct management implications for federal, state and local environmental agencies within the CRE. It is hoped that the protocols will become adopted and used by numerous entities so data between sites can be compared to eventually evaluate the cumulative effects of multiple restoration projects. Those who choose to adopt the protocols will have the opportunity to compare data from their restoration site with other restoration sites using the identical protocols to get a holistic picture of the impacts restoration is having on the estuary and to also learn from other efforts.

Standardized monitoring protocols will fill an unmet need within the estuary.

Agencies and organizations within the CRE have begun to understand the need for monitoring coordination and move away from piecemeal efforts. Restoration managers can learn from their own restoration site, but can greatly benefit from the results of others' projects as well. Standardized monitoring protocols can provide a common link between projects and can facilitate collaboration and learning. Managers can collaborate and discuss important question such as:

- Are the goals of an individual restoration project being met and if so are the funds being allocated throughout the project wisely?
- How best can data collection costs be shared among projects?
- How should restoration efforts be prioritized within the estuary?
- What question should Managers' be asking of each restoration site?
- Are restoration projects, in the aggregate, successful in meeting their desired goals and how are they effecting the health of the estuary overall?

This type of discussion is very valuable in determining what restoration efforts work and which don't and where to focus future restoration efforts. Collaborative efforts can help to find common flaws in the protocols and suggestion methods to fine tune them as restoration efforts progress.

Standardized monitoring protocols will help managers to evaluate restoration success.

Eventually, the implementation and use of standardized protocols will result in the collection of scientifically valid data sets. These datasets will be analyzed and used to determine whether goals and objectives of individual project were met. Project success, to potentially be recognized years from now, depending on the duration of restoration projects and subsequent monitoring, will help to guide restoration projects in the future. For projects being conducted with the intent to provide more or better habitat for ESA listed salmonids, success may be evaluated in terms of how well the habitat is able to support these fish, and if these fish really are using the habitat provided by the restoration project. And further, whether the restoration projects help to increase the abundance of ESA listed salmonids.

Standardized monitoring protocols will help managers evaluate restoration actions within a given project and among multiple projects.

Directly comparable datasets among projects using standard monitoring protocols will help managers to shape the course of direction for each monitoring project. Since RM&E actions will be conducted using an adaptive management approach, lessons will be learned at each restoration site that may help to guide current or future restoration actions in other habitats. The benefit of using a standard framework is that attributes from each project can be directly compared to other projects to determine whether or not restoration actions are on target or need to be modified. Eventually, managers will be able to evaluate the success or failure of restoration actions on an estuary-wide basis to understand the cumulative effects of numerous restoration actions on the habitat and CRE resources.

The process of creating and the use of standard protocols for restoration projects in the CRE can be used as learning tool for future large-scale monitoring programs.

Future restoration programs can benefit from the lessons learned in the CRE. The habitat restoration effort is being conducted by numerous agencies, academic institutions, non-profit groups, and volunteers. Future monitoring programs can use the CRE case study, to understand how to adopt a formal estuary program, how to create, implement and use standard monitoring protocols among numerous agencies in multiple habitats, and how best to house and analyze information gathered from each site to facilitate best management decisions. The CRE restoration effort will greatly help to contribute to the success of future large-scale monitoring efforts, by providing a case study to learn from.

2.8 Potential of Standardized Protocols to Restoration Projects in the CRE

The CRE is a complex system that supports numerous uses: it provides habitat for fish and wildlife species, functions as a migration corridor for anadromous fish, supplies land suitable for agriculture and other uses, and furnishes a route for interstate commerce all while supporting business and industry within the region. Due to constant human interaction, many habitats have become degraded or significantly altered from their natural state. There is a current drive to restore altered or converted habitats to help provide new habitat for ESA listed salmonids and other species. Although there is no formal CRE-wide monitoring program, most agencies have agreed that standardization of restoration is an unmet need and has the potential to 1) provide restoration managers with the information needed to make critical decisions and 2) understand the cumulative effects of multiple restoration projects. It is not practical for every aspect of every restoration project to be monitored for a set duration after the restoration has been completed. The protocol manual consists of one proposal for the minimum amount of data that might be collected at each restoration site.

The key tools to address the complexities of this ecosystem include a manual of standard protocols for habitat restoration projects that is used by multiple entities and a data management system for storing and displaying data generated from the protocols. Standardized data sets taken from monitoring projects within the estuary will enhance our understanding of an important piece of the whole Columbia River system, and will provide comparability with tributary habitat data necessary to a holistic perspective of the Columbia River system. The protocol manual should be of value because managers and policy makers need to know how restoration projects collectively are affecting the natural resources of the river, in particular salmon. Salmon use a variety of habitats within the entire watershed, and it is important to understand how restoration actions are affecting the fish not only within the estuary, but also how they may be affecting the fish's ability to use or get to other habitats upstream from the estuary.

3.0 PROTOCOL DEVELOPMENT

During the summer of 2004 (June-September), under a fellowship with PNNL, I contributed to a collaborative effort to develop and draft a set of protocols for minimum monitoring of habitat restoration projects in the CRE. Participants from PNNL, NOAA and CREST worked to draft each protocol. Due to the duration of my fellowship I was not able to see the protocols through all stages to a final draft. The protocols went through many iterations and have changed significantly since I last worked on them. Although some of my writing is present in the final draft I have chosen to focus on my earlier contributions. The following sections outline my contributions to the collaborative group effort to develop CRE-specific monitoring protocols.

3.1 Literature Collection

My first responsibility was to collect, review and make suggestions of recommended monitoring protocols applicable to the CRE that could be referenced under various protocols in the manual. In an earlier report titled *Plan for Research, Monitoring, and Evaluation of Salmon in the Columbia River Estuary* (2004), the authors include a table with recommended protocols that pertain to certain monitored attributes (attributes to assess physical and biological features within the estuary). The monitoring attributes for which I collected protocols included; landscape features, bathymetry and topography, area (size) restored, passage barriers, temperature, salinity and dissolved oxygen, total edge of tidal channels, water elevation, species composition, size and age structure, and success rate of vegetation plantings. I gathered literature associated with each monitoring attribute to use as references when drafting the protocols. The purpose of collecting this literature was to draw upon and incorporate some of the ideas into the protocols as they were being constructed. After collecting and reviewing the relevant literature I composed an annotated bibliography. This bibliography can be found in Appendix B.

In addition to the recommended literature, I conducted a literature search for other papers that would be relevant to CRE habitat restoration and contacted scientists participating in CRE habitat restoration studies. I found literature from restoration projects in the Salmon River Estuary, the Salmon Recovery Funding Board, Oregon Plan for Salmon and Watersheds, TFW Monitoring Program and the National Estuarine Research Reserve System. I contacted scientists from NOAA Fisheries, U.S. Army Corps of Engineers, Ash Creek Forrest Management, Ducks Unlimited and Columbia Land Trust to find out what protocols their field studies required and how they felt about using a set of standard monitoring protocols.

3.2 Protocol Layout Design

My second task was to develop a template for the layout of each protocol. The purpose was to allow each protocol to be easily understood and contain the minimum amount of information necessary to contribute information to a comprehensive monitoring program. To guide the direction of the overall flow of the protocols, I referred to the Washington Salmon Recovery Funding Board protocols since they are used by numerous agencies within the Pacific Northwest and are familiar to many restoration scientists. The design of the protocol layout went through many iterations. Below is the structure of the overall layout and headings. A description of the contents of each heading is provided.

Protocol for assessing…

-This is the title for each protocol and describes which of the seven metrics are being assessed.

PURPOSE

- This section provides a reason for assessing the particular metric, relevance to other metrics in the manual and overall recommendations for data collection.

GOAL

- To determine what needs to be assessed to complete the protocol

DESIGN

-Suggests a Before/After/Control/Impact (BACI) design (time series type or survey type) or a specific design tailored to the specific metric.

EQUIPMENT

A. ***Field***

B. ***Lab***

- Gives a list of equipment, manuals and measurement devices needed to conduct each protocol.

SITE SELECTION

- Provides specific instructions on where to place monitoring equipment, or what to reference to find how to select a monitoring site.

SAMPLING PERIODICITY
- Provides a description of when and how often to conduct monitoring of each metric and in some cases provides recommendations.
SAMPLING PROTOCOL
- This section gives a step-by-step procedure of how to conduct each protocol.

CALCULATIONS & ANALYSIS
- Some protocols require calculations and analysis of collected data. This section provides a list of calculations pertaining to individual protocols.

REFERENCES
- This section provides references that were drawn upon when writing the protocols and also gives reference to other relevant studies.

When constructing the protocols, thought was given to the ease of use in the field. The block design with specific headings was chosen so that the users could easily refer to his or her place within the protocol, and check of each step as it is completed.

3.3 Restoration Managers' Meeting

The Columbia River Estuary Restoration Project Managers' meeting on restoration monitoring convened by the LCREP, Corps, PNNL and NOAA fisheries on June 23, 2004 acted to facilitate construction of the protocols. During this meeting, restoration managers from numerous agencies conducting habitat restoration came to present and learn new developments about restoration monitoring. A representative from NOAA presented the idea to develop a set of standard monitoring protocols and there was strong support of the participants. Different agencies conducting restoration projects stated they needed protocols to follow, because few or none exist. After some of the managers had a chance to review the minimum monitoring work displayed by NOAA, they stated that the proposed protocols would be feasible and that they were consistent with the work being done currently in the estuary.

3.4 Protocol Recommendations

The draft set of minimum monitoring protocols have gone through many iterations and many considerations were made during their creation. After being part of the development phase, and ironing out what needed to be considered in order to make them feasible for use by multiple entities, I have provided the following recommendations for the draft set of minimum monitoring protocols. The set has been released for peer review and field testing and may benefit from the following recommendations. These recommendations may also be considered for incorporation into future editions and some will be relevant to the implementation scenario detailed in chapter 4.

Data Collection Forms

Currently, the set of protocols do not have any attached forms on which to record field data. In order to further standardize data collection efforts and to facilitate data entry into a central database, forms should be included at the end of each protocol. These could be prepared in a spreadsheet, defining the measurements that need to be recorded and in what units each measurement should be taken. Some protocols require the use of dataloggers, in which case the data can be directly downloaded to a computer, but for those requiring physical measurements of a particular habitat metric, data collection would become more accurate if each entity was using the same data sheet to record information. This recommendation is particularly relevant to the proposed CRE-specific database in chapter 5.

The following is an example of a data sheet for a protocol. It provides a basic framework to record data from barriers that hinder fish passage (in particular ESA listed Salmon). It is drawn from a protocol for assessing passage barrier characteristics.

ExampleField Data sheet for Passage Barrier Characteristics

Date:____________________________

Inventoried by:______________________________

Description	**Dimensions of barrier/ alteration (m)**	**Material Type**	**Age of Structure**	**Structure Location (GPS coordinates, Lat, Long)**	**Size of affected area (m^2)**
Dike breach/ removal					
Tidegate replacement/ modification					
Tidegate removal					
Channel excavation					
Culvert replacement					
Other (e.g. plugs/constrictions)					

Comments:

Project Cost

Funding for monitoring projects can be variable over time and project managers need to know how much to allocate to complete each protocol. Individual protocols have associated costs: personnel, field and lab equipment, surveys, computer software, identification books, and monies needed to prepare and analyze collected data, etc. I suggest that each protocol include a section outlining project costs. In *Regional Standards to Identify and Evaluate Tidal Wetland Restoration in the Gulf of Maine*, by Neckles et al. (2000), the authors include a section that approximates project cost. The following is an example from the cost section of the hydrology protocol included in that paper:

"Costs are estimated for work performed in one sampling period (e.g. pre-restoration, post restoration year one, year five, etc.) at a site no larger than 10 hectares (22 acres). For variables that require more sampling at larger sites, costs will be greater. Collection of tidal signal data using 2 automated recorders requires about \$1500 for equipment, 2-4 days of professional work for deployment and data collection and 1-3 days of professional work for data-processing. Alternatively, use of tide staffs would require about \$200 for equipment, and 2-4 days of professional work for data processing. Generating a contour map requires about \$1500 for equipment, 3 days of field work and 2-4 days of professional work. Alternatively, generating a hyposemtric curve of marsh elevations requires about \$500 for equipment, 2 days of field work, and 2-4 days of professional work. Survey and other equipment can often be borrowed from agencies and academic institutions."

It may be that managers need to prioritize their monitoring efforts within a given habitat and an approximation such as the one described above will help them to better identify cost levels necessary to allocate their funds.

Level of Expertise

The skill requirements to successfully conduct each protocol may vary. Even though the protocols were designed to be used by numerous entities within the CRE, some sections may need to be conducted by skilled professionals. I recommend incorporating a section that describes which portions of the protocols are feasible for specified skill levels. An example of this type of description can be found in *Regional Standards to Identify and Evaluate Tidal Wetland Restoration in the Gulf of Maine* (Neckles et al. 2000).

4.0 PROPOSAL FOR IMPLEMENTING STANDARD MONITORING PROTOCOLS

Monitoring protocols will be the cornerstone for a comprehensive and coordinated monitoring program. After helping to develop the minimum set of monitoring protocols and reviewing numerous restoration and monitoring program literature, I propose the following implementation scenario for a CRE-wide effort to standardize data collection efforts and facilitate data sharing.

The implementation of standard monitoring protocols will require consideration of both technical and institutional parameters, as discussed in sections 1.4 and 1.5, in addition to the following elements:

I. Restoration coordination taskforce
II. Monitoring and restoration coordination workshop
III. Coordination strategy
IV. CRE-specific database (chapter 5)

The restoration coordination taskforce I propose would be comprised of members from the Pacific Northwest Aquatic Monitoring Partnership and the Lower Columbia River Estuary Partnership. This entity would act as the central coordination hub within the CRE and would be charged with six responsibilities: 1) developing, distributing and training in the use of standard monitoring protocols, 2) integrating efforts of individual restoration projects, 3) establishing a centralized data management system, 4) establishing sustaining relationships with major funding agencies, 5) hosting workshops and meetings on protocol changes and overall status of estuary restoration and 6) running an outreach and education program to enhance restoration support.

The second element of the implementation scenario would be a restoration coordination workshop hosted by the taskforce. The major objective of the initial workshop would be to invite entities to participate in a CRE-wide standard monitoring program. It would also be used as an opportunity to familiarize each restoration group with each others' efforts and to provide contact information for further coordination and data sharing.

The third element of the implementation scenario would be the development of an overall coordination strategy for restoration efforts. The overall strategy involves facilitating the flow of information among restoration projects, between the taskforce and funding agencies and between the taskforce and each restoration project. These activities could be orchestrated by the taskforce. A subset of the coordination strategy is the task of inventorying existing data and databases. Each entity would provide input as to what types of data their agency holds or is collecting and what existing databases are most commonly used by restorationists.

A fourth and final part of the implementation scenario would be my proposed CRE-specific database described in the following chapter. This database would house data collected using the standard monitoring protocols and would keep a running inventory of restoration projects within the CRE. The database I propose would provide the user with:

- Instant feedback of monitoring results and calculations
- Instant site comparability
- Instant comparison of projects with similar restoration goals
- Access to restoration literature
- Comments on project progress to enhance learning
- Designs and protocols for new data collection projects
- Lists of project contact information
- Feedback on use of standardized protocols

The four elements described above comprise the entire implementation scenario. They would be conducted in the order outlined above and would be directed with the guided by the central taskforce. Each element is described in detail in the subsequent sections.

Figure 2 describes monitoring elements and their relationships that are important to the entire implementation scenario. An integration taskforce working in association with individual restoration projects would facilitate overall restoration coordination and data sharing. The proposed scenario would require partnerships among the participating parties and also with funding agencies.

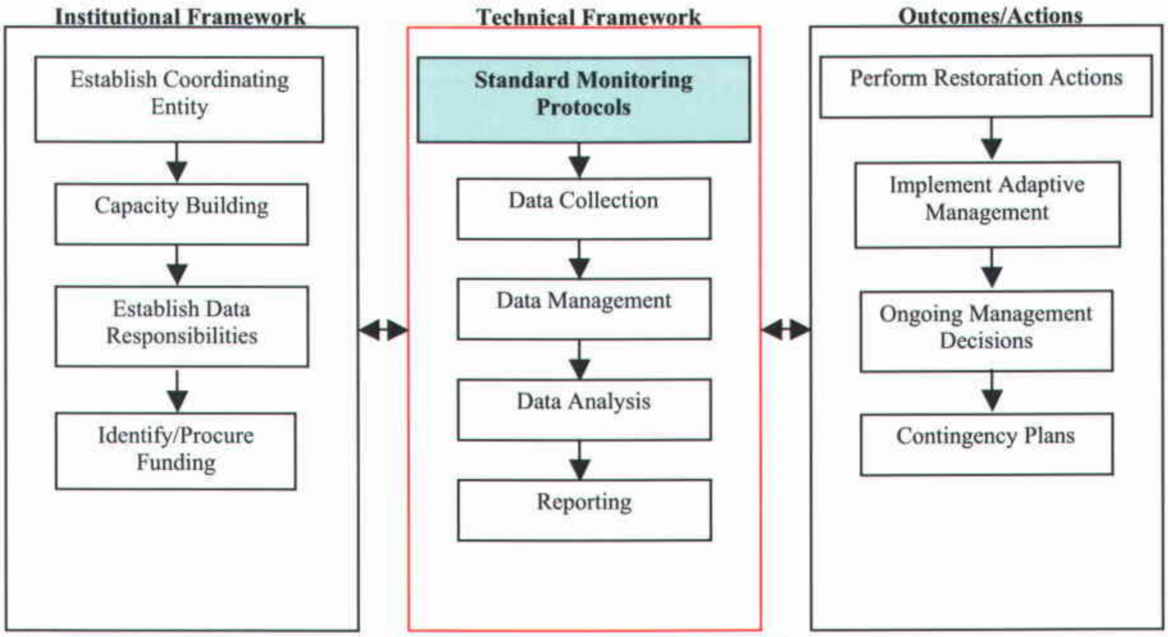

Figure 2. Monitoring program components (red box) and their relationship to other monitoring program elements (Modified from CERP Monitoring and Assessment Plan 2004).

4.1 Proposed Restoration Coordination Taskforce

After reviewing literature on the status of restoration in the CRE, it was evident that there are numerous entities trying to coordinate efforts, but two major agencies stand out from the rest, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and LCREP. PNAMP is composed of many leaders of monitoring programs throughout the Pacific Northwest and is mainly concerned with coordinating state, federal and tribal monitoring programs for ESA listed salmonids. Their main goals are to expand communication between institutions, advance resource and policy decisions through improving scientific information, promote cost-sharing among monitoring programs through use of standard and coordinated monitoring efforts and share information gathered among many monitoring participants (PNAMP 2005_1). LCREP, on the other hand, is one of 28 National estuary programs. It is comprised of a 22-member board with a goal of "*bringing together the whole picture; building capacity of partners and leverage resources and providing information; and removing barriers to better management of the lower Columbia River through collaboration, convening and coordination* (LCREP 2005)."

Since PNAMP and LCREP have very similar ideas and goals for further coordination I propose they establish a formal coordination taskforce focused on restoration monitoring within the estuary. The taskforce would be comprised of individuals from different agencies choosing to participate in a coordinated restoration monitoring effort. The taskforce would be charged with: 1) implementing, distributing and training in the use of standard monitoring protocols, 2) integrating efforts of individual restoration projects, 3) establishing a centralized data management system, 4) establishing sustaining relationships with major funding agencies, 5) hosting workshops and meetings on protocol changes and overall status of estuary restoration and 6) running an outreach and education program to enhance restoration support.

Many benefits would be realized through a centralized restoration monitoring taskforce. First, the taskforce would become the integrating entity among all projects conducting restoration that choose to use the standard monitoring protocols. This means that the scopes of separate projects would be optimized to avoid duplication; share necessary costs, staff, equipment, information and experience; and develop ongoing restoration monitoring strategies through an adaptive management approach. Second, they would help to coordinate efforts at different levels (federal, state, local and tribal). This would promote better agency relationships and present an accurate image of effective performance to external observers such as the U.S. Congress. Third, they would help to gain broad stakeholder support through outreach and education programs. This would be important to sustain the overall restoration effort through funding and other challenges.

4.2 Monitoring and Restoration Coordination Workshop

The main purposes for conducting a monitoring and coordination workshop, hosted by the taskforce, would be to invite restoration groups to participate in CRE-wide restoration monitoring effort, establish a coordination strategy and procedures, and introduce the standard monitoring protocols. The first task would be to introduce the role of the taskforce and describe the standard monitoring protocols. Subsequent activities would include: 1) providing a strategy for coordinating efforts, 2) taking an inventory of existing databases, 3) proposing a CRE-specific database, and 4) coaching on how to build relationships with funding agencies. Each of these topics is described further in the following sections.

At the end of the workshop individual restoration project participants would sign up to be trained in the appropriate use of the standard monitoring protocols. The taskforce would facilitate this endeavor and would schedule a series of group training sessions. The authors of the protocol manual could help with the instruction along with taskforce representatives. Project managers would be required to attend one of the sessions to ensure that they are familiar with the protocols and their use.

4.3 Coordination Strategy

As described above in section 4.1, the taskforce would have many responsibilities and would act as the central coordination hub. Information would be passed from the taskforce to individual restoration projects and vice versa. In addition, individual projects would be granted access to data from other restoration projects and project contact information through the central database managed by the taskforce. There would be two-way communication between the taskforce and individual projects, between the taskforce and funding agencies and also among projects, as depicted in Figure 3.

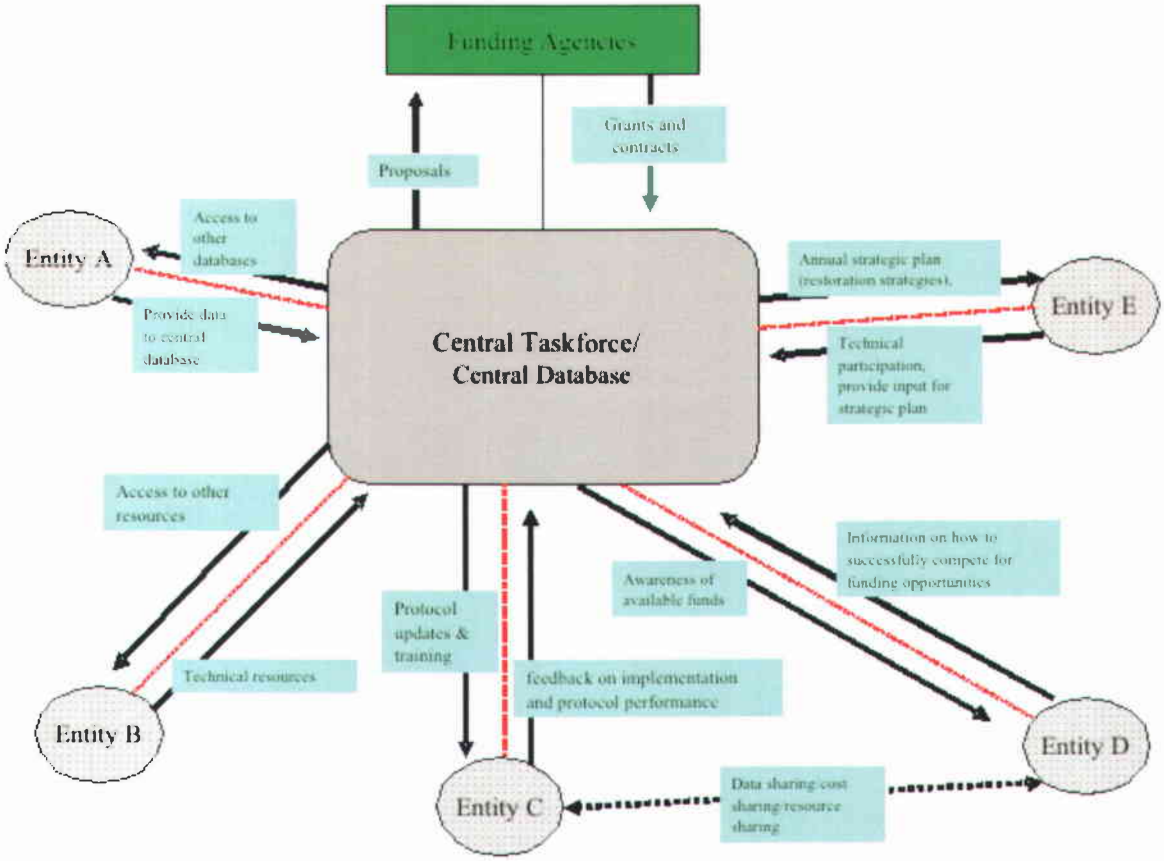

Figure 3. The exchange of information and relationships that will develop when efforts are coordinated through a central taskforce (entities represent separate restoration projects).

This exchange of information would greatly enhance communications among restoration projects, the taskforce and funding agencies. This coordination strategy could provide the framework to help make restoration efforts more efficient.

4.3.1 Inventory Existing Data and Databases

During the initial coordination meeting it is essential to establish what data are being collected by separate entities and what databases are being used to house data. This information would be essential to implementing monitoring protocols because the central database would need to be updated with previously collected information so that data collected prior to the implementation can be used. Also, a formal discussion of who is doing what in the estuary could help project participants to gain a better appreciation for the overall estuary restoration effort and make new contacts. Most of the existing data are presently housed in regional or individual agency databases.

As it stands now there is no CRE-specific data management system in place, but numerous regional databases. Two regional databases have been proposed: one for the restoration, monitoring and evaluation management plan in response to the Federal Columbia River Power System Biological Opinion in 2000 (PNAMP 2004) and the second by the Northwest Power and Conservation Council in partnership with NOAA to create a regional data network that seeks the use of existing databases for data management and data sharing for salmon recovery efforts under the FCRPS BiOp (PNAMP 2004). Other existing regional databases include StreamNET, Columbia River data access in real time (DART), Fish Passage Center and the Pacific Coastal Salmon Recovery Fund Data System (Washington Comprehensive Monitoring Strategy 2002).

4.4 Technical Framework Implementation

The standardized monitoring protocols are intended to be used by multiple entities within the CRE. The protocols would help to guide data collection, and would facilitate data management, analysis and reporting (the technical components of standard monitoring protocol implementation) (CERP Monitoring and Assessment Plan 2004). This section describes the specific technical components of a restoration monitoring program.

4.4.1 Data Collection

The draft set of standard monitoring protocols attached in Appendix A outline a minimum set of data that could be collected from each restoration site. Data could be collected using datalogging instruments, aerial photographs, ground surveys and transects, or a combination of the above. The metrics that could be collected are the following from Diefenderfer et. al (2005): hydrology, water quality, landscape features, bathymetry and topography, vegetation changes resulting from tidal reconnection and fish temporal presence, size/age structure and species composition. The metrics represent a minimum set that those authors recommend be collected at each site.

Hydrology (water elevation)

Reestablishing historical wetland areas to tidal inundation is an important restoration goal within the CRE. Assessing the influence of hydrology on wetland development is critical. Tidal inundation into historical wetland areas after a dike or levee breach has implications on vegetation tolerances (Thom et al. 2002), salinity, tidal channel progression, tidal exchange (Williams and Orr 2002) and sedimentation and erosion (Coats et al. 1995). Hydrology can be measured using continuous water level recorders (pressure transducers) (Diefenderfer et al. 2005).

Water Quality (salinity, temperature and dissolved oxygen)

Salinity, temperature and dissolved oxygen play a role in the presence or absence and quantity of flora and fauna within a wetland. The majority of restoration actions within the CRE seek to enhance the abundance of ESA listed salmonids and it is especially important to measure water temperature, a significant parameter, which affects the overall survival and growth of the fish (Schuett-Hames et al 1999). As described above, salinity has an implication for vegetation tolerance (Thom et al. 2002) and dissolved oxygen has implications for fish and benthic organisms. Water quality can be measured with dataloggers placed throughout the restoration site.

Landscape Features

Restoration actions associated with tidal reconnection have the potential to facilitate land cover changes and landscape changes within a wetland (e.g. tidal channels and vegetation cover). It is important to understand and record the trends and changes at the large scale landscape level that occur as a result of restoration actions. Landscape feature analysis requires aerial surveys. An example of an analysis that has already been performed to assess changes in land cover was completed in a study by Garono et al. (2003). Aerial surveys are expensive and restoration projects can benefit from cost-sharing for such a survey. Landscape features can be measured by preparing landscape classifications through interpretation of aerial imagery and verifying classification in the field.

Bathymetry and Topography

Bathymetry and topography within a system undergoing restoration action change as a result of tidal reconnection. These changes may affect marsh development processes such as marsh gradient, channel profile, and sediment characteristics (Williams et al. 2002, Williams and Orr 2002). Changes such as these may result in adjustments in the distribution and abundance of flora and fauna within the system (Diefenderfer et al. 2005). This metric can be measured with surveying equipment or with the use of a Total Station (Diefenderfer et al. 2005).

Vegetation Change Resulting from Tidal Reconnection

As described above, plant distribution may change as a result of tidal inundation. This in turn may have an effect on the response of fish and wildlife populations that utilize vegetated habitats. This metric can best be evaluated through ground survey and transect procedures (Diefenderfer et al. 2005). A large variety of such procedures have been proposed and should be tailored to the monitoring objectives.

Fish Temporal Presence, Size/Age-Structure, and Species Composition

Wetland habitat, particularly in the Pacific Northwest, provides rearing habitat for anadromous fish that migrate through the CRE to the ocean (Miller and Simenstad 1997, Simenstad and Cordell 2000). Estuarine wetland habitat also provides foraging habitat for juvenile salmonids (Shreffler et al. 1992, Miller and Simenstad 1997). It is important to take an inventory of the fish that utilize restored habitats to understand the changes in community structure from different types of restoration actions. This metric can be measured by capturing fish through various collection techniques such as beach seines, fyke trap nets, pit traps and dip nets (Diefenderfer et al. 2005).

4.4.2 Data Management

To further coordinate and standardize habitat restoration and monitoring efforts within the CRE, there is a need to develop a central database that each manager can use to house individual project data and that can be viewed and queried by anyone interested in understanding more about CRE habitat restoration. Chapter 5 provides an example of a CRE-specific database I propose for habitat restoration efforts choosing to use the standard monitoring protocols. The major incentive to provide data to a common database is to contribute data to a larger program that allows funding agencies to get a better understanding of the big picture. This would give the funding agency an incentive to continue to provide the funding.

4.4.3 Data Analysis

Two levels of data analysis will be critical to understanding the dynamics of CRE habitat restoration efforts on ESA listed salmon and the overall health of estuarine habitats: project and program. Individual projects should analyze data from their own site through time to assess the status and trends of their individual restoration projects, but should also provide their datasets to a central database so that data can be analyzed at the program level. The program level data interpretation will seek to evaluate the cumulative effects of multiple restoration projects.

Even though cumulative effects cannot be assessed at this time, one set of monitoring protocols has been drafted and is ready for use throughout the estuary. These protocols provide standard data that will need to be analyzed through various techniques. The interoperability of the protocols facilitate analysis of metrics either individually or in combination with use of GIS. The following descriptions provide examples of ways protocol generated data can be analyzed.

Hydrology- Using the Before-After-Control-Impact (BACI) time series design, water elevation can be analyzed and compared before and after restoration. The reconnection of backwater sloughs will allow tidal influence into new areas and will help shape wetland recovery. Timeseries data could be analyzed in GIS layers or incorporated into various hydrology models. Data could also be analyzed to understand how long different areas of a restored wetland are being inundated by the tide (Diefenderfer et al. 2005).

Landscape Features- Aerial surveys of restoration sites throughout the estuary may target the physical features within the landscape, particularly vegetation and tidal channel development. Under ideal conditions, a few of the more distinct classes of tidal wetland vegetation could be recognized in these aerial images and then digitized in a GIS. The vegetation classes could then be used to determine landscape feature change over time. The aerial photography must be ground-truthed, georeferenced and orthorectified before evaluations can be conducted.

Water Quality (Salinity, Temperature and Dissolved Oxygen)- This time series of data could be put in a graph or added in a GIS layer. An analysis could be conducted to look at the influence of water quality on vegetation. For example, layers could be made for both parameters in a GIS and the data could be analyzed for the effects of salinity intrusion on vegetation distribution.

Bathymetry and Topography- Restorationists can conduct an elevation survey within their site and include their data as a GIS. A layer for bathymetry or topography could be overlayed with a vegetation layer, and on top of that placed a water quality layer to see the influence of multiple controlling factors within a restoration site.

Fish Temporal Presence, Size/age-structure and Species Composition- Fish presence data could be analyzed with water quality data to get an understanding of what salinity and temperature levels within a restoration site different fishes prefer. Also, species composition numbers could be analyzed against hydrology data to get an understanding of species composition at varying inundation periods and water levels.

The important concept to note is that there may be relationships between metrics so different evaluation techniques should be used to discern these relationships. The major goals of data analysis should be to review collected data and seek patterns, identify changes and differences, test hypotheses, and seek ways to reduce project uncertainty (CERP Monitoring and Assessment Plan 2004).

4.4.4 Reporting & Data Sharing

Large-scale restoration within the CRE will require many years of restoration work followed by several years of monitoring. It is important to evaluate the progress of each individual restoration site to describe project status and trends. Annual reports should be composed for each project and written in a way that is beneficial to many stakeholders and decision makers. Reports should be submitted to the central taskforce for distribution to other project managers, stakeholders and the public. Annual meetings and workshops could be hosted by the taskforce to share project successes and failures and evaluate protocol use.

Project progress reports should include a discussion of the datasets from the various habitat metrics, measured against performance indicators to evaluate which metrics are on target and which are not. Some possible performance indicators for the CRE are described in chapter 3 of the report *Plan for Research, Monitoring, and Evaluation of Salmon in the Columbia River Estuary* (Johnson et al. 2004), and others are suggested or implied by the documents from other states cited earlier. A comprehensive summary of individual project status followed by a meeting and dissemination of results should be an incentive for sharing data. The following chart from the *Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery* depicts the elements for easy access and sharing of watershed data (Washington Comprehensive Monitoring Strategy 2002). These ideas go hand-in-hand with the proposed database and taskforce described in earlier sections.

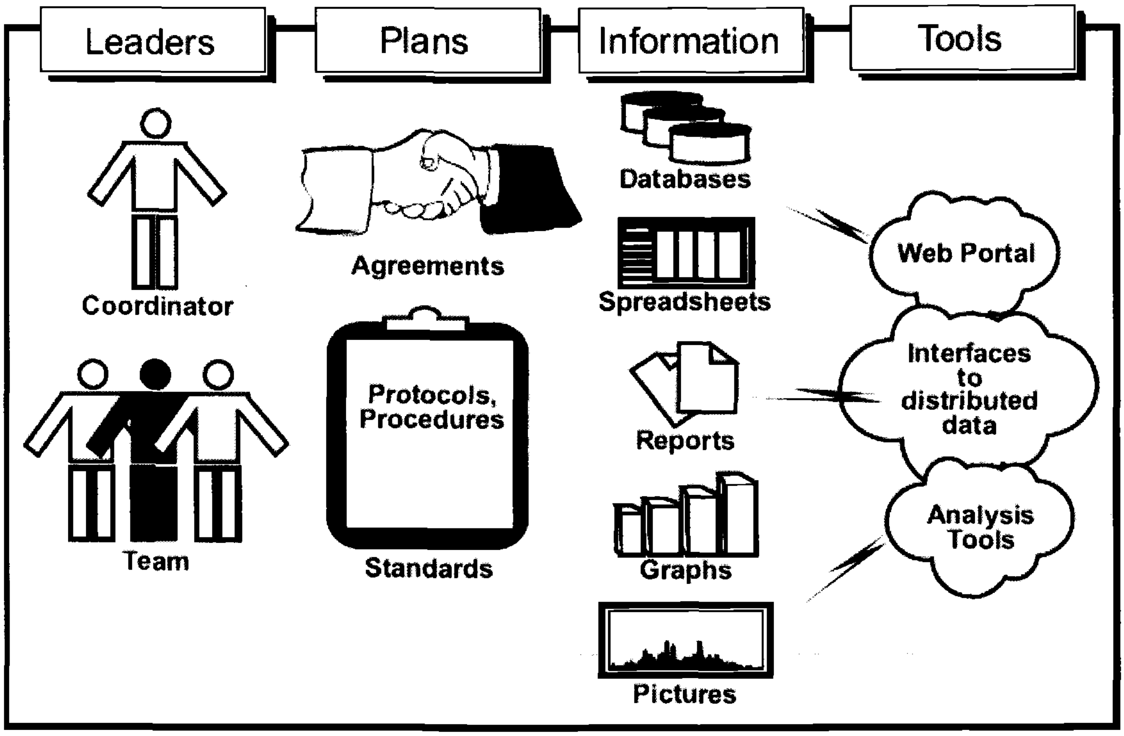

Figure 4. Elements of effective data sharing. (From *Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery 2002).*

4.4.5 Quality Assurance/Quality Control

Quality assurance and quality control are very important elements to any monitoring program. Each study should incorporate a QA/QC program through each phase of the monitoring program: data collection, data management, data analysis and reporting. The QA/QC program helps to ensure that data collection and analysis are meeting study objectives and that reporting of project elements are accurate. Each entity within the CRE choosing to use the standard protocols should have their own QA/QC program in place prior to any data collection and data entry activity to makes sure that the data supplied to the central database were entered correctly and documented sufficiently to facilitate comparison.

4.5 Institutional Implementation

4.5.1 Existing Institutional Framework

Numerous institutions within the CRE are tied to restoration projects whether they provide funding or are actually performing on-the-ground monitoring and restoration. Most projects are carried out by a suite of partners and few are conducted by a single entity. Agencies have individual mandates to uphold that sometimes inhibits them from working in a collaborative fashion, but many do not. For example, the U.S. Army Corps of Engineers collects data for their own agency mandates and those data are part of the public record under the Freedom of Information Act. However, they also collaborate to share data as long as it fits within one of the Corps authorities (Ebberts 2005). The lack of coordination between federal and state laws, agency mandates, permitting programs, funding, institutional bureaucracies, agency responsibilities, and interagency requirements are unsolved barriers to complete restoration cohesiveness. Table 3 below gives a selection of various agencies and the mandates they must uphold. Also contained within the table are projects that they are currently working on within the CRE or tidally influenced portions of the estuary. Some projects within the table are listed under one or more agencies.

The agencies listed in the table would greatly benefit from standard monitoring protocols. Standard data monitoring protocols will benefit the entire CRE restoration effort in the following ways: reduce project and agency costs, reduce project duplication, allow for collaboration and data sharing, help agencies meet their required mandates, allow Congress to channel funds to critical areas and bring attention to the overall CRE restoration effort.

Agency	General Mandate	CRE restoration projects: within the floodplain and tidally influenced areas	References
NOAA Fisheries	Describe and identify essential fish habitat, restore essential fish habitat, Conservation of Endangered and Threatened species (ESA jurisdiction & Biological Opinion)	Funds LCREP projects	Northeast Midwest Institute 2005; NOAA Restoration Center 2005
U.S. Army Corps of Engineers	Implements and enforces §404 of Clean Water Act (permitting for wetlands dredge and fill activities)	Crims Island Habitat Restoration, Chinook River Restoration	U.S. Army Corps of Engineers, Portland District 2005[2,3]; CERES 2005
Bonneville Power Administration	Enhance and support fish and wildlife resources under the Northwest Power Act, implement measures under the ESA.	Ft. Columbia Tidal Reconnection, Brownsmead, Burlington Bottoms	LCREP 2004; Byrnes 1996
U.S. Environmental Protection Agency	Water quality, permitting under §404 of Clean Water Act	Smith and Bybee Lakes; EMAP	CERES 2005; LCREP 2004
United States Fish and Wildlife Service	Wetlands permitting, protection, planning, restoration and enhancement of fish and wildlife habitat, jurisdiction under many federal mandates	Crims Island Habitat Restoration, Steigerwald National Wildlife Refuge	LCREP 2004; CERES 2005; U.S. Army Corps of Engineers, Portland District 2005[2];
United States Geological Survey	Provides science and engineering to long-term monitoring studies	Crims Island	U.S. Army Corps of Engineers, Portland District 2005[2]; USGS 2005

Table 3. Selected current agency mandates and projects for agencies working on CRE habitat restoration.

Lower Columbia River Estuary Partnership	Develops and implements a Comprehensive Conservation and Management Plan for the National Estuary Program, protects and restores CRE habitats through on-the-ground efforts and education	Ft. Columbia Tidal Reconnection, Lewis and Clark, Deep River, Brownsmead	LCREP 2004; LCREP 2005$_1$
Columbia River Estuary Study Taskforce	provides coastal and estuarine services and coordinates efforts between state, local and federal agencies	Brownsmead, Warren Slough, Deep River, Chinook River	LCREP 2004; CREST 2005
Ducks Unlimited	conserves, restores and manages wetlands and associated areas	Baker Bay Estuary, Deep River, Burlington Bottoms,	LCREP 2004; Ducks Unlimited (http://www.ducks.org/)
Columbia Land Trust	Works with landowners to conserve land and manage it under a stewardship plan	Walker Island, Lord Island, Germany Creek, Sandy River Delta, Crims Island	LCREP 2004
Washington Department of Fish and Wildlife	Maximize fish and wildlife related recreation, protect and recover salmon listed under the ESA	Shillapoo National Wildlife Reserve, Germany Creek	LCREP 2004; WDFW 2002
Oregon Department of Fish and Wildlife	Enhance fish and wildlife and their habitats	Sauvie Island Wildlife Reserve, Sturgeon Lake	LCREP 2004;

Table 3 Cont'd

4.5.2 Cost/Funding

Funding for habitat restoration projects is a very important institutional parameter. The scope of restoration projects varies considerably and it is important that long-term funds be secured so that monitoring projects can be seen to completion. A review of project costs from OWEB (2005), LCREP (2004) and $USACE_2$ (2005) shows there to be a range from $40,000 to $2.8 million. Funding agencies need to know if the money they are providing is benefiting the resource that the restoration is targeting. In the case of the CRE, the question that needs to be answered is, is the habitat provided through restoration projects helping to increase the abundance of ESA listed salmonids? Federal funding appropriations are frequently unstable so it is very important to see what the results are from the money being spent so that future monitoring efforts can be prioritized if funding is an issue (Salmon Recovery Funding Board 2004). Table 4 shows Congressional appropriations to the major funding agencies within the CRE that participate in salmon recovery efforts.

Projects seeking Congressional funding need to be particularly conscious of the overall performance of their restoration dollars. Congress' objective for dispensing funds is to get a return on their investment. Projects receiving Congressional funding need to report on what Congress is obtaining for each dollar spent and how long funding needs to continue (Salmon Recovery Funding Board 2004).

Standard protocols will improve the cost-effectiveness of projects and promote shared data collection campaigns. The CRE restoration effort can greatly benefit from lessons learned elsewhere. For example, the Puget Sound LIDAR Consortium consists of representatives from Kitsap County, Kitsap PUD, City of Seattle, Puget Sound Regional Council, NASA, and the USGS. They came together and agreed upon common methods for developing LIDAR topography for the Puget Sound Region and have been very successful at sharing costs and collected data (PSLC 2005). The proposed implementation strategy described in this report will facilitate cost and data sharing.

Department/Agency	FY 01 Enacted	FY02 Enacted	FY03 Enacted	FY 04 Enacted	FY 05 Enacted	FY 06 Pres Bud	Notes
Discretionary Funding:							
Department of the Army							
Army Corps of Engineers	102.7	108.8	113.5	116.8	113.3	116.6	
Department of the Interior							
Bureau of Land Management	7.6	10.6	11.3	11.2	11.3	11.4	
Bureau of Reclamation	20.5	34.0	41.2	40.0	43.6	40.5	
United States Fish and Wildlife Service	10.1	20.2	22.6	28.2	17.9	15.5	
Bureau of Indian Affairs	2.7	3.2	3.2	3.2	3.1	3.2	
United States Geological Survey	3.6	3.6	3.7	4.4	4.3	4.4	
Department of the Interior Total	44.5	72.0	82.3	87.0	80.2	75.0	Note 1
Department of Commerce							
National Marine Fisheries Service	25.5	24.6	27.7	27.9	29.7	41.4	
Department of Agriculture							
United States Forest Service	54.3	56.5	44.8	48.5	41.5	41.5	
NRCS	23.9	27.4	39.6	39.6	43.4	42.4	
Department of Agriculture Total	78.2	83.9	84.5	88.3	84.9	83.9	Note 1
Environmental Protection Agency	18.2	18.3	18.9	18.3	17.0	17.3	Note 2
Total Discretionary Appropriations	269.1	307.5	327.0	338.2	325.1	334.2	
Mandatory Funding:							
Department of Energy							
Bonneville Power Administration Direct Fish Costs	184.0	253.3	237.8	302.3	274.6	238.0	Note 3
Total Funding (Discretionary and Mandatory)	453.1	560.8	564.8	640.5	599.7	572.2	

1 Department of the Interior and Department of Agriculture 2005 and 2006 numbers are estimates. Final allocations may change.
2 Estimated number for 2005 pending finalization of EPA's 2005 Operating Plan.
3 Transmission budget for 2006 is $0 ($37.9 million in FY05) due to completion of transmission projects required by 2000 Biological Opinion.

Table 4. Columbia River federal basinwide salmon funding in millions of dollars. (Modified from SalmonRecovery.gov).

4.5.3 Training/Capacity Building

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is a capacity building initiative within the Pacific Northwest. It strives to coordinate monitoring efforts in California, Oregon and Washington. It is an *ad hoc* group compromised of state, federal and tribal representatives that bring together different aspects of watershed monitoring: fish monitoring, effectiveness monitoring and data management (PNAMP 2004). Their efforts are directed towards coordination of monitoring at every level: data collection, data analysis, data management, and reporting so that mulit-agency efforts can benefit from regional coordination (PNAMP 2004). The PNAMP framework is very comprehensive and may help to lay the foundation for tightening coordination efforts within the CRE as standard protocols are introduced and a formal restoration, monitoring and evaluation program is developed.

The proposed taskforce described in section 4.1, could work through PNAMP to train individuals in the use of standardized protocols. The taskforce could set up a field workshop to teach restoration managers and field restoration groups in the correct use of the protocols. This would help to further coordinate data collection efforts, making sure that everyone using the protocols was trained in a consistent manner.

4.5.4 Data Responsibility/Accountability

Currently, most agencies are limited to collecting and reporting data that fall within their area of authority or responsibility (PNAMP 2004). This limitation causes agency focus to be restricted to specific sites they manage and doesn't lend for a broader view of larger landscape-level analysis. To overcome this obstacle, standard protocols and analysis tools will allow agencies to fulfill their individual mandates, while also facilitating analyses beyond the individual site level. Common protocols will allow data to be compared and analyzed at different landscape levels with a higher order of precision (PNAMP 2004).

By agreeing to participate in contributing to and using information contained in a centralized database, individual participants need not give up responsibility or accountability for their individual data projects. However, it may be necessary for the coordinating taskforce to negotiate limitations on the liabilities data contributors may incur when their data are used more broadly than originally intended.

5.0 PROPOSED CRE-SPECIFIC DATABASE

The following is step-by-step description of a database framework I propose for CRE restoration projects choosing to use standard monitoring protocols and willing to provide data to a central database. It is a concept, and if implemented, would need further input by the taskforce and individual projects. It would also need to be designed by a computer professional. The database proposed here is an overall concept containing elements that would be important to people collecting data in the CRE. The proposed database would be housed and maintained in a World-Wide Web accessible format to facilitate use by numerous geographically-dispersed participants. The web-based database would be maintained and updated by the taskforce and individual project participants and would be accessible to anyone interested in CRE habitat restoration. It is intended to be user-friendly and relatively simple to develop and maintain. The basic design and function would allow the webpage to be used by numerous groups. It would provide easy access to high quality, statistically valid data, since all the data will have been collected using the standard monitoring protocols. This database could and should be used in combination with other databases that house different information to get a more holistic perspective of how restoration efforts are affecting the estuary and its resources. The database, in due time, would house data that can eventually be used to assess cumulative effects of multiple restoration projects.

With a central, CRE-specific database for salmon habitat restoration projects (as I propose) for storing and querying individual project data, the following would be possible:

- Instant feedback of monitoring results and calculations
- Instant site comparability
- Instant comparison of projects with similar restoration goals
- Access to restoration literature
- Comments on project progress to enhance learning
- Designs and protocols for new data collection projects
- Lists of project contact information
- Feedback on use of standardized protocols

In the paragraphs to follow, descriptions of the principal web-based database features are provided.

Figure 5 below is a concept for the homepage for the Columbia River Estuary Monitoring Restoration database. It would allow the user to select from four different options. If the user selects the current projects button, they would be directed to the current projects page illustrated in Figure 6. The map included in figure 6 was produced by the Lower Columbia River Estuary Partnership. The database would use a map similar to this to depict where restoration projects are occurring. The current projects button would allow a user to select a project by clicking the appropriate number on the map or selecting a site through the list in the right hand column. Once a selection is made, the next window to appear is the options menu (Figure 7).

The second option on the database homepage is the beginning users button. This option would present a summary of overall restoration efforts in the CRE and provide a tutorial of how to navigate through the database. It would also allow the user to view restoration data (Figure 8) and run through calculations (Figure 9 and Figure 10).

The third database homepage option is the experienced users button. In addition to analyzing and calculating data that is provided by the database, this option would allow advanced users to access geo-referenced aerial imagery and download GIS layers necessary for thorough GIS analysis under the spatial data button of the options menu for a given project.

The final option within the database homepage is the summary of restoration efforts option. This option would allow stakeholders to get an understanding of the results and issues of habitat restoration within the CRE without having to access individual projects. This link would provide stakeholders with an assessment of overall habitat restoration specifications and gives a summary of how much area has been restored to date.

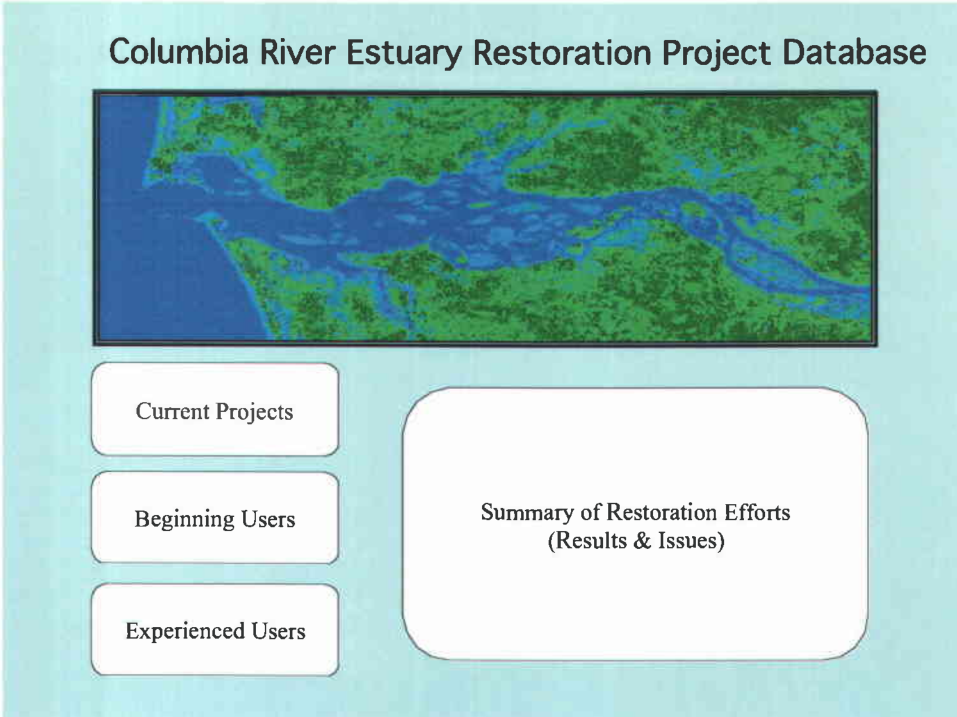

Figure 5. Database homepage.

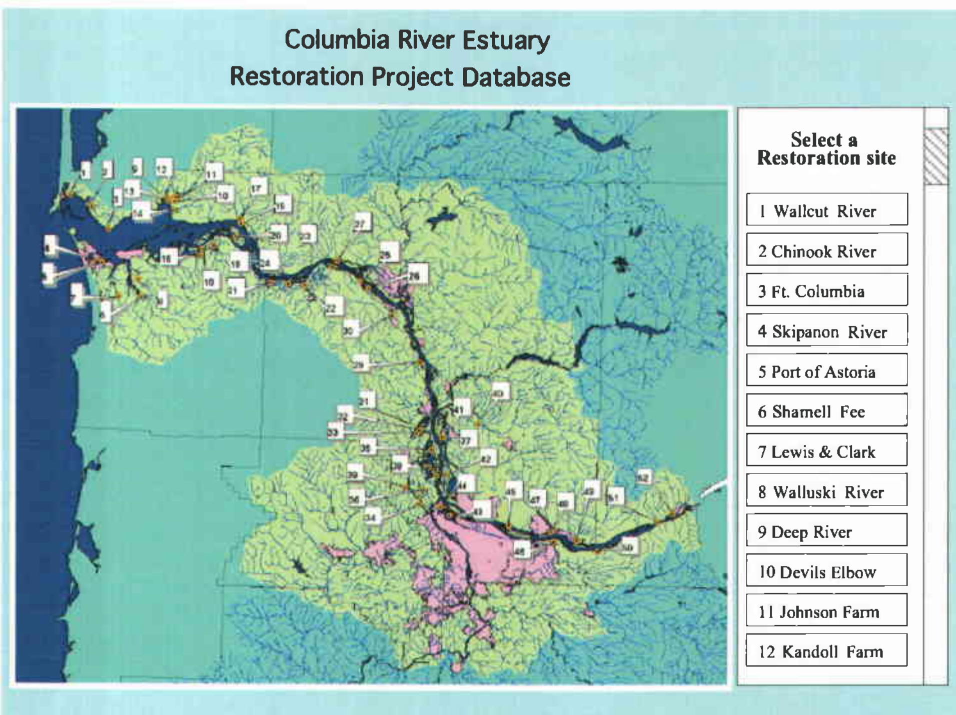

Figure 6. Current projects page. (Map produced by LCREP 2004).

The overall web-based structure of the proposed database is provided in database options text box.

The options menu would provide the user with several tools necessary to access high quality data. The user could select one of the six options or may choose to go back to the database homepage to select a different project. The first option, the "view data" option, would allow the user to view data that have already been collected.

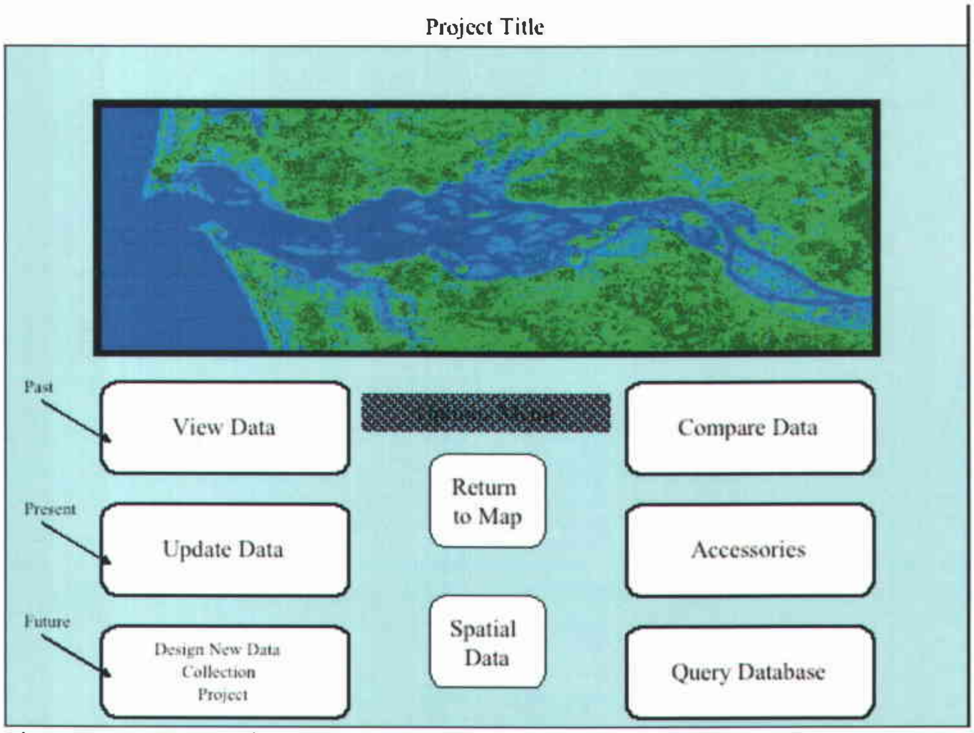

Figure 7. Database options menu.

The *view data* window (Figure 8) would give the user three different view options: by date, by metric or all data. If the *view data* by date is selected, the database would provide a spreadsheet list of the data by date categorized by habitat metric. If the *view data* by metric is chosen, the database would provide data for each metric. The user would then have the option to select a metric and see the data associated with it in a spreadsheet (Figure 9). All data are housed in Excel spreadsheets that cannot be changed, but the user does have the use of the sorting

DATABASE OPTIONS

VIEW DATA
UPDATE DATA
DESIGN NEW DATA COLLECTION PROJECT
SPATIAL DATA
COMPARE DATA
ACCESSORIES
QUERY DATABASE

function. The other capability under this function would be the calculations button. This would allow the user to view calculations associated with the collection of data from each metric. The possible calculations (Figure 10) that could be included in the database are found at the end of each protocol in Appendix A. Figure 10 shows an example of possible calculations that could be made from the fish temporal presence, size/age-structure and species composition metric. The user could select one of the blue boxes with an associated calculation and the answer would appear in the answer screen.

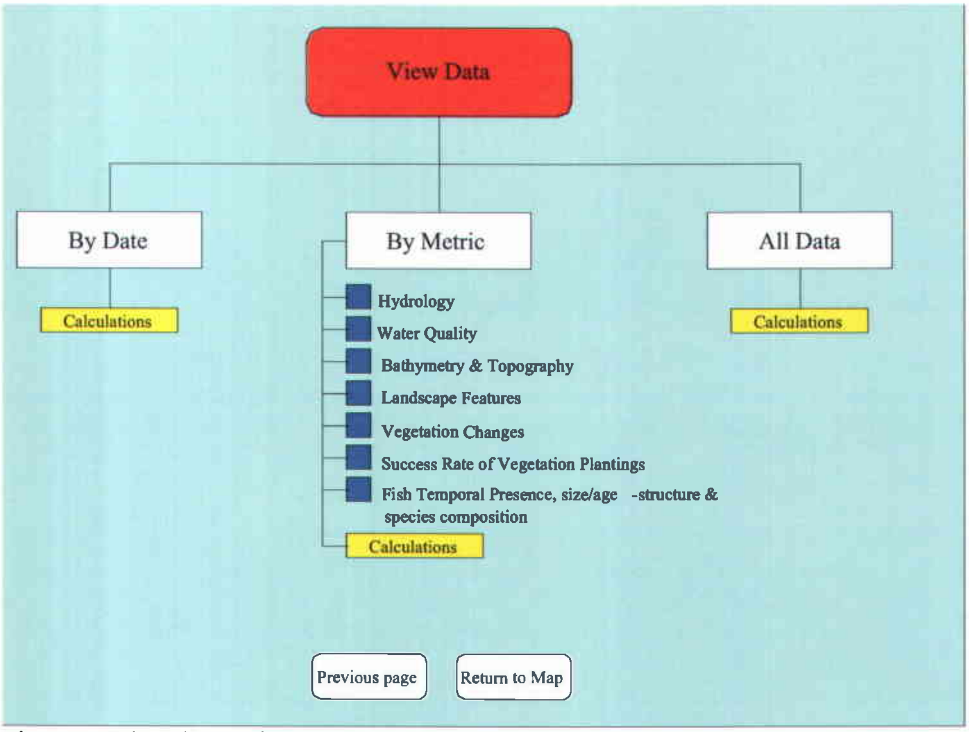

Figure 8. View data option.

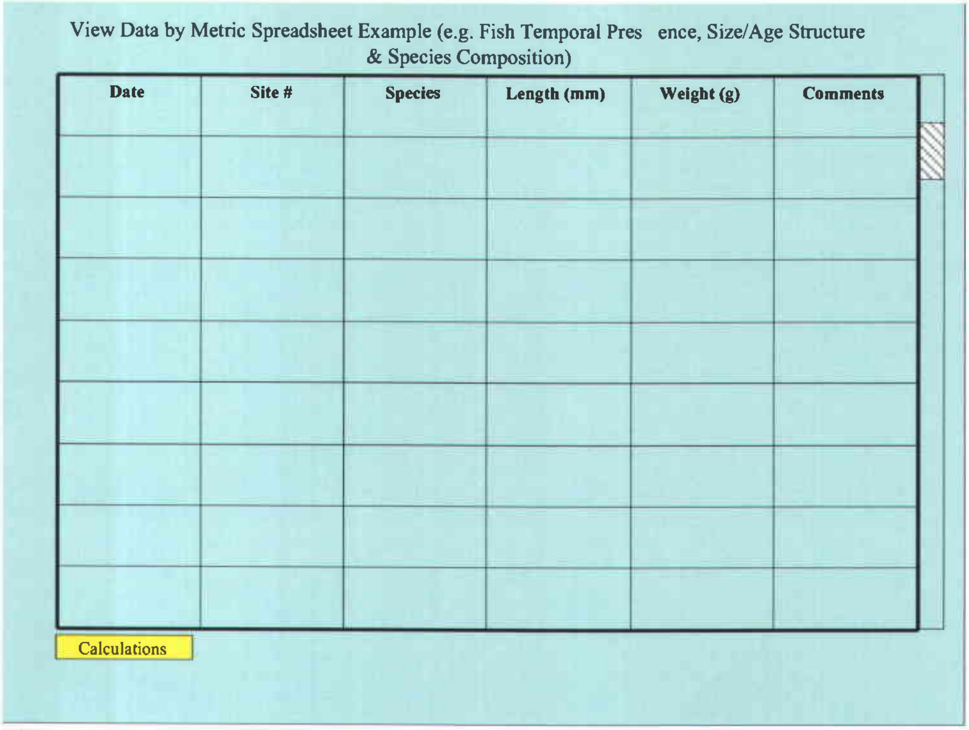

Figure 9. Example of a spreadsheet under the view data by metric option.

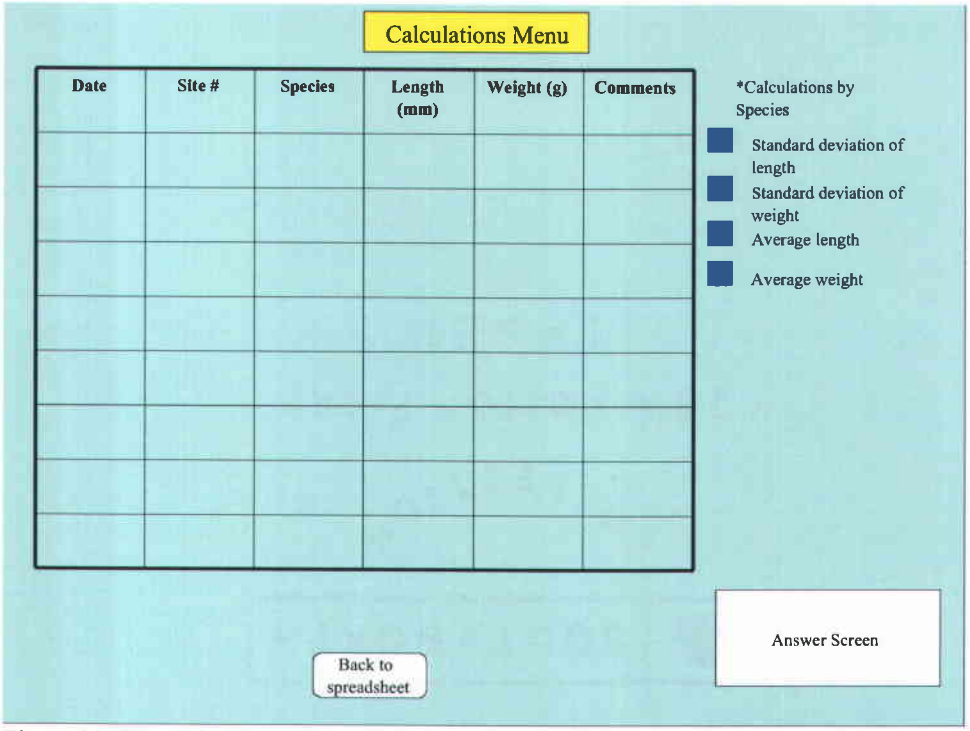

Figure 10. Example of possible calculations from the fish temporal presence, size/age-structure and species composition metric stemming from figure 7 & 8.

DATABASE OPTIONS

VIEW DATA
UPDATE DATA
DESIGN NEW DATA COLLECTION PROJECT
SPATIAL DATA
COMPARE DATA
ACCESSORIES
QUERY DATABASE

The next choice is the *update data* menu (Figure 11). This option would provide restoration managers with the capability to update the database. This is the only option that would allow the data to be edited and changed; entities choosing to use the standardized protocols could obtain a password to provide data to the database through the taskforce. If the *update data* menu is chosen, a password screen would appear that requires a login name and password. Once an individual is logged into the system, a spreadsheet would appear for the selected habitat restoration project. It would be an editing window where new data may be entered and edited. Once all the data and all parameters for metric calculations are entered the user could select a submit changes button and then would exit from the editing window. The next screen to appear would be a full extent spreadsheet view of the data (the same view a user would have if they were to select the view data button). The user could double check to make sure the data are correct and if not may select the edit further button which will take the user back to the editing window. Once the changes are made and the submit changes button is selected then the data will be stored in the database. The user could then return to the options menu to view the newly added data and run through the calculations.

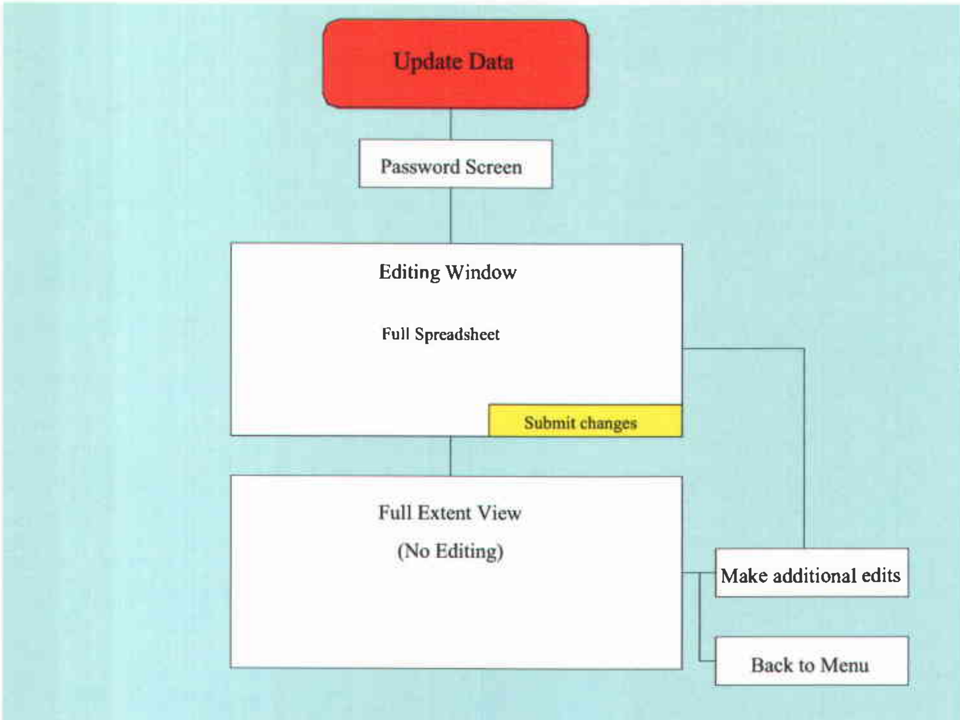

Figure 11. Update data option.

DATABASE OPTIONS

VIEW DATA
UPDATE DATA
DESIGN NEW DATA COLLECTION PROJECT
SPATIAL DATA
COMPARE DATA
ACCESSORIES
QUERY DATABASE

The third option would allow the user to *design a future data collection project.* It would allow each user to select the type of project he/she wants to conduct (e.g. dike breach, vegetation plantings, culvert replacement, tidal reconnection project, tide gate modification etc.) (Figure 12). The user would then be asked specific questions about the project and would have to enter parameters and constraints such as, the desired schedule data collection objectives, project locations, funding and other resources available, and any specific constraints. Once all of the parameters were entered into the system then a step-by-step data collection plan would be generated, incorporating the standardized protocols.

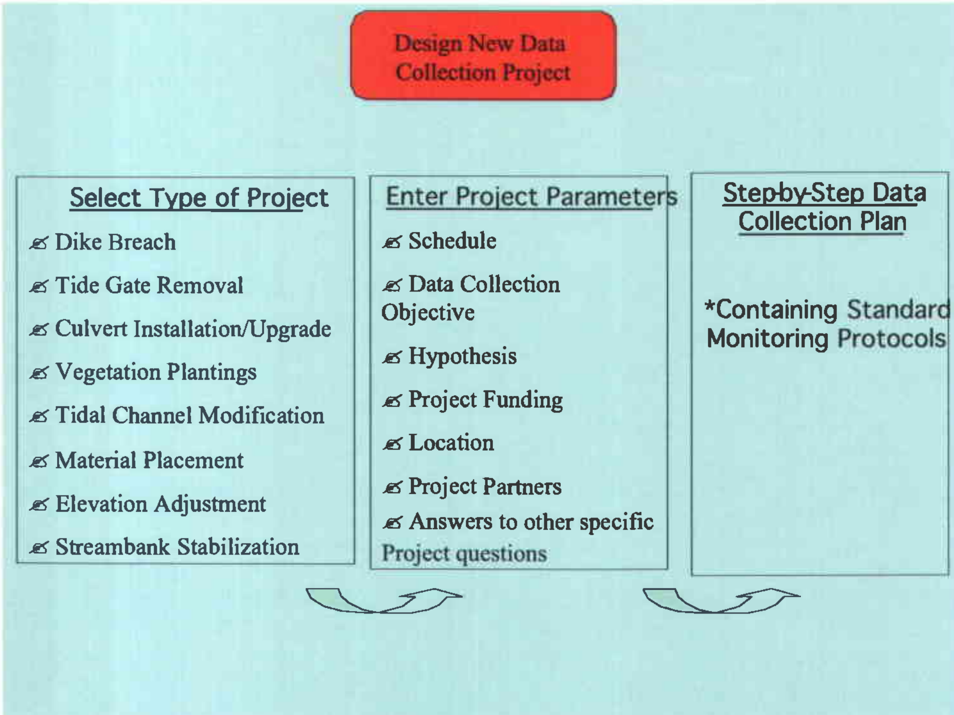

Figure 12. Design new data collection project.

DATABASE OPTIONS
VIEW DATA UPDATE DATA DESIGN NEW DATA COLLECTION PROJECT ***SPATIAL DATA*** COMPARE DATA ACCESSORIES QUERY DATABASE

Selection of *spatial data* button from the options menu provides a list of downloadable spatial datasets provided by individual projects in the CRE. The spatial datasets would include different GIS layers as well as raster and vector data that could be used in a GIS analysis. It would also include individual shapefiles for easy data transferability. The calculations and analysis section within a few of the monitoring protocols requires the collection of data that could be converted into a GIS. Spatial analysis would be essential to look at the cumulative effects of restoration within the CRE. Each dataset would be accompanied by metadata so each person accessing the data would be provided with the reason for collecting the data and how they were collected.

DATABASE OPTIONS

VIEW DATA
UPDATE DATA
DESIGN NEW DATA COLLECTION PROJECT
SPATIAL DATA
COMPARE DATA
ACCESSORIES
QUERY DATABASE

The *compare data* button (Figure 13) within the options menu gives the user two different choices. To get to the options menu, the user must select a restoration project from the homepage. Once the selection is made the project will be accessed by the database. This option offers the user the choice of comparing their first selection (when first entering the website) to another restoration project dataset or allows the user to compare to entirely different datasets. Either way, there would be a split screen with two chosen datasets which could be viewed the same way as under the view data button. The screen would consist of two side-by side spreadsheets and can be sorted with use of the sort function. This enables direct comparability of data from each of the collected metrics in the standard monitoring protocols for an instant site comparison. Not only does it have that advantage, it also would allow the user to compare calculations required by the protocols from each restoration site (as described under the view data option). The other advantage is that site data could be directly compared with performance indicators to determine whether or not the goals of the restoration project were being met. This would allow the manager to determine which portions of habitat monitoring are successful and those that are not. To do this the user could select the sites to be compared and then choose the *compare against performance indicators* button to get an idea of how the site is progressing over time. Access to this information would be helpful for generating annual progress reports for each restoration site.

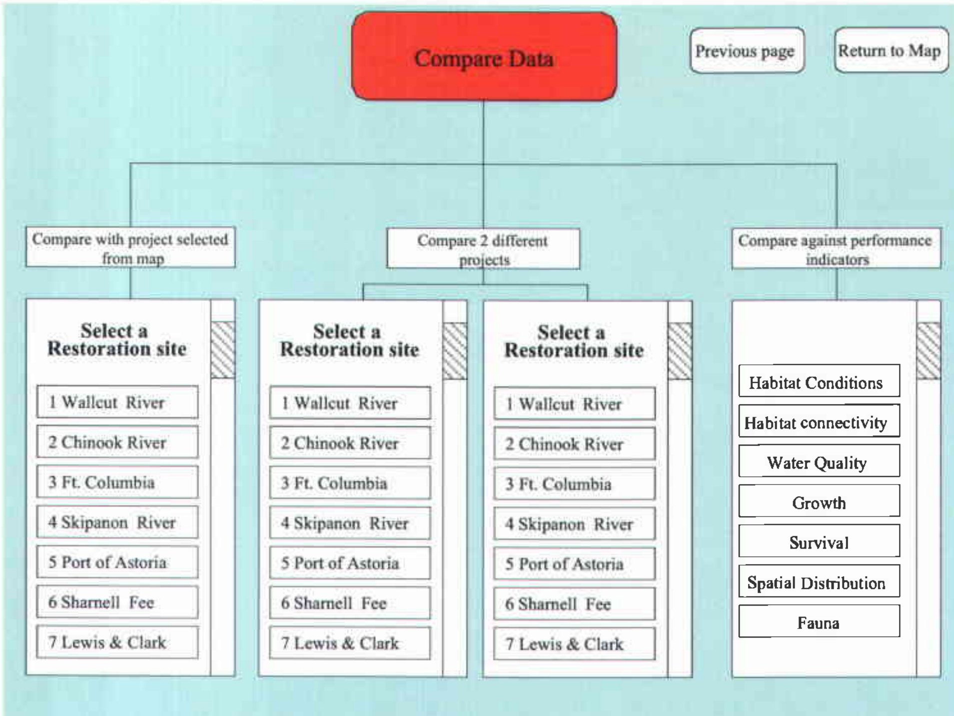

Figure 13. Compare data option.
(performance indicators modified from Johnson et al. 2004)

<u>DATABASE OPTIONS</u>

VIEW DATA
UPDATE DATA
DESIGN NEW DATA COLLECTION PROJECT
SPATIAL DATA
COMPARE DATA
ACCESSORIES
QUERY DATABASE

The *accessories option* (Figure 14) contains five different choices: post a comment, project contacts, protocol feedback, restoration literature and links to other databases. After selecting the post a comment button, a window would appear allowing the user to comment on restoration actions. Also, within this window users could review previously posted comments. This window would provide a place for dialogue among the CRE restoration community and the opportunity to learn from other restoration sites.

The project contacts window would list all of the projects that use the standard protocols and participate in the CRE long-term restoration monitoring effort. The window would also offer a spreadsheet of project participants and contact information.

This window is designed to help in facilitating collaboration and joining projects with similar restoration goals.

The protocol feedback window would allow managers to provide feedback on the use of standardized protocols. This would allow the taskforce to report on the relative implementation success of the protocols at sponsored meetings and workshops so the protocols could be continually refined. Managers and restorationists in the field work with the protocols on a daily basis and have the best ability to detect problems and propose improvements.

The database also provides a link for restoration literature that would be posted by the taskforce and the separate project participants. Eventually the database would house numerous data for many projects, and literature would be written on the success or failure of those projects. This would be a way to keep track of the literature and to reference it for future studies.

Finally, the database would provide web links to other databases that house restoration and monitoring information. These databases would include those described during the monitoring coordination workshop or any new projects restorationists and the taskforce may encounter.

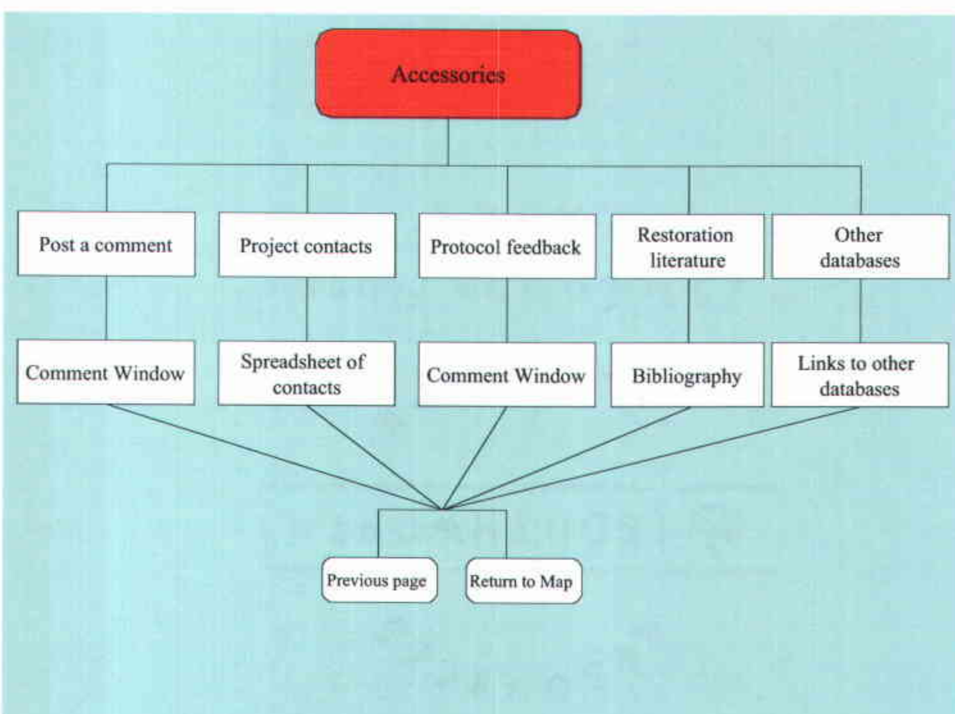

Figure 14. Accessories options.

DATABASE OPTIONS
VIEW DATA UPDATE DATA DESIGN NEW DATA COLLECTION PROJECT SPATIAL DATA COMPARE DATA ACCESSORIES ***QUERY DATABASE***

This option would provide the user with the opportunity to search the database for specific data. Once the data were found it would provide a link back to the homepage so the user could get a visual identification of where the data were collected. By entering descriptors in the query line, a user would be able to obtain project data specific to his/her needs.

6.0 LONG-TERM IMPLEMENTATION CONSIDERATIONS

Long-term monitoring for habitat restoration projects is essential for understanding the overall trajectory of the restoration site and ensuring the overarching goal (or final outcome) is achieved: to increase the abundance of ESA listed salmon stocks through carefully designed habitat restoration projects. As described by the Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery (2002), "*It is important to recognize that agency programs themselves do not generally lead to final outcomes.*" Restoration projects will lead to habitat improvements, which in turn, are intended to increase salmon abundance and productivity. To attain the overarching goal there needs to be coordination among multiple parties, standard protocols, a centralized taskforce and data management system, and willingness on the part of all CRE restoration participants for collaboration and data sharing. A system-wide effort can greatly lead to evaluating the overall performance of restoration actions.

6.1 Review Performance of Restoration Actions

Monitoring data collected over time supports management decisions that may require certain actions. Comparison of restoration data to performance indicators within an annual review can help to determine how a project is progressing and flush out what actions need to be taken, if any. Performance indicators describe structural and functional parameters within a system (Bisbal 2001) and can be expressed in three different ways: desired change, targets or benchmarks (Washington Comprehensive Monitoring Strategy 2002). For example "*the same habitat restoration indicator (habitat area) can be expressed as 1) an increase in habitat area (change), 2) a specified percent increase in area protected or restored by a certain date (target) or 3) an amount or percentage of habitat that achieves a desired condition or state by a certain date (e.g. 50 percent of streams meet particular water quality standards by a certain date, benchmark)*" (Washington Comprehensive Monitoring Strategy 2002).

6.2 Adaptive Management Approach

Long-term monitoring is an element of adaptive management. If established early in the project planning phase, and put into practice during subsequent phases of habitat monitoring and management decisions, it can be used to advance the performance of the site being restored (Thom 2000). Another advantage of the adaptive management framework is that is provides the manager with the capability to make midcourse corrections (Thom and Wellman 1996). This is advantageous because when restoring a habitat, managers are faced with uncertainty and adaptive management helps them to combat the uncertainty when it arises, not after the fact.

6.3 Contingency Planning

Contingency plans describe what should happen in the event that a restoration project fails (Thom and Wellman 1996) or what to do in case of natural or anthropogenic disturbance. Contingency plans can be built into the budget of a restoration project so funds are set aside from the outset and are available in case of a major disaster (Adamowicz 2005). Situations that would grant a contingency plan would be a funding failure, natural calamity (severe storm event, tsunami, etc.) and man-made calamities (oil spill, effects from dredging activity, dam operations, etc.). Because standard monitoring protocols facilitate agency cost-sharing, a portion of the total restoration fund of a project could be pooled and some could be set aside for contingencies.

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