CHaMP | Columbia Habitat Monitoring Program

2011 Pilot Year
Lessons Learned
Project Synthesis Report

March 31, 2012

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for

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Columbia Habitat Monitoring Program: 2011 Pilot Year

Lessons Learned Project Synthesis Report

March 31, 2012

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This document is a summary of the lessons learned from work conducted by the Columbia Habitat Monitoring Program (CHaMP) in the 2011 pilot year.

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LIST OF ACRONYMS

AMIP	Adaptive Management Implementation Plan
AREMP	Aquatic and Riparian Effectiveness Monitoring Program
BPA	Bonneville Power Administration
CCT	Colville Confederated Tribes
CDFG	California State Department of Fish and Game - Coastal Watershed Planning and Assessment Program
CHaMP	Columbia Habitat Monitoring Program
CRITFC	Columbia Inter-Tribal Fish Commission
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DPS	Distinct Population Segment
EMAP	Environmental Monitoring and Assessment Program (USEPA)
ESU	Evolutionarily Significant Unit
GIS	Geographic Information System
GRTS	Generalized Random-Tessellation Stratified
IMW	Intensively Monitored Watershed
ISEMP	Integrated Status and Effectiveness Monitoring Program
ISRP	Independent Science Review Panel
MERR	Monitoring, Evaluation, Research, and Reporting plan (NPCC)
NOAA	National Oceanic and Atmospheric Administration
NWFSC	Northwest Fisheries Science Center (NOAA Fisheries)
NPCC	Northwest Power and Conservation Council
NPT	Nez Perce Tribe
NREI	Net Rate of Energy Intake
OBMEP	Okanogan Basin Monitoring and Evaluation Program
ODFW	Oregon Department of Fish and Wildlife
PFC	Properly Functioning Condition
PIBO	PACFISH/INFISH Biological Opinion
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
QA	Quality Assurance
QC	Quality Control
RBT	River Bathymetry Toolkit
SRSRB	Snake River Salmon Recovery Board (Washington)
TIN	Triangulated Irregular Network
UCSRB	Upper Columbia Salmon Recovery Board
USBR	US Bureau of Reclamation
USGS	US Geologic Society
USEPA	US Environmental Protection Agency
UTM	Universal Transverse Mercator
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife
YN	Yakama Nation

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I. INTRODUCTION

The purpose of the Columbia Habitat Monitoring Program (CHaMP) is to implement a habitat monitoring protocol for fish habitat status and trends throughout the portion of the Columbia Basin that is accessible to anadromous salmonids using a programmatic approach to standardized data collection and management that will allow effective data summarization at various spatial scales important for the management of fish and habitat.

The CHaMP project began as a collaboration of federal, state, tribal, and private sector partners to address the 2008 Biological Opinion for the Federal Columbia River Power System (BiOp), as modified by the 2009 Adaptive Management Implementation Plan (AMIP). The BiOp calls for habitat restoration in tributaries as a means of mitigating losses of salmon and steelhead through operation of the mainstem Columbia and Snake River hydroelectric system.

CHaMP was first proposed in 2010 for implementation in 26 Columbia Basin watersheds. As a result of scientific and policy level reviews of the program by the Independent Science Review Panel (ISRP), Northwest Power and Conservation Council (NPCC), Bonneville Power Administration (BPA) and others, it was implemented in 2011 as a pilot project in eight Columbia Basin watersheds. This document is the CHaMP 2011 Pilot Year Lessons Learned Synthesis Report.

The CHaMP 2011 Pilot Year Lessons Learned Project Synthesis Report is organized into three main chapters described below.

Lessons Learned:

- **KMQs, Principles, ISRP concerns, and Project Implementation**

This chapter contains an organized list of Lessons Learned bullets on topics covered in more detail in the later two chapters. The bullets are ordered in a way that makes sense programmatically, that is, they address key management questions (KMQs) first, NPCC/ISRP concerns second, and programmatic questions third.

The bullets are written in two parts: a statement about what was learned, followed by a recommendation to managers about how to proceed. Each bullet also refers the reader to the section(s) of this document where supporting information and interpretations can be found.

In cases where a clearly superior approach has not been identified (i.e., there are multiple options) or when more consideration is required by managers, the recommendation is for managers to consider the options and make a decision.

Data Review:

- **What we learned from the 2011 data**

This chapter explores the data relevant to the questions being asked of the CHaMP project. The focus of this chapter is to answer programmatic questions relating to the KMQs, NPCC principles, ISRP concerns, and project feasibility.

Interpretations and discussions based on data from the 2011 pilot year (399 surveys at 338 unique sites) are presented. The data include 78 habitat metrics calculated from measurements taken using the CHaMP protocol and tools during each survey. There is currently redundancy within the metrics; however, the list will be truncated to an optimized list of only the most relevant and instructive metrics after the three year rotating panel design that CHaMP uses has finished its first cycle, and when we are able to clearly define temporal variability in the habitat and fish data.

A specific approach to interpreting the CHaMP 2011 data at three spatial scales is also presented; in the future, other approaches will likely be possible. The utility of the CHaMP dataset will increase in subsequent years as the sample size increases and as more sophisticated/predictive habitat indices are developed. Policy and technical input will be required to choose the best approach(es) and refine the tools to address KMQs.

Implementation Review:

- **What we learned from project implementation and how it could it be made more effective**

This chapter summarizes the lessons learned during implementation of CHaMP in the 2011 pilot year that are relevant to improving future implementation. Each element of the project is discussed, by topic area. A common format is used so that information is easy to find, and a succinct summary of information is provided for each topic.

The implementation review presents how each CHaMP element was developed and implemented, “What Worked” and “What Didn’t Work”, and recommendations for improving each element in future years. Potential options are provided in cases where there is not one clear recommendation.

II. LESSONS LEARNED: KEY MANAGEMENT QUESTIONS, NPCC PRINCIPLES, ISRP CONCERNS, AND PROJECT IMPLEMENTATION

During the process of developing the CHaMP project, BPA and regional decision makers developed and posed a set of key management questions (KMQs) to CHaMP project developers. The KMQs were drawn from the 2009 Columbia River Basin Fish and Wildlife Program document (http://www.nwcouncil.org/library/2009/2009-09/Default.asp) and were also part of the 2008 FCRPS BiOp.

In March 2011, the ISRP, in its Review of the Columbia Habitat Monitoring Program (CHaMP) Protocols (ISRP 2011-10, March 30, 2011 http://www.nwcouncil.org/library/isrp/isrp2011-10.pdf) posed another set of questions to CHaMP developers. The NPCC provided a third set of important questions and directions in its June 10, 2011 decision document. In this document, the NPCC indicated support for the concept of a coordinated, standardized approach to monitoring habitat characteristics and evaluating the effects of changes in those characteristics, so long as the federal agencies followed or incorporated certain NPCC principles during the development of CHaMP.

The KMQs, NPCC and ISRP questions presented above, and a summary of the implementation review described in detail in Chapter IV, are described in the sections that follow.

Key Management Questions

As mentioned above, BPA and regional decision makers developed and posed a set of KMQs to the CHaMP developers (see the text box on this page for a list of these questions). These questions were drawn from the 2009 Columbia River Basin Fish and Wildlife Program document and were also part of the 2008 FCRPS BiOp.

Standardized salmonid habitat data, collected at sites capable of characterizing conditions throughout the Columbia Basin, are required to answer the KMQs. Through pilot project implementation in 2011, CHaMP collected such data at 338 unique sites representing 15 focal species/major population groups within eight BPA-funded subbasins and the Asotin subbasin (see Table 1). These subbasins represent a subset of what could ultimately be 26 focal species/major population groups from 19 subbasins in the Columbia Basin if CHaMP is implemented at its full design capacity.

Chapter III, Data Review, introduces the dataset that was collected in 2011. Altogether, habitat data from 399 unique visits, including repeat visits as part of two variability studies and visits to sites in the non-CHaMP project Intensively Monitored Watersheds (IMWs) in the Entiat, Lemhi, John Day, and Asotin rivers, were collected following CHaMP's standardized protocols and methodologies. In the final dataset, to be published and released to the public upon distribution of this report (in April 2012), 78 individual habitat metrics were measured or calculated for each sampling visit, which can be rolled up into 22 habitat indicators. These indicators may be calculated at the subbasin scale, for which CHaMP was originally designed, or at smaller scales, such as the assessment units used by expert panels or for reaches studied in IMWs.

CHaMP provides the building blocks for answering these
Key Management Questions

- What are the tributary habitat limiting factors or threats preventing the achievement of desired tributary habitat performance objectives?
- What are the relationships between tributary habitat actions and fish survival or productivity increases, and what actions are most effective?
- Which actions are most cost-effective at addressing identified habitat impairments?

There is currently redundancy within these 78 habitat metrics, but this is beneficial during the development phase of CHaMP as we continue to explore and develop the most predictive and applicable fish/habitat relationships. This list of metrics will be truncated to an optimized list of only the most relevant and instructive metrics, perhaps as soon as 2014,

Table 1. Summary of 2011 sites surveyed with CHaMP protocol and tools

	CHaMP Sites	ISEMP IMWs	Total Sites Surveyed With CHaMP Protocol and Tools
Methow	25		25
Entiat	16	60	76
Wenatchee	23		23
Tucannon	24		24
South Fork Salmon	25	8	33
Lemhi	25	17	42
John Day	50	9	59
Upper Grande Ronde	56		56
BPA-Funded Total	244	94	338

* In addition to these sites funded by BPA through CHaMP or ISEMP, 10 sites in the Asotin were funded/surveyed by Washington SRSRB and 13 sites were surveyed in coastal streams of California by CDFG—Coastal Watershed Planning and Assessment Program.

after the three year rotating panel design used by CHaMP has finished its first cycle and we're able to clearly define temporal variability in the habitat and fish data.

Interpretive tools are required to answer the KMQs described previously. In Chapter III, we illustrate one approach (the habitat quality index derived from CHaMP habitat and concurrent fish data) that interprets the 2011 dataset at three spatial scales: the subbasin scale, the assessment unit/HUC5 scale, and the site-level scale. At each scale, we show how habitat can be easily interpreted/ evaluated in ways that could inform restoration action prioritization, identification of limiting factors, and ways to evaluate/quantify action effectiveness. In the data summary and interpretation section of Chapter III, we demonstrate that one year of CHaMP data provides a comparable diagnoses of conditions within the Wenatchee subbasin as existing data (five years of data collected by ISEMP using the Upper Columbia habitat monitoring protocols; https://isemp.egnyte.com/h-s/20120330/46a02dc2e0af4d6e) and professional judgment (by the Upper Columbia Expert Panel), and is consistent with existing restoration action prioritization. Specifically, we show that CHaMP interpretive tools and data can be used to identify the same "good" and "bad" habitat as other approaches can. We posit that this demonstration suggests that CHaMP will be even more valuable in watersheds that do not benefit from the large amount of data available in the Wenatchee. Finally, the utility of the CHaMP data set will increase in future years as the sample size increases with completion of the three year design and as more sophisticated/predictive habitat indices are developed (e.g., the NREI, change detection), and as interpretive models are developed.

A process whereby scientists and policy managers work together to select and adjust the appropriate interpretive tools is also required to answer the KMQs. The ISRP, in their March 2011 review of CHaMP, was the first to recognize that "CHaMP alone does not address all of these [key management] questions", and the NPCC emphasized this point by directing the agencies to "develop the analytical, evaluation and reporting elements of habitat effectiveness monitoring to accompany CHaMP monitoring consistent with ISRP's review." Representatives from BPA, NOAA, USBR, NPCC, and other agencies agreed, during a policy roundtable discussion at the November 2011 CHaMP post-season meeting, that the community must engage collectively to answer these questions. Such collective engagement, they decided, will require a forum around which the technical, policy, implementation, and management objectives and roles can be reconciled. This forum would build the analytical framework necessary to translate CHaMP data into answers to KMQs. Therefore, CHaMP data are a foundation upon which answers to the KMQs can be developed within an analytical framework geared specifically to developing answers useful to policy decision makers. CHaMP data will also be useful to others (e.g., restoration practitioners) because it could provide additional guidance for individual projects and proposed work.

Finally, a sustainable program is required to answer the KMQs because it will take several years of data to arrive at meaningful answers. Chapter IV describes the lessons learned through implementation of CHaMP in the 2011 pilot year.

KMQ: Describe how your project actively supported the coordination and standardization of regional and project-specific monitoring efforts with other federal, state, and tribal monitoring programs including the development and adoption of standard requirements for metrics, sample designs, data collection protocols, data dictionary, metadata, and data access.

The CHaMP project was designed specifically to develop a coordinated and standardized approach to habitat monitoring for status and trend, as well as effectiveness monitoring at the project scale, across the Columbia Basin region. CHaMP demonstrated that it met these goals in nearly every regard in 2011.

Collaboration: Project collaborators in the 2011 pilot included federal (BPA, NOAA), state (ODFW), tribal (CRITFC), and private entities. In addition, two groups not funded by BPA ((i.e., the California State Department of Fish & Game's (CDFG) Coastal Watershed Planning and Assessment Program, and contractors hired by the Washington State Snake River Salmon Recovery Board (SRSRB) to monitor the Asotin River watershed)) also participated as collaborators during the entirety of 2011 project implementation. While data from California and the Asotin were not used in the analyses presented in Chapter III, Asotin data were used in NREI model validation, and participation by these groups provided outside expertise and additional protocol testing while further demonstrating the utility of CHaMP and our ability to collaborate across geographic and institutional boundaries.

Collaboration in 2011 involved common training, universal participation by all collaborators in two variability studies, close collaboration during field surveys and data processing (e.g., ODFW and CRITFC used shared study designs and worked well together in the field and during analyses), participation by willing collaborators in data analyses (e.g., CRITFC made notable contributions to data analyses reported at the post-season workshop), and all collaborators participated in developing lessons learned (e.g., ODFW clearly represented the co-managers views on the utility of CHaMP data during the post-season workshop).

The role of the various collaborators is evolving to its proposed potential; however, in 2011, there was a heavy emphasis on collaborators focusing on data collection (see Table 2). The pressure and numerous challenges of developing the CHaMP program only weeks ahead of implementation (e.g., the final protocol was published a few days before training; data capture tools were beta tested during the field season; data quality control and quality assurance tools were completed just in time for data analysis and final reporting) made it very difficult to spend the time and effort necessary for more robust collaboration.

All pilot project collaborators have been invited to participate in ongoing efforts to refine the habitat protocol and workflow for 2012 (e.g., CRITFC is leading development of a riparian monitoring module, etc) to respond to the 2011 lessons learned. The relative ease of collaboration and high level of productivity among the 2011 collaborators suggests that expanding beyond the pilot level and bringing on additional collaborators will be both feasible and fruitful. Once fully expanded, CHaMP is anticipated to involve, in addition to 2011 pilot project collaborators, participation from a wider range of federal (USGS), state (WDFW), and tribal (YN, NPT, CCT) entities.

One uncertainty is the relative level of willingness new collaborators will have to adopt the standardized CHaMP approach. Entities that are willing or eager to participate and use CHaMP protocols and tools will find collaboration easier than those who may be reluctant to switch from other monitoring methods.

CHaMP will collaborate with other programs in the future. In 2012, CHaMP will explore the possibilities for comparison and integration of CHaMP data with data collected by other programs like PIBO (the PACFISH/INFISH Biological Opinion) and AREMP. Collaboration with the OBMEP (Okanogan Basin Monitoring and Evaluation Program) effort is

Table 2. CHaMP collaborators and roles (pilot effort and full program)

Collaboration Role	Collaborator
Scientific and policy oversight of the CHaMP project	NPCC with ISRP, BPA, NOAA
Funding	BPA, NOAA
Project Development Leadership (responsible for meeting project deliverables like coordination, protocol development, tool development, study designs, data quality control and assurance, data management and reporting)	NOAA, Terraqua Inc., Ecological Research Inc., Quantitative Consultants Inc., South Fork Research Inc., and Sitka Technologies Inc.
Project Development Participation (participate in coordination, protocol development, tool development, study designs, data quality control and assurance, data management, and reporting)	Pilot effort: All the preceding plus ODFW, CRITFC, and CDFG . Full Program: All the pilot collaborators and all future collaborators who participate in CHaMP monitoring.
Field Data Collection	Pilot effort: Terraqua Inc. (with subcontractor Tetra Tech EC Inc.), Ecological Research Inc., Quantitative Consultants Inc., ODFW, CRITFC, and CDFG. Full Program: The above plus future collaborators who participate in future CHaMP watersheds.
Data Analysis	Pilot effort: Primarily NOAA, Quantitative Consultants Inc., South Fork Research Inc., Ecological Research Inc., Sitka Technologies Inc. and Terraqua Inc. with significant participation by CRITFC and ODFW. Future: Metric generation tools (including the mechanistic models referred to by the ISRP) will have been built into the CHaMP data management system to a level of sophistication that all CHaMP collaborators (and other entities as well) will be able to access all relevant CHaMP data and perform any analysis that they would like with the 2011 and future datasets. At the post-season workshop, ODFW very clearly articulated that CHaMP data are useful for existing/on-going management questions and confirmed that the co-managers certainly have the expertise to analyze data generated by CHaMP.
Data Interpretation	NPCC with ISRP, BPA, NOAA, USBR, CRITFC, ODFW, and the project development staff all committed (during the 2011 post-season policy roundtable discussion) to participating in a forum that would develop an analytical framework for interpreting CHaMP data to best answer the Key Management Questions.

planned for 2013. Finally, BPA, USBR, NOAA, and NPCC are working to develop a framework that will clearly show where CHaMP fits into the broader RM&E program.

Standardization: In 2011, the CHaMP project conducted habitat monitoring work in eight watersheds funded by BPA (Table 1) that previously had either no habitat monitoring or monitoring that was conducted using several different protocols, different metrics and data dictionaries, and disparate data management approaches. The CHaMP pilot demonstrated that several groups could collect a standard set of habitat metrics using comparable sampling designs, a common protocol, one data dictionary with standard metadata, and within a single integrated data management system that further enforced standardization by instituting common and rigorous quality control and quality assurance practices. Use of sampling designs with components that were common across all subbasins facilitated standardization and helped meet CHaMP objectives, yet designs were flexible enough to meet local needs. A joint training session with universal participation and the data management system that standardized reference materials, site selection practices, and data uploading and storage procedures also promoted standardization.

KMQ: Describe how your project collaborated with regional federal, state and tribal agencies, and/or non-governmental entities to establish a coordinated, standardized, web-based distributed information network and a regional information management strategy for water, fish, and habitat data.

Two variability studies conducted in 2011 demonstrated that the data collected using CHaMP protocols was standardized among crews (see Chapter III, Variability Studies). While variability between crews was low for many metrics and high for others, in no case was any one crew obviously deviating from the protocol and, intentionally or unintentionally, implementing non-standardized approaches. Metrics with a high between-crew variability may still have utility for trend analysis because they may embody temporal signals better than other metrics; alternately, they may be dropped from the protocol if such utility does not become obvious in further testing in 2012 and 2013.

Collaboration between the CHAMP project and regional federal, state and tribal agencies, and/or non-governmental entities participating has roots that extend back several years within the related ISEMP program. Since 2003, ISEMP has been a leading motivator of regional data management and created and tested the STEM DataBank, data management tools like the Automated Template Modules and Aquatic Resources Schema database, and other architecture, and has also experimented with various aspects of web-based data management. During this development, ISEMP staff participated in regional monitoring and data management forums (e.g., most notably in the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) data management leadership team and Northwest Environmental Data Network), and have participated in the leadership team for information systems like MonitoringMethods.org. Additionally, ISEMP staff have participated in efforts to standardize how information is described and organized. For example, ISEMP staff assisted with the development of the Salmon Monitoring Advisor website, which developed guidance on best monitoring practices and defines the basic terminology used for communicating about statistical study designs for long-term salmon monitoring programs. This lexicon has been built into the CHaMP protocol, study design documentation, CHaMPMonitoring.org, MonitoringMethods.org, and other regional data management initiatives.

The expertise of Sitka Technology Group augmented ISEMP's experience during the development of CHaMP. Sitka had also been developing coordinated, standardized, web-based information networks and regional information management strategies for BPA's Fish and Wildlife Program. Sitka's work on the Pisces contract management software and the CBFish.org proposal management software, and their development of the regionally accepted MonitoringMethods.org website, facilitated both the development of CHaMPMonitoring.org and the coordination of the regional federal, state and tribal agencies, and/or non-governmental entities using this new data management system.

Regional federal, state and tribal agencies, and/or non-governmental entities participating in CHaMP all use the common CHaMPMonitoring.org data management system. CHaMP collaborators provided critical input in 2011 on aspects of the system's operations and utility through use of the system and participation in the extensive lessons learned process that CHaMP undertook. This process included on-line forums, user surveys, participation in the three-day post-season workshop, and participation in drafting this report. CHaMP collaborators will continue to participate in changes to CHaMPMonitoring.org as this system is further developed during CHaMP's pilot phase.

KMQ: Describe how your project established necessary administrative agreements to collaboratively implement and maintain the network and strategy.

CHaMP handled administrative agreements for project collaboration primarily as coordinated contracts between BPA and the various contractors. The original Fish and Wildlife Program Proposal described the conceptual structure for CHaMP, and the development of individual contracts solidified this structure. One BPA project (number 2011-006-00) consolidated most project contracts, but two other contracts (project numbers 1998-016-00 and 2009-004-00) were modified to facilitate participation in CHaMP by ODFW and CRITFC, respectively. Use of common scope-of-work language including common milestones, deliverables, and due dates facilitated coordination and standardization among these various agreements. Each of these contracts required common data management system (CHaMPMonitoring.org) use. More importantly, however, was the fact that use of CHaMPMonitoring.org was necessary to interpret and generate metric data from measurements taken from the various collaborators. Collaborators essentially had no choice but to use the common information network because all the necessary tools were built into CHaMPMonitoring.org, thereby ensuring coordinated, standardized, web-based information sharing.

One area of concern that arose during the pilot year is the need to develop a strategy to accommodate what may be widespread and enthusiastic adoption of the CHaMP protocol and tools by agencies either funded by BPA or funded by other entities. It was convenient and desirable in 2011 to accommodate participation by the CDFG and SRSRB to ensure that the tools built for CHaMP were robust enough to work across geographic and institutional boundaries, regardless of the funding source. Other non-BPA-funded agencies (e.g., USFS, BLM, and USGS) have expressed similar interest in the use of the CHaMP protocol and tools in the future. The use of the CHaMP protocol and tools beyond BPA requirements is valuable, if for no other reason than to promote the further standardization of protocols, further establish the scientific applicability of the protocol, and to develop larger, more robust datasets against which to compare Columbia Basin status and trend data. However, the logistical challenges of supporting non-BPA-funded use of the CHaMP protocol and tools still needs to be explored and, if appropriate, accommodated.

NPCC Principles and ISRP Concerns

The NPCC provided CHaMP developers with an important questions and directions in their June 10, 2011 decision document. In it, the NPCC supported the concept of a coordinated, standardized approach to monitoring habitat characteristics and evaluating the effects of changes in those characteristics and called for the federal agencies to follow or incorporate the following principles in the development of CHaMP:

- Implement CHaMP in an incremental approach in selected basins undergoing active restoration and fish and habitat monitoring;
- Revise and develop CHaMP to address Scientific Review in collaboration with ISRP, NPCC and other participants in habitat monitoring/evaluation; and,
- Within one year, the agencies should develop the analytical, evaluation and reporting elements of habitat effectiveness monitoring to accompany CHaMP monitoring consistent with ISRP's review. This effort should include five elements focused on integrating viable salmonid population (VSP) parameters and comparing different model outputs used.

The NPCC decision document incorporated by reference a "Review of the Columbia Habitat Monitoring Program (CHaMP) Protocols" conducted by the ISRP (ISRP 2011-10, March 30, 2011 http://www.nwcouncil.org/library/isrp/isrp2011-10.pdf). Therefore, this section of this chapter simultaneously addresses both NPCC principles and ISRP concerns and recommendations.

NPCC Principle: Implement CHaMP in an incremental approach in selected basins undergoing active restoration and fish and habitat monitoring.

ISRP: Field test protocols and habitat parameters in selected basins to test for appropriateness or value.

The CHaMP project categorically adopted NPCC and ISRP recommendations to focus initial activities on a subset of CHaMP watersheds at geographically diverse locations in the Columbia Basin where restoration is occurring and where both habitat and fish population monitoring are sufficiently developed.

The original project proposal was for monitoring in habitat supporting 26 focal species/major population groups in 19 subbasins in the Columbia Basin. CHaMP developers selected these watersheds based on recommendations from the BiOp tributary workgroup, which were then reviewed and modified by the regional process developing the Anadromous Salmonid Monitoring Strategy which is incorporated into the NPCC Monitoring, Evaluation, Research, and Reporting (MERR) Plan by reference.

In 2011 the project scope was scaled-back so that CHaMP could build upon existing, strong RM&E efforts, such as in intensively monitored watersheds. As implemented during the pilot year in 2011, CHaMP collected standardized habitat data at 338 unique sites and coupled efforts with IMWs and other fish monitoring taking place in each of the nine pilot subbasins (Table 1).

The pilot approach proved to be a wise choice and convenient for CHaMP developers. CHaMP staff and collaborators worked at maximum capacity to support the pilot effort while, nearly concurrently, developing key project elements (e.g., protocol, designs, data management tools, analysis) during this first year. While additional watersheds would have brought additional collaborators who would have shared some of the load, it is quite possible that some elements of CHaMP would have failed under the increased workload of a fully implemented project.

One of the ramifications of the pilot approach is that the full scope of habitat data called for in the BiOp will take longer to be collected and understood. In particular, this may affect the co-managers' ability to make decisions about fish habitat within the subbasins not included in the pilot effort.

The level of effort under CHaMP is forecast to remain at or near pilot levels in 2012, which will afford time to complete development of CHaMP project elements. At such a time, the challenges of building out to full design will be minimized.

NPCC Principle: The overarching program goal is cost-effectiveness.

ISRP: We think the statement that a 3-person crew could sample a site per day on average may be optimistic for sites that are located in roadless areas or sites that are otherwise difficult to access, given the large number of habitat attributes and the time required for digitizing channel morphology.

ISRP: We are unsure whether it will be possible for crews to address possible field constraints, such as limited time available for sampling, problems posed by weather conditions, and logistic difficulties in sampling particular sites., while still meeting the expectations of the CHaMP protocol.

CHaMP developers revised the protocol after the February 2011 workshop with the ISRP, particularly in regard to ensuring that field implementation of the protocol would meet the overarching NPCC program goal of cost-effectiveness, and, consequently, the ability of field crews to complete surveys in one day. Original budget directions in 2010 from CHaMP developers to collaborators, at the time CHaMP was originally proposed, advised that sites should be completed in a 10 hour day with a 10 percent contingency and, with data processing, workflow should be planned assuming that four sites per week could completed. By the time of the February 2011 ISRP workshop, the field work completion target was described as a “three-person-day field survey at 80-90 percent of all sites” in the first version of the CHaMP protocol. Subsequent to the ISRP workshop, final protocol development still advised this site completion target but also maximized the amount of time savings in the field by dropping measurements, truncating or expediting measurement methods, using additional automated tools, and optimizing data capture with long-term data management needs (e.g., quality control, quality assurance, and data storage).

The last point above related to automated tool use is an important cost-savings and standardization feature of CHaMP: when data capture tools worked as designed, all data were captured electronically in the field thereby minimizing the need for expensive and inaccurate hand data entry. ISEMP’s experience is that this approach eliminates about 90 percent of quality control and quality assurance issues that usually result from transcription errors. While considerable time (minimum one hour up to four hours, rough average of two hours per site) was still spent on topographic data processing, quality control, and quality assurance, for each site in 2011, continued development of data capture tools and practices is on track to reduce this dramatically in 2012.

The most objective way to summarize and demonstrate that sites were completed within the one-day allocation is to compare actual expenses versus proposed expenses in relation to work accomplished. The results of such comparisons show that CHaMP completed surveys at 253 of 255 sites (Table 1) within the budget allocated to six different contractors. When the two variability studies are factored in, CHaMP completed 314 of 316 planned visits all within budget.

A reduction in anticipated costs for field surveys in 2012 further supports the ability of CHaMP protocols to be performed cost-effectively. At the seven subbasins funded through BPA project 2011-006-00, total field costs, including labor for training, data collection, data QC/QA, and expenses including travel and consumable equipment costs, and, for some collaborators, participation in annual meetings and other coordination activities, is forecasted to drop from about $920,000 in 2011 to about $828,000 in 2012, a 10 percent reduction in costs.

Direct measurements of time spent at each site, an unrealized goal for 2011, are intended to be built into data capture tools in 2012 to help us better quantify, and control, the expense of field surveys.

To address the ISRP concern that logistical problems in the field could limit the ability to complete surveys, CHaMP developed a rule that would cap the amount of effort a crew was obligated to spend at a site at two days if confronted by untenable field conditions. In such cases, crews were to complete surveys using a truncated approach that replaced the total station surveying elements of the protocol with measurements done with depth rods and tape measures. The efficacy of this approach was mixed. During only seven sites of 338 total sites (about two percent of the total), was the two-day rule imposed. However, the alternate methods were not sufficient to adequately capture many of the topographic metrics generated through the standard survey protocol. While this flexible, alternate approach was required at less than five percent of CHaMP sites, development efforts will be dedicated to ensuring that the alternate methods used in 2012 will capture as many of the topographic metrics as possible.

NPCC Principle: Develop information and technology transfer among CHaMP cooperators.

ISRP: Identify roles for each cooperator in CHaMP effort.

ISRP: Will cooperators eventually have the staff expertise not only to collect the data using CHaMP protocols, but to effectively understand and use the modeling programs and other analytical tools to support and document the benefits of their habitat restoration programs?

The CHaMP Data Management System uses a suite of automated/semi automated tools to capture and process information, thereby minimizing the time it takes to convert field measurements into data meaningful to policy decision making and also thereby minimizing data transcription errors and other quality control/quality assurance issues. This data management system includes a study design and site evaluation tool, total stations for capturing topographic surveys, a data logger application for auxiliary data, geo-processing tools, a centralized data storage repository, and a website for reviewing and accessing data. Collectively, these tools support data documentation, data capture, quality assurance review, backup and archiving, metric generation, data display, mapping, and distribution, and lower the overall cost of data management.

Data collected during the field season (July 1 through September 30, 2011) were available to CHaMP collaborators for analysis by early November 2011. The final dataset will be published concurrent with the distribution of this final report in April 2012. In future years, when the data quality control and assurance tools and workflow are optimized and the lessons learned reporting burden is less, publication of the final dataset could be achieved by the end of the calendar year in which it was collected.

For information about cooperator roles please refer to the discussion about collaboration under the heading "Key Management Questions" in this chapter, and Table 2.

NPCC Principle: Revise and develop CHaMP to address scientific review in collaboration with the ISRP, NPCC and other participants in habitat monitoring/evaluation.

ISRP: Field test protocols and habitat parameters in selected basins to test for appropriateness or value.

ISRP: Resolve differences in habitat monitoring approaches among other groups by coordinating and comparison testing protocols on site.

ISRP: Consider a cautionary approach to implementation, e.g., initiate several modestly sized CHaMP protocol tests (focused, for example, on a range of watersheds across the Columbia Basin where both habitat and fish population monitoring efforts are occurring) in which different approaches to design, data collection, data storage, and data analysis, can be compared to provide a test of the efficacy of scaling up from past efforts while still allowing and encouraging other promising, or well proven, efforts to continue.

Appropriateness and Value: The CHaMP pilot effort in 2011 (i.e., conducting monitoring in a selected subset of subbasins) was a direct response to the concern raised by the ISRP and others about the "appropriateness or value" of the habitat metrics generated by CHaMP. The appropriateness or value of the habitat metrics generated by CHaMP will eventually be tested in several ways following the metric inclusion rule set that CHaMP has incorporated in all drafts of its protocol (see Bouwes et al. 2011 under the "Protocol Documents" heading at http://champmonitoring.org/Program/Details/1#documents

In summary, a metric is considered appropriate or valuable if it has information content (i.e., provides information directly related to salmonid productivity as shown in scientific literature or analysis), data form (i.e., provides robust statistical information that is repeatable, detects heterogeneity, etc.), and is feasible to collect (i.e., can be collected in the field with contemporary tools within a three-person-day field survey at 80-90 percent of all sites likely to be encountered).

The full testing of the appropriateness and value of metrics will require at least two more years of data habitat collection (in pilot subbasins) and perhaps three years more in subbasins that have yet to be brought into the project. The reason that three years of data are important is that the study design used by CHaMP is a three-year rotating panel design. This means that a complete sample will take three years in each watershed to fully capture the spatial and temporal variability that we anticipate in the data. Furthermore, the information content of habitat metrics depends on quantifying relationships with fish metrics – generation of the fish data will also take time to collect and analyze. For a preliminary discussion of fish-habitat relationships, please refer to the next section.

Some metrics generated in 2011 that may appear to perform poorly at capturing spatial variability (status) may turn out to be valuable in capturing temporal variability (trends). Only time will tell. Metrics that do not capture spatial or temporal variability sufficiently (i.e., they fail the data form rule) will be dropped from the protocol. Eventually, other metrics will be dropped as well because the information content criteria will become progressively more stringent. For example, as relationships between CHaMP habitat metrics and fish productivity are further quantified, it is likely that a gradation in information content will be revealed. Some metrics will prove to be very useful at predicting salmonid productivity while others may be less useful. At some time, only the metrics with the best explanatory power will be retained and lower-value metrics will be dropped. It is quite possible that this empirical process will eventually result in a significantly reduced habitat protocol in the future with optimized cost-effectiveness. This assessment of value will be enhanced with future watersheds

Several approaches were used in 2011 to verify whether metrics met the CHaMP inclusion rules. Feasibility is best judged by cost and no particular problems were identified relative to cost. Data form is best analyzed through variability testing and information content is best analyzed by comparing the relative value of habitat metrics for predicting fish productivity.

Variability Testing: CHaMP conducted variability tests in 2011 to meet several ISRP concerns (e.g., spatial roll-up of data from site to subbasin, demonstration of how CHaMP data be used to meet key management questions, repeatability, and comparability with other programs, etc.). Please refer to Chapter III, Data Review, for variance decomposition analyses and other data analyses performed using 2011 pilot year data.

Other Programs: In 2011, CHaMP protocols were not specifically tested against other programs' because there was not sufficient time to respond to this ISRP recommendation nor funds to conduct those tests in addition to the previously proposed variability testing. However, we have demonstrated through the use of the RBT tool that digital elevation models produced by CHaMP topographic surveys can be used to calculate most, if not all, the "stick and tape" metrics generated by other programs and, for most non-topographic auxiliary habitat data metrics, the CHaMP protocol uses methods that were drawn directly from other programs like PIBO and the USEPA's Environmental Monitoring and Assessment Program (EMAP) effort, so comparison testing of these metrics would be a straightforward exercise.

In 2012, CHaMP will explore the possibilities for comparison and integration of its data with data collected by other programs like PIBO. Our understanding of the ISRP recommendation to "resolve differences" and "compare" between programs is that the goal should be optimizing the utility of habitat information developed by different federal (and state and tribal) monitoring programs to policy decision makers, and that this could best be done at the level of interpretation rather than the level of field measurements.

For example, it may be that PIBO and CHaMP measure channel width, channel depth, fine sediment, and riparian cover in slightly different ways, yet all of these metrics need to be rolled up to the site and subbasin scale for interpretation by policy decision makers. It is the roll-up process that will likely be the most effective way to integrate information from the two programs and this roll-up process would account for other issues like potential overlap in sample locations.

Adaptive Designs: The ISRP recommendation to implement several "different approaches to data collection, data storage, and data analysis" suggested an adaptive management approach to the design of the CHaMP program. While we were unable (due to insufficient planning time and budgets) to implement several different approaches in an "active" adaptive management fashion, we should, through the nature of the pilot program and ongoing lessons learned exercises (including additional protocol and analysis development) be able to optimize CHaMP through a more "passive" adaptive manage approach.

ISRP: Describe how will the results obtained from monitoring individual sites within a watershed be "rolled up" to the entire watershed to advance generalizations about status and trends in habitat condition for the watershed as a whole?

ISRP: Re-visit the number of sites (more sites/less intensity vs. few sites of high intensity) .

In the data summary and interpretation section of Chapter III, we illustrate one approach to "rolling up" data to the entire watershed. While the comparisons we make at the subbasin level suffer from some idiosyncrasies in fish monitoring methods in 2011, the subbasin-scale figures should at least illustrate how this analysis could be accomplished in future years. In fact, there are a number of possible ways to roll up data to the subbasin scale. Technical experts need to explore with policy decision makers what the most important roll ups should look like.

Also in the data summary and interpretation section of Chapter III, we illustrate several ways to interpret the data at finer scales of resolution including at the assessment unit/HUC5-scale. We use a case study in the Wenatchee River to show that CHaMP interpretive results generate the same "common knowledge" answer that has been arrived at in the Wenatchee with years of data, restoration project planning, and professional knowledge, suggesting that CHaMP data and "roll ups" could be even more valuable in watersheds with much less existing information.

With regard to the ISRP question about tradeoffs in number of sites vs. intensity at sites, we have not yet analyzed the data to specifically determine whether a higher density of smaller sites produces a more cost-effective signal, but we intend to conduct such an analysis.

This question could be examined in several ways. One approach might be to take more measurements (including topographic survey shots) at fewer sites. An unpublished study by Bangen & Wheaton (2012; summarized in Chapter III) using CHaMP 2011 data suggests ways to measure levels of certainty within CHaMP topographic surveys. Bangen & Wheaton (2012) conclude that the level of effort employed by CHaMP at each site is adequate for capturing meaningful changes in channel topography. Another way to address this issue could be to look at more, smaller sites. In 2011, we collected data at higher intensities (more sites per mile of stream) in at least two places (i.e. the Entiat IMW and John Day ISW).

ISRP: We also suggest that CHaMP provide a clearer description of how site selection is influenced, if at all, by proximity to ongoing instream or riparian restoration actions.

ISRP: Given CHaMP's approach for selecting watersheds, it remains to be demonstrated how well the results obtained through the CHaMP project can be extrapolated to unmonitored watersheds within the interior Columbia River Basin.

Site selection may be influenced by proximity to ongoing restoration actions because the CHaMP study designs balance two needs: standardization and flexibility.

CHaMP achieves standardization by implementing a basic design within all watersheds to characterize the status and trends of selected habitat indicators that are relevant to the survival and growth of key salmonid populations at two spatial scales: across all CHaMP watersheds, and within each watershed. Within each CHaMP watershed, staff use the GRTS (Generalized Random-Tessellation Stratified) algorithm to select sampling locations that included 45 sites to be sampled over a three year period organized into an annual panel of 15 sites and three rotating panels of 10 sites each. The basic CHaMP design supports stratification (the default stratification framework is based on geomorphic groupings of sites into three valley classes (source, transport, and depositional) but other forms of stratification are possible.

CHaMP allows flexibility because the basic design structure can be modified to meet individual watershed needs, particularly effectiveness monitoring designs, yet retain the basic probability structure of site selection and resource representation. While the standardized, basic study design may detect some "effect" at the site-scale associated with local restoration projects, these site-level influences will get rolled into the overall study design. If such influence(s) are large enough to be detected across the watershed scale, they will be captured at the CHaMP status and trend sites, as appropriate for the stratified design. These effects can be more explicitly studied by taking advantage of the flexibility in the CHaMP designs.

This flexibility accommodates the integration of special studies (such as IMWs or studies of restoration actions at specific sites), allows for increases in the sample size as funds allow, and permits the incorporation of legacy sites (sites with a history of probability based sampling) in the site selection process. Almost all CHaMP watersheds incorporated a change to the basic design framework, as summarized in Table 7(please refer to the section "Basic CHaMP GRTS Design" in Chapter IV).

The Entiat subbasin is just one of several examples of how the proximity of restoration actions can be incorporated into the CHaMP study design. In the Entiat, the subbasin is divided into two separate sample domains: the 20+ miles of mainstem habitat to be manipulated with a suite of restoration actions as part of the Entiat IMW, and the remaining approximately 65 percent of the subbasin that is accessible to anadromous salmonids. In this larger area with few, if any, anticipated restoration projects, sample sites are allocated according to the basic CHaMP sample design. Within the IMW area, however, sample sites are allocated using a stair-step hierarchical design. Sites are specifically selected based on known/planned project treatment areas so that they serve as either treatment or control sites. Therefore, site proximity to restoration actions is specifically built into the design. Both sample designs allow habitat information to be rolled up to the domain level, and then merged to provide the overall picture for the subbasin.

As presented Chapter III, Data Review, CHaMP and ISEMP are currently examining empirically-derived fish-habitat relationships in several subbasins. Our understanding of how CHaMP data could be extrapolated to unmonitored watersheds will be significantly advanced by additional development of these relationships. Spatial and temporal signals in these relationships will guide how CHaMP data may be used in other areas.

<u>ISRP:</u> Evaluate the value of "non-standard" metrics and methods at special sites.

The ISRP asked that CHaMP consider monitoring agricultural pesticides, pharmaceuticals, personal care products, and flame retardants. In 2011, CHaMP considered these "non-standard" metrics and did not incorporate them into CHaMP monitoring largely because there was too little time between the ISRP review and the field season to make the substantial changes to the CHaMP design that might be necessary to incorporate these non-standard metrics.

After further consideration, CHaMP does not recommend incorporating these metrics into the CHaMP surveys in 2012 or 2013. While we understand that such pollutants may affect salmonid productivity in the Columbia Basin, we believe that a number of issues suggest such monitoring be developed, if at all, in an effort separate from CHaMP for several reasons: 1) the cost of such sampling could be prohibitively expensive and not cost-effective largely because, 2) the sample design used by CHaMP to optimize data collection of standard habitat metrics (a one day visit at 35 randomly distributed sites in a subbasin) would not optimize sampling of pollutants (that can be monitored at integration sites at downstream locations and should be monitored more continuously over longer periods of time than one day), 3) interpretive models that could allow integration of standard habitat metrics with non-standard pollution data may not be adequately developed, 4) water pollution is a regulatory issue that is outside of the scope of CHaMP, and 5) CHaMP depends on the voluntary permission of landowners to access private property for habitat sampling – our experience with landowners' concerns suggests that permission to access private property would be significantly more difficult to obtain if landowners perceived that habitat sampling (in this case for pollutants) could open them up to exposure within any particular regulatory process – and water pollution monitoring is one area of concern commonly raised by landowners across all subbasins surveyed to date.

<u>NPCC/ISRP:</u> In those CHaMP watersheds where restoration actions are taking place, but which do not have experimentally controlled restoration treatments as in the IMWs, the ISRP feels that there is still great value in collecting both habitat and fish data at as many sites as possible in order to verify assumptions about relationships between habitat conditions and fish populations.

Fish and habitat data were collected at 152 sites in 2011 Lemhi, Upper Grande Ronde, John Day, South Fork Salmon, Entiat and Wenatchee subbasins by ISEMP, CRITFC, and ODFW. Results from several analyses (including classification and regression tree models, boosted regression trees, and structural equation modeling) verified that the CHaMP habitat protocol generated metrics that are indeed related to densities of juvenile Chinook salmon and steelhead. Please refer to Chapter III for more detailed information on these topics.

NPCC Principle: Within one year, the agencies should develop the analytical, evaluation and reporting elements of habitat effectiveness monitoring to accompany CHaMP monitoring consistent with ISRP's review.

NPCC: Complete the Lesson Learned Report including revisions, linkages/ integration with fish monitoring and proposed expansions.

NPCC: Bonneville and NOAA to meet quarterly with NPCC's Fish and Wildlife Committee to report progress regarding pilot phase testing.

NPCC: Bonneville, the NPCC, and NOAA to prepare a transition plan describing implementation and/or phasing out other habitat monitoring projects.

This report satisfies the lessons learned reporting and will be considered, during the spring of 2012, when decisions are made about the possibility of expanding the number of watersheds to be monitored by CHaMP in 2012 and subsequent years.

Quarterly progress meetings between BPA, NOAA and NPCC are underway as requested. Bonneville, in coordination with NOAA and the NPCC, will continue its review of habitat projects that involve monitoring and evaluation during the winter of 2011, and, while taking into account the results of the ISEMP and CHaMP lessons-learned, will determine the appropriate levels of effort within those projects. These recommendations will be completed by spring of 2012.

Bonneville agrees with the NPCCs request for a transition plan and will continue to coordinate, with NOAA and the NPCC, its review of habitat projects that involve monitoring and evaluation during the winter of 2011. Recommendations describing the appropriate levels of effort within those projects will be completed by spring of 2012.

ISRP: We encourage the periodic exchange of habitat status and trend data and analyses through annual meetings of those organizations engaged in collecting both habitat and fish population information. Periodic (annual or 2-year) habitat workshops would be a useful forum for information exchange between monitoring organizations, particularly with respect to questions about which protocols are and are not working effectively.

CHaMP held a three day workshop to discuss the results of the pilot year effort in November 2011. Despite adequate advance notice and an open invitation, very few representatives of other organizations engaged in habitat monitoring attended, far fewer than attended the ISRP review of CHaMP in February 2011. Perhaps we could have been more proactive with invitations or adjusted the agenda to be more universally appealing, but participation by other groups remains outside of CHaMP's authority and, arguably, direct influence. This may well be another illustration of the need for a higher level of policy/technical coordination, particularly if policy decision makers agree with the ISRP's suggestion for periodic habitat workshops.

ISRP: The utilization of CHaMP in or (non-IMW) watersheds where fish populations are being monitored was not thoroughly explained, including whether the sampling protocols would facilitate an evaluation of restoration effectiveness on fish populations.

ISRP: It was not clear to us how ISEMP and CHaMP, in evaluating restoration effectiveness, propose to accommodate factors affecting fish populations downstream from CHaMP sampling locations (non-wadeable areas downstream of CHaMP sampling sites, including the mainstem, estuary and ocean).

ISRP: We are still not sure how habitat status and trend monitoring data will be related to (integrated with) status and trends of fish population data within CHaMP watersheds to evaluate the effectiveness of specific restoration strategies or general restoration effectiveness in a geographic area (e.g., are the co-managers in a given subbasin successful in restoring stream habitat in their area?).

ISRP: It was unclear which entity or entities will be responsible for conducting fish status and trends monitoring at CHaMP sites, what kinds of fish data would be collected (e.g., site/reach-specific abundance sampling or fish in-fish out), and what kinds of analytical methods will be used to relate fish status and trends to habitat status and trends.

ISRP: We believe that the description of life stages influenced by various habitat measurements could be more refined. Where possible, illuminate how some restoration actions are influencing VSP parameters.

CHaMP is one building block for answering key management questions through the generation and analysis of habitat information. The fish components of the key management questions are being monitored concurrently as part of the RM&E framework and strategy.

In 2011, collaborating agencies (e.g. ODFW, CRITFC) and related projects (e.g., ISEMP status/trend and IMW research) took advantage of the CHaMP designs and habitat sampling to co-locate fish and habitat data collection. Please refer to Chapter III in this report, as well as the 2012 ISEMP Lessons Learned report (https://isemp.egnyte.com/h-s/20120330/46a02dc2e0af4d6e) for much more information on these topics.

Program Structure and Function

In Chapter IV of this document, we examine each element of project implementation, identify which elements worked and which did not, and then provide recommendations for how to better run the project in future years. These recommendations are summarized below. Please refer to Chapter IV for detail about the implementation elements summarized in the sections that follow.

Timeline For Decision Making

The timeline for decision making did not go as planned in 2011. In order to minimize unnecessary challenges, decisions about project scope (i.e., the number of watersheds to be monitored in subsequent years) should be made before December 20th of the preceding year.

Contracting and Funding

Overall, budgets in 2011 were adequately scoped and the contracting structure worked well and should be continued. In 2012, however, budgets should be modified to more clearly reflect planned project development activities such as protocol and software refinements, and coordination and training improvements.

Coordination Staff and Collaborator Roles

The workload distribution of the 2011 pilot was adequate to complete project tasks; however, an evaluation of existing staff roles and workload distribution is warranted as part of the contract development process for 2012. An organizational chart and updated project work plan should be developed.

CHaMP coordination staff should explore mechanisms to encourage and assist cooperation among individuals and collaborators, particularly on project components that require input from multiple parties.

Coordination with Managers (NPCC, BPA, NOAA)

The level of coordination between CHaMP staff and BPA contract staff and NOAA scientific staff worked well in 2011. During 2012, coordination between policy decision makers and CHaMP developers should be improved in order to better answer key management questions. To start, steps should be taken to identify the scope, purpose, and participants in a high-level discussion forum that would develop a framework for using CHaMP data to answer key management questions.

The issue of whether to establish an executive management committee to provide more direct connections between CHaMP staff and BPA managers, and whether to convene a working group that could improve information exchange with NPCC and other agency staff, should be further considered.

Coordination With Regional Programs

The high level of coordination among CHaMP staff and participating collaborators was critical to the success of the 2011 pilot year and should continue in 2012. Coordination with other regional programs will be facilitated through participation in the PNAMP status monitoring coordination forum and working groups. As project development needs continue to decline, more effort should be focused on balancing the management goal of coordinated and standardized regional monitoring with the NPCC's overarching program goal of cost-effectiveness.

The level of effort dedicated to participation in regional coordination programs such as PNAMP should be evaluated in terms of the NPCC's goal of cost-effectiveness and established in proportion to the actual need as determined by policy decision makers. Better coordination should increase cost-effectiveness.

Coordination and Process Tools

Overall, the number and type of coordination tools utilized in 2011 worked well, and familiarity with the tools improved throughout the season.

Use of existing visual communication tools and electronic information distribution mechanisms built into CHaMP-Monitoring.org should continue and be updated/improved to address issues identified in 2011 (e.g., improve public access to CHaMP staff contact information, update email distribution lists, etc). Other web-based tools (e.g., a shared calendar) will be investigated by CHaMP staff to improve overall coordination and staff and collaborator access to information. These coordination and process tools will also be shared on a regular basis with regional entities through PNAMP.

Project staff should reinforce the expectation that crews and project participants will check CHaMPMonitoring.org regularly for updates and to access necessary information. Although internet access can be limited in some areas, crews should ensure regular, reliable connections to improve communication.

Reporting

Report content should continue to be organized in a way that facilitates usage by policy decision makers, content generation, and contribution by technical subject matter experts.

Distribution of a post-season survey to all project collaborators should also continue; however, survey format should be revised to eliminate redundancy and group information in a better way, and the survey should be distributed earlier so that target respondents have more time to complete and return it, and to avoid the risk of crews disbanding prior to survey distribution.

Field Sampling and Protocol Implementation

Logistics and Feasibility

Overall, field sampling as outlined in the CHaMP 2011 protocol was manageable and feasible, and nearly all sites were completed within the maximum two-day period.

Supervisors identified distinct variability in crew work flow, depending on the experience of crew members and their comfort with topographic surveying/data management techniques. A number of recommendations were made for improvement in 2012. For example, directions to crews for locating and laying out sites, and how sites are sampled either as a single site within the recommended period, or as a group of sites within a work hitch, should be improved. Moving to use of a four-person crew, or having a fourth person available for more challenging sites was also recommended.

In early 2012, the CHaMP development team will be evaluating all recommendations and potential mechanisms to improve logistics and the overall feasibility of implementing the protocol. Additional guidance supplements and/or changes to the protocol will be developed prior to the start of the 2012 field season to improve overall implementation success.

Topographic and Auxiliary Data Collection and Standardization

Additional training was identified as a primary means to improve crew auxiliary data collection in 2012, particularly with respect to channel units. Improvements in accuracy and the ease with which some habitat measurements are collected can be achieved through the use of different equipment (e.g., change to a flow meter that is able to detect lower flows, switch to a different instrument for solar input measurements, etc).

Additional training and clarification about drift sampling techniques (sampling, preservation and shipping) combined with modifying the nets, should improve overall sample quality. Samples may need to be sent on a weekly basis after the end of a hitch.

Crew topographic survey inconsistencies were due to systematic survey and/or post-processing errors. These can be corrected post-hoc or avoided altogether in 2012 through additional training and conducting visual checks of the data while in the field. Numerous 2011 project participants identified the importance of additional crew training in total station use, topographic data post-processing, and data layer production (i.e., DEMs and TINs). Training in 2012 should adjusted to provide this extra focus.

Topographic data collection was sufficient in 2011 for change detection analyses; however, additional guidance should be provided on how far outside of the active channel to extend surveys. Due to the steep learning curve associated with topographic data collection and post-processing, an effort should be made to retain 2011 CHaMP crew members for the 2012 season to help improve overall work flow and ensure quality surveys at every site by every crew.

Troubleshooting and Field Season Assistance

The CHaMP Emergencies support framework should continue into the 2012 field season and the existing reporting and response mechanisms should be evaluated and modified as needed, including evaluating the utility and potential ways to improve use of the online forum by crew supervisors and members.

Identifying specific contacts/contact mechanisms for immediate support on data logger, equipment, and general troubleshooting will streamline response time. Additional documentation about common errors and troubleshooting for field crews and supervisors, and how to install fixes should be available prior to the start of sampling.

Feasibility and Implementation of Variability Studies

Many recommendations provided for the 2012 field season focus on improving logistics and efficiencies in conducting variability studies where multiple crews need to interact More detail can be found in Chapter IV.

Budget was also a concern for collaborators, and if variability studies or investigations are to be conducted in addition to core CHaMP project implementation in 2012, budget increases may have to be considered for items such as overtime and travel expenses to retain crew participation in some watersheds.

Scope of Changes to Protocol

Changes to the habitat protocol will involve full participation from all collaborators. Subject area workgroups will be established for auxiliary data, topographic surveys, equipment, drift invertebrate sampling, and perhaps other subject areas. For metric and method changes, it is critical that discussion focus on both whether a metric or method should be changed prior to a full 3-year cycle of field implementation, in addition to what changes should be made. Changes to the protocol will continue to follow the metric inclusion rule set described in the 2011 protocol.

For general content changes, collaborators recommended that, prior to the start of the season, crew supervisors and members should go through each element of the protocol and identify where language is vague in regard to sample procedures (e.g., develop clearer definitions of woody shrubs, provide a clearer definition of wet versus dry wood) and the protocol should be updated after training to address issues that may have arisen. Methods to document confusion or uncertainty about the protocol in-season should be developed so issues can be addressed in protocol addenda as the season progresses. These are good ideas that will be explored during the 2012 protocol development process. Meetings and discussions with collaborators about the CHaMP protocol and changes for 2012 will continue so that sufficient time is available to evaluate and incorporate proposed changes prior to start of the field season. Proposed changes to the protocol will also be coordinated on an annual basis with the region through the PNAMP process.

Equipment

Performance in the Field

Overall, staff should conduct more extensive field testing of new equipment and software prior to the 2012 field season. A better inventory control system will be put in place to ensure that equipment is managed better among and within crews.

Additional recommendations listed below represent only a portion of the feedback that was received from crews. The bulk of technical comments on methodology will be considered during the 2012 development process and will be captured directly within the 2012 CHaMP habitat protocol.

Total Station:

- Improve training and field support to more efficiently address issues and troubleshooting (e.g., especially directions for calibrating total stations).

- Use a heavy-duty tripod and attached prism instead of a bipod to improve efficiency and produce more accurate backsight checks and consider larger prisms for use with backsights.

Data Loggers:

- Equip new data loggers with an internal GPS. Improve workflow and avoid transcription errors.
- Make significant improvements to the field utility of the data logger before the 2012 season. Possibly provide an additional data logger to each crew (e.g., especially for scouting, benchmarks, and site layout) or use scouts to perform some work in advance of the arrival of crews to significantly improve work flow.

Auxiliary Measurement Equipment:

- Investigate the use of the Solametric Suneye for measuring riparian cover instead of the 2011 ocular estimation procedures. This meter would also be an improvement over the Solar Pathfinder tool.
- Significantly improve the drift net setup to improve performance. Similarly, greatly improve the handling and shipping of drift invertebrate samples to improve sample integrity.
- Upgrade to flow meters that can measure flows at depths <10 cm and discharge <0.1 m/s to quantify drift and discharge in low flow conditions on small streams.

Software Applications and Raw Data:

A number of issues arose in 2011 related to data logger software bugs and versioning, particularly early in the field season. Suggested improvements for 2012 include:

- Provide ample time to beta-test all software applications (e.g., data logger, total station) prior to training and field use.
- Ensure changes to field data logger and database software (and to a lesser extent, GIS processing requirements) are more tightly coupled to enhance compatibility.
- Complete data logger application development well in advance of the field season, provide ample beta-testing, and ensure faster turnaround time on any data logger application development during the field season.
- Explore modification of some of the specially designed tools used in the execution and processing of surveys to accommodate other software and hardware platforms. This would promote other organizations to incorporate the CHaMP protocol using qualified survey equipment deemed appropriate according to a modified list of attributes constructed by CHaMP collaborators. However, all software and hardware platforms used must output data in a format common to the entire project and consistent with the specifications of the data management system.

Bulk Purchasing: Quartermaster Approach

Bulk purchasing saved substantial amounts of money during the 2011 pilot year, and the Quartermaster position ultimately streamlined gear distribution and management. Recommendations for 2012 include:

- Use a single CHaMP contractor to buy all equipment in bulk and retain Quartermaster to act as a primary point of contact for equipment training, care, troubleshooting and replacement of broken or malfunctioning instruments; to assign and coordinate delivery of gear to appropriate basin locations; and to implement proper maintenance and expedite all necessary repairs.
- Organize, manage and store all gear at one base location while not in use, and use a database again to account for and track all items bought with CHaMP funds. The Quartermaster should again collaborate with organizers to develop purchase budget for new gear and maintenance of old gear, as necessary.
- Explore providing the leeway for each watershed to purchase relevant gear during the field season for efficiency of use.

Consumables

While the distribution of consumables helped with training and early season surveys, the way these items are handled should be modified for 2012.

- Supply managers of each funded basin with a detailed list of necessary consumables as well as other suggested items that they will be responsible for purchasing pre-season.
- Provide only the more expensive, non-consumable CHaMP equipment items to the funded basins. Collaborators should be expected to take care of their respective CHaMP kit and expedite routine maintenance and repairs as needed.
- Allow CHaMP watersheds that may have access to equipment other than the supplied kit to put it to use, potentially increasing their level of productivity. This must be balanced with protocol standardization and program-level data management.

Building on successes from 2011, a number of things should be continued in 2012.

Inventory

- Ensure access to a central storage facility during the season.
- Establish a single CHaMP shipping account with a major courier to which all associated expenses will be charged.
- Continue questionnaire use to facilitate assessment/reporting of equipment status.

In 2012, staff should explore requiring collaborators to use the gear they are issued for the length of their participation in the project, or the life of the equipment, and making them responsible for storage of the majority of their assigned gear through the winter months.

Service and Maintenance

In 2012, staff will write equipment service costs into budgets to allow repair or replacement, allowing more gear to be available should replacements be needed somewhere else within the project. Recommendations to improve maintenance in 2012 include:

- Return all technical instruments to equipment headquarters at the end of field season for thorough, professional service to ensure proper functionality and the longest life span possible, and install any firmware updates that have become available on the machines at this time.
- Redistribute equipment at training, where each organization will sign to indicate responsibility.

Training

Facilities, Location and Timing

Feedback from participants indicates a review of the timing and location of the 2012 CHaMP training workshop (i.e., CHaMP Camp) is needed. Suggestions include:

- Start CHaMP Camp on a date that balances hiring timelines with sufficient time ahead of the field season for data logger/management staff to address required changes.
- Locate the 2012 camp where there is access to a wide variety of stream types so crews are experience a wider array of site conditions and can receive better training in channel classification.
- Consider evaluating the feasibility of training for crew supervisors ahead of CHaMP Camp to help reinforce their skills and potentially include them as trainers, and assess the potential for additional in-basin training. This would allow for direct work between crew supervisors and crews to catch sampling procedure errors and misunderstandings.

Participation, Staffing and Funding

CHaMP Camp was an intense experience for all involved and several recommendations have been made to improve the experience in 2012. These include:

- Ensure that trainees have read the protocol and all other relevant materials prior to arrival at camp, and provide training prep and time through webinars and online training modules that could be used to help prepare attendees and provide practice opportunities after training, as well as provide training opportunities for new hires who are brought into the project after the pre-season training.
- Increase the number of trainees attending camp so that an adequate number of personnel are trained before the field season to account for mid-season turnover/ sick days/etc.
- Use staff from the 2011 collaborating agencies as trainers in 2012 to increase the number of trainers and also help ensure consistency among trainers on how to implement the protocol. This would also provide additional trainers for total station and post-processing components.
- Consider adding a coordination staffer and two additional event-production staff (logistics) to improve the effectiveness of event coordination.

Curriculum

Overall, the number of people trained and material covered in 2011 was impressive. Considerations for curriculum changes in 2012 include:

- Provide additional time for topographic surveying and post-processing (and shortening of other modules), trying to teach modules in the order that they would be implemented in the field, that is, according to actual work flow.
- Spend additional field time on channel unit classification.

Sampling Design

CHaMP staff recommend continuing the current design, including use of the master sample as the sample frame for existing watersheds, should be continued. for 3 to 5 years until estimates of variation are compiled, and then evaluating if design changes are warranted. Recommended improvements for 2012 include:

- Hire a full-time understudy of the GRTS design specialist with basic GIS skill set to facilitate timely study design and sample frame development. This hire would also buffer the project from anticipated staff turnover when the existing specialist retires.
- Contract with collaborators earlier to allow additional time and leveraging of local GIS skills for development and review of GIS frames.
- Provide sufficient lead time to bring new teams up to speed and set design in place if commitments are made to bring on additional CHaMP watersheds.
- Assure the master sample is available in time for use by all crews at start of field sampling season, and apply the master sample to new watersheds.
- Start the study design process earlier in the year to allow more time for development and formalize and require frame documentation prior to loading to CHaMPMonitoring.org.
- Better align GRTS script input/output with website needs.
- Consider modifying the site selection tool on CHaMPMonitoring.org to accommodate recording in-season field rejection information as distinct from pre-season evaluations.

Data Management

Overall, the number of features and functions built for the 2011 CHaMP data management system, including those which are made available to staff and collaborators for field data management, QC/QA, and analysis, was impressive to most users and was sufficient for 2011 implementation. For 2012:

- Continue staff use of the existing features, and coordinate and share this work with other regional habitat programs through PNAMP.
- Better define data requirements, both for upload and input, and output and use in other tools (e.g., RBT), through work among data management staff, monitoring coordinators, analysts, and crew supervisors, to improve the overall data management process prior to the field season.

Data Flow and the Cloud

The study designs and protocol data dictionary should be finalized by March 30 to allow programmers sufficient time to update and test data capture tools. In addition, data capture tools should be well tested prior to field season to help ensure data quality procedures are actively implemented during the field season. To facilitate QA/QC data management staff could explore expanding the use of some cloud features to pass data back and forth between crews and CHaMP support staff and could research providing an alternate tool for crew data transfer, (e.g., DropBox) or a place to email zipped files, if access to the cloud is difficult or impractical.

Topographic Survey Processing

Many recommendations were made to facilitate topographic survey processing in 2012 as this component of CHaMP was perhaps the most novel aspect of the project. Chapter IV provides a comprehensive list of many of the elements of this process that could be improved for future years. Examples include:

- Finalize and publish data collection and data on MonitoringMethods.org prior to field season start.
- Add direct linkages from the measurement and metric fields to the metadata descriptions for those fields, and to display the data quality constraints for each field.

Data Management System (CHaMPMonitoring.org)

We can now refine and improve the exchange of data between system components. In 2012, data system development should emphasize improvements on interaction points between system components to address the clunkiness experienced by system users in 2011.

Quality Control/Quality Assurance

Prior to the 2012 field season a CHaMP protocol for QC/QA should be developed. Chapter IV provides many details about the contents of this QC/QA protocol. Other recommendations for improvement in 2012 include:

- Implement data logger version control and updates to implement QC procedures.
- Create a Data Broker application to aid in data transfer/management between the field laptop and CHaMPMonitoring.org.
- Modify CHaMPMonitoring.org to include QA/QC scripts to screen data prior to CHaMP database upload.
- Develop QA constraints on the exported data from the logger application that are integrated with CHaMPMonitoring.org data system QC process.

Data Analysis

The need for a full time analyst position has not diminished. We strongly recommend that steps are taken to ensure that the proposed PNAMP cost-share is realized in 2012, or failing that option, that the position be fully funded through CHaMP. Immediate tasks for this position include:

- Design Analysis - If additional sub-basins are funded in 2012 the analyst will immediately begin the process of aligning CHaMP efforts with existing habitat restoration and monitoring efforts in those locations.
- Metric and Indicator Evaluation/Consolidation/Prioritization—Identify duplicative or uninformative measurements and/or deficient effort accompanying field measurements to enable streamlining of the CHaMP protocol and/or indicate the need for greater effort. Early identification is crucial for timely protocol modification and subsequent changes to training curricula, data logger applications, and data storage.
- Metric calculations – Perform work required to automate the generation of some derived metrics/indicators (e.g., NREI).

Longer term tasks (2012-2014) include survey variance partitioning and incorporating fish data.

III. DATA REVIEW: LESSONS FROM THE 2011 PILOT DATA

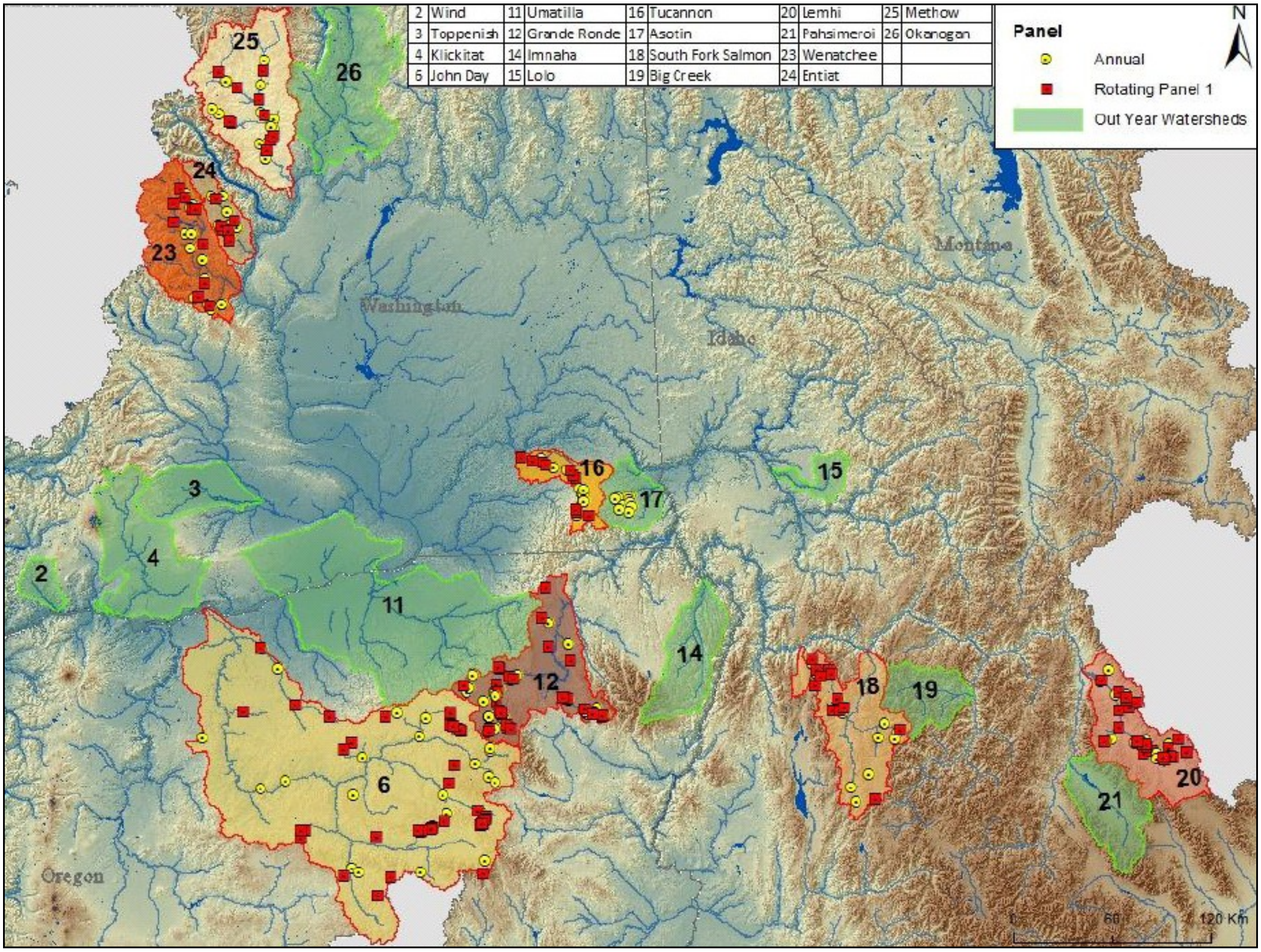


Figure 1. Location of CHaMP 2011 annual and rotating panels.

This chapter presents the analytical framework (data utility plan) that is being developed to interpret CHaMP project data for use in policy decision making, lists the metrics calculated during the 2011 pilot year and where a description of each may be found, provides a specific example of how CHaMP data might be used, and also presents a synthesis and interpretation of data collected during the first year of CHaMP.

Data Utility Plan

The CHaMP and ISEMP projects are working together to develop an analytical framework for interpreting CHaMP habitat data for use in policy decision making. This framework is not complete (as of March 31, 2011) but it is clear that it must provide simple interpretations of complex habitat data for use in management decision making. The elements of this framework will be characterized by:

- Complex data – As many as 78 habitat metrics from as many as 650 sample sites per year need to be summarized and condensed at multiple spatial scales (e.g., subbasin, within subbasin, and site scales) and be summarized for temporal trends.
- Useful interpretations – Graphical and numerical summaries need to directly support answers to key management questions.
- Simple and easy to comprehend – Policy decision makers need interpretations that make sense, can be easily understood, and easily communicated.
- Valid and rigorous – These interpretations will be challenged and therefore must be based on rigorous scientific methodologies that can justified and supported.

The final nature of the interpretations that will underpin the analytical framework will (1) require collaboration between technical developers and policy decision makers before they are finalized and (2) will clearly need to be based on either theoretical or empirical relationships between fish and fish habitat. The collaboration between CHaMP technical developers and policy decision makers will be facilitated by a forum around which the technical, policy, implementation, and management objectives and roles can be reconciled. The theoretical and empirical relationships that will be used for interpreting habitat data are under development and will proceed according to the schedule described here.

Theoretical Interpretations

Interpretations of CHaMP 2011 data based on theoretical relationships will be possible as soon as late spring 2012 and can be further developed in subsequent years. We consider these relationships "theoretical," as opposed to "empirical," because the nature of the relationships will be derived from existing scientific literature. However, there are relatively few habitat metrics that have been explicitly linked to fish metrics within the scientific literature. For example, of 21 interpretive relationships generated by AREMP for the North Cascades province, only three are based on relationships published in scientific literature and the rest were some form of professional judgment. While "theoretical" interpretations of CHaMP data, such as what is presented in Gallo et al. 2005 (Appendix 5; http://www.fs.fed.us/pnw/publications/pnw gtr647/pnw-gtr647a.pdf) may be possible, they will likely not satisfy managers because (1) these interpretations would be metric-specific and would not exploit the explanatory power of the full suite of habitat metrics generated by CHaMP, (2) could only be developed for relatively few metrics and certainly not for some of the more promising metrics made possible by the CHaMP protocol and tools, and (3) would suffer if the underlying research was not validated or otherwise shown to apply to fish populations in CHaMP watersheds.

Empirical Interpretations

The other, preferred, approach is to develop empirical relationships between habitat and fish metrics. In this report, we illustrate one empirical approach where we generate a habitat quality index based on observed relationships between site-scale fish density information collected by ISEMP and CHaMP habitat metrics (see page 48, Classification and Regression Tree Model and Boosted Regression Trees). These empirical approaches require both data collection and sampling designs that accommodate the purpose of developing such relationships. Other empirical relationships will be generated (by ISEMP, CHaMP and other collaborators) at other scales (e.g., subbasin and within subbasin) for other fish metrics (i.e., abundance, survival, and growth). Interpretations based on these empirical approaches will allow for the use of the full suite of CHaMP habitat metrics, can provide managers with information that directly support answers to key management questions, can be reduced to simple visual and numerical scores that are easy to comprehend, and will be validated for the Columbia Basin and supported by rigorous science.

Schedule

While additional years of data collection will be necessary to generate the fish and habitat data necessary to develop empirical interpretative relationships, managers will not have to wait long before CHaMP data is useful for policy decision making. The metric information derived from 2011 data will be available to the public at www. CHaMPMonitoring.org in April 2012 after the final quality assurance tests are run. This information could be immediately useful to Expert Panels for the identification and scoring of limiting factors but would be limited to site-specific inferences. By late spring 2012, this information could be rolled-up for making subbasin scale inferences through the application of sample weightings based on final site evaluation using the GRTS process. In subsequent years, as empirical relationships are generated, descriptions of habitat capacity (numbers of fish supported by observed habitats) will be able to assist the Expert Panels assess PFCs and, ultimately, to determine whether habitat actions are changing productivity indices.

Table 3. Overview of when and how CHaMP data can be used to answer KMQs.

2011 data	– Being used in this report to illustrate examples of interpretive tools -- Available (in late spring 2012) for interpretation by managers using theoretical relationships at all spatial scales. -- Available (in late spring 2012), fish density measurements will be converted to estimates of fish abundance at the site-scale to further develop empirical relationships between fish density and habitat metrics at the site-scale for the generation of habitat quality indices that can be used at all spatial scales and be used by managers for interpretation with low certainty.
2012 data	-- Will be useful to managers for management decisions with moderate certainty as empirical fish/habitat relationships are applied and as the CHaMP data set expands but is not yet complete. -- Will be used to refine empirical fish habitat utilization relationships at the site-scale.
2013 data	-- Will be useful to managers for management decisions with high certainty due to the completion of the 3-year CHaMP design (at pilot subbasins only) and the incorporation of three years of fish data at ISEMP/CHaMP study sites into empirical interpretive relationships based on fish habitat utilization at the site-scale, including temporal variability, for the generation of habitat quality indices that can be used at all spatial scales.
After 2013	-- Additional empirical relationships using additional fish metrics (e.g. survival, growth) will be developed to improve levels of certainty for management decision making.

Table 3 on the preceding page provides an overview of when and how CHaMP data can/could be used by policy decision makers and managers to answer KMQs.

REFERENCE:

Gallo, Kirsten; Lanigan, Steven H.; Eldred, Peter; Gordon, Sean N.; Moyer, Chris. 2005. Northwest Forest Plan—the first 10 years (1994–2003): preliminary assessment of the condition of watersheds. Gen. Tech. Rep. PNW-GTR-647. Portland, OR: U.S. Department of Agriculture, Forest Service, PNW Research Station. 133 p.

Data presented in the next section of this chapter are for display purposes only and are not ready for use in management decision making.

- Comparisons between subbasins should not be made with the data displayed in this chapter as the habitat quality index scales are relative to sites within one subbasins as a result of non-standardized fish sampling methods.
- CHaMP data in the February 29, 2012, report is still provisional and has not been approved for public use at this time. Final data will be used in the final version of this report.
- Scaling of habitat quality indices is not standardized among all subbasins and is subject to substantial revision.
- Boosted regression trees are one method to analyze the fish-habitat relationships. Although we believe this approach has several advantages over other methods, additional analyses may be carried out with CHaMP data.

Data Summary and Interpretation

CHaMP generates a considerable amount of detailed data: 78 metrics (see Table 4 on the following page) and 3D imagery from each of nearly 400 sites were generated in 2011, and the number of sites could increase to as many as 650 per year once CHaMP is fully implemented. In order to be useful for answering the key management questions discussed in the previous chapter, we must develop interpretive tools to significantly reduce and summarize data complexity and volume.

In this chapter we demonstrate a potential tool for generating and displaying indices that may be consumable for the management community for assisting with restoration action prioritization and status assessments. Using CHaMP 2011 data we developed empirically-derived functional relationships between the most predictive habitat metrics and juvenile Chinook salmon density from data collected at 152 sites in the Lemhi, Upper Grande Ronde, John Day, South Fork Salmon, Entiat and Wenatchee subbasins by ISEMP, CRITFC, and ODFW. Classification and regression tree frameworks, with boosted regression tree methods (see more detail in the section on these models later in this chapter), were used to predict juvenile Chinook densities from CHaMP habitat metrics: the resulting score was transformed into a non-parametric habitat quality index and examined at the three spatial scales: the subbasin, assessment unit (HUC5), and site-level. Draft example subbasin summaries of the habitat quality index are provided for all CHaMP subbasins and a specific assessment unit and site examples are described for the Wenatchee subbasin.

Subbasin Scale

In light of the purpose of the CHaMP project to implement habitat monitoring throughout the Columbia Basin, the initial, highest level of summary of CHaMP data might be to compare habitat status and trends between subbasins. As described previously in the “Data Utility Plan” section, additional theoretical or empirical relationships need to be developed that normalize comparisons across subbasins in a way that make between-subbasin comparisons meaningful. We were not able to do that in time for this report, although some basic theoretical and empirical comparison will be completed in late spring 2012 with additional, more rigorous analyses in future years.

Assessment Unit/HUC5 Scale

Restoration actions are generally prioritized at assessment unit scales smaller than the subbasin (e.g., HUC5 watersheds). To facilitate comparison, habitat data from each site was reduced to habitat quality index scores and averaged across the Assessment Unit/HUC5 level (Figures 2 to 9 on pages 24-31) by extrapolating site-level data to all reaches of similar valley classification within the HUC 5 and then averaging all values within the HUC 5 (a weighted-average using stream mileage). These broad scale displays will also be helpful in documenting trends: if restoration projects are leading to actual improvements, more Assessment Units/HUC5s on the maps that follow will evolve from red to green.

In this section, we describe known, real-life restoration action decision making in the Wenatchee subbasin, show that CHaMP data confirms existing information and professional opinion, and suggest that such analyses can help extend our knowledge of habitat quality and availability where less information is available.

The upper Wenatchee subbasin contains three HUC5 watersheds (the Chiwawa River, Lake Wenatchee Tributaries, and Nason Creek, Figure 9, page 31) that are recognized by local experts for having fish habitat of varying quality. In general, the Chiwawa and Lake Wenatchee tributaries are considered to have good habitat while Nason Creek is known to have poor habitat with significant restoration potential. This general

Table 4. CHaMP 2011 metrics collected using the CHaMP protocol, groupings, and where to find their descriptions

Metric Name	Group	Description
Site Length Wetted	Site Length	https://sites.google.com/a/essa.com/rbttech/champ/metrics
Site Length Bankfull		
Site Length Thalweg		
Site Water Surface Gradient	Gradient	
Water Surface Gradient Profile Filtered Mean		
Water Surface Gradient Profile Filtered CV		
Site Sinuosity	Sinuosity	
Integrated Bankfull Width	Bankfull Width	
Bankfull Width Profile Filtered Mean		
Bankfull Width Profile Filtered CV		
Bankfull Width Constriction Profile Filtered Mean		
Bankfull Width Constriction Profile Filtered CV		
Integrated Wetted Width	Wetted Width	
Wetted Width Profile Filtered Mean		
Wetted Width Profile Filtered CV		
Wetted Width Constriction Profile Filtered Mean		
Wetted Width Constriction Profile Filtered CV		
Thalweg Depth Profile Filtered Mean	Depth	
Thalweg Depth Profile Filtered CV		
Centerline Depth Profile Filtered Mean		
Centerline Depth Profile Filtered CV		
Bankfull WidthToDepth Ratio Profile Filtered Mean	Width to depth	
Bankfull WidthToDepth Ratio Profile Filtered CV		
Wetted WidthToDepth Ratio Profile Filtered Mean		
Wetted WidthToDepth Ratio Profile Filtered CV		
Site Wetted Area	Area	
Site Bankfull Area		
Wetted Volume	Volume	
Site Bank Angle Mean	Bank Angle	
Site Bank Angle StdDev		
Pool Area	Pools	
Pool Count		
Pool Frequency		
Pool Volume		
Pool Percent		
Fast-NonTurbulent Area	Fast-NonTurbulent	
Fast-NonTurbulent Count		
Fast-NonTurbulent Frequency		
Fast-NonTurbulent Volume		
Fast-NonTurbulent Percent		

Metric Name	Group	Description
Fast-Turbulent Area	Fast-Turbulent	https://sites.google.com/a/essa.com/rbttech/champ/metrics
Fast-Turbulent Count		
Fast-Turbulent Frequency		
Fast-Turbulent Volume		
Fast-Turbulent Percent		
Site Discharge	Discharge	http://www.monitoringmethods.org/Method/Details/853
Site Measurement of Conductivity	Water Chemistry	http://www.monitoringmethods.org/Method/Details/1248
Site Measurement of Alkalinity		http://www.monitoringmethods.org/Method/Details/874
Drift Invertebrate Biomass Density	Invertebrates	http://www.monitoringmethods.org/Method/Details/849
Measurement of D16	Substrate Size	http://www.monitoringmethods.org/Method/Details/865
Measurement of D50		
Measurement of D84		
Percent of Observations Less Than 2mm		http://www.monitoringmethods.org/Method/Details/868
Percent of Observations Less Than 6mm		http://www.monitoringmethods.org/Method/Details/1245
Boulder and Cobbles	Substrate Distribution	http://www.monitoringmethods.org/Method/Details/867
Course and Fine Gravel		
Sand and Fines		
Wetted Large Wood Frequency per 100m	Large Woody Debris	http://www.monitoringmethods.org/Method/Details/1240
Bankfull Large Wood Frequency per 100m		
Wetted Large Wood Volume by Site		http://www.monitoringmethods.org/Method/Details/872
Bankfull Large Wood Volume by Site		
Wetted Large Wood Volume in Pools		
Bankfull Large Wood Volume in Pools		
Wetted Large Wood Volume in Fast-Turbulent		
Bankfull Large Wood Volume in Fast-Turbulent		
Wetted Large Wood Volume in Fast-NonTurbulent		
Bankfull Large Wood Volume in Fast-NonTurbulent		
Fish Cover Composition LWD	Fish Cover	http://www.monitoringmethods.org/Method/Details/873
Fish Cover Composition Vegetation		
Fish Cover Composition Undercut		
Fish Cover Composition Artificial		
Fish Cover Composition None		
Percent Big Tree Cover	Riparian	http://www.monitoringmethods.org/Method/Details/878
Percent Coniferous Cover		http://www.monitoringmethods.org/Method/Details/1242
Percent Ground Cover		http://www.monitoringmethods.org/Method/Details/1243
Percent Non-Woody Cover		http://www.monitoringmethods.org/Method/Details/1244
Percent Understory Cover		http://www.monitoringmethods.org/Method/Details/1246
Percent Woody Cover		http://www.monitoringmethods.org/Method/Details/1247

Future CHaMP data should have even more predictive power than the 2011 data set.

- Additional years of coincident sampling of fish and habitat will improve our power to detect and identify functional relationships between habitat and fish metrics.
- Additional CHaMP habitat indicators that may have more predictive power for fish metrics of interest (e.g., NREI, hydraulics models, water temperature, sediment transport and change-detection metrics, landscape classifications) will be generated and available for analysis in subsequent years.
- Additional sites will be sampled each year during the three year rotating panel design. The increased sample size will improve certainty in esti-

understanding is reflected in evaluations being made by the Upper Columbia Expert Panel who are scoring properly functioning condition (PFC), a measure of habitat quality, based on existing information and professional judgment. Although these scores are not final for 2012 (the process takes place every 3 years), draft PFC scores range as high as 95% in the Chiwawa, are mostly in the 60-99% range for Lake Wenatchee tributaries, but are down in the 30-60% range for Nason Creek *(preliminary results from the Upper Columbia Expert Panel*; James White, UCSRB, personal communication*)*. Finally, restoration action implementers have already taken action consistent with the general understanding of fish habitat in this well-studied subbasin. Few habitat restoration actions are planned for the Chiwawa (e.g., a few barrier removals, perhaps one side channel project), and Lake Wenatchee tributaries (e.g., one large woody debris project) and relatively low amounts of money are being directed at these HUC5s (e.g., perhaps $350,000 of actions in Lake Wenatchee tributaries). In contrast, major work is being planned for Nason Creek that could include modifications to railroad and highway right-of-ways that could significantly alter a few miles of the Nason Creek channel, reconnect 100+ acres of floodplain and wetlands, and restore physical and biological processes in a significant portion of this watershed. The investment in Nason Creek is anticipated to be high, with total project costs between 10 and 20 million dollars.

CHaMP evaluations using the habitat index generally confirm what previous knowledge has indicated: habitat quality is poor in Nason Creek while habitat quality is good in the Chiwawa and is best in the Lake Wenatchee tributaries. (Figure 9). While such a validation is not remarkable in the Wenatchee, where much is already known regarding the habitat (as a result of several years of ISEMP habitat monitoring), the fact that CHaMP data produces results that match existing understandings in a well-studied watershed, suggests that CHaMP data will be particularly valuable in watersheds where little other information exists. It may be that restoration action planners in other subbasins will want to target the "red" watersheds for treatment while protecting the "green" watersheds, as seems to be the case in the Wenatchee, or may wish to use the CHaMP data to develop more locally-appropriate restoration strategies.

Site Scale

Displaying and interpreting habitat data at the site level is useful for many purposes including reporting, limiting factors analysis, and project effectiveness monitoring. In this subsection, data from two sites (Site WENMASTER-000195 in the Chiwawa (green circles) and Site WC503432-000032 in Nason Creek (red triangles; Figure 10, page 32) are displayed to illustrate this utility. The habitat quality index, calculated using the CHaMP boosted regression tree approach using all habitat metrics, is high for Site WENMASTER-000195 in the Chiwawa (green circles) and is low for Site WC503432-000032 in Nason Creek (red triangles). An examination of the partial dependency plots in Figure 10 shows that while the Chiwawa and Nason Creek sites both score high for average discharge, the Nason Creek site suffers from low pool volume and low pool area. Indeed, at the Nason Creek site, the lack of pools could be interpreted as a limiting factor for fish production at this site. Results for the other metrics vary but the level of contribution of those other metrics is much lower than for pools (note the values in parentheses: wood in pools has only 2.8% of the influence on the overall habitat quality score while the influence of pool volume is about 4 times greater at 10.5%).

Information in these plots can be used to inform restoration action and to set restoration action goals. If the amount of pool volume, at the Nason Creek site, was increased to 0.5 (50 percent of the site) or greater, and pool area was increased to greater than 0.35, then the habitat quality index at this site would improve significantly and we would predict that the site would support significantly more fish. However, a weak restoration action that increased pool metrics to a level below the indicated thresholds might not tip the scale in favor of greater fish production.

Finally, changes over time at a given site can be documented using these CHaMP tools. Imagine that the sites in Figure 10b represent before-treatment (red triangles) and after-treatment (green circles) snapshots at the same site that had undergone restoration actions. In this hypothetical case, the restoration action shifted pool volume from 0.0 to 0.9 and pool area from 0.0 to 0.8. These measureable changes in metrics translate directly into habitat quality indices that can be expressed in terms of juvenile Chinook density. This means that habitat restoration actions success could be interpreted within the currency of numbers of fish supported at a site and could document direct results from restoration investments (please refer to text boxes in this section on important caveats to this message).

Other site level information can be presented and used to evaluate/interpret sites. For instance, topographic survey data and raw metric scores can verify or qualify information derived from the CHaMP habitat quality index predictions. In addition to the deficiencies illustrated in Figure 10b, the Nason Creek site is likely less attractive to fish for several other reasons (see the table of metrics in Figure 10e): its channel geomorphology is less complex and more uniform (note the relatively low coefficient of variation (CV) for the thalweg depth profile, the relatively low site sinuosity, and the fact that 100 percent of the site is comprised of either of two categories of "fast-water" habitat, either turbulent or non-turbulent, and lacks "slow water habitat"). Other metric information further informs the site-level interpretation of these two sites. The Nason site has much less fish cover, has more fine sediment and less boulders/cobbles (which can be beneficial structural elements for salmonids), and there is a marked difference in conductivity and alkalinity which could affect primary and secondary production.

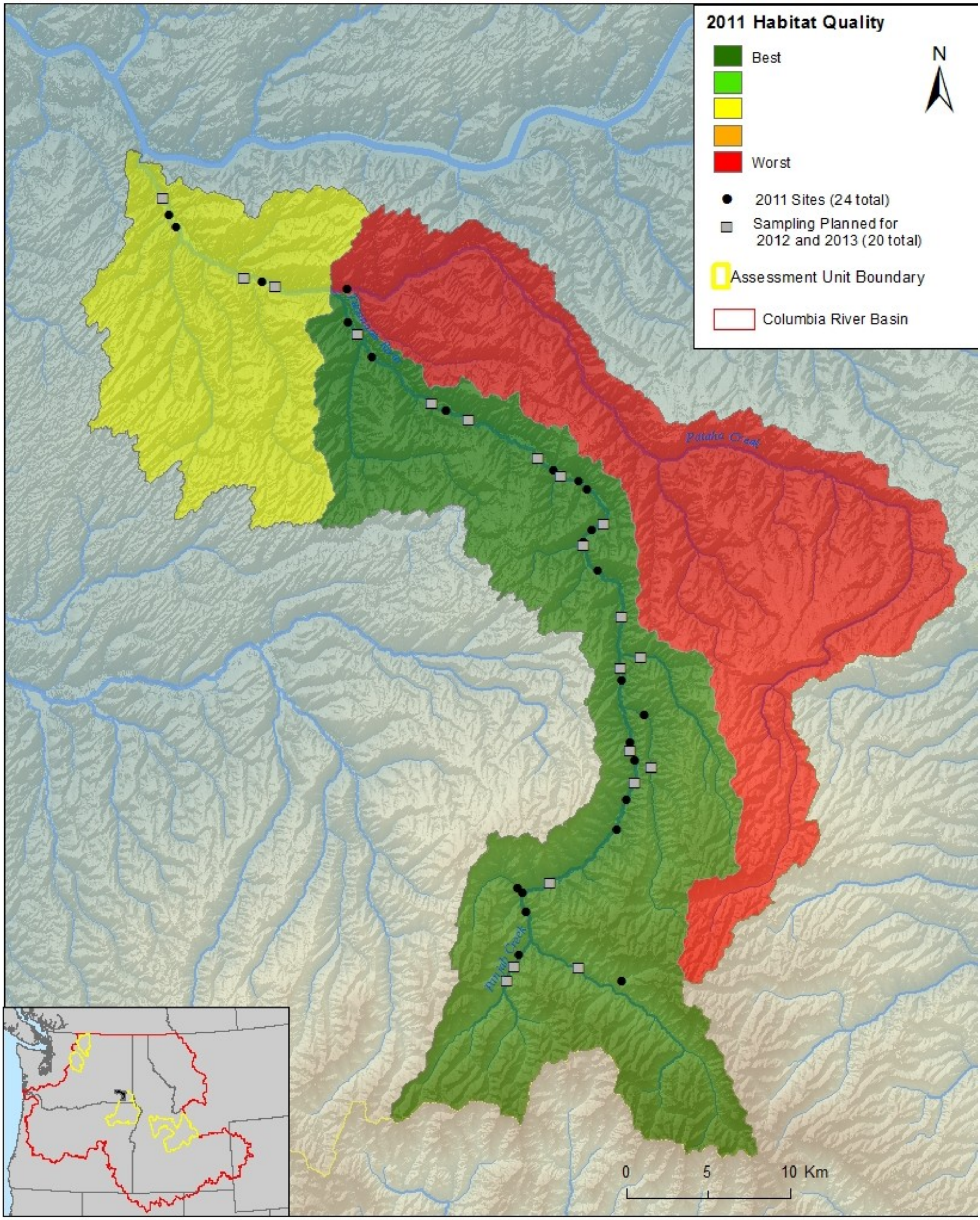
This low level of channel complexity at Nason Creek, relative to the Chickamin site in the Chiwawa, can also be seen in the topographic surveys (Figure 10c and 10d). Habitat units at the Nason site are restricted to runs and riffles where as the Chiwawa site includes depth complexity in the form of scour pools with defined tails. Also, the relative uniform depth at the Nason site is obvious in the topographic image relative to the alternating deep and shallow areas in the Chiwawa site.

Summary

This section illustrated one approach to interpreting the CHaMP data set at three spatial scales. In the future, other approaches will likely be possible.

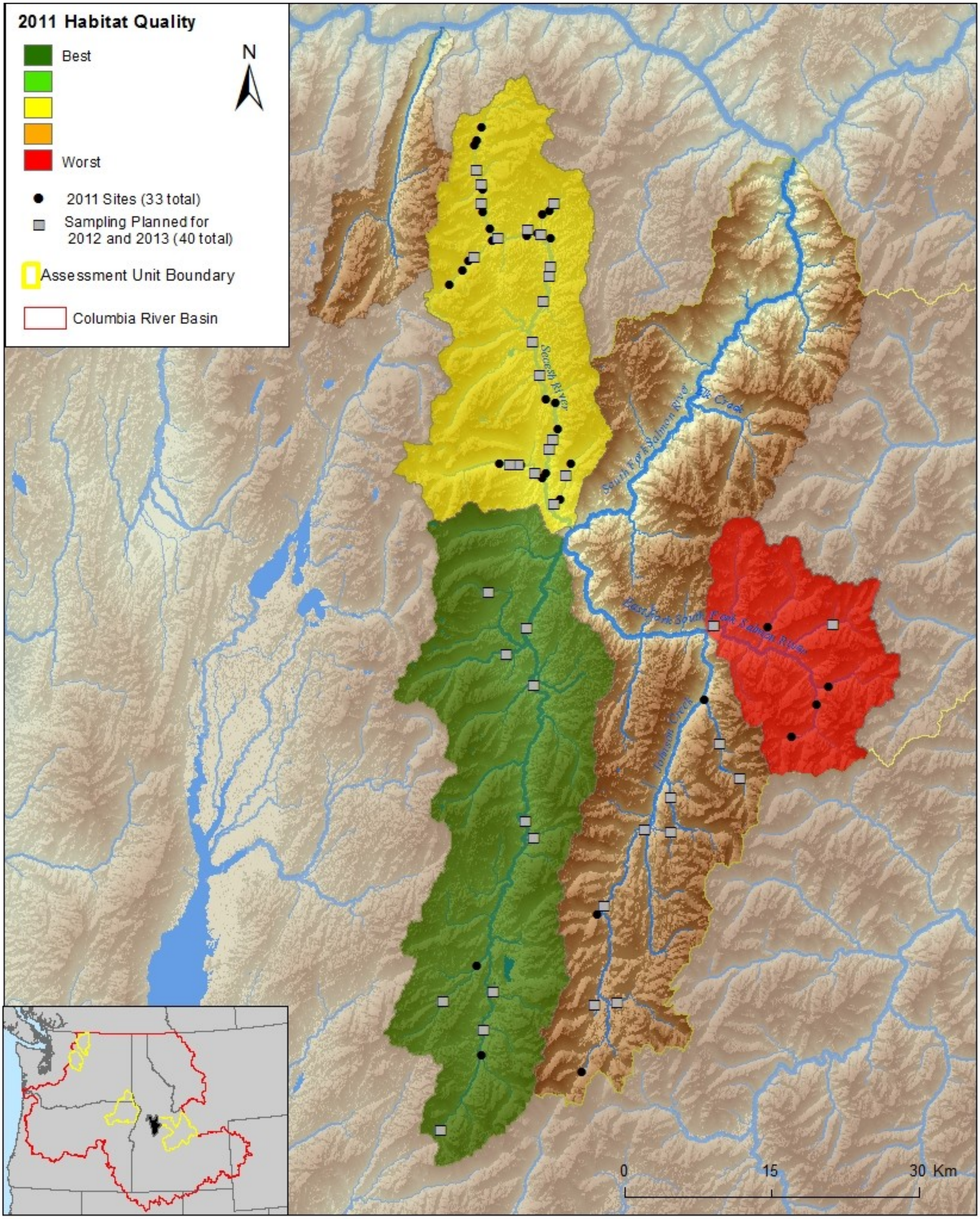
The utility of the CHaMP dataset will increase in the near future as the sample size increases after completion of the three year design, and as more sophisticated/predictive habitat indices are developed (e.g., the NREI, change detection).

Choosing the best approach(es) will require policy and technical input, and therefore necessitates ongoing dialogue between policy decision makers and technicians in order to refine the tools to answer the key management questions.



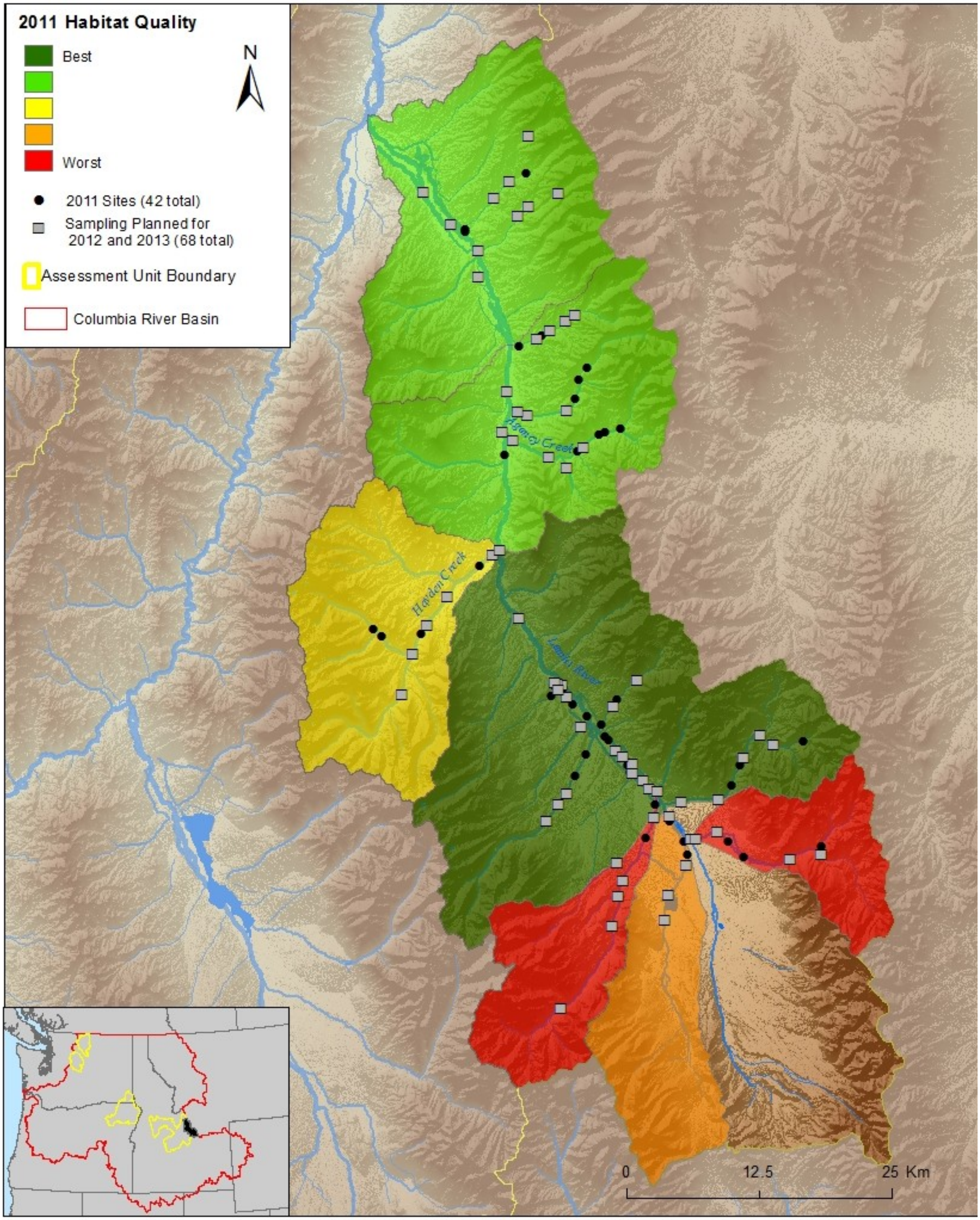
Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 2. Habitat quality indices for the Assessment Unit/HUC 5 scale for the Tucannon



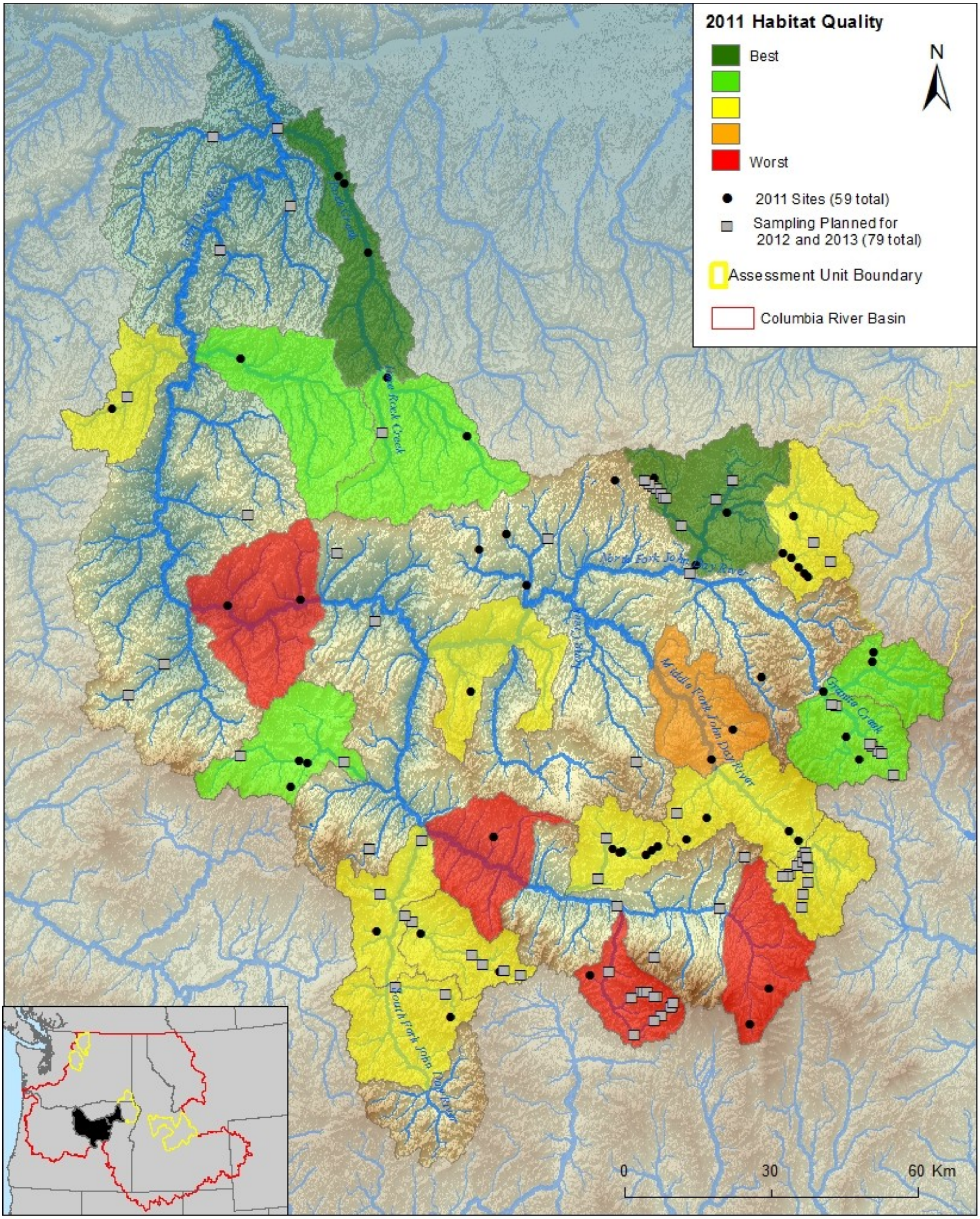
Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 3. Habitat quality indices for the Assessment Unit/HUC 5 scale for the South Fork Salmon



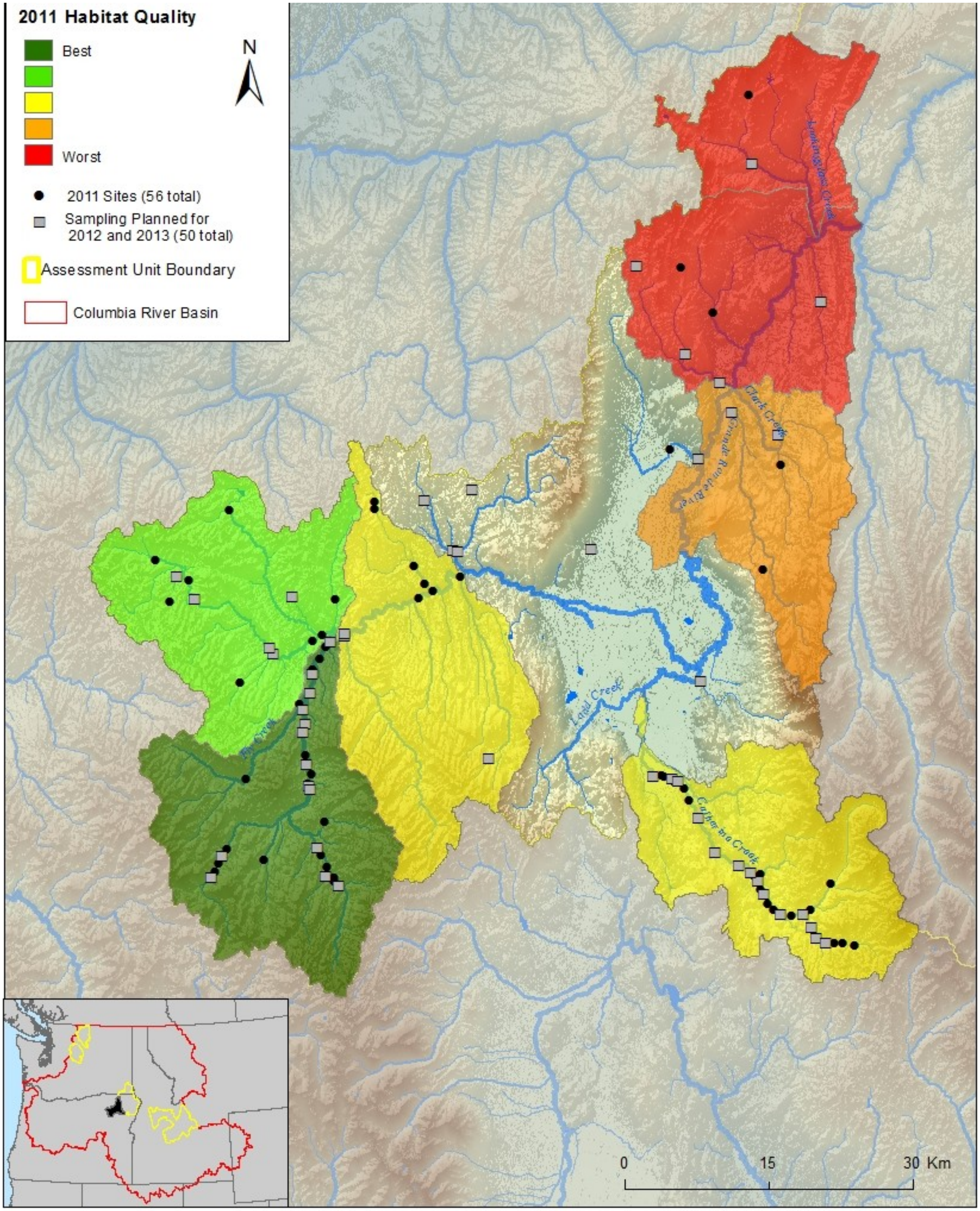
Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 4. Habitat quality indices for the Assessment Unit/HUC 5 scale for the Lemhi



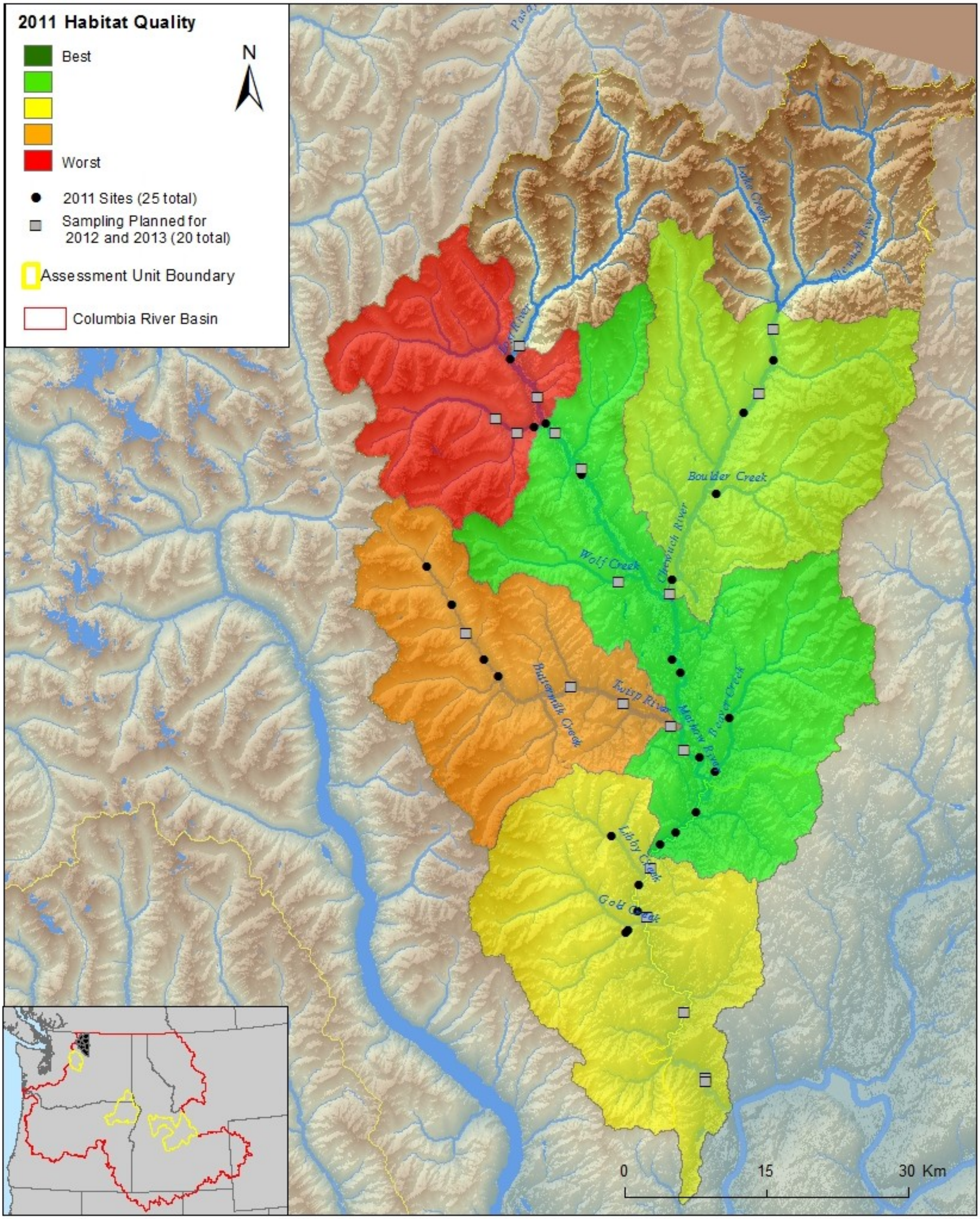
Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 5. Habitat quality indices for the Assessment Unit/HUC 5 scale for the John Day



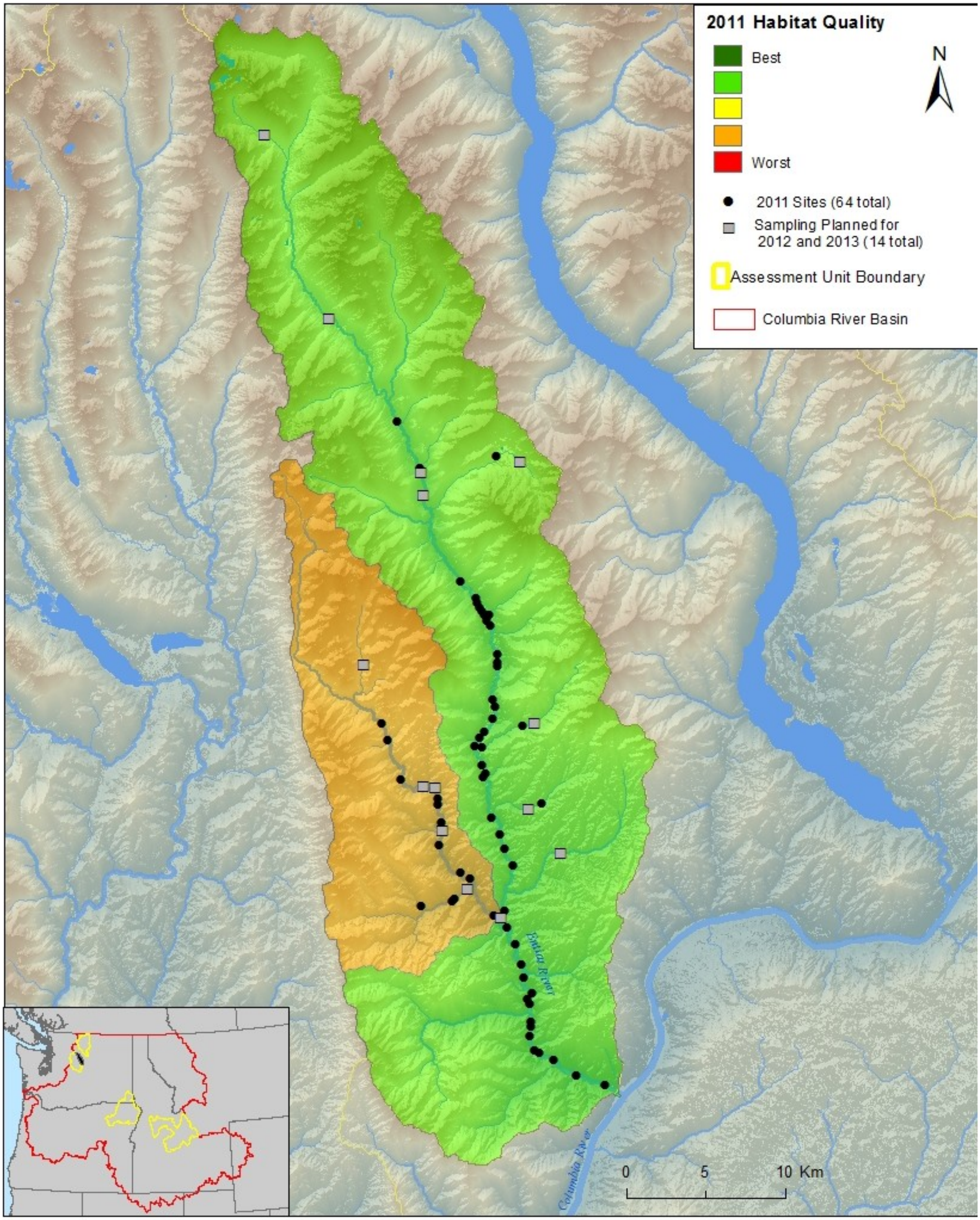
Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 6. Habitat quality indices for the Assessment Unit/HUC 5 scale for the Grande Ronde



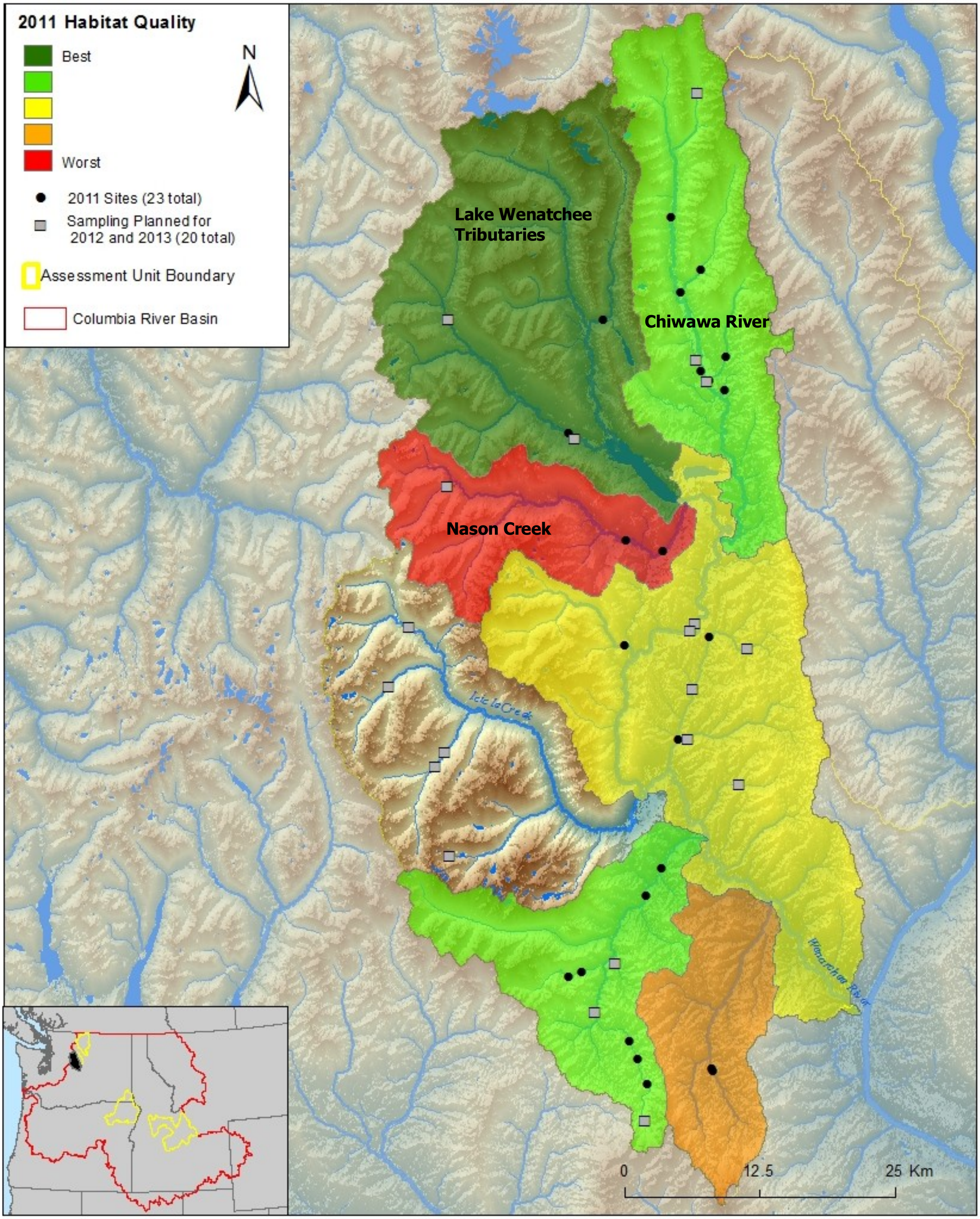
Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 7. Habitat quality indices for the Assessment Unit/HUC 5 scale for the Methow



Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 8. Habitat quality indices for the Assessment Unit/HUC 5 scale for the Entiat



Map by: Jean M. Olson, South Fork Research, Inc.
Date: March 29, 2012

Figure 9. Habitat quality indices for the Assessment Unit/HUC 5 scale for the Wenatchee

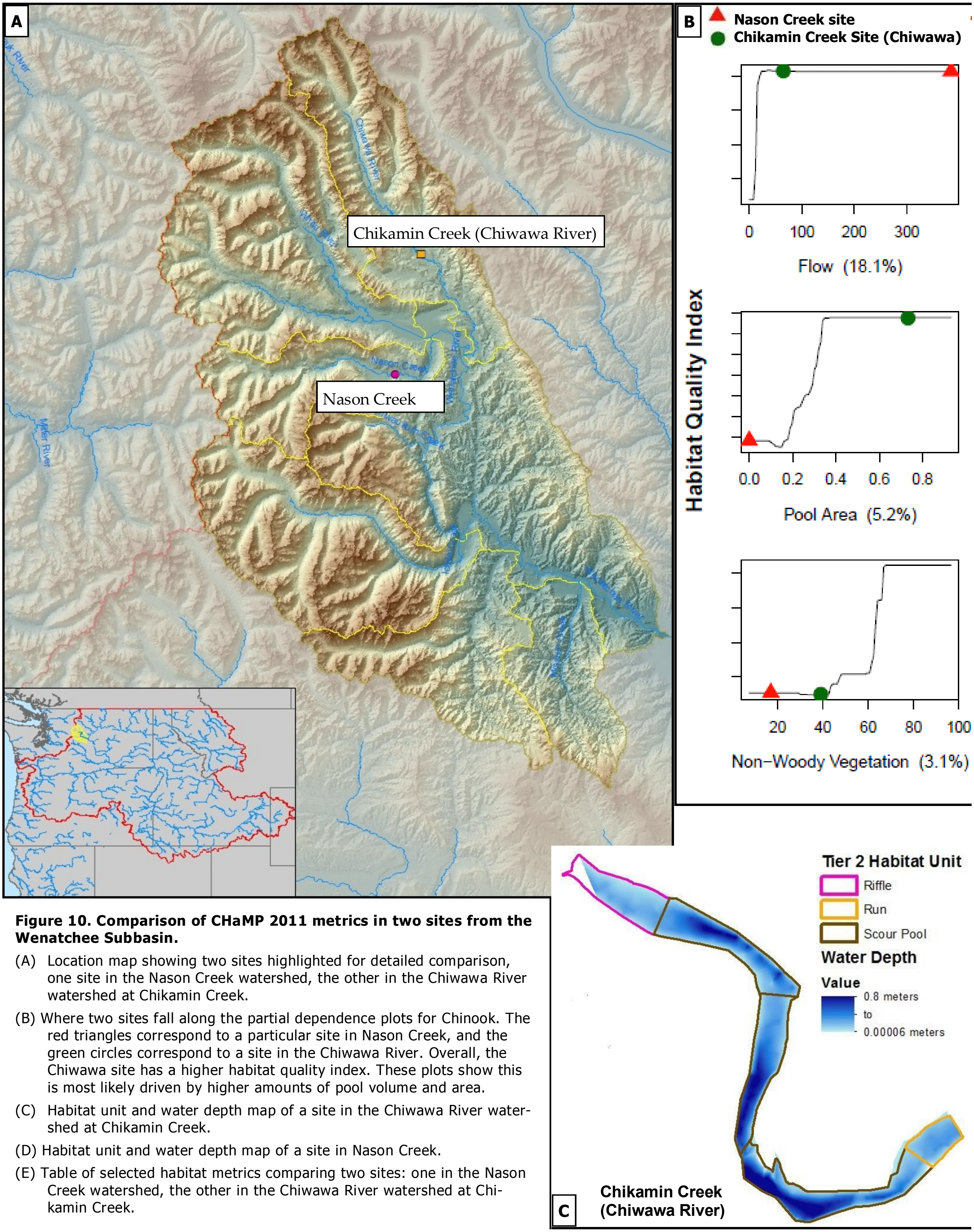


Figure 10. Comparison of CHaMP 2011 metrics in two sites from the Wenatchee Subbasin.

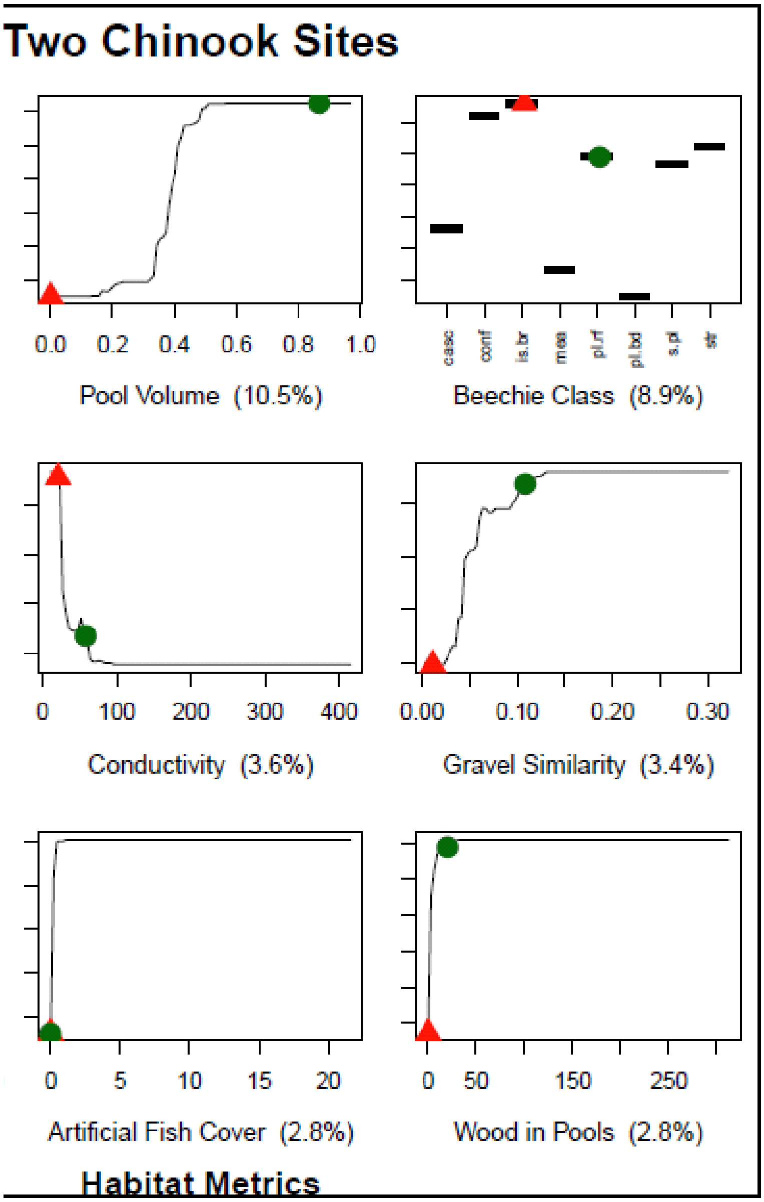
(A) Location map showing two sites highlighted for detailed comparison, one site in the Nason Creek watershed, the other in the Chiwawa River watershed at Chikamin Creek.

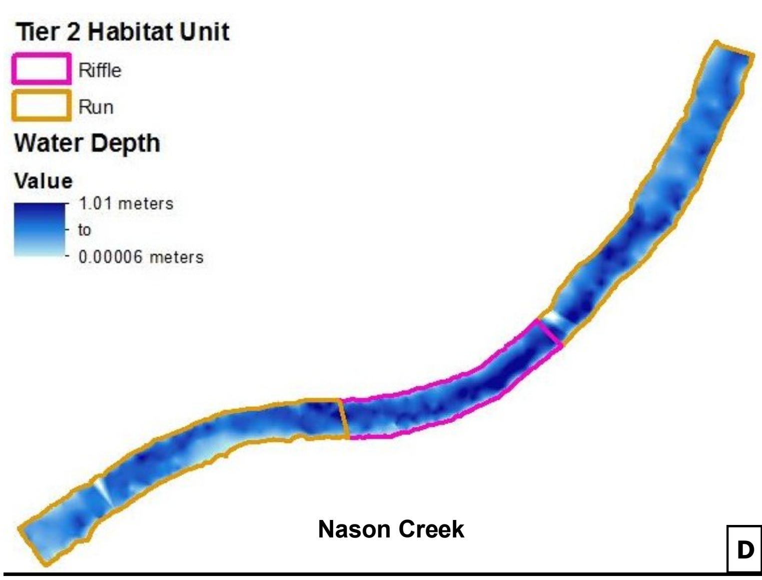
(B) Where two sites fall along the partial dependence plots for Chinook. The red triangles correspond to a particular site in Nason Creek, and the green circles correspond to a site in the Chiwawa River. Overall, the Chiwawa site has a higher habitat quality index. These plots show this is most likely driven by higher amounts of pool volume and area.

(C) Habitat unit and water depth map of a site in the Chiwawa River watershed at Chikamin Creek.

(D) Habitat unit and water depth map of a site in Nason Creek.

(E) Table of selected habitat metrics comparing two sites: one in the Nason Creek watershed, the other in the Chiwawa River watershed at Chikamin Creek.





D

E

Watershed	Nason	Chiwawa
SiteID	WC503432-000032	WENMASTER-000195
Sample Date	8/25/2011	9/12/2011
Stream Name	Nason Creek	Chikamin Creek
Panel	Annual	Annual
Category	Depositional : Public Lands	Transport : Private Lands
Site Water Surface Gradient	0.00	0.01
Site Sinuosity	1.13	1.52
Site Wetted Area	10940.88	577.55
Site Bankfull Area	12267.67	903.39
Wetted Volume	4239.70	94.52
Site Length Thalweg	538.40	115.98
Site Bank Angle Mean	26.02	11.74
Site Bank Angle StdDev	11.61	11.77
Thalweg Depth Profile Filtered Mean	0.58	0.31
Thalweg Depth Profile Filtered CV	0.24	0.50
Bankfull WidthToDepth Ratio Profile Filtered Mean	55.80	35.07
Pool Percent	0.00	68.08
Fast-Turbulent Percent	22.82	16.56
Fast-NonTurbulent Percent	76.52	8.06
Site Discharge	3.05	0.29
Measurement of D16	2.00	13.00
Measurement of D50	28.00	51.00
Measurement of D84	175.00	120.00
Site Measurement of Conductivity	20.90	58.40
Site Measurement of Alkalinity	24.00	40.00
Percent Big Tree Cover	16.40	3.50
Percent Coniferous Cover	70.00	20.00
Percent Ground Cover	40.30	66.10
Percent Understory Cover	38.70	46.00
Percent Woody Cover	88.20	86.60
Boulder and Cobbles	48.00	57.21
Course and Fine Gravel	30.23	32.59
Sand and Fines	21.77	10.20
Fish Cover Composition LWD	0.00	6.62
Fish Cover Composition Vegetation	5.00	17.65
Fish Cover Composition Undercut	0.40	10.82
Fish Cover Composition None	94.60	64.91

Variability Studies

Fish and habitat conditions vary over space and time and this variation is what we hope to capture in the determination of "status" and "trends." This variation is also affected by measurement error among crews and by features of the landscape such as geomorphic valley classification. The ability to quantify and understand the components of variation is critical to knowing whether status and trend data are meaningful and usable by managers. In this section, we look at several ways CHaMP quantified these components to variation in the 2011 pilot year. The conclusion is that data being collected using the CHaMP protocol and design has coherent and measurable factors affecting variation and that this data will be useful for quantifying status and trends.

Habitat Status and Trend: Variance Decomposition

Habitat status data provides a snapshot of the variety of habitat conditions at sampling sites throughout the stream network at various scales (e.g., site scale, assessment unit scale, subbasin scale). When status sampling is repeated over time, trend data can be generated that provide a look at patterns of change over time (usually across years). Patterns of change in this data with a consistent upward or downward component can be evaluated or detected as a trend.

How habitat trend data can inform management decisions:

- A distribution of site-specific trends with a mean of 0 would indicate a lack of change over time (or alternately, indicate no change over time).
- A distribution of site-specific trends that was positive or negative would indicate a regional trend of improving or degrading habitat condition.
- A group of sites with common characteristics trended upward or downward together would indicate that one type of sites was responding differently from another.

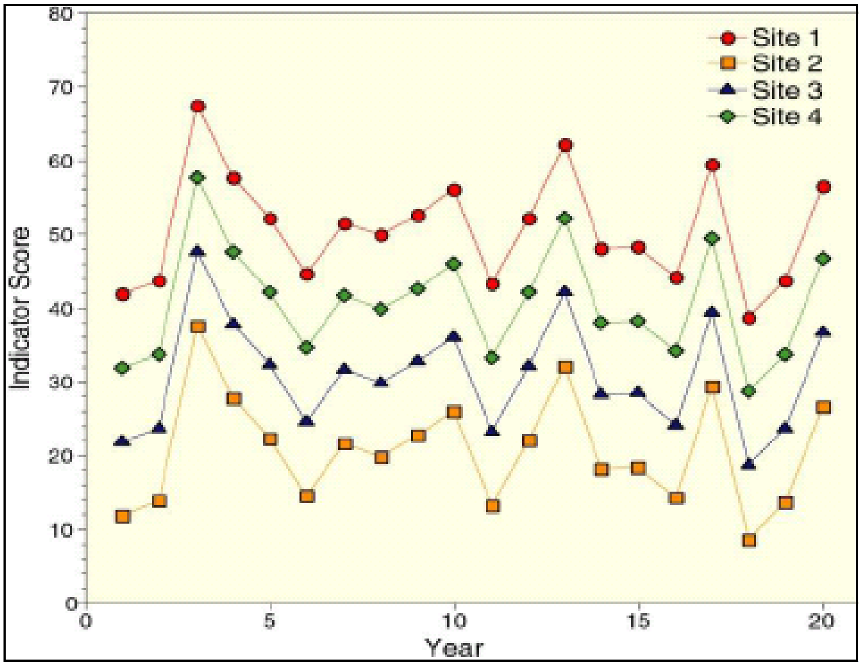


Figure 11. Hypothetical examples of coherent temporal variability (left)

- Trends can be expressed as an underlying 'average' trend across all sites in a region: is habitat condition changing in the subbasin?
- Trends might be expressed as a set of site-specific trends derived from revisiting the same set of sites over time.

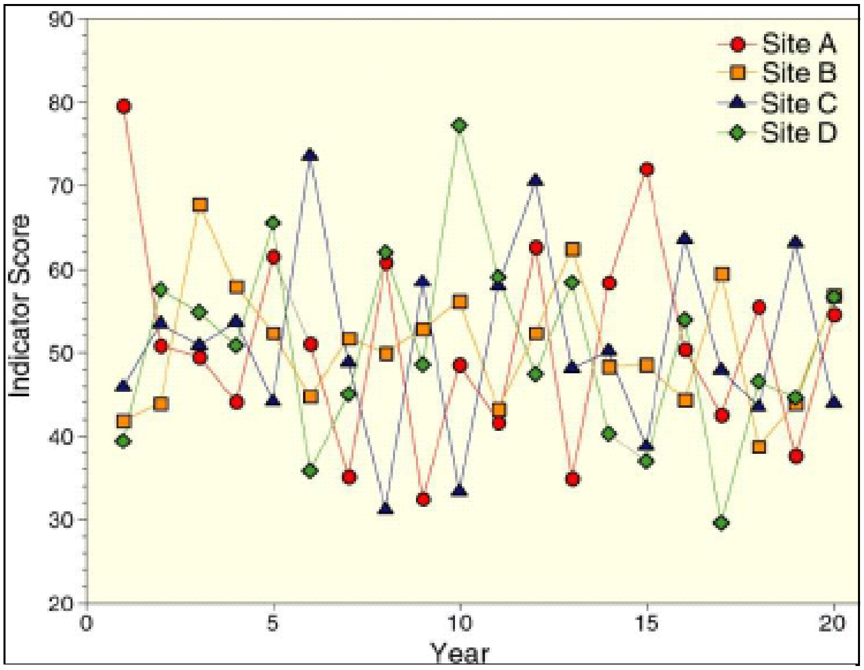
One of the underlying yet often not explicitly stated objectives of any status and trends monitoring program is to describe how fish and habitat conditions vary, and to evaluate how much uncertainty our measurements might introduce to these descriptions.

Variance decomposition

To evaluate how well CHaMP determines status and trends, staff developed a survey design to describe three types/sources of variability:

1. Spatial Variation: the fundamental differences among sites.
2. Yearly Temporal Variation: comes in two parts (a) the common or coherent yearly variation across all sites as might be affected by regional forcing or climate change, and (b) interaction variation among sites, that is, the independent yearly variation at each site driven by site-specific influences.
3. Residual Variation: Extraneous variation created during the yearly sampling season due to (a) Within season temporal variation, (b) Imprecise sampling or measurements and (c) crew-to-crew differences in implementing/repeating a particular protocol.

Between year variability (or yearly temporal variability) affects our ability to detect trends in two ways. The first is, in a sense, prospective: are the designs we've implemented capable of detecting specified trends (i.e., trends of the magnitude we'd like to detect if such trends were present). The second is retrospective: suppose we have been monitoring for 10 - 15 years: what magnitude of trend is detectable, if any? In both cases, the yearly variability will affect trend detection likelihood, whether our object is fish or habitat. Monitoring fish and habitat concurrently can provide corroborating evidence that habitat mitigation is effective if trends of both indicate improvement, or might provide evidence that factors other than habitat are responsible for changes in fish. For example, might an improving habitat condi-



and year-to-year site (site by year interaction) variability (right).

These graphs depict the two parts of yearly temporal variation:

Coherent temporal variation (left) is the common variation across all sites driven by regional effects. Data varies synchronously, as if all sites are influenced by a common factor (e.g., rainfall).

Interaction variation (right) is the independent yearly variation at each site driven by site specific influences. The data varies, but each site is responding to different mechanisms (e.g., local disturbance).

By first accounting for spatial and temporal variation, the CHaMP model is able to evaluate how well particular metrics perform (i.e., how much does data for a metric vary across all sites?) and how much variability is introduced by crews/ techniques.

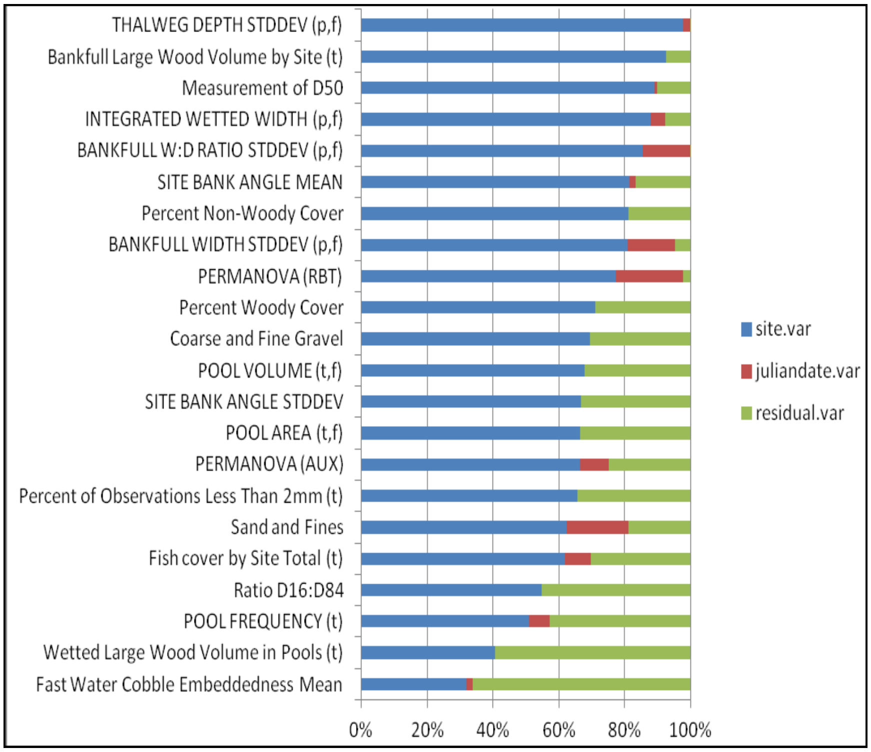


Figure 12. Relative proportion of total variation that is attributable to site, Julian date, and residual covering the set of sites sampled across the nine CHaMP watersheds.

Habitat attributes are ordered by the proportion attributable to site variance. Metrics in caps are derived from the RBT surveys. Two metrics are based on a multivariate combination of individual metric scores: PERMANOVA(RBT) and PERMANOVA(AUX) combine the RBT derived metrics and the non-RBT derived metrics.

NOTES: Avg = average; STDDEV = standard deviation, a measure of variation; t_ = metric was transformed to approximate a normal distribution.

The figure on the left illustrates several important points:

- Site variance comprises ≥80% of the total variance for eight habitat metrics, indicating a relatively clear site signal (high signal:noise ratio). Metrics with a high signal:noise ratio perform well in models.
- Site variance accounts for <60% of total variance for four metrics, meaning these metrics might perform more poorly in modeling; however, these metrics may still be useful for detecting year-to-year variation.
    - If, after two more sampling years, these metrics do not help us understand temporal variance and still perform poorly in explaining differences between sites, they would be dropped from the program.
- The Julian date refers to a coherent/consistent pattern of variation during the index window.
    - If Julian date % is relatively large, it might indicate a consistent trend in the metric during the index window that could be attributed to regional climate or patterns of discharge.
- Metrics derived from topographical surveys (metrics labeled in CAPS) performed relatively better compared with non-topographic metrics.
    - Four of six metrics with the clearest site signal are topographic-based metrics.
    - Of the seven metrics with the "noisiest" site signal, only one is a topographic-derived metric. If these metrics fail to account for temporal variation (after two more years of sampling) they could be dropped from the CHaMP protocol.

tion, along with a decline in fish abundance or productivity indicate something other than (or in addition to, if fish decline were to be faster in the absence of habitat improvement) habitat is affecting fish?

The first CHaMP variance decomposition analysis evaluated the relative performance of the metrics during the 2011 sampling season, i.e., what was the relative amount of residual variation (noisiness) across the set of metrics after we accounted for class/site and within year s temporal variation? In this "basin-wide repeat study" we had two crews sample 25 unique sites twice during the season. The second decomposition analysis focused on evaluating how much variation was introduced by different crews sampling with the same protocol at the same site within a short time window.

The CHaMP 2011 pilot crew variability study involved a survey of six sites in the Upper Grande Ronde by seven different crews to evaluate how well different crews applied the protocol. All crews sampled the same six sites during a short time interval to minimize temporal variation and allow quantification of site and crew variation (see Table 5).

The top and bottom plots on the right show Visit 1 and Visit 2 results for the first and last metrics from Figure 13 on the previous page.

These types of plots can be used to evaluate the "repeatability" of the CHaMP protocol.

The top plot illustrates that the metric standard deviation of the thalweg profile is highly repeatable as evidenced by the 1:1 linear relationship between the two repeat visits (i.e., there is relatively low noise between repeat visits).

The bottom plot illustrates a lot of "noise" associated with the metric cobble embeddedness suggesting a lack of repeatability for this metric.

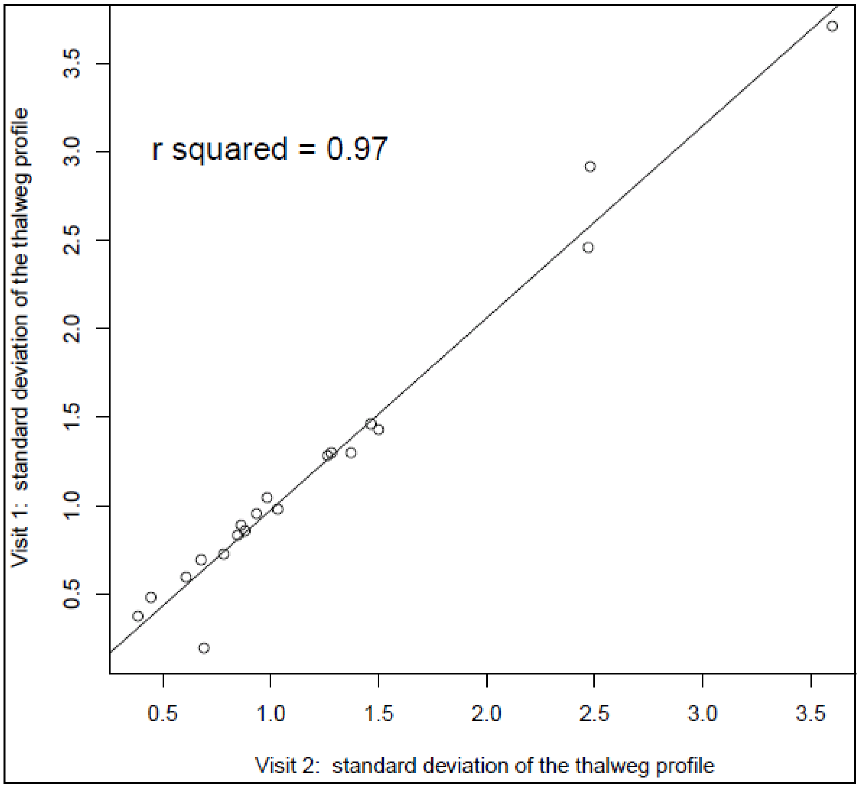


Figure 13. Comparison visit 1 (local crew) with visit 2 (repeat crew) thalweg profile standard deviation RBT derived metric scores, illustrating the repeatability of this measurement protocol.

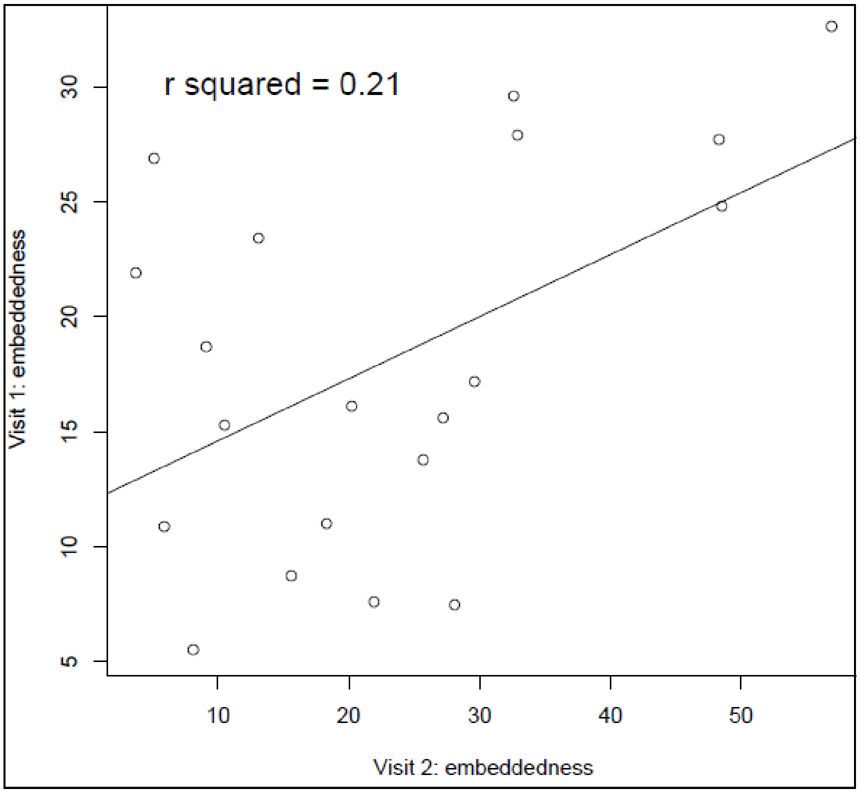


Figure 14. Comparison of visit 1 (local crew) with visit 2 (repeat crew) qualitatively derived embeddedness metric scores, illustrating the lack of repeatability of this measurement protocol.

Table 5. The allocation of crews to sites for the 2011 crew variability study.

SITE	CRITFC	ELR	ODFW JD	ODFW UGR	QCI	TT	TQ	SUM
CBW-235322	1	1	1	1	1	1	1	7
CBW-321338	1	1	1	1	1	1	1	7
Dsgn4-6	1	1	1			1	1	5
dsgn4-92	1	1	1			1	1	5
dsgn4-94	1	1	1		1	1	1	6
dsgn4-277	1	1	1	1	1	1	1	7
SUM	6	6	6	3	4	6	6	37

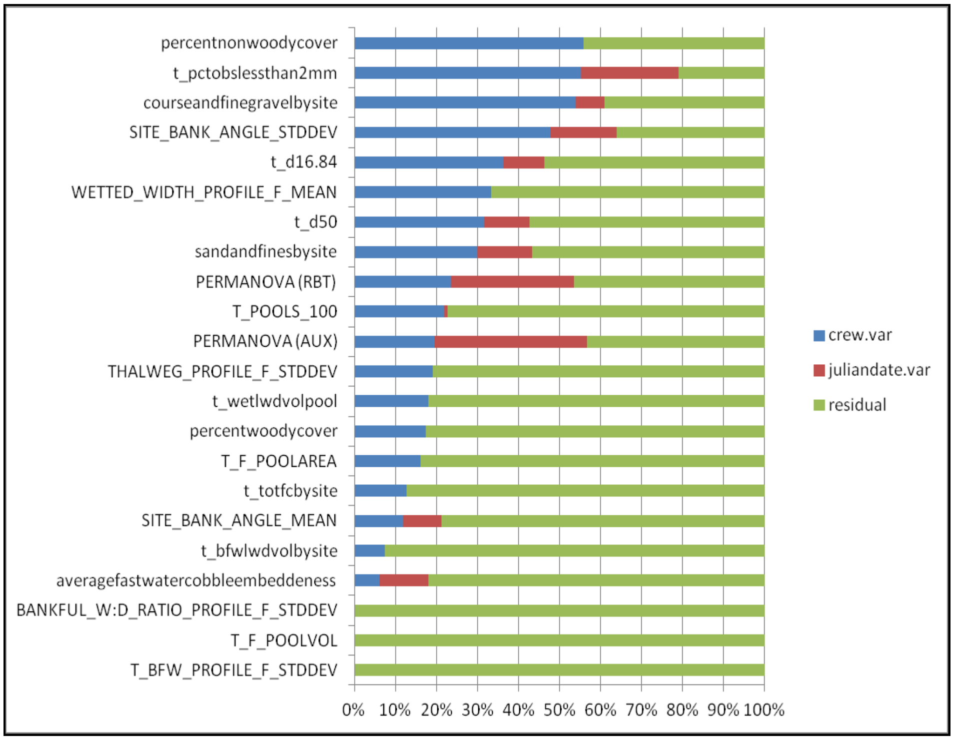


Figure 15. Relative proportion of overall residual variation that is attributable to differences among crews when applying the same protocol in the same location. The metrics are presented in decreasing rank order of which metric is most affected by crew variation. Metrics in all-caps are derived from the topographical surveys.

Sites used in the crew variability study were geographically close to each other (relative to sites across the full set of CHaMP watersheds). Therefore, results are preliminary and should not be interpreted as representative of what might be found if a crew variability study were performed across the region (see example below).

The analysis on this page focuses on the non-topographic data collected by CHaMP (Figure 16; however, which examines the proportion of residual variation attributable to differences among crews does include metrics derived from topographic surveys). Detailed analysis of crew variability specific to topographic data collection and products is presented on the next pages.

Summaries from the 2011 pilot year illustrate the basic variance components that CHaMP can estimate with a single year's data. Our variance decomposition analyses with a single year's worth of data allowed us to compare the performance of various measurement protocols and differences among crews. As the data are from one year only they are preliminary and not yet sufficient to estimate the yearly temporal components of variation. CHaMP's overall spatial and temporal design framework (described later in this report) will allow estimation of the major components of variation after the design runs its full three year course.

The graph on the left (Figure 15) shows that crew variability was relatively low for the embeddedness metric during the crew variability study, but for the region-wide survey, residual variation for this same metric was proportionally the highest.

- This might occur because the metric was relatively consistent or easy to evaluate among the set of sites used for the crew variability study.

Most of the non-topographic metrics have relatively high crew variation (six of the eight with highest % crew).

- The three metrics with essentially no crew variation are topographic, demonstrating the value in CHaMP topographic surveys.

Crew Variability in Topographic Data

Figure 16. The sites sampled within the crew variability study included 3 lower stream order sample reaches: Photos A. Fly Creek, B. Spring Creek, C. West Chicken Creek and the three mainstem sample reaches: Photos D. Grande Ronde River upper, E. Grande Ronde River middle, and F. Grande Ronde River lower.

The analysis of topographic surveys conducted using the CHaMP protocol as part of the Crew Variability Study showed that crews are collecting data that accurately quantifies habitat status and that is powerful enough to detect trends. Specifically, crews are collecting topographic data of sufficient quality and consistency that the DEMs they produce show the same basic spatial patterns with distributions and summary statistics that are within acceptable levels of error, and is of adequate quality to support geomorphic change detection for both obvious changes (reported) and subtle changes in the channel and along channel margins. The largest observed differences between crews were attributed to systematic errors that are easy to identify and remedy in the data editing or QA/QC process. These errors are also easy to avoid with more targeted training and QA/QC procedures.

The variability between crews representation of one of the small tributary streams, Fly Creek, is illustrated in Figure 18 with DEMs and water depth maps. A study by Bangen & Wheaton (2012) set out to resolve the following specific questions:

1. What are the magnitudes of inter-crew variability within sites and what proportion can be attributed to systematic surveying or processing errors and blunders?
2. Does the magnitude of inter-crew variability show consistency in different portions of the survey extent (e.g., greater on banks or floodplains and less in the in-channel habitat)?
3. What are the magnitudes of intra-crew variability between sites?
4. To what extent does crew variability limit our ability to reliably calculate DEM derived metrics such as water depth and detect and interpret geomorphic changes to physical habitat from time series data?

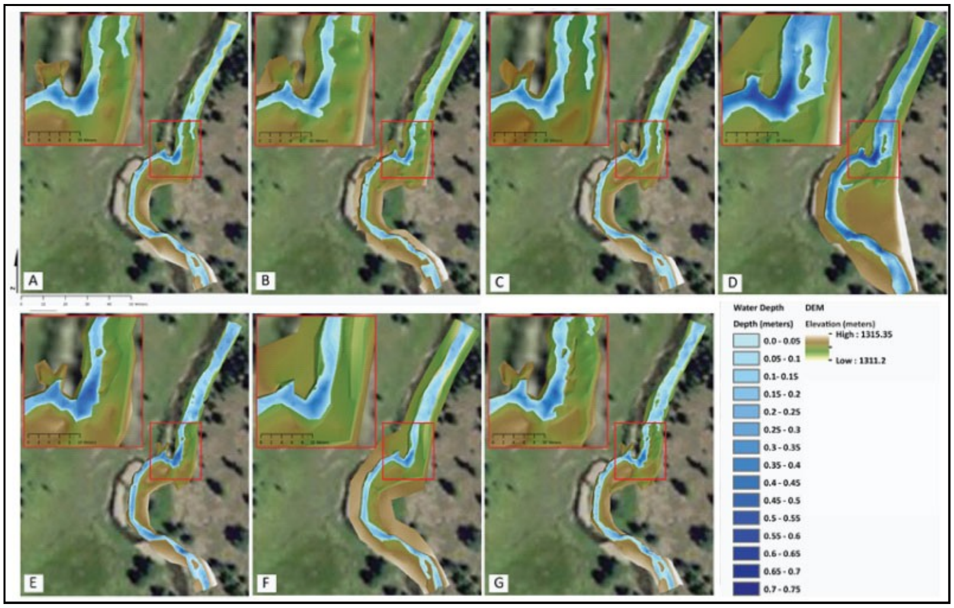


Figure 17. Illustration of topographic survey variability among seven CHaMP crews at Fly Creek site. DEMs and water depth maps derived from topographic surveys. Figure from Bangen & Wheaton (2012).

Analysis methods included both basic statistical and advanced spatial analysis approaches. Statistical methods were geared towards summarizing differences in topographic survey metrics (e.g., total number of points collected, survey extent, etc), while the spatial analysis approaches consisted of estimating spatially variable DEM errors in each DEM (e.g., Wheaton et al. 2010a), and various raster comparison methods of the interpolated topographic surfaces (e.g., TINs, DEMs) and their derivatives in ArcGIS. For example, a cell-by-cell statistical comparison of maximum-minimum analysis was used to quantify the maximum range of crew variability in DEMs and water depth rasters at each sample reach.

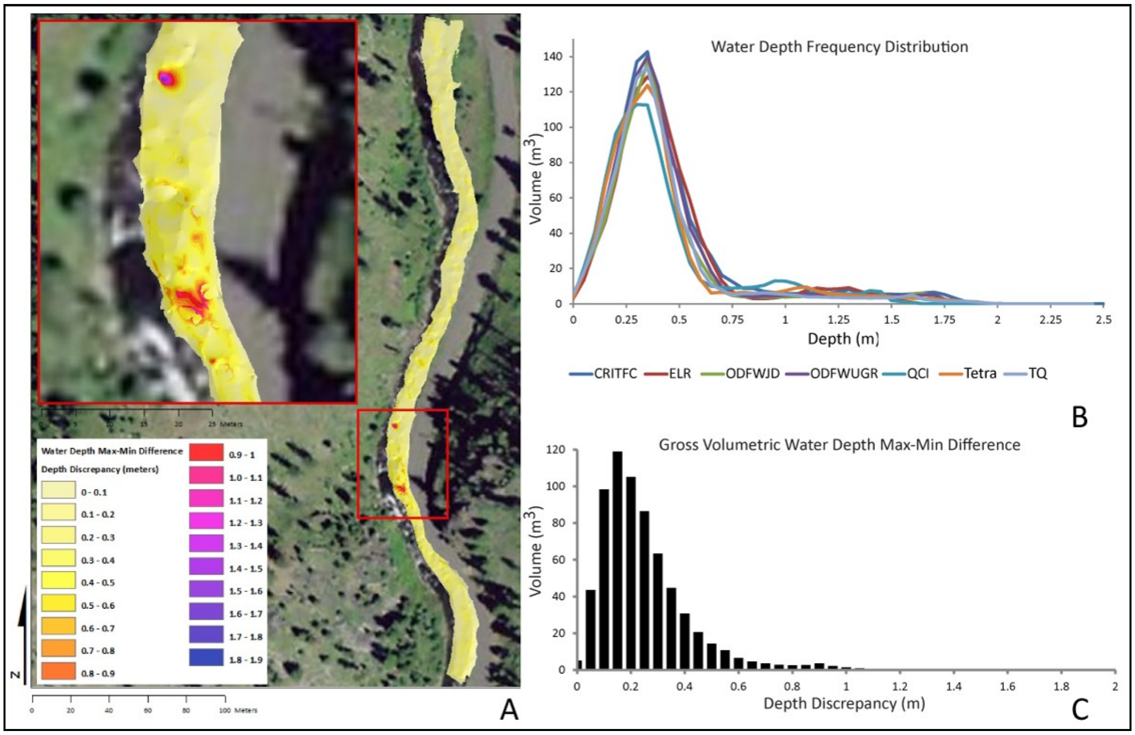
The maximum range of topographic variability across all sites, was on average 27.5 cm (σ=22.6 cm), and average elevation uncertainty was estimated at

23.4 cm (σ=4.2 cm). In general, large (> 20 cm) observed DEM maximum-minimum elevation differences were explained by simple survey or post-processing blunders attributable to a single crew. Both estimates were heavily skewed by higher variability and uncertainties in bank and over bank errors, with in-channel estimates generally lower. Spatially segregating the maximum-minimum difference rasters into in-channel and overbank areas revealed that the channel had generally lower differences (μ = 0.17 cm; σ=8.2 cm) and the largest volumetric discrepancies between crews occurred beyond the wetted channel boundary. Similarly, in channel DEM uncertainty was typically on the order of 10-12 cm. This is encouraging as the CHaMP protocol emphasizes concentrating survey effort in the wetted channel to accurately capture that quantity and quality of available fish habitat.

While some blunders (e.g., incorrect total station base unit height) resulted in substantial reach wide discrepancies between crews (c. 2m), most errors (e.g., incorrect survey rod height) resulted only in large magnitude elevation differences in relatively small, localized areas (e.g., range of a few pixels to several m2).

A similar analysis of the maximum range of variability was done for the derived water depths. Results of the cell by cell max-min water depth raster difference revealed that the maximum mean variability in water depths is between 5.6 and 7.9 cm for the three lower order creeks, and between 9.1 and 17.2 cm for the mainstem creeks. Even in the reach with the highest variability, Middle Grande Ronde (Figure 18- A & C), the majority of the volumetric difference is contributed by cells with a discrepancy of 10 to 25 cm (mean= 17.2 m). When compared with mean water depths of 11 cm for the three lower order sites and 23 cm for the mainstem sites, these statistics may seem of concern. However, as Figure 18 B illustrates, the water depth distributions from these surveys show a very high degree of consistency, and the max-min analysis deliberately emphasizes the absolute worse-case comparison and outliers.

Analysis of DEM-derived water depth rasters at each site indicate minimal discrepancy in mean water depth. At both lower order and mainstem sites the mean water depth between crews differed by only a few centimeters (Fly Creek mean range=0.11–0.12 m; Spring Creek mean range=0.06–0.07 m; West Chicken Creek mean range = 0.14–0.17 m; Grande Ronde River upper mean range=0.17–0.21 m; Grande Ronde River middle mean range=0.29–0.33 m; Grande Ronde River lower mean range=0.17–0.21 m). It was observed that maximum water depth values have a greater range of inter-crew variability. The difference in this extreme end member may be attributed to either systematic blunders or that some crews were unable to detect and survey the maximum pool depth of the deepest pool in the reach.



Three Important Take-homes:

- The largest discrepancies between crews are due to systematic survey and/or post-processing errors;
- Most of the systematic errors are easy to identify, straight-forward to correct post-hoc, and can be avoided with better training, targeted QA/QC;
- The bank areas with the higher uncertainties are not the focus of the habitat surveys, and can be improved with more consistency in how crews survey breaklines in these areas.

Figure 18. Influence of topographic survey variability at Grande Ronde River middle sample reach on water depth estimation. A) Maximum water depth differences between all crews. While there were some large observed differences in DEM-derived water depths between crews (A—areas in red-purple) these areas tended to be highly localized . B) This is illustrated in the gross volumetric inter-crew water depth difference distribution (B) that shows the largest proportion of observed differences in the range of 10 to 25 centimeters. Figure adapted from Bangen & Wheaton (2012).

Ability to Detect Geomorphic Change

One of the advantages of doing repeat topographic surveys at monumented sites is that DEMs from the surveys can be differenced as shown in Figure 20 to calculate a DEM of difference (DoD). The DoD shows spatially where erosion and deposition took place, allows estimation of net change in storage terms of a sediment budget, and can provide direct mechanistic evidence of how these physical changes result in changes to physical habitat for fish (Wheaton et al. 2010b). CHaMP will use geomorphic change detection methods, which estimate the uncertainty in the individual DEMs, propagate these uncertainties into the DoD, and allow the distinction of real geomorphic change from noise (Wheaton et al. 2010a). Obviously, the variability in how crews survey a reach contributes to this ability to detect change. To test this idea, plausible scenarios of geomorphic change were created and differenced against each crew's survey.

In Figure 20, a scenario is shown where an obvious major channel change took place resulting in an avulsion. In the scenario, a beaver dam was built at the upstream end of a meander bend. The beaver dam backed up flow, such that during a flood the preferential flow was across the meander bend, eventually resulting in a major avulsion (red erosion area), where much of the scoured material was deposited downstream as channel bars. The resulting DoD shows a strong net degradational sediment budget with erosion outpacing deposition. Six of the seven crews would have been able to capture consistent spatial patterns and volumes of erosion and deposition for the in-channel areas. However, five of the crews failed to collect sufficient points out on to the floodplain (Figure 17) and thus show budgets with greater proportions of deposition than was actually the case. One crew mis-specified the instrument elevation, which resulted in a systematic vertical offset. Although that crew's DoD results appear non-sensible, the patterns are actually consistent with other crews and the data could be easily repaired to correct this problem. Results from a scenario depicting more subtle (barely detectable) changes showed a high degree of consistency from crew to crew for detecting in-channel changes and wide variability in detecting subtle bank-erosion (i.e., < 20 cm laterally) depending on the degree to which specific crews surveyed the bank edges in adequate resolution.

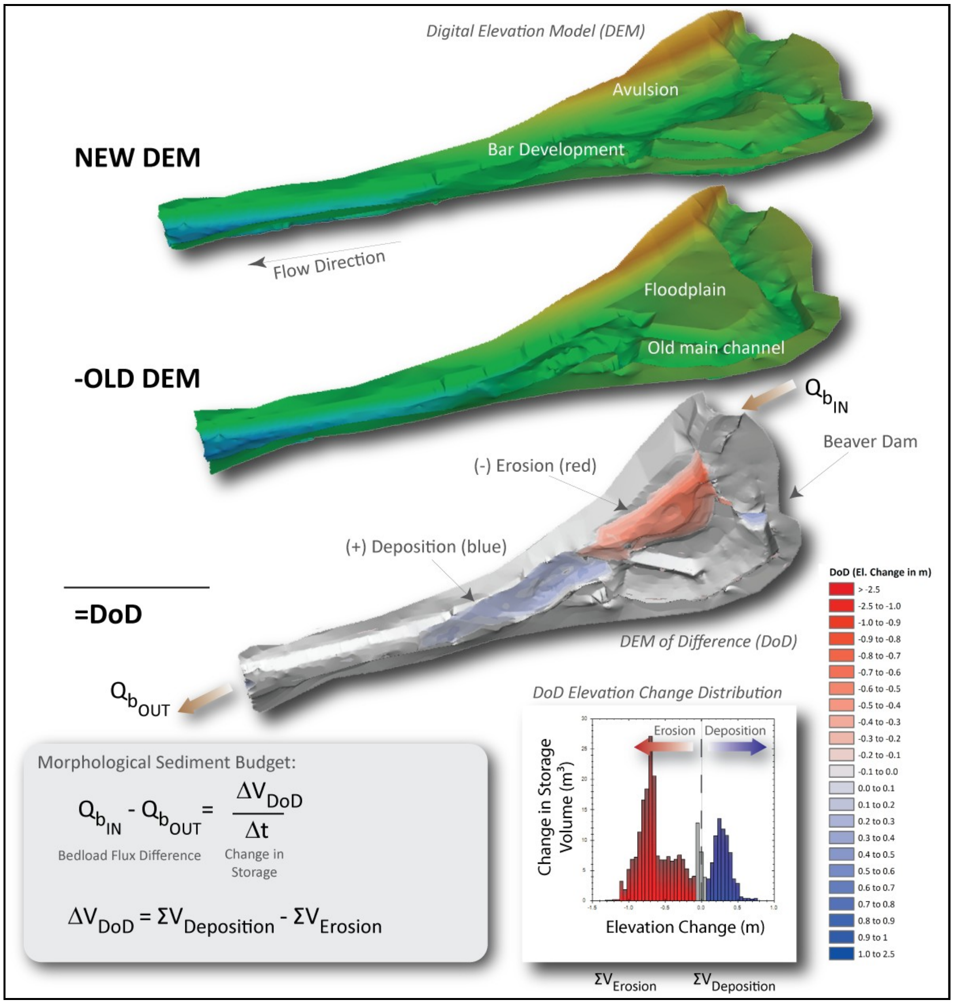


Figure 19. Geomorphic Change Detection via creation of a DEM of Difference (DoD) (Joe Wheaton, USU).

Primary Conclusions and Recommendations:

- **Crews are collecting topographic data of sufficient quality and consistency** so that DEMs and water depths show the same basic spatial patterns and their distributions and summary statistics are within acceptable levels of error.
  - Additional guidance on point densities and breakline data collection could help promote higher qualities and consistency.
- **The largest observed differences between crews were attributed to a systematic error** by one crew (different crews across sites). Most such systematic errors are easy to identify and remedy in the data editing or QA/QC process (e.g., TIN busts).
  - These errors are also easy to avoid with more targeted training and QA/QC procedures.
- **The topographic data between crews is of adequate quality to support geomorphic change detection** for both obvious changes (reported) and subtle changes in the channel and along channel margins. However, crews were not given adequate guidance on how far to extend their survey extents out into areas that the channel could plausibly migrate into.
  - These floodplain areas can generally be surveyed with minimal effort to facilitate a more accurate portrayal of future geomorphic changes.

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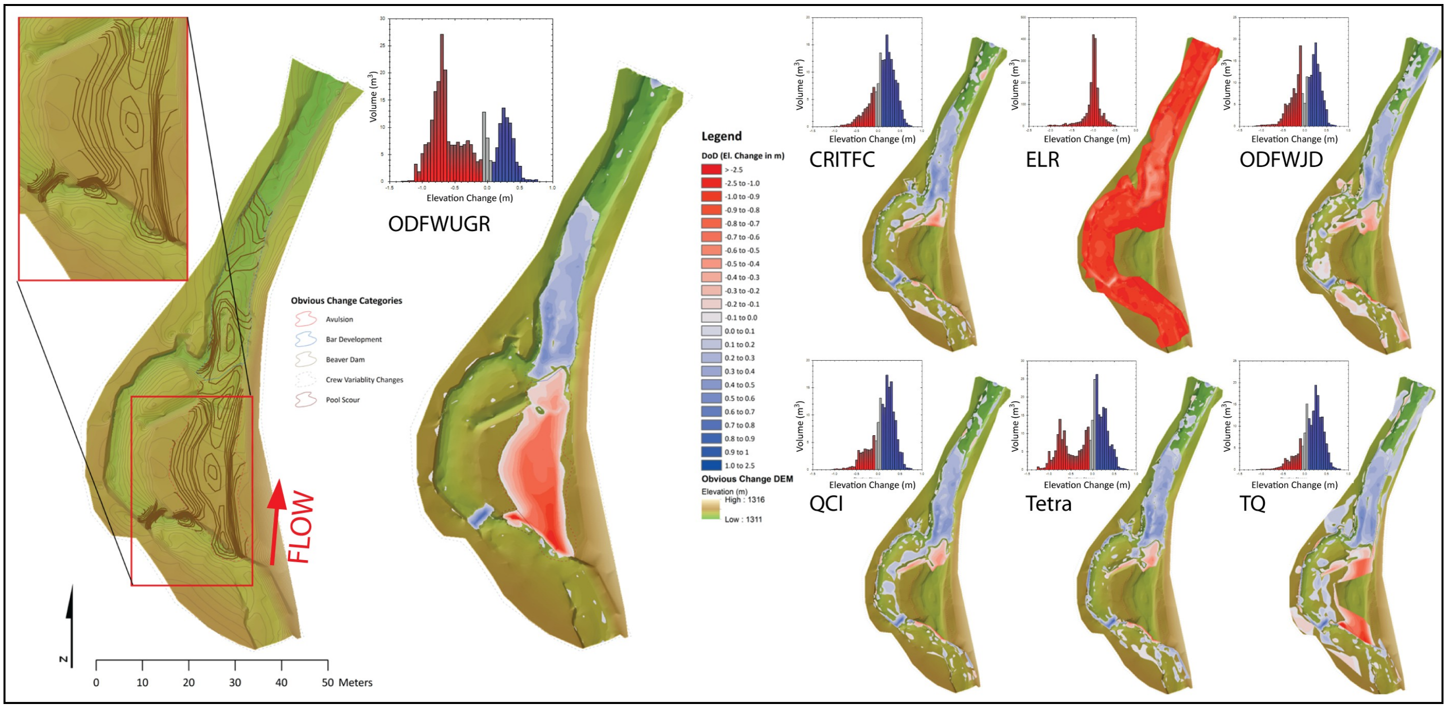

Figure 20. Results of modeled 'obvious' geomorphic change of Time 2—Time 1.

Here the ODFW/UGR crew represents 'true' change. Areas in blue represent deposition while areas in red represent erosion. Histograms represent gross volumetric differences. Results indicate crews need to increase survey area extents in in order to capture geomorphic changes occurring outside of the active channel, here in the form of channel avulsion and floodplain erosion from the construction of a channel spanning beaver dam. Figure from Bangen & Wheaton (2012).

Effectiveness of Stratification:

Sampling designs like the one used by CHaMP can be made more powerful for decision making if they account for known sources of variation. As demonstrated here, the CHaMP sampling design was more efficient and powerful through stratifying sample sites using a valley class geomorphic framework where the sites were allocated into three strata: Source, Transport, and Depositional. Previous multivariate classification of habitat metrics measured in the Wenatchee and Lemhi subbasins indicated that a three part classification framework using a valley class geomorphic framework (based on work by Tim Beechie) provided an acceptable level of site distinction that could be used as a stratification framework.

Figure 21 illustrates how well this stratification partitioned spatial variation. For three metrics, the valley class stratification accounted for 40% or more, and for eight metrics, 20% or more of the spatial variation. An analysis of variance indicates that there is a significant effect of the classification ($p < 0.05$) for most of the attributes, even though the proportion attributable to valley class might be low. The significance likely arises from the large sample size available for testing, allowing for detection of small differences in the mean between valley class types.

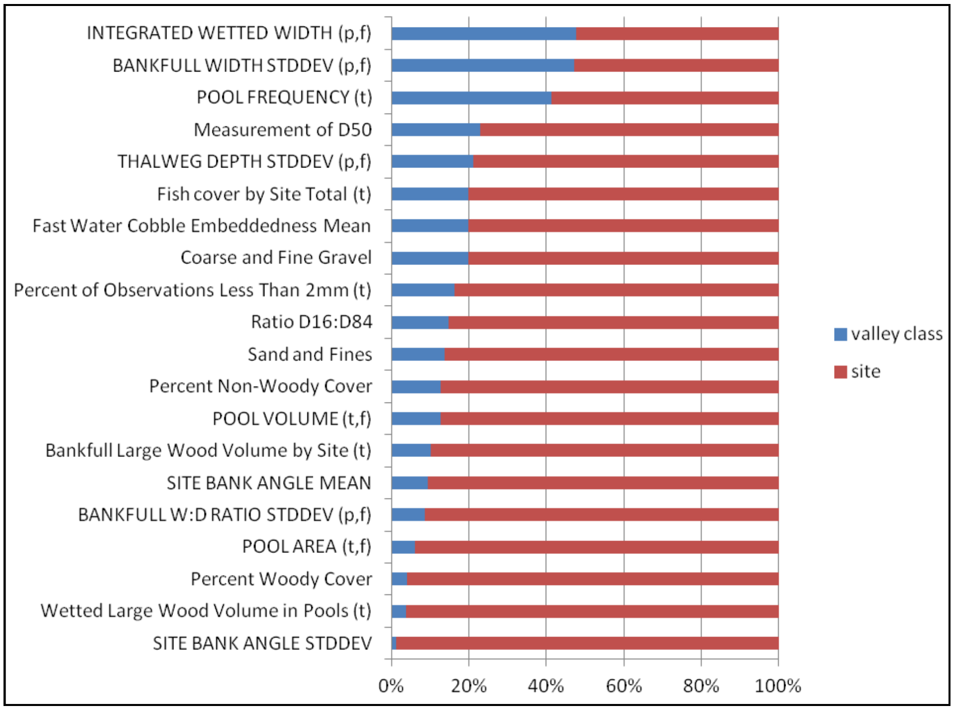

Figure 21. The relative proportion of site to site variation that is associated with the classification of sites into valley class (i.e., effectiveness of stratification).

Provisional Conclusions About the CHaMP Variance Decomposition Framework (based on 2011 pilot year data):

- CHaMP's 2011 variance decomposition provides a preliminary estimate of the relative noisiness of a range of habitat metrics.
- Metrics calculated from the quantitative topographical surveys are less noisy than metrics calculated from qualitatively determined metrics.
- For some metrics, different crews using the same protocol introduce significant variation, implying that more training for these metrics is needed.
- CHaMP's survey design stratification accounts for significant spatial variation for some metrics, sufficient to warrant continuation through completion of the first three year cycle.

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Substantial information about design principles and applications can be found at: www.epa.gov/nheerl/arm and www.salmonmonitoringadvisor.org

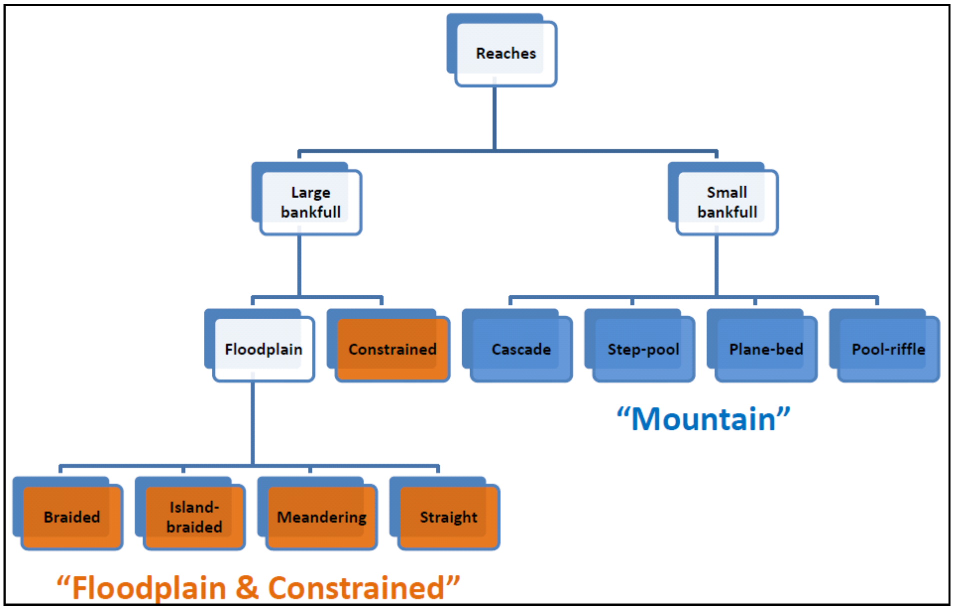

Figure 22. Simple Beechie channel classification system.

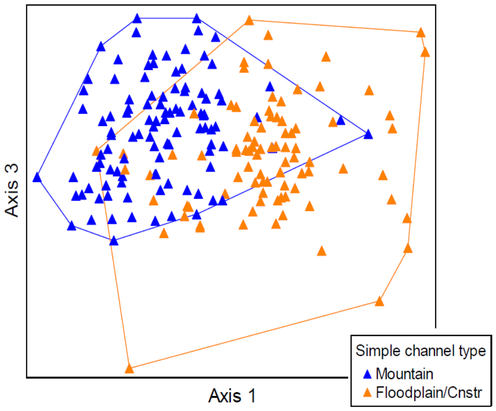

Figure 23. Non-metric Multidimensional Scaling (NMDS) ordination of 2011 CHaMP sites with overlay of simplified channel type.

Ordination plots revealed that by aggregating Beechie's classes into two groups, Mountain sites formed a relatively distinct group compared to Floodplain & Constrained sites. This relationship will increase the signal that can be derived from the CHaMP dataset.

Ordination and Development of Spatially Explicit Models

The power of information extracted from datasets such as CHaMP's in 2011 can be improved by accounting for sources of variation within statistical analyses even if they are not built into the sampling design. As demonstrated here, the CHaMP dataset is more powerful in distinguishing between sites when landscape disturbance and valley geomorphic class are accounted for when analyzing habitat data.

Where to perform habitat actions is a key management question. One approach CHaMP began exploring to answer this question is the development of a spatially explicit framework for identifying locations where habitat conditions might be relatively poor compared with other locations. The premise is that targeting mitigation in areas where conditions are worst might improve efficacy of habitat restoration.

To illustrate how this process might work, CHaMP synthesized three sets of analyses:

1) Classification of watersheds (USGS 6th field hydrologic account units, HUC-6) by their natural features and by their disturbance characteristics.

2) Evaluation of the resolution of Beechie's valley geomorphic classification system.

3) Determination of relationships between classes of HUC-6 disturbance and habitat condition.

If there were a relationship between in-channel habitat (which requires onsite measurements) and disturbance classes (based on mapped information), then predicted habitat condition could be estimated from the HUC-6 disturbance patterns.

Brief review of the HUC-6 classification

Whittier et al (2011) developed a HUC-6 landscape classification across the Pacific Northwest in two parts: a natural characteristics classification and a human disturbance classification. The natural classification accounted for seven climate, land form, geologic, and stream form attributes. The disturbance classification accounted for urban land use, agricultural land use, impervious surface, and road density. The disturbance classification generated a disturbance score for each HUC-6 watershed, which was then incorporated into the CHaMP data file for each site monitored, with each site receiving the Whittier based disturbance score in its respective HUC-6.

Figure 22 above illustrates a hierarchical organization of Beechie's stream geomorphic classes. A multivariate classification of habitat metrics indicated that aggregating Beechie's classes into two groups (Mountain and Floodplain/constrained) yielded a reasonable separation of channel types.

CRITFC analyzed the relationship between Whittier disturbance level and several key fish habitat variables. A distinct difference existed between a variety of habitat metric scores at sites with low disturbance compared with sites with high disturbance scores when sites were organized by the mountain and floodplain/constrained channel classes (Figure 23).

Figures 25 and 26 on the following page shows bank angles were steeper with higher disturbance regardless of channel type, indicating a possible effect of anthropogenic stressors on channel incision. The volume of large woody debris was reduced in disturbed areas

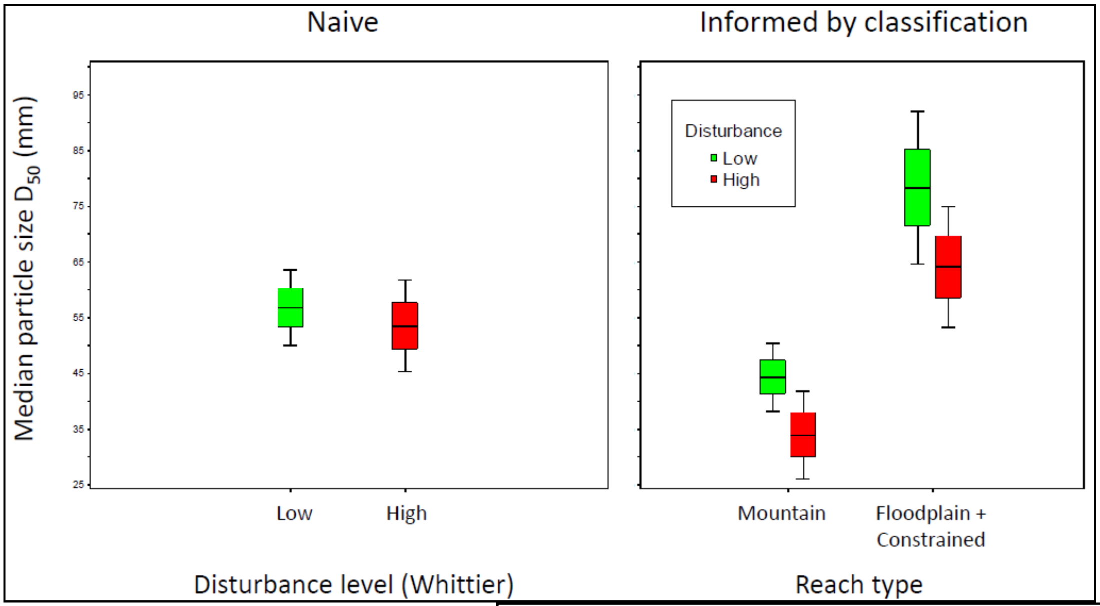

Figure 24. By assigning sites a level of low or high land use disturbance *and* a "Mountain" or "Floodplain & Constrained" valley type, patterns in measured habitat conditions that match predictions are revealed.

Note the differentiation that occurs between the plots on the far left once landscape classification is considered (near left, no boxplot overlap).

and greater in floodplain and constrained reach types. Percent fines and sand as substrate was higher in disturbed areas, possibly due to erosive inputs of sediment from the surrounding landscape into the stream channel (Vannote et al. 1980). In floodplain and constrained reaches, pool tail fines increased with disturbance as expected. Contrary to initial expectations, pool tail fines decreased with disturbance in mountain reaches; possibly because the accumulation of fine sediment in higher elevation pool-riffle, step-pool, and cascade reach morphologies is a naturally occurring process. These relationships among habitat metrics and level of disturbance were not detected when data were analyzed naively without the use of a river channel classification.

This kind of information can be used in two ways: (1) as a tool for targeting restoration and (2) for evaluating project effectiveness at the landscape scale. Both the variables used to develop the disturbance gradient and the geomorphic classes are landscape features that can be mapped across the entire domain. The maps on the following page display the spatial pattern in stream networks in the various condition classes, indicative of the locations where highest probability of poor habitat condition would be expected (Figure 26). These are areas where restoration could be targeted.

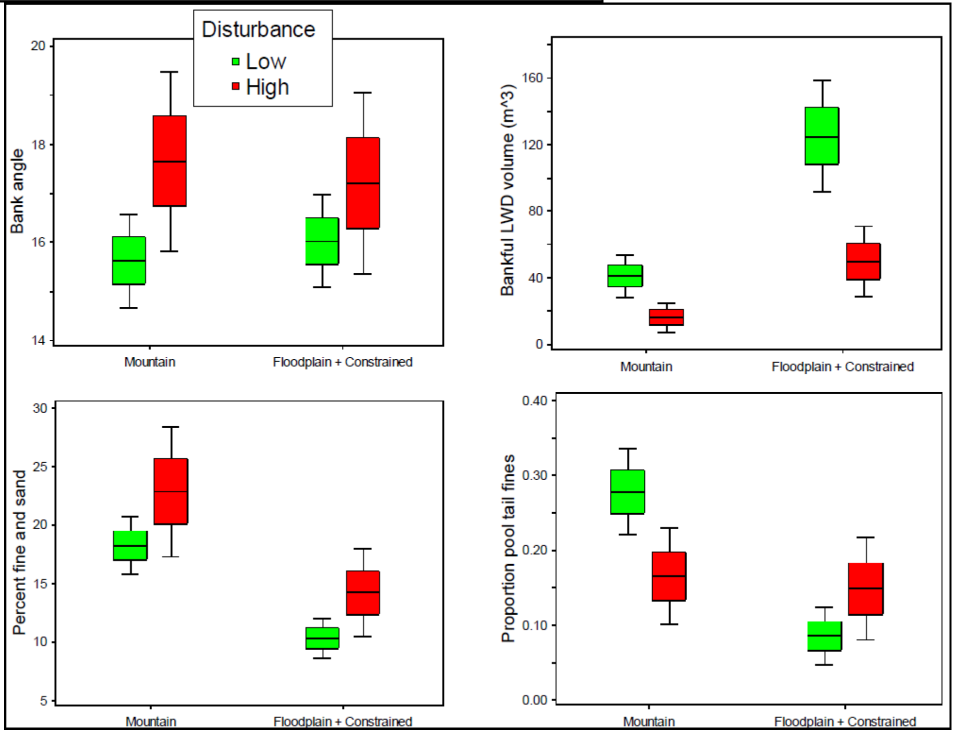

Figure 25. Boxplots illustrating how use of Whittier and Beechie classification systems sharpen our ability to describe disturbance effects and to evaluate responses to restoration.

There are clear differences in several of the habitat metrics between mountain and floodplain/constrained streams (no overlap in the boxplots). There are also clear differences between those with low and high disturbance. In some cases (e.g., the case illustrated above for pool tail fines), the disturbance effect is in the opposite direction--a decrease for mountain streams and an increase for floodplain/constrained streams.

The overall impact of restoration can then be tracked by the progression of the distribution of habitat metrics at restored locations toward those at the "best" sites (i.e., tracking the movement of highly-disturbed values (red boxes) toward minimally-disturbed values (green boxes) in Figures 24 and 25 (above).

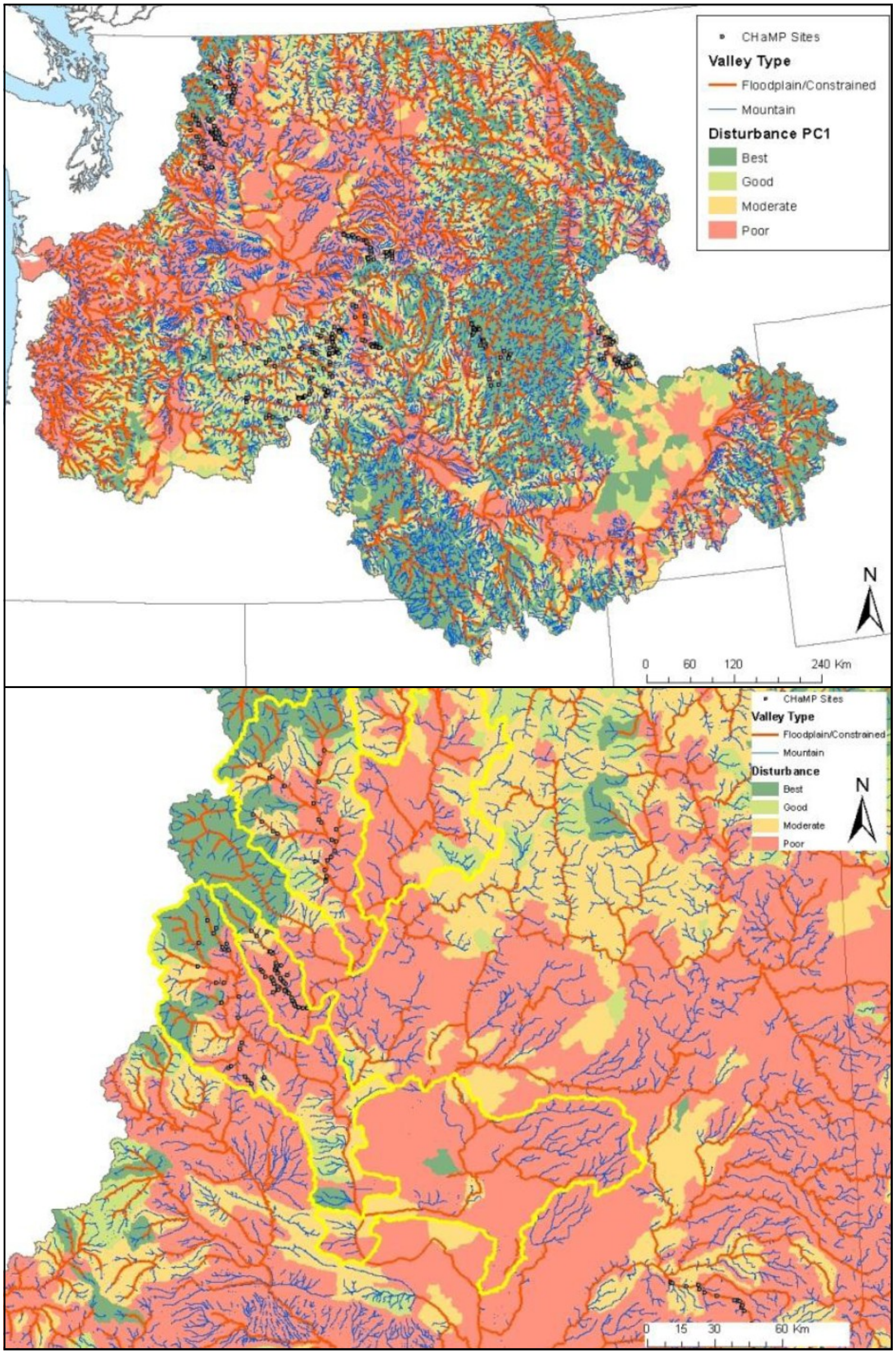

Figure 26.

Maps illustrating where the probability of finding poor habitat condition is likely to be high and therefore where habitat restoration might be concentrated.

The stream network is classified into two geomorphic groups: (Mountain and Floodplain & Constrained) because patterns of disturbance and recovery goals could differ.

The lower panel is a closer look at the Upper Columbia region of the upper panel.

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Fish Habitat Relationships

The primary goal of CHaMP is to generate habitat data – indicators of fish habitat quality and quantity (capacity) - and detect changes in habitat conditions. Although the project does not collect fish data, a major expectation of the project is that data collected will be used to better define and quantify relationships between fish populations and freshwater habitat. Indeed, comments by the ISRP regarding the CHaMP protocol emphasized the need to verify assumptions in the relationship between CHaMP habitat data and fish metrics. Therefore, we present results from three different analyses of fish-habitat relationships including structural equation modeling, boosted regression trees modeling, and the net rate of energy intake model. Results from these analyses verify the fish-habitat assumptions questioned by the ISRP.

Structural Equations Modeling

Results from a structural equation modeling (SEM) analysis performed by CRITFC found that, indeed, habitat data collected using the CHaMP protocol was significantly related to densities of juvenile Chinook salmon at study sites within the Upper Grande Ronde River. Structural equation modeling helped tease out complex relationships among fish and their habitat. These results help to verify assumptions that underlie the utility of the CHaMP habitat protocol. As similar analyses are performed on the entire CHaMP dataset, spanning more subbasins and the two remaining years in the initial CHaMP study design to capture temporal variability, such relationships between fish and habitat will be useful for predicting the results of restoration action effectiveness and can help optimize project types and location.

A SEM allows a graphical depiction of ecological hypotheses. This approach was used to evaluate the interactive effects among stream flow, large woody debris, pool frequency, and juvenile spring Chinook salmon density in the upper Grande Ronde River and Catherine Creek basins (Figure 27). Juvenile salmon density was estimated at CHaMP sites via snorkel surveys conducted by CRITFC and ODFW. Using SEM, CHaMP habitat data were used ask how are habitat metrics causally related and to what degree, and what is the influence of habitat on juvenile salmon densities? Analyses were conducted at two levels of spatial resolution: a global model including all sites, and a multi-group approach that accounted for different channel types.

Global model results

As expected, the volume of large woody debris in pools and frequency of pool area both had positive effects on fish density. However, this relationship was swamped by the influence of mean annual flow, indicating that position of sites in the landscape needs to be accounted for when attempting to predict fish densities across an entire watershed.

Mean annual flow exhibited a negative relationship with frequency of pool area, perhaps because sites at the upper-

Structural Equations Modeling was used to test assumptions about habitat metrics and juvenile Chinook density.

- Arrows show the direction and size of effect among metrics (dashed line = non-significant interaction).
- Numerical values indicate standardized path coefficients and multiple R^2 correlations.

The global SEM showed that volume of LWD in pools and the frequency of pool area both had positive effects on fish density.

However, because the position of the sites in the landscape was not considered, the effect of mean annual flow swamped the effects of the LWD and pool variables.

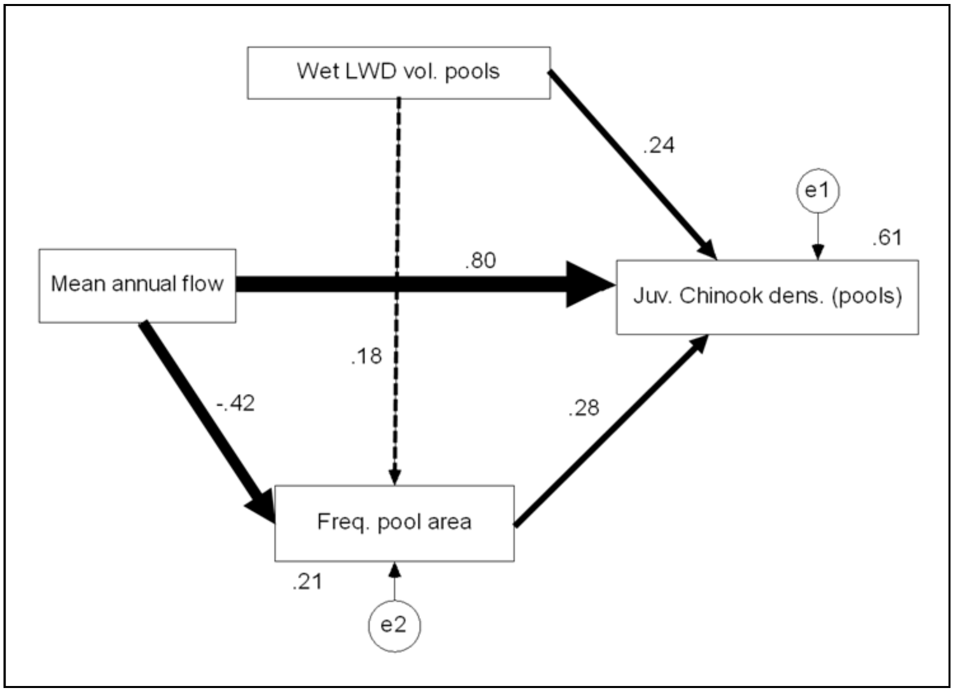


Figure 27. Global SEM results link habitat metrics with juvenile Chinook salmon density.

most elevation (and thus lower stream flow) of this study extent were typically step pool or pool riffle channel morphologies.

Mean annual flow therefore had an indirect, negative effect on fish density via its path through pool frequency. Contrary to expectations, large woody debris in pools did not increase the frequency of pool area, as this relationship was insignificant.

Multi-group results

In an attempt to deal with the overwhelming influence of mean annual flow in the global SEM, important insights and findings from the NDMS analysis (i.e., how fish habitat metrics differ according to mountain vs. floodplain & constrained channel types) were used in a multi-group SEM approach.

Using the same model specification, variables, and data as for the above global SEM, a multi-group SEM revealed very different behavior among channel types (Figure 28).

In contrast to the global model, large woody debris in mountain reaches was found to positively affect the frequency of pool area, which is in accordance with predictions of the river continuum concept (Vannote et al. 1980) that headwater streams will be more influenced by nearby terrestrial vegetation.

In headwater streams, the variables specified in the model did not predict fish density, indicating that factors other than those in the model affected fish density in those reaches. In floodplain and constrained reaches, all the hypothesized relationships among variables were significant, and slightly more variation in fish density was predicted in by the multi-group model ($R^2 = 0.64$) than in the global model ($R^2 = 0.61$).

Also in contrast to the global SEM, the frequency of pool area increased with mean annual flow in floodplain and constrained reaches, possibly because lower, slow water reaches were pooled up into long glides and runs because of lower gradients.

Conclusions from Structural Equations Modeling:

- The SEM is a useful tool for simplifying complex relationships and determining unique effects of single habitat characteristics on salmon populations.
- The model described interactive effects among stream flow, large wood, pool frequency and juvenile Chinook salmon density in the upper Grande Ronde River basin.
- Important lessons carried over from multivariate analyses:
  - Stream flow and/or watershed position are often controlling variables.
  - Geomorphic channel type (e.g., mountain vs. floodplain & constrained reaches) needs to be accounted for when describing fish-habitat relationships.
- Channel type sub-models behaved differently than global SEM and from each other. For example, the high elevation mountain reaches behaved differently than lower elevation floodplain & constrained reaches.

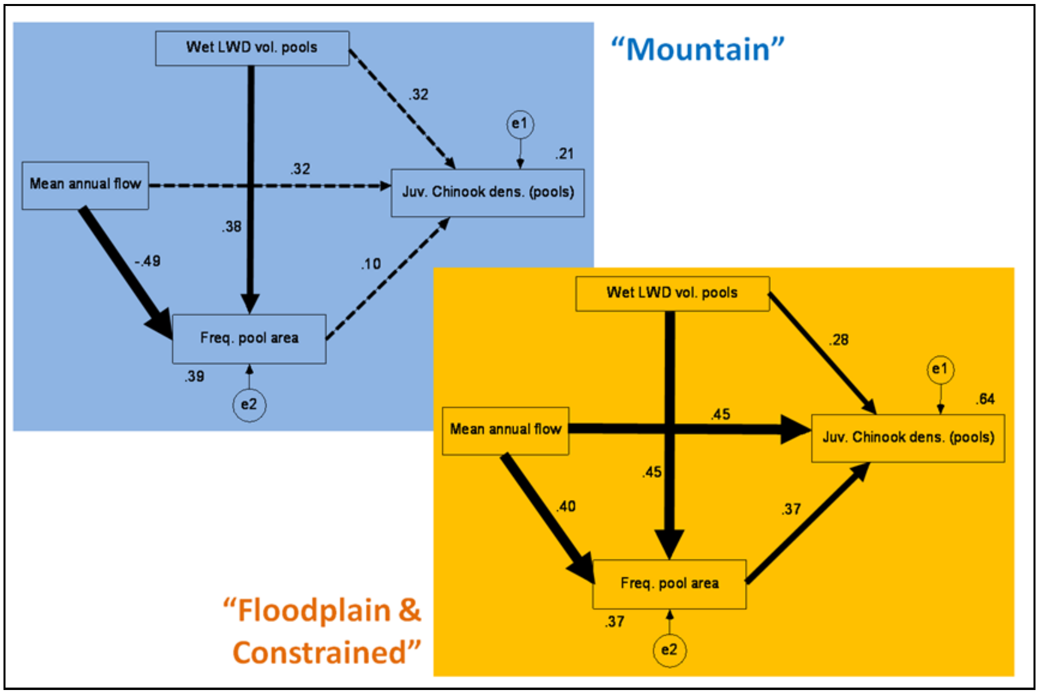


Figure 28. Multi-group SEM results by mountain vs. floodplain and constrained channel types.

Through use of multi-group SEM and "sub-models" based on channel type, differences in habitat variable behavior were detected.

Sub-models behaved differently from each other, and from the global model.

Classification and Regression Tree Model and Boosted Regression Trees

Habitat data from 152 CHaMP habitat sites, that were also sampled for fish in 2011 by ISEMP crews in the Lemhi, Upper Grande Ronde, John Day, South Fork Salmon, Entiat and Wenatchee subbasins, were compared to the density of juvenile Chinook salmon and steelhead using boosted regression tree models.

Results from these analyses supported the SEM analyses and verified that the CHaMP habitat protocol generated metrics that are indeed related to densities of juvenile Chinook salmon and steelhead. These results show that certain metrics have relatively large influence on salmonid densities, and could be targets for improvement through restoration actions, while other metrics are less important. Metrics with little relative influence are candidates for excluding from the CHaMP protocol in the future; however, these metrics may have much larger utility in detecting trends which won't be apparent until after the third year of sampling. Therefore, all metrics from 2011 will be collected for two more years (the duration of the CHaMP rotating panel study design) before metrics are fully evaluated and, if not sufficiently useful, dropped from the protocol.

The analysis

CHaMP used a classification and regression tree (CART) framework to learn about habitat metric correlations with juvenile fish densities, and the relative importance of each habitat metric in certain fish-habitat relationships, that is, which metrics are most important in predicting juvenile fish densities. A CART model builds a decision tree by creating "branches" at breakpoints along predictor variables that minimize prediction error (Figure 29, right)

Compared to other fish/habitat relationship modeling approaches like linear regression, single decision trees are more prone to inaccuracy .

To remedy this, a "boosted" regression tree (BRT) model can be built. A BRT consists of a model built to fit an initial tree with subsequent tree(s) added to deal with the data not explained well by the previous set of trees. Use of a BRT can dramatically improve the accuracy of

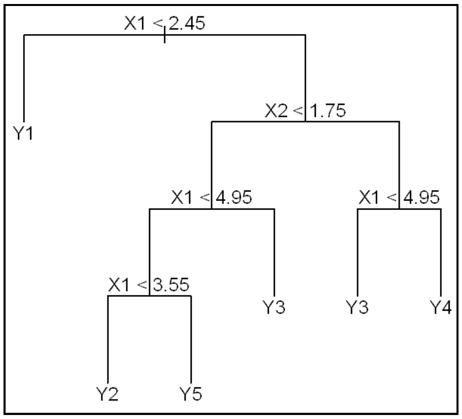
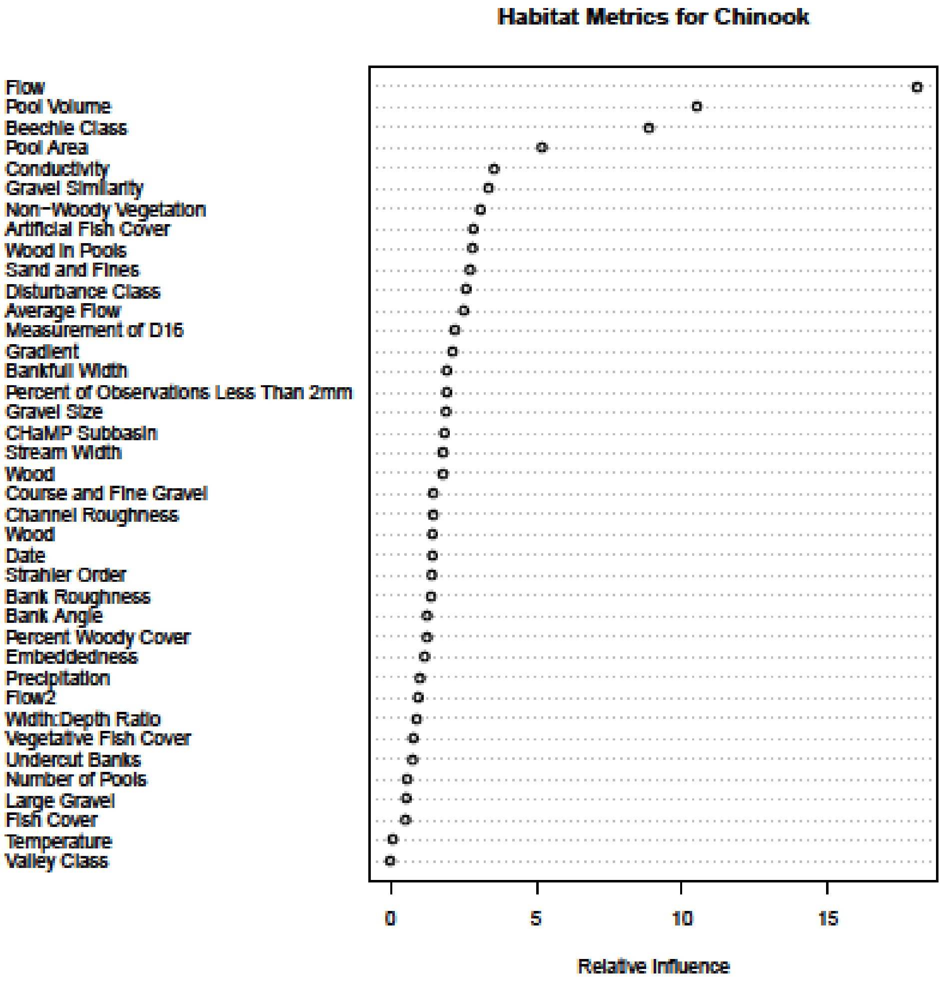


Figure 29. A single decision tree based on a response variable, Y, and two predictor variables, X1 and X2.

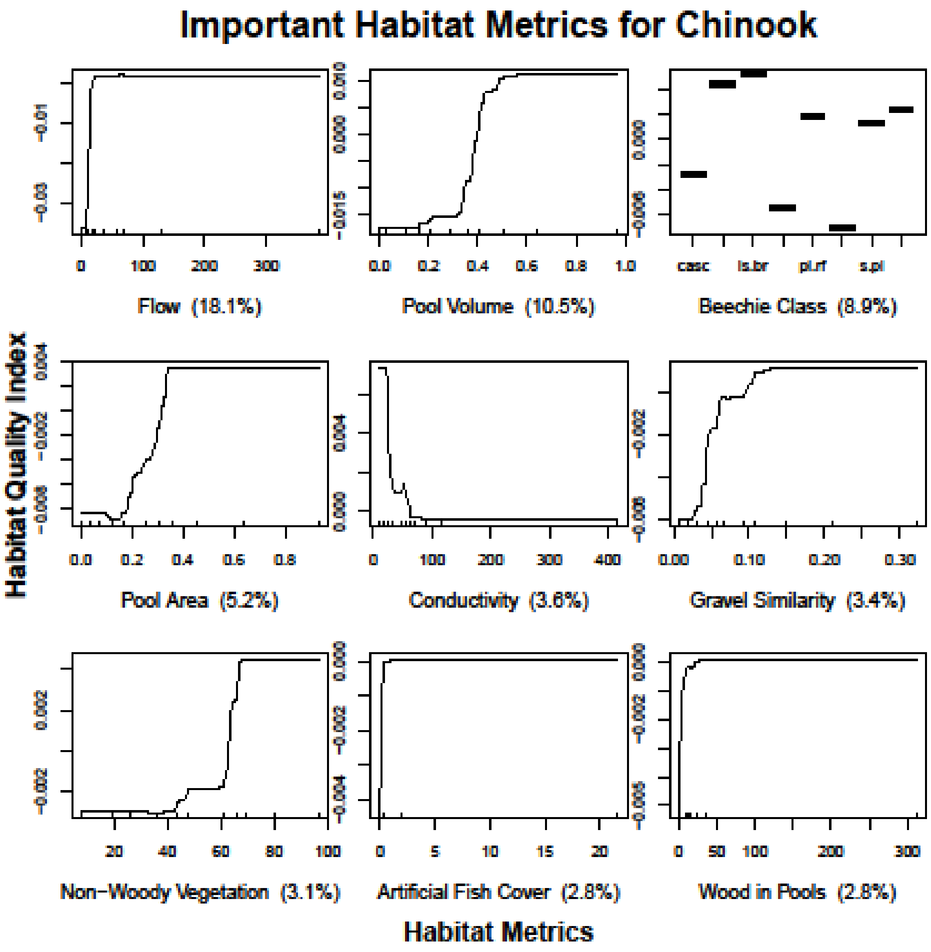
Starting at the top, data from a particular site follow one of the branching paths, leading to a predicted response, Y.



A BRT approach was used to identify and compare the metrics important for predicting juvenile Chinook densities.

The relative influences have been scaled to sum to 100, and the habitat metrics are arranged from most important at the top to least important at the bottom.

Figure 30. The relative importance of various habitat metrics in predicting the density of juvenile Chinook using fish density data from ISEMP and various collaborators and habitat data collected by CHaMP in 2011, analyzed using a boosted regression tree approach.



Plots of the relative importance (shown in parenthesis) of the nine most important habitat metrics for predicting juvenile Chinook densities, and how density may change in response to changes in a single habitat metric.

The y-axis is a function of the predicted value of juvenile density, which has been centered on 0. —Higher values on the y-axis correspond to higher expected juvenile densities, and vice-versa.

The black line describes the predicted value for each value of the habitat metric. Along the bottom of each plot, the tick marks show the deciles of the data for that particular habitat metric.

In many cases, predicted densities rose or fell sharply once a certain metric value was neared/attained.

Habitat "thresholds" like this can be used to help identify and address limiting factors by providing quantifiable goals for restoration work, that is, how much work it's going to take to move conditions from one side of the threshold to the other.

Figure 31. Partial dependence plots showing the marginal effect of the nine most important habitat metrics identified from a BRT on juvenile Chinook densities using fish density data from ISEMP and various collaborators and habitat data collected by CHaMP in 2011.

the final multi-tiered decision framework (Schapire 2002).

The benefits of using a CART-based/ BRT approach are that data transformations are not needed and the model captures predictor metric interactions. Non–linear responses to predictor metrics are allowed, such as thresholds or optimum ranges. Further, the inputs to and results from a BRT are easily interpreted.

For this report, a BRT model was developed to predict fish density from habitat metrics and to describe how fish density may change in response to shifts in metric values. Use of this BRT approach can help identify which metrics habitat restoration projects should target to have the greatest effect on fish populations. Also the BRT also allows the exploration of the relative importance of each metric within a multi-metric model.

The results of the BRT analysis using 2011 CHaMP data confirm known relationships between habitat and fish densities, such as juvenile Chinook are found in higher densities in areas with higher flow, more pools, and good water quality. The BRT approach implies that habitat restoration action should be targeted at increasing slow water refugia and/or reducing the conductivity of the water to at least 30 μmhos/cm to be the most effective at improving juvenile Chinook densities.

A BRT analysis of steelhead densities across CHaMP watersheds identified different habitat metrics as relatively important. For example the percentage of woody cover was the most important metric in predicting juvenile steelhead density (after accounting for differences between subbasins and Beechie classes).

Overall, the ability to detect differences in habitat metric-fish density relationships can be used to guide restoration actions based on goals for the target species. However, other BRT analyses conducted within specific subbasins (e.g. see the use of BRTs to analyze fish and habitat data in the Wenatchee subbasin as reported in the draft ISEMP 2011 Lessons-Learned report) suggest that different habitat metrics may be more important in some subbasins than in others. Analyses conducted on datasets with multiple years of fish-habitat data confirm that accounting for year-to-year variability in spawners and environ-

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mental conditions is important to establishing fish-habitat relationships.

The BRT analytical framework can be used to answer questions such as what habitat characteristics should be targeted for restoration for a specific species, and how much restoration is necessary to achieve the best fish population response. Combined with quantitative status and trend data, BRT methods can be used to help answer the question, “Are habitat actions effectively helping salmonid populations?” However, before managers use BRT results for decision-making, additional work by CHaMP staff should be done to more specifically define threshold levels and additional years of data should be collected and incorporated into this type of analysis.

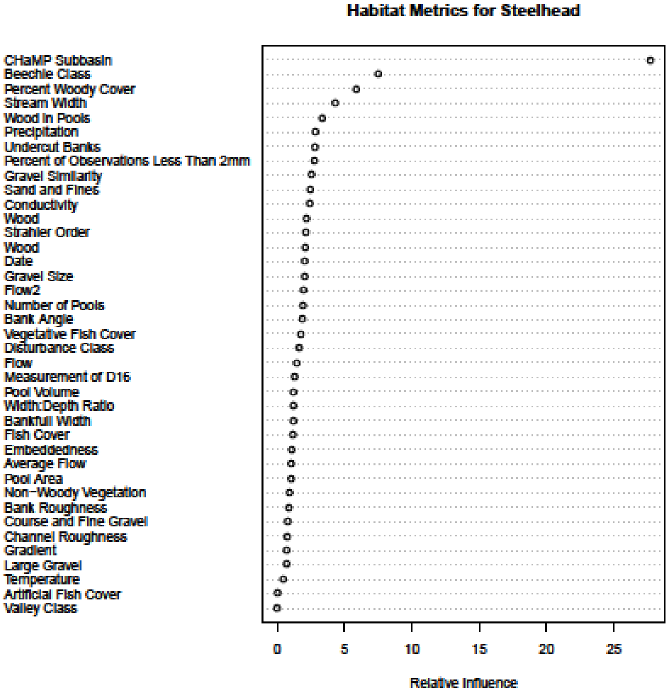


Figure 32. The relative importance of various habitat metrics in predicting the density of juvenile steelhead using fish density data from ISEMP and collaborators and habitat data collected by CHaMP in 2011, analyzed using a BRT approach.

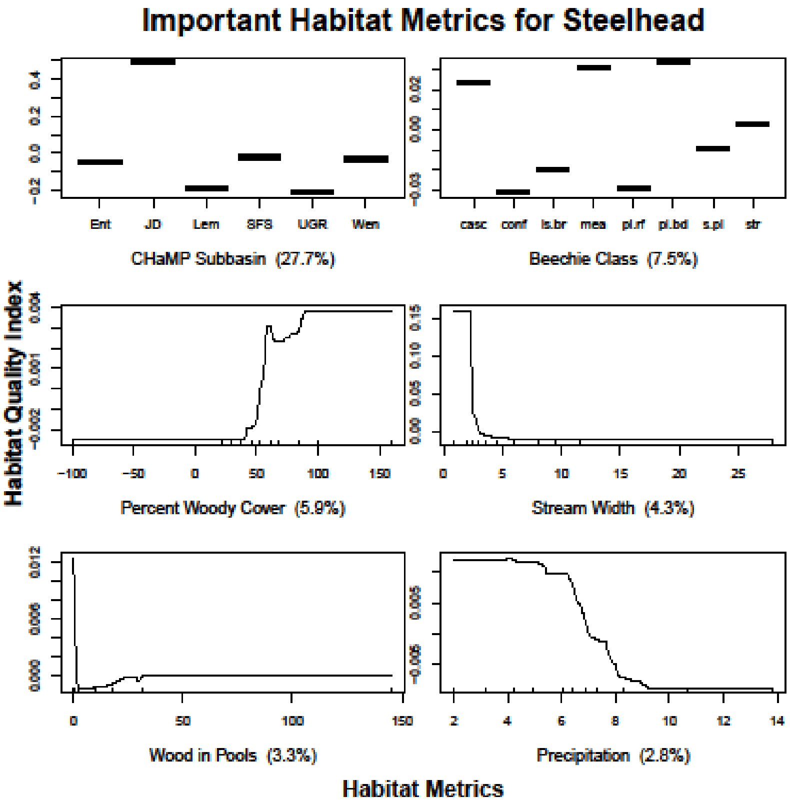


Figure 33. Partial dependence plots showing the marginal effect of the six most important habitat metrics identified from a BRT on juvenile steelhead densities using fish density data from ISEMP and collaborators and habitat data collected by CHaMP in 2011.

(TOP) A BRT approach was used to identify and compare the metrics important for predicting juvenile steelhead densities. The relative influences have been scaled to sum to 100, and the habitat metrics are arranged from most important at the top to least important at the bottom.

(LEFT) Plots of the relative importance (shown in parenthesis) of the six most important habitat metrics for predicting juvenile steelhead densities, and how density may change in response to changes in a single habitat metric.

The y-axis is a function of the predicted value of juvenile density, which has been centered on 0. —Higher values on the y-axis correspond to higher xpected juvenile densities, and vice-versa.

The black line describes the predicted value for each value of the habitat metric. Along the bottom of each plot, the tick marks show the marginal effects of the deciles of the data for that particular habitat metric.

Preliminary Conclusions CART/BRT Approach:

Important covariates for Chinook:

- Flow, pools (volume and area), Beechie class, water quality (conductivity)

Important covariates for steelhead:

- Substrate, Beechie class, riparian cover

BUT

- Notable differences across subbasins and species
- Important year effect not included

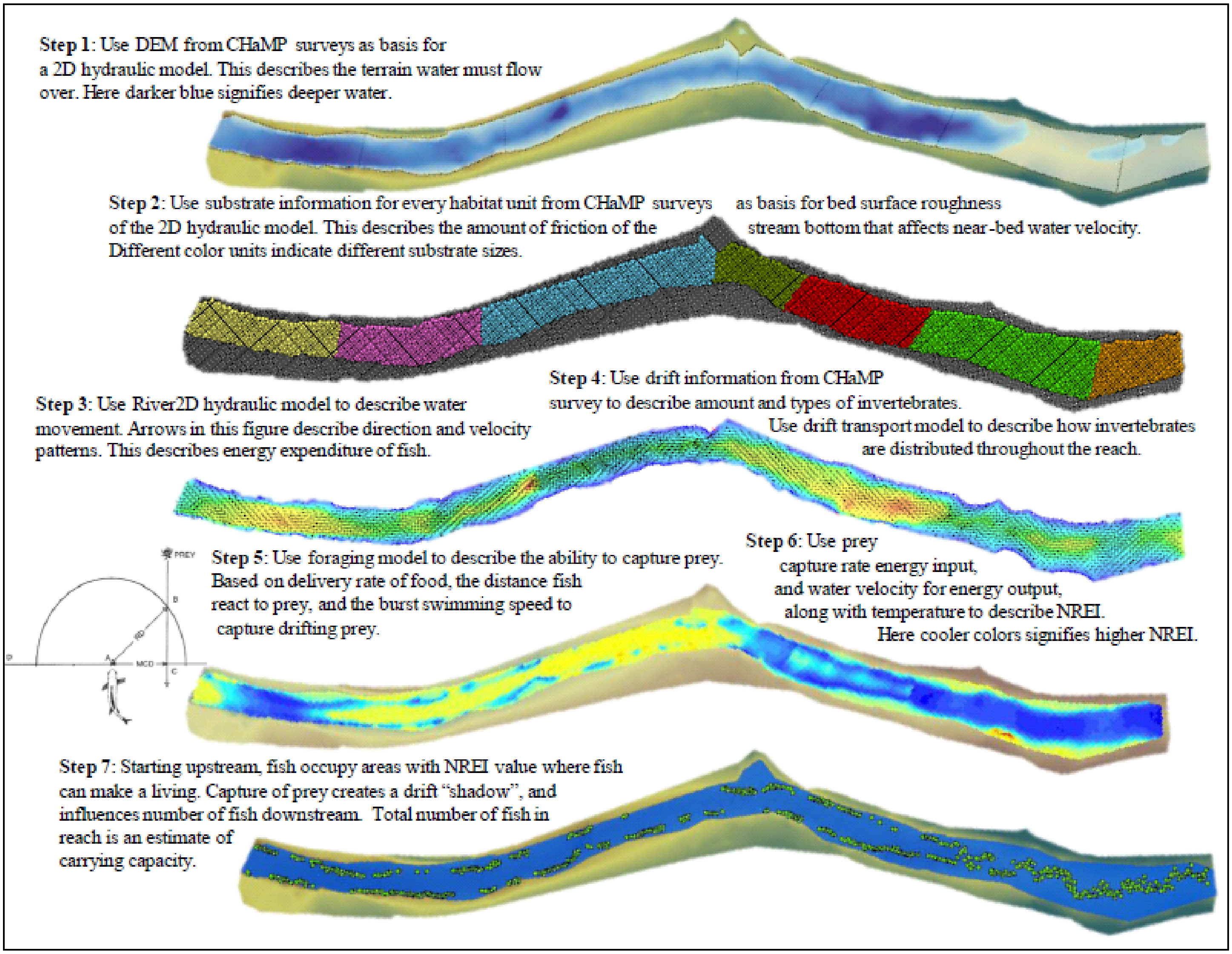
Net Rate Energy Intake and Predicting Carrying Capacity

Habitat monitoring, like that done by CHaMP, is based on the assumption that knowledge of habitat quality is a surrogate for quantifying the number (and survival and growth) of salmonids because, it is assumed, that habitat is directly related to processes that control salmonid populations. For example, stream temperature and food availability and consumption are known to effect fish growth (Railsback and Rose 1999), and such knowledge about fish growth, bioenergetics (Hanson et al. 1997) and habitat carrying capacity (Hayes et al 2007) are used in practice as the basis of many habitat restoration projects/programs.

One logical "missing link" between habitat and salmonids, rooted in basic ecology, is how salmonids using a particular habitat expend energy through work (i.e., metabolism and swimming) and take-in energy through feeding. The Net Rate Energy Intake (NREI) index has been demonstrated in recent research to be more widely applicable as an index of habitat quality than other habitat metrics. Once it is further validated within the CHaMP project, it is possible that it will prove to be the most relevant habitat metric for predicting salmonid metrics. Complete validation of this metric was not possible at this time because it relies on water temperature data that won't be collected until the temperature loggers deployed in 2011 are retrieved in 2012.

Quantifying physical structure is a large emphasis of the CHaMP habitat protocol. The protocol was specifically designed so that data collected by CHaMP can be used as input(s) for a variety of models designed to evaluate fish-habitat relationships, and will help affirm assumptions about these relationships.

The NREI model represents how hard a fish has to work to capture food and grow. The model is based on the premise that by taking the difference



Step 1: Use DEM from CHaMP surveys as basis for a 2D hydraulic model. This describes the terrain water must flow over. Here darker blue signifies deeper water.

Step 2: Use substrate information for every habitat unit from CHaMP surveys as basis for bed surface roughness of the 2D hydraulic model. This describes the amount of friction of the stream bottom that affects near-bed water velocity. Different color units indicate different substrate sizes.

Step 3: Use River2D hydraulic model to describe water movement. Arrows in this figure describe direction and velocity patterns. This describes energy expenditure of fish.

Step 4: Use drift information from CHaMP survey to describe amount and types of invertebrates. Use drift transport model to describe how invertebrates are distributed throughout the reach.

Step 5: Use foraging model to describe the ability to capture prey. Based on delivery rate of food, the distance fish react to prey, and the burst swimming speed to capture drifting prey.

Step 6: Use prey capture rate energy input, and water velocity for energy output, along with temperature to describe NREI. Here cooler colors signifies higher NREI.

Step 7: Starting upstream, fish occupy areas with NREI value where fish can make a living. Capture of prey creates a drift "shadow", and influences number of fish downstream. Total number of fish in reach is an estimate of carrying capacity.

Figure 34. Using CHaMP survey data to estimate energy available (NREI) and carrying capacity of juvenile steelhead in a stream reach.

between energy gained (food ingested) and energy spent (metabolism and swimming costs), the NREI for salmonids can be estimated (Figure 34, Step 6). In addition, the NREI can be converted into growth rates of salmonids, which are thought to influence survival.

The model can be used to map areas of a reach where fish can make a living, that is., the area has a positive NREI. The number of foraging areas that have a positive NREI can serve as an estimate of carrying capacity of the reach (Step 7).

The overall mechanistic model is composed of a number of individual models:

- Hydraulic models use a 3D representation of the streambed to generate spatially explicit depth and velocity estimates and show how water flows through the reach.
- A drift transport model uses the hydraulic model output to predict how drifting food items are delivered throughout the reach.
- A mechanistic foraging model predicts which drifting food items will be captured by foraging fish (energy intake) in the modeled stream reach., and how much energy it has to expend in the process (through swimming and metabolism). In a number of cases the sampling designs were integrated with the needs of local collaborators while adhering to CHaMP design principles. We will describe our designs and show how we met multiple objectives simultaneously (regional habitat status-trends, fish-habitat dataset, project and watershed effectiveness monitoring).

CHaMP data inputs used by the individual models include:

- Temperature,
- Discharge
- Invertebrate drift
- The DEM (digital 3D map of the channel)
- Channel unit substrate type

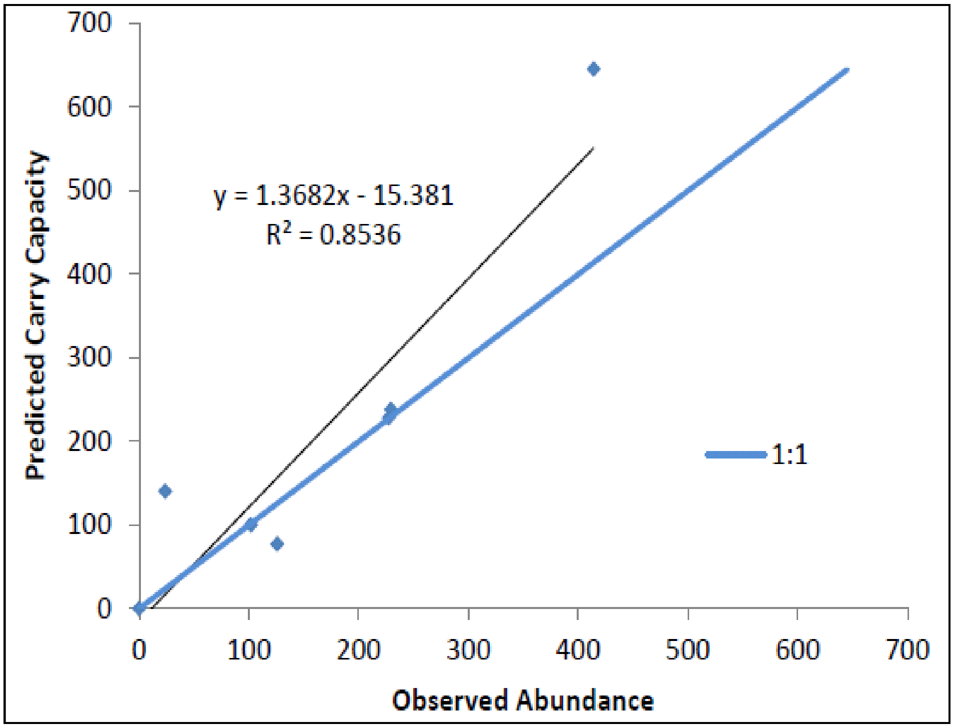


Figure 35. Observed vs. predicted abundance of fish across reaches in eight different streams. If we were able to predict actual abundance, the points would fall on the 1:1 line.

Mechanistic Model Validation

To evaluate how well the model might predict steelhead abundance, project staff used CHaMP survey information from seven sites in the John Day and one site in the Asotin to estimate NREI and carrying capacity, then compared model calculations to observed fish numbers from these basins.

Although very preliminary, the NREI model predicted the number of fish extremely well. The hope is that once it is fully developed, the model will be very informative in translating CHaMP survey information into metrics that describe fish performance and abundance.

Other applications of this approach include estimating how changes to the stream channel from habitat restoration projects designed to address limiting factors could translate into changes in NREI and habitat carrying capacity within a stream, and evaluating the benefits of stream restoration (see Figure 36, opposite).

Estimating Energy Availability (NREI) and Carrying Capacity of Salmonids in a Stream Reach - Preliminary Conclusions:

CHaMP/ISMEP staff has just recently begun to test this mechanistic model to predict growth, abundance and production of a reach.

The model has not been calibrated and several large simplifying assumptions were made to complete these analyses for this report.

Nonetheless, the model performed remarkably well, so there is optimism that further development will produce a product that synthesizes several metrics collected from CHaMP and describes what they mean to salmonids.

The many potential applications of this approach include:

- Synthesizing several habitat metrics into an index that is related to salmonid abundance, growth and possibly, survival;
- Evaluating limiting factors;
- Assessing the benefits of stream restoration actions; and
- Producing accurate information to be used in other analytical frameworks.

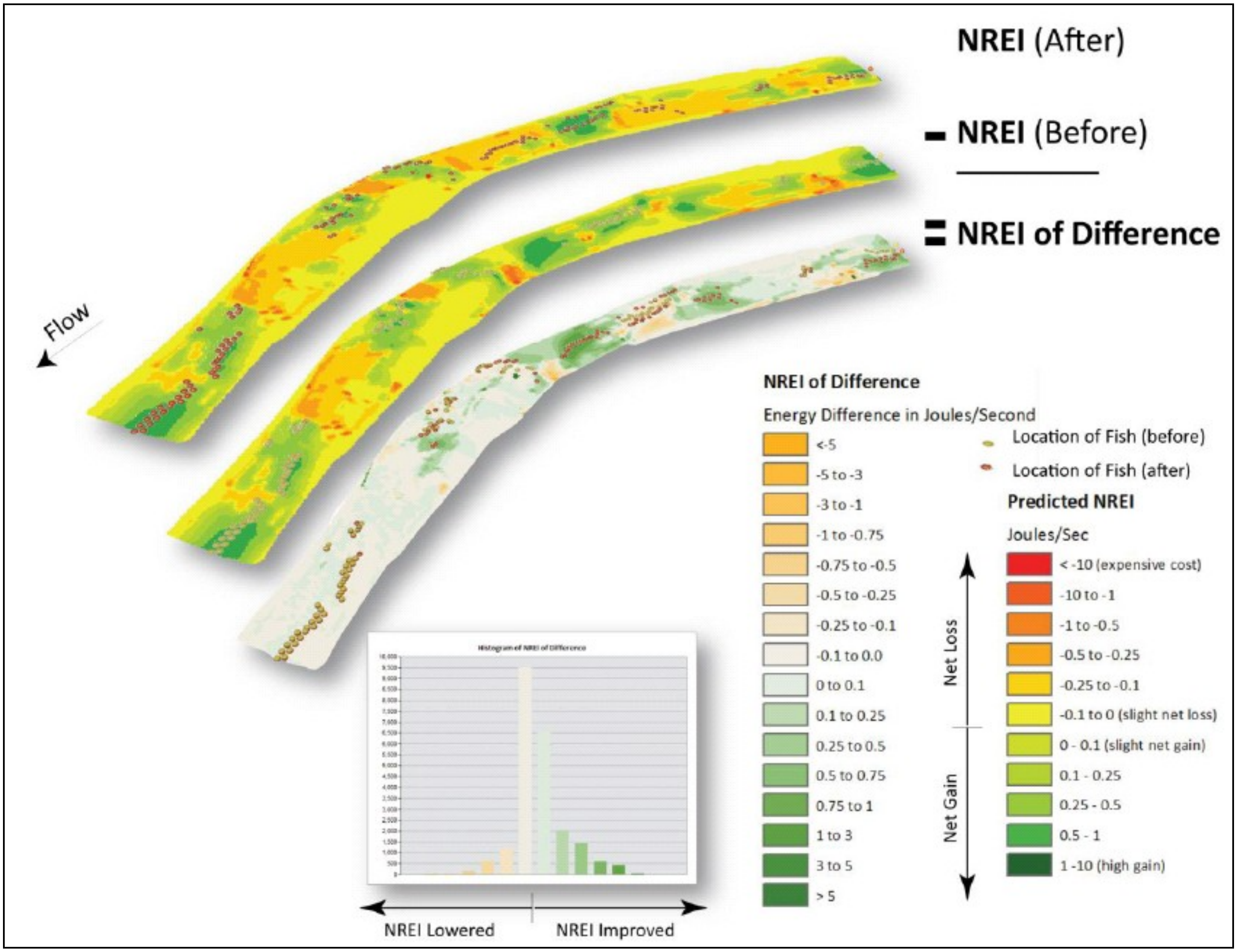


Figure 36. Expected change in energy available (NREI) and carrying capacity of a reach of the South Fork in the Asotin IMW due to a hypothetical restoration action.

The above figure depicts a DEM that was built using survey data collected via the CHaMP protocol and then altered to reflect expected changes from a proposed restoration action (the addition of wood).

The "Before" NREI surface was subtracted from the "After" surface to create a "NREI of Difference" surface.

This resultant surface depicts and quantifies how the habitat action could potentially create more fish.

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IV. IMPLEMENTATION REVIEW: LESSONS FROM THE 2011 PILOT YEAR

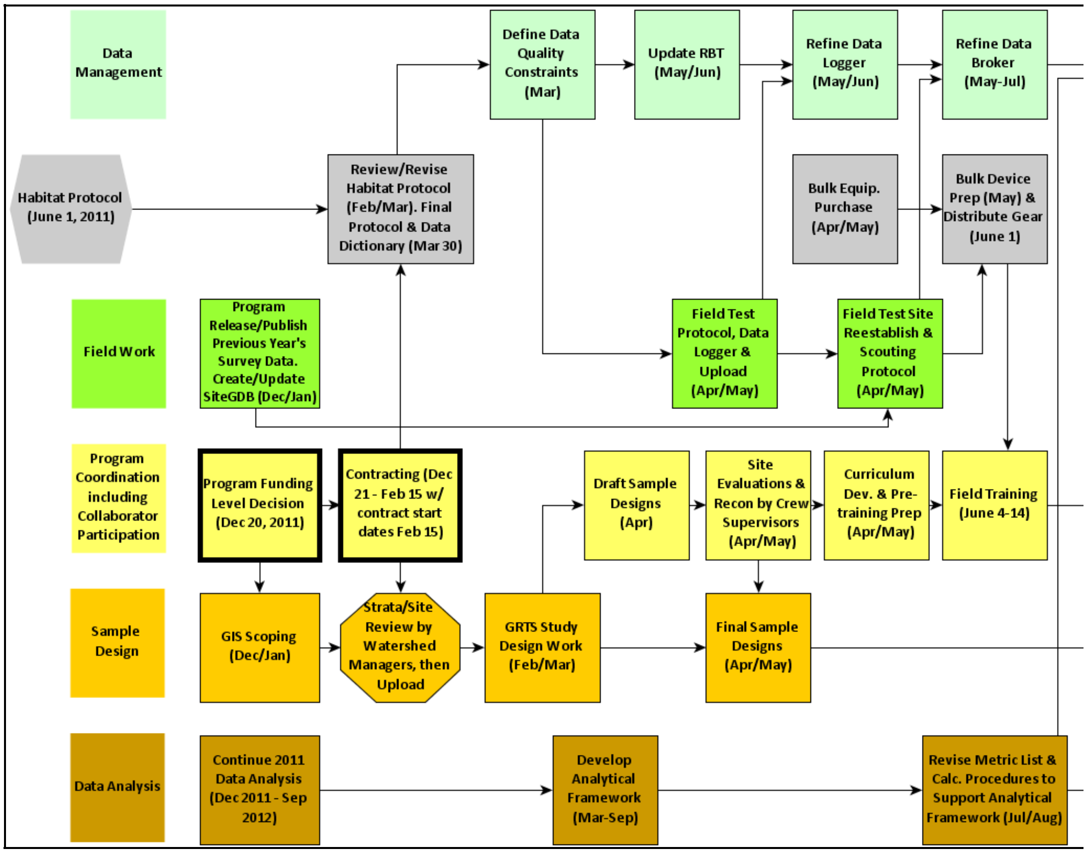
Timeline for Decision Making

What Worked

- A large, complex monitoring program was launched efficiently under a tight timeline.
- The field data collection and data processing and management tools were completed in time to allow a preliminary analysis prior to the post-season workshop and final reporting deadlines.

What Didn't Work

- The short project development and decision making timelines resulted in inefficiencies and irretrievable costs.
- There was insufficient time to adequately respond to comments on the habitat protocol prior to field use.
- The unusually long work weeks put in by CHaMP staff and collaborators led to morale problems at all levels.
- The initial delay in launching CHaMP created a "ripple effect" throughout 2011 such that other planned milestones and deliverable dates fell behind schedule.



Program Level Decision Making, Funding & Coordination

Project Funding Decision Making Timeline

The CHaMP project was originally proposed in June 2010. Project coordination staff developed a 2011 "Flow Path" diagram, which described six threads of activities that would be required to successfully implement CHaMP in the pilot year.

These six activity threads (data management; protocol, equipment and tool development; coordinated contracting and collaborative field implementation; field assistance and variability studies; sample design, and data analysis) were not linear or distinct, and overlapping roles for each thread were assigned to different contractors.

The original 2011 Flow Path timeline included a milestone for program contracting occurring from December 2010 to April 2011, with anticipated contract start dates in March 2011. However, significant reconsideration of the proposed project occurred at BPA during early 2011 regarding uncertainties about the implementation of a project with such a large scope. A review process by the ISRP and subsequent NPCC recommendations to implement CHaMP were also delayed significantly. Approval for the project to proceed was finally issued on May 6, 2011, which resulted in a highly compressed timeline for project implementation. Key activities therefore occurred months behind the ideal schedule.

Despite the tight timelines and high levels of expectation that characterized the development of CHaMP, training and other pre-season activities were completed in time to allow field sampling to occur as planned beginning in early July 2011. Further, the project was able to complete a pilot version of standardized habitat monitoring and data collection.

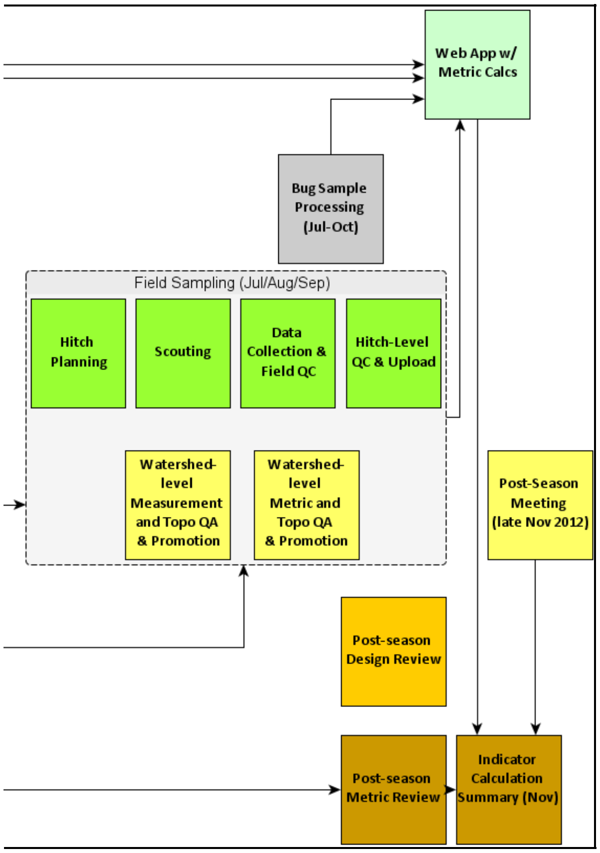


Figure 37.
Proposed 2012 Flow Path diagram.

Recommendations for 2012:

The timeline for decision making did not go as planned in 2011. For 2012, events should follow the schedule outlined in the above Flow Path diagram in order to minimize unnecessary challenges that would arise from change, especially as 2012 will continue to be confounded with challenges from development activities that were not completed in 2011. To address issues identified in this report regarding timelines, CHaMP coordination and BPA staffs have developed a revised Flow Path for 2012.

Project-Level Contracting and Funding

The CHaMP project grew out of recommendations from the AMIP process in early 2010 with a very compressed timeline for expected monitoring implementation. Although CHaMP was originally proposed as a collection of coordinated deliverables embedded within several project proposals submitted to the Fish and Wildlife Program in June 2010, in November 2010, BPA project managers made the decision to consolidate most of the CHaMP contracts within the single project (Project #2011-006). This approach allowed for coordinated contracting activities (e.g., boilerplate statements-of-work with uniform language between contractors conducting the same tasks) and unified, coordinated budgeting for all contractors.

In 2011, budgets for implementation were scoped with an assumption that the habitat monitoring protocol would be completed well in advance of implementation. However, the protocol took longer to complete and the associated continuing development costs strained implementation budgets.

Recommendations for 2012:

Overall, budgets in 2011 were adequately scoped and the contracting structure worked well and should be continued. In 2012, however, budgets should be modified to more clearly reflect planned project development activities, (e.g., protocol and software refinements, and coordination and training improvements).

Contracting and Funding

What Worked

- Using standardized contracts and language made deliverable tracking more efficient and promoted standardized data collection.
- The centralizing of the bulk of the proposal writing and contract development minimized contractors' costs.
- The funding allocated to each contractor was largely adequate.
- The collaborators that already had close working relationships, and those that were developed through CHaMP collaboration, were able to support each other with contract performance.

What Didn't Work

- The priorities and rationale behind the funding were not always clearly established and/or communicated to development team members.
- The budgets for 2011 were inappropriately scoped so that while budgets were sufficient for implementation costs, they were insufficient for actualized program development costs in many areas.

Coordination Staff & Collaborator Roles

What Worked

- We completed a pilot year of standardized habitat monitoring and data collection within 10 major population groups.
- Rigorous scientific designs were standardized across subbasins and yet were flexible enough to accommodate local needs.
- We developed a coordinated, standardized, web-based information sharing system.
- The use of a team of skilled individuals with a history of collaboration under ISEMP promoted efficiency and resulted in overall success.
- Communication and project coordination improved over the course of the season.

What Didn't Work

- A lack of clear roles and assignments early in the process led to insufficient division of the work load and hindered timely action by CHaMP coordination staff.
- Entities often focused on the development of their task and did not budget enough time to review and collaborate with others associated with their products.

Coordination Staff and Collaborator Roles

CHaMP was proposed as a collaborative effort across several entities and projects. Coordination work was conducted by a team of contractors who had experience coordinating large-scale monitoring work under ISEMP. An informal work plan was based around the 2011 Flow Path diagram, which described six threads of activities that would be required to successfully implement CHaMP.

It was envisioned that project collaborators would:

- Be composed largely of co-managers or other agencies with experience operating in CHaMP watersheds,
- Have advisory roles in scoping the project,
- Help design sampling within their watershed of interest,
- Participate in standardized training,
- Implement field sampling, and
- Be involved in post-season data analysis and reporting through participation in a post-season workshop where input could be provided and incorporated into the draft annual report.

The delayed start date for CHaMP precluded significant pre-season scoping activities, thereby limiting collaborators' abilities to serve in an advisory capacity; however, collaborators were able to carry out their remaining roles as planned.

Recommendations for 2012:

The workload distribution for the 2011 pilot year was adequate to complete project tasks; however, an evaluation of existing staff roles and workload distribution is warranted as part of the contract development process for 2012. In addition, CHaMP coordination staff should explore mechanisms to encourage and assist cooperation among individuals and companies, particularly on project components that require input from multiple parties.

Coordination with Managers (NPCC, BPA, NOAA)

As part of project development and management, CHaMP staff coordinated frequently with BPA contract managers (e.g., daily) and regularly NOAA scientific staff (e.g., monthly).

Coordination with policy decision makers at NPCC, BPA, and NOAA was less frequent and was centered on four important decision dates: 1) ISRP review of CHaMP, 2) funding decisions, 3) a mid-season progress update, and 4) a post-season workshop. These were considered effective milestones for communication by all entities involved.

During the 2011 Post-Season Workshop, BPA, NOAA and NPCC staff supported convening a high-level discussion forum prior to 2012 implementation to provide better definition around policy and management staff expectations, and clarify how CHaMP may inform decision-making.

Recommendations for 2012:

The level of coordination between CHaMP staff and BPA contract staff and NOAA scientific staff worked well in 2011. Therefore, coordination in 2012 should continue on a similar schedule and time-frame.

Coordination with policy and management staff should be improved in 2012 through identification of participants for a high-level discussion forum, the formation of which was supported by managers at the November 2011 workshop.

CHaMP staff should revisit the potential to 1) establish an executive management committee to inform direct communications between CHaMP and BPA managers and maintain a strong link with NOAA scientific staff, and 2) create a working group to improve information exchange with NPCC and other agencies.

Coordination with Managers

What Worked

- The frequency and intensity of coordination with managers seemed sufficient once the project was initiated and steadily improved over the course of the 2011 pilot year.
- The high level of interest in CHaMP from policy decision makers encouraged coordination staff and helped in the acquisition of funds.

What Didn't Work

- The last minute decisions by managers about funding constrained implementation.
- Coordination between CHaMP staff and policy decision makers was not as open and efficient as it could be.

Coordination with Regional Programs

CHaMP's goals and objectives are explicitly and intentionally consistent with BPA's key management goal of coordination and standardization of regional and project-specific monitoring efforts among other federal, state, and tribal programs. Within the CHaMP watersheds, habitat monitoring in 2011 was highly coordinated and standardized in an unprecedented fashion; however, staff had little time to coordinate outside of CHaMP watersheds in large part due to the necessary preoccupation with project development. A higher level of participation in regional programs (e.g., PNAMP) by CHaMP staff could help advance the key management goal. Such increased participation will likely become more feasible once internal coordination work tapers off as project development is completed in 2012 and 2013.

Recommendations for 2012:

The high level of coordination among CHaMP staff and participating collaborators was critical to the success of the 2011 pilot year and should continue in 2012. In the future, CHaMP staff should explore developing new alliances with interested regional programs and managers, particularly those who are using BPA funds for restoration or habitat initiatives, as a way to improve long-term habitat action effectiveness monitoring within CHaMP watersheds.

As project development needs decline, more effort should focus on coordinating CHaMP with other regional monitoring programs to meet the overarching NPCC program goal of cost effectiveness. However, the dedication of effort to participation in regional programs such as PNAMP should be evaluated in terms of the NPCC's goal of cost-effectiveness. Ramping up of coordination with regional entities not participating directly in CHaMP should occur in proportion to reductions in internal coordination efforts resulting from development completion, and in proportion to actual need.

Coordination with Regional Programs

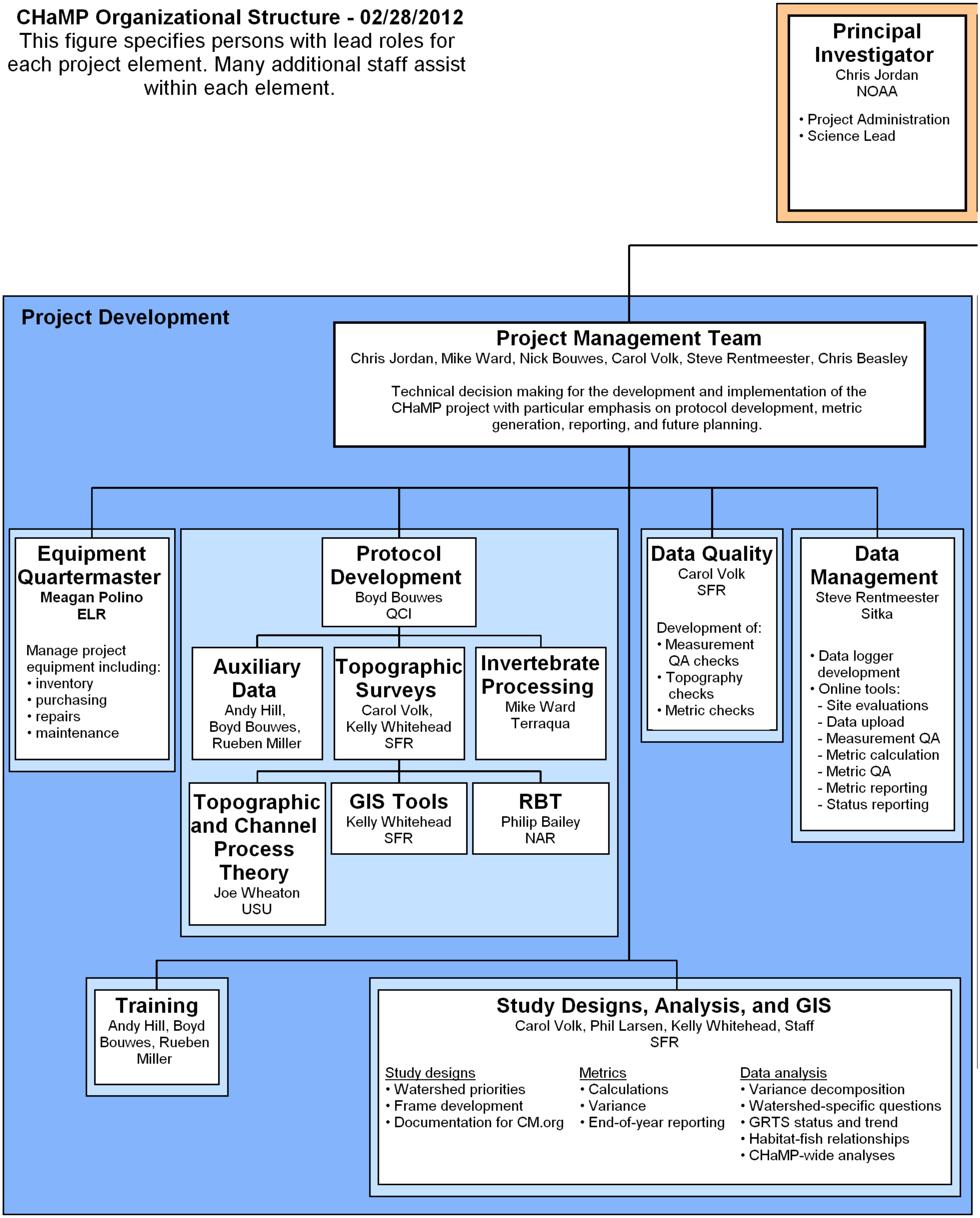
What Worked

- Participating collaborators reported that the level of coordination between CHaMP staff and regional implementers was satisfactory.
- Participating collaborators reported that discussions were open and there was an honest attempt by CHaMP staff to incorporate concerns and comments.
- CHaMP was able to participate in a limited capacity with monitoring methodology development and data management activities coordinated by PNAMP.

What Didn't Work

- There was insufficient time to fully coordinate with managers not directly involved with CHaMP in 2011.
- Regional entities not participating directly in the CHaMP pilot year may not have been well informed about its implementation and progress.

CHaMP Organizational Structure - 02/28/2012
This figure specifies persons with lead roles for each project element. Many additional staff assist within each element.



Principal Investigator
Chris Jordan
NOAA
- Project Administration
- Science Lead

Project Development

Project Management Team
Chris Jordan, Mike Ward, Nick Bouwes, Carol Volk, Steve Rentmeester, Chris Beasley

Technical decision making for the development and implementation of the CHaMP project with particular emphasis on protocol development, metric generation, reporting, and future planning.

Equipment Quartermaster
Meagan Polino
ELR

Manage project equipment including:
- inventory
- purchasing
- repairs
- maintenance

Protocol Development
Boyd Bouwes
QCI

Auxiliary Data
Andy Hill, Boyd Bouwes, Rueben Miller

Topographic Surveys
Carol Volk, Kelly Whitehead
SFR

Invertebrate Processing
Mike Ward
Terraqua

Topographic and Channel Process Theory
Joe Wheaton
USU

GIS Tools
Kelly Whitehead
SFR

RBT
Philip Bailey
NAR

Data Quality
Carol Volk
SFR

Development of:
- Measurement QA checks
- Topography checks
- Metric checks

Data Management
Steve Rentmeester
Sitka

- Data logger development
- Online tools:
  - Site evaluations
  - Data upload
  - Measurement QA
  - Metric calculation
  - Metric QA
  - Metric reporting
  - Status reporting

Training
Andy Hill, Boyd Bouwes, Rueben Miller

Study Designs, Analysis, and GIS
Carol Volk, Phil Larsen, Kelly Whitehead, Staff
SFR

Study designs
- Watershed priorities
- Frame development
- Documentation for CM.org

Metrics
- Calculations
- Variance
- End-of-year reporting

Data analysis
- Variance decomposition
- Watershed-specific questions
- GRTS status and trend
- Habitat-fish relationships
- CHaMP-wide analyses

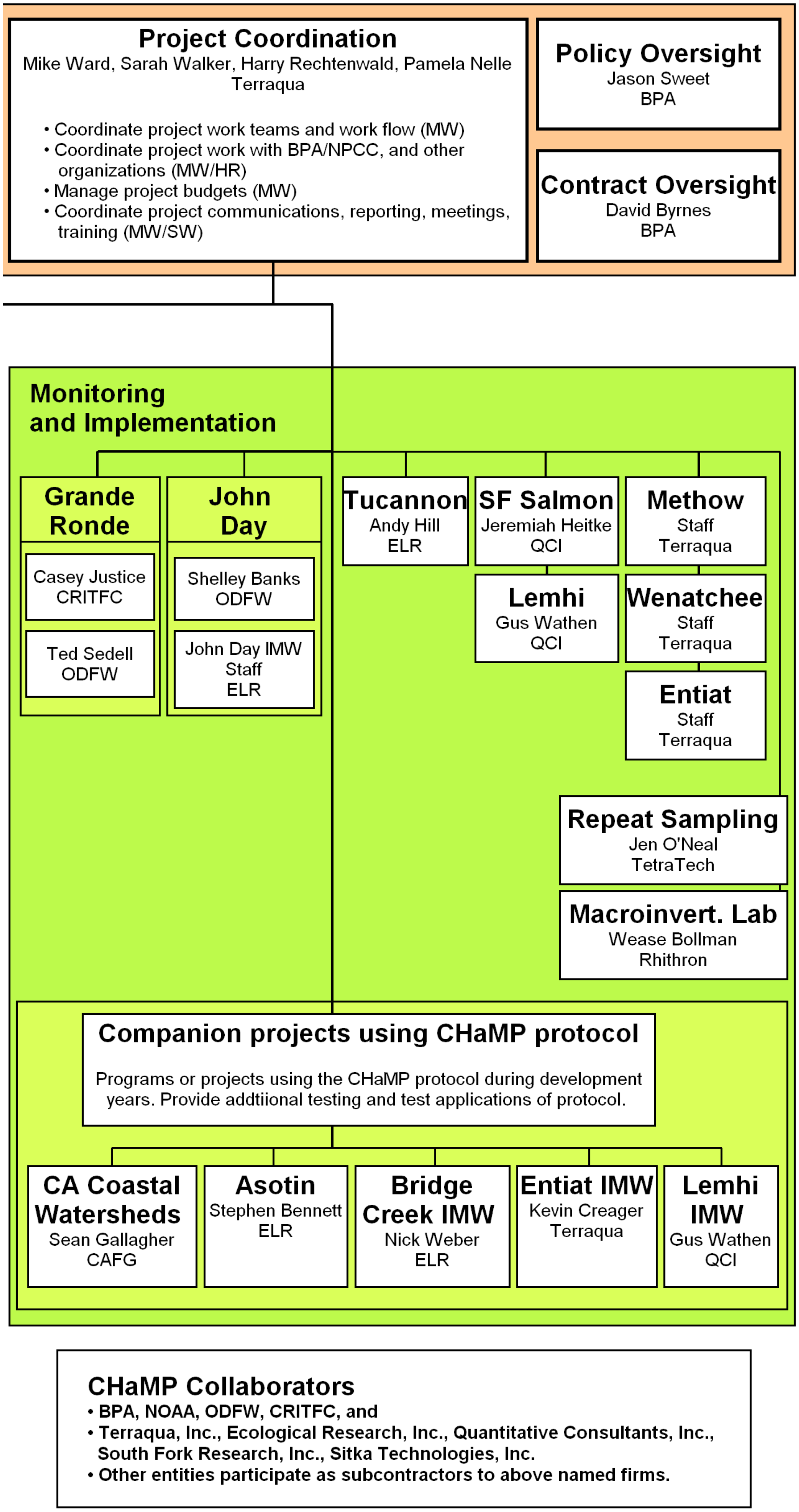


Figure 38. CHaMP organizational structure.

Coordination Process and Tools

What Worked

- The coordination conference calls promoted and facilitated communication among ISEMP/CHaMP and BPA/NPCC staff.
- A private Wiki page facilitated staff project planning and protocol development.
- Broadsheets were compiled which detailed information in a condensed, visual format for staff/management review.
- A Flow Path diagram provided a visual snapshot of the pilot year.
- The CHaMPMonitoring.org website helped disseminate mid-season decisions and any changes to the protocol, while email distribution lists facilitated mass communication.

What Didn't Work

- The different communication tools had varied levels of use and there was no central pipeline for all information throughout the season.
- The timing of the weekly coordination call made it hard for field staff to participate at times or as requested.
- The use of the Wiki diminished as project implementation progressed and the lack of a protocol for content management led to material getting buried.
- The level of detail provided by the broadsheet was not always helpful for management staff.
- The 2011 Flow Path diagram did not encompass the whole year.
- The CHaMPMonitoring.org bulk email lists were not perfected prior to the start of season and there was no "public" project staff page.

Coordination Process and Tools

A number of tools were established throughout the CHaMP 2011 pilot year to facilitate coordination and planning among core CHaMP staff and implementation leads. These included weekly ISEMP/CHaMP coordination conference calls, a CHaMP "Wiki" page, technical development process diagrams (broadsheets), project timeline flow diagrams, and electronic tools embedded within the CHaMPMonitoring.org website such as email distribution lists and crew resources.

The Wiki was established during the project and protocol development phase to enable protected sharing of information within an internet-based environment. It allowed core development staff to share internal documents and solicit feedback from other team members, helped to prioritize workload, and identified steps necessary for the completion of key tasks.

The broadsheets, developed to depict and outline the steps and timelines involved with the development of CHaMP technical, computer, and data management elements, facilitated review and feedback from staff and collaborators.

Finally, the CHaMPMonitoring.org website was developed as the "user interface" and

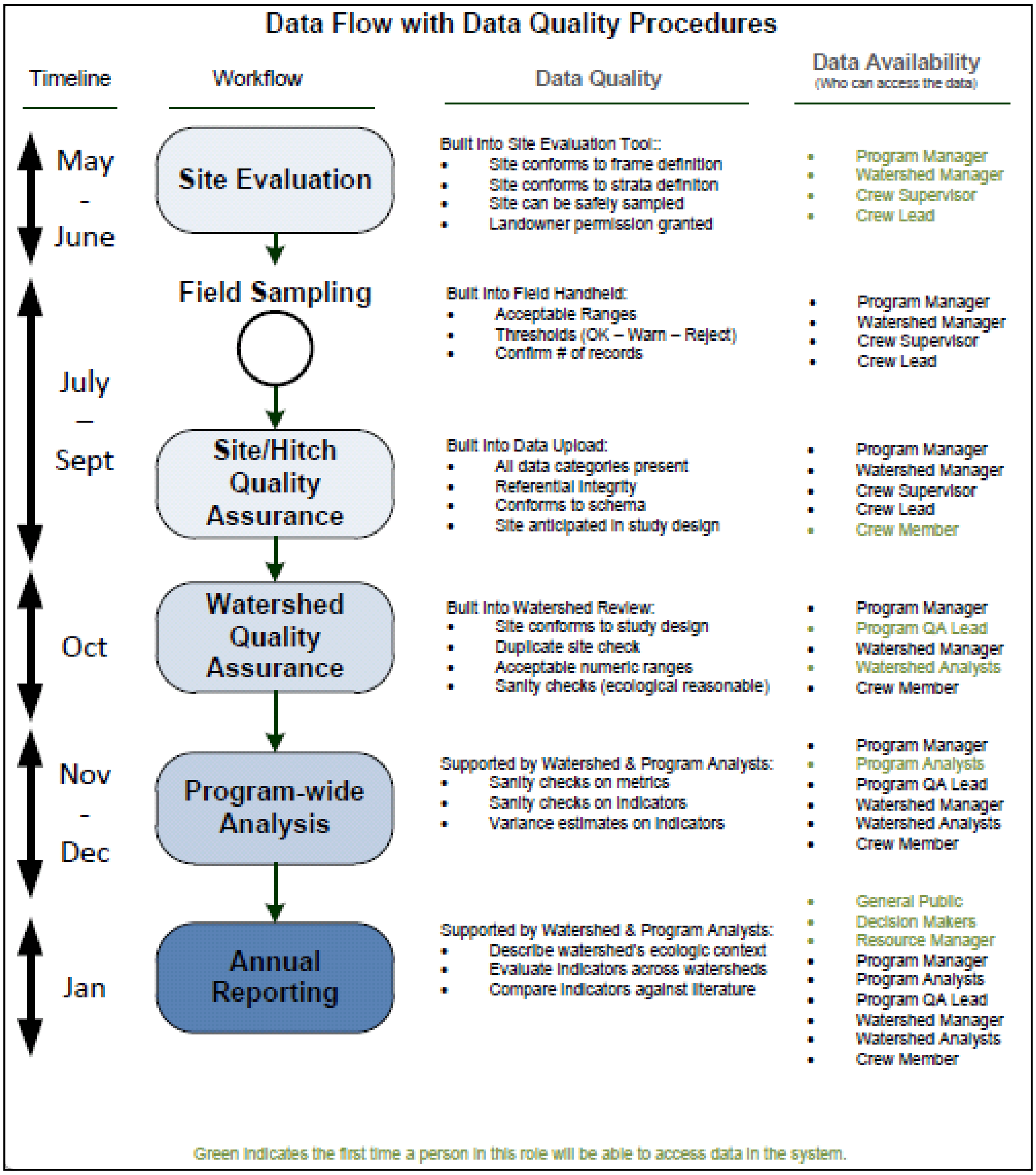


Figure 39. Broadsheet were a useful tool for coordinating scopes and timelines among the many team members. This one depicts data flow with data quality procedures.

data management system application, and also to provide public access to information about the project. The site currently contains a number of internal coordination tools that are available to registered users, such as email distribution lists and contact information.

Recommendations for 2012:

Overall, the number and type of coordination tools utilized in 2011 worked well, and familiarity with the tools improved throughout the season. For 2012, existing Wiki content should be organized (and archived as appropriate), and a management framework should be developed and implemented if Wiki use is continued beyond 2012. In addition, the use of existing visual communication tools and electronic information distribution mechanisms built into CHaMPMonitoring.org should continue and be updated and improved to address issues identified in 2011. These included improving public access to CHaMP staff contact information and maintaining updated email distribution lists. Other web-based tools (e.g., a shared calendar) should be investigated by CHaMP staff to improve overall coordination and staff and collaborator access to information. In addition, discussion should take place regarding whether it is possible for project participants to be able to log into one place for access to all tools and information for which they have been granted privileges.

For the 2012 field season project staff should reinforce the expectation that crews and project participants should check CHaMPMonitoring.org regularly for updates and to access necessary information and files. Although terrain sometimes limits internet access, crews should be asked to ensure secure and reliable internet access whenever possible. This will improve overall communication and the in-season ability for CHaMP support staff to contact crews, and for interfacing with CHaMPMonitoring.org.

Reporting

The organizational structure of CHaMP helped facilitate the development of the 2011 Pilot Year Draft Project Report since CHaMP development and coordination staff members were assigned particular roles (e.g., Quartermaster, Crew Supervisor etc.), and delegated responsibility for particular tasks. This division of labor meant it was relatively easy to compile information from the experts on each specific project element into a comprehensive document.

A post-season survey was used to collect information from all collaborators and participant levels. The open-ended format resulted in wide-ranging responses that highlighted accomplishments and issues from multiple perspectives. Requesting candid input regarding "What Worked", "What Didn't Work", and "What could be improved in 2012" facilitated organization and concise presentation of participant feedback, and enabled development of discrete recommendation sections for the 2012 season.

Recommendations for 2012:

Generally, report content should continue to be organized in a way that facilitates review of the project by managers. The report should include a review of the project as a whole, the data, and project elements, including what worked and didn't work, and what could be improved.

A post-season survey should be distributed to all project collaborators at the end of the field season. However, the format should be revised to eliminate redundancy and group information in a better way, and the survey should be distributed earlier so that target respondents have more time to complete and return it, and to avoid the risk of crews disbanding prior to survey distribution.

Reporting

What Worked

- The use and format of the post-season survey helped gather information from all project participants and develop draft report content.
- Designating technical subject matter experts allowed for a more informed and accurate end-of-season report.
- Collaborators appreciated and valued the inclusion of field staff in the post-season workshop.

What Didn't Work

- The development and distribution of the post-season survey was rushed to avoid losing crew input as they disbanded at the end of the season.
- The survey could have benefitted from more review as some areas were redundant.
- There was inadequate time for CHaMP staff to develop the report content due to an overlap with other top priority tasks such as data analysis.

Logistics

What Worked

- There were no significant issues with the logistics of field sampling other than equipment problems, most of which were human-caused.
- Mid- and late-season logistics went smoothly once stream discharge stabilized and crews had a good work flow in place.
- Time constraints were typically not an issue as crews identified sites that would need more time or personnel and planned accordingly.

What Didn't Work

- Too much time was spent early in the season trying to find sites below bankfull or with flows appropriate for sampling.
- Where sites were not scouted this added more logistical maneuvering for the entire crew and had the potential to slow sampling.
- Establishing benchmarks, monuments and site markers was sometimes time consuming.
- It took more time than expected in the beginning for crews to establish a smooth work flow.

Field Sampling and Protocol Implementation

The CHaMP 2011 pilot field season presented many opportunities to develop and test a habitat monitoring effort that combined traditional fish habitat methods with geomorphic surveying techniques using state-of-the-art tools and technology. Since CHaMP is a new project that uses highly sophisticated tools, implementation challenges arose for both development staff and field technicians.

The sections that follow review implementation from the following perspectives::

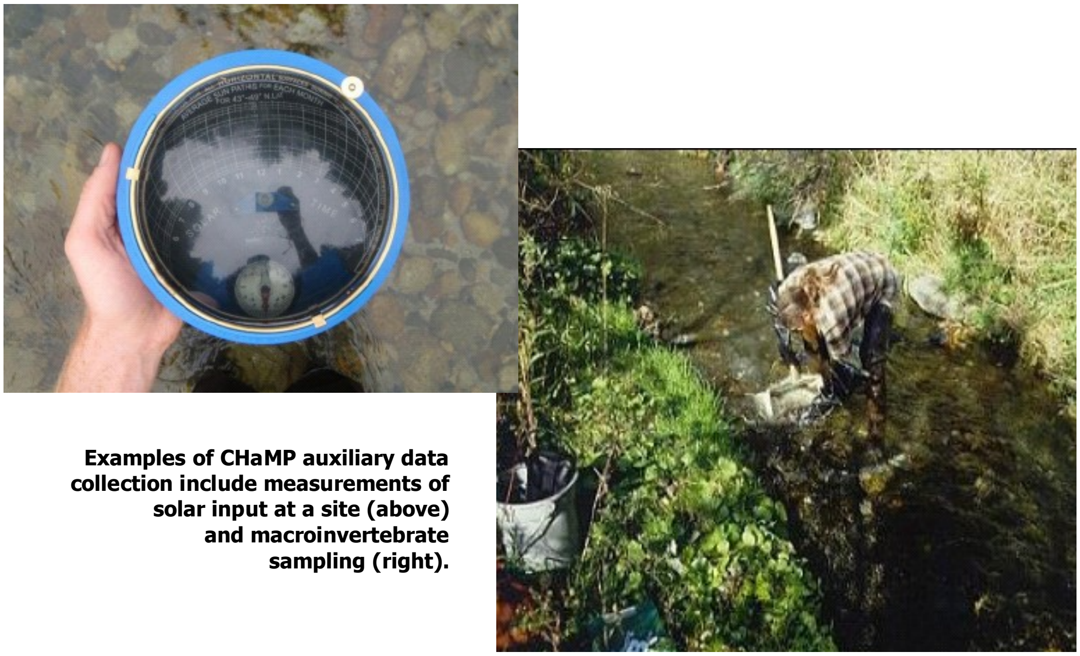
- Could crews implement the protocol as written within the allocated amount of time? (Logistics and Feasibility).
- What were the specific issues associated with field sampling and, perhaps most importantly, could crews implement the protocol in a standardized manner? (Topographic and Auxiliary Data Collection and Standardization) .

Content that follows is based on feedback solicited from everyone who participated throughout the 2011 field season.

Logistics and Feasibility

The CHaMP protocol was designed for a three-person crew to be able to complete both topographic and auxiliary data collection at a site within a two-day period.

- **Topographic surveys** provide a georeferenced spatial context for the channel morphology. This part of the protocol captures stream geomorphic features, including maximum pool depths and crested depths, thalweg profile, bank characteristics, channel unit perimeters and other channel topography extending to the first floodplain or other elevations beyond bankfull.
- **Auxiliary data collection** involves channel unit-level measurements and information used to derive site-level metrics. Channel unit-level measurements include LWD counts, fish cover estimates, and ocular estimates of substrates. Pool tail fines and pebble count measurements are collected in a subset of channel units. Site level information includes water quality measurements, site and solar pathfinder photos, riparian cover estimates, and macroinvertebrate drift samples.



Examples of CHaMP auxiliary data collection include measurements of solar input at a site (above) and macroinvertebrate sampling (right).

As context for the discussion of logistics and feasibility of implementation, a description of the overall field sampling work flow is provided below.

Field Sampling Workflow

To start, the survey crew lay out the site, with two crew members monumenting the bottom of the site and working upstream to the top placing transect flagging. The third crew member establishes monuments, benchmarks, control points, and potential survey set-up locations.

Once a site has been laid out, two crew members begin the topographic survey, while the third crew member identifies and flags channel units and collects auxiliary data that is used to determine the condition of salmonid habitat for all life stages within the Columbia River basin. Once the survey is complete, all crew members remove flagging from the site.

After a crew completes data collection at a site, the protocol calls for a review of the data to help ensure the site was surveyed accurately and completely, and to check that all data required for subsequent analyses has been collected (e.g., auxiliary data QC/QA and uploading to the CHaMPMonitoring.org, topographic survey data post-processing with CHaMP GIS tools, and RBT metric calculations).

Overall, field sampling as outlined in the CHaMP 2011 protocol was feasible, and nearly all sites were completed within the maximum two-day period. This is encouraging given both the amount of time required for topographic surveys and auxiliary data collection at a site, as well as the steep learning curve associated with some of the equipment.

Recommendations for 2012:

Supervisors identified distinct differences in crew work flow that arose from differences in crew members' experience and comfort with topographic surveying and data management techniques. A number of recommendations for incorporation into the 2012 protocol were made. For example, the instructions to crews for locating and laying out sites, and how sites are sampled, either as a single site within the recommended period, or as a group of sites within a work hitch, should be improved. Also the use of scouts could improve efficiency if they perform various aspects of site layout in advance of the arrival of survey crews. Moving to use of a four-person crew, or having a fourth person available for more challenging sites, was also recommended.

In early 2012, the CHaMP development team will be evaluating all recommendations and potential mechanisms to improve logistics and the overall feasibility of implementing the protocol. Additional guidance supplements and/or changes to the protocol will be developed prior to the start of the 2012 field season to improve overall implementation success.

Feasibility

What Worked

- Overall, the CHaMP protocol proved feasible to conduct in a day for smaller sites (<12 m) with little complexity and brush; at larger (>12 m), more complex and brushy sites it was usually feasible to complete both the auxiliary and topographic portions of the survey in two days.
- Scouting helped with planning, establishing benchmarks, placing temperature loggers, and identifying streams that should be sampled early or late season, all of which helped streamline the sampling process and gave crews more time to focus on data collection.

What Didn't Work

- There was a steep learning curve and it took some time for crews to become efficient at complete protocol implementation.
- We underestimated potential problems associated with site complexity, high flows, relearning aspects of the protocol after training, traversing with the total station, and work flow, which had to be addressed early in the season.
- The very large, brushy sites were challenging to survey prior to delivery of 4.5 m rods.
- Measuring the solar input was time-consuming due to number of photos required.
- Establishing the site layout, benchmarks and markers was time-consuming.

Auxiliary Data Collection

What Worked

- Standardization was at an acceptable level for the pilot year, aided by the site layout process and the repeatability of survey components.

What Didn't Work

- The more subjective measures were less repeatable and difficult to standardize, even from crew member to crew member.
- The delineation of channel units was highly influenced by stream discharge and crews were inconsistent in determining channel units at the tier two level.
- Undercuts were not well represented in the fish cover measurements.
- Measuring particle size distribution and embeddedness was time consuming and embeddedness was applied inconsistently.
- Algae mats made it difficult to count qualifying fines in the pool tail fines measurements, which were also hard to conduct during high flows or turbidity.
- The large wood categories may underestimate the amount of wood at a site.
- Stream discharge was difficult to conduct in small streams or at low flow as the flow meter not sensitive enough, and holding the rod at 60% depth did not produce the most accurate and repeatable measurements.
- The ability to make consistent comparisons of deciduous riparian cover across sites or years may be limited by the season in which the estimate is made.
- The allocation of macroinvertebrate drift sampling time varied dramatically.

Topographic and Auxiliary Data Collection and Standardization

As mentioned previously, auxiliary and topographic data collection comprise the bulk of the CHaMP field sampling protocol. Topographic survey data collection was found to vary among crews, with respect to site layout techniques, the number of points collected, overall survey extent, and survey accuracy. Fortunately, many of the issues that were identified will be relatively easy to correct through training prior to the 2012 field season.

Crew supervisors reported that many of the auxiliary data collection components of the protocol that were quantitative in nature were fairly straight-forward, while qualitative elements of the protocol, such as cobble embeddedness, often presented challenges for crew members, both within and across crews.

Feedback from the 2011 season also identified the need for more definition and guidance for some elements, such as defining time of day and/or length of sampling period for some measurements/metrics, such as macroinvertebrate drift sampling. Sampling in 2011 also revealed that the protocol may not adequately capture important habitat cover features (e.g., undercut banks). Crews and supervisors also identified the need for more precise (e.g., flow meters), and more efficient (e.g., Solometric Suneye) field equipment and tools.

Additional discussion about proposed changes to the protocol for 2012 is provided on pages 69 while equipment information may be found on 70.

Macroinvertebrates: Sample Collection and Processing Procedures

Rhithron and CHaMP staff met after the field season to review macroinvertebrate sample results and discuss possible changes to training, equipment, and the protocol to improve the 2012 season. Overall, compared to samples collected by other programs, (e.g., NOAA and WDOE) the samples collected under the CHaMP protocol had significantly more debris (and sometimes more insects). This suggests that the CHaMP protocol, or how it is implemented, should be examined and altered as necessary to improve the data.

Sample handling and processing methodologies were both reviewed. Sample processing methods will be evaluated for the 2012 season, particularly with respect to metrics and the level of taxonomic detail needed to inform NREI modeling, as well as exploring weighing samples to derive biomass. Sample handling was found to be inconsistent in terms of use of preservatives, labeling and shipping. Specifically, samples were not stored in enough alcohol or an improper ratio of alcohol to water was used, some samples were unusable due to drying, improper storage or delayed shipment, and some labels were unreadable or inaccurate. To address these issues, Rhithron staff have outlined methods for storage and shipping to improve overall sample quality in 2012.

Recommendations for 2012:

Field sampling went well in 2011 considering that it was a pilot year. However, crew and supervisors identified a number of improvements needed in the areas of auxiliary and topographic data collection.

Additional training was identified as a primary means to improve crew auxiliary data collection in 2012, particularly with respect to channel units. Improvements in accuracy and the ease with which some habitat measurements are collected can be achieved through the use of different equipment, for example, using a flow meter calibrated for lower flows, or switching to a different instrument for solar input measurements.

Crew topographic survey inconsistencies were largely due to systematic survey and/or post-processing errors. These can be corrected post-hoc or avoided altogether in 2012 through additional training and conducting visual checks of the data while in the field. Numerous 2011 project participants identified the need for and importance of additional crew training in Total Station use, topographic data post-processing, and data layer production, (i.e., DEMs and TINs). Training in 2012 should be adjusted to provide this extra focus.

Topographic data collection was sufficient in 2011 for change detection analyses; however, additional guidance should be provided on how far outside of the active channel to extend surveys. Due to the steep learning curve associated with topographic data collection and post-processing, an effort should be made to retain 2011 CHaMP crew members for the 2012 season to help improve overall work flow and ensure quality surveys at every site by every crew.

Additional training and clarification about drift sampling techniques (sampling, preservation and shipping), combined with modifying the nets, should improve overall sample quality. Samples may need to be sent on a weekly basis after the end of a hitch.

Topographic Data Collection

What Worked

- The establishment of benchmarks, site markers, and monuments created permanent sites that crews can relocate and use in future surveys.
- Collecting and processing the data in the same work hitch helped with data consistency and QC/QA.
- The topographic survey point collection method augmented with breaklines created robust TINs and DEMs, while the breaklines, thalweg, and top and toe of banks data tightened up surveys.

What Didn't Work

- Work flow divergence among crews resulted in differing levels of understanding of the data being collected and how to best collect topographic data in different subbasins and under varying flow regimes.
- Crews collected substantially different amounts of lines and points such that differences in breakline and point collections were evident.
- The topographic survey description codes were applied inconsistently throughout the study area.
- The habitat unit perimeters were inaccurately delineated by crews during post-processing by point skipping along wetted edges.
- Not all the topographic points important for the RBT calculations were captured in the topographic survey.
- The goal of a certain number of sites/year may have been met by sacrificing other elements such as data quality or skipping difficult sites, etc.

Troubleshooting and Field Season Assistance

What Worked

- Collaborators felt an honest attempt was made to keep communication channels open between CHaMP coordination staff and field implementers.
- The CHaMP emergencies field crew assistance framework was efficient and facilitated rapid responses to issues that arose.
- The combination of all support routes, for example, phone, website, email, and technical subject matter staff assistance resulted in minimal down time.
- Closely tracking problems and solutions facilitated others learning from previous issues, eventually eliminating the recurrence of such issues.
- Appointing a lead for communication with dealers and representatives resulted in positive business relationships and eliminated the potential for multiple parties calling a vendor with the same problem.
- The troubleshooting conference calls early in the season facilitated the ability of technical subject matter experts, crews, and equipment staff (i.e., Juniper, Nikon reps) to identify issues and solutions.
- Equipment malfunctions in the field were generally handled swiftly, with replacement equipment delivered promptly to allow crews to keep working.
- The CHaMPMonitoring.org website was very useful for consolidating all the necessary information for CHaMP implementation, including data management, QA/QC, and disseminating changes to software and the protocol.

Troubleshooting and Field Season Assistance

Not surprisingly, considering it was the pilot year of the project, many issues came up during the 2011 season. Topics included protocol implementation, site selection, equipment, data processing, as well as general help questions concerning software use to responding to damage to expensive instruments. Response time to issues varied depending on complexity, for example, issues relating to software bugs, data processing and management often took a longer time to resolve than issues related to site selection.

A virtual switchboard consisting of a designated email account and phone number to call

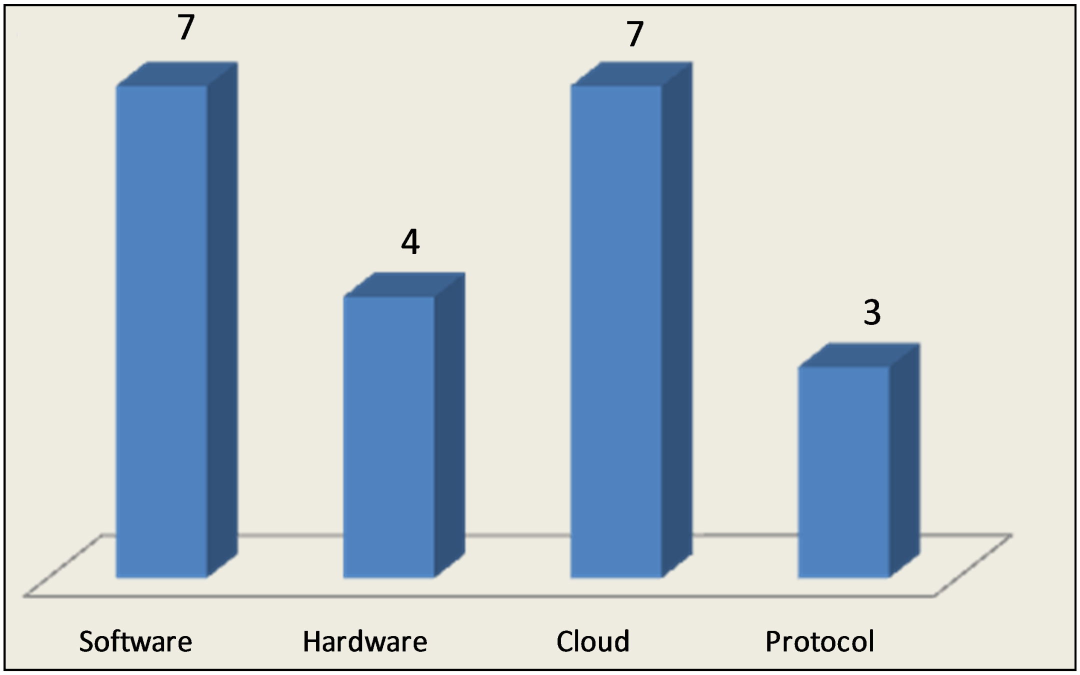


Figure 40. Type and number of help requests directed to CHaMP emergencies email account or phone line, July-August, 2011.

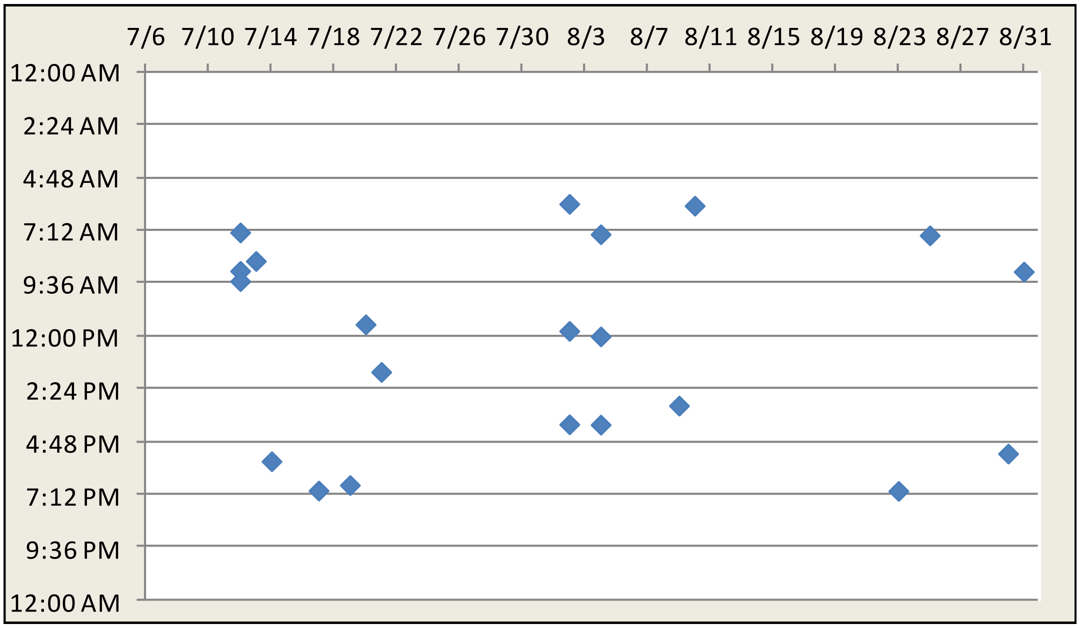


Figure 41. Distribution (date, time of day) of CHaMP emergencies contacts, July-August 2011.

for support was established as part of an overall field crew support framework. The email and phone number were staffed from approximately 6 a.m. to 10 p.m., 7 days a week during the field season, in order help prevent crew down time.

If an issue was reported via the CHaMP emergencies framework it was directed to the appropriate technical subject matter expert. This facilitated problem solving in a timely and appropriate manner and allowed documentation of the issue so that if similar problems should occur in the future, a solution was already in place for referral. However, some issues were reported through direct communication with subject matter experts, rather than via the CHaMP emergencies framework, and while both approaches worked well, the initial response time was faster if the issue was routed through CHaMP emergencies.

Early in the season, a discussion forum was also established to facilitate collaborator information and dialogue related to GIS and topographic data post-processing issues. As the season developed, a "Crew Resources" page was added to CHaMPMonitoring.org to further define appropriate routes for assistance, post notices about critical software updates, etc.

Issues seemed to taper off significantly towards the end of the active field season. This may be a result of crews consulting existing information on known issues and then implementing the fix while in the field, or simply because many of the technical and mechanical kinks were worked out as the season progressed.

Recommendations for 2012:

The CHaMP emergencies support framework should continue into the 2012 field season and the existing reporting and response mechanisms should be evaluated and modified as needed, including evaluating the utility of, and potential ways to improve use of, the online forum by crew supervisors and members.

Identifying specific contacts and the best way to contact them for immediate support on equipment problems (e.g., total station), and general troubleshooting will streamline the response time. Also, providing a document for field crews and supervisors prior to the start of sampling on common errors and how to troubleshoot them, or where to download a fix and how to upload it would also be useful.

Troubleshooting and Field Season Assistance

What Didn't Work

- Resolving the data logger and software issues was slow and caused some crews to resort to paper datasheets for the majority of their field season.
- Actual supervisor and crew use of the online forum established to document GIS processing issues and share potential solutions was disappointingly light.
- Some crews did not always have reliable or regular internet access, making it hard at times for CHaMP support staff to establish communication regarding important information and updates.
- Emails sent directly to technical subject matter experts were not always cc'd to the CHaMP emergencies framework, and this hindered the ability to maintain current documentation of all the issues and their resolutions.

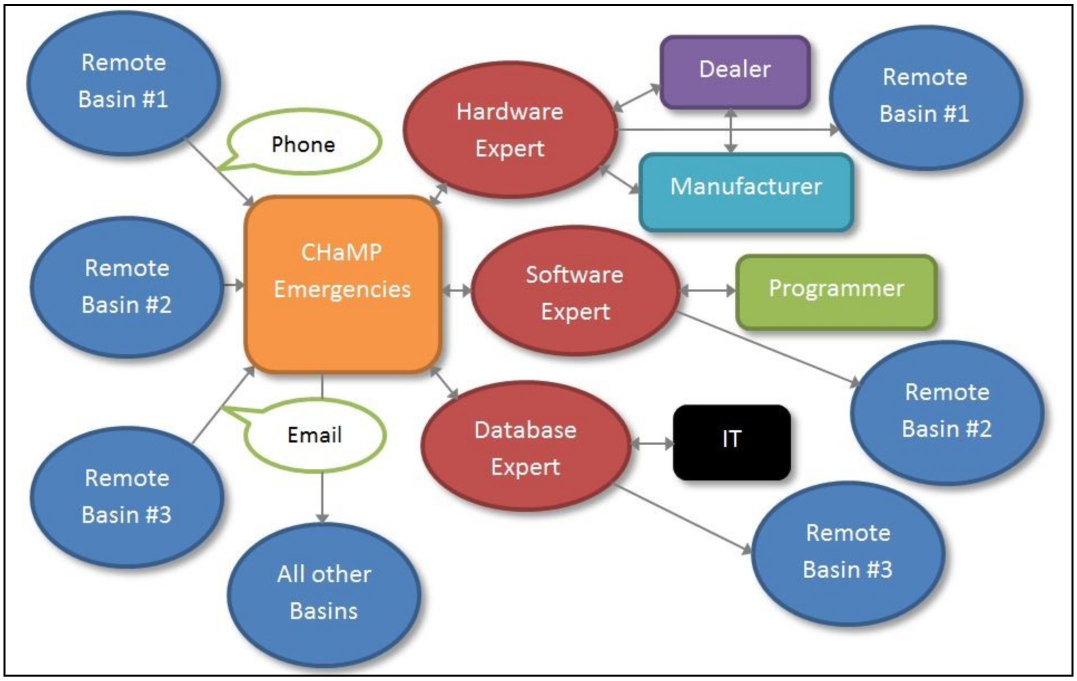


Figure 42. "CHaMP Emergencies" troubleshooting Chain-of-Action.

Feasibility and Implementation of Variability Studies

What Worked

- The study design was implemented and all 25 sites were successfully sampled.
- Many sites were completed quickly and most crews did not have to travel far or significantly alter schedules to complete the extra sites.
- Many implementation questions were addressed through a document that provided survey crews with the information needed to survey the revisit sites.

What Didn't Work

- Hasty development and limited preparation time prevented early GIS processing and distribution of critical requirements and standardized instructions.
- The variability study was difficult for some collaborators to implement due to staff structure and the cost of travel.
- Some decisions were made days before or during crew sampling so that planning logistics and providing direction to the sampling locations was difficult.
- Late changes resulted in lost crew time, decreased efficiency in the field, and significant data alignment problems that took many days to repair.
- Communication between study designers and watershed managers was insufficient during study planning and implementation.
- The specific responsibilities of crew supervisors and members with respect to the repeatability survey planning and quality control were never defined.
- Low flow created problems with sampling at three of the smaller sites.

Feasibility and Implementation of Variability Studies

The variability studies implemented in 2011 included a basin-wide revisit design to examine temporal variability among sites and the repeatability of the protocol, and a crew-to-crew variability design to assess crew and stream size variability.

Collaborator feedback regarding the feasibility and implementation of the variability studies varied greatly and resulted in many recommendations for 2012.

Recommendations for 2012:

Two variability studies were successfully implemented in 2011. To improve these studies in 2012, coordinators should select resurvey sites in advance of the sampling season, improve benchmark establishment, ensure native crews leave control point pins for resurvey crews, and assess whether 2011 benchmark elevations, bearings, GIS transformation, or a resection of a survey will be used for repeat sites, and if so, incorporate this information into the total station. Communication should be improved to include a more efficient means of relaying information about where, when, and how many sites will be sampled. Efficiencies may also be gained through coordination between watershed managers and resurvey crews well ahead of the survey period.

For any variability studies conducted in addition to core CHaMP project implementation in 2012, additional funds may be needed for items such as overtime and travel expenses in order to retain crew participation in some watersheds.

Basin-Wide and Crew-to-Crew Studies

- For the basin-wide study, 25% of all sites were revisited (total = 25 sites). At least two sites in each CHaMP watershed were revisited by a crew from another CHaMP watershed.
- The crew-to-crew study utilized seven crews to visit six sites where the sites were either (A) three small and three large sites or (B) similar to the most common size class of sites (3rd order streams) that were most likely encountered throughout the sampling universe of all CHaMP sites.

Scope of Changes to the Protocol (including non-standard metrics) Before 2012

Changes to the habitat protocol will involve a heightened level of collaboration including the invitation of full participation from all collaborators. Subject area workgroups will be established for auxiliary data, topographic surveys, equipment, drift invertebrate sampling, and perhaps other subject areas. For metric and method changes, it is critical that discussion focus on both whether a metric or method should be changed prior to a full 3-year cycle of field implementation, in addition to what changes should be made.

Changes to the protocol will continue to follow the metric inclusion rule set described in the 2011 protocol. For general content changes, collaborators recommended that, prior to the start of the season, crew supervisors and members should go through each element of the protocol and identify where language is vague in regard to sample procedures, (e.g., develop clearer definitions of woody shrubs, provide a clearer definition of wet versus dry wood) and the protocol should be updated after training to address issues that may have arisen. Methods to document confusion or uncertainty about the protocol in-season should be developed so issues can be addressed in protocol addenda as the season progresses. These are good ideas that will be explored during the 2012 protocol development process. Meetings and discussions with collaborators about the CHaMP protocol and changes for 2012 will continue so that sufficient time is available to evaluate and incorporate proposed changes prior to start of the field season.

Equipment - Field Performance

What Worked

- The Nikon Total Station units were adequate, lightweight, packable, and performed well with minor issues.
- The Allegro data logger was adequate for field use, and performed well in the rain, with adequate battery life.
- The Solar Pathfinder was adequate and using a tripod made leveling and orienting it much easier.
- The laptop computers performed well, had adequate memory for intensive tasks like GIS, and using comparable computer equipment helped standardize crew data management and work.

Equipment

Performance in the Field

Crews experienced some technical issues and a learning curve with the new equipment, as would be expected of any pilot year. For the most part, the equipment was high quality and adequate to the task, although some equipment did not perform as well as was anticipated. Overall, the more technical equipment was more temperamental in the field than less technical gear.

Hurried buying may have contributed to equipment performance issues. For example, the total station evaluation process put portability above quality, resulting in the purchase of a model that was at times slow to collect shots which ultimately resulted in a significant slow down in some surveys.

At times, the learning curve associated with high-tech instruments and electronic data management complicated use in the field. In response to early season equipment issues a CHaMP emergencies technical support framework was created to identify and track problems, and communicate solutions in an efficient manner.

Recommendations for 2012:

Overall, more extensive field testing of new equipment and software should be conducted prior to the 2012 field season. A better inventory control system will be put in place to ensure that equipment is managed better among and within crews.

The following list of recommendations represents only a portion of the feedback that was received from crews. The bulk of technical comments on methodology will be considered during the 2012 development process and will be captured directly within the 2012 CHaMP habitat protocol.

Total Station:

- Training and field support will be improved to more efficiently address issues and troubleshooting (e.g., especially directions for calibrating total stations).
- Use a heavy-duty tripod and attached prism instead of a bipod to improve efficiency and produce more accurate back
- sight checks; consider larger prisms for use with backsights.

Data Loggers:

- Equip new data loggers with an internal GPS and improve workflow to avoid transcription errors.
- Significant improvements to the field utility of the data logger should be made before the 2012 season. If an additional data logger was provided to each crew (e.g., especially for scouting, benchmarks, and site layout) or scouts were used to perform some work in advance of the arrival of crews, work flow could be significantly improved.

Auxiliary Measurements:

- Significant changes should be considered for the riparian measurements, including investigating the use of the Solametric Suneye for measuring riparian cover instead of the 2011 ocular estimation procedures. This meter would also be an improvement over the Solar Pathfinder tool.
- Significant improvements could be made to the drift net setup to improve performance. Similarly, the handling and shipping of drift invertebrate samples can be improved significantly in 2012 to improve sample integrity.
- Upgrade to flow meters that can measure flows at depths <10 cm and discharge <0.1 m/s to quantify drift and discharge in low flow conditions on small streams.

Software Applications and Raw Data:

A number of issues arose in 2011 related to data logger software bugs and versioning, particularly early in the field season. For 2012, ample time should be provided to beta-test all software applications (e.g., data logger, total station) prior to training and field use. Suggested improvements include:

- Ensure changes to field data logger and database software (and to a lesser extent, GIS processing requirements) are more tightly coupled to enhance compatibility.

CHaMP uses a large amount of "high tech" equipment for topographic and auxiliary survey data collection, including Total Stations and hand-held data loggers running custom software applications.

Equipment - Software Applications and Raw Data

What Worked

- The Foresight and GIS programs were user friendly, facilitated survey data editing, and enabled novice users to create DEMs.
- The data logger application performed well once bugs were worked out and streamlined data upload.

What Didn't Work

- The crews' ability to shoot features like bars was constrained by which codes could be converted into GIS as a line.
- Bugs in the data logger application necessitated four version updates throughout the season, with some data lost and some auxiliary data entered into Excel instead of the logger.
- It was difficult to visually evaluate raw data on the logger, while the multitude of directories and .csv files created were cumbersome and made visual quality checks difficult after data collection.
- Translating GPS information verbally or from a hand-written data sheet created an opportunity for significant error that could require a site revisit.
- Merging information from the logger and paper forms was difficult when two crew members collected data.
- The total station software was unreliable and versioning updates throughout the season were difficult to distribute and created data file compatibility issues.

- Complete data logger application development well in advance of the field season, provide ample beta-testing, and ensure faster turnaround time on any logger application updates during the field season.
- Explore modification of some of the specially designed tools used in the execution and processing of surveys to accommodate other software and hardware platforms. This would promote other organizations to incorporate the CHaMP protocol using qualified survey equipment deemed appropriate according to a modified list of attributes constructed by CHaMP collaborators. However, all software and hardware platforms used must output data in a format common to the entire project and consistent with the specifications of the data management system.

Equipment - Field Performance

What Didn't Work

- Total station issues included:
  - loss of lines when auto-line work was turned on.
  - taking >30 seconds to shoot a single point; slow response if batteries not full; refusal to take points after long use.
  - occasional crashing/ freezing required battery removal and/or shut down/restart.
  - producing shots consistently higher or lower by ~1.5 m while in reflectorless mode.
  - challenging to use on very sunny days (glare).
- Data logger issues included:
  - would stop responding and require reset (in office and field).
  - touch screen would freeze , require reboot.
  - would not turn back on after it was powered off.
  - cloth case didn't fit well, fell off at times, provided little extra protection.
- Solar Pathfinder didn't perform as well as expected; top piece scratched easily, unit was hard to use in the rain.
- Pool tail fines grid material was not durable.
- Flow meters not waterproof or sensitive enough for low flows.
- Bipod not practical for use in windy conditions, inaccurate backsight checks.
- Mini prism was difficult for total station to shoot at distances over 50 m; problem became greater with increased distance; tendency to get unexplained vertical and horizontal errors.
- Camera photo number rollover issue caused errors.

Equipment - Bulk Purchasing

What Worked

- All of the field equipment was successfully ordered, assembled, and distributed.
- Bulk purchasing was advantageous in that it:
  - created substantial discounts and cost savings,
  - standardized gear among the field crews,
  - ensured that equipment was ordered by individuals expert in that field,
  - Triggered free vendor field training, software upgrades and updates,
  - promoted a higher level of customer service from manufacturers and dealers,
  - ensured customization requests were fulfilled, and
  - reduced paperwork and the logistics needed to reimburse equipment purchasers or organizations.
- The Quartermaster role improved gear organization and distribution, allowed centralized tracking of different pieces, eliminated duplication of effort, and focused identification of repair needs.

What Didn't Work

- Shipping costs added up when gear was sent between the inventory storage base and other subbasins.
- Multiple buyers, even if for different types of gear, caused some confusion and inconsistencies, as purchasing processes varied slightly between organizations.
- Gear storage in more than one location was inefficient and made it difficult to track items in a single database.

Bulk Purchasing: Quartermaster Approach

While BPA provided funding for the purchase of all the necessary equipment for CHaMP implementation in the pilot watersheds in 2011, the use of a bulk purchasing approach resulted in significant project cost-savings ($106,000; see Figure 43) . Purchasing tasks were divided among a few development team participants, depending on their expertise, and large quantities of like equipment were procured by a sole buyer.

Once all the necessary equipment had been purchased, each item was assigned an identification label, as only electronic items came with serial numbers. The equipment was then grouped into kits and distributed by the CHaMP coordinators to managers of each pilot watershed at CHaMP Camp.

Early into the field season, the role of gear Quartermaster was developed to centralize equipment inventory tracking, assess maintenance needs, and provide gear distribution and crew support.

Recommendations for 2012:

In 2012, a single CHaMP contractor should be used to buy all the equipment in bulk since bulk purchasing saved substantial amounts of money during the 2011 pilot year and one contractor will avoid the confusion seen in 2011 with variations in purchasing processes among contractors. However, providing some leeway for each watershed to purchase relevant gear during the field season for efficiency of use should be explored.

The Quartermaster should be available for crews as a primary point of contact for equipment troubleshooting, replacement of broken or malfunctioning instruments, and to assign and coordinate delivery of gear to appropriate basin locations. The Quartermaster should also be responsible for ensuring proper maintenance and expediting all necessary repairs, and should continue to work with collaborators to develop budgets for new gear and maintenance of old gear as necessary.

For 2012, all of the gear should be stored at one base location while not in use, and a database should be maintained that tracks all items bought with CHaMP funds.

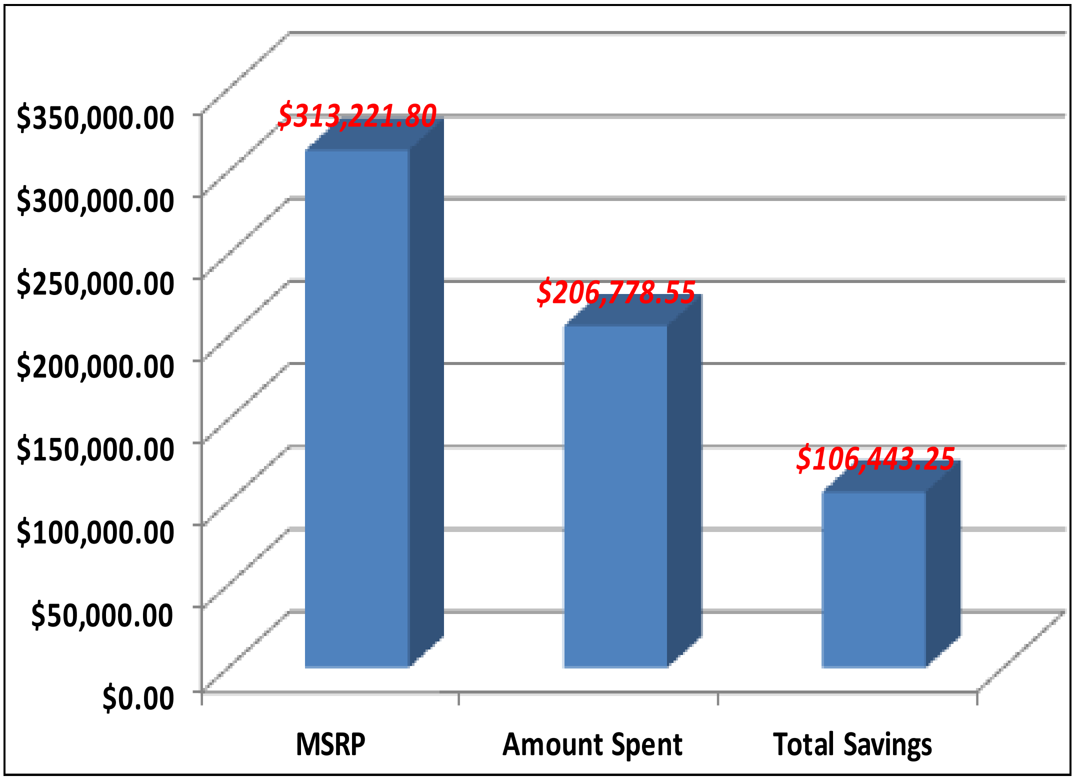


Figure 43. Dollars saved on CHaMP survey equipment through the use of bulk purchasing.

Consumables

CHaMP coordinators used BPA funds to purchase a limited number of consumables that were appropriate for accomplishing particular surveying tasks, such as preservative for macroinvertebrates, flagging, tape, labels and zipties, etc, and were necessary to demonstrate that the tools being recommended by CHaMP were feasible. These consumable items were provided to pilot basins at the start of the 2011 field season. However, prior to start of the season it was not formally agreed that if project managers continued to use the CHaMP tools they would replenish the consumables once their initial supply diminished.

Although the consumables used were typically fairly inexpensive, costs added up when large quantities became involved, and distribution was difficult, and nor was the CHaMP equipment fund set up to replenish consumables throughout the season. While the distribution of consumables helped with training and early season surveys, the way these items are handled should be modified for 2012. Managers of each funded basin should be supplied with a detailed list of necessary consumables as well as other suggested items that they will be responsible for purchasing pre-season.

Recommendations for 2012:

Only the more expensive, non-consumable CHaMP equipment items should be provided to the funded basins. Collaborators should be expected to take care of their respective CHaMP kit and expedite routine maintenance and repairs as needed. In addition, CHaMP watersheds that may have access to equipment other than the supplied kit should be allowed to use it, potentially increasing their level of productivity, although this should be balanced with protocol standardization and program-level data management.

Equipment - Consumables

What Worked

- Providing the necessary consumables at training illustrated the appropriate items to use for specific tasks.
- Supplying consumables eliminated the possibility of organizations showing up to training without the appropriate supplies.
- Individual crews purchasing their own consumables mid-season ensured purchases were specific with respect to item and quantity.

What Didn't Work

- Providing consumables during training encouraged crews to expect replenishment by CHaMP which may have resulted in less responsible practices.
- Replenishment of consumables during the season became a time-consuming task for buyers and CHaMP training organizers.

By purchasing in bulk, the CHaMP project saved over $100,000 in 2011.

ITEM	QTY	LIST PRICE	OUR COST	EXT. QTY	EXT. PRICE	EXT. DISC. PRICE	SAVINGS
Nikon Nivo 5C w/ Optical Plummet	1	$10,995.00	$7,412.35	23	$252,885.00	$170,484.05	$82,400.95
Incl: 2 Li-Ion Long Life Batteries, Charger,							
USB Cable, Tribrach, Plastic Carrying Case							
Foresight DXM Office Software	1	$399.00	$0.00	23	$9,177.00	$0.00	$9,177.00
Foresight 2.2.5 EDM and Contour Software	1	$1,200.00	$820.00	10	$12,000.00	$8,200.00	$3,800.00
Metal Topo Foot for Prism Pole	1	$15.00	$11.00	23	$345.00	$253.00	$92.00
Sokkia Heavy Duty Wood/Fiberglass Tripod	1	$225.00	$195.00	23	$5,175.00	$4,485.00	$690.00
Seco 2.6m Ultralight Prism Pole	1	$169.95	$115.00	23	$3,908.85	$2,645.00	$1,263.85
Seco 4.7m Ultralight Prism Pole	1	$271.95	$185.00	23	$6,254.85	$4,255.00	$1,999.85
Seco Mini-Bipod w/ Thumb Release	1	$167.95	$118.00	23	$3,862.85	$2,714.00	$1,148.85
Seco Tilting Mini-Prism Assembly	1	$165.00	$115.00	23	$3,795.00	$2,645.00	$1,150.00
Seco Standard Locking Prism System	1	$159.00	$136.50	23	$3,657.00	$3,139.50	$517.50
Lufkin Metric Pocket Tape	1	$10.75	$9.00	23	$247.25	$207.00	$40.25
Extra Li-Ion Battery Pack for Nivo C	1	$125.00	$80.00	46	$5,750.00	$3,680.00	$2,070.00
18X Eyepiece for Nivo C	1	$268.00	$177.00	23	$6,164.00	$4,071.00	$2,093.00
Total Package Price		$14,171.60	$9,373.85		$313,221.80	$206,778.55	$106,443.25
Pricing includes two days training, two years warranty, two years software updates						Overall Savings of 34%!	

Table 6. Survey equipment pricing showing specific bulk purchasing discounts.

Equipment - Inventory, Service and Maintenance

What Worked

- Using the Quartermaster to manage equipment inventory eliminated the challenges of coordinating among multiple locations.
- A unified inventory database consolidated all the relevant information about the equipment disposition.
- A single shipping account made it easier to keep track of equipment movement and costs.
- Many crews followed all gear maintenance instructions, thus preventing equipment problems.
- When equipment needed servicing, a rapid response ensured a quick replacement and eliminated down time.
- Extra inventory was very useful during the field season.

What Didn't Work

- The lack of an inventory system prior to training made it hard to track all the gear.
- Crews had to compile information to establish the inventory system at short notice.
- The Quartermaster was required to be available during the field season almost all of the time.
- Maintaining one inventory storage location has the potential to incur greater shipping expenses.
- Who was responsible for replacing damaged equipment had not been defined prior to the start of the field season and the extra shipping costs fell on the gear storage entity.
- The lack of a service and maintenance protocol hindered timely action on repairs.

Inventory

At the start of the field season, multiple parties were made responsible for some inventory in their respective locations, but this approach required frequent phone conversations among the individual parties that were storing and distributing gear. To improve efficiency, inventory management was changed mid-season and all the equipment was transferred to a single storage location managed by the Quartermaster, who was also tasked with development and maintenance of an Access database to track equipment disposition. The database consolidated multiple spreadsheets and ensured that all information was up-to-date. In addition, a detailed questionnaire was developed for collaborators to clearly evaluate and report equipment status.

Recommendations for 2012:

Building on the successes of 2011, a number of things should be continued in 2012. Access to a central storage facility during the season should be ensured, and a single CHaMP shipping account to which all associated expenses will be charged should be established with a major courier.

Collaborators should be required to use the gear they are issued for the length of their participation in the project, or the life of the equipment, and they should be responsible for storage of the majority of their assigned gear through the winter months. In addition, questionnaire use should be continued to facilitate the assessment and reporting of equipment status.

Service and Maintenance

The 2011 CHaMP budget did not include funds for major repairs or maintenance costs, nor was there a protocol that designated financial responsibility for equipment loss or breakage. However, equipment had been purchased with the expectation of a full implementation of CHaMP in 2011, and thus equipment availability exceeded the requirements of the 2011 pilot basins. The extra inventory was used to replace broken field gear where needed. Thus, rather than repairing equipment and the time out of the field that would enforce, staff were able to send new equipment out immediately.

At this time, a few pieces of equipment are awaiting repair, as well as many that require servicing before the 2012 season. The majority of field equipment items will not require professional servicing or maintenance between seasons, but, a few items would greatly benefit from an annual overhaul, particularly the total stations.

Recommendations for 2012:

Equipment service costs should be written into budgets to allow for repair or replacement since the current extra inventory will not persist as the project progresses into full implementation.

All technical instruments should be returned to equipment headquarters at the end of field season for thorough, professional service to ensure proper functionality and the longest lifespan possible. Any firmware updates that have become available should also be installed at this time. This equipment would then be redistributed at training, where each organization would take on the responsibility for repair and replacement if necessary.

Training

Overview

The CHaMP pre-field season training was held from June 2 to June 11, 2011. This timing allowed southern crews to start their field season by June 15 and accommodated those agencies who did not start hiring staff until June 1.

Standardized training was provided to all crews. Training was conducted by staff from the CHaMP and ISEMP projects for approximately 70 participants at stream-side field locations, classroom settings, and in computer labs. Participants were taught how to conduct habitat surveys according to the CHaMP protocol, as well as the basic aspects of fish ecology affected by physical habitat, and a sense of enthusiasm was fostered among trainees for the use of the new tools and approaches to measuring salmonid habitat.

The 10-day time provided for this training period was anticipated to be less than optimum, so the training event was structured to maximize training time and minimize outside distractions. Therefore, all participants studied, ate, and socialized at the on-site facilities and adhere to a daily rigorous training schedule from 7:00 a.m. until dinner time .

The cost of instruction, facilities, meals, vehicles, and equipment was covered by CHaMP. Facilities and meal costs were maintained within allowable levels based on federal per diem regulations.

Facilities, Location, and Timing

The CHaMP habitat protocol is technologically advanced and utilizes electronic hardware and software applications. The venue therefore had to accommodate the safe storage and charging of electronic equipment, provide space for two computer labs with high-speed internet access, be located near suitable stream locations, and be convenient for feeding, housing, and teaching as many as 80 trainees and trainers.

A community center in Brewster, Washington, was selected to house "CHaMP Camp 2011", and included camping grounds, a gymnasium for meals, group instructions, and gear storage and charging, a commercial kitchen for service of meals catered by local restaurants, access (with 20 minutes) of several stream sites, proximity to local businesses and services, and amenities including a pool and recreational facilities. Trainees were transported to stream locations in vans to minimize logistics.

Recommendations for 2012:

Based on feedback from participants, the timing and location of the 2012 CHaMP camp should be reviewed. The timing of CHaMP camp should balance hiring timelines and starting training sufficiently ahead of the field season so that data logger and data management staff can address any required changes. The location of the 2012 camp should ensure there is access to a wide variety of stream types so crews are trained on a wider array of site conditions and can receive better training in channel classification. It may also be important to evaluate the feasibility of training for crew supervisors ahead of CHaMP camp to help reinforce their skills and potentially include them as trainers in CHaMP camp, and assess the potential for additional in-basin training. This would allow for direct work between crew supervisors and crews to catch sampling procedure errors and misunderstandings.

Training - Facilities, Location and Timing

What Worked

- Camping and the use of local caterers was cost-effective and environmentally friendly.
- The venue's recreation facilities encouraged participant bonding and offered an opportunity for crews to recharge and refocus.
- The timing of the training was appropriate as crews were almost immediately dispatched to start sampling in their own subbasins.

What Didn't Work

- The location was not central and access to a wide range of stream sites and conditions similar to what crews would encounter in their subbasins was limited.
- Some northern watershed trainees felt they grew rusty in the 2-3 week gap between training and the start of their field season (July 5).

"CHaMP Camp" 2011 field training was held at a community center in Brewster, WA. This venue provided the opportunity for trainers & trainees to stay and learn on-site throughout the entire 10-day period.

Training - Participation, Staffing & Funding

What Worked

- Successfully coordinated a relatively large-scale event.
- The ratio of trainer:trainee was appropriate and allowed for one-on-one interactions.
- Qualified trainers available for questions at anytime and for extra help after hours.

What Didn't Work

- Not all attendees had read through the protocol prior to arrival and were therefore not as prepared as they should have been.
- Insufficient event-production and coordination staffing, and the effects of a compressed pilot timeline created undue stress and extra work for trainers, and made it hard for trainees to access some staff in the evening.
- The way the training was structured made learning some modules difficult.
- Trainers could have been more consistent about their approach to some topics and how they taught the protocol.
- Most of the collaborators did not send enough personnel to training to account for potential crew turnover during the season.

Participation, Staffing and Funding

As required, all CHaMP crews participated in the training with the exception of personnel who were hired after the June training event to replace or augment existing field staff.

The training event was staffed by coordinators contracted directly to the CHaMP project, event production staff (two logistics personnel and two night watchmen) and caterers subcontracted by the CHaMP coordination contractor.

The trainers were drawn from the ISEMP contractors who had developed the protocol, and were unfortunately also occupied during the event with managing equipment, curriculum development and modifications, and tracking changes in the protocol and data capture tools. This meant the trainers were fully occupied working long hours and were not as available to trainees as they might have been. Nonetheless, the experience gained in 2011 from organizing and convening CHaMP camp will allow for better planning and improved staffing to decrease stress and allow more time for dialogue between trainers and students in the future.

Recommendations for 2012:

CHaMP camp was an intense experience for all involved and several recommendations have been made to improve the experience in 2012. Ensuring that trainees have read the protocol and all other relevant materials prior to arrival at camp would partially address this issue, as would extending the training window through webinars and online training modules. These could be used to help prepare attendees and provide practice opportunities after training, and partially address the issue of training new hires who are brought into the project after the pre-season training event should also be considered. Alternatively, the number of trainees attending could increase so that an adequate number of personnel are trained before the field season starts to account for mid-season turnover and sick days.

If additional watersheds are added in the future it would be prudent to add an additional training and/or more trainers, perhaps by using staff from the 2011 collaborating agencies as trainers in 2012. This would also help ensure consistency among trainers from year to year and provide additional trainers for total station and post-processing components.

Also, the addition of a coordination staffer and two additional event-production staff to cover logistics would help improve event coordination.

Curriculum

Participants were divided into study groups of approximately 10 students per group. The course started with a day of orientation with lectures in fish ecology, the scientific method, and the policy motivations behind CHaMP. Equipment was also distributed on day one and students were introduced to basic tools and procedures.

During the next 6 days, students rotated between concurrent classes in each methodology. Methods modules were about a half day in length. The last 3 days were set aside for conducting actual surveys from start to finish, under the guidance of trainers, so participants had a chance to integrate all the methods and to develop efficient work flows. As it transpired, only 2 of the last 3 days were spent conducting actual surveys and the tenth day was spent organizing equipment and travelling back home.

CHaMP Camp: June 2-11, 2011

Over 70 trainees, including watershed managers, crew supervisors and crew members, participated.

Training involved classroom and computer lab sessions, and intensive field work on protocol methods, metrics and implementation.

Recommendations for 2012:

Overall, the number of people trained and material covered in 2011 was impressive. Considerations for curriculum changes in 2012 include additional time for topographic surveying and post-processing (and shortening of other modules), trying to teach modules in the order that they would be implemented in the field, (i.e., according to actual work flow), and spending additional field time on channel unit classification.

Training - Curriculum

What Worked

- The curriculum was well organized and the modular structure allowed for in-depth learning of individual protocol pieces.
- The half-day time allotment was ideal for most modules.
- The module class size was good and putting attendees into crews created a positive learning environment.
- Crews received basic GIS processing training in a short period of time.

What Didn't Work

- A full 10 days of learning left little time to let things sink in.
- The modular approach was sometimes confusing compared with teaching the real field sequence of events.
- Overall, some modules need more time allocated to them and some less.
- The amount of material covered, pace of instruction, and the steep learning curve made the topographic survey and post-processing challenging.
- The TIN-based water surface model was poorly understood and under-emphasized during training.
- Some aspects of the topographic survey that were optional during training were in fact required for some metric calculations.
- Differences in crew members' GIS backgrounds broke up the flow of training sessions.
- Not all crew members performed all aspects of sampling during the field sessions.
- Protocol changes during training made it hard for trainees to keep up, and forced on-the-fly changes of GIS tools.

Sampling Design - Staffing and Funding

What Worked

- The GRTS expert was in close contact with GRTS statisticians.
- The GIS expert and GRTS design specialist were both familiar with the study design requirements of each watershed.
- Funding was adequate for 2011 staffing levels.

What Didn't Work

- Staffing went from sufficient to understaffed quickly and ultimately staffing was inadequate to meet watershed-specific needs of eight watersheds in a timely fashion.
- It was difficult to accommodate all the GIS frame needs without contracted local GIS support from wa-

Sampling Design

Staffing and Funding

Study design staffing consisted of a part-time GRTS design specialist and part-time GIS technician. The GRTS design specialist was contracted mid-February, 2011, leaving less than three months for study design and frame development and loading information for eight watersheds to CHaMPMonitoring.org. This was complicated by delayed contracting with collaborators, concurrent CHaMPMonitoring.org development, and the growing pains associated with developing pilot-year study designs.

Recommendations for 2012:

To facilitate a timely study design and frame development a full-time understudy of the GRTS design specialist with a basic GIS skill set should be hired. Additionally, contracting with collaborators should occur earlier to allow additional time and leveraging of local GIS skills for development and review of GIS frames.

Low Flow Season

The CHaMP protocol does not explicitly state an index window within which CHaMP surveys are to occur. In one instance, the field season is defined as June 15 through September 30 but the concept that sampling must occur during an index window, such as the summer low flow period, is not clearly specified. It was the intention of the CHaMP protocol developers that the index window for CHaMP surveys would be:

- As short as possible within operational field constraints,
- Optimized to reduce measurement variation (e.g., flows, weather conditions), and
- Ecologically based.

Under these conditions, the index window would therefore coincide with the low flow period of the year.

In practice, 2011 was a year of unusually high snowpack and subsequent runoff and low flow was not encountered until late in the sampling season in many watersheds. As a result, many sites were sampled outside low flow conditions and in some watersheds sampling was conducted in high flow conditions in the early part of the season.

Recommendations for 2012:

For year-to-year consistency, staff should identify a way to ensure that the first surveys of the year are not done in high flows. Various approaches could be used such as: (1) requiring that flows decline below some critical level as determined by a USGS gage before starting surveys, or (2) do sites on approximately the same date each year to increase comparability. Sampling at low flows should be balanced with resampling in a time period similar to the previous years', and crews should sample all sites unless they are completely dry. In addition to increasing comparability, drift should be sampled at low flows to provide a measure of food availability during the warmest part of the summer when water temperatures are high and fish growth may vary from optimal to low to negative, depending on the thermal stress.

The development of an index of surface fines to subsurface fines concentrations that reflects the fish egg incubation environment may be investigated, but it should be noted that minor trends in superficial layers of sediment may confuse the evaluation of whether fine sediment deposition is occurring.

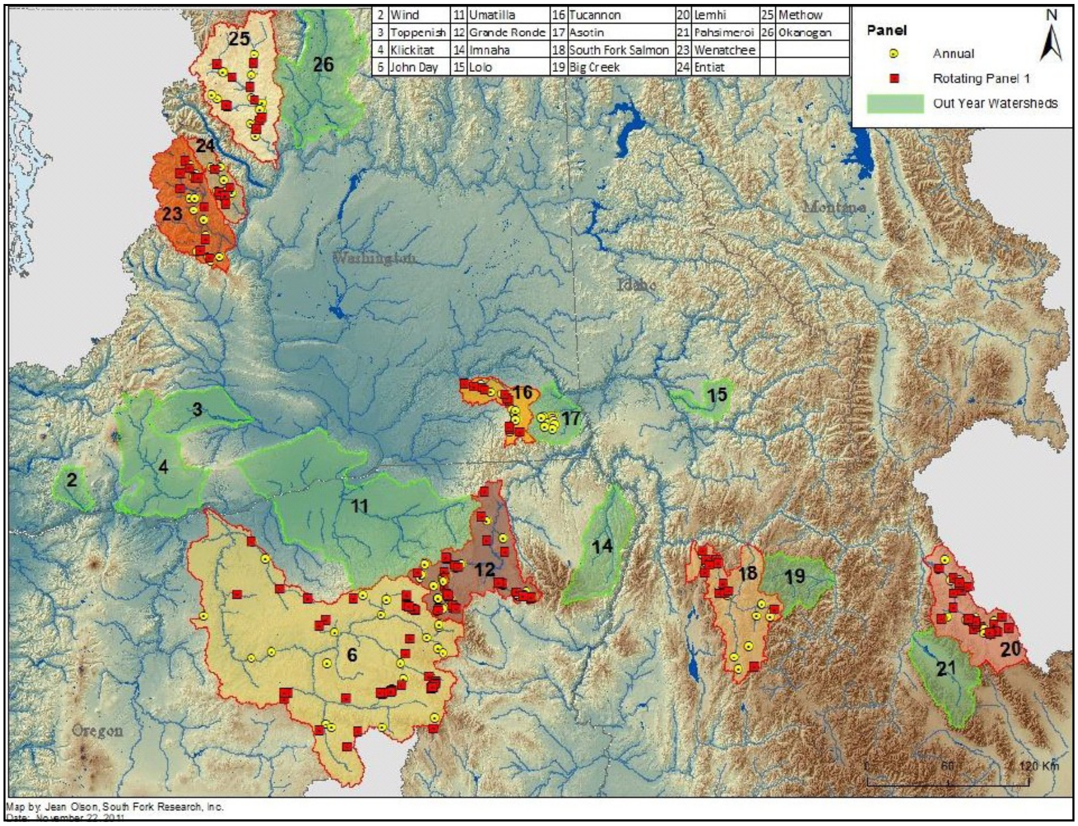
Sampling Design - Low Flow Season

What Worked

- Low flow sampling enabled data collection at many sites that would be difficult or impossible to survey or sample accurately at other times.
- Sampling during low flows helped standardize flow-dependent methods and likely improved surveyor ability and ocular estimates.
- The focus on the low flow season captures a focal point for stress on the fish due to high water temperatures and covers the holding, spawning, and initial incubation period for spring Chinook.

What Didn't Work

- Sampling across different flow regimes meant that crews identified habitat features, and channel units in particular, differently in different flow regimes.
- Pool tail fines became more difficult to evaluate unequivocally as flows declined and algal mats that trap fines formed on the substrate.
- Subbasin specific limitations on survey timing exist. For example, some sites became intermittent or dry later in the season and thus were not sampled.
- The existing depth protocol and flow meter may make it difficult to sample drift later in the summer.



Map by: Jean Olson, South Fork Research, Inc.
Date: November 22, 2011

Figure 44. CHaMP 2011 annual and rotating panel watersheds and site locations.

Basic CHaMP GRTS Design

The primary objective of CHaMP's spatial and temporal study design is to characterize the status and trends of selected habitat indicators that are relevant to the survival and growth of key salmonid populations at two spatial scales: across all CHaMP watersheds, and within each watershed. CHaMP adopted the use of probability or sample surveys to obtain a representative sample of habitat conditions, incorporating randomization in the selection of locations where habitat conditions were to be measured. Specifically, the GRTS (Generalized Random-Tessellation Stratified) algorithm was used to select spatially-balanced sampling locations within each CHaMP watershed.

CHaMP's basic design selected 45 sites to be sampled over a 9 year period, organized into four panels: an annual panel (15 sites to be monitored each year), and three panels each on a 3 year cycle with one panel starting in year 1 (10 sites), a second in year 2 (10 sites), and a third in year 3 (10 sites). After 3 years, all sites will have been sampled at least once. After 9 years, all sites will have been sampled for at least 3 years (allowing an estimate of trend at all 45 sites).

CHaMP utilizes a default stratification framework based on geomorphic groupings of sites into three valley classes: source, transport, and depositional. These valley classes are based on aggregations of Beechie's geomorphic classification (T. Beechie, personal communication) and analyses conducted on Wenatchee and Lemhi habitat datasets that indicated that valley class distinctions accounted for significant spatial variation.

The basic CHaMP design supports stratification, increases in sample size as funds allow, accommodates the integration of special studies (such as ISEMP intensive monitoring), and the incorporation of legacy sites (sites with a history of probability based sampling) in the site selection process. The basic design structure can be modified to meet individual CHaMP needs yet retain the basic probability structure of site selection and resource representation. Almost all CHaMP watersheds incorporated a change to the basic design framework, as summarized in Table 7.

Basic CHaMP GRTS Design

What Worked

- A statistically sound design balanced the need to estimate both habitat condition status and trend.
- The design could be tailored to meet specific watershed needs such as the integration of legacy sites with the overall CHaMP status and trend objectives.
- The design allows for the estimation of spatial, temporal, and residual estimates of variation that can be used to establish precision of status and the sensitivity of trend detection.
- Sample sizes can be tailored to meet budget constraints.
- Sample distribution in many watersheds appeared random and the sample design accommodated the split between steelhead and Chinook spawning and rearing distribution.
- Crews received good support producing their GRTS design and selecting sites.

What Didn't Work

- The initial unified approach was not used since specific needs necessitated tailoring the design by watershed.
- Sample sizes might not be sufficient to detect differences among desired groupings or detect subtle habitat trends.
- The initial stratification might not achieve desired results (e.g., clustering of Chinook sites noted in one basin).
- The tools for incorporating legacy sites using a GRTS draw were not developed early on and some legacy samples were not spatially balanced.
- Some crews were unclear of how to take advantage of the GRTS local variance estimates for legacy sites.

Sampling Design - Balance of Local vs. CHaMP Needs

What Worked

- Designs were completed for pilot watersheds in time to conduct field sampling.
- There was significant interaction between study design staff and the CHaMP teams, which facilitated crew learning and understanding of the basic design principles and the implications of incorporating specific watershed monitoring goals.

What Didn't Work

- The process slow and painstaking at times, leading to designs created at the last minute.

Table 7. Summary of 2011 changes to basic CHaMP GRTS design framework

CHaMP Watershed	Sample Size	Stratification	Legacy sites incorporated	Special studies
Entiat	16 CHaMP plus 60 mainstem Entiat IMW study	Special study strata were used within the IMW portion of the CHaMP domain	Yes	Yes, IMW
Methow	CHaMP	CHaMP	Yes	No
Tucannon	CHaMP	By treatment/control	No	Focus primarily on treatment/control evaluation
Wenatchee	CHaMP	CHaMP	Yes	No
John Day	2 x CHaMP plus additional special study sites	CHaMP and special study strata	Yes	IMW & ISW special study sites incorporated into design.
Upper Grande Ronde / Catherine Cr.	2 x CHaMP	Three domains: UGR Chinook, Cath Cr. Chinook, and steelhead where no Chinook; Unstratified within UGR and Chinook domains; CHaMP valley class in steelhead.	Yes	No
Lemhi	CHaMP plus additional	By priority watershed only	Yes	No
South Fork Salmon	20 sites (10 annual; 10 on 3yr cycle)	Modified CHaMP (split Source into two strata)	No	No
Secesh	CHaMP	No stratification	Yes	No

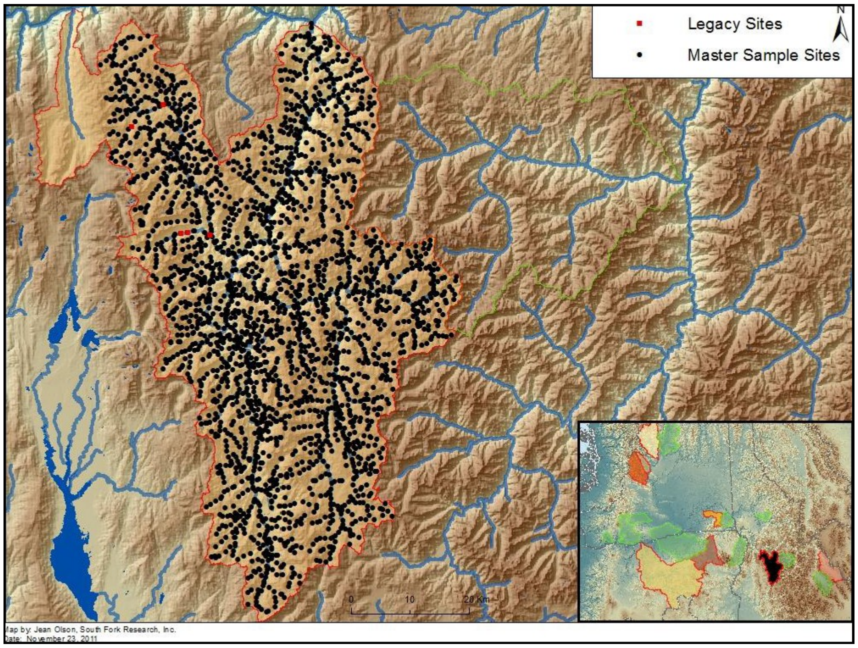


Figure 45. South Fork Salmon watershed 2011 master sample and legacy sites.

Recommendations for 2012:

For many habitat attributes change occurs slowly unless there is a major event. Monitoring programs have to balance whether or not sampling these slowly changing attributes annually is cost effective or if more effort should go toward sampling more sites. CHaMP staff recommend continuing the current design for three to five years until estimates of variation are compiled, and then evaluating if design changes are warranted.

Watershed Outreach and Balance of Local vs. CHaMP Design Needs

Study design staff worked with each of the candidate CHaMP watershed teams to describe the rationale behind, and ground rules for, the site selection process. Within the ground rule limits staff worked to accommodate the individual needs of each CHaMP watershed (see Table 7).

Local interests included effectiveness monitoring (treatment and control design in the Tucannon and an IMW in the Entiat), use of pre-existing sample locations (legacy sites) as part of the sample (Wenatchee, South Fork Salmon, Entiat, Methow, Grande Ronde, and John Day), and specific sampling needs, such as varied effort in the Entiat, Lemhi, John Day and South Fork Salmon due to overlap in ISEMP and CHaMP objectives and sampling needs. Logistical considerations included multiple sampling organizations (Grande Ronde and John Day), high-density sampling (Grande Ronde), sampling organization frame overlap (John Day), and small site counts within strata (Tucannon, Lemhi and Grande Ronde).

CHaMP staff considered using workshops to explain the design and site selection principles to, and expectations of, each watershed team; however, practical issues (e.g., uncertainty about level of funding, number of workshops and staffing that would be needed) led to working with each CHaMP watershed team individually. This involved significant interaction with each team with respect to agreeing on the set of overarching CHaMP objectives, how they would be achieved, and how watershed specific objectives could be incorporated.

The flexibility of the master sample along with the ability to incorporate legacy sites facilitated the process of communicating with individual CHaMP teams, and of adapting the general design principles to accommodate specific needs, and still maintained the integrity of CHaMP's basic objectives across watersheds. Table 7 provides a summary of watershed-specific modifications made to the basic CHaMP design.

Recommendations for 2012:

If commitments are made to bring on additional CHaMP watersheds, sufficient lead time is needed to bring new teams up to speed and set designs in place. Setting up workshops could be one tool to bring new CHaMP watersheds up to speed on the design process.

Master Sample

A stream network master sample is a dense GRTS-selected set of points from which subsets can be extracted to meet particular design objectives. CHaMP used a Northwest-wide master sample (covering OR, WA, and ID) that was developed from the NHD Plus hydrography at an average density of one site per km. Use of a common master sample facilitated the integration of site selection across multiple monitoring programs or regions, and eased the site selection process for those not familiar with the application of the R-based GRTS algorithm.

For each CHaMP watershed, the relevant portion of the region-wide master sample was selected and then screened to include those sites that met the target criteria listed in the CHaMP protocol. Sites meeting the target criteria were then stratified and supplemented with legacy sites where appropriate.

Stratification aims to achieve several objectives: account for the variation in habitat condition by network derived classes (e.g., stream power, geomorphic class), obtain an adequate sample size across subbasins within some CHaMP watersheds, and obtain a sample with the same proportion of public and private sites as in the target population.

In many cases probability surveys had been conducted in CHaMP watersheds and a set of these legacy sites meeting target criteria was incorporated into each watershed's design so that the spatial pattern was preserved. Figures 46-48 illustrate, for the South Fork Salmon River, the series of steps used in the selection of candidate sites. Figure 45 contains the distribution of master sample and legacy sites across the entire watershed. Figure 46 refines this set of sites to target the desired TRT population domains and proposed stratification. Figure 48 illustrates the set of candidate sites to be evaluated for potential field sampling.

Recommendations for 2012:

Use of the master sample as the sample frame for existing watersheds should be continued in 2012. Staff should ensure that the master sample is available in time for use by all crews at start of field sampling season, and the master sample should be applied to any new watersheds.

Sample Design - Master Sample

What Worked

- Using a master sample ensured that all CHaMP data can be integrated in a statistically valid manner, which is a strength of the project design.
- The development of spatial and temporal designs among participating CHaMP watersheds was consistent.
- The ability to adapt to changing needs within each CHaMP watershed as candidate designs were discussed was crucial.
- The ability to incorporate ancillary monitoring projects (e.g., ISEMP restoration experiments) was crucial.

What Didn't Work

- Using the master sample might not be optimal for each CHaMP watershed's individual needs.
- The limits of the master sample were reached in small watersheds where sufficient sites were not always available.

Sampling Design - Frame Development

What Worked

- Design documentation format was finalized in early March.
- Collaboration between CHaMP and local GIS staff when available to generate sampling frames enabled frame edits as needed and streamlined the overall process.
- The frame development was completed for all watersheds prior to CHaMP camp, although two watersheds required revision post-training.
- The CHaMPMonitoring.org website documented both temporal and spatial designs.

What Didn't Work

- Customized designs necessitated a complicated design documentation process and this documentation was not available for some watersheds until after training.
- The concurrent development of frames and sample draws led to multiple iterations of revisions and draws.
- A lack of local GIS support made finalizing the frame more challenging and time consuming.
- Frame finalization became a low priority after study design development and did not go through final formatting review until after the field season.

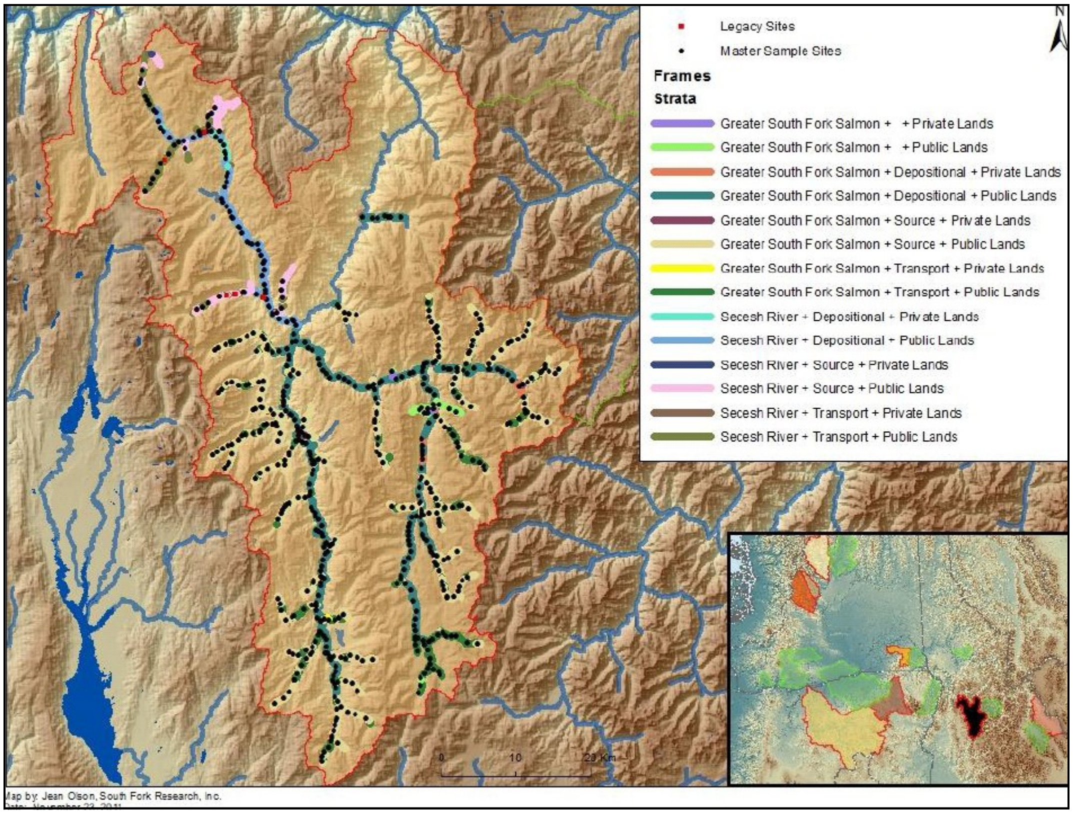


Figure 46. South Fork Salmon watershed 2011 master sample and legacy sites with frames.

Documentation and Frame Development

The study design process consisted of four parts: developing the questions of interest, developing the sampling frame (i.e., what part of the master sample was relevant to specific watershed TRT populations), performing the GRTS sample draw, and loading the design and frame to CHaMPMonitoring.org.

Watershed coordinators and interested parties worked with the CHaMP study design expert to design a scheme within each watershed that met overall project and local objectives. Frame development often occurred concurrently with study design discussions, with CHaMP providing GIS support for developing sampling frames based on an NHD Plus hydrography network. Initial frame extents were based on excluding first order streams, areas with gradients >12% (barriers), and areas outside of anadromy.

Watershed coordinators and local interest groups then revised frame extents to meet local needs, for example, matching previous sampling frame extents using local GIS processing whenever possible to generate the new frame extents. Frames were then transferred to NHD Plus hydrography and sites within a frame were attributed with study design strata for GRTS design processing. GRTS scripts selected sites in a spatially balanced fashion and then sample and oversample, use order, and block designations were made post-GRTS processing.

As a final step and prior to loading to CHaMPMonitoring.org, sample and oversample lists were checked to ensure study designs met initial sampling design requirements.

Recommendations for 2012:

In 2012 the study design process should be started earlier in the year to allow more time for development and the frame documentation should be formalized and required prior to loading to CHaMPMonitoring.org. In addition, GRTS script inputs and outputs should be better aligned with website needs.

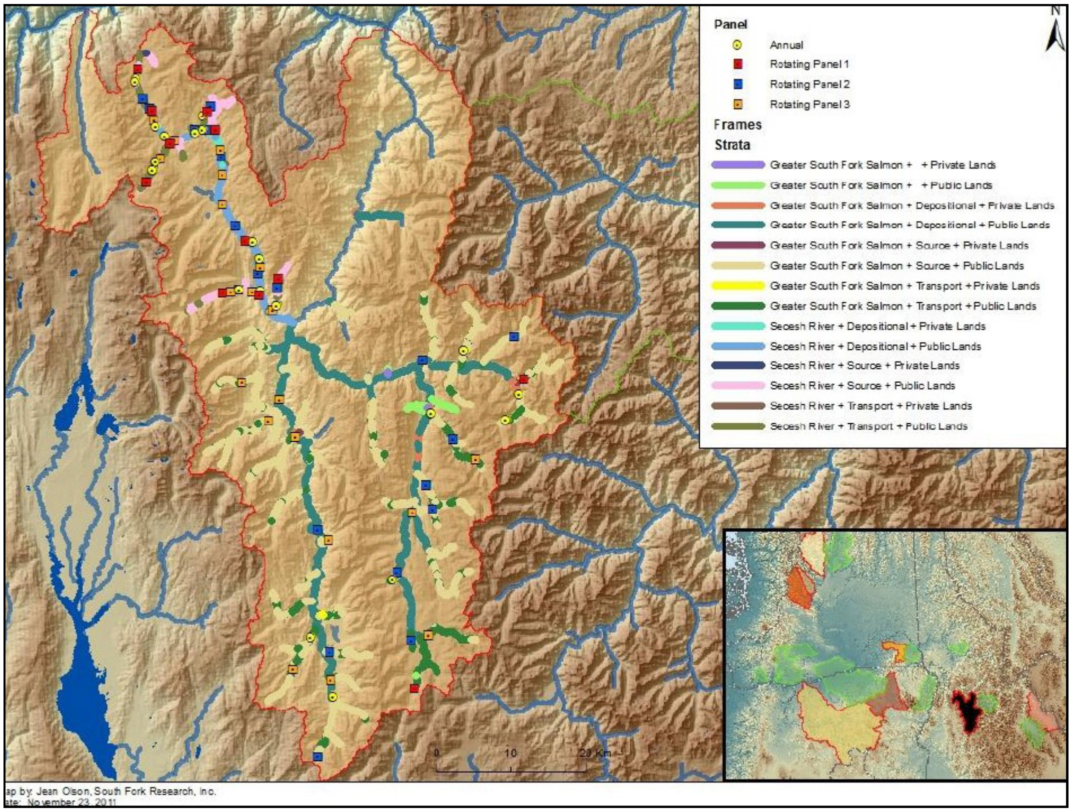


Figure 47. South Fork Salmon watershed 2011 master sample and legacy sites with sample draw.

Study Design - Documentation and Sample Draw

What Worked

- The CHaMP study designs allowed the integration of existing GRTS designs with the new CHaMP designs.
- The study designs and submission formats were able to accommodate top priority local design needs.
- A standard format limited formatting errors during the submission process.
- Loading legacy data with the same metrics as the GRTS master sample simplified post-processing needs.
- Coordination was good and almost all watersheds made it through the process before CHaMP camp.

What Didn't Work

- R scripts managing the GRTS draw often needed hand manipulation of input files, while output files did not meet all format requirements for submission to CHaMPMonitoring.org and also needed hand editing.
- The sampling frame and study design decisions changed during the development of the eight watershed designs.
- The study design development process identified questions that needed input from, and additional coordination by, multiple parties to resolve.

REFERENCES:

Larsen, D.P., A.R. Olsen, and D.L. Stevens, Jr. 2008. Using a master sample to integrate stream monitoring programs. Journal of Agricultural, Biological, and Environmental Statistics 13:243-254.

Stevens, D. L., Jr., and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics **14**:593-610.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially-balanced sampling of natural resources in the presence of frame imperfections. Journal of American Statistical Association 99:262-278.

Sampling Design - Site Evaluation Tool

What Worked

- The web-based evaluation tool made site data viewable and accessible to all CHaMP staff and participants, and stored tax parcel information that supported landowner contacts.
- The site evaluation information was recorded in a consistent format, and was easily exportable for use by analysts and crews.
- This web-based site evaluation tool represents a vast improvement over previous site evaluation tracking formats.

What Didn't Work

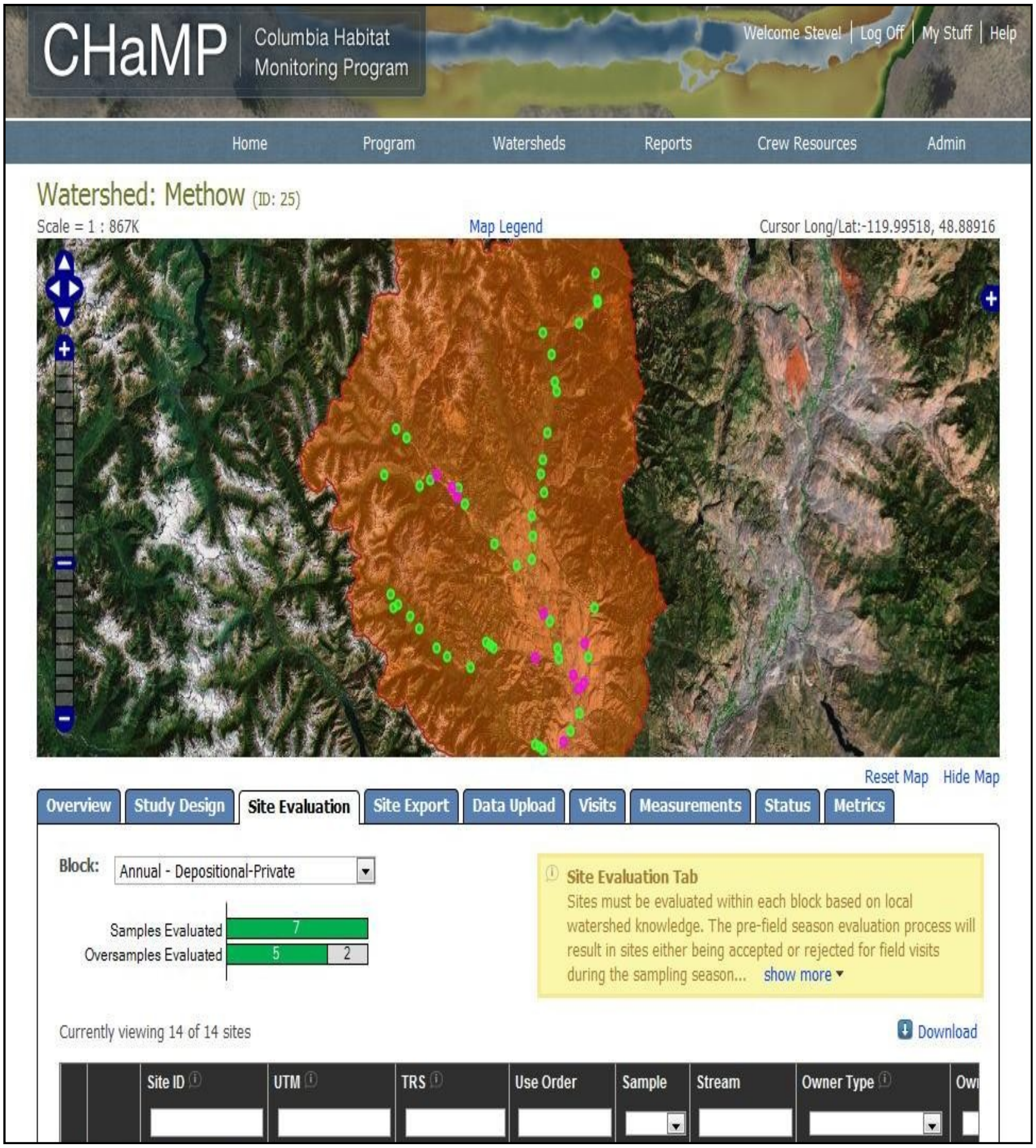
- The site evaluation tool was unavailable before the start of some field seasons.
- The tool did not have landowner contact information, which made a reliance on local knowledge more critical.
- The nexus with the data logger, that is, recording in-season field rejections on the logger, was not intuitive.

Site Evaluation Tool

Site evaluation was completed using a tool housed on the CHaMPMonitoring.org website that allowed crew supervisors and landowner liaisons to review potential sites within panels and strata. Each site was evaluated for conformity with the study design objectives, safety for crew members, and landowner permission to access the site if it was on private land. Whenever available, county tax parcel information was presented in tabular and map-based formats to provide as much landowner contact information as possible. Crews evaluated 1.5 to 2 times the number of sites targeted for sampling to provide an oversample of sites to account for rejection of a site during field sampling. If sites were rejected during field sampling, the reason for rejection was recorded in the data logger.

Recommendations for 2012:

Modifying the site selection tool on CHaMPMonitoring.org to accommodate recording in-season field rejection information as distinct from pre-season evaluations would be valuable.



Watershed: Methow (ID: 25)

Scale = 1 : 867K

Cursor Long/Lat:-119.99518, 48.88916

Block: Annual - Depositional-Private

Samples Evaluated 7

Oversamples Evaluated 5 2

Site Evaluation Tab

Sites must be evaluated within each block based on local watershed knowledge. The pre-field season evaluation process will result in sites either being accepted or rejected for field visits during the sampling season... show more

Currently viewing 14 of 14 sites

Figure 48. Screen shot of CHaMPMonitoring.org site evaluation tool.

Data Management

The CHaMP Data Management System was designed to support the CHaMP protocol by documenting the statistical design, efficiently supporting field data collection, ensuring consistent data formatting and quality, and providing public access to field data measurements, derived metrics, maps, charts, and other data visualizations.

This Data Management System includes a study design and site evaluation tool, total stations for capturing topographic surveys, a data logger application for auxiliary data, geoprocessing tools, a centralized data storage repository, and a website for reviewing and accessing data. Collectively, these tools support data documentation, data capture, quality assurance review, backup and archiving, metric generation, data display, mapping, and distribution, and lower the overall cost of data management.

CHaMP Data Management System goals:

- Transparency—ensure that methodologies, analytical procedures, raw measurements, derived metrics and summary reports are readily available to program participants, resource managers, decision makers, and the general public.
- Accountability—clear reporting of progress and completeness (what data has been uploaded vs. what data new expect to have) at multiple scales including program-wide, within watershed, and individual site levels.
- Flexibility—in recognition that data management is challenging, when there is limited time at the end of a day or hitch, and data management is not a favorable activity, ensure the data system does not create unnecessary impedance or bottlenecks.
- Quality Assurance—design appropriate checks at progressive stages in the workflow to balance the need for data quality vs. requiring repetitive work. Support users in cleaning data to remove anomalies and errors, while maintaining original versions of field data.
- Efficiency—minimize the time spent on data management; this includes minimizing the "number of clicks" as well as the time for data transfer.

Recommendations for 2012:

Overall, the number of features and functions built for the 2011 CHaMP data management system, including those which are made available to staff and collaborators for field data management, QC/QA, and analysis, was impressive to most users and sufficient for 2011 implementation. Continued use of the existing features is recommended.

Prior to the 2012 field season data management staff should work with monitoring coordinators, analysts, and crew supervisors to better define data requirements, both for upload and input, and output and use in other tools, (e.g., RBT) to improve the overall data management process.

Data Management - Staffing and Funding

What Worked

- The software development contractors rapidly developed an advanced data system which freed up the core CHaMP contractors to focus on protocol development and defining requirements.

What Didn't Work

- It was difficult to manage high pressure timelines and expectations across many contractors.
- A consistent approach to data quality was not understood or agreed upon.
- An agreement about approaches to data management and associated priorities was not always reached in a timely fashion.
- Planned content development was sacrificed to deal with first-year production issues.

Data Management - Data Flow and the Cloud

What Worked

- In-season reporting on workflow stages (site evaluation, capture, upload, metric generation) was performed by watershed, strata, and according to its analysis priority.
- QA reviews were completed on 94% of visits, and RBT metrics were generated on over 80% of visits by mid-November.
- Raw measurements, topographic data products, and derived metrics were downloadable by watershed or across entire program via the web-interface.
- Using role-based permissions controlled who could edit measurements and metrics and ensured limited access to sensitive data.
- Crews reported that the data flow order was sensible, and that the cloud was a useful interface.

What Didn't Work

- Some data system development and debugging occurred during the active field-season.
- There was a limited ability to compare planned versus completed site visits.
- Analysis priorities were managed outside of CHaMP-Monitoring.org.
- Data upload speeds were slower than expected due to the large volume of photos.
- Significant issues with synchronizing the cloud with the computers made addressing data processing questions difficult.
- Crews had to repeatedly edit data at times to make the edits stick.
- There was inconsistent access to internet among crews.

Data Flow and the Cloud

Although CHaMP set an ambitious timeline for data capture, compilation, validation, and summarization, an integrated data system, active program management, and appropriately scoped data collection contracts ensured that timelines were met.

Recommendations for 2012:

The study designs and protocol data dictionary should be finalized by March 30 to allow programmers sufficient time to update and test data capture tools. In addition, data capture tools should be well tested prior to field season to help ensure data quality procedures are actively implemented during the field season. To facilitate QA/QC data management staff could explore expanding the use of some cloud features to pass data back and forth between crews and CHaMP support staff and could research providing an alternate tool for crew data transfer, for example, DropBox or a place to email zipped files, if access to the cloud is difficult or impractical.

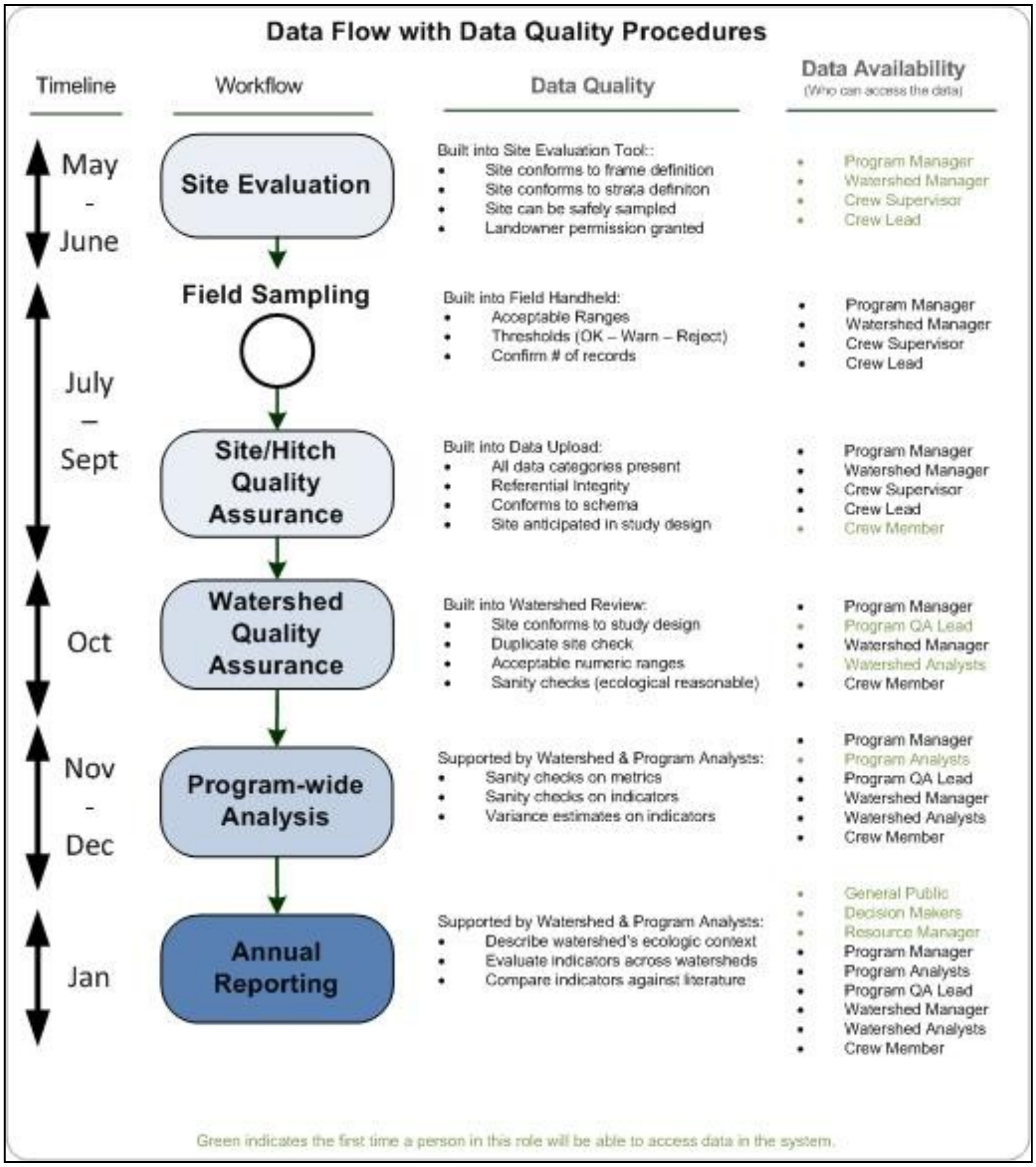


Figure 49. CHaMP data flow with data quality procedures.

Topographic Survey Processing

CHaMP field crews used a total station to collect topographic data. These data were then imported into Foresight software which is used to open topographic survey files and review and edit 3D line work. Once this editing work was completed the Foresight software creates a file for import into ArcView GIS, which was used to complete post-processing of the topographic data.

Once data were in ArcView, crews utilized two custom-designed tool packages: a Transformation Tool (Joe Wheaton et al., Utah State University), to transform data appropriately to the earth's surface, and CHaMPTools (South Fork Research) to assist crews in visualizing, editing, and exporting data in a standardized format and environment.

Final products from survey processing included: a packaged survey geodatabase for key features of a survey (e.g., channel units, survey extent, and topography points), water surface TIN, survey TIN, and original Foresight and total station files. CHaMPmonitoring.org implemented an executable version of RBT that generated standardized RBT products available via CHaMPmointoring.org. Both GIS and metric products were QAed by crews.

Also as part of the CHaMP pilot, ISEMP field crews tested RTK and robotic total stations to evaluate their potential for future use by CHaMP field crews.

Recommendations for 2012:

Many recommendations were made to facilitate topographic survey processing in 2012 as this component of CHaMP was perhaps the most novel aspect of the project. Chapter IV provides a comprehensive list of many of the elements of this process that could be improved for future years. In addition, steps such as finalizing and publishing data collection and data on MonitoringMethods.org prior to the beginning of field season and adding direct linkages from the measurement and metric fields to the metadata descriptions for those fields, and to display the data quality constraints for each field, should be followed.

Specific GIS Recommendations:

- Improve the number and disposition of QC/QA checks during topographic processing. Include visualizations, notifications, and requirements for RBT processing, such as bankfull point presence, channel unit and island coding checks, and elevation ranges/standard deviations for TINs.
- Investigate software improvements, (e.g. ArcGIS licenses) to allow detrending and use of RBT tools locally (but under controlled CHaMP tool settings), and production Mapping extension for advanced feature editing and QC/QA.
- Adjust the post-processing workflow to allow QA of RBT products and metrics earlier and prior to CHaMPMonitoring.org compilation.
- Develop advanced data import utility to accommodate RTK and total station formats.
- Simplify structure of survey geodatabase and editing processes (feature additions, removals, publishing).
- Test metric sensitivity to TIN quality and RBT artifacts.
- Develop repeat survey workflow.
- Provide better explanations in error messages when a particular task fails to complete to facilitate crew troubleshooting.
- Provide more training and detailed guidelines during QA process to ensure a greater level of consistency in topographic processing in the future within and across crews; emphasize avoiding over-editing of the data to make it look better.
- Build more flexibility into GIS tools for crews, for example, enable bar shots/code to be brought into GIS as a line to save post processing time.
- Create a tool to import extra DXFs and transform them both.
- Delineate habitat units after the TIN/DEM/Water Depth is created.
- Emphasize matching habitat units with the site map.
- Create documentation of server-side validation/QC checks to assist in troubleshooting/topographic data repair of upload and RBT processing errors.

Topographic Survey Processing - General, Foresight

What Worked

- Overall, 2011 was a good first year effort.
- The Foresight software was user friendly and made editing the survey data straightforward, and crew members mastered Foresight faster than GIS.

What Didn't Work

- Individuals not present at a given survey performed some post-processing on the data.
- Some crews processed data long after the surveys were completed.
- The data were not republished after changes were made to surveys.
- The instructions for editing points and lines in Foresight versus GIS were not clear.
- The Foresight software was error-prone, and its use added another layer of processing steps.
- Some crews edited files heavily in Foresight.
- The intent of the use of Foresight should be clearly defined as it was originally intended for use as a band-aid for data transfer during development.

Topographic Survey Processing - GIS and RBT

What Worked

- Using standardized GIS tools for uploading and editing topographic data worked very well; crews processed data with minimal oversight and novice users could make DEMs
- Follow up by a GIS expert gave each crew immediate feedback on DEMs and information about how to improve their surveys.
- The standardized GIS format meant data were RBT-ready.
- There were few errors during the post-season TIN processing (e.g., dams) due to the emphasis on TIN QA.
- Initial review of RBT artifact geodatabases revealed issues that were addressed by Essa Technologies before provisional data were released.

What Didn't Work

- The QA process for vector data were unconstrained leading to higher than expected levels of vector data point mislabeling.
- The overlapping development of RBT scripts and CHaMP tools created inconsistencies.
- Too many file types and a lack of consistent terminology in the geodatabase.
- The GIS software was very difficult for some new users to learn and use successfully; conversely GIS tools were not flexible enough for the more advanced users.
- Visits by the GIS analyst to each watershed did not always occur at the start of the field season.
- Varying crew schedules and levels of GIS expertise hindered the transfer of tool and version update processing instructions to crews.
- QA process was rushed by the short timeline between delivery and production.
- QA wasn't budgeted for and was hard to predetermine the level needed for the RBT data that wasn't available until Oct.

Specific RBT Recommendations:

- Provide access to survey data earlier in development process.
- Involve RBT developers (Essa Technologies) earlier in protocol development process to improve anticipation of programmatic processing needs.
- Update RBT scripts to accommodate complex sites (wetted and bankfull polygon creation, multithreaded channels, etc).
- Implement RBT in GIS ArcServer environment for development purposes.

Metadata Library

The CHaMPMonitoring.org application was built to manage field measurements and derived metrics. Metadata were developed to describe how these field measurements and derived metrics were calculated.

The metadata are managed by the MonitoringMethods.org application (developed for PNAMP and EcoTrust). Employing web services supported the integration of the two data systems, enabling metadata management in the regionally-centralized MonitoringMethods.org and display of this metadata on CHaMPMonitoring.org for quick access by program participants. Similarly, web services were used to display the list of monitoring projects (from the Taurus project proposal system) that participate in CHaMP.

Recommendations for 2012:

Finalize and publish data collection and data on MonitoringMethods.org prior to the beginning of field season.

Add direct linkages from the measurement and metric fields to the metadata descriptions for those fields, and to display the data quality constraints for each field.

Metadata Library

What Worked

- Metadata were readily available directly from CHaMPMonitoring.org.
- Units of measure were displayed directly in data tables for all fields.
- Regional programs able to easily reference metadata.

What Didn't Work

- Metadata not directly linked to the measurements or metrics.
- Metadata not actively updated during the field season.
- General public could not view draft data analysis methods via MonitoringMethods.org.

Data Management System (CHaMPMonitoring.org)

Five distinct tools were built during the pilot season to support the flow of data from capture to analysis.

1) Data Logger Application – field capture of auxiliary data
2) CHaMP GIS Tools – process topographic points into polygons and TINs
3) CHaMPMonitoring.org – web-based application to view, edit, distribute data
4) CHaMP Database – backend database for compilation and storage
5) River Bathometry Toolbox (RBT) – generate metrics from topography and surface water DEM

In addition, a cloud file server was employed to support transfer of files from field laptops to CHaMPMonitoring.org and to ensure files were securely backed up at an offsite facility.

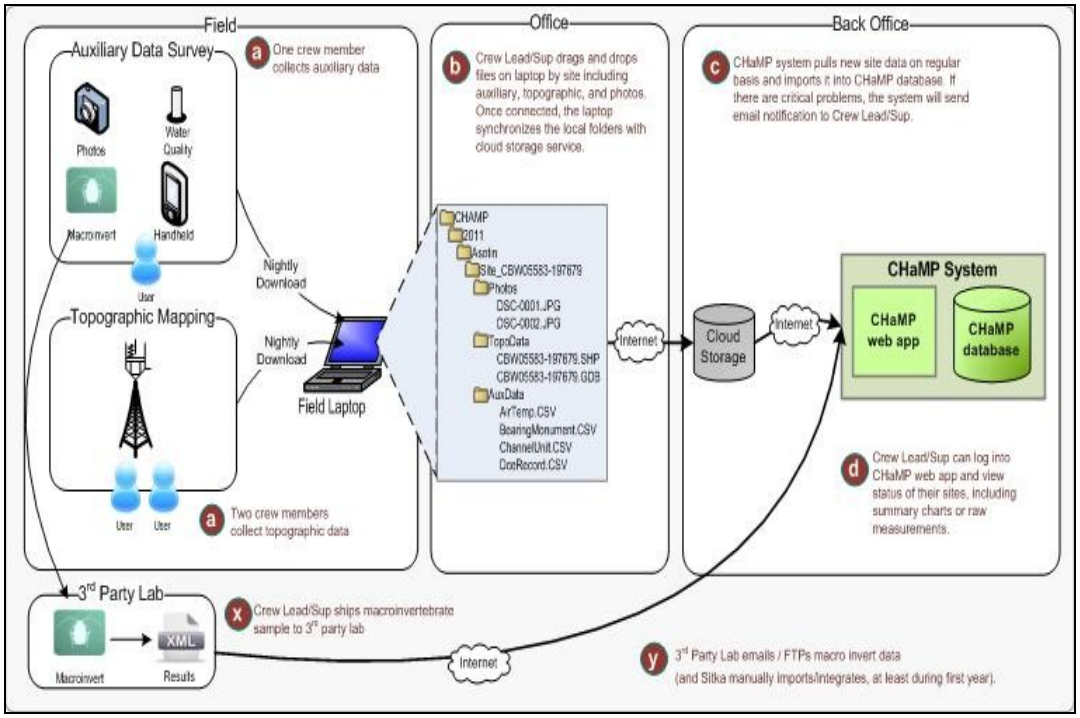
Recommendations for 2012:

We can now refine and improve the exchange of data between system components. In 2012, data system development should emphasize improvements on interaction points between system components to address the "clunkiness" experienced by system users in 2011. Key interaction points and improvements include:

- Data Logger—do not support user-created site export lists.
- Data Logger—send 1 data packet vs. 18 files to Laptop
- Field Laptop—send data packets up to cloud with minimal or no synching down to the Laptop.
- Data Logger—enforce data validation rules on logger.
- CHaMP Tools—consistent validation rules with RBT
- CHaMP Database—improve grid loading speed to CHaMPMonitoring.org

Other improvements should include:

- Developing a user click function so website immediately seeks out new data on the cloud.
- Improving access to survey geodatabases, RBT artifacts, DEMs via website and the cloud.
- Changing "Local_Crew" attribute for differentiation, e.g. if agencies/watersheds have multiple crews.
- Ensuring all crew permissions are correct ahead of sampling trips.



a One crew member collects auxiliary data

a Two crew members collect topographic data

b Crew Lead/Sup drags and drops files on laptop by site including auxiliary, topographic, and photos. Once connected, the laptop synchronizes the local folders with cloud storage service.

c CHaMP system pulls new site data on regular basis and imports it into CHaMP database. If there are critical problems, the system will send email notification to Crew Lead/Sup.

d Crew Lead/Sup can log into CHaMP web app and view status of their sites, including summary charts or raw measurements.

x Crew Lead/Sup ships macroinvertebrate sample to 3rd party lab

y 3rd Party Lab emails / FTPs macro invert data (and Sitka manually imports/integrates, at least during first year).

Figure 50. CHaMP data flow steps, from capture to analysis.

Data Management System

What Worked

- System components developed by independent teams, allowing concurrent development in a short time period.
- In-season QC testing helped illuminate error earlier; data and programming errors easier to isolate and repair.
- Cloud-based file storage provided secure data backup at minimal cost; access to data if away from CHaMP computer.
- Effective for managing data stream; file structure driven by study design, site evaluation.
- Data loggers and field laptops were not dependent on internet connection.
- Conference calls to go over common data upload errors resolved most issues; made process much easier for rest of the season.

What Didn't Work

- Lots of upload errors.
- Slow synch time between laptop, cloud, web app.
- Cloud account password lost and required reset.
- Laptop Personal cloud software needed many updates.
- Multi-component system made it difficult to find/repair errors.
- 2 – 24 hour time lag between laptop and cloud updates; time lag made fixing data upload errors harder.
- If "Local Crew" used to attribute entries, hard for staff to id surveying crew.
- Geodatabases stored in .zip files in database made querying, using data hard.

Quality Control/ Quality Assurance

What Worked

- The QC/QA process and error fixes were fairly simple once all the issues were identified.
- The website interface for QA was straightforward and user friendly (e.g., graphs helped identify small errors such as anomalous discharge measures).
- The website identified errors in the .csv files which made QC easier.
- The auxiliary data from the logger was uploaded to CHaMPMonitoring.org and compiled across all watersheds.
- The QA guidelines were well-defined and were implemented consistently across the entire project.
- QA was supported by the automatic update of calculated values and charts.
- Web-based editing eliminated the data versioning troubles that are common in distributed data management approaches.
- Metrics are easily regenerated based on current data.
- Defined workflow stages (e.g., "In QA") supported communication between crew members and analysts regarding the status of the dataset.
- The "Promote Data" button allowed crew members to control when data became available.
- Auxiliary metrics were generated on all available data.
- Semi-automated error checking procedures were built into CHaMPMonitoring.org.

Quality Control/Quality Assurance

CHaMP data quality procedures were divided into two categories: quality control and quality assurance. Quality control (QC) was differentiated from quality assurance (QA) to define a tiered approach that could be implemented systematically across crews, implemented sequentially through progressive steps, and implemented efficiently by crew members.

- Quality Control - This constrained the values that could be entered into the data system by setting absolute limits from a physical (e.g., pebble diameter must be greater than zero millimeters) or protocol basis (e.g., site length must be between 120 -600 m). QC constraints were defined as required fields, absolute expected minimums and maximums for numeric fields, and a drop down lists of acceptable values for text fields. These constraints were recorded in a data dictionary specific to the CHaMP protocol.
- Quality Assurance - These are procedures implemented to verify data quality after information had been entered into the data system. These checks were commonly conditional on multivariate parameters, ecological reasoning, or local site condition (e.g., maximum expected count for large woody debris pieces).

During the 2011 field season, the data logger was programmed to identify values that did not conform to QC/QA constraints; when it 'caught' data that triggered QC/QA constraints it turned the field background color red or yellow, respectively. In addition, the CHaMP-Monitoring.org data system 'Data Upload' tab also tested for QC/QA constraints. It produced an error when it identified QC constraints, and prohibited the upload of files with errors, thus requiring crews to fix QC errors in the .csv files prior to upload. The system produced a warning when it identified QA issues.

Data quality reviews were performed at the end of the season after all data had passed basic QC. The CHaMPMonitoring.org system was used to generate a set of calculated values and charts (defined in the Quality Assurance Guidelines document) for crews to review. Examples of calculated values include: station discharge, LWD count for site, ratio of site length to width category, and sample duration for drift biomass.

Two basic chart types– index plot and horizontal bar chart – were used. Crew members were able to review data compiled across the watershed or for individual sites. In addition, they were able to edit measurement values directly on the website, which triggered updates to the calculated values and charts. After reviewing the data, crew members clicked a button to promote a site to being ready for data analysis.

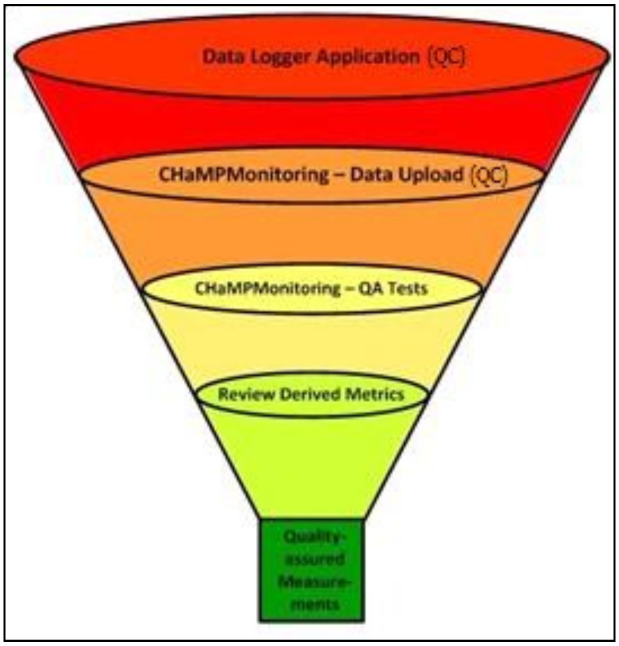


Figure 51. CHaMP QC/QA process

Recommendations for 2012:

Prior to the 2012 field season a CHaMP protocol for QC/QA should be developed. This would include, for example, guidance on what set of data quality procedures should be enforced at the time of data capture, reviewed at the end of the day, or reviewed at the end of the season, and will require the input and participation of crew supervisors who have prior experience with the CHaMP protocol. This protocol could outline implementers' duties during quality assurance and what this process involves, and emphasize more QC/QA during data collection and topographic processing stages, such as implementing QC procedures at the time of data capture to improve overall data quality and help to minimize the time and effort required to complete QA reviews at the end-of-the-season.

It also could include a workflow manager for QA procedures to help guide the order that QA is completed, document what procedures were completed, and provide feedback to crew members.

For the data loggers, versioning control on data logger software is desirable, as is exploring the option to integrate GIS with the handheld logger unit to view/edit data prior to upload. This would require providing a modified screen shot on the data logger. Also needed is an update to the data logger/application to implement QC procedures, that is, make the logger require user verification to remove the need to edit .csv files prior to data upload and reduce number of errors during upload to CHaMPMonitoring.org. It is critical that QC procedures do not inhibit data capture efforts and instead serve as a training tool to re-enforcement protocol requirements.

Also recommended is the development of a Data Broker application for the laptop to automate data download from the data logger and upload to CHaMPMonitoring.org. This application would eliminate the need to drag and drop files from the data logger to the laptop and would support auto-updates to the data logger application on the handheld. Ensuring participation from crew supervisors during both the design phase and the application testing phase is crucial.

On the website side, development of QA/QC scripts is recommended for the data once they have been exported from the logger and prior to upload into the CHaMP database. Modifications to CHaMPMonitoring.org to allow data to be upload more readily and support editing data on the website before data are sent to QA are desirable as this will provide crews an opportunity to fix quality control errors (e.g., need to update ChannelUnitId for pebbles) on the website and eliminates the need to edit .csv files on the laptop. Enabling plots of bivariate data is a simple way to identify potential outliers and data entry errors.

Also valuable would be to develop QA constraints on the exported data from the logger application that are integrated with CHaMPMonitoring.org data system QC process, and modify QA views to help ensure that users are editing the correct visit.

Lastly, creating a function that would allow an administrator to re-import files from the cloud if they are not the most recent, or to delete them from the database and re-import again, would be valuable.

Quality Control / Quality Assurance

What Didn't Work

- The hierarchical error checking system made QC/QA difficult.
- Not enough QC was done on the data logger, for example, required fields were not enforced at the time of data capture.
- There were many data formatting errors due to loggers not working.
- Data entry and editing .csv files was time consuming and resulted in data file format inconsistencies.
- There was inconsistent QC between the data logger and CHaMPMonitoring.org.
- Overall, there was not enough time allotted for QA.
- Early season high flows delayed sampling and therefore QA reviews.
- There was insufficient communication about implementers' duties.
- QA guidelines, values, and charts were not developed or available on the website until the end of season.
- Users had to pick the visit for each site when performing the QA edits.
- Once the data were in the QA stage it was difficult to fix QC errors.
- There were delays between editing .csv files and updates appearing on CHaMPMonitoring.org.
- There was a large time lag between changes on the cloud showing up on the website and corrections made to .csv files on the cloud were not transferred to the website so corrections had to be made again manually on the website.

Data Analysis-Staffing and Funding

What Worked

- CHaMP and ISEMP staff were able to backfill the data analysis role to the degree that they were technically capable and available, and contribute to data analysis tasks.

What Didn't Work

- The cost share with PNAMP was not well developed resulting in the data analysis position not being funded.
- Insufficient staffing led to a heavy use of the ISEMP biometrician.
- The data analyst tasks will require additional effort for completion.
- The lack of an in-house data analyst curtailed our ability to synchronize data with the CHaMP databases and create useful templates to incorporate fish data and generate reports.

Data Analysis

Staffing and Funding

The 2011 CHaMP project work plan identified the need for a full time data analyst position, which was described as cost-share with PNAMP. The goal of the data analyst position is to evaluate the efficacy of the project, recommend changes informed by findings of the field data, and develop a standardized suite of analyses to be conducted in an identical fashion for the duration of the project.

As envisioned, this position would be responsible for five primary tasks during CHaMP initiation:

1. Design Analysis:

Project proponents recognize that CHaMP is being implemented in a number of watersheds with pre-existing habitat restoration actions. During initiation the analyst would assume primary responsibility for aligning the distribution of CHaMP sampling effort to best address both the data requirements of CHaMP and those of existing restoration and monitoring actions within targeted watersheds.

2. Metric Calculations:

CHaMP authors developed a suite of metrics and indicators many of which require substantial post-processing (e.g., NREI). The data analyst would identify appropriate statistical methods and develop software programs or scripts necessary to generate derived metrics/indicators from raw data.

3. Metric and Indicator Evaluation/Consolidation/Prioritization:

As developed, CHaMP produces a large and diverse suite of metrics and indicators. Similar to many habitat survey protocols, some of these metrics are closely related. At the termination of the 2011 field season, the analyst was to assume primary responsibility for evaluating the metrics for the purpose of identifying their information content. In the long-run, this initiative is intended to enable an informed reduction in sampling effort via the removal of duplicative metrics and/or metrics with negligible information content. Conversely, these analyses are simultaneously intended to identify weaknesses in the existing CHaMP protocol (e.g., insufficient effort in the generation of field data underlying metrics).

4. Survey Variance Partitioning:

The analyst would assume primary responsibility for conducting standard GRTS survey variance partitioning. Ultimately, this exercise will evaluate the sufficiency of sampling effort given survey error and inter/intra-annual variation within the context of the spatial scales across CHaMP (i.e., within and among watersheds, ESU's, DPS's, and ecoregions).

5. Incorporation of Fish Data:

While CHaMP does not explicitly include funding for the collection of fish data (e.g., abundance, productivity, distribution, etc.), a primary goal of the project is relating these features to CHaMP metrics and indicators. The data analyst would assume primary responsibility for relating fish indicators to CHaMP metrics and indicators using available fish information from existing fish monitoring activities co-located in CHaMP watersheds.

Recommendations for 2012:

The need for a full time analyst position has not diminished. We strongly recommend that steps are taken to ensure that the proposed PNAMP cost-share is realized in 2012 or that the position be fully funded through CHaMP.

Immediate tasks for this position include:

- Design Analysis - begin the process of aligning CHaMP efforts with existing habitat restoration and monitoring efforts in new watersheds if they are funded.
- Metric and Indicator Evaluation/Consolidation/Prioritization - identify duplicative or uninformative measurements and/or deficient effort accompanying field measurements to help streamline the protocol and/or identify the need for more effort. Early identification is crucial to enable protocol modification and subsequent changes to training curricula, data logger and storage applications.
- Metric Calculations - substantial work is required to automate the generation of some derived metrics/indicators (e.g., NREI).

Longer term tasks (2012-2014) include survey variance partitioning and incorporation of fish data.

APPENDIX A

Variance Decomposition Models

A more detailed description of potentially relevant components of variation can be summarized by the following model that refines the components defined above and includes various levels of interaction.

$$X_{ijklmn} = A_i + B_i t + C_j + D_{k(i)} + E_{k(i)}\, t + (C * D)_{jk(i)} + F_l + G_m + H_n + e_{ijklmn}$$

Indices

- i – class/region
- j – year
- k – site
- l – Julian date of sampling
- m – days between sampling
- n - crew

Terms

- Xijklmn – Habitat metrics
- Ai – region/class fixed effect
- Bit – region/class trend – fixed effect
- Cj – site random year effect
- Dk(i) – site, nested in region/class, random effect
- Ek(i)t – site, nested in region/class, trend – fixed effect
- C * Djk(i) – site by year interaction – random effect
- Fl – date of first sampling event – random effect
- Gm – days separating repeat sampling events – random effect
- Hn – crew effect – fixed effect to explore specific crew effect, random effect to explore repeatability
- eijklmn – Unaccounted for "residual".

Ultimately, this model (or versions of it) will be used to evaluate spatial and temporal patterns in the data, as well as to explore the distribution of variance around each term.

The model has many more terms than might be relevant in any single analysis, but gives us a common frame to work from. The base model can be used in a univariate (ANOVA and Bayesian) as well as multivariate (permutation) form. Model selection can be used to differentiate between candidate models.

For evaluating the relative performance of CHaMP metrics we used the following "submodel" applied to the CHaMP 2011 dataset:

$$Xikl = Ai + Dk(i) + Fl + eikl$$

Indices

- i – class/region
- k – site
- l – Julian date of sampling

Terms

- Xikl – Habitat metrics
- Ai – region/class fixed effect
- Dk(i) – site, nested in region/class, random effect
- Fl – julian day of sampling – random effect
- eikl – Unaccounted for "residual".

We lumped region and site into a single variance term because we were primarily interested in the relative magnitude of the residual (or noise) term across the different metrics to answer questions about the relative performance across the various CHaMP set of metrics (see Figure 15).

Crew effect evaluation used this submodel:

$$X_{ikln} = A_i + D_{k(i)} + H_n + F_l$$

Indices

- i – size
- k – site
- l – Julian date of sampling
- n - crew

Terms

- X_{ikln} – Habitat metrics
- A_i – size (large or small, fixed effect)
- $D_{k(i)}$ – site, nested in size class, random effect
- F_l – julian day of sampling – random effect
- H_n – crew effect
- e_{ikln} – Unaccounted for "residual".