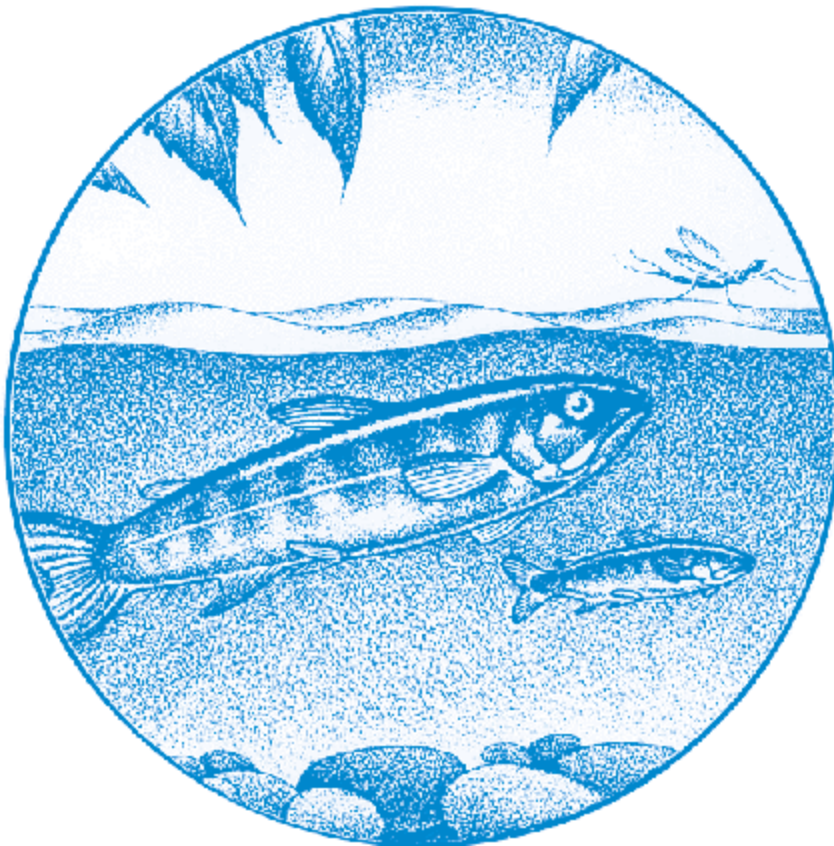# Monitoring and Evaluation:
Stastical Support for Life-cycle Studies

Annual Report
2003

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2003 Annual Report

Statistical Support for Salmonid Survival Studies

Contract No. 00012494

Project No. 198910700

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Executive Summary

This report summarizes the statistical software development and consulting activities performed under Contract No. 00012494, Project No. 198910700 funded by Bonneville Power Administration during 2003. These efforts are focused on improving the design, analysis, and interpretation of salmonid tagging studies conducted in the Columbia Basin.

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1.0 Project Overview

Project 198910700 was initiated in 1989 to improve monitoring and evaluation capabilities of the Columbia River Fish and Wildlife Program (FWP) by developing better measurement tools and study designs to evaluate relationships between ambient environmental conditions and the survival of juvenile and adult salmonids. Orginally, this project was entitled, "Epidemiological survival methods: Development of survival relationships using concomitant variables measured from individual smolts implanted with PIT-tags." After PIT-tag survival studies using the methods developed through this project were initiated in 1993, other tagging methods were evaluated, and the title evolved to become "Statistical support for salmonid survival studies," to better characterize its role in supporting the Columbia River FWP.

The ongoing mission of this project is the development of statistical tools for analyzing fisheries tagging data in the most precise and appropriate manner possible. This mission also includes providing statistical guidance on the best ways to design large-scale tagging studies. This mission continues because the technologies for conducting fish tagging studies continuously evolve. In just the last decade, fisheries biologists have seen the evolution from freeze-brands and coded wire tags (CWT) to passive integrated transponder (PIT) tags, balloon-tags, radiotelemetry, and now, acoustic-tags. With each advance, the technology holds the promise of more detailed and precise information. However, the technology for analyzing and interpreting the data also becomes more complex as the tagging techniques become more sophisticated. The goal of the project is to develop the analytical tools in parallel with the technical advances in tagging studies, so that maximum information can be extracted on a timely basis. Associated with this mission is the transfer of these analytical capabilities to the field investigators to assure consistency and the highest levels of design and analysis throughout the fisheries community. Consequently, this project provides detailed technical assistance on the design and analysis of tagging studies to groups requesting assistance throughout the fisheries community.

Ideally, each project and each investigator would invest in the statistical support needed for the successful completion of their study. However, this is an ideal that is rarely if every attained. Furthermore, there is only a small pool of highly trained scientists in this specialized area of tag analysis here in the Northwest. Project 198910700 provides the financial support to

sustain this local expertise on the statistical theory of tag analysis at the University of Washington and make it available to the fisheries community. Piecemeal and fragmented support from various agencies and organizations would be incapable of maintaining a center of expertise. This funding assures the continuity of support needed to assist organizations on an as-needed basis, as well as provide the necessary support to develop the analytical technologies needed in the foreseeable future.

This project continues to respond to the changing needs of the scientific community in the Pacific Northwest as they face new challenges to extract life history data from an increasing variety of fish tagging studies. The mission of the project is to help assure tagging studies are designed and analyzed from the onset to extract the best available information using state-of-the-art statistical methods.

The overarching goals of the project is to assure statistically sound survival studies so that fish managers can focus on the management implications of their findings and not be distracted by concerns whether the studies are statistically reliable or not. Specific goals and objectives of the study include the following:

1. Provide consistent application of statistical methodologies for survival estimation across all salmon life cycle stages to assure comparable performance measures and assessment of results through time, to maximize learning and adaptive management opportunities, and to improve and maintain the ability to responsibly evaluate the success of implemented Columbia River FWP salmonid mitigation programs and identify future mitigation options.

2. Improve analytical capabilities to conduct research on survival processes of wild and hatchery chinook and steelhead during smolt outmigration, to improve monitoring and evaluation capabilities and assist in-season river management to optimize operational and fish passage strategies to maximize survival.

3. Extend statistical support to estimate ocean survival and in-river survival of returning adults. Provide statistical guidance in implementing a river-wide adult PIT-tag detection capability.

4. Develop statistical methods for survival estimation for all potential users and make this information available through peer-reviewed publications, statistical software, and

technology transfers to organizations such as NOAA Fisheries, the Fish Passage Center, US Fish and Wildlife Service, US Geological Survey (USGS), US Army Corps of Engineers (USACE), Public Utility Districts (PUDs), the Independent Scientific Advisory Board (ISAB), and other members of the Northwest fisheries community.

5. Provide and maintain statistical software for tag analysis and user support.

6. Provide improvements in statistical theory and software as requested by user groups. These improvements include extending software capabilities to address new research issues, adapting tagging techniques to new study designs, and extending the analysis capabilities to new technologies such as radio-tags and acoustic-tags.

2.0 Overview of Annual Accomplishments, 1 December 2002 – 30 November 2003

A summary of annual accomplishments this last year for Project 198910700 include the following:

1. Maintenance of existing software programs, including SURPH, PitPro, USER, and SampleSize. Among the annual maintenance activities include updating PitPro to include the PIT-tag coil configurations used during the 2003 juvenile and adult migrations.

2. Program USER 2.1 was enhanced to USER 2.5. The enhancements include the ability to use the program in batch mode for repetitive analysis of multiple datasets. A user's manual and online manual were produced for Program USER 2.1 (RPA 193).

3. A user's manual and online manual were produced for Program PitPro 1.0 (RPAs 82, 83).

4. A user's manual and online manual were produced for Program SampleSize 1.0 (RPA 193).

5. Program SURPH.2 was enhanced to SURPH 2.1. At the request of users, the format of the data input files was improved to make it simpler and more intuitive. A user's manual and online manual were produced for SURPH 2.1 (RPAs 82, 83).

6. Developed new statistical models to jointly analyze smolt downstream and adult upstream PIT-tag detections.

7. Investigated statistical approaches to analyze adult radiotelemetry information on survival, fallbacks, and straying.

8. Assisted NOAA Fisheries, USACE, USGS, WDFW, Mid-Columbia PUDs, and the Nez Perce Tribe in the design and analysis of salmonid survival studies.

2.1 Maintenance of SURPH.2, USER.2, and PitPro Software

The statistical software programs SURPH 2.1, USER 2.1, PitPro 1.0, and SampleSize 1.0 developed at the UW to design and analyze PIT-tag, balloon-tag, radio-tag, and acoustic-tag survival studies are also maintained, debugged, and enhanced at the UW. Maintenance involves upkeep of a unified UNIX-PC based program suitable for both UNIX and PC users. As computer systems are routinely upgraded, the software must be altered to work on the newer systems and computer platforms. Other maintenance issues include responding to user questions and providing users with manuals and individual instruction. (RPAs 82, 83, 193)

2.2 Software Manuals

A major focus this last year was to update or publish new user manuals for all the statistical software packages produced by this project. The hard-copy manuals were produced as well as online support manuals associated with the software packages. Four manuals were produced this last year.

2.2.1   SURPH 2.1 User Manual
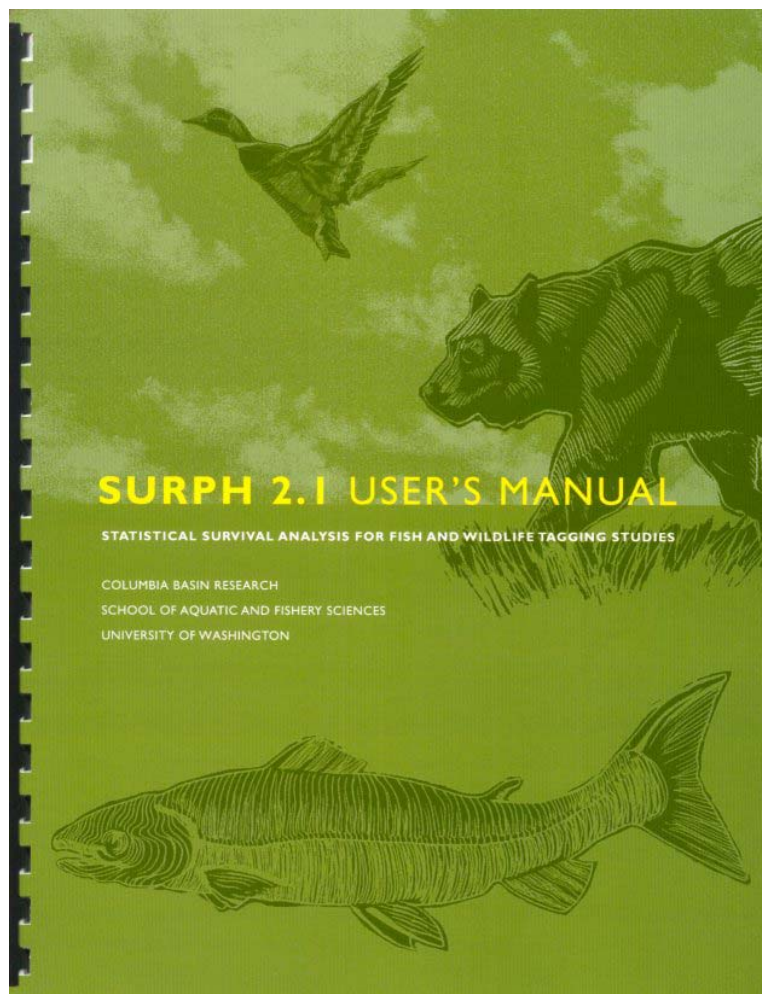
This manual provides primarily a description of the user interface for SURPH 2.1. The manual describes how to load input data, the modeling options for describing survival and detection processes, how to model and compare alternative release-recapture models, parameter estimation, hypothesis testing, and diagnostics.   This manual shows step-by-step input commands along with the anticipated screen displays of analysis and summary statistics. The manual also explains the nature of the analyses output and associated statistical interpretation. The SURPH 2.1 program and online manual can be found at http://www.cbr.washington.edu/paramEst/SURPH/.

2.2.2   USER 2.1 Manual
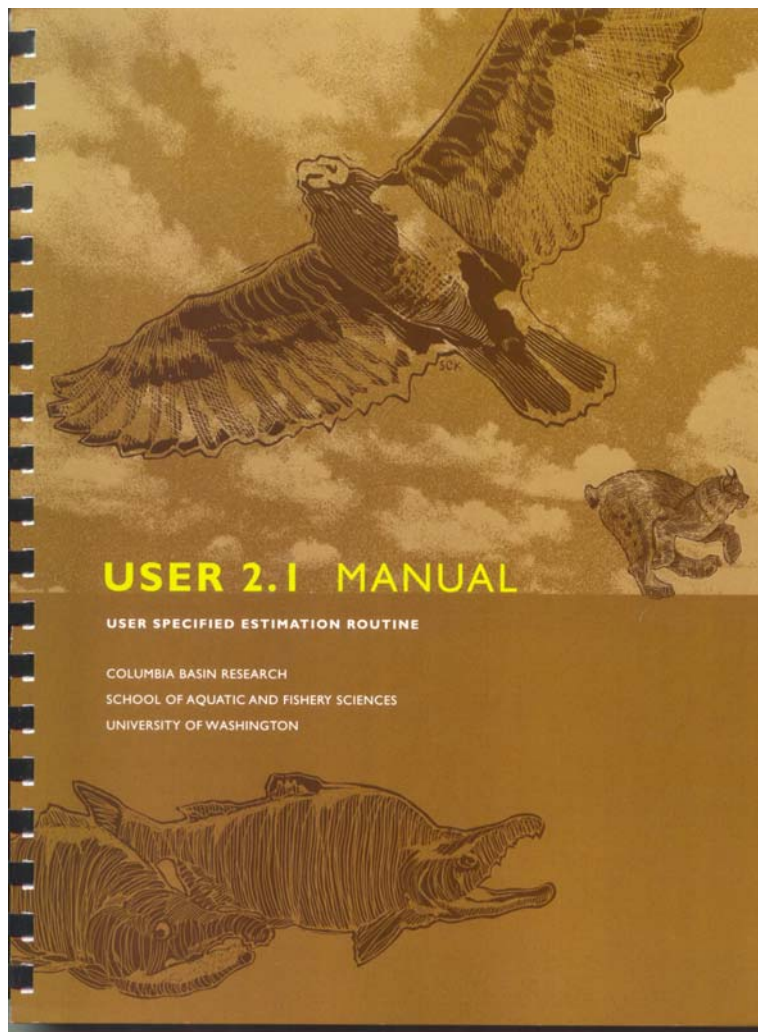
This manual is primarily a description of the user interface for USER 2.1. The program provides a flexible platform to develop statistical likelihood models to estimate demographic parameters from a wide variety of tagging studies (i.e., PIT-tag, balloon-tag, radio-tag, acoustic-tag). The program is capable of developing models and analyzing any count data that can be described by multinomial or product-multinomial distributions. The manual describes data input, model specifications, and parameter estimation with illustrations from the screen displays. The manual also includes annotated examples of modeling and data analyses. The USER 2.1 program and online manual can be found at http://www.cbr.washington.edu/paramEst/USER/.

2.2.3   PitPro 1.0 User Manual
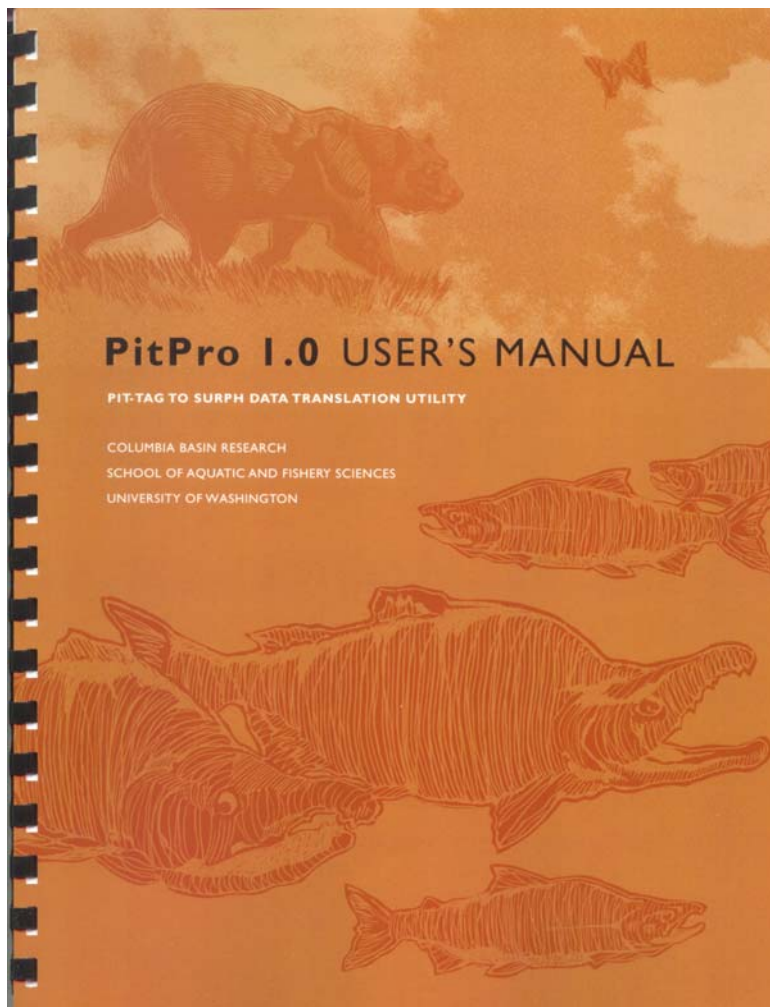
This manual describes the use of Program PitPro to convert PIT-tag data files in PTAGIS to input files ready for survival analysis in SURPH 2.1. This utility converts the various PIT-tag detections at the multitude of detection coils within a juvenile bypass system or at adult counting windows and ladders into capture histories. The program also includes the coil configurations in past years so that investigators can interrogate PTAGIS and obtain the correct detection histories regardless of where or when the detections occurred. The manual describes the various commands needed to obtain PIT-tag summary information and the various output files available to investigators . The manual describes the use of PitPro in both an interactive as well as batch mode. The PitPro 1.0 program and manual can be found at http://www.cbr.washington.edu/paramEst/SURPH/Utilities/PtagisUtilities.html.

2.2.4 SampleSize 1.1 User's Manual
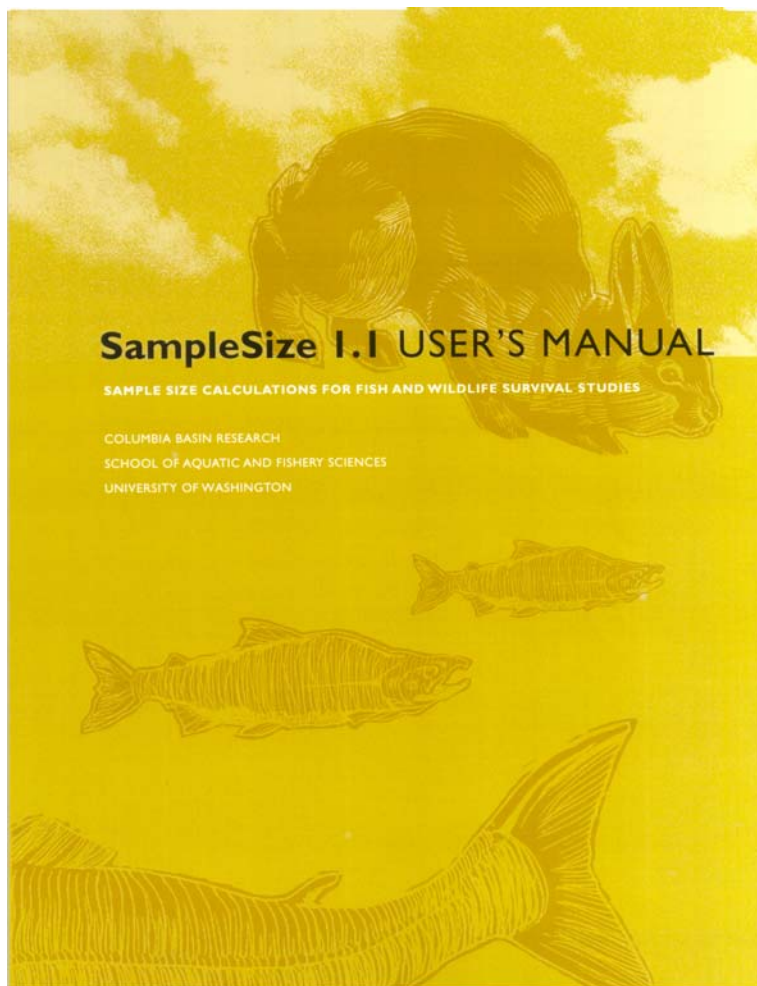
This manual describes the use of Program SampleSize 1.1 to determine sample sizes for the following survival studies: (a) single release-recapture, (b) paired release-recapture, and (c) transport/inriver ratio. The program determines the anticipated precision (i.e., half-width of 90% or 95% confidence intervals) as a function of release size, detection probabilities, transport removals, and anticipated survival. Precision curves are generated as a function of the user's choice of design variables. The manual illustrates the use of the program with annotated examples and screen displays. The SampleSize 1.1 program and manual can be found at http://www.cbr.washington.edu/paramEst/SampleSize/.

2.3 Adult Survival Studies

Working in conjunction with NOAA Fisheries, new research efforts were begun to develop statistical release-recapture models focused on salmonid adult survival studies. Two concurrent efforts are underway:

1. Development of PIT-tag models to jointly analyze smolt outmigration and adult upriver detection histories.

2. Development of radio-tag models to analyze the complex upriver migration behavior of adult salmonids including survival, fallbacks, and straying.

The PIT-tag models will eventually permit the simultaneous analysis of smolt inriver survival, ocean survival, transport/inriver ratios, and adult upriver survival probabilities. These models will take into account the transportation of juveniles from multiple dams and the multiple years of adult returns from a single smolt cohort. The radiotelemetry models will be a flexible set of analyses that can examine both the intricate behavior of adult salmonids at a dam and the straying of adults to multiple tributaries as they proceed upriver. The statistical modeling exercises will permit comparison of the absolute and relative information acquired using radio-tag versus PIT-tag adult survival studies. Current efforts have identified that classical Cormack-Jolly-Seber (CJS) models provide "survival" estimates that are, in actuality, a complex expression of adult survival, straying, and detection processes—and of limited utility. The new generation of models underway will permit more detailed as well as more interpretable parameters for fisheries managers to use in monitoring and evaluating adult returns.

3.0 Technical Papers and Reports

The following technical reports and publications in peer-reviewed journals have been completed and made available to the fisheries community during the last year as a consequence of this BPA project and its technology transfer:

Papers

1. Johnson, G. E., J. B. Hedgepeth, J. R. Skalski, and A. E. Giorgi. 2003. Markov-chain analysis of fish tracks to map the biological zone of influence of a water withdrawal portal. *Fisheries Research* (accepted).

Reports or Technology Transfer

1. McMichael, G. A., D. R. Geist, T. P. Hanrahan, E. V. Arntzen, R. P. Mueller, R. A. Moursund, J. A. Carter, J. M. Becker, C. A. McKinstry, W. A. Perkins, D. D. Dauble, T. M. Degerman, J. R. Skalski, R. L. Townsend, B. B. James, and D. R. Thornhill. 2003. Chinook salmon in the Priest Rapids Project. Report prepared for the Public Utility District No. 2 of Grant County. Battelle, Pacific Northwest Division, Richland, WA.

2. Muir, W. D., S. G. Smith, R. W. Zabel, D. M. Marsh, and J. R. Skalski. 2003. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia river dams and reservoirs, 2002. Annual report to the Bonneville Power Administration from the National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA.

3. Normandeau Associates, Inc., Mid Columbia Consulting, Inc., and J. R. Skalski. 2003. Estimated direct mortality and injury of juvenile salmonids in passage through The Dalles Dam spillway, Columbia River in spring and summer 2002. U.S. Army Corps of Engineers, Portland District, Portland, OR.

4. Normandeau Associates, Inc., Mid Columbia Consulting, Inc., and J. R. Skalski. 2003. Juvenile salmonid survival in passage through modified spillbays at Bonneville Dam, Columbia River. U.S. Army Corps of Engineers, Portland District, Portland, OR.

5. Normandeau Associates, Inc., J. R. Skalski, and Mid Columbia Consulting, Inc. 2003. Survival/condition of chinook salmon smolts under different turbine operations at McNary Dam, Columbia River. Prepared for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, WA, under Contract No. DACW68-02-D-002.

6. Normandeau Associates, Inc., and J. R. Skalski. 2003. Evaluation of smolt mortality and injury associated with passage through a modified top spill bulkhead spillway at Wanapum Dam, Columbia River. Prepared for Grant County PUD No. 2, Ephrata, WA.

7. Robichaud, D., K. K. English, J. R. Skalski, B. L. Nass, J. Lady, C. Sliwinski, and A. Blakley. 2003. Survival of chinook smolts during various spill configurations at Wanapum and Priest Rapids dams, 2002. Draft A. Prepared for PUD No. 2 of Grant County, Ephrata, WA.

8. Skalski, J. R., R. L. Townsend, T. W. Steig, J. W. Horchik, G. W. Tritt, and R. D. McDonald. 2003. Estimation of Rock Island project passage survival of yearling chinook salmon smolts in 2003 using acoustic and PIT-tag release-recapture methods. PUD No. 1 of Chelan County, Wenatchee, WA.

9. Steig, T. W., J W. Horchik, G. W. Tritt, J. R. Skalski, and R. Ngouenet. 2003. Comparison of PIT tagged and acoustic tagged juvenile chinook, steelhead and sockeye salmon passing Rocky Reach Dam in 2002. Chelan County Public Utility District No. 1, Wenatchee, WA.

4.0 Summary of Technology Transfer Efforts

Each year, research staff of this project are asked to assist fisheries investigators in software instruction and support, data analyses, study design, and sample size calculations. These efforts are used to help elevate the scientific rigor of life-cycle studies conducted in the Columbia Basin. Support is provided to federal and state agencies, tribes, and public utility districts dealing with smolt and adult salmonid tagging studies. These efforts are summarized, in part, by the joint authorship of technical reports and papers listed in Section 3.0. Other efforts are characterized by attending technical support meetings in the community, direct person-to-person assistance, and collaboration on survival studies.

The technical support is of two categories of effort. Direct effort supported by funds of this project. Typically, these efforts are of limited duration, 1-5 staff/days, with the focus on assisting investigators in study design or analysis efforts. The intent is to assist investigators or agencies with technical issues or difficulties but not directly collaborate on an investigation. The second type of support is indirect support where funds are not directly used to support consulting efforts. Rather, technical support exists because of the capabilities and long-term staffing made available by BPA ongoing funding. In these circumstances, agencies and investigators avail themselves of UW Columbia Basin Research assistance by funding such efforts themselves. Nevertheless, such assistance and technological expertise would not exist if it were not for BPA

ongoing funding. Table 4.1 summarizes the levels of direct and indirect support provided the fisheries community during the period 1 January – 1 November 2003.

Table 4.1. Summaries of direct and indirect BPA support of fish tagging studies, 1 January – 1 November 2003, by this BPA project staff.

Organization	Staff/Hours	
	Direct	Indirect
US Army Corps of Engineers	36	36
US Geological Survey/Cook Lab	22	
Washington Department of Fish and Wildlife	24	
NOAA Fisheries	76	
Douglas County Public Utility District	4	35
Chelan County Public Utility District	18	290
Grant County Public Utility District	20	375
Nez Perce Tribe	10	
Idaho Fish and Game	56	
Oregon Department of Fish and Wildlife	2	
Total	268	736