PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Monitoring And Evaluation Statistical Support

BPA project number: 9105100
Contract renewal date (mm/yyyy): 1/2000 ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
University of Washington

Business acronym (if appropriate) UW

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
NPPC Doc 94-55: 3.2F.1 Regional Analytical Methods Coordination, 3.3A.1 Coordinated Information Systen, 4.3B Development of Performance Standards, 4.3C Population Monitoring, 5.2A.7 Third-Party Evaluation of Snake River Spring Migrants

FWS/NMFS Biological Opinion Number(s) which this project addresses
NMFS 1995 Hydrosystem Operations BO: RPA 13, Develop comprehensive monitoring, evaluation and research program; RPA 16, Investigate effects of dissolved gas supersaturation; RPA 17, Test hypotheses underlying life cycle models.

Other planning document references
NMFS 1995 Proposed Recovery Plan for Snake River Salmon: Task 0.3.a, Develop coordinated information system; Task 0.3.b, Coordinate regional approach for biological analysis and modeling; Task 2.1.d, Conduct monitoring, evaluation, and research to support flow augmentation effects; Task 21.d.2, Investigate relationships between flows and ocean survival; Task 2.1.d.3, Evaluate juvenile survival during downstream migration; Task 2.1.d.3, Evaluate effectiveness of pulsing operations; Task 2.2.d, Evaluate effects of spill on salmonid migration,; Task 2.2.d.3, Investigate the effects of dissolved gas supersaturation; Task 2.3.c, Consolidate regional efforts and capabilities to support monitoring and evaluation; Task 2.6.c, Conduct monitoring and evaluation to

improve adult passage success; Task 2.11.b, Test underlying hypotheses of life cycle models.

Short description
Develops statistical methods needed in monitoring and evaluating salmonid recovery plans. Provides added-value analyses of tagging data to address regional issues. Provides smolt migration timing predictions on internet for the fisheries community.

Target species
Chinook salmon, coho, and steelhead

Section 2. Sorting and evaluation

Subbasin
Systemwide

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☒ Anadromous fish ☐ Resident fish ☐ Wildlife	☐ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☒ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☒ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description
20537	Bonneville Power Administration Non-Discretionary Projects Umbrella

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
8332300	Smolt Condition & Arrival Timing at Lower Granite [IDFG]	Dependent. Program RealTime uses PIT-tag detections and passage index

		data to generate in-season, real-time, internet-based information on status and prediction of migration timing for ESA-listed wild stocks as they pass through FCRPS.
8401400	Smolt Monitoring at Federal Dams [NMFS-ETSD]	Dependent. Program RealTime uses PIT-tag detections and passage index data to generate in-season, real-time, internet-based information on status and prediction of migration timing for ESA-listed wild stocks as they pass through FCRPS.
8712700	Smolt Monitoring by Non-Federal Entities [PSMFC]	Dependent. Program RealTime uses PIT-tag detections and passage index data to generate in-season, real-time, internet-based information on status and prediction of migration timing for ESA-listed wild stocks as they pass through FCRPS.
8910700	Statistical Support for Salmonid Survival Studies [UW]	Complementary. This project develops the statisitical methods used in providing the value-added analyses of historical tagging data.
8910800	Monitoring and Evaluation Modeling Support [UW]	Complementary. RealTime model is linked with the CRiSP model of Project 8910800 to extend predictions of migration timing to sites below Lower Granite Dam. Supports DART which provides real-time, on-line database services and presentations.
9008000	Columbia Basin PIT-Tag Information System (PTAGIS) [PSMFC]	Dependent. Provides high quality real-time PIT-tag data made available through PTAGIS as input to the daily runs of the Program RealTime PIT-forecaster to generate internet-based predictions of run timing for individual and combined ESA wild stocks.
9102800	Monitoring Smolt Migration of Wild Snake River Spring/Summer Chinook [NMFS]	Dependent. This project PIT-tags wild ESA-listed stocks in natal streams. PIT-tag detections are used by Program RealTime the following spring to make in-season predictions for potential use by TMT and fisheries community.

9107200	Sockeye Samon Captive Broodstock [IDFG]	Complementary. This project applies Program RealTime to make run-timing predictions for Redfish Lake sockeye available for use by the TMT and fisheries community.
9202604	Spring Chinook Salmon Early Life History [ODFW]	Dependent. This project PIT-tags wild ESA-listed stocks in natal streams. PIT-tag detections are used by Program RealTime the following spring to make in-season predictions for potential use by TMT and fisheries community.
9302900	Survival Estimation for Dam/Reservoir Passage [NMFS]	Complementary, provides analytical and statistical support to respond to NMFS requests to enhance survival estimation capabilities incorporated in Program SURPH. Responds to requests to NMFS to investigate alternative analyses.
9403300	Fish Passage Center [PSMFC]	Dependent. Uses the in-season smolt index passage information that is provided by the FPC's database center in the RealTime Passage Index Forecaster program to generate on-line forecasts of in-season passage for ESA-listed wild chinook and steelhead.
9503400	EW Program Support [BPA-UW]	Complementary. Provides technical assistance and statistical support essential to BPA's independent decision-making processes through peer review of monitoring and evaluation requirements.
9600600	PATH Facilitation, Technical Assistance & Peer Review [ESSA]	Complementary. Analyzes and interprets tagging data in ways other research entities currently do not perform. Provides an added-value to historical tagging data by testing hypotheses, estimating parameters, and modeling interrelationships.
9600800	PATH Participation by State & Tribal Agencies [ODFW]	Complementary, by analyzing of historical tagging data and publishing reports which are made available to PATH.
9601700	Technical Support for PATH [BioAnalysts]	Complementary, by analyzing tagging data which is provided to

		PATH as requested.
9700200	PATH-UW Technical Support	Complementary. Provides analyses of selected data sets and issues related to PATH deliberations.

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1991	Report on historical brand release data for the Snake River. Report identified serious bias in travel time estimation using brand data and the difficulties in establishing travel time relationships with existing data.	3.2F.1 Regional and analytical methods. Identified current methods of travel time and calculations inadequate for monitoring outmigration performance.
1992	Report on "strawman" smolt monitoring design for Snake/Columbia River systems. Report became the conceptual design for the existing PIT-tag detection system for the Snake River.	4.3C Population monitoring. Outlined system for a PIT-tag smolt monitoring program.
1993	Report on adult PIT-tag returns. Results showed annual patterns of adult returns differed across years even for closely related river systems.	7.1C Collection of life history data. Developed the natural variation in adult returns.
1994	Development and testing of Program RealTime PIT Forecaster statistical software using pattern recognition and neuronets to predict outmigration timing of spring runs of wild Snake River spring/summer chinook at Lower Granite Dam in real time.	4.3C Population monitoring. Developed more precise predictions of outmigration timing and made it publically available in real time.
1995	Refinement of RealTime PIT Forecaster statistical software and initial testing of RealTime Passage Index Forecaster statistical software to predict outmigration timing of summer/fall runs of juvenile subyearling chinook at Lower Granite Dam.	4.3C Population monitoring. Developed more precise predictions of outmigration timing and made it publically available in real time.
1996	RealTime model linked with CRiSP model of Project 8910800 to extend predictions of migration timing to include Lower Snake River hydroprojects and McNary Dam. Expansion of internet access to include historical run timing and flow data at hydroprojects.	4.3C Population monitoring. Developed more precise predictions of outmigration timing and made it publically available in real time.

1997	RealTime predictions continued along with the addition of Redfish Lake sockeye salmon and steelhead. Study of effects of river pulsing on smolt travel times, estimation of FGE and SE from PIT-tag data, season-wide survival rates, and growth rates.	5.2D.3 Independent third-party evaluation of spill effectiveness and spill alternatives.
1998	Completed study of relationships between coho age-at-return CWT data and early ocean survival as function of ocean conditions. Assessed internal consistency of hydroacoustics, PIT-tag and balloon-tag studies in explaining Lower Granite Dam survival.	7.1C Collection of life history data. Characterized 17 years of ocean survival relationships of coastal coho stocks at 15 hatcheries for baseline information on natural mortality.

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	In-Season Statistical Support	a	Provide RealTime predictions.
2	Statistical Analysis of Historical Tagging Data	a	Analysis of adult returns and ocean survival using CWT data.
		b	Analysis of adult returns using PIT-tag data.
		c	Analysis of spawner-recruit databases.
		d	Analysis of relation of flow pulsing and smolt outmigration dynamics.
3	Statistical Support for Region	a	BPA technical support.
		b	NW technical support.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	1/2000	11/2000	RPA 13		22.00%
2	1/2000	12/2000	RPA 17		66.00%
3	1/2000	12/2000	RPA 13		12.00%
				Total	100.00%

Schedule constraints
None.

Completion date

Open as long as BPA requires technical support.

Section 5. Budget

FY99 project budget (BPA obligated): $319,952

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel	Includes 3% raise.	%47	158,298
Fringe benefits		%11	37,932
Supplies, materials, non-expendable property	Includes computer upgrades, software licenses, services, etc.	%4	14,669
Operations & maintenance	O&M costs occur across a number of budget items. For FY 2000, 41% of budget = 139,546.	%0	
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel		%0	1,700
Indirect costs	26% of the total direct costs less costs for equipment and office lease.	%18	60,866
Subcontractor	BioAnalysts, Inc.	%15	50,000
Other	Office lease	%5	16,892
TOTAL BPA FY2000 BUDGET REQUEST			$340,357

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
		%0	
		%0	
		%0	
		%0	
Total project cost (including BPA portion)			$340,357

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$343,000	$347,000	$349,000	$352,000

Section 6. References

Watershed?	Reference
☐	Bates, D. M., and D. G. Watts. 1988. Nonlinear regression analysis and its applications. John Wiley & Sons. New York, NY. 365 pp.
☐	Belsley, D. A., E. Kuh, and R. W. Weloch. 1980. Regression diagnostics, identifying influential data and sources of collinearity. Wiley & Sons. New York, NY. 292 pp.
☐	Greenwood, P. E., and M. S. Nikulin. 1996. A guide to chi-squared testing. Wiley & Sons. New York, NY. 280 pp.
☐	Hosmer, D. W., and S. Lemeshow. 1989. Applied logistic regression. Wiley & Sons. New York, NY. 307 pp.
☐	Kendall, M., and A. Stuart. 1979. The advanced theory of statistics. Volume 2. MacMillan. New York, NY. 748 pp.
☐	McCullagh, P., and J. A. Nelder. 1989. Generalized linear models. Chapman and Hall. New York, NY. 511 pp.
☐	Perez-Comas, J. A., and J. R. Skalski. 1998a. Preliminary assessment of the effects of pulsed flows on smolt migratory behavior. Volume IV in the Design and Analysis of Salmonid Tagging Studies in the Columbia River Basin. BPA.
☐	Perez-Comas, J. A., and J. R. Skalski. 1998b. Analysis of in-river growth for PIT-tagged spring chinook salmon smolt. Volume V in the Design and Analysis of Salmonid Tagging Studies in the Columbia River Basin. BPA.
☐	Newman, K. 1998a. Estimating salmonid survival with combined PIT-CWT tagging. Volume II in the Design and Analysis of Salmonid Tagging Studies in the Columbia River. Bonneville Power Administration. Portland, OR.
☐	Newman, K. 1998b. Experiment design and statistical models to estimate the effect of transportation on survival of Columbia River system salmonids. Volume III in the Design and Analysis of Salmonid Tagging Studies in the Columbia River. BPA.
☐	Ryding, K. E. 1998. Analyzing adult retuns to assess ocean effects and salmon survival relationships. MS thesis. Univ. of Washington. Seattle, WA.
☐	Ryding, K. E., and J. R. Skalski. 1998. Multivariate regression relationships between ocean conditions and early marine survival of coho salmon. Can. J. Fish. Aquat. Sci. (submitted).
☐	Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Macmillan. New York, NY.
☐	Seber, G. A. F., and C. J. Wild. 1989. Nonlinear regression analysis and its applications. Wiley & Sons. New York, NY. 365 pp.

☐	Skalski, J. R. 1996. 1996 Post-season evaluation of run-timing predictions of outmigrating smolt at Rock Island, Wanapum and Priest Rapids Dams. Grant County Public Utility District. Ephrata, WA.
☐	Skalski, J. R. 1997. 1997 Post-season evaluation of run-timing predictions of outmigrating smolt at Rock Island, Wanapum and Priest Rapids Dams. Grant County Public Utility District. Ephrata, WA.
☐	Skalski, J. R., R. L. Townsend, R. F. Donnelly, and R. W. Hilborn. 1996. The relationship between survival of Columbia River fall chinook salmon and in-river environmental factors. Bonneville Power Administration. Portland, Oregon. 246 pp.
☐	Townsend, R. L., P. Westhagen, D. Yasuda, and J. R. Skalski. 1995. Evaluation of the 1994 Predictions of the Run-Timing of Wild Migrant Yearling Chinook in the Snake River Basin. Bonneville Power Administration, Portland, Oregon.
☐	Townsend, R. L., P. Westhagen, D. Yasuda, J. R. Skalski, and K. Ryding. 1996. Evaluation of the 1995 Predictions of the Run-Timing of Wild Migrant Yearling Chinook in the Snake River Basin using Program RealTime. Bonneville Power Administration.
☐	Townsend, R. L., D. Yasuda, and J. R. Skalski. 1996. Evaluation of the 1995 Predictions of the Run-Timing of Wild Migrant Subyearling Chinook in the Snake River Basin using Program RealTime. Bonneville Power Administration, Portland, Oregon.
☐	Townsend, R. L., D. Yasuda, and J. R. Skalski. 1997. Evaluation of the 1996 Predictions of the Run-Timing of Wild Migrant Spring/Summer Yearling Chinook in the Snake River Basin using Program RealTime. Technical report to BPA.
☐	Townsend, R. L., D. Yasuda, and J. R. Skalski. 1998. Evaluation of the 1996 Predictions of the Run-Timing of Wild Migrant Subyearling Chinook in the Snake River Basin using Program RealTime. Bonneville Power Administration, Portland, Oregon.
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PART II - NARRATIVE

Section 7. Abstract

Project was initiated in 1991 in response to the Endangered Species Act (ESA) and the subsequent 1994 CBFWA call for regional analytical methods for monitoring and evaluation. The project supports BPA's need for independent assessment and provides statistical support for the Northwest fisheries community by analyzing historical tagging data to investigate mitigation dynamics, salmonid life histories and productivity, and provide real-time analysis to monitor outmigration timing and water budgets. Results are documented in technical reports, peer-reviewed literature, and interactive internet presentations.

Section 8. Project description

a. Technical and/or scientific background

The Pacific Northwest tags more fish and monitors fish movements more intensely and their recoveries than anywhere else in North America. Tens of millions of dollars are spent on fish tagging and data retrieval each year. However, there is no overriding analytical framework to the design and analyses of these studies to assure optimal performance or maximum benefits from the data. The Columbia Basin Fish and Wildlife Program (CBFWA) recognized these needs in their call for a regional center for conducting analyses and the development of needed analytical tools and analyses (3.2F.1). The plan also called for a coordinated information system on anadramous fish databases (3.3A.2) and the need to monitor populations, provide timely transfer of information, and develop needed monitoring technologies (4.3C.1). Despite these overwhelming needs, given the high expenditures on tagging and data collection, no agreement on a coordinated information system for anadramous fish data, methods of their analyses, or timely dissemination of information to the public has been agreed upon. This project exists to meet some of these pressing demands for sound statistical analysis of tagging data and the dissemination of data in a timely manner in order to evaluate and monitor mitigation activities in the Columbia Basin. The project contributes to mitigation activities by providing sound information from historical or real-time tag detections in order to adapt management strategies to the most current information on salmonid migration and success. The project also assists by resolving statistical and data analysis issues, so that managers can focus on biological or resource issues rather than on data analysis uncertainties.

Apart from its essential role in the fish and wildlife program, BPA needs and uses the support provided by this project to accountably perform and preserve its ability to independently make decisions related to operations of the Hydrosystem and commitment of fiscal and material federal resources for fish and wildlife mitigation programs. This project also provides critical analysis for efficient use of limited mitigation funds on both a real-time and planning horizon basis.

To support real-time monitoring and information dissemination, the project provides real-time analyses of data and smolt passage indices to predict outmigration timing at eight Snake and Columbia River dam sites. This information is coupled with travel time information and barging projections in the Snake River Basin. Daily updates are provided for yearling and subyearling chinook , steelhead, and sockeye from April through September of each year since 1994. These predictions, along with supporting information, can be retrieved and independently analyzed using interactive software and graphs on the internet (*http://www.cqs.washington.edu)*.

The second element this project provides is value-added analyses of historical tagging data by testing hypotheses, estimating parameters, and modeling interrelationships without the tremendous costs of additional field studies. These analyses have provided information to scientific groups like the Plan for Analyzing and Testing Hypotheses (PATH) forum that is currently reviewing available information and assessing future information needs. An example is the analysis of adult returns from

Priest Rapids hatchery in relationship to in-river conditions during juvenile outmigration (Skalski et al. 1996). Other investigations have looked at the effects of pulsing river flows on smolt travel speeds (Perez-Comas and Skalski 1998a) and estimation of growth rates of outmigration smolt (Perez-Comas and Skalski 1998b). This project has also examined 17 years of CWT data from coastal coho stocks and developed multivariate age-at-return models to investigate early ocean survival relationships. Ryding (1998) and Ryding and Skalski (1998) have found that early ocean survival of coho to be correlated with sea surface temperature and upwelling. They found a narrow range of optimal conditions that have occurred once in every 4-5 years that results in five-fold higher survival rates. As provisions for handling salmonid stocks have become more restricted, the value of retrospective analyses of existing data sets becomes increasingly important. These investigations also provide needed information to perform sample size calculations and to design field investigations more precisely (Newman 1998a, b). The specific analyses performed each year changes as BPA information needs shift to reflect the changing needs of the fisheries community. A technical publication series of tag analyses is published under the contract to disseminate information learned from these added-value analyses (see Reference section).

The third element of the project is to provide regional statistical consulting in support of BPA program needs and the Northwest fisheries community. These activities have led to the improved design and analysis of PIT-tag, CWT, balloon-tag, and radiotelemetry survival studies and hydroacoustic evaluations of Snake/Columbia River investigations. The goal is to raise the quantitative rigor of fisheries investigations in the Columbia Basin so that mitigation programs can be better and more cost-effectively evaluated and monitored.

b. Rationale and significance to Regional Programs

The Fish and Wildlife Program (FWP) calls for the establishment of coordinated analytical methods in the region (3.2F.1), the coordination of information systems (3.3A.1), the development of performance standards (4.3B), population monitoring (4.3C), and third-party evaluation of Snake River spring migrants (5.2A.7). This project is addressing all of these issues by providing in-season and post-season evaluation of smolt outmigration success and adult return information.

The goals of the FWP explicitly call for efforts to monitor and evaluate the success of mitigation activities in the Columbia Basin. Program RealTime's projections of smolt passage provide the community, and in particular, the TMT, with up-to-date information on the status and trends of the smolt outmigration in order to make decisions regarding spill and transportation strategies. These capabilities are improved, expanded, and tailored annually to the growing needs of the BPA and the community. The project turns routine information collection in the region into a viable monitoring program during smolt outmigration. The statistical analysis of historical tagging data crosses agency lines in order to assimilate information on salmonid population dynamics irrespective of tag origin. This project takes a regional perspective on tag analyses to identify general biological trends and to make generic recommendations on future study design and analysis. The project personnel are available to all interested parties needing assistance in the design and analysis of fish tagging studies. The importance of proper design and

analysis is ever increasing as the costs of studies increase, fish abundance decreases, and the urgency for current and timely information increases.

The results of this project provide formal input to other ongoing programs such as the technical support for the PATH process (Projects 9700200, 9600600, and 9507000) and modeling support for monitoring and evaluation activities (Project 8910800).

c. Relationships to other projects

Besides the formal relationships noted earlier to other FWP projects, there are other significant interchanges with related programs. The results of this project have been transferred and applied to Mid-Columbia Public Utility Districts' Smolt Monitoring and Assessment programs to develop migration timing predictions for Mid-Columbia salmon stocks from hydroacoustic index programs. This project also generates on-line internet-based run-timing predictions, historical and current year passage plots for ESA stocks and the run-at-large that are available for incorporation on the TMT web page. The ability to extract fish guidance efficiency (FGE) and spill effectiveness (SE) estimates from Snake River PIT-tag studies has been transferred to the Army Corps of Engineering (ACOE) as part of their monitoring and evaluation program. The project also provides statistical support to ACOE in the design and analysis of PIT-tag, radiotag, and balloon-tag study designs and coordination with other technologies such as hydroacoustics. The project also provides statistical consulting to the interagency project on pinniped-salmonid predation investigation in the Northwest, and specifically to the Washington Department of Fish and Wildlife.

Project 8910700, Statistical Support for Salmonid Survival Studies, has the charge to develop statistical methods tailored to the Columbia Basin smolt and adult salmonid survival investigations. Statistical methods developed by that project are used by regional investigators (e.g., NMFS) for the design and analysis of their tagging studies. This project, 8910700, Monitoring and Evaluation: Statistical Support, may use some of those same techniques in the value-added analysis performed in support of BPA's need for independent review and assessment. The purpose of this project, however, unlike Project 8910700, is to analyze historical tagging data to address BPA needs and address issues not being assessed by other agencies conducting tagging studies. Statistical support on a range of design and analysis issues is extended to all regional parties.

This project is grateful for the cooperation of the FPC, PSMFC, and ACOE in providing raw data from their primary data centers that make up the information supplied by DART in a compatible, concise, and useful manner to the general public.

d. Project history (for ongoing projects)

Project 9105100 was initiated in 1991 in response to the Endangered Species Act (ESA) listings of salmonids in the Snake River Basin of the Columbia River. Objectives of the project are to (1) synthesize information from historical fish tagging studies to improve understanding of migration dynamics, demographics, and hydropower effects on listed stocks and (2) develop improved monitoring and evaluation capabilities to provide

better in-river management to optimize operational and fish passage strategies for endangered and threatened salmon populations.

Since 1991, this project has evaluated historical tagging studies to help design future research and determine the reliability of existing information. The project has explored possible relationships between juvenile survival and adult returns with river flows, abundance of hatchery stocks, pulsing, ocean conditions, and ambient river conditions. This project has also developed new approaches and statistical tools which generate on-line internet-based information including real-time in-season predictions of migration status. This information, along with flow predictions and transportation levels, provides fish managers with the opportunity to integrate the status of the smolt migration with river management options. Run-timing predictions are now available for both the Snake and Mid-Columbia and for NMFS evolutionary significant units (ESUs) as well as river runs as a whole for spring and fall chinook salmon, steelhead, and sockeye.

Specific biological results of the project to date include:

1. Evaluation of travel time information contained in freeze-brand data.
2. Evaluation of the annual pattern of adult salmon returns to the upper Snake River from PIT-tag data.
3. Recommendations for complete life-cycle survival studies using combined PIT/CWT releases.
4. Evaluation of the relationship between Priest Rapids hatchery fall chinook adult returns and river conditions.
5. Evaluation of effects of river pulsing on smolt travel times.
6. Evaluation of the benefits of smolt transportation at Priest Rapids and McNary Dams.
7. Evaluation of coho ocean survival relationships.
8. Evaluation of the internal consistency of hydroacoustic, PIT-tag, and balloon-tag studies in explaining project survival at Lower Granite Dam.

Together, these biological results are helping to evaluate past management decisions and improve future efforts to enhance wild salmonid stocks.

Summary of Project Achievements

Specific accomplishments by year include:

1991: Report on historical brand release data for the Snake River. Report identified serious bias in travel time estimation using brand data and the difficulties establishing travel time relationship with existing data.

1992: Report on a “strawman” smolt monitoring design for Snake/Columbia River systems. This strawman became the conceptual design for the existing PIT-tag detection system for the Snake River.

1993: Report on adult PIT-tag returns. Results showed annual patterns of adult returns differed across years even for closely related river systems.

1994: Development and testing of Program RealTime PIT Forecaster statistical software using pattern recognition and neuronets to predict the outmigration timing of spring runs of wild Snake River spring/summer chinook at Lower Granite Dam real-time.

1995: Refinement of RealTime PIT Forecaster statistical software and initial testing of RealTime Passage Index Forecaster statistical software to predict outmigration timing of summer/fall runs of juvenile subyearling chinook at Lower Granite Dam. Report on transportation benefit analysis methods showed estimation differences among investigators may be related to analysis methods they selected. Recommendations on proper statistical models provided.

1996: RealTime model of this project linked with CRiSP model of Project 8910800 to extend predictions of migration timing to include Lower Snake River hydroprojects and McNary Dam. Investigated extending real-time outmigration prediction to Mid-Columbia hydroprojects. Expansion of Internet access to cover historical run timing and flow data at all major hydroprojects. Expansion of on-line interactive internet-based information to include in-season time series of PIT detections for NMFS Snake River Basin Ecologically Significant Units (ESUs) [i.e. ESA-listed juvenile spring/summer chinook, fall chinook and sockeye salmon] as they pass through the FCRPS. Report on Priest Rapids hatchery returns of fall chinook versus river conditions developed which found upstream-downstream study designs to be of limited quantitative reliability.

1997: RealTime projections continued along with the addition of Redfish Lake sockeye salmon and steelhead. Investigations included the study of the effects of river pulsing on smolt travel times, the estimation of fish guidance efficiency (FGE) and spill effectiveness (SE) from PIT-tag data and the estimation of season-wide survival rates and smolt growth rates.

1998: Completed study of the relationships between coho age-at-return CWT data and early ocean survival as a function of ocean conditions. Assessed internal consistency of hydroacoustics, PIT-tag, and balloon-tag studies in explaining Lower Granite Dam project survival of outmigrating smolts.

Project Reports and Papers:

Technical Reports

Giorgi, A. E. 1990. Mortality of yearling chinook salmon prior to arrival at Lower Granite Dam on the Snake River. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-16570-1.

Skalski, J. R. and A. E. Giorgi. 1993. Juvenile passage program: A plan for estimating smolt travel time and survival in the Snake and Columbia Rivers. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-3.

Smith, S. G., J. R. Skalski, and A. E. Giorgi. 1993. Statistical evaluation of travel time estimation based on data from freeze-branded chinook salmon on the Snake River, 1982-1990. Technical Report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-4.

Skalski, J. R., G. Tartakovsky, S. G. Smith, P. Westhagen, and A. E. Giorgi. 1994. Pre-1994 season projection of run-timing capabilities using PIT-tag databases. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-7.

Newman, K. 1995. Adult salmonid PIT-tag returns to Columbia River's Lower Granite Dam. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-6.

Townsend, R. L., P. Westhagen, D. Yasuda, and J. R. Skalski. 1995. Evaluation of the 1994 predictions of the run-timing of wild migrant yearling chinook in the Snake River Basin. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-8.

Skalski, J. R., R. L. Townsend, R. F. Donnelly, and R. W. Hilborn. 1996. The relationship between survival of Columbia River fall chinook salmon and inriver environmental factors. Final Report. Analysis of Historic Data for Juvenile and Adult Salmonid Production: Phase II. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-10.

Townsend, R. L., P. Westhagen, D. Yasuda, J. R. Skalski, and K. Ryding. 1996. Evaluation of the 1995 Predictions of the run-timing of wild migrant yearling chinook in the Snake River Basin using Program RealTime. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-9.

Townsend, R. L., D. Yasuda, and J. R. Skalski. 1996. Evaluation of the 1995 predictions of the run-timing of wild migrant subyearling chinook in the Snake River Basin using Program RealTime. Technical report to Bonneville Power Administration, Portland, Oregon. DOE/BP-35885-11.

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Adaptive Management Implications

This project promotes adaptive management by: (1) providing monitoring and evaluation statistical support to the Northwest fisheries community; (2) making statistical models, design and analysis tools, software, and web-based tools available to all parties to improve monitoring and evaluation capabilities; (3) providing internet-based information integration capabilities, historic timing plots and real-time predictions on the status of smolt migrations for ESA stocks, NMFS Snake River Basin ESUs and other Columbia Basin fish stocks for use by NMFS, TMT, and other members of the fisheries community to assist in-season management of fish and river resources; and (4) publishing results on the development and design of analysis tools, the analyses of historical and real-time tagging data and other information for use by the fisheries community, the NPPC and expert scientific forums like the Independent Scientific Advisory Board (ISAB), the Independent Scientific Review Panel (ISRP) and participants of the plan for analyzing and testing hypotheses (PATH).

Budget History

Year	Annual Budget Obligated	Year	Annual Budget Obligated
1991	$321,453	1995	286,062
1992	47,337	1996	457,393
1993	225,248	1997	192,000
1994	219,308	1998	310,000

e. Proposal objectives

The overall objective of the project is to provide BPA and the rest of the fisheries community with statistical guidance on design, analysis, and interpretation of fish tagging studies which will lead to improved monitoring and evaluation of salmonid mitigation programs in the Columbia/Snake River Basin. This overall goal is being accomplished by making fisheries data readily available for public scrutiny, providing statistical guidance on the design and analyses of studies by hands-on support and written documents, and providing real-time analyses of tagging results during the smolt outmigration for review by decision makers.

Specific objectives of the project are as follows.

Objective 1: Provide in-season statistical support by providing real-time analyses of smolt outmigration dynamics for ESA demes and runs-at-large for the Snake and Columbia Rivers.

Objective 2: Provide statistical analyses of historical tagging data to extract extra-value information on salmonid population dynamics and their interactions with the environment, and provide statistical guidance on the design and analysis of fisheries tagging studies.

Objective 3: Provide BPA and the northwest fisheries community with professional support as needed in the design, analysis, and interpretation of fisheries tagging studies.

These tasks provide an interrelated set of goals whose aim is to assure that the maximum information is extracted from the myriad of tagging programs in a cost-effective manner for the benefit of all members of the fisheries community.

The first objective will be accomplished with the posting of run-timing predictions at eight Snake/Columbia River dams on a daily basis during the 2000 spring and summer smolt outmigrations. This reporting of "percent run to date" and "date to specified percentiles of the run" has been publicly posted on the internet at *http:www.cqs.washington.edu/crisprt* since 1994. In 2000, these run projections will include yearling and subyearling chinook salmon, Redfish Lake sockeye salmon, and steelhead. In addition to the daily projections, historical and current year data on smolt passage and river conditions will be made available in an interactive environment for display and user analysis. Similar post-season evaluations have been performed annually (Townsend et al. 1995; 1996a, b; Townsend et al. 1996, Townsend et al. 1997, Townsend et al. 1998).

The second objective provides value-added analyses of historical fish tagging data. The results of historical tag analyses are prepared as BPA technical reports in a continuing series (see Project History). For 2000, the analyses will address, among others, four areas under Objective 2:

Task 2.1: Analysis of chinook salmon CWT returns and the effects of ocean conditions on early adult survival.

Task 2.2: Analysis of adult chinook and steelhead PIT-tag returns and relationships between stocks, years, and river conditions. Also investigates the possible relationship between smolt condition during outmigration and adult returns.

Task 2.3: Analysis of spawner-recruit data to investigate changes in productivity over time and across watersheds.

Task 2.4: Investigates relationship between pulsing in river flows and smolt outmigration dynamics.

Task 2.1 is going to extend the analysis of age-at-return data from CWT for the study of early ocean survival of chinook salmon. Ryding (1998) successfully used a multivariate analysis of CWT data to investigate relationships between early ocean survival and oceanographic conditions based on a meta-analysis of coho hatchery stocks in Washington state. This task will investigate similar relationships for coastal stocks of chinook salmon. Task 2.2 will investigate the growing database of information contained within adult salmon PIT-tag returns. Specifically, this analysis will identify relationships between the frequency of returns and inriver conditions after conditioning on stock and year effects. The analysis will also examine relationships between the probability of

return and smolt condition (i.e., size) at time of tagging. Analyses will be based on a generalized linear models (GLM) tailored to tag return data. In Task 2.3, available information on spawning counts and smolt production will be analyzed to assess spawner-recruit relationships. The analysis will focus on the ability of survey techniques to provide accurate and precise information to the fisheries community. Analyses may lead to recommendations on how spawner-recruit studies may be improved in the region. The last task, 2.4, will evaluate available data from the Snake River on possible relationships between pulsed flows and smolt outmigration dynamics to assess the possible benefits of alternative spill strategies at hydroprojects. Total extent of Objective 2 will depend on existing BPA information needs during 2000.

The third objective is to provide regional statistical consulting on fisheries issues in support of monitoring and evaluation projects. An ongoing effort of this project is to provide statistical analysis and review on an as-needed basis to BPA as technical issues arise. This assistance also includes technical review and development of issue papers on technical needs and capabilities of future fish tagging studies. This technical support is essential to BPA's independent decision-making abilities regarding hydrooperations and monitoring and evaluating the fisheries program. Another component of this task is to provide statistical support and assistance to the Northwest fisheries community. In 1997, this included providing technology transfer of PIT-tag survival estimation methods for salmonid stocks to the Nez Perce tribe. Other assistance has included guidance on PIT-tag analyses, hydroacoustic study design, and adaptations of PIT-tag detectors to spillways for the Army Corps of Engineers (ACOE). In-season migration analyses to the TMT, fall chinook survival analyses for NMFS, transfer of technology for extracting survival data from radiotelemetry tagging studies of smolt for Mid-Columbia Public Utility Districts (PUDs), transfer of the technology for in-season run-timing estimates for the smolt outmigration to Mid-Columbia PUDs (Skalski 1996, 1997), and technical reports on smolt survival relationships to the PATH process were also performed. Technology transfer of survival analysis to Washington Department of Fish and Wildlife (WDFW) and participation on the interagency pinniped predation study was provided in 1998. These efforts will continue on an as-needed basis.

f. Methods

State-of–the-art statistical methods designed specifically for each task and analysis are used in this project.

In the run-timing predictions, generalized least squares is used to estimate run-timing estimates weighted to take into account both historical run-timing patterns and historical passage numbers. This weighted least squares pattern recognition program also used feedback loops to account for intra- and interannual variations. Detailed descriptions of the algorithm and program output can be found in DOE/BP-35885-11.

Other tag analyses, depending on the nature of the data and objectives of the analysis, use generalized linear models (McCullagh and Nelder 1989), maximum likelihood estimation (Kendall and Stuart 1979: 38-81), or nonlinear and generalized regression techniques (Seber and Wild 1989, Bates and Watts 1988), and multivariate analyses (Ryding 1998). Validity of the analyses are assessed using residual analyses (Belsley et al. 1980), analysis of deviance procedures to test parameter significance and

goodness-of-fit statistics (Hosmer and Lemeshow 1989, Greenwood and Nikulin 1996). Special attention is given to the distributional properties of the tagging data (Seber 1982) which is rarely assumed to be normally distributed, but instead is based on discrete probability distribution such as binomial, multinomial, hypergeometrics or Bernoulli.

This project makes extensive use of tagging data collected and stored by the Pacific States Marine Fisheries Commission (PSMFC) and the Fish Passage Center (FPC). Data from these primary data centers are retrieved, summarized, analyzed, and displayed for public access in the second-tier data center managed by the University of Washington (UW). This project has been successfully accomplishing its mission since 1991. Continued success depends on continued cooperation with staff from PSMFC and FPC.

g. Facilities and equipment

This project is supported by 6 SUN UNIX workstations, 1 X-terminal, and 3 personal computers. The computer system is also supported by a network computer system, allowing a dynamic amount of storage capacity to meet the project needs and a T1 communications line for ethernet access to the internet.

h. Budget

Personnel costs are consistent with previous years adjusted for promotions and Washington state wage adjustments of 3% for AY2000. Supplies include a UNIX workstation for $3,500; upgrades to software; copy services, internet access on a T1 line, and mailing costs. Travel costs include three trips planned to Portland, Oregon, to consult with BPA sponsor and other fisheries offices located in Portland. Because research offices are located off-campus, indirect costs are 26% instead of 52% associated with on-campus projects but require additional costs for office lease, furniture, etc., but with substantial savings.

Section 9. Key personnel

John R. Skalski
Professor of Biological Statistics
School of Fisheries
University of Washington
FTE = 0.17

Dr. Skalski directs the project, guides staff and graduate student progress on research, provides statistical theory underlying the research developments, sets and monitors project milestones, and monitors budget. He also provides public presentation of results, authors peer-reviewed scientific publications, and consults with interested parties on the design and analysis of tagging studies. Dr. Skalski is the author of over 50 papers and books on fish and wildlife studies.

Jose Antonio Perez-Comas, Research Scientist
Postdoctoral Research Associate
School of Fisheries
University of Washington
FTE = 0.50

Dr. Perez-Comas is a research scientists and postdoctoral candidate responsible for analyzing large historical PIT-tag databases. He is developing specialized statistical analyses to extract fish guidance efficiency (FGE) and spill effectiveness (SE) from PIT-tag data, investigate relationships between ocean and river conditions on survival, estimating growth rates, and investigating relationships between river pulsing, flows, hatchery releases, and inriver survival. Dr. Perez-Comas presents results in technical reports and peer-reviewed journals.

Albert E. Giorgi, Consultant
BioAnalysts, Inc.
FTE = 0.07

Dr. Giorgi has 16 years' expertise as a scientists investigating fish passage issues in the Snake/Columbia River Basin. He provides internal peer review of the ongoing research, helps to set research goals, participates in the design and analysis of research, and co-authors technical reports and papers. Dr. Giorgi also provides technical support to BPA on regional issues of importance to the agency.

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EDUCATION

B.S.	Wildlife Management/Biology, University of Wisconsin, Stevens Point	1974
M.S.	Wildlife Science, Oregon State University	1976
M.S.	Biometry, Cornell University	1978
Ph.D.	Biometry, Cornell University	1985

EMPLOYMENT HISTORY

1978-1985	Research Scientist, Battelle Pacific Northwest Laboratory, Richland, WA

1985-1987	Senior Research Scientist, Battelle Marine Research Laboratory, Sequim, WA
1987-1995	Associate Professor, University of Washington, Center for Quantitative Science, School of Fisheries, Seattle, WA
1992-1995	Interim Director, Center for Quantitative Science in Forestry, Fisheries, and Wildlife, University of Washington
1994-1995	Chair, Interdisciplinary Graduate Program in Quantitative Ecology and Resource Management, University of Washington
1995-Present	Professor, University of Washington, School of Fisheries, Seattle, WA

CERTIFICATION

Certified Wildlife Biologist, 1982, The Wildlife Society.

EXPERIENCE

Dr. Skalski has 20 years of experience as a research scientist and professor of biological statistics. His expertise is in the statistical methods of parameter estimation, sampling theory, impact assessment, population dynamics, and mark-recapture theory. Of particular relevance is his experience and expertise in effects assessment on mobile species and the design and analysis of animal tagging studies. He has been chief statistician on accident assessments of major oil spills, design and analysis of impact assessment studies of major energy production facilities, hydroacoustic fish surveys, and fish tagging studies. He has worked on the design and analysis of Columbia River salmonid tagging studies for nine years.

SELECTED PUBLICATIONS

Lowther, A. B., and J. R. Skalski. 1998. A multinomial likelihood model for estimating survival probabilities and overwintering for fall chinook salmon using release-recapture methods. J. Agri. Biol. and Envir. Stat. 3:223-236.

Skalski, J. R. 1998. Estimating season-wide survival rates of outmigrating smolt in the Snake River, Washington. Can. J. Fish. Aquat. Sci.55:761-769.

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Skalski, J. R., and D. S. Robson. 1992. Techniques for Wildlife Investigations: Design and analysis of capture data. Academic Press. 237 pp.

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EDUCATION

B.S.	"Licenciado" in Biological Sciences, University of Buenos Aires	1977
M.S.	Fisheries, University of Washington	1990
Ph.D.	Fisheries, University of Washington	1996

EMPLOYMENT HISTORY

1978-1987	Researcher, National Institute for Fisheries Research and Development, Argentina
1996-Present	Postdoctoral Research Associate, University of Washington, School of Fisheries, Seattle, WA

EXPERIENCE

Dr. Perez-Comas' research has focused on fish stock assessment and management; in particular, the development of techniques for the analysis of fisheries field experiments.

After his formative years at the National College of Buenos Aires (Colegio Nacional de Buenos Aires) where he acquired a general knowledge of biology, mathematics, history and Hispanic, European and classic literature, he graduated from the University of Buenos Aires with majors in Zoology and Marine Biology. From 1978 to 1987, he worked as researcher for the National Institute for Fisheries Research and Development (INIDEP), Argentina's federal fisheries agency. There, Dr. Perez Comas studied the distribution, population dynamics and biology of hake, squid and other important Patagonian fish, often taking active part in the planning and development of fishery assessment surveys. In 1987, his interest in completing his education on fisheries-applied Statistics and ecological modeling brought him to Seattle, he obtained his M.S. and Ph.D.

from the University of Washington. As a graduate student and Ph.D. candidate he worked with Dr. Ellen K. Pikitch in topics related to mesh size selectivity, discard and survival of fish escaping trawl nets. He actively participated in conference and meetings such as the Western Groundfish Conference and meetings of the ICES Working Group on Fishing Technology and Fish Behavior.

Currently, Dr. Perez Comas works with Dr. John R. Skalski in the study of migratory behavior and survival of salmon in the Columbia basin. Dr. Perez Comas still keeps ties with INIDEP, his first employer, as well as with the Mixed Technical Commission for the Maritime Front (Comisión Técnica Mixta del Frente Marítimo), the Argentine-Uruguayan Fishery Commission, for which he often serves as external reviewer and consultant. He is also a member of The Ecological Society of America.

RECENT PUBLICATIONS

Perez-Comas, J. A., Erickson, D. L., and Pikitch, E. K. 1998. Cod-end mesh size selection for rockfish and flatfish of the U.S. West Coast. *Fish. Res.* 34: 247-268.

Erickson, D. L., Perez Comas, J. A., Pikitch, E. K. and Wallace, J .R. 1996. Effects of catch size and codend type on the escapement of walleye pollock (*Theragra chalcogramma*) from pelagic trawls. *Fish. Res.* 28: 179-196.

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Suuronen, P., Perez Comas, J. A., Lehtonen, E. and Tschernij, V. 1996. Size related mortality of herring (*Clupea harengus* L.) escaping through a rigid sorting grid and trawl codend meshes. *ICES J. Mar. Sci.* 53(4): 613-622.

Pikitch, E. K., Suuronen, P., Erickson, D. L. and Perez Comas, J. A.. 1995. Codend size-selection: good concept, but does it really work? *In*: Solving Bycatch. Considerations for today and tomorrow. Alaska Sea Grant College Program, Report No 96-03, University of Alaska, Fairbanks: 107-114.

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1 December, 1998

EDUCATION

B.S.	Biology, Humboldt State University	1972
M.S.	Biology, Humboldt State University	1975
Ph.D.	Fisheries, University of Washington	1981

EMPLOYMENT HISTORY

1972-1974	Research Assistant, Humboldt State University, Sea Grant Program, Arcata, CA
1978-1981	Fisheries Research Biologist, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Resource Ecology and Fisheries Management Division, Seattle, WA
1982-1990	Fisheries Research Biologist, Sub-Task Manager, National Marine Fisheries Service, Northwest Fisheries Center, Coastal Zone and Estuarine Studies Division, Seattle, WA
1990-Present	Fisheries Scientist, BioAnalysts Inc., Boise, ID

PROFESSIONAL AFFILIATIONS

American Fisheries Society
Pacific Fishery Biologists

FACULTY APPOINTMENT

1989-Present	Affiliated Faculty, School of Fisheries, University of Washington, Seattle, WA

EXPERIENCE

Since 1982, Dr. Giorgi's research has focused on the biology of Columbia River salmonids and the effects of the hydroelectric system on fish migration dynamics, survival and demographics. He has been a principal investigator evaluating the effects of increasing reservoir elevation at Rocky Reach Dam, the effects of reservoir drawdown on smolt passage and survival in the Snake River, and the effects of surface collection at Bonneville Dam Second Powerhouse and Rocky Reach Dam. Currently his research

emphasis is assessing the feasibility of using miniaturized radio tags to estimate smolt survival in the Columbia River. He has co-authored five different status reviews of salmon and steelhead stocks in the Mid-Columbia Basin and Snake River, as well as a status review for white sturgeon in the Kootenai River. Currently he is an analyst in two regional technical forums; the Plan for Analyzing Testable Hypotheses (PATH), and the NPPC Multi-species Framework. Dr. Giorgi has also evaluated the effectiveness of regional water management strategies for recovery of ESA-listed salmon and steelhead stocks, and the use of surface flow bypass alternatives at Snake and Columbia River dams.

PUBLICATIONS AND REPORTS

Dr. Giorgi has published more than 50 technical reports and authored or edited more than 12 articles in peer-reviewed publications.

Section 10. Information/technology transfer

The primary product of this project is a technology transfer of information on fish tagging results and the most appropriate methods of design and analysis of tagging studies.

Since 1994, the internet (World Wide Web) has been used to convey projections of smolt run-timing (Program RealTime) and provide central access to a variety of current and historical data on fish tagging and environmental variables. This web site (*http://www.cqs.washington.edu*) received over 363,000 inquiries by users accessing various software features of the site in 1997. All programs and databases are available to any user or organization to download to their own sites. System programmers are continually available to assist users on their requests and to customize output to user needs.

Other technical information is disseminated by BPA technical reports and peer-reviewed literature. Senior investigators continue to be available to provide public presentations and to address questions from interested parties one-on-one. The third research task of providing regional statistical support on an as-needed basis provides for this interchange. Results of analyses are also given directly to interested parties (i.e., PATH) on an as-needed basis to assist in regional assessments of salmonid issues.

Congratulations!