Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Assess Smolt Condition for Travel Time Analysis: Physiology, Health, and Survival

Bonneville project number, if an ongoing project 8740100

Business name of agency, institution or organization requesting funding

USGS, Biological Resources Division, Columbia River Research Laboratory

Business acronym (if appropriate) CRRL, USGS-BRD

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name

NPPC Program Measure Number(s) which this project addresses.
4.2A, 5.0A, 5.7A.4, 5.7B.17, 5.8A.8, 5.9A.1, 7.2D.1, 7.2D.3

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.

The project specifically addresses the following recovery tasks outlined in the NMFS Snake River Salmon Recovery Plan through USGS research and technical assistance to cooperating agencies: 0.3.a, 2.1.d.1, 2.1.d.5, 4.4a, 4.4c, 4.4d.

Subbasin.

Snake River, Columbia River and tributaries.

Short description.

Investigate the effects of rearing and river conditions on migration and smolt-to-adult survival in salmon and steelhead, maintain a comprehensive database, develop non-invasive methods for assessment of smoltification, and provide technical assistance to cooperating fishery agencies.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	+	Research		Ecosystems
	Climate	X	Monitoring/eval.	X	Flow/survival
	Other		Resource mgmt	+	Fish disease
			Planning/admin.	+	Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.

Smoltification, physiology, endangered species, rearing conditions, life history, Columbia River, salmon.

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2, 3	Objective	Task a,b,c	Task
1	Investigate the effects of rearing and river conditions on the physiology and migration success of juvenile salmonids.	1a	Analyze hatchery stock rearing data to identify factors contributing to smolt-to-adult survival.
		1b	Work cooperatively with reference hatcheries to interpret, summarize, and report findings from individual hatchery analysis.
		1c	Develop cooperative sampling with regional fish managers for non-invasive monitoring of wild salmon populations.
		1d	Determine performance indicators for production based on wild fish physiology monitoring.
2	Develop a consistent database of juvenile salmonid physiology and adult survival.	2a	Integrate hatchery rearing and adult return data with Assessment of Smolt Condition for Travel Time Analysis (ASCTTA) project database.
		2b	Analyze integrated ASCTTA data for effects of rearing on smoltification, travel time, and adult returns.
3	Develop and evaluate indices of smolt condition and health.	3a	Determine lysozyme Types I and II distribution during smoltification.
		3b	Validate eye pigment ratio as indicator of smolt condition, with correlation to gill sodium, potassium ATPase levels.
4	Provide technical assistance to cooperating agencies and BPA funded projects.	4a	Provide research and sampling design review, and laboratory analysis to cooperating agencies, for determination of physiological status of juvenile salmon and

			steelhead.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	04/1999	04/2000	40%
2	04/1999	04/2004	20%
3	04/1999	04/2000	20%
4	04/1999	04/2004	20%

Schedule constraints.

Project objective 1 is updated annually based on the concerns and requests of Columbia basin fish managers and their needs. Objective 2 carries over annually and provides the long term evaluation needed to develop new management goals based on past experience. Objectives that outline tasks specific to method development (3) or evaluate particular life history stages such as rearing, are designed as single year projects (4), with the replication necessary for anadromous species generally provided by three years of release data, and should include some provision for monitoring and evaluation of adult returns.

Completion date. Enter the last year that the project is expected to require funding.
2004

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		115,000
Fringe benefits		34,500
Supplies, materials, non-expendable property		5,000
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Video equipment for field reflectance measurements, spectrophotometer for eye pigment measurements.	5,000
PIT tags	# of tags:	
Travel		3000
Indirect costs		63,650
Subcontracts		
Other	per diem, meetings/field crews/publication	5000

	costs	
TOTAL		231,150

Outyear costs

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	$238,000	$245,000	$136,480	$140, 574
O&M as % of total				

Section 6. Abstract

Assess Smolt Condition for Travel Time Analysis (ASCTTA) evaluates the effects of physiology on smoltification as related to juvenile migration of Columbia and Snake River salmon and steelhead. The broad approach of the project addresses research and monitoring measures of the FWP, providing physiological standards for production fish, evaluation of production practices, and assessment of environmental effects on salmon survival. Innovative non-invasive methods for smolt assessment, designed for field application, are developed and validated against standard biochemical procedures by rigorous replication and correlation. Smolt assessment is conducted in cooperative efforts between production, research, and management agencies to determine strategies to improve smolt-to-adult survival. A comprehensive database is maintained.

The project assists in the design of monitoring or research experiments to provide specific answers to management questions regarding smolt development and its effect on the success of juvenile migrants. Current tasks include a review of rearing practices at ASCTTA reference hatcheries to determine practices that promote smoltification. Central to this evaluation is a determination of causes of residualism and precocity leading to reduced numbers of migrants and migration rates, factors leading to negative interactions between hatchery and wild fish. Development of non-invasive methods has become more critical because of listings under the Endangered Species Act. Demands for our technical assistance have increased as agencies institute changes in rearing and management practices that require physiological monitoring to determine the effects on smoltification.

Section 7. Project description

a. Technical and/or scientific background.

The successful return of juvenile salmon as adults is based on the successful interaction between the physiology of the fish and the environment. The complex life history of anadromous fish requires evaluation and isolation of those factors that promote adult returns. From the time of spawning through the juvenile and adult migrations, the physiology of the fish is an indicator of the probability of success under specific environmental conditions. Results of the past ten years have shown that performance

differs among hatchery stocks and wild fish. Differences include travel time and numbers of migrants, level of smoltification, physiological condition, and fish health. Rearing practices vary at the hatcheries and in the wild; a comparison of these differences and differences in juvenile and adult migrants will identify factors that contribute to higher adult returns.

Assessment of Smolt Condition for Travel Time Analysis (ASCTTA) has monitored Columbia River salmon and steelhead for the past ten years (Rondorf *et al.* 1989; Beeman *et al.* 1990, 1991; Maule *et al.* 1994). The major goal of the project was to determine the physiological mechanisms of smoltification that contribute to faster migration rates. Rapid migration reduces the exposure time of juvenile fish to predation, disease, environmental effects of the impounded river, and reduces the interactions of hatchery fish with wild and resident fish populations. This project provided information on smolt status to the Fish Passage Center for management of the Water Budget for flow augmentation. As water management has changed, the project emphasis shifted to investigating life history factors, in particular rearing conditions, that promote smoltification. Non-lethal methods developed to determine smolt condition (Beeman *et al.* 1994, 1995; Schrock *et al.* 1994; Haner *et al.* 1995) allow continued research and monitoring under the restrictions of Endangered Species Act listings and decreasing adult returns.

Increasingly, other agencies have requested consultations with us to develop physiological monitoring programs (see Section 8). We provide these agencies with the analytical capabilities to monitor physiological variables for adaptive management purposes. Research emphasis has been to investigate different strategies, such as ANatures≅ rearing systems, acclimation before release (Viola and Schuck 1995), and altered temperature (Adams and Thorpe 1987, Foote *et al.* 1991) and feeding regimes (Corey and English 1985). The goals of these studies have been to reduce residualism and precocity, and to produce mitigation and supplementation fish similar to their wild counterparts. The physiological assessment that we provide gives the managers a measure of the potential success of their actions before the three to five years required for adult returns.

In 1997, we began an evaluation of our 10-year database to determine variables of juvenile salmon life histories that are most predictive of adult returns. Our tasks for 1997 and 1998 are to combine our database on smolt physiology with databases on hatchery practices and environmental conditions, and conduct multivariate analyses. During this time we will also continue to collaborate with other agencies; however, some tasks associated with developing non-invasive methods are still in progress. In 1999, we will expand our database to a basin wide record of physiological and environmental measurements, we will continue to provide technical assistance to other related projects in the basin, and we will continue to develop, test, and apply non-lethal measurements of fish condition and health.

As salmon stocks decline in the Columbia River basin, research efforts have intensified to decrease residualism and precocity. Decreases in the number of migrants and increases in their travel times have compelled management agencies to develop strategies to produce fish with the smolt characteristics similar to wild fish. Complex endocrinological changes drive and accompany smoltification (Barron 1986).

Immunological, biochemical, morphological, and behavioral changes are well documented, but interactions among the changes remain obscure (Zaugg and McLain 1972, Hoar 1976, Folmar and Dickhoff 1981, Barton *et al.* 1985, McCormick *et al.* 1987, Bradley and Rourke 1988, Borgatti *et al.* 1992) . Smolt indices, especially gill sodium, potassium-activated adenosine triphosphatase (ATPase) activity and condition factor are used to assess the effects of hatchery rearing, release strategies, river environment, and passage conditions. Although travel time and survival continue to be the most critical measures of success for juvenile migrants, efforts to produce salmon and steelhead that are physiologically ready for rapid migration need to be intensified as adult returns decline. The rearing environment may affect stress response, immune function, and disease resistance in juvenile salmon (Salonius and Iwama 1993). We have received requests from regional fishery professionals identifying rearing practices as an important area of interest, and asking for our assistance. A major requirement for evaluation of rearing programs is the ability to assess physiological condition of fish. The development of laboratory facilities and staff within each agency would be unreasonably expensive. The ASCTTA project provides this capability to cooperating agencies throughout the region.

Gill sodium, potassium ATPase activity, remains the physiological measurement most often used to evaluate the potential osmoregulatory capacity of juvenile salmon (Giles and Vanstone 1976, McCormick *et al.* 1989, Zaugg and Beckman 1990, Borgatti *et al.* 1992). The measurement is now being applied to evaluation of changes in rearing practices. We continue to determine gill ATPase activity as the measure against which all other smolt indices are validated, while developing new non-invasive methods to eliminate the necessity of tissue collection for field monitoring of smoltification. Lysozyme, an enzyme found in mucus, is bactericidal against fish pathogens (Grinde 1989) and shows a decline during smoltification when ATPase activity is increasing (Schrock, unpublished data). The non-specific enzyme, present as two isoenzymes in rainbow trout (Grinde *et al.* 1988), displays genetic heritability in breeding experiments and has been proposed as a possibility for selective breeding programs (Roed in *et al.* 1993). The lysozyme response is closely linked to the cortisol stress response and disease resistance in salmon (Fevolden *et al.* 1991, 1992, 1994), a response that needs to be understood during smoltification and migration when stress (Barton 1985) and immune responses (Maule *et al.* 1987) may be compromised. A survey of baseline levels of mucus lysozyme has been completed for reference stocks of the ASCTTA project, and the mucus lysozyme profile for juvnile spring chinook and coho salmon during smoltification has been documented. We propose to determine the ratio of Type I to Type II lysozyme in chinook and coho emigrants to determine the role of the two lysozyme species in disease resistance during the migration.

Visual pigments change during different life stages in Pacific salmon (Beatty 1965). There is a shift in pigment dominance during smoltification (Alexander *et al*. 1994), and measurement by reflectance spectroscopy may offer a non-invasive method of assessing smoltification. We propose to measuring the ratio of rhodopsin to porphyropsin in smolting salmon using reflectance spectroscopy. The ratio will be documented during smoltification, and correlated to levels of gill sodium, potassium ATPase in hatchery and wild salmon and steelhead.

The scope of the ASCTTA project provides a central, organized program of response to regional requirements for continued monitoring and evaluation of juvenile salmon and

steelhead. Demand for smolt monitoring capabilities is expected to continue in the region as long as Columbia basin agencies manage hatchery and wild salmon stocks. Research and methods will be needed to address specific management needs, including new indices of smolt condition and health, adapted to Endangered Species Act restrictions. Results will be evaluated by analysis and reporting of research data, and the successful application of methods to management requirements.

b. Proposal objectives.

Objective 1. Effects of rearing and river conditions on physiology and migration success of salmon. The assumption is that rearing practices, river conditions, and juvenile salmon physiology influence adult returns.

Task 1a: Null hypothesis: Detectable physiological differences in juvenile salmonids do not relate to adult survival.

We are currently expanding our 10-year database with rearing and adult return data to determine which measures of smolt physiology, hatchery rearing practices (e.g., raceway density, feeding regimen) and river environmental conditions (e.g., flow, temperature) are most predictive of adult survival. The comprehensive database will be completed in 1999 for all reference hatcheries with updated adult returns for the final release data from 1996.

Task 1b. Null hypothesis: There is no physiological difference among fish reared under different rearing practices.

Physiological records from the ASCTTA project, and hatchery production records will be analyzed using multivariate analyses to determine principal hatchery practices contributing to smolt-to-adult survival. Reports will be prepared for all ASCTTA hatcheries in cooperation with hatchery personnel as their schedules allow.

Task 1c. Null hypothesis: There is no physiological difference between wild and hatchery reared salmon.

Cooperative sampling of wild and hatchery fish will be developed applying non-invasive methods for smolt assessment. The physiological condition of wild salmon under varied environmental regimes will be documented and reported. Sampling will take place in conjunction with other agencies to avoid duplication of effort. Results will be compared with records from production and wild migrants using the ASCTTA comprehensive database.

Task 1d. There is no null hypothesis associated with this task.

Data from non-invasive monitoring of wild and hatchery fish will be analyzed by mutlivariate analysis, and compared to existing measures of smoltification to determine

performance indicators for production based on the physiological attributes of wild fish.

Objective 2. Develop and maintain a consistent database on the health and physiology of hatchery and wild salmon of the Columbia basin.

No hypotheses are associated with this objective. A database documenting smolt physiological, when combined with rearing and river conditions will provide a means of determining those physical and environmental conditions most important to promoting smoltification and migration of juvenile salmon. Predictions of success for specific stocks as measured by smolt-to-adult survival will be made from statistical analysis and interpretation of results. Real time evaluation of annual rearing and river conditions will predict what management measures need to be taken to ensure smolt-to-adult survival.

Objective 3. Develop and evaluate non-invasive indices of smolt condition and health for monitoring of endangered and threatened species. The assumption is that non-invasive methods of evaluating smolt condition and health provide measurements that are useful predictors of migration success and survival to adult.

Task 3a. Null hypothesis: There is no change in the concentration or activity of Type I and Type II lysozyme in salmon during smoltification.

Lysozyme is an immune system enzyme found in blood and mucus of fish and is an important first line of defense from bacterial pathogens. We have determined that mucus lysozyme activity changes during smolt development and may be an excellent simultaneous measure of smolt development and health. Others (Grinde *et al.* 1988) have reported that there are two types of lysozyme and that a shift from Type I to Type II occurs when Atlantic salmon enter the ocean. The assumption is that the Pacific salmon and steelhead will have two types of lysozyme, and that the ratio will change during smoltification. A critical assumption is that fish will be available for sampling.

Task 3b. Null hypothesis: There is no difference in changes of visual pigment ratios and changes in gill sodium, potassium ATPase during smoltification in salmon.

Work conducted in Canada (Alexander et al. 1994) has shown that the ratio of eye pigments (rhodopsin : porphyropsin) changes during smoltification. In those studies analyses of eye pigment required killing fish. We believe that current technology will allow us to determine the eye pigment ratio by reflectance spectroscopy. In order to establish this measure as a smolt index, we will compare the variability of visual pigment ratio to that of other established smolt indices. The value of this measure of smoltification is that it will be completely non-invasive and obtainable with minimal handling. The assumption is that current reflectance spectroscopy technology will allow us to discriminate between the two pigments.

Objective 4. Provide technical assistance for interagency, cooperative projects. The assumption is that requests for technical assistance will continue at their current level.

The are no null hypotheses associated with this objective. Project proposals from requesting agencies will be screened for relevance to an understanding of smolt-to-adult survival. We will assist with research design, sample size, physiological screening, data analysis and interpretation. Results will be incorporated into our comprehensive database (Objective 2). See Section 8 for a list of projects for which we currently provide technical assistance.

c. Rationale and significance to Regional Programs.

This project contains research objectives 1 & 3, and objectives 2 & 4 that provide assistance and monitoring for other projects (please see Section 8 for a listing of current collaborators). The cooperative nature of the projects listed in Section 8 allows us to determine rearing factors that control smolt development and ultimate survival without our direct involvement in the day-to-day rearing operations. It should also be noted that in virtually all of the projects listed we have been involved in the experimental design to ensure that sampling is adequate for physiological measures, meets the objectives of the collaborators and optimizes information obtained. We frequently bring in other collaborators who can use the same design and fish to meet additional objectives.

The rationale for the project is found in multiple measures of the FWP. A number of measures, taken separately, or combined, require a basin wide approach to the evaluation of production and management measures to increase adult returns. Research and monitoring are mandated under 5.0F and 5.9A. Performance standards for various salmon and steelhead species are considered under 5.4A, 5.4B, and 5.7A. Production for both mitigation and supplementation is addressed under 7.0B, 7.0D, 7.1F, 7.2A, 7.2D, 7.4A, and 10.2. Environmental factors affecting juvenile migration are considered under 6.1D, 6.1E, 7.0B, and 7.8G. A basin wide program of technical assistance with a centralized database will provide managers with access to information to make informed decisions about habitat, rearing, breeding, release, and adult programs to improve fish health and numbers in the Columbia basin.

This project continues with modifications to accommodate the knowledge gained in the past ten years that include: 1) influences of life history and environment on juvenile fish condition, migration, and survival to adult, 2) expansion of the project database to include rearing and river effects, 3) development of innovative, non-lethal measurements of fish health to allow further research under ESA restrictions and dwindling stocks, and 4) the development of technical assistance program to coordinate interagency agency research to avoid duplication of effort.

d. Project history

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- Project reports and technical papers

Beeman, J.W., D.W. Rondorf, J.C. Faler, M.E. Free, and P.V. Haner. 1990. Assessment of smolt condition for travel time analysis. Annual report 1989 (Contract DE-A179-87BP35245) to Bonneville Power Administration, Portland, Oregon.

Beeman, J.W., D.W. Rondorf, J.C. Faler, P.V. Haner, S.T. Sauter, and D.A. Venditti. 1991. Assessment of smolt condition for travel time analysis. Annual report 1990 (Contract DE-A179-87BP35245) to Bonneville Power Administration, Portland, Oregon.

Beeman, J.W., D.W. Rondorf, and M.E. Tilson. 1994. Assessing smoltification of juvenile spring chinook salmon (*Oncorhynchus tshawytscha*) using changes in body morphology. Can. J. Fish. Aquat. Sci. 51:836-844.

Beeman, J.W., D.W. Rondorf, M.E. Tilson, and D.A. Venditti. 1995. A non-lethal measure of smolt status of juvenile steelhead based on body morphology. Transactions of the American Fishery Society 124:764-769.

Haner, P.V., J.C. Faler, R.M. Schrock, D.W. Rondorf, and A.G. Maule. 1995. Skin reflectance as a non-lethal measure of smoltification for juvenile salmonids. North American Journal of Fisheries Management 15:814-822

Maule, A.G., J.W. Beeman, R.M. Schrock, and J.V. Haner. 1994. Assessment of smolt condition for travel time analysis. Annual report 1991-1992 (Contract DE-A179-87BP35245) to Bonneville Power Administration, Portland, Oregon.

Maule, A.G., D.W. Rondorf, J. Beeman, and P. Haner. 1996. Incidence of *Renibacterium salmoninarum* infections in juvenile hatchery spring chinook salmon in the Columbia and Snake Rivers. J. of Aquatic Animal Health 8:37-46.

Maule, A.G., R.M. Schrock, C. Slater, M.S. Fitzpatrick, and C.B. Schreck. 1996. Immune and endocrine responses of adult chinook salmon during freshwater immigration and sexual maturation. Fish and Shellfish Immunology 6:221-233.

Rondorf, D.W., J.W. Beeman, J.C. Faler, M.E. Free, and E.J. Wagner. 1989. Assessment of smolt condition for travel time analysis. Annual report 1988. (Contract DE-A179-87BP35245) to Bonneville Power Administration, Portland, Oregon.

Schrock, R.M., J.W. Beeman, D.W. Rondorf, and P.V. Haner. 1994. A microassay for gill sodium, potassium-activated ATPase in juvenile Pacific salmon. Transactions of the American Fisheries Society 123:223-229.

- Summary of major results achieved

ASCTTA has provided an understanding of smoltification and its importance to juvenile survival in an impounded river. The project originally provided real time measurements of smolt condition in hatcheries and during migration for the Fish Passage Center to use when making management decisions for the Water Budget. A ten year record now exists of physiological indices for juvenile salmon and steelhead from hatcheries and during the migration. The indices have gained acceptance as tools to assess fish status and many agencies request our help in evaluating their fish management strategies and the physiological condition of fish populations. Four non-lethal indices of smoltification have been developed by the project and two more are in development. Please see prior list of publications which contain our results.

- Adaptive management implications:

Smolt indices were used by the Fish Passage Center for real time information about migrating juveniles for management of the Water Budget. ASCTTA has adapted to changing fish passage and production goals by modifying individual tasks and objectives. Objectives were designed to meet specific management goals or to determine physiological function of juvenile salmon during critical periods in their development. Methods developed by the project are now being used by other agencies and projects for the evaluation of health and condition during rearing, smoltification and migration. The methods have been applied in technical assistance to other projects to determine the level of smoltification: 1) in radio tagging studies to determine dam passage efficiencies, 2) in relationship to smolt migration patterns, 3) in assessing condition of migrants in a reintroduction project, 4) to determine the effects of rearing in Natures ponds, 5) to determine the effects of rearing temperatures on precocity and residualism, 6) to assess release strategies, and 7) to evaluate the effects of nutritionally enhanced feeds.

An example of the adaptive management inherent in this project is our ability to respond to changes in water management and the effects of those changes on smolts. In 1994 salmon managers began the spill program to provide an alternative passage route (i.e., non-turbine) for emigrating juvenile salmonids. Spill can cause increased gas supersaturation; it was necessary to monitor fish to ensure that the increased spill did not cause significant mortality. Within a very short time, the ASCTTA developed, validated and instituted a gas bubble disease (GBD) monitoring program. In 1996, the GBD monitoring and research objectives became a separate BPA-funded project (BPA number 96-201). The monitoring was subsequently turned over to the Smolt Monitoring Program which is administered by the Fish Passage Center.

- years underway 11
- past costs $3,886,122

e. Methods.

Objective 1. Effects of rearing and river conditions on physiology and migration success of salmon.

Task 1a. Our annual databases of smolt monitoring (1988-1996) will be combined with data from the 15 hatcheries where we have monitored smolt releases during the past 10 years. A hatchery survey completed in 1998 provides the means to comprehensively summarize rearing factors that influence the physiological measurements we take. The type of data collected included information on stocks and adult spawners, facility design, water sources and temperatures, feed, disease management, raceway stocking densities, and release strategies, among others. Over fifty variables are included in the hatchery database and include records for all years sampled at each hatchery. Temperature and feed data is documented on a monthly basis. We have also begun collecting data on river conditions (e.g., temperature, flow, spill) and this database will document river conditions during each of the past 10 years. These databases along with the data we have collected on fish condition (e.g., gill ATPase, condition factor, prevalence and severity of BKD) will

be analyzed using multivariate analyses to determine factors which contribute to adult survival as determined from coded-wire tag data and adult returns to the hatchery. The primary critical assumptions are that factors of salmon life history before they enter the ocean influence adult survival, or that the variables upon which we have data are critical to salmon survival. We anticipate that most of the work under this task will be completed by 1999 and that the main activities will be those described in Objective 2.

Task 1b. In order to adequately evaluate the short term success of altered hatchery practices (Objective 4) and the efficacy of non-invasive indices of fish condition and health (Objective 3), we must determine how those characteristics vary in the wild fish we are trying to mimic. We have considerable data on gill ATPase and condition factor in wild fish; however, we have no data on mucus lysozyme and visual pigment ratios in wild fish. These non-invasive techniques and critical assumptions are described under Objective 3 below.

Task 1c. This task will be initiated if the opportunity to monitor wild and hatchery migrants becomes available through our technical assistance program. The proposed budget does not allow for establishment of our own monitoring and sampling program.

Task 1d. The success of this task depends on Task 1c being undertaken. A critical assumption is that there is a difference in smolt indices of wild and production fish as measured by the non-invasive methods we employ.

Objective 2. Develop and maintain a consistent database on the health and physiology of hatchery and wild salmonids of the Columbia basin.

Tasks under this objective involve expanding the database described under Objective 1 to include virtually every hatchery that releases anadromous salmonids in the Columbia River basin. After the database is established, it will be updated and re-analyzed annually. Moreover, as information develops about the influence of factors outside of those in the database, those data will be added. Critical assumptions are the same as those under Objective 1. Another assumption is that hatcheries will continue to raise and release anadromous salmonids into the Columbia River basin.

Objective 3. Develop and evaluate non-invasive indices of smolt condition and health for monitoring of endangered and threatened species.

Task 3a. Juvenile salmon will be sampled at hatcheries and during the migration to determine changes in the ratio of Type I and Type II. Lysozyme will be extracted from kidneys and purified, followed by determination of the activity of the two types of lysozyme at 50^{o} C (Grinde *et al.* 1988). Concentrations and ratios of Type I and Type II lysozyme in smolting juvenile Pacific salmon will be documented for the first time.

Task 3b. Eye pigment changes will be measured in juvenile salmon by reflectance spectroscopy during rearing, at release, and during the migration to determine the relationship between changes in eye pigments known to occur during smoltification (Alexander *et al.* 1994) and other smolt indices, such as gill sodium, potassium ATPase. The method is a novel application of fiber optic reflectance probe technology, and the purpose of its development is to replace the need to sample tissues to determine smolt

status for gill ATPase analysis. Eye pigment ratios will be be correlated with gill ATPase measurements for method validation.

For both tasks - We do not know the appropriate sample size for these physiological measurements because we do not know the variability to expect. As we gather data, we will conduct power analyses to ensure that sample size is adequate to detect biologically significant differences. Critical assumptions are that smolt condition and health are important to survival, and that changes in ratios of mucus lysozyme types, and in visual pigment ratios are indicative of fish condition and/or health.

4. Provide technical assistance on interagency cooperative projects.
Task 4a. During 1997 and 1998 we will be collaborating with other projects (see Section 8). We have every indication that these requests for technical assistance will continue; and that the analyses describe in Objectives 1 and 2, and development of non-invasive methods described in Objective 3 will increase our value to similar projects in the region. This is, of course, a critical assumption.

Factors that could limit the success of this project are basically the inverse of the critical assumptions. If the data with which we are analyzing hatcheries, river conditions and fish condition are not predictive of fish survival, then this project does not serve a purpose. Furthermore, if hatcheries are closed, or if there is no further research to modify hatchery practices to raise more successful smolts, then our technical assistance will not be needed.

f. Facilities and equipment.

The Columbia River Research Laboratory (CRRL) has three state-of-the-technology analytical laboratories totaling 1600 sq. ft. dedicated to enzymology, immunology and cell culture, and general physiology. In addition to standard equipment such as centrifuges, pH meters, and balances, the laboratories are equipped with VIS-UV and reflectance spectrophotometers, enzyme-linked-immunosorbent assay (ELISA) plate readers, flame photometer, and -80 C freezers. The lab is staffed with trained technicians and biologists proficient in these techniques with backgrounds in fishery genetics, immunology, physiology, and endocrinology. The 1500 sq. ft. wet lab facilities with 64 tanks are more than adequate to conduct any level of investigation into fish development or behavior, including studies on disease resistance, predator avoidance, thermal preference, osmoregulation, swimming performance and bioenergetics.

All of the laboratory equipment is linked to the CRRL computer network which services 80 users at CRRL and has 8 gigabytes of memory. Computer software available for data analyses includes SAS, Excel, rBase, Statgraphics, and a variety of other word processing and data management software. The CRRL has its own T-1 line for Internet access. The quality of the CRRL laboratory capability is indicated by our publications addressing physiological variables. Moreover, the fact that we have the equipment and expertise available, means that others in the region need not equip additional laboratories to obtain

data about the health and development of fish of any species.

Field monitoring capabilities include 25 vessels and gear for electroshocking, radio telemetry, hydro acoustic, and in-river field sampling.

g. References.

Adams, C.E. and J.E. Thorpe. 1989. Photoperiod and temperature effects on early development and reproductive investment in Atlantic salmon (*Salmo salar* L.). Aquaculture 79:403-409.

Barron, M.G. 1986. Endocrine control of smoltification in anadromous salmonids. Journal of Endocrinology 108:313-319.

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Section 8. Relationships to other projects

The ten year presence of the Assessment of Smolt Condition for Travel Time Analysis in the Columbia River basin has resulted in acknowledgment of the Columbia River Research Laboratory as a resource for technical answers, assistance, and cooperation regarding smoltification and migration of juvenile salmon and steelhead. Assistance is rendered in the scope of the project if requests fulfills project objectives, and does not interfere with project tasks.

Rock Island Evaluation, WDFW **Study of the Influence on Precocity and Residualism in Wenatchee River Steelhead Smolts**

Hatcheries Program, WDFW **Survival Differences in Coho Salmon Reared under Semi-natural Conditions and Standard Conditions in a Hatchery**

Fish Management, WDFW **Cowlitz Falls Anadromous Fish Reintroduction Project**

Hatcheries Program, WDFW Snake River Laboratory
Stress in Acclimated versus Direct Stream Released Fish: Tucannon River Spring Chinook and Lyons Ferry Fall Chinook

Abernathy Salmon Culture Technology Center, USFWS
Effectiveness of β-Glucans as Feed Additives For Increasing Disease Resistance
Determination of the Seasonality of Mucus Lysozyme During Smoltification

Idaho Fishery Resource Office, USFWS **Evaluation of Fish Cultural Techniques at Dworshak National Fish Hatchery**

USGS-BRD, WFRC **Cohabitation Experiment: Effects of Stress on Chinook Salmon Exposed to Chinook Salmon Infected with *Renibacterium salmoninarum*.**

Idaho Fishery Resource Office, USFWS **Post release attributes and survival of of hatchery and natural fall chinook in the Snake River**

USGS, Oregon Cooperative Fishery Research Unit **Behavior and fate of juvenile salmonids entering tailwaters of the Dalles Dam via spill.**
U.S. Army Corp of Engineers funded project.

USGS Oregon Cooperative Fishery Research Unit
Evaluation of facilities for collection, bypass and transportation of outmigrating chinook salmon. U.S. Army Corp of Engineers funded project.

Section 9. Key personnel

Robin M. Schrock, Research Fishery Biologist	1.0 FTE
Dr. Alec G. Maule, Research Physiologist	0.5 FTE

Robin M. Schrock

Education

M.S., University of Wisconsin, Stevens Point, WI (Natural Resource Management - Fisheries) 1986

B.A., Portland State University, Portland, OR (Biology and German) 1982

Diploma, School for Medical Technologists, Bern, Switzerland 1975

Experience

Research Fishery Biologist, USGS-Biological Resources Division, Columbia River Research Laboratory 1991 to present

Fishery Biologist, USFWS-National Fishery Research Center Marrowstone Field Station 1987-1991

Publications

Schrock, R.M., J.W. Beeman, D.W. Rondorf, and P.V. Haner. 1994. A microassay for gill sodium, potassium-activated ATPase in juvenile Pacific salmonids. Transactions of the American Fisheries Society.

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Newcomb, C.B. Schreck, A.N. Palmisano, R.M. Schrock, G.A. Wedemeyer, R.D. Ewing, and C.W. Hopley, 1991. Smolt quality assessment of spring chinook salmon. Annual report to Bonneville Power Administration.

Alec G. Maule

Education

B.A., University of California, Riverside (Psychology) 1969
B.S., California Polytechnic University, San Luis Obispo (Natural Resource Management) 1979
M.S., Oregon State University (Fisheries Science) 1982
Ph.D., Oregon State University (Fisheries Science) 1989

Employment

Assistant Professor of Fisheries (Courtesy), OSU (1991-present)
Adjunct Associate Professor of Biology, Portland State University (1992-present)
Research Physiologist, USGS, BRD, Columbia River Res. Lab. (1991-present)

Publications (most recent 5 of 29)

Maule, A.G., and M.G. Mesa. 1994. Efficacy of electrofishing to assess plasma cortisol concentration in juvenile chinook salmon passing hydroelectric dams on the Columbia River. North American Journal of Fisheries Management 14:334-339.

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Professional Service

I am currently an Associate Editor for the Journal of Aquatic Animal Health

American Fisheries Society
Fish Health Section
Snieszko Graduate Award Committee (Chair) 1989-91
Physiology Section (Charter member)
Vice Pres., Pres.-elect, Pres., Past-President 1993-97
Awards Committee (Chair) 1997-98
Oregon Chapter AFS Legislative Committee 1983-84

	Annual Meeting, Program Committee	1985-93
	Director of Internal Committees	1989-90
	Pres.-elect/Pres./Past Pres.	1990-93
Regional Committees	Dissolved Gas Team	1995 -present.
	Grand Coulee Dam Dissolved Gas Committee (Chair)	1996 -present.

Section 10. Information/technology transfer

Research results will be published in peer reviewed journals. Annual reports will be prepared, and reports written with cooperating agencies. The project database will be available in several forms. Sections of the database pertaining to specific reference hatcheries will be released to the cooperating agencies and hatcheries. In the case of participation in production level research projects, we will publish annual reports and peer reviewed articles. The database will be available through the Coordinated Information System and the USGS metadata archive system.