PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Recondition Wild Steelhead Kelts

BPA project number: 20141
Contract renewal date (mm/yyyy): ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Columbia River Inter-Tribal Fish Commission

Business acronym (if appropriate) CRITFC

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
4.1A, 7.0A.1, 7.1B.2, 7.1C.3, 7.2C,7.4, and 7.4K

FWS/NMFS Biological Opinion Number(s) which this project addresses
XII.2.b. (terms and conditions to reduce adult mortality), NMFS 1998 Supplemental Biological Opinion.

Other planning document references
Wy-Kan-Ush-Mi Wa-Kish-Wit

Short description
Test various methods to recondition wild steelhead kelts to help increase the contribution of repeat spawners to rebuilding depleted populations. Methods developed in this study could be used basin wide to help reduce kelt passage mortality .

Target species
Steelhead (Oncorhynchus mykiss)

Section 2. Sorting and evaluation

Subbasin
Yakima River

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more	If your project fits either of these	Mark one or more categories

caucus	processes, mark one or both	
☒ 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

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Identify kelts	a	Evaluate ultrasound and morphological identification techniques to distinguish pre- and post-spawned steelhead.
		b	Locate facilities that have access to kelts in the Columbia and Snake rivers.
2	Recondition kelts	a	Identify and collect kelts at Prosser Dam (Yakima River) bypass.
		b	Test Scenario 1: Immediately transport collected kelts and release them below Bonneville Dam.
		c	Test Scenario 2: Perform short-term

			reconditioning and release kelts below Bonneville Dam.
		d	Test Scenario 3: Perform long-term reconditioning and captive spawning.
		e	Test Scenario 4: Perform long-term reconditioning and release to spawn naturally.
3	Monitor and evaluate kelt reconditioning	a	PIT tag (134.2 kHz) all experimental fish before transportation and/or reconditioning.
		b	Monitor returning test fish in the Yakima River.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	3/2000	7/2000	Identify female and male kelts with 99% and 95% accuracy, respectively. Identify sites above Bonneville Dam where kelts can be collected.		60.00%
2	7/2000	5/2002	Survival of kelts and release in good condition..		30.00%
3	6/2000	4/2003	Return of experimental fish to Yakima River (Prosser Dam).		10.00%
				Total	100.00%

Schedule constraints
None foreseeable

Completion date
2004

Section 5. Budget

FY99 project budget (BPA obligated):

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel		%31	24,780

Fringe benefits		%10	7,806
Supplies, materials, non-expendable property	No indirect charged to non-expendable property (17,500 ultrasound)	%10	8,150
Operations & maintenance		%8	6,105
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags: 150	%1	435
Travel		%9	7,234
Indirect costs		%23	18,180
Subcontractor		%0	
Subcontractor	OSU	%9	7,562
Other		%0	
		TOTAL BPA FY2000 BUDGET REQUEST	$80,252

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
		%0	
		%0	
		%0	
		%0	
		Total project cost (including BPA portion)	$80,252

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$70,000	$70,000	18,000	$20,000

Section 6. References

Watershed?	Reference
☐	Bruce, R., A. Ward, and A. Slaney. 1990. Returns of pen-reared steelhead from riverine, estuarine and marine releases. Trans. Am. Fish. Soc. 119:492-499.
☐	Caudle, A. 1998. Use of ultrasound to identify the sex of Columbia River chinook salmon. (Draft report available from the Columbia River Inter-Tribal Fish Commission) Portland, OR.
☐	Crim, L.W., C.E. Wilson, Y.P. So, and D.R. Idler. 1992. Feeding, Reconditioning, and Rematuration Responses of Captive Atlantic Salmon (Salmo salar) Kelts. Can. J. Fish. Aquat. Sci. 49: 1835 – 1842.
☐	Foster, J.R., and C.B. Schom. 1989. Imprinting and homing of Atlantic salmon (Salmo salar) kelts. Can. J. Fish. Aquat. Sci. 46:714 -719.
☐	Gauthier, D., L. Desjardins, J.A. Robitaile, and Y. Vigneault. 1989. River spawning of artificailly reconditioned Atlantic salmon (Salmo salar). Can. J. Fish. Aquat. Sci. 46:824-826.
☐	Hasler, A.D, A.T. Scholz, R.M. Horrall. 1978. Olfactory imprinting and homing in salmon. American Scientist 66 (3), 347-355.
☐	Johnston, C.E., R.W., Gray, A. McLennan, and A. Paterson. 1987. Effects of photo., temp.,

	and diet on the reconditioning response, blood chem., and maturation of Atlantic salmon kelts (Salmo salar) held in freshwater. Can. J. Fish Aquat. Sci 44:702-711
☐	Kato, F. 1991. Pacific Salmon Life Histories- edited by Groot and Margolis. Universtiy of British Coumbia Press. Vancouver, BC.
☐	Leider, S.A. 1985. Precise timing of upstream migrations by repeat steelhead spawners. Trans. Am. Fish. Soc. 114:906–908.
☐	Leider, S.A., M.W. Chilcote, and J.J. Loch. 1986. Comparative life history of hatchery and wild steelhead trout (Salmo gairdneri) of summer and winter races in the Kalama River, Washington. Can. J. Fish. Aquat. Sci. 43:1398–1409
☐	Moffett, I.J., G.J.A. Kennedy, and W.W. Crozier. 1996. Freshwater reconditioning and ranching of Atlantic salmon, Salmo salar L., kelts: growth and reproductive performance. Fisheries Management and Ecology. 3: 35-44.
☐	NMFS (National Marine Fisheries Service). 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. Seattle, WA.
☐	NMFS (National Marine Fisheries Service). 1997. Endangered and threatened species: Listing of several evolutionary significant units (ESUs) of west coast steelhead. Final rule. Federal Register 62 (159):43937-43940
☐	NMFS (National Marine Fisheries Service). 1998. Supplemental Biological Opinion. NMFS Northwest Region. Seattle, WA.
☐	NPPC (Northwest Power Planning Council). 1986. Compilation of information on salmon and steelhead losses in the Columbia River Basin. Portland, Oregon.
☐	NPPC (Northwest Power Planning Council). 1995. 1994 Columbia River Fish and Wildlife Program (revised 1995). Portland, Oregon.
☐	Poole, W.R., M.G. Dillane., and K.F. Whelan. 1994. Artificial reconditioning of wild sea trout, Salmo trutta L., as an enhancement option: initial results on growth and spawning success. Fish. Mgmt Ecol. 1(3):179-192.
☐	SSR (Stock Summary Reports). 1992. Stock summary report for Columbia River anadromous salmonids. Vol. IV: Above McNary. (available from the Bonneville Power Administration). Portland, OR.
☐	TRP (Tribal Restoration Plan). 1995. Wy-Kan-Ush-Mi Wa-Kish-Wit: The Columbia River anadromous fish restoration plan of the Nez Perce, Umatilla, Warm Springs, and Yakama tribes. Columbia River Inter-Tribal Fish Commission, Portland, OR
☐	U.S. v. Oregon. 1997. 1996 all species review, Columbia River fish management plan. Technical Advisory Committee. Portland, OR.
☐	Wingfield, W. 1976. Holding summer steelhead adults over to spawn second year. 27th Northwest Fish Culture Conference. Twin Falls, ID.
☐	Whitt, Charles R. 1954. The Age, Growth, and Migration of Steelhead Trout in the Clearwater River, Idaho. Thesis submitted to the University of Idaho Graduate School
☐	Zar, J.H. 1984. Biostatistical Analysis. Prentice Hall, Inc. Englewood Cliffs, New Jersey.
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PART II - NARRATIVE

Section 7. Abstract

Wild steelhead (*Oncorhynchus mykiss*) kelts that enter the juvenile collection systems at mainstem and tributary dams are now being returned to the river, where they are believed to die. If treated and nurtured (i.e., reconditioned) to spawn again, these kelts could help rebuild wild populations and maintain the iteroparity that is now being selected out of upriver stocks by high cumulative mainstem passage mortalities. Such reconditioning has succeeded elsewhere with steelhead and Atlantic salmon (*Salmo salar*). In year 1 we will validate ultrasound and visual methods to discriminate kelts from prespawners, and we will identify other sites where wild kelts could be collected. In years 1-3 we will collect 150-200 wild Yakama R. steelhead kelts at Prosser Dam and test reconditioning under four scenarios: 1) immediate transportation and release below Bonneville Dam, 2) short-term reconditioning and release below Bonneville Dam, 3) long-term reconditioning and spawning in captivity, 4) long-term reconditioning and release below Prosser Dam to spawn naturally during the ensuing spawning season. In years 1-4, we will monitor post-release survival and returns for scenarios 1, 2, and 4 using PIT tags and detectors at Prosser Dam. The Yakama Indian Nation (YIN) will contribute technician time, equipment, and facilities at Prosser Dam and at Cle Elum Hatchery; OSU will provide expertise in reproductive physiology and will help develop therapeutic regimes. Reproductive benefits and production-scale costs will be estimated for each scenario to help evaluate its feasibility for a long-term reconditioning program.

Section 8. Project description

a. Technical and/or scientific background

Problem Statement

Populations of wild steelhead *(Oncorhynchus mykiss)* have dramatically declined from historical levels in both the Columbia and Snake rivers (*US v. Oregon* 1997). Steelhead are now listed as endangered in the upper Columbia River and threatened in the Snake River under the Endangered Species Act (NMFS 1997). Causes of the declines are numerous and well known (NPPC 1986; TRP 1995), yet efforts to enhance wild populations are lacking (*US v. Oregon* 1997).

Regional plans recognize the need to protect and enhance weak upriver steelhead populations while maintaining the genetic integrity of those stocks (NPPC 1995). So far, mitigation for dam passage mortalities in the Columbia Basin has focused on aiding juvenile migrants and upstream-migrating adults. But steelhead are potentially iteroparous, and wild steelhead kelts (i.e., post-spawn adults) may be an important but overlooked source of genetic material for rebuilding depleted wild populations. Unfortunately, methods to enhance the survival of downstream-migrating kelts have not been explored in the basin, although the National Marine Fisheries Service recognizes the potential value of kelts for achieving rebuilding goals (NMFS 1998) and has requested that research be conducted to reduce dam passage mortality of kelts (Biop XII 2.b.).

Literature Review

Repeat spawners (i.e., kelts that survive to spawn again) may have significantly augmented early populations of Snake and Columbia River steelhead. At least 2% of wild steelhead returning to Idaho's Clearwater River were repeat spawners when there were only two downstream dams (Lewiston Dam and Bonneville Dam; Whitt 1954). Most of those repeat spawners were females (Whitt 1954), which suggests that repeat spawners may contribute disproportionately to the next generation. Recent estimates of repeat spawners in tributaries of the lower Columbia River (e.g., Kalama River) have exceeded 17% (NMFS 1996), with some fish returning to spawn four consecutive times (Leider et al. 1986). In contrast, it is believed that very few, if any, repeat spawners currently exist in the Snake or Upper Columbia River subbasins (R. Carmichael, ODFW, pers. com.). Kelts attempt to leave the Snake and Columbia River — as evidenced by their capture in the juvenile collection systems at mainstem dams — but none are believed to survive to spawn again under present conditions. Unfortunately, both historical and current information about steelhead kelts in the Columbia R. is very limited.

Columbia R. steelhead kelts may be reconditioned to spawn again through appropriate selection, therapeutic treatments, feeding, and/or downstream transport around mainstem dams. Past reconditioning efforts have succeeded. For example, when Siletz River (Oregon coastal) summer steelhead were reconditioned for a full year in fresh water (analogous to our Scenario 3), all of the females gained weight, over 60% of them ripened for artificial spawning the next year, and the resulting progeny contributed to the adult run two years after their release as smolts (Wingfield 1976).

Other iteroparous anadromous salmonids — like Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*) and masu salmon (*Oncorhynchus masou*) — also have been successfully reconditioned (Johnston et al. 1987; Gauthier et al. 1989; Kato 1991, Crim et al. 1992, Poole et al. 1994, Moffet et al. 1996). For example, fifteen Atlantic salmon kelts were reconditioned 6-10 mo. in freshwater tanks, and five of the six females are believed to have spawned in the stream enclosure into which they subsequently were placed (Gauthier et al. 1989). Atlantic salmon that had been reconditioned for shorter periods (1-3 mo.) in freshwater tanks and released to rear in the ocean a few months were able to home back to their natal streams, rather than to the reconditioning or release sites (Foster and Schom 1989). Therefore, short-term reconditioning probably will not impair the ability of steelhead spawners to home back to their natal streams — an ability acquired through olfactory imprinting as juveniles (Hasler et al. 1978; Bruce et al. 1990). Moffet et al. (1996) also successfully reconditioned Atlantic salmon kelts, but concluded that high labor costs made reconditioning an effective enhancement strategy only when the value of the reconditioned fish exceeds that of traditional hatchery fish. Given the genetic and cultural value of wild summer steelhead in the Columbia Basin and their ESA status, reconditioning is worth investigating.

Some limited and scattered reconditioning efforts are beginning. In 1999, the Corps of Engineers proposes to have hatchery personnel teach Corps technicians how to discriminate between kelts and pre-spawn fallbacks in juvenile collection systems at Walla Walla District dams. One objective is to determine how many kelts may be available — in later years — for collection and transportation below Bonneville Dam (analogous to our Scenario 1) to satisfy a condition of NMFS' Biological Opinion (NMFS 1998). In 1998, ODFW attempted to recondition 29 Snake R. steelhead that had returned to and been spawned at Wallowa Hatchery (M. Edwards, ODFW, pers. comm.). Fungal infections were treated with formalin, and fish were force-fed beef liver on a stick followed later by a soft krill-based pellet. Only two males of the 29 test fish survived beyond a month, and both are readily taking feed this fall. The YIN intends to begin collecting and attempting to recondition wild steelhead kelts in the Yakima R. in 1999 as part of the Yakima/Klickitat Fisheries Project (D. Fast, YIN, pers. comm.). Despite reconditioning successes elsewhere, it will probably take a few years of careful, coordinated study to develop the selection standards, treatments, and diets necessary to consistently recondition wild steelhead kelts in the mid- and upper-Columbia R. Basin.

Needed Research

Further research is needed to:

- Distinguish kelts from pre-spawn fallbacks with consistently high accuracy, especially when ESA-listed stocks are involved;
- Identify locations where wild kelts can be collected;
- Select kelts that have a high probability of being reconditioned;
- Determine the most effective reconditioning treatments, environments, and diets; and
- Evaluate the cost effectiveness of the various reconditioning scenarios.

Kelts must be accurately identified to avoid collecting and trying to recondition pre-spawned fish, especially those of listed stocks, which frequently co-occur with the kelts. Although most summer steelhead on their spawning migration pass upper Columbia and Snake River dams in September and October (*US. v. Oregon* 1997), some overwinter in the mainstems before completing their upstream migration during the same April-May period when many kelts are returning downstream (Whitt 1954; NMFS 1998). Thus, pre-spawn fish are also captured in the juvenile bypass systems along with the kelts. Distinguishing between the two can be difficult.

Corps employees at Snake River dams have been attempting to identify and enumerate kelts among the thousands of adult steelhead that fall back through the juvenile collection systems each year. However, these employees have little confidence in the accuracy of their visual methods (R. Baxter, USACE, pers. com.), so the Corps will use experienced personnel from agency hatcheries to train its dam technicians in hopes of increasing the accuracy of kelt identification in 1999. The YIN hatchery staff working at Prosser Dam is confident that they can distinguish between kelts and pre-spawners, but there is still considerable doubt whether **un**validated visual methods — whether used by the Corps, by the YIN, or by anyone else — will be sufficiently accurate to avoid mistaking some pre-spawners as kelts. Hence, we propose to use ultrasound technology, which promises high accuracy and precision (see Methods for details), to validate visual methods in at least the first year (FY00).

Also in the first year we will compile an inventory of sites above Bonneville Dam where wild kelts may be collected in future years. We expect that many sites similar to Prosser Dam — where kelts, interested partners, and complementary resources are available — can be found during the inventory.

The location of the collection site can greatly influence the quality of kelts that can be selected for reconditioning. The brightest fish showed the best response to reconditioning in the limited 1998 trial at Wallowa Hatchery (M. Edwards, ODFW, pers. com.), and tributary collection sites (e.g., weirs at acclimation sites, Prosser Dam on the Yakima R.) may provide kelts in better condition than at collection sites downstream on the mainstem. Regardless, an important need addressed by this study is to identify the qualities that allow some kelts to be reconditioned so that resources are not futilely invested on moribund animals.

Perhaps the greatest research need is to identify and develop a regime of treatments, environmental conditions, and diets that are most effective for reconditioning. Is formalin the best treatment for fungal infections? What critically important nutrients are most deficient in post-spawned salmonids (e.g., essential amino acids, fat-soluble vitamins) and what are the most effective means of administering those nutrients (e.g., in the diet, via injection)? Could hormone treatments (e.g., growth hormones) retard or reverse senescence? The subcontract to OSU (Dr. Marty Fitzpatrick) will help address these needs, and the three-year study period will allow some time to begin testing and refining basic treatments.

We must also determine which reconditioning scenario(s) work(s) best. Will immediate transport to below Bonneville Dam (Scenario 1) — which the Corps may eventually implement from Snake R. dams in response to the Biological Opinion (NMFS 1998) — produce any returns to the collection site? What are the economic costs and genetic considerations of long-term reconditioning and captive spawning (Scenario 3), as is being attempted by ODFW at Wallowa Hatchery? This project would begin to answer these questions by monitoring the repeat spawners produced by the four scenarios and by estimating the benefits and costs of production-scale reconditioning programs.

Lastly, this project will augment and connect the small, scattered kelt collection and reconditioning efforts now being independently initiated by the Corps, agencies, and tribes. Should one or more reconditioning scenarios prove feasible, then we anticipate that implementation will become a funded part of existing or new production programs.

b. Rationale and significance to Regional Programs

Steelhead kelts – now being removed from juvenile bypass systems and returned to the river, where they are believed to die – are a potentially valuable resource for rebuilding depleted runs of wild steelhead. Reconditioning wild kelts could help satisfy one of the core needs common to all restoration plans: how to rebuild wild/natural populations expeditiously in ways that preserve the genetic and life history diversity within, and the overall fitness of, those populations.

For example, the Fish and Wildlife Program calls for actions that:

- give "priority..to rebuild weak upriver populations, including populations listed under the Endangered Species Act" (4.1A);
- "…provide immediate increases in natural production and survival" (7.0A.1);
- improve the "…conservation of biodiversity, including identification of …alternative approaches to artificial production…" (7.1B.2);
- "…identify limiting factors for wild and naturally spawning populations" (7.1C.3);
- protect and restore depleted populations on a site-specific basis as quickly as possible, while recognizing the legitimate associated biological concerns (7.2); and
- pursue new production initiatives, including captive broodstock and supplementation programs (7.4).

NMFS's Supplemental Biological Opinion (XII 2.b.) calls for:

- an "approach to evaluate dam passage rate and success (including dam and system survival) of adult steelhead returning to the ocean after spawning (kelts)," and
- an examination of the feasibility of "transportation of steelhead kelts as a possible means of reducing dam passage mortality."

Wy-Kan-Ush-Mi Wah-Kish-Wit advocates supplementation as a useful and necessary restoration measure (5B, Hypothesis 4). Reconditioning kelts may provide some of the benefits of supplementation without many of the associated concerns.

This approach has the advantages of:

- Assisting wild populations using wild fish that have already spawned naturally and that would otherwise die.

- Using existing juvenile collection facilities and hatchery facilities (i.e., efficiency).
- Broad applicability throughout the region where wild steelhead stocks are depleted.
- Maintaining and enhancing iteroparity, a life history quality that is being lost.
- Applying techniques that have been successful with coastal steelhead and Atlantic salmon.
- Directly mitigating, in place and in kind, kelt mortalities caused by the hydrosystem.

A kelt reconditioning program could substantially bolster efforts to restore natural populations of Columbia and Snake River steelhead. To illustrate, assume 60% of the female kelts could be reconditioned to spawn the next year (Wingfield 1976; reconditioning success rate for Siletz R. kelts) and assume an average fecundity of 4,611 (SSR 1992; average fecundity of Lyons Ferry Hatchery steelhead), then 500 captured female kelts could produce over 1.4 million eggs. If incorporated into a supplementation program, these eggs might produce 413,000 smolts (SSR 1992; 0.295 egg-to-smolt survival rate for Lyons Ferry Hatchery) and 2,024 adults (SSR 1992; 0.0049 smolt-to-adult survival for Dworshak NFH). This potential result — equivalent to 23% of the wild steelhead adults counted at Lower Granite Dam in 1998 — would be achieved with kelts that otherwise had virtually no chance of survival: contemporary management essentially considers them dead.

Reconditioning may also help maintain and restore life-history diversity in wild stocks. Iteroparity, a life-history trait now being selected out of upstream populations by high mainstem passage mortalities, might be restored to historical levels and perhaps enhanced. Repeat spawning could also improve within-population genetic variability by increasing the number of cohorts represented in each spawning year. In addition, if females tend more toward iteroparity than do males (Whitt 1954; Leider et al. 1985; Bruce et al. 1990; NMFS 1996), kelt reconditioning could produce disproportionately large increases in egg and juvenile production.

c. Relationships to other projects

This project will have immediate relationships to the Yakima/Klickitat Fisheries Project (YKFP), the Corps' smolt collection and transportation program, and the Lower Snake River Compensation Program (LSRCP). Future relationships with other fish production projects in the basin are likely.

The YKFP will contribute facilities, equipment, and some staff already employed at Prosser Dam and at Cle Elum Hatchery to this project. Facilities at the hatchery that would otherwise be idle at that time of year.

We expect to continue freely sharing ideas and information between this project and the Corps kelt identification program, with an emphasis on how the two efforts could complement each other. For example, at our request, the Corps' System Configuration Team is presently (11/98) considering whether to fund ultrasound validation of their visual methods to identify. If funded, this Corps work could reduce the scope (e.g., need to validate ultrasound at a hatchery) and costs of Objective 1 of this study.

ODFW has shared information freely with us about their reconditioning effort at Wallowa Hatchery, funded by the LSRCP. If ODFW continues its reconditioning study, then this project will replicate the Wallowa Hatchery work using wild Yakima R. steelhead at Cle Elum Hatchery facilities (Scenario 3). This project would also complement ODFW's work by assessing the other three scenarios and by testing and developing better reconditioning techniques, primarily through cooperation with OSU reproductive physiologist, Dr. Marty Fitzpatrick. In general, this project will augment and coordinate pioneering initiatives by ODFW, the YIN, and others.

Several organizations will contribute to this project's inventory of prospective kelt collection sites (Task 1.b) by providing information about the abundance of kelts available at collector dams and other locations. If this project proves that reconditioning is feasible, we would provide information and perhaps limited other assistance to production programs that wish to implement it or to further develop it.

d. Project history (for ongoing projects)

None, this is a new project

e. Proposal objectives

Objective 1: Identify kelts

Hypotheses related to objective – Identification techniques can be developed to accurately distinguish pre- and post-spawned (kelt) steelhead.

Primary assumptions necessary to test hypotheses:

- Ultrasound images can be used to detect the presence or absence of eggs and sperm,
- Certain morphological traits (damaged fins, girth, coloration) are unique to kelts, and
- Other kelt collection points (weirs, dams, traps) are available in the Columbia R. Basin

To avoid the handling and/or potential "reconditioning" of pre-spawned fish, particularly of ESA-listed stocks, it is imperative that accurate discriminating techniques be developed. We believe the added reassurance of ultrasound is worthwhile, and plasma steroid assays could provide an additional level of validation (M. Fitzpatrick, OSU, pers. comm.) if ultrasound were not sufficient to help us achieve accuracy targets in the first year (i.e., classification accuracy of 99% and 95% for female and male kelts, respectively).

We assume that locations other than Prosser Dam and mainstem collector dams have access to outmigrating kelts. Results will include a list of kelt collection sites, rough estimates of the number of kelts available at each site, existing site resources (i.e., facilities and staff), and names of contact persons, which will be into the first annual report and final report to BPA. Results of our kelt identification work will also be communicated directly to Corps employees who handle kelts at mainstem collector dams.

Objective 2: Recondition kelts

Hypotheses related to objective - Steelhead kelts, captured during migration to the ocean, can be reconditioned to spawn again.

Primary assumptions necessary to test hypotheses:

- Wild kelts will accept feed and survive the stresses of a hatchery environment.
- Dermal infections (e.g., fungus) can be treated to prevent spreading and mortality.

- Capture and handling will not substantially increase mortality of test fish.
- Adequate numbers of kelts can be collected to test various reconditioning scenarios.

The true test of reconditioning is whether wild steelhead escapement in the Yakima River and elsewhere can be stabilized and perhaps increased (see Objective 3). However, an important intermediate test is whether reconditioning can keep the kelts alive through their first critical weeks in captivity. Preliminary results of reconditioning will be available in the late spring of 2000, with the following two years providing results from refined methods. We will pursue an intermediate (and arbitrary) goal of 50% survival through one month of reconditioning, although lower rates may still be acceptable to managers when ESA-listed stocks are involved. Annual and final results will be submitted to and published by BPA and probably submitted for publication in a professional journal.

A note to reviewers: Please also consider this project for funding with the budget set-aside for innovative proposals. The low cost of the project and the potential value of the results compensate for the fact that more than one year will be needed to test and refine reconditioning methods (we propose three years) and to evaluate the effectiveness of the four scenarios based on return of repeat spawners to Prosser Dam (two years after last release, at very low cost).

Objective 3: Monitor and evaluate kelt reconditioning.

> *Hypotheses related to objective 3* – Success of reconditioning can be monitored after transportation and/or long-term reconditioning takes place.

Primary assumptions necessary to test hypotheses:

- Surviving test fish will home back to Prosser Dam.
- PIT tags can be detected on returning adults.
- Reconditioned fish passing Prosser Dam will eventually spawn in their natal stream.
- Data obtained from the study will be adequate to evaluate the reproductive benefits and economic costs of production-scale implementation of reconditioning.

Adult PIT tag detectors slated for Bonneville (North ladder only) and Prosser Dam will allow us to track returning reconditioned fish. An adult PIT tag detector is scheduled for installation at Prosser Dam in 1999 or 2000 if the prototype proves successful at Bonneville Dam. With adult PIT tag detection, return rates for reconditioned fish can be evaluated among all test scenarios. Spawning success will ultimately have to be assumed for Scenarios 1, 2, and 4, however, because they will spawn naturally, unobserved. Fecundity and egg survival rate will be obtained from Scenario 3 (captive brood), which may be useful in evaluating the reproductive contribution of natural spawners in the other three scenarios. The benefits of reconditioning — in terms of spawners, eggs, fry, and/or smolts produced — will be estimated for all scenarios and compared to production-scale cost estimates for the respective scenarios. Results of this objective will be submitted to BPA in annual and final reports. Results may also be submitted for publication in a professional journal.

f. Methods

Objective 1: Identify Kelts (FY00)

<u>Task 1.a: Evaluate ultrasound and morphological identification techniques:</u>

Ultrasound is proposed to validate and help develop what we hope will be quick and inexpensive visual methods to distinguish kelts from prespawners. A large proportion of the approximately 200 adult steelhead that are collected in Prosser Dam's juvenile bypass system over a 10-week period are believed to be kelts, with only a few being pre-spawners (D. Fast, YIN, pers. com.). Adult steelhead collected in the system will be retained for ultrasound examinations every second day. For the examination, fish will be dipnetted from the juvenile separator, anesthetized in a buffered solution of MS-222 and fresh river water in a 380-l sampling tank, and scanned with an Aloka® 5.0 MHz ultrasound machine. The ultrasound examination technique includes placing a 5.0 MHz linear probe on the abdomen of the fish just posterior of the pectoral fin and then moving posteriorly on the abdomen to image the testes or ovaries. The machine displays an image in real time to permit feedback to the operator and the images can be stored on VHS videotapes for later viewing. Kelts will be retained in a holding enclosure, and pre-spawners will be released back into the Yakima R. Collection and sampling will be conducted during the peak fallback months of April and May.

In addition, we will validate ultrasound methods by using the same device to scan spawners at Wallowa Hatchery (T. Whitesel, ODFW, pers. com.) and/or at the Minthorn Springs facility (G. James, CTUIR, pers. com.). Target numbers for validation are 15 spawners of each gender, with scans of each spawner before and after spawning (60 sample scans, total). Scans of partially spawned females will also be collected to determine if incompletely spawned kelts can be identified. Following validation at the hatchery, ultrasound images collected at Prosser will then be compared to the visual examinations from Prosser to determine the accuracy of the visual methods.

Concurrent with the ultrasound examinations we will also collect data on fish length, girth, fin condition, H/W origin (based on fin clips), physical anomalies, and other traits that may distinguish kelts from pre-spawners. Local hatchery experts from Cle Elum hatchery will help examine fish and identify the morphological characters that distinguish kelts from pre-spawners. The goal is to develop quick and very accurate methods to identify kelts, with arbitrary target accuracies of 99% for females and 95% for males.

Should ultrasound fail to clearly distinguish kelts from pre-spawners in year 2000, we will probably employ blood plasma steroid assays in year 2001 for validation. OSU would conduct this work under the direction of Dr. Martin Fitzpatrick, OSU reproductive physiologist.

Task 1.b: Locate other facilities that have access to kelts (FY00)

Prosser Dam and Snake and Columbia River collector dams are not the only sites where wild steelhead kelts may be available for collection and reconditioning. Other possibilities include mainstem and tributary dams in the mid-Columbia and weirs associated with production facilities (e.g., Little Sheep Creek) or fish traps (e.g., the Imnaha R. adult trap). For this objective, we will interview tribal and agency staff and staff of the mid-Columbia dam operators to identify where, in their area of knowledge, wild steelhead kelts might be readily collectable upstream of Bonneville Dam. A list of these sites, approximate numbers of steelhead falling back past the facility, and names of contact persons will be published in the annual report.

Obj. 2: Recondition Kelts (FY00-02)

Under this objective we will collect kelts at Prosser Dam (Task 2.a) and test four scenarios that include various potential survival benefits and levels of reconditioning:

Scenario	Task	Description	Potential Survival Benefits	Spawning

			Circumvent Mainstem Passage Mortality	Therapy: Medical and Diet Treatment	Saltwater Rearing	
1	2.b	Immediate transportation and release below Bonneville	downstream		✓	Natural
2	2.c	Short-term reconditioning and release below Bonneville	downstream	✓	✓	Natural
3	2.d	Long-term reconditioning and captive brood stock	downstream & upstream	✓		Captive
4	2.e	Long-term reconditioning and release near the collection site	downstream & upstream	✓		Natural

All scenarios require temporary (1-5 day) holding at Prosser, and approximately equal numbers of kelts will be assigned to each of the four test scenarios (*ca*. 30-50 fish per treatment, initially). PIT tags (134.2-kHz) will be implanted while the fish are anesthetized for the ultrasound examination, and specimens reserved for reconditioning (all fish except those assigned to Scenario 1) also will be tagged at the base of the dorsal fin with combinations of colored floy tags to facilitate identification during reconditioning. Fish for Scenario 1 will be trucked periodically 200 mi. to below Bonneville Dam and immediately released. Specimens reserved for the other three scenarios will be given their first treatment (formalin and/or hydrogen peroxide) for dermal fungus and trucked to Cle Elum Hatchery for the remainder of their reconditioning in holding ponds at that facility. The Yakama Indian Nation will manage the reconditioning facility, at no cost to this project.

Reconditioning will require further treatments for fungus and a specialized feeding regime. Dr. Martin Fitzpatrick and other OSU researchers will help design and implement reconditioning treatments for the experiment. Initial feeding probably will involve hand (force) feeding a mixed diet of herring (or other natural feed) and a pellet of artificial nutrient supplement. Previous reconditioning studies demonstrate that a natural food source (e.g., herring, smelt) helps initiate feeding, but a pellet supplement, preferably with amino acid and betaine compounds, is necessary for proper nutrition (Crim et al. 1992; Miffed et al. 1996). Relevant knowledge gained by ODFW at Wallowa Hatchery in 1999 (assuming their reconditioning work continues) will be incorporated into this study's design.

Reconditioning for Scenarios 2, 3, and 4 will be the same for the first 2-6 wk, a period when the primary object is to keep the animals alive and get them to feed voluntarily. We expect greater than 50% attrition, particularly in the initial year. Fish that begin to accept feed regularly during this period — but no more that one-third of those remaining — will be assigned to Scenario 2, be checked to ensure that each bears a functional PIT tag, have their floy tags removed, and be trucked to below Bonneville Dam for release in May or June. The released fish are expected to rear for a few months in the ocean, then — if they survive — to return in the summer/fall of the same year or following year to spawn.

Reconditioned kelts remaining at Cle Elum Hatchery in September (after long-term reconditioning) will be divided equally by gender into test groups for Scenarios 3 (captive spawning) and 4 (release for natural spawning). If fewer than six females remain, all will be assigned to Scenario 3. Fish in Scenario 3 that ripen in the same year will either be spawned at Cle Elum Hatchery or transported to another facility, if it is better suited for steelhead spawning and incubation. Fish in Scenario 4 will be monitored for plasma steroid indicators of impending readiness to spawn, and those that are ripening will be checked for functioning PIT tags and floy tags, trucked to below Prosser Dam, and released to home to their natal stream to spawn naturally. Evaluation of their subsequent survival and spawning success is described under Objective 3.

Obj. 3: Monitor and Evaluate Kelt Reconditioning (FY00-04)

Survival and ripening for repeat spawning is the ultimate performance objective for the study. At the end of three years of reconditioning tests and monitoring subsequent returns, we expect to be able to evaluate the general feasibility of reconditioning for preserving and restoring populations of steelhead and to estimate the relative costs and reproductive benefits of the four reconditioning scenarios, if implemented on a production scale.

Our ability to measure success varies among the four scenarios. Scenarios 1 (immediate release below Bonneville) and 2 (short-term reconditioning and release below Bonneville) are the treatments that involve the least amount of holding and care and that allow the fish to return to the ocean and (possibly) benefit from natural saltwater rearing. Our evaluation strategy for these two scenarios depends on the prototype adult PIT tag detector proving effective at Bonneville Dam in 1999, and subsequent installation of a detector at Prosser Dam. Installation at Prosser is tentatively planned for 1999 or 2000. Without adult PIT tag detection, we may not know if any of the Scenario 1 or Scenario 2 fish survived after their release. Alternatively, if PIT tag detectors ***are*** in place at Prosser, where all returning adult steelhead can be interrogated, we will know how many survived and successfully migrated back to their point of capture, Prosser Dam. Even one fish returning from either of these two scenarios in the first year would be noteworthy and encouraging.

The number of fish that survive until they readily accept feed at 2-6 wk will determine how many can be assigned to each of Scenarios 2, 3, and 4. Scenario 4 (long-term reconditioning, release below Prosser in the fall) will be evaluated based on the subsequent passage of released fish through the adult fish passage facility at Prosser Dam. If adult PIT tag detection were available at the dam, passage of Scenario 4 fish would be monitored through the PIT tags implanted in them, otherwise their passage would be monitored visually by fish counters via the colored floy tags they bear. Survival, homing, and subsequent spawning success will not be monitored, except in the case where a tagged fish is observed during spawning ground surveys or during its downstream passage as a kelt. Lengths and weights of Scenario 4 fish will be recorded prior to release. Potential contribution of gametes would be estimated based on the fecundity of captive-spawned fish in Scenario 3.

Scenario 3 (long-term reconditioning and captive spawning) will be the easiest to evaluate and will provide information on the reproductive potential (i.e., the benefits) of reconditioning in general. Fish ripening in the first year will be detected by assaying blood plasma hormone levels in the fall/winter and separated from fish that are not ripening. In the spring, ripe spawners will be weighed and measured for length, then anesthetized and live-spawned. Fecundity and mean egg size will be measured for females. Milt samples from all males will be tested for motility and cryopreserved at the University of Idaho. We will try to recondition these kelts another time, and fish that did not ripen will be held an additional year.

In summary, our objective is to test and further develop methods to recondition wild steelhead kelts. Most test fish will probably die in the initial attempts, but any survival would constitute some success for populations proposed for ESA listing. If sufficient numbers of fish return from the various scenarios, we will compare the relative survivals using the G-test (Zar 1984). After three years of trials and returns, we will compile costs for the different scenarios, extrapolate them to production-scale, and compare each to the expected reproductive benefits (numbers of eggs, fry, smolts produced) and other considerations related to production-scale implementation of each scenario.

g. Facilities and equipment

The primary facilities for the proposed research are associated with Yakama Nation's Cle Elum hatchery. Wild kelts will be collected from the Prosser dam juvenile bypass facility and held temporarily in ponds near the dam.

h. Budget

Personnel costs for the proposed research include: research biologist, research scientist (OSU) and a managing scientist. All positions require a part-time commitment only and comprise 27% of the total 2000 budget. A large portion (18%) of 2000 costs will go towards the purchase of an ultrasound machine (objective 1). If this task is funded by the USACE, our 2000 budget will be substantially less. The second largest cost (20%) is indirect fees for administrative and other support purposes. The total cost ($90,252) of the project has been significantly reduced by the YIN involvement.

Section 9. Key personnel

Research Biologist: Allen F. Evans
Title: Fisheries Biologist
FTE: 0.5

Education: B.A., The College of Wooster, Wooster, Ohio. May 1995.
Major Biology

Rhodes University, Grahamstown, South Africa. May – August 1994.
Attended graduate fisheries classes and conducted research for the Department of Ichthyology.

Publications: Co-author, 1998 "Symptoms of Gas Bubble Trauma Induced in Salmon (Oncorhynchus spp.) by Total Dissolved Gas Supersaturation of the Columbia and Snake Rivers". Annual Technical Report for contract 95BI3961. Bonneville Power Administration, Portland, OR.

Co-author, 1996. "The Possible Significance of Egg Size on Post-hatched Growth of rainbow trout (Oncorhynchus mykiss)". Proceeding of the Aquaculture Association of Africa. No 5. Page (s) 137-143.

Employers:
- Columbia River Inter-Tribal Fish Commission (Current Employer)
- National Biological Service (now Biological Resources Division)
- Department of Ichthyology at Rhodes University.

Allen has four years research experience with salmonids, which includes experience handling and anesthetizing –especially steelhead. Allen has also obtained aquaculture skills by operating and maintaining a small rainbow trout hatchery in South Africa. Allen has demonstrated field research leadership in the past two years, supervising 10 seasonal employees, while conducting salmonid research in the mainstem Columbia River. Allen will maintain the following responsibilities for work conducted in 2000: Serves as field biologist by conducting ultrasound test and reconditioning. Analyze, synthesize and prepare data for technical reports, publications and seminars. Produce technical papers and give scientific presentations. Maintain scientific sampling permits (ESA etc…) and coordinate research needs with other agencies. Data collected during this research is intended to support a master's thesis at Oregon State University under the primary direction of Dr. Martin Fitzpatrick.

Managing Scientist: Roy E. Beaty
Title: Fisheries Scientist
FTE: 0.1

MS Fisheries Science (statistics minor); Oregon State University, 1992
BS Fisheries Science, Oregon State University, 1986
BS Business Administration, Oregon State University, 1986

Current Employment
Managing Scientist, Columbia River Inter-Tribal Fish Commission, responsible for the Mainstem, Estuary, and Ocean Program of the Fishery Science Department. Also, ***Owner, Willowell Nursery***, specializing in native plants. Work with developers and conservation groups to salvage native plants from development sites and reuse them in private landscapes and public restoration projects.

Employment History
Managing Scientist, Columbia River Inter-Tribal Fish Commission 1991-Present
Fisheries Scientist: Fish Passage, CRITFC 1989-91
Graduate Fishery Intern/Research Assistant, CRITFC and OSU 1987-89
General Manager, Growers Refrigerating Co. 1985-86
Tactical Microwave Systems Operator/Repairman/Team Chief, US Army 1976-80

Expertise
Undergraduate studies focused on the technical and business aspects of aquaculture, with graduate research into the effects of management actions on Columbia River upriver bright fall chinook salmon. Developed knowledge of technical issues and methods of mainstem juvenile and adult passage through participation in regional coordinating and scientific review groups. Personal interests and abilities are inclined towards implementation of action-oriented resource restoration and management projects.

Publications (selected)

Beaty, R.E. 1996. Evaluation of Deschutes River fall chinook salmon. Tech. Rep. 96-6, Columbia River Inter-Tribal Fish Commission, Portland, OR.

Beaty, R.E. 1996. Changes in size and age at maturity of Columbia River upriver bright fall chinook salmon (*Oncorhynchus tshawytscha*): Implications for stock fitness, commercial value, and management. Tech. Rep. 96-7, Columbia River Inter-Tribal Fish Commission, Portland, OR. (reprint of MS thesis, OSU 1992)

Beaty, R.E., B.L. Parker, K. Collis, and K. McRae. 1991. Controlled angling for northern squawfish at selected dams on the Columbia and Snake rivers. Report C. *In* C.F. Willis and A.A. Nigro, *editors*. Development of a System-wide Predator Control Program: Stepwise Implementation of a predation Index, Predator Control Fisheries, and

Evaluation Plan in the Columbia River Basin. 1991 Ann. Rep., Contract DE-BI79-90BP07084, Bonneville Power Administration, Portland, OR

Advising Scientist: MARTIN STONE FITZPATRICK
Title: Associate Professor
FTE: 0.1
Department of Fisheries & Wildlife
Oregon State University
Corvallis, OR 97331
Ph: 541-737-1086

EDUCATION:

B.A. Harvard University 1980, Biology, cum laude
M.S. Oregon State University, 1985, Physiology/Fisheries
Ph.D. Oregon State University, 1990, Physiology/Fisheries

PROFESSIONAL EXPERIENCE:

1998 - present Associate Professor of Research, Department of Fisheries and Wildlife, Oregon State University
1991 - 1998 Assistant Professor of Research, Department of Fisheries and Wildlife, Oregon State University
1993 - 1994 Consultant, Microsoft Corporation, Redmond, Washington
1990 - 1991 Faculty Research Associate, Post-Doctoral Position, Department of Fisheries and Wildlife, Oregon State University
1989 - 1990 Faculty Research Assistant, Department of Fisheries and Wildlife, Oregon State University
1981 - 1989 Graduate Research Assistant, Department of Fisheries and Wildlife, Oregon State University
1979 - 1980 Curatorial Assistant, Harvard Museum of Comparative Zoology, Cambridge, Massachusetts

AWARDS AND HONORS:

· Savery Outstanding Young Faculty, 1998, College of Agricultural Sciences, Oregon State University
· Oregon Cooperative Fishery Research Unit group award for outstanding research, 1992, Director of Cooperative Research Units, Washington, D.C.
· Oregon Cooperative Fishery Research Unit group award for outstanding research, 1992, American Institute of Fishery Research Biologists, Washington, D.C.
· Savery Outstanding Graduate Student, 1989, College of Agricultural Sciences, Oregon State University
· DeLoach Graduate Fellowship, 1988-89, Oregon State University
· Hugo Krueger Research Award, 1987, Oregon State University
· Sigma Xi Grant-In-Aid of Research, 1985-86, The Scientific Research Society, New Haven, Connecticut
· Walter G. Jones Memorial Scholarship/Fisheries Development Award, 1985, Oregon State University

GRANTS IN LAST FIVE YEARS

USDA, 1998-00, $94,000 to M.S. Fitzpatrick
USAID, 1998-01, $138,550 to M.S. Fitzpatrick

Oregon Sea Grant, 1998-00, $167,316 to C.B. Schreck & M.S. Fitzpatrick
Environmental Health Sciences Center, 1997-8, $25,000 to M.S. Fitzpatrick.
USAID, 1996-98, $144,000 to M.S. Fitzpatrick
Confederated Tribes of the Umatilla, 1996-7, $120,885 to M.S. Fitzpatrick
Western Regional Law Center, 1995-97, $140,000 to M.S. Fitzpatrick
US Army Corps of Engineers, 1995, $17,727 to M.S. Fitzpatrick
Berkeley Antibody Company, 1993, $10,000 to M.S. Fitzpatrick
Great Lakes Fishery Commission, 1993-95, $65,000 to M.S. Fitzpatrick
USAID, 1992-95, $102,000 to M.S. Fitzpatrick

JOURNAL AND PROPOSAL REFEREE:
Journals: General and Comparative Endocrinology
Biology of Reproduction
Aquaculture
Living and Aquatic Resources
Journal of Fish Biology
The Progressive Fish-Culturist
Journal of Aquaculture in the Tropics
Marine and Freshwater Research
Proposals: National Science Foundation
U.S. Agency for International Development, PSTC program
U.S. Department of Agriculture, CSRS program
U.S. Department of Agriculture, SBIR program
Maryland Sea Grant College Program

PROFESSIONAL SOCIETIES:
American Association for the Advancement of Science
American Fisheries Society
Society of Integrative and Comparative Biology
Gamma Sigma Delta, Honor Society of Agriculture
Phi Kappa Phi Honor Society
Sigma Xi, The Scientific Research Society

UNIVERSITY SERVICE:
Departmental Diversity Committee, Departmental Staff Restructuring Task Force, Scholarship Committee, Good of the Department Committee, Search Committee for Deputy Director of the Egypt/CRSP project, Search Committee for Multimedia Copyright Manager, Graduate Review Committee, Graduate Student Representative to Faculty

PUBLICATIONS:
Refereed
Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck (1998). Masculinization of Nile tilapia by immersion in methyldihydrotestosterone and methyltestosterone. Aquaculture., in press.

Contreras Sanchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B. Schreck (1997). Masculinization of Nile tilapia (Oreochromis niloticus) by single immersion in 17a-methyldihydrotestosterone and trenbolone acetate. In: Proceedings of the Fourth International Symposium on Tilapia in Aquaculture (K. Fitzsimmons, ed.), pp. 783-790, Northeast Regional Aquacultural Engineering Service, Ithaca, NY.

Contreras Sanchez, W.M., C.B. Schreck, M.S. Fitzpatrick, and C.L Pereira (1997). Effects of repeated, acute stress on the reproductive performance of rainbow trout (Oncorhynchus mykiss). Biology of Reproduction., in press.

Green, B.W., K.L. Veverica, and M.S. Fitzpatrick (1997). Fry and fingerling production. In: Dynamics of pond aquaculture (H. Egna and C. Boyd, eds.), pp. 215-243, CRC Press, Boca Raton, FL.

Yeoh, C.-G., C.B. Schreck, G.W. Feist, and M.S. Fitzpatrick (1996). Endogenous steroid metabolism is indicated by fluctuations of endogenous steroid and steroid glucuronide levels in early development of the steelhead trout (Oncorhynchus mykiss). General and Comparative Endocrinology 103, 107-114.

Yeoh, C.-G., C.B. Schreck, M.S. Fitzpatrick, and G.W. Feist (1996). In vivo steroid metabolism in embryonic and newly hatched steelhead trout (Oncorhynchus mykiss). General and Comparative Endocrinology 102, 197-209.

Knoebl, I., M.S. Fitzpatrick, and C.B. Schreck (1996). Characterization of a glucocorticoid receptor from the brains of chinook salmon, Oncorhynchus tshawytscha. General and Comparative Endocrinology 101, 195-204.

Maule, A., R. 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 Immunol. 6, 221-233

Fitzpatrick, M.S., W.L. Gale, C.H. Slater, and C.B. Schreck (1995). Gonadal androgen receptors in fishes. In: Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish (F.W. Goetz and P. Thomas, eds.), p. 308, Fish Symposium 95, Austin, TX.

Gale, W.L., M.S. Fitzpatrick, and C.B. Schreck (1995). Immersion of Nile tilapia (Oreochromis niloticus) in 17a-methyltestosterone and mestanolone for the production of all-male populations. In: Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish (F.W. Goetz and P. Thomas, eds.), p. 117, Fish Symposium 95, Austin, TX.

Contreras-Sanchez, W.M., C.B. Schreck, and M.S. Fitzpatrick (1995). Effect of stress on the reproductive physiology of rainbow trout, Oncorhynchus mykiss. In: Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish (F.W. Goetz and P. Thomas, eds.), p. 183, Fish Symposium 95, Austin, TX.

Slater, C.H., M.S. Fitzpatrick, and C.B. Schreck (1995). Characterization of an androgen receptor in salmonid lymphocytes. In: Proceedings of the Fifth International Symposium on Reproductive Physiology of Fish (F.W. Goetz and P. Thomas, eds.), p. 327, Fish Symposium 95, Austin, TX.

Slater, C.H., M.S. Fitzpatrick, and C.B. Schreck (1995). Characterization of an androgen receptor in salmonid lymphocytes: possible link to androgen induced immunosuppression. General and Comparative Endocrinology 100, 218-225.

Slater, C.H., M.S. Fitzpatrick, and C.B. Schreck (1995). Androgens and immunocompetance in salmonids: specific binding in and reduced immunocompetence of salmonid lymphocytes exposed to natural and synthetic androgens. Aquaculture 1136, 363-370.

Fitzpatrick, M.S., R.L. Chitwood, C.B. Schreck, and L.L. Marking (1995). Evaluation of three candidate fungicides in adult spring chinook salmon. The Progressive Fish-Culturist. 57, 153-155.

Schreck, C.B., M.S. Fitzpatrick, and K.P. Currens (1995). Management of Pacific salmon broodstock. In: Broodstock and egg and larval quality (N.R. Bromage and R.J. Roberts, eds.), pp. 197-219, Blackwell Science Ltd., London.

Feist, G., C.-G. Yeoh, M.S. Fitzpatrick, and C.B. Schreck (1995). The production of functional sex reversed male rainbow trout with 17a-methyltestosterone and 11b-hydroxyandrostenedione. Aquaculture. 131, 145-152.

Fitzpatrick, M.S., W.L. Gale, and C.B. Schreck (1994). Binding characteristics of an androgen receptor in the ovaries of coho salmon, Oncorhynchus kisutch. General and Comparative Endocrinology 95, 399-408.

Royland, J.E., L.J. Weber, and M. Fitzpatrick (1994). Testes size and testosterone levels in a model for weightlessness. Life Sciences 54, 545-554.

Fitzpatrick, M.S., C.L. Periera, and C.B. Schreck (1993). In vitro steroid secretion during early development of mono-sex rainbow trout: sex differences, onset of pituitary control, and effects of dietary steroid treatment. General and Comparative Endocrinology 91, 199-215.

Nonrefereed:
Fitzpatrick, M.S., G.W. Feist, R.L. Chitwood, E.P. Foster, and C.B. Schreck (1996). Sex steroid levels in Columbia River white sturgeon. In: Culture and Management of Sturgeon and Paddlefish, International Congress on the Biology of Fishes (S. Doroshov, F. Binkowski, T. Thuemler, and D. MacKinlay, eds.), p. 181, Physiology Section, American Fisheries Society, Vancouver, BC.
Foster, E.P., M.S. Fitzpatrick, G.W. Feist, and C.B. Schreck (1996). Study of reproduction biomarkers in Columbia River Fish Species. In: Contaminant Effects on Fish, International Congress on the Biology of Fishes (B. Barton and D. MacKinlay, eds.), pp. 61-66, Physiology Section, American Fisheries Society, Vancouver, BC.

Section 10. Information/technology transfer

Aside from annual progress reports, significant results may be published in a peer reviewed journal. Methods for distinguishing kelts from prespawners (e.g., ultrasound versus visual morphological examination), will be provided as a handbook to interested users; workshops and given to USACE for future kelt identification efforts at mainstem collector dams. Data on possible kelt collection points will be made available for streamnet if useful or desired. Methods for reconditioning, if successful, will be presented to aquaculturists and fish managers and researchers at the Northwest Fish Culture Conference, meetings of the American Fisheries Society, etc. Findings will also be presented at BPA Project Reviews and/or in other review forums, as requested. We will be available to advise decision makers who are considering the relative merits of long-term application of one or more of the management scenarios

Congratulations!