Title: Replicated stream system for the evaluation of hatchery and wild juvenile salmonid interaction and development of innovative culture technologies

Proposal Number: 35015

Direct questions

Have there been ecological studies that truly accomplished replication in environments?

Artificial streams have been used in ecological studies for many years. Lamberti and Steinman (1993) provide a comprehensive review of the use of artificial streams in ecological studies. More recently, Dube et al. (2002)describe Canada's decade long program to develop artificial stream systems as an alternative to field surveys. The number of artificial streams used in fish and lotic ecology studies are extremely numerous as well. A search of the Fish and Fisheries Worldwide database using "artificial stream" resulted in 98 ecology papers that used artificial streams in the experimental design. Imre et al. (2002) is a recent example of the type of research done using artificial streams. This paper reported the use of 12 individual stream sections that were 5 m long, 0.92 m wide, and 0.40 m deep. The experiment examined the role of visual isolation on population density of rainbow trout juveniles. Keeley (2002) used a the same set-up for an experiment to asses territory size in steelhead.

An alternative to artificial streams is whole ecosystem manipulation. This approach is favored by some (Schindler 1987; Likens and Bormann 1985). It is often the only way to test ecosystem function hypothesis, but there are obvious limitation to this approach. It is not often possible to alter whole ecosystems to estimate cause and effect. In addition, experimentation to measure ecosystem response such as change in fish populations does not often lend itself to standard experimental designs ((Mellina and Hinch 1995; Downes et al. 2002). Issues of replication, misrepresentation of cause and effect relationships, and autocorrolated data sets are all difficult to resolve when trying to design experiments at the ecosystem scale (Hulbert 1984; Walters et al. 1989, Millard et al. 1985).

Artificial streams solve experimental design issues by reducing the spatial and temporal scales and increasing the level of control the scientist can exercise over the relevant environmental and biological variables. The assumption is that the inevitable loss of realism that occurs when a natural stream ecosystem is represented by an artificial stream is offset by the ability to control and manipulate variables of interest (Hoffman 1993). Many researchers have accepted this premise, and the result as been the construction of large artificial stream systems (Swift et al. 1993).

The inherent benefits of using large artificial stream systems have led to the construction of a number of facilities. Swift et al. (1993) noted that there are 10 large-scale outdoor artificial stream system in the United States. The systems are all single pass systems containing alternating pools and riffles. Channel lengths ranged from 50 m to 518 m, and 1 m wide. The number of channels ranged from a 1 to 12. It was noted that few of the facilities provide enough replication for experimental designs capable of detecting small to modest (<50%) differences in variables of interest. The lack of replication in some of the outdoor artificial streams was seen as a limitation.

The feasibility of constructing streams that are truly replicates was not addressed in the proposal. Replication is one of the basic principals of experimental design. The purpose of replication is to provide an estimate of experimental error(Montgomery 1991). Replication as it applies to this proposal was going to be accomplished using multiple channels (experimental units) that have similar flow and physical habitat characteristics. The question of if the replicates in this experiment would be truly comparable will depend on the level of variation of physical, chemical, and biological process over the length of each channel.

The proposed channel layout is designed to allow experimenters to minimize physical differences between replicates. Unlike other outdoor artificial research facilities, the proposed facility will be concrete lined. This is an important advantage, as it will allow the complete removal, cleaning and recreation of physical habitat components within the stream channel as needed by each experiment. This activity can be readily accomplished using small excavators and loaders. A significant cost savings is associated with having the concrete floors already in place. In addition, concrete will minimize hydraulic connectivity between the channels preserving experimental unit independence. The decision as to what form the physical habitat should take will rest with individual research programs. In addition, some experiments may desire an established channel with algal and invertebrate populations, while others may desire a newly established channel. The care taken in establishing physical habitat within each channel will dictate the physical comparability between replicates. Imre et al. (2002) showed that the average velocity and depth did not vary significantly among treatments. As long as the physical habitat placed in the channel, and volume and depth of water are comparable between replicates then physical comparability of replicates is reasonably achieved at the proposed facility.

Chemical and biological comparability between the replicates is more difficult to insure. Swift et al. (1993) addressed this issue in detail through examination of the historical database available from the 518 long MERS facility located in Monticello, Minnesota. This facility has eight side-by-side channels alternating between pools, riffles and runs. The water source for the channel is the Mississippi River. Physical and chemical parameters had the lowest variability between channels (CV<20%) within and among replicates. Biological processes including primary production, respiration, and leaf decomposition rate were more variable with a CV between 20 and 80%. Calculated biological variables such as Index of Biological Integrity, richness, and functional feeding group abundance were the most variable with a CV of >100%. The high levels of variability did not detract from the experimental power of the facility, however, as among station variability (comparing data from stations in all eight streams) was similar to within station variability. The authors suggested that increased precision could be achieved through increased sampling replication, and concluded that the replicates were reasonably similar to one another. The authors went on to note that large artificial streams are a rare resource. Artificial streams increase our ability to understand the function of natural stream ecosystems (McIntire 2002). This fact will ultimately improve our understanding of the impact of hatchery supplementation on existing salmonid populations and provide valuable guidance for management decisions. Careful planning and operation will result in experiments at the proposed facility that have defensible replication.

<u>What is the origin of the proposed design of 16 replicated streams?</u>

The origin of 16 stream channels was founded on spatial constraints of the property, the amount of water available, and projected use of the facility. The existing concrete lined ponds on which the stream cannels will be placed has dimensions of 100 m long and 60 m width. Hulbert (1984) notes that larger numbers of replicates are more desirable than larger numbers of treatments. The basis for this is that the ability to detect change using ANOVA techniques improves as replication increases (Montgomery 1991). The proposed 16 channel artificial stream system would allow a single factor experiment with one control and three treatments to be replicated four times. Some designed experiments are replicated only two times, but the inherent variability of lotic systems encourages larger numbers of replicates hence the desire for a minimum of 16 channels. Based on the review by Swift et al. (1993) a system of 16 channels would make the proposed facility the largest in the United States. Moreover, a larger number of stream channels provides for the opportunity to have multiple experiments occurring at the same time since not all experiments will require 16 channels. Finally, the proposed design tried to balance the need for numerous replicates with the potential for some experiments to require larger scale and less replication. Channel widths of approximately 3.5 m were a compromise between available space and the number of replicates. We are interested in exploring other alternatives as part of the first years work. In particular, we hope to develop a modular wall system that would allow different numbers of replicates to be established. This system would be movable using the same equipment that is used to place substrate in the channels, and would maintain hydraulic independence between the channels. McIntire (2002) implied that artificial stream systems trade numerous replicates for increased scale. We believe that the proposed facility due to its large size, abundant water, and existing infrastructure is a good compromise between replication and scale. We are, however, eager to receive input from the research and management community.

We believe that there is strong regional support for the 16-channel facility. Letters from the National Marine Fisheries Service, Pacific Northwest National Laboratories, United States Geological Survey, and Idaho State University are attached indicating support for the concept of the replicated stream research facility, and a desire to participate in the development of the proposed facility.

## Will consultation lead to new research proposals?

The salmon restoration effort in the Columbia Basin involves numerous organizations. The first years effort was intended to advertise the opportunity to participate in the design and operation of the replicated stream research facility. A primary objective of this consultation would be to identify projects that would benefit from access to the proposed facility. Existing funded projects may decide that the advantages offered by the facility and transfer a portion of their planned work. Once the facility is established it is likely that entirely new research projects will be proposed using the research capabilities offered at the facility as the focal point of the proposal. This process will take time. Moreover, it is difficult to predict what types of projects and budgets will be directed toward the proposed research facility. It is also possible that other funding agencies besides BPA will decide to work at this facility. For example, the National Science Foundation has recently funded a cutthroat trout hybridization project that could make use of portions of the proposed facility (Ernest Keeley, personal communication). New proposals are a likely outgrowth of operation of the proposed facility, but there will also be considerable opportunity to integrate modify projects to take advantage of the research opportunities available at the proposed facility.

<u>What is the basis of fall chinook use and why would these fish come from Hanford?</u>

Fall chinook were chosen as an initial proposed experiment because in the Snake and Columbia River have valuable wild populations that are currently being influenced by hatchery operations. Fall chinook by virtue of a relatively short freshwater residence also make a good candidate for the initial experiment since data could be collected relatively quickly. In effect, the initial experiment was intended to be a facility start-up activity that would still have an excellent chance of producing quality data that was applicable to current management activities. Further, the short time frame associated with the experiment would provide an opportunity for other experiments to rapidly follow. Hanford reach fish were identified as an obvious source of fish mainly because it would be relatively easy to obtain access to wild fish gametes.

We also anticipated that the first years worth of planning would identify other experiments and if the consensus were that they would advance science and management to a larger degree than the original experiment then those experiments would receive priority. The opportunity for a regional research facility such as is proposed will only be fully realized with significant and sustained planning. Identifying and prioritizing experiments to be conducted will ultimately dictate which salmon stocks are used.

<u>What fish transfer and fish disease protocols would be implemented to protect investment in the facility and the local environment?</u>

This Hagerman Valley is famous for its aquaculture industry and there is a strong interest in not introducing fish that would potentially result in the establishment of disease. The Hagerman Valley currently supports salmonid-based aquaculture of rainbow trout, and steelhead. Fish transfer and disease protocols are already in place for these species. Coho and chinook salmon have been raised in the past at various locations. In particular, chinook salmon were raised at the Rangen Research Facility. Most recently, BPA project 9606700 "Captive chinook rearing technology" was funded and operated from 1999 to 2001. Chinook salmon were brought to these locations in cooperation with the State of Idaho. Both administrative and engineering controls were in place to minimize the risk of disease including certification of disease free status, and iodine drips on rearing system effluent. Another advantage of the proposed facility design is that because the channels will be lined with concrete should disease issues occur, the entire facility may be dewatered and sanitized. This option does not exist with earthen lined channels.

In summary, there are previous projects in the Hagerman area that have used chinook salmon, and other species such as steelhead and coho have been or are currently being reared in the area. Thus, it is possible to bring fish to the proposed facility using administrative and engineering controls in full cooperation with applicable state and federal laws.

What does 5.7 FTE but only $94,000 actually mean?

The detailed budget is provided in Attachment 1, 2 and 3 corresponding to project year 2003, 2004, and 2005. Year 2003 has a total FTE load of 1.0 based on these attachments thus of 5.7 was an error, but the dollar amount was correct.

The proposed project is divided into three phases. Phase 1 is planning and design intended to better define the needs of various research organizations and to develop a schedule of research projects. Phase 2 is the construction portion of the project. Attachment 2 shows the estimated cost associated with developing the proposed facility. Due to existing infrastructure, land, and water the project construction cost is relatively low. Recent construction projects in the Columbia Basin associated with salmon management have cost millions of dollars. In comparison, proposed project is a relatively low dollar construction project that may reduce the scope of monitoring required on other BPA funded projects (such as basin wide monitoring as is occurring on the Clearwater River, ID) thus contributing to lower overall cost. In addition, there may be opportunities for cost savings when detailed engineering and design occurs. Phase 3 of the project is the experimentation portion of the proposal. As was previous stated, this experiment was intended to provide high quality date and serve as an initial operation check for the facility and staff. We remain flexible, however, as to what experiment is done first.

**Attachment 1**

FY 2003 for BPA

| **Personnel** | Description | |
|---|---|---|
| Ernie Brannon | $8500/month, 0.1 FTE | $10,200 |
| Dave Smith | $8000/month, 0.8 FTE | $76,800 |
| Keya Collins | $3400/month, 0.05 FTE | $2,040 |
| Ron Hardy | $8500/month, 0.05 FTE | $5,100 |
| | Subtotal | $94,140 |
| | | |
| **Fringe** | | |
| Ernie Brannon | 28.50% | $2,907 |
| Dave Smith | 28.50% | $21,888 |
| Keya Collins | 34.50% | $704 |
| Ron Hardy | 28.50% | $1,454 |
| | Subtotal | $26,952 |
| | | |
| **Travel** | | |
| | Air (roundtrips to Northwest cities) | $2,500 |
| | Miles (800 miles RT Hagerman, 10 trip/year) | $2,920 |
| | Dormitory, $25/night, 40 night/yr | $1,000 |
| | Subtotal | $6,420 |
| | | |
| **Supplies and Materials** | | |
| | office supplies | $500 |
| | auto level | $2,000 |
| | computers | $3,500 |
| | flow meter | $3,500 |
| | sample vials, bags, markers, slides, film | $800 |
| | Subtotal | $10,300 |
| | | |
| **Equipment** | | |
| | none | $0 |
| | | |
| **Services** | | |
| | none | |
| | | |
| **Facilities** | | $0 |
| | | |
| **Subcontracts** | | |
| FishPro, Inc | facility design | $78,000 |
| RiverMaster Engineering, Inc. | inlet and outlet structure design | $12,000 |
| CRITFC | Andre Talbot (0.1 FTE, 28.5% fringe) | $13,107 |

| | | |
|---|---|---|
| **Total direct cost** | | $240,919 |
| **Facilities and Administrative Cost** | 31.5% of Total Direct Cost and on first $25,000 of each subcontract<br>FishPro = $7,875, Rivermasters = $3,780, and CRITFC = $4,129 | $59,195 |
| **Total Project Cost** | | $300,114 |

**Attachment 2**

FY 2004 for BPA

| **Personnel** | Description | |
|---|---|---|
| Ernie Brannon | $8925/month, 0.1 FTE | $10,710 |
| Dave Smith | $8400/month, 0.8 FTE | $80,640 |
| Keya Collins | $3570/month, 0.05 FTE | $2,142 |
| Ron Hardy | $8925/month, 0.05 FTE | $5,355 |
| | Subtotal | $98,847 |
| **Fringe** | | |
| Ernie Brannon | 28.50% | $3,052 |
| Dave Smith | 28.50% | $22,982 |
| Keya Collins | 34.50% | $739 |
| Ron Hardy | 28.50% | $1,526 |
| | Subtotal | $28,300 |
| **Travel** | | |
| | Air (roundtrips to Northwest cities) | $2,500 |
| | Miles (800 miles RT Hagerman, 10 trip/year) | $2,920 |
| | Dormitory, $25/night, 40 night/yr | $1,000 |
| | Subtotal | $6,420 |
| **Supplies and Materials** | | |
| | office supplies | $500 |
| | water quality probe for continuous monitoring | $6,000 |
| | sample vials, bags, markers, slides, film | $800 |
| | Subtotal | $7,300 |
| **Equipment** | | |
| | front loader (Bobcat) | $36,000 |
| **Services** | | $0 |
| **Facilities** | | $0 |
| **Subcontracts** | | |
| FishPro, Inc | | |
| | inlet structure | $28,000 |
| | spring development and pipeline | $50,000 |
| | inlet and outlet structure installation | $36,000 |
| | wall construction | $100,000 |
| | outfall | $28,000 |
| | habitat material storage area/rock/logs | $56,000 |

| | | |
|---|---|---|
| | netting/lighting | $78,000 |
| | Subtotal | $376,000 |
| RiverMaster Engineering, Inc. | inlet and outlet structure design/fabrication | $72,000 |
| CRITFC | Andre Talbot (0.2 FTE, 28.5% fringe) | $26,214 |
| **Total direct cost** | | $651,081 |
| **Facilities and Administrative Cost** | 31.5% of Total Direct Cost and on first $25,000 of each subcontract<br>no overhead on cap equipment > 5K<br>FishPro = $7,875<br>Rivermasters = $7,875<br>CRITFC = $7,875 | $192,715 |
| **Total Project Cost** | | $843,796 |

**Attachment 3**

FY 2005 for BPA

| | | |
|---|---|---|
| **Personnel** | Description | |
| Ernie Brannon | $8500/month, 0.2 FTE | $10,710 |
| Dave Smith | $8000/month, 0.8 FTE | $80,640 |
| Keya Collins | $3400/month, 0.5 FTE | $2,142 |
| Ron Hardy | $8500/month, 0.1 FTE | $10,710 |
| Technician | $3000/month, 1.0 FTE | $36,000 |
| | Subtotal | $140,202 |
| | | |
| **Fringe** | | |
| Ernie Brannon | 28.50% | $3,052 |
| Dave Smith | 28.50% | $22,982 |
| Keya Collins | 34.50% | $739 |
| Ron Hardy | 28.50% | $3,052 |
| Technician | 34.50% | $12,420 |
| | Subtotal | $42,246 |
| | | |
| **Travel** | | |
| | Air (roundtrips to Northwest cities) | $2,500 |
| | Miles (800 miles RT Hagerman, 10 trip/year) | $2,920 |
| | Dormitory, $25/night, 40 night/yr | $1,000 |
| | Subtotal | $6,420 |
| | | |
| **Supplies and Materials** | | |
| | office supplies | $500 |
| | stands for flow meter (structural aluminum) | $2,500 |
| | computers | $3,500 |
| | dry suits | $1,700 |
| | sample vials, bags, markers, slides, film, cal solutions | $800 |
| | Subtotal | $9,000 |
| | | |
| **Equipment** | | |
| | none | $0 |
| | | |
| **Services** | | |
| | water sample analysis, weekly, 156 analysis | $0 |
| | at $35/sample | $5,460 |
| | tank space, $5/week/tank, 40 tanks, 16 weeks | $3,200 |
| | | |
| **Facilities** | | $0 |

**Subcontracts**

| | | | |
|---|---|---|---|
| CRITFC | Andre Talbot (0.2 FTE, 28.5% fringe) | | $26,214 |
| | technicians (1.5 FTE, 34.5% fringe) | | $61,200 |
| | | Subtotal | $87,414 |

| | | |
|---|---|---|
| **Total direct cost** | | $293,942 |
| **Facilities and Administrative Cost** | 31.5% of Total Direct Cost and on first $25,000 of each subcontract<br>CRITFC = $7875 | $100,467 |
| **Total Project Cost** | | $394,409 |

## Attachment 4

**UNITED STATES DEPARTMENT OF THE INTERIOR**

**U. S. GEOLOGICAL SURVEY**
**BIOLOGICAL RESOURCES DIVISION**
**WESTERN FISHERIES RESEARCH CENTER**
**6505 NE 65TH STREET**
**SEATTLE, WA 98115-5016**
**(206) 526-6282 FAX (206) 526-6654**

August 15, 2002

David L. Smith
University of Idaho
Aquaculture Research Institute
Moscow ID 83844-2260

Dear Dave,

I regret that I have not had time to review in detail your proposal to develop a replicated stream research facility. After a quick review, however, I see that it emphasizes the importance of replication for increasing the statistical power and validity of experiments to evaluate the ecological and behavioral interactions between hatchery salmon and wild salmon. I am in full agreement with those statements, and also agree that the interaction of hatchery and wild fish is a critical issue because of the current emphasis placed on hatcheries for restoring fisheries and fish populations. Many studies of hatchery-wild interactions suffer or have not been attempted for lack of the opportunity for replication such as that to be afforded by your proposed stream channels. The proposed facility should provide exciting opportunities to gain new information about a critical issue in the Pacific Northwest.

My lack of familiarity with the details, however, prevent me from giving an unqualified recommendation. Without more time to pursue details, I cannot be confident that a single facility can or would be in demand by other investigators. Another uncertainty is that behavioral and competitive outcomes are affected by environmental context (e.g., water temperature, food composition and quantity, water chemistry, cover, channel size, pool depth, ...), and it is unclear how much latitude exists for varying these and other parameters at the proposed facility, and the consequences. I'm also unsure of whether fish health restrictions will severely restrict the geographic scope for the facility by precluding movement of fish from other areas. I mention these issues not as criticism, but to indicate areas where I have insufficient knowledge to allow an unreserved recommendation for the project.

Sincerely,

Reg Reisenbichler

Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

August 19, 2002

Mr. David L. Smith
University of Idaho Aquaculture Research Institute
Moscow, ID 83844-2260

Subject: Replicated stream system for the evaluation of hatchery and wild juvenile salmonid interaction and development of innovative culture technologies

Dear Mr. Smith:

I read your proposal to the Bonneville Power Administration and have discussed it with fisheries staff here at the Pacific Northwest National Laboratory (PNNL). The concept of developing a facility for investigating interaction between wild and hatchery salmonids is technically sound. This type of research facility could also provide opportunities for tests in addition to those outlined in your proposal. If the replicated stream system is funded and built, I would hope the Natural Resources staff at PNNL could work with the University of Idaho and the Columbia River Inter Tribal Fisheries Commission to investigate potential solutions to other aquatic resource challenges.

If you would like, you can use this letter to indicate that my staff at PNNL support the construction of this type of facility and recognize its application to salmonid research in the Columbia River basin. Good luck with your proposal.

Sincerely,

Dennis D. Dauble
Director, Natural Resources Division
Environmental Technology Directorate

:db

cc: File/LB

902 Battelle Boulevard • P.O. Box 999 • Richland, WA 99352

Telephone (509) 376-3631 ■ Email dd.dauble@pnl.gov ■ Fax (509) 373-1153

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Northwest Fisheries Science Center
Manchester Research Station
PO Box 130
Manchester, WA 98353

August 20, 2002

Dave Smith
University of Idaho
Aquaculture Research Institute
P.O. Box 442260
Moscow ID 83844-2260

Dear ~~Mr. Smith~~ Dave.

For a number of years, the National Marine Fisheries Service, Northwest Fisheries Science Center, Resource Enhancement and Utilization Technologies (REUT) Division has been conducting research to promote Conservation Hatchery technologies to aid recovery of imperiled salmonid stocks in the Pacific Northwest. Ecological interaction studies conducted in replicated stream sections have been central to our evaluation of emerging technologies for conservation efforts. We fully support efforts to develop replicate test channels at other laboratories in the Northwest (such as proposed in Mainstem and Systemwide Project 35015). We feel these type facilities are critical for clarification of hatchery-wild interactions and for full development of hatchery reform principles. Please contact me if you need further information.

Sincerely,

Tom

Thomas A. Flagg
Program Manager,
Salmon Enhancement

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