FINAL Meeting Notes
Lewis River License Implementation
Aquatic Coordination Committee (ACC) Meeting
June 14, 2007
Ariel, WA

ACC Participants Present (16)

Jim Byrne, WDFW
Clifford Casseseka, Yakama Nation (via teleconference)
Eric Kinne, WDFW
George Lee, Yakama Nation
Erik Lesko, PacifiCorp Energy
Jim Malinowski, Fish First
Kimberly McCune, PacifiCorp Energy
Bryan Nordlund, NMFS (via teleconference)
Todd Olson, PacifiCorp Energy
Frank Shrier, PacifiCorp Energy
Shelley Spalding, USFWS (via teleconference)
Karen Thompson, USFS
Steve Vigg, WDFW
John Weinheimer, WDFW
Shannon Wills, Cowlitz Indian Tribe (via teleconference)
Mike Burger, BioSonics, Inc.

Calendar:

July 11, 2007	TCC Meeting	Merwin Hydro
August 8, 2007	TCC Meeting	Merwin Hydro
August 9, 2007	ACC Meeting and Habitat Prioritization Synthesis Subgroup Meeting	Merwin Hydro

Assignments from June 14th Meeting:	**Status:**
Kinne: Provide Shrier with data regarding portable raceways.	**Complete – 7/20/07**
Shrier: Acquire more detail on the HTI 1997 hydroacoustic study, including what equipment was used and report back to the ACC relating to the differences of the study compared to that of BioSonics hydroacoustic study.	**In progress**
Lesko: Modify the HPP to include (1) language that states, "*the Swift portion of the HPP will continue for five years prior to the installation of the Swift downstream collector*"; and (2) comments from ACC representatives indicating value in monitoring adult coho movements in the upper basin after release.	**Complete – 6/25/07**
Shrier: Review the Acclimation Pond Plan and send revision to the technical committee for final review and approval. The goal for completion is July 2007.	**Pending Engineering Review – Plan delayed until Oct. 07**
McCune: Email a copy of the draft FERC letter to Steve Vigg regarding the Swift No. 2 project surge arresting protector (SAS).	**Complete – 6/15/07**

Assignments from May 10th Meeting:	Status:
Shrier/McCune: Schedule BioSonics to provide a presentation on the Yale Entrainment Study at the June 14, 2007 ACC meeting.	**Complete – 5/11/07 MaryLou Keefe presenting.**

Opening, Review of Agenda and Meeting Notes

Frank Shrier (PacifiCorp Energy) called the meeting to order at 9:10 a.m. Shrier conducted a review of the agenda for the day. In addition, Shrier requested a round-table introduction for the benefit of new attendees and for those participating via conference call.

Shrier requested comments and/or changes to the ACC Draft 5/10/07 meeting notes. No changes were requested and ACC attendees present approved the meeting notes at 9:20am.

Relicensing Schedule Update

The National Marine Fisheries Service (NMFS) BiOp is very close to submittal to the Federal Energy Regulatory Commission (FERC). PacifiCorp now estimates issuance of licenses for around November 1, 2007.

Eric Kinne (Washington Department Fish and Wildlife - WDFW) requested PacifiCorp get back to him on or before August 9, 2007 regarding if they should take Spring Chinook eggs this fall as part of Section 8.4.1 of the Settlement Agreement.

Nutrient Enhancement – Jim Malinowski

Jim Malinowski (Fish First) provided copies of correspondence with WDFW (Attachment A) regarding state wide allocation of hatchery origin salmon and steelhead carcasses. Malinowski informed the ACC that Fish First will continue to focus their efforts on nutrient enhancement and keep the ACC informed as they proceed.

Steve Vigg (WDFW) informed the ACC that they have submitted an innovative project solicitation proposal to the Bonneville Power Authority (BPA) titled, Shad for Nutrient Enhancement, which is a pilot project to evaluate the efficacy of using the abundant Columbia River Shad run as a resource for stream nutrient enhancement throughout the Columbia Basin. Potential shad use would be evaluated by four criteria: availability, disease risk, fish product, and demand. More details can be viewed in the Proposal provided by WDFW, see Attachment B.

Yale Entrainment Report – Mike Burger, BioSonics, Inc.

Mike Burger (BioSonics) presented a PowerPoint (Attachment C) for ACC attendees review to include a visual of a typical echogram, illustration of target strength, fish trace and a series of individual echoes.

Burger discussed how the hydoacoustic trace formation program extracts fish traces from acoustic data based on the following:

- Echo Intensity (Target Strength) – does the echo meet a minimum threshold?
- Echo Shape – does the echo have the appropriate shape relative to a theoretical echo? If the echo is distorted the echo is rejected.
- * Location of Adjacent Echoes
- * Linearity of Echoes
- * Number of Echoes

** Location, linearity and number are all factors BioSonics uses so they can confidently call it a fish.*

Noise bands are not classified as fish traces.

Shrier informed the ACC attendees that he would try to get more detail on the HTI study from 1997, including what equipment was used and report back to the ACC relating to the differences of the hydroacoustic studies.

Bryan Nordlund (NMFS) suggested that a possible reason for the difference could be single beam vs. split beam study.

Any comments on the Yale Entrainment Report are due on or before June 15, 2007.

<Break 10:15am>
<Reconvene 10:25am>

Phased approach to construction of the Merwin Fish Trap

Olson informed the ACC attendees that PacifiCorp is proceeding with 30% design. He provided a PowerPoint presentation (Attachment D) which illustrates the existing Merwin Trap features. Olson discussed the design consideration to include the foot print of the Merwin Powerhouse, the number of fish returning during a 24 hour period, the river flows under which the trap should be operational, the specific flow and flow hydraulics through ladder, the fish behavior, the automated features to minimize safety risks, and the ability to sort, hold fish, then place in transport trucks with minimum stress to fish. In addition, Olson provided a handout titled, *Merwin Upstream Collection and Transport Facility Phased Implementation Proposal Summary, dated May 31, 2007* for more detail (Attachment D-1)

Olson communicated to the ACC attendees that PacifiCorp proposes the build-out occur in two phases:

Phase 1	Phase 2
Corner trap	Add entrance or
Pump station	Add pump
400 cfs max	600 cfs max
Fish lift	Split flows between entrances
Sorting facility	

Olson requested feedback from the ACC on the phased approach.

Nordlund would like further discussion on the timing between Phases 1 and 2, and he expressed concerns regarding if attraction flows were sufficient.

Swift Surface Fish Collector Design Update

Olson provided a PowerPoint presentation (Attachment E), which illustrates a number of options explored by the engineering design team. Regarding access to the Fish Collector, PacifiCorp has decided on the access trestle as the best option. See the attachment for further location detail.

Olson discussed the reservoir operations regarding seasonal elevation fluctuations, the needed year around operations, the juvenile fish behavior, hydraulic conditions, that it's favorable for fish collection and the design velocities. In addition, Olson provided visual detail on the collection enhancement structure, trestle and mooring, and the sorting area.

Olson informed the ACC attendees that the location of the debris boom is yet to be confirmed.

George Lee (Yakama Nation) expressed that he is looking for more natural flow. He further expressed that the Yakama Nation will oppose the use of the Swift Surface Fish Collector for the life of the license. Shrier stated that according to the Settlement Agreement, PacifiCorp will revisit at year 17 of the new licenses.

2007 Habitat Preparation Plan (HPP) Comment

Steve Vigg (WDFW) requested PacifiCorp modify the HPP in accordance with WDFW comments provided on May 31, 2007 where appropriate and incorporate their letter (Attachment F) for the record.

Lesko will modify the HPP to include (1) language that states, "*the Swift portion of the HPP will continue for five years prior to the installation of the Swift downstream collector*"; and (2) comments from ACC representatives indicating value in monitoring adult coho movements in the upper basin after release.

Study Updates

Shrier provided the following study updates:

Swift Constructed Channel Concept Design – Completing wetland delineation now for upper and lower release. On schedule for construction of both projects in 2008. Comment period ended on 5/25/07 and PacifiCorp will provide a final document incorporating ACC comments.

Swift Upper Release Design – Comment period ended on 5/25/07. PacifiCorp received several comments from WDFW and as such PacifiCorp is working with internal engineers to address these comments.

Large Woody Debris (LWD) Study – InterFluve is reviewing all comments received and modifying the plan as appropriate.

Habitat Synthesis Tool **–** Each subgroup participate is taking responsibility for a species to complete the additional links and photos that are needed. The goal of the subgroup is to have the work product ready before the next cycle of funding this year. Subgroup is meeting today after the ACC meeting.

Hatchery Upgrades (Pond 15) – PacifiCorp has submitted 60% design drawings for review. All comments are due on or before June 15, 2007. The goal is to start construction early next year.

Hatchery and Supplementation Plan (H&S) – Still waiting for completion of HGMPs. The goal is to complete the H&S Plan in December 2007.

Acclimation Pond Plan - Shrier informed the ACC attendees that he will review the Acclimation Pond Plan and send to the technical committee for final review and approval. The goal for completion of Plan is July 2007. Kinne will provide Shrier with data for portable raceways.

New Topics

Swift 2 Powerhouse **-** Shrier informed the ACC that Cowlitz PUD lost use of one of the Swift No. 2 units last March 2007, which restricts PacifiCorp's ability to make full use of the Swift No. 1 plant without sending water over the canal wasteway. PacifiCorp has discussed with the PUD about using the surge arresting structure (SAS). Use of the SAS would be infrequent for both emergency and operational purposes. Emergency uses include operations of the SAS due to load rejections or unexpected outages at the Swift No. 2 Project. The Utilities expect that use of the SAS would be limited to approximately 10 hours per month. Once Swift No. 2 units 21 & 22 are back on line, PacifiCorp will not need to use the SAS in the above manner. The Utilities have run this past the Services and have their approval, and will be sending a letter to FERC.

Malinowski noted it would be better for excess water to be released through the SAS rather than over the wasteway.

Vigg requested that PacifiCorp provide him a copy of the draft letter to the FERC.

July ACC Meeting **-** The ACC agreed to cancel the July 12, 2007 meeting. The regularly scheduled monthly meetings will resume on Thursday, August 9, 2007, 9:00am - 3:00pm at the Merwin Hydro Facility.

Agenda items for August 9, 2007

- Study/Work Product Updates
- Relicensing/BiOp Update

August 9, 2007	September 13, 2007
Merwin Hydro Facility	Merwin Hydro Facility
Ariel, WA	Ariel, WA
9:00am – 3:00pm	9:00am – 3:00pm

Meeting Adjourned at 11:45am

Handouts

- Final Agenda
- Draft ACC Meeting Notes 5/10/07
- Fish Carcass Koenings letter from Fish First, dated June 15, 2007 (Attachment A)
- Fish First nutrient enhancement letter to WDFW, dated April 6, 2007 (Attachment A)
- WDFW proposal: Shad for Nutrient Enhancement (Attachment B)
- BioSonics, Inc. – Yale Entrainment Hydroacoustic PowerPoint (Attachment C)
- Phased Approach to Construction of the Merwin Fish Trap PowerPoint (Attachment D)
- Merwin Upstream Collection and Transport Facility Phased Implementation Proposal Summary, dated May 31, 2007 (Attachment D-1)
- Swift Surface Fish Collector Design PowerPoint (Attachment E)
- Letter from WDFW regarding the Habitat Preparation Plan, dated June 12, 2007 (Attachment F)

FINAL Meeting Notes
Lewis River License Implementation
Aquatic Coordination Committee (ACC) Meeting
Sub-Committee on Habitat Prioritization Synthesis
June 14, 2007
Ariel, WA

ACC Participants Present (6)

Jim Byrne, WDFW
Erik Lesko, PacifiCorp Energy
Jim Malinowski, Fish First
Kimberly McCune, PacifiCorp Energy
Frank Shrier, PacifiCorp Energy
Steve Vigg, WDFW

Calendar:

August 9, 2007	ACC Meeting and Habitat Prioritization Synthesis Subgroup Meeting	Merwin Hydro

Assignments from June 14th Meeting:	**Status:**
Byrne: Add the Lewis River mainstem bull trout data in the matrix.	**Complete – 8/9/07**
Shrier: Modify the HUC colors throughout the matrix document for consistency.	**Complete – 7/16/07**
Shrier: Modify the column that reads "Habitat Issues" to read "Specific Habitat Needs".	**Complete – 6/14/07**
Shrier: Modify all cells, where appropriate, to wrap text.	**Complete – 6/14/07**
Shrier: Modify "Funding" title to "Previous PacifiCorp Funding".	**Complete – 6/14/07**
McCune: Add the PacifiCorp funding detail in the matrix, where appropriate.	**Complete – 6/19/07**

Opening, Review of Agenda and Meeting Notes

Shrier called the meeting to order at 12:10pm.

Shrier reviewed the latest draft of the synthesis matrix with the subgroup attendees and discussion took place regarding updating of the new matrix to include grouping by HUC and color coded accordingly, what categories should remain, what makes sense and what should be removed. Shrier informed the attendees that a few species remain incomplete and he will attempt to fill in the blanks. George Lee (Yakama Nation), Jim Byrne (WDFW) and Adam Haspiel (USFS) will be submitting additional data to Shrier before the next schedule meeting in August.

Byrne indicated that the mainstem Lewis was not represented in the matrix for bull trout. Byrne will add the additional data. In addition, he requested that the HUC colors be consistent throughout the matrix document.

Erik Lesko (PacifiCorp) would like to include a ranking system of some sort to aid those who might use the tool but know nothing about the area.

Byrne suggested the addition of more funding specifics for those projects that have been previous funded by PacifiCorp. McCune indicated that the information does exist in the Aquatic Funding Annual Reports and the addition did seem a bit redundant, although it can be easily extracted from the annual report. McCune will add the funding detail in the matrix where appropriate.

Shrier will create another CD to include all the modifications and resubmit to the subgroup for review and comment after the August 9, 2007 ACC meeting.

Next Meeting

August 9, 2007
Merwin Hydro Facility
Ariel, WA
1:00pm – 3:00pm

Meeting Adjourned at 12:40pm

Handouts

- Final Agenda

Attachment A

June 15, 2007

Dr. Jeffery P Koenings
Director
Washington Department of Fish & Wildlife
600 Capital Way N
Olympia, WA, 98501-1091

Dear Dr. Koenings:

Lew Atkins, the Assistant Director, Fish Program, responded to my recent letter concerning the Lewis River and state wide allocation of hatchery origin salmon and steelhead carcasses. He says that your agency is committed to using the best available science in managing the State's fishery resources. The sad state of state salmon and steelhead stocks and numerous scientific studies indicating that the resource agencies' role in allowing over-harvest of those stocks and the resultant starving of our streams of nutrients makes us question that statement.

The truth is that your agency like the other state and federal agencies responsible for managing this precious Northwest resource have selectively applied available science. NW rural landowners have had extreme restrictions on land use near streams based on such science while the science is clear that over-harvest and resultant low spawning rates and low stream nutrient levels is the major problem and restrictions on hydro, hatcheries or habitat will have little benefit if the over-harvest and low nutrient level issues are not addressed.

The data Mr. Atkins provided Fish First for 2006 (preliminary) state wide disposition of salmon and steelhead carcass biomass and the data the department provided for 2006 Lewis River Hatchery complex disposition is:

Categories	Statewide	Lewis River Hatcheries
Native American Tribes	7.3%	13% (4% Treaty, 9% Non-Treaty)
Food Banks	26.2%	3% (N Clark County Food Bank)
Sold to American Canadian	13.3%	49% (no breakdown of food bank use)
Live Fish Returned Upstream	14.7%	(Included in nutrient enhance total)
Nutrient Enhancement	17.7%	31%
Disposal On-station	19.9%	4%
Education & Other	0.9%	0%
Total	100.0%	100%

This tabulation raises a number of questions:

1. Why is the Native American tribe carcass allocation so much higher for the Lewis River complex than the statewide allocation?
2. Why is the Clark County food bank allocation so much lower than the statewide allocation?

3. Why is the “On-station” statewide disposal percentage so much higher than for the Lewis River complex level?

Mr. Atkins stated that:

> “After the fish become the property of American Canadian, although WDFW does not track the products, we do know that a portion goes to institutions and food banks. However, we do not have data on how eggs contained in the carcasses are utilized, other than the eggs are non-viable and not to be used for propagation. The total revenue to the State derived from the contract with American Canadian was $58,107.52 in 2005 and $31,427 in 2006.”

This statement raises these questions:

1. How can you determine how many pounds of biomass goes to food banks if you don’t insist on reports from Canadian American on disposition of the biomass sold to them? We have been told by Lewis River Hatchery complex staff that all of the biomass given to Canadian American was being processed for the Grays Harbor Food Bank. We do know of at least one incidence where a Canadian American truck loaded with hatchery carcasses traveled directly to the Canadian border.

2. The salmon and Steelhead eggs contain significantly more nutrients per pound than other parts of the fish. Those nutrients would be better used in our streams than sold to the Japanese food markets as we understand Canadian American does.

3. The revenue obtained from the sale of these carcasses seems extremely low compared to their value as stream nutrients. While we do not believe we should have to pay for carcasses we are placing in area streams at no cost to the state, Fish First requests that if the small revenue involved is critical, that we be given the right to buy for nutrient enhancement placement the biomass now being sold to Canadian American from the Lewis River hatcheries. We would increase the donation of food quality biomass to Clark County Food Banks from the current rather low level.

Please revise Washington State Department of Fish and Wildlife’s hatchery carcass disposition policy to focus on restoring marine derived nutrients to all NW streams and particularly the Lewis River system. We have no problem with providing fish to the tribes for ceremonial and subsistence purposes and a reasonable percentage of the carcass biomass for food banks as long as detailed records are maintained to be sure none of the remaining biomass is used for purposes other than nutrient enhancement programs. None of the non-food portion of the carcass biomass from any hatchery should be transported out of the hatchery basin since that makes that biomass ineligible to be placed in any NW stream.

Sincerely,

Gary Loomis
President Fish First
June 15, 2007

Cc: Christine Gregoire
Brian Sonntag
Brian Baird
Norman Dicks
Don Benton
Richard Curtis
Jim Dunn
Bill Fromhold
Jim Moeller
Ed Orcutt
Craig Pridemore
Deb Wallace
Joseph Zarelli
Jerry Gutzwiler
Miranda Wecker
Dr. Kenneth Chew
Gary Douvia
Conrad Mahnken, Ph.D
Chuck Perry
Will Roehl
Fred Shiosaki
Shirley Solomon

State of Washington
Department of Fish and Wildlife
Mailing Address: 600 Capitol Way N • Olympia WA 98501-1091 • (360) 902-2200; TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia WA

April 6, 2007

Mr. Gary Loomis
Fish First
P. O. Box 1505
Woodland, WA 98674

Dear Mr. Loomis:

I want to thank you for your letter to Director Koenings regarding your interest in salmon and steelhead enhancement in Washington river systems; and especially as related to nutrient enhancement in the Lewis River basin. The Director's office forwarded your letter to the Fish Program for a direct response to you.

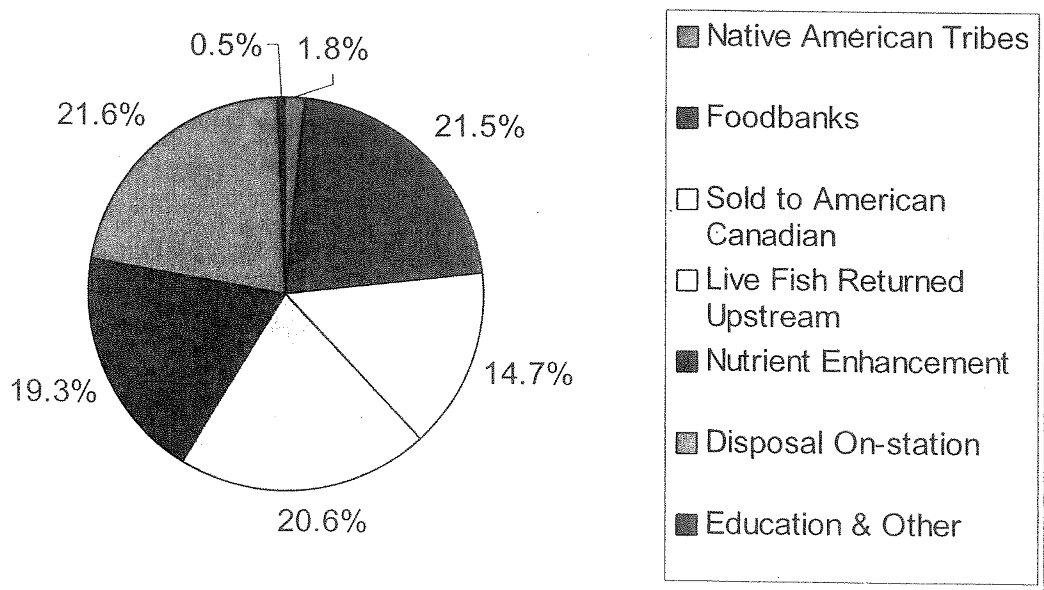
We are in agreement that marine derived nutrients play an important role in stream productivity. State law and policies govern the procedures for utilizing returning hatchery salmon and steelhead that are in excess of hatchery broodstock goals and beyond the capacity of fisheries to harvest. Thus, the collective will of the citizens of Washington determine the allocation of this resource in a manner that provides maximum value to society. In addition, Federal court cases, e.g., US v. Oregon, provide for ceremonial and subsistence (C&S) quotas during years when fisheries fall short of the allocation for that purpose. Although use of carcasses for stream nutrient enhancement is one use, especially for lower quality carcasses, it is not the only beneficial use. Many Washington citizens benefit from fresh food-quality salmon and steelhead donated to both Tribal and local food banks.

We appreciate your attempt to summarize the preliminary and incomplete data provided to you by The Washington Department of Fish and Wildlife (WDFW) staff at the Lewis River Hatchery complex. We do not finish the validation and summarization of our hatchery carcass disposition data until May of the year following collection. In some cases, the data you presented in your letter and attached report was incomplete or misinterpreted, and thus misleading.

We will provide a more complete, accurate and holistic representation of the state-wide hatchery carcass disposition based on the annual report prepared by our Science Division, (Attachment 1). This summary presents the validated 2005 data for salmon and steelhead carcass disposition from WDFW Hatcheries. The preliminary disposition summary for 2006 is also presented for comparison, however the 2006 data are not finalized and will not be officially disseminated until May 2007. As illustrated in Figure 1 below, the percentage disposition of 762,531 surplus anadromous salmonids returning to Washington hatcheries in 2005 was:

- ✓ Native American Tribes 01.8%
- ✓ Foodbanks 21.5%
- ✓ Sold to American Canadian 14.7%
- ✓ Live Fish Returned Upstream 20.6%
- ✓ Nutrient Enhancement 19.3%
- ✓ Disposal On-station 21.6%
- ✓ Education & Other 00.5%

Figure 1. Salmonid Disposition - 2005



The actual percentage of fish contributing to nutrient enrichment of within-basin streams is about 40%, i.e., the sum of two categories: live fish returned upstream to spawn (20.6%) and nutrient enhancement actions (19.3%). Due to the difficulty in handling large quantities of fish during short time periods, about 21.6 percent of the total available number of salmonids had to be sent to landfills or otherwise disposed of before being allocated to a beneficial use. This portion of fish may represent an opportunity to provide more fish for nutrient enhancement programs if the logistics could be optimized. These three categories represented about 61.5 percent of the total fish in 2005 and 52.3 percent in 2006 (preliminary).

The number of fish sold to American Canadian was only 14.7% of the total in 2005 and 13.3% in 2006. Several of your questions related to what becomes of the fish after being purchased by the fish processor. After the fish become the property of American Canadian, although WDFW does not track the products, we do know that a portion goes to institutions and food banks. However, we do not have data on how eggs contained within the carcasses are utilized, other than the eggs are non-viable and not to be used for propagation. The total revenue to the State derived from the contract with American Canadian was $58,107.52 in 2005, and $31,427.14 in 2006.

I hope this information clarifies the fish disposition data, and addresses the main questions and issues that you raised in your letter. As an agency, we are committed to using the best available science in managing the State's fishery resources. Furthermore, the surplus hatchery salmon and steelhead resources are used in a variety of ways – added value processing, food banks, Tribal food and C&S, stream spawning, nutrient enhancement, and educational – to provide the highest possible cumulative values to the citizens of Washington.

Sincerely,

Lew Atkins
Assistant Director
Fish Program

Enclosure: Attachment 1

Attachment 1. Disposition of salmon and steelhead from WDFW Hatcheries –source Catie Mains, Annual Report, WDFW Science Division. Note: 2006 data are preliminary and subject to change (Not for Official Release)

Disposition	2005		2006 (preliminary)	
	Number of Fish	Percent	Number of Fish	Percent
Donated to Native American Tribes (Chinook, coho, steelhead):	13,544	1.8%	43,928	7.3%
Donated to Foodbanks (Chinook, chum, coho, steelhead):	163,612	21.5%	158,040	26.2%
Sold to American Canadian (Chinook, pink, chum, coho, steelhead)[1, 2]:	112,300	14.7%	80,112	13.3%
Live Fish Returned to Stream Upstream of Hatchery (Chinook, pink, chum, coho, kokanee, sockeye, steelhead):	156,870	20.6%	88,902	14.7%
Nutrient Enhancement (Chinook, chum, coho, kokanee, pink, steelhead):	147,157	19.3%	106,732	17.7%
Disposal On-station, rendering, or landfill (Chinook, pink, chum, coho, kokanee, sockeye, steelhead):	165,071	21.6%	119,955	19.9%
Donated to Education, Research, or transferred outside WDFW (Chinook, pink, chum, coho, steelhead):	3,977	0.5%	5,526	0.9%
Total Fish - including live fish returned to stream (Chinook, pink, chum, coho, kokanee, sockeye, steelhead):	762,531	100.0%	603,195	100.0%
Non-viable eggs sold to American Canadian in (Chinook, chum, coho):	672,827	--	732,585	--

Proposal: Shad for Nutrient Enhancement -- Demonstration of Fishery Supply, Disease Evaluation, Product Type and Potential Use

Section 1. Administrative

Project title: Shad for Nutrient Enhancement -- Demonstration of Fishery Supply, Disease Evaluation, Product Type and Potential Use

Organization: Washington Department of Fish and Wildlife

Short description

A pilot project to evaluate the efficacy of using the abundant Columbia River Shad run as a resource for stream nutrient enhancement throughout the Basin. Potential would be evaluated by four criteria: availability, disease risk, fish product, and demand.

Information transfer

Information transfer is needed among various state, federal, Tribal and private entities throughout the term of this project. At present, availability of salmon carcasses for nutrient enhancement in Southwest Washington has been a topic of considerable discussion between WDFW and various fishery enhancement groups in a variety of forums -- in the context of an increasing demand and a limited supply. Furthermore, this topic has been discussed from a system-wide perspective in the US v. Oregon forum -- in the context of expanded implementation of this salmon enhancement method. Therefore, we would use a variety of media and fora to provide both progress reports and final results -- to maximize timely reporting and facilitate regional input. Progress during implementation of the Shad Nutrient pilot project would be reported via: (a) the public WDFW web-site, (b) the WDFW Sport advisory Group and the Commercial advisory Group, (c) press releases, (d) coordination meetings with fish enhancement groups (e.g., Fish First and LCRFEG), (e) Columbia River Technical Advisory Committee (US v. Oregon TAC, and (f) written progress reports. The final results would be documented in the BPA project completion report, the WDFW public web site, oral presentations including a status report to the Northwest Power Planning Council, and peer-review research publications.

Contacts

Contact name	Role(s)	Address	Phone	Email
Todd Pearsons	Project Lead	Washington Department of Fish & Wildlife 201 North Pearl Street Ellensburg WA 98926	509 925-4467 fax 509 925-4702	pearstnp@dfw.wa.gov
Tony Meyer	Interested Party	Lower Columbia Regional Fish Enhancement Group 12404 SE Evergreen Highway Vancouver, WA 98683	360-882-6671 fax [left blank]	cwfish@comcast.net
	Technical	U.S. Geological Survey	509.538.2299	

Matthew Mesa	Contact	5501A CookUnderwood Rd Cook WA 98605	fax 509.538.2843	matt_mesa@usgs.gov
Gary Loomis	Interested Party	Fish First PO Box 1505 Woodland WA 98674	360-901-0871 fax [fax left blank]	gloomis@gloomis.com
Steven Vigg	Project Lead	WDFW State of Washington, Department of Fish & Wildlife, 2108 Grand Avenue Vancouver, WA 98661	360-906-6710 fax 360-906-6776	viggscv@dfw.wa.gov
Susan Gutenberger	Technical Contact	U.S Fish & Wildlife Service Lower Columbia River Fish Health Center Willard, Washington	509-538-2400	Susan_Gutenberger@fws.gov
Joan Thomas	Technical Contact	WDFW 600 Capitol Way N, NRB Olympia WA 98501-1091	360-902-2667 fax 360-902-2943	thomajbt@dfw.wa.gov

Section 2. Location

Province: Mainstem/Systemwide **Subbasin:** Columbia Lower

Specific locations

Lat/long	Location desc	Waterbody (lake or stream)	County/State	Subbasin	Resolution	Primary?
	Bonneville Dam, Fishery Zone 2S, Washougal Reef			Columbia Lower	area	No
	The Dalles Dam			Columbia Gorge	area	No

Section 3. Species

Primary
Anadromous: Shad: American Shad

Secondary
Anadromous: All Anadromous Salmonids

Section 4. History (not used in this review process)

Section 5. Relationships to other projects

Funding source	Project ID	Project Title	Relationship
BPA	Project 2001-055-00	Influences of Stocking Salmon Carcass Analogs on Salmonids in Klickitat River Tributaries	Provides a scientific foundation for this work.
BPA	2001-055-00	Influences of Stocking Salmon Carcass Analogs on Salmonids in Yakima River Tributaries	Provides scientific basis for current work.
BPA	2001-055-00	Assessment of Three Alternative Methods of Nutrient Enhancement (Salmon Carcass Analogs, Nutrient Pellets, and Carcasses) on Biological Communities in Columbia River Tributaries	Provides scientific basis for current work.
Other: Lower Columbia Fish Enhancement Group	LCFEG-USGS	USGS Nutrient Assessment Study Phase III	Provides information on the effectiveness of stream nutrient enhancement to restore juvenile salmonid production in watersheds previously identified as nutrient deficient. This projects's activities follow Phases I (low-level water chemistry assessment of the Washougal, Lewis, and Wind River watersheds conducted in 2003) & II (documentation of in-stream biological productivity via assessments of periphyton (algae), macroinvertebrate (bug), and fish production (e.g., species composition, biomass, and growth) last year). Phase III involves the continued collection of baseline data as well as placing nutrient media (e.g. inorganic fertilizers or carcass analogs) in some of these same sites. Addition of the analogs, processed from Chinook salmon carcasses and directly consumable by both aquatic and terrestrial species, to nutrient-deprived streams is expected to increase juvenile salmon rearing densities in local streams.

Section 6. Objectives

Objective title	Description	Relevant Subbasin Plan	Relevant strategy(ies)	Page number (s)
1. Fishery Supply	Document the availability of American shad in Lower Columbia River fisheries -- in terms of time of year,location, gear type and quantity of fish.	Lower Columbia	Provide conditions that best fit those natural behavior patterns and river processes that most closely approximate the physical and biological conditions	15

			needed by the relevant species.	
2. Disease Evaluation	Develop a sampling design, collect representatives samples of American shad adults, and conduct pathology tests on samples -- to determine suitability of carcasses for nutrient enhancement.	Lower Columbia		
3. Product Type	Develop criteria and test the feasibility of using various American shad product types, e.g., fresh, frozen, chipped, and pasturized analogs -- as a source of marine-derived nutrients in Columbia Basin streams.	Lower Columbia		
4. Potential Use	Survey representatives of state, Tribal, federal and private entities regarding the current and potential use of American shad products for nutrient enhancement -- in terms of area, current productivity, desired productivity, amount of product, and potential risks.	Lower Columbia	Potential use of American shad for nutrient enhancement would be evaluated on a system-wide basis.	

Section 7. Work elements

Work element name	Work element title	Objective(s)	Start date	End date	Estimated budget	Sponsor performs work?
Analyze/Interpret Data	Develop criteria and test the feasibility of using various American shad product types.	3. Product Type	5/1/2008	12/31/2008	$45,000	Yes
	Description: The feasibility of utilization of the following American shad products will be evaluated: fresh, frozen, chipped, and pasturized analogs -- as a source of marine-derived analogs in Lower columbia River streams.					
Analyze/Interpret Data	Evaluate American shad fishery data	1. Fishery Supply	1/1/2008	3/1/2008	$18,000	Yes
	Description: Analyze available data on past shad fisheries -- sport, Tribal, and commercial -- relative to area, gear type, amount of catch , and time of year.					
Collect/Generate/Validate Field and Lab Data	Conduct fish pathology tests and analyze results.	2. Disease Evaluation	5/1/2008	8/31/2008	$14,400	No
	Description: Fish pathology tests will be conducted by USFWS Lower Columbia River Fish Health Center 60 fish sample x 8 collections.					
Other	Test fishing to acquire American shad for disease samples and carcass analogs.	1. Fishery Supply	5/1/2008	8/31/2008	$14,000	Yes

	Description: One or more fishermen will be contracted to test fish for American shad at various locations in cluding Fishery zone 2S, Washougal Reef, Bonneville Dam and The Dalles Dam					
Other	Process American shad into pasturized carcass analogs.	3. Product Type	5/1/2008	8/31/2008	$20,000	No
	Description: A contractor or fish feed company will be contracted to process and pasturize American shad into carcass analogs.					
Produce Annual Report	Final demonstration project completion report.	1. Fishery Supply 2. Disease Evaluation 3. Product Type 4. Potential Use	1/1/2009	6/1/2009	$25,000	Yes
	Description: The Draft final report will be produced by 3-1-2009 and the reviewed and revised final completion report will be completed by 6-31-2009					
Produce Inventory or Assessment	Assessment of Fish Carcass utilization for nutrient enhancement.	4. Potential Use	9/1/2008	2/28/2008	$21,000	Yes
	Description: The present level of of salmon carcass utilization will be assessed for Nutrient enhancement utilization in Columbia basin streams. An assessment of the potential demand for all types of fish carcass or analog utilization -- salmon carcass plus American shad or other fish species --for nutrient enhancement in the Columbia Basin will be conducted.					
Produce/Submit Scientific Findings Report	Progress reports	1. Fishery Supply 2. Disease Evaluation 3. Product Type 4. Potential Use	1/1/2008	12/31/2008	$6,000	Yes
	Description: Progress reports in various forums would be provided to cooperators on a quarterly basis, or more frequent if needed to dessiminate information.					
				Work Element budget total:	**$163,400.00**	

Section 8. Budget

Item	Note	FY 2008 cost ($)	FY 2009 cost ($)
Personnel	Research Scientist	$26,000	$26,000

Personnel	WDFW Bio 3	$13,305	$13,305
Other	Pathology lab work	$14,400	
Capital Equipment	Fish processing equipment	$8,157	
Supplies	Field supplies -- for sampling and processing fish samples	$4,500	
Travel		$2,000	$1,000
Fringe Benefits		$11,535	$11,535
Overhead		$16,629	$15,034
Itemized budget totals		$96,526	$66,874

FY 2008-2009 Itemized budget total: $163,400.00

Cost sharing

Type of funding source	Funding source or organization	Item or service provided	FY 2008 est value ($)	FY 2009 est value ($)	Cash or in-kind?	Status
state	WDFW -- Mitchell Act Operations	Personnel -- Steve Vigg, WDFW Regional Fish Manager: 1 month 2008, 1 month 2009	$10,453	$10,453	Cash	Confirmed
Cost share estimate totals			$10,453	$10,453		

FY 2008-2009 total cost share estimate: $20,906

Section 9. Project future (not used in this review process)

Section 10. Narrative

View narrative in new window

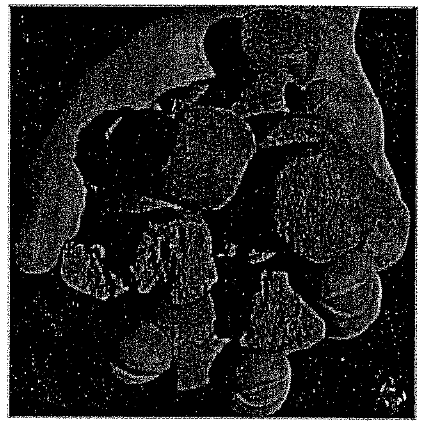
FEATURE: FISH HABITAT

Todd N. Pearsons
Dennis D. Roley
Christopher L. Johnson

Pearsons is a senior research scientist and Johnson is a fish biologist with the Washington Department of Fish and Wildlife, Olympia. Pearsons can be contacted at pearstnp@dfw.wa.gov. Roley is a retired nutritionist with Bio-Oregon, Inc. living in Astoria, Oregon.

Development of a Carcass Analog for Nutrient Restoration in Streams

ABSTRACT: Resource managers are becoming more interested in restoring nutrients to food-limited salmonid bearing streams, but all of the current approaches have some shortcomings. The objective of our work was to develop a nutrient restoration product that reduced these shortcomings. The product we developed, a carcass analog, was made from fall Chinook salmon (*Oncorhynchus tshawytscha*) from Spring Creek Hatchery, Underwood, Washington. These fish were pasteurized during the process that dried the ground salmon carcasses into a fishmeal. No known fish pathogens were detected in the pasteurized product. The analogs were easy to transport and distribute throughout the stream channel, generally sank to the bottom, and were retained within the channel. Approximately half of the analog had dissolved or been eaten after being in streams two weeks, and the analog was almost gone after four weeks. We discuss other studies that have demonstrated that carcass analogs reproduce the main food pathways historically provided by salmon carcasses and contributed to productivity of resident and anadromous salmonids. Our evaluation indicates that the carcass analog is a viable candidate for stream nutrient restoration in food-limited streams.



A handful of carcass analogs.

Desarrollo de un simulador análogo de despojos de salmón para la restauración de nutrientes en ríos utilizados por salmonidos

RESUMEN: Los administradores de recursos han desarrollado un creciente interes en la restauración de nutrientes en ríos utilizadas por el salmón que presentan limitaciones de recursos de alimenticios. Las soluciones disponibles para el manejo esta situación presentan algunas problemas. El objetivo principal de este estudio fue el de desarrollar un método de restauración de nutrientes que facilitara este proceso. El producto desarrollado fue un simulador análogo de despojos preparado con salmón Chinook (*Oncorhynchus tshawytscha*) del criadero de Spring Creek. Los despojos de peces fueron pasterizados durante el proceso de molienda y deshidratación para convertirlos en harina de pescado. Después de este proceso no se detectaron o identificaron organismos patógenos en los despojos. Los análogos se transportaron fácilmente y fueron distribuidos a través del lecho de los ríos. Los análogos fueron submergidos para que permanecieran dentro del lecho del río. Los resultados mostraron que un 50 % de los análogos fueron disueltos o consumidos después de permanecer en la corriente aproximadamente dos semanas; resultados posteriors demostraron que los análogos no se detectaron después de cuatro semanas. Otros estudios sugieren que los análogos preparados con despojos de salmón reproducen patrones de redes alimenticias y restauración de nutrientes similar a los históricamente provistos por despojos de salmon. Estos nutrients contribuyen a la productividad de poblaciones anadrónomas y residentes de salmonidos. Esta evaluación indica que los análogos de despojos son una alternativa viable para la restauración de nutrientes en ríos con baja disponibilidad de alimentos.

INTRODUCTION

Interest among resource managers in restoring nutrients to food-limited salmonid streams is growing (Bilby et al. 2001; Gende et al. 2002; Stockner 2003). Salmonid populations that rear in some tributaries appear to have relatively low food availability, which may be contributing to reduced growth and survival, and ultimately hindering restoration efforts (Achord et al. 2003). Historically, large numbers of salmon returned to natal rivers to spawn (Gresh et al. 2000), contributing huge amounts of nutrients to aquatic ecosystems via their carcasses and eggs (Larkin and Slaney 1997; Gresh et al. 2000; Naiman et al. 2002). Gresh et al. (2000) estimated that only 6–7% of the marine-derived nitrogen and phosphorous historically delivered to rivers of the Pacific Northwest is currently reaching those streams. Salmon eggs and carcasses are eaten by invertebrates and fish (Bilby et al. 1996; 1998; Gende et al. 2002; Hicks et al. 2005), and the nutrients released by the decomposing carcasses can facilitate increased plant and microbial production that subsequently increases invertebrate production, resulting in increased food availability for fish (Bilby et al. 1996; Naiman et al. 2002; Schindler et al. 2003). Unfortunately, the numbers of adult salmon that spawn in streams has been severely reduced (Nehlsen et al. 1991) and undoubtedly has caused a reduction in the availability of food for young salmon and trout (Gresh et al. 2000; Achord et al. 2003; Schindler et al. 2003). In addition to a reduction in the amount of marine-derived nutrients, the capacity of stream systems to retain nutrients has also been diminished due to reduction in stream complexity and increases in peak flows (Cederholm and Peterson 1985; Pearsons et al. 1992; Gende et al. 2002).

Stocking hatchery salmon carcasses has great potential to restore marine-derived nutrients and wild salmonid productivity (Bilby et al. 1998; Stockner 2003; Wipfli et al. 2004; Hicks et al. 2005); however, the strategy is not without risk. For example, stocking carcasses that have pathogens may increase the exposure of salmonids to a variety of diseases. Concerns about disease transmission have led the states of Oregon, Washington, and Idaho to institute prohibitions on the transfer of carcasses outside of fish health management zones. As a result, placement of carcasses is not an option in many nutrient poor systems due to the absence of an approved source. The addition of salmon carcasses to mitigate for low nutrient levels is further limited by low carcass availability. There often are not enough carcasses from hatcheries to produce nutrient levels comparable to what salmon historically contributed (Gresh et al. 2000).

Some alternative approaches to stocking hatchery carcasses may have lower ecological risks and more broad scale application (i.e., not enough hatchery carcasses to meet the need). One method that has been used widely in British Columbia is the addition of inorganic nutrients during the spring and fall (Johnston et al. 1990; Ashley and Slaney 1997). The nutrients stimulate algae growth, increase invertebrate production, and elevate food availability for the fish. However, this method does not directly provide a food source for fish and wildlife during the fall (e.g., fish flesh), as spawning salmon do (Bilby et al. 1998; Gende et al. 2002). In addition, inorganic nutrients may be contaminated with pollutants, and may not contain macroelements or rare earth elements contained in salmon (Gende et al. 2002).

Another possible option, which is the subject of this article, is to develop and stock a product that is made out of salmon carcasses but is pathogen free (termed "carcass analogs"). The advantages of using carcass analogs may be that they: (1) reproduce natural pathways of food production, (2) are pathogen free so they can be stocked without concern about spreading disease, (3) are potentially very available and independent of salmon runs, (4) are easy to store, carry, and distribute, (5) contain rare earth elements that may be important for salmonid survival, and (6) recycle nutrients from fish byproducts that would ordinarily be treated as waste. Analogs could be produced from unused fish parts from commercial fisheries and may provide the same nutrient and food benefits as salmon carcasses.

The objective of our work was to develop a pathogen-free product that would reproduce the food pathways historically provided by salmon carcasses. This article is about the development of a product, the effort of distribution into streams, and the physical behavior and dissolution of the analog in streams. The analogs that we developed were recently evaluated in Alaska and the results indicated that the initial benefits were similar to salmon carcasses (Wipfli et al. 2004). Salmon carcasses and analogs increased the condition, lipid levels, and production of stream-resident salmonids. A forthcoming article will evaluate the food pathways provided by the analog described in this article and the effects on the growth and abundance of salmonids in tributaries in Washington state (Pearsons et al. in press).

METHODS

Development of the carcass analog

We endeavored to develop an appropriate manufacturing process for the salmon carcass analog that, coupled with appropriate additives, would result in an analog that would: (1) stand up to packaging and transportation to the treatment sites, (2) have a flesh-like texture as it picked up water, (3) dissolve at a controlled rate as hydration continued, and (4) be free of undesirable pathogens. We wanted the analog to dissolve at approximately the same rate as a salmon carcass would decompose at mean water temperatures of between 10 and 20°C (Chaloner et al. 2002). The size of the analog also needed to be large enough so that it would rest above the substrate surface (i.e., large enough not to fall between interstitial spaces of the stream substrate), but small enough to be manufactured easily.

The core component of the analog, which was used in initial developmental tests and subsequent production, was a fishmeal made from salmon carcasses. Bio-Oregon produced salmon fishmeal in the fall of 1999, 2000, and 2001 from fall Chinook salmon (*Oncorhynchus tschawytcha*) carcasses from Spring Creek National Fish Hatchery (NFH), Underwood, Washington. Most of the salmon that were used during 1999 and 2000 were carcasses that had been spawned at the hatchery. However, during the fall of 2001 many more adults returned to the hatchery than were needed for production purposes, and most of the Chinook were killed soon after entering the hatchery (i.e., before they were spawned). The fresh, raw carcasses were coarsely ground and dried to a meal using swept surface, steam-tube dryers. Liquid ethoxyquin was added (0.02%) to each batch prior to drying to prevent lipid oxidation. The steam temperature was a minimum of 121 °C and the mass of ground carcasses approached 100 °C. The steam was then turned off after about 7.8 hours, but for the next four hours the sweeping mechanism continued to mix the meal until it cooled to less than 32 °C. The meal, which now had moisture content of about 10%, was then removed from the dryer and placed in bulk bags for storage.

One of the greatest challenges that we encountered was finding an approach that would restrict the analog from dissolving too quickly. Following many unsatisfactory results (Table 1), cold extrusion was evaluated as a method of manufacturing the salmon carcass analog. Cold extrusion is used by Bio-Oregon to make pelleted fish feed up to 10 mm in diameter. A hydraulic motor-driven auger is used to push the pellet dough (20–26% moisture) through a die plate with holes of the desired pellet diameter. A spinning knife on the outside surface of the die then cuts the pellets off at the desired length, usually equal to the diameter of the hole. The advantage of this technology compared to compaction technology is that moisture levels up to 30% are tolerated. This enables the use of binders that require greater amounts of water, and if necessary, heat for their activation. Following extrusion, this water is removed by evaporation using a natural gas dryer. This is necessary to form a physically durable, microbiologically stable pellet. The ingredients that were used in the develop-

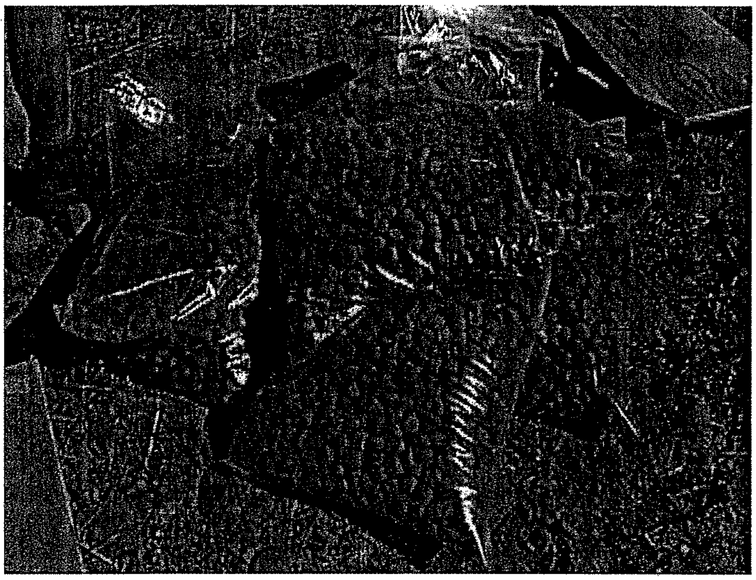
Table 1. Methods that were evaluated to develop carcass analogs.

Method	Variables tested	Rate of dissolution	Comments
Compaction technology using a pre-gelatinized corn flour to bind.	(1) Compaction pressures of 1,054 to 2,109 kg/cm^2, (2) level of pre-gelatinized corn flour, (3) salmon meal particle size, and (4) added water level.	Analogs dissolved in 9.4 to 10.1 h in static water at 10 °C; no apparent affect of any of these variables on the dissolution rate of the salmon carcass analogs.	The salmon meal/corn flour additive mixture just sloughed off as the water penetrated the analog.
Compaction technology using a variety of different additives/ binders.	(1) Wheat starch, which will gelatinize under 1,405 kg/cm^2 of pressure, (2) a combination of two refined alginates, (3) sodium carboxymethylcellulose, (4) guar gum, (5) partially hydrolyzed marine fishmeal protein, and (6) porcine gelatin.	Analogs dissolved in 9.4 to 10.1 h in static water at 10 °C.	Water entering the analog did not activate the binders and slow the dissolution rate of the analog as we had hoped.
Cold extrusion and stickwater binder.	Soluble proteins in stickwater, a byproduct of Bio-Oregon's production of low ash fishmeal from Pacific whiting (*Merluccius productus*) offal.	The analogs were stable in water up to 10 °C. Above 10 °C the analogs started to soften and fell apart once the temperature reached 15 °C.	Once dried, the analogs were tough and durable. We subsequently determined the melting point of the fish gelatin to be 12-15 °C.
Cold extrusion and porcine gelatin/stickwater binder: a test pellet press with 82 kg of pressure was used to form several 3.2 cm diameter pellets with the 4 formulations. The pellets were then dried overnight in a forced air convection oven at 30 °C.	Porcine gelatin was 10%, 15%, 20%, and 25% of the gelatin/ stickwater mixture.	There was a direct correlation between gelatin concentration and pellet toughness when the gelatin/ stickwater mixture contained up to 20% gelatin.	There was no discernable toughness difference between pellets made with 20% or 25% gelatin of the gelatin/stickwater mixture. Porcine gelatin has been used extensively at Bio-Oregon as a fish feed binder for many years and it has a melting point of 35-40 °C.
Cold extrusion and 20% porcine gelatin of the gelatin/stickwater binder.	Pellets were dried overnight in a warm, forced air natural gas dryer.	In a few days they had softened, but were still intact. After about three weeks they had softened a little more, but were still intact in 20 °C water.	Success–Used this approach to produce analogs.

Table 2. Ingredients and characteristics of carcass analogs produced in 2001 and 2002.

	9/7/01	8/30/02
Ingredient		
Weight of dough processed (kg)	1,926	2,722
Ground salmon meal	65.4%	46.4%
Hydrolyzed, pasteurized and deboned marine fish offal	23.6%	24.6%
Whole Pacific sardine (*Sardinops sagax*)/salmon scrap meal [a]	0.0%	17.0%
Gelatin	7.8%	8.2%
Dried marine fish bone	2.3%	3.8%
Algibind [b]	0.9%	0.0%
Characteristic		
Moisture of finished analog	13.0%	3.6%
Nitrogen composition of analog	9.6%	10.9%
Phosphorous composition of analog	2.1%	2.3%
Nutrient ratio of analog (N:P; target 6:1)	4.7:1	4.8:1
Lipid level of salmon meal	9.6%	17.0%
Average weight/analog (g)	11.9	10.7
Nutrient density of analog relative to salmon carcass	4.5	5.0

[a] It was necessary to blend the salmon meal with some deboned/deoiled whole Pacific sardine/salmon scrap meal and dried marine fish bone during 2002 to bring the lipid level of this mixture down.
[b] Algibind is a crude sodium alginate manufactured from seaweed, specifically *Ascophyllum nodosum*.



Carcass analogs were packaged in 20 kg bags.

ment of the analog are presented in Table 2.

During 2001, the adjusted dough extruded easily and the 2.5 cm salmon carcass analog pellets were dried for close to three days using forced ambient temperature air. We dried the analogs without heat to prevent case hardening and maximize their density. During 2002, the analog pellet dough extruded with difficulty because it was very tough. The salmon carcass analog pellets were dried for about one hour using forced 93 °C temperature air. Prior experimentation suggested that it was not necessary to dry the analogs with cooler air in order to achieve maximum density. The salmon carcass analogs were removed from the dryer, screened to remove over or under size analogs, and packaged in 20 kg bags.

Evaluation of analogs for fish pathogens

Two types of evaluations were conducted to determine if the analogs were free of any harmful fish pathogens (Table 3). First, fishmeal that had been through the pasteurization process, and was used to make the analogs, was tested for viral and bacterial fish pathogens. Since the source material may not have contained many pathogens, we also spiked the ground salmon carcasses with pathogens to determine if they were killed during the pasteurization and drying process. The Washington Department of

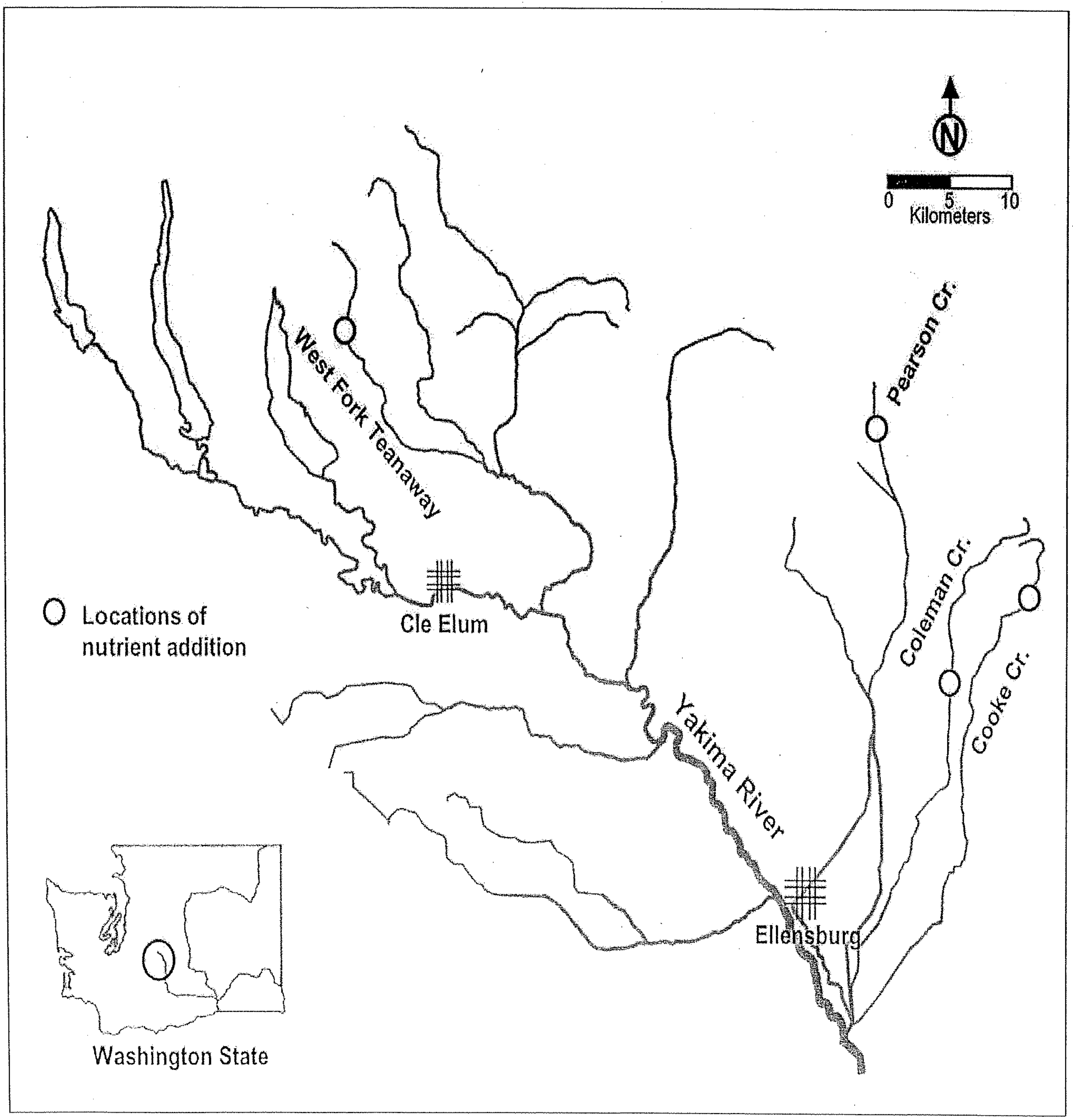
Table 3. Presence of pathogens tested in fishmeal and fishmeal spiked with pathogens. Results of all pathogen tests were negative.

Pathogen	Origin[a]	Lab[b]	n	Year
Infectious Hematopoietic Necrosis Virus (IHNV)	1	1	2	1999
	1	2	11	1999/2000
	2	2	2	2000
Infectious Pancreatic Necrosis Virus (IPNV)	1	1	2	1999
	1	2	11	1999/2000
	2	2	2	2000
Viral Hemorrhagic Septicemia Virus (VHS)	1	1	2	1999
Flavobacterium pyschrophilium	1	1	2	1999
Flexibacter columnaris	1	1	2	1999
Aeromonas salmonicida	1	1	2	1999
	1	2	11	1999/2000
	2	2	2	2000
Yersinia ruckeri	1	1	2	1999
	1	2	11	1999/2000
	2	2	2	2000
Vibrio sp.	1	1	2	1999
Renibacterium salmoninarum	1	2	11	1999/2000
	2	2	2	2000
Myxobolus cerebralis	1	2	11	1999/2000
	2	2	2	2000

[a]Origin: (1) Fishmeal made from fall Chinook salmon from the Spring Creek National Fish Hatchery (SCNFH) Underwood, WA, (2) fishmeal made from pelagic marine fish offal.
[b]Lab: (1) Washington State Department of Fish and Wildlife, Fish Health Laboratory, (2) Washington Animal Disease Diagnostic Laboratory.

Fish and Wildlife (WDFW) Fish Health Laboratory screened the fishmeal that Bio-Oregon produced in the fall of 1999 from Spring Creek National Fish Hatchery fall Chinook carcasses. Viral and bacterial fish pathogens were evaluated using cell culture procedures for fish tissues as outlined in the American Fisheries Society (AFS) *Fish Health Bluebook* (Thoesen 1994). The Washington Animal Disease Diagnostic Laboratory (WADDL), Washington State University, examined an additional 13 fishmeal samples, including 11 samples of fishmeal made in the fall of 1999 and 2000 from Spring Creek National Fish Hatchery fall Chinook carcasses. Two additional fishmeal samples were examined that were made from a non-salmon mixture of pelagic marine fishes (offal), and included partially hydrolyzed protein. These non-salmon fishmeal samples were included because fishmeal including partially hydrolyzed protein is an excellent binder for use in producing analogs. These 13 fishmeal samples were tested for the presence of fish pathogens, including viruses, bacteria, and the myxozoan, *Myxobolus cerebralis*, the

Figure 1. Locations of the study streams.



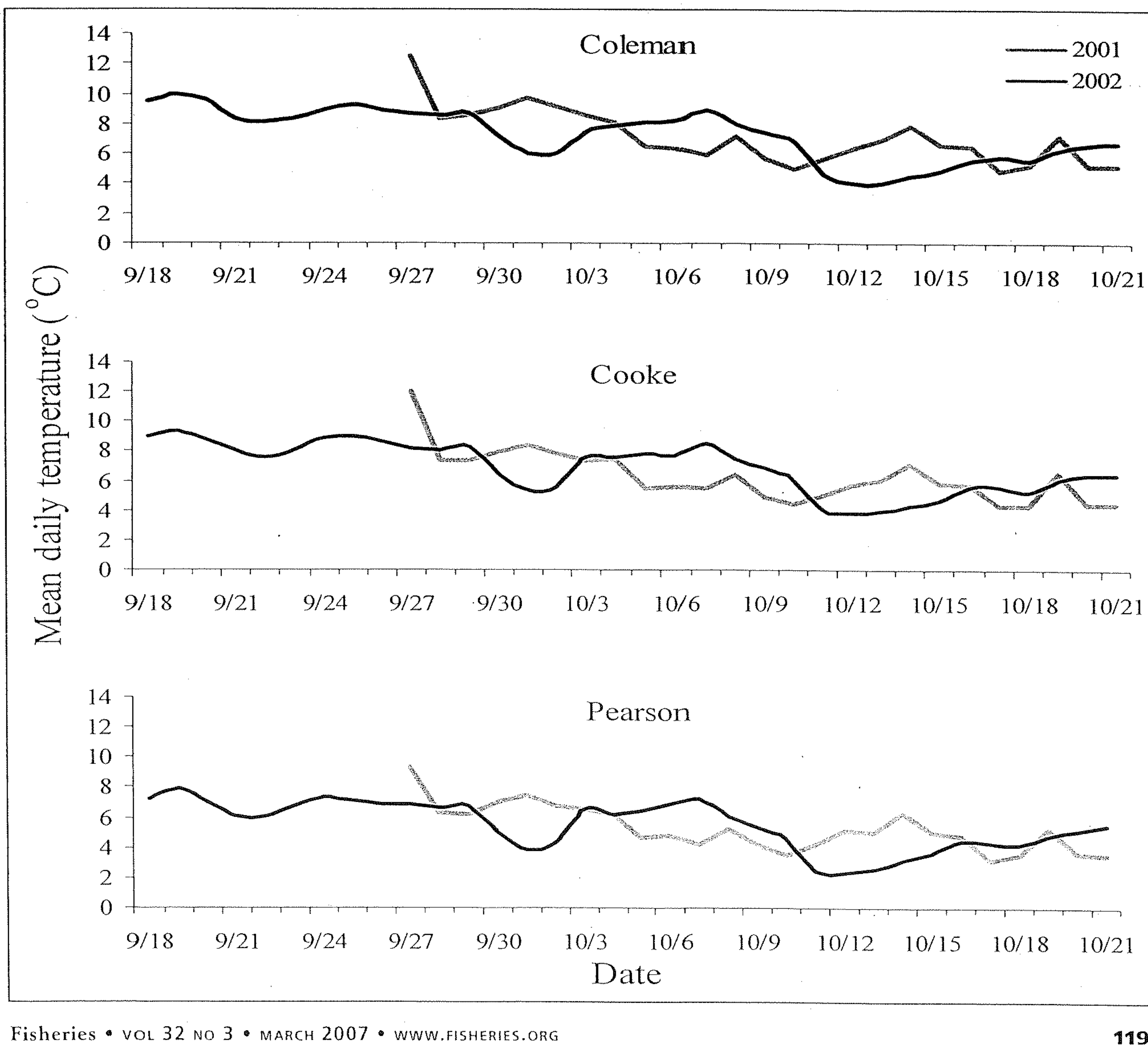
causative agent of whirling disease (Table 3). WADDL met or exceeded the standard procedures outlined in the AFS *Fish Health Bluebook* (Thoesen 1994) and the OIE *Diagnostic Manual for Aquatic Animal Diseases* for the examination of fish tissue for pathogenic bacteria and viruses. WADDL also ran a single round polymerase chain reaction (PCR) test on each of the processed samples as described in Baldwin and Myklebust (2002). Fishmeal samples, including a portion of one fishmeal sample and one sample spiked with *R. salmoninarum*, were tested on a *R. salmoninarum* monoclonal enzyme linked immunosorbent assay (ELISA).

WADDL also analyzed samples from an experiment at Bio-Oregon during 2001, which was done to determine if selected fish pathogens were completely inactivated during the cooking/drying process to make salmon meal. Fishmeal samples in two different dryers were infected with a bacterial and viral pathogen prior to pasteurization. An excess of 1.4 x 10^{10} colony forming units of *A. salmonicida* and 5 x 10^{10} IPNV plaque forming units were added to one dryer containing 1,662 kilograms of raw ground salmon carcasses and 1.4 x 10^{12} colony forming units of *R. salmoninarum* and 6.5 x 10^{8} IHNV plaque forming units were added to the other dryer containing 1,809 kilograms of raw ground salmon carcasses. Prior to introduction, each bacteria/virus combination was added to 15 L of phosphate-buffered saline to facilitate the distribution of pathogens in the raw ground salmon. After 10 minutes of mixing in a steam tube dryer, approximately 500 g of the raw ground salmon/bacteria-virus mixture was removed from each of the 2 dryers and placed in sterile plastic bags. After these samples were taken, the steam was turned on to start the cooking/drying process. After the pasteurization process was completed, another 500 g sample was taken from each of the 2 dryers.

Distribution of analogs into streams

Four tributaries of the upper Yakima River were stocked with carcass analogs to determine the ease of distribution and the initial performance of analogs in natural

Figure 2. Mean daily temperature in treatment streams during analog presence in 2001 and 2002.



streams. Three of these tributaries (Pearson, Coleman, and Cooke) drain the Colockum Mountain range and enter the Yakima River near the town of Ellensburg (Figure 1). Historically these tributaries probably contained spawning steelhead (O. *mykiss*) and coho salmon (O. *kisutch*), but presently support only resident fishes. The fourth stream (West Fork Teanaway River) flows into the Teanaway River from the northwest and the Teanaway River enters the Yakima River near Cle Elum. This stream probably contained steelhead, coho, and Chinook salmon and now contains very small runs of Chinook salmon and steelhead. Steelhead migrate downstream after spawning and thus did not contribute carcass material at the study sites. Analogs were used to mimic benefits provided by the coho and Chinook salmon that historically spawned in these streams. Fish assemblages in these tributary streams were dominated by trout (e.g., rainbow trout O. *mykiss*, cutthroat trout O. *clarki*, brook trout *Salvelinus fontinalis*) and sculpins.

Carcass analogs (small white items) nestled into stream interstices.

Salmon carcass analogs were stocked during 19–20 September 2001 and 18–19 September 2002 to correspond with natural spawn timing of spring Chinook salmon in the upper Yakima River. Treatments consisted of stocking carcass analogs in a 1-km long stream section of each treated tributary. Analogs were stocked at densities of 30 g carcass analog material/m^2 of bank full channel width. Stocking densities were derived from published relationships between salmon carcass densities and maximum stable isotope compositions (Bilby et al. 2001). The amount of nutrients provided by carcasses was then adjusted for water weight. The nutrient density in carcass analogs was about 4.5 to 5.0 times higher than in carcasses because of the difference in moisture content. Analogs were placed into large buckets and evenly distributed throughout the reach by tossing a predetermined number per lineal stream length.

Analogs were examined periodically (e.g., daily to weekly) to determine the rate of decomposition, invertebrate colonization, and rate of retention within the stream channel. We attempted to weigh individual analogs, but this method proved to be unfeasible because the analog absorbed water (increased weight) and broke apart after a few weeks. Temperature loggers were placed in the stocked reaches to monitor temperature. Temperature loggers failed (2001) or could not be retrieved (2002) in the West Fork Teanaway River.

RESULTS

Carcass analog specifications

Analogs averaged 2.5 cm in diameter, 2.5 cm tall, weighed 11.9 g (2001) and 10.7 g (2002) and were brown. During 2001, the analog pellets contained 13.0% moisture, which is too high for long-term microbial stability. However, this was not a concern for our test because they would be distributed into Yakima River tributaries in 9 to 10 days. During 2002 the moisture level was 3.6%, which was suitable for longer-term stability. Despite the lowered moisture content of analogs in 2002, we still observed condensation within the bags when we stored them in our uninsulated shop. In the shop, the packaged analogs experienced a large diurnal fluctuation in the air temperature during autumn, which would cause moisture in the analogs to migrate to a colder surface (i.e., the inside of the bag). We also observed that the analogs produced in 2001 molded in the bag if they were kept for over a month. The analogs produced in 2002 have not molded in over four years of storage in our shop. Ingredients and characteristics of carcass analogs produced in 2001 and 2002 are presented in Table 2.

Distribution of analogs into streams

Overall, the behavior of the analog met our expectations. The analogs were easy to transport and distribute throughout the stream channel. The analogs generally sank to the bottom and were retained within the channel. The size of the analogs facilitated the retention within the channel because they were small enough to be trapped by rocks and wood but large enough not to sink into interstices of rocks making them unavailable to species that live above the substrate. During 2002, some of the analogs floated because they had less moisture content than those stocked in 2001. Approximately 15–20% of the bags in 2002 contained analogs that floated. In general, the analogs that floated traveled approximately 30 m before they were retained in the channel, subsequently absorbed water, and sank. Some of the analogs may have traveled up to 100 meters.

Approximately 50% of the analog had dissolved or been eaten two weeks after stocking, and the analog was nearly gone after four weeks. Analogs were likely colonized by a matrix of fungi and bacteria which produced a rubbery "skin" that was difficult to penetrate for about a week. Later on (approximately week 3), periphyton began to grow on the analogs and the analogs appeared as small piles of fine material. After four weeks trace amounts of the analog could be seen, but most was dissolved or eaten. Few invertebrates were observed on the analogs during the day. Stream temperatures in Cooke, Coleman, and Pearson ranged from 1–13 °C during the times that analogs were in the stream

(Figure 2), but generally averaged between 6 and 7°C. Water temperatures were variable and generally decreased with time (Figure 2). The West Fork Teanaway was generally three degrees warmer than the streams for which we had thermograph data.

Evaluation of analogs for fish pathogens

All of the fishmeal pathogen tests for the first evaluation were negative (Table 3). All fishmeal samples tested for *R. salmoninarum*, except for the spiked positive controls, had a negative optical density (OD) reading (i.e., were negative for the organism). The results of a single round polymerase chain reaction (PCR) assay on each of the enzyme processed samples was negative for *Myxobolus cerebralis* myxospores.

The pathogen inactivation test was inconclusive for most of the pathogens tested because all but one of the samples collected before pasteurization tested negative for the pathogens of interest. The infectious pancreatic necrosis virus (IPNV) was the only agent recovered from the raw ground salmon inoculated with control organisms. This virus was not recovered from salmon meal after pasteurization, suggesting that the cooking/drying process converting the raw ground salmon to a dry fishmeal was successful in inactivating IPNV. Large numbers of bacteria were detected in the spiked samples that may have reduced detection of target bacteria prior to pasteurization. However, after pasteurization the numbers of contaminating bacteria was dramatically reduced and target bacteria were still not detected.

DISCUSSION

We found that we could develop a nutrient enhancement product from recycled fish waste that has the potential to restore food pathways previously provided by salmon. Carcass analogs have many desirable properties, such as ease of distribution and potentially high ecological benefits relative to costs, and should be considered a viable candidate among the suite of food enhancement techniques available for streams (Wipfli et al. 2004). The amount of work to distribute analogs was probably similar to that for distributing dry inorganic nutrients such as the "silver bullets" used in British Columbia and was considerably less work than stocking hatchery salmon carcasses (T. Pearsons, personal experience). Carcass analogs and inorganic nutrient products have high nutrient densities relative to carcasses. Salmon carcasses have a relatively low nutrient density because of their relatively high water content. The nutrient density in carcass analogs is about 5 times higher than in carcasses because of the difference in moisture content. That is, the nutrients in 1 kg of analogs are similar to nutrients in 5 kg of carcasses. This density difference makes analogs a more efficient way of distributing nutrients. The analogs might reproduce the natural food pathways better than inorganic nutrients because they provide a direct food source in the fall, similar to carcasses (Wipfli et al. 2004; Pearsons et al. in press). Carcass analogs also present fewer pathogen risks than stocking salmon carcasses, are relatively easy to store, and are more readily available to stock into areas without salmon hatcheries or in areas where salmon hatchery carcasses are unable to meet the nutrient need. Furthermore, analogs have the potential to be stocked at the same time as naturally spawning salmon, but carcasses from hatcheries are sometimes unavailable at these times because of the need to conduct pathogen screening. In summary, we believe that carcass analogs have the following desirable characteristics, which in combination are not provided by any other nutrient addition technique: carcass analogs have the potential to reproduce some natural food pathways (Wipfli et al. 2004; Pearsons et al. in press), are easy to store and transport, are available in large quantities and at the appropriate times, are more likely to be approved by regulatory agencies (e.g., those responsible for issuing water quality and fish transportation permits), and pose low risk to aquatic communities.

Studies in Alaska and Washington indicate that carcass analogs have the potential to restore food pathways provided by salmon and also increase the productivity of stream-resident salmonids. Wipfli et al. (2004) found that short-term condition, production, and lipid content of resident and anadromous salmonids were increased when exposed to salmon carcasses and carcass analogs. Pearsons et al. (in press) demonstrated that resident and anadromous salmonids directly consumed the analog in tributaries of the Yakima River. Furthermore, stable isotope analysis revealed that nutrients from analogs were incorporated into periphyton and invertebrates. Finally, an increase in growth during the fall was detected in rainbow trout exposed to analogs (Pearsons et al. in press).

The decomposition of carcass analogs was similar to what has been reported for salmon carcasses. Chaloner et al. (2002) reported that mass loss of pink salmon carcasses was initially rapid and then declined over time. Approximately half of the carcass mass remained after about 2.5 weeks (Chaloner et al. 2002), which was similar to what we observed for the analogs and also for spring Chinook salmon carcasses in the Yakima River. Some salmon tissues such as eggs, internal organs, and skin, decomposed at a slower rate than muscle tissue (Chaloner et al. 2002). These slower degrading tissues could persist for over six weeks, which was longer than the duration of analogs. Thus, carcass analogs are likely to represent the degradation rate of muscle tissue well, but not the slower degrading tissues such as skin. However, salmon spawn over weeks to months, so mimicking carcass availability would require multiple applications of the analog or analogs that degrade at different rates.

The most natural way to restore historic food pathways is to restore salmon to their historic abundance and distribution. However, it is unlikely that historic abundances will ever occur again in many locations (Lackey 2003). Thus, if managers want the ecosystem benefits of restored marine derived nutrients, then a continual nutrient addition program should be instituted in locations where salmon runs are depleted. Distribution of carcass analogs appears to be a reasonable method of re-establishing important food pathways. Where escapement is not managed for nutrient needs (Bilby et al. 2001) or where other factors such as habitat degradation or interactions with other species prevent high returns of salmon, carcass analogs might be used to restore nutrients to desired levels of aquatic productivity.

Although our pathogen inactivation experiment was not conclusive for most pathogens, the pasteurization process that fishmeal experienced was likely to kill all pathogens. IPNV appeared to be inactivated during the pasteurization experiment. IPNV has been shown to be generally more stable than the other control virus, Infectious Hematopoietic Necrosis Virus (IHNV), leading one to speculate that the inactivation of IPNV by the cooking/drying process should result in inactivation of IHNV as well (Inouye et al. 1992). Alternatively, our pathogen results may have been confounded by low sensitivity of the tests. Detection of pathogens in fishmeal may be lower than conventionally tested fish parts and high growth of non-target bacteria in the control sample may have decreased our ability to detect target bacteria. The pasteurization process that was used is the same process that is used for producing fish feed and human foods. The cooking/drying conditions (times/temperatures) described for the production of salmon fishmeal from raw ground salmon easily exceed those of the standard pasteurization conditions that have been employed by Bio-Oregon for the last 40 years to pasteurize fish digest (cooked, enzyme digested offal). During the period prior to 1960, raw carcasses and viscera of adult salmon included in the diet of juveniles were responsible for the complete transmission of bacterial kidney disease (Wood and Wallis 1955) and mycobacteriosis (Ross et al. 1959; Wood and Ordal 1958). When this practice was discontinued and pasteurized salmon parts were used in fish feed, the incidence and severity of bacterial kidney disease was reduced and mycobacteriosis was apparently eradicated from fish reared in Pacific Northwest hatcheries (Fryer and Sanders 1981).

Moffitt-Westover (1987) studied the bacterial flora in the Oregon Moist Pellet, a fish feed manufactured by Bio-Oregon for public resource fish hatcheries in the Pacific Northwest. This included an examination of the pasteurized fish offal digest, a major protein/lipid fish feed ingredient, before and after improvements were made in the pasteurization process. She stated that the pasteurization specifications for the fish offal digest (65 °C for 15 minutes followed by 82 °C for 5 minutes) are sufficient for the destruction of pathogenic organisms (Moffitt-Westover 1987). She tested the pasteurized fish digest for the presence of eight fish and nine human bacterial pathogens after process improvements were made. The fish digest was not examined for viral pathogens or Myxosporidia, specifically *Myxobolus cerebralis*. The fish pathogens that were examined included *Aeromonas hydrophila*, *A. salmonicida*, *Mycobacteria*, *Pseudomonas*, *Renibacterium salmoninarum*, *Vibrio anguillarum*, *Yersinia ruckeri*, and *Streptococcus* Group B. None of these organisms were found. *Mycobacteria*, *Pseudomonas*, and *Streptococcus* Group B are also human pathogens. The additional human pathogens included *Clostridium perfringens*, *Salmonella*, *Shigella*, *Staphylococcus aureus*, *Streptococcus* Group A, and *Yersinia enterocolitica*. Only C. *perfringens* was found. This is not surprising since this bacterium is widely distributed in nature and forms heat resistant spores. Therefore, if the salmon carcass analog contained some C. *perfringens* spores they would not cause significant additional exposure. Also, there are significant hurdles to the germination and growth of C. *perfringens*. This organism is a strict anaerobe and cannot tolerate the level of dissolved oxygen in freshwater streams. The analog and stream also lack the kind of nutrients needed for C. *perfringens* to germinate and grow, and the water temperature (1–16°C) is much colder than 37–40°C, the optimum for C. *perfringens*.

The result of WADDL's examination of 13 fishmeal samples for *Myxobolus cerebralis* was not definitive. However, sustained high temperatures (>85 °C for more than 5 hours) applied to the ground salmon carcass material to dry it to a meal would inactivate *Myxobolus cerebralis* spores. Wolf and Markiw (1982) demonstrated that hot smoking of rainbow trout infected with whirling disease inactivated the M. *cerebralis* spores. More specifically, they found that 66 °C held for 40 minutes is lethal.

Pathogen screening has been performed on fish inside and outside of the reaches that we stocked analogs (Pearsons et al. in press). Preliminary results suggest that the frequency and severity of pathogens in wild fish has not been affected by the analogs. In addition, the benefits provided by the analogs to the aquatic food web, and more specifically to juvenile salmonids, appear to mimic those provided by salmon carcasses (Wipfli et al. 2004; Pearsons et al. in press).

Although the analog that we produced had many desirable properties, improvements could be made. We recommend repeating the pathogen inactivation experiment that we attempted, to further reduce the low scientific uncertainty of pathogen inactivation by pasteurization, but modifying it to produce positive replicated results in the fishmeal sample prior to pasteurization. This would include determination of the sensitivity of standardized methods on fishmeal. Furthermore, decreasing the buoyancy of the analog would also decrease the amount of analog that is exported from the desired stocking location. Producing a product with a long shelf life would also be advantageous. Finally, although potentially impractical from a manufacturing standpoint, creation of analogs of various sizes might enable large terrestrial animals to eat analogs as well as provide a variety of decomposition rates. Alternatively, analogs could be stocked at a variety of times to more closely mimic nutrient pulses provided by decaying salmon (Pearsons et al. in press).

There also has been some concern that pollutants (e.g., mercury, polychlorinated biphenyls, and the pesticide DDT) detected in adult salmon could be transferred to streams following their migration from the ocean (Ewald et al. 1998, Naiman et al. 2002, Sarica et al. 2004). Stocking of analogs would not eliminate this concern. The presence and concentration of potential pollutants was not evaluated in this study. However, if subsequent work does identify the presence of such substances in the analogs, the benefits of nutrient addition would have to outweigh the detriments of introducing pollutants for analog addition to be a reasonable restoration strategy. Alternatively, it may be possible to reduce pollutants in analogs by using fish sources that have low amounts of pollutants, or by removing pollutants in the process of developing the analog. This would be an important topic for future inquiry. Furthermore, restoration of salmon runs could pose a greater pollution problem because pollutants transported by salmon could not be removed. In summary, with the exception of the pollution risk uncertainty, the risks of analog placement appear to be low but the potential benefits appear to be high. Similar to recommendations for salmon carcass studies (Gende et al. 2002; Schindler et al. 2003), we recommend large-scale, long-term experimentation of carcass analogs in food-limited streams where salmon carcasses are unavailable or insufficient to meet ecosystem goals.

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ESSAY: FISH HABITAT

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The Clear-water Paradox of Aquatic Ecosystem Restoration

INTRODUCTION

Several important resource policy questions involving trophic status, public perception, and fundamental approaches to aquatic ecosystem restoration were recently raised by Lackey (2003). Two of these questions are of particular relevance to the discussion of nutrients, water clarity, and aquatic ecosystem restoration: (1) is there an inherent policy conflict between adding nutrients to watersheds to restore salmon populations (and associated ecosystem function) and societal pressure to protect and enhance water quality, given that Western society typically desires both, and (2) is there a regulatory bias toward achieving "distilled water" in lakes, reservoirs, rivers, and streams such that the important beneficial role of waterborne nutrients is not given equivalent consideration and legislative weight? We believe the current answer to both of these questions to varying degrees is yes, and issues addressed by these questions form the basis for what we call the "clear-water paradox" of aquatic ecosystem restoration.

In this essay we: (1) review general roles, perceptions, and management of waterborne nutrients, (2) propose, define, and describe the nature and causes of the clear-water paradox of aquatic system restoration, and (3) discuss requirements for addressing and resolving this paradox.

BACKGROUND

Carbon (C), nitrogen (N), and phosphorus (P) are naturally occurring elements that are essential for growth and reproduction of all aquatic life forms. These nutrients drive primary and secondary productivity, and their concentration, ratio, and spatial/temporal availability dictate aquatic system metabolic rates and trophic status. Although excessive nitrogen and phosphorus are commonly recognized as pollutants in eutrophic waterways, societal awareness of the positive effects of these nutrients in oligotrophic ecosystems and their central role in regulating biological productivity is surprisingly limited. It is critical to recognize the importance of balance of C, N, and P, and how dysfunction occurs not only by too little or too much, but also by creating nutrient imbalances that can shift productive "classic" short-chain grazer communities into longer-chain ultra-oligotrophic microbial food webs that support minimal fish biomass and dissipate energy through picoplankton-dominated pathways with associated high respiratory costs (Weisse and Stockner 1992).

Eutrophication, the artificially elevated concentration of nutrients in natural waters, has occupied the center stage of applied limnology for nearly half the previous century (Vollenweider 1968; National Academy of Sciences 1969; Schindler 1974; Stockner 2003, and references therein). However, during the past 40 years, the opposite process, cultural oligotrophication, has become an important emerging problem in altered aquatic ecosystems in north temperate and boreal regions world-wide (Ney 1996; Stockner and Milbrink 1999; Stockner et al. 2000; Pieters et al. 2003; Stockner 2003; Hyatt et al. 2004). Cultural oligotrophication is the human-caused reduction of naturally occurring nutrients in aquatic systems. We recognize that natural ecosystems with high or low nutrient concentrations and ecosystem productivity do occur, and we are definitely not proposing that all aquatic ecosystems be "homogenized" to a middle ground of moderate productivity. Our intent is to raise scientific awareness of the magnitude and extent of culturally-induced oligotrophication such that these dysfunctional ecosystems (Ney 1996; Stockner et al. 2000) receive adequate restoration attention.

Water bodies located in formerly glaciated north and south temperate watersheds tend to be naturally oligotrophic (nutrient poor; Stockner and Milbrink 1999). Typically, these systems are characterized by low mean annual water temperature regimes, short growing seasons, underlying granitic geology, and relatively nutrient poor watersheds. Oligotrophication caused by dam and levee construction, habitat alteration, acidification, and declining returns of salmon derived nutrients at these latitudes worldwide has rendered many aquatic systems ultra-oligotrophic (Ney 1996; Stockner et al. 2000). Such systems now possess extremely clear, nutrient deficient water relative to their former naturally oligotrophic status and exhibit significantly reduced biological productivity. In their nutrient deprived states, these rivers, lakes, or reservoirs are incapable of supporting their historical pre-oligotrophication yields of fish. Kootenay Lake in British Columbia is a classic case of cultural oligotrophication in which pelagic kokanee (*Onchorhynchus nerka*) annual spawning escapement collapsed from 2–3 million to 250,000 following construction of two upstream hydroelectric impoundments and over 100 km of continuous levee construction, which sequestered inflowing nutrients and drastically reduced habitat diversity (Ashley et al. 1997,1999; Anders et al. 2002).

Limited societal awareness of cultural oligotrophication may be due in part to the fact that ultra-oligotrophic systems, although biologically constrained and ecologically dysfunctional at worst, often appear aesthetically pleasing. Eutrophic systems generate attention because they develop nuisance aquatic plant and algae growth that limit desired human activities and uses, and because they often look, taste, and smell bad. Alternatively, ultra-oligotrophic systems typically look pristine and don't violate clean water criteria. Hence they don't attract the equivalent attention because their productivity losses occur slowly over many decades. The causal mechanism (e.g., impoundment) is often associated with valuable societal benefits (i.e., hydroelectric power and flood control). Hence, oligotrophication is often quietly viewed "as the cost of doing business."

Local, regional, and national water quality policies and standards rightly exist to protect aquatic ecosystems from eutrophication and myriad organic and inorganic pollutants. These existing standards or policies could theoretically be used to protect natural water bodies from oligotrophication, but are rarely invoked, despite the fact that the magnitude of ecological damage and food web disruption associated with ultra-oligotrophy may rival that of eutrophication (Ashley et al. 1999; Stockner et al. 2000). For example, the U.S. Environmental Protection Agency (EPA) defines water quality standards as inclusive of beneficial uses, water quality criteria, and an anti-degradation policy. The beneficial uses (goals for the waterbody) often include "fish and aquatic life," whereas the water quality criteria are the minimum conditions that support the most sensitive beneficial use, and anti-degradation is designed to protect existing water quality from further degradation. Violations of water quality standards can and do occur even though the water quality criteria are achieved, e.g., the concentration of some contaminant in fish tissue might impair the "fishing" beneficial uses, but the water column concentrations are not above the water quality criteria. Since water quality standards include beneficial uses, the U.S. Clean Water Act is a policy tool that could be invoked to protect waters from cultural oligotrophication. In theory, anthropogenically-caused ultra-oligotrophic water quality should qualify as a violation of water quality standards when it results in impairment of the fish and aquatic life beneficial use. The EPA allows for the use of biocriteria, which should allow for consideration of ecosystem services. However, it is clear that the EPA's national nutrient criteria are focused primarily on addressing cultural eutrophication. The existing anti-degradation policy allows designation of waters as Outstanding (Natural) Resource Waters, which would prohibit any anthropogenic degradation of water quality. This policy would not address waters already naturally oligotrophic (e.g., Crater Lake, Oregon), but if used, could be invoked for naturally oligotrophic waters to prevent further depletion of nutrients.

THE CLEAR-WATER PARADOX

Clear water is the typically desired condition of public waterways. Entities as diverse as the Clean Water Act, and local or regional water clarity criteria support the notion that if clear is good, then crystal clear is even better. Understandably, the U.S. Clean Water Act was passed when increased turbidity of public waters was often associated with increased contamination, toxicity, and significant eutrophication problems. Of course such conditions still exist. However, natural biological turbidity is not automatically correlated with contamination, and biologically productive and ecologically functional aquatic systems are not always crystal clear. In fact, they often produce intermittent or seasonal conditions that may not be aesthetically pleasing to humans yet are necessary for the functioning of the ecosystem (Stockner et al. 2000). Herein lies the clear-water paradox of aquatic ecosystem restoration: Western society wants crystal clear public waters and ecosystem services or benefits like harvestable fish populations but simultaneously enforces water quality standards that limit or prohibit the biological productivity and ecological processes required to produce and maintain those benefits.

To understand the degree to which extreme water clarity is culturally engrained, one simply needs to envision initial responses by water resource and fisheries managers and the public to the two images presented in Figure 1. Initial responses by these groups tend to be positive to clean rock or substrate and more negative regarding the algae covered rock. Progress may be claimed when the same groups recognize clean substrate as an indicator of a potentially nutrient deficient system and the lower photo as an indicator of a more productive ecosystem that provides societally valued ecosystem services. To be emphatically clear: we are not promoting eutrophication or relaxation of legitimate water quality protection laws and enforceable standards that have protected countless water bodies from eutrophication and deleterious pollutants. Rather, we are promoting ecological education as a pathway toward protecting, restoring, and maintaining balanced aquatic ecosystems.

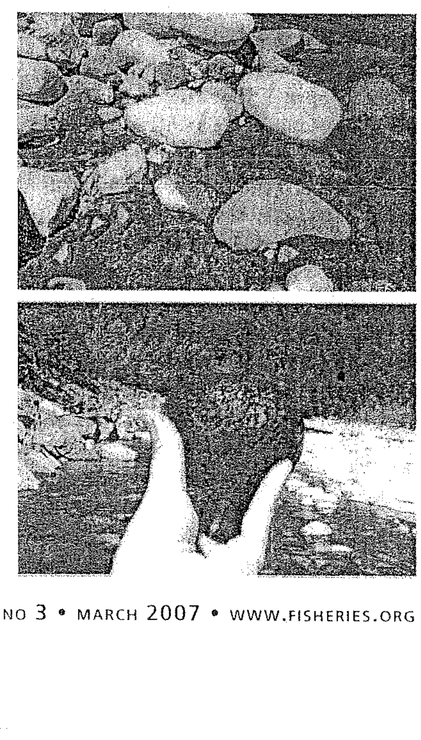
Due to this paradox, water resource agencies and restoration-oriented limnologists and fisheries biologists may find themselves caught between opposing management paradigms. Environmental quality monitoring and enforcement agencies are responsible for maintaining water quality standards in public waters. Some water quality standards are essentially managing for distilled water, in ecological terms. Alternatively, fishery researchers, restoration-oriented limnologists, and fisheries biologists are simultaneously designing and implementing fishery and aquatic ecosystem restoration programs that recognize the essential role of nutrient availability and its relationship with water clarity, including restorative nutrient addition prescriptions. Thus, the clear-water paradox involves conflicting "restoration" approaches among resource agencies despite their shared mission of environmental protection and some resemblance of a "normally functioning" ecosystem.

RESOLVING THE PARADOX

A fundamental change in the way aquatic resource managers and Western society view and understand aquatic resources is needed to resolve this paradox, including:

- Informative debate and accurate definition of the cultural oligotrophication problem within and among agency and public groups;

Figure 1. Differences in periphyton accrual or algal productivity on native substrates upstream (top) and downstream (bottom) from an experimental nutrient addition site in Norris Creek, British Columbia during 2005.



- Developing a better ecological, professional, and societal understanding of the cultural oligotrophication problem;
- Developing and adopting more consistent, ecologically relevant nutrient policy and standards among agencies; and
- Implementing successful aquatic ecosystem restoration projects that may not be associated with crystal clear water.

Although resolving the clear-water paradox involves formidable tasks such as changing a well-established societal paradigm, notable progress is being made in the field of restoration limnology. Unlike the aforementioned societal oversight, cultural oligotrophication and successful remedial measures are receiving increasing attention among the international ecological and limnological communities, and within local and regional water resources and fishery management agencies. For example, Washington and Oregon now have policies that attempt to address oligotrophication through the introduction of salmon carcasses (see http://wdfw.wa.gov/hab/ahg.shrg_t11.pdf) and British Columbia has been conducting stream and river enrichment experiments since the 1980s (Ashley and Slaney 1997).

A small meeting of ecologists and limnologists, held in Uppsala, Sweden in 1998, first focused scientific attention on the ecological effects and restoration options related to cultural oligotrophication (Stockner and Milbrink 1999). A second landmark international conference, on restoring nutrients in salmonid ecosystems sponsored by the American Fisheries Society was convened in Eugene, Oregon, in 2001, and included nearly 400 participants from Canada, Scandinavia, Japan, and the United States. This meeting produced a comprehensive peer-reviewed collection of nutrient addition studies designed to compensate for cultural oligotrophication of lakes, reservoirs, rivers, and streams (AFS Symposium 34: Stockner 2003). Contributors to this volume reported recent developments and challenges to the science of nutrient enrichment in various regions of the world. A subsequent review of 24 sockeye salmon nursery lake enrichment experiments in British Columbia concluded that lake fertilization was a successful technique for conserving and enhancing sockeye salmon populations (Hyatt et al. 2004). Most recently, a group of fishery consultants, researchers, and managers presented a symposium on nutrient enrichment as part of the Oregon Chapter of the American Fisheries Society meeting in Sunriver, Oregon (www.orafs.org/meeting2006/final_abstracts.pdf).

Advances in the emerging fields of nutrient enrichment and restoration limnology reveal the prevalence of cultural oligotrophication in north and south temperate regions of the world. Most of the hydroelectric reservoirs and downstream riverine ecosystems in British Columbia, Sweden, and Norway are culturally ultra-oligotrophic (Stockner and Milbrink 1999). Increased awareness of the cumulative effect and extent of ultra-oligotrophy and the important role of salmon-derived nutrients have contributed to an increasing number of nutrient restoration prescriptions and adaptive management experiments in streams, rivers, lakes, and reservoirs around the world, generally at or north of the 49th parallel (Ashley et al. 1997; Ashley et al. 1999; Murota 2003; Nakajima and Ito 2003; Stockner 2003; Ashley and Stockner 2003; Stockner and Ashley 2003; Thomas et al. 2003; Reimken et al. 2003; Anders 2006). Finally, ongoing interest in cultural oligotrophication among aquatic resource managers and researchers is reflected by a special session at the upcoming meeting of the International Limnological Society, in Montreal, Canada, in 2007, entitled "Cultural Oligotrophication: Causes, Consequences and Corrections" (www.sil2007.org).

CONCLUSIONS

Successful science-based restoration of culturally oligotrophic and eutrophic ecosystems will require improved understanding of these issues within the managing agencies and the general public. It will also require the development and implementation of appropriate fisheries and water resource management policies. This paradox is not unique. Similar conflicts exist where society's biases create ecological problems—for example, the conflict between fire suppression in forests and increasing concerns about catastrophic burns, or the removal of large woody debris from streams despite overwhelming evidence of its ecological importance. The move towards science based ecosystem management will no doubt uncover additional examples.

However, as the rigor, understanding, and predictability of limnological restoration improve, successful restoration programs will likely emerge, increasing the credibility and public support for science-based ecosystem restoration. This ecological or limnological restoration paradigm represents a significant change from past univariate, symptom-specific treatment approaches that often failed to restore fisheries and their supporting ecological processes. Rather than asking fishery and water resource managers and the public to choose between clear water or valued ecosystem services, education and effective ecological restoration involving the biologically productive middle ground, where appropriate, should provide a scientifically defensible strategy for restoring culturally oligotrophic ecosystems.

ACKNOWLEDGEMENTS

We would like to thank John Stockner and Harvey Andrusak for reviewing an earlier draft of this article, and Thomas Fontaine, Brian Missildine, Robbins Church, Martin Fitzpatrick, and one anonymous reviewer for providing input that greatly improved the article.

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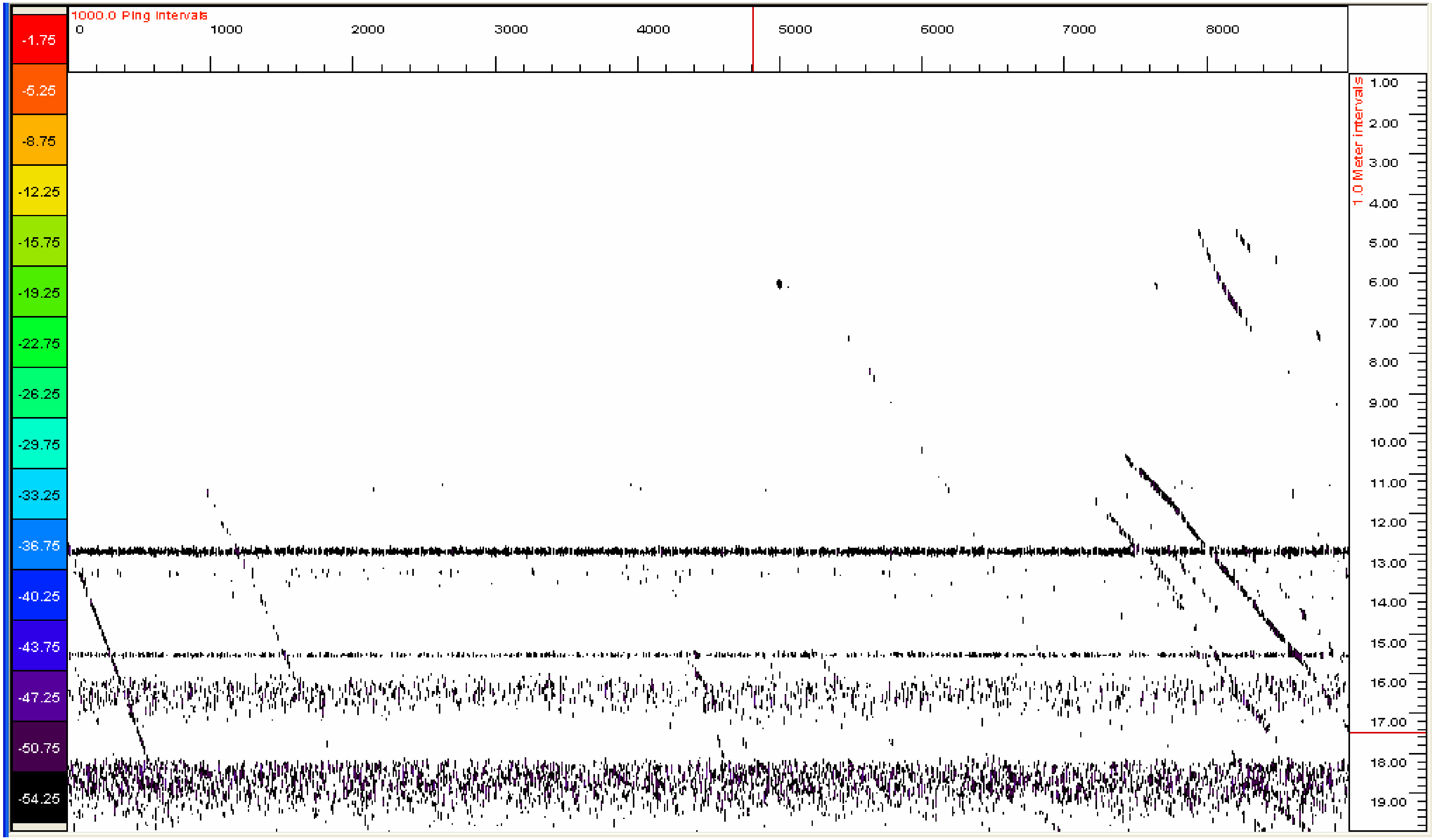
ECHOGRAM



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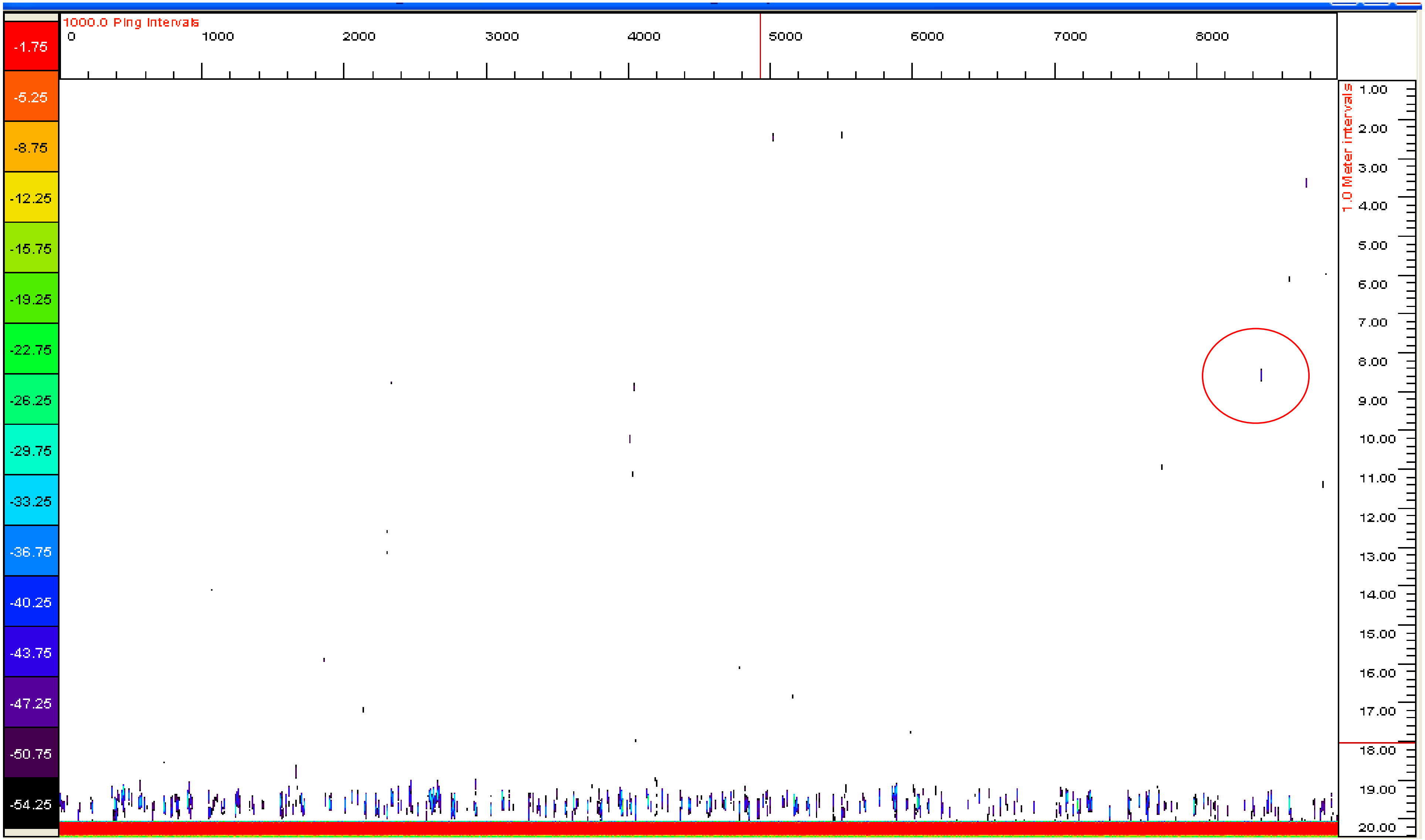
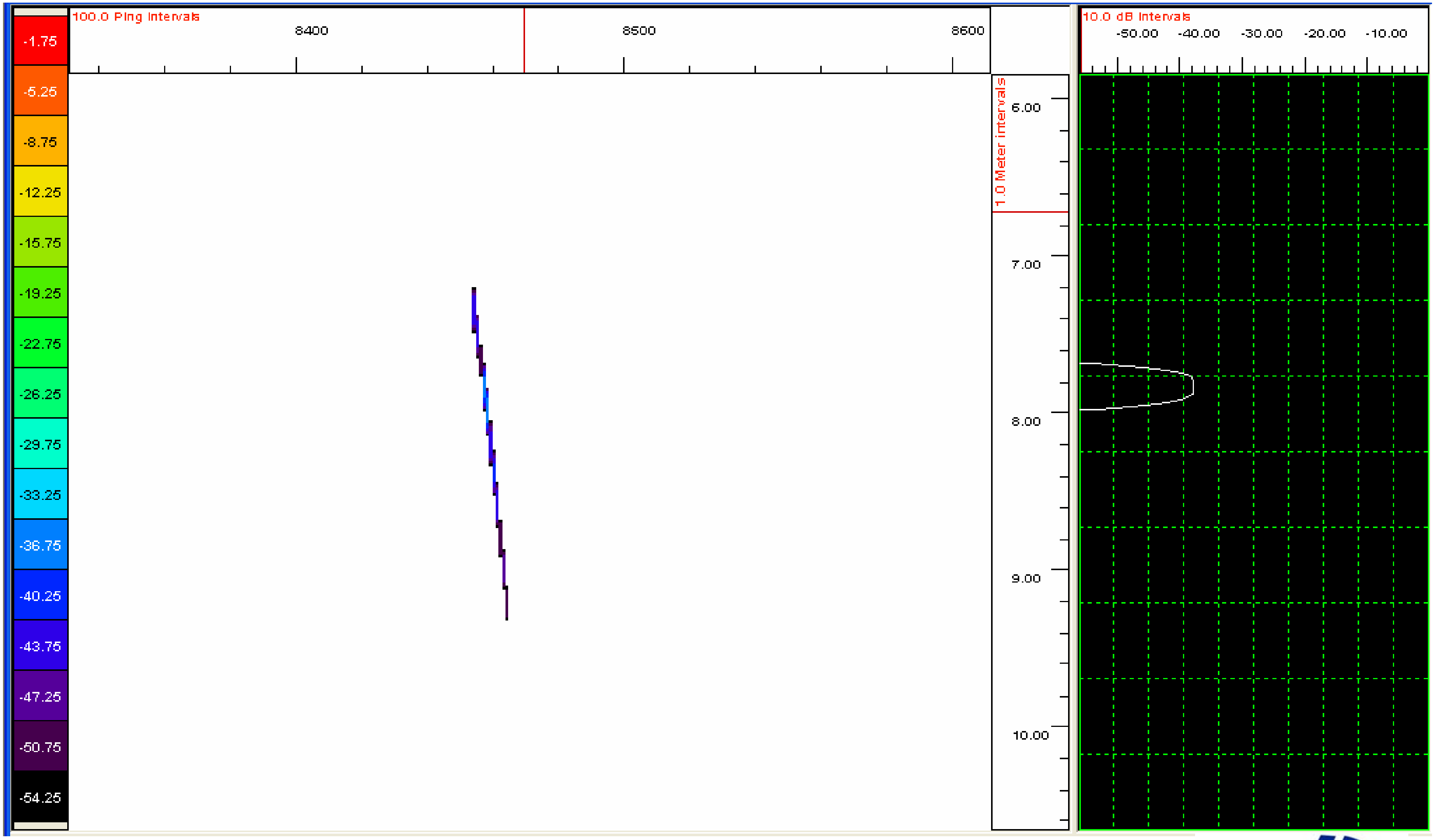
Fish Trace



BioSonics®

Fish Trace = Series of individual echoes



Trace Formation Program

Extracts Fish Traces From Acoustic Data Based On:

- Echo Intensity (Target Strength)
- Echo Shape
- Location of Adjacent Echoes
- Linearity of Echoes
- Number of Echoes

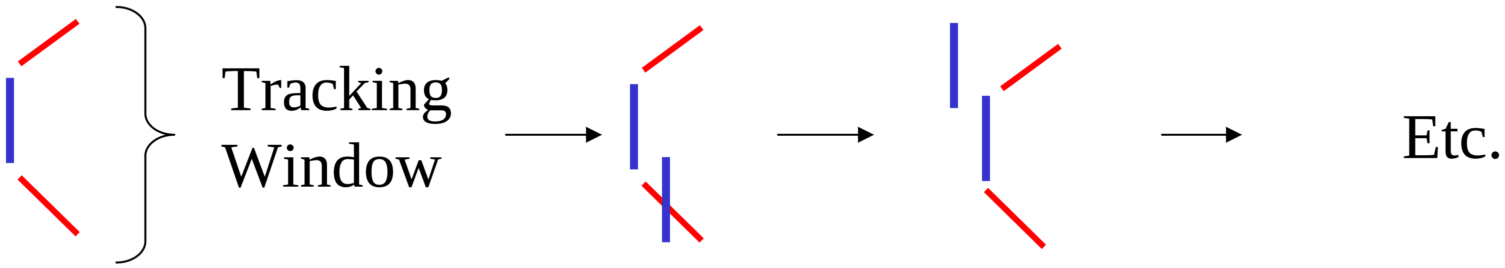
Echo Intensity

Does the echo meet a minimum threshold?

Echo Shape

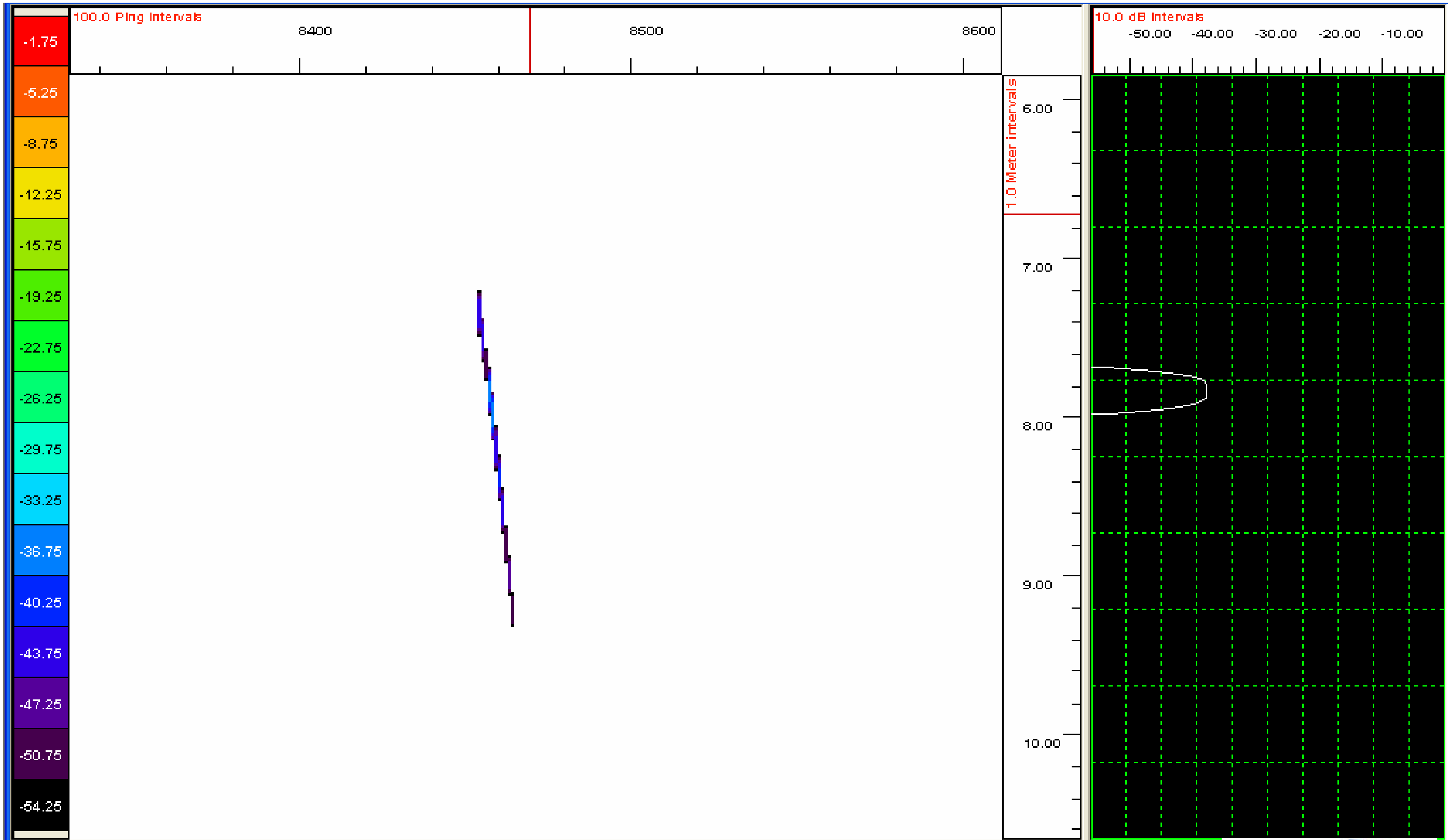
Does the echo have the appropriate shape relative to a theoretical echo?

Location of Adjacent Echoes



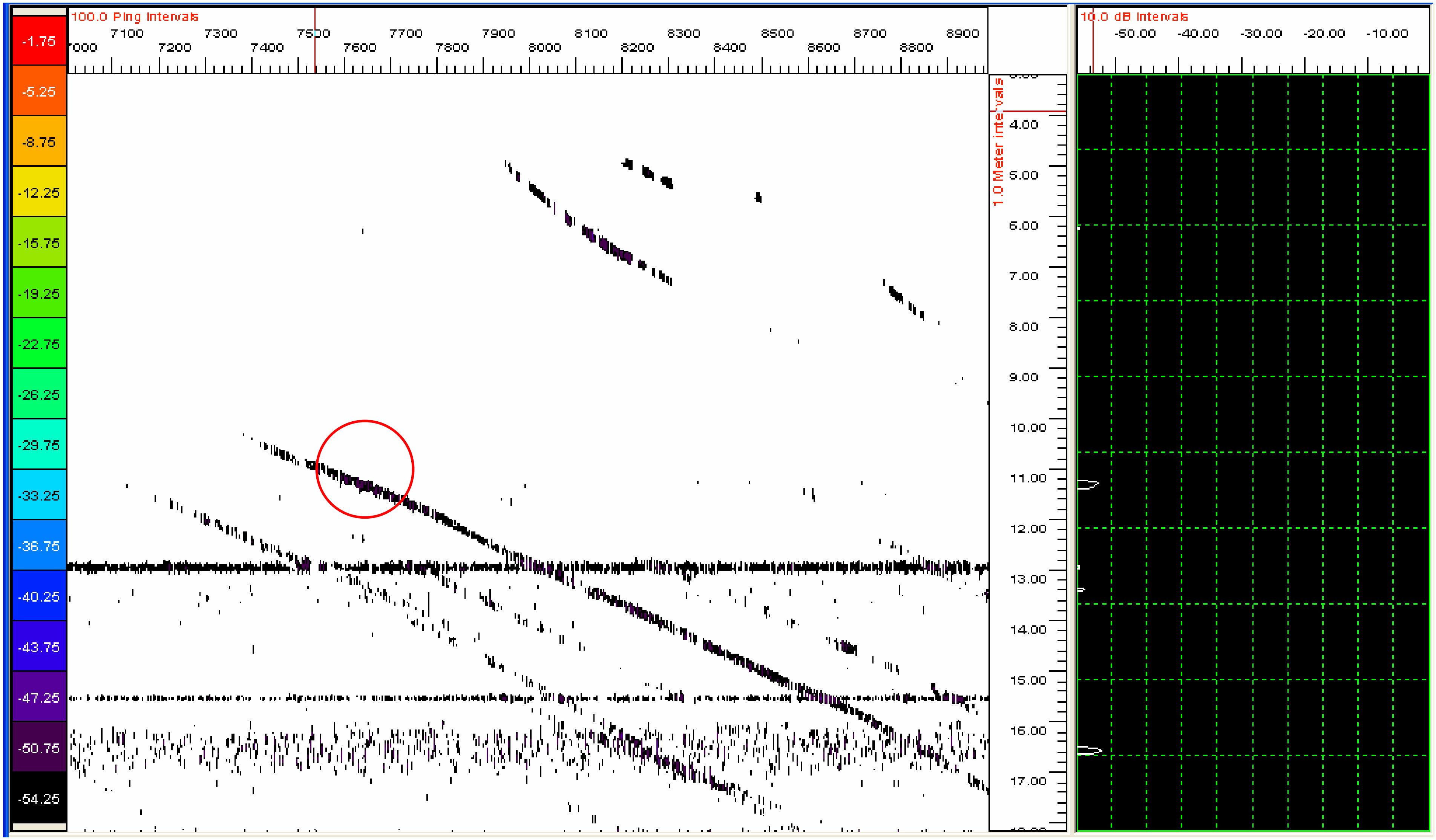
Linearity of Echoes

Number of Echoes in the Trace



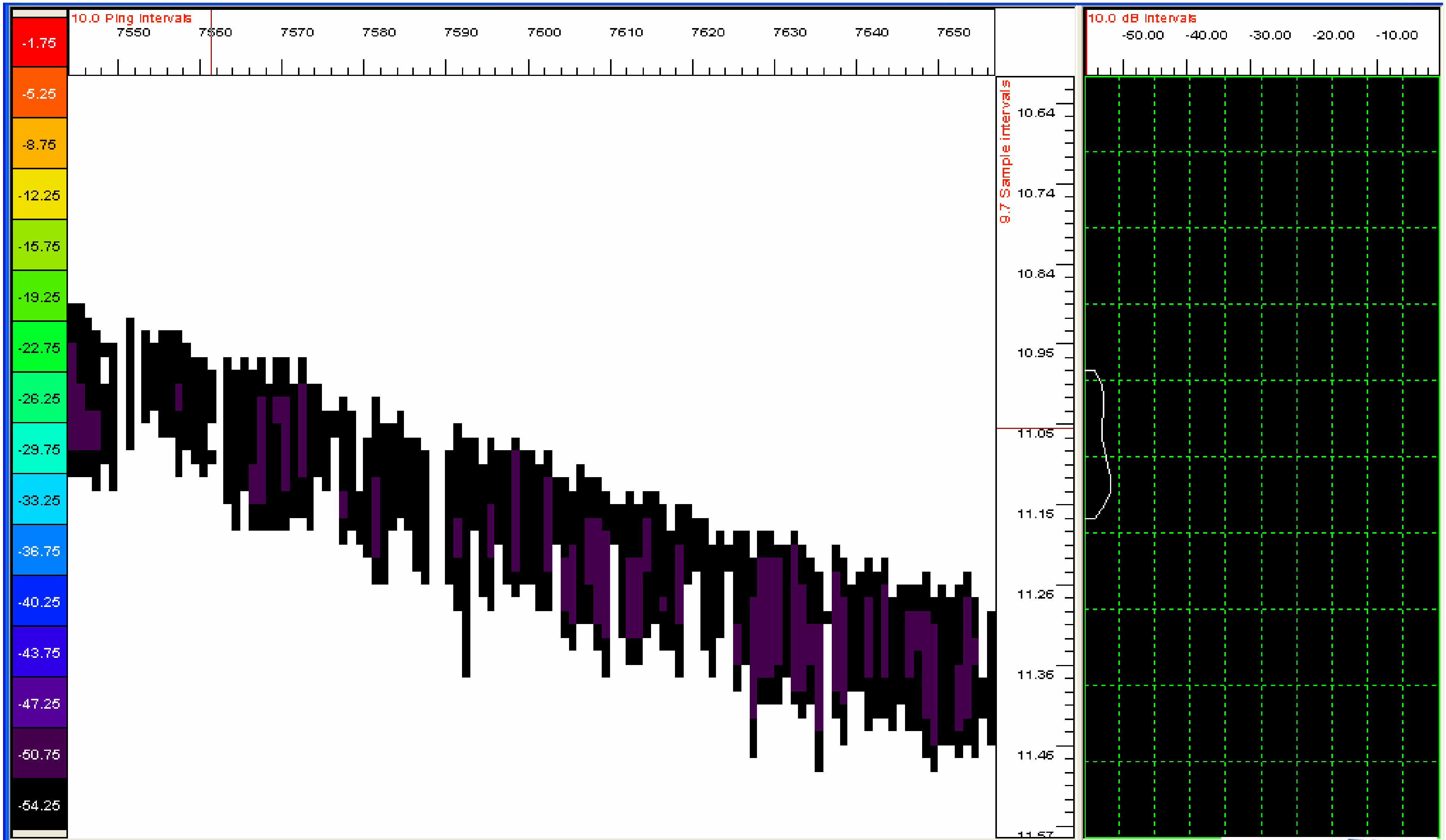
-1.75
-5.25
-8.75
-12.25
-15.75
-19.25
-22.75
-26.25
-29.75
-33.25
-36.75
-40.25
-43.75
-47.25
-50.75
-54.25
100.0 Ping Intervals
8400
8500
8600
1.0 Meter Intervals
6.00
7.00
8.00
9.00
10.00
10.0 dB Intervals
-50.00
-40.00
-30.00
-20.00
-10.00

BioSonics®



100.0 Ping Intervals
7000 7100 7200 7300 7400 7500 7600 7700 7800 7900 8000 8100 8200 8300 8400 8500 8600 8700 8800 8900
1.0 Meter intervals
4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00
10.0 dB Intervals
-50.00 -40.00 -30.00 -20.00 -10.00
-1.75 -5.25 -8.75 -12.25 -15.75 -19.25 -22.75 -26.25 -29.75 -33.25 -36.75 -40.25 -43.75 -47.25 -50.75 -54.25

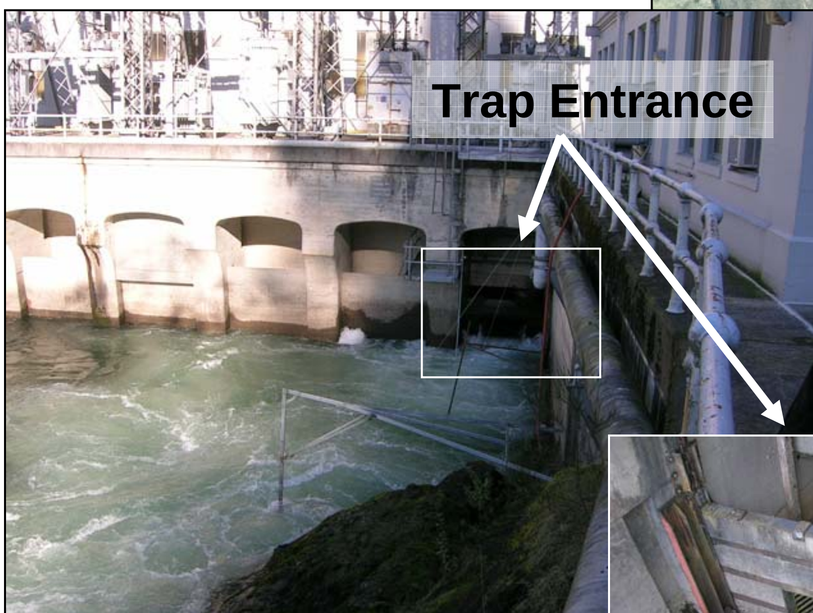
BioSonics®

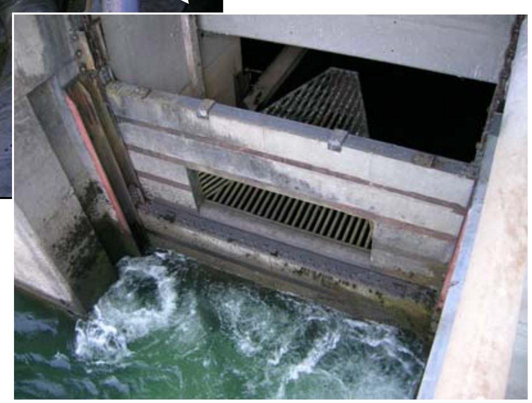

-1.75
-5.25
-8.75
-12.25
-15.75
-19.25
-22.75
-26.25
-29.75
-33.25
-36.75
-40.25
-43.75
-47.25
-50.75
-54.25
10.0 Ping intervals
7550
7560
7570
7580
7590
7600
7610
7620
7630
7640
7650
9.7 Sample intervals
10.64
10.74
10.84
10.95
11.05
11.15
11.26
11.36
11.46
10.0 dB intervals
-50.00
-40.00
-30.00
-20.00
-10.00

BioSonics®

Existing Merwin Trap Features

- Single Trap, 35cfs
- Fish hopper to truck
- No sorting facility





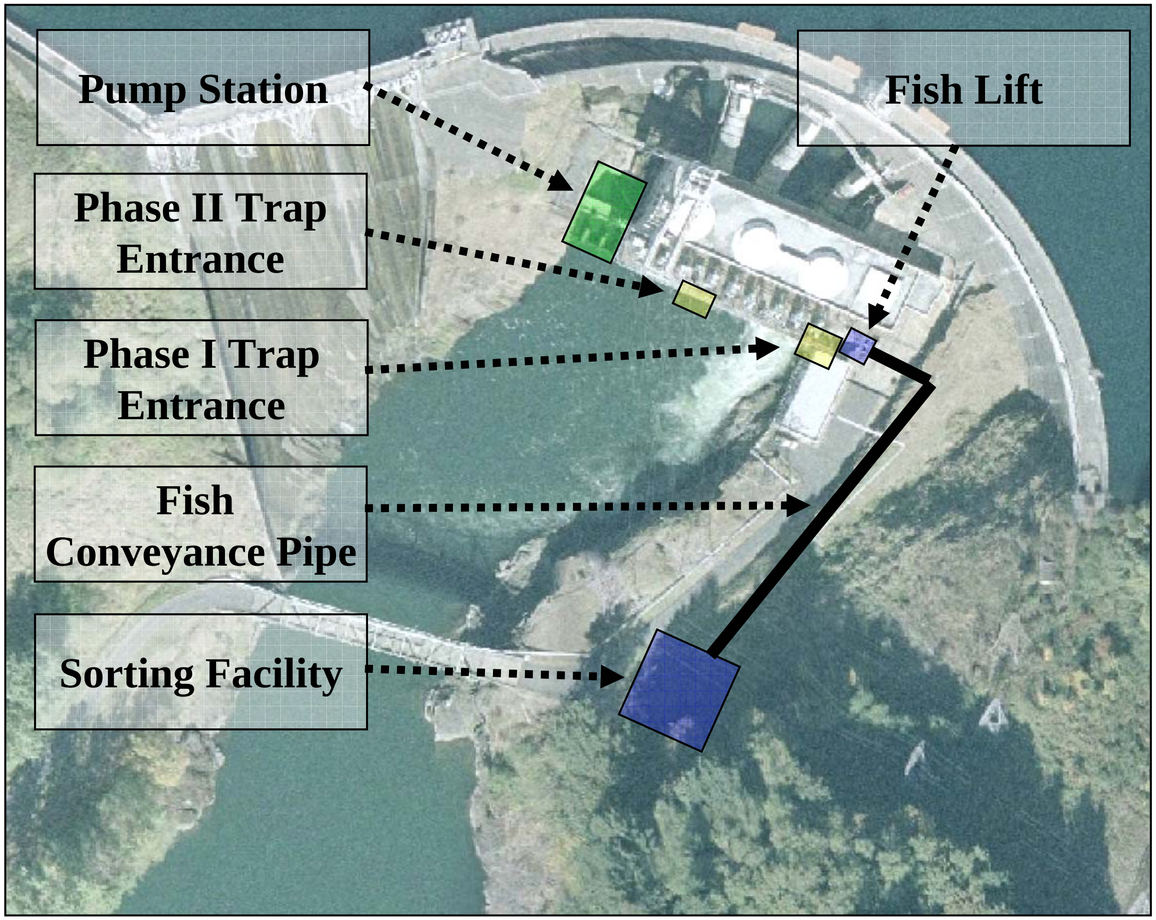
Merwin Trap – Design Considerations

- Foot print of Merwin Powerhouse
- Number of fish returning during a 24 hour period
- River flows under which the trap should be operational
- Specific flow and flow hydraulics through ladder
- Fish behavior
- Automated features to minimize safety risks
- Ability to sort, hold fish, then place in transport trucks with minimum stress to fish

Merwin Trap – Phased approach to construction

– Phase I
  - Corner Trap
  - Pump Station
  - 400cfs Max
  - Fish Lift
  - Sorting Facility

– Phase II
  - Add Entrance or
  - Add Pump
  - 600cfs max
  - Split flows Between Entrances



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A DIVISION OF PACIFICORP

825 NE Multnomah, Suite 1500
Portland, Oregon 97232

May 31, 2007

Merwin Upstream Collection and Transport Facility
Phased Implementation Proposal Summary

- Propose Phased Implementation
  - Phase I
    - Corner Trap (see Appendix C)
    - 400cfs attraction flow
    - Three to five year trap performance and fish behavior study
  - Phase II pending study outcome
    - Add second entrance (see Appendix D), OR
    - Add 200cfs attraction flow (see Appendix E), OR
    - Combination of both

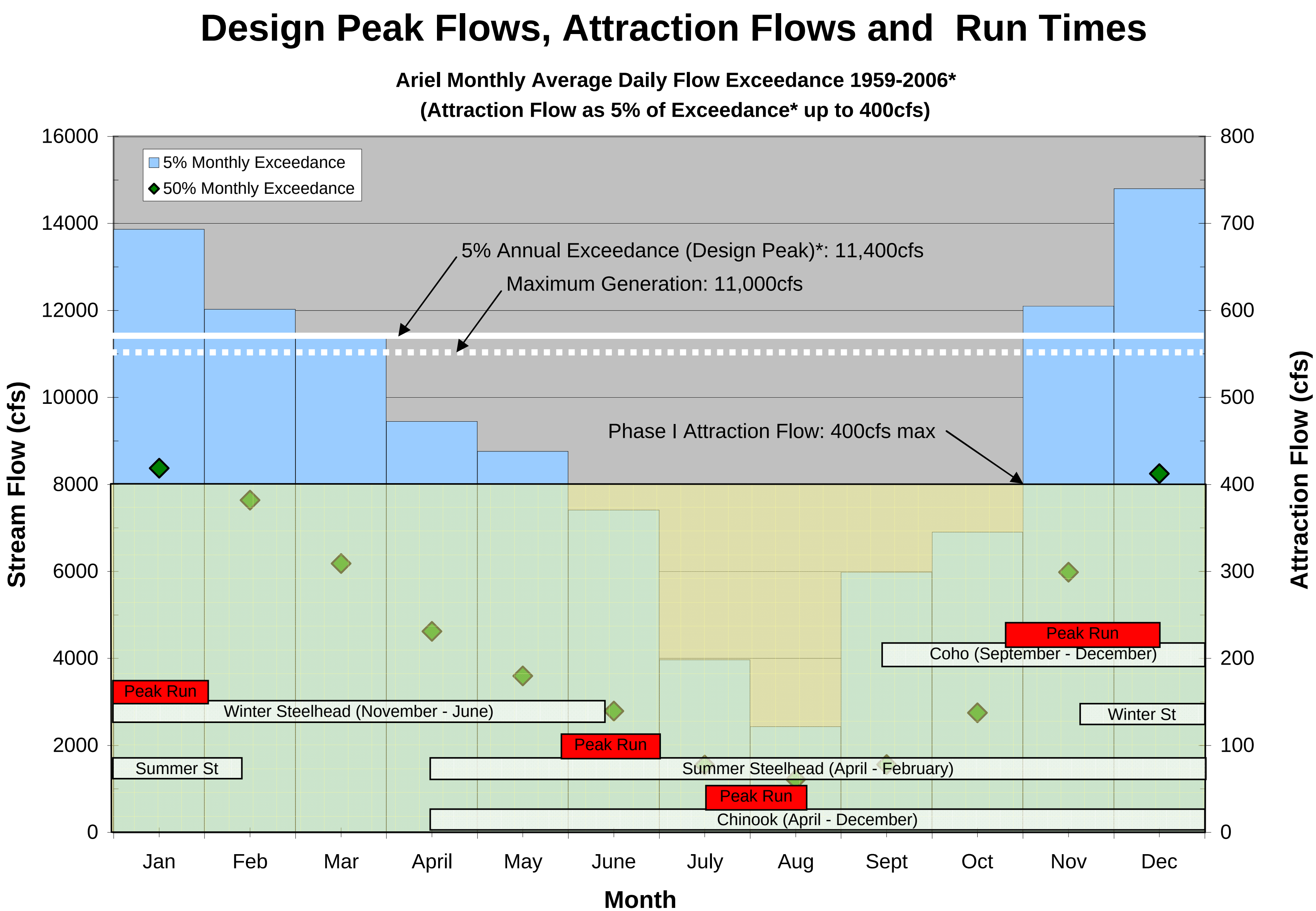
- Phased implementation will support the 95% ATE goal and will better implement resources where needed. Even if it is determined that Phase II enhancements are needed, the proposed three to five year study period will not significantly impact the long-term success of the re-introduction program.
  - Attraction flows provided by Phase I will meet or exceed NMFS guidelines during the Summer Steelhead and Spring Chinook peak runs (see Appendix A and Appendix B).
  - The proposed 400 cfs attraction flow is more than 10 times the existing flow of 35 cfs which is already successful in collecting Winter Steelhead and Coho brood stock and will support the H&S plan.

- Objective is to develop a study in collaboration with the agencies that includes measurable performance metrics and benchmarks. These metrics have not yet been specified, but may include the following:
  - Trap collection efficiency
  - Tailrace behavior
  - Fallback rate
  - Stress indicators (descaling, etc.)
  - Others

Appendix A
Species Run Time Summary

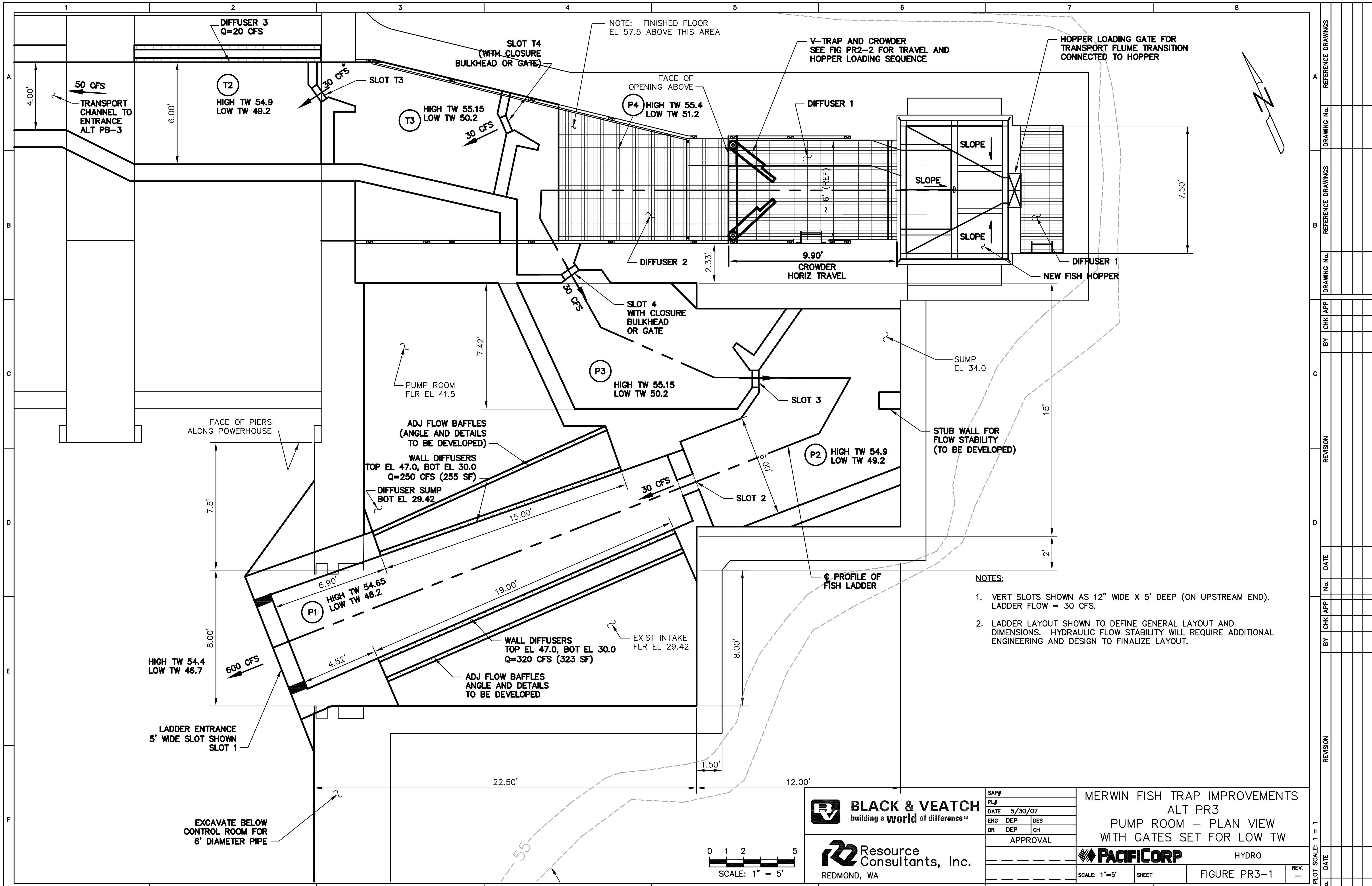
- ***Spring Chinook***
  - Almost all Spring Chinook will return when attraction flows meet or exceeds NMFS guidelines.
  - H&S Plan
    - Select 65 Natural Origin Returns (NORs) as broodstock
    - Actions to occur for 15 years then review.
    - Adults from juvenile supplementation program to be transported upstream upon return to Merwin trap.
- ***Summer Steelhead***
  - Almost all Summer Steelhead will return when attraction flows meet or exceed NMFS guidelines.
  - H&S Plan
    - Hatchery broodstock requirement is about 300 adults which is consistently met with current trap and 35cfs attraction flow.
    - No proposed changes for summer steelhead.
- ***Winter Steelhead***
  - Most Winter Steelhead will return when attraction flows are less than the 5% of design peak recommended in the NMFS guidelines. However, attraction flows will be no lower than 3% of design peak which is equal or better than other similar facilities in the region.
  - Hatchery broodstock requirement is only 60 adults, which is consistently met with existing trap and attraction flows of 35cfs.
  - H&S Plan
    - Select 50 NORs beginning March 1 to produce 50,000 smolts
    - Actions to occur for 15 years then review.
    - Adults from juvenile supplementation program to be transported upstream upon return to Merwin trap.
- ***Coho***
  - Almost all Early Coho return when attraction flows meet or exceed NMFS guidelines.
  - Late Coho will return when attraction flows are less than the 5% of design peak recommended in the NMFS guidelines. However, attraction flows will be no lower than 3% of design peak which is equal or better than other similar facilities in the region.
  - Hatchery broodstock requirements are currently met with current trap attraction flow of 35 cfs.
  - H&S Plan – A target of 9,000 adult early coho based on EDT habitat capacity to be transported and released upstream of Swift Dam.
  - The majority of adult coho are trapped and handled at the Lewis River ladder.

Appendix B – Design Peak Flows, Attraction Flows and Run TimeS



*Reference 1-18-07 Memo "Merwin Upstream 5% Exceedance Flow Estimates"

Appendix C - Corner Trap Plan


DIFFUSER 3
Q=20 CFS
50 CFS
TRANSPORT CHANNEL TO ENTRANCE ALT PB-3
4.00'
6.00'
T2
HIGH TW 54.9
LOW TW 49.2
30 CFS
SLOT T3
SLOT T4 (WITH CLOSURE BULKHEAD OR GATE)
T3
HIGH TW 55.15
LOW TW 50.2
30 CFS
NOTE: FINISHED FLOOR EL 57.5 ABOVE THIS AREA
FACE OF OPENING ABOVE
P4
HIGH TW 55.4
LOW TW 51.2
V-TRAP AND CROWDER SEE FIG PR2-2 FOR TRAVEL AND HOPPER LOADING SEQUENCE
DIFFUSER 1
6' (REF)
HOPPER LOADING GATE FOR TRANSPORT FLUME TRANSITION CONNECTED TO HOPPER
SLOPE
SLOPE
SLOPE
7.50'
DIFFUSER 2
2.33'
9.90'
CROWDER HORIZ TRAVEL
DIFFUSER 1
NEW FISH HOPPER
30 CFS
SLOT 4 WITH CLOSURE BULKHEAD OR GATE
7.42'
PUMP ROOM FLR EL 41.5
P3
HIGH TW 55.15
LOW TW 50.2
SLOT 3
SUMP EL 34.0
STUB WALL FOR FLOW STABILITY (TO BE DEVELOPED)
15'
FACE OF PIERS ALONG POWERHOUSE
ADJ FLOW BAFFLES (ANGLE AND DETAILS TO BE DEVELOPED)
WALL DIFFUSERS TOP EL 47.0, BOT EL 30.0 Q=250 CFS (255 SF)
DIFFUSER SUMP BOT EL 29.42
6.00'
P2
HIGH TW 54.9
LOW TW 49.2
30 CFS
SLOT 2
15.00'
7.5'
2'
6.90'
P1
HIGH TW 54.65
LOW TW 48.2
19.00'
℄ PROFILE OF FISH LADDER
EXIST INTAKE FLR EL 29.42
8.00'
8.00'
4.52'
WALL DIFFUSERS TOP EL 47.0, BOT EL 30.0 Q=320 CFS (323 SF)
ADJ FLOW BAFFLES ANGLE AND DETAILS TO BE DEVELOPED
HIGH TW 54.4
LOW TW 46.7
600 CFS
LADDER ENTRANCE 5' WIDE SLOT SHOWN SLOT 1
1.50'
22.50'
12.00'
EXCAVATE BELOW CONTROL ROOM FOR 6' DIAMETER PIPE
55
NOTES:
1. VERT SLOTS SHOWN AS 12" WIDE X 5' DEEP (ON UPSTREAM END). LADDER FLOW = 30 CFS.
2. LADDER LAYOUT SHOWN TO DEFINE GENERAL LAYOUT AND DIMENSIONS. HYDRAULIC FLOW STABILITY WILL REQUIRE ADDITIONAL ENGINEERING AND DESIGN TO FINALIZE LAYOUT.
SCALE: 1" = 5'
BLACK & VEATCH
building a world of difference
R2 Resource Consultants, Inc.
REDMOND, WA
SAP#
PL#
DATE 5/30/07
ENG DEP DES
DR DEP CH
APPROVAL
MERWIN FISH TRAP IMPROVEMENTS
ALT PR3
PUMP ROOM – PLAN VIEW
WITH GATES SET FOR LOW TW
PACIFICORP
HYDRO
SCALE: 1"=5'
SHEET
FIGURE PR3-1
REV. –
REFERENCE DRAWINGS
DRAWING No.
REVISION
PLOT SCALE: 1 = 1

CALCULATION SHEET

R2 Resource Consultants, Inc.

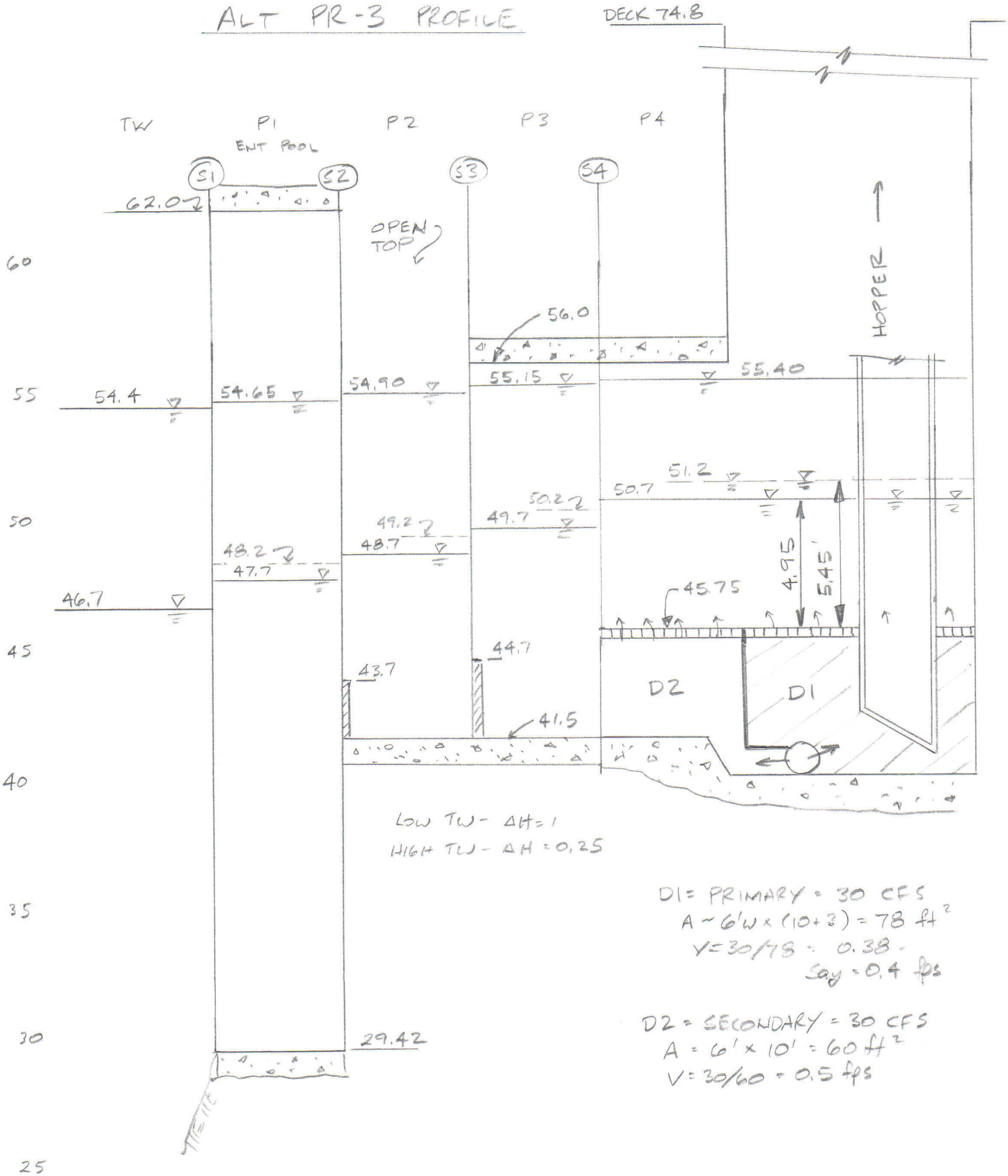
SHEET NO. 1/2

DESIGN BY DEP DATE 5/10/07 CHECKED BY ____ DATE ____

PROJECT Merwin Trap JOB NO. ____

SUBJECT ALT PR-3 + PB-3 - PROFILE CALCULATION NO. ____ FILE NO. ____

ALT PR-3 PROFILE

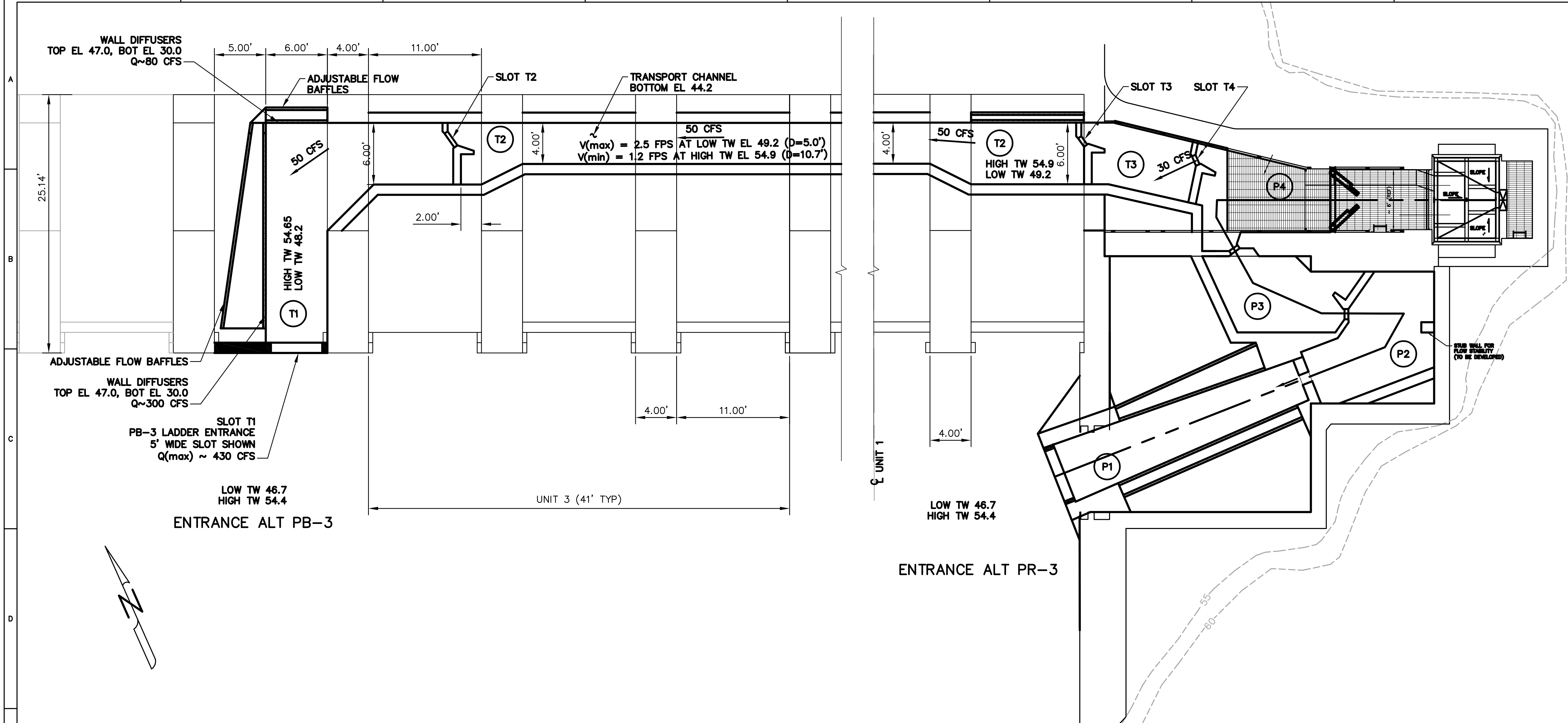


Low TW - ΔH = 1
HIGH TW - ΔH = 0.25

D1 = PRIMARY = 30 CFS
A ~ 6'W × (10+3) = 78 ft^2
V = 30/78 = 0.38
Say = 0.4 fps

D2 = SECONDARY = 30 CFS
A = 6' × 10' = 60 ft^2
V = 30/60 = 0.5 fps

Appendix D- Pump Bay Trap Plan (Center of Powerhouse)



NOTES:

1. CONFIGURATION SHOWS PLAN OF ALT PR3 AND PB3.
2. A SINGLE ENTRANCE FOR ALT PB3 CAN BE PROVIDED AT ANY PUMP BAY LOCATION.

SCALE: 1" = 10'

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Resource Consultants, Inc.
REDMOND, WA

SAP#	
PL#	
DATE	5/30/07
ENG DEP	DES
DR DEP	CH
APPROVAL	

MERWIN FISH TRAP IMPROVEMENTS
ALT PR3 & ALT PB3
OVERALL PLAN VIEW
PUMP ROOM AND PUMP BAY ENT

PACIFICORP — HYDRO

SCALE: 1"=10' | SHEET | FIG PR3-2 | REV. —

R2 Resource Consultants, Inc.

CALCULATION SHEET

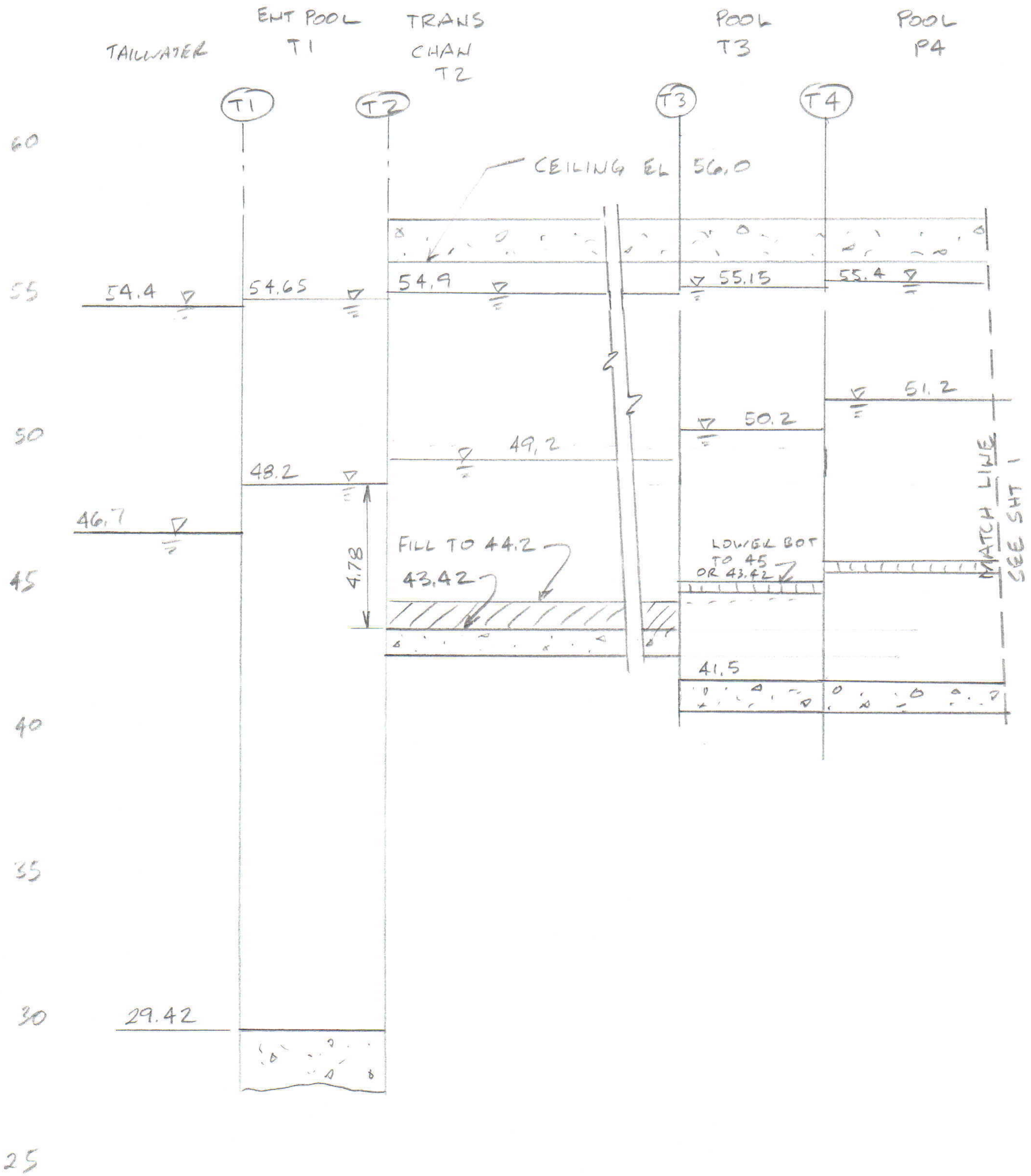
SHEET NO. 2/2

DESIGN BY DEP DATE 5/11/07 CHECKED BY ______ DATE ______

PROJECT MERWIN TRAP JOB NO. ______

SUBJECT ALT PR-3 + PB-3 - PROFILE CALCULATION NO. ______ FILE NO. ______

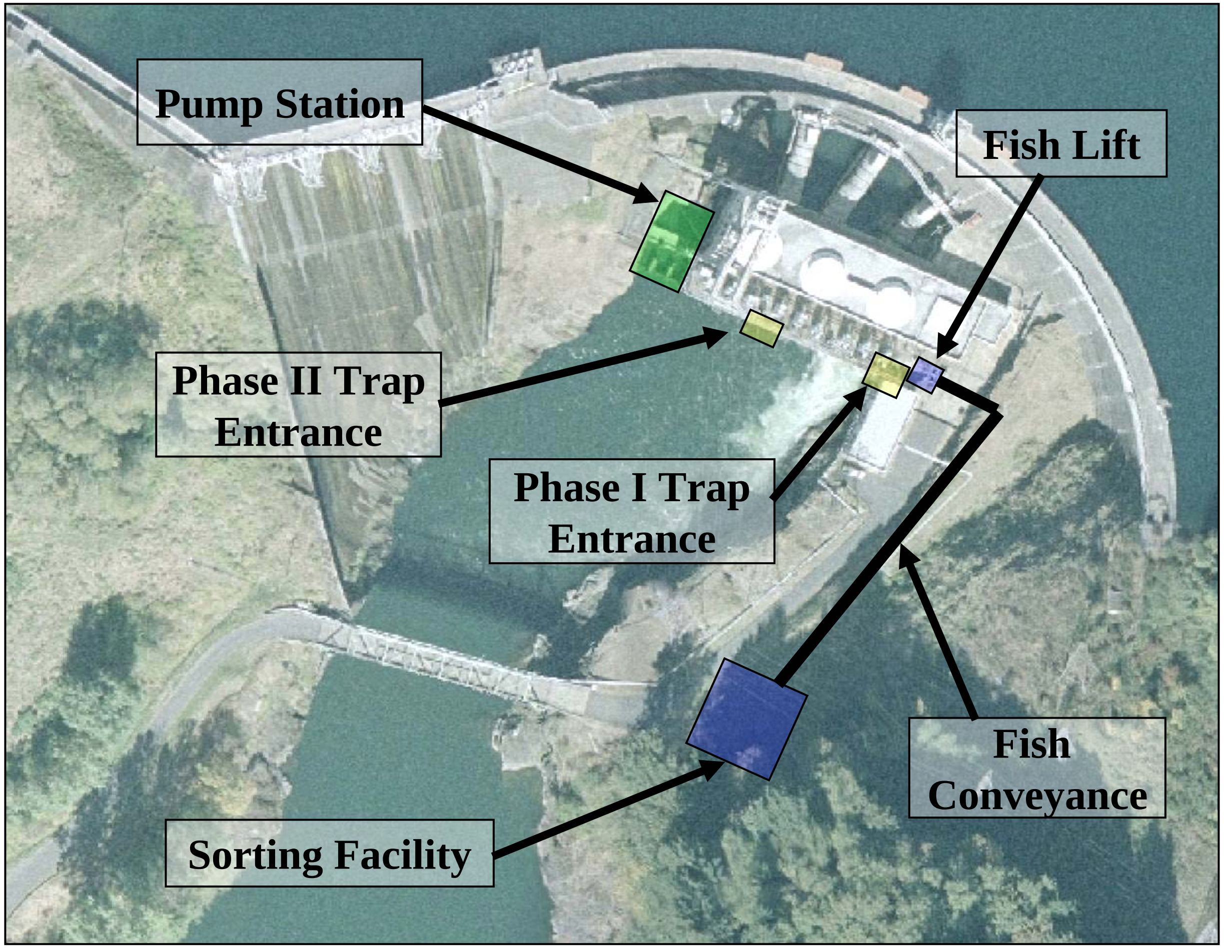
ALT PB-3 PROFILE



Appendix E - Bay 4 Pump Station Schematic

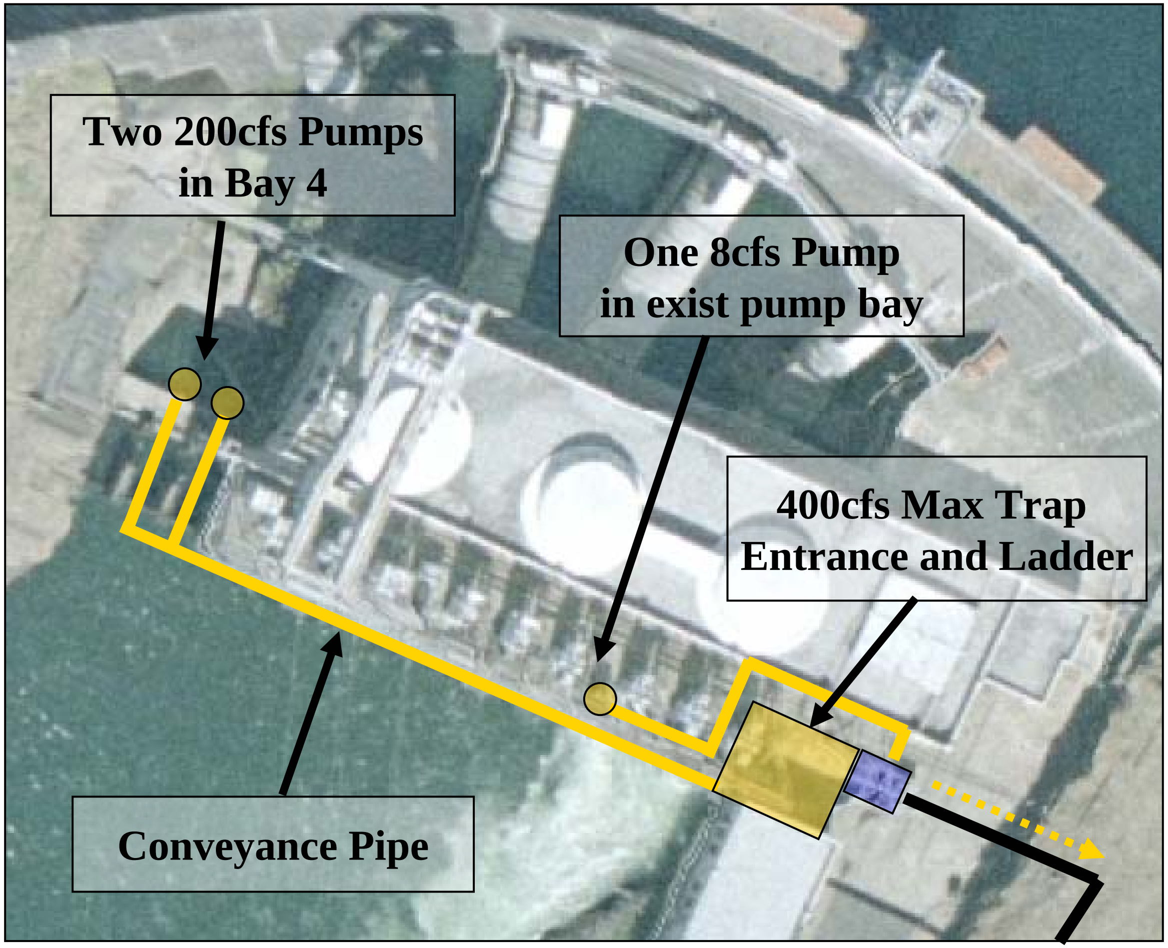
General Site Plan

- Merwin Dam Site



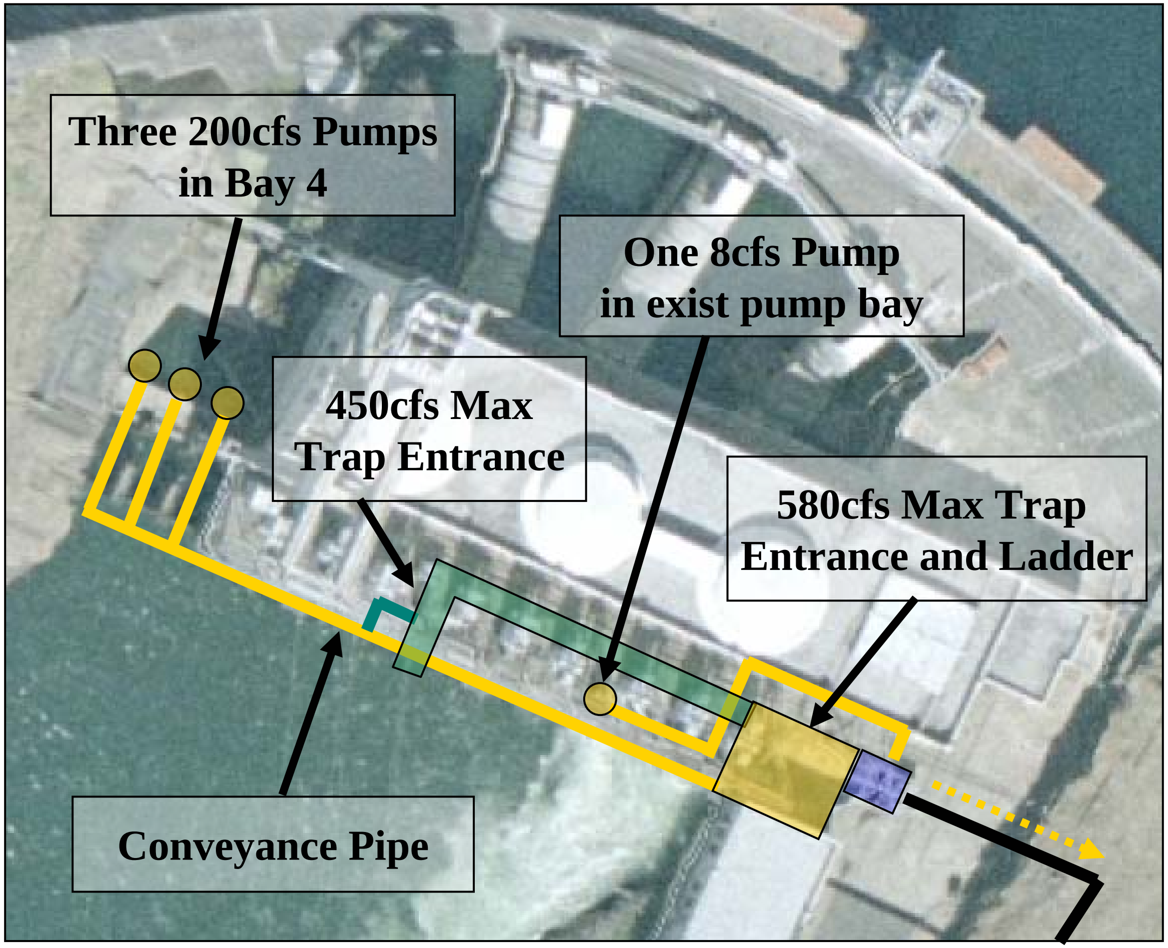
Phase I

- Corner Trap, Attraction Flow: 400cfs max

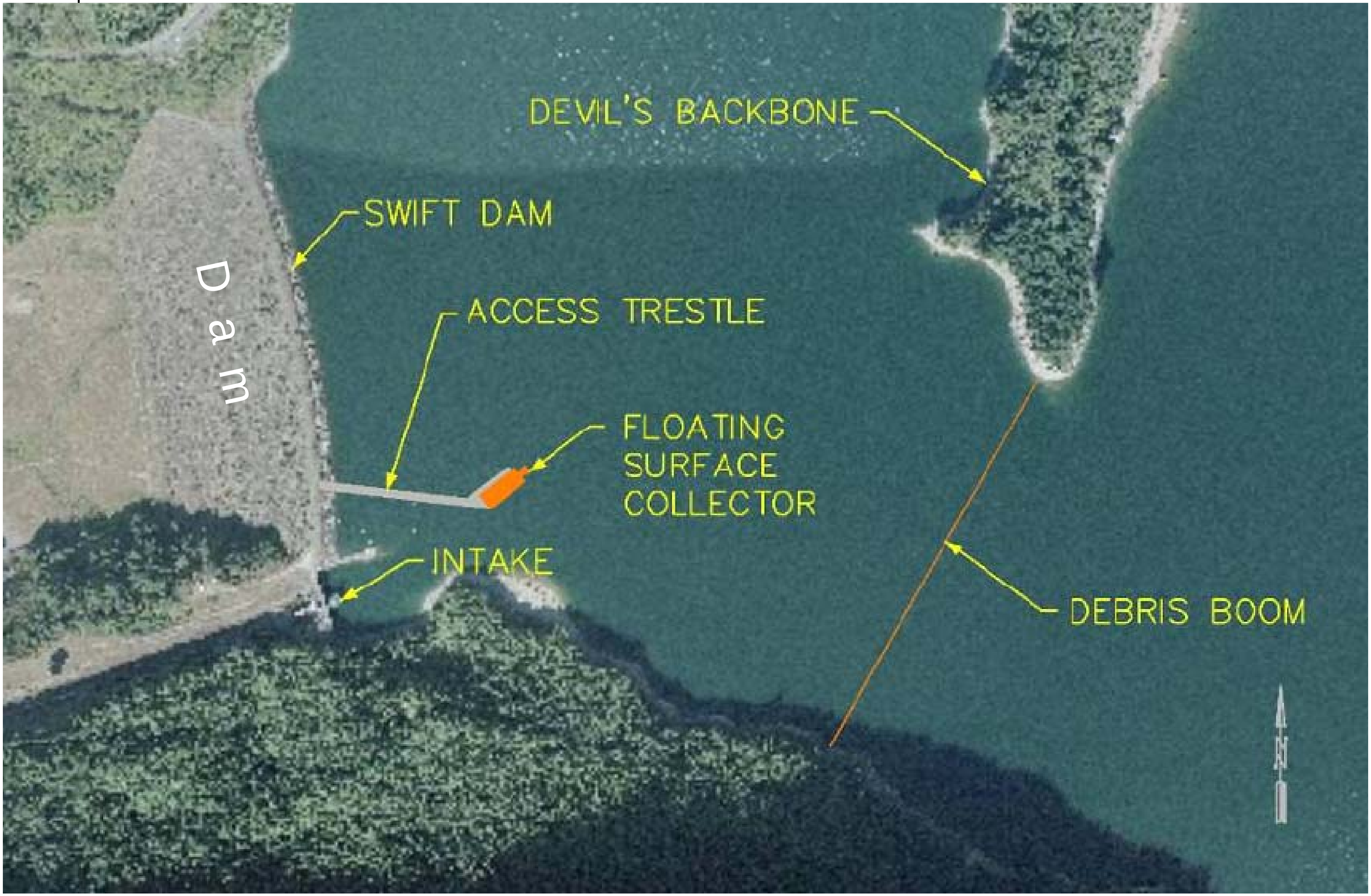


Phase II

- Add trap entrance and/or 200cfs Pump for 600cfs max



Swift Fish Collector - Location



Swift Fish Collector - Design Considerations

- Reservoir and Probable Maximum Flood operations
  - Operational between elevations 900 to 1000 ft msl.
- Year around operations
- Juvenile fish behavior
- Hydraulic Conditions
  - Favorable for fish collection
  - Gradual increase in velocity until fish are captured
- Floatation
  - Facility must stay level to achieve the design velocities

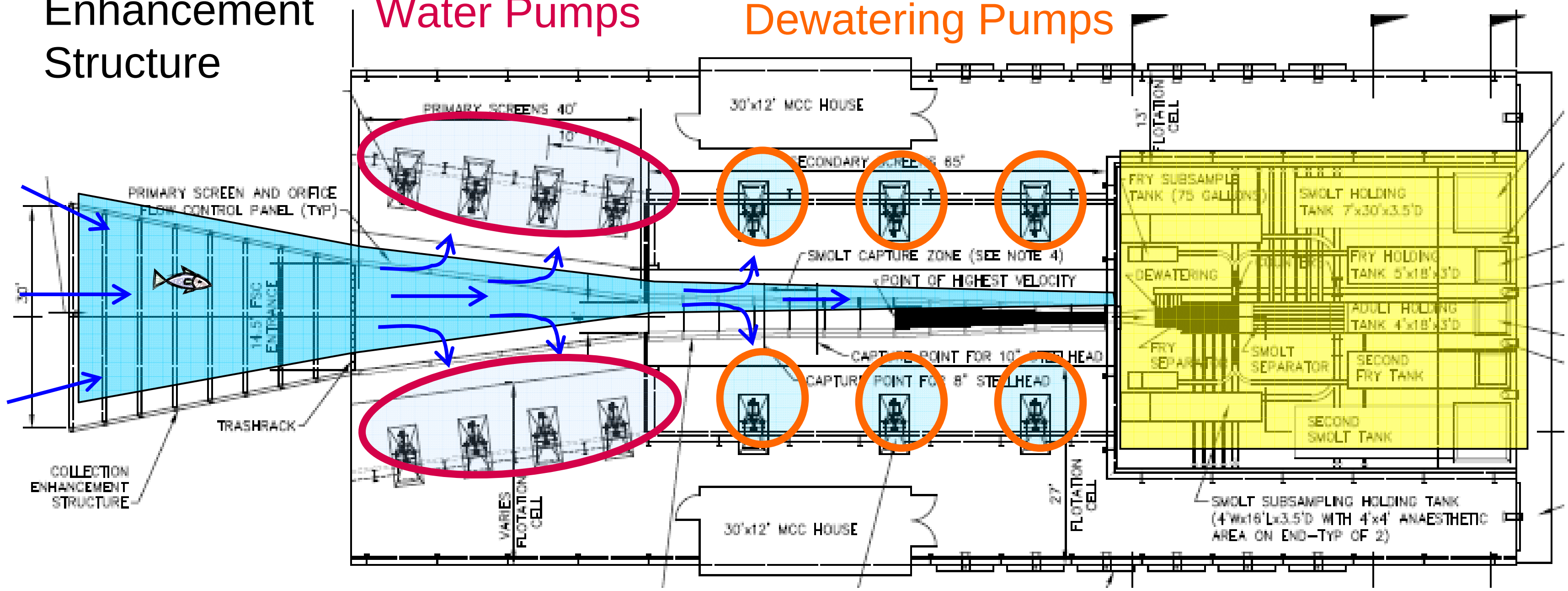
Swift Fish Collector

Collection Enhancement Structure

Primary Attraction Water Pumps

Secondary Dewatering Pumps

Sorting Area



600 cfs → **200 cfs** → **7 cfs**

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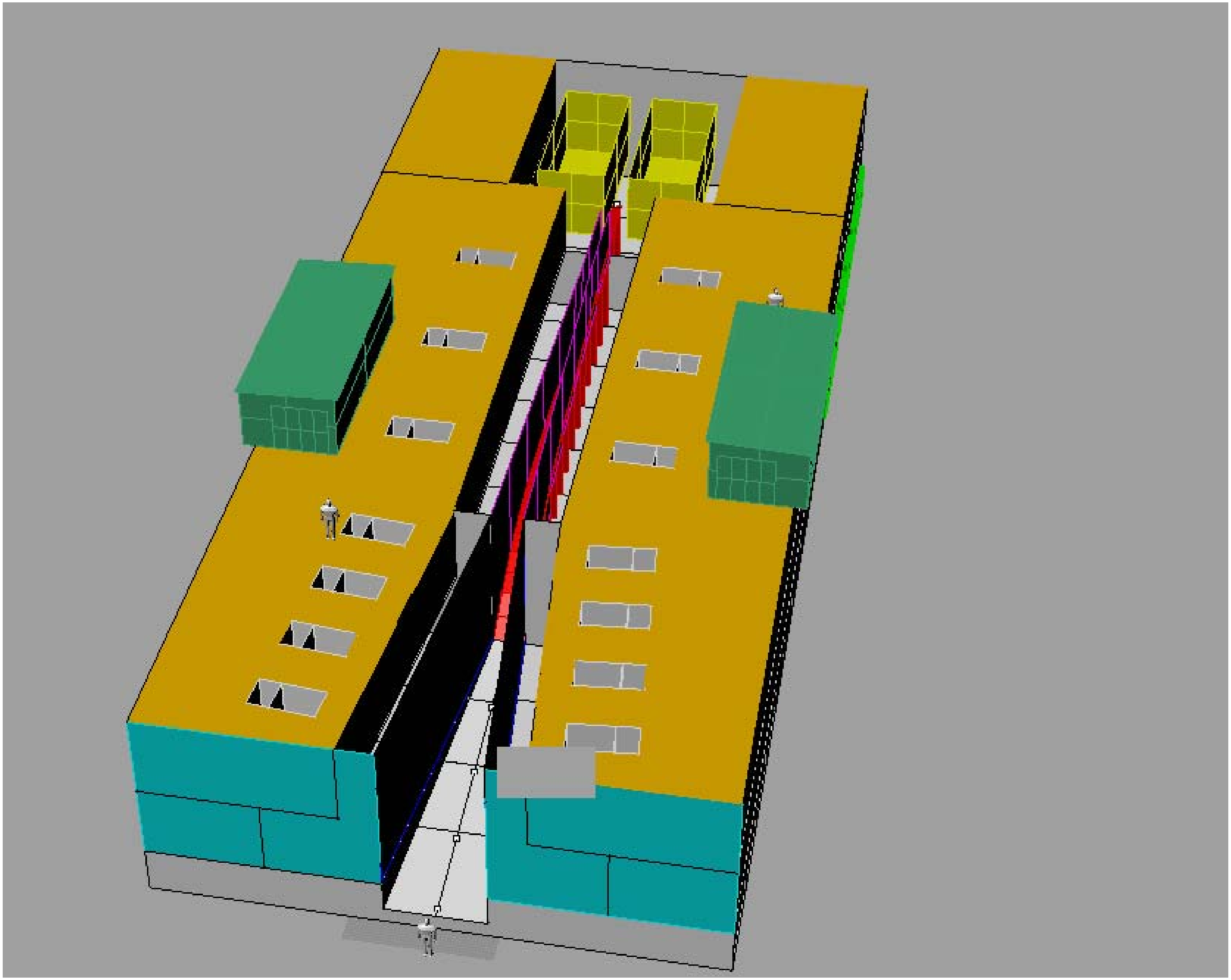
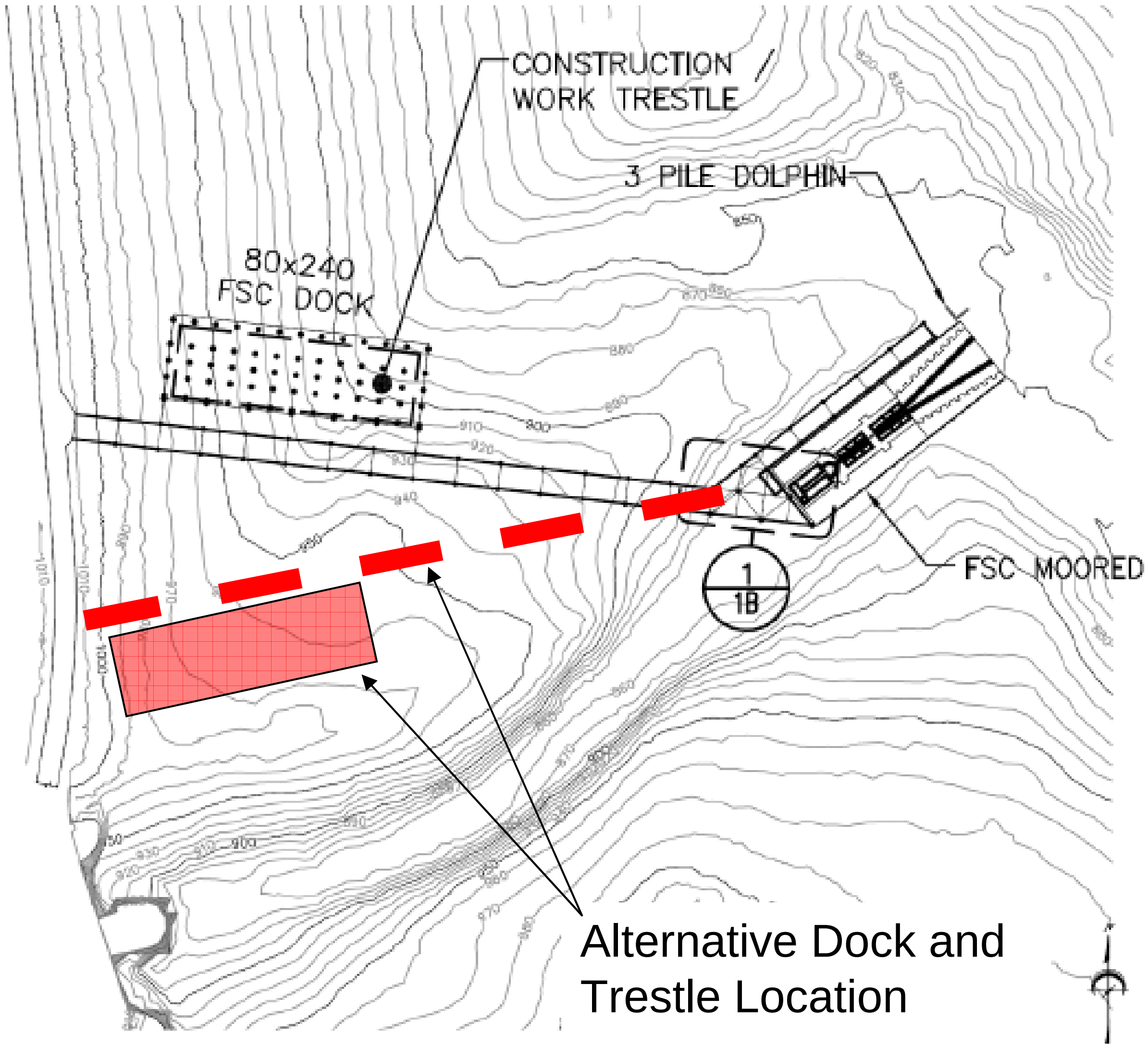
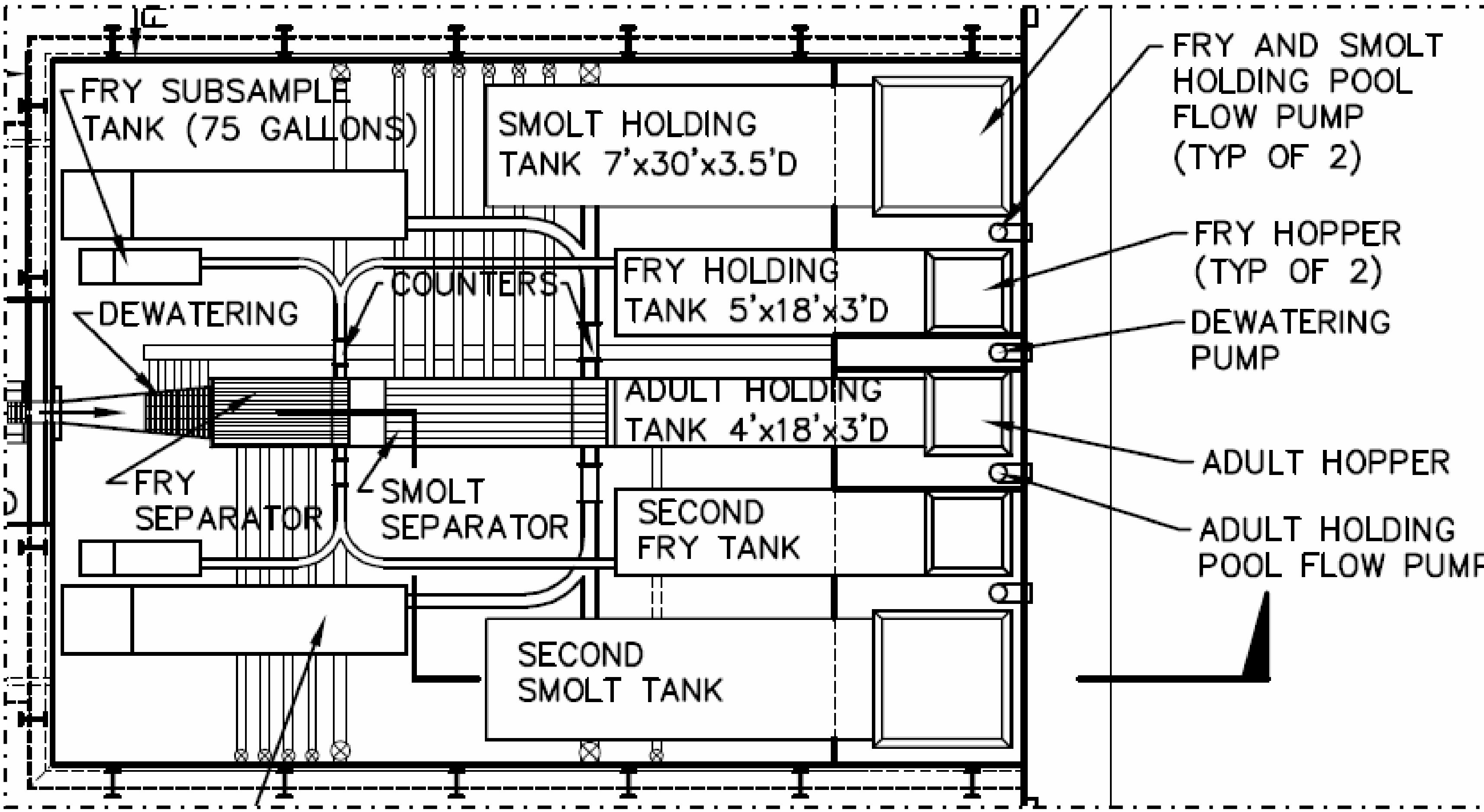


Swift Fish Collector – Trestle and Mooring



Swift Fish Collector – Sorting Area



Washington Dept of Fish and Wildlife
Region 5
2108 Grand Blvd.
Vancouver, WA 98661

Tuesday, June 12, 2007

Frank Shrier
PacifiCorp
825 NE Multnomah,
Portland, OR 97232

Dear Mr. Shrier,

The Washington Department of Fish and Wildlife (WDFW) sent written comments regarding the 2007 Habitat Preparation Plan (Plan) to PacifiCorp on May 31, 2007 (see Attachment 1). The final version of the plan, dated June 6, 2007, did not incorporate our comments or address our concerns. Section 3.0 of the Plan states, "*On an annual basis this plan shall be reviewed and modified if necessary by the Aquatics Coordination Committee.*" It was our intention that our comments be considered by the entire ACC as potential modifications to the plan.

WDFW's position is that adult coho placed into Swift Reservoir should have their movements monitored in order to determine spawning areas. This information is valuable in order to know where redds are dug (i.e., where gravel is conditioned), the distribution of usable spawning habitat, the distribution of carcass nutrients, and what tributaries produce coho parr that could compete and predate on bull trout. In 2006, WDFW and PacifiCorp staff identified juvenile coho salmon present commingled with bull trout young of the year in the P-7 and P-8 tributaries of Pine Creek. These coho parr now have the opportunity to prey upon (i.e., "take") listed bull trout. Additionally, coho juveniles have been observed in Range, Drift and S-10 Creeks.

We note that Bernadette Hudson, representing the Lower Columbia Fish Recovery Board (LCFRB), also expressed the value of monitoring coho movements in her comments to PacifiCorp dated May 31, 2007. We believe these concerns of WDFW and LCFRB should at least be referenced in the final draft. Furthermore, ACC members should be given the opportunity to discuss the coho distribution issue, and if concurrence is achieved, an adult coho monitoring task should be incorporated into the revised Plan.

The Plan states: "*According to the settlement agreement schedule (Section 7.4: Habitat Preparation Plan), excess hatchery fish will be transported to Swift reservoir from 2005 through 2009, to Yale reservoir from 2014 through 2018 and to Merwin reservoir from 2018 through 2022. This schedule will provide nutrient enhancement and spawning gravel preparation for formal reintroduction efforts as described in Section 4.0 of Settlement Agreement.*"

This time line was based on the assumption that a completed license would be issued in 2003 or 2004. Since the time for license issuance has slipped, the plan should reflect that fish will be placed in Swift Reservoirs for five years after the license is issued. For example, if the license is issued this year (2007), then fish should be placed in Swift through 2012. Since the placement of fish is designed for preparation of spawning gravels, it would be most advantageous to continue conditioning the gravels through 2012 – when full reintroduction and downstream passage is scheduled to begin. Similarly, the timelines on placing adult hatchery fish in the other reservoirs would slip by the same number of years

I thank you in advance for consideration of our comments and concerns. Please feel free to contact Steve Vigg, John Weinheimer, and/or Jim Byrne if you wish to discuss the issues in more detail.

Sincerely,

Patrick A. Frazier
Regional Fish Program Manager – Region 5
Washington Department of Fish and Wildlife

Attachment.

Attachment 1. WDFW comments sent to Kimberly McCune May 31, 2007

>>> John Weinheimer 05/31/2007 3:06 PM >>>

Hi Kim, here are some comments from Jim Byrne for WDFW:

This will be the third year that 2,000 coho will be released at the Swift boat ramp. When the idea of releasing large numbers of coho above Swift was first raised in the Aquatics Resource Group (ARG), WDFW made a strong case that the movements of these fish should be monitored.

WDFW proposed using stream walkers, floats and ariel surveys to follow coho movements; basically duplicating the proven techniques used in annual steelhead spawner surveys. The response was inadequate, one helicopter flight was organized, and only two redds were spotted.

There also was discussion where coho might travel. Concerns were voiced that coho might ascend into Rush or Pine Creeks (the only bull trout spawning streams in the upper basin) and negatively interact with juvenile bull trout. It was proposed that coho would not ascend, due to high flows in these stream. The language in the present spawning agreement does not call for any tracking of fish although it provides for annual modifications (Section 3.0).

In snorkels and electroshocking in the P-7 and P-8 tributaries of Pine Creek during 2006, PacifiCorp and WDFW personnel found substantial number of coho parr. These parr have the potential to prey upon bull trout young of the year. Coho fry were also found in tributary streams to Swift Reservoir, where they were not expected. This unintended consequence of random release of coho adults may put listed bull trout at additional risk.

WDFW plans to put additional efforts on P-7 and P-8 to attempt to quantify the coho-bull trout balance in these streams. This episode highlights the importance of base line and subsequent monitoring efforts. WDFW believes there is still value in determining coho spawning locations in the upper basin, and the feels plan should be modified to incorporate a series of adequate spawner surveys throughout the upper basin.

The plan stipulates that adult placement would be limited to five years. It was not anticipated that the license would be delayed. WDFW proposes that the plan be continued until the completion of the Swift downstream passage facility.

Take care, John W.