US Army Corps of Engineers
North Pacific Division

Salmon Passage Notes

Snake and Columbia River Fish Programs

September 1995

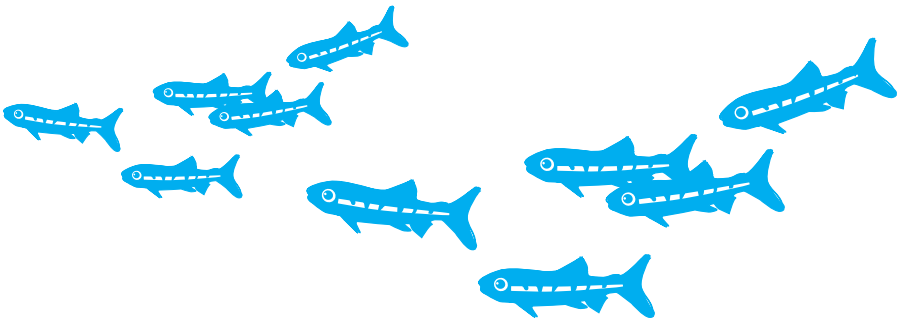
1995 Migration Exceeds Expectations

by Sonya Bruce, Resource Writers Incorporated.

They arrived by the tens of thousands, from the Clearwater and the Salmon, the Imnaha and the Grand Ronde, the Yakima and the Okanogan. In all, yearling and subyearling salmon and steelhead smolts passed Snake and Columbia River dams by the millions this spring, exceeding biologists' pre-season predictions. The number of smolts peaked in May, with a record 910,000 smolts collected in one day at Lower Granite Dam. Counts remained strong well into June, with several hundred thousand smolts a day entering collection systems at the projects.

There was a surprisingly large 1995 out-migration, according to Corps fishery biologist Jim Athearn, outdistancing 1993 and 1994 by millions of fish. The number of wild Snake River smolts in the migration, while a small percentage of the total, was estimated at twice what it has been in either of the past two years, with over 1.4 million collected and 1.2 million transported at the Snake River dams.

Even with many of the juvenile fish being diverted away from the bypass systems and over the spillways, over 24.4 million smolts of all species, hatchery and wild, came into collection facilities at Lower Granite, Little Goose and Lower Monumental Dams on the Snake River, and into McNary Dam on the Columbia. About 75 percent of these fish were transported down the river and released below Bonneville Dam. The remainder were bypassed back into the river, with some tagged as part of a study to compare adult returns of salmon migrating in-river versus those transported by barge.



Spill was a major means of moving juvenile salmon past the concrete this migration season.

Wild Snake River spring and summer chinook salmon, species protected under the Endangered Species Act, are of particular interest because measures outlined in the NMFS 1995 Biological Opinion are tailored to speed their recovery. NMFS' pre-season estimate for wild spring and summer chinook smolts was 1.3 million. By July 3, that number of wild chinook smolts had been collected from lower Snake River dams, and NMFS raised the estimated total to over 1.8 million.

Determining the actual number of smolts that pass through the Columbia and Snake River system in the spring is a difficult proposition. NMFS' Biological Opinion calls for spill as one passage route to get smolts past the dams. Fewer fish enter the juvenile bypass system collection areas when large amounts of water are being spilled, and there is no accurate way to gauge how many fish go over the spillways.

The best we can do, Athearn said, is assume a given proportion is being spilled, based on the percentage of the river flow that is spilling. For example, if 30 percent of the inflow is being spilled, we can assume that 30 percent of the smolts go with the spill, he said. But even that is a risky assumption since spill occurs largely at night, when most smolts move down the river and when it interferes less with returning adult fish, which generally travel during the day.

Some of the smolts bypassed at each dam might enter the collection system at another dam downstream, further complicating the estimates. As Athearn explained, we don't know which of the

fish bypassed at one project are bypassed at the next and so forth. Even the hatchery release counts have an element of uncertainty; a percentage of these smolts become "residuals" that never leave the river; many others die before reaching the first dam.

Despite the difficulties, the numbers suggest the 1995 smolt migration far exceeded pre-season expectations. Based on daily evaluations of fish condition, the fish were also judged to be healthy.

Neither the 1996 nor the 1997 out-migrations are expected to come close to this year since adult returns have taken a drastic downturn in recent years. That trend continued this year, with only 10,194 adult spring chinook and 15,030 summer chinook salmon passing Bonneville Dam by the end of July. The 10-year averages are 84,000 and 24,000, respectively, for these runs. The adult spring chinook count is 50 percent of what it was last year, while summer chinook salmon returned at 84 percent of last year's count.

In addition to the adults, there were 2,375 spring and 2,068 summer chinook jacks, precocious males that return to spawn after only one year in the ocean. The jack spring chinook count at Bonneville Dam was six times better this year than last, and twice as high as 1993, while summer chinook jacks were only slightly better than 1994 counts.

A high jack count can presage a good return of adults the following year. There may not be a dramatic improvement in 1996, but the increased jack count could mean more adults in 1996 despite the fact that poor outmigrations in 1993 and 1994 will be rippling through the population for the next few years.

Counting Smolts

How do you count thousands of 4 to 12-inch smolts in a holding tank? Fish by fish," according to Dave Hurson, a biologist with the Corps' Walla Walla office. While initial smolt estimates are derived electronically, the Corps's final fish collection and transportation numbers come from actual hand counts that correct the electronic tallies and check for different species.

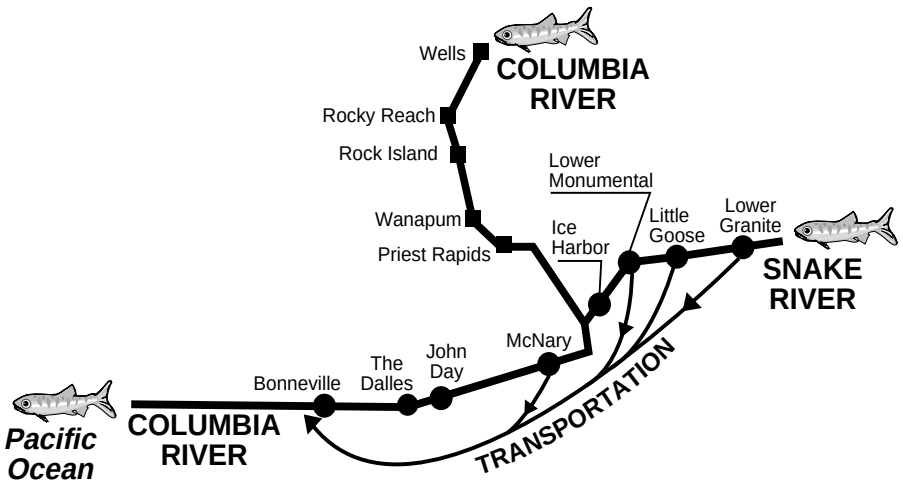
Biologists conduct counts using an automatically timed gate between the fish collection system and a sampling tank. On a predetermined schedule, the gate flips open, usually for only a matter of seconds, to let the smolts swim into the tank. The smolts are counted electronically as they swim from the sample tank to the sample holding tank, where they accumulate until the next morning.

To confirm the count and verify species, the smolts in the sample holding tank are recounted by hand. There can be thousands of smolts in each sample during the peak of the migration, and it takes a team of human counters to do the job. The fish are then released to continue their migration.

A 10 percent sample means opening the gate and collecting smolts for a total of six minutes during a given hour. The count is then extrapolated to the entire 60 minutes to estimate the total smolts collected.

The Corps loads barges and trucks by weight, and the smolts vary greatly in length and size. It may take up to 20 chinook salmon or as few as four steelhead to total a pound. The electronic counts, coupled with the species breakdown weight estimates, are used to assure that the transport vehicles are not overloaded on any given trip.

Fish Transport Route



Implementing Plans for Salmon

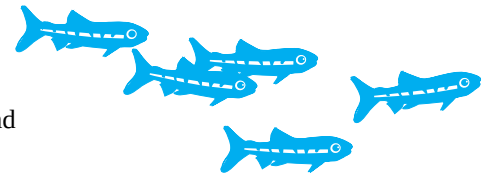
Since the listings of three species of Snake River salmon under the Endangered Species Act in 1991 and 1992, the region has intensified efforts to improve conditions for these fish. Snake River sockeye, spring/ summer chinook and fall chinook salmon species are all considered in danger of extinction.

A number of factors have contributed to the current state of salmon stocks in the Columbia and Snake River Basin. Among these are the Corps' eight hydroelectric dams on the lower Columbia and Snake Rivers. The dams impede fish migration, and create reservoirs that alter water velocities and temperatures, interfering with juvenile salmon migration patterns and improving conditions for slow-water predators.

In March 1995, the National Marine Fisheries Service issued a Biological Opinion for 1995 and future years on planned operation of the federal hydropower system, calling for a number of actions at the dams to halt and reverse declines of the listed Snake River salmon species. The Corps subsequently issued a Record of Decision to implement these actions.

These include operational and physical changes at the dams and studies of alternative changes, for the near and long terms.

1995 River Operations for Fish



Operation of the federal hydro system projects this spring and summer stacked up well against the flow and spill objectives for salmon outlined in the National Marine Fisheries Service (NMFS) Biological Opinion on hydrosystem operations.

The Biological Opinion, released by NMFS in March, called for increased flows in the Columbia and Snake Rivers to assist juvenile fish in their downsteam migration.

The Opinion established an adaptive management approach for implementing its recommendations throughout the migration season. This in-season management is accomplished primarily through the Technical Management Team (TMT) which is composed of federal managers from NMFS, Bureau of Reclamation, Bonneville Power Administration, U. S. Fish and Wildlife Service (USFWS) and the Corps.

TMT weekly meetings provide a forum to receive and review water conditions and flow forecasts, biological data and recommendations from NMFS, USFWS, and from state and tribal fishery interests as well as pertinent information from other concerned or affected parties.

The Opinion called for flow objectives to be met at Lower Granite Dam on the lower Snake River and at McNary Dam on the Columbia. Objectives for the spring period are based on runoff forecasts and were 95 thousand cubic feet per second (kcfs) at Lower Granite, beginning April 10. At McNary, the spring flow objective was 249 kcfs beginning April 20.

Flow objectives for the summer period were 51.4 kcfs at Lower Granite (June 21 to August 31) and 200 kcfs at McNary (July 1 to August 31).

In April, May and June, target flows were successfully met for the most part. On the Snake River, flows throughout the spring and summer **averaged** slightly above the objectives.

On the Columbia River the flow objectives at McNary Dam were met in the spring portion of the juvenile salmon migration but as expected, the summer flow objectives could not be met. Studies indicate in only two years of an historical 50-year period have flows been high enough to meet the 200 kcfs flow objective at McNary.

The Corps and Bureau of Reclamation held off drafting storage reservoirs to meet flow objectives until after April 10 based on recommendations from the Technical Management Team (TMT). Because of a cool spring, the juvenile salmon out-migration got off to a slow start and the team decided to save water for use later in the migration period when higher flows would be more beneficial to juvenile salmon. When smolt migration picked up later in the month, releases began from Grand Coulee and Dworshak projects.

In addition to flow objectives, the Biological Opinion recommends that 80 percent of migrating juvenile salmon pass the dams via non-turbine routes—through the bypass and collection system or over the spillway.

This 80 percent fish passage efficiency (FPE) goal requires much of the flow at each project to be routed over dam spillways. Spill at projects that normally would be collecting juvenile fish, reduces the number of fish transported. The Biological Opinion called for spill at the four lower Snake River dams from April 10 through June 20 and from April 20 through June 30 at the four Columbia River dams except during periods of low flow conditions.

During low flow conditions, the Biological Opinion calls for limited spill so that more fish would be transported from dams with fish collection facilities, or “collector” dams, unless the TMT recommended otherwise.

Spill occurred 24 hours a day at Ice Harbor Dam on the Snake and at John Day, The Dalles and Bonneville dams on the Columbia throughout the Spring period specified by the Opinion. Spill at the collector dams—Lower Granite, Little Goose and Lower Monumental on the Snake River, and McNary on the Columbia—during the Spring period was for 12 hours at night, when the highest number of smolts tend to move past the dams.

While spill helps smolts get past dams, it can pose a threat to fish in the form of gas bubble trauma. Because Northwest states have water quality standards for gas supersaturation, NMFS requested and received waivers from Idaho, Oregon and Washington to allow gas levels caused by the spill to exceed their standards. The states allowed gas levels up to 120 percent below the dams and no more than 115 percent at the forebay above the next downstream dam.

At times, spill had to be reduced or curtailed at some dams when total dissolved gas levels exceeded the allowed state water quality standards. Data from the instruments measuring total dissolved gas was entered into a data base every four hours and necessary adjustments in spill were made daily.

The dissolved gas problem became particularly acute in the Snake River during May when streamflows increased above 100 kcfs and power generating unit outages at Ice Harbor reduced the hydraulic capacity of the powerhouse to about 70 kcfs. As a result, flow above powerhouse capacity had to be spilled and gas supersaturation levels below Ice Harbor began to exceed state standards.

As the peak runoff period approached, Snake River operations were concentrated at maintaining flows at Ice Harbor near 100 kcfs when possible. This was done by regulating outflows from Dworshak Dam in Idaho so that, when combined with flows in the Clearwater and Snake rivers, the total flow at Lower Granite would be about 100 kcfs.

From late May well into June natural Snake River runoff could not be regulated to lower levels and flows exceeded powerhouse capacities of Snake River projects. This situation forced excess water to be spilled at volumes that resulted in instances of TDG levels exceeding state standards. As the peak flow subsided, the Corps reduced spill at the three dams upriver from Ice Harbor for about three weeks in an attempt to keep gas levels within the standards.

Juvenile salmon that entered the bypass and collection systems were transported from Lower Granite, Little Goose and Lower Monumental dams beginning in April. At McNary, the Biological Opinion calls for all smolts collected to be bypassed back into the river until more than 50 percent of the daily total of chinook salmon are subyearling. The Corps began barging fish from McNary on the 22nd of June.

Also, as called for in the Biological Opinion, the Corps operated three of the four lower Snake River projects at or near their minimum operating pool levels for most of the out-migration period. On several occasions during the peak runoff period these reservoirs were filled to help reduce flows and spill that were causing TDG levels to exceed state standards.

Beginning in April, John Day reservoir was operated at the minimum level at which irrigation pumps could

function, except for a period when water was temporarily stored in the reservoir to reduce spill at John Day and avoid exceeding state TDG standards.

The Biological Opinion gives preferred treatment to the endangered Snake River fall chinook. Should it be necessary to make a choice between meeting flow objectives in early spring versus later in the summer, the Corps and Bureau of Reclamation are to reserve water for the fall chinook migration. The goal is to have reservoirs as full as possible by July 1 so that stored water will be available for flow augmentation for fall chinook during the summer.

This year, we were lucky. Runoff in the basin was above 90 percent of average—one of the better water years in some time. Precipitation throughout April and early May boosted runoff volumes in the Snake River and flow objectives were met with minimal drafting of storage reservoirs.

By the first of July, Grand Coulee and Dworshak were full; Hungry Horse was 10 feet shy of full and Libby, 17 feet below full (partly due to operations on behalf of another endangered species, the Kootenai River white sturgeon).

This year proved to be a true test of the TMT adaptive management concept with the team called upon weekly to make such recommendations as whether to cut back flows and power generation out of Dworshak to help reduce spills and high TDG levels at downstream projects. And, most recently, the team recommended to keep flows up in the early part of August to coincide with the shape of listed juvenile fish migration in the lower Columbia River, even though this meant using all the available storage for the month.

The TMT helped in making the migration season's Columbia/Snake operation a largely successful one with operations that put fish first.

Study Progress

While operations on the river were shaped, monitored and modified for fish during the migration season, progress continued on various elements of the Corps System Configuration Study (SCS) which evaluates possible structural changes at the dams to increase fish survival.

Phase I was the initial, or reconnaissance, phase of the SCS. An April 1994 draft Phase I report detailed what we know about reservoir drawdowns and various other alternatives, and provided cost estimates.

Per the NMFS Biological Opinion, Phase II SCS evaluations are on a fast track for completion so the region will be able to make major decisions in the next few years on long term changes to improve conditions for fish. By no later than 1999, the region will be making decisions on whether to implement reservoir drawdowns as well as other actions.

Related research continued during the 1995 juvenile fish migration season. The research scientists are compiling and analyzing the data from that research now. The next issue of Salmon Passage Notes will give a summary of their findings. The annual meeting to report on Corps-funded fish research in Portland in September is open to the public [please see box] and will also cover this information.

Test Surface Bypass Slotted Gates Installed

One of the SCS elements is surface bypass systems for juvenile fish. While design continues on ways to improve existing juvenile fish bypass systems, the Corps is looking at surface bypass technology as one potentially superior system. Surface bypass systems would intercept the fish within the upper portion of the water column, where they normally migrate (around the top 20 to 30 feet). Structures placed in front of the dam face could attract juvenile fish and guide them either over a spillway or through a bypass channel.

Several types of guidance systems for surface bypass were tested at Ice Harbor and The Dalles dams this spring. Structures with vertical slot entrances were installed at the upstream face of selected spillways and in front of the powerhouse ice and trash sluiceways. They extend 40 to 50 feet from the surface of the water, and provide a narrower channel for water flow to create an attraction current.

At these two particular dams, the ice and trash sluiceways have functioned as juvenile bypass routes, carrying juvenile fish through existing channels to exit downstream of the dam. The sluiceways were built in the 1970s when debris in the river was a bigger problem. They seemed a natural choice for testing effectiveness of vertical slot entrances.

At Ice Harbor, a third test guidance system was created by placing a "stoplog" in front of a spillway tainter gate. Stoplog arrangements allowed flow over the spillway from the upper portion of the forebay water column and created a more horizontal or surface-skimming attraction flow. With these tests, researchers can compare efficiencies with which the various bypass concepts pass migrating fish, and assess other effects on juvenile fish.

Guidance effectiveness is measured using hydroacoustic monitoring and radio telemetry. For hydroacoustic monitoring, instruments called "tranducers" are strategically placed to record movements of objects in the water, and send messages to a computer. In this manner, researchers can deduce whether large or small numbers of fish are attracted through various passage routes.

Telemetry involves tracking individual radio-tagged fish using air-mounted and underwater antennas. The Corps and National Marine Fisheries Service have been collecting data on fish guidance through the test gates, to be applied in designing the full-fledged surface bypass system prototypes. The data is currently being compiled and analyzed.

Two views of the vertical slot structure installed at The Dalles Dam this Spring.
Photos by Bill Johnson, Portland District

Improvements to Existing Fish Passage Systems

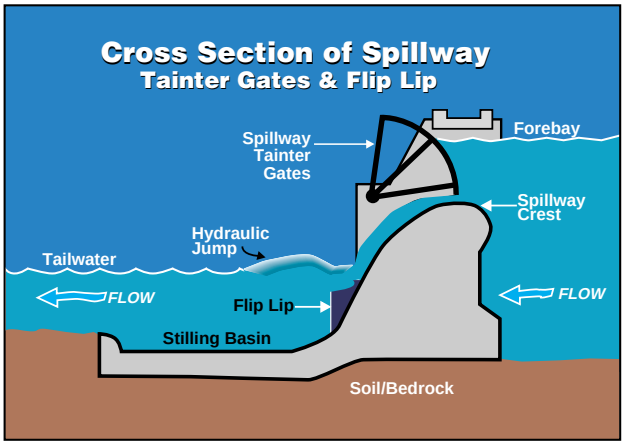
Since Bonneville Dam was built in the 1930s the Corps and the region have sought solutions to the impacts of Federal dams on fish. Adult fish ladders were included in the design and built into each of the eight lower Snake and Columbia River dams. These create a gradual series of steps and pools to allow adult salmon to ascend 100 feet from the tailrace water level (downstream of the dam) to the forebay area (upstream) of each dam. The ladders have proved to be pretty effective means of getting adult salmon through the dams.

Juvenile fish passage has been a tougher challenge. In the years since the dams have been in operation, many improvements have been made to juvenile fish passage routes. There are four ways juvenile fish can navigate the dams—through the juvenile bypass systems, over the spillways, through the turbines, and in specially equipped barges and trucks.

In most of the existing bypass systems, juveniles are guided away from the turbine intakes by huge screens—called submerged traveling screens—and drawn up into a gatewell, into channels that take them through the dams. They are then either released back to the river downstream of the dam, or held in raceways for loading onto barges or trucks for transport past the remaining dams.

The guidance efficiency of these bypass systems is not perfect—in fact, about 70 percent of one species of salmon, fall chinook, swim *under* the submerged screens that were designed to guide the fish away from the turbines. On the other hand, the systems successfully guide 80 to 90 percent of steelhead salmon and 60 to 70 percent of spring/summer chinook salmon upward through the bypass channel. The fish that are guided have about a 97 or 98 percent survival rate through the dams.

The Corps is making improvements to existing bypass systems. Extended length submerged screens are being installed in front of the turbine intakes at Lower Granite and Little Goose Dams for operation in 1996, to increase the percentage of juvenile fish guided to the bypass channels. By 1997, McNary Dam will have the longer screens, and John Day by 1998 or 1999, subject to test results and surface bypass studies. Ice Harbor Dam now has screens in front of its turbines and is scheduled to have a complete conventional juvenile bypass by 1996.



Graphic depiction of a spillway with deflectors "flip lips" - to reduce gas supersaturation problems.

Gas Abatement Studies

Spillway passage is considered a safe way to get the fish past the concrete: about 97 to 99 percent survive. But spill can create problems with gas supersaturation. When water plunges deep into the spillway basin, nitrogen gas is entrained in the water, resulting in gas supersaturation. High levels of gas supersaturation can cause gas bubble trauma in fish, when air bubbles get into their circulatory systems.

At some of the dams, spillway deflectors, or "flip lips," have been installed to provide a more horizontal spill flow. Ice Harbor will have spillway deflectors in time for the 1997 migration. John Day Dam will have partial installation in 1997; complete for the 1998 season. Other potential modifications are being explored to further reduce gas supersaturation problems.

The gas abatement studies apply system-wide, to all of the eight lower Columbia and Snake river dams. Studies are being coordinated to provide information and suggested structural solutions to fit in with other passage improvement measures such as surface bypass and reservoir drawdowns.

Turbine Passage

Turbine passage is the least desirable route for the fish to take. Up to 15 percent of juvenile fish passing through a turbine unit can be killed by pressure problems, blade strike or from predation if they exit in a disoriented state.

Studies to improve conditions in the turbine areas is another area of concentration, where engineering solutions look promising for reducing injury rates to migrating juveniles that elude the bypass systems. Scientists have been working to refine the design of the turbines to reduce turbulence and negative pressures (cavitation) from water flows through the turbine units. More often than direct strike, these are the causes of injury to fish passing through the turbines in their downstream migration.

A team of engineering and biology experts from federal agencies, utility companies, the Electric Power Research Institute, Battelle Northwest Laboratory and others are pooling their talents in these turbine survival studies.

Fish Guidance Experiments

There is also a potential for using guidance systems such as light and sound generation technology, as well as physical barriers, to guide fish to and through dam passage systems. Sound can provide a barrier for migrating fish or it can be used to move fish. Researchers have found that sensors in fishes' bodies pick up on pressure changes and fish respond to those changes.

On-the-river sound tests were conducted at Bonneville Dam this summer. Currently the acoustic program focuses on juveniles, but the use of acoustics could be expanded to adult salmon or as a potential means to control predatory fish behavior.

At Ice Harbor a "floating guidance curtain" may be tested in 1996. The curtain would be made of a flexible material, starting upstream of the dam and suspended from the surface of the water down 60 feet, to act as a guidance wall. Migrating juveniles tend to stay near the shorelines as they travel, and it is thought that the curtain would create a new "shoreline" to guide the fish to a bypass.

The goal in all the work we are doing is improvement—in methods, equipment, facilities—that will help fish passage conditions in the Columbia River system," says John Kranda, Portland District fisheries program manager for the Corps. "Better understanding of hydraulic conditions, fish behavior and their responses to structural changes is essential to making any significant progress in passage effectiveness and improved fish survival."

Dawn Edwards, Portland District Public Affairs Office, contributed to this story.

Corps Salmon History

If you have requested a copy of "Saving the Salmon: A History of the U.S. Army Corps of Engineers' Role in Protecting Anadromous Fish on the Columbia and Snake Rivers," it's on the way. The Government Printing Office expects to finish printing in November, at which time we will mail the history free of charge to requestors. If you have not yet requested a copy and would like to be added to the mailing list, please send your request, including your name and full mailing address, to Dr. Bill Willingham, North Pacific Division Historian, U.S. Army Corps of Engineers, P.O Box 2870, Portland OR 97208-2870.

Public Meeting on Research Results

A meeting, open to the public, is scheduled to be held in Walla Walla, Washington on September 26-27, 1995, for researchers to share their findings from studies conducted on adult and juvenile salmon behavior and survival. The meeting will focus on research funded by the Corps during the past year. For further information please contact Teri Barila at (509) 527-7275, 201 N. 3rd Ave. Walla Walla, Washington 99362.

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