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Summary of Existing CWT Program and Identification of Additional Harvest Management/Monitoring Needs

(Mainstem/Systemwide Province)

October 24, 2002

Prepared for the
Northwest Power Planning Council

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DRAFT: This document has not yet been reviewed or approved by the Northwest Power Planning Council

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Table of Contents

List of Figures

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Abstract

The existing CWT Program is a composite of several long term coded wire tag (CWT) marking, recovery and database management programs conducted by ODFW, WDFW, USFWS and PSMFC. The joint program addresses long-term survival of populations of anadromous salmonids reared in the Columbia River Basin and coastal streams of Washington and Oregon. BPA contributes to this major marking and recovery program at a rate proportional to the number of fish produced at BPA funded hatcheries.

The expected outcome of continuing this project is to provide a long and consistent time series of survival and distribution data that can be used to measure trends in abundance of selected hatchery stocks. In addition, the tagged hatchery stocks will be used to provide data relevant to the management of natural stocks, including many that are listed as threatened and endangered under the ESA.

The vast majority (more than 95 percent) of salmon and steelhead that are tagged with a CWT are hatchery fish. Each time a population of fish is tagged, information relating to species, date, where, how many, and other pertinent information is captured and then forwarded to PSMFC's Regional Mark Processing Center where it is processed and made available to users via the on-line 'Regional Mark Information System' (RMIS).

Since death of the fish is a perquisite of tag removal and data collection, CWT data are primarily used as a tool for estimating survival of populations of fish. The PIT tag is the means most commonly used to estimate survival of individual salmon and steelhead in the Columbia River system.

The CWT tag program, like the PIT tag program, is unique in that they provide an essential service to fish managers, researchers, mitigation agencies and others. Both programs assist in the generation, storage and dissemination of data that is used to estimate fish survival. Both programs are primarily interested in and responsible for the accuracy, completeness and integrity of the data and information that is generated and stored in databases. Both are interested in and responsible for ensuring that the data and information in the databases are open to all who may wish to use it. Both the CWT and the PIT program are defined by the quality, integrity, reliability, and the statistical robustness of the data and information they generate, store, and make available to users./ The CWT program is not responsible for the use the data and information are put to.

The goal of the existing CWT marking programs, in conjunction with other Columbia River marking programs, is to tag a statistically valid number of coho and chinook salmon from Columbia River hatcheries such that accurate estimates of survival and distribution in the ocean, in freshwater fisheries and escapement areas can be made.

Historically, the objective of the CWT program has been to release adequate numbers of CWT marked fish to ensure sufficient power of detecting a 50% difference in survival among compared groups (i.e. p= 1-0.95/2). *This specific objective, and the means to achieve it and other marking objectives, may be affected by a new basin-wide marking plan currently under development by the co-managers in the Columbia Basin.* Although this plan is currently under development, additional marking and sampling likely will be required. Much of that expanded work will require the use of the CWT coupled with electronic tag detection sampling programs. Consequently, additional funding will be required to accomplish this work.

ODFW, WDFW, and USFWS carry out a coordinated sampling effort to collect CWTs from mature salmon and steelhead, which return to fisheries (sport and commercial) and escapement areas (spawning grounds, hatcheries, and Bonneville Dam fishways). Heads collected from marked salmonids are transported to tag recovery labs at Clackamas (OR), Olympia (WA), and Vancouver (WA) where the CWTs are recovered and decoded. The CWT recovery and catch/sample information is likewise forwarded to the Regional Mark Processing Center where it is made available to users via RMIS.

Fish managers, researchers, mitigation agencies and others use the CWT release and recovery data to evaluate a number of administrative, management and environmental effects on salmon and steelhead. For example, the harvest management agencies combine CWT data with other data and information to estimate the effects of harvest regulation on populations of salmon and steelhead. Others use CWT data to estimate the rates of escapement into the wild of a population of hatchery fish. Others, including BPA, use CWT data to determine survival of different hatchery operations, hence the effectiveness of the hatchery programs they fund. Others use CWT data to determine the effectiveness of specific hatchery or other management actions.

This CWT marking and recovery program is consistent with the Fish and Wildlife Program goals for monitoring and evaluation. In addition to monitoring the status of both threatened and endangered stocks, CWT recovery data are used to assess a wide variety of studies designed to improve survival of hatchery produced salmonids.

CWT recovery data also provide critical information for evaluating stock rebuilding programs under measures now sponsored by the 2000 FCRPS Biological Opinion.

Identification of Additional Harvest Management / Monitoring Needs

There are several other related harvest management / monitoring needs identified in the Reasonable and Prudent Alternative (RPA) Action Items contained in the FCRPS Biological Opinion. They are briefly summarized here:

RPA 164: Proposals to test the efficacy of selective harvest gear types, methods, or locations, particularly in mainstem areas above Bonneville

RPA 165: Studies or projects to develop and/or apply new (or improve existing) harvest management models and/or stock assessment tools to improve preseason planning and/or in-season fishery management decisions, particularly as may be necessitated by selective fishery regimes

RPA 166: Studies or projects to develop and/or implement changes in existing catch sampling programs, data recovery programs, or data bases, particularly as may be necessitated by selective fishery regimes and associated changes in fish marking strategies

RPA 167: Studies to assess or improve estimates of incidental mortalities in fisheries (selective or non-selective) significantly affecting ESUs addressed in the RPA

RPA 168: Studies or projects that would address the question of how increased fishery selectivity resulting from selective fishery regimes might be used to increase the survival of listed fish and/or increase the harvest of abundant, non-listed fish

Recommendations for Improving Monitoring and Evaluation

A number of recommendations are presented to meet new requirements of increased precision and accuracy for monitoring and evaluation. Only two of a number of CWT related recommendations are presented here.

Other monitoring-related needs, described in the FCRPS biological opinion, are summarized in Section VI.A of this document.

1) Pressing Need for Funding a PSMFC Statistician Position

The existing CWT program is basically sound and time tested for over 30 years. However, it is also complex and still lacks a mature statistical framework. There is an over-arching need for qualified statistical help in planning well designed CWT studies. Given the nature and scale of the mark-recapture program, and all of the variables and sources of potential tagging and sampling error, most tagging and recovery programs would greatly benefit from additional statistical analyses and advisory guidance.

The ISRP 2000 Review likewise recommended an advisory statistician position to help the CWT program upgrade its capabilities to deliver the desired precision of data to meet the Implementation Goals.

The statistician position would assist tagging and recovery agencies in designing and reviewing their respective CWT projects to ensure the precision and accuracy of CWT information needed for evaluating stock status and fishery impacts on listed species.

2) New Funding likely Required to Upgrade Marking and Recovery Programs

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Changes in the status of Columbia River and Coastal populations of salmon and steelhead have resulted in a number of proposed changes in the way these populations are managed and regulated. These proposed changes translate into at number of potential impacts to the CWT program. It is anticipated that the number of fish to be marked will increase in the future. In addition, the loss of the adipose clip as the external mark signifying a fish that has been CWT marked may adversely impact the rate and cost of tag recovery. The proposed changes support the need for a statistical review of the utility, quality, integrity, reliability, and statistical robustness of the current and possible future CWT program.

It is critical to stress that changes in the number of fish to be marked and in the manner in which fish with a CWT are identified will impact the mark and recovery rates, the accuracy, reliability, and statistical robustness of the data collected and the ease and cost of collecting these data. If budgets are not increased, the number of populations marked, and the types of data collected will likely be reduced to compensate for the lack of adequate budgets.

I. Marking Approaches and their Differing Objectives

The role of the coded wire tag (CWT) as a key population identification tool in the Columbia Basin is best understood in the context of the general nature of fish marking methods. Marking programs for juvenile hatchery salmon generally fall into three categories. Hierarchically, the three categories run from broad to narrow in scope and application. Similarly, the kinds of questions that can be addressed change from general to specific and the cost of marking increases as the scope narrows. As would be expected, the population identification tools also change for each of the categories.

Mass Marking

Mass marking is the broadest in scope and application. Mass marks are used to identify a fish's origin at the broadest scale, hatchery exploitable (marked) and wild (unmarked). Identifications based on mass marks are used on juvenile and adult salmon, in the natural environment, in fisheries, and in fish collected at hatcheries, dams, and traps. Mass marks are generally fin clips, but also include dyes, blank wire tags, and other non-specific means of identifying hatchery fish. Regionally, hatchery steelhead, coho and spring chinook salmon are mass marked with an adipose fin clip.

Mass marking with an adipose fin-clip generally costs about $30 per 1,000 juvenile fish marked.

Group Marking

Group marking is intermediate in scope and application. This type of marking is used to identify a specific population or stock of fish. Group size can vary greatly, a few hundred to millions. Groups are identified by source (hatchery or wild), stock, location, time and fish size. Group marking identifies fish at a finer level of resolution (the group) than mass marking (hatchery or wild). Group marked fish are sampled in all the same places as mass marked fish, but depending on the type of mark used, often require sacrificing the fish to identify the group. In the Pacific Northwest the coded-wire tag (CWT) is the most common type of group mark used for salmon. Other types of group marks include photonic tags, visual implant tags, and fin mark combinations.

CWT marking costs vary, but are generally about $120 per 1,000 juvenile fish marked (4-5 cents/tag plus marking costs).

Individual Fish Marking

Individual fish marking is the narrowest in scope and application. This type of marking identifies fish at the finest level of resolution, an individual fish. This type of marking is generally used on fish in captivity (research studies and captive broodstock) and for research and monitoring within a specific freshwater area (rearing or migration). The most commonly used individual marking technique for Pacific Northwest salmon is the Passive Induced Transponder (PIT) tag. Other techniques include radio tags, some types of visual implant tags, and genetic pedigree.

Costs are higher with this type of tagging, a PIT tag currently costs $2.25 per tag. Application costs are substantially higher than that for CWTs as each tag must be injected by hand.

II. Description of the Existing CWT Program

A. Broad Overview

The current **CWT Program** is a composite of several long term CWT marking and recovery programs conducted by ODFW, WDFW, USFWS and PSMFC that contribute to the annual estimates of survival of hatchery and wild salmonid stocks throughout the Columbia Basin. In addition, this program provides data which can be used to address many of the critical uncertainties associated with releases of hatchery reared fish.

The CWT provides accurate estimates of survival when applied in sufficient numbers. Subsequent CWT recoveries have been used to statistically measure differences in performance between experimental groups. Such uses include measuring performance of fish subjected to different hydroelectric passage regimes (barging versus direct release), differences in response to rearing and growth regimes in hatcheries, and basic survival differences between hatchery and wild produced smolts. Likewise, rates of production of upriver and lower river hatchery and wild fish can be determined and accounted for. Further, the CWT marking and recovery program meets basic monitoring and evaluation objectives in both the Fish and Wildlife Program and in the 2000 Biological Opinion.

Prior to this program, groups of CWT marked fish were released from Columbia Basin hatcheries in an inconsistent and random pattern, with some hatcheries included for several years in succession and production from other hatcheries not tagged at all. This pattern of inconsistent tagging resulted in critical uncertainties in the proportion of fish from specific stock groups (wild and hatchery) in escapement and fisheries, where fish of Columbia River origin (both wild and hatchery) mingle with fish from other locations. It further made determination of hatchery effectiveness very difficult because it assumed that both production capabilities from each hatchery and stray rates were the same, which was found to be untrue based on other tagging studies.

The CWT serves a population or stock identification niche very different from that of the PIT tag. Both tag types serve important roles and neither tag can replace the other. Because of its significantly larger size, the highly effective PIT tag can not be used on many smaller sized fish that are routinely marked with CWTs. Cost is also a factor as PIT tags presently cost $2.25/tag (vs. 4-5 cents/CWT tag). As there is no coast-wide sampling program for PIT tags, the niche for PIT tags is presently limited to fish identification purposes within the Columbia Basin (i.e., dam passage, straying, etc).

B. Multiple Funding Sources for the CWT Program

1. Broad Based Funding for CWT Marking Studies

CWTs were first introduced in the late 1960s as an alternative to fin clipping and various types of external tags. Coast-wide use quickly followed and led to the early establishment of large scale tagging programs funded and operated by the five State/Province fisheries agencies (ADFG, CDFO, WDFW, ODFW, CDFG). Tagging programs have continued to expand, with over 55 federal, state, tribal, and private agencies (including Canada) now releasing over 45 million CWT marked salmonids yearly. Hundreds of tagged groups of fish are released each year at an annual cost of approximately six million dollars for the tags and labor. The releases represent a wide variety of studies.

Approximately 19 million (40%) of the 45 million salmonids tagged coast-wide annually are released in the Columbia Basin. The vast majority are either chinook or coho salmon. Of these, circa 7 million (33%) are marked with BPA direct funding. On a coast-wide basis, approximately 15% of the 45 million yearly releases are funded directly by BPA.

Prior to 1989, a number of hatcheries in the Columbia Basin released their production year after year without representative tagged groups to determine return rates, contribution to fisheries, etc. Many of these fish groups were produced under the authority and funding of regional programs such as the Lower Snake River Compensations Plan or Mitchell Act. Because these production groups were not tagged under those programs, they became labeled as "missing production groups'.

In 1989, BPA began funding the tagging of these "missing production groups" to monitor a limited number of indicator hatchery populations to provide basic life history and survival information applicable to wild and naturally occurring populations. The "Missing Production" studies of ODFW, WDFW and USFWS were all funded by BPA and fell under this category. In 2000, these three projects were renamed "Annual Stock Assessment - CWT Study" to more accurately reflect their status. Each of these projects includes budget lines for the purchase of tags, the tagging process, and the subsequent sampling and reading of recovered tags.

2. Funding for Tag Recovery Programs

Although many agencies release tagged salmonids, the burden of the CWT sampling and recovery falls on the five state fisheries agencies in Alaska (ADFG), British Columbia (CDFO), Washington (WDFW), Oregon (ODFW) and California (CDFG). Smaller but important tag recovery programs are also carried out by NMFS, NWIFC, and USFWS.

Beginning in 1982, BPA has funded a 'fair share' portion of the respective CWT recovery costs as 6-8 million of the annual 45 million coast-wide CWT salmonid releases are marked in the Columbia Basin with BPA funding. Oregon and Washington's freshwater and ocean recovery programs are impacted the most, with approximately 15% of their recoveries coming from BPA funded releases. At present, an estimated $12 million is expended coast-wide annually in the recovery effort. Of this, approximately $2.2 million is funded by BPA for recovery efforts in the lower Columbia Basin (Washington and Oregon) and Oregon ocean fisheries.

Regional coordination of these tagging and recovery programs is provided by the Regional Mark Processing Center which is maintained by the Pacific States Marine Fisheries Commission (PSMFC). In 1992, BPA expanded its funding to include partial support of the operational costs of the Regional Mark Processing Center in accomplishing its role as a centralized coordination and data management center for all CWT data.

C. Benefits of the CWT Program

CWT recovery data provide survival estimates and other key information for evaluating various Columbia Basin stock rebuilding programs and stock status updates. Fish managers, researchers, and others subsequently use the data in studies on stock selection, disease and diet evaluations, rearing density studies, size and time of release studies, evaluation of juvenile passage past hydroelectric dams, overall harvest contribution studies, timing of runs, and current life history parameters.

Specific applications of CWT data by managers, researchers and others include:

- Estimates of fish straying into and out of specific subbasins
- Annual preseason forecasts and final run size estimates
- Stock composition of runs to the Columbia River mouth
- Comparison of survival rates between different stocks throughout the basin
- Estimates of inter-dam passage losses (**indirect estimates only*)
- Estimates of freshwater and marine catch
- Population abundance and trends
- Catch distribution by time and area in the ocean and freshwater
- Contribution to the various marine and freshwater fisheries

There are concerns with the status of many specific stocks returning to the Columbia River Basin, including those stocks listed under the ESA. This project provides survival data that are essential for the monitoring and recovery of these threatened stocks. The federal ESA often depends on CWT marked hatchery fish to function as surrogates for wild populations that are listed. In some cases, hatchery produced salmonids are listed and CWT recovery data can be used to directly monitor these stocks. Finally, the CWT recovery program provides data that are essential to managers and researchers attempting to identify factors limiting salmonid production in the Columbia River Basin.

CWT recovery data are also invaluable to regulatory agencies whose actions have a large effect on the health of Columbia River salmonid populations. CWT data can be used to develop accurate estimates of run size. The forecasts are used in modeling ocean and inside fisheries for the purpose of regulation development. Monitoring capability of harvest sharing between U.S. and Canadian fisheries required by the Pacific Salmon Treaty would also be diminished without this sampling program. This is equally true for efforts to identify harvest of Columbia River salmonid stocks in Canadian and Alaskan fisheries. The Pacific Fishery Management Council also requires the use of CWT data to evaluate the effect of proposed ocean seasons on Columbia River salmonid stocks.

Indicator stocks are also used to limit harvest of Columbia River salmonids in ocean and Columbia River fisheries. The *U.S. v. Oregon* Columbia River Compact depends on the CWT recovery program to manage fisheries in a manner to limit the handling and harvest of listed salmonids while targeting on harvestable hatchery reared fish.

The CWT program also has the potential of supporting a wide range of Fish and Wildlife Program measures and the 2000 FCRPS Biological Opinion action items since it provides fundamental stock identification throughout the life cycle of the stocks. Virtually every measure that requires population survival estimates can be aided by the use of CWT tagged fish.

D. Major Components of the Existing CWT Program

1. Stock Assessment Tagging (ODFW, WDFW, USFWS)

The goal of ODFW, WDFW, and USFWS's stock assessment tagging programs is to tag a statistically valid number of coho and chinook salmon from each hatchery such that accurate estimates of survival and distribution in the ocean and spawning grounds can be made. These data will allow for more accurate assessments of the proportion of wild and hatchery stocks in the Basin and further allow for valid statistical comparisons to be made among project groups.

Survival differences between chinook and coho determine the number of fish needed for tagging such that 25-30 recoveries from each group are made in total or in each fishery or escapement location (de Libero 1986). In addition, 'among group' comparisons require that release numbers of CWT marked fish are adequate such that the probability of detecting a 50% difference in survival among groups is p= 1-0.95/2. Survivals of fish released in this project can be used for comparison with CWT groups originating from other projects throughout the region.

These fish are randomly selected for tagging from the general hatchery population. At some hatcheries, more than one tag group is used for a species because the release timing or size of each group are different enough that survival may be different. Because each tag group may represent up to several million untagged fish, it is important to have as many tag groups at a particular hatchery as necessary to make an accurate estimate of total adult contribution.

After fish are selected from the general rearing population and brought to the tagging trailer, CWTs are applied into the snouts of the fish and the adipose fin is removed (Ambrogetti 1976). The marking procedures are presented in the Manual of Procedures for Coded-Wire Tagging of Pacific Salmonids" (PMFC 1987).

Upon return to the fisheries, hatchery and spawning grounds as adults, tagged coho and chinook salmon traditionally were identified by the missing adipose fin as the external flag. Beginning in 1999, however, hatchery origin coho in the Columbia Basin have been mass marked by removing the adipose fin. Thus, identification of CWT marked coho now requires the use of an electronic tag detector. Beginning in 2001, the adipose clip is also being used to mark hatchery production spring chinook throughout much of the Columbia Basin so they can be differentiated in the fisheries and on the spawning grounds. Electronic detection is also used to recover CWTs from returning spring chinook in the mainstem fisheries and at the hatcheries.

Biological data are collected along with the snout of the fish. Once the snouts are collected, they are transported to the 'Head Lab' where the CWTs are removed and then decoded. The tag recovery data for all the individual tags recovered are recorded into the respective sampling agency's fisheries database where the data are collated and expanded based on the sampling rate of the various collection sites. The recovery data are then sent to PSMFC for entry into the Regional Mark Information Center database (RMIS) for user access via the internet. This flow of information is shown in Figure 1.

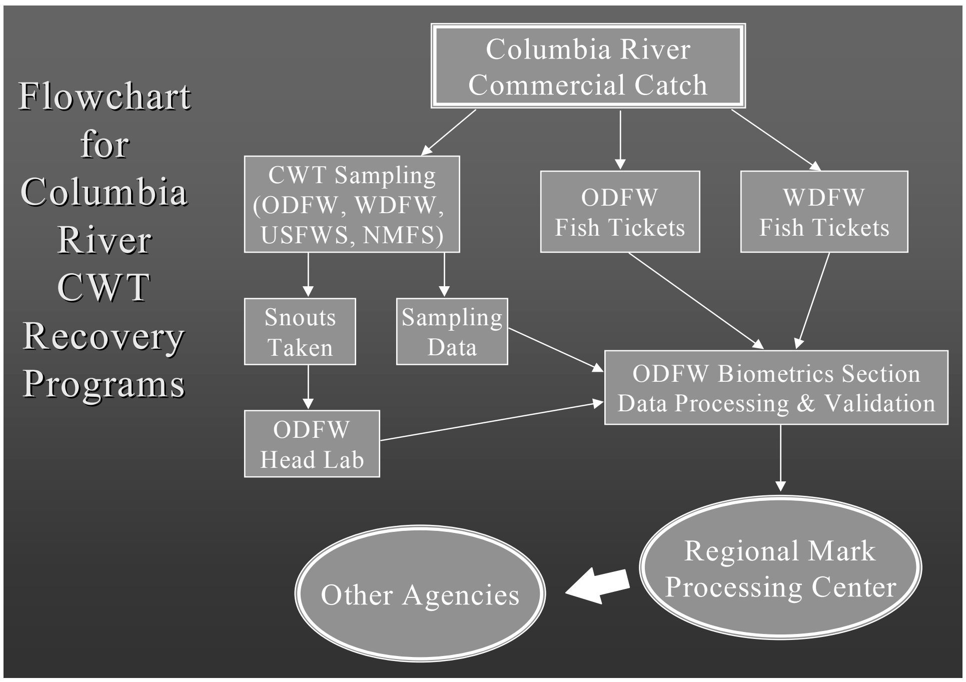


Figure 1. General pattern of CWT data collection and processing, using the commercial fisheries in the Columbia River as an example.

ODFW, WDFW and USFWS fish managers and researchers subsequently analyze the CWT release and recovery data and produce various reports. One of these is the Annual Stock Assessment Report. (This report was formerly known as the Annual Coded Wire Program Missing Production Groups Annual Report). The report is generated by linking the respective release data with the summarized tag recoveries by time and area. The recovery information for hatcheries in the basin is obtained from the PSMFC database after the data are finalized for the most recent year. The total estimated recoveries by each catch type and location and the sum of total recoveries for each tag group is retrieved and the total survival (estimated recoveries/total tags released) is calculated. The contribution rate (total tags recovered by fishery or escapement/total tags recovered) is calculated at the 95% confidence level. When two or more tag groups are released from a site in a given year, the null hypothesis that survival was not significantly different at the 95% confidence level is tested.

Similarly, the Stock Assessment Reference Summary is prepared by ODFW, WDFW and USFWS for each hatchery, brood year, and species that had CWTs. Because many fish were released without representative CWTs before 1989, a single Production Expansion Factor (PEF) is calculated for each hatchery, brood year, and species. This PEF is used to expand recovery information for unmarked fish released, and to determine a general picture of the overall contribution and survival rates for each facility.

Total survival and distribution graphs for each hatchery and species are prepared, and summaries of release and recovery information are included in the Annual Report. ODFW, WDFW and USFWS's stock assessment hatcheries are provided below:

ODFW Stock Assessment Hatcheries:

CWT marking for ODFW's stock assessment is performed at a number of ODFW's Columbia Basin hatcheries including Big Creek, Bonneville, Cascade, McKenzie, Marion Forks, Oxbow, Sandy, South Santiam, South Fork Klaskanine, and Willamette Hatchery.

WDFW Stock Assessment Hatcheries:

WDFW stock assessment tagging occurs at ten Columbia Basin hatcheries: Grays River, Elochoman, Toutle, Fallert Creek, Kalama Falls, Lewis River/Speelyai, Washougal, Klickitat, and Ringold Hatchery.

USFWS Stock Assessment Hatcheries:

USFWS's stock assessment tagging occurs at four federal fish hatcheries: Little White Salmon, Carson, Willard, and Eagle Creek. Representative groups of spring chinook production are tagged and adipose clipped at Little White Salmon and Carson national fish hatcheries. Representative coho production at Willard and Eagle Creek national fish hatcheries is similarly marked.

2. CWT Recovery in the Columbia Basin and Adjacent Marine Waters

a. Columbia Basin CWT Sampling Program

ODFW and WDFW jointly share the task of sampling the Columbia River sport and commercial fisheries for CWT marked salmonids.

Sport and commercial fisheries target salmon and steelhead stocks throughout the lower 395 miles of the Columbia River stretching from the mouth at Buoy 10 to the Priest Rapids Dam. The primary mainstem sport fisheries occur from Bonneville Dam downstream (including Buoy 10) and at Hanford Reach on the upper Columbia. Tributary sport fisheries primarily occur from The Dalles Dam downstream. The Treaty Indian commercial fisheries operate between Bonneville and McNary dams while the non-Indian commercial fishery is limited to the area from Bonneville Dam downstream. Additional sampling occurs for fish returning to hatcheries and natural escapement areas.

All fish encountered are examined for the presence of CWTs. Fish containing a CWT will have their snout removed and will be sampled for pertinent biological data. Pertinent biological data will vary from project to project and may include length, weight, sex, skin Catches received by commercial fish processors at their plants will be sampled

for CWTs at the minimum 20% level. All snouts recovered from these fisheries are delivered to the ODFW tag recovery lab in Clackamas. In conjunction with CWT sampling, a random portion of the catch is sampled for average weight and pertinent biological data. These data are used to determine species specific average weights that are applied to poundages recorded on fish tickets to estimate the total salmonid catch by species in Columbia River Treaty Indian and non-Indian commercial fisheries.
color, other marks, and a scale sample.

1) Columbia River Commercial Fisheries

Columbia River non-Indian and Treaty Indian commercial salmon and steelhead fisheries (Figure 2) may occur during February through October, but the majority of the landings occur during March and from mid-August through October. Seasons are set during the year based on expected run strength of various salmon and steelhead stocks.

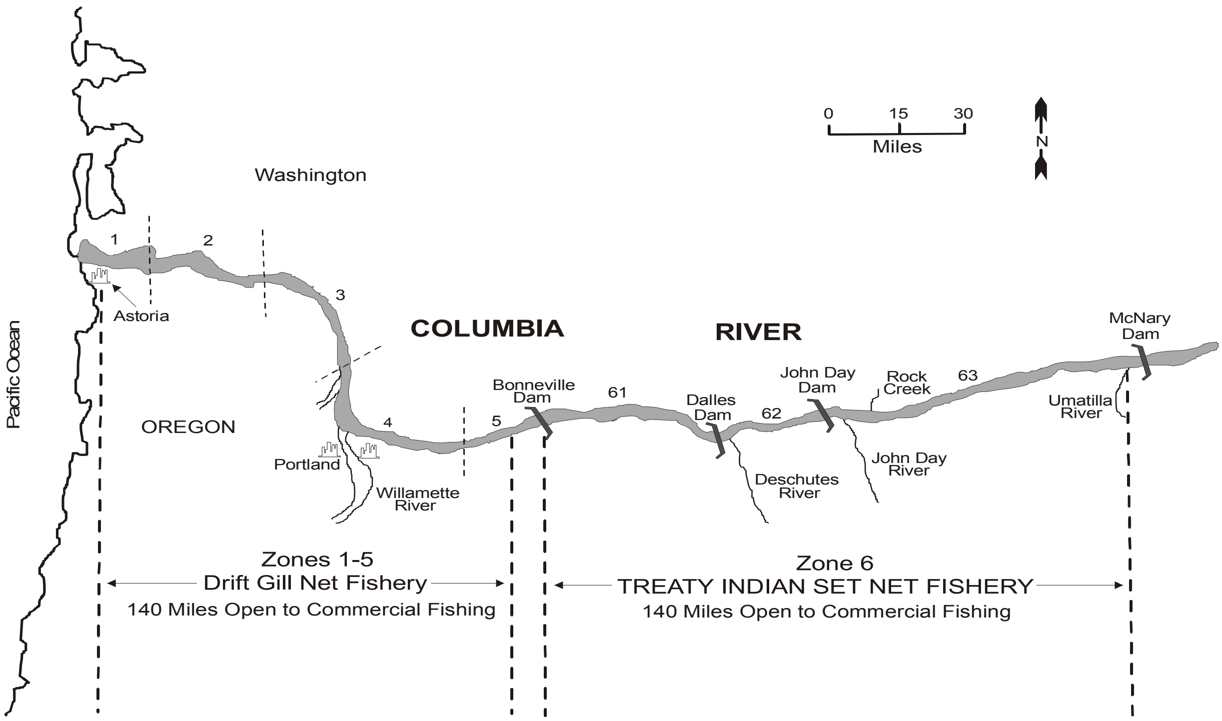
In recent years, the ESA has severely restricted mainstem non-Indian commercial fisheries and has greatly increased the need for precise stock accounting in fisheries. The BPA funded Select Area Fishery Enhancement Project has increased the time and area in which Columbia River non-Indian commercial fisheries occur in select areas. These fisheries generally occur during late April through early June and August through October and effectively harvest net-pen reared salmon while limiting the handle of ESA listed fish.

Catches received by commercial fish processors at their plants will be sampled for CWTs at the minimum 20% level. All snouts recovered from these fisheries are delivered to the ODFW tag recovery lab in Clackamas. In conjunction with CWT sampling, a random portion of the catch is sampled for average weight and pertinent biological data. These data are used to determine species specific average weights that are applied to poundages recorded on fish tickets to estimate the total salmonid catch by species in Columbia River Treaty Indian and non-Indian commercial fisheries.

2) Columbia River Sport Fisheries

The sport fishery on the lower Columbia River (Figure 3) occurs year round with the majority of the catch occurring during mid-February through March and late-May through September. The salmonid catch is comprised of spring chinook, summer steelhead, coho, fall chinook, and winter steelhead. With the advent of selective fisheries, a spring chinook fishery may also occur in April, dependent on the run size forecast.

Sport anglers encountered on the water, at bank fishing locations and at boat ramps or moorages will be queried regarding success in catching fish. Boat and bank effort will be estimated by aerial ‘fly over’ counts conducted over the lower Columbia River twice a week during February through October. These data will be used as part of a statistical creel program that will estimate monthly effort and catch for lower Columbia River salmonid fisheries. This fishery has been sampled as part of a statistical creel program since 1969. The sport fishery located near the Columbia mouth is known as the Buoy 10 fishery and occurs during early August through mid-October. Nearly all of the Buoy 10 catch is fall chinook and coho with a few steelhead being landed. The fishery has been sampled since its resurgence in 1982. Effort and catch is estimated on a weekly basis but is not part of the statistical creel program. Effort is indexed by on ground trailer and rod counts at popular launch sites and bank angling locations. Anglers are queried for success at boat ramps and bank fishing locations, but no on-water sampling occurs.



Commercial Fishing Zones on the Columbia River Below McNary Dam.

Figure 2. Columbia River non-Indian and Treaty Indian commercial salmon and steelhead fisheries

The lower Columbia sport fishery (including Buoy 10) is sampled at the 20% minimum sampling level for CWT recovery.

Effort and catch data are used to estimate Washington tributary spring chinook fisheries, which typically occur between April and June. The fisheries occur on lower Columbia and Bonneville Pool tributaries plus Ringold on the upper mainstem Columbia. Anglers are queried for success at boat ramps and bank fishing locations. Effort is estimated based on number of boats and bank angler counts. Bonneville Pool tributaries are managed jointly between WDFW and Yakama Indian Nation (YIN) to meet hatchery escapement goals in addition to harvest sharing.

The Hanford Reach fishery occurs from mid-August through October. Anglers are interviewed at boat ramps or bank fishing locations. Trailer counts are made to estimate total effort. Angler success data is used to estimate total catch. In addition, limited creel sampling of the salmonid sport fisheries in the mainstem Columbia River between Bonneville and McNary dams began in 1994.

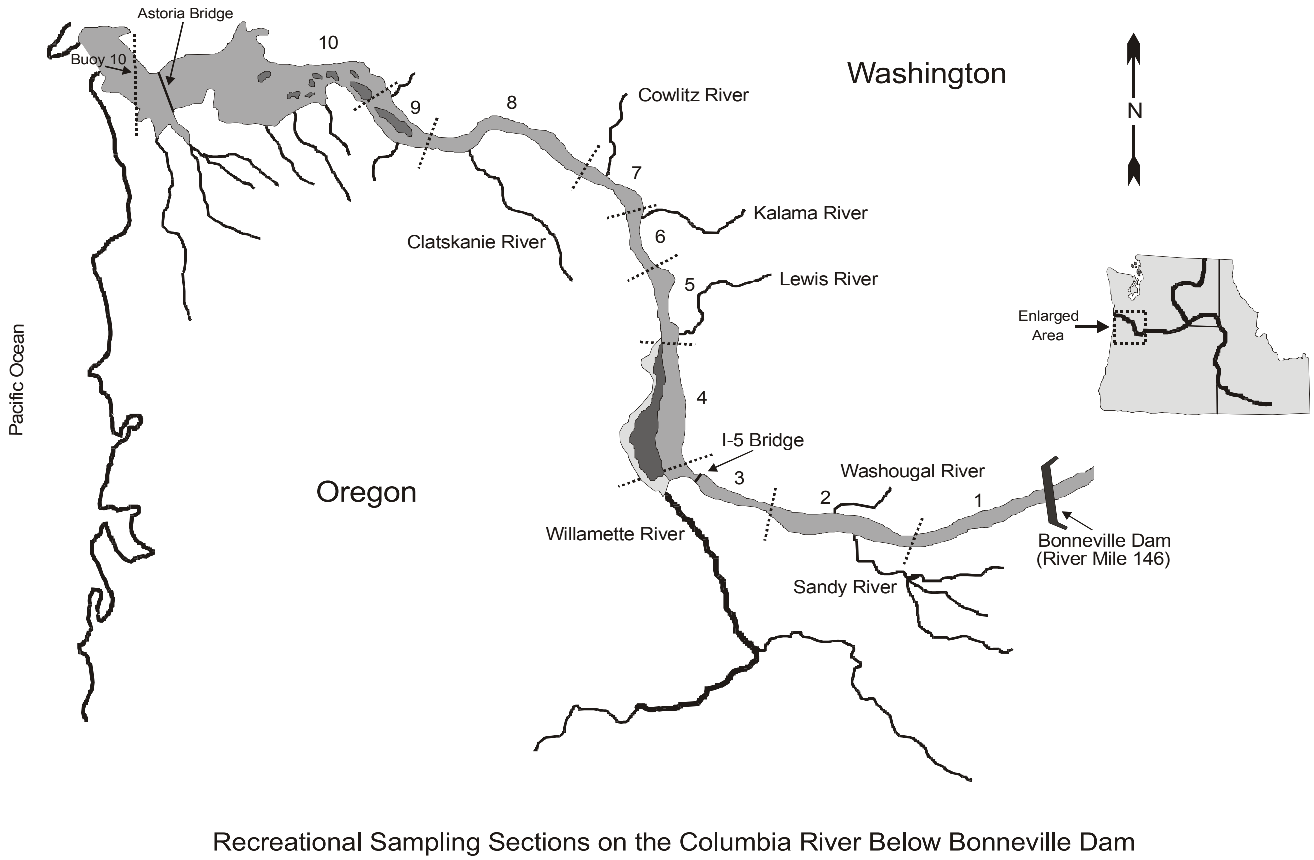


Figure 3. Recreational sampling sections on the Columbia River below Bonneville Dam.

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3) Hatchery Sampling

Spring and fall chinook plus coho are sampled at several Columbia River hatcheries and spawning grounds between the mouth of the Columbia and Priest Rapids Dam during August through January. In conjunction with biological sampling, snouts are recovered from fish containing CWTs. In most cases, hatchery sampling for CWT marked fish is conducted at the 100% level.

4) Spawning Ground Surveys

Spring and fall chinook plus coho are sampled in the Columbia River mainstem and tributaries from the mouth of the Columbia to Priest Rapids Dam during August through January. Peak counts (redd or live and dead fish) are used to estimate the total natural spawning populations. In addition to sampling for CWTs and biological data, fish are separated into adults and jacks, and to stock based on skin color or external marks.

5) Selective Fisheries Sampling

Beginning in 1998, the adipose clip on hatchery coho was reassigned to be a mass mark for identifying hatchery fish. As such, the majority of the coho now returning to the Columbia River will be adipose marked but will not contain a CWT. Therefore, electronic equipment will be required for the detection of CWTs. This situation will greatly reduce the efficiency of the CWT sampling process and additional samplers will be needed to maintain adequate sampling rates in fisheries and at escapement areas.

Since 1998, funding for additional Oregon field sampling staff has been obtained via the Sport Fish Restoration Program (SFR). Oregon State funds were also secured via the Fish Restoration Act to purchase electronic detection wands. Washington has identified some tentative funding sources for expanded sampling but will require additional support from BPA for sampling as well as procurement of electronic tag detection equipment. Oregon has identified additional SFR and other state funding sources to match with available BPA and other federal funding to sample and monitor selective type fisheries in both Columbia River and ocean locations in 2003.

Beginning in 2001, the majority of the hatchery produced spring chinook returning to the Columbia River will be mass marked with the adipose fin clip. Selective sport and commercial fisheries targeting these mass marked spring chinook will occur primarily during March and April, with some fisheries occurring during the first half of May. Additional funds will be required to sample selective spring chinook fisheries. ODFW and WDFW budgets include dollars necessary to sample these fisheries in 2003.

b. Oregon Ocean Fisheries CWT Sampling

Oregon's ocean commercial troll and recreational fisheries target a multitude of regional and West Coast chinook and coho salmon stocks along the approximately 310 miles of the Oregon Coast and in both state and federal offshore waters. The evaluation of Columbia River salmonid stocks through BPA-funded CWT sampling is an essential component for determining stock composition, distribution, and survival characteristics of these important stocks. Recent inclusion of several Columbia River system stocks under the federal Endangered Species Act (ESA) and other critical stocks have increased the need for information for evaluating impacts in regional fisheries. It also provides life history information to evaluate stock rebuilding strategies and management alternatives.

Beginning in 1998-99, the ODFW initiated an expanded marine sampling and monitoring program for both commercial and recreational fisheries and species caught off Oregon. This effort includes all marine recreational species in a comprehensive sampling plan and results from the collapse of several marine rockfish/bottomfish stocks, new requirements from the revised Magnuson-Stevens Fishery Conservation and Management Act (1996) and the potential of added ESA listings. A fully integrated and funded program will take two or more years to complete. Much of this effort is directed towards developing a newly integrated ocean bottomfish/salmon recreational sampling project within the Marine Resources Program that will extend marine fishery sampling coverage over more Oregon port landing locations (Figure 1), species and time periods. Immediate benefits for ocean salmonid, and Columbia River stock CWT assessment include: (1) increased port coverage to ensure minimum sampling rates and (2) less bias in sampling by added personnel available to increase coverage.

The ODFW Marine Resources Ocean Salmon Management (OSM) Program implements the ocean sampling and CWT collection program in close consultation with the Department's Inter-jurisdictional Fisheries Program in Portland.

A statistically-based and unified ocean commercial troll and recreational angler creel program has been in place since 1979. Project objectives are: (1) implement non-biased representative sampling at a minimum rate of 20% of landings by week, catch area (troll) and port (recreational), and species strata; (2) provide necessary CWT sampling and recovery data to evaluate stock contribution and distribution in Oregon's ocean fisheries; (3) provide information for evaluating stock survival rates; and (4) deliver collected data into PSMFC's regional RMIS database for regional and international salmon management forums to implement management strategies that meet harvest impact criteria for Columbia River basin stocks. Seasonal port samplers are hired to collect CWT and other biological data at coastal ports. Salmon detected by electronic means to contain a CWT have their snouts removed for later CWT extraction and decoding.

Funding provided by BPA represents only part of the overall federal/state support necessary to initiate and operate Oregon's yearly ocean salmonid CWT sampling program. BPA supported about one third of the total OSM ocean sampling costs in 2002.

1) Ocean Commercial Troll Fisheries

Oregon's ocean commercial troll fishery has changed from historically targeting coho to a directed chinook fishery during the 1990s. Critical wild salmonid stock management and rebuilding needs for such stocks as Oregon's coastal wild coho have precipitated this change. Although ocean troll chinook regulations vary by coastal area, with several ocean areas closed for part or all of the season, the ocean season generally opened for most of the Oregon coast in mid April and extended through October. July has generally been closed to trolling in recent years, due to harvest impacts on Oregon Coastal Natural (OCN) Coho. Additional but limited "late season" state water ocean troll fisheries take place during October and November to harvest healthy local chinook stocks.

The majority of ocean-caught chinook are harvested in August and September, although significant landings are made in all months the season is open. Columbia River stocks are distributed over a wide time and area during the season. In 2002, troll chinook were landed at about *75* buying locations (including limited fish sellers selling off individual salmon trollers*)*, mostly at Oregon's 12 major coastal ports (Figure 4).

Oregon's ocean salmon fisheries are established by the Pacific Fishery Management Council (PFMC) and the State of Oregon in April each year. Seasons are established on the basis of several factors including regional species (chinook and coho) stock status. Columbia River basin stocks are important in setting these yearly harvest strategies as they include ESA-listed and other "critically" managed Columbia River chinook and coho populations.

Oregon's marine recreational fishery (Figure 4) has operated for chinook salmon only for certain times and areas since the mid 1990's, due to high catch impact levels on Oregon's OCN coho and other critical regional stocks. An April through October season, with the month of July generally closed, spans most of the central coast, with shorter more limited chinook seasons in both southern Oregon and north, off the Columbia River. Some fisheries for coho have occurred for the ocean area off the Columbia River where high levels of Columbia River hatchery coho can be targeted.

More recently (1998 and 1999), the Pacific Fishery Management Council and the states of Oregon and Washington have developed new targeted "selective" type (fin clipped only) ocean recreational fisheries to specifically harvest mass marked public hatchery coho under highly controlled conditions in the July-early September period. These fisheries are heavily monitored under specific operational salmon plans, for impacts on wild stocks and with high levels of catch monitoring, at-sea observers, and shore-side sampling at ports of landing. Large numbers of Columbia River coho stocks are the principal stocks in this type of fishery.

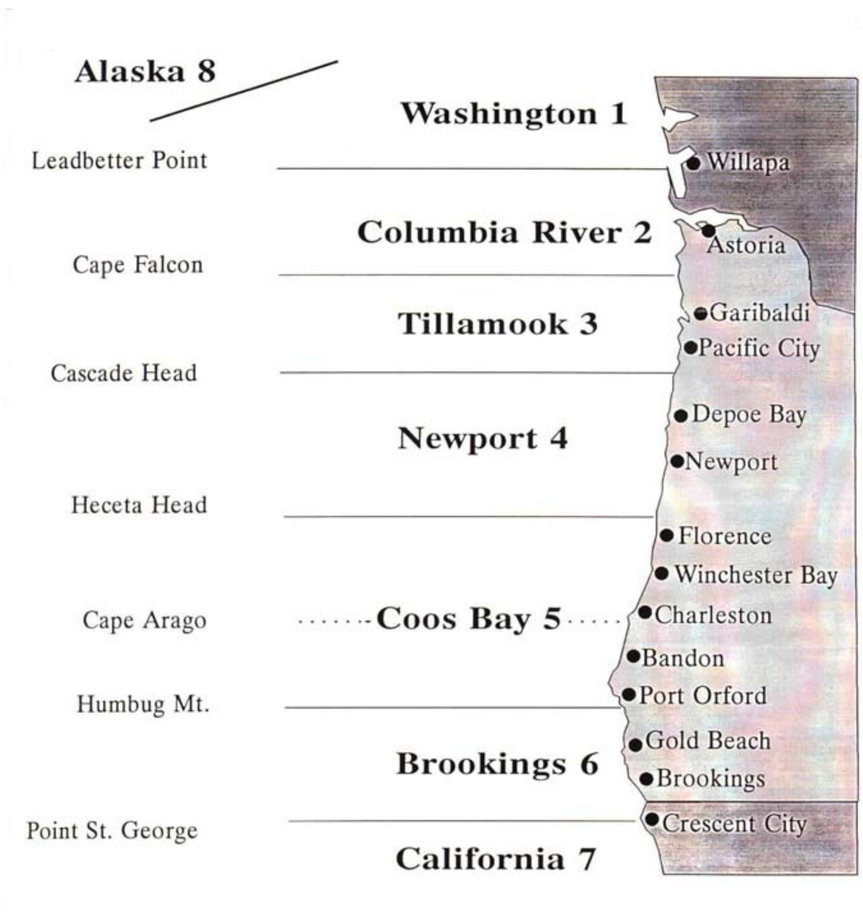

Figure 4. Oregon ports and ocean catch management areas for salmon commercial and recreational fisheries.

Oregon's seasonal ocean summer recreational chinook catch is spread over several months from late spring through early fall, with exceptions. About one third of the overall Oregon chinook catch occurring in August. The Columbia River ocean area coho fishery takes place during July-September with most of the catch occurring in August.

3. Tag Extraction and Data Management

Snouts are delivered to tag recovery labs in Clackamas, Oregon (ODFW), Vancouver, Washington (USFWS), or Olympia, Washington (WDFW) where the CWT is extracted and decoded. The resulting tag code is entered and verified on a computer. Associated fishery/recovery and biological data, collected when snouts are recovered, are uploaded to the computer and merged with previously entered CWT recovery data. Based on program specific sampling rates, individual tag recoveries are increased by an expansion factor to estimate the total number of that particular tag present in a given fishery, hatchery, or natural escapement area.

CWT recovery data are summarized to estimate the number of CWTs recovered for each tag code for each sampling program. Throughout this process, the data are diligently error checked and errors corrected to ensure quality data. The CWT recovery data are then transferred to PSMFC and distributed to managers for making inseason fishery management decisions.

Summarized CWT data recoveries, fishery catch estimates, and estimated escapements for most Columbia River salmonid stocks are provided by several state and federal agencies for additional data analysis. Data analysis includes run reconstruction of all major salmonid stocks. Total returns are categorized by age and stock. Included in total returns are fishery catches, escapement estimates for both hatchery and natural spawn fish, and dam counts. Preseason run size forecasts also are developed annually. Data are provided to the *U.S. v. Oregon* TAC on status of ESA listed stocks and is summarized annually in technical reports. Annual stock assessment reports are produced and distributed to fish resource agencies throughout the basin. All resultant databases are updated annually and are used in a variety of management forums.

The ocean recreational fishery is sampled at most major coastal ports including multiple charter boat business locations, and private boat fisherman at moorages, marinas, and launch ramp sites. The evaluation of this angler and trip effort, expanded landed catch estimates by time and catch area, and CWT sampling are collectively used to evaluate Columbia River basin stock representation in both Oregon and regional fisheries for establishing appropriate management strategies. These CWT data provide wider information for a variety of users through PSMFC's RMIS system.

4. Regional Mark Processing Center's Role in Data Management

Once the CWTs are decoded and processed by ODFW, USFWS and WDFW's tag recovery labs, the recovery and associated catch/sample data are reported to PSMFC's Regional Mark Processing Center. The data are then subjected to another battery of error checks. Upon validation, the recoveries are combined with the coast-wide recoveries reported by other agencies. Data users may then query the on-line 'Regional Mark Information System' (RMIS) to obtain tag recovery data (summary reports or raw records) for research and harvest management analysis applications.

RMIS provides on-line access to all coast-wide CWT data, including that for the Columbia Basin tagging studies. Data sets include: 1) Release; 2) Recoveries; 3) Catch/Sample; 4) Location codes, and 5) Data Descriptions.

The process of data reporting, validation, user access, and distribution to Canada is diagramed in Figure 5.

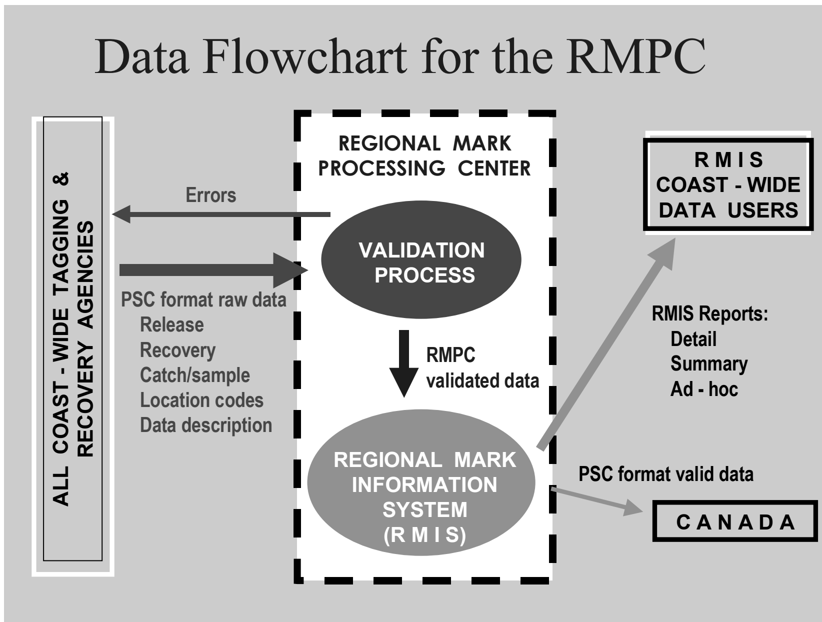

Figure 5. CWT data flowchart for the Regional Mark Processing Center, including validation, loading into RMIS for online user access, and distribution to Canada and other data users.

The CWT data can be accessed on PSMFC's computer via the following methods:

Telnet:	telenet.psmfc.org
FTP:	ftp.psmfc.org
WWW:	www.rmis.org

III. Technical and Scientific Background of CWT Marking

The Independent Scientific Review Panel (ISRP) reviewed the entire set of CWT tagging and recovery programs in 2000. Their report was supportive of the use of the CWT marking technology for stock monitoring and research purposes in the Columbia Basin. However, in view of recent low marine survival and/or reduced sampling (due to budget constraints), they questioned if the CWT program was capable of delivering enough data of high enough precision to answer the management questions for rebuilding the Columbia River stocks. In specific, they questioned if the number of tagged fish released was adequate, and if the regionally agreed 20% sampling rate was adequate. Other questions included whether marked fish lost their CWT, if CWT marked fish had a significantly different mortality than unmarked fish, and if marked hatchery fish were indeed representative of wild stocks as assumed.

Answers to these ISRP questions are provided below in the context of looking carefully at the assumptions of the CWT program and relevant scientific research. Areas of needed improvement are noted.

A. Basic Assumptions of CWT Marking

There are a number of basic assumptions made in the CWT tagging program (PMFC 1982b, Vreeland 1987).

1) Tagged fish are representative of the defined untagged group of fish. As such, the tagged fish are representatively selected for tagging and are treated the same as the untagged fish both before and after tagging.
2) Survival and behavior are not affected by tagging. Tagged and untagged fish have the same survival rates and maturity schedules.
3) The CWT mark is retained throughout the life of the fish. In other words, tag shedding is non-existent or is estimated and corrected for in calculations of contribution, survival, etc.
4) Marked and unmarked fish have the same marine distribution and are equally vulnerable to be harvested in the fisheries.
5) The probability of being sampled in the catch is independent of whether a fish is marked or unmarked.
6) Last, tagged hatchery fish are representative of adjacent wild stocks.

These assumptions could only be fully met in a perfect world. However, the more remarkable fact is that the assumptions have proved fairly robust as evidenced through experience gained over three decades of large scale CWT usage along the entire West Coast.. As such, the CWT program has become an essential tool for stock assessment and management (including hatchery assessments), and a host of research programs (Washington, 1982; Hankin 1985; Shaul and Clark, 1990; Hobday and Boehlert, 2001). It has also become an integral part of the U.S./Canada Salmon Treaty for stock assessments, management, resource allocations and data exchange (PSC 1989; Lapi et al. 1990; PSC 1995a)

Not unexpectedly, the regional CWT program also has some problems that have reduced its effectiveness. The problems largely stem from the fact that the entire program gradually evolved during the 1970s on a rather 'piecemeal', agency by agency basis. There was no statistical framework established at the offset to provide guidelines on tagging levels and subsequent required sampling rates to obtain adequate estimates of variability in the tag recovery data.

Since that first decade, there has been considerable statistical research that now provides guidelines on tagging levels and models for evaluating variability, including several Ph.D. dissertations and master's theses (de Libero 1986; Vreeland 1987; Pascual 1993) plus a variety of papers on various aspects of statistical theory and applications (Neely 1982; Webb 1985; Clark and Bernard 1987; Geiger 1990; Newman 1990; Perry et al. 1990, Schnute et al. 1990, Vreeland 1990; and Schnute 1992; to list a few). Much more statistical work, however, remains to be done.

B. Do CWTs Effect the Survival and Growth of Salmonids?

It is paramount to determine if CWT marking is detrimental to fish and results in a higher mortality rate, lower growth rate, and/or behavioral changes that could bias analyses of observed recoveries. Some researchers reported that the effects of CWT marking on salmon were negligible (Jefferts et al. 1963; Bergman et al. 1968; Opdycke and Zajac 1980; Eames and Hino 1983; Thrower and Smoker 1984; Elrod and Schneider 1986). Others reported varying minor effects, including 4% reduced survival for hatchery coho (Bergman 1968) and 16% for tagged wild chinook (Blankenship and Hanratty 1990). Zajac (1985) found that tagging of unhealthy fish will likely cause high mortality, and that the spread of disease from group to group and station to station is a real threat without proper care of tagging equipment. Morrison and Zajac (1987) also found that misplaced tags can damage olfactory tissue with unknown effects on straying.

None of the above studies, however, could be classified as a rigorous evaluation of the impact of CWTs on tagged fish. For many years, a definitive study proved very difficult to design and implement because untagged fish (i.e. the controls) must also be marked in order to identify and remove unmarked strays (other facilities or wild fish) from the returning production control group. As such, marking the control could itself affect survival. This problem was resolved by the discovery that fish otoliths can be marked with specific banding patterns induced by brief shifts in water temperature. This proved to be an excellent mark for the control population as the entire hatchery production can be marked simultaneously without the stress of handing.

With funding provided by BPA, WDFW undertook an ambitious seven-year study in 1990 to evaluate the combined effects of handling, anesthesia, adipose clipping and CWT marking on the survival and growth of hatchery reared salmon (Blankenship et al., In Prep). The study was done with spring chinook at Cowlitz, Carson, and South Santiam hatcheries in the lower Columbia Basin, using three consecutive brood years (1989,1990,1991). Spring chinook were selected because of their known difficulty to rear in the hatchery.

The entire production of each hatchery was otolith marked with thermal banding patterns to be able to identify adult strays returning to the hatcheries. In addition, approximately one third of each production group was CWT marked and adipose clipped by standard procedures. Tagged and untagged fish were accurately counted so that the proportion of tagged to untagged fish was known. Approximately 1.5 million juvenile spring chinook were marked each of the three years.

The hypothesis was that Ad+CWT marked juvenile spring chinook fish would return as adults in the same proportion to the unmarked production if CWT implantation did not affect survival. In other words, the proportion of CWT marked adult fish at return would equal the proportion of tagged fish released as juveniles and the ratio of the two groups would equal 1.0. A ratio lower than 1.0 (e.g. 0.9) would mean that the untagged fish had a higher survival rate than the tagged fish.

Over 25,000 tagged and untagged fish returned to the three hatcheries over the course of the study. As expected, there was a variable response to CWT tagging seen at the hatcheries. The lowest ratio, 0.91, occurred at Carson NFH for the 1989 brood and was at least partly explained by a serious outbreak of disease (hematopoietic necrosis) during tagging. The highest ratio, 1.27, occurred at Santiam Hatchery for the 1989 brood and was known to have some errors because of problems with an obscured otolith mark.

When the results of the entire experiment were pooled across all three hatcheries and all return years, no significant difference was found in the CWT ratio between hatcheries ($F = 1.1$, $P = 0.39$). Likewise, no significant difference was found between the proportion of fish released with CWTs and the proportion returning with CWTs to the hatcheries ($t = 0.68$, $P > 0.25$). Blankenship et al.(in prep) also found no significant differences in size at return between tagged and untagged adults. They concluded that the presence of a CWT did not reduce the survival or growth of spring chinook.

C. Is Tag Loss a Serious Problem in CWT Marked Salmon?

Tag loss is a universal problem for CWT marking programs, even though it typically represents a very small fraction of the total release (1-5% normal range, with extremes up to 40% or more with inexperienced tagging crews). As such, tag loss is routinely measured and used to correct counts of total tag releases. Failure to adjust the release numbers downward for tag loss results in artificially low estimates of adult recapture rates.

The rate of 'shed tags' varies widely between tagged groups and is a function of several variables, including size of fish at the time of tagging, location and depth of tag placement in the head, and experience of the tagging crew (Blankenship, 1990).

Prior to 1996, tag loss estimates in adult fish were based on recovery of adipose clipped fish that did not have a CWT. However, the estimates were biased by naturally missing adipose fins loss which is variable in stocks and occurs in about 0.05% (5 in a 1,000) of the natural production (Blankenship 1990). As such, the percent 'shed tags' in a given time/area sampling stratum was useful only in a generic way at best. There simply is no way to extrapolate generic tag loss back to a specific CWT release group.

Today, the adipose clip is the mass mark for most coho and many chinook stocks in the Columbia Basin. Hence, one can no longer get *any* sense of the percentage of shed tags from field sampling data. Consequently, it is imperative that adequate estimates of tag loss be determined *prior* to release of the fish.

Blankenship (1990) provides key guidelines for measuring tag loss. He examined the effects of time and fish size on CWT loss in four groups each of chinook and coho juveniles. The groups were tagged and then held for up to 293 days after tagging to evaluate tag loss. He found that the rate of tag loss was highest in the days immediately following the tagging. Estimates of tag loss became less and less biased as the time interval between tagging and measurement of tag loss increased. Final tag loss rates ranged from 1.1 to 5.3%, with the higher rates seen in smaller sized fish at the time of tagging. No significant tag loss was seen after 29 days in any of the chinook or coho groups of tagged fish.

Based on the experimental results, Blankenship recommended that tagged chinook and coho salmon be held for at least four weeks after tagging before determining a final tag loss rate. However, approximately 50% of the current CWT release groups do not come close to this recommend time interval for tag loss measurements.

In a review of the quality of the CWT release data, the Pacific Salmon Commission's Technical Committee on Data Sharing (PSC 1999) found that approximately 28% of the chinook and 45% of the coho release groups were sampled for tag loss in the time interval of 0-5 days. An additional 14% of the chinook and 11% of the coho releases were sampled for tag loss in the interval of 6-20 days. Roughly half of the releases (57% of the chinook and 44% of the coho) were held at least 20 days before sampling for tag loss.

Unfortunately, the PSC study also identified a trend towards shorter time intervals for measuring tag loss. As noted earlier, measurements of tag loss in the first five days after tagging is the least accurate and provides an underestimate of true tag loss. This results in an overestimation of the number of tags released, which in turn results in an under-bias of estimated tag recoveries in the fisheries, etc.

This is clearly an area in which tagging agencies in the Columbia Basin could and should substantially improve.

D. Are Hatchery Fish Representative of Wild Fish?

The assumption that hatchery fish accurately represent their counterpart wild stocks in the adjacent waters is admittedly a leap of faith. The genetic bottlenecks result from limited brood stock selection and the hatchery rearing regime almost guarantee that there are significant differences. On the other hand, it is a reasonable assumption that the hatchery fish should be fairly representative in migratory patterns, timing in the fisheries, etc.

And in reality, it is the only real option available in most cases. It is both very expensive and difficult to collect adequate numbers of wild fish for tagging. In addition, there is some evidence that trapping and handling wild fish for tagging results in significantly lower survival (Blankenship and Hanratty, 1990).

E. What is the Basis for the Regional Agreement on 20% Catch Sampling Rate?

In the mid 1970s, a coast-wide agreement was established that CWT recovery agencies would sample 20% of the commercial catch in the ocean fisheries for the recovery of tags. This sampling goal was soon expanded to include ocean recreational fisheries and freshwater commercial and recreational fisheries. As noted previously, there was no statistical framework for CWT mark-recapture studies at that time. Rather the recommended 20% sampling rate guideline was based on estimated needs when sampling for multiple marks (PSC 1999),

One could argue that the 20% sampling rate goal is excessive to obtain quality recovery data. Certainly sampling every fifth fish is far in excess of what one would see in any quality control sampling program in the manufacturing industries, etc. In addition, field sampling programs are very expensive to maintain.

It could be equally argued that the 20% sampling rate is a minimum level at best given the coast-wide scale of the CWT sampling program and the dilution effect as salmonid stocks move through a succession of fisheries in their long migratory paths. Sampling success in a fishery for a given tagged stock can range from high numbers of recoveries (peak of migratory presence) to rare occurrences (either tail of migratory presence) or no recoveries. Hence, it is very important to sample at high enough rates to obtain quality data for those time/area strata where recoveries are far less frequent.

At worse, the 20% sampling rate goal is reasonable even though it was not based on statistical theory. Recovery agencies have consistently tried to maintain the 20% sampling goal for the past three decades. As such, tagging agencies have been able to use the 20% sampling rate as a 'constant' when determining how many tagged fish should be released for a given objective.

It must be emphasized, however, that there is considerable variation and even some under-sampling across fisheries. Many fisheries are sampled at less than the 20% rate as a result of logistical or budgetary constraints. The PSC Technical Committee on Data Sharing viewed this variation and under-sampling as the most serious concern relating to uncertainty in estimates from CWT analyses (PSC 1999).

F. Are Tagging Rates Adequate?

As a first level appraisal, current tagging rates likely aren't adequate to provide the necessary accuracy and precision needed for evaluation and monitoring. This question needs to be carefully reviewed given the past decade of poor marine survival coupled with reduced numbers of recoveries because of curtailed fisheries and/or reduced sampling effort (due to budget constraints).

There is no simple answer to the question of how many fish should be tagged. It is specific to the given study and depends on many factors (PMFC 1982a; de :Libero 1986; Vreeland 1987). These include:

a) Study objectives
b) Precision required
c) Type of estimates used (i.e. total fish being released; percent tag loss, etc)
d) The kind of experimental design (i.e. use of replicates or not, etc)
e) Expect rate of survival from release to recovery
f) Recovery sampling rates (both fisheries and terminal areas)
g) Recovery data from past tagging studies
h) Species to be tagged and location of the hatchery
i) Cost of the study in each phase of the rearing, tagging and recovery process.

The fundamental requirement of any mark/recapture program is that the number marked must be large enough to provide the desired statistical precision (Nielsen 1992). And that in turn depends on the objectives of the study. For example, as a general guideline, many more hatchery fish must be tagged for studies to determine stock contribution to specific fisheries by time and area (fishery management perspective) than needed to evaluate total fishery contribution for hatchery stock assessment or experimental research (hatchery perspective).

The desired statistical precision must be determined first, along with the confidence limits and the Type 1 error (i.e. reject null hypothesis when true). And since statistical precision is defined primarily by the number of tags recovered, the study design must include an initial assessment of expected recoveries based on previous sampling experience (Nielsen 1992). Given that the coast-wide CWT sampling goal is well established at 20% of the catch, tagging agencies can use this to their advantage and adjust the number of tags released to meet desired goals of accuracy and precision.

Once the desired number of tag recoveries is determined, the number of tagged fish can be determined. This number depends on further evaluation of expected survival of tagged fish, tag loss rates, sampling rates if known to deviate from the standard 20% rate, previous tagging studies, and other factors listed above.

Nielsen (1992) presents a basic approach for mark recapture studies. Vreeland (1987) approaches the question from the hatchery evaluation view point and presents a number of equations specific for evaluating total contribution to the fisheries and variance estimates based on given sampling rates.

Reisenbichler and Hartmann (1980) also provide methods for predicting the expected precision of contribution to a fishery based on the number of fish marked and the number of years that the marking study is repeated. They recommended that releases of tagged fish should be repeated for at least three or four broods to substantially improve precision of the contribution estimates. They also found in their modeling that there was little advantage to releasing more than 50,000 marked fish per release group.

In summary, the question of how many fish to tag is clearly unique to the given tagging study. In addition, a variety of tools are now available to researchers and fish managers to help them determine the correct number. However, experience has shown that limited effort is expended on this key aspect of tagging studies. The basic reason is most likely because of the level of statistical skills required to even understand how to determine the number of fish to mark. Most tagging programs would greatly benefit from the development of easier to use 'tools' and a standardized methodology wherever possible.

IV. Recommendations to Improve the Existing CWT Program

The current CWT program is basically sound and proven effective over the course of the past 30 years of experience. However, the ISRP recommendation was correct. The present CWT program does need to do look for ways to improve the accuracy and precision of its estimates of contribution and survival, and also determine whether existing tagging and sampling rates continue to be appropriate. A similar recommendation was made by the PSC Working Group on Mark-Recovery Statistics in view of recent low survival rates (PSC 1999).

There are several known 'problem areas' that warrant change and would make a significant improvement to the precision and accuracy of CWT based estimates.

A. Improve Accuracy of Counts of Tagged and Untagged Fish Released

The single most important source of error in estimating contribution involves the estimate of the number of both tagged and untagged fish released. Therefore rigorous procedures must be developed and followed to count the number of tagged and untagged fish released, and to determine where the tagged fish are representative of the total release (PMFC 1982a; Vreeland 1990).

It has been nearly twenty years since the PMFC workshop participants voiced their concern about counts. However, a variety of counting methods continues to be used at the hatcheries to get release estimates. The least desirable method, the so-called 'book estimate', involves regular subtraction of the dead fish and is fraught with problems. More commonly, various weight-derived methods are used but these too can have sizeable inherent error. The optimal method is to obtain actual physical counts. Vreeland (1987, 1990) and de Libero (1986) strongly stressed that mechanical or electronic counters are the only adequate method for getting accurate release numbers. Therefore, more attention must be given to moving away from the alternative types of counting and standardizing on actual counts of releases by either mechanical or electronic counters.

B. Expand the Use of Replication

Pascual (1993) reported that the majority of tagged release studies over the years have not had replicate tag groups. As such, those studies had no direct way to measure within-group variability nor get confidence limits on the estimates of contribution.

A number of statistical studies in the past fifteen years have strongly emphasized the importance of replication when designing and carrying out CWT studies. Reisenbichler and Hartmann (1980), for example; stressed the need for replication within the release group (i.e. within brood variation) and across three to four years (between brood variation). The Workshop on CWT Experiment Design (PMFC 1982a) recommended replication for all tagging studies and also stressed the need for replication within-year and among-years to provide measures of standard error and variability in production and contribution over time. De Libero (1986) recommended at least three replicates to indicate if the estimates were internally consistent . He felt, however, that more replicates were better. Vreeland (1987) and Pascual (1993) likewise stressed the power of replication for CWT studies.

CWT studies today are trending towards increased use of replicates. However, replication remains in the minority of studies in spite of the strong statistical endorsements to do so. As such, there is need to seriously address the reasons why and to see what can be done to improve the statistical quality of tag studies in the Columbia Basin.

C. Improve Accuracy of Tag Loss Estimates

The tagged to untagged ratio in a release group is a key parameter used in applying the total number of tag recoveries to the total contribution of a hatchery. As such, accurate estimates of tag loss are very important. Current problem areas include inadequate sample sizes and short term retention before release. Vreeland (1987) pointed out that a 1% post release tag loss can translate into a 10% underestimate of the contribution if tag loss is not accounted for. He recommended that approximately 2,000 tagged fish be sampled for tag loss to get the necessary precision to within 1%. In practice, however, sample sizes for tag loss estimation are typically much lower.

Regarding short-term retention, roughly half of the tagged coho and over a quarter of the tagged chinook groups are released within the first five days of tagging (PSC 1999). As shown by Blankenship (1990), this is the period of greatest tag loss. Hence more effort is needed to extend the retention period to 30 days at which time tag loss has essential ceased.

D. Better Estimates Needed of Number of Fish to Tag

As discussed earlier, the number of fish to tag is study specific and requires considerable effort to determine the appropriate number. Yet a quick scan of the CWT release data shows a disproportional number of release groups of approximately 25,000 tagged fish. This is believed to result from the work of Reisenbichler and Hartmann. In their refereed paper (1980), they recommended that tagged release groups need not be larger than 50,000 tagged fish. However, that paper was preceded several years by a virtually identical ODFW agency report in which they recommended groups no larger than 25,000 tagged fish. It is highly likely that this earlier '25,000 group size' recommendation took 'root' on a wide spread basis because there were no other formal tagging guidelines at the time. It is also very likely that many tagging studies in the Columbia Basin today simply repeat the same tagging design of the past years because 'that is how it is done'.

Given the predominance of 25,000 tagged fish groups, a major effort should be undertaken to determine if this tagging level is adequate in view of the recent reduced survival rates and lower numbers of tag recoveries in the fisheries.

Few tagging agencies have the benefit of qualified statisticians specifically tasked to provide this type of statistical evaluation and guidance for researchers and fish managers. Hence, most tagging studies today simply continue to rely on what was done in past release studies for determining how many fish to mark. As such, tagging rates can range from being very inadequate to excessive for the given study objectives.

In summary, much more statistical research is needed to provide researchers and fish managers with better and easier to use tools for determining the number of fish to mark.

E. Recommended Number of Observed Tag Recoveries

Guidance is harder to find on the minimal number of observed tag recoveries necessary. De Libero (1986) developed a model that related coefficients of variation with numbers of observed tag recoveries. He found that five or fewer recoveries per replicate were too low for stable estimates. A minimum of 10 recoveries was suggested per replicate, and a minimum of three replicates for a given study. However, he recommended that 25 -30 recoveries be targeted if more precision was desired.

F. Need for Statistician Position

The above five discussion items highlight the fundamental point that the CWT program is complex and still lacks a mature statistical framework. There is an over-arching need of the entire CWT program for qualified statistical help in planning well designed CWT studies. Given the nature and scale of the coast-wide mark-recapture program, and all of the variables and sources of potential tagging and sampling error, most tagging and recovery programs would greatly benefit from additional statistical analyses.

With regard to the Columbia Basin, the ISRP recommended an advisory statistician to help the CWT program upgrade its capabilities to deliver the desired precision of data to meet the Implementation Goals. Without question, this would be the top priority of the tagging and recovery agencies as well as it is a win/win situation for all.

V. Existing CWT Program's Accomplishments and Results

A. Summary of Major Results

For the past two decades, CWT recoveries from sampled ocean and Columbia River fisheries and escapement have provided survival data to regional fishery managers and researchers. They use this information to: 1) define distribution, contribution, exploitation rates, and survival rates for Columbia River stocks; 2) set present and future management strategies; 3) establish regional coordination and consistent evaluation standards to assess specific salmon stocks and their contribution to Oregon, West Coast, Canadian, and Southeast Alaska fisheries; and 4) assess potential listing for Columbia River stocks under the federal ESA.

Specific results are reported by fish managers for the individual projects of the BPA funded component of the CWT program. In general terms, these projects include

a) Improved sampling of ocean and freshwater fisheries (project no. 1982-013-01)

b) CWT release and recovery data readily available to regional fishery managers (all projects)
c) Improved representation of hatchery production in region wide monitoring and stock assessment programs (project numbers: 1989-013-02, 1989-013-03 and 1989-013-04
d) Evaluation of Photonic and Visual Implant Elastomer tagging techniques (project 1989-013-02).

B. Adaptive Management Implications

The BPA provided support for the CWT recovery project beginning in 1982 and the CWT marking project beginning in 1989. Since their inception, both projects have undergone significant changes in response to program reviews and stock status evaluation needs for Columbia River basin salmon and steelhead stocks.

Marking and recovery programs both existed prior to the involvement of the BPA. BPA's funding of the recovery program was initiated to increase recoveries of CWTs from Columbia River basin salmonids and the marking program was initiated when it was recognized by the BPA that there was a need for comprehensive post-release monitoring of all major hatchery salmon release groups. This recognition resulted in the three BPA-funded "Missing Production" CWT marking projects (one each for USFWS, ODFW, and WDFW) in 1989. The funding of the marking project, or "Missing Production" project, resulted in a substantial increase in the number of juvenile hatchery salmon released with a CWT which in part necessitated changes in the CWT recovery program for adult salmon.

Additionally, the CWT recovery and marking projects have been reviewed several times in conjunction with the BPA funding process. Each review resulted in increased demands being placed on these projects and the projects were subsequently adapted to accomplish these new demands. In general, results of BPA reviews and the aforementioned fishery management changes have resulted in increased data collection and analysis needs for the CWT marking and recovery projects.

The most significant changes during the last 10-20 years have been the need for smaller and more discrete fish population units plus the increased precision demanded for stock compositions of fish landed in fisheries and returns to escapement areas. The latter is a direct result of many salmonid stocks in the Columbia River basin being listed under the ESA. The ultimate result of these changes has been an increased need for personnel required to apply CWT marks, sample fisheries, sample returns to escapement areas, recover and decode CWTs, and analyze data for the purpose of performing stock status evaluations for salmonid populations inhabiting the Columbia River basin.

The information needs from the CWT marking and recovery programs also have changed dramatically during the last 20 years. The program has been able to adapt to these changes and continue to provide critical data to the region for use in monitoring status of and management of fisheries impacting Columbia River basin salmonid populations.

Specific examples of changes to the CWT marking and recovery programs over the last 10-20 years are as follows:

1) Historically, commercial and sport fisheries were managed to meet escapement needs for broad stock groupings, such as upriver spring chinook. Now fisheries are

managed to remain within ESA-imposed impact limits on listed stocks, such as Snake River wild spring chinook or upper Columbia River wild spring chinook. There has been a corresponding need to manage fisheries more intensively with immediate tag reading and stock compositions being performed inseason to track impacts to listed species. Additionally, post season run reconstruction must be completed for listed stocks as compared to the broad stock groupings used historically. Ultimately, these changes have resulted in increased personnel needs to sample fisheries, recover and decode CWTs, and analyze CWT data from fisheries and escapement areas.

2) Incomplete tagging coverage of important stocks in the Columbia Basin posed a major problem in the 1980s. This was resolved in 1989 when BPA began funding the 'Annual Stock Assessment - CWT Studies' (ODFW, WDFW, USFWS) to provide expanded tagging of salmonid stocks throughout the Columbia River basin. This allowed more precise fishery stock compositions and run reconstruction for listed stocks instead of broad stock groupings. The increased tagging resulted in increased number of snouts that must be processed by ODFW, WDFW, and USFWS tag recovery labs.
3) Mass marking of spring chinook and coho salmon for the purpose of developing selective fisheries has resulted in the desequestering of the adipose fin clip and a CWT indicator mark. Additional equipment such as CWT detection wands and CWT detection tubes are now required to recover CWTs.
4) Historically, CWT release, recovery, and catch/sample information was only available via large printed reports. As such, the data were often obsolete even before users received the hardcopy reports. These data are now readily available via the Regional Mark Processing Center's 'RMIS' web site. Additionally, the RMIS query system has undergone major upgrades for improved user access to the CWT release and recovery data via the internet.

Since their inception, the CWT marking and recovery projects have provided data that are necessary for adaptive management strategies within the Columbia River basin to be successful. Applications include modification to management and implementation of programs outside the CWT monitoring program. Hatchery rearing and release strategies are routinely reviewed and modified based on post-release monitoring results from CWT marking and recovery data. Specific examples include:

1) Results from experiments and production monitoring during the 1970’s and 1980’s, using CWT coho smolts, showed that for ODFW Columbia River basin hatcheries later release groups (late May to early July) generally had better survival than earlier release groups (March to mid May). This information resulted in a substantial shift of ODFW hatchery coho production to later release dates. Recoveries of CWT coho in 1993 showed extremely poor survival of later release groups in comparison to earlier release groups. In light of both sets of results ODFW has shifted hatchery coho releases to a broader range of dates and a more equitable distribution of fish among release dates.
2) Rearing studies were completed for spring chinook reared and released from Cowlitz Hatchery and fall chinook reared and released from Lyons Ferry Hatchery. The survival rates, estimated using CWT recovery data, were used to evaluate fish

reared to fingerling size prior to release versus fish reared to yearling size prior to release. Based on the results of these studies, it was determined that yearling releases were effective in increasing survival rates of hatchery-reared spring and fall chinook.

Recoveries of CWT adult salmon on spawning grounds, at hatcheries, dams and fish traps are used to identify strays and determine which specific stocks and release strategies resulted in those strays. This information is used to modify hatchery programs including changes in release strategies and stocks reared. Specific examples include:

1) For example, as part of the BPA-funded SAFE project releases of SAB stock fall chinook were shifted from Big Creek Hatchery to Klaskanine Hatchery to reduce straying of this stock to lower Columbia River tributaries and hatcheries. In this case the CWT marking and recovery data was used to identify that the straying was occurring and was subsequently used to document that the change in release location did correct the problem.
2) Fall chinook were reintroduced to the Umatilla River and CWTs were applied to identify adults upon their return to freshwater. Based on CWT recovery data it became clear that a portion of the Umatilla releases strayed into the Snake River basin, including Lyons Ferry Hatchery, upon their return as adults. Based on this data the WDFW adopted a new policy to immediately recover and decode CWTs from marked fish returning to Lyons Ferry Hatchery to ensure that stray fish from other basins are not included in the fall chinook broodstock. Additionally, fall chinook containing CWTs are electronically removed at Lower Granite Dam to minimize inappropriate hatchery impacts on listed Snake River fall chinook.

3) Hatchery fish released stray into natural production areas. CWT-marked hatchery fish are recovered during spawning ground surveys to estimate abundance of natural spawning populations. CWT recovery data allows for the estimation of the number of hatchery fish straying to natural spawning areas. Documenting the number of stray hatchery fish in natural spawning areas produces more accurate estimates of abundance of naturally produced fish.

C. Benefits to the Fish and Wildlife Program

The CWT is the most important identification tool used both coast-wide and in the Columbia Basin for estimating survival of populations of salmonid fish. There is no back up system. The CWT data are used to monitor the status of both threatened and endangered stocks and to maintain the status of healthy stocks. In addition, a wide variety of CWT studies are used to evaluate hatchery production and to improve hatchery procedures. Unfortunately, most production is now hatchery based and thus hatchery practices must be monitored.

Some have argued that the CWT program primarily provides information to evaluate production activities that are outside the scope of the Fish and Wildlife Program, or that serve needs of harvest managers other than the narrow focus described in the Program. *The key point is that the CWT is a tool for stock identification. As such, it can* *and does serve a wide variety of purposes, including both Fish and Wildlife Program objectives and those of harvest management.*

The federal ESA depends on CWT marked hatchery fish to function as surrogates for wild listed populations. Marked hatchery fish function as indicator stocks that provide estimates of survival and exploitation rates for wild fish and aid in monitoring the status of listed salmonid populations.

The CWT program has the potential of supporting a wide range of Fish and Wildlife Program measures since it provides fundamental stock identification throughout the life cycle of the stocks. Virtually every measure that requires stock identification can be aided by the use of CWT information, provided that the fish are marked. Fish and Wildlife measures that *either are or could be* supported by the CWT marking and tag recovery program are listed below:

FWP - Section 4: Salmon Goal and Framework

Goal: Double salmon and steelhead runs without loss of biodiversity, while also providing for Indian and non-Indian harvest.

This goal requires identification and monitoring of key index stocks, a role superbly suited to the CWT Program.

FWP - Section 5: Juvenile Salmon Migration

Goal: Evaluate the relative benefits of transportation and in river passage.

Pit tags provide excellent data on juvenile in-river passage between the dams, while CWTs can provide estimates of adult population survival rates of transported versus non-transported juveniles. CWTs can also be used to test hypotheses on flow-water velocity, travel time and survival of juvenile outmigrants if sampled fish are sacrificed.

FWP - Section 6: Adult Salmon Migration

Goal: Determine adult salmon and steelhead migration patterns, including behavior, timing, movement, straying, etc.

Again, Pit tags and CWTs are both effective identification tools for differing aspects of this goal. Pit tags provide valuable information on the timing and movement of adult passing the dams. The CWT, in turn, is exceptionally well suited for broad scale migratory studies because of the multi-agency tag recovery program functioning both within the Columbia Basin and on a coast-wide basis. In addition, the CWT release and recovery data are readily available to users via the Regional Mark Center's on-line RMIS system.

FWP - Section 7: Salmon Production and Habitat

Goal: Evaluation of salmon production and habitat, including information on carrying capacity in the Columbia River, its estuary and near-shore ocean, and also statistics on stock status, life history and other information on wild and naturally spawning populations.

CWTs are a proven stock identification tool for evaluation of the various impacts of hatchery production activities on fish survival and facility performance. Other identification tools are required as well, particularly when monitoring genetic and ecological impacts of hatchery fish on wild and naturally spawning stocks.

FWP - Section 8: Harvest

Goal: Evaluate and monitor harvest to minimize the impact on threatened or listed stocks while allowing harvest on healthy hatchery stocks

CWTs have long been used effectively for stock assessment purposes, whether from the viewpoint of the hatchery or from the fishery management perspective.

Stock assessment studies are designed from a hatchery viewpoint. The studies have localized objectives designed to measure contribution and distribution of a particular stock(s) among the various fisheries and escapement. In addition, the CWTs provide key information on the straying (incidence and distribution) of returning adult salmonids. With these data, the effectiveness of a hatchery program can be evaluated on a stock by stock basis.

Stock contribution studies are also done from the focus of the fishery management perspective. In this case, fishery managers seek information on the contribution rate of stocks in a given fishery (i.e. by time and area strata) in order to better manage harvest rates for conservation purposes, and to protect endangered and threatened stocks encountered in the fishery.

D. BPA Funding of the CWT Program

1. CWT Recovery Program (21 years)

Year	ODFW/WDFW
1982	$ 245,000
1983	549,100
1984	546,000
1985	579,814
1986	598,634
1987	600,000
1988	870,478
1989	813,251
1990	738,663
1991	872,452
	ODFW/WDFW/PSMFC*
1992	1,324,279
1993	1,285,319
1994	1,329,363
1995	1,241,271
1996	1,251,738
1997	1,400,759
1998	1,483,364
1999	1,778,597
2001	2,000,000
2002	2,068,000
All Years:	$21,576,082

*(Partial Mark Center funding added in 1992 for data management functions)

2. BPA Funding of 'Annual Stock Assessment - CWT Study' Tagging

Year	USFWS	ODFW	WDFW
1989	157,796	117.993	142,679
1990	170,614	110,000	148,468
1991	271,410	294,991	16,928
1992	294,786	35,000	207,972
1993	406,790	98,950	620,429
1994	360,865	45,341	250,000
1995	502,700	125,000	198,063
1996	205,965	125,689	294,667
1997	362,913	140,000	302,517
1998	407,942	189,725	333,193
1999	399,460	32,788	317,581
2000	110,586	212,675	373,852
2001	114,094	201,195	411,213
2002	113,363	208,413	397,028
All Years:	$3,879,284	$1,937,760	$4,014,590

E. Reports and Technical Papers

The CWT data are used to produce a variety of products and specific reports which are listed below. Some of these are produced by the CWT Program. Most, however, are a secondary product of agency programs that rely on CWT data for carrying out their specific duties and responsibilities. This includes stock evaluations, hatchery evaluations, and harvest management analyses. In the listing below, no attempt has been made to separate the CWT Program reports from the secondary source reports and technical papers.

Products (General Description):

- Age and stock composition for all Columbia River mainstem and tributary fisheries.
- Run reconstruction for all major salmonid stock and ESA listed substocks returning to the Columbia River.
- Survival and harvest rates for specific salmon stocks.
- Preseason forecasts for all major salmonid stocks and ESA substocks.
- Historical databases for Columbia River salmon stocks.
- Annual status reports summarizing fish runs, population status, fisheries, and escapements, including:

Specific Reports:

Joint ODFW/WDFW reports:

- Columbia River Fish Runs and Fisheries - Annual Status Report.
- The Lower Columbia River and Buoy 10 Recreational Fisheries.

ODFW reports:

- Willamette River Spring Chinook Salmon Run, Fisheries, and Passage at Willamette Falls.
- Status of Willamette Spring Chinook Run Size Predictions
- Preliminary Results of Columbia River Commercial Fisheries.
- Spawning ground survey reports.
- Steelhead data summaries.
- Stock Assessment of Anadromous Salmonids
- Annual Coded-Wire Tag Program: Oregon - Stock Assessment ("Missing Production Groups")

WDFW Reports:

- Age and stock composition of spring/fall chinook returning to WA hatcheries.
- Age and stock composition of natural spawning populations of spring and fall chinook returning to Washington tributaries.
- Summary of CWT recoveries on spawning grounds in Washington.
- Summary of CWT recoveries in Washington tributary fisheries.
- Bonneville Dam observations.
- Accountability of spring and fall chinook returns to the Columbia River basin and preseason forecasts.

- Coho database for OPI (Oregon Production Index).
- Annual Coded-Wire Tag Program: Washington - Stock Assessment ("Missing Production Groups")

USFWS Reports:

- Annual Coded-Wire Tag Program: USFWS - Stock Assessment ("Missing Production Groups")

Regional Mark Processing Center Reports:

The Mark Center no longer produces formal hard copy reports on CWT recoveries because of frequent data submissions and revisions. However, all validated CWT release and recovery data are available to users via the online data retrieval system (RMIS) located at the website 'www.rmis.org' on the internet.

Other Reports:
Direct management applications of this information are provided to the Pacific Fishery Management Council (PFMC) for inclusion in their annual Review of Ocean Salmon Fisheries and preseason salmon management reports (stock assessments and evaluation of annual fishery options). The CWT information is also instrumental in the assessment of critical regional salmonid stocks under the US/Canada Salmon Interception Treaty, and their monitoring of stock rebuilding through the Pacific Salmon Commission (PSC). Collected CWT information is reported by the PSC's technical committees in annual technical reports. Recent evaluations of Columbia River salmonid stocks for possible listing under the federal ESA are included in federal Stock Status reviews.

VI. Relationship of Existing CWT Program and Needs Associated with the 2000 FCRPS Biological Opinion

A. FCRPS Biological Opinion

The December, 2000 FCRPS Biological Opinion identified a number of needs relating to harvest management monitoring and data acquisition programs. As noted throughout this summary, many of these needs are met, or at least partially met, by the existing CWT Program. However, additional harvest management and harvest monitoring needs are identified in Chapter 9 of the Biological Opinion, and are expanded upon further in the Action Agencies' one year Implementation Plan. For convenience, they are summarized in abbreviated form below, along with potential selection criteria and desired elements for proposal guidance. The reader is referred to the opinion and the implementation plan for further elaboration on the need and intent of these actions.

RPA 164: Proposals to test the efficacy of selective harvest gear types, methods, or locations

Possible criteria / desired elements:

- Location/applicability above Bonneville Dam
- Effectiveness of catching fish
- Degree of species selectivity
- Reliance on mark selectivity
- Feasibility/timeline to integrate into existing fisheries or deploying in new fisheries
- Likely incidental mortality effects (and degree to which these are assessed)
- Degree of cultural acceptability and/or tribal involvement
- Cost of deployment and operation

RPA 165: Studies or projects to develop and/or apply new (or improve existing) harvest management models and/or stock assessment tools to improve preseason planning and/or in-season fishery management decisions, particularly as may be necessitated by selective fishery regimes

Possible criteria / desired elements:

- Functionality in context of selective fisheries, including mark-selective fisheries
- Compatibility/integration with existing and/or broader models (e.g., PSC chinook model; relevance to PSC Selective Fisheries Evaluation Committee objectives)
- Usefulness to US v OR Technical Advisory Committee (TAC) needs
- Degree of improvement in escapement estimates or estimation methodologies (i.e. a-run, b-run estimates)

RPA 166: Studies or projects to develop and/or implement changes in existing catch sampling programs, data recovery programs, or data bases, particularly as may be necessitated by selective fishery regimes and associated changes in fish marking strategies

Possible criteria / desired elements:

- o Relevance to implementation of selective fishing regimes
- o Responsiveness to needs associated with revised marking strategies (e.g., de-sequestering of adipose fin clip; relevance to electronic tag detection requirements)
- o Degree of integration with regional and/or US/Canada data format agreements/protocols
- o Extent to which critical uncertainties are addressed

RPA 167: Studies to assess or improve estimates of incidental mortalities in fisheries (selective or non-selective) significantly affecting ESUs addressed in the RPA

Possible criteria / desired elements:

- o Applicability to fisheries with significant impact on listed ESUs, whether existing or new, selective or non-selective, in sport or commercial fisheries in the Columbia River system
- o Study design, including importance of variables evaluated (e.g., gear type, handling methods, temperature effects, short vs longer term mortality, encounter rates, recapture effects, etc.)

RPA 168: Studies or projects that would address the question of how increased fishery selectivity resulting from selective fishery regimes might be used to increase the survival of listed fish and/or increase the harvest of abundant, non-listed fish

Possible criteria / desired elements:

- o Scope of application
- o Treatment of uncertainties (e.g., delayed/incidental mortalities)

B. Key Support to be Provided by the CWT Program

Key support will be provided by the CWT Program to meet high priority Biological Opinion needs in the following two areas:

1) <u>Coast-wide CWT Information Integrated at the SubBasin Level</u>

The CWT system has been used by fisheries agencies in the Columbia Basin for the last three decades as the major stock identification tool for monitoring the status of hatchery and wild salmonid stocks. On a comparative basis, approximately 40% of the 45-50 million tags released coast-wide originate in the Columbia Basin.

Unfortunately, the Pacific Salmon Commission's CWT data specification formats for location sites (i.e. hatcheries, tag release sites, sampling sites, stocks) do not mesh well with the subbasin assessment and planning approach of the NWPPC's Fish and Wildlife Program. For example, the CWT system uses the Pacific Salmon Commission's hierarchical location coding scheme (seven levels, 19 characters) for release sites, hatcheries, stocks, catch areas, and tag recovery sites. Several thousand of these PSC location codes need to be cross referenced to the sub-regions and subbasins designated by the Fish and Wildlife Program.

2) <u>PSC Location Sites to be Mapped to Longitude and Latitude</u>

Similarly, the PSC location codes need to be mapped to longitude and latitude coordinates. Once that is accomplished, the PSC codes can then be mapped to the Longitude Latitude Identifier (LLID) system which is a consistent stream-based system used by PSMFC's StreamNet and a variety of state and federal agencies in the Pacific Northwest. With this system, a unique LLID has been assigned on 1:100,000 scale hydrography for each unique stream.

Data which carry the LLID and measurements along a stream may then be located precisely on a map with this hydrography. This system allows data users to transfer and store data along with information about where this data is located in a simple, yet precise format. It also confers the capacity to analyze and display disparate sets of stream-based data sets together.

Once the cross referencing work is completed for the location codes, software applications will be developed on the Mark Center's Regional Mark Information System (RMIS) to provide users with the ability to evaluate stocks from a subbasin approach. Information on coast-wide distribution patterns, contribution rates to the various fisheries, escapement rates and straying information will be retrievable. Users will also be provided the option of 'rolling up the data' to the subregion level (i.e. pooling data across several subbasins). Lastly, the data are expected to be available as graphic displays to better visualize the distribution of coast-wide recoveries across time and area.

VII. Needed Future Actions

1. Pressing Need for a PSMFC Statistician Position
   (*strongly recommended in the ISRP Review)*

The need for a statistician position for the CWT marking and recovery projects has become very clear during the last several years. The advisory statistician position would provide much needed help in improving the design of both marking and recovery projects in the Columbia Basin. This will greatly improve the precision and accuracy of the CWT information needed for evaluating stock status and the fishery impacts on listed species.

Duties associated with this position would include:

a) Assist in the design of new CWT marking projects to ensure that adequate numbers of CWTs are being applied in an appropriate distribution
b) Evaluate existing fishery sampling rates to determine if they are adequate for stock composition purposes
c) Assist in developing statistical models for estimating confidence intervals for abundance indices (i.e. spawning survey counts)
d) Assist in development of better procedures for measuring numbers of tagged fish released.(i.e. procedures and necessary sample sizes)

2) Increased Need for Precision and Accuracy will Require Expanded Data Collections

Quality CWT data relies upon adequate numbers of tags being recovered in the various sampling strata of interest. There is an increasing need today for managing and monitoring smaller and more discrete fish population units. In addition, increased precision is demanded for stock compositions of fish landed in fisheries and returns to escapement areas. As such, it has become increasingly more difficult to recover adequate numbers of CWTs from the finer scaled strata

The increased complexity created by these demands requires additional effort to recover enough CWTs to provide the data necessary to adequately monitor and evaluate the status of Columbia River salmonid stocks and estimate fishery impacts on listed stocks. As noted by the ISRP, the 20% sampling rate may not be adequate to provide the data necessary to determine catch by the discrete populations as will be required in future years. Increased precision for smaller discrete populations will require increased funding for the additional personnel required to collect snouts and recover and decode CWTs.

3) Expanding CWT Marking will be Required for the Basinwide Plan

Expanded marking will be required to meet the requirements of the Biological Opinion for stock monitoring and evaluation. In particular, Action 174 requires the development and implementation of a comprehensive marking plan for all salmon and steelhead artificial production programs in the Columbia Basin. This was to be accomplished by the end of 2001 but likely will be completed in 2002, based on current progress. As such, the details of the basin-wide marking plan remain unknown at this point. However, it is safe to conclude that additional marking and sampling will be required, and much of that expanded work will require the use of the CWT. Consequently, additional funding will be required to accomplish this work.

4) Current Funding Levels are Inadequate to meet New Information Requirements

Funding for the past several years has not kept pace with the needs of the various state marking and tagging programs. These program components all have a very high percentage of their budgets for labor costs as both tagging and sampling for tag recovery is very labor intensive. As funding was restricted in these past four years, the necessary cuts were primarily made in operations, primarily data management, and maintenance to be able to maintain the necessary staff levels required collect snouts in the field and recover and decode CWTs in the lab. The programs are now at the point that staff will need to be cut in 2003 if additional funding isn't provided to compensate for both cost of living and merit advances.

Additionally, the lack of funding for the data management portion of the project has resulted a lack of personnel available to the states of Oregon and Washington to perform complete error checks of CWT recovery data prior to transferring data to the PSMFC mark recovery database. Additional funding is necessary to allow the each state (Oregon and Washington) to dedicate personnel to ensure that accurate data are provided to the CWT mark recovery database in a timely manner and effectively implement changes recommended by the PSMFC statistician/coordinator (see following paragraph). Funding for additional data management personnel would allow the states to respond to the an objective identified in the ISRP Review, participate on the CWT Oversight Committee to determine standard cost guidelines for CWT marking and recovery projects and approve annual changes from these guidelines.

5) Selective Fisheries have Higher Sampling Costs

The development of selective fisheries, which began with coho in 1997, is also expected to increase in the near future. Mass marking of spring chinook has become a reality. As such, selective sport fisheries enacted in the Willamette River in 2000 and the lower Columbia River in 2001 are likely to be enacted for Lower Columbia River tributaries in 2002 and Bonneville Pool tributaries in 2004. In 2002, the first full fleet test of a selective commercial fishery will occur. Depending on the results of this fishery, selective commercial fisheries may be adopted annually.

Selective fisheries will allow the expansion of fisheries into timeframes that are currently closed for salmon fishing and therefore will require additional fishery samplers to continue to sample these fisheries at the 20% rate for CWT recovery purposes. Selective fisheries also require electronic detection of CWTs due to the fact that the adipose fin clip no longer serves as a CWT indicator. Electronic detection of CWTs will slow down the sampling process and also require additional sampling effort to maintain a 20% sampling rate. Increased fishing opportunity, and associated catch of hatchery-produced spring chinook, will increase the number of CWTs that require recovery and decoding. Mortality rate studies will likely occur in conjunction with the development of selective fisheries. These studies may require additional data collection that would likely occur in conjunction with the current CWT recovery project. Although funding for additional sampling should be provided by the study increased coordination levels will be required to ensure the sampling is adequate in quantity and distribution to provide data that is adequate for both CWT recovery project and study needs.

6) Expanded Sampling Effort needed for Expected New Fishery Opportunities

Improved freshwater rearing and migration conditions plus improved ocean rearing conditions appear to have significantly improved survival rates of Columbia River basin salmonids in recent years. Based on modifications to operation of the Columbia River Hydrosystem and long-term weather patterns these improved rearing and migration conditions are expected to continue for the next several decades. Presumably, the rearing and migration conditions would result in improved returns of salmonids to the Columbia River basin which would again allow expanded fishing opportunities as in 2001. This in turn will require additional personnel to recover and decode CWTs collected from salmonids caught in the new fisheries and returning to escapement areas.

7) Increased Tagging of Wild Stocks Recommended

Tagging of wild fish could become a higher priority in future years. Currently hatchery stock fish are commonly used as a surrogate for wild populations and applying CWTs to wild stocks would be preferable. Beginning in 2001, CWTs were applied to wild/natural fall chinook spawning in the lower Columbia River just below Bonneville Dam. As opportunities avail themselves, the marking project may be increased to include other wild stocks in the Columbia River basin.

8) Increased Sampling in Escapement Areas Recommended

Increased sampling in escapement areas may also become a higher priority in future years. Spawning ground surveys in the lower Yakima River have been funded by the Chinook Technical Committee in the past. However, funding for those efforts have been drastically reduced or eliminated altogether in recent years. Additional funds may be required in conjunction with BPA-funded recovery efforts in the Yakima River subbasin.

Mass marking strategies currently in place for spring chinook and coho salmon should aid in determination of annual abundance of naturally produced fish. Some funds may be required to collect and read scales of unmarked fish to identify any stray unmarked hatchery fish spawning in the wild. This would improve the accuracy of the abundance estimate for wild spring chinook and coho salmon in Columbia River tributaries.

Last, mapping of fall chinook redd locations in Columbia River tributaries downstream of the Klickitat River may aid in determining annual spawning distribution and identifying critical spawning locations. This information could be included in the BPA-funded StreamNet database and can be used to address Goals 1 and 2 in the 5-year implementation plan. Additional funds would be required to purchase GPS equipment to identify redd locations, GIS equipment to map redd locations, and increased staff to collect raw data and incorporate data into the StreamNet database.

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