Chapter 2.—Overview of the Coded Wire Tag Program in the Greater Pacific Region of North America

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Abstract

The coded wire tag (CWT) was introduced in the greater Pacific region (Alaska, British Columbia, Washington, Idaho, Oregon, and California) in the late 1960s as an alternative to the fin clip and external tag for identification of anadromous salmonids—particularly hatchery origin fish. Coastwide use of the CWT quickly followed, and fisheries agencies in Alaska, British Columbia, Washington, Oregon, and California established ocean sampling and recovery programs. In 2009, 47 Federal, Provincial, State, Tribal, and private entities release more than 50 million salmonids with the CWT yearly. Regional coordination of these tagging programs is provided by the Regional Mark Processing Center (RMPC) operated by the Pacific States Marine Fisheries Commission (PSMFC). The center also maintains a centralized database for coastwide CWT releases and recoveries, as well as for associated catch and sample data. CWT data are provided to users through an interactive on-line data retrieval system.

An expert panel review of the CWT system in 2005 identified specific problems with the CWT system. In 2008, a CWT workgroup developed a response and an action plan to address those problems. Solutions included measures to increase the precision of the data through increased tagging and sampling, use of electronic tag detection methods, and more rigorous self review of agencies' procedures.

After 40 years, the CWT program in the greater Pacific region of North America continues to be the most important tool for salmonid research and management. The CWT system has served critical management and research needs for many years and remains the only stock identification tool that is Pacific coastwide in scope and provides unparalleled information about ocean distribution patterns, fishery impacts, and survival rates for Pacific salmon along the Pacific coast.

Introduction

The CWT is widely used by fisheries agencies on the West Coast of North America as a tool to collect information on natural and hatchery reared stocks of salmon and steelhead (*Oncorhynchus* spp.). Information from CWTs is used by these agencies to evaluate hatchery contributions to catch, smolt to adult survival rates, spawner abundance on spawning grounds, differential in-hatchery treatments, and other related studies that may be important for fisheries management and research.

The migratory nature of salmonids necessitated the development of a cooperative coastwide effort for using tag codes, sampling fisheries, tag recovery, data collection, and data exchange among all fisheries agencies in the U.S. and Canada. This paper presents an overview of the CWT system now in place and a brief history of its development.

History

The invention of minute CWTs (0.25 × 1.1 mm) that could be easily implanted in the tough nasal cartilage of juvenile salmonids (fig. 1) greatly changed marking studies because of this tag's numerous advantages over fin clipping. The first tags were developed in the 1960s (Jefferts et al., 1963; Bergman et al., 1968) and carried up to five longitudinal colored stripes. More than a dozen different colors provided approximately 5,000 different codes, compared to the 15–20 fin mark codes normally used to identify groups of fish.

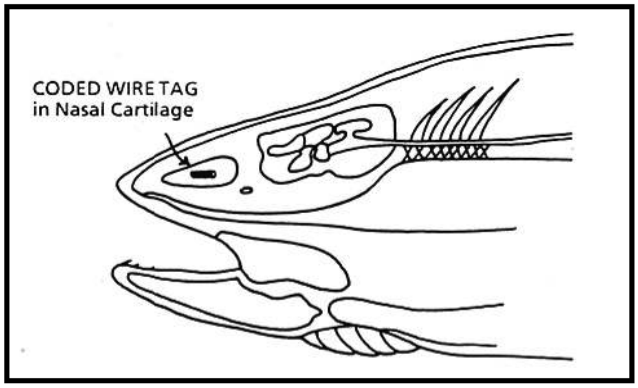

Figure 1. Longitudinal section through the head of a juvenile salmonid showing the correct placement of a CWT in the nasal cartilage. (After Koerner, 1977; extracted from Johnson, 2004.)

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Binary coded tags were introduced in 1971 by Northwest Marine Technology, Inc. (NMT). These new tags quickly replaced color coded tags because of their greatly improved readability and the enormous number of available codes per agency. In 1971, 250,000 unique codes were available on standard length binary tags (1.1 mm). The new tags provided unique codes for many years, and additional tens of thousands of binary codes were possible with a slight format change (such as adding alphabetic letters) on the wire (Johnson, 1990).

The large number of available binary codes, low cost per tag, ease of application, and high retention rates opened the way to large-scale experimentation by tagging agencies, including multiple experiments on any single stock of fish, because all experimental groups could be accurately identified regardless of recovery location or time. Another major advantage was that all experimental groups could be treated the same during the tagging process, thus reducing the variability in survival and behavior imparted by clipping different fins.

In 1985, a significant development was the introduction of sequentially coded wire tags (s-CWT), at that time using binary coding, and currently, using decimal codes. These allow identification of small batches of tags cut from the same spool, and even individual identification. Although for many large-scale projects, the standard coding system, where all tags cut from a spool are identical, is all that is required, the s-CWT made a wide range of smaller scale projects viable (Solomon, 2005).

The present decimal coding system was introduced in January 2000. More than 1 million different batch codes are available with this new decimal tag code system, providing capacity for many years to come (Solomon, 2005). Because the decimal system is much easier to read and decode, errors have decreased and data accuracy has been enhanced.

In 1977, the region agreed to reserve the adipose fin removal mark as an indicator flag of a tagged coho (*O. kisutch*), Chinook salmon (*O. tshawytscha*), or steelhead (*O. mykiss*) (Pacific Marine Fisheries Commission Memorandum, 1977). This was later expanded to include chum (*O. keta*), sockeye (*O. nerka*), and pink (*O. gorbuscha*) salmon (Pacific Marine Fisheries Commission Memorandum, 1978).

In 1996, the States of Oregon and Washington decided to adipose fin clip all hatchery reared coho smolts, not just the ones with CWTs, before release thereby implementing mass marking of hatchery reared coho. They did this to implement mark selective fisheries, manage hatchery broodstocks, and to determine the population composition and origin of natural spawners. Soon after, Canada also began mass marking hatchery reared coho that were released from their hatchery facilities in Southern British Columbia. Recently, most hatchery reared Chinook released into the Columbia River also have been mass marked and the practice is expanding to salmon releases up and down the Pacific Coast. In 2008, more than 37 million coho and more than 101 million Chinook were mass marked (Pacific Salmon Commission Selective Fisheries Evaluation Committee, 2008). In the past, fish were checked for a missing adipose fin to indicate that it had a CWT. Due to mass marking, it is necessary in many sampling areas to use electronic metal detectors to detect CWTs, such as handheld wands to pass over the salmon's snouts and tube detectors to pass the fish through.

Management Needs

Many State, Federal, Tribal, and private reporting agencies in the U.S. and Canada participate in a massive coastwide coded wire tagging effort to provide essential data for effective conservation and management of Pacific salmonid stocks. This information provides the basis for monitoring the fisheries, allocating harvest rights among competing domestic users, improving productivity of hatchery stocks, establishing escapement goals, and satisfying Tribal treaty obligations. These data also play a key role in the U.S. – Canada Salmon Treaty allocations and management of transboundary stocks. The data from CWTs are the primary management tool on the Pacific Coast used to allocate salmon catch in the various sport, commercial, and Tribal fisheries. Fishery management agencies rely on CWT data because the CWT program includes fully integrated tagging, sampling, and recovery operations along the entire West coast of North America. CWTs provide sufficient resolution for stock specific assessments, and coded wire tagging is the only stock identification technique for which a historical record back to the mid-1970s of stock specific assessments may be computed. No other practical mark-recovery system has yet been devised that is capable of providing such a high level of detail in a very timely fashion (Pacific Salmon Commission, 2008).

The historic success of the CWT program has been in no small part due to the high level of coordination and cooperation among the coastal U.S. and British Columbia and to the consistency of CWT tagging and recovery efforts across the many jurisdictions. Despite the emergence of other stock identification technologies, including various genetic methods and otolith thermal marking, the CWT recovery program remains the only method currently available for estimating and monitoring fishery impacts on individual stocks of coho and Chinook salmon when implementing fishing agreements under the Pacific Salmon Treaty (Hankin et al., 2005).

It is essential that the data from coded wire tagged salmon releases and their subsequent recovery is available to all fisheries management agencies and their analysts in order to make scientifically based decisions. The PSMFC hosts the RMPC. This office maintains the on-line Regional Mark Information System (RMIS) to facilitate exchange of CWT data among release agencies, sampling and recovery agencies, and other data users. The on-line query system is available at: http://www.rmpc.org. The RMPC also serves as the U.S. site for exchanging U.S. CWT data with Canada for Pacific Salmon Treaty purposes. Through this data exchange, both the U.S. and Canada house a complete copy of Pacific coastwide CWT datasets.

Tag Description and Tagging Methods

The CWT is a small length of stainless steel wire 0.25 mm in diameter and typically about 1.1 mm in length, although one-half, one and one-half, and double length tags also are used in some circumstances. The tag is coded with a series of factory-etched decimal numbers, which allow identification of the spool of wire (typically 10,000 tags) from which it was cut (standard format, see fig. 2), or the particular batch, or even the individual fish (sequential format). The tag is cut, magnetized, and implanted into suitable tissue with an injector; two types are widely used. The Mark IV is an electrically operated machine suitable for marking large numbers of fish, while the Handheld Multishot Injector is used where smaller numbers are involved. The usual target tissue in small salmonids is an area of muscle, connective tissue, and cartilage in the snout, but a number of other sites also are used, particularly in non-salmonids (Solomon, 2005).

Tags are injected into fish using a range of injectors, which are in widespread use. The Mark IV automatic tag injector is designed for large-scale projects tagging thousands or even millions of fish (see fig. 3). The handheld multiple shot tag injector is available for portability in the field and generally used for tagging hundreds or possibly thousands of fish. A single shot injector is available for laboratory trials and small-scale experiments tagging up to a few hundred fish. The newest system is the high capacity AutoFish system (see fig. 4), which is a self-contained system housed in a large trailer and can process 60,000 fish in 8 hours and is used to tag several million fish per year. It accomplishes adipose fin clipping and/or coded wire tagging without the fish being anesthetized or touched by humans (Solomon, 2005). The AutoFish system results in very high tag/mark retention rates. Retention rates ranged from 98.45 to 100% in California in 2008 (Pacific States Marine Fisheries Commission, 2008).

Figure 2. A magnified section of coded wire before it is cut and inserted as a tag (photograph by NMT).

Figure 3. Interior of a manual tagging trailer using Mark IV tag injectors (photograph by George Nandor).

CWTs have some advantages over other tag types or tag systems. They can be used on very small fish, down to 22 mm in length; they have minimal impacts on fish survival (Vander Haegen et al., 2005), growth, and behavior (Quinn and Groot, 1983); the tags have high retention rates over periods of years and with fish growth (Munro et al., 2003); coding capacity is almost unlimited; tags are inexpensive allowing for large numbers of fish to be tagged; and tags are easily identified and decoded if recovered anywhere in the world.

Figure 4. Interior view of an AutoFish trailer (photograph by George Nandor).

Coastwide Coordination

The coastwide CWT system—including the services of the RMPC—are coordinated through the activities of two principal organizations: (1) Regional Committee on Marking and Tagging (Mark Committee); and (2) Pacific Salmon Commission (PSC—established by the U.S.–Canada Pacific Salmon Treaty).

Regional Committee on Marking and Tagging (Mark Committee).—All tagging and recovery agencies on the Pacific coast are represented by the 14-member Mark Committee (appendix A, table A1). PSMFC's Regional Mark Coordinator serves as chair for the committee. Agency membership includes mark coordinators for the five member States of PSMFC (Alaska, Washington, Oregon, Idaho, and California), the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Canada Department of Fisheries and Oceans (CDFO), British Columbia Ministry of Environment, Fish and Wildlife Branch, and the Metlakatla Indian Community in Southeast Alaska. In addition, the Northwest Indian Fisheries Commission (NWIFC) coordinates the tagging and fin marking activities of 20 Treaty Tribes in western Washington. The Columbia River Intertribal Fish Commission (CRITFC) serves the same role for four Tribes in the Columbia River basin (Regional Mark Committee, 2001). Private aquaculture, universities, and other nongovernmental organizations are coordinated through the respective State or Provincial coordinator.

The Mark Committee provides oversight and guidance to the RMPC. In addition, the Mark Committee meets each year in the spring to expedite coastwide coordination of fin marking and tagging activities. Regional agreements are reviewed and updated if necessary during this annual meeting.

Regional agreements and restrictions on fin marking and CWT usage are reached by committee consensus after thorough discussion of the issues. A 30-day review period follows publication of the Mark Meeting minutes to allow for agency reconsideration of an issue if necessary. If no objections are raised, the agreement stands as recorded in the minutes.

In those situations where unanimity cannot be achieved, the decision is reached by a two-thirds majority affirmative vote. All issues referred to a vote require a quorum of at least 75% of the committee members being present. Twelve votes are possible (appendix A, table A1). A single vote is assigned to the State/Province level or Federal agency level regardless of the respective number of coordinators serving on the committee (Regional Mark Committee, 2001).

The Mark Committee does not have any legal authority to enforce the regional agreements. Therefore, cooperation and compliance are voluntary. This has not been a serious weakness since all agencies mutually benefit from the cooperative environment. Implicit peer pressure among the agencies has supported the system because noncompliance can negatively affect studies of other agencies.

Pacific Salmon Commission U.S.–Canada Treaty.—PSC commissioners agreed in November 1987 that no unified U.S.–Canada CWT database would be established under the auspices of the commission. Instead, it was agreed that each country would maintain a single database, with parallel structure, to expedite exchange of CWT data between the two Nations.

The U.S. commissioners subsequently considered the site for the U.S. database and selected PSMFC's RMPC. This position was supported by the Working Group on Mark Recovery Databases. Advantages of the RMPC cited by the working group included long-term experience in CWT data administration, coastwide representation of all fisheries agencies, well-established coordination and reporting procedures, no start up costs to PSC, reduced time for implementation of the new formats, and lack of vested interest in any data interpretation or applications. The RMPC's primary role is to collect, validate, archive, and exchange U.S. data with Canada in the PSC data exchange formats (Pacific Salmon Commission Joint Technical Committee on Data Sharing, Joint Working Group on Mark Recovery Databases, 1989).

Role of PSMFC's RMPC

In 1970, Oregon's RMPC formally became the regional center when it was funded through the Anadromous Fish Act (Public Law 89 304) to establish and maintain a regional database for mark recoveries. In 1988, the RMPC was selected by the U.S. Section of the PSC to house and maintain the CWT database in the U.S. and to be the designated site for sharing data with Canada (Pacific Salmon Commission Joint Technical Committee on Data Sharing, Joint Working Group on Mark Recovery Databases, 1989).

In general, the RMPC supports and facilitates the ongoing CWT-related needs of: (1) the member States of the PSMFC; (2) the Regional Committee on Marking and Tagging (Mark Committee); and (3) the PSC.

Regional Coordination Role

The RMPC provides coordination for marking programs by: (1) establishing regional agreements for fin marking and use of CWTs with the assistance of agency coordinators; (2) recommending changes for upgrading the regional CWT database to meet expanding or changing user requirements; (3) assisting agencies to improve timeliness of reporting, with special emphasis on tag recovery data; and (4) developing recommendations for improving coordination and quality of CWT studies, with emphasis on experimental design, sampling design, estimation procedures, statistical problems, and documentation.

Data Management Role

The RMPC manages data by: (1) maintaining and upgrading a regional database for all CWT releases and recoveries, plus release data for fish groups given other types of marks; (2) ensuring that reported data meet established format standards and pass validation procedures; (3) developing and maintaining on-line computer applications for querying and reporting from the database—known collectively as the Regional Mark Information System (RMIS); (4) providing electronic copies of data sets upon request; and (5) implementing recommended changes in the regional database exchange formats to meet expanding requirements for new information.

The primary focus of the RMPC's data management activities since 1977 has been to serve as a clearinghouse for CWT release and recovery data, with special emphasis on timely reporting of data, standardization of data formats, and integrity of the data. Analysis of the politically sensitive recovery data, however, has remained the responsibility of the reporting agencies and other interested data users in order to maintain the RMPC's neutrality and the trust of all agencies submitting data.

Tagging and Release Programs

Scale of Tagging Effort and Cost

Coastwide, more than 50 million juvenile salmon and steelhead are now coded wire tagged annually by some 47 State, Federal, Tribal, and private entities in the U.S. and Canada (appendix A, table A2). Chinook salmon tagging levels are the highest (circa 40 million), followed by coho salmon (7–9 million), and steelhead at about 1.5 million. (Tagging of other species in recent years has been of minor importance—occurring at levels in the mere tens of thousands annually). This massive tagging effort involves approximately 1,100 new tag codes each year. Hundreds of separate studies are involved.

Total tagging cost exceeds US $9 million annually. The cost per individual fish ranges between 15 and 20 cents, depending on local labor costs, logistics of tagging, and number of tags purchased for a given code. (Individual tags range between 8.7 and 16.4 cents each, with price determined by order size and delivery time.)

There also are costs in recovering CWTs. These costs are associated with sampling the various fisheries, spawning ground surveys, sorting and enumerating returning adults at fish hatcheries, and finally dissecting the snouts and reading the tags in tag recovery laboratories. These costs are often difficult to define since they usually are part of larger fish management program budgets. The Alaska Department of Fish and Game estimated in 2004 that their sampling cost was approximately $20 per tag and their cost to dissect and decode the tag in the lab and make the data publicly available was another $18 per tag (Clark, 2004). Approximately 275,000 tags are recovered each year at a cost of $12–13 million annually (Hankin et al., 2005).

Current Uses of CWT Data

CWT data are used in hatchery management to evaluate rearing and release experiments, to estimate adult production, and to manage broodstocks, harvest, and natural populations (i.e., natural spawning population composition) (Independent Scientific Review Panel and Independent Scientific Advisory Board 2009).

Although there are many kinds of tagging studies, they can be divided into three basic types (Pacific Marine Fisheries Commission, 1982): experimental (e.g., multiple comparisons), stock assessment, and stock contribution. Contribution is defined as the number of fish of a defined group occurring in a specific fishery. Fishery, as used here, is defined in a broad sense to include harvest and escapement (fish that return to natal streams to spawn).

Experimental tagging studies in hatchery management are designed to compare the relative survival or contribution of two or more experimental groups to the fisheries. Studies in this category deal with diet comparisons, time or site of release, pond density factors, disease control, and genetics.

Stock assessment studies (from generally a hatchery viewpoint) have localized objectives and are designed to measure contributions and distributions of particular stocks among various fisheries, as well as escapement of those stocks. With this information, the success of a hatchery's production or of natural production can be evaluated. The data also may have value to fishery management if adequate numbers of fish are tagged.

Stock contribution studies also are done for stock assessment purposes; however, the focus is from the fishery management perspective. In this case, fishery managers seek information on the contribution rates of key stocks in a given fishery (by time and area strata) in order to better manage harvest rates for conservation of the resource. The major difference between stock assessment and stock contribution studies is in the number of fish tagged. Stock contribution studies require far more tagged fish to generate meaningful recovery rates on a regional basis.

Tagged Releases of Salmonids—Total Amounts Released

Tagging programs are carried out at more than 260 Federal, State, Tribal, and private hatcheries and rearing facilities on the West Coast. In addition, natural origin fish are trapped and tagged at numerous sites. The principal tagging facilities are presented by State and Province in appendix A. Unless otherwise noted in the legend, the facilities are operated by the State or Province. Sites for tagging naturally produced fish in streams are not plotted because they are too numerous. Coastwide totals for all fishes released known to contain a CWT are shown in appendix A, table A3.

Tagging agencies also may opt to use so-called "blank wire" tags to mark some hatchery stocks. In the past, blank tags literally were blank in that there was no code present. Northwest Marine Technology, Inc. has since replaced them with 'agency only' blank wire so that the responsible releasing agency can be identified. It differs in that the wire carries a single (2-digit) code for the agency. As such, the tag carries limited information on the origin of the tagged fish based on the agency code.

Blank wire tags and agency-only wire tags are not CWTs. They physically look like CWTs, are injected in the same manner as CWTs and have similar magnetic properties enabling them to trigger automatic diversion gates and electronic CWT detectors; however, blank wire and agency-only wire tags do not possess a specific etched binary or decimal code and, upon recovery, cannot be resolved to a specific tag code (Pacific Salmon Commission Data Standards Work Group, 2009).

Blank wire was used by various agencies in situations where stocks need to be marked for identification purposes only. For example, the Washington Department of Fish and Wildlife (WDFW) and NMFS operated a trap at Lower Granite Dam (lower Snake River) to selectively remove tagged fish while untagged fish were allowed to pass upstream.

The incentive for using blank wire is simply reduced cost over full CWTs. The current price for blank wire is $38 per 1,000 tags as compared to $92 per 1,000 tags for CWTs, depending on quantities purchased. By coastwide agreement, re-use of tag codes is not approved (Regional Mark Committee, 2001). In those cases when a tag code is re-used, whether by accident or intentionally, any subsequent recoveries may be regarded as unresolved discrepancies as determined by the agency reporting the tag recovery (Pacific Salmon Commission Data Standards Work Group, 2009). All coastwide releases known to contain blank or agency-only wire tags are shown in appendix A, table A4.

Tagged Releases of Salmonids – Releases by Location

See the figures and tables in appendix A for historical release numbers, maps, and facilities information regarding the greater regional geography of releases:

- Alaska State: Figures A1–A3, Tables A6–A7
- British Columbia Province: Figures A4–A6, Tables A8–A9
- Washington State: Figures A7–A9, Tables A10–A11
- Oregon State: Figures A10–A11, Table A12
- Idaho State: Figures A12–A13, Table A13
- California State: Figures A14–A15, Table A14

CWT Sampling, Recovery, and Abundance Estimation Procedures

Many agencies release tagged salmonids, but the burden of ocean tag recoveries falls on five agencies: Alaska Department of Fish and Game (ADFG), CDFO, WDFW, Oregon Department of Fish and Wildlife (ODFW), and California Department of Fish and Game (CDFG). In the lower Columbia River, ODFW and WDFW jointly share the primary responsibility for sampling the commercial, Tribal, and recreational fisheries. A sixth agency, Idaho Department of Fish and Game (IDFG), also samples its freshwater fisheries and hatchery returns for CWT-marked fish.

In addition, the 20 western Washington Treaty Tribes jointly carry out a sizable and important component of the coastwide sampling effort. Their Tribal fishery recovery information is combined with non-treaty recoveries and processed by WDFW. The Quinault Nation, Quileute Tribe, and Colville Tribe, however, maintain their own recovery and reporting programs.

Limited sampling is conducted by a few other agencies. In Alaska, NMFS and the Metlakatla Indian Community maintain sampling programs for their respective fisheries and escapement. In the upper Columbia River (Washington), the Yakama Tribe maintains a CWT sampling program. The Nez Perce Tribe likewise has a sampling program for the Snake River in Idaho. Their respective CWT recovery datasets are submitted to the RMPC. Lastly, USFWS maintains a sampling

program on the Klamath and Trinity Rivers system in northern California, as well as sampling programs at its various salmon and steelhead hatcheries in Washington, Oregon, Idaho, and California.

Sampling Design

The sampling programs of the participating agencies are comparable in overall design but differ in many specifics because of constraints imposed by local conditions and differing approaches to mark recovery. There are, however, common elements of the major recovery programs.

All major recovery programs sample landings of commercial marine and mainstem river fisheries for CWT-marked Chinook and coho salmon. Electronic tag detection equipment is used by Oregon, Idaho, and Washington to sample Chinook and coho salmon landings. In British Columbia, electronic sampling is limited to coho landings. In California and Alaska, visual sampling for adipose clips is the only method used to retrieve CWTs. Representative samples are randomly taken at ports throughout the State or Province at appropriate time intervals, ranging from days to weeks, to track changes in stock composition in the harvest and to also estimate survival rates for the intercepted stocks of interest.

An important component also is the sampling of recreational fisheries. The emphasis typically is focused on sampling day boats and charter boats in marine waters. Creel sampling also is carried out in some inland fisheries.

Another common element is the sampling of escapement. This includes both returns to the hatchery and surveys of the spawning grounds. Historically, spawning ground surveys have been the weakest component of the sampling coverage by nearly all recovery agencies in that they are infrequently sampled for tags. However, it has received ever increasing attention and importance with the implementation of the Pacific Salmon Treaty and recommendations from CWT program reviews.

All recovery agencies strive to randomly sample at least 20% of commercial and sport landings to have a statistically acceptable estimate of total tag recoveries for a given area-time stratum. Hatcheries generally are sampled at high rates, often at 100%. When sampled, spawning locations are sampled at levels up to 50% (Pacific Salmon Commission, 2008). In some cases, fisheries sampling coverage may exceed 50% if landing port coverage by samplers is high (Nandor et al., 2008).

Coastwide, CWT sampling coverage has some limitations. Chinook and coho salmon are the only species sampled in commercial and sport fisheries, both marine and freshwater, on a coastwide basis. Sampling and reporting is very well coordinated for Chinook and coho through various joint technical committees within the region. Some sampling does occur for chum, sockeye, pink salmon, and steelhead. In such cases, it typically involves agency-specific management objectives in marine terminal areas or limited freshwater areas.

Catch and Sampling Procedures (Visual and Electronic)

Field samplers typically work on the docks and sample commercial landings at buying stations. Recreational vessels also are sampled as they return to port. The basic sampling unit is the boatload of fish, not the individual fish. Samplers attempt to randomly sample vessels, whether they are day boats or trip boats. In the latter case, some of the larger vessels must be subsampled because of the size of the catch. Bins of fish then become the sampling units.

Sampled fish testing positive for the presence of a CWT (electronic sampling, see fig. 5) or missing the adipose fin (visual sampling) are set aside for removal of the head or snout. The sampler then records species, sex, and fork length of the fish on a small waterproof label and encloses it with the head in a plastic bag for later processing. Scale samples and weight information also may be collected.

Information on the sampled unit (boat load or bin) is recorded on a sample form. This typically includes catch location, catch period, gear type, processor, species, total fish sampled, total marks recovered, and sample date.

Figure 5. Electronic sampling of commercially caught Chinook salmon using a hand heldwand detector (photograph by George Nandor).

Processing and Tag Recovery

A simplified flowchart showing an example of CWT processing procedures is shown in figure 6. Heads removed from adipose clipped salmonids are transported frozen or preserved to the agency's CWT laboratory for tag removal and decoding. The tiny tags are recovered by dissection, aided by an electronic metal detector that indicates which portion of the snout the tag is in after each successive sectioning of the sample. If no tag is found, the sample is passed through a magnetic field to re-magnetize the tag (if present). The sample is then passed through a highly sensitive tubular tag detector to confirm the absence of a tag.

Following tag extraction, the tag is decoded under a low power microscope. After the initial reading, a second tag reader makes an independent reading for verification. Several agencies now use a small video camera to project the tag image on a screen, thereby making it easier to decode (see fig. 7).

Figure 7. A recovered CWT magnified and displayed on a monitor for easy reading (photograph provided by ODFW).

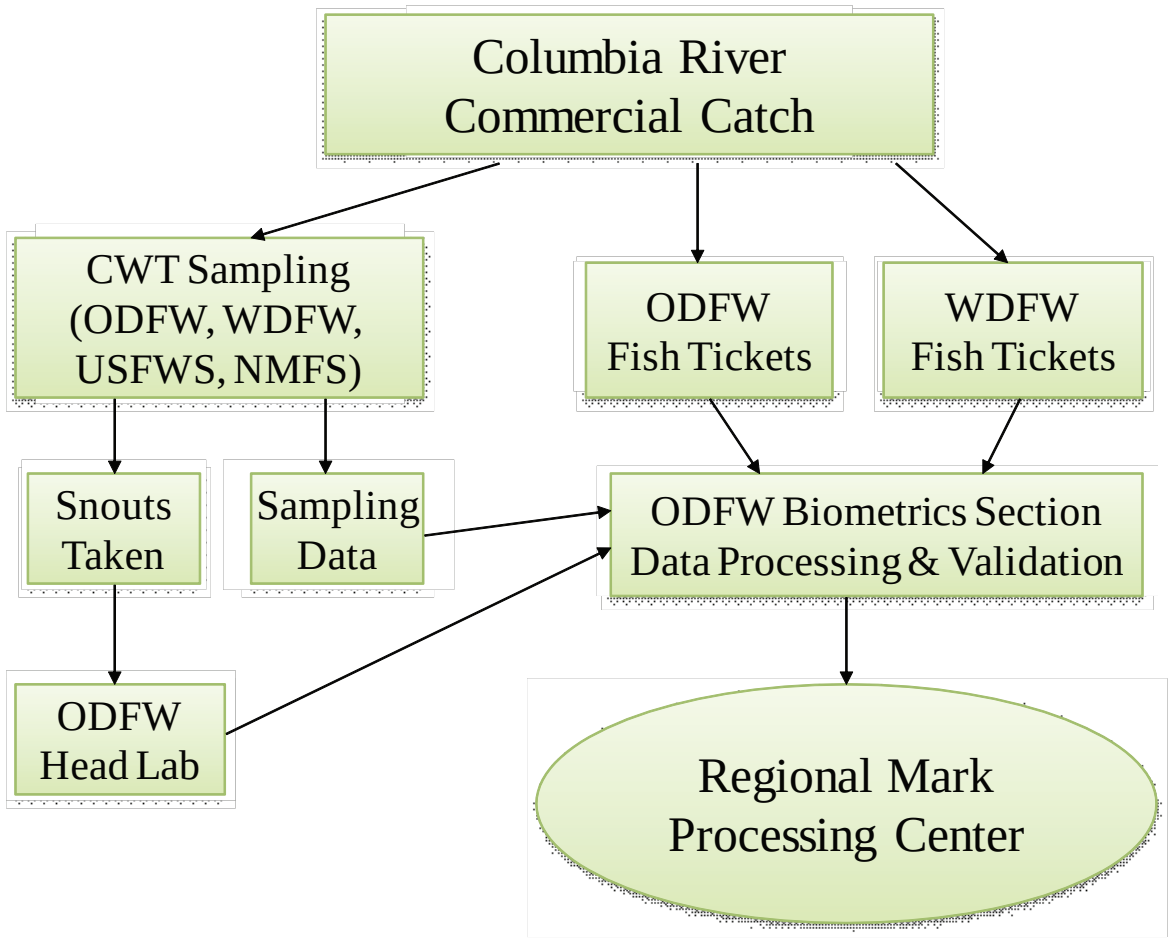

Figure 6. Flowchart showing program example: Columbia River CWT recovery system.

Once decoded, the tag code and associated sampling data are entered into a spreadsheet or database for further processing. Several error checks are run, including verification that the tag code is legitimate (i.e., was previously released) and that the species is correct. Questionable tag codes are re-read by dissection laboratory personnel, and pertinent supplementary data are checked to resolve other errors.

Upon validation, the "observed recoveries" are made available for use in preliminary reports. This includes expansion of the observed recoveries into "estimated recoveries" (see equations below) for the given area time stratum once the catch sample data are available.

Recovery Estimation

The total number of fish from a particular release group that are caught in a particular area (or landed at a particular port) during a particular time period can be estimated in a two-step process:

$$R_T = aR_O,$$

where

R_T is the estimataed total recoveries of tags bearing the release group's code,

R_O is the observed number of tags of the appropriate code, and

a is a sampling expansion factor: (total catch)/(sampled catch).

Equation 1.
Step 1: Estimate the number of tagged fish in the fishery sample for that area (or port) and time (Johnson, 2004).

$$C = bR_T,$$

where

C is the total estimated contribution of the release group to the fishery in that area at that time, and

b is a marking expansion factor: (total fish released)/(total fish marked).

Equation 2.
Step 2: Account for the fraction of the release group that was tagged (Johnson, 2004).

The contribution estimates then are summed over all relevant area (port) and time strata.

CWT Database and RMIS

Upon completion of the expansion process, the recovery agency submits the observed and estimated tag recovery data and associated catch and sample data via Internet transfer to the RMPC. The RMPC then checks the data for errors and works with the recovery agency to resolve discrepancies. Once validated, the data (incomplete or complete) are combined with those of other recovery agencies to document coastwide recoveries of any given tag code.

The data flow process of the RMPC is shown in figure 8. The CWT data are submitted to the RMPC where they are loaded and validated against an extensive set of checks. These checks are to verify the integrity and accuracy of the data elements. Two elements of critical importance are: (1) the number of fish released with the CWT for each tagged release group; and (2) the number of estimated recoveries for each reported observed tag recovery.

Once validated, the data are moved into a relational database and made accessible via the RMIS online. Likewise, validated datasets are posted to Canada (CDFO) on a regular basis as specified in the bilateral Pacific Salmon Treaty.

Types (Classes) of Data

Related to the processes described above, there are five main classes of CWT data in the database: Release, Catch/Sample, Recovery, Catch & Effort, and Location. In addition, the CWT database contains some descriptive metadata (e.g., Description data) referring to many rows of data among the main five data classes. This metadata is intended to help maintain a permanent centralized record of CWT program progress and special events that are reflected in the data values. The five classes of data are described as follows:

Release.—When a group of fish is released from a hatchery or other release site containing any number of coded wire tagged fish, the group is associated with a unique tag code. Any pertinent information from releasing agencies regarding the release group is submitted to the RMPC by the responsible State, Provincial, or Federal agencies. There are approximately 44,000 tagged release groups in the database dating back to 1968.

When groups of fish are released without coded wire tagged fish present, the release group is called an untagged/unassociated group. The release group is assigned a 12-character alpha-numeric identifier. This information is likewise submitted to the RMPC. There are approximately 95,000 untagged release groups in the database dating back to 1952.

Catch / Sample.—Tagged fish are sampled Pacific coastwide by sampling agencies from various commercial, recreational, Tribal, and escapement fisheries. These agencies usually record the sampling area, number caught, and percent of catch that was sampled and related information. This information is called Catch/Sample data and is collected by sampling agencies for submission to the RMPC on a yearly basis by specific reporting agencies. There are currently about 320,000 Catch/Sample records in the database.

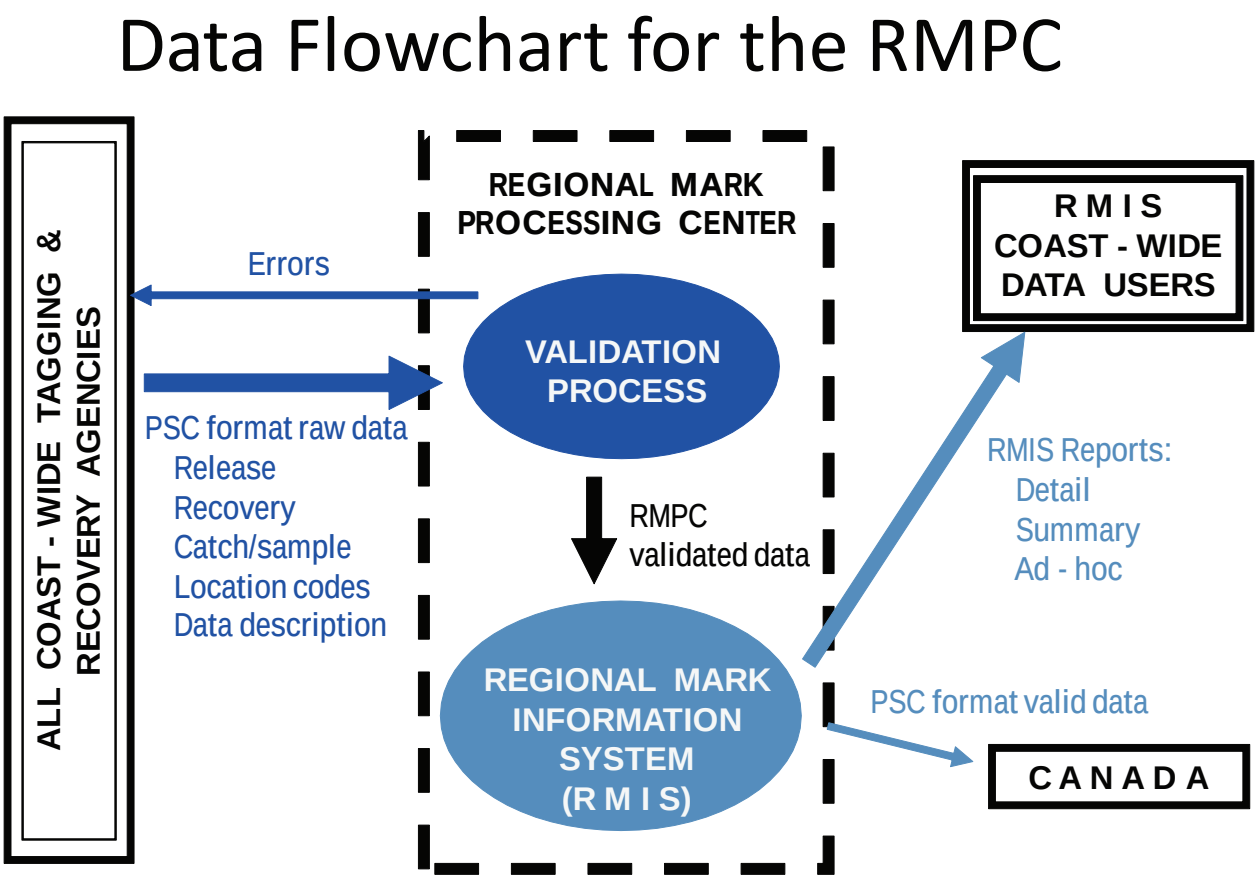

Figure 8. Flowchart showing flow of datasets through the PSMFC RMPC.

Recovery.—When tags are removed from fish and decoded, the tag is linked to the specific location of catch, date of catch, fishery, and other related biological data. Where possible, the ratio of the number of fish sampled to the total catch is multiplied by the total number of tags extracted to form the Estimated Number of fish. These data are collected by sampling agencies for submission to the RMPC on a yearly basis along with Catch/Sample data. Individual recovery records correspond to one observed (decoded) tag.

Each recovery record has an associated "Status of Tag." This status is coded as follows:

"1" Tag read OK
"2" No tag
"3" Tag lost before read
"4" Tag not readable
"7" Unresolved discrepancy
"8" Head not processed
"9" Pseudo tag, blank wire

In addition to passing rigorous validation tests, the status "1" recoveries must match by tag code with a tagged release group. There are currently about 5.5 million status "1" recovery records in the database. Recoveries with a status other than "1" are not included in most RMIS reports. There are currently about 1.3 million non-status "1" recoveries in the database.

Catch & Effort.—Catch effort is the amount of fish caught by a specified amount of effort. It also can be defined as the catch of fish, in numbers or in weight, taken by a defined unit of fishing effort. Typically, effort is a combination of gear type, gear size, and length of time gear is used. Catch per unit of effort is often used as a measurement of relative abundance for a particular fish. There are currently about 140,000 Catch & Effort records in the database.

Location.—The geographic locations of release, sample, and specific recovery of fish also are assembled by specific location reporting agencies. Collectively, these are called Location data and are submitted to the RMPC along with all other classes of data.

There are five types of locations. Within each type of location, the location record is uniquely identified coastwide by a 19-character Location Code. That code is associated with a textual description of the location and a geographical reference to the location. In 2009, there were approximately 14,000 locations in use in the database.

The five types of locations are described as follows:

1. **Recovery Site**: Indicates as closely as possible the actual geographic place where a tagged fish was caught. They usually are specified within larger Catch Areas in the sampling stratum. This type of location is found only in Recovery data.
2. **Catch Area**: Corresponds to geographic areas where sampling occurred for a given fishery. They may encompass several recovery sites. This type of location is found in Catch/Sample and Catch & Effort data.
3. **Hatchery**: Specifies the name of the hatchery or rearing facility for non-wild release groups. This type of location is found only in Release data.
4. **Release Site:** Specifies the geographic release location of the release group. It may differ from the hatchery. This type of location is found only in Release data.
5. **Stock:** Differs from all other locations in that they identify the brood stock or morphology of a release group rather than a geographic location. Stocks usually correspond to the name of a stream or if the stock was mixed, a composite of stream names. This type of location is found only in Release data.

Validation and Maintenance

Immediately after the reporting agency has transferred the recovery and catch/sample dataset to the RMPC (fig. 8), the RMPC then checks the data for errors and works with the reporting agency to resolve discrepancies. Once validated, the data (preliminary or final) are combined with those of other reporting agencies to document coastwide recoveries of any given tag code.

U.S.-Canada Data Exchange

The CWT system consists of several elements:

- There are separate U.S. and Canadian CWT reporting databases. The U.S. system (RMIS) is maintained by the RMPC of the PSMFC. The Canadian system (Mark Recovery Program, MRP) is maintained by the CDFO (fig. 9).
- Both countries acquire CWT data that originates within their country and provide access to information contained in their databases in a manner that satisfies users of their country.
- Reporting requirements and centralized responsibilities for data exchange between Canada and the U.S. are standardized to ensure both databases are identical.

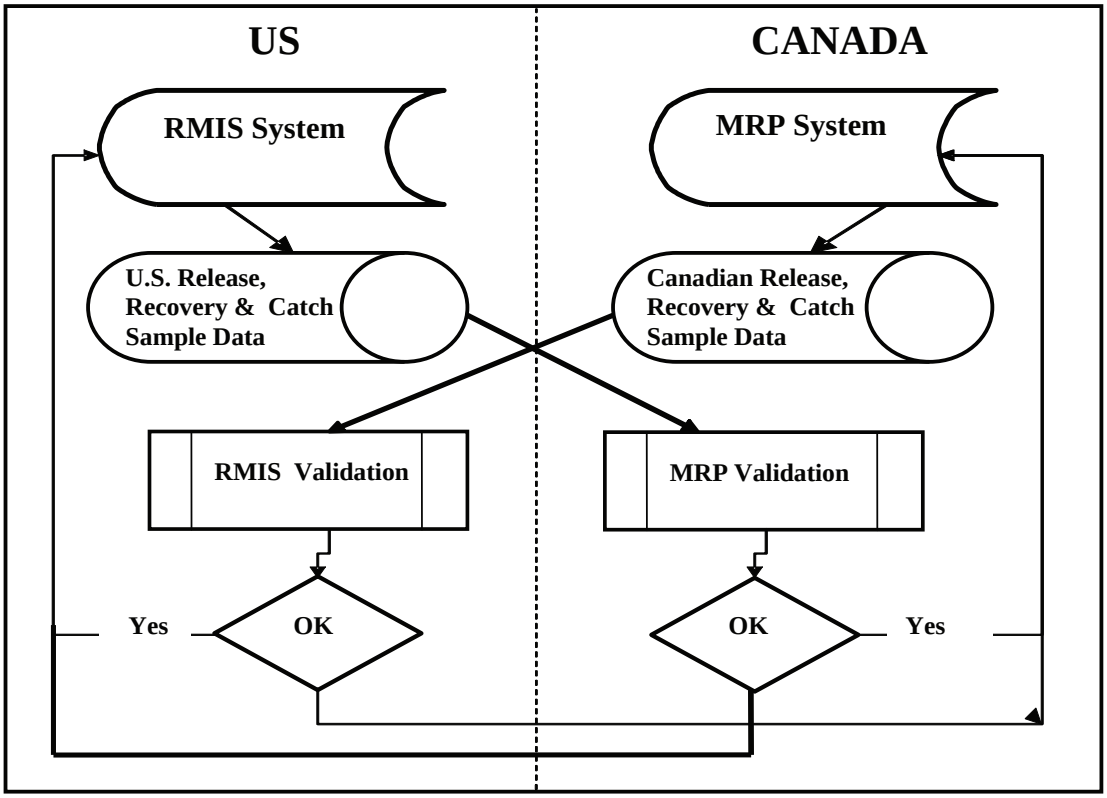

Figure 9. Main components of the data exchange protocols between the Canadian and U.S. CWT database systems (Pacific Salmon Commission (PSC), 2008).

- Cooperative development of standardized formats for reporting release, recovery, and catch sample data has been employed. The release system provides information on all releases coastwide, tagged and untagged. The recovery system encompasses the sampling and recovery information for all fisheries and escapement locations coastwide.
- There are inter-agency processes for review, coordination, and modification of CWT data.
- There are agreed upon rules for data validation and procedures for correction. The rules are specified in the PSC Data Standards Workgroup (DSWG) database specification report (Pacific Salmon Commission Data Standards Work Group, 2009), which may be found on the PSMFC web site. Validation rules indicate when columns must contain one of a set of allowed codes, such as for fishery type, gear type, species, agency code, or tag status. In addition, tag codes reported in a recovery file must match a tag code reported in a release file in the database. Information regarding species, sampling periods, and other data items in a catch/sample file must match the corresponding information in the recovery file. The location codes (for releases, recoveries and sampling sites) must follow certain rules such that the database operations can sort data by location. These are just some of the validation rules used. All reporting agencies are responsible for ensuring that complete and accurate data are reported (Pacific Salmon Commission, 2008).

RMIS Online Web-Accessible Data

RMIS is comprised of three principal Internet based reporting systems for public download of CWT and related datasets. They are: (1) RMIS Standard Reporting System; (2) RMIS Analysis Reporting System; and (3) RMIS Catch & Effort Data Reporting System. RMIS is located at the following address: http://www.rmpc.org.

The **RMIS Standard Reporting System** is an application that allows the user to build a query, select, and optionally preview the result set row by row, and then run a formatted report of their choice using the result set. The report may then be returned to the browser, or sent to their email address. Data retrieval includes selection by location or by tag code as well as many other data elements.

All classes of data are available in user-customizable raw data download format. In addition, RMIS Standard Reporting has the following report formats available in either textual summary (with page headers) or textual detail (one report row per line) levels:

- Release reports by tag code or release id: 5 reports (detail)
- Release reports by adipose clip: 1 report (summary).
- Recovery reports by tag code: 18 reports (summary and detail).
- Recovery reports by tag list: 2 reports (summary and detail).
- Recovery reports by hatchery of release: 7 reports (summary and detail)
- Catch / Sample reports: 1 report (detail)
- Location reports: 1 report (detail)

The **RMIS Analysis Reporting System** was developed to facilitate the analysis of coastwide salmon recovery information in terms of actual geographic areas used for management of the various fisheries. It refers to a version of the CWT database that is summarized by tag code, “management-fishery” units, and age class of returning fish. RMIS Analysis allows the user to auto-generate and maintain lists of tag codes based on various criteria—such as morphological characteristics of the fish releases. RMIS Analysis also provides a means of organizing (grouping) tag codes and/or management-fisheries by various user-identified criteria and using the group definitions as units for aggregation in report output.

RMIS Analysis Reporting has the following report formats available:

- CWT- based recovery reports: 9 reports (summary and detail).
- Management-fishery based recovery report: 1 report (summary).

The **RMIS Catch & Effort Reporting System** provides a means of selecting and downloading raw datasets of Catch & Effort data. There are no formatted reports available of Catch & Effort data.

The RMPC website also includes many other features such as:

- Status charts of all CWT metadata (“Descriptions”) selectable by data class and reporting agency which allow user tracking and review of data update activity.
- Status charts showing all current data processing information from the RMPC including load date and number of records loaded into the database.
- Running ticker of recent news developments regarding the RMPC computer system and the CWT database updates.
- Coastwide discussion forum for discussion of data management and related issues.
- Image gallery illustrating many aspects of coastwide CWT system and field processes.
- A set of numerous CWT related publications available for download.

Current Issues Impacting the CWT Program

The recent Report of the Expert Panel on the Future of the CWT Recovery Program for Pacific Salmon (Hankin et al. 2005) identified current issues and problems with the current CWT system and provided an extensive discussion of these issues. The issues include whether indicator stocks adequately represent natural populations, statistical uncertainty of CWT-based estimates, increasingly finer scales of fishery-time resolution to conserve individual populations of fish, mass marking, and selective fisheries. A review of California hatchery programs found that tagging levels were insufficient to calculate exploitation rates and escapement estimates of hatchery produced fish (Joint Hatchery Review Committee, 2001). The Columbia River Hatchery Reform Project also identified the need for increased tagging levels to better evaluate the success of hatchery rearing programs in the Columbia River Basin (Hatchery Scientific Reform Group, 2009). Additionally, coded wire tagging and subsequent fishery sampling efforts have been reduced due to budget constraints (ISRP/ISAB 2009-1).

Recommendations for improving the CWT program include reviewing indicator stocks to advance the understanding of the relationship between hatchery reared indicators stocks and their natural counterparts, increasing tagging rates of release groups and/or increasing sampling rates of fisheries to increase statistical precision, improving enforcement of sampling and CWT collection laws, increased use of electronic CWT detection methods, increased spawning ground surveys, and better reporting of all escapement data. More details of the recommendations are available in An Action Plan in Response to Coded Wire Tag (CWT) Expert Panel Recommendations (Pacific Salmon Commission, 2008).

The CWT system also has other limitations in that capital equipment costs are high; tags must be recovered from the fish for decoding, which is lethal for the fish; a sophisticated sampling and recovery program is needed for good statistical precision of the data; a tag recovery laboratory must be available; a computer data system is needed to record data and upload data to the central database (RMIS); and a trained staff is essential for success.

Future of the CWT Program

The 2008 bilateral agreement for the conservation and harvest sharing of Pacific salmon under the jurisdiction of the Pacific Salmon Treaty assures the continued use of CWTs as the primary data source for managing fisheries covered by the treaty. The governments of Canada and the U.S. agreed to invest $15 million ($7.5 million in each respective currency) to improve the coastwide CWT program. CWT technology also is expected to remain important for managing salmon populations and in salmon policy decision making in the Columbia River Basin (ISRP/ISAB 2009-1). Although tagging efforts have leveled off in most of the region, California has recently expanded to tagging 25% of all hatchery salmon released through the implementation of a Constant Fractional Marking Program ,which resulted in the tagging of about 8 million fall Chinook salmon in 2007 and 2008 (Pacific States Marine Fisheries Commission, 2008). Tagging and recovery efforts are funded by virtually all fisheries agencies in the region and by other entities that are responsible for funding fisheries mitigation programs. All this bodes well for the continued viability of the CWT program.

Improvements are needed, however. It is critically important for all fisheries agencies in the region to support the CWT program. This support not only includes funding but the commitment to exchange and share the data in a timely manner so that all agencies have equal access to the data. Agencies must implement the solutions provided by the CWT workgroup with reference to the priorities identified in An Action Plan in Response to Coded Wire Tag (CWT) Expert Panel Recommendations. The region also has to address the impact of mark selective fisheries on naturally produced (unmarked) fish through the increased use of double index tag groups of fish that act as surrogates for wild fish or through some other method, such as genetic stock identification. As stated above, tagging agencies must determine the proper number of tagged fish for the representative release groups and sampling agencies must implement robust sampling of fisheries and freshwater escapement areas, particularly spawning grounds, to increase precision of the statistical analyses. One of the keys for the program is the continued operation and maintenance of the RMIS and the CWT database by the PSMFCs's RMPC, which requires it to be adequately funded to facilitate the necessary data exchange that makes this regional CWT program a success.

Summary

After 40 years, the CWT program in the greater Pacific region of North America continues to be the most important tool for salmonid research and management. This paper has given an overview of the of the development of the CWT, how the tagging program meets management needs, current regional coordination procedures, the scale of tagging efforts and subsequent sampling and recovery procedures, data exchange through the centralized regional database, current issues impacting the CWT program, and the future of this program. It is important to note, however, that the various agencies' tagging, fish release, and recovery programs are considerably more complex than presented here. Additional specific information must be obtained directly from the agency tag coordinators (contact information available from the RMPC web site) and the RMPC for a complete understanding and assessment of specific tagging programs.

All tagging methods have their advantages and disadvantages, and the CWT is no exception. The implementation of electronic detection methods, increased tagging and sampling rates, and the use of statistical analysis to increase precision of data all help to increase the effectiveness of the program to meet management needs. The widespread use of these tags over a long period of time, along with the regional coordination among the tagging and sampling agencies, is unprecedented anywhere else in the world and is its greatest strength. In addition, CWTs are being used in conjunction with other marking and tagging methods (e.g., genetic markers, scale patterns, otolith banding, and PIT tags) to provide an enhanced analysis of Pacific salmon population dynamics.

More specific information about the Pacific coastwide CWT system also is available online at http://www.rmpc.org with links to other publications and resources pertaining to the program.

Acknowledgments

A special acknowledgment needs to be made of J. Kenneth Johnson, who managed the RMPC from 1979 until 2006. His previous CWT overview papers of 1990 and the subsequent update of 2004 were the basis for this document. Ken graciously gave his permission to use his previous written material as needed to produce this paper.

We also want to acknowledge Brett Holycross, a GIS Specialist at PSMFC, for his work in creating the maps showing the release locations of coded wire tagged fish. Amy Roberts at PSMFC is to be thanked for formatting the various drafts and the final version of the manuscript for submission. Charlie Paulsen and Kevin Malone are to be thanked for reviewing this paper and providing very helpful comments and suggestions.

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Appendix A. Overview of the Coded Wire Tag Program in the Greater Pacific Region of North America.

Table A1. Votes (total, 12) assigned to the 14-member Mark Committee in the event there is no consensus on an issue involving fin marking or CWT use.

[Private and other nongovernmental organizations are represented by State or Provincial coordinators]

Jurisdiction	Committee Representatives (total) — U.S. and Canada	Number of members	Number of votes
Coordinating agency	Pacific States Marine Fisheries Commission (Chair – non-voting)	1	0
State agencies			
–Alaska	Alaska Department of Fish and Game	1	1
–Washington	Washington Department of Fish and of Wildlife	1	1
–Oregon	Oregon Department of Fish and Wildlife	1	1
–California	California Department of Fish and Game	1	1
–Idaho	Idaho Department of Fish and Game	1	1
Federal agencies			
–U.S. Fish and Wildlife Service	Region wide	1	1
–National Marine Fisheries Service	Alaska and Northwest regions and centers	2	1
Tribal groups			
–Annette Island (SE Alaska)	Metlakatla Indian Community, 1 tribe	1	1
–Western Washington	Northwest Indian Fisheries Commission, 20 tribes	1	1
–Columbia River basin	Columbia River Intertribal Fisheries Commission, 4 tribes	1	1
Canada			
–Federal level	Canada Department of Fisheries and Oceans	1	1
–Provincial level	British Columbia Ministry of Environment, Fish and Wildlife Branch	1	1

Table A2. Federal, State, Tribal, and private entities, and associated abbreviations (as used in RMIS), in the Pacific Northwest of North America that have formerly used or are currently using CWTs for salmonid fishes.

[Bolded abbreviations identify entities currently reporting releases of CWT-marked salmonids (2006–09)]

Agency	Agency name
AAC	American Aquaculture Corporation (AK)
AAI	Alaska Aquaculture, Inc
ADFG	**Alaska Department of Fish and Game**
AFSP	Aboriginal Fishery Strategy Program (BC)
AKI	**Armstrong Keta, Inc. (AK)**
ANAD	Anadromous Inc. (OR)
ASLC	**Alaska Sealife Center**
BCFW	British Columbia Fish and Wildlife
BHSR	Burnt Hill Salmon Ranch (now OPSR) (OR)
BURR	Burro Creek Hatchery
CDFG	**California Department of Fish and Game**
CDFG-KT	**California Dept. of Fish Game Klamath / Trinity**
CDFO	**Canada Department of Fisheries and Oceans**
CDFR	Canada Dept. of Fisheries and Oceans - Research
CDWR	**California Department of Water Resources**
CEDC	Clatsop Economic Development Council (OR)
CERA	Ceratodus Fisheries (OR)
CHEH	Chehalis Tribe (WA)
CIAA	**Cook Inlet Aquaculture Association (AK)**
COLV	Colville Tribe (WA)
COOP	**Washington Department of Fisheries – Cooperative**
CRFC	Columbia River Inter-Tribal Fish Commission
CTWS	Confederated Tribes of the Warm Springs of Oregon
DIPC	**Douglas Island Pink and Chum, Inc. (AK)**
DOMS	Domsea Farms, Inc. (OR-WA)
EBMD	**East Bay Municipal Utilities District (CA)**
EDUC	Educational Facility (excluding UW) (WA)
ELWA	**Lower Elwha Klallam Tribe (WA)**
ESRP	Eel River Salmon Restoration Project (CA)
FWS	**U.S. Fish and Wildlife Service**
H&H	Harris & Hugie Company (OR)
HECK	C.W. Heckard Company (OR)
HFAC	Humboldt Fish Action Council (CA)
HOH	**Hoh Tribe (WA)**
HSU	Humboldt State University (CA)
HVT	**Hoopa Valley Tribe (CA)**
IDFG	**Idaho Department of Fish and Game**
JAME	Jamestown Klallam Tribe (WA)
KAKE	**Kake Non-Profit Fisheries Corp. (AK)**
KETA	Keta Company (OR)
KRAA	**Kodiak Regional Aquaculture Association (AK)**

Agency	Agency name
KRHI	Klawock River Hatchery, Inc. (AK)
KRUK	Karuk Tribe (CA)
KTHC	**Ketchikan Tribal Hatchery Corporation (AK)**
LUMM	**Lummi Tribe (WA)**
MAKA	**Makah Tribe (WA)**
MIC	**Metlakatla Indian Community (AK)**
MTSG	Mattole Salmon Group (CA)
MUCK	**Muckleshoot Tribe (WA)**
NBS	National Biological Survey
NERK	Nerka Incorporated (AK)
NEZP	**Nez Perce Tribe (ID)**
NFA	**Nome Fishermen's Association**
NISQ	**Nisqually Tribe (WA)**
NLNS	Nehalem Land & Salmon (OR)
NMFS	**National Marine Fisheries Service (AK)**
NOOK	Nooksack Tribe (WA)
NSED	**Norton Sound Development Corp**
NSRA	**Northern SE Regional Aquaculture Assn. (AK)**
OAF	Oregon Aquafoods, Inc.
ODFW	**Oregon Department of Fish and Wildlife**
OPSR	Oregon-Pacific Salmon Ranch (formerly BHSR)
OSU	Oregon State University
PGAM	**Port Gamble S'Klallam Tribe (WA)**
PGHC	**Port Graham Hatchery Corporation (AK)**
PLCO	Pacific Lumber Company (CA)
PNPT	Point No Point Treaty Council (WA)
PPWR	Puget Power (WA)
PSE	Puget Sound Energy (WA)
PUYA	**Puyallup Tribe (WA)**
PWHA	**Prince of Wales Hatchery Association (AK)**
PWSA	**Prince William Sd Aquaculture Corporation (AK)**
QDNR	**Quinault Department of Natural Resources (WA)**
QUIL	**Quileute Tribe (WA)**
RMPC	Regional Mark Processing Center
ROWH	**Rowdy Cr. Hatchery (CA)**
SHOL	Shoalwater Tribe (WA)
SIUF	Siuslaw Fisheries (OR)
SJ	**Sheldon Jackson College (AK)**
SJRG	San Joaquin River Group (CA)
SKOK	**Skokomish Tribe (WA)**
SOF	Silverking Oceanic Farms (CA)

Table A2. Federal, State, Tribal, and private entities, and associated abbreviations (as used in RMIS), in the Pacific Northwest of North America that have formerly used or are currently using CWTs for salmonid fishes.—Continued

Agency	Agency name
SPOK	Spokane Tribe (WA)
SQAX	Squaxin Island Tribe (WA)
SRKC	Smith River Kiwanis Club
SSC	Skagit System Cooperative (WA)
SSLC	Seaward Sealife Center
SSRA	**Southern SE Regional Aquaculture Assn. (AK)**
STIL	**Stillaguamish Tribe (WA)**
SUQ	**Suquamish Tribe (WA)**
SYCL	South Yuba River Citizens League, CA
THCC	Tlingit-Haida Central Council (AK)
TULA	**Tulalip Tribe (WA)**

Agency	Agency name
TYEE	Tyee Foundation (CA)
UA	University of Alaska
UI	University of Idaho
UPSK	**Upper Skagit Tribe**
USFS	U.S. Forest Service
UW	**University of Washington**
VFDA	**Valdez Fisheries Development Association (AK)**
WDFW	**Washington Department of Fish and Wildlife**
WREG	Washington Regional Enhancement Groups
YAKA	**Yakama Tribe (WA)**

Table A3. Total CWT Releases by Species and State/Province since inception of CWT program in 1968 (Regional Mark Information System Database [online database]).

State / Province	Chinook	Coho	Steelhead	All Other	State/Province Total
Alaska	38,855,791	33,894,600	556,354	34,291,279	107,598,024
California	167,397,186	5,209,465	6,291,336	452,966	179,350,953
British Columbia	133,174,780	50,263,861	6,452,425	11,176,083	201,067,149
Idaho	55,838,627	1,447,878	24,584,157	448,676	82,319,338
Oregon	156,667,313	48,540,659	8,795,176	314,023	214,317,171
Washington	426,038,213	121,901,556	17,987,746	7,639,180	573,566,695
Species Total	977,971,910	261,258,019	64,667,194	54,322,207	1,358,219,330

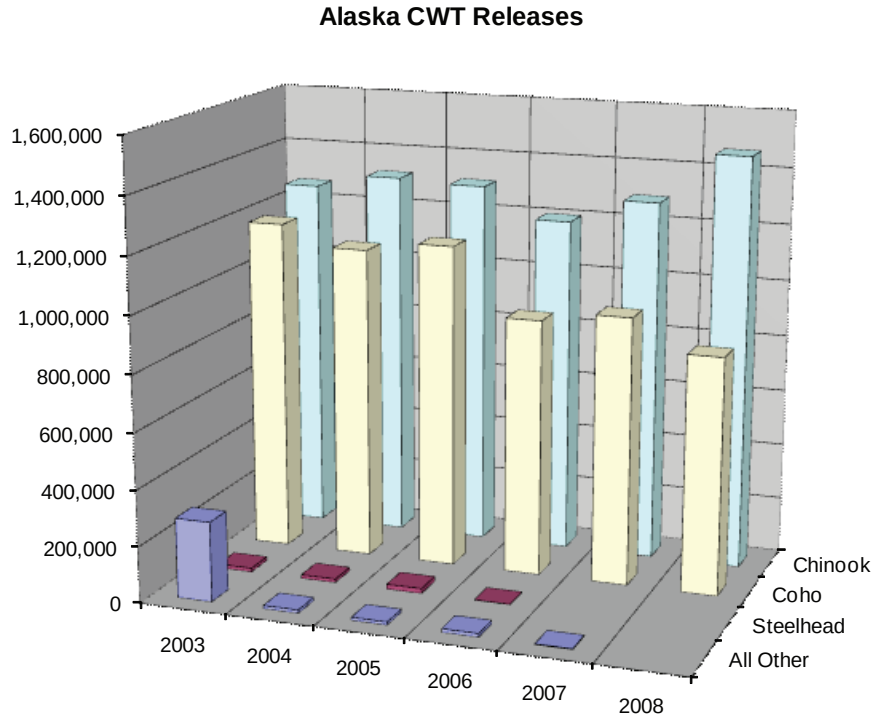
Table A4. All releases with blank or agency-only wire since inception of CWT program in 1968. (Regional Mark Information System Database [online database]).

State	Chinook	Coho	Steelhead	All Other	State Total
Alaska	0	2,412	0	15,362	17,774
Idaho	1,571,709	0	1,117,307	0	2,689,016
Oregon	19,134,773	282,651	447,683	0	19,865,107
Washington	18,131,576	147,654	3,615,582	0	21,894,812
Species Total	38,838,058	432,717	5,180,572	15,362	44,466,709

Table A5. Total CWT Recoveries by Species and Area recovered since inception of CWT program in 1968.

[Totals include all instances where a tag read was attempted at a tag recovery lab (i.e., where Tag Status is '1', '4', '7', or '9'; Regional Mark Information System Database [online database]). *By-catch recoveries from ocean fisheries targeting other non-salmonid species]

Area / State / Province	Chinook	Coho	Steelhead	All Other	Area Total
Alaska	318,018	445,356	1,118	172,822	937,314
California	277,758	20,031	5,194	0	302,983
British Columbia	331,832	787,455	7,778	26,508	1,153,573
High Seas*	6,236	453	264	26	6,979
Idaho	39,417	0	38,744	18	78,179
Oregon	523,178	547,084	44,142	709	1,115,113
Washington	677,529	1,247,034	42,261	5,397	1,972,221
Species Total	2,173,968	3,047,413	139,501	205,480	5,566,362



	2003	2004	2005	2006	2007	2008
All Other	283,918	11,514	10,614	12,652	2,460	
Steelhead	13,394	12,598	17,454	998		
Coho	1,185,311	1,114,923	1,151,119	915,307	952,008	842,718
Chinook	1,267,752	1,316,355	1,305,385	1,199,439	1,287,286	1,467,256

Figure A1. All CWT Releases in Alaska State by species and year from 2003 to 2008 (Regional Mark Information System Database [online database]).

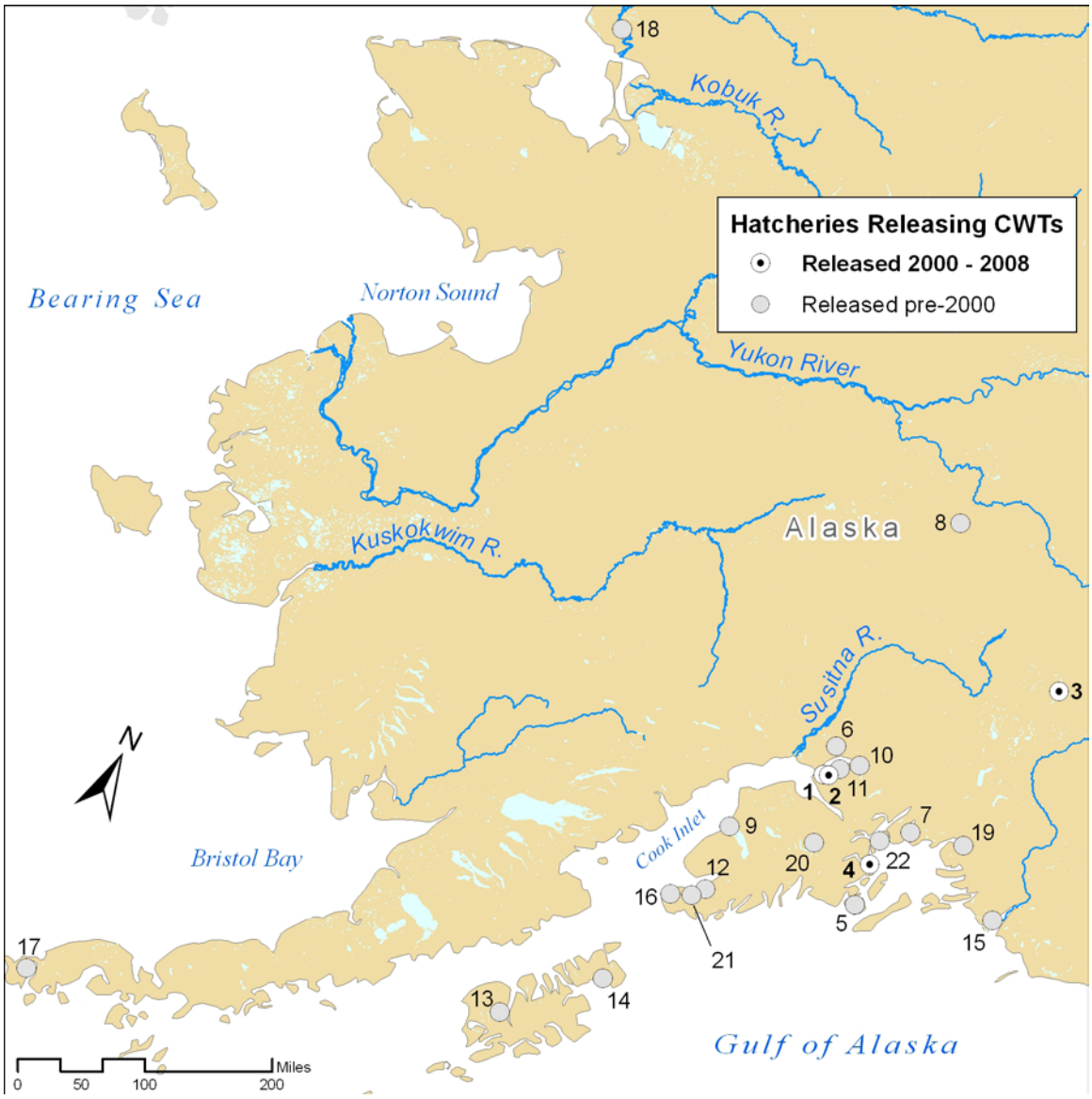


Figure A2. Hatcheries and rearing facilities in greater Alaska state (excluding Southeast area) that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

Table A6. Legend: hatcheries and rearing facilities in greater Alaska state (excluding Southeast area) that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

AK Facilities Releasing: 2000–2008		AK Facilities Releasing: pre–2000		AK Facilities Releasing: pre–2000	
1	Elmendorf	5	A F Koernig	13	Karluk
2	Fort Richardson	6	Big Lake	14	Kitoi Bay
3	Gulkana	7	Cannery Creek	15	Mile 25 Spawning Channel
4	Main Bay	8	Clear	16	Port Graham
		9	Crooked Creek	21	Tutka Bay
		10	Eklutna	22	Wally Noerenberg
		11	Fire Lake		
		12	Halibut Cove		

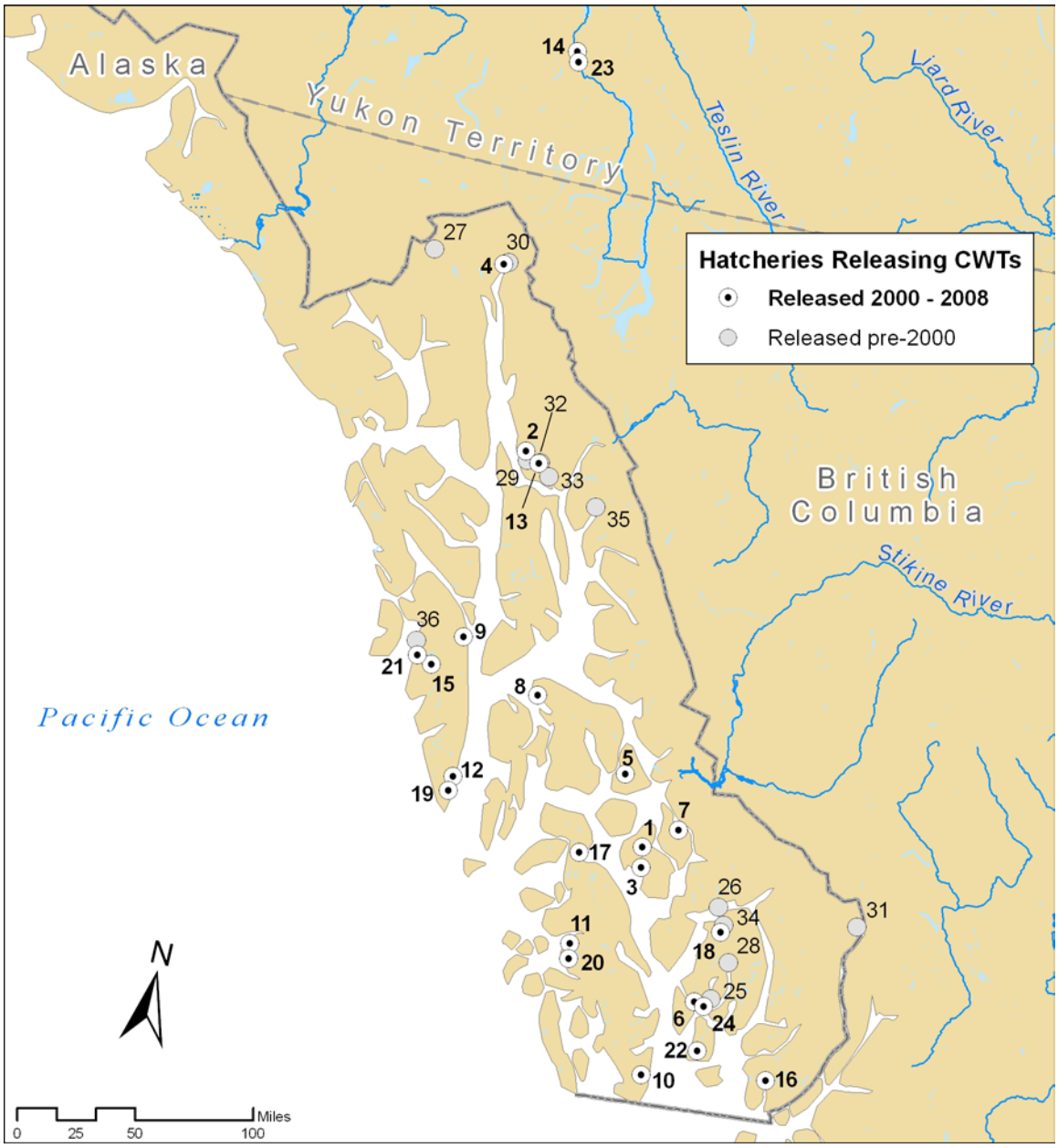
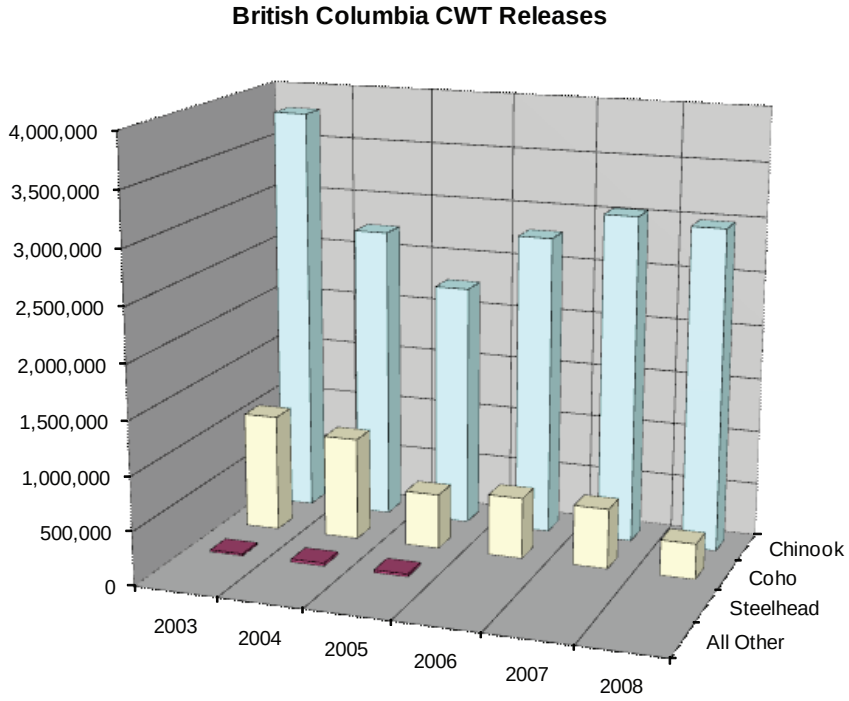


Figure A3. Hatcheries and rearing facilities in Alaska state, Southeast area, and the Yukon Territory in Canada that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

Table A7. Legend: hatcheries and rearing facilities in Alaska state, Southeast area, and the Yukon Territory in Canada that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

AK- Southeast Facilities Releasing: 2000–2008			AK- Southeast Facilities Releasing: 2000–2008	
1	Anita Bay		20	Port Saint Nicholas
2	Auke Creek		21	Sheldon Jackson
3	Burnett Inlet		22	Tamgas Creek
4	Burro Creek		23	Whitehorse (Canada/ Yukon T)
5	Crystal Lake		24	Whitman Lake
6	Deer Mountain			
7	Earl West Cove		**AK- Southeast Facilities Releasing: pre - 2000**	
8	Gunnuk Creek			
9	Hidden Falls		25	Beaver Falls
10	Kendrick Bay		26	Bell Island Net Pens
11	Klawock		27	Big Boulder Instream
12	Little Port Walter		28	Carroll Inlet
13	Macaulay		29	Fish Creek
14	McIntyre Creek (Canada/ Yukon T)		30	Jerry Myers
15	Medvejie		31	Marx Creek
16	Nakat Inlet		32	Salmon Creek
17	Neck Lake		33	Sheep Creek
18	Neets Bay		34	Shrimp Bay
19	Port Armstrong		35	Snettisham



	2003	2004	2005	2006	2007	2008
All Other						
Steelhead	17,902	27,507	24,500			
Coho	1,085,199	951,416	510,070	566,831	556,583	328,765
Chinook	3,792,128	2,725,567	2,252,355	2,784,773	3,038,841	2,984,434

Figure A4. All CWT Releases in British Columbia Province by species and year from 2003 to 2008 (Regional Mark Information System Database [online database]).

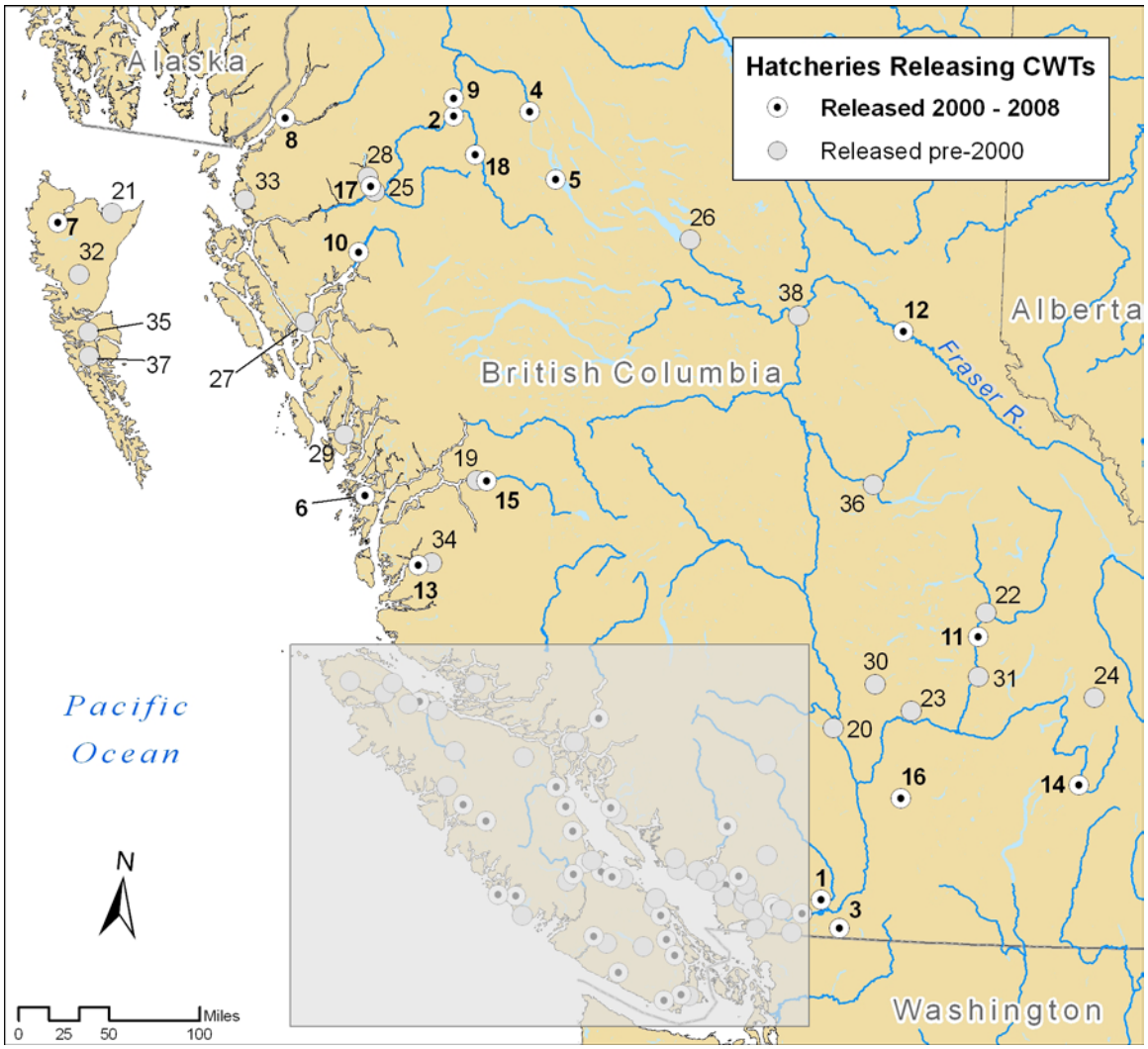


Figure A5. Hatcheries and rearing facilities in greater British Columbia Province (excluding Vancouver Island area) that have released salmonids with CWTs.

Table A8. Legend: hatcheries and rearing facilities in greater British Columbia Province (excluding Vancouver Island area) that have released salmonids with CWTs.

BC Facilities Releasing: 2000 - 2008		BC Facilities Releasing: pre - 2000	
1	Chehalis River	19	Bella Coola River
2	Chicago Creek	20	Bridge River
3	Chillwack River	21	Chown Brook
4	Fort Babine	22	Clearwater
5	Fulton River	23	Deadman River
6	Heiltsuk	24	Eagle River
7	Husby Forest Products	25	Eby Street
8	Kincolith River	26	Fort St. James
9	Kispiox River	27	Hartley Bay Creek
10	Kitimat River	28	Kitsumkalum
11	N. Thompson River	29	Klemtu Creek
12	Penny	30	Loon Creek
13	Shotbolt Bay	31	Louis Creek
14	Shuswap River	32	Masset
15	Snootli Creek	33	Oldfield Creek
16	Spius Creek	34	Oweekeno
17	Terrace	35	Pallant Creek
18	Toboggan Creek	36	Quesnel River
		37	Sewell Inlet
		38	Spruce City Wildlife Association

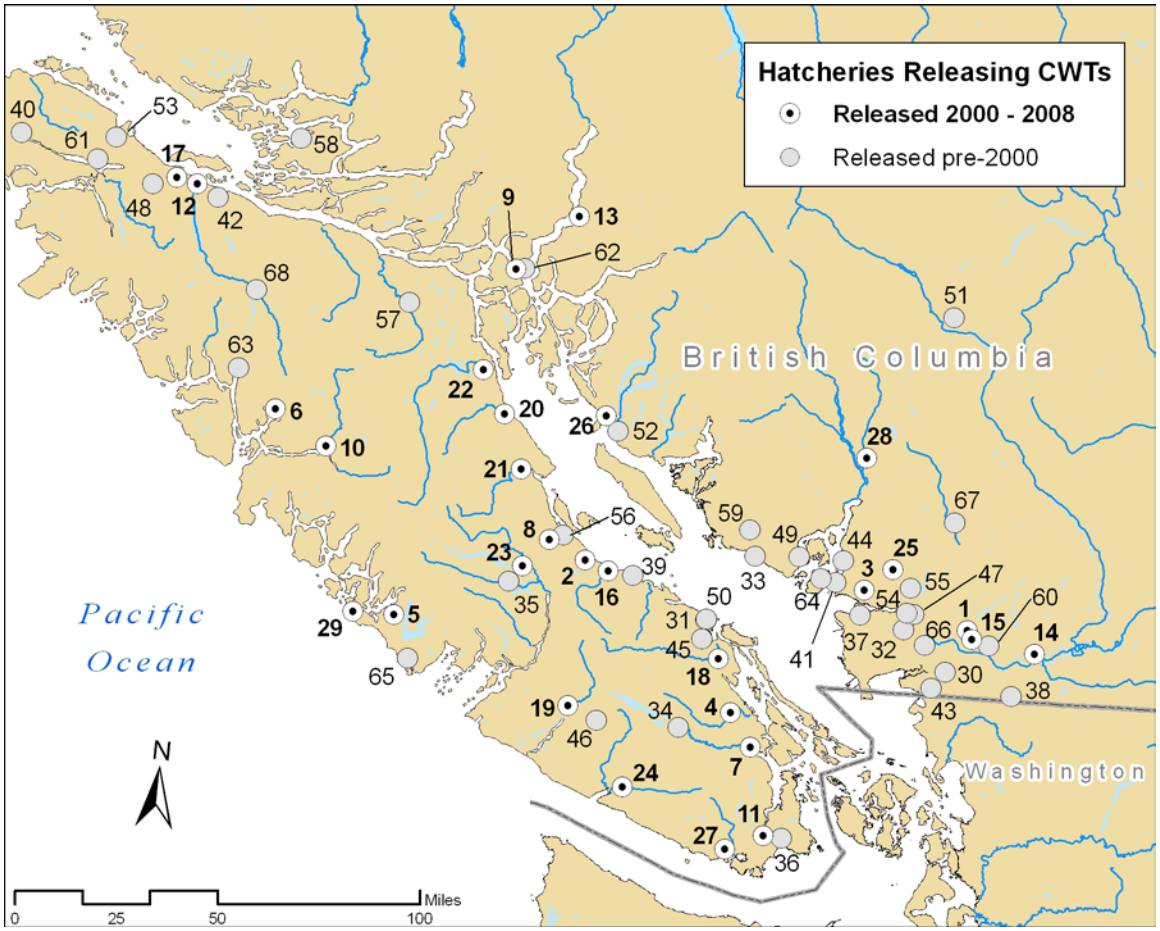
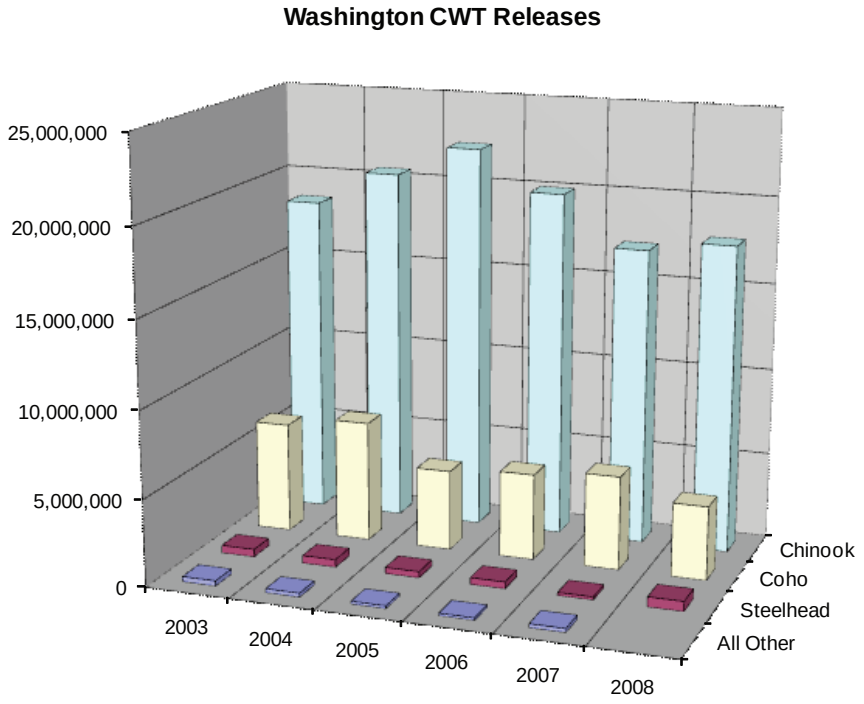


Figure A6. Hatcheries and rearing facilities in British Columbia Province, Vancouver Island area that have released salmonids with CWTs.

Table A9. Legend: hatcheries and rearing facilities in British Columbia Province, Vancouver Island area that have released salmonids with CWTs.

BC- Vancouver area Facilities Releasing: 2000 - 2008	
1	Alouette River
2	Big Qualicum River
3	Capilano River
4	Chemainus River
5	Clayoquot
6	Conuma River
7	Cowichan River
8	Fanny Bay
9	Gillard Pass
10	Gold River
11	Goldstream River
12	Gwa'ni
13	Homalco-Taggares
14	Inch Creek
15	Kanaka Creek
16	L. Qualicum River
17	Marble River
18	Nanaimo River
19	Nitinat River
20	Oyster River
21	Puntledge River
22	Quinsam River
23	Robertson Creek
24	San Juan River
25	Seymour River
26	Sliammon River
27	Sooke River
28	Tenderfoot Creek
29	Tofino
BC- Vancouver area Facilities Releasing: pre - 2000	
30	Anderson Creek Pen
31	Brandon Island
32	Brunette River
33	Chapman Creek

BC - Vancouver area Facilities Releasing: pre-2000	
34	Cowichan Lake
35	Englishman River
36	Esquimalt Harbor
37	False Creek
38	Fraser Valley
39	French Creek
40	Holberg Inlet
41	Horseshoe Bay
42	Kokish River
43	L. Campbell River
44	Lions Bay
45	Malaspina College
46	N. Vancouver Outdoor School
47	Noons Creek
48	O'Connor Lake
49	Ouillet Creek
50	Pacific Biological Station
51	Pemberton F&G
52	Powell River
53	Quatse River
54	Reed Pt.
55	Richards Creek
56	Rosewall Creek
57	Sayward F&G
58	Scott Cove Creek
59	Sechelt
60	Stave River
61	Stephen's Creek
62	Stuart Island
63	Tahsis River
64	Terminal Creek
65	Thornton Creek
66	Tynehead Hatchery
67	Upper Pitt River



	2003	2004	2005	2006	2007	2008
All Other	293,861	224,622	156,444	140,542	223,315	
Steelhead	439,161	442,338	358,738	389,673	176,535	572,397
Coho	6,366,174	6,969,286	4,639,626	4,978,300	5,404,630	4,246,960
Chinook	18,521,616	20,496,289	22,247,845	19,983,132	17,126,881	17,737,965

Figure A7. All CWT Releases in Washington State by species and year from 2003 to 2008 (Regional Mark Information System Database [online database]).

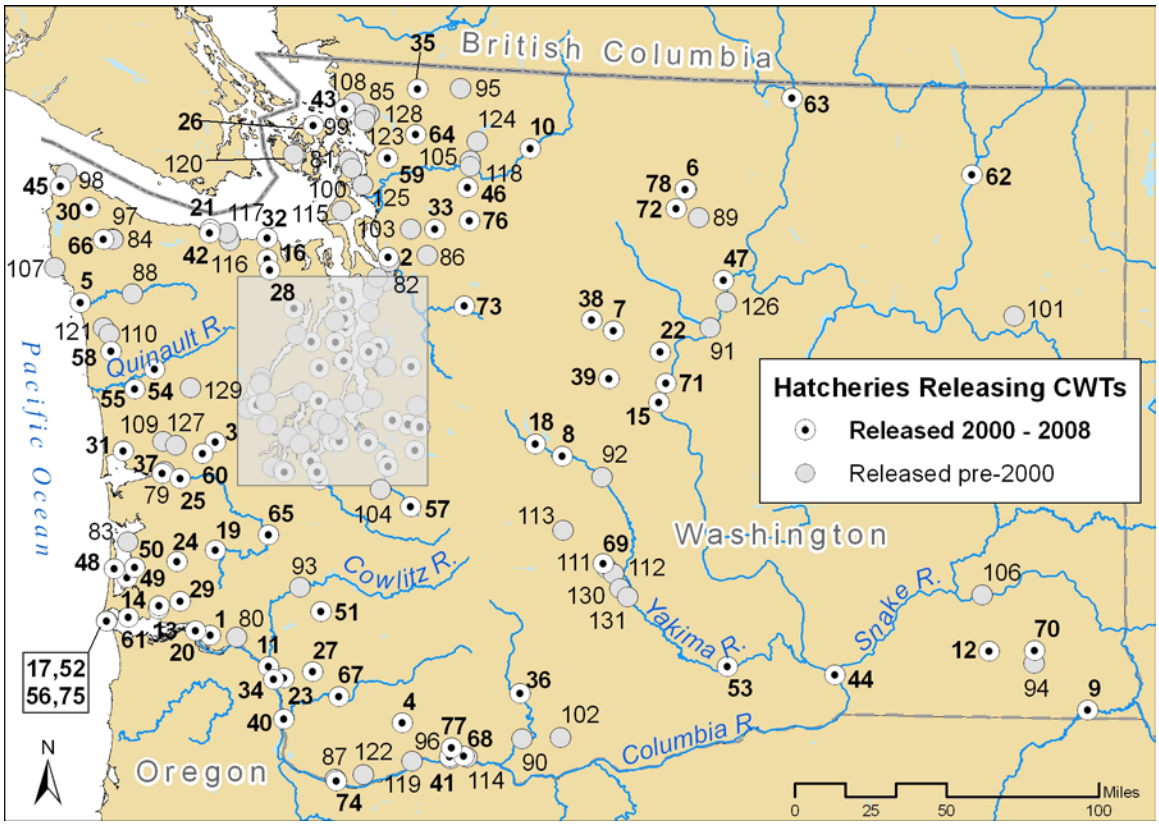


Figure A8. Hatcheries and rearing facilities in greater Washington State (excluding Puget Sound area) that have released salmonids with CWTs (includes federal, state, tribal, other facilities).

Table A10. Legend: hatcheries and rearing facilities in greater Washington State (excluding Puget Sound area) that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

WA Facilities Releasing: 2000 - 2008		WA Facilities Releasing: pre - 2000	
1	Beaver Creek	79	Aberdeen Net Pens
2	Bernie Gobin	80	Abernathy
3	Bingham Creek	81	Anacortes Net Pens
4	Carson NFH	82	Battle Creek
5	Chalaat Creek	83	Bay Center Net Pens
6	Chewuch Rearing Pond	84	Bear Springs Rearing Pond 2
7	Chiwawa	85	Bellingham
8	Cle Elum	86	Brenner
9	Cottonwood Creek Pond	87	Camas Net Pens
10	County Line Ponds	88	Canyon Springs Pond
11	Cowlitz Salmon	89	Carlton Rearing Pond
12	Dayton Rearing Ponds	90	Champion Pond
13	Deep River Net Pens - Lower	91	Chelan
14	Deep River Net Pens - Upper	92	Clark Flat Pond
15	Dryden Pond	93	Cowlitz Trout
16	Dungeness	94	Curl Lake Rearing Ponds
17	Eastbank	95	Deadhorse Creek Pond
18	Easton Pond	96	Drano Lake Pens
19	Eight Creek Project	97	Eagle Creek
20	Elochoman	98	Educket Creek
21	Elwha	99	Fairhaven Net Pens
22	Entiat NFH	100	Fidalgo Bay Net Pens
23	Fallert Creek	101	Ford
24	Forks Creek	102	Goldendale
25	Friends Landing Net Pens	103	Harvey Creek
26	Glenwood Springs	104	Kapowsin Lake Net Pens
27	Gobar Pond	105	Lake Shannon Net Pens
28	Gray Wolf River Acclimation Pond	106	Little Goose Dam
29	Grays River	107	Lonesome Creek
30	Hoko Falls	108	Mamoya Pond
31	Humptulips	109	Mary Brothers Rearing Pond
32	Hurd Creek	110	Mule Pasture Pond
33	Jim Creek	111	Naches
34	Kalama Falls	112	Nelson Springs Ponds
35	Kendall Creek	113	Nile Springs Ponds
36	Klickitat	114	Northwestern Lake Pens
37	Lake Aberdeen	115	Oak Harbor Net Pens
38	Lake Wenatchee Net Pens	116	Peninsula College
39	Leavenworth NFH	117	Port Angeles Net Pen
40	Lewis River	118	Puget Sound Energy Spawning
41	Little White Salmon NFH	119	Rock Creek Net Pens
42	Lower Elwha	120	San Juan Net Pens

Table A10. Legend: hatcheries and rearing facilities in greater Washington State (excluding Puget Sound area) that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).—Continued

WA Facilities Releasing: 2000 - 2008		WA Facilities Releasing: pre - 2000	
43	Lummi Sea Ponds	121	Shale Creek
44	Lyons Ferry	122	Skamania Trout
45	Makah NFH	123	Squalicum Net Pens
46	Marblemount	124	Sulphur Springs
47	Methow	125	Swinomish Channel Rearing Ponds
48	Nahcotta Net Pens	126	Wells Dam Spawning Channel
49	Naselle	127	Weyco Pond
50	Nemah	128	Whatcom Creek
51	North Toutle	129	Wynoochee River Pens
52	Priest Rapids	130	Yakima
53	Prosser	131	Yakima Net Pens at Wapato Dam
54	Quinault Lake		
55	Quinault NFH		
56	Ringold Springs		
57	Rushingwater Acclimation Pond		
58	Salmon River Rearing Pond		
59	Samish		
60	Satsop Springs Rearing Ponds		
61	Sea Resources		
62	Sherman Creek		
63	Similkameen		
64	Skookum Creek		
65	Skookumchuck		
66	Solduc		
67	Speelyai		
68	Spring Creek NFH		
69	Stiles Pond		
70	Tucannon		
71	Turtle Rock		
72	Twisp Acclimation Pond		
73	Wallace River		
74	Washougal		
75	Wells		
76	Whitehorse Pond		
77	Willard NFH		
78	Winthrop NFH		

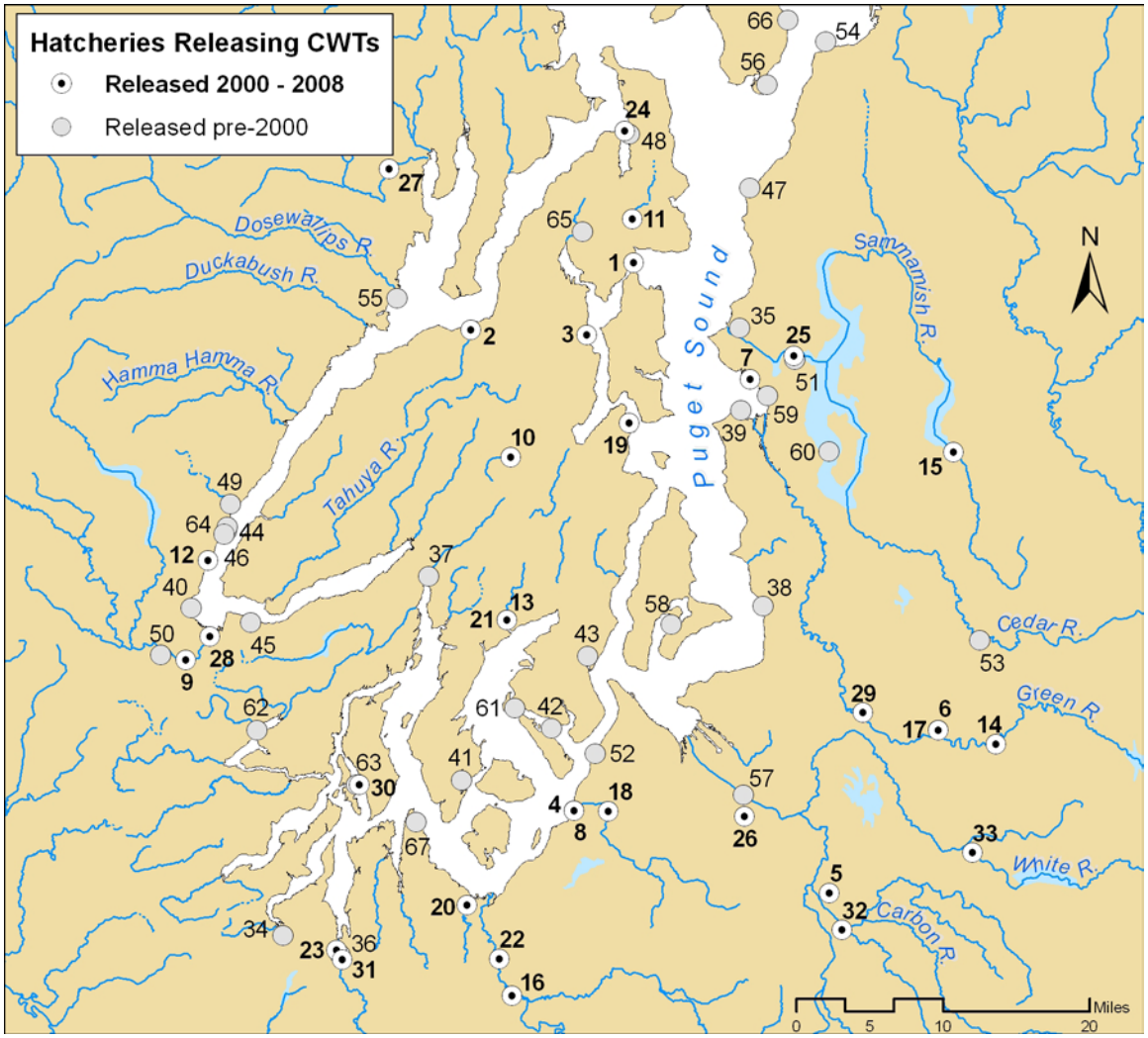
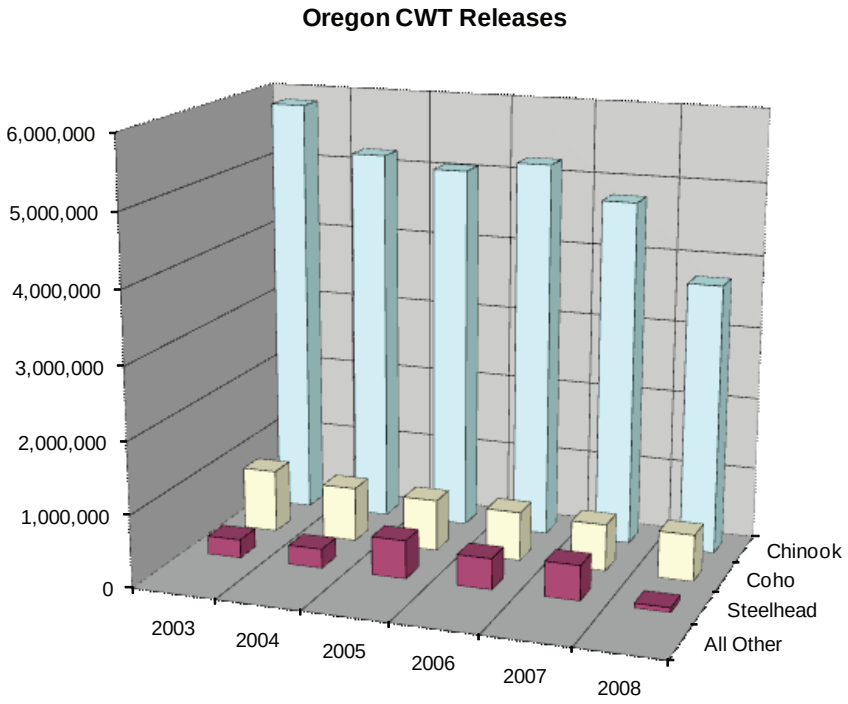


Figure A9. Hatcheries and rearing facilities in Washington State, Puget Sound area, that have released salmonids with CWTs (includes federal, state, tribal, other facilities).

Table A11. Hatcheries and rearing facilities in Washington State, Puget Sound area, that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

WA- Puget Sound area Facilities Releasing: 2000 - 2008		WA- Puget Sound area Facilities Releasing: pre - 2000	
1	Agate Pass Sea Pens	34	Allison Springs
2	Big Beef Creek	35	Ballard Salmon Club
3	Brownsville Net Pens	36	Capitol Lake Rearing
4	Chambers Creek	37	Coulter Creek Rearing Pond
5	Clarks Creek	38	Des Moines Net Pens
6	Crisp Creek Rearing Pond	39	Elliott Bay Seapens
7	Elliott Bay Tribal Net Pens	40	Enetai
8	Garrison	41	Filucy Bay Net Pens
9	George Adams	42	Fox Island Net Pens
10	Gorst Creek Rearing Ponds	43	Gig Harbor Pens
11	Grovers Creek	44	Glen Ayr Net Pens
12	Hoodsport	45	Hood Canal Marina Net Pen
13	Hupp Springs Rearing	46	Hoodsport Marina Net Pens
14	Icy Creek	47	Leabugten Wharf Net Pens
15	Issaquah	48	Little Boston Creek
16	Kalama Creek	49	Long Live the Kings - Lilliwaup
17	Keta Creek	50	McKernan
18	Lakewood	51	Montlake
19	Manchester Fuel Depot	52	Narrows Marina Pens
20	McAllister	53	NWSSC - Cedar River
21	Minter Creek	54	NWSSC - Everett Net Pens
22	Nisqually	55	Pleasant Harbor Net Pens
23	Percival Cove Net Pens	56	Possession Bait Pond
24	Port Gamble Net Pens	57	Puyallup
25	Portage Bay	58	Quartermaster Harbor Net Pens
26	Puyallup Tribal	59	Seattle Aquarium
27	Quilcene NFH	60	Seward Park
28	Ricks Pond	61	Shaw Cove Net Pens
29	Soos Creek	62	Shelton
30	South Sound Net Pens	63	Squaxin Island Pens
31	Tumwater Falls	64	Sund Rock Net Pens
32	Voights Creek	65	Webster's
33	White River	66	Whidbey Island Net Pens
		67	Zittel's Marina Pens



	2003	2004	2005	2006	2007	2008
All Other						
Steelhead	255,405	267,531	529,766	427,459	483,527	63,661
Coho	867,756	751,448	710,592	678,468	645,243	643,512
Chinook	5,835,307	5,198,497	5,053,743	5,210,819	4,771,561	3,731,202

Figure A10. All CWT Releases in Oregon State by species and year from 2003 to 2008 (Regional Mark Information System Database [online database]).

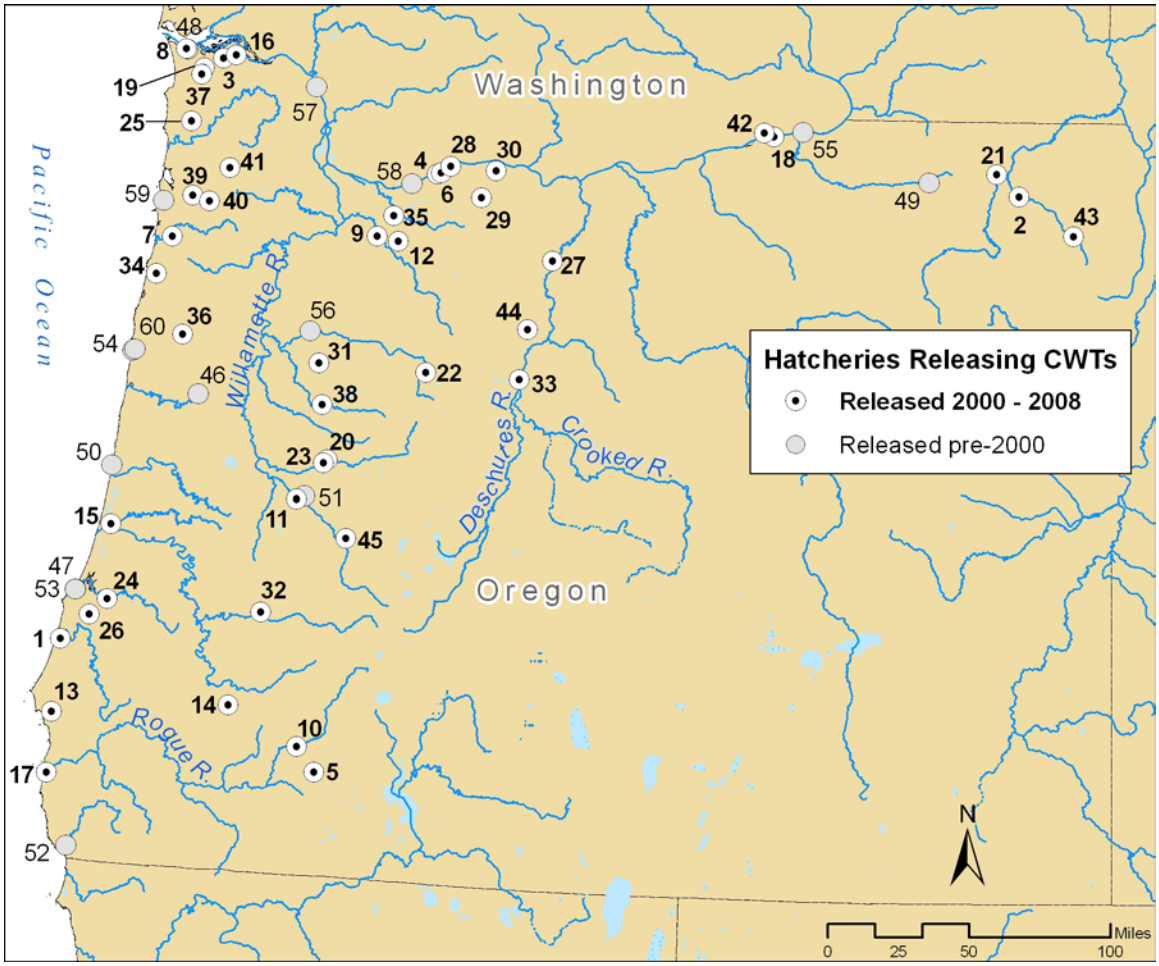
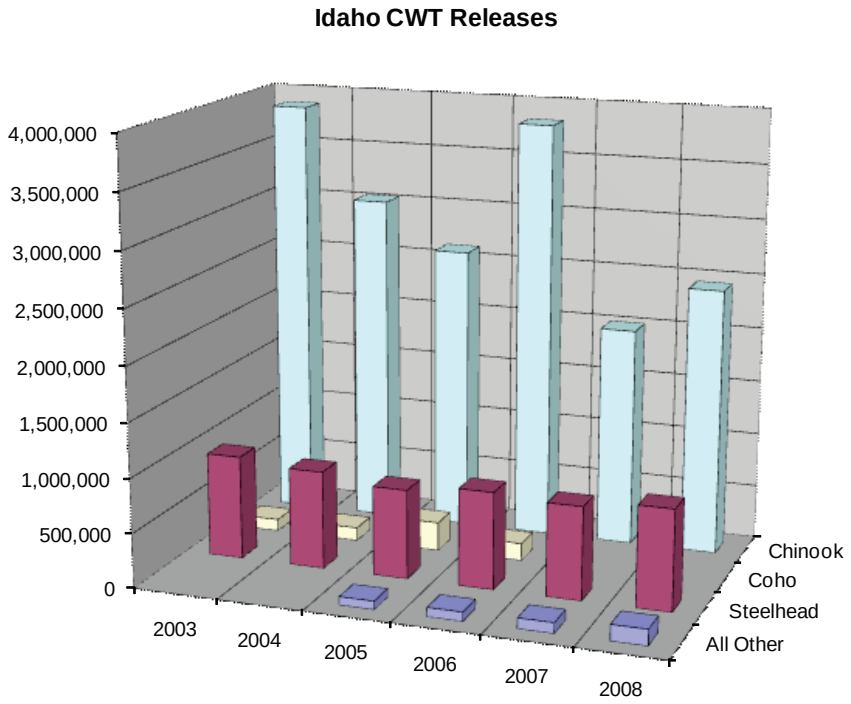


Figure A11. Hatcheries and rearing facilities in Oregon State that have released salmonids with CWTs (includes federal, state, tribal, other facilities).

Table A12. Legend: hatcheries and rearing facilities in Oregon State that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

OR Facilities Releasing: 2000 - 2008		OR Facilities Releasing: 2000 - 2008	
1	Bandon	33	Round Butte
2	Big Canyon Pond	34	Salmon River
3	Big Creek	35	Sandy
4	Bonneville	36	Siletz
5	Butte Falls	37	South Fork. Klaskanine Pond
6	Cascade	38	South Santiam
7	Cedar Creek	39	Trask River
8	CEDC Youngs Bay Net Pens	40	Trask River Pond
9	Clackamas	41	Tuffy Creek Pond
10	Cole M. Rivers	42	Umatilla
11	Dexter Ponds	43	Wallowa
12	Eagle Creek NFH	44	Warm Springs NFH
13	Elk River	45	Willamette
14	Galesville Trap		
15	Gardiner Creek	**OR Facilities Releasing: pre - 2000**	
16	Gnat Creek		
17	Indian Creek Pond	46	Alsea
18	Irrigon	47	Anadromous Inc. - Coos Bay
19	Klaskanine	48	Astoria High School
20	Leaburg	49	Bonifer Pond
21	Lookingglass	50	Domsea Farms
22	Marion Forks	51	Fall Creek Trap
23	McKenzie	52	Jack Creek
24	Morgan Creek	53	Oregon Aqua Foods - Coos Bay
25	Nehalem	54	Oregon Aqua Foods - Yaquina Bay
26	Noble Creek	55	Social Security Pens
27	Oak Springs	56	Stayton Pond
28	Oxbow	57	Trojan Pond
29	Parkdale	58	Wahkeena Pond
30	Powerdale Dam Trap	59	Whiskey Creek
31	Roaring River	60	Yaquina Bay Salmon Ranch
32	Rock Creek		



	2003	2004	2005	2006	2007	2008
All Other			76,250	83,470	95,873	145,884
Steelhead	951,208	897,044	818,304	888,304	851,451	921,169
Coho	109,091	121,237	263,106	159,364		
Chinook	3,869,498	3,032,528	2,611,490	3,827,833	2,007,010	2,441,291

Figure A12. All CWT Releases in Idaho State by species and year from 2003 to 2008 (Regional Mark Information System Database [online database]).

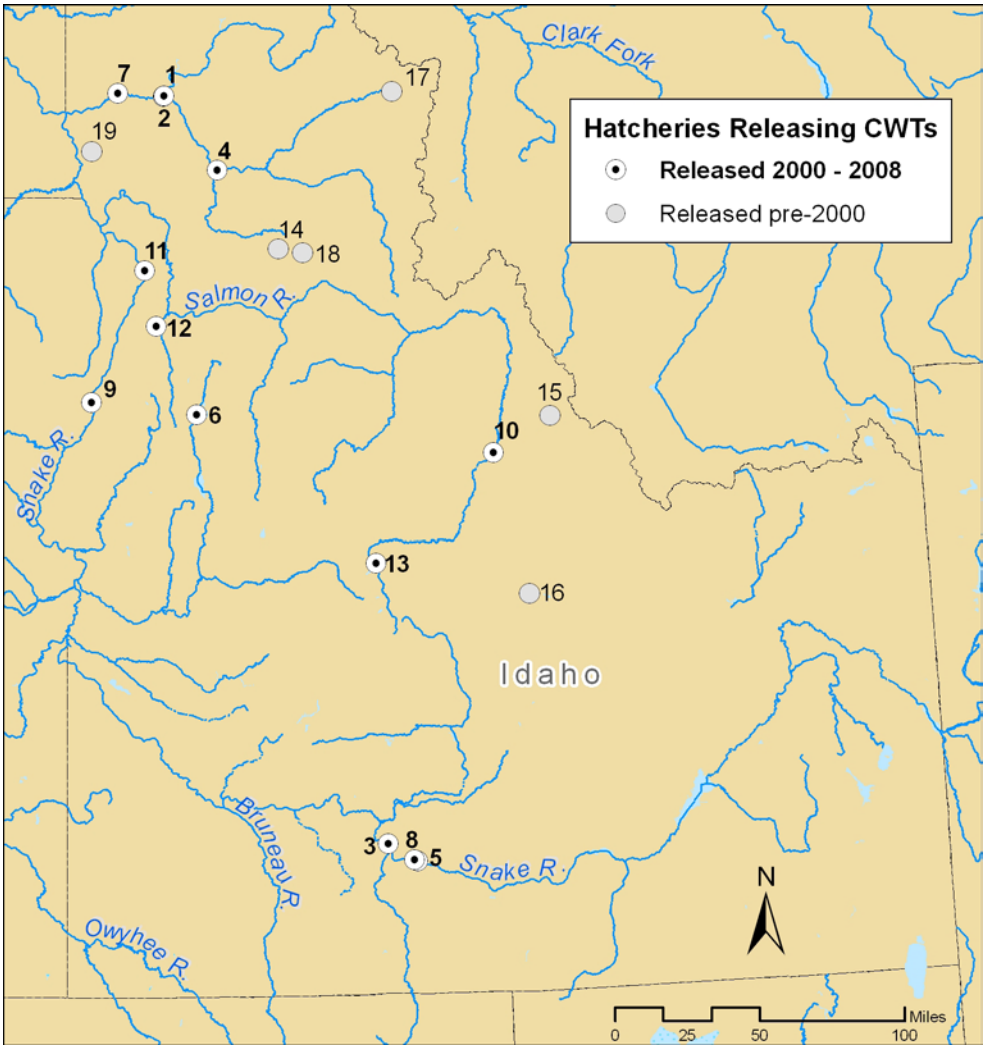
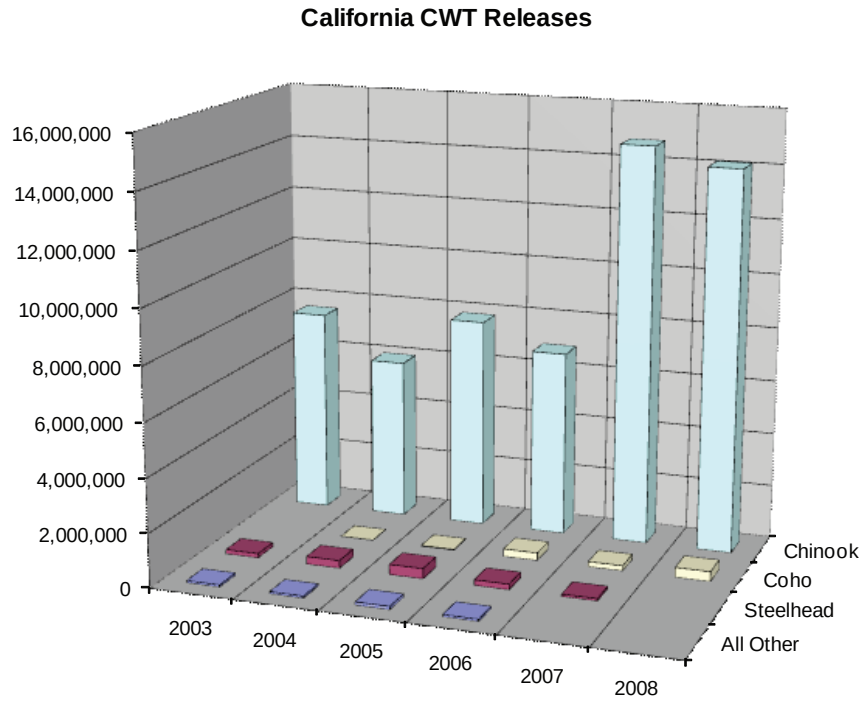


Figure A13. Hatcheries and rearing facilities in Idaho State that have released salmonids with CWTs (includes federal, state, tribal, other facilities).

Table 13. Legend: hatcheries and rearing facilities in Idaho State that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities)

ID Facilities Releasing: 2000 - 2008		ID Facilities Releasing: 2000 - 2008	
1	Clearwater	12	Rapid River
2	Dworshak NFH	13	Sawtooth
3	Hagerman NFH		
4	Kooskia NFH	ID Facilities Releasing: pre - 2000	
5	Magic Valley	14	Crooked River Ponds
6	McCall	15	Hayden Creek
7	Nez Perce Tribal	16	Mackay
8	Niagara Springs	17	Powell Rearing Ponds
9	Oxbow	18	Red River Ponds
10	Pahsimeroi	19	Sweetwater
11	Pitt Landing		



	2003	2004	2005	2006	2007	2008
All Other	74,605	73,865	113,538	74,397		
Steelhead	159,207	284,959	380,730	205,819	85,842	
Coho		6,160	25,803	281,021	190,737	366,579
Chinook	7,566,562	5,975,524	7,824,466	6,892,055	14,756,567	14,129,051

Figure A14. All CWT Releases in California State by species and year from 2003 to 2008 (Regional Mark Information System Database [online database]).

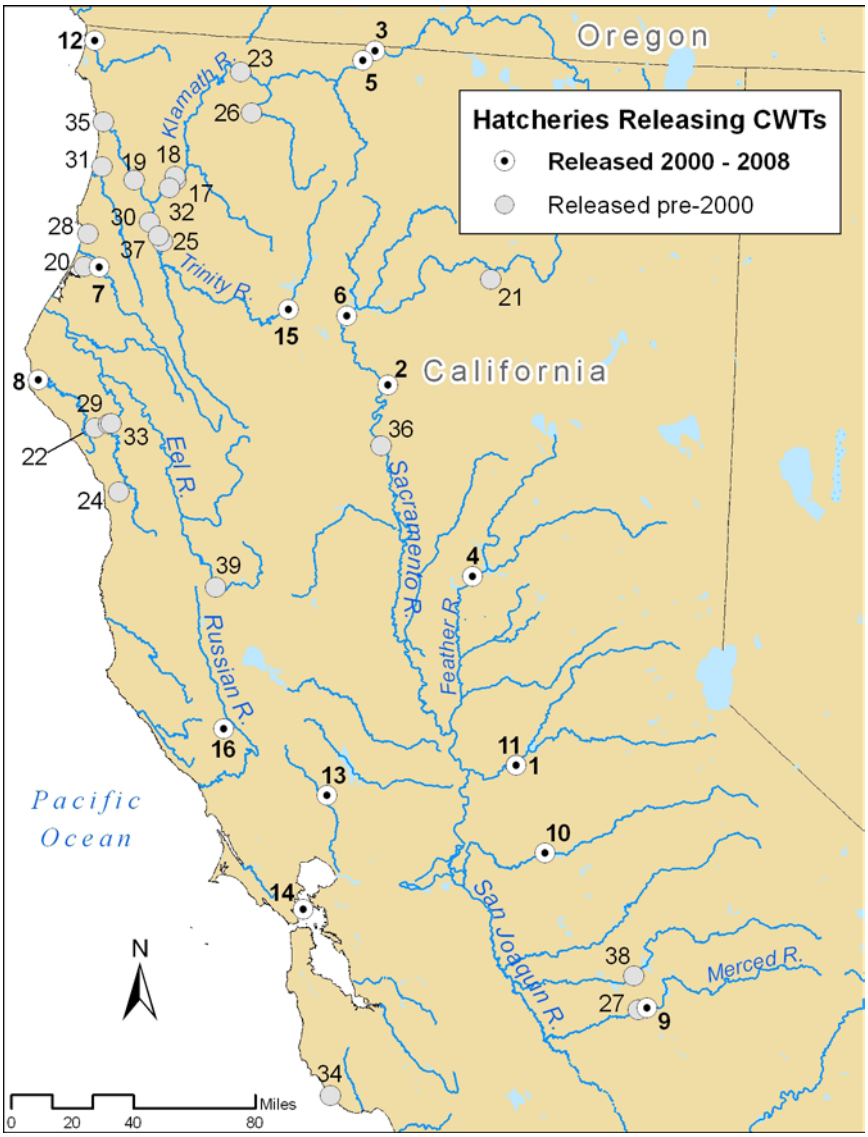


Figure A15. Hatcheries and rearing facilities in California State that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

Table A14. Legend: hatcheries and rearing facilities in California State that have released salmonids with CWTs (includes Federal, State, Tribal, other facilities).

CA Facilities Releasing: 2000–2008		CA Facilities Releasing: pre–2000	
1	American River	17	Camp Creek
2	Coleman NFH	18	Camp Creek Enhancement Facility
3	Fall Creek Ponds	19	Cappel Creek Rearing Facility
4	Feather River	20	City of Arcata Ponds
5	Iron Gate	21	Crystal Lake
6	Livingston Stone NFH	22	Dinner Creek Ponds
7	Mad River	23	Grider Creek Ponds
8	Mattole Salmon Group	24	Hollow Tree Creek Ponds
9	Merced River Fish Facility	25	Horse-Linto
10	Mokelumne River	26	Kelsey Creek
11	Nimbus	27	La Grange Fish Facility
12	Rowdy Creek	28	Little River Pond
13	Silverado Fisheries Base	29	Marshall Creek Ponds
14	Tiburon Sea Pens	30	Mill Creek
15	Trinity River	31	Prairie Creek
16	Warm Springs	32	Red Cap Creek
		33	Redwood Creek Ponds
		34	Silverking Oceanic Farms
		35	Spruce Creek
		36	Tehama-Colusa Fish Facility
		37	Tish-Tang Rearing
		38	Tuolumne River Fish Facility
		39	Van Arsdale