Lessons Learned Report: Mass Marking and Mark-Selective Fisheries

Pacific Salmon Commission Selective Fishery Evaluation Committee

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LIST OF ACRONYMS WITH DEFINITIONS

ADFG	Alaska Department of Fish and Game	**MSF**	Mark-Selective Fishery
AK	Alaska	**MU**	Management Unit
BC	British Columbia	**NMT**	Northwest Marine Technology Inc.
BY	Brood Year	**NSF**	Non-Selective Fishery
CA	California	**NWIFC**	Northwest Indian Fisheries Commission
CDFO	Canadian Department of Fisheries and Oceans	**ODFW**	Oregon Department of Fish and Wildlife
CDFW	California Department of Fish and Wildlife	**OR**	Oregon
COLR	Columbia River	**PBT**	Parentage-based Tagging
CoTC	Coho Technical Committee	**PSC**	Pacific Salmon Commission
CTC	Chinook Technical Committee	**PSMFC**	Pacific States Marine Fisheries Commission
CWT	Coded-wire Tag	**PST**	Pacific Salmon Treaty
DGM	Data Generation Model	**RMIS**	Regional Mark Information System
DIT	Double Index Tag	**SFAWG**	SFEC- Analytical Work Group
ER	Exploitation Rate	**SFEC**	Selective Fishery Evaluation Committee
ETD	Electronic Tag Detection	**SFRCWG**	SFEC - Regional Coordination Work Group
FRAM	Fisheries Regulation Assessment Model	**SHRP**	Recreational Head Recovery Program
ID	Idaho	**US**	United States
IDFG	Idaho Department of Fish and Game	**WA**	Washington
MM	Mass Marking	**WDFW**	Washington Department of Fish and Wildlife
MOU	Memorandum of Understanding		

GLOSSARY OF TERMS USED IN THIS REPORT

Brood Year (BY): The year in which eggs were deposited or collected (spawning year).

Clipped: Fish with a fin removed as an external mark.

Coded-wire Tag (CWT): A tag containing a numeric code that is inserted into the nasal cartilage of young salmon for the purpose of identifying a specific release group. Each numeric code is associated with release information, including date and location of release, hatchery, stock, fish size, and number of fish with the same code (referred to as a release group). Tags are typically recovered from returning adults through fisheries and escapement sampling.

Double Index Tag (DIT): Paired release groups, each tagged with a unique CWT tagcode, where both groups are presumed identical except that one group is externally marked (adipose fin clipped) and one group is unmarked (not adipose fin clipped). Double index tagged groups are used to determine differential exploitation rates on marked and unmarked fish subjected to mark-selective fisheries.

Escapement: Adult fish that "escape" fisheries.

Exploitation Rate (ER): Mortality due to landed catch and incidental mortality; expressed as total fishing mortality divided by total fishing mortality plus escapement.

Fishery Regulation Assessment Model (FRAM): A model used to estimate the coho management unit and fishery-specific impacts.

Incidental Mortality: Mortality incurred during fishing that is in addition to landed catch. For example, some fish die as a result of being caught and released.

Indicator Stock: A coded-wire tagged hatchery stock used as a surrogate to make inferences for a particular wild stock or group of stocks. Indicator stocks are usually hatchery stocks chosen from the same watershed or region, having the same life history characteristics (e.g., summer or fall run, yearlings or fingerlings) and they are assumed to have the same migration path and distribution as the natural-origin stock they represent.

Marked: Fish with the adipose fin removed.

Mass Marking: A method of marking large groups of fish to differentiate them from unmarked fish e.g., for harvest opportunities in mark selective fisheries (MSFs). The adipose fin clip was selected as the preferred external mark for fish produced by hatcheries for MSFs.

Management Unit (MU): Under the Pacific Salmon Treaty Southern Coho Agreement, a geographically-based aggregate of naturally spawning coho populations, managed under a single set of exploitation rate caps.

Mark-selective Fishery (MSF): A fishery that require marked fish (i.e., those with adipose fin clips) and unmarked fish (those with intact adipose fins) to be differentially retained (e.g., marked fish kept, unmarked fish released).

Natural-origin: Originating from spawning in the natural environment, as opposed to spawned in a hatchery. Often considered "wild".

Smolt: The stage in the salmonid lifecycle when physiology shifts from freshwater to marine metabolism.

Sport Head Recovery Program (SHRP): A sampling program for recreational fisheries that relies upon anglers voluntarily returning heads from marked salmon so CWTs may be recovered.

Stock: An aggregation of fish spawning in a particular stream or lake during a particular season which to a substantial degree do not interbreed with any group spawning at a different time.

Unclipped: Fish with all fins intact.

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EXECUTIVE SUMMARY

The importance of maintaining a coastwide coded-wire tag (CWT) program was recognized in a memorandum of understanding between the United States (US) and Canada, the Parties, which accompanied the 1985 Pacific Salmon Treaty (PST). In 1991, the co-chairs of the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC) expressed concerns regarding the ability to maintain a viable CWT program in light of increasing interest in mass marking (MM) of hatchery fish and mark-selective fishing (MSF).

An Ad-hoc Selective Fishery Evaluation Committee (ASFEC) was established by the PSC to investigate potential impacts of MM/MSF on the CWT program. In 1995, the ASFEC concluded that MM/MSF would likely adversely affect the CWT program, advised against employing MM and MSFs for Chinook, and included recommendations pertaining to selection of a mass mark and implementation of a double index tagging (DIT[2]) program to try to maintain the viability of the CWT program for Coho salmon (ASFEC 1995).

The ASFEC defined viability of the CWT program in terms of three specific criteria:

1) it must provide the ability to use CWT data for assessment and management of wild stocks of Coho and Chinook salmon;
2) it must be maintained such that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk; and,
3) it must provide the ability to estimate stock-specific exploitation rates by fishery and age.

In 1998, the PSC adopted an "Understanding of the PSC Concerning Mass Marking and Selective Fisheries" (Appendix A)) and established a permanent Selective Fisheries Evaluation Committee (SFEC). The SFEC's current terms of reference were adopted in 2004 (SFEC 2004). Protocols for agencies to annually submit proposals for MM and MSFs were adopted at this time. The SFEC facilitates coordination and reporting of MM and MSFs among the Parties, affected agencies, and existing coastwide and regional committees established to monitor activities related to the coastwide CWT program.

The CWT program remains the only tool available to estimate and monitor coastwide impacts on individual stocks of natural-origin fish (PSC 2005 and Nandor 2009). The ability to use CWT data to estimate fishery and age-specific exploitation rates is critical to implementing the June 1999 and June 2008 PST agreements. For Chinook, these agreements require the evaluation of impacts on individual stocks on a fishery and age-specific basis for Individual Stock Based Management (ISBM) fisheries. For southern Coho, the agreements establish exploitation rate constraints on naturally spawning management units (MUs). Uncertainty in CWT sampling data has increased in recent years due to reductions in tag recoveries, resulting from reductions in both marine survival rates and in exploitation rates, in spite of increased numbers of CWTs applied to Chinook indicator stocks. Mark selective fisheries contribute further uncertainty to the data.

[2] A double index tag (DIT) group is comprised of two related coded-wire tag (CWT) groups, one marked and one unmarked. Differences in return rates between the paired DIT groups are intended to provide information on the cumulative impacts of MSFs on unmarked fish.

The SFEC prepared this report to encapsulate principal "Lessons Learned" by the agencies and the SFEC regarding MM and MSF since the late 1990's. The scope of this report concerns the impacts of MM and MSF on the viability of the CWT system for PST and fishery management purposes, as listed above. The report summarizes high-level key messages. Detailed analyses are not included, but references are provided for supporting analyses and documentation. The history of MM and MSF is briefly described. Benefits of MM and MSF are outlined but not quantified, while costs, including equipment costs coastwide, are quantified. Lessons learned relating to the viability of CWT tagging, sampling, and reporting systems, with respect to the conduct of MM and MSF, are identified, and recommendations are provided.

Mass marking provides a means of increasing harvest opportunities (through MSFs) within constraints established for the conservation of comingled natural-origin stocks by providing a visual means of distinguishing fish produced for harvest. Currently, this benefit is primarily realized in recreational fisheries. Because MSF provides the ability to selectively retain marked hatchery fish while releasing unmarked fish, mortalities on comingled natural-origin stocks (or stocks being enhanced for rebuilding) can be reduced relative to non-selective fisheries (NSFs). The removal of additional hatchery fish can alleviate some of the potential impacts of artificial production on the genetic integrity and diversity of natural-origin stocks. Mass marking provides a means of identifying first generation hatchery fish for management of hatchery brood stock, and estimating and managing the composition of hatchery and natural-origin fish on the spawning grounds.

The implementation of MM and MSFs increases costs for agencies. Agencies have MM large numbers of hatchery Chinook and coho. Approximately 34 million coho and 117 million Chinook are currently being MM annually. Mass marking this large number of fish has required a large initial investment in mobile tagging and marking trailers, and a substantial annual budget for the labor involved in MM at hatcheries. With the adipose clip (which was previously sequestered under the PST as an identifier for fish tagged with a CWT) selected as the preferred MM, visual detection methods are no longer able to distinguish fish containing CWTs. Agencies have invested substantially in electronic tag detection (ETD) equipment which has reduced the cost of recovering CWTs from MM fish. Electronic tag detection has proven to be accurate and reliable in recovering tags. Double index tagging (DIT) programs, recommended by SFEC to assess differences in exploitation patterns of marked and unmarked fish under MSF, incur increased costs for both tagging and recovery of CWTs. There has been a significant increase in workload and sampling costs where sampling large numbers of marked and unmarked fish is required. Mark-selective fisheries also require additional fishery monitoring and reporting.

Key areas of concern with coastwide coordination of the CWT program under an MSF regime include: implementation of coastwide tagging and sampling for tag recovery, agency coordination of regulations with sampling strata, and standard reporting compliance (including annual proposal submissions and post-season reporting) by agencies to the PSC.

The SFEC has drawn the conclusion as documented in this report, that based on the lessons learned over the seventeen years of MM and MSF, the CWT program, as it is currently functioning, does not meet criteria 1 or 3 for viability as defined by the ASFEC in 1995. Meeting criteria 2, that "it must be maintained such that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk," depends on policy determination of whether the current level of management risk is acceptable or not.

The twenty-four lessons learned by the SFEC about impacts of MM and MSF to the viability of the CWT program, with links to the section where they are discussed, are as follows:

1. No viable alternative to the adipose fin clip has been identified as a permanent visual mark for MM anadromous salmon. From Selection of a Mass Mark.

2. Mark-selective fisheries complicate implementation of PSC fishing regimes. From Significance of MSFs to Implementation of PST Agreements.

3. Mark-selective fisheries can significantly change the magnitude, distribution, and uncertainty of fishery mortalities for unmarked fish (usually natural-origin). From Harvest Sharing Agreements.

4. Estimation of the fishery mark rate (the proportion of encounters that are marked by time-fishery strata) is critical to harvest management involving MSFs. If mark rates are overestimated, impacts of MSFs on unmarked fish will be underestimated; conversely, if mark rates are underestimated, mortalities of unmarked fish will be overestimated. From Planning Tools and Harvest Sharing Agreements.

5. Mark-selective fisheries require a coordinated and consistent approach to implementation of MM, MSFs, and coastwide sampling to enable accurate assessment and management of impacts to natural-origin fish. Adequate tagging and unbiased sampling programs in fisheries and escapement are required for analysts to detect potential differences between mortalities of marked and unmarked fish due to encounter rates in MSFs. Fishery sampling programs have been developed to provide data required to reliable estimates of stock-specific mortality of unmarked fish in individual MSFs, however they have not been implemented coastwide. Alignment of sampling with MSF spatial and temporal strata is required, to facilitate standard reporting of estimations of mortality for marked and unmarked fish. From Development of MSFs and Coastwide Coordination of CWT Sampling Programs.

6. Electronic sampling has not been employed coastwide, although it is required to recover DITs in MSFs. Cost, accuracy, practical feasibility, and policy concerns are some of the challenges faced by agencies in incorporating this technology into sampling programs. From Coastwide Coordination of CWT Sampling Programs.

7. Mass marking combined with visual sampling increases the cost of CWT recovery, by increasing sampling effort, and costs for storage, transport and tag removal. From Sampling for DITs.

8. The increased costs associated with handling and sampling large numbers of marked and unmarked fish has resulted in reduced rates of sampling at some facilities and in fisheries because of agency budgetary constraints. From Coastwide Coordination of CWT Sampling Programs and Costs.

9. Visual sampling may adversely affect relations with salmon processors and First Nations, because it requires the removal of a large number of snouts or heads. From Sampling for DITs.

10. Improved coordination of harvest management regulations and sampling programs is needed. The SFEC has been unable to develop methods for estimation of MSF impacts on unmarked fish by stock and age under the promulgated regulations. From Regulation of MSFs and Planning and Assessment of MSFs and Coastwide Coordination of CWT Sampling Programs.

11. Dissimilar regulations for adjacent areas having slight variations in species, gear, size and bag limit restrictions have complicated compliance, enforcement, and impact assessments. Similar regulations across spatial and temporal strata may reduce angler confusion and enforcement and assessment burdens. Based on reductions in retention of unmarked catch since the inception of MSFs, it is evident that angler behaviour has been modified to harvest selectively for marked fish. From Regulation of MSFs.

12. Existing rates for release mortality, mark retention, and mark recognition errors are derived from studies that have indicated substantial variability by gear, vessel type, location, species, and size of fish encountered. Nonetheless, methods and models employed for stock and fishery assessments assume these rates are known with certainty. From Planning Tools.

13. A bilateral model does not exist for pre-season planning or post-season evaluation of MSFs for Chinook. From Chinook and Development of MSFs.

14. Fishery planning and post-season assessments for MSFs rely upon assumption-based methods that do not account for uncertainty. From Planning and Assessment of MSFs.

15. Agencies currently rely on Fisheries Regulation Assessment Model (FRAM) estimates of coho MU-specific exploitation rates for both pre-season projections and post-season mortality estimates. Managers have not accounted for uncertainty in estimating mortalities of unmarked fish in MSFs, instead accepting point estimates produced by the coho FRAM. The uncertainty of projections of mark rates and hence stock specific mortalities from MSFs by the coho FRAM can vary widely from year to year due to the uncertainty of abundance forecasts, variations in migration patterns, and conduct of fisheries. From Planning Tools.

16. The SFEC has been unable to develop methods to estimate stock-age-fishery impacts of individual MSFs when multiple MSFs impact CWT release groups. From Planning and Assessment of MSFs.

17. Double index tagging programs have not been implemented as recommended. Agencies may not believe that the information provided by the DIT programs justifies their cost. In some instances, cumulative impacts of MSFs have not been large enough to reliably estimate differences in return rates of marked and unmarked fish using DIT programs. From Regulation of MSFs and Double Index Tagging (DIT) and Planning and Assessment of MSFs.

18. Uncertainty of fishing impacts on unmarked fish not represented by a DIT group has reduced the ability to estimate impacts of MSFs on unmarked fish. From Double Index Tagging (DIT).

19. Coordination among those who set fishery regulations, design the sampling protocols, use the data in models and design data warehouses is critical. From Regulation of MSFs and Coastwide Coordination of CWT Sampling Programs.

20. Improvements in reporting and access to information about MSF regulations and impacts on unmarked fish are needed. A prototype for electronic reporting of MSFs has been jointly developed by WDFW and NWIFC for recreational Chinook marine MSFs in Puget Sound and Washington coastal waters. From Coastwide Coordination of Reporting.

21. The Pacific States Marine Fisheries Commission (PSMFC) Regional Mark Information System (RMIS) has been modified to accommodate reporting of data for MM releases and CWT recoveries from MSFs. Data standards have been developed by the PSC Data Standards working group and implemented by the Regional Mark Processing Center (RMPC) in the RMIS. From Coastwide Coordination of Reporting.

22. Agencies are providing complete MM proposals for the SFEC review by the November 1 deadline. Mass marking levels have stabilized for Chinook and coho production in Washington and Oregon. From Review of MM and MSF Proposals by the SFEC.

23. MSF proposals are of limited value in assessing potential impacts on the viability of the CWT program because domestic fishery planning processes have not been completed, so details regarding the location, magnitude, and regulations are often unavailable for review by the SFEC and the PSC. From Review of MM and MSF Proposals by the SFEC.

24. Post-season reporting of MSFs remains problematic. In 2013 catch year, 3 post-season reports were received out of 16 coho MSFs implemented coastwide, and 4 post-season reports out of 26 Chinook MSFs were received. SFEC continues to recommend improving compliance with post-season reporting (SFEC 2015). From Post-Season Reporting of MSFs.

The SFEC makes the following six recommendations to the PSC:

1. **Maintain the CWT program.** The reports of the CWT Expert Panel (PSC 2005), the CWT Workgroup (PSC 2008), and the Coded-wire Tagging Improvement Team (Joint CWT Implementation Team 2015) provide recommendations to maintain and improve the CWT program. No other coastwide system has been designed to be capable of providing the management and scientific data required for supporting the type and scope of analyses currently relied upon by the PSC.
2. **Ensure that there are CWT groups representing all MM releases** to help identify the source of MM fish encountered in fishery sampling efforts.
3. **Evaluate and improve the DIT program**. Double index tagging is the only analytical tool available, independent from model-based methods, to estimate and evaluate impacts of MSFs on unmarked stocks. Despite SFEC recommendations to implement more DIT programs, agencies have been dropping DIT groups as they struggle with budgetary pressures. Such decisions are being made while MSFs continue to replace NSFs as agencies attempt to maintain levels of harvest as wild stocks decline. As the magnitude

of MSFs impacts has reached a level where differences in total fishing mortality exploitation rates should be reliably detected, the number of DIT groups being released has declined. Evaluations of DIT programs for both Chinook and coho are underway by the SFEC. Once those are completed, recommendations will be available for the agencies. In the interim, the CTC and the CoTC can provide agencies with a list of critical DIT programs for stocks originating within their respective jurisdictions. With the expansion of Chinook MSFs to coastal waters, the SFEC has also recommended that agencies review their sampling methodologies to ensure that ETD is employed where necessary to recover DIT groups (SFEC 2015).

4. **Develop, evaluate and support tools, models, and databases for MSF**. Mass marking and MSFs have become fixtures of the overall enhancement and management effort directed at Pacific salmon. The SFEC, along with the CTC and the CoTC, must continue to develop models, monitoring programs, and analytical methods to improve bilateral capabilities to generate reliable estimates of MSF impacts in pre-season planning models and post-season evaluation, including investigation of methods to estimate unmarked impacts using the Data Generation Model currently in development by the CTC. Methods for estimation of fishery specific exploitation rates have not been developed for MSFs.

   To incorporate changes to fisheries and sampling resulting from MM and MSFs, a comprehensive and cohesive evaluation of CWT-based models and analytical methods is needed to ensure the viability of the CWT and to implement PST agreements on fishing regimes. Explicit statements on the data requirements and standards required of the models should be part of these evaluations, supporting the coastwide effort to coordinate the collection (sampling) and reporting of data. Methods for data collection, compilation, and reporting to the database, and analyzing MM and MSF data should be standardized, implemented across agencies, and evaluated, to minimize costs and address increased uncertainties.

5. **Maintain and enhance the RMIS** to provide access to detailed information on the coastwide tagging and recovery of CWTs in Chinook and coho salmon. Data standards developed by the PSC Data Standards Working Group have been developed and implemented and the RMIS manages data to these standards. Development and implementation of standards for coastwide fishery regulation data management and estimates of mortalities of unmarked DIT groups are needed.

6. **Improve compliance with SFEC-identified fishery sampling and MSF data reporting requirements.** Gaps in assessment from lack of resources for tagging, sampling and data management contribute to increasing levels of uncertainty. Post-season reporting of where and when MSFs occurred, fishery regulations, estimated total mortalities and fishery mark rates, and sampling methods implemented for all fisheries and escapement, is currently lacking and is critical to evaluating the success of MSFs. Evaluation of the pilot database and reporting system in development at WDFW and NWIFC for Washington marine Chinook MSFs for expansion to coho salmon and other agencies is recommended. One report in the system is already compatible with the existing post-season reporting template and could be enhanced so all agencies could use it for MSF postseason reporting.

Recommended roles for the SFEC into the future include:

1. Continue support for technical and policy processes to develop agreements and to clarify responsibilities for maintaining a functional CWT program. These processes must build upon recommendations presented by the CWT Workgroup in 2008 (PSC 2008).
2. Work more closely with the Chinook and coho technical committees to provide support in the analysis of MSFs for incorporation into stock and fishery assessment methods and management models.
3. Limit review and evaluation of MSF proposals to new or substantially altered MSFs, and shift its focus from prior assessment of MSF proposals to post-facto evaluation.

1 INTRODUCTION

The development of a binary coded-wire tag (CWT) in 1971 ushered in a major technological development in the tagging and management of Pacific salmon. Groups of juveniles could be uniquely coded prior to release with a tiny, magnetized CWT inserted into the snout. A coastwide agreement was reached for recovering tags and reporting recoveries (Johnson 2004). The adipose fin clip was sequestered through coastwide agreement in 1977 to serve as a visual indicator to samplers to identify fish containing CWTs (Nandor et al. 2010). Protocols for sampling and reporting of CWT releases and recoveries made it possible to conduct several thousand marking experiments simultaneously.

Since the late 1970's a coastwide CWT database management system, the Regional Mark Information System (RMIS), has been in place at the Regional Mark Processing Center (RMPC). It is maintained by the Pacific States Marine Fisheries Commission (PSMFC), who coordinate the reporting of CWT releases and recoveries and provide access to detailed information on the coastwide harvest of Chinook and coho salmon (Nandor et al. 2010). Snouts are collected and dissected, CWTs are recovered and decoded, and information on the time, fishery, and location of the CWT recovery is reported to the RMIS by agencies in the Pacific Northwest.

Coded-wire tag data proved pivotal in informing Pacific Salmon Treaty (PST) negotiations for Chinook salmon by providing insight on the level of reductions required to address emerging conservation concerns and identifying alternative management strategies for a coastwide rebuilding program. When the PST was signed in 1985, the United States (US) and Canada, the Parties, also agreed to a Memorandum of Understanding (MOU) (PST Section B – Data Sharing, 1985) committing both countries to maintain a viable CWT program:

"The Parties agree to maintain a coded-wire tagging and recapture program designed to provide statistically reliable data for stock assessments and fishery evaluations."

Coded-wire tagged indicator stocks, almost entirely comprised of hatchery releases, were established as surrogates for closely associated natural-origin Chinook and coho stocks to monitor impacts of fisheries under PSC fishing regimes. Tagged release groups of hatchery fish originating from local brood stocks were assumed to be representative of natural stocks with similar early life history patterns and adult return timing (Nandor et al. 2010).

In the early 1990s, the PSC found itself at the center of heated policy and technical debates over the potential impacts of mass marking (MM) and mark-selective fisheries (MSF) on the integrity and viability of the CWT program. Mass marking refers to the marking or fin clipping of hatchery fish for the purpose of providing an opportunity for selectively retaining them and releasing unmarked fish under mark-selective fishing regulations. At that time, the central focus of salmon management was on the conservation of naturally spawning stocks of coho and Chinook. Mass marking and MSFs were pursued as a strategy to increase the harvest of hatchery fish within established constraints to conserve stocks of naturally spawning fish.

An Ad-hoc Selective Fishery Evaluation Committee (ASFEC) was established by the Pacific Salmon Commission (PSC) to investigate the implications of implementing MM and MSFs on the viability of the CWT program. The Ad-Hoc SFEC issued its report in 1995 (ASFEC 1995), recommending that if MM and MSF were to proceed, electronic detection and double index

tagging (DIT[3]) should be used to try to maintain the viability of the CWT program. The ASFEC also advised against using MSFs for Chinook salmon.

Recognizing the reality of pressures for continued implementation of MM and MSFs, the PSC ultimately adopted an "Understanding of the PSC Concerning Mass Marking and Selective Fisheries" (Appendix A) and established a permanent Selective Fisheries Evaluation Committee (SFEC) in 1998 (Appendix E of the 13th Annual Report of the PSC, 1998). The SFEC's current terms of reference were adopted in 2004 (SFEC 2004).

The SFEC facilitates coordination and reporting of MM and MSFs among the Parties, affected agencies, and existing coastwide and regional committees established to monitor activities related to the coastwide CWT program. The SFEC has three components: (1) an Oversight Committee, comprised principally of the Co-Chairs of the PSC SFEC, Coho, Chinook, and Data Sharing Committees; (2) an Analytical Work Group (SFAWG) which is responsible for developing methods and conducting analyses of impacts of MM and MSF on the viability of the CWT program; and (3) a Regional Coordination Work Group (SFRCWG) which monitors, reviews and coordinates information sharing between the agencies on MM and regional sampling programs, including ETD.

An understanding adopted by the PSC in 2004 (Appendix to the 19th Annual Report of the PSC, p168) established procedures for the SFEC to review agency proposals for MM and MSFs on an annual schedule that will permit the SFEC to provide timely advice to the PSC. The SFEC reviews MSF proposals that involve fisheries that are expected to impact Chinook or coho indicator stocks. Agencies are to provide annual MM and MSF proposals, as well as post-season MSF reports, for all hatchery Chinook and coho stocks expected to be harvested by fisheries of interest to the Southern, Northern, and Fraser Panels.

The scope of this report concerns the impacts of MM and MSF on the viability of the CWT system for PST and fishery management purposes, with "viability" defined by ASFEC (1995) as meeting the following three criteria:

1) it must provide the ability to use CWT data for assessment and management of wild stocks of coho and Chinook salmon;

2) it must be maintained such that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk; and,

3) it must provide the ability to estimate stock-specific exploitation rates by fishery and age (ASFEC 1995).

Despite the additional challenge posed by MM and MSFs, the CWT system remains the only source of data for the purposes the PST. The CWT system does remain viable for other non-PST-related analyses using marked and tagged fish, (e.g., evaluation of hatchery programs, estimating stock contributions to fisheries, conducting comparative survival experiments, and monitoring trends in marine survival rates).

[3] A double index tag (DIT) group is comprised of two related coded-wire tag (CWT) groups, one marked and one unmarked. Differences in return rates between the paired DIT groups are intended to provide information on the cumulative impacts of MSFs on unmarked fish.

1.1 *Significance of MSFs to Implementation of PST Agreements*

Mark-selective fisheries complicate implementation of PSC fishing regimes. Chinook salmon MSFs increase the difficulty of estimating total mortalities, fishery harvest rates and abundance indices. Coho salmon MSFs increase the difficulty of estimating exploitation rates for unmarked fish from individual naturally spawning Management Units (MUs) by each Party's fisheries.

Uncertainty around actual impacts by MSFs creates risk for the resource and potential conflict among stakeholders in terms of sharing of allowable fishery impacts. For the resource, the impact of uncertainty due to MSFs depends on the portion of total fishing mortality accounted for, how close the predicted exploitation rates are to the management objective, and the portion of the total exploitation rate that is attributable to MSFs. If a precautionary management approach is not taken and there is no buffering for the uncertainty, then the resource bears the risk of over-harvest and under-escapement from underestimating MSF impacts. Conflict among the stakeholders and between management entities emerges when resource compensation is required for overfishing or a precautionary approach is taken and buffering occurs to account for the uncertainty interjected by MSFs.

1.1.1 Chinook

The PST Agreement for Chinook salmon (PSC 2008) establishes regimes for Aggregate Abundance Based Management (AABM) in highly mixed stock fisheries in southeast Alaska (SEAK), northern BC (NBC), and the West Coast of Vancouver Island (WCVI), as well as for Individual Stock-Based Management (ISBM) regimes for other fisheries.

Estimation of mortalities on unmarked fish impacted by MSFs requires the implementation of catch monitoring programs to estimate and report the number of legal and sub-legal marked and unmarked fish released, as well as those retained, by fishery strata. Differential impacts of fisheries on marked and unmarked components can accumulate over time and affect stock abundance forecasts and hence calculation of the abundance indices that drive AABM regimes. In addition, the PST Chinook Agreement is in transition from retained catch based to total mortality based AABM regimes. Evaluation of ISBM regimes depends on the availability of CWT data and the capability to distinguish differential impacts on marked and unmarked fish.

No bilateral planning tool presently exists to evaluate MSF impacts on Chinook salmon. The PSC Chinook model does not account for MSF. The model does not separate marked and unmarked components and annual, regional fishery strata are too coarse to evaluate the fine time-area fisheries employed to implement MSFs. The Pacific Fishery Management Council employs Chinook FRAM to evaluate MSFs for U.S. fisheries occurring south of the BC/WA border.

A bilateral model does not exist for pre-season planning or post-season evaluation of MSFs for Chinook.

1.1.2 Southern Coho

The PST Southern Coho Agreement establishes regimes that require the Parties to constrain total fishery-related exploitation rates on southern BC and southern US naturally spawning coho Management Units (MUs). A bilateral fishery planning tool, the Coho Fisheries Regulation

Assessment Model (FRAM), is employed to generate pre-season projections and post-season estimates of MU and fishery-specific exploitation rates.

Empirical estimation of mortalities on unmarked fish imparted by MSFs requires the implementation of catch monitoring programs to estimate and report the number of marked and unmarked fish (both tagged and untagged) retained and released by MU and fishery strata. For several reasons, many catch monitoring programs are unable to provide these estimates. This lack of comprehensive stock and fishery assessment capabilities for all coho MUs specified by the Southern Coho Agreement (e.g., CWT releases of indicator stocks, escapement estimation and recovery estimates, coordination between fishery regulation and sampling programs), coupled with the low exploitation rate fisheries (reducing the number of CWT recoveries and increasing the uncertainty of recovery estimates) and limitations of available methodologies (particularly the inability to separate estimates of total mortalities imparted by multiple MSFs), means that estimates of MU-specific exploitation rates for both MSFs and non-selective fisheries (NSFs) are based on the (assumption-based) coho FRAM (see section 4.1).

1.1.3 Harvest Sharing Agreements

Mark-selective fisheries can, in some cases, significantly change the magnitude and distribution of mortalities and catches compared to non-selective fishing. This may lead to renegotiation of harvest sharing agreements to help achieve agreed upon allocations. Substantial MSFs can reduce the fishery mark rates, increasing the proportion of unmarked fish encountered, in subsequent fisheries, possibly constraining these fisheries.

> Mark-selective fisheries can significantly change the magnitude, distribution and uncertainty of fishery mortalities for unmarked fish (usually natural-origin).

US fisheries are constrained by the Endangered Species Act (ESA) listed stocks by total exploitation rate ceilings (e.g., Columbia River and Puget Sound Chinook). The 2008-2017 US v. OR Management Agreement constrains harvest rates on natural-origin spring Chinook in the Columbia River in such a way that treaty and non-treaty catch allocations (according to treaties with individual tribes) within existing NSFs are expected to be maintained. Allocations have been adjusted to address catch balancing provisions for spring Chinook. Mark selective fishery impact estimates are dependent on encounter and release mortality rates, with studies and negotiations required for all stakeholders to agree on these parameters.

2 MASS MARKING

Mass marking and MSFs have been implemented as a strategy to increase harvest of hatchery fish within constraints established for exploitation rates on natural-origin stocks. MM was also implemented by agencies as a tool to differentiate hatchery and wild fish in brood stocking and on the spawning grounds.

2.1 *Selection of a Mass Mark*

Mark-selective fisheries require an easily recognizable external mark. The ASFEC recommended removal of the adipose fin as the mass mark of preference because: 1) the adipose fin clip was likely to have a minimal and consistent mark-related mortality rate and marking was believed to have negligible impacts on behavior from mark application, 2) agencies had

experience with adipose fin clipping when marking CWT release groups, and, 3) anglers had familiarity based on knowledge gained from adipose fin clip identification in steelhead fisheries (ASFEC 1995). Because the adipose fin had been sequestered as the external identifier for a CWT, the ASFEC also recommended that electronic detection be employed to sample where CWT recoveries were expected, to minimize costs of CWT recovery.

The adipose fin clip mark also allows for identification, segregation and assessment of hatchery and natural-origin adults returning to hatcheries, captured in streams and on the spawning grounds, and also provides a tool for genetic management of brood stock.

Numerous studies have shown that fish that have their adipose fins removed do not experience significantly lower survival than fish with all their fins left intact (Vander Haegen et al. 2005, Vincent-Lang 1993, and SFEC 2006). Historically the adipose fin was considered to be a remnant fin, composed of fatty tissue, which was of no significant importance. Recent studies, however, have challenged that assumption. Buckland-Nicks et al. (2012) reported that the adipose fin was innervated (connected to the nervous system). The authors called the adipose fin a "precaudal flow sensor," allowing improved maneuverability in turbulent waters. Reimchen and Temple (2004) found increased caudal fin amplitude in juvenile steelhead whose adipose fins had been removed relative to fish whose adipose fins were still intact. The authors suggest that removing the adipose fin may reduce swimming ability in fast turbulent water.

No other permanent visual external mark has been identified as a viable alternative to the adipose fin clip for anadromous salmon. For example, studies have found that the ventral fin clip can result in significant decreases in survival (0 – 75%), and can also result in substantial fin regeneration, in the order of 0-44% (SFEC 2006).

No viable alternative to the adipose fin clip has been identified as a permanent visual mark for MM of anadromous salmon.

2.2 *History of Mass Marking*

Mass marking of salmonids with clipping of the adipose fin began in 1995 (Nandor et al. 2010). The following list outlines the development of MM.

- The adipose fin mark was sequestered as a coastwide indicator for anadromous salmonids tagged with a CWT in 1977 by regional agreement (Nandor et al. 2010).
- In 1986 the adipose fin mark was de-sequestered as a CWT flag for steelhead, and the left ventral fin mark was subsequently adopted as a CWT flag for steelhead in the Columbia Basin (PSMFC 1984).
- Hatchery coho were first MM in 1984 in BC by the CDFO with a ventral (pelvic) clip. This was used for a 1986 MSF during the World Expo '86 event.
- In 1995 WA, OR, and southern BC began marking hatchery coho salmon The adipose fin clip was used in WA and OR, and the ventral clip was used by the CDFO. The CDFO switched to the adipose fin clip beginning with brood year (BY) 1996 coho.
- Washington state legislative directives were enacted for MM coho (1997 Washington State Senate Bill of coho) and Chinook (1998 Washington State Senate Bill 6264), in 1997 and 1998 respectively.

- Chinook MM began with BY 1998 for a limited number of Puget Sound fall Chinook and Columbia River spring Chinook stocks.
- Western WA co-managers subsequently developed MOUs on MM and MSFs for coho (Implementation Plan: Coho Mass Marking and Selective Fisheries, April 15, 1997) and Chinook (Implementation Plan: Chinook Mass Marking and Selective Fisheries, June 16, 1999).
- By 2001 the Columbia Basin agencies had converted to ETD for CWT recoveries in steelhead, eliminating the need for the ventral fin mark CWT flag for steelhead in the Columbia Basin.
- The US Congress issued a mandate to MM all hatchery salmon for federally funded hatcheries in 2003 and 2004 (United States Congress Department of Interior's Appropriation Bill). Section 138 of the US Interior Appropriations bill states:

  "The United States Fish and Wildlife Service shall, in carrying out its responsibilities to protect threatened and endangered species of salmon, implement a system of mass marking of salmonid stocks, intended for harvest, that are released from federally operated or federally financed hatcheries including but not limited to fish releases of coho, chinook, and steelhead species. Marked fish must have a visible mark that can be readily identified by commercial and recreational anglers."

  Similar MM directives have been included annually in appropriations bills since 2003.
- Essentially, all hatchery coho yearling production intended for harvest from southern BC, WA, and OR has been marked or tagged since 2005. Participating facilities extend from the north end of Vancouver Island, BC south through OR. There is no MM of coho in AK, northern BC, or CA.
- By 2009, almost all hatchery Chinook production intended for harvest from hatcheries in WA, OR, and ID was marked or tagged. Chinook are not MM in AK, BC, or CA.
- Mass marking of millions of coho and Chinook established momentum for rapid expansion of MSFs for coho and Chinook. As Rutter (2004) stated in his opening remarks for the PSC CWT Workshop:

  "The train of mass marking and mark-selective fisheries is moving rapidly down the tracks, and doesn't look like it will be stopped anytime soon."

2.3 *Mass Marking Levels*

The majority of the coastwide coho production from southern BC, WA, and OR is being MM. Approximately 34 million coho are currently mass marked coastwide annually. Trends in MM levels are displayed in Figure 2-1 (SFEC 2015). Although there has been a gradual decline in coastwide coho hatchery production since brood year 1997 (from a high of 70 million in brood year 1999 to 42 million in 2013 brood year), there have been no significant changes to proposed marking levels from BY 2001 to BY 2013. Marking levels of MM Chinook have remained around 115-120 million smolts, of an annual production of roughly 150 million smolts in recent years.

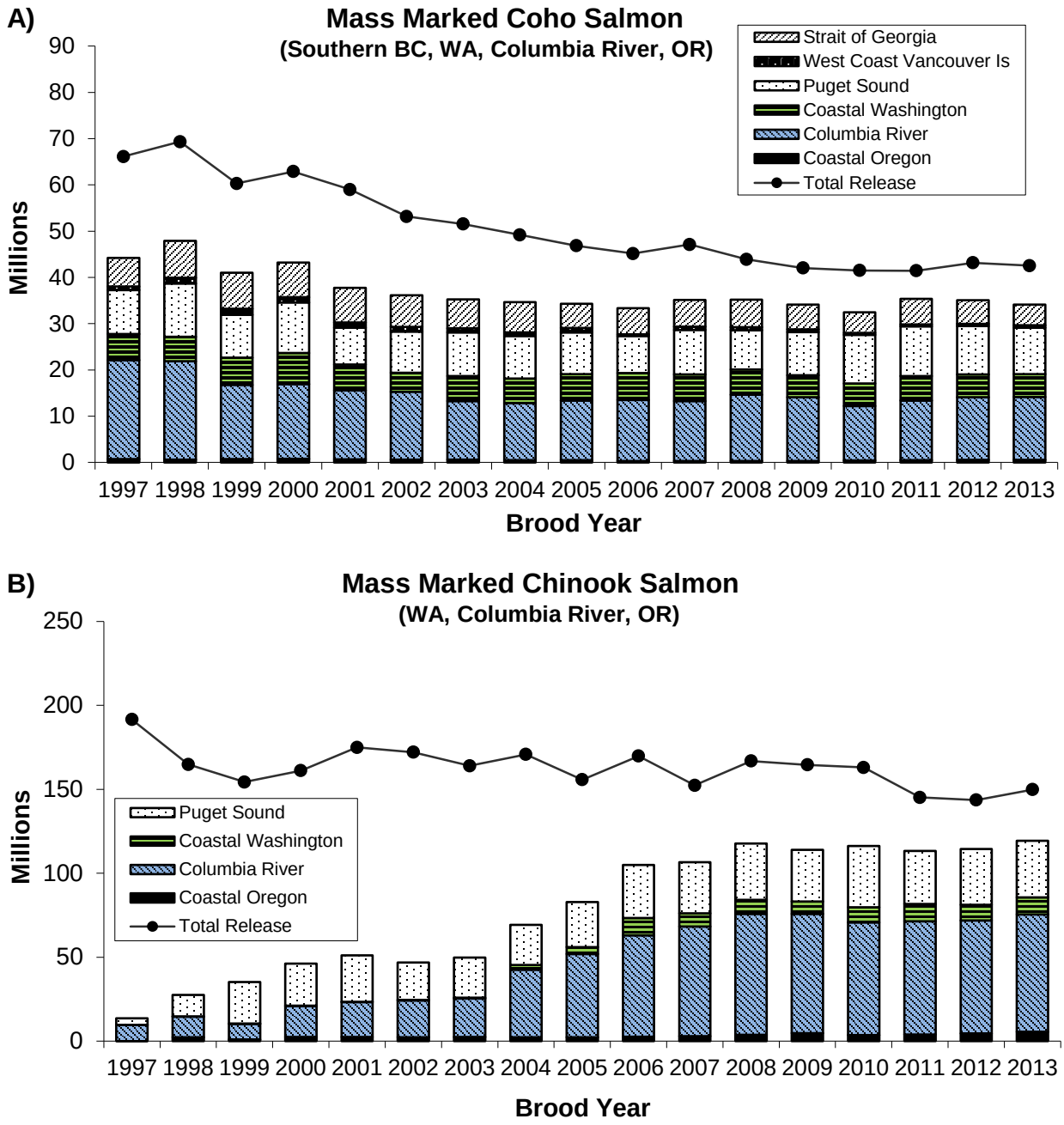

Figure 2-1 Number of mass marked coho (panel A) and Chinook salmon (panel B) released by region and brood year, 1997–2013. The solid line represents total hatchery releases by brood year with the exception that fry releases of coho are not included. Values used for brood years 1997–2010 are actual release numbers; values for brood years 2011–2013 are proposed release numbers (SFEC 2015).

3 MARK-SELECTIVE FISHERIES

Mark-selective fisheries were implemented to increase harvest of hatchery-origin fish within the constraints established for exploitation rates on natural-origin stocks. Since the introduction of

MSFs in 1998 (for coho) and 2003 (for Chinook), interest in MSFs has grown, as a means to increase fishing opportunities on hatchery production while limiting impacts on natural-origin stocks.

3.1 *Development of MSFs*

The SFEC recommended that the implementation of MSFs begin slowly and increase as the monitoring and reporting systems required to maintain a viable CWT program were developed (ASFEC 1995). The first coho MSF was conducted in WA ocean areas in 1998. Since then, the number of coho MSFs has grown, and as of 2015, they were conducted from the OR/CA border to Cape Caution in BC (Figure 3-1and Figure 3-2). The first Chinook MSFs were conducted in the Strait of Juan de Fuca in 2003. Since then the number of Chinook MSFs has grown and as of 2014 they were conducted from OR/CA border to the Strait of Juan de Fuca (Figure 3-3).

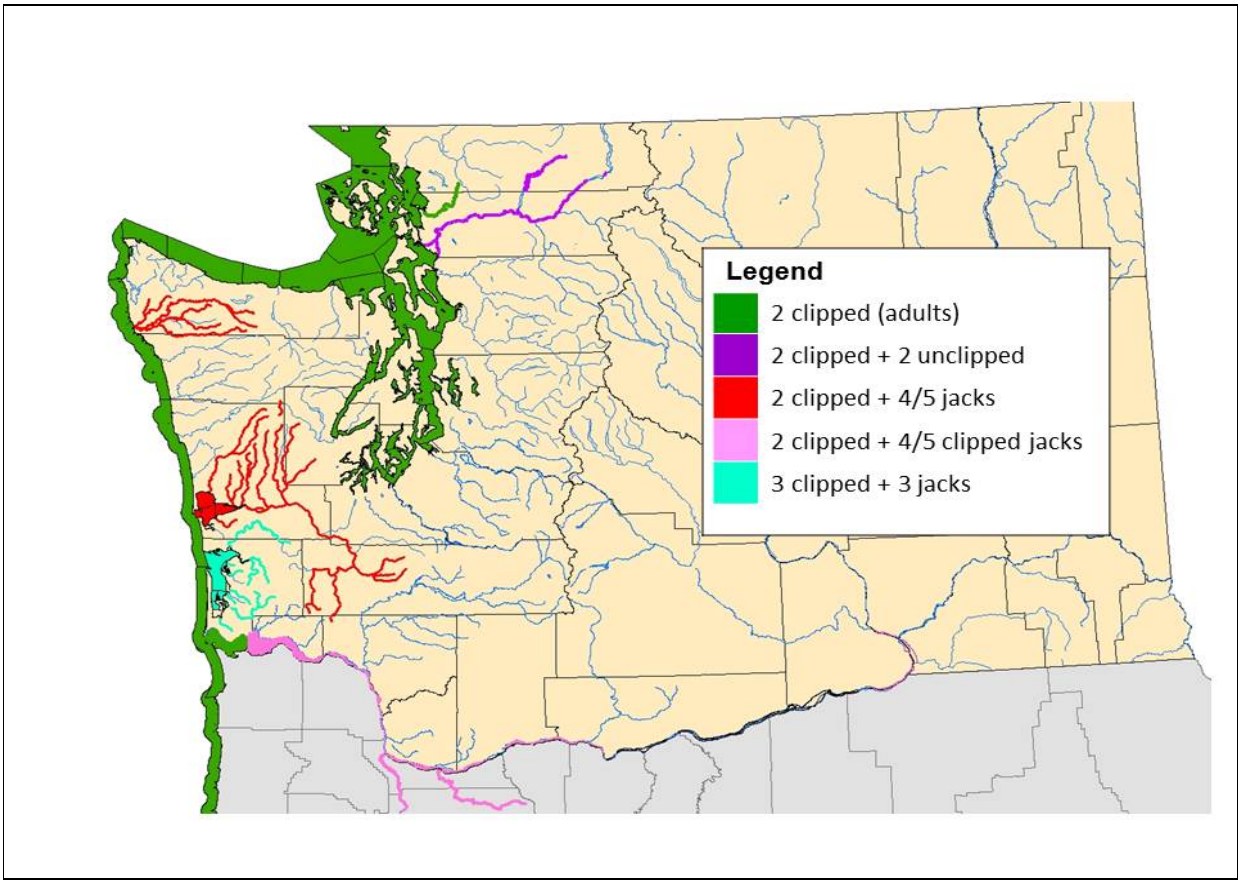

Figure 3-1 Map showing proposed recreational coho MSF regulations in WA and OR in 2015.

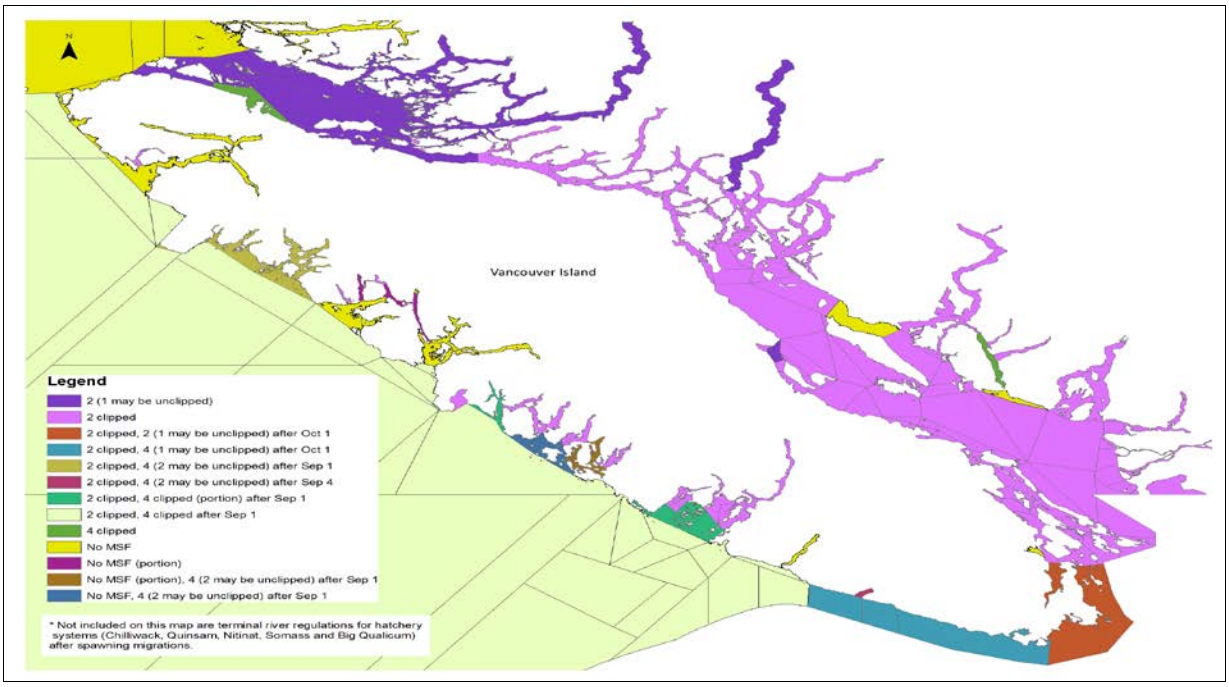

Figure 3-2 Map showing proposed recreational coho MSF regulations in southern BC in 2015.

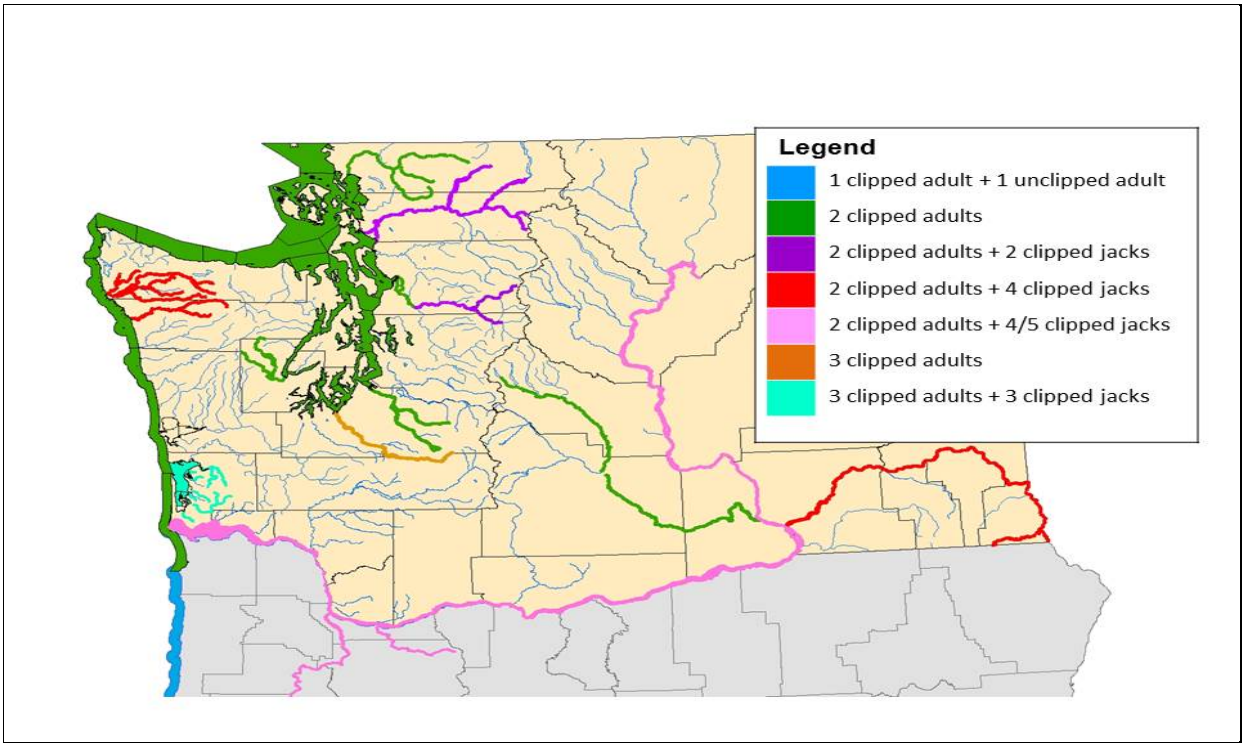

Figure 3-3 Map showing proposed recreational Chinook MSF regulations in WA and OR in 2015.

During the early stages of implementation, MSFs were small in magnitude and low in intensity; consequently, there was a high level of uncertainty in the resulting estimates of mortalities on unmarked fish. As MSFs have gained popularity, they have increased in number and size across regions within the Southern Panel area, often replacing existing NSFs (Figure 3-4). With this change in management, the number of unmarked mortalities has likely been reduced as fish are released that otherwise would have been retained. There is, however, increased uncertainty around these mortalities due to the need for estimations of release mortality rates and the inability to sample released fish for CWTs. As reliance on MSFs increases, sampling programs need to be developed along with the fisheries to properly account for encounters of unmarked fish (see Coastwide Coordination of CWT Sampling Programs for more detail). Analysts must be able to detect differences in mortalities between marked and unmarked fish due to encounter rates in MSFs. Without adequate sampling efforts, uncertainty surrounding unmarked mortality estimates cannot be evaluated. WDFW's Puget Sound recreational Chinook MSFs in marine areas are an example where sufficient sampling and reporting of both marked catch retained and unmarked catch released can better account for impacts on unmarked fish.

Adequate tagging and unbiased sampling for CWTs in fisheries and escapement is required to evaluate impacts of MSFs.

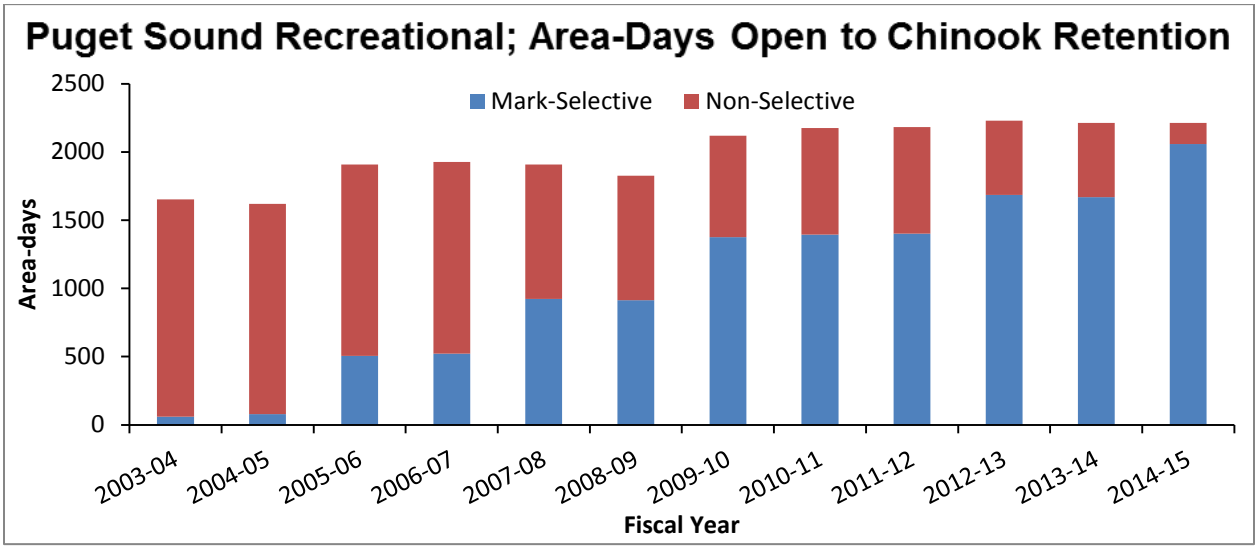

Figure 3-4 Number of days open to recreational Chinook retention in Puget Sound marine areas by fishery type.

3.2 *Regulation of MSFs*

In an attempt to provide increased opportunity for anglers to harvest fish, fishery managers often design and implement complex regulations (e.g., mixed-bags or different retention restrictions across small spatial or temporal resolutions, see Figures 3-1, 3-2, 3-3) without regard for the need to assess their impacts. Mark-selective fishery regulations should be designed to be as simple and as similar as possible across spatial and temporal strata. Mixed-bag fisheries are one type of complex regulation that may be considered by fishery managers when the fishery mark rate is lower and/or sufficient escapement of natural-origin stocks is expected to occur. A

mixed-bag fishery is one where an angler may retain different proportions of clipped or unclipped fish, and often may include jacks as well as adults.

Improved coordination, within and between agencies, of harvest management regulations and sampling programs is needed. The SFEC has been unable to develop methods for estimation of MSF impacts on unmarked fish by stock and age under the promulgated regulations.

Implementation of complex MSF regulations may help to provide increased angler opportunity, but this may increase angler confusion and decrease angler compliance, resulting in a need for greater enforcement. For example, local anglers familiar with the regulation boundaries may fish adjacent to a boundary, knowing they can move into an area allowing retention of unmarked fish if approached by an enforcement officer. Coordination between managers in the design of corresponding regulations in adjacent areas, with similar species, gear, size, and bag limit restrictions could increase compliance, and at the same time simplify assessments.

Compliance can be difficult to enforce due to the complexity of regulations. Similar regulations across spatial and temporal strata minimize angler confusion and enforcement burdens.

Based on reductions in retention of unmarked catch since the inception of MSFs, it is evident that angler behaviour has successfully been modified to harvest selectively for marked fish. However, habituation to MSFs may cause anglers to voluntarily release either marked or unmarked fish when not required by regulation and this behaviour increases the difficulty of quantifying impacts of MSFs.

4 PLANNING AND ASSESSMENT OF MSFS

Estimation of the fishery mark rate (the proportion of encounters of marked fish by time-fishery strata) is critical to harvest management planning. If mark rates are overestimated impacts of MSFs on unmarked fish will be underestimates; conversely, if mark rates are underestimated, mortalities of unmarked fish will be overestimated.

Estimation of the fishery mark rate by time-fishery strata is critical to harvest management planning involving MSFs.

4.1 *Planning Tools*

Models are employed to plan MSFs. These models estimate various types of mortalities as the ratio of marked to unmarked fish changes due to selective retention of marked fish. Five types of mortalities are associated with MSFs: 1) marked and unmarked fish that are legally retained; 2) fish that cannot be legally retained and die from stress or injury after release; 3) unmarked fish that are erroneously retained ("unmarked retention error"); 4) marked fish that are released and die from stress or injury ("marked recognition error"); and 5) fish that are encountered during a MSF but are killed prior to landing "drop off mortalities" (e.g., fish killed by pinniped predation). Initial studies have been conducted to examine incidental MSF mortality parameters, including marked release rates and unmarked retention rates (Conrad and McHugh, 2008), however further investigations are warranted. Existing mortality rates for release, mark retention, and mark recognition errors are derived from studies that have indicated substantial variability by gear, vessel type, location, species, and size of fish encountered. Nonetheless,

methods and models employed for stock and fishery assessments assume these rates are known with certainty.

A bilateral model does not exist for pre-season planning or post-season evaluation of MSFs for Chinook. The PSC Chinook model does not account for MSFs. The model does not separate marked and unmarked components and annual, regional fishery strata are too coarse to evaluate the fine time-area fisheries used to implement MSFs. Chinook MSFs are being implemented at time-area scales and under regulations (e.g., bag limit variations) that the existing CTC model is not capable of providing. The Chinook FRAM is employed by the Pacific Fishery Management Council (PFMC) to evaluate Chinook salmon MSFs in US domestic fishery planning south of the BC/WA border.

The CTC is developing a Data Generation Model (DGM), a simulator that generates catch and incidental fishing mortality data for unmarked and untagged (natural-origin), marked and untagged (MM), unmarked and tagged (unmarked DIT), and marked and tagged (marked DIT or single index tagged) release groups in fisheries impacting Chinook stocks and in spawning escapements. The DGM provides a means of generating true data to evaluate the deterministic, assumption-based analytical methods and models employed by the CTC. The DGM consists of two components:

(1) a Monte Carlo simulation module for stock distribution and selective and non-selective fisheries encompassing appropriate types of release mortalities in the presence of uncertainty and variability. The module enables a user to provide a set of input data files which specify the simulation configuration (number of stocks, ages, time periods, and fisheries, migration mechanism, sizes of marked and unmarked releases), scenario (time-specific fishery harvest rates and retention restrictions), and number of times the scenario is to be simulated. For each specified scenario, the module generates a database of catches and escapements by stock, age, and fishery; and,

(2) a CWT Sampling Module (SM): The SM simulates recovery of coded-wire-tags (CWTs) from databases generated by the simulation module, given user-specified sampling rates for fisheries and spawning escapements under visual vs. electronic tag detection methods. The user can specify the number of times the sampling process is to be simulated on a given DGM data set. Each set of simulated CWT recoveries is saved independently in a database.

Although the DGM is being designed for Chinook, it can be modified for coho salmon.

The Coho Fisheries Regulation Assessment Model (FRAM) is a coastwide bilateral model having algorithms designed to evaluate MSFs for coho salmon. The model has been employed for pre-season planning and to generate post-season estimates of exploitation rates on naturally spawning stocks of coho salmon under the PST Southern Coho Agreement. The coho FRAM is an accounting tool that generates monthly estimates of mortalities for marked and unmarked fish by stock and fishery strata. Projections of mark rates and mortalities of MSFs by the coho FRAM are based on abundance forecasts, base period data, and proposed fisheries regulations (see Figure 4-1 below).

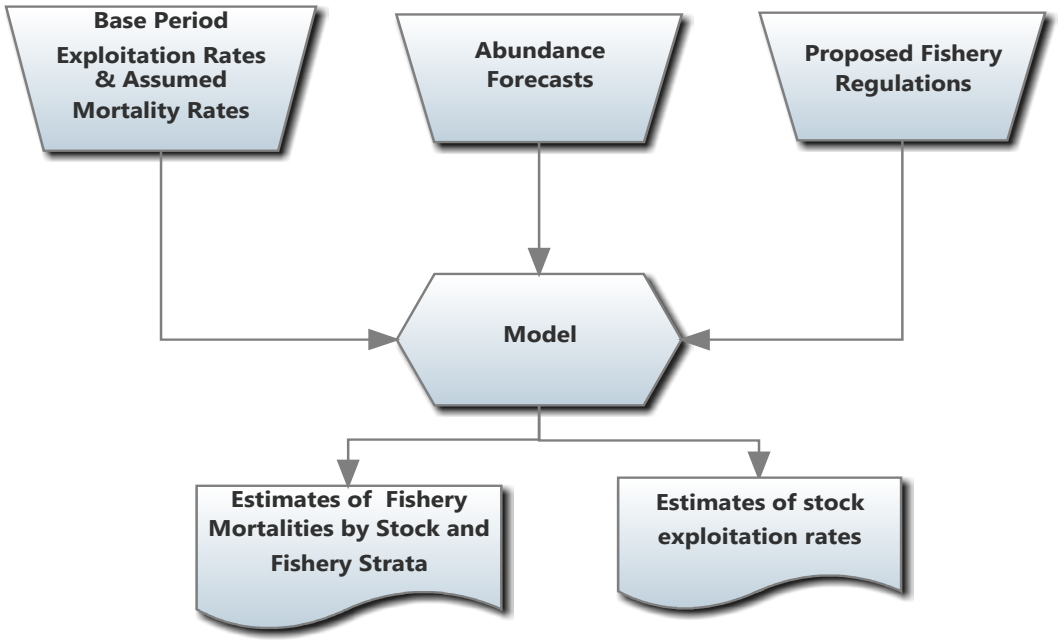

Figure 4-1. Fisheries Regulation Assessment Model: structure and components.

Projections of mark rates for stocks and mortalities of MSFs by the Coho FRAM are highly uncertain, due to the uncertainty of abundance forecasts, variations in migration patterns from those observed during the model base period, and deviations in the conduct of fisheries from pre-season expectations.

Pre-season projections and post-season estimates of exploitation rates (ERs) are assumption-based, relying on presumptions of stable base period stock distribution patterns. Since coho FRAM is deterministic, uncertainty is not considered and point estimates are frequently interpreted as being true to a high degree of precision. The coho FRAM pre-season projections of fishery mark rates can differ substantially from post-season and in-season estimates (see Figure 4-2 below).

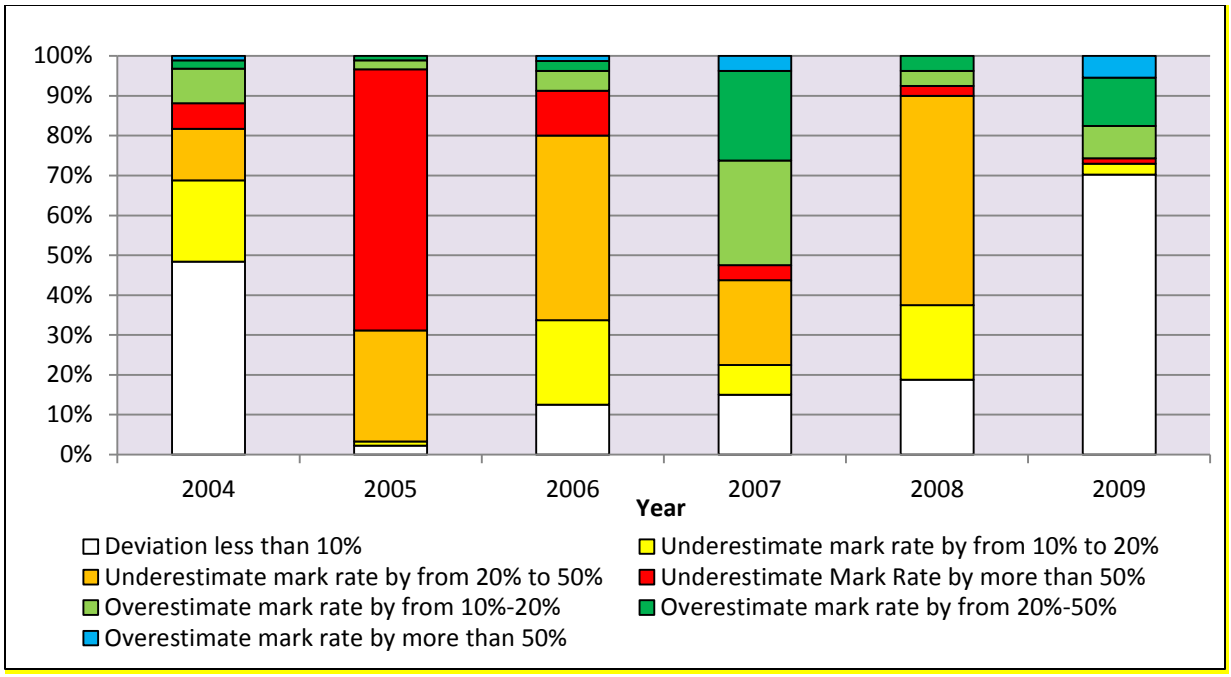

Figure 4-2. Coho Fisheries Regulation Assessment Model performance; deviations of post-season estimates from pre-season expectations.

4.2 *Stock Assessment*

Stock assessment involves estimation of stock and fishery specific exploitation rates. For coho and Chinook salmon, recoveries of tagged indicator stocks in fisheries and escapement provide the data required for estimation of exploitation rates. These are used for post-season evaluation of fishery impacts on natural-origin stocks and as input for pre-season management models, such as the coho FRAM. Indicator stocks are usually hatchery stocks chosen as being representative of the natural-origin stock from the same watershed or region, and with the same life history characteristics (e.g., summer or fall run, yearlings or fingerlings) and are assumed to have the same migration path and distribution. Prior to MM and MSFs, the marked and tagged groups were assumed to be representative of natural-origin stocks. However this assumption is violated once MSFs were prosecuted for coho and Chinook salmon. With MSFs the distributions of marked and unmarked (including natural stocks) will differ as a higher proportion of unmarked fish survive.

Estimation of mortality rates in MSFs has proven to be challenging, due to complexity of fishery regulations and lack of a means for estimating impacts of individual MSFs when multiple MSFs impact stock groups.

Double index tagged groups are intended to provide data for estimation of unmarked mortalities in MSFs, and estimates of total exploitation can be made by comparison of the proportion of unmarked and marked releases returning to the hatchery. However a method of estimation of fishery specific exploitation rates across multiple MSFs is not currently available. As fishery regulations become more complex this becomes more challenging. The SFEC has been unable to develop methods for estimation of MSF impacts on unmarked fish by stock and age under the promulgated regulations.

5 VIABILITY OF THE CWT PROGRAM

For Chinook and coho salmon, PSC has focused bilateral coordination on developing and implementing fishing regimes designed to conserve and manage "wild" (natural-origin) fish since the PST was adopted. The ASFEC defined "viability" of the CWT program for the PSC in terms of three specific criteria:

1) it must provide the ability to use CWT data for assessment and management of wild stocks of coho and Chinook salmon;
2) it must be maintained such that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk; and,
3) it must provide the ability to estimate stock-specific exploitation rates by fishery and age (ASFEC 1995).

The first criterion for viability, that the CWT program provide CWT data for assessment and management of wild (natural-origin) stocks of coho and Chinook salmon, requires: 1) Coastwide Coordination of Tagging Programs, 2) Coastwide Coordination of CWT Sampling Programs in fisheries and escapements, and 3) Coastwide Coordination of Reporting protocols, as discussed in detail in the sections below. Electronic tag detection is needed throughout the migratory range where DIT stocks are encountered, and to reduce costs of CWT recovery in both MSFs and NSFs. Agency marking, tagging and sampling programs are not being coordinated to the level necessary to provide the data required for stock and fishery assessments. Disconnects between fishery regulators and those responsible for conducting sampling programs, declining use of DIT, incomplete coastwide participation in ETD, and increasing budget constraints are the underlying issues for the current lack of coordination between and within agency programs.

Key issues in coordination are: implementation of coastwide tagging and sampling for tag recovery, agency coordination of regulations with sampling strata, and standard reporting compliance (including annual proposal submissions and post-season reporting) by agencies to the SFEC.

The second criterion defining viability of the CWT program is that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk. The 2005 CWT Expert Panel report indicated that MSFs increase the uncertainty of fishery impacts on unmarked fish (PSC 2005). The degree of uncertainty is determined by the intensity (proportion of marked fish removed) and spatial-temporal fishing patterns of individual stocks. However, the concept of risk and its acceptability are value-laden and situational, depending on socio-economic-cultural perspectives. Management agencies may not take uncertainty into account when planning or evaluating MSF impacts. Typically, point estimates are employed using algorithmic, assumption-based methods or models without accounting for uncertainty. Without DIT or some other means of validation or comparison, there is no independent means for evaluation of the error in projections or estimates of MSF impacts.

Harvest planning and post-season assessments rely upon assumption-based methods and do not account for uncertainty.

Uncertainty of fishing impacts on unmarked fish not represented by a DIT group has resulted in reduced ability to estimate impacts of MSFs on unmarked fish.

The third criterion defining viability of the CWT program is that it must provide the ability to estimate stock-specific exploitation rates by fishery and age. The ability to allocate mortalities of unmarked fish by stock and age among fisheries is required for implementation of PSC fishing regimes for both Chinook and coho salmon. The ASFEC, the SFEC, and the CWT Expert Panel have been unable to devise methods to estimate mortalities of unmarked fish in the presence of multiple MSFs. The wide variety of retention (size and mark status) regulations applied in MSFs, for both Chinook and coho, makes estimating mortalities of unmarked fish more challenging.

Estimation of mortality rate in MSFs has proven to be challenging, due to complexity of fishery regulations and lack of data collection, reporting, and analytical methods for assessing impacts of multiple MSFs.

5.1 *Coastwide Coordination of Tagging Programs*

Under MSF, marked and unmarked fish undergo different patterns of exploitation as they migrate and are harvested. Consequently the assumption (which is key to the coho FRAM and PSC Chinook model) that recoveries of tagged fish can be used as reasonable surrogates for assessment of fishery impacts to natural-origin stocks no longer holds. The ASFEC and the SFEC recommended that impacts of MSFs be estimated using differences in recovery rates from DIT releases, consisting of two groups of tagged releases, one marked and the other unmarked, of fish from the same brood stock and rearing/release protocols (SFEC 2002).

5.1.1 Double Index Tagging (DIT)

A double index tag (DIT) group includes two related coded-wire tag (CWT) groups, one clipped and one unclipped. For DIT-based estimates of fishery impacts on natural-origin stocks to be unbiased, both marked and unmarked fish must be sampled for CWTs in all fisheries and in escapements where DIT groups are expected to be encountered.

Double index tagging programs are required to provide a means to estimate fishery impacts on natural-origin stocks using observed rather than model based assumptions. Double index tagging is capable of reliably detecting differences in total fishery exploitation rates on paired releases when those differences exceed 10 percentage points (not a 10% difference). However, most DIT tagging levels have been too low and differential impacts of MSFs have only recently reached levels where DIT can be expected to produce reliable estimates of differences in exploitation rate between marked and unmarked paired releases. Without DIT, agencies are relying on assumption-based model projections of MSFs and lack an independent means for validation or comparison.

Double index tagging is intended to provide a means to estimate fishery impacts on unmarked natural-origin fish independent of assumption-based methods. Tagging and sampling levels must be sufficient for analysts to detect potential differences between marked and unmarked mortality rates.

During early stages of MSF development, differences in fishery impacts of MSFs on DIT groups were often too small to reliably detect, causing agencies to question whether the costs of DIT releases and associated sampling were justified. Over time, agencies have increasingly employed MSFs. However, some have discontinued use of DIT when differential impacts of

MSF on DIT pairs are now expected to reach levels where they can be reliably detected. Uncertainty of fishing impacts on unmarked fish not represented by a DIT group has reduced the ability to estimate impacts of MSFs on unmarked fish.

Mark-selective fisheries have more than doubled in number since 2007, with new areas and stocks fished under mark-selective regulations. A DIT group is needed for most PSC indicator stocks in order to evaluate the impacts of MSFs on each natural-origin stock represented by an indicator stock. It was recommended that agencies review their indicator stock programs in light of these new MSFs and any other new MSFs likely to be proposed in future years and evaluate the need for including additional DIT groups (SFEC 2015).

Actions to address deficiencies in the CWT program for Chinook (PSC 2005) were undertaken with the Coded Wire Tag Improvement Program from 2009 to 2015, but no comparable program has been implemented for coho. Analyses of coded-wire tagging levels were developed by CoTC and CTC members for many of the indicator stocks and recommendations for increased tagging were made for some of these stocks (SFEC 2011). In 2011, to improve the CWT program while under declining budgets, Northwest Marine Technology Inc. (NMT) offered free CWTs to agencies. Subsequently, a few agencies requested and received free tags from NMT, however most agencies could not afford the additional costs of applying additional tags and of the resulting increase in sampling effort on the returning adults.

Budgetary concerns have resulted in the discontinuation of some DIT programs which has increased uncertainty in the data available for stock and fishery assessments and constrained the ability of agencies to estimate stock-age mortalities of unmarked fish in MSFs.

Catch and escapement sampling in some areas is still inadequate for providing the data required for analysis of MSF impacts. This inadequate data and lack of analyses, combined with the large tagging and sampling costs of DIT programs, has led certain agencies to abandon DIT programs (with several more under consideration for termination). Since there is no viable alternative to DIT programs for estimating fishery impacts of MSFs on natural-origin stocks independently of assumption-based methods and models, this trend is alarming. Analysis of Chinook salmon DIT data are documented in CTC Exploitation Rate and Calibration reports since 2009 (TCCHINOOK 2010, 2011, 2012a, 2012b, 2014, 2015). A paper on the coho salmon DIT program is currently in preparation (Alexandersdottir in preparation).

Up to date analyses of currently available DIT data for Chinook and Coho Salmon are needed and a discussion paper describing the critical function of DIT programs should be prepared.

5.2 *Coastwide Coordination of CWT Sampling Programs*

The execution of MM and MSFs require additional resources and coordination, and add complexity to sampling programs. Under MSFs, there are additional demands on the fishery sampling programs to collect information needed to assess impacts on released fish (e.g., encounters and releases by size, age class and mark status, and compliance rates). Under MM and implementation of DIT, sampling is more labor intensive and costly, in some cases resulting in reduced sampling rates, because of budgetary and logistical constraints. Unrecovered DITs in unsampled fisheries and fisheries that are not electronically sampled create gaps in analyses of fishery impacts on unmarked (natural-origin) fish. If the resources for sampling programs are

fixed, collection of the additional data for MSFs requires a reduction in existing sampling programs. This can decrease precision and increase uncertainty in estimates.

The methods used to estimate mortalities of unmarked fish in MSFs depend, in part, on adequate (and unbiased) sampling of all fisheries and escapements, where tagged fish are expected to be present.

MSFs require additional fishery monitoring, and place increased demands on fixed sampling resources.

Electronic tag detection can detect CWTs in both clipped and unclipped fish, reducing the number of heads requiring removal, however all fish must still be individually handled and checked for CWTs. The reduction of fishery exploitation rates under the PST and domestic management measures implemented in order to reduce impacts on natural-origin stocks have substantially reduced the number of CWT fishery recoveries and increased the number of fish returning to hatchery facilities. Because of the increased demand on sampling resources, some facilities have either implemented or are considering sampling hatchery returns for coho salmon at reduced rates (referred often to as "subsampling"). Subsampling is not recommended for Chinook salmon because of the complexity of multiple ages of returns from individual CWT release groups.

The use of DIT requires all unmarked fish to be sampled electronically to recover CWTs from unmarked pairs. This substantially increases the number of fish that samplers have to handle and process.

Electronic tag detection has not been employed coastwide because of challenges related to the cost, accuracy, practical feasibility, and policy concerns of incorporating this technology into sampling programs.

Fishery sampling designs have not always been developed in collaboration with stock assessment and harvest management plans. Mark-selective fisheries have been prosecuted without consideration to limitations of catch sampling programs or the technical feasibility of evaluating impacts. Complex regulations (e.g., mixed-bag retention restrictions or fisheries at fine spatial or temporal scales) are being promulgated without regard to the need for, or capability to collect, the data required for stock and fishery assessments or to evaluate MSFs. Sampling designs must correspond to the same spatial and temporal strata described by the regulations for the fishery to improve the accuracy of expansions for catch and CWT recoveries Agencies proposing MSFs need to coordinate sampling programs with the development of analytical tools to measure the impacts of these fisheries.

Coordination among those who set fishery regulations, design the sampling protocols and design the data warehouses is critical, but in most cases is lacking.

Where recovery of all CWTs from the unmarked component of DIT release groups in a fishery is not possible, as is the case in visual sampling, data gaps can occur for both MSFs and NSFs. Where data gaps are present, a means of indirectly generating recoveries must be devised for analyses. This makes the analyses more time consuming and it decreases confidence in the estimated impacts on unmarked (natural-origin) fish. In some areas, such as Puget Sound,

sampling programs have been enhanced to collect the information necessary to evaluate impacts on released encounters in MSFs, but in other areas, such as the Columbia River, sampling programs are not providing the data necessary to evaluate impacts of MSFs. A deliberate and consistent sampling regime has proven to provide reliable estimates of CWT recoveries.

Mark-selective fisheries require a coordinated and consistent approach to implementation of MM, MSFs, according to a coastwide sampling methodology, which allows accurate assessment and management of impacts to natural-origin fish. Fishery sampling programs have been developed to provide data required to develop reliable estimates of stock-specific mortality of unmarked fish in individual MSFs, however they have not been implemented coastwide.

5.2.1 Electronic Tag Detection (ETD)

With the advent of MM and the loss of an external mark to identify fish containing CWTs, ETD has been developed to detect CWTs in both juvenile and adult fish, and to reduce costs of CWT recovery. Electronic tag detection provides a means to recover CWTs from unclipped tagged fish belonging to DIT groups, as well as from clipped tagged fish in marked releases. The ability to detect CWTs prior to removal of snouts eliminates the collection of snouts from fish that do not contain CWTs, reducing costs of storage, transport and processing for recovery of CWTs.

Both visual sampling and electronic sampling are employed to detect fish that have CWTs. Both methods may use electronic tag detection equipment however the two methods differ in how fish are first separated for CWT sampling. When visual sampling is employed, fish are initially examined for presence or absence of an adipose fin clip, and then only the marked (adipose fin clipped) fish are checked for CWTs (either snouts from all clipped fish are removed or, if ETD is used, only snouts from fish identified as containing a CWT are removed). Therefore, with visual sampling, CWTs will be recovered only from marked fish; no CWTs will be recovered from unmarked DIT fish. With complete electronic sampling both marked and unmarked fish are sampled for presence of a CWT. Visual sampling is still being relied upon in AK, northern BC, BC recreational fisheries, CA, and some fall Chinook fisheries on the Columbia River (see Table 5-1 and Table 5-2).

Previous hatchery investigations of visual sampling found that rates of missed tags sometimes exceeded 10% annually (Cross et al. 1994). Because electronic sampling involves interrogation of all fish and CWT sampling and detection is independent of mark status, the rate of missed tags should be minimal. However, it has been suggested that errors in CWT recovery may be greater than in the past, possibly because of increased sampling demands or unintended bias toward unclipped fish by samplers.

Table 5-1 Current fishery sampling methods for tagged coho salmon

Region	Fishery	Type of Sampling	Comments
Alaska	Commercial Recreational	Visual Visual	
Northern BC	Commercial Recreational	Visual Voluntary (Visual)	Some terminal areas are not sampled. Coho catches on ice boats are only sampled if there are Chinook in catch (most of the time). Anglers are encouraged to turn in heads from marked coho only; therefore, tag recoveries of unmarked coho are not expected (fisheries are non-selective).
West Coast Vancouver Island	Commercial Recreational	Electronic Voluntary (Visual)	Incidental recoveries in fisheries on other species; non-retention of unmarked coho. Anglers are encouraged to turn in heads from marked coho only; therefore, tag recoveries of unmarked coho are not expected (fisheries are mostly mark-selective).
Strait of Georgia	Commercial Recreational	Electronic Voluntary (Visual)	Incidental recoveries in fisheries on other species; non-retention of unmarked coho. Anglers are encouraged to turn in heads from marked coho only; therefore, tag recoveries of unmarked coho are not expected (fisheries are mostly mark-selective).
Puget Sound	Commercial Recreational	Electronic Electronic	
Washington Coast	Commercial Recreational	Electronic Electronic	
Oregon Coast	Commercial Recreational	Electronic Electronic	The only commercial coho fishery on the Oregon coast proposed to occur is North of Cape Falcon and is mark-selective; therefore, recoveries of unmarked coho are not expected. The ocean recreational fishery is mark-selective except for a non-selective season during the first few weeks of September. Tag recoveries from unmarked coho are anticipated in September.
Columbia River	Commercial Recreational	Electronic Electronic	
California	Commercial Recreational	Visual Visual	

Table 5-2 Current fishery sampling methods for tagged Chinook salmon

Region	Fishery	Type of Sampling	Comments
Alaska	Commercial Recreational	Visual Visual	
Northern BC	Commercial Recreational	Electronic Voluntary (Visual)	All Chinook are now electronically sampled and all tags are decoded (this has been the case since 2007). Anglers are encouraged to turn in heads from marked Chinook only; therefore, tag recoveries of unmarked Chinook are not expected.
West Coast Vancouver Island	Commercial Recreational	Electronic Voluntary (Visual)	Anglers are encouraged to turn in heads from marked Chinook only; therefore, tag recoveries of unmarked Chinook are not expected.
Strait of Georgia	Commercial Recreational	Electronic Voluntary (Visual)	Anglers are encouraged to turn in heads from marked Chinook only; therefore, tag recoveries of unmarked Chinook are not expected.
Puget Sound	Commercial Recreational	Electronic Electronic	
Washington Coast	Commercial Recreational	Electronic Electronic	
Oregon Coast	Commercial Recreational	Electronic Electronic	
Columbia River	Commercial Recreational	Electronic/Visual Electronic/Visual	Spring and summer Chinook fisheries are electronically sampled. Fall Chinook are visually sampled. CWTs from unmarked fall Chinook will not be recovered. Spring and summer Chinook fisheries are electronically sampled. Fall Chinook are visually sampled, except for the Buoy 10 fishery which is electronically sampled. CWTs from unmarked fall Chinook will not be recovered, except for the Buoy 10 fishery.
California	Commercial Recreational	Visual Visual	

5.2.2 Electronic Tag Detection (ETD) Equipment

Different types of ETD equipment have been developed for use in CWT sampling in hatchery returns, fisheries and escapements. There are two primary types of ETD equipment, stationary tubes and hand-held wands.

Tube detectors are used in hatcheries and fish processing plants where large numbers of fish must be examined. Tubes detectors automatically separate and count fish with and without CWTs as fish are individually passed through a tube. Fish that signal positive for CWT presence are diverted into a tote for sampling, while those without a CWT go into another tote for processing. Tube detectors have been shown to be highly effective and accurate at detecting CWTs (ASFEC 1997, Olson 2007). Although fish must pass through the tube individually, large batches can be sampled in a relatively short amount of time. CDFO employs tube detectors in all hatcheries releasing MM coho and in most processing plants. Tube detectors are used by ODFW and WDFW at most of their larger hatcheries.

Hand-held CWT detection wands are used by holding the fish in one hand and rubbing the wand on the snout. This is the instrument of choice when sampling small numbers of fish or in field situations such as CWT sampling on spawning grounds. When used properly, the wands have been shown to be highly accurate at detecting tags (ASFEC 1997, Vander Haegen et al. 2001, Olson, 2007).

Electronic tag detection is accurate and reliable when used properly.

Northwest Marine Technology Inc. (NMT) continues to develop and refine ETD equipment. In 2012, NMT developed and began to market a new hand-held detection T-wand that is more ergonomic for samplers and has a significantly higher sensitivity for detecting CWTs. This new wand eliminates the need for wanding inside the mouth of large fish. The original version of the wand required wanding of large fish both on the surface of the snout and inside the mouth to ensure tag detection. Agencies are in the process of replacing older wands with the T-wands.

Samplers must be trained to properly use ETD equipment and to avoid differential tag detection rates on marked and unmarked fish. Although use of ETD equipment is not complicated, agency training and follow up is essential to minimize potential for biases in CWT detection and subsequent recovery and reporting. Parken and Riddell (2007) presented evidence that samplers using a wand when sampling Chinook fisheries may miss tags, as well as recover false positives, where the wand beeped and there was no tag.

5.2.3 Sampling for DITs

ADFG, CDFO, ODFW, and CDFW conduct visual sampling programs which will not recover the unclipped component of DIT programs required to assess impacts of MSFs (Table 5-1 and Table 5-2). Mass marking and MSFs of Chinook salmon have recently been proposed for implementation in CA. If MM and MSFs are undertaken, and tagged fish are released without an adipose fin clip, electronic tag detection will be needed in sampling programs throughout CA.

The following sampling programs do not meet SFEC recommendations, largely due to financial and logistic challenges:

- ADFG does not sample unmarked catch for CWTs, but as of 2015 employs visual sampling in concert with ETD (electronic screening) at four ports in recreational fisheries

and at ten of the eleven ports where commercial catch sampling occurs for Chinook salmon taken in the commercial troll fishery. At all eleven ports samplers are deployed to on-board commercial buying stations or tenders to sample the marked catch of Chinook and coho for CWT. In other ports, ADFG conducts visual sampling of marked catch (typical for coho in fisheries with Chinook non-retention), or electronic screening of marked fish (typical for Chinook troll fisheries). Electronic screening is also employed in the summer gillnet and seine fisheries in SEAK. Freezer troll catch in SEAK is generally delivered head off, but heads of marked Chinook and coho are retained and delivered to an ADFG port sampler. Upon delivery of freezer troll caught heads, normal CWT sampling processes are invoked, including electronic screening.

- CDFO does not sample unmarked catch in recreational fisheries for CWTs. CDFO relies on a voluntary head recovery program to provide CWT samples from recreational fisheries. In this program, anglers are asked to submit heads from marked Chinook and coho to head depots distributed throughout BC. This program does not provide a sample of CWTs from unmarked DIT catch, in non-selective and mark mixed-bag fisheries.
- Sampling for CWTs in Canada's commercial catch is inconsistent with respect to sampling of unmarked catch. Catch sampling in Canada's commercial fisheries with Chinook or coho target or by-catch varies from visual sampling of marked catch (typical for coho in fisheries with Chinook non-retention), to electronic sampling of both marked and unmarked catch (typical for Chinook troll fisheries). Freezer troll catch in Canada's northern troll fishery is sampled for CWTs in unmarked catch. Commercial trollers that freeze their catch typically deliver head off, discarding the heads at sea. In Canada's northern troll fishery, typically 70-80% of the catch is landed frozen-head off. To ensure this sector can be sampled for CWTs, both of marked and unmarked catch, CDFO has modified the conditions of license for a proportion of these license holders requiring all their Chinook and coho heads be retained and delivered to catch sampling technicians. Because storing heads represents a financial cost to fishers if freezer space limits the trip duration, these conditions only apply to a fraction of the fleet sufficient to ensure the sampling target is reached.
- WDFW and the treaty tribes employ ETD at all hatcheries and in all fisheries with some exceptions on the Columbia River. The lower Columbia River fall Chinook, mid-Columbia River summer Chinook fisheries and some tributary fisheries are visually sampled. This is due to cost and workload issues. In the lower Columbia River, ODFW and WDFW share sampling responsibilities, although reporting is handled by ODFW. The SFEC has recommended that sampling of Columbia River fall Chinook fisheries be converted to electronic sampling to recover DIT groups (SFEC 2015).

Some visual sampling programs (e.g., SEAK troll and Columbia River fall Chinook) have begun using wands to screen marked fish for tags, largely as a cost-saving measure to minimize costs for storage, transportation and processing of MM snouts that do not contain CWTs. This screening may reduce potential reluctance of buyers to allow sampling, as intact fish are worth more in the market place. However, this electronic screening of marked fish will not recover the unmarked portion of DITs.

Because visually sampled fisheries requires the removal of all heads from marked fish (including those without CWTs), MM has increased sampling effort and cost.

With visual sampling, data are collected from more individual fish, and more snouts are collected, inventoried, shipped and processed. In the order of five times as many heads as CWTs may be collected. With higher mark rates in some terminal fisheries, this number can be even greater. While dissection labs can process snouts without tags more quickly than snouts with tags, there are still logistical issues with storing and handling the large numbers of snouts that do not contain CWTs. For example, the Canadian dissection lab was unable to dissect all the coho snouts taken in 2012, completing them in the following fiscal year. In 2013, coho snouts from marked fish recovered in voluntary (visually sampled) recovery programs were so numerous they created storage issues at storage depots.

The increased number of heads or snouts from marked fish recovered in visual sampling programs can overwhelm the capacity of dissection labs and delay processing and reporting of results.

Some processors are reluctant to cooperate with sampling programs that require removal of snouts from fish that do not contain CWTs. Salmon processors and fishers understand and accept that snouts from a small portion of fish must be removed for management purposes. Prior to MM of Chinook salmon, only about 5% of harvested Chinook were marked in most ocean fisheries, and approximately 95% of those fish had tags. As MM has expanded, up to 20% of the Chinook salmon catch might be marked in distant ocean fisheries, with higher mark rates closer to terminal locations if MSFs do not remove marked fish from the return. Typically one quarter of the harvest is sampled. Prior to MM, on average, snouts were collected from 1% to 2% of the harvest, and now they are taken from 4% to 10%. Fresh fish markets command a premium price for "head-on" intact fish, both because the fish are more presentable and because the eye is used as an important indicator of freshness. Since processors sell their fish on a per pound basis, increased snout removals combined with a decreased market value for head-off product impacts processor willingness to comply with sampling programs. In addition, handling of all fish with ETD sampling methods may affect fish quality.

The removal of snouts has reduced cooperation of some processors by increasing their costs (paying fishers for heads that are removed) and resulting in loss of market opportunities for head-on whole fish.

Salmon processing plants may balk at the installation of tube detectors or when sampling delays processing. Tube detectors can sample fish at a much higher rate than wands, but tube detectors require a significant amount of dedicated physical space. In almost every processing plant, space is valuable and it can be difficult to set up large equipment. AK has not implemented electronic sampling partly due to these concerns.

Working relationships may be better with some processors, where more sampling may take place (assuming catch is distributed randomly between processors for a given catch gear type and harvest location). In Canadian fisheries, CDFO works with processors to address their concerns about sampling operations, and educates processors that sampling is legally mandated under their federal Fisheries Act. In general, once mandatory sampling requirements and reasons for the information have been explained, processors are cooperative.

Removal of heads from marked fish in First Nation fisheries can interfere with ceremonial and traditional use of heads for food. Use of the entire fish is an important cultural aspect of ceremonial and traditional uses of salmon, particularly for early runs of salmon to freshwater

fishing areas, such as spring Chinook ceremonial fisheries. In Canada, CDFO must respect the rights-based fishery for food, social or ceremonial purposes, so head samples are not mandatory for First Nations fisheries. Sampling for CWTs in these fisheries is generally through a voluntary head submission program. Coded-wire Tag Implementation Program funds were used to improve communication and increase First Nations ownership of head sampling and data collection in the Fraser River and head submissions increased with the funding but have decreased since the end of the program (Chuck Parken, Personal Communication 2015).

Increased occurrence of marked fish in visually sampled fisheries may strain relations with First Nations.

Voluntary head recovery programs for recreational fisheries cannot logistically incorporate ETD (without requesting anglers to submit heads from all catch, clipped and unclipped). Therefore CWTs are not recovered from unclipped DIT release groups. WDFW converted their voluntary recovery program to direct sampling. CDFO maintains their voluntary recovery program due to sampling logistics and costs. ODFW samples recreational fisheries directly.

For recreational fisheries that rely on voluntary head submissions, MM has resulted in a decreased rate of head submissions and a lower awareness factor [4] (Nicholas Komick, Personal Communication 2014). The CDFO Sport Head Recovery Program (SHRP) provides anglers who submit tagged heads with information about the origin of their fish, but participation by anglers in submitting heads declined with the implementation of MM because for fish having no tag a thank-you letter was sent with no origin information. This was reportedly a key motivation for submitting heads. Recently, the thank-you letter has been revised to include origin information for all recoveries in that area.

With CWTs being rare in recreationally harvested MM fish, thank-you letters often didn't report fish origin information, and recreational anglers had less incentive to voluntarily submit heads.

5.3 *Coastwide Coordination of Reporting*

The CWT program has been in place coastwide since the late 1970s for coordination of marking and recoveries in AK, BC, WA, ID, OR and CA. This has required extensive coordination and and voluntary cooperation by all participating agencies to share CWT release and recovery data, along with agreement to collect sampling information needed for expansions of the recovered CWTs. Many improvements have been made in recent years in data integrity validation, data management, and coordination, especially for Chinook as a result of the 2008 PST Chinook Agreement (CWTIT 2015).

Agencies now have comprehensive relational CWT databases with internet-based applications. Through the efforts of the PSC Data Sharing Committee, data fields have been added as the need for more detailed and complete reporting has increased, and data validation processes have become more robust to assure accuracy. Efficiency of data exchange has been improved due to use of the internet and made data quickly accessible to all users once it passes the RMIS data validation standards.

[4] The awareness factor measures the proportion of marked fish that are caught by anglers that are submitted in a voluntary recovery program.

Data management and data sharing has evolved with advances in technology, enabling reporting and sharing of CWT data on a coastwide basis among all of the participating agencies. These data and reports are also available to the public on the PSMFC RMIS website.

Release, sampling and tag recovery reporting must be standardized for CWT analyses. For DIT, reporting agencies must identify and link paired DIT group releases. Recovery data must accurately describe CWT sampling activities, voluntary or mandatory head or snout submission, tag detection method employed (electronic or visual), and type of fishery sampled (mark-selective, non-selective or mixed).

Data standards have been developed by the PSC Data Standards Working Group and the RMIS manages data to these standards.

Improvements in reporting and access to information about MSF regulations and impacts on unmarked fish are needed. A prototype for electronic reporting of MSFs has been jointly developed by WDFW and NWIFC for recreational Chinook marine MSFs in Puget Sound and Washington coastal waters.

5.3.1 Review of MM and MSF Proposals by the SFEC

Proposals for MM and MSFs are due by November 1 of the year before the MM or MSFs being proposed. The SFEC review of MM and MSF proposals received annually is provided to the PSC. Deviations from marking protocols are submitted to the PSMFC Mark Committee for approval.

Agencies are providing completed MM proposals for SFEC review by the November 1 deadline. Mass marking levels have stabilized for Chinook and Coho production in WA and OR.

Annually submitted mark-selective fishery proposals have been indicating continued expansion of both coho and Chinook MSFs. Regulations are becoming increasingly complex in spatial and temporal resolution, and in retention restrictions. The SFEC is concerned that monitoring, sampling, and estimation methods have not been adequate to provide CWT recovery data and the analysis required under PST commitments. Greater coordination is needed to ensure that sampling will be adequate to provide the data needed for evaluation of MSFs and their impacts on the viability of the CWT program.

MSF proposals are of limited value in assessing potential impacts on the viability of the CWT program because domestic fishery planning processes have not been completed, so details regarding the location, magnitude, and regulations are often unavailable for review by the SFEC and the PSC.

5.3.2 Post-Season Reporting of MSFs

The PSC has requested that management agencies conducting MSFs provide two post-season reports (see Appendix B. Mark-selective Fishery Post-season Report Templates), describing MSFs, annually to the PSC.

The first report requested provides information on sampling methods used to recover CWTs in all fisheries and escapement locations, not just in the MSFs. Information on sampling procedures is needed to estimate impacts for the unmarked group encountered in MSFs, which

depends on the method of sampling (electronic or visual) and the CWT processing protocol (e.g., are all tagged fish sampled also processed for CWT extraction in the lab).

The second report provides post-fishery information on MSFs that have occurred, including where and when MSFs occurred, fishery regulations, estimated total mortalities and fishery mark rates, and what sampling occurred. This table provides information on whether MSFs that were proposed actually occurred and how these fisheries were sampled. For Chinook MSFs, reporting of total fish retained and released as legal, sub-legal, marked and unmarked, along with estimates of total release mortalities is required for estimation of impacts to natural-origin fish.

These two tables should be completed for the PSC post-season meeting of the year following the fishery year. For instance, reports on summer fisheries occurring in one year should be available by the January post-season meeting the next year. The post-season annual reports produced by the US and Canadian sections for PSC's post-season review have not included all of this information in recent years.

Although the information may be available in other agency reports, the post-season MSF information needs to be submitted to the PSC using the report templates provided, to enable more efficient dissemination of post-season data to the PSC's CTC and CoTC. Agencies have generally not provided these reports in the format requested by the SFEC, and by the requested deadline (SFEC 2015). Representatives of the SFEC have been stepping up efforts in recent years to coordinate with key staff within the agencies to acquire these post-season reports in a timely fashion.

In 2013 catch year, three post-season reports were received out of sixteen for Coho MSFs implemented coastwide, and four post-season reports out of twenty-six for Chinook MSFs were received. SFEC continues to recommend improving compliance with post-season reporting timelines (SFEC 2015).

In addition, agencies have not provided more detailed post-season reports that contain estimates of stock-age mortalities for unmarked fish in MSFs.

Post-season reporting of fishery regulations, sampling activities and estimated mortality rates has been standardized recently in the post-season reporting template. However, because MSF fishery regulations are being employed at spatial and temporal strata that differ from fishery sampling designs, data on catches and CWT recoveries collected from sampling of MSFs may be unsuitable or insufficient for analysis.

Alignment of sampling with MSF spatial and temporal strata is required for standard reporting and estimation of mortality of marked and unmarked fish.

6 BENEFITS AND COSTS OF MM AND MSFS

The benefits of MM and MSFs are socially and culturally determined; their identification and quantification are not within the scope of the SFECs responsibilities. The costs however, are of concern to the SFEC because of their impact on the viability of the CWT program and the ability to evaluate the effectiveness of PST fishing regimes in meeting management objectives and obligations.

6.1 *Benefits*

The following benefits of MM and MSF have been listed by various sources. The SFEC is unaware of any rigorous efforts to quantify these benefits, however.

- Mass marking provides a means of increasing harvest opportunities within constraints established for the conservation of comingled natural-origin stocks by providing a visual means of selective retention of fish produced for harvest by enhancement facilities. Currently, this benefit is primarily realized in recreational fisheries.
- Because MSFs provide the ability to selectively retain marked hatchery fish while releasing unmarked fish, and most of the released fish are expected to survive, mortalities on comingled natural-origin stocks can be reduced relative to NSFs. Depending on the mark rate of encountered fish, more hatchery fish might be harvested within conservation constraints established to protect natural-origin fish.
- Mass marking provides a means of distinguishing hatchery fish intended for harvest from natural-origin production and fish produced for rebuilding or supplementation of depressed stocks.
- Mass marking provides a means of identifying first generation hatchery fish for management of hatchery brood stock.
- Mass marking provides a means of identifying the composition of hatchery and natural-origin fish on the spawning grounds.
- Mark-selective fisheries provide the ability to selectively remove hatchery fish, potentially alleviating some of the impacts of artificial supplementation on the genetic integrity and diversity of natural-origin stocks.
- Mark-selective fisheries can contribute to economic benefits resulting from harvest of fish produced by enhancement facilities and build public support for continued funding for enhancement and fishery agencies.
- Depending on the relative abundance of marked and unmarked fish encountered in a fishery, MSFs may help sustain economic infrastructure for recreational and commercial fishing sectors.

6.2 *Costs*

The implementation of MM and MSFs increases costs for agencies that release or encounter marked fish. The implementation of MSFs complicates stock assessments and fishery management. Execution of an MSF requires additional resources (labor and operating expenses) to collect the CWT recovery data required to monitor and analyze the fisheries. Added costs of sampling due to MM and the de-sequestering of the adipose fin have not been quantified in this report, however it is accepted by the SFEC that sampling costs are greater than would be without MSFs and MM.

- With MM, the producing jurisdiction bears the costs of MM, but the harvesting jurisdictions bear the burden of increased costs for recovery and reporting of CWTs (e.g., conversion to electronic sampling, collecting, transporting, and processing snouts). Agencies that conduct MM have given little consideration to impacts of MM on sampling

programs conducted by other agencies. For example, the MM of far north migrating Chinook originating from Columbia River hatcheries has substantially increased the cost of collection, shipping, and processing incurred by AK and BC because visual sampling is employed. For example, approximately 70% of the marked Chinook caught in 2014 in the southeast Alaskan (SEAK) troll fishery did not contain a CWT.

- Mass marking requires significant initial capital investment and significant annual labor resources (see Equipment Costs). Capital investment includes the purchase of specialized marking trailers, and modifications at the production facilities in order to accommodate the marking process (see Table 6-1).
- Annual labor costs associated with MM include hiring both temporary crews for marking the fish, as well as the additional agency staff to supervise and maintain automatic marking and tagging trailers, and manage the marking program.
- At some hatcheries, MM has resulted in changes to rearing practices or rearing structures. Fish to be MM must be accessible for marking and then marked fish must be kept separated from the unmarked fish for accounting. At some hatcheries this has required adjustments in ponding schedules, the addition of new rearing containers, or retrofitting large ponds with dividers.
- Double index tagging requires additional funding for the annual purchase and application of CWTs. With DIT, the number of fish tagged and the number of release groups is doubled which also doubles the tagging costs. Table 6-2 lists approximate direct application costs for current MM and DIT numbers regionally.

Double index tagging programs require a major increase in workload and sampling costs. They require the CWT tagging of two groups of fish for each release they represent and require CWT sampling of both marked and unmarked fish wherever recoveries of DIT groups are expected.

- Due to the use of the adipose fin clip as a mark, visual sampling methods to identify fish containing CWT requires that snouts be removed, shipped, and processed from all marked fish in samples of fisheries and escapements, unless ETD is employed. With DIT, the snouts of all unmarked fish in samples of fisheries and escapements also need to be removed, shipped, and processed. To reduce the number of heads collected, shipped, and processed, ETD equipment can be used, but fishery samplers must handle every fish encountered to sample for the presence of a CWT.
- Electronic tag detection equipment is expensive. Agencies have invested a substantial amount in ETD equipment. Those agencies that converted to electronic sampling had substantial initial investments in ETD equipment. Agencies are now upgrading their inventories of wands to the new T-Wand (Table 6-3).
- Agencies have recently added almost 600 new T-wands mostly through CWTIP grants, at a total cost of $1.9 million US.
- Sampling locations with large numbers of fish (i.e. hatcheries and processing plants) often require additional staging space and equipment (e.g., tables and tote hoists) to accommodate ETD.

- Electronic sampling involving large numbers of marked fish is labor intensive and time consuming, increasing agency costs to maintain CWT sampling rates.
- The ability to rely upon DIT to quantify differences in exploitation rates between marked and unmarked fish requires CWT sampling of both marked and unmarked fish in all fisheries and in escapements where DIT groups are expected to be encountered, increasing costs of personnel, processing, transporting, and supplies.
- Excess hatchery returns of coho to the hatchery due to improving marine survival rates and declining exploitation rates, along with the additional sampling effort required by MM and ETD, has resulted in reduced sampling rates for CWTs in some hatcheries.

The increased costs associated with handling and sampling large numbers of marked fish (and unmarked fish where DIT release groups may be encountered) has resulted in sampling at reduced rates at some facilities and reduced sampling at other locations.

- For recreational fisheries, MSFs have imposed additional financial and logistic burdens for voluntary CWT recovery programs due to the large number of MM heads encountered.
- The implementation of MSFs also requires revision of CWT reporting systems and databases, modifying sampling programs and protocols for fisheries and escapements, revising analytical tools, and developing new analytical methods and fishery models.
- Agencies conducting MSFs are responsible for annually reporting information from fish encountered in MSFs. Dedicated staff time is required to provide data essential to evaluate impacts of the MSF on natural-origin stocks within specific timelines.

The substantial increase in the cost of hatchery production and of fishery and escapement sampling has increased parochialism in deciding which programs to support. The focus of the agencies and funders providing the resources for sampling has transitioned from coastwide management or enhancement objectives to funding projects that provide the maximum amount of information to support their individual purposes. For example, as part of its mitigation responsibility, the Bonneville Power Administration (BPA) is willing to pay for the CWTs and the insertion of the CWT for many hatchery programs providing fish for harvest, but is reluctant to share the burden of costs associated with programs that sample adult fish to recover the tags.

6.2.1 Equipment Costs

Prior to MM, southern US agencies relied on mobile tagging trailers to meet the needs of tagging and fin clipping at their hatcheries. The implementation of MM exceeded the capacity of agency trailers and marking crews. This resulted in the development of new trailer designs and new technology that automated both the marking and tagging of large numbers of hatchery-produced Chinook and coho. The challenge of marking millions of fish was compounded by the fact that most stocks have a limited biological window when they can be marked, and the majority of the marking must be accomplished in the spring. The AutoFish System, developed by NMT, uses advanced technology to sort and process juvenile fish without the use of anesthetic or human contact. In general, these automated marking and tagging machines have improved the consistency and quality of marking and tagging compared to traditional manual marking methods. Hand et al. (2010) showed higher clip quality, higher CWT retention, and less

mortality using automated tagging trailers compared to manual trailers with an inexperienced crew. However, Hand et al. (2010) also stated that with an experienced manual marking and tagging crew the difference would not be significant.

The practicality of automatic trailers is viewed differently by the various agencies depending on their hatchery operations. The CDFO has not purchased any of these trailers and would not expect them to be cost effective for their program because of relatively small numbers of tagged and marked fish at each hatchery. The NWIFC, the USFWS, and the ODFW have found them more cost effective than manual trailers, and frequently employ them at hatcheries that have both tagging and marking needs. The NWIFC and the USFWS have found them useful for tagging in locations where finding a crew may be problematic. The WDFW has found them most useful for tagging, and less cost effective for marking large numbers of fish. They hire experienced crews for manual trailers that can perform as well as the automatic trailers, and operate them without the additional cost of a skilled trailer operator. Given the large number of fish to be marked in the short time interval available, and high costs of automated trailers, the WDFW employs manual marking at most sites.

The WDFW, the NWIFC, the USFWS, the IDFG, and the ODFW have purchased both manual and automatic marking trailers to implement MM. Most of the funding came from federal appropriations. Total trailers purchased and approximate costs are listed in Table 6-1.

AutoFish System trailers currently cost approximately $1,345,000 US (Northwest Marine Technology 2015) and can process approximately 60,000 fish per eight hour day. They require a specially trained operator and one or two temporary employees to process fish outside the average size. In contrast, older manual CWT trailers required a trained operator, a crew of ten to twelve, and could process approximately 35,000 fish per day. The new manual fin clipping trailers can hold up to twelve employees, and a full crew can process approximately 75,000 fish per day.

Table 6-1 Summary of coastwide investments (in $US) in MM trailers

Type	# Units	Approximate Cost (at time of purchase)	Total Cost
Manual Clipping	34	$90,000	$ 3,060,000
Automatic	24	$1,000,000	$24,000,000
Total cost for Region			$ 21,060,000

Annual marking costs will depend on the type of trailer used, agency-specific costs, and whether indirect costs are included. The USFWS and the WDFW have estimated that total agency costs are approximately $44 and $48, respectively, per 1,000 fish marked (Mark Kimbel, Personal Communication 2007). The WDFW incurs additional costs for sampling and support of the MM program of $2.25 million US annually.

Agencies that converted to electronic sampling had substantial initial investments in ETD equipment. Agencies are now upgrading their inventories of wands to the new T-Wand.

Table 6-2 2014 estimated direct application costs (in $US) for MM and DIT groups (updated from Olson 2007)

Species	Activity	Fish (millions) (# DIT stocks)	Application Cost/1,000	Total Cost
Coho	MM	34.3	$30	$1,029,000
	DIT	0.927 (15)	$130	$120,510
Chinook	MM	117	$30	$3,510,000
	DIT	3.305 (13)	$130	$429,650
Total cost for Region				$5,063,160

Table 6-3 Agency investment (in $US) in ETD equipment to 2015

Type	# Units	Cost (per unit)	Total Cost
Wands	800 (334 returned)	$5,000	$4,000,000
New T-Wands	589	$3,750 (minus $1k per old wand return)	$1,874,750
Tubes	114	$29,000	$3,385,800
Total Investment			$9,260,550

7 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the CWT program, as it is currently functioning, does not meet criteria 1 ("it must provide the ability to use CWT data for assessment and management of wild stocks of coho and Chinook salmon") or criteria 3 ("it must provide the ability to estimate stock-specific exploitation rates by fishery and age"), for viability as laid out by the ASFEC in 1995. The determination of whether criteria 2 ("it must be maintained such that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk,") is being met depends on policy determination of whether the current level of management risk is acceptable or not.

The SFEC makes the following recommendations (described in more detail in sections below), to the PSC, based on the lessons learned in the past 20 years of implementation of MM and MSFs: maintain the CWT program; ensure CWT groups exist to represent all MM releases; evaluate and improve the DIT program; develop, evaluate and support tools, models and databases for MSFs; maintain and enhance the RMIS; improve compliance with fishery sampling and data reporting requirements; and, adjust the future focus of the SFEC.

7.1 *Maintain the CWT Program*

The importance of maintaining the viability of the coastwide CWT program was recognized in a MOU, between the US and Canada, which accompanied the 1985 PST. In 1991, the chairs of bilateral technical committees of the PSC expressed concerns regarding the ability to maintain a viable CWT program in light of increasing interest in MM of hatchery fish and MSFs. The reports of the CWT Expert Panel (PSC 2005), CWT Workgroup (PSC 2008) and the CWTIT (2015) provide recommendations to maintain and improve the CWT program.

Other marking/tagging methods may provide management and scientific data but are not capable of providing the coastwide data provided by the CWT program (including the comprehensive, standardized data management system and associated agency infrastructure) to support the type and scope of analyses required to evaluate PSC fishing regimes at comparable cost.

There is increasing interest in deploying lower cost marking/tagging methods other than CWT. Some programs are beginning to experiment with and incorporate a form of genetic analysis that uses single nucleotide polymorphism, or SNP, technology to identify individual fish within populations. Others are experimenting with PBT, parentage-based tagging, as a new methodology to monitor and evaluate hatchery stocks. The PBT approach requires annual genotyping of hatchery brood stock in order to genetically tag the progeny. While both methods eliminate the cost associated with physically tagging the offspring, there is an increased cost in the tissue sampling and analysis. In addition, genetic sampling would likely not be cost-effective coastwide and is currently not able to provide the degree of detail necessary to estimate exploitation rates and stock contributions, particularly in large-scale, multi-stock fisheries (Morishima and Alexandersdottir 2013). Other marking/tagging methods could provide management and scientific data but are unlikely to provide the data provided by the CWT program to support the type and scope of analyses fisheries data currently relied upon by the PSC at comparable cost. Lack of adequate funding seems to be the primary reason for agencies reducing participation in CWT tagging, rather than lack of confidence in the CWT program due to MM.

7.2 *Ensure CWT Groups Exist to Represent All MM Releases*

Some MM stocks are released without a representative CWT group. Therefore, these stocks cannot be accounted for in fishery stock composition analyses. The SFEC recommends that all MM releases be represented by a CWT release group to help identify the source of MM fish encountered in fishery sampling efforts.

7.3 *Evaluate and Improve the DIT Program*

There is increasing concern regarding the ability to implement the DIT methodology, as a tool to monitor MSF impacts on unmarked fish. The SFEC recommends that consideration be given to increasing the use of DIT and expanding electronic sampling (SFEC 2015). The ability to implement and maintain DIT programs has been reduced as agencies struggle with budgetary pressures, in the absence of a convincing analysis demonstrating their value. The inability of agencies to fully fund application of CWTs, CWT sampling, and tag recovery, combined with incomplete ETD coverage, reduces the ability to rely upon DIT to provide data that can be used to estimate and evaluate impacts of MSFs independent from model-based methods.

Formal evaluations of DIT programs for both Chinook and coho should be completed and in the interim, agencies could be provided with a list of critical DIT programs for stocks originating within their respective jurisdictions by the SFEC.

7.4 *Develop, Evaluate and Support Tools, Models, and Databases for MSF*

Mass marking and MSFs have become fixtures of the overall enhancement and management effort directed at Pacific salmon. To incorporate changes to fisheries and sampling resulting

from MM and MSFs, a comprehensive and cohesive evaluation of CWT-based models and analytical methods will be needed to ensure the viability of the CWT program and to implement PST fishing regimes. Explicit statements on the data requirements and standards required of the models should be part of these evaluations. CDFO is currently reviewing the results of the southern BC coho MSF (DFO 2015) and will document deficiencies in data, models and assessments, with contributions from the CoTC.

Revised data requirements (for models) and data collection standards would form the basis of a coastwide effort to coordinate the sampling and reporting. Methods for monitoring, data recording, reporting to the database, and analyzing MM and MSF data should be standardized, implemented across agencies, and evaluated, with the goal to minimize costs and address increased uncertainties. This would aid in preserving the viability of the CWT program and the validity of the data used in PSC fishery models.

With the use of MM and MSF expected to expand the future, the SFEC, along with the CTC and CoTC, must continue to develop models, monitoring programs, and analytical methods to improve bilateral capabilities, to generate reliable projections for MSFs in pre-season planning models, and to produce postseason estimates. Existing methods and models need to be evaluated and new ones developed. The CTC is developing a Data Generation Model (DGM), capable of producing simulated datasets of CWT recoveries under a variety of conditions and fisheries, including MSFs. The data produced by the DGM will make it possible to evaluate the performance of alternative algorithms and methods to estimate impacts of MSFs against known true values.

Other assessment tools, including thermal marking and DNA PBT marking, have been implemented by multiple agencies. A review of the current status of the three assessment tools/methods (CWT, DNA and thermal marking), comparing costs, capabilities, benefits and their ability to meet assessment needs for PST would be useful.

7.5 *Maintain and Enhance RMIS*

The RMIS has been in existence for over 40 years and has undergone many improvements and revisions to meet the evolving needs of fisheries managers with increasing complexity of marking and tagging programs and of selective fisheries. The PSC Data Sharing Committee guides the development and maintenance of RMIS. Database changes affect all of the agencies that provide data to RMIS, as well as clients using the data. Changes can be difficult for some agencies to implement, particularly small agencies with limited resources. Changes must be thoroughly reviewed by all agencies before implementation, to improve fisheries assessment and management. The integrity of the RMIS database is vital to management of PSC fisheries. Development and implementation of standards for coastwide fishery regulation data management and for estimation of mortalities of unmarked DIT groups is currently needed.

7.6 *Improve Compliance with SFEC-identified Fishery Sampling and MSF Data Reporting Requirements*

As MSFs expand and continue to be prosecuted there will be a continued need for the SFEC to review and document impacts of MM and MSFs on the viability of the CWT program. Post-season reporting of where and when MSFs occurred, fishery regulations, estimated total mortalities and fishery mark rates, and sampling methods implemented for all fisheries and

escapement, is currently lacking and is critical to evaluating the success of MSFs. Agencies conducting MSFs have not been providing these reports (SFEC 2015). Tables required for MSF post-season reporting to PSC are in Appendix B. The SFEC should evaluate whether the pilot database and reporting system developed by WDFW and NWIFC for Washington marine Chinook MSFs could be extended to coho salmon and other agencies. One report in the system is already compatible with the existing post-season reporting template and could be enhanced so all agencies could use it for MSF postseason reporting.

7.7 *Focus the SFEC in the Future*

The SFEC is responsible for evaluating impacts of MM and MSFs on the viability of the CWT program and recommending measures to address the identified concerns (Appendix A). The SFEC was directed to help inform agencies of impacts of proposed MM and MSFs on their CWT tagging, sampling, and reporting systems, including their ability to provide the data necessary to support the work of PSC Technical Committees for Chinook and coho.

An overview of legislative directions and emerging policies for each agency could provide insight into future agency directions and priorities and provide some awareness where they may not be congruent with or provide constraints to PST objectives. For example, southern BC Chinook are being assessed by the Canadian Committee on Status of Endangered Wildlife in Canada (COSEWIC).

Agency budgetary concerns and burgeoning MSFs have affected the ability of the SFEC to fulfill its functions. For example, budgetary concerns have resulted in the discontinuation of some DIT programs, increased uncertainty in the quality of data available for stock and fishery assessments, and hampered the ability of agencies to produce post-season reports, which provide estimates of stock-age mortalities of unmarked fish in MSFs.

Domestic fishery planning processes are not completed by the time when MSF proposals are to be submitted to SFEC for review. The SFEC has not been able to provide proactive advice on methods to estimate mortalities of unmarked fish in MSFs due to the timing of domestic fishery planning processes and the creativity and burgeoning complexity of regulations promulgated by agencies.

Because of these challenges the SFEC recommends that, the future focus of the committee include the following responsibilities:

1. Continue support for technical and policy processes to develop agreements and to clarify responsibilities for maintaining a functional CWT program. These processes must build upon recommendations presented by the CWT Workgroup in 2008 (PSC 2008).
2. Work more closely with the Chinook and coho technical committees to provide support in the analysis of MSFs for incorporation into stock and fishery assessment methods and management models.
3. Limit review and evaluation of MSF proposals to new or substantially altered MSFs and shift its focus from prior assessment of MSF proposals to post-facto evaluation.

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9 APPENDICES

Appendix A. Understanding of the Pacific Salmon Commission Concerning Mass Marking and Selective Fisheries (Revised February 2004)

Understanding of the
Pacific Salmon Commission
Concerning
Mass Marking and Mark Selective Fisheries

February 2004 Policy Statement

The Pacific Salmon Treaty's Memorandum of Understanding (MOU) obliges the Parties to, among other things, "maintain a coded-wire-tag and recapture program designed to provide statistically reliable data for stock assessment and fishery evaluation." The Pacific Salmon Commission (PSC) recognizes that the selective fisheries for marked hatchery coho and Chinook salmon can impact the coastwide coded-wire-tag (CWT) program. For the sole purpose of fulfilling this MOU obligation, the PSC has established the following policies and procedures. This policy does not preclude the PSC from evaluating the impacts of, and making recommendations concerning, mass marking or selective fishery plans as they affect the negotiation and establishment of Treaty annex provisions**.**

It shall be the policy of the PSC to review proposals for mass marking and selective fisheries to determine consistency with the Parties' commitment to the MOU provisions regarding the reliability of data needed for management of salmon fisheries within the jurisdiction and management area of the Treaty, including whether they impose substantial cost increases for agencies to conduct required data collecting programs.

The PSC shall establish a Selective Fishery Evaluation Committee (SFEC) to perform the activities set forth in the attached Terms of Reference.

To facilitate the SFEC review, the Parties shall do their utmost to ensure that their domestic managers submit all proposals for mass marking (MM) and mark-selective fisheries (MSF) which could potentially affect stocks or fisheries of concern to the PSC in accordance with the following schedule:

1. Not later than June 1 of each year. Provide early notice containing the agency's plans to consider conducting MSFs over the next 3-5 years.
2. Not later than June 1 of the year prior to implementation. Provide new or substantially changed MM or MSF project proposals.
3. Not later than November 1 of the year prior to implementation. Provide proposals for MM or MSF programs that are anticipated to continue annually without substantive change.
4. Upon completion of domestic fishery planning processes, agencies conducting MSFs are to provide final selective fishery plans.

5. Upon completion of MM programs, agencies are to report the number of fish that were actually mass marked and the extent to which releases are (single and double index) tagged for assessment.
6. Agencies shall report results of MSFs conducted during a season in the annual post-season report provided, using a format specified by the SFEC.
7. Not later than November 30 of the year following conduct of MSFs. Agencies are to report fishery and stock-age-specific estimates of mortalities for unmarked fish impacted by MSFs to the PSC technical committees

- The PSC shall consider, by the annual February PSC meeting, the SFEC reviews of proposals for MM and MSFs and discuss potential actions to address concerns related to any MM or MSF proposals that the SFEC determines will significantly and adversely affect the CWT program.
- The Parties will do their utmost to ensure that MM and MSF proposals are developed in consultation with domestic co-management agencies or processes, and that proposing agencies or entities provide information required by the SFEC and adhere to reporting requirements to enable the PSC technical committees to complete their assignments in a timely manner.
- After the occurrence of a selective fishery and when the data are available, the PSC shall review the management agency report on the actual conduct of the fishery with respect to its impact on the CWT program, and recommend changes and improvements.

Terms of Reference for the Selective Fishery Evaluation Committee

I. Reporting and Committee Structure: The Selective Fishery Evaluation Committee (SFEC) will report to the PSC and will be comprised of a Steering Committee and two working groups: the Regional Coordination Working Group (RCWG) and the Analytical Working Group (SFAWG). All official members of the Steering Committee and working groups will be considered members of the SFEC.

A. Steering Committee: The Steering Committee will be comprised of:
   1. the co-chairs of the PSC Coho Technical Committee, Chinook Technical Committee, and Data Sharing Technical Committee;
   2. the co-chairs of the two working groups;
   3. agency mass-marking/selective-fishery coordinators; and
   4. additional agency representatives approved by the responsible Party.

B. Regional Coordination Working Group (RCWG): The RCWG may be comprised of members of the Steering Committee and other PSC technical committees and of the agency representatives approved by the responsible Party. All RCWG members should contribute actively to the work of this group.

C. Selective Fishery Analysis Working Group (SFAWG): The SFAWG may be comprised of members of the Steering Committee and other PSC technical committees and of the agency representatives approved by the responsible Party. All SFAWG members should contribute actively to the work of this group.

II. Duties of the SFEC

A. Serve as a coastwide clearinghouse to facilitate the appropriate level of coordination and reporting on MM and MSF programs among the Parties, affected agencies, and existing coastwide and regional committees established to monitor activities related to the coastwide CWT program;
B. Provide advice to the PSC regarding potential adverse impacts of MM and MSFs on the CWT program;
C. Assess and monitor the cumulative impacts of MSFs on stocks of concern to the PSC;
D. Provide MM or MSF project proponents with information regarding concerns for potential impacts of their projects on the CWT program.
E. Receive and review MM and MSF proposals from the proponent(s) as early in the planning process as possible to identify potential issues and concerns regarding impacts on the CWT program.
F. Establish a technical evaluation process that will:
    1. Review proposed mass-marking/selective-fisheries initiatives developed by the proponent(s) and identify potential impacts on other jurisdictions and the CWT program;
    2. Review, in consultation with relevant PSC technical committees, procedures and protocols for marking, sampling, and evaluation developed by the proponent(s) and, if appropriate, develop and recommend alternative procedures to address potential concerns or measures that could be taken to mitigate for adverse impacts on the CWT program;
    3. Establish standard formats and reporting requirements for agencies conducting MSFs to use when providing post-season information. Review post-season agency evaluations of the performance of MSFs and their estimates of mortalities on stocks of concern to the PSC;
    4. Identify information needs or request modifications of proposals to meet concerns regarding impacts on the CWT program; and
    5. Conduct, at agreed intervals, technical evaluations of mass marking and selective fishery programs in order to assist the Parties to maintain the integrity of the CWT program.
G. Work with PSC Technical Committees to establish formal standards and objectives for a viable CWT program to enable more precise evaluation of potential impacts of MM and MSFs on the viability of the coastwide CWT program and to guide the development of mitigation measures.
H. Specific duties of the Steering Committee include being responsible for overall coordination and prioritization of the activities for the working groups and being the focal point for reporting to the PSC. The agency mass-marking/selective-fishery coordinators should ensure that mass marking and selective fishery proposals are provided to the SFEC in a timely manner.

III. Specific duties of the RCWG, among other related activities, include:

A. Coordinate and report on continuing research on electronic detection and mass marking technologies;
B. Collate and share information on CWT sampling procedures and programs; suggest modifications to sampling and monitoring programs to proponents;
C. Review MM proposals to determine potential impacts on sampling and tagging programs;
D. Provide agencies with a list of MM and MSF proposals received by the SFEC;
E. Provide the necessary liaison with the Data Standards Working Group of the Data Sharing Technical Committee to ensure that necessary modifications are made to PSC data exchange formats to maintain the integrity of the CWT program; and
F. Prepare an annual report summarizing mass marking statistics, index tag groups, and sampling programs for marks and CWTs.

IV. Specific duties of the SFAWG, among other related activities, include:

A. Design marking and sampling strategies that will achieve desired precision for CWT-based estimates;
B. Develop analytical tools for the evaluation, by the SFEC and MSF proponents, of MM programs and MSFs and their potential impacts on the coastwide CWT program;
C. Provide the necessary technical liaison with agencies and other coastwide committees working on selective fishery evaluation models;
D. Review and recommend parameter values for assessing impacts of MSFs;
E. Develop analytical tools for estimating the impacts of MSFs on escapements and exploitation rates for naturally spawning Coho and Chinook stocks based on post-season information;
F. Review MSF proposals and provide advice to the proponents regarding the design of MSFs and the conduct of sampling and monitoring programs; and
G. Recommend guidelines, procedures, and/or time frames necessary to evaluate the success of MSFs in conserving naturally spawning stocks.

L. Cassidy and J. Davis
Chairs

Appendix B. Mark-selective Fishery Post-season Report Templates

Templates are provided below in Appendix Tables B.1 and B.2.

Appendix Table B.1. Coded-wire tag sampling methods and processing of tags in all fisheries and escapement locations. This information is required for estimation of impacts on unmarked fish.

Agency		***WDFW***		**Year** ***2011***			
		Chinook Salmon			**Coho Salmon**		
Region	**Sector**	**CWT Sampling Method**	**Tag Detection Method**	**Tags Processed**	**CWT Sampling Method**	**Tag Detection Method**	**Tags Processed**
Ocean	Troll	Direct	Electronic	All	Direct	Electronic	All
Strait of Juan De Fuca	Troll	Direct	Electronic	All	Direct	Electronic	All
Strait of Juan De Fuca	Recreational	Direct	Electronic	All	Direct	Electronic	All
Puget Sound	Net	Direct	Electronic	All	Direct	Electronic	All
Area 8/8A	Recreational	Direct	Electronic	All	Direct	Electronic	All
Freshwater	Recreational	None	None	NA	None	None	NA
Freshwater	Net	Direct	Electronic	All	Direct	Electronic	All

Appendix Table B.2. Information on MSFs that have occurred, locations, periods and locations and what sampling and monitoring was conducted to recover CWTs and estimate total encounters and unmarked mortality and compliance in these MSFs. Compliance includes estimation of mark recognition error (marked fish released) and unmarked retention error (unmarked fish retained and landed). This table provides information on actual implementation of MSFs proposed for season.

Agency						Year					Estimate Type															
Fishery Information						MSF Regulations					Sampling program						Estimated Catches and Releases								Release Mortality Rates	
																	Marked Fish				Unmarked Fish					
Contact Information	Fishery Area	Fishery type	Start Date (MM/DD/YY)	End Date (MM/DD/YY)	Target Species for Fishery	MSF Species	Bag limits adult and juvenile by mark status	Lower Size Limit	Upper Size Limit	Other	CWT sampling method	CWT Detection method	Heads Processed	Mark Rate	Method for Catch Estimation	Method for Release Estimation	Retained	Legal Sized Fish Released	Sub-Legal Sized Fish Released	Extra-Legal Sized Fish Released	Retained	Legal Sized Fish Released	Sub-Legal Sized Fish Released	Extra-Legal Sized Fish Released	Legal and Extra-Legal Sized Fish	Sub-Legal Sized Fish