

**Methods Report:
Monitoring Mark-Selective Recreational Chinook Fisheries
In the Marine Catch Areas of Puget Sound (Areas 5 through 13)**

REVISED DRAFT

January 30, 2012

Prepared by:

Laurie Peterson and Mark Baltzell

**Washington Department of Fish and Wildlife
Fish Program
600 Capitol Way North
Olympia, Washington 98501**

TABLE OF CONTENTS

TABLE OF CONTENTS	i
TABLE OF TABLES	iii
TABLE OF FIGURES	iii
INTRODUCTION	1
Comprehensive Sampling and Monitoring Program.....	2
History of By-Area Monitoring Plans.....	2
Methods Development to Estimate Total Chinook Encounters	3
Selective Fishery Reporting--Need for Centralized Methods Report	4
Methods Report Objectives.....	5
MARINE CATCH AREAS OF PUGET SOUND: Overview of Mark-Selective Chinook Fishery Seasons and Sampling Plans by Area	7
Areas 5 and 6	9
Summer Areas 5 and 6 MSF Overview	9
Summer Areas 5 and 6 Sampling Design History	10
Area 7.....	11
Winter Area 7 MSF Overview	11
Winter Area 7 Sampling Design History	12
Areas 8-1 and 8-2.....	13
Winter Areas 8-1 and 8-2 MSF Overview	13
Winter Areas 8-1 and 8-2 Sampling Design History	14
Areas 9 and 10.....	15
Summer Areas 9 and 10 MSFs Overview.....	17
Summer Areas 9 and 10 Sampling Design History	18
Winter Areas 9 and 10 MSFs Overview	18
Winter Areas 9 and 10 Sampling Design History	19
Area 11.....	20
Summer Area 11 MSF Overview.....	21
Summer Area 11 Sampling Design History.....	22
Winter Area 11 MSF Overview	22
Winter Area 11 Sampling Design History	23
Area 12.....	23
Winter Area 12 MSF Overview	23
Winter Area 12 Sampling Design History	23
Area 13.....	25
Summer Area 13 MSF Overview.....	25

Summer Area 13 Sampling Design History	25
METHODS	27
1. Full Murthy Estimate Design	27
Dockside Sampling	28
Sampling Strata and Site Selection	28
Dockside Interview Procedures	28
Boat Surveys	29
Special stratification considerations: Area 10 Winter Tengu Derby.....	30
Test Fishing.....	30
Voluntary Trip Reports	31
Estimating Catch and Effort.....	32
Estimating Chinook Encounters.....	33
Estimating Fishery Impacts.....	38
Total Encounters and Mortalities	38
CWT Impacts	38
2. Reduced Murthy Estimate Design	40
Overview	40
Dockside Sampling: Strata and Shifts.....	41
Catch and Effort Estimation.....	41
Estimating Chinook Encounters and Impacts	42
3. Aerial-Access Design	43
Overview	43
Catch and Effort: Sampling and Estimation.....	44
Dockside Sampling	45
Aerial Surveys.....	46
Sample Fraction and Fishery-Total Estimates	46
Estimating Chinook Encounters.....	46
Assumptions.....	46
Derby Sampling	47
Area 7.....	47
Charter Boats	47
4. Baseline Sampling Design	48
Overview	48
Dockside Sampling	48
Baseline Survey: Sampling Sites and Shifts	49
Voluntary Trip Reports	49
Estimating Chinook Encounters and Impacts	50

Total-fishery CWT Impacts	50
ACKNOWLEDGEMENTS	52
REFERENCES	53
APPENDICES	56
Appendix A. History of <i>Intensive</i> (i.e., creel estimates for special studies) versus <i>Baseline</i> Sampling in Puget Sound/Strait of Juan de Fuca Marine Catch Areas, showing mark-selective fishery seasons and sampling designs by calendar year, 2003-2010.	57
Appendix B. Mark-selective fishery impact estimation details.	61
Appendix C. Total estimators for the aerial–access sample design.....	67
Appendix D. WDFW statistical weeks (Monday through Sunday) by calendar year, 2003-2011.	71
Appendix E. List of sampled sites included in the Puget Sound Sampling Unit’s sample frame to monitor mark-selective Chinook fisheries, by area and season (winter or summer), with a list of the most current (as of 2010 season) sampling designs used. Refer to Methods Sections 1-4 for sampling design descriptions.	80

TABLE OF TABLES

Table 1. Sampling/estimation details on target parameters associated with monitoring mark-selective Chinook fisheries in the Marine Catch Areas of Puget Sound.....	34
Table 2. Summary of results from a hypothetical bias evaluation (conducted by Pete McHugh of WDFW) to identify the mark-selective Chinook fishery areas and seasons (winter or summer) where we should continue implementing the special treatment of charter boat catches (i.e., separate census approach vs. the private-boat fleet), versus those areas/seasons where pooling charters into the Murthy estimate of total catch for the fleet would cause negligible (<3%) bias.	37

TABLE OF FIGURES

Figure 1. Map of Western Washington, showing the Marine Catch Areas of Puget Sound (Areas 5 through 13) and the Washington coast (Areas 1 through 4).	8
Figure 2. Map of Marine Catch Areas 5 and 6 in the Strait of Juan de Fuca, where a pilot mark-selective Chinook fishery has occurred each summer since 2003. The Areas or sub-Areas (i.e., west of Ediz Hook in Area 6) open under mark-selective Chinook harvest regulations each summer since 2003 are shaded in dark gray (see WDFW Sport Fishing Rules for additional details). <i>Map courtesy of David Bramwell, WDFW.</i>	9
Figure 3. Map of Marine Catch Area 7 in Puget Sound, where a pilot winter mark-selective Chinook fishery has occurred each year since 2008. Open white circles correspond to the approximate location of the four public ramps or marinas where angler interviews and catch sampling occurred (1 = Friday Harbor Marina, 2 = Cornet Bay State Park Ramp, 3 = Washington Park Ramp, 4 = Bellingham Ramp).....	12
Figure 4. Map of Marine Catch Areas 8-1 (left panel) and 8-2 (right panel) in Puget Sound, where pilot mark-selective Chinook fisheries have occurred each winter since the 2005-06 winter season. Circled numbers correspond to access sites sampled during dockside sampling activities (<i>Area 8-1</i> : 1 = Camano Island State Park, 2 = Coupeville Ramp, 3 =Maple Grove Ramp, 4 = Oak Harbor Ramp, and 5= Norton Street [Everett] Ramp [refer to site number 1 in the Area 8-2 map]. <i>Area 8-2</i> : 1 = Norton Street [Everett]	

Ramp, 2 = Camano Island State Park, 3 = Dagmar’s Landing, 4 = Mukilteo State Park, and 5 = Tulalip Marina)..... 14

Figure 5. Map of Marine Catch Area 9 in Puget Sound. Circle symbols correspond to the approximate location of the four public ramps or marinas where angler interviews and catch sampling occurred during the Area 9 winter mark-selective Chinook fishery (starting winter 2008-09). Triangles correspond to locations sampled during the Area 9 summer selective Chinook fishery (starting summer 2007). Numbers inside the symbols correspond to the following ramp names: 1) = Fort Casey [Keystone], 2) = Everett (Norton/10th Street), 3) = Mukilteo State Park, 4) = Edmonds Marina Dry Storage, 5) = Kingston, and 6) = Port Townsend Boat Haven ramps. 16

Figure 6. Map of Marine Catch Area 10 in Puget Sound. Circle symbols correspond to the approximate location of the public ramps or marinas where angler interviews and catch sampling occurred during the Area 10 winter mark-selective Chinook fishery (starting winter 2007-08). Triangles correspond to locations sampled during the Area 10 summer selective Chinook fishery (starting summer 2007). Numbers inside the symbols correspond to the following ramp names: 1) = Kingston, 2) = Edmonds Marina Dry Storage, 3) = Shilshole, 4) = Armeni, 5) = Manchester, and 6) = Brownsville ramps..... 17

Figure 7. Map of Marine Catch Area 11 in Puget Sound, where a pilot mark-selective Chinook fishery has occurred each summer since 2007, from June 1-September 30, and each winter since 2010 (February 1-April 30). Note that the circled numbers in this figure correspond to special-area regulations for Area 11 fishing seasons (see *WDFW Sport Fishing Rules Pamphlet* for details)..... 21

Figure 8. Map of Marine Catch Area 12 in Puget Sound, where the first pilot mark-selective Chinook fishery was implemented during the winter season from February 1 through April 30, 2010. 24

Figure 9. Map of Marine Catch Area 13 in Puget Sound, where a pilot mark-selective Chinook fishery has occurred each summer since 2007, from May 1-September 30. Note that the circled numbers in this figure correspond to special-area regulations for Area 13 fishing seasons (see *WDFW Sport Fishing Rules Pamphlet* for details)..... 26

Figure 10. Conceptual diagram of the monitoring plan implemented during pilot mark-selective Chinook fisheries in Puget Sound Marine Catch Areas requiring the *Full Murthy Estimate Design* (also, see Appendix A). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon. 27

Figure 11. Conceptual diagram of the monitoring plan implemented during pilot mark-selective Chinook fisheries in Puget Sound Marine Catch Areas in which we applied the *Reduced Murthy Estimate Design* (see table, Appendix A). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon. The grey-filled, dashed circle around the *Test Fishing* component indicates that the test fishing activity may or may not be included in the *Reduced Murthy Estimate* monitoring plan, depending on the particular area and season being sampled (see Appendix A)..... 42

Figure 12. Conceptual diagram of the monitoring plan implemented in the Areas 7 and 9 winter mark-selective Chinook fisheries, starting in winter 2008 (Appendix A). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon. 44

Figure 13. Conceptual diagram of the monitoring plan for *Baseline Sampling* of mark-selective Chinook fisheries (also, see Appendix A). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon. 51

INTRODUCTION

In recent years, abundant runs of hatchery Chinook salmon (*Oncorhynchus tshawytscha*) have been mixed with depressed runs of wild Chinook salmon in the marine environments of the Puget Sound and Strait of Juan de Fuca. Providing recreational anglers with opportunities to harvest abundant hatchery stocks while simultaneously protecting weaker, wild stocks, such as Endangered Species Act (ESA)-listed Puget Sound Chinook salmon, has proven to be a significant conservation and management challenge. The combination of large-scale hatchery marking (i.e., adipose fin clipping) programs and mark-selective harvest regulations makes it possible for anglers to pursue and harvest hatchery Chinook salmon while minimally impacting wild salmon populations. In such “mark-selective fisheries” (MSFs), anglers are generally allowed to retain adipose-fin clipped (“marked”) hatchery fish and are required to release unharmed any unclipped (“unmarked,” predominantly wild) salmon encountered.

The Washington Department of Fish and Wildlife (WDFW) implemented the first recreational pilot mark-selective Chinook fishery in the marine waters of Washington State within Areas 5 and 6 (Strait of Juan de Fuca) during summer 2003, based on agreements between the State of Washington and Northwest Treaty Tribes during the annual North of Falcon salmon season-setting process (WDFW 2008a). The pilot fishery purpose, as stated in state-tribal agreement documents (e.g., Northwest Treaty Tribes and the Washington Department of Fish and Wildlife, 2007), is defined as follows:

“The purpose of the ‘pilot’ fishery is to collect information necessary to enable evaluation and planning of potential future mark-selective fisheries. The ‘pilot’ fishery provides a basis for determining if the data needed to estimate critical parameters can be collected and if the sample sizes needed to produce these estimates with agreed levels of precision can be realistically obtained.”

Over the past eight years (since 2003), in addition to the mark-selective Chinook fishery in Areas 5 and 6, WDFW has implemented additional pilot-level mark-selective Chinook salmon fisheries in several Puget Sound Marine Catch Areas (Areas 5 through 13) during both the summer and winter seasons (**Appendix A; Figure 1**). The first wintertime Chinook MSF was established on a pilot basis in Areas 8-1 and 8-2, from October 2005 through April 2006, and has continued each winter season ever since (with varying fishery season length; see **Appendix A**). Additionally, beginning in 2007, summer selective Chinook fisheries were established in Areas 9, 10, 11, and 13 and winter selective Chinook fisheries in Areas 7, 9 and 10. Also, as a result of the 2009 North of Falcon process, Chinook MSFs were established for the first time in Areas 11 and 12 during the winter season (February through April) of both 2010 and 2011. Thus, as of the close of summer 2010 fishing season, pilot *summer* selective Chinook seasons have occurred in Areas 5 and 6 for eight years (2003-2010; Thiesfeld and Hagen-Breaux 2005a, Thiesfeld and Hagen-Breaux 2005b, WDFW 2008a, WDFW 2009a, WDFW 2010g, and WDFW 2011) and in Areas 9, 10, 11, and 13 for four years (2007-2010; WDFW 2007a and 2007b, WDFW 2009b and 2009c, WDFW 2010e and 2010f, and WDFW 2011). Pilot *winter* selective Chinook fisheries have occurred in Areas 8-1 and 8-2 for five complete seasons (2005-06, 2006-07, 2007-08, 2009, and 2009-10; WDFW 2008b, WDFW 2009d, WDFW 2010b), Areas 9 and 10 for three winter seasons (2008, 2008-09, and 2009-10; WDFW 2010c, WDFW 2010d), Area 7 for three winter seasons (2008, 2009, and 2009-10; WDFW 2009e, WDFW 2010a), and in Areas 11 and 12 for one winter season from February 1 through April 30, 2010. Consistent with the 2004 Puget

Sound Chinook Harvest Management Plan (Puget Sound Indian Tribes and WDFW 2004), a key goal of implementing each of these mark-selective Chinook fisheries has been to provide meaningful opportunity to the recreational angling public while minimally impacting ESA-listed Puget Sound Chinook salmon.

The State of Washington and Northwest Treaty Tribes have planned the pilot mark-selective Chinook fisheries in Puget Sound based on assumptions about the performance of each fishery and how the fishery was predicted to affect wild (unmarked) and hatchery (marked) Chinook salmon. For example, the total number of marked and unmarked Chinook salmon encountered in these fisheries was estimated during the pre-season planning process using the Chinook Fishery Regulation Assessment Model (FRAM) and assumptions about fish abundance and angler effort levels. The sampling and monitoring programs in place for the pilot selective fisheries have provided a means of verifying these pre-season assumptions. More fundamentally, results of the sampling programs have been used to determine if the data needed to provide usable estimates of critical parameters can be collected, and if the sample sizes needed to produce these estimates with agreed levels of precision can be realistically obtained (WDFW 2008a and 2008b).

Comprehensive Sampling and Monitoring Program

Given the pilot nature of the mark-selective Chinook fisheries in Puget Sound, WDFW's Puget Sound Sampling Unit (PSSU) has been tasked with implementing a comprehensive sampling and monitoring program to collect the data needed to evaluate each pilot mark-selective Chinook fishery and its impact on unmarked salmon. As per state-tribal agreement (e.g., WDFW and NWIFC 2009), we have developed area-specific sampling plans consisting of several comprehensive and complementary sampling components, including dockside creel sampling, test fishing, on-water or aerial effort surveys, and angler-completed voluntary trip reports (VTRs). We have tailored area-specific sampling plans so that we could reliably estimate the following critical parameters needed for evaluating mark-selective fisheries: *i*) the mark rate of the targeted Chinook population, *ii*) the total number of Chinook salmon harvested (by size [legal or sublegal] and mark-status [marked or unmarked] group), *iii*) the total number of Chinook salmon released (by size and mark-status group), *iv*) the coded-wire tag- (CWT) and/or DNA-based stock composition of marked and unmarked Chinook mortalities¹, and *v*) the total mortality of marked and unmarked double index tag (DIT) CWT stocks. In addition, we have acquired and analyzed relevant data characterizing other aspects of the pilot fisheries, including descriptors of fishing effort, fishing success (catch [landed Chinook] per unit effort), the length and age composition of encountered Chinook, and the overall intensity of our sampling efforts.

History of By-Area Monitoring Plans

Area-specific sampling and monitoring plans for mark-selective Chinook fisheries in Puget Sound have evolved over the past eight years, ever since the first mark-selective Chinook fishery was established in Areas 5 and 6 in 2003, in response to state-tribal negotiations at the annual North of Falcon and Pacific Fishery Management Council (PFMC) salmon season-setting processes. Factors such as the need for timely in-season creel estimates of salmon encounters (i.e., retained *and* released salmon) to assess pilot Chinook MSFs in-season, costs of shore-based and on-water monitoring, feasibility of on-water sampling of Chinook encounters by size/mark

¹ Though the necessary tissue samples have been collected, DNA-based estimates of stock composition are presently unavailable for Puget Sound/Strait of Juan de Fuca mark-selective fisheries. In the present report, methods for producing CWT-based (unexpanded) estimates of the stock composition of marked Chinook harvest are provided.

status, bias and precision considerations for dockside and on-water based estimates, expansion of the WDFW voluntary trip report (VTR) program in recent years, and other factors specific to each area have been influential in affecting the development and evolution of annual selective fishery monitoring plans. In addition, reaching state-tribal agreement on area-specific monitoring plans has hinged on whether or not certain sampling components are included or not in each area's sampling design, and at what defined intensity level of sampling --e.g., components such as dockside creel sampling, test fishing, on-water effort surveys or aerial surveys, test fishing, and/or angler-completed voluntary trip reports. In the next section of this report (*Marine Catch Areas of Puget Sound*), we describe the evolution of our agreed-to sampling and monitoring plans for each Puget Sound Marine Catch Area (Areas 5-13) in which mark-selective Chinook fisheries have been implemented and evaluated.

Methods Development to Estimate Total Chinook Encounters

In addition to developing and implementing comprehensive monitoring designs, a key facet of WDFW's selective fishery evaluation program over the years has included working with our tribal counterparts to develop and refine methods for estimating Chinook encounters and associated mortalities in mark-selective Chinook fisheries. To analyze and report on selective Chinook fishery data from the 2003 through 2007 seasons, we applied two methods to estimate total Chinook encounters in marine recreational mark-selective fisheries in Puget Sound. Consequently, within our annual post-season selective fishery reports for the 2003-2007 seasons, we presented two different Chinook encounters estimates, resulting from the two separate methods, and compared them. As Conrad and McHugh (2008) discuss in their thorough evaluation of the two methods, both the Method 1 (M1) and Method 2 (M2) approaches were designed to estimate the same quantity (total Chinook encounters), yet they often yielded differing results, which made it difficult to interpret post-season estimates of fishery impacts. The two approaches are best described (from Conrad and McHugh's [2008] publication) as follows:

- Method 1 (M1) – M1 estimates of total Chinook encounters are derived from the combination of dockside observations of landed catch and angler interview responses about salmon releases; thus, as Conrad and McHugh point out, the accuracy of Method 1 estimates depends heavily on the ability of anglers to correctly recall and report the number of Chinook they actually encountered and released. M1 relies on creel survey data to estimate the total number of Chinook harvested and the total number of Chinook released and then apportions the total encounters (estimated number harvested plus estimated number released) to four size/mark status categories (legal-size and marked [LM], legal-size and unmarked [LU], sublegal-size and marked [SM], and sublegal-size and unmarked [SU]) using test fishery or angler-completed voluntary trip report (VTR) data.
- Method 2 (M2) – M2 estimates of Chinook encounters are obtained using the creel survey estimates of the total number of legal-size, marked Chinook harvested in combination with the test fishery or VTR data to estimate both the total number of Chinook encounters and to apportion the encounters to four size/mark status categories (LM, LU, SM, SU). As Conrad and McHugh (2008) discuss, the M2 estimator was derived assuming that anglers retain all LM Chinook encountered; therefore, its accuracy depends on the extent to which angler behavior deviates from this idealized case.

To identify a single, reliable estimate of total Chinook encounters in mark-selective Chinook fisheries, Conrad and McHugh (2008) quantitatively evaluated sources of bias in the M1 and M2

approaches and considered possibilities for correcting the bias within each method. For Method 1, they reviewed evidence that suggested a combination of digit bias² and prestige bias³ contributed to M1 over-estimating the true number of Chinook encounters, especially when encounter rates were high in a selective fishery. For Method 2, they evaluated evidence indicating that LM Chinook release occurs on both an intentional *and* unintentional basis. In combination, the authors found that intentional and unintentional releases likely contributed to a 12-13% underestimate of actual (true but unknown) encounters by M2.

Based on their analyses and practical considerations regarding the most feasible bias correction approaches, Conrad and McHugh ultimately recommended using Method 2 with a correction for the release of legal-size marked Chinook as the preferred method for estimating total Chinook encounters in mark-selective Chinook fisheries. In particular, they determined that an “unbiased” estimate of total Chinook encounters could be obtained under Method 2 using:

$$\text{Bias-Corrected M2} = \text{Original M2 Estimate} / (0.87)$$

In August 2008, WDFW and tribal representatives conducted a thorough technical review of Conrad and McHugh’s recommended bias-corrected (i.e., “M2-adjusted”) method for estimating total Chinook encounters in mark-selective Chinook fisheries. The state-tribal technical group agreed that the recommended M2-adjusted approach would enable the most reliable, single estimate of total Chinook encounters in mark-selective Chinook fisheries. Consequently, starting with our selective fishery data analyses conducted in Summer/Fall 2008 and thereafter, WDFW applied Conrad and McHugh’s M2-adjusted estimation approach to report the estimated Chinook encounters and associated mortalities in Chinook MSFs (see **Appendix B** for complete computational details). From this point forward, our post-season reports contained one “best estimate” of Chinook encounters; we no longer presented two different, sometimes conflicting, estimates of Chinook encounters based on two separate approaches with inherent biases. Further, based on Conrad and McHugh’s (2008) analysis and recommendations, we determined that we could apply the M2-adjusted method in cases where an estimate of the total number of LM Chinook harvested is obtained through less intensive survey approaches (e.g., estimates of total Chinook harvest resulting from the WDFW Catch Record Card [CRC] system, coupled with field estimates of LM Chinook relative abundance from voluntary trip reports).

Selective Fishery Reporting--Need for Centralized Methods Report

Since pilot mark-selective Chinook fisheries were first implemented in Puget Sound in 2003, WDFW has produced a detailed post-season data report evaluating each mark-selective Chinook fishery implemented in Puget Sound, as well as two multi-year reports (WDFW 2008a, 2008b). We have generated a separate post-season data report for each area and season (winter or summer), containing estimates of each of the critical selective fishery parameters listed above along with comparisons to FRAM pre-season predictions of the key parameters.

In July 2010, technical staffs from the WDFW Puget Sound Sampling Unit, Northwest Indian Fisheries Commission (NWIFC), and Puget Sound Treaty Tribes met to discuss potential

² A type of angler recall error in which anglers report the number of salmon they encounter as a rounded approximation of what they actually release (e.g., reporting that 10 salmon were released when the true number was actually 9 or 11). See Conrad and McHugh (2008) for further detail.

³ When anglers exaggerate the number of fish that they caught to be perceived as a better angler. See Pollock et al. (1994) and Conrad and McHugh (2008) for further detail.

reporting efficiencies in WDFW's mark-selective Chinook fishery post-season reports. NWIFC and tribal representatives had initiated the idea for such a meeting, considering that we at WDFW had been submitting a separate post-season report for each area and season (since 2003) to the co-managers, resulting in redundancies between individual reports, particularly in the Methods section. Also, over the years we kept adding sections to the selective fishery annual reports, in response to individual tribal co-manager requests, and sustained those additions in each future report, resulting in ever-lengthening post-season reports. From both the WDFW and tribal technical perspectives, we needed to prioritize the most essential reporting elements and achieve efficiencies to streamline the selective fishery reporting work load.

Thus, at the July 2010 meeting the WDFW and tribal staffs worked on prioritizing the most essential elements (i.e., tables, figures, and appendices) needed in WDFW's annual post-season selective fishery reports in an effort to define reporting efficiencies. Based on these decisions (details available in a WDFW memo dated August 16, 2010, summarizing the July 2010 meeting), WDFW would begin implementing the agreed-to reporting efficiencies within our draft 2009-10 winter selective fisheries report.

Further, we agreed that a key efficiency in the annual reporting process would be for WDFW staff to produce a centralized Methods Report. The Methods Report would be a stand-alone document that includes the details of each area's Chinook MSF study design (for both winter and summer fisheries), sampling procedures, data analysis methods, and all equations used to generate estimates and variances. We determined that the Methods Report would be cited in future annual data reports (starting with the draft winter 2009-10 post-season report), enabling us to eliminate methods-related redundancies contained in the previous by-area annual reports. Thus, the Methods Report presented herein is a key outcome of state-tribal collective ideas for creating selective fishery reporting efficiencies.

Methods Report Objectives

The purpose of this Methods Report is to provide detailed documentation of WDFW Puget Sound Sampling Unit's sampling designs and procedures used to monitor and evaluate the critical selective fishery data parameters (as defined above) for pilot mark-selective Chinook fisheries implemented in Puget Sound since 2003. In particular, we focus on documenting details of the most current selective fishery monitoring designs, sampling procedures, data analysis methods, and all equations used to generate estimates and variances. As such, this Methods Report is considered a companion document accompanying each of WDFW's annual post-season data reports (i.e., serves as a Methods Section for each report), beginning with the draft 2009-10 winter selective fisheries report and continuing with each report thereafter. Further, we will update this Methods Report if any of the methods described herein are modified in the future (i.e., after 2010) based on state-tribal technical agreement.

In the following pages, we first provide a full description of each Marine Catch Area in Puget Sound (Areas 5 through 13) with accompanying maps. Within each area's section, we also present an overview of the recreational mark-selective Chinook fishery seasons that have occurred in the area to date. Additionally, we describe the evolution since 2003 of our agreed-to sampling and monitoring plans for each Puget Sound Marine Catch Area in which mark-selective Chinook fisheries have been implemented and evaluated using sampling and monitoring programs. In the subsequent Methods section of the report, we provide a detailed account of our sampling procedures and post-season estimation methods within the context of

the Puget Sound Sampling Unit's four primary sampling designs, which we present in a sequence of numbered "Sections" as follows: 1) *Full Murthy Estimate Design*; 2) *Reduced Murthy Estimate Design*; 3) *Aerial-Access Design*; and 4) *Baseline Design*. If specific sampling protocols from Section 1 of this report are identical to methods used within the sampling designs presented in Sections 2 through 4, we cite the methods description in Section 1 to avoid redundancies in later sections. Also, we refer the reader to WDFW's "2010 Puget Sound Sampling Manual" (available at www.recfin.org) to review examples of specific data collection forms that are used when implementing each sampling design. Finally, in a series of appendices to this report we provide: *A*) the detailed history of intensive (i.e., creel estimates) versus baseline sampling in Puget Sound/Strait of Juan de Fuca Marine Catch Areas with selective fishery seasons and sampling plan components (years 2003-2010); *B*) a detailed description of our encounters and mortalities estimation scheme; *C*) aerial-access design estimators; *D*) statistical week tables by calendar year (corresponding to statistical weeks referenced in WDFW's annual selective fishery data reports); and *E*) a table of sampled sites and sampling designs per area and season (winter or summer) for the Puget Sound recreational mark-selective fishery sampling program.

MARINE CATCH AREAS OF PUGET SOUND: Overview of Mark-Selective Chinook Fishery Seasons and Sampling Plans by Area

The Marine Catch Areas of Puget Sound include Areas 5 through 13 (**Figure 1**), extending from the mouth of the Sekiu River (western-most border of Area 5) eastward through the Strait of Juan de Fuca, then extending northward to the Canadian border to Point Roberts (Area 7) and southward through central (Areas 8-1, 8-2, 9, and 10) and southern (Areas 11 and 13) Puget Sound. Washington coastal Marine Catch Areas include Areas 1 through 4 (**Figure 1**). In this section of the report, we present descriptions of each of the Puget Sound Marine Catch Areas (5 through 13) with accompanying maps, as well as an overview of the specific pilot mark-selective Chinook fishery (MSFs) seasons and the history of sampling plans implemented in each area from 2003 to present.

Within each area's section below, we organize the information for mark-selective Chinook fishery seasons and sampling plans based on two overall season categories, "summer" and "winter" fisheries. Typically we consider summer selective fisheries in Puget Sound marine areas to be those that are conducted during the June through September period, while winter selective fisheries are those conducted in the October through April time period. Further, based on WDFW's selective fishery data collected over the years, and considering Conrad and McHugh's (2008) multi-year and multi-area analysis, summer selective Chinook fisheries are generally characterized as: (1) relatively high effort fisheries; (2) fisheries that are generally directed at maturing Chinook that are migrating through an area; and (3) compared to winter fisheries, have fewer Chinook released and more salmonid species encountered relative to the number of Chinook harvested. In contrast, winter selective Chinook fisheries can be characterized as: (1) relatively low-effort fisheries; (2) fisheries that are primarily directed at resident Chinook that are over-wintering in Puget Sound; and (3) compared to summer fisheries, typically have more Chinook released relative to the number of Chinook harvested (see Conrad and McHugh 2008).

In addition to the area-specific regulations described in each area's section below, the following regulations were common to all of the summer and winter mark-selective Chinook fisheries implemented in Puget Sound: *i*) anglers were allowed to retain up to two legal-sized (≥ 22 inches [56 cm]) marked Chinook salmon per day and were required to immediately release all unmarked or sublegal-size Chinook, *ii*) required to use single-point, barbless hooks while fishing for salmon, *iii*) held to a combined (all salmon species) two-fish daily limit during the mark-selective Chinook fishery, and *iv*) held to a handling rule that prevented them from bringing unmarked and/or sublegal Chinook aboard their vessels.

WDFW's by-area sampling plans for mark-selective Chinook fisheries in Puget Sound have evolved over the past eight years based on state-tribal negotiations at the annual North of Falcon and Pacific Fishery Management Council (PFMC) salmon season-setting processes. Factors such as the need for timely in-season creel estimates of salmon encounters (i.e., retained *and* released salmon) to assess the pilot Chinook MSFs in-season, costs of shore-based and on-water monitoring, feasibility of on-water sampling of Chinook encounters by size/mark status, bias and precision considerations for dockside and on-water based estimates, expansion of the WDFW voluntary trip report (VTR) program in recent years, and other factors specific to each area have been influential in affecting the development and evolution of annual selective fishery monitoring plans. Considering that in this section we focus on the history of each area's sampling plans, rather than the detailed methods of the plans themselves, we refer the reader to

Sections 1 through 4 in the Methods section of this report for specific descriptions of our four primary monitoring designs, sampling components included in each design, and the procedures used to conduct all sampling activities.

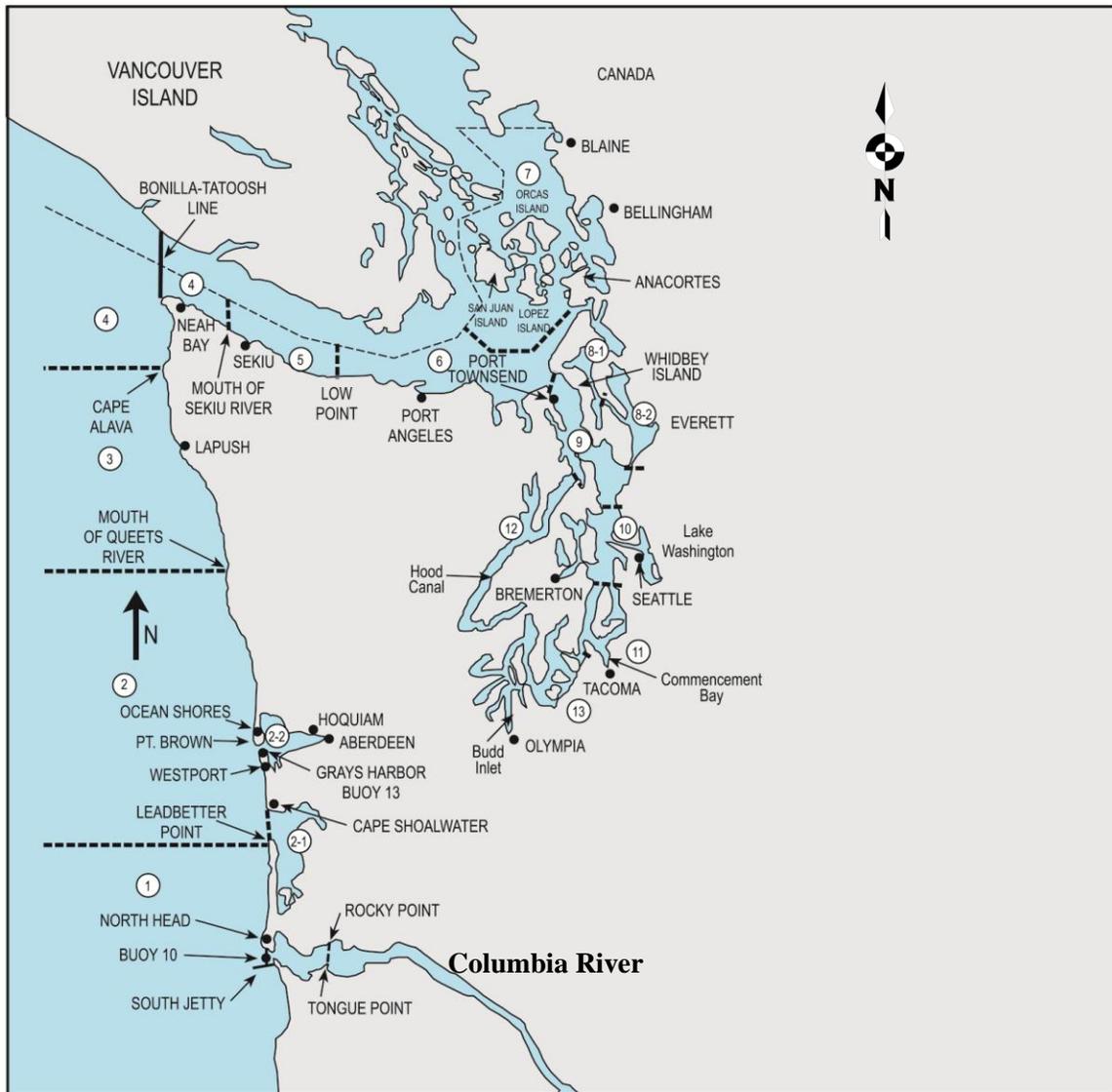


Figure 1. Map of Western Washington, showing the Marine Catch Areas of Puget Sound (Areas 5 through 13) and the Washington coast (Areas 1 through 4).

Areas 5 and 6

At nearly 1,000 square miles (>2,500 km²), Marine Areas 5 and 6 (hereafter: Areas 5 and 6) encompass the majority of U.S. waters in the Strait of Juan de Fuca (**Figure 2**). Area 5 stretches eastward from the mouth of the Sekiu River (eastern end of Area 4) in the west to the Lyre River in the east, and northward from the Olympic Peninsula to the U.S.-Canada border. Extending from Area 5 in the west to Whidbey Island in the east, and southward from the US-Canada/Area 7 boundaries to Admiralty Inlet, Area 6 encompasses the east-central end of the Strait of Juan de Fuca, including Discovery and Sequim bays. Each summer since the first year (2003) of a pilot mark-selective Chinook fishery (MSF) in Area 6, however, only the western portion Area 6 (westward of Ediz Hook) was open to Chinook harvest under MSF regulations in order to meet both fishery management and assessment objectives (WDFW 2008a); whereas, the entirety of Area 5 was open during the Chinook MSF. While both Areas 5 and 6 attract local, tourist, and charter-based angling activity during summer months, Area 5 is generally regarded as being more of a “destination” fishery than Area 6.

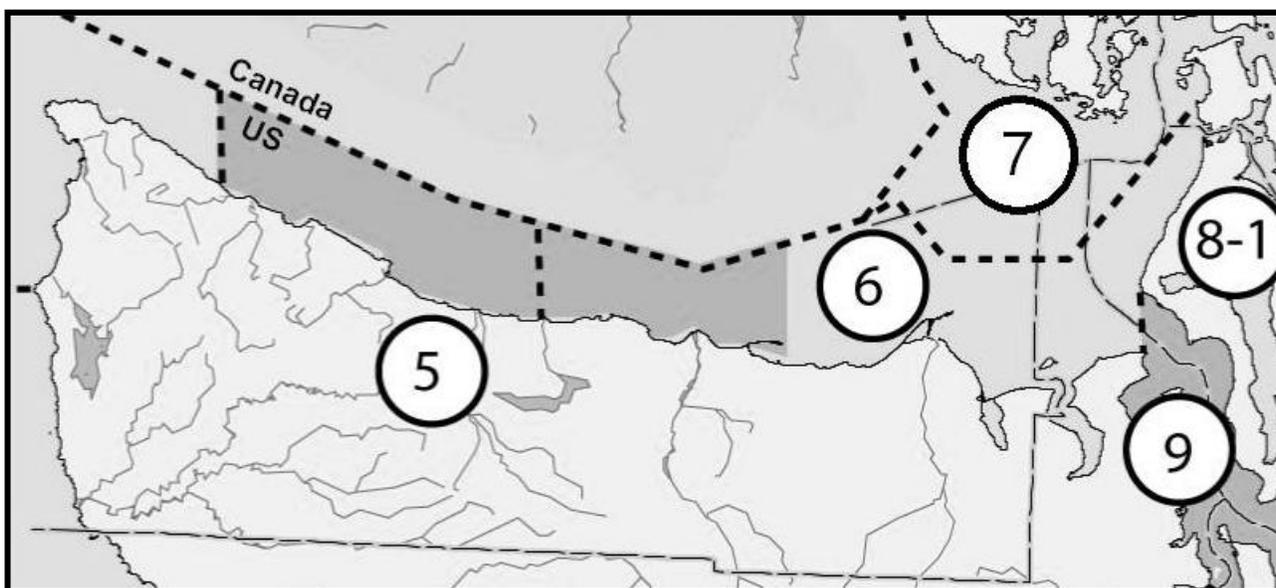


Figure 2. Map of Marine Catch Areas 5 and 6 in the Strait of Juan de Fuca, where a pilot mark-selective Chinook fishery has occurred each summer since 2003. The Areas or sub-Areas (i.e., west of Ediz Hook in Area 6) open under mark-selective Chinook harvest regulations each summer since 2003 are shaded in dark gray (see WDFW Sport Fishing Rules for additional details). *Map courtesy of David Bramwell, WDFW.*

Summer Areas 5 and 6 MSF Overview

During the summers of 2003 through 2007, the Areas 5 and 6 Chinook MSF was scheduled to start on July 1 (except, in 2003, the start date was July 5; see **Appendix A**) and run continuously until either the quota of harvested Chinook was attained or a set number of days was reached, whichever came first (quota of 3,500 in years 2003-2006; quota increased to 4,000 in 2007). In contrast, during the summers of 2008 through 2010, the Chinook MSF in Areas 5 and 6 was managed based on a season rather than a quota. During 2008, the Chinook MSF season was scheduled from July 1 through August 9, and this season was implemented for this entire scheduled season as planned. For both the 2009 and 2010 seasons, the Chinook MSF season in Areas 5 and 6 was scheduled to extend from July 1 through August 15. In actuality, WDFW

closed the 2009 season approximately one week early (on August 6), due to higher than expected encounters of unmarked sublegal-size Chinook salmon in Area 5 in particular. However, during summer 2010, the Areas 5 and 6 Chinook MSF season was open during the entire scheduled period of July 1 through August 15.

In addition to Chinook salmon, Areas 5 and 6 anglers pursued and encountered coho salmon (*O. kisutch*; typically also under mark-selective regulations during July through September), sockeye (*O. nerka*), and, during odd years, pink salmon (*O. gorbuscha*).

Summer Areas 5 and 6 Sampling Design History

During the 2003 through 2007 summer seasons (July through September), WDFW implemented our most intensive sampling design, the *Full Murthy Estimate Design* (**Section 1**), to monitor the mark-selective Chinook and coho fisheries in Areas 5 and 6 (**Appendix A**). As shown in **Figure 10**, this design incorporates intensive dockside creel surveys (two out of four weekdays [Monday-Thursday] and every Friday, Saturday, and Sunday were sampled each week) to enable in-season estimates for quota management, along with on-water effort surveys (boat surveys), test fishing (one test boat in each Area), and collecting voluntary trip reports (VTR) from the angling public.

Starting in summer 2008, we implemented several sampling design efficiencies in Areas 5 and 6 as part of the selective fishery monitoring plans agreed-to during 2008 North of Falcon meetings. The design efficiencies were area-specific with sampling components tailored to each of the areas separately (**Appendix A**).

Area 5

In Area 5, we implemented the *Reduced Murthy Estimate Design* (**Section 2, Figure 11**) beginning in 2008 and have continued implementing this design each season since. To ensure that long-term fishery sampling targets were not compromised, the *Reduced Murthy Estimate Design* has been accompanied by a high level of opportunistic *Baseline Sampling* (see **Section 4**) in Area 5.

Additionally, starting in 2008 and continuing each season thereafter, we employed an enhanced Voluntary Trip Report (VTR) program in Area 5 to obtain estimates of Chinook encounter rates by size class (legal or sub-legal) and mark status (ad-marked or unmarked). For the enhanced VTR program, an additional WDFW technician was hired to work exclusively on distributing and collecting VTRs from the angling public in Area 5. This VTR technician also educated anglers about the VTR program in a focused effort to increase the sample size of VTR-based encounters data.

Summer 2008 was also the final season of implementing the test fishing activity in Area 5 to obtain estimates of Chinook encounter rates by size class and mark status. Following the 2008 season in Area 5, we compared test fishery-based Chinook encounter rate data with that from VTRs, and statistical tests showed that the mark rates and legal-size fractions were not significantly different when comparing the two data sources (WDFW 2009a). For example, the estimated legal-size fraction differed between datasets by less than five percent (VTR vs. test fishery: 88% vs. 92%; $P = 0.606$). Overall, we determined that the enhanced VTR effort provided a sample that could serve as a reasonable proxy for the Area 5 test fishery dataset. As

such, during the 2009 North of Falcon process we negotiated to discontinue the test fishing activity in Area 5 to achieve cost savings and monitoring efficiencies. Summer 2009 was the first season in which we did not operate a test fishing vessel in Area 5 (**Appendix A**).

Area 6

In Area 6, starting in summer 2008 and continuing each season thereafter, our mark-selective Chinook fishery monitoring design incorporated Baseline angler/catch sampling only and therefore did not include an on-the-water (i.e., boat surveys, test fishing) sampling component. Thus, in 2008 we began implementing substantial sampling design efficiencies in Area 6 compared to years 2003-2007 (**Appendix A**). While this *Baseline Sampling* approach (**Section 4, Figure 13**) does not provide a means for generating in- or immediately post-season estimates of *fishery total* catch and effort, the observed catch per angler trip and species composition data obtained from baseline sampling are combined with Catch Record Card (CRC) data to produce the fishery-total estimates at a later time (approximately one year following the fishery).

Also beginning in 2008, we implemented our enhanced VTR program in Area 6 to obtain estimates of Chinook encounter rates by size class and mark status, similar to the expanded VTR program implemented successfully in Area 5. Once the post-season CRC-based retained Chinook estimates are available for a given Area 6 Chinook MSF season, we can then apply the proportion of legal-marked Chinook obtained from VTRs in Area 6 to the CRC-based retained Chinook estimate, enabling an estimate of total Chinook encounters and associated mortalities using Conrad and McHugh's (2008) bias-corrected method (**Appendix B**).

Area 7

Area 7 encompasses the marine waters in and around the San Juan Islands. Its boundaries extend from mainland Washington in the east (inclusive Bellingham Bay) to the US–Canada border in the west, and from approximately Smith Island in the south to the US–Canada border in the north (**Figure 3**). Covering more than 800 square miles (2,050 km²) of marine waters, Area 7 is one the largest WDFW Marine Catch Areas in Washington's Strait of Juan de Fuca/Puget Sound region (i.e., Areas 5-13).

Winter Area 7 MSF Overview

During the month of February 2008, WDFW implemented a pilot winter mark-selective Chinook fishery in Area 7 for the first time. Following the successful implementation and monitoring of the one-month pilot season in 2008, the Area 7 winter selective Chinook fishery season was lengthened slightly in subsequent years, based on state-tribal agreements at North of Falcon (**Appendix A**). For the second year of the Area 7 winter Chinook MSF, the fishery duration was expanded to 2.5 months, from February 1 through April 15, 2009. Likewise, for the third winter MSF season in Area 7, the fishery season was expanded to five months, from December 1, 2009 through April 30, 2010.

In terms of its characteristics as a winter fishery, Area 7 experiences both local and destination-based (i.e., tourist) angling effort; the majority of this effort is focused on immature Chinook salmon (i.e., anglers commonly refer to immature Chinook salmon as “blackmouth”).

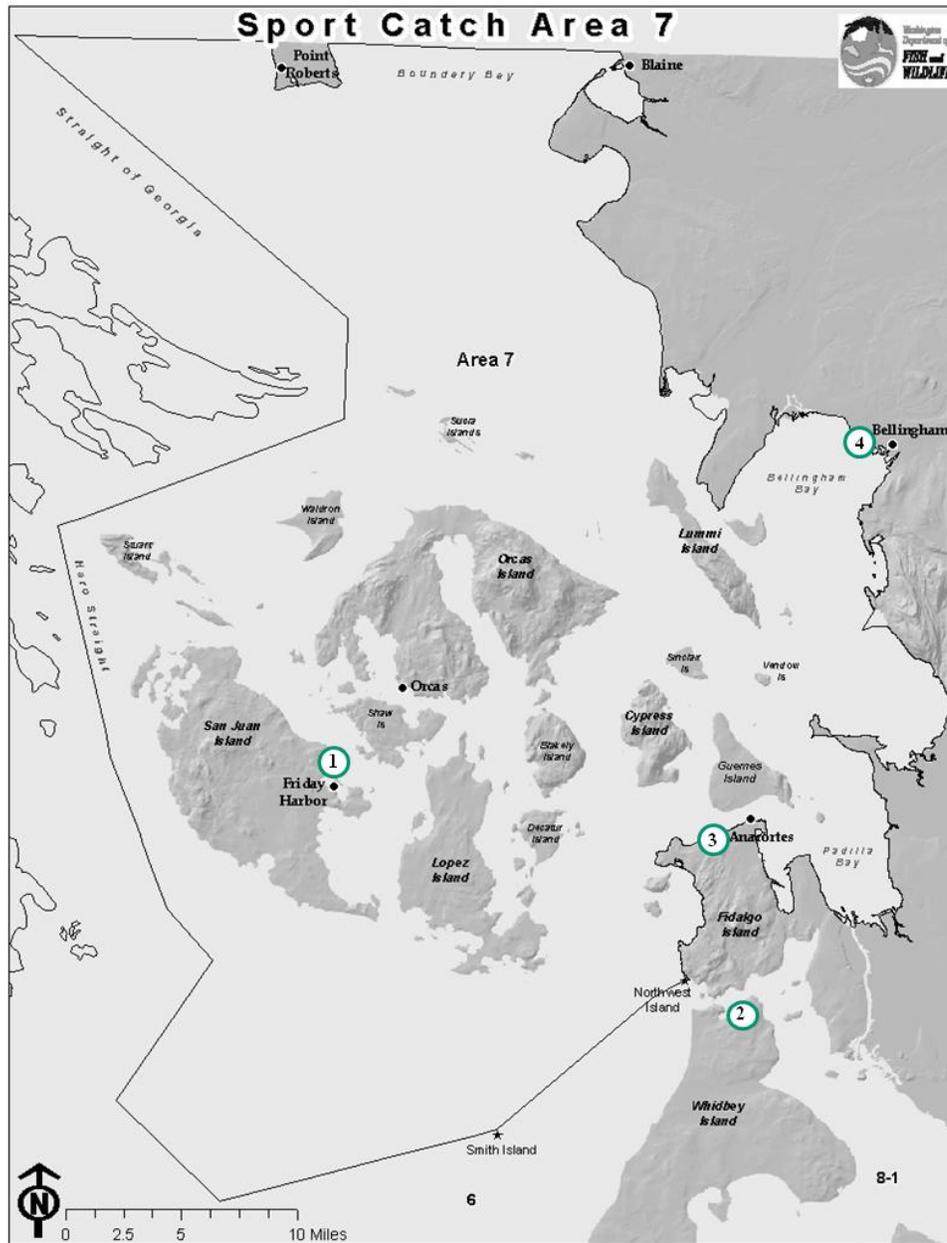


Figure 3. Map of Marine Catch Area 7 in Puget Sound, where a pilot winter mark-selective Chinook fishery has occurred each year since 2008. Open white circles correspond to the approximate location of the four public ramps or marinas where angler interviews and catch sampling occurred (1 = Friday Harbor Marina, 2 = Cornet Bay State Park Ramp, 3 = Washington Park Ramp, 4 = Bellingham Ramp).

Winter Area 7 Sampling Design History

For the winter Area 7 recreational mark-selective Chinook fishery, we applied the *Aerial-Access Design* to monitor and evaluate key selective fishery parameters (**Section 3, Figure 12**), starting with the first season in February 2008 (**Appendix A**) and continuing each winter thereafter. As shown in **Figure 12**, the *Aerial-Access Design* in Area 7 consists of conducting dockside angler interviews (with catch sampling) at four moderate-to-high use access sites (Washington Park, Bellingham, Cornet, and Friday Harbor Marina ramps; these sites remain fixed throughout the season), as well as aerial effort surveys (i.e., rather than on-water boat surveys as conducted for

the Murthy Estimate, described in **Section 1**), test fishing, and voluntary reports of completed trips provided by charter anglers, private anglers, and derby participants.

Beginning with the winter 2009-10 mark-selective Chinook season in Area 7 (December 1, 2009 - April 30, 2010) and continuing thereafter, the frequency of sampling days within weekday (Monday-Thursday) and weekend (Friday-Sunday) strata was reduced within the *Aerial-Access Design* to accommodate sampling efficiencies as agreed to in our state-tribal monitoring plans (**Appendix A**). To achieve the reduced frequency (while still producing in-season biweekly creel estimates, albeit with reduced precision), we randomly selected $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two week interval. We also randomly selected $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling. To ensure that sampling targets were attained, we supplemented the days of intensive sampling for the *Aerial-Access Design* with a high level of opportunistic *Baseline Sampling* (see **Section 4**) in Area 7.

Areas 8-1 and 8-2

Area 8-1 includes the marine waters extending from Deception Pass southward through Skagit Bay and Saratoga Passage (south of Fidalgo Island) between Whidbey Island and Camano Island. Area 8-2 encompasses all marine waters from Port Susan south to Port Gardner, between Everett and Whidbey Island (**Figure 4**). During the winter mark-selective Chinook season in Areas 8-1 and 8-2, fishing was permitted throughout both areas, excluding waters in and immediately adjacent to Tulalip Bay (Area 8-2). As in other winter salmon fisheries in Puget Sound, immature Chinook salmon (“blackmouth”) were the predominant fish targeted and encountered in Areas 8-1 and 8-2 during the winter months.

Winter Areas 8-1 and 8-2 MSF Overview

WDFW implemented the first winter mark-selective Chinook pilot fishery in Areas 8-1 and 8-2 from October 1, 2005 through April 30, 2006. This initial season of the Areas 8-1/8-2 fishery represented WDFW’s first experience with implementing winter blackmouth fisheries under mark-selective harvest regulations in any of Washington’s marine waters. From October 1, 2006 through April 30 2007, WDFW implemented the second year of the winter mark-selective Chinook fishery in Areas 8-1 and 8-2 (**Appendix A**). Following the 2006-07 season, our analysis of monitoring data revealed higher than predicted encounters of sublegal-size Chinook, particularly during the month of October 2006 (WDFW 2008b). The following 2007-08 winter Chinook MSF season in Areas 8-1/8-2 was reduced to a six-month season (excluding the month of October), from November 1, 2007 through April 30, 2008. The fourth year of the 8-1/8-2 winter MSF was further reduced to a four-month season, from January 1 through April 30, 2009, due in particular to pre-season modeled predictions of fishery impacts on Puget Sound Chinook stocks of concern, such as Stillaguamish Chinook. The fifth (2009-10) and sixth (2010-11) Areas 8-1/8-2 winter Chinook MSF seasons were expanded once again to six-month seasons, from November 1 through April 30 (**Appendix A**).

Though coho (*O. kisutch*) and chum salmon (*O. keta*) are occasionally (during October primarily) caught by anglers fishing in Areas 8-1 and 8-2 between October and April (e.g., WDFW 2008b), Chinook salmon are the predominant (>95%) species targeted and encountered in both areas during blackmouth seasons.

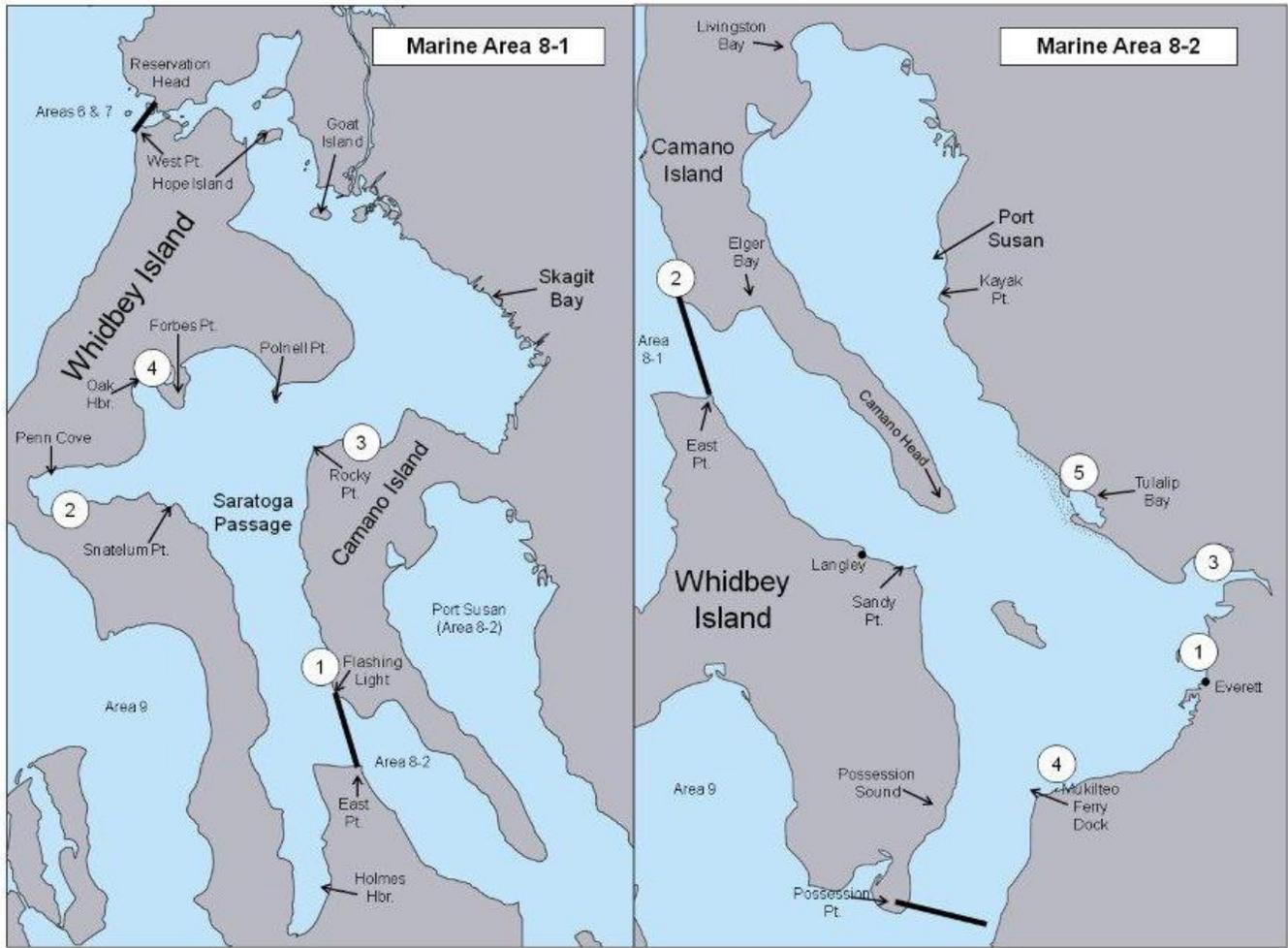


Figure 4. Map of Marine Catch Areas 8-1 (left panel) and 8-2 (right panel) in Puget Sound, where pilot mark-selective Chinook fisheries have occurred each winter since the 2005-06 winter season. Circled numbers correspond to access sites sampled during dockside sampling activities (*Area 8-1*: 1 = Camano Island State Park, 2 = Coupeville Ramp, 3 =Maple Grove Ramp, 4 = Oak Harbor Ramp, and 5= Norton Street [Everett] Ramp [refer to site number 1 in the Area 8-2 map]. *Area 8-2*: 1 = Norton Street [Everett] Ramp, 2 = Camano Island State Park, 3 = Dagmar’s Landing, 4 = Mukilteo State Park, and 5 = Tulalip Marina).

Winter Areas 8-1 and 8-2 Sampling Design History

During the first four seasons of the Areas 8-1 and 8-2 winter selective Chinook fishery, WDFW applied the *Full Murthy Estimate Design* (**Section 1**) to monitor and evaluate critical selective fishery parameters in Areas 8-1 and 8-2 (**Appendix A**). As shown in **Figure 10**, the *Full Murthy Estimate Design* incorporates intensive dockside creel surveys (two out of four weekdays [Monday-Thursday] and every Friday, Saturday, and Sunday were sampled each week) to enable in-season catch and effort estimates, along with on-water effort surveys (boat surveys), test fishing (one test boat in each Area), and collecting voluntary trip reports (VTR) from the angling public. During these initial four winter seasons of the Areas 8-1/8-2 fishery, our sampling design remained the same each year except that during the winter 2009 season (January 1 – April 30, 2009), we shared a test fishing vessel between Areas 8-1 and 8-2 rather than operating a separate test boat in each Area as we had during the previous three seasons.

Beginning with the 2009-10 winter season in Areas 8-1/8-2 (November 1, 2009 – April 30, 2010), we initiated sampling design efficiencies within our overall monitoring plan, consistent with state-tribal agreed-to monitoring plans (**Appendix A**). A key efficiency that we began during the 2009-10 winter season, and continued during the 2010-11 winter season, has been implementing the *Reduced Murthy Estimate Design* (**Section 2, Figure 11**). To achieve a reduced sampling frequency, we randomly selected $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two week interval. We also randomly selected $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling. To ensure that long-term fishery sampling targets were attained, the *Reduced Murthy Estimate Design* approach has been accompanied by a high level of opportunistic *Baseline Sampling* (**Section 4**) in Areas 8-1/8-2.

Additionally, starting in winter 2009-10 and continuing thereafter, we did not conduct test fishing in Areas 8-1/8-2. We had operated our test fishing boat during the initial four seasons of the winter Chinook MSF in Areas 8-1/8-2 to obtain estimates of Chinook encounter rates by size class (legal or sub-legal) and mark status (marked or unmarked). Beginning in winter 2009-10 (following North of Falcon discussions during spring 2009), however, we relied on our intensive Voluntary Trip Report (VTR) program to obtain estimates of Chinook encounter rates by size class/mark status in Areas 8-1/8-2. For the intensive VTR program, our winter season samplers were scheduled such that they could distribute VTR forms to anglers as they launched from sampled access sites, and samplers collected the completed VTR forms from anglers as they exited the sampled access sites.

Areas 9 and 10

Marine Area 9 is a relatively large area encompassing over 200 square miles (512 km²) of marine water in central Puget Sound. Area 9 starts at the mouth of Admiralty Inlet (i.e., its northern boundary is at the Partridge Point–Point Wilson line) and extends southward to the Apple Cove Point–Edwards Point line, including the marine waters extending south from Foulweather Bluff to the Hood Canal Bridge (**Figure 5**).

Marine Area 10 is the catch area immediately south of Area 9, which includes the waters immediately adjacent to the largest population center in the Puget Sound Region (i.e., Seattle). Encompassing between 100 and 200 square miles (206-512 km²) of marine water, Area 10 extends southward from the Apple Cove Point–Edwards Point line to an east-west line projected through the north tip of Vashon Island (**Figure 6**).

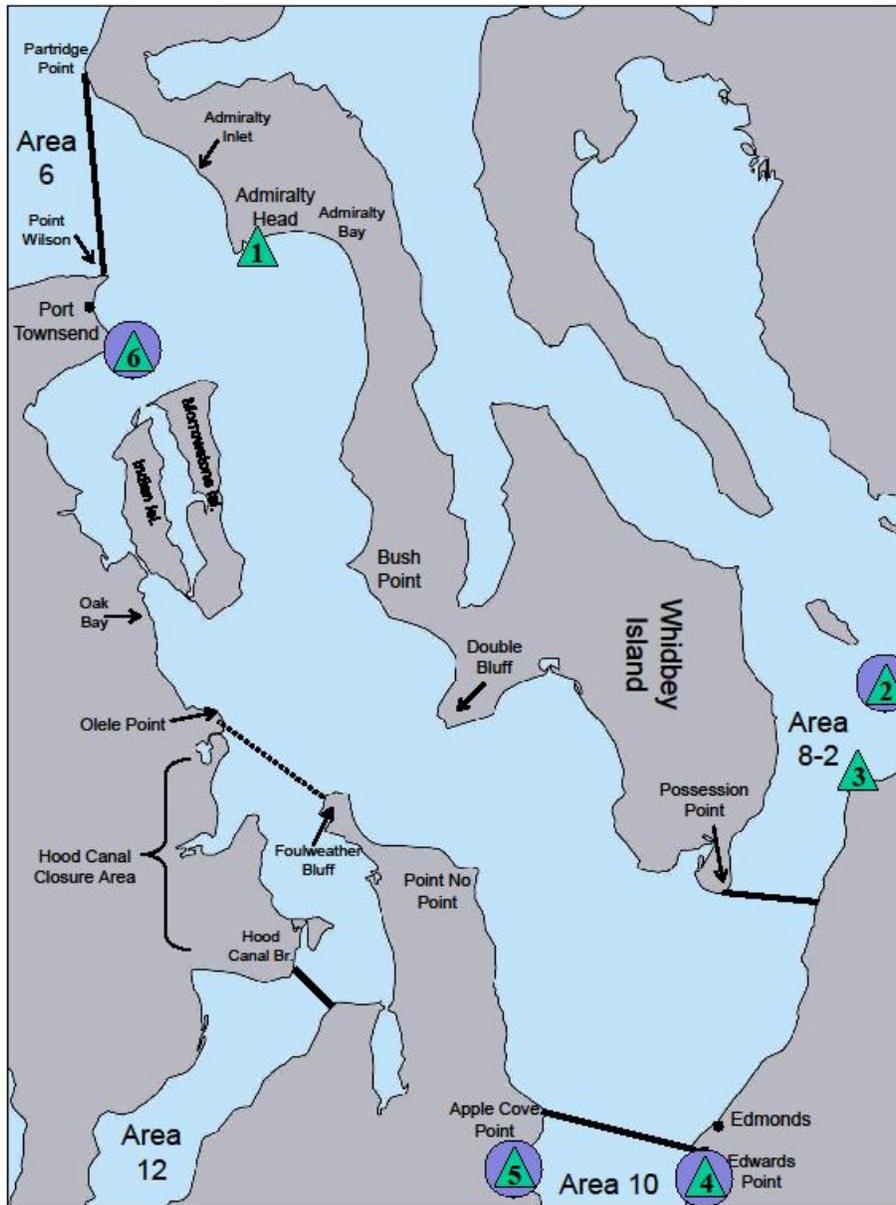


Figure 5. Map of Marine Catch Area 9 in Puget Sound. Circle symbols correspond to the approximate location of the four public ramps or marinas where angler interviews and catch sampling occurred during the Area 9 winter mark-selective Chinook fishery (starting winter 2008-09). Triangles correspond to locations sampled during the Area 9 summer selective Chinook fishery (starting summer 2007). Numbers inside the symbols correspond to the following ramp names: 1) = Fort Casey [Keystone], 2) = Everett (Norton/10th Street), 3) = Mukilteo State Park, 4) = Edmonds Marina Dry Storage, 5) = Kingston, and 6) = Port Townsend Boat Haven ramps.

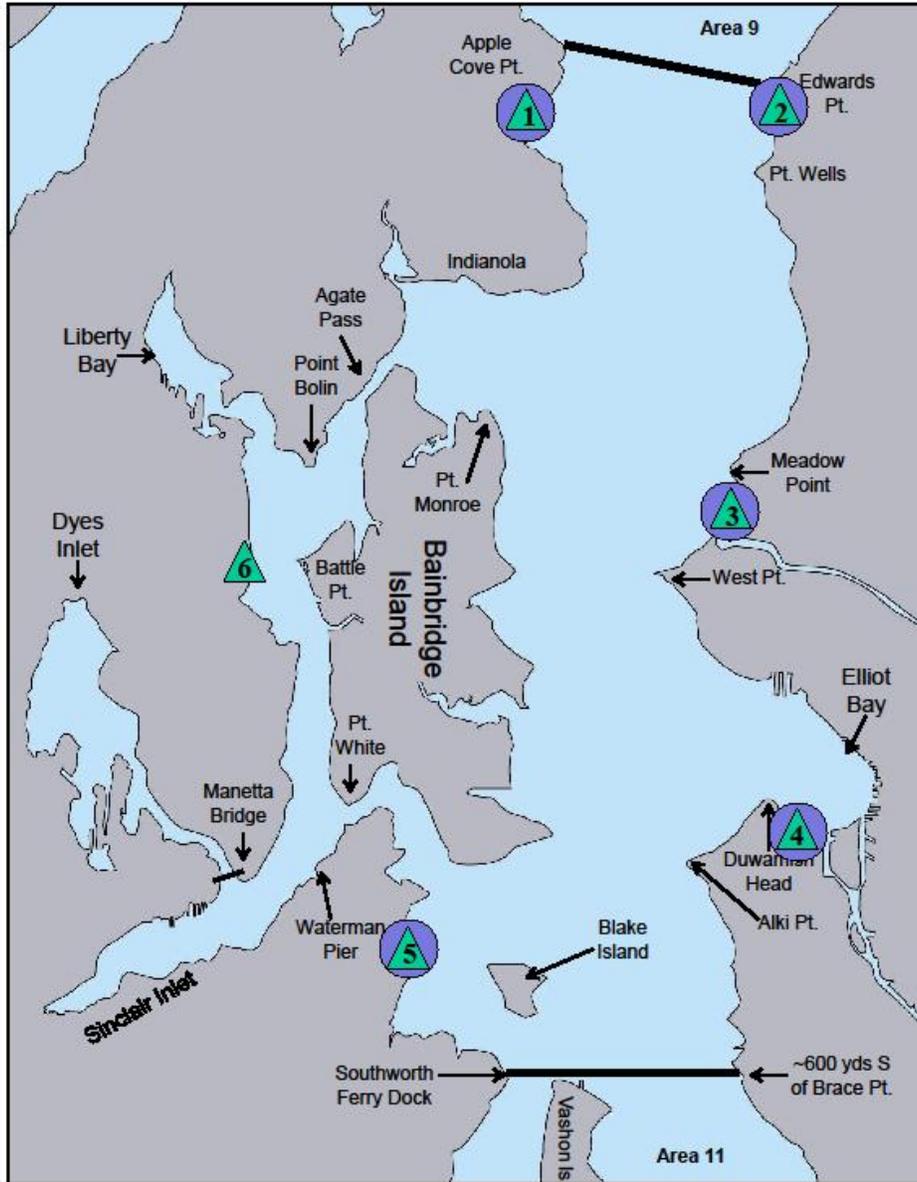


Figure 6. Map of Marine Catch Area 10 in Puget Sound. Circle symbols correspond to the approximate location of the public ramps or marinas where angler interviews and catch sampling occurred during the Area 10 winter mark-selective Chinook fishery (starting winter 2007-08). Triangles correspond to locations sampled during the Area 10 summer selective Chinook fishery (starting summer 2007). Numbers inside the symbols correspond to the following ramp names: 1) = Kingston, 2) = Edmonds Marina Dry Storage, 3) = Shilshole, 4) = Armeni, 5) = Manchester, and 6) = Brownsville ramps.

Summer Areas 9 and 10 MSFs Overview

The first season of the Areas 9 and 10 summer mark-selective Chinook fishery began on July 16, 2007 with tremendous popularity among the angling public. This was the first time that Areas 9 and 10 were open for Chinook fishing during the summer since 1993, providing anglers a unique opportunity to catch Chinook salmon in the middle of an urban area. The first mark-selective Chinook fishery in Areas 9 and 10 was scheduled to begin on July 16, 2007 and continue through

August 15 (31 days), or until the combined quota of 7,000 retained marked Chinook was attained (of which, only 1,700 Chinook could be harvested in Area 10), whichever occurred first. In total, the Area 9 selective Chinook fishery was open for 16 days, from July 16 through July 31. The Area 10 selective Chinook fishery was open for 13 days, from July 16 through July 28.

For the second year of the Areas 9 and 10 Chinook MSFs in summer 2008, the fisheries were managed on a quota basis, with a combined-area landed-catch goal of 7,000 marked Chinook. Pre-season management guidance emphasized target catch totals of 4,000 and 3,000 marked Chinook for Areas 9 and 10, respectively, and a maximum season length of 31 days (i.e., July 16th-August 15th) if the quota was not achieved. As implemented, Area 10 was open continuously from July 16th to August 15th (31 days of fishing). While Area 9 opened and closed on the same dates, it was closed temporarily on August 11th so that the status of landed catch relative to the allocated quota could be evaluated (i.e., the Area 9 season was 30 days in length).

For the third and fourth years of the Areas 9 and 10 summer Chinook MSFs (2009 and 2010), the fisheries were managed on a season basis (rather than a quota), from July 16 through August 31 (i.e., maximum season length of 47 days). In summer 2009, the season had general harvest management guidelines (as modeled pre-season in FRAM) of 8,851 landed marked Chinook in Area 9 and 2,923 in Area 10. As implemented, both areas were open continuously from July 16th to August 31st (47 days of fishing). Similarly, in summer 2010, the fisheries were open continuously from July 16th to August 31st, with general harvest management guidelines (as modeled pre-season in FRAM) of 5,314 landed marked Chinook in Area 9 and 2,042 in Area 10.

During the summer time, Areas 9 and 10 draw appreciable local, tourist, and charter-based angling effort. In addition to Chinook salmon, these anglers pursue and encounter coho salmon (*O. kisutch*) and, during odd years, pink salmon (*O. gorbuscha*).

Summer Areas 9 and 10 Sampling Design History

WDFW implemented our most intensive sampling design, the *Full Murthy Estimate Design* (**Section 1**), to monitor the pilot mark-selective Chinook fisheries in Areas 9 and 10 during summer 2007 and continuing each season thereafter (**Appendix A**). As shown in **Figure 10**, the *Full Murthy Estimate Design* incorporates intensive dockside creel surveys (two out of four weekdays [Monday-Thursday] and every Friday, Saturday, and Sunday are sampled each week) to enable in-season catch and effort estimates, along with on-water effort surveys (boat surveys), test fishing (one test boat in each Area), and collecting voluntary trip reports (VTR) from the angling public.

Winter Areas 9 and 10 MSFs Overview

From January 16 to April 15, 2008, the WDFW implemented a pilot mark-selective Chinook fishery in Area 9 during the winter season for the first time. Based on state-tribal agreements at 2008 North of Falcon meetings, the second year of the Area 9 pilot winter selective Chinook fishery was expanded to include the month of November (season: November 1-30, 2008 and January 16-April 15, 2009). WDFW implemented the third year of the Area 9 winter mark-selective Chinook fishery with the same season length as the previous year, November 1-30, 2009 and January 16 through April 15, 2010 (**Appendix A**). Likewise, the fourth (2010-11) winter Chinook MSF season in Area 9 was scheduled for the same four-month period.

In Area 10, WDFW implemented a pilot mark-selective Chinook fishery during the winter season for the first time from December 1, 2007 through January 31, 2008. Similarly, the second season of the Area 10 winter fishery was implemented from December 1, 2008 through January 31, 2009. Based on state-tribal agreements made at 2009 North of Falcon meetings, the third year of the Area 10 pilot winter selective Chinook fishery was expanded to include the months of October and November (season: October 1, 2009 through January 31, 2010). Similarly, the fourth (2010-11) winter Chinook MSF season in Area 10 was scheduled for the same period from October 2010 through January 2011 (**Appendix A**).

As is the case for other winter salmon fisheries that occur in Puget Sound, immature Chinook salmon (“blackmouth”) are the predominant fish targeted and encountered by anglers fishing in Areas 9 and 10 during the winter months.

Winter Areas 9 and 10 Sampling Design History

Area 9

For the first season of the winter Area 9 recreational mark-selective Chinook fishery (January 16 – April 15, 2008), WDFW applied the *Full Murthy Estimate Design* (**Section 1**) to monitor and evaluate critical selective fishery parameters in Area 9 (**Appendix A**). As shown in **Figure 10**, the *Full Murthy Estimate Design* incorporates intensive dockside creel surveys (two out of four weekdays [Monday-Thursday] and every Friday, Saturday, and Sunday were sampled each week) to enable in-season catch and effort estimates, along with on-water effort surveys (boat surveys), test fishing (one test boat in each area), and collecting voluntary trip reports (VTR) from the angling public.

Starting with the second season (November 1-30, 2008 and January 16 – April 15, 2009) of the winter Area 9 recreational mark-selective Chinook fishery, and continuing each winter thereafter, we applied the *Aerial-Access Design* to monitor the Area 9 winter fishery (**Section 3, Figure 12; Appendix A**). We shifted to implementing the *Aerial-Access Design* in the second year primarily because, after the first year of the Area 9 winter study, we learned that the large geographic expanse of Area 9 was not amenable to conducting the on-the-water effort surveys needed for the Murthy Estimate design. The previous boat-based design required coordinating three different boats to cover all of Area 9 during rough on-the-water conditions in the winter time, proving difficult and challenging (in terms of both logistics and safety) for field personnel.

In comparison, the *Aerial-Access Design* has been particularly well-suited for evaluating selective fisheries occurring in large geographic areas such as Areas 7 and 9. As shown in **Figure 12**, the *Aerial-Access Design* in Area 9 consists of dockside angler interviews (with catch sampling) at four moderate-to-high use access sites (Port Townsend Ramp, Everett Ramp, Edmonds Dry Storage, and Kingston Ramp; these sites remain fixed throughout the season), as well as aerial effort surveys (i.e., rather than on-water boat surveys as conducted for the Murthy Estimate), test fishing, and voluntary reports of completed trips provided by charter anglers, private anglers, and derby participants.

Beginning with the winter 2009-10 mark-selective Chinook season in Area 9 (November 1-30, 2009 and January 16 - April 15, 2010) and continuing each winter season thereafter, the frequency of sampling days within weekday (Monday-Thursday) and weekend (Friday-Sunday) strata was reduced within the *Aerial-Access Design* to accommodate sampling efficiencies as

agreed in our state-tribal monitoring plans (**Appendix A**). To achieve the reduced frequency (while still producing in-season biweekly creel estimates, albeit with reduced precision), we randomly selected $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two week interval. We also randomly selected $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling. To ensure that sampling targets were attained, we supplemented the days of intensive sampling for the *Aerial-Access Design* with a high level of opportunistic *Baseline Sampling* (**Section 4**) in Area 9.

Area 10

During the first two seasons of the Area 10 winter selective Chinook fishery (December 1 – January 31, 2007-08 and 2008-09), WDFW applied the *Full Murthy Estimate Design* (**Section 1**) to monitor and evaluate key selective fishery parameters in Area 10 (**Appendix A**). As shown in **Figure 10**, the *Full Murthy Estimate Design* incorporates intensive dockside creel surveys (two out of four weekdays [Monday-Thursday] and every Friday, Saturday, and Sunday were sampled each week) to enable in-season catch and effort estimates, along with on-water effort surveys (boat surveys), test fishing, and collecting voluntary trip reports (VTR) from the angling public.

Beginning with the third (2009-10) winter Chinook MSF in Area 10 (October 1, 2009 – January 31, 2010), and continuing during the 2010-11 winter season, we initiated sampling design efficiencies within our overall Area 10 monitoring plan, consistent with state-tribal sampling and monitoring agreements (**Appendix A**). The primary efficiency implemented during the 2009-10 season was within the dockside creel sampling component, in which we reduced the frequency of sampling days per week as part of the *Reduced Murthy Estimate Design* (**Section 2, Figure 11**); whereas, the test fishing, VTR, and boat survey sampling components remained the same as in previous seasons. To achieve a reduced design for dockside sampling, we randomly selected $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two week interval. We also randomly selected $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling. To ensure that long-term fishery sampling targets were not compromised, the *Reduced Murthy Estimate Design* has been accompanied by a high level of opportunistic *Baseline Sampling* (**Section 4**) in Area 10.

Area 11

Marine Area 11 is the catch area immediately south of Area 10. At just over 80 square miles (205 km²), Area 11 encompasses the central-south Puget Sound marine waters extending from the northern end of Vashon Island southward to the northernmost Tacoma Narrows Bridge, including the marine waters of Colvos Passage on the western shore of Vashon Island (**Figure 7**).

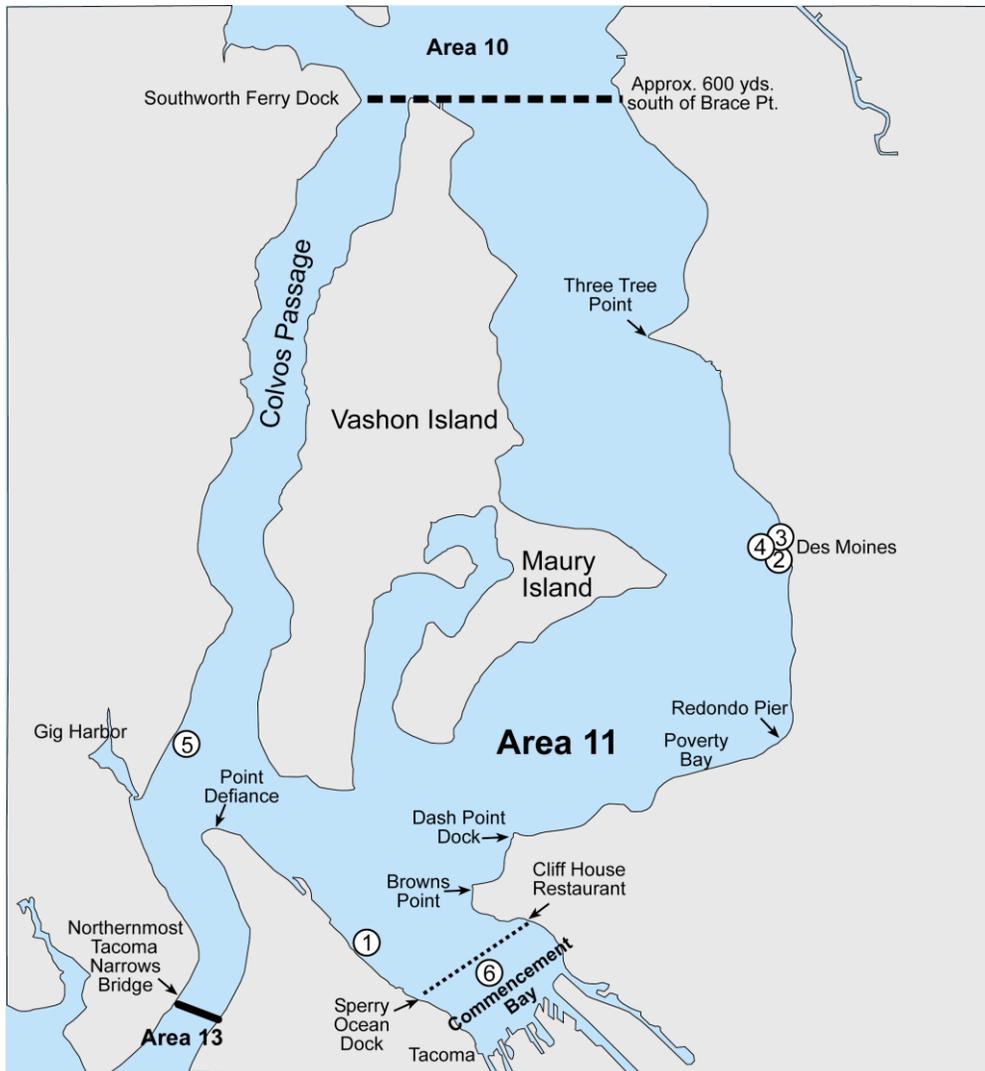


Figure 7. Map of Marine Catch Area 11 in Puget Sound, where a pilot mark-selective Chinook fishery has occurred each summer since 2007, from June 1-September 30, and each winter since 2010 (February 1-April 30). Note that the circled numbers in this figure correspond to special-area regulations for Area 11 fishing seasons (see *WDFW Sport Fishing Rules Pamphlet* for details).

Summer Area 11 MSF Overview

The first season of a pilot recreational mark-selective fishery for Chinook salmon in Area 11 began on June 1, 2007 and extended through September 30, 2007. The 2007 Area 11 summer pilot fishery, as well as the 2007 Area 13 summer pilot Chinook MSF (see the *Area 13* section below), represented WDFW’s first experience implementing mark-selective regulations for Chinook in a southern Puget Sound marine area. During each subsequent year (2008-2010) of the Area 11 pilot Chinook MSF, the season has continued to extend from June 1 through September 30 (**Appendix A**).

Given its proximity to the urban center of Tacoma, Area 11 draws appreciable local, tourist, and charter-based angling effort during summer months. In addition to Chinook salmon, these

anglers pursue and encounter coho salmon (*O. kisutch*) and, during odd years, pink salmon (*O. gorbuscha*).

Summer Area 11 Sampling Design History

During the first two summers (June 1-September 30, in 2007 and 2008) of the Area 11 pilot mark-selective Chinook fishery, WDFW applied the *Full Murthy Estimate Design* (**Section 1**) to monitor the Area 11 fishery. As shown in **Figure 10**, the *Full Murthy Estimate Design* incorporates intensive dockside creel surveys (two out of four weekdays [Monday-Thursday] and every Friday, Saturday, and Sunday were sampled each week) to enable in-season catch and effort estimates, along with on-water effort surveys (boat surveys), test fishing, and collecting voluntary trip reports (VTR) from the angling public.

Beginning with the 2009 summer season (June 1 – September 30), we implemented sampling design efficiencies within our overall monitoring plan for the Area 11 Chinook MSF, consistent with state-tribal agreements made at the 2009 North of Falcon meetings. A key efficiency that we began in 2009, and have continued each season since, has been implementing the *Reduced Murthy Estimate Design* (**Section 2, Figure 11; Appendix A**). To ensure that long-term fishery sampling targets were not compromised, the *Reduced Murthy Estimate Design* approach has been accompanied by a high level of opportunistic *Baseline Sampling* (**Section 4**) in Area 11.

In addition, starting in 2009 and continuing each season thereafter, we employed our enhanced Voluntary Trip Report (VTR) program to obtain estimates of Chinook encounter rates by size class (legal or sub-legal) and mark status (ad-marked or unmarked) in the Area 11 Chinook MSF. For the Area 11 enhanced VTR program (similar to the Areas 5 and 6 enhanced VTR program), an additional WDFW technician was hired to work exclusively on distributing and collecting VTRs from the angling public. This VTR technician also educated anglers about the VTR program in a focused effort to increase the sample size of VTR-based encounters data.

During the 2010 season (June 1- September 30) of the Area 11 Chinook MSF, we implemented an additional sampling efficiency consistent with state-tribal monitoring agreements made during the 2010 North of Falcon process. For the first time, we did not operate a test fishing vessel in Area 11 during summer 2010. We relied on our enhanced VTR program to obtain estimates of Chinook encounter rates by size class and mark status, with an overall sample size goal of 600 Chinook encounters from VTRs (150 per month on average) over the course of the four-month season.

Winter Area 11 MSF Overview

WDFW implemented the first pilot recreational mark-selective Chinook fishery in Area 11 during the winter season from February 1 through April 30, 2010 (**Appendix A**). Similarly, the second year of the Area 11 winter fishery was scheduled from February 1 through April 30, 2011.

As is the case for other winter salmon fisheries that occur in Puget Sound, immature Chinook salmon (“blackmouth”) are the predominant fish targeted and encountered by anglers fishing in Area 11 during the winter months.

Winter Area 11 Sampling Design History

During the first season of the Area 11 winter selective Chinook fishery (February 1 – April 30, 2010), WDFW applied the *Reduced Murthy Estimate Design* without the test fishing component (see **Section 2, Figure 11**). Intensive efforts to distribute and collect VTRs from the angling public provided the Chinook encounter data needed to estimate Chinook encounter proportions by size class (legal or sublegal) and mark status (marked or unmarked). Our Area 11 winter fishery sampling design also incorporated reduced-frequency dockside creel sampling (compared to the *Full Murthy Estimate Design*), in which we randomly selected $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two week interval. We also randomly selected $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling. As in other areas and seasons, to ensure that long-term fishery sampling targets were not compromised, the *Reduced Murthy Estimate Design* has been accompanied by a high level of opportunistic *Baseline Sampling* (**Section 4**).

Area 12

Marine Catch Area 12 consists of the waters within Hood Canal, including all waters south of the Hood Canal Bridge (**Figure 8**). Hood Canal is a fjord-like arm within western Puget Sound. The canal is 110 km long with a large 180 degree bend (commonly referred to as the “Great Bend”) that begins approximately 80 km into the canal. Hood Canal is between 2 km and 4 km wide for most of its length. Low dissolved oxygen and other water quality issues have plagued Hood Canal in recent decades, with the problem growing increasingly worse to the extent that numerous fish kills have been observed in recent years (e.g., Spring 2002, Fall 2003, September 2006, September 2010; see Hood Canal Dissolved Oxygen Program, <http://hoodcanal.washington.edu/>).

Winter Area 12 MSF Overview

WDFW implemented the first pilot recreational mark-selective Chinook fishery in Area 12 during the winter season from February 1 through April 30, 2010 (**Appendix A**). Likewise, the second year of the Area 12 winter fishery was scheduled from February 1 through April 30, 2011. As is the case for other winter salmon fisheries that occur in Puget Sound, immature Chinook salmon (“blackmouth”) are the predominant fish targeted and encountered by anglers fishing in Area 12 during the winter months.

Winter Area 12 Sampling Design History

For the first season of the Area 12 winter selective Chinook fishery (February 1 – April 30, 2010), WDFW implemented our *Baseline Sampling* design (see **Section 4** and **Figure 13**) to monitor the pilot mark-selective Chinook fishery in Area 12 (**Appendix A**). Additionally, intensive efforts of sampling staff to distribute and collect VTRs from the angling public provided the data needed to estimate Chinook encounter proportions in the winter Area 12 Chinook MSF by size class (legal or sublegal) and mark status (marked or unmarked).

While this *Baseline Sampling* approach does not provide a means for generating in- or immediately post-season estimates of *fishery total* catch and effort, the observed catch per angler trip and species composition data obtained from baseline sampling are combined with Catch Record Card (CRC) data to produce the fishery-total estimates at a later time (approximately one year following the fishery). Once the post-season CRC-based retained Chinook estimates are

available for the Area 12 Chinook MSF season, we can then apply the proportion of legal-marked Chinook obtained from VTRs in Area 12 to the CRC-based retained Chinook estimate, enabling an estimate of total Chinook encounters and associated mortalities using Conrad and McHugh's (2008) bias-corrected method (**Appendix B**).



Figure 8. Map of Marine Catch Area 12 in Puget Sound, where the first pilot mark-selective Chinook fishery was implemented during the winter season from February 1 through April 30, 2010.

Area 13

Extending southward from the northernmost Narrows Bridge, Marine Area 13 includes all marine waters (~125+ mi² [320 km²]) in the southern terminus of Puget Sound (**Figure 9**). Marine Area 13 is geographically complex and includes several islands, inlets, and passageways. Given its proximity to the urban center of Olympia, Area 13 draws appreciable local, tourist, and charter-based angling effort during summer months. In addition to Chinook salmon, these anglers pursue and encounter coho salmon (*O. kisutch*) and, during odd years, pink salmon (*O. gorbuscha*).

Summer Area 13 MSF Overview

The first season of a pilot recreational mark-selective fishery for Chinook salmon in Area 13 began on May 1, 2007 and extended through September 30, 2007. The 2007 Area 13 summer pilot fishery, as well as the 2007 Area 11 summer pilot Chinook MSF (see *Area 11* section above), represented WDFW's first experience implementing mark-selective regulations for Chinook in a southern Puget Sound marine area. During each subsequent year (2008-2010) of the Area 13 summer pilot Chinook MSF, the season has continued to extend from May 1 through September 30 (**Appendix A**).

Summer Area 13 Sampling Design History

Beginning in summer 2007 and continuing each season (May 1 – September 30) thereafter, WDFW implemented our *Baseline Sampling* design (see **Section 4** and **Figure 13**) to monitor the pilot mark-selective Chinook fishery in Area 13 (**Appendix A**). While this *Baseline Sampling* approach does not provide a means for generating in- or immediately post-season estimates of *fishery total* catch and effort, the observed catch per angler trip and species composition data obtained from baseline sampling are combined with Catch Record Card (CRC) data to produce the fishery-total estimates at a later time (approximately one year following the fishery). Once the post-season CRC-based retained Chinook estimates are available for a particular Area 13 Chinook MSF season, we can then apply the proportion of legal-marked Chinook obtained from VTRs in Area 13 to the CRC-based retained Chinook estimate, enabling an estimate of total Chinook encounters and associated mortalities using Conrad and McHugh's (2008) bias-corrected method (**Appendix B**).

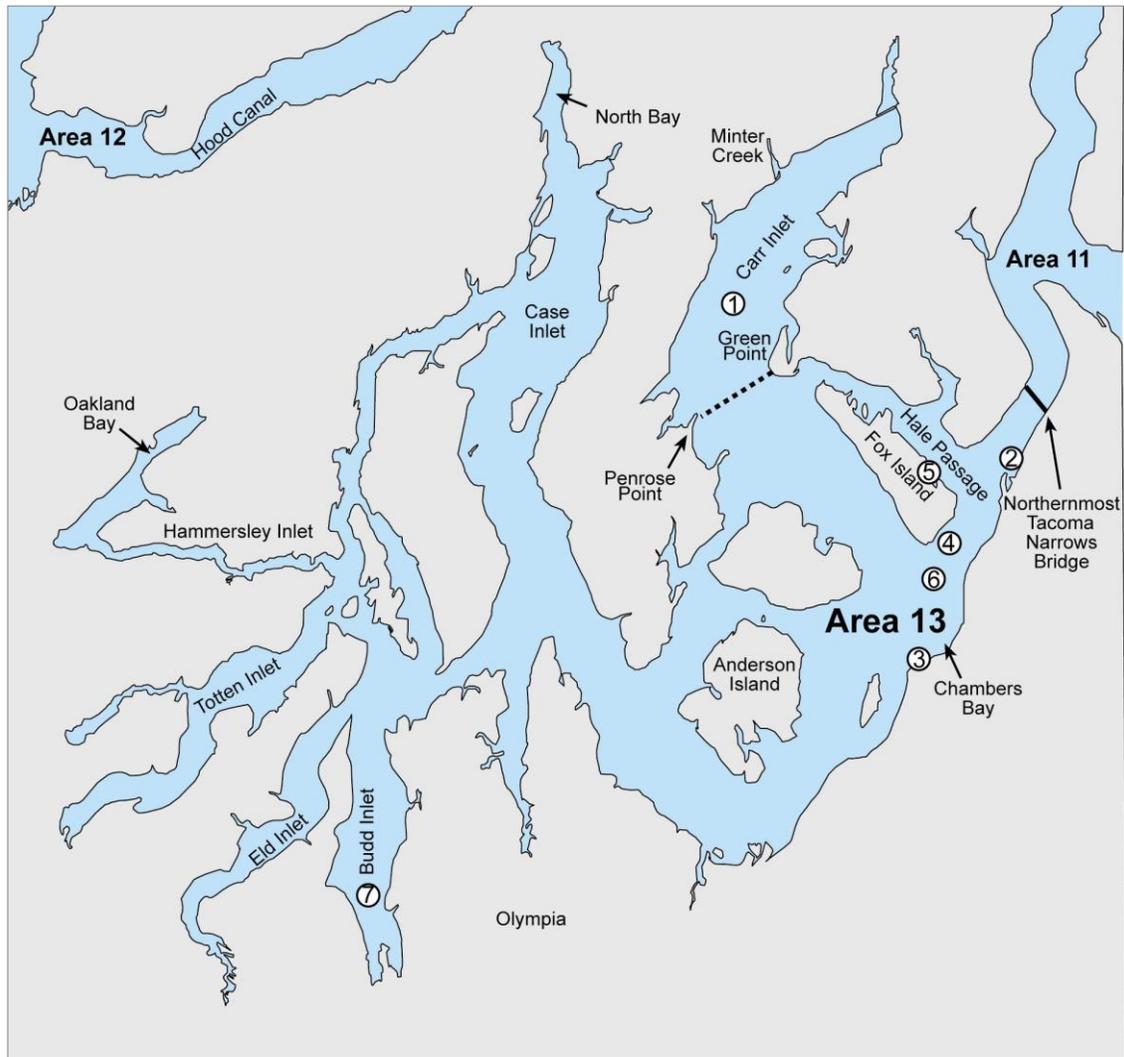


Figure 9. Map of Marine Catch Area 13 in Puget Sound, where a pilot mark-selective Chinook fishery has occurred each summer since 2007, from May 1-September 30. Note that the circled numbers in this figure correspond to special-area regulations for Area 13 fishing seasons (see *WDFW Sport Fishing Rules Pamphlet* for details).

METHODS

1. Full Murthy Estimate Design

WDFW’s Puget Sound Sampling Unit has implemented the comprehensive monitoring plan shown in **Figure 10** (hereafter referred to as the “*Full Murthy Estimate Design*”) to intensively monitor the mark-selective Chinook fisheries in the Marine Catch Areas of Puget Sound (e.g., in Areas 5, 6, 7, 8-1, 8-2, 9, 10, and 11). The table in **Appendix A** lists the areas and seasons (winter and summer) in which we have applied this design from 2003 to present.

The general study design is built around Murthy’s population-total estimator (Murthy 1957, Cochran 1977) and is focused specifically on obtaining daily estimates of total catch and total effort. This sampling program incorporates comprehensive and complementary data collection strategies, including: 1) dockside-based angler interviews and catch sampling; 2) on-the-water total (instantaneous) effort surveys; 3) test fishing; and 4) voluntary reports of completed trips provided by private anglers and charter boat operators (**Figure 10**).

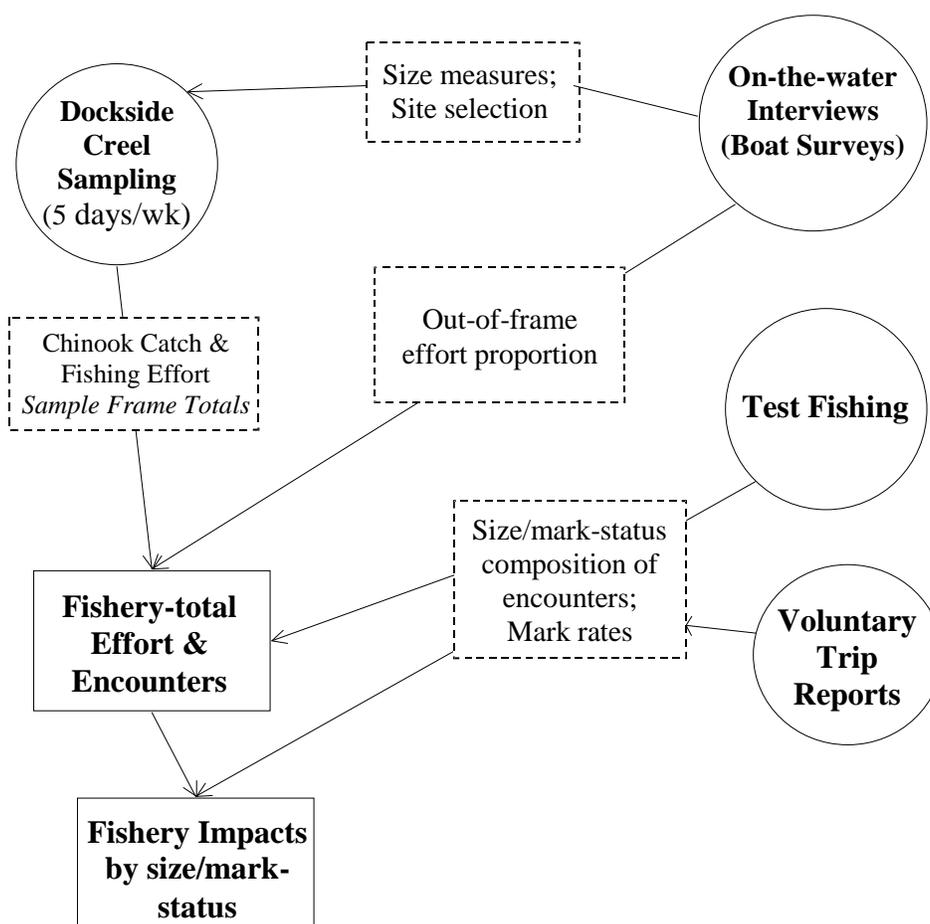


Figure 10. Conceptual diagram of the monitoring plan implemented during pilot mark-selective Chinook fisheries in Puget Sound Marine Catch Areas requiring the *Full Murthy Estimate Design* (also, see **Appendix A**). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon.

Dockside Sampling

Catch and effort are estimated by creel surveys following the procedures detailed in WDF and NWIFC (1992), with the exception that expansion factors (i.e., cluster sizes or “size measures”) are determined in-season, rather than using previously determined effort levels. Our dockside angler-interview efforts follow a two-stage stratified cluster sample design. At the first stage, we select sample days from all available selective-fishery days using three time-based strata; at the second stage, we randomly select (with probability proportional to size, PPS) fishery-access points (i.e., public ramps, boathouses, etc.) at which we interview anglers (the clusters) to collect data about their fishing trips and to sample their catch.

Sampling Strata and Site Selection

We collect data on total catch (observed harvest and reported releases⁴) and total angling effort using a two-stage stratified cluster sample design. At the first stage, we select five sample days from three temporal strata (weekday [Monday-Thursday], with $n = 2$ days sampled; Friday, with $n = 1$ day sampled; and weekend [Saturday-Sunday], with $n = 2$ days sampled) during each week of the fishery. On each selected sample day, we select two access points (i.e., public ramps, boathouses, etc.) from the marine area for creel sampling. Access site (i.e., cluster) selection is achieved at the second stage using a probability-proportional-to-size (PPS) sampling algorithm (the Yates-Grundy or “natural” method, Cochran 1977). The measure of size used in PPS sampling is equivalent to the fraction of total sample-frame effort attributed to a given site; this quantity is estimated using data collected during instantaneous on-the-water surveys (i.e., “boat surveys”) conducted routinely during the course of the fishery.

Before the start of the fishery, we determine our access-site sample frame based on a compilation of all known, publicly accessible (i.e., “sampleable”), and moderate-to-high effort boat-launch facilities present in the area. The table in **Appendix E** lists the sampled sites included in our sample frame to date for each area and season. Given that some effort is excluded from our sample frame (i.e., private and/or low-effort access sites), we also estimate the out-of-frame effort proportion from boat survey data (see *Boat Surveys* section below) and account for this quantity in estimates of fishery-wide totals (e.g., catch and effort).

Dockside Interview Procedures

On each day scheduled for sampling, 1 to 3 ramp samplers (or more, depending on the specific ramp, day length, anticipated angler effort, etc.) are stationed at each selected access site so that they can interview all anglers exiting the fishery at the selected sites. During interviews, samplers acquire data on the number of anglers fishing in each boat, the Marine Catch Area(s) fished, trip duration, trip intent (i.e., targeted species), and fish encounter composition (kept and/or released, by species). When an interviewed party possesses Chinook or coho salmon, samplers inspect the fish for CWTs using wand detectors, and collect snouts from CWT-positive

⁴ In a 2008 evaluation of bias in mark-selective fishery parameter estimates, Conrad and McHugh (2008) concluded that angler recall errors likely cause bias in interview-based estimates of total salmon *releases*. In their evaluation, Conrad and McHugh recommended a bias-corrected “Method 2” approach for estimating Chinook encounters (and releases). Technical representatives from the State and Treaty Tribes agreed to Conrad and McHugh’s recommended approach in August 2008; thus, we focus exclusively on this bias-corrected approach in our methods documentation herein.

individuals for later lab processing. Samplers also take length measurements (fork length to nearest cm and total length to nearest mm) and collect scale samples from landed Chinook.

Sampling shifts last from approximately dawn until dark to enable samplers to intercept all boats and anglers departing the fishery from sampled sites. If any boats are missed during the sampling shift (i.e., sampler noticed the boat/anglers exiting the site but could not sample them), samplers count all missed boats and record the total count on the sampling form (i.e., for later use during the catch estimation process).

Additionally, to help shape test-fishing efforts (described below under *Test Fishing*) on an in-season basis, dockside samplers collect data on the type and frequency of fishing methods employed by the private fleet during angling excursions. Specifically, samplers inquire about and record the predominant (based on time) angling method that was employed for boats that successfully encountered Chinook. Responses are recorded on the sampling form according to the following five fishing method categories:

- 1) Weight and bait (i.e., mooching or slow trolling with lead and herring/anchovy);
- 2) Downrigger trolling (using hardware, bait, or both in combination);
- 3) Jigging (i.e., drifting and jerking pole up and down, e.g., using Buzz Bombs, Point Wilson Darts, or Crippled Herring);
- 4) Diver trolling (e.g., trolling with a Deep Six or a Pink Lady using hardware, bait, or both in combination); and
- 5) Other methods (e.g., fly fishing).

Based on these responses, test fishers employ the same methods in approximately the same proportions as the recreational fleet.

Finally, given their daily exposure to anglers participating in the mark-selective Chinook fisheries, dockside samplers educate anglers about regulations and the proper release of unmarked or sublegal-size Chinook salmon as time allows. Samplers work with the angling public to convey that mark-selective regulations permit the retention of only the adipose fin-clipped (marked) Chinook salmon >22 in (>56 cm) and require the immediate careful release (outside the gunwales and without bringing the fish on board) of all unmarked Chinook encountered. Dockside samplers also offer anglers a “dehooker” (tool enabling the careful, quick release of a fish from an angler’s hook and line while the fish is still in the water) with an accompanying pamphlet describing proper dehooker use, mark-selective fisheries in general, and accurate species/mark-status (i.e., adipose-fin clipped vs. unmarked) identification.

Boat Surveys

In order to obtain precise and up-to-date size measures (i.e., for site selection and within-frame total estimation) and out-of-frame effort proportion estimates (i.e., for expanding catch and effort estimates for our sample frame to fishery-total values), we implement on-the-water effort surveys (boat surveys) to estimate the proportion of angler effort originating from different fishery-access points, also referred to as site size measures. Boat surveys are comprehensive in space (i.e., they spanned the entirety of each marine area) and are assumed to be instantaneous in time. To maximize angler contact, surveys are scheduled during periods of peak fishing effort.

While traversing each area, the boat-survey samplers attempt to intercept all actively fishing boats, and ask occupants how many anglers are on board and where they intend to tie up or exit the fishery upon completing their trip. We exclude non-fishing vessels and vessels that were under way from our sample.

We conduct approximately a minimum of two and an average of four boat surveys per month in each area being surveyed. Additional boat surveys are conducted whenever significant changes in effort patterns are anticipated (e.g., if access sites or fisheries in adjacent marine areas open or close). Using the most recent boat-survey results, we calculate the size measures of sites contained in the sample frame for each week during an area's mark-selective fishery season.

Special stratification considerations: Area 10 Winter Tengu Derby

During each season of the Area 10 winter selective Chinook fishery (see table in **Appendix A** for season dates), we have modified our protocol slightly for collecting and analyzing on-the-water survey data during the "Tengu Derby" period only. The Tengu Derby is the longest running salmon derby in Washington State. The derby is confined to Elliott Bay and is open only to anglers who fish using "mooching"⁵ methods. Each winter, the Tengu Derby occurs on Sundays only, starting with the last Sunday in October through the last Sunday in December.

During the Tengu Derby period in Area 10, we stratify on-water effort survey data based on Tengu days (Sundays) versus non-Tengu days (non-Sundays), to account for any shifts in Area 10 angler effort proportions per access site (i.e., site size measures) due to the derby. We typically conduct 2 boat surveys on 2 Sundays per month and 2 surveys on 2 non-Sundays per month (4 boat surveys total) during the Tengu Derby period. For the Sunday boat surveys, we ask anglers specifically whether or not they were Tengu Derby participants, and samplers record this information on the survey form. Area 10 boat survey data from previous seasons have shown that most of the Tengu Derby participants originate from the Don Armeni Ramp in West Seattle (e.g., WDFW 2010d). This shift in ramp use due to the derby causes an increase in the proportion of angler effort using Armeni Ramp on Sundays versus other days of the week. Thus, to calculate site size measures, we separate out Tengu anglers from the boat survey data for non-Sundays. Whereas, we include Tengu anglers in calculating Sunday size measures throughout the derby period. The separate size measures, stratified based on day type (Sundays vs. non-Sundays) during the Tengu period only, are then applied to the observed dockside data to generate catch and effort estimates using the usual Murthy estimator method (see the section below titled *Estimating Catch and Effort*).

Test Fishing

In order to obtain accurate estimates of the size (legal or sublegal) and mark-status (marked or unmarked) composition of the pool of Chinook salmon encountered by anglers participating in a mark-selective Chinook fishery, we conduct a recreational test fishery during the entirety of the mark-selective Chinook season, if this sampling component is included in the particular area's sampling design (see table, **Appendix A**). Our test boat crew consists of two WDFW technicians per boat (one boat per area) fishing with a single rod each for approximately five days a week (Monday-Friday; weather permitting). To better ensure the accuracy of test-fishing data, samplers fish for Chinook with similar methods and gear as the recreational fleet. We

⁵ Mooching is essentially fishing with a light banana-shaped weight to pull a hooked herring down to the desired fishing depth. Most moochers use a "plug-cut" herring, which spins as it rises and falls.

prescribe the proportions of time that the test boats should spend fishing with different methods based on dockside interview results from the preceding week (described above under *Dockside Interview Procedures*). Also, test fishers focus their efforts at locations within the Marine Area that optimizes their overall encounter rate and mirrors choices made by the at-large private fleet.

For each fish brought to boat, test fishers log details of the encounter number, time sampled, species, mark status (marked or unmarked, if applicable), and DNA sample number (if applicable). Care is taken to handle all fish as gently as possible. Chinook that are not lost via “drop off” are brought on board and measured in a cotton mesh net. For each Chinook brought on board, samplers record the fork length (cm), total length (mm), and collect three scales. Scales are collected following procedures outlined by the International North Pacific Fisheries Commission (1963), to enable age analysis of Chinook encountered in the fishery. For Chinook salmon encounters only, test fishers collect DNA samples (~1-cm² piece of dorsal fin tissue). Tissue samples are collected to obtain DNA for future genetic analysis of stock composition.

The test fishery data on Chinook encounters are used to estimate the fishery-wide composition of Chinook encounters based on proportions of four size/mark status groups -- legal-size and marked (LM), legal-size and unmarked (LU), sublegal-size and marked (SM), and sublegal-size unmarked (SU). These size/mark status proportions are ultimately used to apportion total Chinook encounters to these same classes for use in fishery-impact estimation (**Appendix B**).

Voluntary Trip Reports

Voluntary Trip Reports (VTRs) are completed and returned by a subset of private fleet anglers, to obtain additional information on Chinook encounter rates by mark status and size class in mark-selective Chinook fisheries. Anglers are asked to record the date, number of anglers, target species, Marine Catch Area, each Chinook or coho hooked, whether the fish was kept or released, species (if they positively identified the fish), whether the fish was legal-size (≥ 22 inches [56 cm] total length) or sublegal-size, and whether the fish was adipose fin-clipped (marked) or not clipped (unmarked).

In recent years we have implemented several measures to expand and increase the success of our VTR program. First, samplers distribute our new and improved, user-friendly VTR form that is easier for anglers to complete compared to our previous VTR form. Dockside samplers maximize the distribution of VTRs by handing out the VTR forms as anglers launch, and collecting the VTRs as anglers exit the fishery. Additionally, samplers provide participants with a brochure describing the intent of VTRs and their significance to fishery monitoring, and answer VTR-related questions. To increase the response rate, participants are given three options for returning completed VTRs to WDFW: hand-delivering them to samplers, placing them in on-site drop boxes, or sending them via U.S. mail (pre-paid); if they were unsuccessful (i.e., no encounters occurred [harvested or released]) on their trip, the samplers request that participants keep their forms for future trips.

For each area’s mark-selective Chinook fishery, we summarize the VTR-based Chinook encounters data over the season and calculate Chinook encounter proportions by size/mark-status group (i.e., LM, LU, SM, and SU). We then compare the VTR-based Chinook encounter rates with equivalent data from the test fishery and determine whether to use VTR and/or test fishery Chinook encounter rate data for subsequent fishery impact estimation steps (see **Appendix B** and the section titled *Estimating Chinook Encounters* below).

Estimating Catch and Effort

By combining in-sample dockside interview data from sampled sites with estimated site size measures, we generate daily catch and effort estimates (and variances) using Murthy's population-total estimator (Murthy 1957, Cochran 1977) for private boats in our sample frame. We then expand these estimates to account for the out-of-frame effort proportion and then again to obtain stratum-wide totals (**Table 1**). Estimated parameters include total effort (boats and angler trips) and salmon encounters (retained and released) by species and mark status (i.e., adipose fin-clipped [marked] or not clipped [unmarked]). We estimate releases of salmon species other than Chinook using the Murthy estimator method; whereas, we estimate Chinook releases through a different approach incorporating Conrad and McHugh's (2008) recommended bias correction, as detailed below in the *Estimating Chinook Encounters* section.

We use WDFW's catch estimation application within Microsoft Access (developed by Kurt Reidinger, WDFW Fish and Wildlife Biologist) to enter the in-sample data from sampled sites, generate expanded estimates, and produce variance estimates for all sampled strata. Specifically, within the catch estimation system, sample-frame total catch and effort parameters are estimated using the Murthy's total estimator equations (Murthy 1957; Cochran 1977), as follows:

$$(1) \quad \hat{Y} = \frac{[(1 - P_2) * (E_1 / P_1) + (1 - P_1) * (E_2 / P_2)]}{(2 - P_1 - P_2)}$$

Where:

\hat{Y} = daily estimator (e.g., anglers, marked Chinook retained, etc.),
 P = proportion of effort (size measure) at sites 1 and 2, and
 E = sampled (observed) count at site 1 and 2.

The variance around sample-frame totals is estimated according to:

$$(2) \quad V(\hat{Y}) = \frac{(1 - P_1)(1 - P_2)(1 - P_1 - P_2)}{(2 - P_1 - P_2)^2} * \left[\frac{E_1}{P_1} - \frac{E_2}{P_2} \right]^2$$

All accounting for missed boats/anglers is done within WDFW's Microsoft Access catch-estimate system; using the average catch-per-boat estimated for a given site-day combination and the number of missed boats logged on forms, an estimate of unobserved catch is incorporated into the sample-frame totals. An analogous computation is made to account for the number of anglers not interviewed from the missed boats.

Finally, we expand daily catch and effort estimates generated for our sample frame to fishery totals based on the proportion of effort (estimated from boat-survey data) that originated from out-of-frame access sites, as follows:

$$(3) \quad \hat{Y}_{adj} = \frac{\hat{Y}}{(1 - \hat{p}_{nonsampled})} = \frac{\hat{Y}}{\hat{q}}$$

where:

- \hat{Y}_{adj} = daily estimator after expansion by an estimate of the proportion of effort that originated from the non-sampled access sites, and
- \hat{q} = expansion factor to account for the proportion of effort originating from out-of-frame access sites, $\hat{p}_{nonsampled}$ (i.e., sites not included in the sample frame and therefore never sampled).

The variance of expanded total estimates is approximated as:

$$(4) \quad V(\hat{Y}_{adj}) = \hat{Y}_{adj}^2 * \left[\frac{\hat{V}(\hat{Y})}{\hat{Y}^2} + \frac{\hat{V}(\hat{q})}{\hat{q}^2} \right]$$

The reliability of our estimates of catch and/or effort obtained using the above-described approach depends on the validity of the following four assumptions:

- Boat surveys provide unbiased estimates of access-site size measures and out-of-frame effort proportions (*Assumption 1*);
- Relative angling effort originating from a particular access site (i.e., its size measure) is proportional to total catch landed at that site (*Assumption 2*);
- All anglers exiting the fishery at a sampled site are interviewed and they accurately report all salmon caught and kept or released (if boats are missed they are counted and catch and effort estimates are expanded appropriately (*Assumption 3*); and
- Catch per unit effort does not differ significantly between in-frame and out-of-frame sites (*Assumption 4*).

Although Conrad and Alexandersdottir (1993) assessed the effects of *Assumption 2* violations on estimates of catch and effort for Puget Sound salmon fisheries, *Assumptions 1, 3, and 4*, have not been explicitly evaluated to date.

Estimating Chinook Encounters

To minimize the influence of angler recall bias on our assessment, we estimate Chinook releases as the difference between retained Chinook catch (i.e., from the Murthy estimator, based on *observed* landings) and total Chinook encounters (i.e., releases = encounters – retained catch) generated using the bias-corrected Conrad and McHugh (2008) approach. Briefly, encounters are estimated by dividing the creel estimate of landed legal-marked Chinook harvest by a field estimate (based on test fishery and/or VTR encounters data) of the estimated proportion of the fishable Chinook population that is of legal size and marked (i.e., our former “Method 2” approach; e.g., WDFW 2008b). Given that this former “Method 2” approach yields negatively biased estimates if anglers release any of the legal-marked Chinook they encounter, Conrad and

Table 1. Sampling/estimation details on target parameters associated with monitoring mark-selective Chinook fisheries in the Marine Catch Areas of Puget Sound.

Activity	Focal Parameter(s)	Secondary Parameter(s)	Sample Unit(s)	Finest Estimation Time Step	Comments
Dockside Creel Sampling	Fishing effort (boat & angler trips); kept and released fish ¹	Catch rates (CPUE); length, age, and CWT composition of harvest ² ; collection of angler fishing methods.	Angler trip; kept fish; reported fish release	Week ¹	Within weeks, estimates are also produced by strata (weekday/weekend). For quota purposes, finer-scale estimation is pursued when needed.
On-the-water Surveys (Boat Surveys)	Proportion of total angler effort accessing fishery via sample-frame sites (i.e., site “size measures”) versus out-of-frame sites. Size measures were used to select sites for dockside creel surveys using a probability proportional to size (PPS) site selection process, and to produce total-fishery creel estimates.	Data on spatial distribution of recreational fishing boats in the area.	Boats and anglers	Month	For the post-season report, document in this cell the number of boat surveys conducted by fishery area and time stratum (typically monthly time strata).
Aerial Surveys (See Section 3 below: Aerial-Access Design)	Fraction of total area’s effort (boats) captured in the sample frame via creel surveys (Sample Fraction, f_{ij}).	Total boat counts at assumed peak effort time interval (instantaneous count); spatial distribution of fishing boats in the area.	Boats	Season	For the post-season report, document in this cell the number of aerial surveys conducted over the catch area, and number of total fishing days available in the season. Note: To date, WDFW has applied the Aerial-Access Design to monitor the Areas 7 and 9 winter mark-selective Chinook fisheries only.
Test Fishing	Size (legal/sublegal) and mark-status composition (marked, unmarked) of encountered Chinook	Chinook length, age, and DNA-based stock composition; species composition of non-Chinook encounters	Fish encounterer	Month	For the post-season report, document in this cell whether test fishing data and/or VTR data (see row below) were used to estimate the mark/size class proportions used for subsequent impact estimation steps.
Voluntary Trip Reports (VTRs)	Size (legal/sublegal) and mark-status composition (marked, unmarked) of encountered Chinook	Encounter data for non-Chinook species (e.g., coho) that the angler may record on the VTR form	Fish encounterer	Month	If both VTR- and test fishery-based Chinook encounters data were available, we compared the two data sets using homogeneity tests; results of such statistical tests and evaluation of sample sizes informed which source of Chinook encounters data (or combination of sources) to use in fishery impact estimation.
Overall Fishery Impacts Estimation	Total Chinook encounters and mortalities, by size/mark-status group	Ratios of encounters and mortalities per kept Chinook	N/A	Month	Estimated on a monthly time step but considered at the season-total level.
Coded-wire tag (CWT) Impacts Estimation	Marked/unmarked double-index tag (DIT) encounters and mortalities	N/A	N/A	Month	The temporal resolution of DIT impacts is constrained by the total number of tags recovered.

¹ Under the "bias-corrected Method-2" approach, Chinook releases can be estimated only as finely as test fishery data allow.

² The length and CWT composition of landed catch was assessed on a season-wide basis for impact estimation.

McHugh estimated a “correction” factor to account for this phenomenon and incorporated it into their estimator (See **Appendix B** for complete computational details). Although we no longer provide estimates of Chinook releases based solely on angler accounts within our annual mark-selective Chinook fishery reports, we do generate the angler interview-based Chinook release estimates and house these data in our WDFW catch estimation system database. Also, we provide in our annual post-season reports the angler interview-based estimates of releases for salmon species other than Chinook (e.g., WDFW 2010b).

Estimating the Proportion Legal-size and Marked

In several of the Puget Sound Chinook MSF areas and seasons we have collected on-the-water Chinook encounters data via both the test fishery and VTR methods (see **Appendix A**). Thus, to estimate the proportion of the fishable Chinook population that is of legal size and marked (LM), we first must evaluate whether to incorporate test fishery and/or VTR-based Chinook encounters data in the estimate of this LM proportion. We evaluate the sample sizes of VTR and test fishery data, data quality, and the results of homogeneity tests (chi-square tests) to assess if there are significant differences between the two data sources.

In most cases we assume the test fishery data, when available, provides the best estimate (i.e., least biased and most precise) of Chinook encounter rates in a mark-selective Chinook fishery. We make this assumption considering the training and experience of our WDFW scientific technicians who conduct the test fishery sampling (i.e., high level of salmon identification expertise and fishing skills), and considering our focused efforts to emulate the fishing patterns of the recreational fleet, both in terms of gear types used and sub-areas fished. However, in limited specific cases (e.g., WDFW 2010a) we may elect to use the VTR data in combination with test fishery data to increase the sample size of the Chinook encounters data set for use in fishery-impact estimation steps (**Appendix B**). In such cases we pool season-total VTR and test fishery data sets only if homogeneity tests (i.e., chi-square tests; significantly different if $p > 0.05$) indicate that the two data sets were *not* statistically different (i.e., reject null hypothesis that the two data sets exhibit the same encounter rate proportions [LM, LU, SM, and SU] if $p < 0.05$). Further, in limited cases, even when test fishery data are available, we may elect to use the VTR data rather than the test fishery data (e.g., Area 11 summer 2009 selective Chinook fishery; WDFW 2010e); i.e., if the test fishery sample size is low combined with significant differences between VTR and test fishery data sets.

Charter vs. Fleet Breakout

During the initial years (through summer 2008) of monitoring the summer mark-selective Chinook fisheries in Areas 9, 10, and 11, as well as the winter Chinook MSFs in Areas 7, 8-1, 8-2, 9, and 10 (through winter 2008-09), our procedure was to separate charter vessels from private (non-charter) boats to generate total-area catch and effort estimates (e.g., WDFW 2009e). We used the Murthy estimator method to estimate total salmon encounters for private boats in each area, while a complete census (from VTRs and follow-up phone calls) approach was used for charter boats. The main exception to this practice has been in Areas 5 and 6, where since 2003 we have included charter vessels in our total-area estimates for the fleet due to the very small proportion of effort represented by charter boats in Areas 5 and 6, and because our samplers typically have been able to sample the catches (at our sampled sites) of the few charter boats that make trips in the two areas.

Given the logistical and estimation difficulties resulting from our separate charter/fleet sampling breakout in several of the Puget Sound areas, we explored datasets from past years and considered bias analytically in order to identify the areas/seasons where a special charter treatment is absolutely necessary. Briefly, we evaluated how much CPUEs for the overall fleet versus charter boats would have to differ and/or how great the charter effort proportion (of the total effort) would have to be in order for a meaningful bias to impact our catch estimates (McHugh 2009). For this theoretical assessment, Pete McHugh of WDFW computed the percent bias ($[\text{est'd} - \text{true}] / \text{true}$) for charter:fleet CPUE ratios and identified combinations that resulted in a bias that equaled or exceeded 3% (our default value for assumed “negligible bias”). We then considered these results parallel to CPUE ratios and charter effort proportions that we have documented in selective fishery reports produced through the 2008 season (see **Table 2**). From this evaluation, we determined that pooling charter and fleet data in the Murthy estimates would not significantly compromise estimate integrity for Area 11 in the summer and Areas 7, 8-1, 9, and 10 during the winter (**Table 2**). The combination of charter effort proportions (very small) and CPUE ratios (relatively high) suggested that pooling would cause negligible (<3%) bias; therefore, beginning in 2009, we included charter vessels in our Murthy estimate for these areas. In comparison, our analysis showed that a separate treatment of charter vessels (census approach) would still be necessary in Areas 9 and 10 in the summer and Area 8-2 in the winter (**Table 2**). Although, due to low to non-existent charter boat effort in the Area 8-2 winter MSF in the subsequent years following our initial analyses (**Table 2**), we discontinued the separate treatment for Area 8-2 charter boats (i.e., included as part of the Murthy estimate instead), beginning with the 2008-09 winter season and continuing thereafter. For the Areas 9 and 10 summer MSFs, however, charter effort proportions and charter:fleet CPUE ratios have remained consistently high over subsequent years, necessitating the continued separate treatment for charter vessels.

Thus, for the specific areas in which charter boats have exhibited a significantly different (higher) catch per unit of effort compared to private boats (e.g., Areas 9 and 10 summer Chinook MSF; **Table 2**), we acquire catch and effort data for charter boat anglers through a separate comprehensive effort. We contact known salmon charters operating in each mark-selective Chinook fishery area and coordinate with them so that they complete and return catch and effort information for all trips taken using supplied Voluntary Trip Report (VTR) forms. Total salmon catch (kept and released) and fishing effort data are assumed to be the result of a complete census and simply added to the survey-based estimates generated for the private fleet.

For the Areas 9 and 10 summer mark-selective Chinook fishery, the charter operators regularly report their retained Chinook and effort numbers (via phone reports or VTRs), but in some cases the released Chinook information by size/mark status is incomplete. In this situation, we apply the Conrad and McHugh (2008) bias-corrected method to estimate charter boat Chinook releases with variances (see *Total Encounters and Mortalities* section below and **Appendix B**). We first assume the retained Chinook number from charter boats is a known quantity with zero variance. We then divide the retained Chinook number by the estimated proportion of legal-marked Chinook in the fishery, which we obtain from the test fishery data, and apply Conrad and McHugh’s recommended bias correction factor. We assume that charter anglers experience the same size/mark-status composition as did test fishers. Given these assumptions, we estimate total charter encounters (and variance) according to Equation 1 (Eqn. 2 for variance) in **Appendix B**. We then apportion this estimate into size/mark group-specific estimates using the same methods as for the at-large private (**Appendix B**). To arrive at fishery-wide estimates,

charter totals and variances (i.e., for releases) are added to survey-based (private fleet) values at the appropriate step.

Table 2. Summary of results from a hypothetical bias evaluation (conducted by Pete McHugh of WDFW) to identify the mark-selective Chinook fishery areas and seasons (winter or summer) where we should continue implementing the special treatment of charter boat catches (i.e., separate census approach vs. the private-boat fleet), versus those areas/seasons where pooling charters into the Murthy estimate of total catch for the fleet would cause negligible (<3%) bias.

Area	Season	Year	Charter Effort Proportion	Charter CPUE	Fleet CPUE	Charter:Fleet CPUE Ratio	Treatment of Charters & Rationale (Starting in 2009 Season)
7	winter	2008	0.6%	0.28	0.28	0.98	<u>Treatment:</u> Census for remainder of 2008-09 blackmouth season but do not pursue a separate breakout thereafter; <u>Rationale:</u> The combination of low charter effort and the similar charter and fleet CPUEs suggested that separate treatment is probably not necessary.
8.1	winter	2005-06	0.1%	0.00	0.09	0.00	<u>Treatment:</u> Do not pursue a separate breakout unless boat survey data indicate a major change in charter activity levels; <u>Rationale:</u> 3 years of data indicate that charter activity is negligible.
8.1	winter	2006-07	0.0%	--	0.09	--	
8.1	winter	2007-08	0.2%	0.17	0.21	0.81	
8.2	winter	2005-06	2.3%	0.41	0.08	4.89	<u>Treatment:</u> Charters should be censused as during past seasons; <u>Rationale:</u> charters composed 1-2% of the effort total and had a consistently higher CPUE than the fleet did.
8.2	winter	2006-07	1.4%	0.35	0.11	3.25	
8.2	winter	2007-08	1.1%	0.67	0.15	4.56	
9	summer	2007	--	--	--	--	<u>Treatment:</u> Continue censusing charters via phone and VTRs and treat separately; <u>Rationale:</u> Monitoring requirements are generally stricter for quota-managed or intensively-managed summer Chinook selective fisheries.
9	summer	2008	1.5%	0.23	0.20	1.15	
9	winter	2008	0.7%	0.76	0.20	3.79	<u>Treatment:</u> Do not pursue a separate breakout; <u>Rationale:</u> Even though charters have a higher CPUE versus the fleet, they make up a small proportion of winter angling activity in Area 9.
10	summer	2007	--	--	--	--	<u>Treatment:</u> Continue censusing charters via phone and VTRs and treat separately; <u>Rationale:</u> Monitoring requirements are generally stricter for quota-managed or intensively-managed summer Chinook selective fisheries.
10	summer	2008	4.6%	0.27	0.07	4.17	
10	winter	2007-08	0.4%	1.10	0.25	4.47	<u>Treatment:</u> Do not pursue a separate breakout; <u>Rationale:</u> Even though charters have a higher CPUE versus the fleet, they make up a small proportion of winter angling activity in Area 10.
11	summer	2007	0.2%	0.57	0.13	4.33	<u>Treatment:</u> Do not pursue a separate breakout unless boat survey data indicate a major change in charter activity levels; <u>Rationale:</u> Charter activity is very limited in Area 11.

Estimating Fishery Impacts

Total Encounters and Mortalities

We characterize the overall impacts of the fishery in terms of grand-total estimates of encounters and mortalities and by using estimates specific to each of the four size/mark-status groups (i.e., legal-marked [LM], sublegal-marked [SM], legal-unmarked [LU], and sublegal-unmarked [SU]; **Table 1**). In contrast to the post-season reports that we completed prior to 2008 (e.g., WDFW 2007a and 2007b), from August 2008 and thereafter we have used only one approach to estimate total Chinook encounters and, consequently, mortalities. This single method was selected as a result of a thorough State–Tribal review of bias potential in estimators of encounters in MSFs (see Conrad and McHugh 2008 for details). In brief, encounters are estimated by dividing creel estimates of legal-marked Chinook harvest by our best estimate (from the test fishery and/or VTRs) of the proportion of the targeted Chinook population that is of legal size and marked, inclusive of a bias correction accounting for the modest level legal-marked Chinook release that occurs in this fishery. We then decompose total encounters into size/mark-status group-specific estimates using the test fishery- or VTR-based encounters composition data (**Appendix B**).

We estimate total Chinook mortality resulting from the fishery by applying assumed mortality rates to the total harvest and release estimates for the four size/mark-status groups (LM, LU, SM, and SU). For retained Chinook, the mortality estimate is equivalent to the total harvest estimate for the applicable size/mark-status group. We apply selective fishing mortality (*sfm*) rates of 15% and 20% to legal (marked and unmarked) and sublegal (marked and unmarked) release totals, respectively, to estimate release mortality. See **Appendix B** for a complete description of our impact estimation procedure, including formulae for total and variance estimators.

The final step of our overall impacts assessment involves comparing fishery outcomes to pre-season expectations. To do this, we compare season-total estimates of Chinook encounters and mortalities to pre-season modeled values (i.e., FRAM final model run for applicable fishery season) for each size and mark status category.

CWT Impacts

To understand the potential effects of mark-selective Chinook fisheries on the CWT program, we estimate the total number of unmarked-tagged Chinook mortalities that may have occurred during the course of the mark-selective Chinook season in each Marine Catch Area. To do this, we acquire information for all marked CWT double index tag (DIT) groups present in landed catch from the Pacific States Marine Fisheries Commission’s Regional Mark Information System (RMIS) and then apply the methods described by the Pacific Salmon Commission’s Selective Fisheries Evaluation Committee–Analysis Work Group (SFEC-AWG 2002) to estimate the number of unmarked DIT fish encountered⁶. We subsequently estimate the number of these fish that may have died due to hook-and-release impacts using an *sfm* analogous to that used in FRAM modeling. Given our interest in characterizing the impacts of mark-selective regulations on the CWT program and not recreational fishing in general, we use an *sfm* of 10% in all unmarked-DIT mortality calculations. Thus, we use 10% instead of 15% (applied above to legal-

⁶ For all unmarked-DIT encounters and mortalities calculations, we relied on the unmarked-to-marked abundance ratio (λ) estimated for DIT groups at the time of juvenile release.

sized releases) since unseen drop-off mortality (the 5% differential) is a feature common to selective and non-selective recreational Chinook fisheries.

For each mark-selective Chinook fishery, we estimate Chinook encounters and mortalities for each recovered DIT individually and then sum estimates for each hatchery, brood year, and area based on the methods described by SFEC-AWG (2002). Thus, the estimated number of unmarked mortalities is calculated as:

$$(9) \quad \hat{U}_a^{MSF} = \lambda^{REL} \hat{M}_a^{MSF} sfm$$

with associated variance:

$$(10) \quad Var(\hat{U}_a^{MSF}) \approx (\lambda^{REL})^2 sfm^2 \hat{M}_a^{MSF} \frac{1-s}{s}$$

where:

- sfm = selective fishing mortality rate (10%, *excludes drop-off mortality*),
- $U_{a,i}^{MSF}$ = aged a unmarked DIT mortalities from stock i in the selective fishery,
- $M_{a,i}^{MSF}$ = aged a marked DIT mortalities from stock i in the selective fishery,
- s = sampling rate of the catch,
- λ^{REL} = unmarked-to-marked ratio *at release* for fish in a DIT group⁷
- $Var(U_{a,i}^{MSF})$ = variance of $U_{a,i}^{MSF}$.

In addition to estimating unmarked-DIT mortalities, we pool all CWTs (DIT and otherwise) recovered during the fishery and, based on this total, report the proportional contribution (unexpanded recoveries) of different hatcheries to the total Chinook harvest.

⁷ λ^{REL} is used instead of λ at escapement (λ^{ESC}) to estimate total unmarked-DIT impacts attributable to each mark-selective Chinook fishery. While mortality estimates derived using λ^{REL} and λ^{ESC} provide upper and lower bounds to actual unmarked-DIT impacts, λ^{ESC} is typically not yet available (at the time of post-season data analysis and reporting) for all of the broods that are encountered during the particular area's mark-selective Chinook fishery. Further, DIT analyses conducted for other mark-selective Chinook (CTC 2007) and coho (Joint Coho DIT Analysis Workgroup 2003) fisheries have suggested that the choice in λ minimally affects final mortality estimates.

2. Reduced Murthy Estimate Design

Overview

Beginning with the summer 2009 mark-selective Chinook fisheries in Areas 5 and 11 and the winter 2009-10 Chinook MSF seasons in Areas 8-1, 8-2, 10, and 11 (see table, **Appendix A**), WDFW implemented a reduced monitoring approach to generate in-season creel estimates compared to the *Full Murthy Estimate Design* described in **Section 1**. For this scaled-back approach, hereafter termed “*Reduced Murthy Estimate Design*,” we apply the Murthy estimator method (Murthy 1957, Cochran 1977) as documented in **Section 1** above, except that we provide in-season catch estimates based on a reduced dockside-sampling component (i.e., fewer sites and days sampled; see below for details). WDFW has implemented this approach in recent years in order to achieve sampling design efficiencies agreed-to between the State and Tribes at North of Falcon (e.g., WDFW and NWIFC 2009). With the exception of reducing the dockside sampling frequency as detailed below, all other methods documented in **Section 1** for the *Full Murthy Estimate Design* also apply to the *Reduced Murthy Estimate Design*.

The *Reduced Murthy Estimate Design* incorporates comprehensive and complementary data collection strategies, including: 1) dockside-based angler interviews and catch sampling; 2) on-the-water total (instantaneous) effort surveys; 3) test fishing (in select areas; see **Appendix A**); and 4) voluntary reports of completed trips provided by private anglers and charter boat operators (**Figure 11**). With the reduced design, we are able to achieve sampling efficiencies while still producing in-season creel estimates (albeit at reduced precision levels compared to the full design) of the following critical parameters needed for evaluating mark-selective Chinook fisheries: *i*) the mark rate of the targeted Chinook population, *ii*) the total number of Chinook salmon harvested (by size [legal or sublegal] and mark-status [marked or unmarked] group), *iii*) the total number of Chinook salmon released (by size and mark-status group), *iv*) the coded-wire tag- (CWT) and/or DNA-based stock composition of marked and unmarked Chinook mortalities, and *v*) the total mortality of marked and unmarked double index tag (DIT) CWT stocks. To ensure that long-term fishery sampling targets are not compromised, the *Reduced Murthy Estimate Design* approach is accompanied by a high level of opportunistic *Baseline Sampling* (see **Section 4** for details).

Procedures for conducting sampling activities such as dockside angler interviews with catch sampling, recovering coded-wire tag (CWT) recoveries, on-water effort surveys, test fishing, voluntary trip reports (VTR), and estimation procedures for critical data parameters are identical to the methods documented in **Section 1** above. Thus, in the following section, we highlight the methods that are particular to the *Reduced Murthy Estimation Design*.

Dockside Sampling: Strata and Shifts

We collect data on total catch (observed harvest and reported releases⁸) and total angling effort using a two-stage stratified cluster sample design based on Murthy's population-total estimator (Murthy 1957, Cochran 1977). For the *Reduced Murthy Estimate Design*, at the first stage, we randomly select $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two-week interval. We also randomly select $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling. On each selected sample day, we select two access points (i.e., public ramps, boathouses, etc.) from the area for creel sampling. Access site (i.e., cluster) selection is achieved at the second stage using a probability-proportional-to-size (PPS) sampling algorithm (the Yates-Grundy or "natural" method, Cochran 1977). The measure of size used in PPS sampling is equivalent to the fraction of total sample-frame effort attributed to a given site; this quantity is estimated using data collected during instantaneous on-the-water surveys (i.e., "boat surveys") conducted routinely during the course of the fishery.

Before the start of the fishery, we determine our access-site sample frame based on a compilation of all known, publicly accessible (i.e., "sampleable"), and moderate-to-high effort boat-launch facilities present in the area. The table in **Appendix E** lists the sampled sites included in our sample frame for each area and season. Given that some effort is excluded from our sample frame (i.e., private and/or low-effort access sites), we also estimate the out-of-frame effort proportion from boat survey data (see *Boat Surveys* in **Section 1** above) and account for this quantity in estimates of fishery-wide totals (e.g., catch and effort).

Catch and Effort Estimation

By combining dockside interview data with estimated size measures, we generate daily estimates (and variances) of total fishing effort and landed Chinook catch (by mark-status group) for our sample frame using Murthy's population-total estimator (Murthy 1957, Cochran 1977; see **Section 1** for equations and other details). We then expand these estimates to account for the out-of-frame effort proportion and then again to obtain stratum-wide totals.

To generate weekly catch and effort estimates, the four-day "weekday stratum" estimate for Monday-Thursday of each week (based on $n=2$ days sampled out of $N=8$ available weekdays per two-week period) is added to the "weekend stratum" (Friday-Sunday) estimate for the particular week (based on $n=2$ days sampled out of $N=3$ available weekend days per week). The eight-day weekday estimates for each two-week period are then split evenly between individual weeks in the two-week block to enable weekly estimates, with variances computed using the $n=2$ days sampled out of $N=8$ available weekdays in the appropriate variance equation (see **Section 1**, *Catch and Effort Estimation*, for the Murthy estimator and variance equations).

⁸ In a 2008 evaluation of bias in mark-selective fishery parameter estimates, Conrad and McHugh (2008) concluded that angler recall errors likely cause bias in interview-based estimates of total salmon *releases*. In their evaluation, Conrad and McHugh recommended a bias-corrected "Method 2" approach for estimating Chinook encounters (and releases). Technical representatives from the State and Treaty Tribes agreed to Conrad and McHugh's recommended approach in August 2008; thus, we focus exclusively on this bias-corrected approach in our methods documentation herein.

Estimating Chinook Encounters and Impacts

Methods for estimating Chinook encounters and mortalities encounters by size class (legal, sublegal) and mark group (marked, unmarked) using the bias-corrected Conrad and McHugh (2008) approach are the same as described in **Section 1** and in **Appendix B**. Further, methods for estimating the total number of unmarked and coded-wire tagged (CWT) Chinook mortalities (i.e., using analysis of double index tag [DIT] groups) are identical to those described in **Section 1** (under *CWT Impacts*).

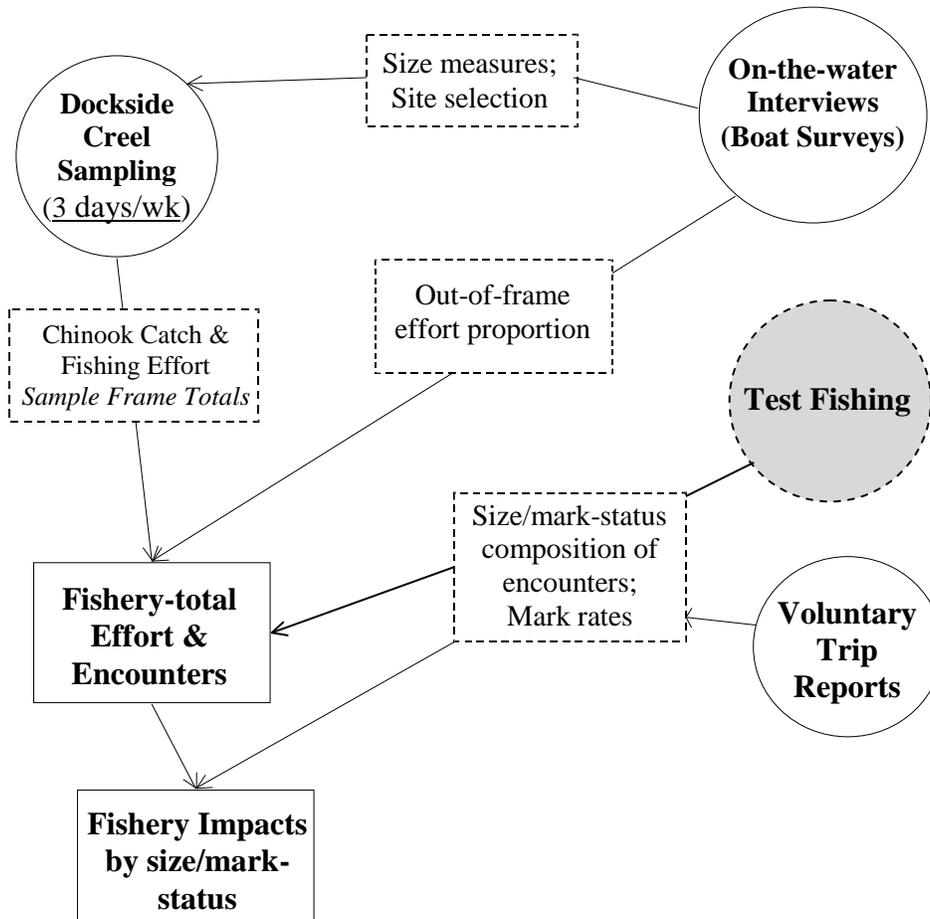


Figure 11. Conceptual diagram of the monitoring plan implemented during pilot mark-selective Chinook fisheries in Puget Sound Marine Catch Areas in which we applied the Reduced Murthy Estimate Design (see table, **Appendix A**). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon. The grey-filled, dashed circle around the *Test Fishing* component indicates that the test fishing activity may or may not be included in the *Reduced Murthy Estimate* monitoring plan, depending on the particular area and season being sampled (see **Appendix A**).

3. Aerial-Access Design

Overview

WDFW has applied the *Aerial-Access Design* to monitor the Areas 7 and 9 winter mark-selective Chinook fisheries, starting in the 2008 winter mark-selective Chinook season and continuing thereafter (**Appendix A**). Our overall sampling program for the Areas 7 and 9 winter fisheries has incorporated comprehensive and complementary data collection strategies, including dockside angler interviews (with catch sampling), aerial effort surveys, test-fishery-based sampling, and voluntary reports (VTR) of completed trips provided by charter anglers, private anglers, and derby participants (**Figure 12**).

We determined that the aerial-access approach was the most suitable design for surveying large geographic areas such as Areas 7 and 9 during the winter time. The *Aerial-Access Design* incorporates aerial survey-based total effort counts rather than on-the-water surveys (i.e., as implemented for the Murthy estimator method in **Section 1** above; Murthy 1957, Cochran 1977) to assess proportions of angler effort originating from access sites in the fishery, including the sites in our sample frame as well as those outside of our frame. Due to the expansive area and complex geography characterizing Areas 7 and 9, and because of anticipated adverse conditions on the water during the winter time, we determined that our usual boat-based approach for assessing proportions of effort from different access sites would be riskier (to both the success of the study and safety of field personnel) and far more costly than the aerial-based design described below.

In the following section, we detail the methods specific to the *Aerial-Access Design* as implemented in the Areas 7 and 9 winter mark-selective Chinook fisheries since winter 2008. Methods for several of the sampling activities implemented during the Areas 7 and 9 winter selective fisheries are identical to procedures already described above in **Section 1**. These include protocols for dockside angler interviews with catch sampling, test fishing, and our efforts to distribute and collect voluntary trip reports (VTRs). Additionally, methods for estimating Chinook encounters and mortalities due to the Areas 7 and 9 winter fisheries are the same as described in **Section 1** and in **Appendix B**. Also, methods for estimating the total number unmarked and coded-wire tagged (CWT'd) Chinook mortalities due to the Areas 7 and 9 winter selective fisheries (i.e., using analysis of double index tag [DIT] groups) are identical to those described in **Section 1** (under *CWT Impacts*).

Thus, in the following section we focus on describing the methods that are unique to the *Aerial-Access Design* implemented in Areas 7 and 9 during the winter time, including the dockside sampling site frame and shifts, conducting aerial surveys, estimating the sample fraction (**Appendix C**) and producing fishery-total estimates of retained catch and effort, as well as specific approaches used for charter boat and derby sampling.

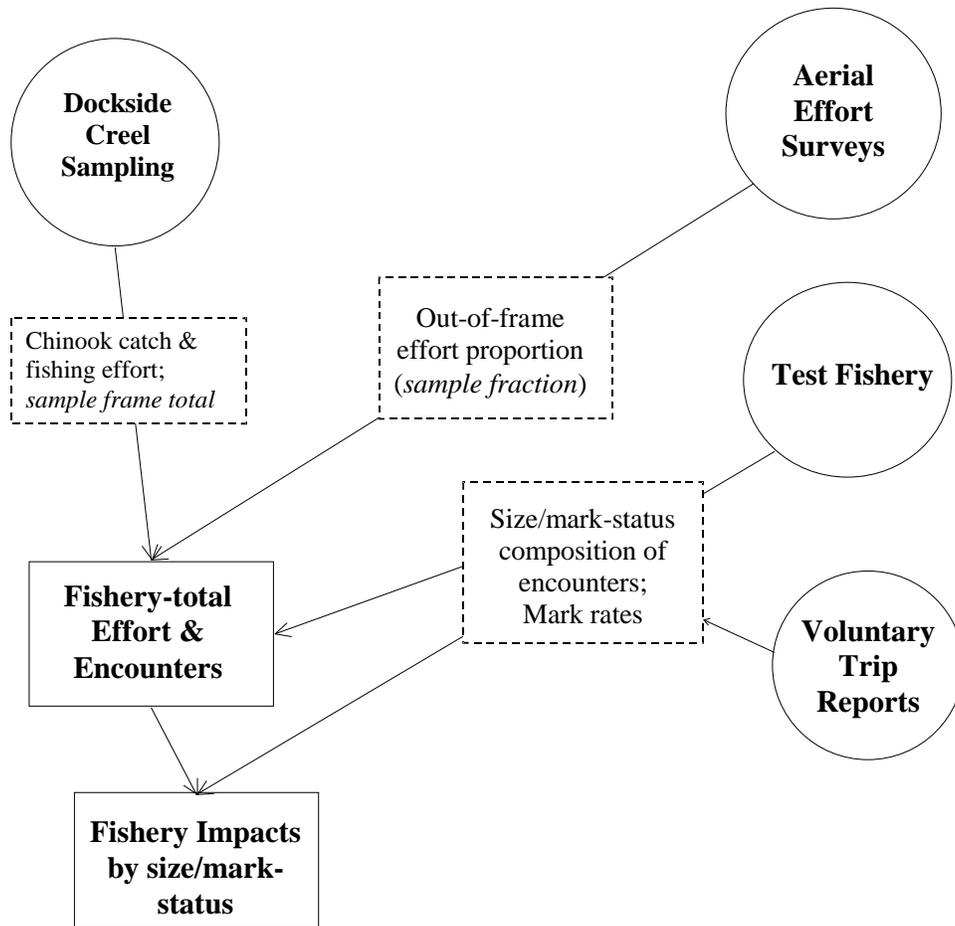


Figure 12. Conceptual diagram of the monitoring plan implemented in the Areas 7 and 9 winter mark-selective Chinook fisheries, starting in winter 2008 (**Appendix A**). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon.

Catch and Effort: Sampling and Estimation

We collect data on total catch (observed harvest and reported releases⁹) and total angling effort using an aerial-access design (e.g., Volstad et al. 2006) whereby: 1) catch and effort data are obtained by interviewing *all* anglers departing the fishery at four access sites that were staffed on randomly selected sample days (within Monday-Thursday and Friday-Sunday strata); 2) the fraction of total fishing effort contained in our sample frame is estimated from paired peak activity counts (i.e., boats) for sample frame sites and peak aerial boat counts (i.e., for all of Areas 7 and 9) on days when both dockside sampling and aerial surveys were possible; and 3) total catch and effort estimates are obtained for all sample days by expanding sample-frame observations by the estimated sample fraction.

⁹ In a 2008 evaluation of bias in mark-selective fishery parameter estimates, Conrad and McHugh (2008) concluded that angler recall errors likely cause bias in interview-based estimates of total salmon releases. In their evaluation, Conrad and McHugh recommended a bias-corrected “Method 2” approach for estimating Chinook encounters (and releases). Technical representatives from the State and Treaty Tribes agreed to Conrad and McHugh’s recommended approach in August 2008; thus, we focus exclusively on this bias-corrected approach in our methods documentation herein.

Dockside Sampling

We collect data on total catch and total angling effort using a two-stage stratified sample design. At the first stage, we randomly select sample days each week from two temporal strata -- weekday (Monday-Thursday) and weekend (Friday-Sunday) periods. For the 2008 and 2009 winter mark-selective Chinook fisheries in Areas 7 and 9 (see table, **Appendix A**), we selected five sample days from two temporal strata (weekday [Monday-Thursday], with $n = 2$ days randomly sampled; weekend [Friday-Sunday], with each day always being sampled) during each week of the Areas 7 and 9 fisheries.

However, beginning with the winter 2009-10 mark-selective Chinook season and continuing thereafter, the frequency of sampling days within weekday (Monday-Thursday) and weekend (Friday-Sunday) strata has been scaled back in Areas 7 and 9 to accommodate sampling efficiencies as agreed to in our state-tribal monitoring plans. To achieve the reduced frequency (while still producing in-season biweekly creel estimates, albeit with reduced precision), we randomly select $n=2$ out of $N=8$ possible weekday stratum days (Monday-Thursday) for sampling in each two week interval. We also randomly select $n=2$ out of $N=3$ possible weekend stratum days (Friday-Sunday) each week for sampling.

On selected sample days, we staff access sites in our sample frame (i.e., public ramps, boathouses, etc.) for creel sampling. In Area 7, our dockside sample frame includes four moderate-to-high effort, public boat launch facilities used to access Area 7 (these are fixed sites throughout the season for the aerial-access design), including Bellingham, Cornet, and Washington Park ramps and Friday Harbor marina. Similarly, in Area 9, our dockside sample frame includes four fixed sites that are moderate-to-high-effort public boat ramps, including Everett Public Ramp, Edmonds Dry Stack, Kingston Ramp, and Port Townsend Boat Haven Ramp (**Appendix E**).

In contrast to the approach we have used in other marine areas (i.e., $n = 2$ sites are randomly [non-uniform probabilities based on-the-water interviews] chosen from a sample frame; see **Section 1** and **Section 2** above), for the aerial-access design we staff *all* four sites in each area on scheduled sample days. We visit all sample sites on scheduled sample days so that we can maximize our sample size and minimize the degree of expansion required to obtain fishery-wide estimates of catch, effort, and angler-reported releases. Finally, given that some effort is excluded from our sample frame (i.e., private and/or low-effort access sites), we estimate sample frame coverage from aerial overflight data and account for this quantity in estimates of fishery-wide totals (see below and **Appendix C**).

At access sites selected for sampling on scheduled sample days, samplers interview *all* parties (from both fishing and non-fishing vessels) exiting the Area 7 and Area 9 fisheries. During interviews, samplers acquire data on trip duration (time of start, time of finish), trip intent (i.e., targeted species), fishing method(s) employed (downrigger or diver trolling, jigging, mooching, or other), and fish encountered (kept and/or released, by species). When an interviewed party possesses Chinook or coho salmon, samplers inspect them for CWTs using wand detectors, and collect snouts from CWT-positive individuals for later lab processing. Additionally, samplers take length measurements (fork and total) and collect scale samples from landed Chinook.

Aerial Surveys

Due to the vast size and complex geography of Area 7 and Area 9, we use an aerial overflight approach in each area to estimate total fishery effort and thus the proportion of effort captured in the four-site sample frame in each area (i.e., the sample fraction [$f = 1 - \text{the out-of-frame effort prop}^n$]). Surveys are conducted on a subset ($n =$ a minimum target of approximately 5 per month) of scheduled (i.e., dockside) sample days and are timed to coincide with the assumed period of peak activity for winter fisheries (1000-1400). Trained WDFW staff conduct the surveys from fixed-wing aircraft piloted by WDFW-enforcement or chartered personnel.

For each aerial survey, samplers (aerial observers) circumnavigate the entirety of Areas 7 and 9, counting all recreational vessels observed while marking them on a map form. Aerial observers make no attempt to distinguish recreational boats as being either fishing or non-fishing vessels; however, obvious non-fishing vessels such as sail boats, commercial crabbing vessels, etc., are noted as such on forms and omitted from final counts. On average, flights take 1.25 hours over Area 7 and 0.5 hours over Area 9 and are flown at an elevation of 1,000 ft (305 m).

Sample Fraction and Fishery-Total Estimates

For each flight, we estimate the sample fraction, f , by pairing the aerial total boat count with the sample-frame total for boats active during the flight period (i.e., determined from interview details). We then obtain stratum-specific estimates of the mean sample fraction (and its variance) and use these values to obtain stratum- and fishery-total estimates of angling effort and landed catch (**Table 1**). The estimators (totals and variances) associated with this complemented aerial-access approach are provided in **Appendix C**.

Estimating Chinook Encounters

To minimize the influence of recall bias on our assessment, we estimate Chinook releases as the difference between estimated catch (i.e., based on *observed* landings) and total Chinook encounters (i.e., releases = encounters – retained catch) generated using the bias-corrected Conrad and McHugh (2008) approach. Briefly, encounters are estimated by dividing the creel estimate of legal-marked Chinook harvest by a field estimate (based on test fishery and/or VTR encounters data) of the proportion of the fishable Chinook population that is of legal size and marked (i.e., our former “Method 2” approach; e.g., WDFW 2007a). Given that this approach yields negatively biased estimates if anglers release any of the legal-marked Chinook they encounter, Conrad and McHugh estimated a “correction” factor to account for this phenomenon and incorporated it into their estimator. See **Appendix B** for complete computational details.

Assumptions

For the aerial-access design to yield unbiased estimates of catch and effort, a number of assumptions must be met. First, key assumptions for this design that are similar to the Murthy design (Murthy 1957, Cochran 1977) described in **Section 1** include:

- Catch per unit of effort (e.g., retained Chinook per angler trip) does not differ between sites in the sample frame and those sites outside of the sample frame.
- All anglers are interviewed and accurately report catch and encounters.

Second, by adding the aerial-access based sampling fraction to our calculations, we also assumed the following:

- The relative proportion of effort originating from sites within and outside of our sample frame does not differ between fair weather (i.e., when flight is possible) and poor weather days (i.e., when aerial surveys cannot be conducted).
- All boats that are actively fishing are accurately counted (e.g., boats are neither missed nor double counted).
- Boat ingress and egress rates are equal.
- Anglers accurately report their periods of fishing activity.
- The relative proportion of effort originating sites in our sample frame and out-of-frame sites does not differ between weekday and weekend days.

Derby Sampling

Area 7

We employ extra measures to acquire catch (harvest and releases) and effort data for the Area 7 Chinook salmon derbies, including the “Texas Hold ‘Em Derby” (typically first weekend in December), the “Roche Harbor Salmon Classic Invitational Derby” (first weekend in February), and the “Anacortes Derby” (last weekend in March). With the cooperation of derby staff and participating anglers, we attempt to acquire information on catch and effort using derby-specific VTR forms. Also, WDFW personnel staff the derbies to encourage VTR completion as well as to collect biological data (lengths, scales, and coded-wire tags) from landed Chinook.

In some Area 7 winter seasons, there has been a low VTR return rate from derby participants and we could not reliably census total Chinook encounters (retained *and* released) based on VTR returns. Nevertheless, we obtained length and scale samples from the majority of landed (weighed) Chinook in the derby, and derby organizers provided information on total angler trips, boats, and numbers of harvested Chinook. To estimate total Chinook releases (and associated variances) in each Area 7 derby, we applied the Conrad and McHugh (2008) approach (see **Appendix B** for computational details), the same method used to estimate Chinook releases for the private-boat fleet in Area 7.

Charter Boats

We include charter vessels in our aerial-access creel estimates for the Areas 7 and 9 winter mark-selective Chinook fisheries. This practice began due to logistical and estimation difficulties of separating charter and private fleet approaches, and after determining through a bias evaluation (McHugh 2009; see **Table 2**) that combining charter and private fleet data in the aerial-access estimates would not significantly compromise estimate integrity for the Areas 7 and 9 winter selective fisheries (see *Charter vs. Fleet Breakout* in **Section 1** above). The combination of charter effort proportions (very small) and CPUE ratios (relatively high) in these areas suggests that pooling causes negligible (<3%) bias (McHugh 2009).

4. Baseline Sampling Design

Overview

The WDFW Puget Sound Sampling Unit (PSSU) implements the *Baseline Sampling* design to monitor all recreational finfish fisheries in the Marine Catch Areas of Puget Sound (Areas 5-13) on a year-round basis, and to monitor shorter-term mark-selective Chinook fisheries (MSFs) such as the summer Chinook MSF in Area 6 (July 1 – mid-August) and Area 13 (May 1-September 30), as well as the winter Chinook MSF in Area 12 (February 1-April 30) (**Appendix A**). Data collection activities focus on conducting dockside angler interviews (with catch sampling) and distributing/collecting voluntary trip reports (VTR) provided by private anglers. From these data we estimate catch rates (i.e., catch per unit effort, CPUE), mark rates (based on VTRs), and landed-catch composition (age, length, and CWT). Additionally, we summarize relative catch and effort patterns over each season based on the assumption that Baseline-sampling observations of these parameters are good indicators of associated fishery-wide trends.

When both Baseline Sampling and “Intensive” studies (i.e., in-season creel estimate studies documented in **Sections 1-3** above) occur simultaneously in a particular marine area, however, the latter subsumes the former sampling approach when scheduled days and sites overlap (i.e., their spatial and temporal sample frames are not mutually exclusive). Thus, as a discrete sampling activity, Baseline Sampling occurs at a reduced level during Intensive study periods.

In contrast to the intensive survey designs employed in some mark-selective Chinook areas (see **Sections 1-3** and **Appendix A**), Baseline Sampling results cannot be used to produce in-season (or immediately post-season) fishery-total estimates of effort, encounters (retained catch + releases), and unmarked double index tagged (DIT) Chinook impacts. It should be noted, however, that marine areas with baseline sampling observations will ultimately (approximately one year from the close of the fishery) be incorporated into WDFW’s Catch Record Card (CRC) system to estimate catch and effort at the fishery-total level.

Baseline Sampling procedures for conducting dockside angler interviews and the VTR program, including all data parameters collected, are identical at the elemental level to the methods described in detail in **Section 1** above for the Full Murthy Estimate Design (see *Dockside Interview Procedures* and *Voluntary Trip Reports* in **Section 1**). Thus, in this *Baseline Sampling* section, we highlight the methods and estimation approaches particular to the Baseline design.

Dockside Sampling

To acquire catch, effort and biological data using the Baseline Sampling design, WDFW samplers conduct angler interviews at selected access sites in each Marine Catch Area of Puget Sound. Baseline sampling is opportunistic in nature, with overall sampling effort allocated across space and time in a manner that maximizes the number of angler interviews obtained per sample effort. Site visits ranged from short (e.g., “no effort” samples) to full-day sampling events. When present, samplers interview all (or nearly so) anglers exiting the fishery at the selected access site. The interview and catch-sampling procedures employed in these areas are identical to those used in the intensively-monitored Chinook mark-selective fisheries with in-season catch estimates (see **Sections 1-3** above). Thus, samplers acquire information about: 1)

angling effort (boat and angler trips, trip length), 2) encounters composition (retained and/or released) by species and mark status (marked versus unmarked, Chinook and coho salmon only), and 3) landed Chinook size (fork and total length) and age (scales are collected and ultimately read) composition. Samplers also inspect landed Chinook and coho salmon for CWTs using wand detectors and acquire snouts when CWTs are present; resulting tag data are used to estimate the CWT-based composition (unexpanded) of landed catch.

Baseline Survey: Sampling Sites and Shifts

In terms of day-to-day coverage, Baseline Sampling is conducted every Friday, Saturday, and Sunday, and on either two or all weekdays (i.e., between Monday and Thursday) depending on the marine area in question. On a given sampling day, one to four access sites may be staffed in a given area, with the greatest site coverage typically occurring from Friday to Monday. Sites are selected based on the anticipated distribution of angling effort among sampleable sites (i.e., sample frames theoretically include all publically accessible access sites) on any given sample day, with high effort sites being visited most frequently. In contrast to the sample frames used during Intensive studies (see **Sections 1-3** above), low-effort and/or shore/pier access sites can be selected for Baseline Sampling on occasion. Also, Baseline site selections are adaptive and samplers therefore may re-locate to a different location on a scheduled day if the originally chosen site lacks angling effort; samplers may also make “spot checks” of activity levels at one or more low-effort sites when traveling to/from scheduled sites.

When conducting a Baseline survey, samplers interview anglers at selected sites during eight- to ten-hour shifts. In the summer, Baseline shifts are timed to capture the peak period of trip completion¹⁰; in the winter, shifts capture nearly 100% of a given day’s effort. Finally, samplers attempt to interview as many anglers at a site as possible, regardless of their apparent success, target species, fishing mode, or other factors. When angler presence exceeds a sampler’s capacity, samplers interview a subsample of parties. When sub-sampling, samplers are instructed to be random in their selection of subjects.

Voluntary Trip Reports

For the Baseline design, as with the Intensive sampling designs presented in **Sections 1-3** above, we employ an expanded Voluntary Trip Report (VTR) program to obtain estimates of Chinook encounter rates by size class (legal or sub-legal) and mark status (ad-marked or unmarked), similar to our approach used successfully in a number of fisheries since summer 2008 (WDFW 2009a). WDFW samplers work closely with the angling public in each Marine Catch Area to distribute (particularly as boats launch) and collect (i.e., as boats exit the fishery) large quantities of VTR forms at our sampling sites. In addition, in recent years we have taken several measures to help expand and increase the success of our VTR program. First, we developed a simplified, user-friendly form and assigned a dedicated sampler the duty of distributing forms to every possible angling party at the start of their trip (i.e., to recruit participants on site). The VTR samplers focus their attention on high-use access sites only and begin their shifts early (typically 0500 hours) in order to intercept as many anglers as possible. Additionally, samplers provide participants with a brochure describing the intent of VTRs and their significance to fishery monitoring, and answer VTR-related questions. To increase the response rate, participants are

¹⁰ In marine areas where activity is influenced by tidal cycles, Baseline shift start and end times are typically adjusted to capture the period peak trip completion.

given three options for returning completed VTRs to WDFW: hand-delivering them to samplers, placing them in on-site drop boxes, or sending them via U.S. mail (pre-paid); if the anglers are unsuccessful (i.e., no encounters occurred [harvested *or* released]) on their trip, participants are encouraged to keep their forms for future trips.

Estimating Chinook Encounters and Impacts

While the Baseline Sampling approach does not provide a means for generating in- or immediately post-season estimates of *fishery total* catch and effort, the observed catch per angler trip and species composition data obtained from baseline sampling are combined with Catch Record Card (CRC) data to produce the fishery-total estimates at a later time (approximately one year following the fishery). Once the post-season CRC-based retained Chinook estimates are available for a particular area's Chinook MSF season, we can then apply the proportion of legal-marked Chinook obtained from VTRs in the area to the CRC-based retained Chinook estimate, enabling an estimate of total Chinook encounters by size/mark status (LM, LU, SM, and SU) and associated mortalities using Conrad and McHugh's (2008) bias-corrected method (see details of computational steps in **Appendix B**).

Total-fishery CWT Impacts

Once the post-season CRC-based retained Chinook estimates are available for a particular area's Chinook MSF season, we can calculate the sample rate for the fishery, which we need in order to apply the methods described above (*CWT Impacts*, **Section 1**) to estimate the total number of unmarked-tagged Chinook mortalities that may have occurred during the course of the mark-selective Chinook season. We then acquire information for all marked CWT double index tag (DIT) groups present in landed catch from the Pacific States Marine Fisheries Commission's Regional Mark Information System (RMIS) and then apply the methods described by the Selective Fisheries Evaluation Committee–Analysis Work Group (SFEC-AWG 2002) to estimate the number of unmarked DIT fish encountered. We subsequently estimate the number of these fish that may have died due to hook-and-release impacts using an *sfm* analogous to that used in FRAM modeling. Given our interest in characterizing the impacts of mark-selective regulations on the CWT program and not recreational fishing in general, we use an *sfm* of 10% in all unmarked-DIT mortality calculations. We use 10% instead of 15% (applied to legal-sized releases) since unseen drop-off mortality (the 5% differential) is a feature common to selective and non-selective recreational Chinook fisheries.

For each mark-selective Chinook fishery, we estimate Chinook encounters and mortalities for each recovered DIT individually and then sum estimates for each hatchery, brood year, and area based on the methods described by SFEC-AWG 2002. The methods and equations used for these estimation steps are shown in **Section 1** above.

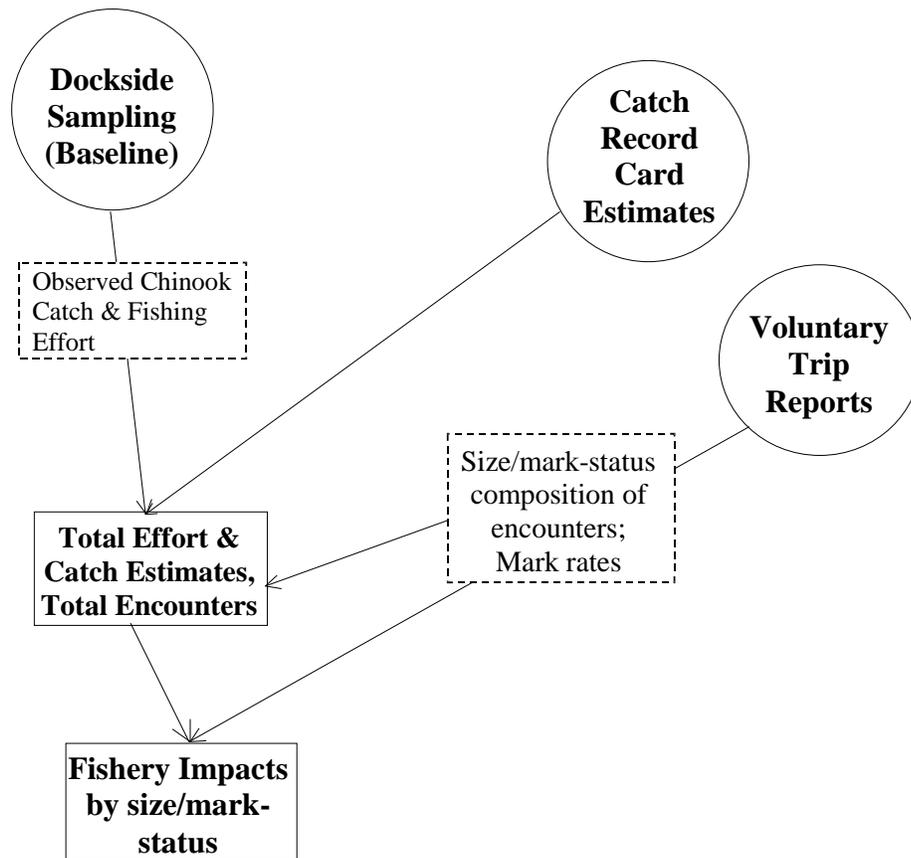


Figure 13. Conceptual diagram of the monitoring plan for *Baseline Sampling* of mark-selective Chinook fisheries (also, see **Appendix A**). Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. ‘Encounters’ includes both harvested and released Chinook salmon.

ACKNOWLEDGEMENTS

This Methods Report is the result of the dedicated efforts of several individuals. First, we thank the WDFW Puget Sound Sampling Unit field supervisors and their staff, whose efforts and expertise have been critical to the success of evaluating recreational mark-selective Chinook fisheries in Puget Sound marine areas. These staff have conducted the dockside creel surveys, test fishery sampling, on-the-water effort surveys, aerial surveys, the voluntary trip report program, angler education, as well as compiled, error-checked, and delivered high-quality monitoring data to enable mark-selective fishery evaluations. In particular, from Central Sound, we thank Slim Simpson (Central Sound Sampling Supervisor), Jeff McKee, Kathy Young-Berg, Sue Kraemer, Pete Sergeeff, Toby Black, Courtney Adkins, Jim Pykonen, Mike Petronelli, as well as the seasonal sampling crews in Central Puget Sound. From the Strait of Juan de Fuca/Peninsula area, we thank Larry Bennett (Peninsula Sampling Supervisor), Connie Warren, Jessica Slipper, Jaron Sikes, Raese Reeves, Ken Wall, as well as the seasonal sampling staff in Sekiu, Port Angeles, and Port Townsend. From North Sound, we thank Steve Axtell (North Sampling Supervisor), Al Esparza, Marcus Thompson, Dean Toba, Patrick Morrison, Lynn Stricker, Mary Mureau, Jim Repoz, Angela Foster, Alan (Skeeter) Lowe, Nathan Layman, Chad Paul, Phil Colwell, and the seasonal sampling staff in the north. From South Sound as well as Hood Canal and the Kitsap Peninsula, we thank Dan O'Brien (South Sound Supervisor), Justin Terry, John Moore, Tom Mathews, Paul Lorenz, Scott Walker, Cara Crowley, Mike Elam, Karen Shields, Mary Raymond, Tiffany Henderson, Katrina Outland, Bryan Blazer, Lea Ronne, Dave Parrao, John Rohr, and the South Sound seasonal sampling crew. Additionally, we thank WDFW pilots Marty Kimbrel, Jim Hodgson, and Kevin Nelsen and samplers Mark Baltzell, Chris Moran, Ellie Heikilla, Brant Boelts, Lee Dyer, and Brianna Murphy for their time in surveying Areas 7 and 9 from the sky.

At the WDFW Headquarters in Olympia, we thank both Lance Campbell and John Sneva for their scale-reading expertise. We also thank Gil Lensegrav and the CWT Lab staff for their help and expertise in providing decoded CWT data. Also at the Olympia Headquarters office, Lee Dyer provides substantial help with personnel logistics and support services for mark-selective fishery sampling projects. Mark Baltzell provides timely in-season creel estimates, schedules all boat surveys and aerial surveys, and produces post-season analyses and reports. Karen Kloempken manages the WDFW sampling databases and provides finalized post-season data. Are Strom has completed "R" programming updates and database development to enable efficient analyses of selective fishery data and produce tables and figures our post-season selective fishery reports. WDFW biometrician Kris Ryding has provided helpful consultations on our study designs and estimation approaches. Also, WDFW leaders in salmon policy and fish management such as Pat Pattillo, Jim Scott, John Long, Doug Milward, and Steve Thiesfeld, have provided tremendously helpful input and guidance over the years.

Finally, we extend a special thanks to Robert Conrad of Northwest Indian Fisheries Commission (NWIFC) for his dedicated efforts and expertise in working with us to develop and refine mark-selective fishery estimation methods. We have appreciated his thorough reviews of our annual mark-selective Chinook fishery reports and multi-year reports, and his constructive comments and helpful suggestions have improved our reports immensely. We also thank NWIFC biometrician Marianna Alexandersdottir for her helpful reviews and valuable guidance regarding sampling design and estimation methods, reporting efficiencies, and new opportunities to plan a collaborative online database that will better enable information sharing. Additionally, we thank the tribal representatives and technical experts who have worked with us over the years, particularly Craig Bowhay, Kit Rawson, Bob Hayman, Scott Chitwood, Hap Leon, Rebecca Bernard, and others who have contributed valuable reviews and suggestions regarding our mark-selective fishery sampling methods and reports.

REFERENCES

- Cochran, W.G. 1977. *Sampling Techniques* (third edition). John Wiley and Sons. New York.
- Conrad, R.H. and M. Alexandersdottir. 1993. Estimating the harvest of salmon by the marine sport fishery in Puget Sound: evaluation and recommendations. Northwest Fishery Resource Bulletin 1.
- Conrad, R., and P. McHugh. 2008. Assessment of Two Methods for Estimating Total Chinook Salmon Encounters in Puget Sound/Strait of Juan de Fuca Mark-Selective Chinook Fisheries. Northwest Fishery Resource Bulletin Manuscript Series No. 2. <http://www.nwifc.org/publications/northwest-fishery-resource-bulletin/>; <http://wdfw.wa.gov/publications/> (Selective Fishing).
- CTC (Pacific Salmon Commission-Chinook Technical Committee). 2007. Annual Report on catch, escapement, exploitation rate analysis, and model calibration of Chinook salmon under Pacific Salmon Commission jurisdiction, 2006. Report TCCHINOOK (07)-1. Vancouver, B.C., Canada. 211 pp.
- International North Pacific Fisheries Commission. 1963. International North Pacific Fisheries Commission Annual Report, 1961.
- Johnson, N., S. Kotz, and N. Balakrishnan. 1994. Continuous univariate distributions. Volume 1. John Wiley & Sons, NY, 2nd edition.
- Joint Coho DIT Analysis Workgroup. (Northwest Indian Fisheries Commission, Western Washington Treaty Tribes, and Washington Department of Fish and Wildlife). 2003. Analysis of coho salmon double index tag (DIT) data for the brood years 1995-1997. Northwest Fishery Resource Bulletin No. 12. Olympia, WA. 160 pp.
- McHugh, P. 2009. Unpublished e-mail memo to NWIFC Biometrician Robert Conrad. February 4, 2009. Washington Department of Fish and Wildlife. Olympia, Washington.
- Murthy, M.N. 1957. Ordered and unordered estimators in sampling without replacement. *Sankhya* 18:379-390.
- Northwest Treaty Tribes and the Washington Department of Fish and Wildlife. 2007. A "Pilot" Winter Blackmouth Mark-Selective Sport Fishery, Areas 8.1 & 8.2, 2007-2008. June 12, 2007.
- Pollock, K. H., C. M. Jones, and T. L. Brown (editors). 1994. Angler survey methods and their application in fisheries management. American Fisheries Society, Special Publication 25. Bethesda, Maryland.
- Puget Sound Indian Tribes and WDFW. 2004. Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component. Olympia, WA. 253 pp.
- SFEC-AWG. 2002. Pacific Salmon Commission, Joint Selective Fisheries Evaluation Committee Report, Investigation of methods to estimate mortalities of unmarked salmon in mark-selective fisheries through the use of double index tag groups. TCSFEC (02)-1, February 2002.
- Thiesfeld, S.L., and A. Hagen-Breaux. 2005a. 2003 Chinook Selective Fishery, Marine Areas 5 and 6. January 12, 2005. Washington Department of Fish and Wildlife. Olympia, Washington. <http://wdfw.wa.gov/publications/> (Selective Fishing).

- Thiesfeld, S.L., and A. Hagen-Breaux. 2005b. 2004 Chinook Selective Fishery, Marine Areas 5 and 6. January 12, 2005. Washington Department of Fish and Wildlife. Olympia, Washington. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Volstad, J.H., K.H. Pollock, and W.A. Richkus. 2006. Comparing and combining effort and catch estimates from aerial-access designs as applied to a large-scale angler survey in the Delaware River. *North American Journal of Fisheries Management* 26:727-741.
- Washington Department of Fish and Wildlife (WDFW). 2007a. Marine Areas 9 and 10 Selective Chinook Fishery, July 16-31, 2007: Post-season Report. Draft Report: October 3, 2007. Washington Department of Fish and Wildlife. Olympia, Washington. 82 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2007b. Marine Areas 11 and 13 Selective Chinook Fishery, 2007: Post-season Report. Draft Report: October 30, 2007. Washington Department of Fish and Wildlife. Olympia, Washington. 80 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2008a. A Multi-year Assessment of the Marine Areas 5 and 6 Selective Chinook Fishery: 2005-2007. Final Report Draft: March 14, 2008. Washington Department of Fish and Wildlife. Olympia, Washington. 177 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2008b. A Multi-year Assessment of the Marine Areas 8-1 and 8-2 Selective Chinook Fishery: 2005-2007. Final Report Draft: February 25, 2008. Washington Department of Fish and Wildlife. Olympia, Washington. 149 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2009a. Marine Areas 5 and 6 Mark-Selective Recreational Chinook Fishery, Summer 2008: Post-season Report. Revised Draft Report: February 17, 2009. Washington Department of Fish and Wildlife. Olympia, Washington. 64 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2009b. Marine Areas 9 and 10 Mark-Selective Recreational Chinook Fishery, July 16-August 15, 2008. Revised Draft Report: February 23, 2009. Washington Department of Fish and Wildlife. Olympia, Washington. 60 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2009c. Marine Areas 11 and 13 Mark-Selective Recreational Chinook Fishery, Summer 2008. Revised Draft Report: February 24, 2009. Washington Department of Fish and Wildlife. Olympia, Washington. 64 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2009d. Marine Areas 8-1 and 8-2 Mark-Selective Recreational Chinook Fishery, November 1, 2007-April 30 2008. Revised Draft Report: February 20, 2009. Washington Department of Fish and Wildlife. Olympia, Washington. 62 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2009e. Marine Area 7 Mark-Selective Recreational Chinook Fishery, February 1-29, 2008: Post-season Report. Revised Draft Report: February 20, 2009. Washington Department of Fish and Wildlife. Olympia, Washington. 47 pp. <http://wdfw.wa.gov/publications/> (Selective Fishing).
- Washington Department of Fish and Wildlife (WDFW). 2010a. Marine Area 7 Mark-Selective Recreational Chinook Fishery, February 1-April 15, 2009: Post-season Report. Revised

- Draft Report: June 11, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 50 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Zar, J.H. 1999. *Biostatistical Analysis* (4th Edition). Upper Saddle River, NJ. Prentice Hall.
- Washington Department of Fish and Wildlife (WDFW). 2010b. Marine Areas 8-1 and 8-2 Mark-Selective Recreational Chinook Fishery, January 1-April 30, 2009: Post-season Report. Revised Draft Report: June 14, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 62 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW). 2010c. Marine Area 9 Mark-Selective Recreational Chinook Fishery, November 1-30, 2008 and January 16-April 15, 2009: Post-season Report. Revised Draft Report: June 15, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 50 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW). 2010d. Marine Area 10 Mark-Selective Recreational Chinook Fishery, December 1, 2008–January 31, 2009, Post-season Report. Revised Draft Report: June 17, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 48 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW). 2010e. Marine Areas 11 and 13 Mark-Selective Recreational Chinook Fishery, Summer 2009: Post-season Report. Revised Draft Report: June 21, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 63 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW). 2010f. Marine Areas 9 and 10 Mark-Selective Recreational Chinook Fishery, Summer 2009: Post-season Report. Revised Draft Report: June 28, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 64 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW). 2010g. Marine Areas 5 and 6 Mark-Selective Recreational Chinook Fishery, Summer 2009: Post-season Report. Revised Draft Report: June 29, 2010. Washington Department of Fish and Wildlife. Olympia, Washington. 61 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW). 2011. 2010 Summer Mark-Selective Recreational Chinook Fisheries in Marine Areas 5, 6, 9, 10, 11, and 13: Post-season Report. Draft Report: February 28, 2011. Washington Department of Fish and Wildlife. Olympia, Washington. 88 pp. <http://wdfw.wa.gov/publications/> ([Selective Fishing](#)).
- Washington Department of Fish and Wildlife (WDFW) and Northwest Indian Fisheries Commission (NWIFC). 2009. 2009-10 Co-managers' List of Agreed Fisheries. Olympia, Washington.
- Washington Department of Fisheries and Northwest Indian Fisheries Commission. 1992. Puget Sound salmon sport catch estimation study-1990. Joint report prepared by: Washington Department of Fisheries, Puget Sound Treaty Indian Tribes, and Northwest Indian Fisheries Commission, May 1992.

APPENDICES

Appendix A. History of *Intensive* (i.e., creel estimates for special studies) versus *Baseline* Sampling in Puget Sound/Strait of Juan de Fuca Marine Catch Areas, showing mark-selective fishery seasons and sampling designs by calendar year, 2003-2010.

CRC Area	Sub-Area	Monitoring Intensity	Mark-selective fishery (MSF) Dates & Sampling Design	Date Range(s) of Intensive Creel Est. Studies and Fisheries (Grey = No Intensive Sampling Occurred), by Calendar Year								
				2003	2004	2005	2006	2007	2008	2009	2010	
5	n/a	Intensive	Chinook MSF Period	Jul. 5-Aug. 3	Jul. 1-Aug. 8	Jul. 1-Aug. 10	Jul. 1-Aug. 21	Jul. 1-Aug. 9	Jul. 1-Aug. 9	Jul. 1-Aug. 6	Jul. 1-Aug. 15	
			Coho MSF Period	Jul. 5-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 15	Jul. 1-Sept. 15	Jul. 1-Sept. 18	Jul. 1-Sept. 15	
			Intensive Sampling Period	Jul. 5-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 15	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	
		Sampling Design & Components	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Reduced design creel estimate, boat surveys, test fishing, expanded VTR's.	Reduced design creel estimate, boat surveys, expanded VTR's.	Reduced design creel estimate, boat surveys, expanded VTR's.		
		Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	
6	W. of Ediz Hook	Intensive	Chinook MSF Period	Jul. 5-Aug. 3	Jul. 1-Aug. 8	Jul. 1-Aug. 10	Jul. 1-Aug. 21	Jul. 1-Aug. 9	Jul. 1-Aug. 9	Jul. 1-Aug. 6	Jul. 1-Aug. 15	
			Coho MSF Period	Jul. 5-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	
			Intensive Sampling Period	Jul. 5-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	Jul. 1-Sept. 30	--	--	--	
		Sampling Design & Components	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.		
			Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
			E. of Ediz Hook		--	--	--	--	--	--	--	--
		Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	
7	n/a	Intensive	Intensive Sampling Period, Chinook MSF	--	--	--	--	--	Feb. 1-29	Feb. 1-Apr. 15 Dec. 1-Dec. 31	Jan. 1-Apr. 30 Dec. 1-Dec. 31	

CRC Area	Sub-Area	Monitoring Intensity	Mark-selective fishery (MSF) Dates & Sampling Design	Date Range(s) of Intensive Creel Est. Studies and Fisheries (Grey = No Intensive Sampling Occurred), by Calendar Year							
				2003	2004	2005	2006	2007	2008	2009	2010
			Sampling Design & Components	--	--	--	--	--	Aerial design creel estimate, aerial surveys, test fishing, VTR's.	Aerial design creel estimate, aerial surveys, test fishing, VTR's.	Aerial design creel estimate, aerial surveys, test fishing, VTR's.
		Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
8-1	n/a	Intensive	Intensive Sampling Period, Chinook MSF	--	--	Oct. 1-Dec. 31	Jan. 1-Apr. 30; Oct. 1-Dec. 31	Jan. 1-Apr. 30; Nov. 1-Dec. 31	Jan. 1-Apr. 30	Jan. 1-Apr. 30; Nov. 1-Dec. 31	Jan. 1-Apr. 30; Nov. 1-Dec. 31
			Sampling Design & Components	--	--	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Jan-Apr: Full creel estimate, boat surveys, test fishing (share boat w/ 8-2), VTR's. Nov-Dec: Reduced design creel estimate, boat surveys, expanded VTR's.	Reduced design creel estimate, boat surveys, expanded VTR's.
		Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
8-2	n/a	Intensive	Intensive Sampling Period, Chinook MSF	--	--	Oct. 1-Dec. 31	Jan. 1-Apr. 30; Oct. 1-Dec. 31	Jan. 1-Apr. 30; Nov. 1-Dec. 31	Jan. 1-Apr. 30	Jan. 1-Apr. 30; Nov. 1-Dec. 31	Jan. 1-Apr. 30; Nov. 1-Dec. 31
			Sampling Design & Components	--	--	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Jan-Apr: Full creel estimate, boat surveys, test fishing (share boat w/ 8-1), VTR's. Nov-Dec: Reduced design creel estimate, boat surveys, expanded VTR's.	Reduced design creel estimate, boat surveys, expanded VTR's.
		Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round

CRC Area	Sub-Area	Monitoring Intensity	Mark-selective fishery (MSF) Dates & Sampling Design	Date Range(s) of Intensive Creel Est. Studies and Fisheries (Grey = No Intensive Sampling Occurred), by Calendar Year							
				2003	2004	2005	2006	2007	2008	2009	2010
9	n/a	Intensive	Intensive Sampling Period, Chinook MSF	---	---	---	---	Jul. 16-31	Jan. 16-Apr. 15; Jul. 16-Aug. 15; Nov. 1-30	Jan. 16-Apr. 15; Jul. 16-Aug. 31; Nov. 1-30	Jan. 16-Apr. 15; Jul. 16-Aug. 31; Nov. 1-30
			Sampling Design & Components	---	---	---	---	Full creel estimate, boat surveys, test fishing, VTR's.	Jan-Apr & Jul-Aug: Full creel estimate, boat surveys, test fishing, VTR's. Nov 1-30: Aerial design creel estimate, aerial surveys, test fishing, VTR's.	Jan-Apr & Nov 1-30: Aerial design creel estimate, aerial surveys, test fishing, VTR's. Jul-Aug: Full creel estimate, boat surveys, test fishing, VTR's.	Jan-Apr & Nov 1-30: Aerial design creel estimate, aerial surveys, test fishing, VTR's. Jul-Aug: Full creel estimate, boat surveys, test fishing, VTR's.
		Baseline	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
10	n/a ^{a/}	Intensive	Intensive Sampling Period, Chinook MSF	---	---	---	---	Jul. 16-28; Dec. 1-31	Jan. 1-31; Jul. 16-Aug. 15; Dec. 1-31	Jan. 1-31; Jul. 16-Aug. 31; Oct. 1-Dec. 31	Jan. 1-31; Jul. 16-Aug. 31; Oct. 1-Dec. 31
			Sampling Design & Components	---	---	---	---	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Jan. & July-Aug.: Full creel estimate, boat surveys, test fishing, VTR's. Oct.-Dec.: Reduced design creel estimate, boat surveys, test fishing, VTR's.	Jan. & Oct.-Dec.: Reduced design creel estimate, boat surveys, test fishing, VTR's. Jul-Aug: Full creel estimate, boat surveys, test fishing, VTR's.
		Baseline	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
Elliott Bay ^{a/} (Non-selective)		Intensive	Intensive Sampling Period (same as fishery dates)	Jul. 11-Aug. 17	Jul. 16-Aug. 22	Jul. 8-Aug. 22	Jul. 14-Aug. 20	Jul. 20-Aug. 6	Jul. 4-Aug. 25	Jul. 3-Aug. 24	Jul. 2-Aug. 6
			Sampling Design & Components	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys	Reduced design creel estimate, boat surveys

CRC Area	Sub-Area	Monitoring Intensity	Mark-selective fishery (MSF) Dates & Sampling Design	Date Range(s) of Intensive Creel Est. Studies and Fisheries (Grey = No Intensive Sampling Occurred), by Calendar Year							
				2003	2004	2005	2006	2007	2008	2009	2010
		Baseline		Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
11	n/a	Intensive	Intensive Sampling Period, Chinook MSF	---	---	---	---	Jun. 1-Sep. 30	Jun. 1-Sep. 30	Jun. 1-Sep. 30	Feb. 1-Apr. 30; Jun. 1-Sep. 30
			Sampling Design & Components	---	---	---	---	Full creel estimate, boat surveys, test fishing, VTR's.	Full creel estimate, boat surveys, test fishing, VTR's.	Reduced design creel estimate, boat surveys, test fishing, expanded VTR's.	Reduced design creel estimate, boat surveys, expanded VTR's.
		Baseline	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
12	n/a	Intensive (n/a)	Chinook MSF Period	---	---	---	---	---	---	---	Feb. 1-Apr. 30
			Sampling Design & Components	---	---	---	---	---	---	---	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.
		Baseline	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round
13	n/a	Intensive (n/a)	Chinook MSF Period	---	---	---	---	May 1-Sep. 30	May 1-Sep. 30	May 1-Sep. 30	May 1-Sep. 30
			Sampling Design & Components	---	---	---	---	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.	Baseline sampling, expanded VTR's, post-season Catch Record Card ests.
		Baseline	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round

^{a/} Outside of the summer season, all Elliot Bay (TAF Area Code 17) sampling and estimation is captured in broader Area 10 Baseline and/or Intensive survey efforts. Elliott Bay Terminal Area Fishery (TAF) open Fridays-Mondays or Fridays-Sundays only; intensive monitoring occurs primarily at two focal sites, Armeni and Shilshole Ramps.

Appendix B. Mark-selective fishery impact estimation details.

Below are definitions and equations for all quantities used in estimating mark-selective fishery impacts from the combination of creel survey information, test fishery data (where applicable), and voluntary trip report (VTR) results, and (where applicable) charter and/or derby accounts. The estimation sequence builds from monthly¹¹ estimators of encounters-by-class (i.e., the four size [legal, sublegal] × mark-status [marked, unmarked] groups) to season-wide impact estimates.

A. Total and Class-specific Encounters Estimation

The first step towards quantifying mark-selective fishery impacts by size/mark-status class is to estimate total Chinook encounters (\hat{E}_i , includes retained + released Chinook; See *Monthly Encounters* below) for each month of the fishery. Secondly, encounters are apportioned to the appropriate size/mark-status group using encounters-composition data collected from the test fishery or voluntary trip reports (See *Estimating Chinook Encounter Composition* on following page).

Monthly Encounters

\hat{E}_i = Total Chinook encounters for month i , which is estimated by combining creel estimates of legal-marked Chinook harvest (\hat{K}_{LMi} , defined on subsequent page) with an estimate of the proportion of the fishable Chinook population that is of legal size and marked (\hat{p}_{LMi} , defined on subsequent page). Given the potential for negative bias in \hat{E}_i if anglers release any of the legal-marked Chinook that they encounter, the \hat{E}_i estimator also includes a “correction” to account for this phenomenon (i.e., $1-p_{LM-R}$, where p_{LM-R} is the estimated legal-marked Chinook release rate)¹². \hat{E}_i and its variance are estimated as:

$$(1) \quad \hat{E}_i = \frac{\hat{K}_{LM}}{[\hat{p}_{LM}(1-p_{LM-R})]}$$

$$(2) \quad \text{var}(\hat{E}_i) = \frac{1}{[(1-p_{LM-R})^2]} * \left[\frac{\hat{K}_{LMi}^2}{\hat{p}_{LMi}^2} * \left(\frac{\text{var}(\hat{K}_{LMi})}{\hat{K}_{LMi}^2} + \frac{\text{var}(\hat{p}_{LMi})}{\hat{p}_{LMi}^2} \right) \right]$$

¹¹ **Note:** For fisheries characterized by short-duration seasons (i.e., ~ 1 month), the “monthly” estimators described in this appendix are synonymous season-total estimators.

¹² Equations 1 and 2 were modified based on a 2008 state-tribal evaluation of sources of bias in estimates of total Chinook encounters in mark-selective fisheries. Based on a review of relevant data, the current operational p_{LM-R} (combined intentional and unintentional LM Chinook release rate) applied in the bias-corrected \hat{E}_i estimator is 0.13. See Conrad and McHugh (2008) for further detail.

Estimating Chinook Encounter Composition

\hat{p}_{LMi} = the test fishery, or VTR-based, estimate of the proportion of Chinook encounters that are legal-sized (L) and marked (M) during month i

\hat{p}_{LUi} = the estimated proportion of encounters that are legal-sized (L) and unmarked (U)

\hat{p}_{SMi} = the estimated proportion of encounters that are sublegal-sized (S) and unmarked (M)

\hat{p}_{LUI} = the estimated proportion of encounters that are sublegal-sized (S) and unmarked (U)

For each XY combination (where $X = L$ or S and $Y = M$ or U), \hat{p}_{XYi} and its variance is estimated as:

$$(3) \quad \hat{p}_{XYi} = n_{XYi} / n_i, \text{ and}$$

$$(4) \quad \text{var}(\hat{p}_{XYi}) = [\hat{p}_{XYi}(1 - \hat{p}_{XYi})] / (n_i - 1),$$

Where, n_i = the total number of fish encountered by the test boats (if using test fishery data) or by the VTR participants (if using VTR data) during month i .

Encounters by Size/Mark-status Class

\hat{E}_{LMI} = estimated legal (L), marked (M) encounters during month i

\hat{E}_{LUI} = estimated legal (L), unmarked (U) encounters during month i

\hat{E}_{SMi} = estimated sublegal (S), marked (M) encounters during month i

\hat{E}_{SUI} = estimated sublegal (S), marked (U) encounters during month i

For each XY combination (where $X = L$ or S and $Y = M$ or U) \hat{E}_{XYi} and an estimate of its variance are obtained from:

$$(5) \quad \hat{E}_{XYi} = \hat{E}_i * \hat{p}_{XYi}$$

$$(6) \quad \text{var}(\hat{E}_{XYi}) = \text{var}(\hat{E}_i) * \hat{p}_{XYi}^2 + \hat{E}_i^2 * \text{var}(\hat{p}_{XYi}) - \text{var}(\hat{E}_i) * \text{var}(\hat{p}_{XYi})$$

B. Estimating Retained and Released Numbers by Size/Mark-status Class

Before total mortality can be estimated for each class (LM, SM, LU, SU), class-specific encounters must be separated into retention and release categories. First, given that harvest is estimated only to mark-status class for creel survey purposes (i.e., Murthy estimates or otherwise), estimates of marked and unmarked Chinook retention must be assigned to size classes (See *Apportioned Estimates of Retention to Size Classes* on subsequent page); this is done using mark-status-specific size composition data from dockside sampling (See *Dockside Observations for Apportioning Retained Catch to Class* on subsequent page). Subsequently, size/mark-status group-specific releases are estimated as the difference between class-specific encounters and retention (See *Estimating Release Numbers by Class* on subsequent page).

Dockside Observations for Apportioning Retained Catch to Class

\hat{d}_{LMK} = the estimated proportion of retained (kept, K), marked (M) Chinook salmon that were legal (L);
based on *season-wide*¹³ dockside observations of marked Chinook (as is \hat{d}_{SMK})

\hat{d}_{SMK} = the estimated proportion of retained (kept, K), marked (M) Chinook that were sublegal (S)

The proportion of retained, marked fish in size class X ($X = L$ or S) and its variance are estimated as:

$$(7) \quad \hat{d}_{XMK} = n_{XMK} / n_{MK}$$

$$(8) \quad \text{var}(\hat{d}_{XMK}) = [\hat{d}_{XMK} * (1 - \hat{d}_{XMK})] / (n_{MK} - 1),$$

where n_{MK} and n_{XMK} are *season-wide* total dockside counts of marked fish and the subset of marked fish in size-class X , respectively.

\hat{d}_{LUK} = the estimated proportion of retained (kept, K), unmarked (U) Chinook salmon that are legal (L);
estimated from *season-wide* dockside observations of unmarked Chinook (as is \hat{d}_{SUK})

\hat{d}_{SUK} = the estimated proportion of retained (kept, K), unmarked (U) Chinook that are sublegal (S)

The proportions of retained, unmarked fish belonging to legal and sublegal size classes and their respective variances are estimated as above (Eqns. 7 and 8) but using *season-wide* dockside observations on unmarked (U), not marked Chinook salmon.

Apportioned Estimates of Retention to Size Classes

\hat{K}_{LMi} = the estimated number of legal (L), marked (M) Chinook kept in month i

\hat{K}_{LUi} = the estimated number of legal (L), unmarked (U) Chinook kept in month i

The number of kept, marked encounters, marked fish in size class X (L or S) and its variance is estimated as:

$$(9) \quad \hat{K}_{XMi} = \hat{d}_{XMK} * \hat{N}_{MKi}$$

$$(10) \quad \text{var}(\hat{K}_{XMi}) = \text{var}(\hat{N}_{MKi}) * \hat{d}_{XMK}^2 + \hat{N}_{MKi}^2 * \text{var}(\hat{d}_{XMK}) - \text{var}(\hat{N}_{MKi}) * \text{var}(\hat{d}_{XMK})$$

where \hat{d}_{XMK} and its variance are from Equations 7 and 8 above and \hat{N}_{MKi} is the creel survey estimate of retained marked fish for month (or stratum) i . \hat{N}_{MKi} refers to the adjusted daily estimator, \hat{Y}_{adj} , in Equation 3 on page 33 of this report.

\hat{K}_{SMi} = estimated number of sublegal (S), marked (M) Chinook kept in month i

\hat{K}_{SUi} = estimated number of sublegal (S), unmarked (U) Chinook kept in month i

¹³ Due to small sample sizes for observed, harvested Chinook—particularly for sublegal and/or unmarked classes—dockside length data are pooled across the season to estimate \hat{d}_{yK} .

The number of retained, unmarked fish belonging to legal and sublegal size classes is estimated according to Eqns. 9 and 10 above but using unmarked fish proportions and monthly retention estimates.

Estimating Release Numbers by Class

\hat{R}_{LMi} = the estimated number of legal (*L*), marked (*M*) Chinook released in month *i*

\hat{R}_{LUi} = the estimated number of legal (*L*), unmarked (*U*) Chinook released in month *i*

\hat{R}_{SMi} = the estimated number of sublegal (*S*), marked (*M*) Chinook released in month *i*

\hat{R}_{SUi} = the estimated number of sublegal (*S*), unmarked (*U*) Chinook released in month *i*

For each size/mark-status class (i.e., *XY* combination [*X* = *L* or *S* and *Y* = *M* or *U*]), the number of fish encountered and released is estimated as the difference between total size/mark-status class encounters (\hat{E}_{XYi}) and retention (\hat{K}_{XYi}) during month *i*. The estimator and its variance are:

$$(11) \quad \hat{R}_{XYi} = \hat{E}_{XYi} - \hat{K}_{XYi}$$

$$(12) \quad \text{var}(\hat{R}_{XYi}) = \text{var}(\hat{E}_{XYi}) + \text{var}(\hat{K}_{XYi})$$

C. Estimating Total (and Class-specific) Monthly and Season-wide Mortality

The application of assumed mortality rates (See *Assumed Mortality Rates for Retained and Released Chinook* below) to class-specific estimates of total retention and releases constitutes the final step in quantifying mark-selective fishery impacts.

Assumed Mortality Rates for Retained and Released Chinook

m_K = retention mortality rate, 100% for all retained Chinook (reincarnation is rare among fishes)

sfm_L = release mortality rate for legal (*L*) Chinook, assumed to be a constant 15%

sfm_S = release mortality rate for sublegal (*S*) Chinook, assumed to be a constant 20%

Retention-mortality Estimates

\hat{M}_{LMKi} = estimated mortality due to legal (*L*), marked (*M*) Chinook harvest in month *i* (= \hat{K}_{LMi}).

\hat{M}_{LUKi} = estimated mortality due to harvest of legal (*L*), unmarked (*U*) Chinook in month *i* (= \hat{K}_{LUi}).

\hat{M}_{SMKi} = estimated mortality due to harvest of sublegal (*S*), marked (*M*) Chinook in month *i* (= \hat{K}_{SMi}).

\hat{M}_{SUKi} = estimated mortality due to harvest of sublegal (*S*), unmarked (*U*) Chinook in month *i* (= \hat{K}_{SUi}).

Release-mortality Estimates

\hat{M}_{LMRi} = estimated post-release mortality for legal (*L*), marked (*M*) Chinook in month *i*

\hat{M}_{LURi} = estimated post-release mortality for legal (*L*), unmarked (*U*) Chinook in month *i*

\hat{M}_{SMRi} = estimated post-release mortality for sublegal (*S*), marked (*M*) Chinook in month *i*

\hat{M}_{SURi} = estimated post-release mortality for sublegal (*S*), unmarked (*U*) Chinook in month *i*

All class-specific (*XY* [*X* = *L* or *S*, *Y* = *M* or *U*]) release mortality estimates are obtained from:

$$(13) \quad \hat{M}_{XYRi} = \hat{R}_{XYi} * sfm_Y$$

$$(14) \quad \text{var}(\hat{M}_{XYRi}) = \text{var}(\hat{R}_{XYi}) * sfm_Y^2$$

Season-wide Total and Class-specific Mortality Estimation

\hat{M}_{total} = total season-wide Chinook salmon mortality; this parameter and its variance [$\text{var}(\hat{M}_{total})$] are computed as the sum of all monthly retention and release mortality estimates [i.e.,

$$\hat{M}_{total} = \sum_{i=1}^{\max i} (\hat{M}_{XYKi} + \hat{M}_{XYRi})] \text{ and variances}$$

[$\text{var}(\hat{M}_{total}) = \sum_{i=1}^{\max i} [\text{var}(\hat{M}_{XYKi}) + \text{var}(\hat{M}_{XYRi})]$], respectively, for all four size/mark-status groups (*X* = *L* or *S*, *Y* = *M* or *U*). Season total estimates for subgroups of interest (e.g., unmarked, sublegal Chinook, $\hat{M}_{SU-total}$) are obtained by summing monthly estimates (and variances) across the season for just that group.

D. Characterizing Precision of Estimates

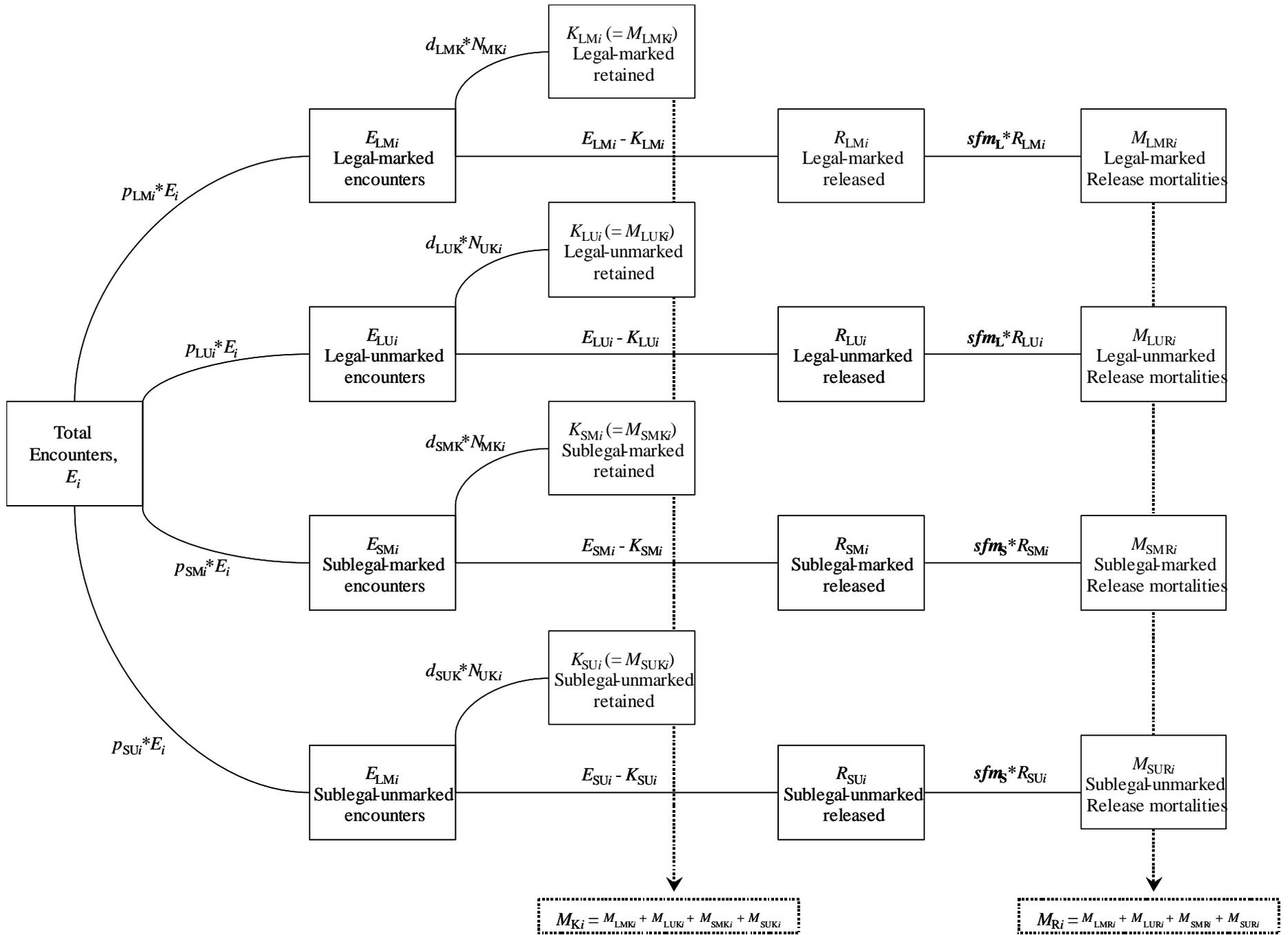
The precision of estimates generated from creel surveys and the preceding fishery impact estimation scheme is characterized using estimates of a parameter's standard error (*SE*), coefficient of variation (*CV* or relative standard error), and approximate 95% confidence interval. For any parameter estimate $\hat{\theta}$ (e.g., \hat{M}_{total} , \hat{K}_{LMi} , \hat{E}_i , etc.), these metrics are estimated using:

$$(15) \quad SE(\hat{\theta}) = \sqrt{\text{var}(\hat{\theta})}$$

$$(16) \quad CV(\hat{\theta}) = [SE(\hat{\theta}) / \hat{\theta}] * 100$$

$$(17) \quad CI = \hat{\theta} \pm 1.96 * SE(\hat{\theta})$$

Figure B1. (On following page) Graphical representation of the approach used to estimate monthly encounters and mortalities by size/mark-status category in mark-selective Chinook fisheries. Boxes depict abundance estimates (encounters, mortalities) whereas the mathematical operations depicted on intermediate connector lines are estimator formulae yielding quantities found in subsequent boxes (moving from left to right). Parameter definitions, complete formulae, and variances are defined in the preceding pages. For short-duration fisheries (~ 1 month or less), monthly and season-total values are equivalent; for all others, season-total impacts are equivalent to the sum of monthly impact estimates (and variances).



Appendix C. Total estimators for the aerial–access sample design.

A. Estimating daily-, stratum-, and season-total fishery parameters

Total fishing effort (in angler trips and boat trips) and Chinook encounters (harvested and/or released, by mark-status group) were estimated for each sampled day i in each stratum j (j = Monday-Thursday and Friday-Sunday strata, by week) by expanding dockside sample-frame totals to the non-sampled fraction of the fishery. First, dockside-frame totals ($y_{ij}^{(ds)}$) were computed for each parameter (effort, catch, or reported releases) by summing observations from sampled sites ($k = 1, 2, 3, \text{ or } 4$):

$$(1) \quad y_{ij}^{(ds)} = \sum_{k=1}^4 y_{ijk}$$

Given that *all* four dockside sample-frame sites were sampled for the entirety of *every* scheduled sample day, $y_{ij}^{(ds)}$ was taken as a census total with zero variance. Combining $y_{ij}^{(ds)}$ with an estimate of the fraction of area-wide effort encompassed by sampled sites (\bar{f}_j , described below) estimated from flight data, daily fishery-wide totals were estimated according to:

$$(2) \quad \hat{Y}_{ij} = \frac{y_{ij}^{(ds)}}{\bar{f}_j}, \text{ with variance}$$

$$\text{var}(\hat{Y}_{ij}) = (y_{ij}^{(ds)})^2 \text{var}\left(\frac{1}{\bar{f}_j}\right)$$

For the weekend stratum (Fri-Sun), during which 100% daily coverage was achieved, stratum totals were taken as the sum of daily values estimated by Equation 2; the variance about stratum totals was taken as the sum of daily variances defined above, where $\text{var}\left(\frac{1}{\bar{f}_j}\right)$ is estimated according to the parametric approach described below (Equation 5). Totals were estimated for the weekday (Mon-Thursday) stratum according to:

$$(3) \quad \hat{Y}_j = N_j \frac{\sum_{i=1}^{n_j} \hat{Y}_{ij}}{n_j}, \text{ with variance}$$

$$\text{var}(\hat{Y}_j) = N_j \left(\frac{N_j - n_j}{n_j} \right) \frac{\sum_{i=1}^{n_j} (\hat{Y}_{ij} - \bar{Y}_j)^2}{n_j - 1} + \frac{N_j}{n_j} \sum_{i=1}^{n_j} \text{var}(\hat{Y}_{ij})$$

Where, N_j and n_j are the total and sampled number of days in stratum j , respectively, and \bar{Y}_j is the mean daily total for sampled days in stratum j .

B. Estimating the sample fraction from aerial and dockside survey data

1. Conceptual overview

We estimated the fraction of area-wide effort encompassed by our dockside sample frame using a parametric statistical approach derived by Wan-Ying Chang, WDFW-Fish Program biometrician (unpublished memo). To do this, we viewed f_{ij} , the true fraction of area-wide effort encompassed by the dockside sample frame, as a fixed unknown parameter; we also considered \hat{f}_{ij} , the fraction estimated from any given aerial survey, to vary as a function of flight time according to a specified probability distribution model (described below), with mean equal to f_{ij} . We further assumed that \hat{f}_{ij} was independent and identically distributed (i.i.d.) across all days within relevant blocks. Based on these assumptions, we constructed a sampling distribution for \bar{f}_j using data from days when both dockside and aerial surveys were conducted (by stratum j , if appropriate). Additionally, we derived an estimator for the variance of fishery totals (i.e., \hat{Y}_{ij} , Equation 3) that was consistent with \bar{f}_j 's sampling distribution.

There are two main advantages of this compared to other estimation approaches. First, depending on the distributional model chosen for \bar{f}_j , this parametric approach provides an analytical basis for computing the bias associated with \hat{Y}_{ij} estimates. This information is needed to understand the quality of estimates, particularly given the potential for bias in ratio estimates in small sample-size cases (e.g., Cochran 1977). Second, using the parametric approach frees us from assuming that sampled and non-sampled angling parties have identical activity patterns within a given day. Given the difficulties associated with sampling the latter group, this assumption is more difficult to test than the i.i.d. assumption described above. Despite these advantages, additional analytical work (e.g., simulations) will likely be needed to fully understand the reliability of the present estimation method under different distributional assumptions.

2. Computing individual f_{ij} estimates and defining stratum boundaries

On all days i within stratum j when both aerial and dockside surveys occurred, f_{ij} was estimated according to

$$(4) \quad \hat{f}_{ij} = \frac{X_{ij}}{m_{ij}},$$

where m_{ij} is the aerial boat count and X_{ij} is the number of boats counted during the aerial survey that ended their trips at sampled access sites, and were fishing at the time of the survey, as discerned from reported trip start and end times. Once all \hat{f}_{ij} values were available, we assessed whether stratum-specific (weekday and weekend; i.e., \bar{f}_j) or pooled (i.e., \bar{f}) sampling distributions were supported by the data collected during the season. Though our power was limited (<10% where evaluated), a variety of statistical comparisons indicated that \bar{f}_j 's were

relatively homogeneous across strata ($P > 0.20$ for t , Mann-Whitney U , and median tests [Zar 1999]); thus, to maximize our sample size, we pooled data and constructed a single \bar{f}_j sampling distribution.

3. Estimating \bar{f}_j and $\text{var}(\frac{1}{\bar{f}_j})$

We estimated \bar{f}_j simply as the arithmetic mean of \hat{f}_{ij} s computed for the season. To estimate the variance of its reciprocal, $\text{var}(\frac{1}{\bar{f}_j})$, we assumed that \hat{f}_{ij} s are i.i.d. Gamma(α, β) random variables; therefore $\bar{f}_j \sim \text{Gamma}(n\alpha, n\beta)$, where α and β are the distribution's shape and scale parameters, respectively, and n is the number of flights that occurred during the season. The Gamma distribution was chosen for modeling \bar{f}_j for two reasons: 1) an expression for the bias in total estimates produced by Equation 2 can be easily derived under this distributional assumption; 2) this distribution can accommodate skewness or mimic a normal distribution, while simultaneously keeping a positive range. With sample α and β values obtained using the Shenton and Bowman "almost unbiased" estimators (Johnson et al. 1994), $\text{var}(\frac{1}{\bar{f}_j})$ was estimated as:

$$(5) \quad \text{var}(\frac{1}{\bar{f}_j}) = [\beta^2(\alpha - \frac{1}{n})^2(n\alpha - 2)]^{-1}$$

and α and β were estimated as:

$$(6) \quad \hat{\alpha} = \frac{n-3}{2nR_n} + \frac{n+1}{6n} - \frac{(n+1)R_n}{18n} - \frac{(4n^2 - 10n + 4)R_n^2}{135n(n+3)}$$

$$\hat{\beta} = \bar{f}_j \left[\frac{2nR_n}{n-1} - \frac{2nR_n^2}{2(n-1)} + \frac{4n(n+1)R_n^3}{9(n-1)(n+3)} - \frac{2n(7n^2 - 60n + 7)R_n^4}{135(n-1)(n+3)(n+5)} \right]$$

where R_n is:

$$(7) \quad R_n = \log \left[\frac{\bar{f}_j}{\sqrt[n]{\prod_{i=1}^n \hat{f}_{ij}}} \right]$$

Finally, given a Gamma distributional assumption, the relative bias ($[\text{expected} - \text{observed}]/\text{expected}$) in total estimates obtained from Equation 2 was computed using:

$$(8) \quad \text{Bias} = \frac{1}{n\alpha - 1} \cdot 100$$

C. Assumptions required for unbiased estimation of fishery parameters

Statistical Assumptions

- 1) The sample fraction estimated for any given day (\hat{f}_{ij}) varies as a function of flight time following a Gamma probability distribution function with a mean equal to the true fraction;
- 2) All days within temporally defined strata have independent and identical probability distributions of \hat{f}_{ij} ; this assumption applies to all days of the fishery if the mean sample fraction is estimated on a season-total level.

Behavioral and Sampling Assumptions

- 1) Salmon encounters (kept and released) per unit effort do not differ for anglers accessing the fishery from sampled and non-sampled access sites.
- 2) Party size (i.e., anglers/boat) does not differ for fishing vessels accessing the fishery from sampled and non-sampled sites.
- 3) The proportion of total recreational boating activity due to fishing is similar for parties accessing the fishery from sampled and non-sampled access sites.
- 4) Dockside samplers interview all boating parties active during flights that return to sampled sites, and aerial observers see all boats present in the area during flight surveys. Both sampling components are free from systematic errors in observation.
- 5) The proportion of total area-wide fishing effort returning to sampled sites (i.e., \bar{f}_j) does not differ between days when flights are and are not possible (i.e., “good” vs. “poor” weather days).

Appendix D. WDFW statistical weeks (Monday through Sunday) by calendar year, 2003-2011.

2003 Statistical Week Calendar (Monday-Sunday)

Stat Month	Week #	Start Date	End Date	Stat Month	Week #	Start Date	End Date	
Jan 1	1	1-Jan	5-Jan	Jul	27	30-Jun	6-Jul	
	2	6-Jan	12-Jan		7	28	7-Jul	13-Jul
	3	13-Jan	19-Jan		29	14-Jul	20-Jul	
	4	20-Jan	26-Jan		30	21-Jul	27-Jul	
	5	27-Jan	2-Feb		31	28-Jul	3-Aug	
Feb 2	6	3-Feb	9-Feb	Aug	32	4-Aug	10-Aug	
	7	10-Feb	16-Feb		8	33	11-Aug	17-Aug
	8	17-Feb	23-Feb		34	18-Aug	24-Aug	
	9	24-Feb	2-Mar		35	25-Aug	31-Aug	
Mar 3	10	3-Mar	9-Mar	Sep	36	1-Sep	7-Sep	
	11	10-Mar	16-Mar		9	37	8-Sep	14-Sep
	12	17-Mar	23-Mar		38	15-Sep	21-Sep	
	13	24-Mar	30-Mar		39	22-Sep	28-Sep	
Apr 4	14	31-Mar	6-Apr	Oct	40	29-Sep	5-Oct	
	15	7-Apr	13-Apr		10	41	6-Oct	12-Oct
	16	14-Apr	20-Apr		42	13-Oct	19-Oct	
	17	21-Apr	27-Apr		43	20-Oct	26-Oct	
	18	28-Apr	4-May		44	27-Oct	2-Nov	
May 5	19	5-May	11-May	Nov	45	3-Nov	9-Nov	
	20	12-May	18-May		11	46	10-Nov	16-Nov
	21	19-May	25-May		47	17-Nov	23-Nov	
	22	26-May	1-Jun		48	24-Nov	30-Nov	
June 6	23	2-Jun	8-Jun	Dec	49	1-Dec	7-Dec	
	24	9-Jun	15-Jun		12	50	8-Dec	14-Dec
	25	16-Jun	22-Jun		51	15-Dec	21-Dec	
	26	23-Jun	29-Jun		52	22-Dec	28-Dec	
				53	29-Dec	31-Dec		

2004 Statistical Week Calendar (Monday-Sunday)

Stat Month	Week #	Start Date	End Date	Stat Month	Week #	Start Date	End Date	
Jan 1	1	1-Jan	4-Jan	Jul	27	28-Jun	4-Jul	
	2	5-Jan	11-Jan		7	28	5-Jul	11-Jul
	3	12-Jan	18-Jan		29	12-Jul	18-Jul	
	4	19-Jan	25-Jan		30	19-Jul	25-Jul	
	5	26-Jan	1-Feb		31	26-Jul	1-Aug	
Feb 2	6	2-Feb	8-Feb	Aug	32	2-Aug	8-Aug	
	7	9-Feb	15-Feb		8	33	9-Aug	15-Aug
	8	16-Feb	22-Feb		34	16-Aug	22-Aug	
	9	23-Feb	29-Feb		35	23-Aug	29-Aug	
Mar 3	10	1-Mar	7-Mar	Sep	36	30-Aug	5-Sep	
	11	8-Mar	14-Mar		9	37	6-Sep	12-Sep
	12	15-Mar	21-Mar		38	13-Sep	19-Sep	
	13	22-Mar	28-Mar		39	20-Sep	26-Sep	
Apr 4	14	29-Mar	4-Apr	Oct	40	27-Sep	3-Oct	
	15	5-Apr	11-Apr		10	41	4-Oct	10-Oct
	16	12-Apr	18-Apr		42	11-Oct	17-Oct	
	17	19-Apr	25-Apr		43	18-Oct	24-Oct	
	18	26-Apr	2-May		44	25-Oct	31-Oct	
May 5	19	3-May	9-May	Nov	45	1-Nov	7-Nov	
	20	10-May	16-May		11	46	8-Nov	14-Nov
	21	17-May	23-May		47	15-Nov	21-Nov	
	22	24-May	30-May		48	22-Nov	28-Nov	
June 6	23	31-May	6-Jun	Dec	49	29-Nov	5-Dec	
	24	7-Jun	13-Jun		12	50	6-Dec	12-Dec
	25	14-Jun	20-Jun		51	13-Dec	19-Dec	
	26	21-Jun	27-Jun		52	20-Dec	26-Dec	
					53	27-Dec	31-Dec	

2005 Statistical Week Calendar (Monday-Sunday)

STAT MONTH	WEEK NO.	START DATE	END DATE	STAT MONTH	WEEK NO.	START DATE	END DATE
Jan 1	1	1-Jan	2-Jan	Jul 7	27	27-Jun	3-Jul
	2	3-Jan	9-Jan		28	4-Jul	10-Jul
	3	10-Jan	16-Jan		29	11-Jul	17-Jul
	4	17-Jan	23-Jan		30	18-Jul	24-Jul
	5	24-Jan	30-Jan		31	25-Jul	31-Jul
Feb 2	6	31-Jan	6-Feb	Aug 8	32	1-Aug	7-Aug
	7	7-Feb	13-Feb		33	8-Aug	14-Aug
	8	14-Feb	20-Feb		34	15-Aug	21-Aug
	9	21-Feb	27-Feb		35	22-Aug	28-Aug
Mar 3	10	28-Feb	6-Mar	Sep 9	36	29-Aug	4-Sep
	11	7-Mar	13-Mar		37	5-Sep	11-Sep
	12	14-Mar	20-Mar		38	12-Sep	18-Sep
	13	21-Mar	27-Mar		39	19-Sep	25-Sep
Apr 4	14	28-Mar	3-Apr	Oct 10	40	26-Sep	2-Oct
	15	4-Apr	10-Apr		41	3-Oct	9-Oct
	16	11-Apr	17-Apr		42	10-Oct	16-Oct
	17	18-Apr	24-Apr		43	17-Oct	23-Oct
	18	25-Apr	1-May		44	24-Oct	30-Oct
May 5	19	2-May	8-May	Nov 11	45	31-Oct	6-Nov
	20	9-May	15-May		46	7-Nov	13-Nov
	21	16-May	22-May		47	14-Nov	20-Nov
	22	23-May	29-May		48	21-Nov	27-Nov
Jun 6	23	30-May	5-Jun	Dec 12	49	28-Nov	4-Dec
	24	6-Jun	12-Jun		50	5-Dec	11-Dec
	25	13-Jun	19-Jun		51	12-Dec	18-Dec
	26	20-Jun	26-Jun		52	19-Dec	25-Dec
						53	26-Dec

2006 Statistical Week Calendar (Monday-Sunday)

Stat Month	Week #	Start Date	End Date	Stat Month	Week #	Start Date	End Date
Jan 1	1	01-Jan	01-Jan	Jul 7	27	26-Jun	02-Jul
	2	02-Jan	08-Jan		28	03-Jul	09-Jul
	3	09-Jan	15-Jan		29	10-Jul	16-Jul
	4	16-Jan	22-Jan		30	17-Jul	23-Jul
	5	23-Jan	29-Jan		31	24-Jul	30-Jul
Feb 2	6	30-Jan	05-Feb	Aug 8	32	31-Jul	06-Aug
	7	06-Feb	12-Feb		33	07-Aug	13-Aug
	8	13-Feb	19-Feb		34	14-Aug	20-Aug
	9	20-Feb	26-Feb		35	21-Aug	27-Aug
Mar 3	10	27-Feb	05-Mar	Sep 9	36	28-Aug	03-Sep
	11	06-Mar	12-Mar		37	04-Sep	10-Sep
	12	13-Mar	19-Mar		38	11-Sep	17-Sep
	13	20-Mar	26-Mar		39	18-Sep	24-Sep
Apr 4	14	27-Mar	02-Apr	Oct 10	40	25-Sep	01-Oct
	15	03-Apr	09-Apr		41	02-Oct	08-Oct
	16	10-Apr	16-Apr		42	09-Oct	15-Oct
	17	17-Apr	23-Apr		43	16-Oct	22-Oct
	18	24-Apr	30-Apr		44	23-Oct	29-Oct
May 5	19	01-May	07-May	Nov 11	45	30-Oct	05-Nov
	20	08-May	14-May		46	06-Nov	12-Nov
	21	15-May	21-May		47	13-Nov	19-Nov
	22	22-May	28-May		48	20-Nov	26-Nov
Jun 6	23	29-May	04-Jun	Dec 12	49	27-Nov	03-Dec
	24	05-Jun	11-Jun		50	04-Dec	10-Dec
	25	12-Jun	18-Jun		51	11-Dec	17-Dec
	26	19-Jun	25-Jun		52	18-Dec	24-Dec
						53	25-Dec

2007 Statistical Week Calendar (Monday-Sunday)

STAT MONTH	WEEK NO.	START DATE	END DATE	STAT MONTH	WEEK NO.	START DATE	END DATE
1	1	1-Jan	7-Jan	7	27	2-Jul	8-Jul
	2	8-Jan	14-Jan		28	9-Jul	15-Jul
	3	15-Jan	21-Jan		29	16-Jul	22-Jul
	4	22-Jan	28-Jan		30	23-Jul	29-Jul
	5	29-Jan	4-Feb		31	30-Jul	5-Aug
2	6	5-Feb	11-Feb	8	32	6-Aug	12-Aug
	7	12-Feb	18-Feb		33	13-Aug	19-Aug
	8	19-Feb	25-Feb		34	20-Aug	26-Aug
	9	26-Feb	4-Mar		35	27-Aug	2-Sep
3	10	5-Mar	11-Mar	9	36	3-Sep	9-Sep
	11	12-Mar	18-Mar		37	10-Sep	16-Sep
	12	19-Mar	25-Mar		38	17-Sep	23-Sep
	13	26-Mar	1-Apr		39	24-Sep	30-Sep
4	14	2-Apr	8-Apr	10	40	1-Oct	7-Oct
	15	9-Apr	15-Apr		41	8-Oct	14-Oct
	16	16-Apr	22-Apr		42	15-Oct	21-Oct
	17	23-Apr	29-Apr		43	22-Oct	28-Oct
	18	30-Apr	6-May		44	29-Oct	4-Nov
5	19	7-May	13-May	11	45	5-Nov	11-Nov
	20	14-May	20-May		46	12-Nov	18-Nov
	21	21-May	27-May		47	19-Nov	25-Nov
	22	28-May	3-Jun		48	26-Nov	2-Dec
6	23	4-Jun	10-Jun	12	49	3-Dec	9-Dec
	24	11-Jun	17-Jun		50	10-Dec	16-Dec
	25	18-Jun	24-Jun		51	17-Dec	23-Dec
	26	25-Jun	1-Jul		52	24-Dec	30-Dec
					53	31-Dec	31-Dec

2008 Statistical Week Calendar (Monday-Sunday)

Stat Month	Week #	Start Date	End Date	Stat Month	Week #	Start Date	End Date
JAN 1	1	1-Jan	6-Jan	JUL 7	27	30-Jun	6-Jul
	2	7-Jan	13-Jan		28	7-Jul	13-Jul
	3	14-Jan	20-Jan		29	14-Jul	20-Jul
	4	21-Jan	27-Jan		30	21-Jul	27-Jul
	5	28-Jan	3-Feb		31	28-Jul	3-Aug
FEB 2	6	4-Feb	10-Feb	AUG 8	32	4-Aug	10-Aug
	7	11-Feb	17-Feb		33	11-Aug	17-Aug
	8	18-Feb	24-Feb		34	18-Aug	24-Aug
	9	25-Feb	2-Mar		35	25-Aug	31-Aug
MAR 3	10	3-Mar	9-Mar	SEP 9	36	1-Sep	7-Sep
	11	10-Mar	16-Mar		37	8-Sep	14-Sep
	12	17-Mar	23-Mar		38	15-Sep	21-Sep
	13	24-Mar	30-Mar		39	22-Sep	28-Sep
APR 4	14	31-Mar	6-Apr	OCT 10	40	29-Sep	5-Oct
	15	7-Apr	13-Apr		41	6-Oct	12-Oct
	16	14-Apr	20-Apr		42	13-Oct	19-Oct
	17	21-Apr	27-Apr		43	20-Oct	26-Oct
	18	28-Apr	4-May		44	27-Oct	2-Nov
MAY 5	19	5-May	11-May	NOV 11	45	3-Nov	9-Nov
	20	12-May	18-May		46	10-Nov	16-Nov
	21	19-May	25-May		47	17-Nov	23-Nov
	22	26-May	1-Jun		48	24-Nov	30-Nov
JUN 6	23	2-Jun	8-Jun	DEC 12	49	1-Dec	7-Dec
	24	9-Jun	15-Jun		50	8-Dec	14-Dec
	25	16-Jun	22-Jun		51	15-Dec	21-Dec
	26	23-Jun	29-Jun		52	22-Dec	28-Dec
					53	29-Dec	31-Dec

2009 Statistical Week Calendar (Monday-Sunday)

STAT MONTH	WEEK NO.	START DATE	END DATE	STAT MONTH	WEEK NO.	START DATE	END DATE
1	1	01-Jan	04-Jan	7	27	29-Jun	05-Jul
	2	05-Jan	11-Jan		28	06-Jul	12-Jul
	3	12-Jan	18-Jan		29	13-Jul	19-Jul
	4	19-Jan	25-Jan		30	20-Jul	26-Jul
	5	26-Jan	01-Feb		31	27-Jul	02-Aug
2	6	02-Feb	08-Feb	8	32	03-Aug	09-Aug
	7	09-Feb	15-Feb		33	10-Aug	16-Aug
	8	16-Feb	22-Feb		34	17-Aug	23-Aug
	9	23-Feb	01-Mar		35	24-Aug	30-Aug
3	10	02-Mar	08-Mar	9	36	31-Aug	06-Sep
	11	09-Mar	15-Mar		37	07-Sep	13-Sep
	12	16-Mar	22-Mar		38	14-Sep	20-Sep
	13	23-Mar	29-Mar		39	21-Sep	27-Sep
4	14	30-Mar	05-Apr	10	40	28-Sep	04-Oct
	15	06-Apr	12-Apr		41	05-Oct	11-Oct
	16	13-Apr	19-Apr		42	12-Oct	18-Oct
	17	20-Apr	26-Apr		43	19-Oct	25-Oct
	18	27-Apr	03-May		44	26-Oct	01-Nov
5	19	04-May	10-May	11	45	02-Nov	08-Nov
	20	11-May	17-May		46	09-Nov	15-Nov
	21	18-May	24-May		47	16-Nov	22-Nov
	22	25-May	31-May		48	23-Nov	29-Nov
6	23	01-Jun	07-Jun	12	49	30-Nov	06-Dec
	24	08-Jun	14-Jun		50	07-Dec	13-Dec
	25	15-Jun	21-Jun		51	14-Dec	20-Dec
	26	22-Jun	28-Jun		52	21-Dec	27-Dec
					53	28-Dec	31-Dec

2010 Statistical Week Calendar (Monday-Sunday)

Stat Month	Week No.	Start Date	End Date	Stat Month	Week No.	Start Date	End Date
Jan 1	1	1-Jan	3-Jan	Jul 7	27	28-Jun	4-Jul
	2	4-Jan	10-Jan		28	5-Jul	11-Jul
	3	11-Jan	17-Jan		29	12-Jul	18-Jul
	4	18-Jan	24-Jan		30	19-Jul	25-Jul
	5	25-Jan	31-Jan		31	26-Jul	1-Aug
Feb 2	6	1-Feb	7-Feb	Aug 8	32	2-Aug	8-Aug
	7	8-Feb	14-Feb		33	9-Aug	15-Aug
	8	15-Feb	21-Feb		34	16-Aug	22-Aug
	9	22-Feb	28-Feb		35	23-Aug	29-Aug
Mar 3	10	1-Mar	7-Mar	Sep 9	36	30-Aug	5-Sep
	11	8-Mar	14-Mar		37	6-Sep	12-Sep
	12	15-Mar	21-Mar		38	13-Sep	19-Sep
	13	22-Mar	28-Mar		39	20-Sep	26-Sep
Apr 4	14	29-Mar	4-Apr	Oct 10	40	27-Sep	3-Oct
	15	5-Apr	11-Apr		41	4-Oct	10-Oct
	16	12-Apr	18-Apr		42	11-Oct	17-Oct
	17	19-Apr	25-Apr		43	18-Oct	24-Oct
	18	26-Apr	2-May		44	25-Oct	31-Oct
May 5	19	3-May	9-May	Nov 11	45	1-Nov	7-Nov
	20	10-May	16-May		46	8-Nov	14-Nov
	21	17-May	23-May		47	15-Nov	21-Nov
	22	24-May	30-May		48	22-Nov	28-Nov
Jun 6	23	31-May	6-Jun	Dec 12	49	29-Nov	5-Dec
	24	7-Jun	13-Jun		50	6-Dec	12-Dec
	25	14-Jun	20-Jun		51	13-Dec	19-Dec
	26	21-Jun	27-Jun		52	20-Dec	26-Dec
						53	27-Dec

2011 Statistical Week Calendar (Monday-Sunday)

Stat Month	Week #	Start Date	End Date	Stat Month	Week #	Start Date	End Date
Jan 1	1	1-Jan	2-Jan	Jul 7	27	27-Jun	3-Jul
	2	3-Jan	9-Jan		28	4-Jul	10-Jul
	3	10-Jan	16-Jan		29	11-Jul	17-Jul
	4	17-Jan	23-Jan		30	18-Jul	24-Jul
	5	24-Jan	30-Jan		31	25-Jul	31-Jul
Feb 2	6	31-Jan	6-Feb	Aug 8	32	1-Aug	7-Aug
	7	7-Feb	13-Feb		33	8-Aug	14-Aug
	8	14-Feb	20-Feb		34	15-Aug	21-Aug
	9	21-Feb	27-Feb		35	22-Aug	28-Aug
Mar 3	10	28-Feb	6-Mar	Sep 9	36	29-Aug	4-Sep
	11	7-Mar	13-Mar		37	5-Sep	11-Sep
	12	14-Mar	20-Mar		38	12-Sep	18-Sep
	13	21-Mar	27-Mar		39	19-Sep	25-Sep
	14	28-Mar	3-Apr		40	26-Sep	2-Oct
Apr 4	15	4-Apr	10-Apr	Oct 10	41	3-Oct	9-Oct
	16	11-Apr	17-Apr		42	10-Oct	16-Oct
	17	18-Apr	24-Apr		43	17-Oct	23-Oct
	18	25-Apr	1-May		44	24-Oct	30-Oct
May 5	19	2-May	8-May	Nov 11	45	31-Oct	6-Nov
	20	9-May	15-May		46	7-Nov	13-Nov
	21	16-May	22-May		47	14-Nov	20-Nov
	22	23-May	29-May		48	21-Nov	27-Nov
Jun 6	23	30-May	5-Jun	Dec 12	49	28-Nov	4-Dec
	24	6-Jun	12-Jun		50	5-Dec	11-Dec
	25	13-Jun	19-Jun		51	12-Dec	18-Dec
	26	20-Jun	26-Jun		52	19-Dec	25-Dec
				53	26-Dec	1-Jan	

Appendix E. List of sampled sites included in the Puget Sound Sampling Unit’s sample frame to monitor mark-selective Chinook fisheries, by area and season (winter or summer), with a list of the most current (as of 2010 season) sampling designs used. Refer to Methods Sections 1-4 for sampling design descriptions.

Marine Area	Season	Sample Design (as of 2010 Season)	Sites in the sample frame
5	Summer	Reduced Creel Estimate	Olson's East Docks
			Olson's West Docks
			Olson's Ramp & Docks
			Van Riper's North
			Van Riper's South
			Curleys Straitside
6	Summer	Baseline Sampling	Freshwater Bay Ramp
			Port Angeles Public Ramp, Ediz Hook
			Port Angeles West Ramp
7	Winter	Aerial Survey Design	Bellingham Ramp
			Cornet Bay Public Ramp
			Washington Park Ramp
			Friday Harbor Marina
8-1	Winter	Reduced Creel Estimate	Camano Island State Park Public Ramp
			Coupeville Public Ramp
			Maple grove Ramp; Camano Island
			Norton Street (Everett) Ramp
			Oak Harbor Marina & Public Ramp
Utsalady Ramp; Camano Island			
8-2	Winter	Reduced Creel Estimate	Camano Island State Park Public Ramp
			Norton Street (Everett) Ramp
			Dagmar's Landing; Forklift Launch
			Mukilteo State Park Public Ramp
			Tulalip Marina & Ramp
			Kayak State Park Public Ramp
			Marysville Public Ramp
			Bayside Marina/Dry stack; Everett
9	Summer	Full Creel Estimate	Fort Casey Public Ramp (Keystone)
			Mukilteo State Park Public Ramp
			Norton Street (Everett) Ramp
			Port Townsend Boat Haven Ramp
	Winter	Aerial Survey Design	Kingston Public Ramp
			Edmonds Marina Dry Stack
			Norton Street (Everett) Ramp
			Port Townsend Boat Haven Ramp
10	Summer	Full Creel Estimate	Kingston Public Ramp
			Manchester Public Ramp
			Shilshole Public Ramp
			Brownsville Marina/Dock/Ramp
	Winter	Reduced Creel Estimate	Armeni Public Ramp
			Kingston Public Ramp
			Manchester Public Ramp
			Shilshole Public Ramp
Edmonds Marina Dry Stack			

Marine Area	Season	Sample Design (as of 2010 Season)	Sites in the sample frame
11	Summer	Reduced Creel Estimate	Armeni Public Ramp
			Gig Harbor Ramp
			Narrows Marina (Boathouse; Ramp; Rental)
			Point Defiance Boathouse
			Point Defiance Public Ramp
			Redondo Ramp
	Winter	Reduced Creel Estimate	Armeni Public Ramp
			Gig Harbor Ramp
Point Defiance Boathouse			
Point Defiance Public Ramp			
12	Winter	Baseline Sampling	Misery Point Ramp
			Pleasant Harbor Boat Ramp
			Salisbury County Park Ramp
			Saltwater Park Ramp (Hood Canal Ramp)
			Quilcene Bay Ramp
13	Summer	Baseline Sampling	Allyn Public Ramp
			Arcadia Ramp
			Boston Harbor Ramp
			Concrete Dock
			Day Island Yacht Club
			Fox Island Public Ramp
			Gig Harbor Ramp
			Grapeview Public Ramp
			Harper Ramp
			Harstene Is Ramp
			Johns Creek
			Luhr Beach Ramp
			Narrows Marina
			Narrows Properties Park
			Point Defiance Boat House
			Point Defiance Ramp
			Redondo Ramp
			Solo Point Ramp
			Steilacoom Public Ramp
			Vaughn Public Ramp
Wollochet Bay Public Ramp			
Wauna Ramp/Shore			
Zittels Marina			