Marine Area 7
Mark-Selective Recreational Chinook Fishery,
February 1-29, 2008

Post-season Report

REVISED DRAFT

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EXECUTIVE SUMMARY

The Washington Department of Fish and Wildlife (WDFW) implemented a mark-selective Chinook fishery (MSF) in Marine Area 7 for the first time during February 2008. Consistent with the 2004 Puget Sound Chinook Harvest Management Plan (Puget Sound Indian Tribes and WDFW 2004) and the intent of previous Puget Sound/Strait of Juan de Fuca mark-selective Chinook fisheries, the primary goal for this pilot fishery was to provide meaningful opportunity to the recreational angling public while minimally impacting ESA-listed Puget Sound Chinook salmon. WDFW's Puget Sound Sampling Unit (PSSU) implemented an intensive monitoring program in Area 7 throughout February in order to collect the data needed to estimate key parameters characterizing the fishery and its impacts on unmarked salmon. Sampling activities included dockside creel sampling, test fishing, and aerial effort surveys. Among other parameters, efforts emphasized data collection needs for the estimation of: *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[1], and *v*) the total mortality of marked and unmarked double index tag (DIT) CWT stocks.

Creel samplers staffed five different access sites on 20 of the 29 days that Area 7 was open under mark-selective harvest regulations. Samplers interviewed an estimated 39% of all participating anglers (n = 1,970 angler trips) and sampled 33% of all marked Chinook harvested (n = 438). Additionally, other PSSU staff conducted eight aerial effort surveys, and spent 18 days (118 hours) on the water pursuing Chinook using test fishing methods, in support of Area 7 monitoring efforts. Based on these activities, we estimated that 4,862 angler trips were completed by a combination of private fleet, charter, and derby anglers during February. With a CPUE of 0.28 Chinook landed per angler trip, these anglers harvested a grand total of 1,324 marked Chinook; they released an estimated 1,639 Chinook (440 marked, 1,195 unmarked, and 4 unknown mark-status). Harvested Chinook averaged 71 cm (range: 51 to 96 cm) in total length and were larger than the legal minimum size limit ($\geq$22 in or 56 cm TL) in most instances (dockside marked Chinook observations, 429 legal /438 total or 98%). Over half (58%) of all harvested individuals were 4-year olds (brood year 2004), with age-3 fish making up the catch remainder. In addition, 75 CWTs were recovered from harvested fish, the majority of which (94.7%) were from Puget Sound (89.3%, predominantly from north Puget Sound facilities) and Hood Canal (5.3%) release sites.

During their month of sampling in Area 7, test fishers encountered 31 Chinook salmon, 77% and 42% of which were of legal size and marked, respectively. With a "CPUE" of 0.28 (LM Chinook encounters / angler trip), test fishers experienced a similar legal-marked Chinook encounter rate as did charter, derby, and at-large private fleet anglers. Chinook encountered by test fishers averaged 63 cm (range: 48 to 89 cm) in total length and were predominantly 3 years in age (67% of marked and 71% of unmarked totals). Given the limited number of test

[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, CWT-based (unexpanded) estimates of the stock composition of marked Chinook harvest are provided.

fishery encounters, we chose to pool data across sources (test fishery, charter/derby angler VTRs) in order to estimate the mark rate and size/mark-status composition of the pool of Chinook encountered in the Area 7 fishery. As a result, we estimated the overall mark rate at 59% and size/mark-status composition at 50.3% legal-marked, 35.4% legal-unmarked, 8.9% sublegal-marked, and 5.3% sublegal-unmarked.

By combining dockside sampling results (i.e., legal-marked Chinook harvest estimates), test fishery/VTR size/mark-status composition data, and charter/derby census results, we generated size/mark-status group-specific estimates of encounters and mortalities. In total, 2,968 Chinook were encountered (retained and released) during the Area 7 fishery, with 1,500 of these being legal-marked, 1,044 legal-unmarked, 267 sublegal-marked, and 155 sublegal-unmarked individuals. Among released encounters, an estimated 30 legal-marked, 156 legal-unmarked, 49 sublegal-marked, and 31 sublegal-unmarked Chinook (266 overall) were estimated to have died due to handling and release effects. Thus, in total, 1,403 marked (92% due to direct harvest) and 189 unmarked Chinook mortalities occurred as a result of the Area 7 fishery. Although estimated marked Chinook impacts greatly exceeded expectations set by pre-season Fishery Regulation Assessment Model runs (model run 3907), the impact of the Area 7 fishery on unmarked Chinook was similar to what was anticipated. Finally, regarding impacts of MSFs on the coded-wire tag (CWT) program, we estimated that 10 unmarked Chinook belonging to double-index tag (DIT) groups may have died due to the handling-and-release impacts of the pilot Area 7 fishery.

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 has proven to be a significant conservation and management challenge. The combination of large-scale hatchery marking (i.e., 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[2].

Since the first marine selective Chinook fishery occurred in Marine Catch Areas 5 and 6 (Strait of Juan de Fuca) in 2003 (WDFW 2008a), mark-selective Chinook salmon fishing regulations have been implemented on a pilot basis in multiple Puget Sound Marine Catch Areas during both summer and winter seasons. As of the close of the 2006-07 fishing season, pilot *summer* selective Chinook seasons have occurred in Areas 5 and 6 for five years (2003-2007; WDFW 2008a) and in Areas 9, 10, 11, and 13 for one year (2007; WDFW 2007a and 2007b); pilot *winter* selective Chinook fisheries have occurred in Areas 8-1 and 8-2 for two complete seasons (2005-06 and 2006-07; WDFW 2008b). In February 2008, the Washington Department of Fish and Wildlife (WDFW) implemented a winter mark-selective Chinook fishery in Area 7 for the first time. Consistent with the 2004 Puget Sound Chinook Harvest Management Plan (Puget Sound Indian Tribes and WDFW 2004) and the intent of previous mark-selective Chinook fisheries, the primary goal for this pilot fishery was to provide meaningful opportunity to the recreational angling public while minimally impacting ESA-listed Puget Sound Chinook salmon.

Given the pilot nature of the Area 7 selective Chinook fishery, WDFW's Puget Sound Sampling Unit was tasked with implementing an intensive monitoring program during the entirety of its February 1-29, 2008 season. Our primary goal was to collect the data needed to estimate key parameters characterizing this fishery and its impacts on unmarked salmon. As per State–Tribal agreement (WDFW and NWIFC 2007), we tailored our sampling so that we could reliably estimate: *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

[2]The regulations specific to the 2008 Area 7 mark-selective fishery allowed for the retention of up to two legal-sized (≥22 inches [56 cm]) marked Chinook salmon per day and required the immediate release of all unmarked or sublegal Chinook. Additionally, anglers were: *i*) required to use single-point, barbless hooks while fishing for salmon, *ii*) held to a combined (all salmon species) two-fish daily limit during the Area 7 mark-selective fishery, and *iii*) held to a handling rule that prevented them from bringing unmarked and/or sublegal Chinook aboard their vessels.

unmarked Chinook mortalities[3], and *v*) the total mortality of marked and unmarked double index tag (DIT) CWT stocks. In addition, we acquired and analyzed relevant data characterizing other aspects of the pilot fishery, 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.

In the following pages, we report the results generated through our Area 7 monitoring activities. We first provide a brief review our in-season sampling and post-season assessment methods and then present detailed results for each component of our selective-fishery monitoring program. Results are presented according to the following sequence: *i*) the intensity (i.e., spatial and temporal coverage) of sampling efforts is described; *ii*) estimates of fishery characteristics obtained from creel survey data are reviewed; *iii*) the results from our recreational test fishery are presented; and *iv*) total fishery impacts—estimated based on the combination of creel and test fishery data—are reviewed and compared with pre-season expectations (i.e., based on Fishery Regulation Assessment Model [FRAM] predictions). Finally, we provide a detailed description of our impact estimation scheme as well as additional and relevant data in a series of appendices (i.e., sample-rate tables and sampling summaries; age composition tables [for landed catch and test fishery encounters]; and raw CWT recoveries).

METHODS

Marine Catch Area Description

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 1**). Covering more than 800 square miles (2,050 km^2) 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 5-12). 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., "blackmouth").

Monitoring Program Overview

Our sampling program for the Area 7 fishery incorporated comprehensive and complementary data collection strategies, including dockside angler interviews (with catch sampling), aerial effort surveys, test-fishery-based sampling, and voluntary reports of completed trips provided by charter anglers, private anglers, and derby participants (Roche Harbor Salmon Classic, February 8-9, 2008) (**Figure 2**). Given that Area 7 is the first selective fishery where we relied on aerial instead of boat surveys, we provide complete detail on this aspect of our design. For other aspects of our monitoring program, we provide only a brief review and refer the reader to WDFW (2007b or 2008b) for additional detail.

[3] 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, CWT-based (unexpanded) estimates of the stock composition of marked Chinook harvest are provided.

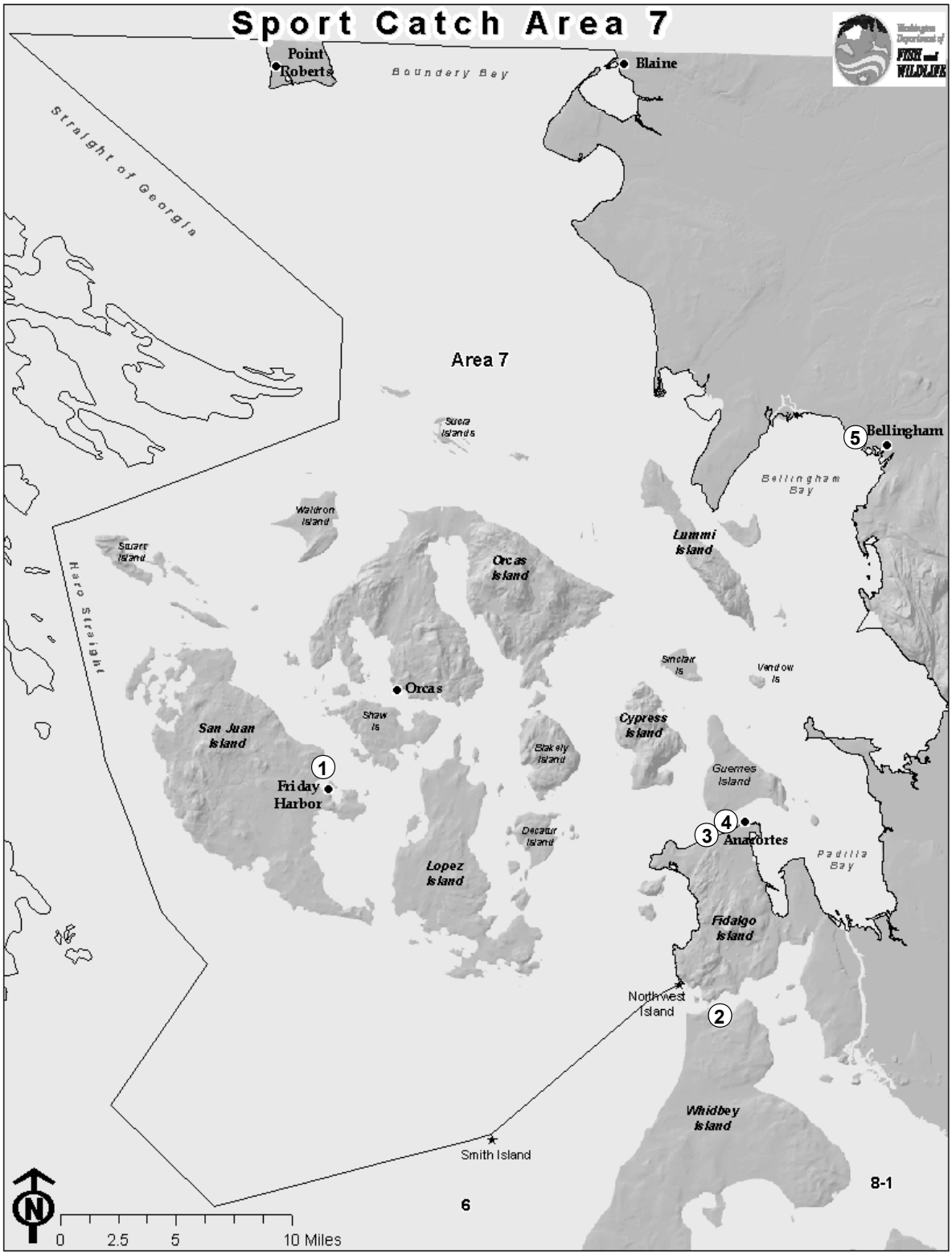

Figure 1. Map of Marine Catch Area 7 in Puget Sound. Open white circles correspond to the approximate location of the five public ramps or marinas where angler interviews and catch sampling occurred (1 = Friday Harbor Marina, 2 = Cornet Bay State Park Ramp, 3 = Washington Park Ramp, 4 = Skyline Marina, 5 = Bellingham Ramp) (Map Courtesy of Brian McTeague, WDFW).

Catch and Effort: Sampling and Estimation

We collected data on total catch (observed harvest and reported releases[4]) and total angling effort using an aerial–access design whereby: 1) catch and effort data were obtained by interviewing *all* anglers departing the fishery at five 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 was estimated from paired peak activity counts (i.e., boats) for sample frame sites and peak aerial boat counts (i.e., for all of Area 7) on days when both dockside sampling and aerial surveys were possible; and 3) total catch and effort estimates were obtained for all sample days by expanding sample-frame observations by the estimated sample fraction.

Dockside Sampling

We collected data on total catch and total angling effort using a two-stage stratified sample design. At the first stage, we selected five sample days from two temporal strata (weekday [Monday-Thursday], with $n = 2$ days sampled; weekend [Friday-Sunday], with each day always being sampled) during each week of the one-month fishery. On selected sample days, we staffed access sites (i.e., public ramps, boathouses, etc.) for creel sampling. Our dockside sample frame included all moderate-to-high effort, public boat launch facilities used to access Area 7, including: Bellingham, Cornet, and Washington Park ramps and Friday Harbor and Skyline marinas. 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; WDFW 2007b), we staffed *all* five sites on scheduled sample days. We opted to visit all sample sites on scheduled sample days so that we could 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 was excluded from our sample frame (i.e., private and/or low-effort access sites), we estimated sample frame coverage from aerial overflight data and accounted for this quantity in estimates of fishery-wide totals (see below and **Appendix A**).

At access sites selected for sampling on scheduled sample days, samplers interviewed *all* parties (from both fishing and non-fishing vessels) exiting the Area 7 fishery. During interviews, samplers acquired 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 possessed Chinook or coho salmon, samplers inspected them for CWTs using wand detectors, and collected snouts from CWT-positive individuals for later lab processing. Additionally, samplers took length measurements (fork and total) and scale samples from landed Chinook.

[4] In a recent evaluation of bias in mark-selective fishery parameter estimates, Conrad and McHugh (2008) concluded that recall errors likely cause bias in interview-based estimates of total salmon *releases*. Thus, although estimates of total salmon releases based solely on angler-reported data were generated for this report (**Appendix G**), we focus exclusively on bias-corrected "Method 2" estimates of Chinook encounters (and releases) in our review of the Area 7 fishery.

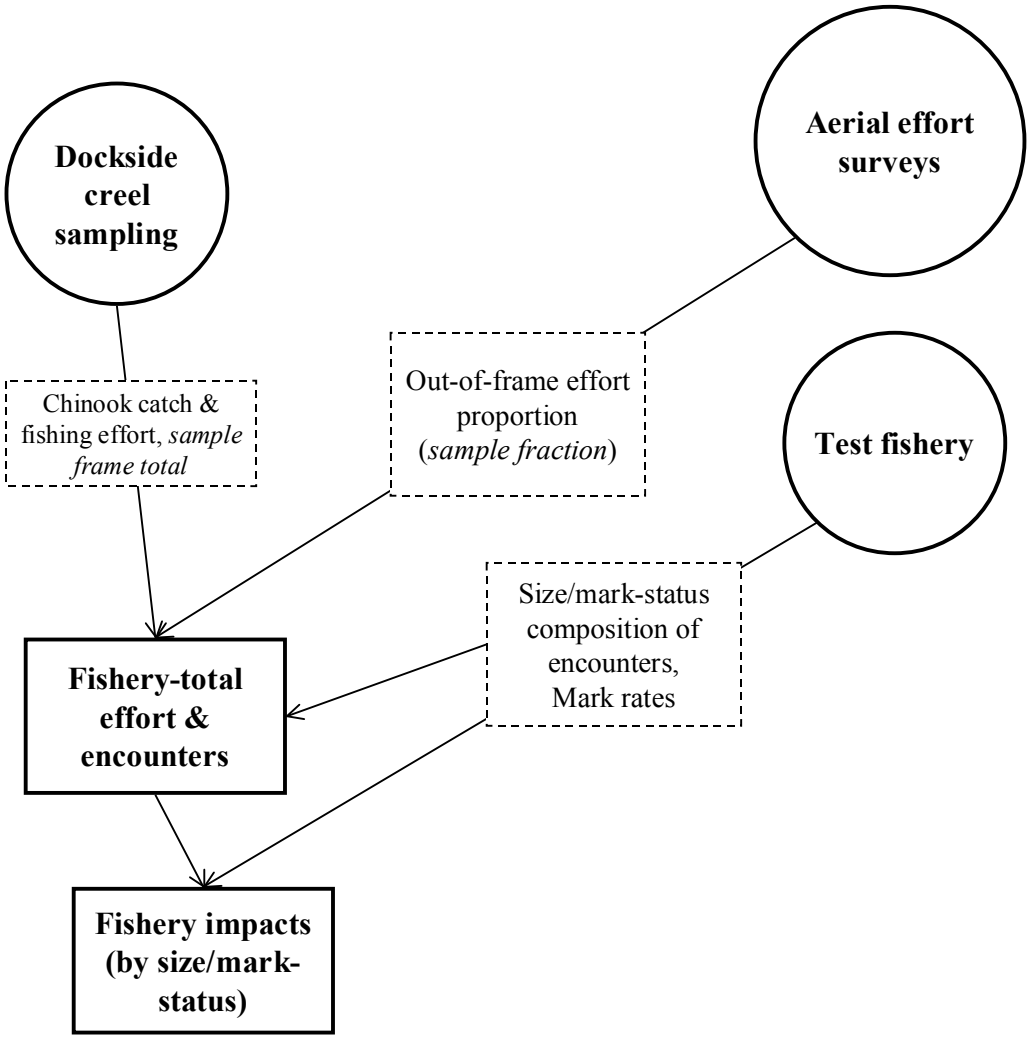

Figure 2. Conceptual diagram of the monitoring plan implemented in Area 7 during its February 2008 mark-selective Chinook season. Circles represent discrete sampling activities, dashed boxes represent parameters that are estimated using data from a given activity, and solid boxes depict key quantities estimated from the comprehensive plan. 'Encounters' includes both harvested and released Chinook salmon.

Aerial Surveys

Due to its vast size and complex geography, we used an aerial overflight approach to estimate total Area 7 effort and thus the proportion of effort captured in our five-site sample frame (i.e., the sample fraction [f = 1 – the out-of-frame effort prop'n]). Surveys were conducted on a subset (n = 8) of scheduled (i.e., dockside) sample days and were timed to coincide with the assumed period of peak activity for winter fisheries (1000-1400). Trained WDFW staff conducted the surveys from fixed-wing aircraft piloted by WDFW-enforcement or chartered personnel. For aerial each survey, samplers (aerial observers) circumnavigated the entirety of Area 7 and counted all recreational vessels observed while marking them on a map form. Aerial observers made no attempt to distinguish recreational boats as being either fishing or non-fishing in nature; however, obvious non-fishing vessels such as sail boats, commercial

crabbing vessels, etc., were noted as such on forms and omitted from final counts. Flights took 1.25 h (time over Area 7) on average and were flown at an elevation of 1,000 ft (305 m).

For each flight, we estimated 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 obtained stratum-specific estimates of the mean sample fraction (and its variance) and used 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 A**. In addition, to minimize the influence of recall bias on our assessment, we estimated 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 were estimated by dividing the creel estimate of legal-marked Chinook harvest by a field estimate 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. Although we do not review estimates of Chinook releases based solely on angler accounts in our assessment, we supply these estimates, as well estimates of retained catch and/or releases for other salmon species, in appendices to this report (**Appendices G**).

Charter and Derby Sampling

Given the higher catch per unit effort (CPUE) of charter and derby anglers relative to that of the private recreational fleet and the difficulty in directly sampling their catch (e.g., due to private moorage), we acquired catch (harvest + releases) and effort data for these anglers through separate efforts. First, before the start of the season we contacted all salmon charters with known operations in Area 7 and requested that they provide catch and effort information for all paid trips taken during the month of February. We supplied all charter captains with postage-paid Voluntary Trip Report (VTR) forms and a memo detailing instructions for proper form completion. For fishery-total catch and effort estimation efforts, charter data were treated as being the result of a complete census (i.e., with zero variance). Second, we took extra measures to acquire catch (harvest and releases) and effort data for the Roche Harbor Salmon Classic Invitational Derby (Feb. 8-9, 2008). With the cooperation of derby staff and participating anglers, we acquired information on catch and effort using derby-specific VTR forms. Also, WDFW personnel staffed the derby to encourage VTR completion as well as to collect biological data (lengths, scales, and coded-wire tags) landed Chinook. After expanding to account for non-response, derby-VTR catch and effort totals (and variances due to expansions) were simply added to creel survey totals (and variances).

Test Fishery Methods

In order to obtain accurate estimates (i.e., free from survey-based recall error) of the size (legal or sublegal) and mark-status (marked or unmarked) composition of the pool of Chinook salmon encountered by anglers participating in the fishery, we conducted a recreational test fishery during the entirety of the mark-selective Chinook season (**Table 1**). Our test boat crew consisted of two WDFW technicians, each fishing with a single rod for five days a week (Monday-Friday). Test fishers focused their efforts at locations that optimized their overall encounter rate and mirrored choices made by the at-large private fleet. Also, test fishers fished for Chinook using the same methods as the recreational fleet, as prescribed by supervisory staff based on dockside interview results for the preceding week. For each fish brought to boat, test fishers logged details on its identity (species), size (fork length and total length), and, if applicable, mark status (marked or unmarked). For Chinook salmon encounters only, test fishers additionally collected scale and DNA samples (~1-cm^2 piece of dorsal tissue).

Estimating Fishery Impacts

Total Encounters and Mortalities

We characterized 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**). As indicated above and in contrast to previous post-season MSF reports, we 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, total encounters were estimated by dividing creel estimates of legal-marked Chinook harvest by the test fishery-based proportion of the targeted Chinook population that was of legal size and marked, inclusive of a bias correction accounting for the modest level of legal-marked Chinook release that may occur in this fishery. We then decomposed total encounters into size/mark-status group-specific estimates using test-fishery encounters composition data.

We estimated 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 was equivalent to the total harvest estimate for the applicable size/mark-status group. We applied 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 involved comparing fishery outcomes to pre-season expectations. To do this, we compared season-total estimates of Chinook encounters and mortalities to pre-season modeled values (FRAM model run no. 3907) for each size and mark-status category.

Table 1. Sampling/estimation details on target parameters associated with the overall Area 7 mark-selective fishery monitoring program (**Figure 1**).

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]	Angler trip; kept fish; reported fish release	Week[1]	Within weeks, estimates are also produced by strata (weekday/weekend).
Test Fishing	Size (legal/sublegal) and mark-status composition (marked, unmarked) of encountered Chinook	Chinook length, age, and DNA-based[3] stock composition; species composition of non-Chinook encounters	Fish encounter	Season (1 month)	Too few encounters occurred to assess mark rates on a finer time scale. In fact, VTRs were ultimately used to bolster test fishery sample sizes.
Overall Fishery Impacts Estimation	Total Chinook encounters and mortalities, by size/mark-status group	Ratios of encounters and mortalities per kept Chinook	N/A	Season (1 month)	The temporal resolution of impact estimates is constrained by that of the test-fishery encounters data.
Coded-wire tag (CWT) Impacts Estimation	Marked/unmarked double-index tag (DIT) encounters and mortalities	N/A	N/A	Season (1 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.
[3] Though samples were collected, DNA-based estimates of stock composition are not yet available for this fishery.

CWT Impacts

To understand the potential effects of the Area 7 mark-selective fishery on CWT-based cohort-reconstruction efforts, we estimated the total number of unmarked-tagged Chinook mortalities that may have occurred during the course of its February 1-29, 2008 season. To do this, we acquired 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 applied the methods described by the Selective Fisheries Evaluation Committee – Analysis Work Group (SFEC-AWG 2002) to estimate the number of unmarked DIT fish encountered[5]. We subsequently estimated the number of these fish that may have died due to hook-and-release impacts using an *sfm* analogous 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 used an *sfm* of 10% in all unmarked-DIT mortality calculations. Thus, we used 10% instead of 15% (applied above to legal-sized releases) since unseen drop-off mortality (the 5% differential) is a feature common to selective and non-selective recreational Chinook fisheries.

[5] 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.

RESULTS & DISCUSSION

Summary of Sampling Efforts

Ramp samplers were present at the five selected access sites (Bellingham, Cornet, and Washington Park ramps; Friday Harbor and Skyline marinas) for the entirety (dawn-dusk shifts) of 20 scheduled sample days. This included 7 weekdays, 5 Fridays, and 8 weekend days (**Table 2**). Dockside efforts yielded samples of 919 boat trips (81% fishing, 19% non-fishing), 1,503 angler trips, and 414 landed Chinook (413 marked, 1 unmarked) for the month of February. Overall, Washington Park (51% of sampled angler trips) and Bellingham ramps (23%) produced the majority of effort contained in our sample frame, while 8-9% of all sampled angler trips originated from each Cornet Ramp, Skyline Marina, and Friday Harbor Marina.

Although 10 aerial surveys were scheduled during our pre-season planning process, inclement weather prevented aerial surveys during the first third of the month. In total, we conducted eight overflights during the one-month fishery (2 weekday, 2 Friday, and 4 weekend flights; **Table 2**; **Appendix D**). All flights occurred during periods of high activity, and viewing conditions were excellent in all cases. Over the eight surveys, aerial observers counted between 45 and 273 (average = 110) recreational vessels in Area 7; between 17 and 114 (average = 52) of these boats returned to sites contained in our dockside sample frame (based on trip times reported during interviews).

Table 2. Sampling calendar for the February 2008 Area 7 mark-selective Chinook fishery. Shaded cells are days when dockside creel sampling was conducted at all five sample-frame sites; "A" denotes days when aerial surveys occurred; "TF" represents test-fishing days; and "RD" represents supplemental Roche Harbor Derby sample days. Bold outer boxes denote strata boundaries (Weekday [Monday-Thursday] and Weekend [Friday-Sunday]); February 18th, President's Day, was included in the Weekend stratum.

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
					1	2 **TF**
3	4 **TF**	5	6	7	8 **RD, TF**	9 **RD**
10 **TF**	11	12 **TF**	13 **A, TF**	14 **TF**	15 **A, TF**	16 **A**
17 **A**	18 **TF**	19 **TF**	20 **TF**	21 **A, TF**	22 **TF**	23 **A**
24 **A**	25 **TF**	26 **TF**	27 **TF**	28 **TF**	29 **A, TF**	

Based on the combination of aerial boat counts and dockside observations of boats active during flights, we estimated that on average approximately half (46%) of all Area-7 fishing effort originated from sites contained in our sample frame (**Appendix D**). At 56% and 36%, respectively, the average sample fraction was higher for weekends than it was for weekdays; these differences were not significant, however (**Appendix A**) so flight data were pooled across strata for total estimation.

Fishery Characteristics

Estimates of Fishing Effort and Catch

Nearly 5,000 angler trips were completed by a combination of private fleet, charter, and derby anglers during the February 2008 Area 7 mark-selective Chinook fishery (**Table 3**). The three groups harvested a grand total of 1,324 marked Chinook and released an additional 1,639 Chinook (440 marked, 1,195 unmarked, and 4 unknown mark-status).

Private fleet anglers completed a total of 4,184 angler trips (2,092 boat trips) in Area 7 during the February selective season (**Table 3**). Over these trips, we estimated that a total of 1,154 Chinook (1,152 marked, 2 unmarked) were retained, yielding a private fleet catch per unit effort (CPUE) of 0.28 landed Chinook retained per angler trip (**Table 3**). Based on reported salmon releases, we also estimated that a total of 1,422 Chinook salmon (375 marked and 1,047 unmarked) were caught and released by this group of anglers.

Charter fishing activity constituted a minor portion of total fishing activity (1% of all angler trips) present in Area 7 during February (**Table 3**). Three separate operators reported taking clients fishing during the fishery resulting in a total of 29 charter-led angler trips (9 boat trips). Charter anglers encountered 20 Chinook salmon, 8 of which were harvested (all marked) and 12 of which were released (2 marked, 10 unmarked). At 0.28 retained Chinook per angler trip, charter-angler CPUE was comparable to that of the non-charter private fleet. Charter anglers retained all legal-marked encounters.

In contrast to salmon charters, the Roche Harbor Salmon Classic Invitational Derby generated a significant amount of catch (12% total landed Chinook) and effort (13% of total angler trips) relative to fishery totals (**Table 3**). Based on a derby-participant response rate of 69% (68 of 99 VTRs returned), we estimated that a total of 198 boat trips and 649 angler trips occurred during the two-day derby (Feb. 8-9). This effort resulted in 370 Chinook salmon encounters (165 harvested [all marked], 205 released [63 marked, 138 unmarked, 4 unknown mark-status]). At 0.25 landed Chinook per angler trip, Roche Harbor Derby CPUE was slightly less than that documented for charter and private-fleet anglers.

Characteristics of Harvested Chinook

Length and Age.—During the course of the Area 7 fishery, 438 (64 derby and 374 at dockside sample sites) retained marked Chinook salmon were sampled at dockside (**Table 4**; note, 1 unmarked Chinook was observed at dockside but not sampled during interviews). All of these

fish were measured and examined for the presence of a CWT. Harvested Chinook ranged from 51 to 96 cm and averaged 71 cm (SD = 8 cm) in total length (**Figure 3**). As might be expected, the Chinook harvested during the Roche Harbor Derby (mean = 72 cm, SD = 8 cm) were slightly larger than those harvested by the private fleet at large (mean = 69 cm, SD = 8 cm; two-sample *t*-test t = -2.56, *P* = 0.006). Overall, the majority (429/438 or 98%) of Chinook harvested were of legal size (≥22 in or 56 cm TL).

While scales were collected from all sampled Chinook, only 399 (63 derby and 336 dockside) of these could be aged. Over half (58%) of all aged Chinook were 4 years old (brood year 2004), and 89% of aged individuals were subyearling outmigrants (**Appendix E**). The remaining age samples were primarily from brood year 2005 (age 3.1 = 41% of total), with 6 2003 brood individuals (ages 5.1 and 5.2) also being observed.

CWT Samples.—We recovered a total of 75 coded-wire tags from the 438 retained marked Chinook salmon that were examined as part of our dockside (*n* = 62) and derby (*n* = 13) sampling efforts (**Table 5**; **Appendix F**). The majority of CWT fish (94.7%) were from Puget Sound (89.3%) and Hood Canal (5.3%) release sites, with the remaining 5% coming from Canadian production facilities in the Georgia Basin (East Coast Vancouver Island and Fraser Basin). For Puget Sound recoveries, north Puget Sound CWT groups were most abundant with nearly half of these tags coming from one release site and rearing facility (Cascade River, Marblemount Hatchery). In addition, 33 of the CWTs recovered were associated with a double-index tag (DIT) group (See Overall Fishery Impacts: Estimated CWT-DIT Impacts for estimated unmarked-DIT mortality results).

Table 3. Estimates of total fishing effort and total salmon catch (harvest and reported releases) during the February 2008 Area 7 selective fishery. Values may not add exactly due to rounding error. AD = marked (i.e., adipose-clipped), UM = unmarked, UNK = unknown mark status.

Angler Group	Stat Wk	Start Date	End Date	Fishing Effort		Retained Chinook		Released Salmon[1]			Total Chinook Encounters
				Boats	Anglers	Marked	Unmarked	AD Chinook	UM Chinook	UNK Chinook	
Private Fleet	5	1-Feb	3-Feb	278	618	166	0	54	151	0	371
	6	4-Feb	10-Feb	209	404	146	0	48	133	0	328
	7	11-Feb	18-Feb	943	1853	501	0	163	457	0	1121
	8	19-Feb	24-Feb	489	993	304	2	99	275	0	679
	9	25-Feb	29-Feb	172	316	34	0	11	31	0	77
Private Fleet Subtotal:				**2092**	**4184**	**1152**	**2**	**375**	**1047**	**0**	**2576**
Roche Derby (8-9 Feb.) Subtotal[2]:				198	649	165	0	63	138	4	370
Charter (1-29 Feb.) Subtotal:				9	29	8	0	2	10	0	20
All Anglers Total:				2299	4862	1324	2	440	1195	4	2966
Standard Error:				145	292	75	1	124	121	2	259
CV (%):				6%	6%	6%	25%	28%	10%	46%	9%
95% CI:				2,015-2,582	4,290-5,435	1,177-1,471	1-3	198-682	957-1,433	3-8	2,458-3,473

[1] Released Chinook were estimated as the difference between total Chinook encounters generated using a bias-corrected "Method 2" estimator. See **Appendix A** and Conrad and McHugh (2008) for additional details.

[2] Given that 67 of 99 derby VTRs were returned, the derby subtotal had to be estimated; thus a derby variance component is included.

Table 4. Summary of harvested Chinook total length samples collected during dockside angler interviews and derby sampling, Area 7, mark-selective Chinook fishery, February 2008. Counts include observations made during both dockside (n = 374, Selective and Baseline Sport sampling) and Roche Harbor Derby (n = 64) sampling.

	Number Sampled		
Mark Type	**Legal-size**	**Sublegal-size**	**Total**
Marked	429	9	438
Unmarked	0	0	0
Undetermined	0	0	0
Total	**429**	**9**	**438**

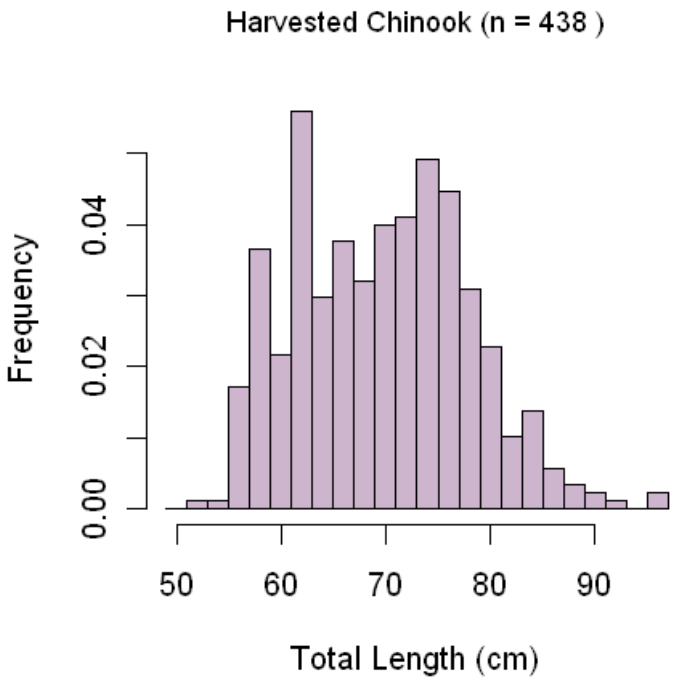

Figure 3. Length-frequency distribution for marked Chinook harvested during the Area 7 February 2008 mark-selective Chinook fishery. The figure includes observations made during both dockside (n = 374, Selective and Baseline Sport sampling) and Roche Harbor Derby (n = 64) sampling.

Table 5. Summary of coded-wire tags recovered from Chinook salmon harvested during the Area 7 February 1-29, 2008 mark-selective Chinook fishery. The field "# DITs" corresponds to the number of tags that belonged to double-index tag groups.

Release Region[1]	Release Site	Rearing Location	CWTs Recovered	No. DITs
British Columbia-Fraser R.	Chilliwack River	Chilliwack River Hatchery	1 (1.3%)	1
British Columbia-Vanc. Isl.	Big Qualicum River	Big Qualicum River Hatchery	2 (2.7%)	
	Puntledge River	Puntledge River Hatchery	1 (1.3%)	
Hood Canal	Finch Creek	Hoodsport Hatchery	1 (1.3%)	
	Purdy Creek	George Adams Hatchery	1 (1.3%)	1
	Skokomish River	Ricks Pond	2 (2.7%)	
Puget Sound-Central	Green River	Icy Creek Hatchery	1 (1.3%)	
	Grovers Creek	Grovers Creek Hatchery	1 (1.3%)	1
	Grovers Creek Hatchery	Grovers Creek Hatchery	1 (1.3%)	1
	Issaquah Creek	Issaquah Hatchery	4 (5.3%)	
Puget Sound-North	Baker River	Unreported	1 (1.3%)	
	Cascade River	Marblemount Hatchery	24 (32.%)	10
	Friday Creek	Samish Hatchery	7 (9.3%)	7
	N.F. Nooksack River	Kendall Creek Hatchery	4 (5.3%)	4
	Skagit River	Unreported	1 (1.3%)	
	Tulalip Creek	Bernie Gobin Hatchery	5 (6.7%)	
	Wallace River	Wallace River Hatchery	8 (10.7%)	5
	Whitehorse Springs	Whitehorse Pond	2 (2.7%)	
Puget Sound-South	Chambers Creek	Garrison Hatchery Lakewood Hatchery	2 (2.7%) 1 (1.3%)	
	Clear Creek	Nisqually Hatchery	3 (4.%)	3
	Deschutes River	Tumwater Falls Hatchery	1 (1.3%)	
	Voight Creek	Voight Creek Hatchery	1 (1.3%)	
		Grand Total	**75**	**33**

[1]Unofficial release regions. Puget Sound regions were designated based on the WDFW marine catch area containing the river/stream network where juvenile releases originated (i.e., Areas 11 and 13 = South; Areas 9 and 10 = Central; and Areas 7, 8-1, and 8-2 = North).

Test Fishing Results

Fishing Time and Gear Type

Test fishers were scheduled to fish five days per week during the month of February. However, as a result of inclement weather, test fishing activity was relatively limited during the first third of the month (**Table 2**). In total, test fishers spent 18 days and 118 hours on the water pursuing Chinook salmon during February (**Table 6**). Given that 100% of the interviewed anglers that successfully encountered Chinook salmon reported doing so while trolling with downriggers, test fishers pursued Chinook using only this method.

Chinook Encounters and Mark Rates

In total, test fishers encountered 31 Chinook salmon as a result of their 18 days and 118 hours of fishing. The majority of encountered Chinook were of legal size (77%), and less than half of these fish were adipose clipped (legal-sized Chinook mark rate: 42%; **Table 6**). The overall mark rate ([LM+SM]/total encounters) was also 42%. With a "CPUE" (i.e., LM Chinook *encounters* / angler trip) of 0.28, test fishers experienced a similar legal-marked Chinook encounter rate as did charter, derby, and at-large private fleet anglers.

Table 6. Composition of test fishery Chinook encounters and associated mark-rate and size/mark-status proportion estimates for the Area 7 February 1-29, 2008 mark-selective Chinook fishery. Variances associated with size/mark-status proportions and mark rates are provided in parentheses.

Stat	Fishing Effort		Legal		Sublegal		
Week	Days	Hours	AD	UM	AD	UM	Total
5	1	7.5	1	2	1	0	4
6	3	13.5	0	0	0	0	0
7	4	25.0	1	6	1	2	10
8	5	39.0	8	4	1	1	14
9	5	33.0	0	2	0	1	3
Total	**18**	**118**	**10**	**14**	**3**	**4**	**31**
Size/mark-status composition:			0.32 (0.01)	0.45 (0.01)	0.10 (0.00)	0.13 (0.00)	
Legal size mark rate:			0.42 (0.01)				
Overall mark rate:			0.42 (0.01)				

Given the limited number of test fishery encounters, we compared the test fishery size/mark-status composition with that estimated from VTR data (i.e., charter, derby, and private sources) in order to determine whether data could be pooled across sources. Specifically, we tested whether or not the frequency of observations in legal or sublegal size classes and marked or unmarked groups differed across the four data sources (i.e., test fishery and the three VTR sources) using χ^2 tests. Though there were too few test fishery observations in the four size/mark-status groups to reliably test for homogeneity at this level, separate legal- vs. sublegal-sized (test for size-class homogeneity: $\chi^2 = 11.7$, df = 3, $P = 0.008$) and marked vs. unmarked (test for mark-status group homogeneity: $\chi^2 = 7.5$, df = 3, $P = 0.059$) comparisons

suggest there were differences among datasets (**Table 7**). Accordingly, we assessed whether homogeneity could be achieved by omitting private VTRs, given their general tendency to differ from test fishery data without some form of quality control. Indeed this was the case (P = 0.34 and 0.07 for size-class and mark-rate comparisons), so we pooled data from the test fishery with those from both derby and charter VTRs to estimate the overall mark rate (61%) and the size/mark-status composition of Chinook encounters (50.3% legal-marked, 35.4% legal-unmarked, 8.9% sublegal-marked, and 5.3% sublegal-unmarked). We used these pooled values in our assessment of overall fishery impacts.

Table 7. Total Chinook encountered (retained and released) by anglers reporting their catch on voluntary trip reports (VTRs), with estimates of legal, sublegal, and overall mark rates. AD = marked (i.e., adipose-clipped), UM = unmarked. Note that the final dataset used for impact estimation was based on the test fishery and charter/derby VTRs.

		Legal		Sublegal			Mark Rates	
Data source	**Effort & Sample Size**	**AD**	**UM**	**AD**	**UM**	**Total**	**Overall**	**Legal**
Test Fishery	36 angler trips	10	14	3	4	31	0.42	0.42
Derby VTR	438 angler trips, 67 2-day VTRs	134	83	22	12	251	0.62	0.62
Charter VTR	16 angler trips, 5 1-trip VTRs	8	10	2	0	20	0.50	0.44
Private VTR	30 angler trips, 11 1-trip VTRs	17	8	10	3	38	0.71	0.68
Pooled data	**520 angler trips**	**169**	**115**	**37**	**19**	**340**	**0.606**	**0.595**
	Size/mark-status Composition:	0.497 (0.001)	0.338 (0.001)	0.109 (0.000)	0.056 (0.000)			

Chinook Size and Age

For marked and unmarked groups combined, the size (total length) of Chinook encountered by test fishers ranged from 48 to 89 cm and averaged 63 cm (SD = 11). Between groups, marked Chinook averaged slightly larger (mean = 64; **Figure 4**) than unmarked Chinook (mean = 63; **Figure 4**) but were not significantly different in size (two-sample t-test: t = -0.3 df = 22, P = 0.334). At 68 cm, the average size of legal-marked Chinook encountered by test fishers was similar to that for fish sampled in the private fleet's catch at dockside (i.e., 69 cm). Based on 26 readable scales (12 AD, 14 UM) collected from Chinook encountered in the test fishery, two thirds (67% AD, 71% UM) of all marked and unmarked individuals present in the targeted pool of Chinook were 3.1 years old (**Appendix E**).

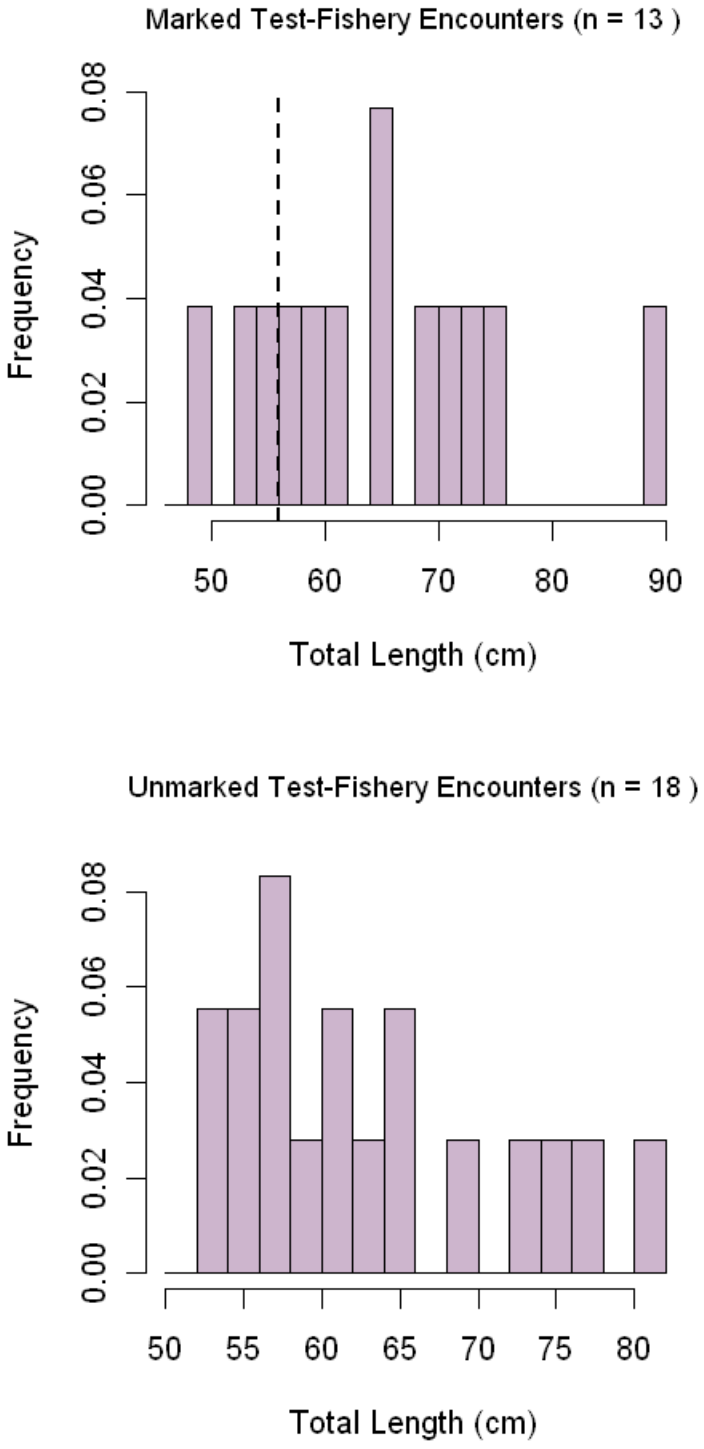

Figure 4. Length-frequency distributions of marked (*upper panel*) and unmarked (*lower panel*) Chinook encountered by test fishers during the Area 7 February 2008 mark-selective Chinook fishery. Note that the vertical dashed line in the upper panel corresponds to the legal size limit (22 in or 56 cm).

Other Fish Species Encountered

In addition to the 31 Chinook salmon encounters described above, test fishers caught and released two lingcod (*Ophiodon elongatus*), one copper rockfish (*Sebastes caurinus*), and two quillback rockfish (*Sebastes maliger*).

Overall Fishery Impacts

Total Encounters and Mortalities

Based on the combination of dockside sampling results (i.e., legal-marked Chinook harvest estimates derived from data in **Table 3** and **Table 4**), test fishery and VTR size/mark-status composition data (**Table 7**), and our intensive charter and derby census efforts (**Table 3**), we estimated that that 1,500 legal-marked, 1,044 legal-unmarked, 267sublegal-marked, and 155 sublegal-unmarked Chinook salmon were encountered by anglers fishing in Area 7 during February 2008 (**Table 8**). These encounters were comprised of an approximately 50:50 mix of retained (1,326 fish) and released (1,639 fish) Chinook salmon. Further, we estimated that just under one (0.9) unmarked Chinook salmon and 1.3 Chinook salmon overall was handled per legal-marked fish harvested. Given the assumed mortality rates of 0.20 for sublegal- and 0.15 for legal-sized Chinook salmon, we additionally estimated that 30 legal-marked, 156 legal-unmarked, 49 sublegal-marked, and 31 sublegal-unmarked Chinook (266 overall) died due to handling-and-release effects; this translates into an estimated 0.1 unmarked and 0.1 marked Chinook release mortality per legal-marked Chinook retained. In total, 1,592 Chinook (1,403 marked and 189 unmarked) mortalities occurred—92% due to direct harvest—as a result of the Area 7 mark-selective fishery. In addition, given the 31 (10 LM, 14 LU, 3 SM, 4 SU) Chinook caught and released in the Area 7 test fishery, an estimated 5 (2 marked, 3 unmarked) Chinook may have died as a result of our sampling activities.

FRAM versus Creel Comparison

The number of fish estimated to have been impacted by the Area 7 February 2008 fishery was considerably greater than was predicted based on pre-season modeling results. Whereas FRAM predicted that a total of 2,172 Chinook would have been encountered during the month of February, field data indicated that actual encounters were 37% higher than this value (**Table 9**, **Figure 5**). Field data also suggested that actual legal-sized and sublegal-sized Chinook encounter rates were 250% higher and 71% lower, respectively, than those expected as a result of pre-season modeling. For harvest and release mortality combined, FRAM predicted that a total of 214 unmarked, 564 marked, and 778 Chinook overall would die during the one-month selective season (**Table 10**, **Figure 5**), with a nearly 50:50 harvest and release mortality prediction. In contrast, creel results indicate that more than twice as many fish may have died during the course of the fishery, with 83% of these impacts being due to marked-Chinook harvest. Finally, despite the fact that observations exceeded expectations in most cases, estimated total unmarked Chinook mortality was comparable to what was expected based on pre-season modeling (**Figure 5**). Further, the FRAM-predicted overall mark rate (52%) was within 10% of what we estimated from field data (60%).

Table 8. Summary of season-wide fishery impact estimates for the Area 7 February 1-29, 2008 mark-selective Chinook fishery. Values may not add up perfectly due to rounding error.

	Total Encounters:	**2,968**	(Creel estimates: 1152 Marked Retained + 2 Unmarked Retained + 1423 Released; Charter & Derby: 173 Marked Retained + 0 Unmarked Retained + 218 Released)							
	V(E):	**66,839**								
Size/mark group	**Encounters**	**No. Retained**	**No. Rel'd**	**Rel. Mort. Rate**	**Rel. Mort.**	**Total Mortality**	**Var**	**SE**	**95% CI**	**CV (%)**
Legal marked	1,500	1,300	199	0.15	30	1,330	5,814	76	1181 - 1480	6
Legal unmarked	1,044	2	1,041	0.15	156	158	301	17	124 - 192	11
Sublegal marked	267	24	243	0.20	49	72	158	13	48 - 97	17
Sublegal unmarked	155	0	155	0.20	31	31	51	7	17 - 45	23
All groups combined	**2,966**	**1,326**	**1,639**		**266**	**1,592**	**6,325**	**80**	**1436 - 1748**	**5**

Table 9. Comparison of modeled (i.e., using FRAM, model run 3907) and estimated total Chinook encounters for the Area 7 February 1-29, 2008 mark-selective Chinook fishery.

Data Source	**Group**	**Total Encounters**	**Legal**	**Sublegal**	**Landed Only**
FRAM Encounters	Unmark.	1,038	303	735	24
	Mark.	1,134	424	710	398
	Total	2,172	727	1,445	422
	% Mark.	52	58	49	94
Estimated (Creel) Encounters	Unmark.	1,199	1,044	155	2
	Mark.	1,767	1,500	267	1,324
	Total	2,966	2,543	423	1,326
	% Mark.	60	59	63	100

Table 10 Comparison of modeled (i.e., using FRAM, model run 3907) and estimated total Chinook mortalities for the Area 7 February 1-29, 2008 mark-selective Chinook fishery.

	FRAM Chinook Mortalities			Estimated Chinook Mortalities		
Mortality Category	**Unmark.**	**Mark.**	**Total**	**Unmark.**	**Mark.**	**Total**
Total (Landed + Released	214	564	778	189	1403	1592
Released Legal	43	24	67	156	30	186
Released Sublegal	147	142	289	31	49	80
Landed Only	24	398	422	2	1324	1326

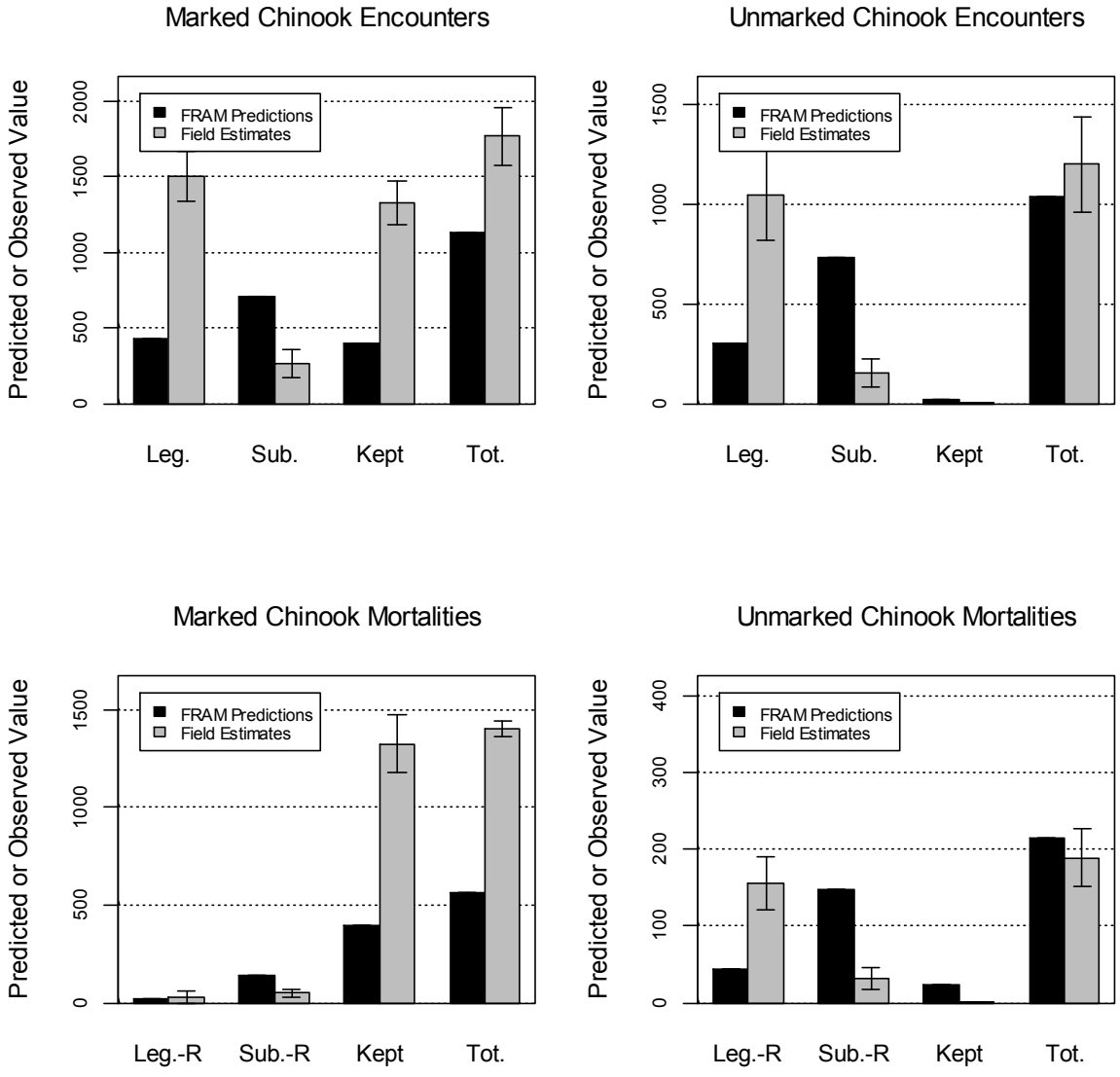

Figure 5. Comparison of modeled (i.e., using FRAM, model run 3907) and estimated total Chinook encounters and mortalities for the Area 7 February 1-29, 2008 mark-selective Chinook fishery. Error bars represent approximate 95% confidence intervals for field estimates.

Estimated CWT-DIT Impacts

Of the 75 coded-wire tags recovered during the Area 7 fishery, 33 belonged to double-index tag (DIT) release groups (**Table 10**). Based on the release details associated with these tags and their unmarked sister groups, we obtained an estimate of the unmarked-to-marked release ratio (λ) at juvenile release for each applicable hatchery of origin and brood year, and we used this value to estimate total unmarked DIT encounters for the entirety of the Area 7 fishery. In total, we estimated that 98 unmarked-DIT Chinook were caught and released during the fishery, nearly a third of which were of Marblemount Hatchery origin (brood year 2004). Given an *sfm* rate of 0.10, we estimate that as many as ten of these unmarked-DIT Chinook may have died as a result of Area 7 mark-selective fishery.

Table 11. Summary of double-index tagged (DIT) Chinook kept by anglers, and estimated total mortality of unmarked DIT Chinook due to hook-and-release impacts resulting from the Area 7 February 1-29, 2008 mark-selective Chinook fishery. AD = marked (i.e., adipose-clipped), UM = unmarked.

Hatchery	Brood Year	DITs Obs'd	AD DIT Harvest		UM DIT Enc.	UM DIT Mortality	
			Est.	var(Est.)		Est.	var(Est.)
George Adams Hatchery	2005	1	3.0	6.12	3.02	0.30	0.06
Grovers Creek Hatchery	2004	1	3.0	6.12	3.41	0.34	0.08
	2005	1	3.0	6.12	2.32	0.23	0.04
H-Chilliwack R. Hatchery	2005	1	3.0	6.12	3.07	0.31	0.06
Kendall Creek Hatchery	2005	4	12.1	24.47	12.14	1.21	0.25
Marblemount Hatchery	2004	10	30.2	61.16	29.77	2.98	0.59
Nisqually Hatchery	2003	1	3.0	6.12	2.98	0.30	0.06
	2004	2	6.0	12.23	6.12	0.61	0.13
Samish Hatchery	2004	1	3.0	6.12	3.18	0.32	0.07
	2005	6	18.1	36.70	16.49	1.65	0.30
Wallace Hatchery	2004	5	15.1	30.58	15.08	1.51	0.30
TOTAL		**33**	**99.8**	**201.84**	**97.58**	**9.76**	**1.94**

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REFERENCES

Cochran, W.G. 1977. Sampling Techniques (third edition). John Wiley and Sons. New York.

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/.

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.

Murthy, M.N. 1957. Ordered and unordered estimators in sampling without replacement. Sankhya 18:379-390.

Puget Sound Indian Tribes and WDFW. 2004. Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component. Olympia, WA. 253 pp.

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/fish/salmon/suggested_reading.htm.

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/fish/salmon/suggested_reading.htm.

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/fish/salmon/suggested_reading.htm.

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/fish/salmon/suggested_reading.htm.

Washington Department of Fish and Wildlife (WDFW) and Northwest Indian Fisheries Commission (NWIFC). 2007. 2007-8 Co-managers' List of Agreed Fisheries. Olympia, Washington.

APPENDICES

Appendix A. 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, 4, or 5 [Bellingham Ramp, Cornet Ramp, Friday Harbor Marina, Skyline Marina, or Washington Park Ramp]):

(1) $$y_{ij}^{(ds)} = \sum_{k=1}^{5} y_{ijk}$$

Given that *all* five 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) $$\hat{Y}_{ij} = \frac{y_{ij}^{(ds)}}{\bar{f}_j}$$, with variance

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

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 $\text{var}(\frac{1}{\bar{f}_j})$ is estimated according to the parametric approach described below (Equation 5). Totals were estimated for the weekday (Mon-Thurs) stratum according to:

(3) $$\hat{Y}_j = N_j \frac{\sum_{i=1}^{n_j} \hat{Y}_{ij}}{n_j}$$, 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 2) 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

$$\hat{f}_{ij} = \frac{X_{ij}}{m_{ij}}, \tag{4}$$

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, 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:

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

and α and β were estimated as:

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

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

where R_n is:

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

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

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

Given the data collected during the Area 7 February 1-29, 2008 fishery (**Appendix D**), we estimated α and β parameters at 4.23 and 0.079, respectively; given the $n = 8$ flights that occurred during the season, the α estimate indicates that total estimates may suffer from a slight negative bias (3%).

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 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 results, and (where applicable) charter and/or derby accounts. The estimation sequence builds from monthly[6] estimators of encounters-by-class (i.e., the four size [legal, sublegal] × mark-status [marked, unmarked] groups) to season-wide impact estimates. Where appropriate, the encounters (kept and released) for charter, derby, and/or other fishery components assessed via a complete census (i.e., totals without variance) are simply added to relevant total private-fleet 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. Secondarily, encounters are apportioned to the appropriate size/mark-status group using encounters-composition data collected in the test fishery (See *Test-fishery 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 ($\hat{K}_{LM\,i}$, defined on subsequent page) with a test fishery-based estimate of the proportion of the fishable Chinook population that is of legal size and marked ($\hat{p}_{LM\,i}$,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-$p_{\text{LM-R}}$, where $p_{\text{LM-R}}$ is the estimated legal-marked Chinook release rate)[7]. $\hat{E}_i$ and its variance are estimated as:

$$(1) \qquad \hat{E}_i = \frac{K_{LM}}{\left[\hat{p}_{LM}\,(1 - p_{LM-R})\right]}$$

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

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

[7] Equations 1 and 2 were modified based on a recent 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 $p_{\text{LM-R}}$ (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.

Test-fishery Encounter Composition

$\hat{p}_{LMi}$ = the test-fishery 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) $\hat{p}_{XYi} = n_{XYi} / n_i$, and

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

where n_i = the total number of fish encountered by test boats 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*) excluding *LM*, $\hat{E}_{XYi}$ and an estimate of its variance are obtained from:

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

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

Since the $\hat{E}_{LMi}$ estimate derived according to Eqn. 5 above is equivalent to that obtained by expanding $\hat{K}_{LMi}$ by the constant 1 - $p_{\text{LM-R}}$, its variance is estimated as:

(7) $\text{var}(\hat{E}_{LMi}) = \text{var}(\hat{K}_{LMi})/(1 - \hat{p}_{LM=R})^2$

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*[8] 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:

$$(8) \qquad \hat{d}_{XMK} = n_{XMK} / n_{MK}$$

$$(9) \qquad \mathrm{var}(\hat{d}_{XMK}) = [\hat{d}_{XMK} * (1 - \hat{d}_{XMK})] / (n_{MK} - 1),$$

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. 8 and 9) but using *season-wide* dockside observations on unmarked (*U*), not marked Chinook salmon.

Apportioned Estimates of Retention to Size Classes

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

$\hat{K}_{LU\,i}$ = 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:

$$(10) \qquad \hat{K}_{XM\,i} = \hat{d}_{XMK} * \hat{N}_{MK\,i}$$

$$(11) \qquad \mathrm{var}(\hat{K}_{XM\,i}) = \mathrm{var}(\hat{K}_{XM\,i}) * \hat{d}_{XMK}{}^2 + \hat{N}_{MK_i}{}^2 * \mathrm{var}(\hat{d}_{XMK}) - \mathrm{var}(\hat{N}_{MK\,i}) * \mathrm{var}(\hat{d}_{XMK})$$

[8] 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 $\hat{d}_{XYK}$.

where $\hat{d}_{XMK}$ and its variance are from 7 and 8 above and $\hat{N}_{MKi}$ is the survey estimate of retained marked fish for month *i* defined in Eqn. 1.

$\hat{K}_{SMi}$ = 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*

The number of retained, unmarked fish belonging to legal and sublegal size classes is estimated according to Eqns. 10 and 11 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:

$$\hat{R}_{XYi} = \hat{E}_{XYi} - \hat{K}_{XYi} \quad (12)$$

$$\mathrm{var}(\hat{R}_{XYi}) = \mathrm{var}(\hat{E}_{XYi}) + \mathrm{var}(\hat{K}_{XYi}) \quad (13)$$

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*), marked (*M*) Chinook in month *i* (= $\hat{K}_{SUi}$).

Release-mortality Estimates

$\hat{M}_{LMR_i}$ = estimated post-release mortality for legal (*L*), marked (*M*) Chinook in month *i*
$\hat{M}_{LUR_i}$ = estimated post-release mortality for legal (*L*), unmarked (*U*) Chinook in month *i*
$\hat{M}_{SMR_i}$ = estimated post-release mortality for sublegal (*S*), marked (*M*) Chinook in month *i*
$\hat{M}_{SUR_i}$ = 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:

(14) $\hat{M}_{XYR_i} = \hat{R}_{XY_i} * sfm_Y$

(15) $\text{var}(\hat{M}_{XYR_i}) = \text{var}(\hat{R}_{XY_i}) * sfm_Y^{\,2}$

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., $\hat{M}_{total} = \sum_{i=1}^{\max i} (\hat{M}_{XYK_i} + \hat{M}_{XYR_i})$] and variances [$\text{var}(\hat{M}_{total}) = \sum_{i=1}^{\max i} [\text{var}(\hat{M}_{XYK_i}) + \text{var}(\hat{M}_{XYR_i})]$], 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:

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

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

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

Figure A1. (*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).

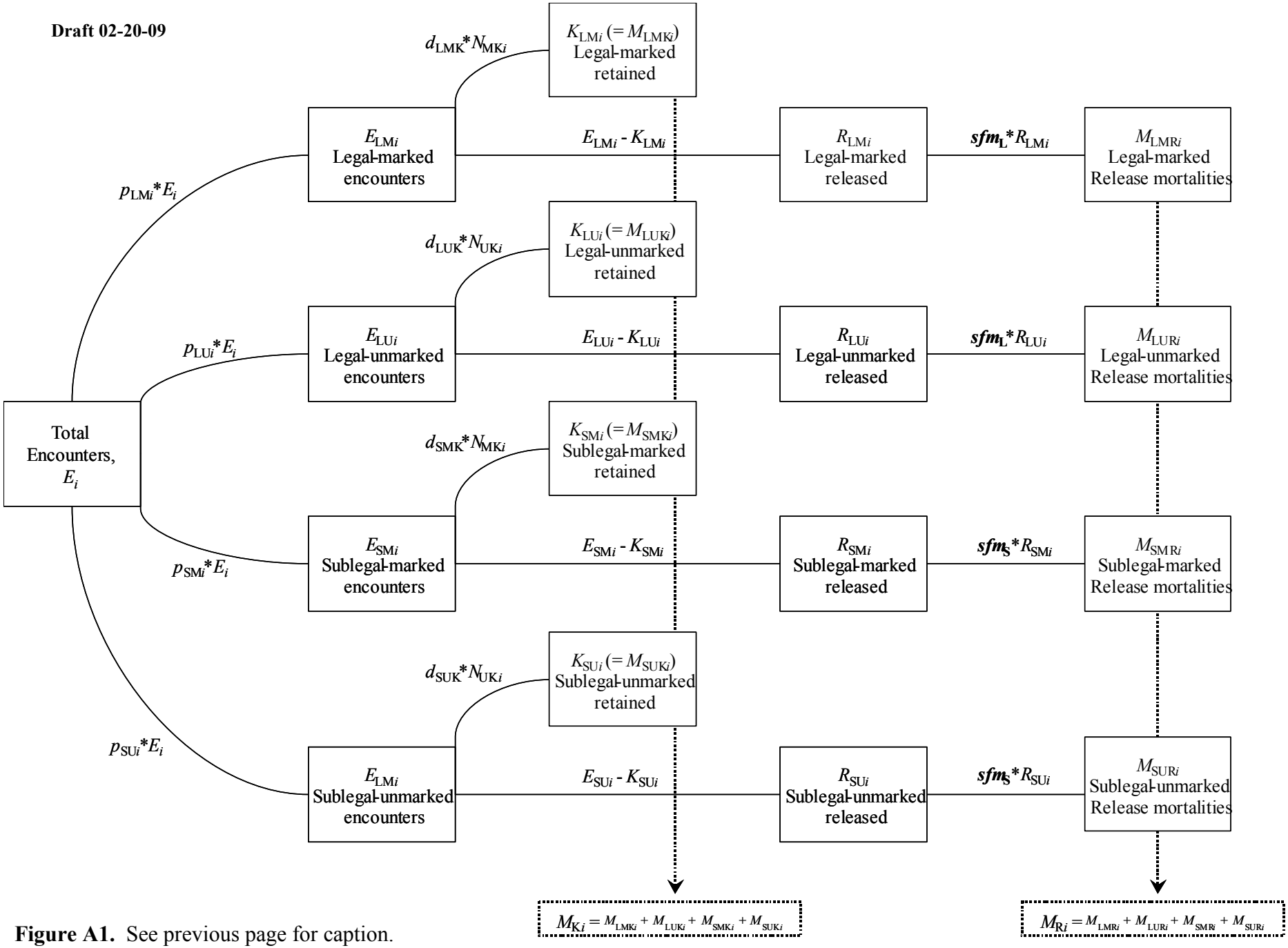

Figure A1. See previous page for caption.

Appendix C. Sampling summary and sample rate estimates from catch and effort sampling that occurred during the February 1-29, 2008 Area 7 selective Chinook fishery.

Data Type	Location	Boats[a]	Anglers	AD Chin. Kept	
				Logged	Sampled[b]
Sample Observations	Bellingham Ramp	161	353	75	48
	Cornet Bay Ramp	57	125	50	50
	Friday Harbor Marina	73	141	23	23
	Skyline Marina	61	115	43	44
	Washington Park Ramp	388	769	222	209
	Roche Harbor Derby	198	438	111	64
	Salmon Charters	9	29	8	0
	Grand Total	947	1970	532	438
Fishery Totals		2299	4862	1324	1324
Overall Sample Rate		**41%**	**41%**	**40%**	**33%**

a Fishing vessels only; an additional 179 non-fishing vessels were interviewed during dockside sampling efforts.

b During busy periods, samplers could not sample all landed (i.e., logged) Chinook for scales, CWTs, and lengths.

Appendix D. Aerial overflight sampling results.

Table D1. Summary of aerial overflight and dockside data used to estimate the fraction of Area 7 effort captured in the five-site sample frame. See Appendix A for computational details and notation.

		Aerial Survey Details			Dockside Sampling Details			
Survey Date	Stratum	Start Time	End Time	Total Boats, m_{ij}	Total Boats, Σy_{ijk}	Fishing Boats	Active Boats, X_{ij}	Sample Fraction, f_{ij}
13-Feb	Weekday	11:42	13:00	59	24	18	17	0.288
15-Feb	Friday	10:43	11:51	45	36	27	26	0.578
16-Feb	Weekend	12:48	13:57	175	115	100	87	0.497
17-Feb	Weekend	10:47	12:00	273	134	110	114	0.418
21-Feb	Weekday	11:55	13:12	48	20	14	12	0.250
23-Feb	Weekend	10:20	11:34	144	74	61	63	0.438
24-Feb	Weekend	13:39	14:58	85	117	98	77	0.906
29-Feb	Friday	9:45	10:47	50	22	14	17	0.340

Appendix E. Age composition of retained (dockside samples, inclusive of derby samples) and encountered (test fishery samples) Chinook salmon, Area 7 February 1-29, 2008.

Source	Mark-status group[1/]	Age[2/] Composition 3.1	4.1	4.2	5.1	5.2	Total
Dockside samples	AD	162 (41%)	187 (47%)	44 (11%)	5 (1%)	1 (0%)	399
Test Fishery	AD	8 (67%)	3 (25%)	0 (0%)	0 (0%)	1 (8%)	12
Test Fishery	UM	10 (71%)	4 (29%)	0 (0%)	0 (0%)	0 (0%)	14

[1/] AD = Adipose fin-clipped (marked); UM = Adipose fin in tact (unmarked).
[2/] Gilbert-Rich age notation, "Total Age". "Age at outmigration", inclusive of time spent in incubation.

Appendix F. CWTs recovered from Chinook salmon during the Area 7 February 2008 mark-selective Chinook fishery.

Recov Date	Tag Code	BY	ReleaseSite	RearingHatchery	Release Agency	DIT Code(s)	FL (cm)	Sex	RecovMark	ReleaseMark	Label
16-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW			M	AD Fin Clp	AD Fin Clp	57854
16-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888			Unkn Marks	AD Fin Clp	41261
16-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888			Unkn Marks	AD Fin Clp	41252
16-Feb	632789	04	WALLACE R 07.0940	WALLACE R H	WDFW	632788		M	AD Fin Clp	AD Fin Clp	57853
17-Feb	632789	04	WALLACE R 07.0940	WALLACE R H	WDFW	632788		M	AD Fin Clp	AD Fin Clp	57856
01-Feb	632875	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		71		AD Fin Clp	AD Fin Clp	32672
01-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	69	F	AD Fin Clp	AD Fin Clp	32671
01-Feb	633369	05	FRIDAY CR 03.0017	SAMISH H	WDFW	633368	61	M	AD Fin Clp	AD Fin Clp	32674
01-Feb	185726	05	R-PUNTLEDGE R	H-PUNTLEDGE R	CDFO		60		AD Fin Clp	AD Fin Clp	42701
01-Feb	210684	05	WHITEHORSE SPRINGS	WHITEHORSE POND	COOP		62	M	Unkn Marks	AD Fin Clp	32673
02-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		65	M	AD Fin Clp	AD Fin Clp	42702
02-Feb	632875	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		67		AD Fin Clp	AD Fin Clp	32675
02-Feb	632879	04	FINCH CR 16.0222	HOODSPORT H	WDFW		72	F	AD Fin Clp	AD Fin Clp	42703
02-Feb	210570	04	TULALIP CR 07.0001	BERNIE GOBIN H	TULA		74		AD Fin Clp	AD+OTOLITH	42704
02-Feb	210571	05	TULALIP CR 07.0001	BERNIE GOBIN H	TULA		54		AD Fin Clp	AD+OTOLITH	49013
03-Feb	633369	05	FRIDAY CR 03.0017	SAMISH H	WDFW	633368	52		AD Fin Clp	AD Fin Clp	42706
03-Feb	210571	05	TULALIP CR 07.0001	BERNIE GOBIN H	TULA		58		AD Fin Clp	AD+OTOLITH	42705
06-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	58		AD Fin Clp	AD Fin Clp	42719
09-Feb	632972	04	ISSAQUAH CR 08.0178	ISSAQUAH H	WDFW		74	M	Unkn Marks	AD Fin Clp	32676
09-Feb	210571	05	TULALIP CR 07.0001	BERNIE GOBIN H	TULA		60		AD Fin Clp	AD+OTOLITH	42707
09-Feb	210571	05	TULALIP CR 07.0001	BERNIE GOBIN H	TULA		59		AD Fin Clp	AD+OTOLITH	49014
09-Feb	632876	04	WALLACE R 07.0940	WALLACE R H	WDFW		72		AD Fin Clp	AD Fin Clp	42709
09-Feb	632876	04	WALLACE R 07.0940	WALLACE R H	WDFW		71	F	AD Fin Clp	AD Fin Clp	42708
10-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		83	F	AD Fin Clp	AD Fin Clp	42730
10-Feb	633369	05	FRIDAY CR 03.0017	SAMISH H	WDFW	633368	54	M	AD Fin Clp	AD Fin Clp	42592
10-Feb	632972	04	ISSAQUAH CR 08.0178	ISSAQUAH H	WDFW		75		AD Fin Clp	AD Fin Clp	42710
13-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		72		AD Fin Clp	AD Fin Clp	42711
13-Feb	632972	04	ISSAQUAH CR 08.0178	ISSAQUAH H	WDFW		71		AD Fin Clp	AD Fin Clp	42732
13-Feb	632874	04	SKOKOMISH R 16.0001	RICKS PD (LLTK)	WDFW		59		AD Fin Clp	AD Fin Clp	42731
14-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		83		AD Fin Clp	AD Fin Clp	42713
14-Feb	632972	04	ISSAQUAH CR 08.0178	ISSAQUAH H	WDFW		71	M	AD Fin Clp	AD Fin Clp	42521
14-Feb	184304	05	R-BIG QUALICUM R	H-BIG QUALICUM R	CDFO		64		AD Fin Clp	AD Fin Clp	42712
14-Feb	632789	04	WALLACE R 07.0940	WALLACE R H	WDFW	632788	68		AD Fin Clp	AD Fin Clp	42714
15-Feb	185032	05	R-CHILLIWACK R	H-CHILLIWACK R	CDFO	185030, 185031, 185154	61		AD Fin Clp	AD Fin Clp	42734
16-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		67	F	AD Fin Clp	AD Fin Clp	42595
16-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		65		AD Fin Clp	AD Fin Clp	42716
16-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	69	F	AD Fin Clp	AD Fin Clp	42523
16-Feb	632871	04	CHAMBERS CR 12.0007	GARRISON H	WDFW		64	F	AD Fin Clp	AD Fin Clp	42522
16-Feb	633369	05	FRIDAY CR 03.0017	SAMISH H	WDFW	633368	59		AD Fin Clp	AD Fin Clp	42718
16-Feb	632877	04	GREEN R 09.0001	ICY CR H	WDFW		73		AD Fin Clp	AD Fin Clp	42717
16-Feb	633172	05	NOOKSACK R -NF 01.0120	KENDALL CR H	WDFW	633171	68		AD Fin Clp	AD+OTOLITH	42715
17-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	61	M	AD Fin Clp	AD Fin Clp	42596
17-Feb	632873	04	DESCHUTES R 13.0028	TUMWATER FALLS H	WDFW		66		AD Fin Clp	AD Fin Clp	46461
17-Feb	633369	05	FRIDAY CR 03.0017	SAMISH H	WDFW	633368	66	M	AD Fin Clp	AD Fin Clp	42721
17-Feb	633285	05	GROVERS CR 15.0299	GROVERS CR H	SUQ	210682	59	M	AD Fin Clp	AD Fin Clp	42720
17-Feb	210591	04	SKAGIT R 03.0176		WDFW		75		AD Fin Clp	AD Fin Clp	42723
17-Feb	632876	04	WALLACE R 07.0940	WALLACE R H	WDFW		67		AD Fin Clp	AD Fin Clp	42722
21-Feb	633369	05	FRIDAY CR 03.0017	SAMISH H	WDFW	633368	66		AD Fin Clp	AD Fin Clp	42724
22-Feb	632871	04	CHAMBERS CR 12.0007	GARRISON H	WDFW		62		AD Fin Clp	AD Fin Clp	42725
23-Feb	210599	04	BAKER R 03.0435		WDFW		68		AD Fin Clp	AD Fin Clp	42729
23-Feb	632875	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		72		AD Fin Clp	AD Fin Clp	42727
23-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	78		AD Fin Clp	AD Fin Clp	42728

Recov Date	Tag Code	BY	ReleaseSite	RearingHatchery	Release Agency	DIT Code(s)	FL (cm)	Sex	RecovMark	ReleaseMark	Label
23-Feb	632783	04	CLEAR CR 11.0013C	NISQUALLY H	NISQ	210589	68		AD Fin Clp	AD Fin Clp	42621
23-Feb	633172	05	NOOKSACK R -NF 01.0120	KENDALL CR H	WDFW	633171	67		AD Fin Clp	AD+OTOLITH	49017
23-Feb	632789	04	WALLACE R 07.0940	WALLACE R H	WDFW	632788	70		AD Fin Clp	AD Fin Clp	49018
23-Feb	210684	05	WHITEHORSE SPRINGS	WHITEHORSE POND	COOP		56	M	AD Fin Clp	AD Fin Clp	42524
24-Feb	632978	04	CHAMBERS CR 12.0007	LAKEWOOD H	WDFW		62	M	AD Fin Clp	AD Fin Clp	42622
24-Feb	210592	04	GROVERS CR HATCHERY	GROVERS CR H	SUQ	632790	58	M	AD Fin Clp	AD Fin Clp	42526
24-Feb	633366	05	PURDY CR 16.0005	GEORGE ADAMS H	WDFW	633365	54	F	AD Fin Clp	AD Fin Clp	42623
24-Feb	185649	05	R-BIG QUALICUM R	H-BIG QUALICUM R	CDFO		59		AD Fin Clp	AD Fin Clp	42652
24-Feb	632964	04	VOIGHT CR 10.0414	VOIGHTS CR H	WDFW		72		AD Fin Clp	AD Fin Clp	42624
28-Feb	633172	05	NOOKSACK R -NF 01.0120	KENDALL CR H	WDFW	633171	58		AD Fin Clp	AD+OTOLITH	42653
08-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		67		Unkn Marks	AD Fin Clp	57004
08-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		66		AD Fin Clp	AD Fin Clp	57005
08-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	65		AD Fin Clp	AD Fin Clp	57003
08-Feb	633172	05	NOOKSACK R -NF 01.0120	KENDALL CR H	WDFW	633171	58		AD Fin Clp	AD+OTOLITH	57006
08-Feb	632468	03	SKOKOMISH R 16.0001	RICKS PD (LLTK)	WREG		74		AD Fin Clp	AD Fin Clp	57002
08-Feb	632789	04	WALLACE R 07.0940	WALLACE R H	WDFW	632788	74		AD Fin Clp	AD Fin Clp	57001
09-Feb	632391	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		57		Unkn Marks	AD Fin Clp	57011
09-Feb	632875	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW		68		AD Fin Clp	AD Fin Clp	57015
09-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	68		AD Fin Clp	AD Fin Clp	57012
09-Feb	632889	04	CASCADE R 03.1411	MARBLEMOUNT H	WDFW	632888	76		AD Fin Clp	AD Fin Clp	57009
09-Feb	210548	03	CLEAR CR 11.0013C	NISQUALLY H	NISQ	210547	67		AD Fin Clp	AD Fin Clp	57010
09-Feb	632783	04	CLEAR CR 11.0013C	NISQUALLY H	NISQ	210589	71		AD Fin Clp	AD Fin Clp	57013
09-Feb	632794	04	FRIDAY CR 03.0017	SAMISH H	WDFW	632795	65		AD Fin Clp	AD Fin Clp	57008

Appendix G. Fishery-total estimates of retained and released salmon (Chinook and other species) catch for the Area 7, February 2008 mark-selective Chinook fishery. Displayed Chinook harvest values are equivalent to those displayed in Table 3. Whereas the Chinook release estimates displayed in Table 3 are based on the Conrad and McHugh (2008) method, values displayed here are based solely on angler-reported data. Values may not add exactly due to rounding error. AD = marked (i.e., adipose-clipped), UM = unmarked, UNK = unknown mark status.

Angler Group	Stat Wk	Start Date	End Date	Retained Chinook		Released Salmon			
				Marked	Unmarked	AD Chinook	UM Chinook	UNK Chinook	UM Coho
Private Fleet	5	1-Feb	3-Feb	166	0	41	162	19	0
	6	4-Feb	10-Feb	146	0	37	138	24	2
	7	11-Feb	18-Feb	501	0	162	449	80	0
	8	19-Feb	24-Feb	304	2	88	258	50	0
	9	25-Feb	29-Feb	34	0	24	55	0	0
Private Fleet Subtotal:				**1152**	**2**	**352**	**1062**	**173**	**2**
Roche Derby (8-9 Feb.) Subtotal:				165	0	63	138	4	0
Charter (1-29 Feb.) Subtotal:				8	0	2	10	0	0
All Anglers Total:				1324	2	417	1211	177	2
Standard Error:				75	1	34	78	15	1
CV (%):				6%	25%	8%	6%	9%	25%
95% CI:				1,177-1,471	1-3	352-482	1,060-1,362	147-207	1-3