NATIONAL MARINE FISHERIES SERVICE REPORT

National Marine Fisheries Service (NMFS) Northwest and Southwest Regions will briefly report on recent developments relevant to salmon fisheries and issues of interest to the Pacific Fishery Management Council (Council). Included in the report will be a progress update on efforts to evaluate the effect of salmon fisheries on southern resident killer whales.

Council Action:

Council Discussion and Guidance.

Reference Materials:

Agenda Item C.1.b, NMFS Report: Evaluating the Effects of Salmon Fisheries on Southern Resident Killer Whales: A Bilateral Workshop Process Co-Sponsored by NOAA Fisheries and Fisheries and Oceans Canada.

Agenda Order:

a.	Agenda Item Overview	Mike Burner
b.	Regulatory Activities	Peter Dygert
c.	Reports and Comments of Advisory Bodies and Management Entities	
d.	Public Comment	
e.	Council Discussion and Guidance	

PFMC
10/12/12

Evaluating the Effects of Salmon Fisheries on Southern Resident Killer Whales: A Bilateral Workshop Process Co-Sponsored by NOAA Fisheries And Fisheries and Oceans Canada

Background. Southern Resident killer whales (*Orcinus orca*) are listed as an endangered species under both the U.S. Endangered Species Act (ESA) and Canada's Species at Risk Act (SARA). The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) and Fisheries and Oceans Canada (DFO) have developed and adopted recovery plans as required by the ESA and SARA. The plans are substantially similar; both describe the biological status of the population and specific threats and factors potentially limiting recovery. The plans establish recovery objectives, identify critical uncertainties and data gaps, and call for research to address the uncertainties and data gaps.

Both recovery plans identify several threats to killer whales: environmental contaminants, insufficient abundance of prey, physical disturbances by vessels, noise pollution, oil spills, diseases, climate change, small population size, and cumulative effects. The recovery plans generally do not characterize the absolute or relative importance of these threats. NOAA Fisheries and DFO have continued existing research and undertaken or supported new research to better understand the threats. Meanwhile, the agencies review proposed actions within their respective jurisdictions for potential negative effects on killer whales and use their authorities to prescribe measures to mitigate such effects.

The bilateral workshop process. To explore the potential effects of salmon fisheries on Southern Resident Killer Whales (SRKW) by reducing their prey, NOAA and DFO jointly sponsored a series of scientific workshops to evaluate the state of the science linking prey abundance – primarily Chinook salmon – to the population dynamics of SRKW. An independent panel of experts was appointed to consider and evaluate scientific information presented at the workshops and to provide a report on its findings on the following key question: *to what extent are salmon fisheries affecting recovery of Southern Resident killer whales by reducing the abundance of their prey, and what are the consequences of this reduction to their survival and recovery?*

The first workshop occurred in September of 2011 in Seattle, the second workshop March 13-15, 2012 in Vancouver, and the last occurred September 18-20, 2012 in Seattle. In the first two of these three-day workshops, scientific studies conducted by NOAA, DFO and other researchers relevant to the topic were presented and discussed among the panel and nearly a hundred invited scientists and observers. The science panel issued a draft report with its preliminary findings in May of 2012. Their report, and the comments received during a public comment period formed the basis of the final workshop in September.

Next steps. Now that the bilateral scientific workshops have been completed, the following will occur:

- The Independent Science Panel will meet as necessary to write its final report, taking into account public and agency comments on its draft report and the presentations and discussions that occurred at the 3rd workshop.

- The Panel's final report is due no later than November 30, 2012. It will be posted on NOAA's website at:

  http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/KW-Chnk.cfm

- Any interested party may submit comments on the Final Report to NOAA Fisheries and Fisheries and Oceans Canada (DFO). Written comments should be sent by January 31, 2013 by email to orca.plan@noaa.gov (all comments received by email will be shared with both agencies) or by regular mail sent directly to one or both agencies. Although we cannot commit to provide specific responses, all comments will be reviewed by the agencies to help inform future management decisions and recovery activities.

- NOAA Fisheries and DFO will confer with a view to coordinate their respective responses to the Final Report. Among other issues, they will consider how the findings and conclusions might

  - affect implementation and development of their respective recovery programs for Southern Resident Killer Whales

  - affect existing and future salmon fishery management decisions

  - influence priorities for research and monitoring

- After reviewing the findings and conclusions in the Final Report and conferring with DFO, NOAA Fisheries will decide whether to issue new guidance for U.S. fisheries or reinitiate ESA consultations on existing U.S. fisheries. DFO also will review the findings and conclusions of the Final Report to help inform decisions regarding Canada's domestic responsibilities.

- If NOAA Fisheries and DFO conclude that changes in salmon fisheries are warranted, they will work within existing domestic processes and the Pacific Salmon Commission to address such changes, with a view to coordinating fishery management responses.

- NOAA Fisheries and DFO will continue their existing practice of cooperating and coordinating research to guide SRKW recovery efforts.

2012 West Coast Salmon GSI Sampling

The West Coast Salmon GSI collaboration had a successful season in 2012, achieving the most comprehensive sampling coverage to date. We collected about 22,000 samples in Washington, Oregon, and California with almost 150 boats participating. Catch rates for Central Valley fall Chinook were the highest we have seen in three years of comprehensive sampling. In Washington this was the first year of funding for sampling, with a resulting increase in fisherman participation and improved coverage of fisheries. Oregon conducted five tests of a fishery-independent sampling design using commercial vessels to assess stock composition and distribution. California added a fourth year of distribution data north and south of Pt. Reyes, and collected additional movement information using acoustic tags. Sampling is planned in all three states in 2013, pending receipt of funds. Analysis is on-going and a full report will be presented to the Council in March 2013.

PFMC
10/29/12

Agenda Item C.2
Situation Summary
November 2012

PRESEASON SALMON MANAGEMENT SCHEDULE FOR 2013

To plan, announce, and meet *Federal Register* deadlines for public hearing sites and the entire preseason salmon management process, staff needs to confirm details of the process prior to the end of November, 2012. The proposed 2013 process and schedule are contained in Agenda Item C.2.a, Attachment 1.

For 2013, Council staff recommends one salmon management option hearing per coastal state, the same schedule as in 2012. The hearings would be:

March 25, 2013 Westport, Washington and Coos Bay, Oregon
March 26, 2013 Eureka, California

In 2013, the March Council meeting will occur in Tacoma, Washington and the April Council meeting in Portland, Oregon. Therefore, the public comment period on Sunday of the April meeting in Portland also serves as a public comment opportunity. If the states desire to have additional hearings, we suggest they organize and staff them as was done in past years. The table below provides the public attendance at the hearing sites since 1998 for Council reference.

Hearing Site Location[1/]	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Westport	4	18	24	30	11	16	16	25	26	34	20	27	21	54	25
Astoria		14													
Tillamook	28		13	16 [2/]	18 [2/]										
Coos Bay	15	31	36	18	40	26	26	105	146	43	60	108	60	19	29
Eureka	16	18	37	12	25	46	-				167	65	34	41	42
Ft. Bragg							27	38							
Sacramento	13														
Santa Rosa			4						500	35					
Moss Landing[2/]	100	51	50	33	14										

1/ Sites in bold are proposed for Council staffing in 2013.
2/ Hearing staffed by state personnel.

<u>Council Action</u>:

1. **Confirm Council-staffed hearing sites and state intentions for additional hearings.**
2. **Approve staff's overall proposed schedule and process for developing 2013 ocean salmon management measures.**

<u>Reference Materials</u>:

1. Agenda Item C.2.a, Attachment 1: Pacific Fishery Management Council Schedule and Process for Developing 2013 Ocean Salmon Fishery Management Measures.

<u>Agenda Order</u>:

a. Agenda Item Overview — Mike Burner
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action**: Adopt a 2013 Preseason Management Schedule

PFMC
10/11/12

PACIFIC FISHERY MANAGEMENT COUNCIL SCHEDULE AND PROCESS FOR DEVELOPING 2013 OCEAN SALMON FISHERY MANAGEMENT MEASURES

Nov 3-7, 2012	The Council and advisory entities meet at the Hilton Orange County, Costa Mesa, California, to consider any changes to methodologies used in the development of abundance projections or regulatory alternatives.
Jan. 22-25, 2013	The Salmon Technical Team (STT) meet in Portland, Oregon to draft The Stock Assessment and Fishery Evaluation (SAFE) document *Review of 2012 Ocean Salmon Fisheries*. This report summarizes seasons, quotas, harvest, escapement, socioeconomic statistics, achievement of management goals, and impacts on species listed under the Endangered Species Act. (February 5 print date, available on-line February 8.)
Feb. 19-22	STT meets in Portland, Oregon to complete *Preseason Report I Stock Abundance Analysis and Environmental Assessment Part 1 for 2013 Ocean Salmon Fishery Regulations*. This report provides key salmon stock abundance estimates and level of precision, harvest, and escapement estimates when recent regulatory regimes are projected on 2013 abundance, and other pertinent information to aid development of management options (February 28 print date, March 1 mailed to the Public and available on-line).
Feb. 23 through Mar. 4	State and tribal agencies hold constituent meetings to review preseason abundance projections and range of probable fishery options.
Mar. 6-11	Council and advisory entities meet at the Hotel Murano in Tacoma, WA to adopt 2013 regulatory alternatives for public review. The Council addresses inseason action for fisheries opening prior to May 1 and adopts preliminary alternatives on March 8, adopts tentative alternatives for STT analysis on March 9, and final alternatives for public review on March 11.
Mar. 12-16	The STT completes *Preseason Report II: Proposed Alternatives and Environmental Assessment Part 2 for 2013 Ocean Salmon Fishery Regulations* (March 19 print date, March 20 available to the public).
Mar. 12-31	Management agencies, tribes, and public develop their final recommendations for the regulatory alternatives. North of Cape Falcon Forum meetings are tentatively scheduled for March 13-14 and March 26-28.
Mar. 20	Council staff distributes *Preseason Report II: Proposed Alternatives and Environmental Assessment Part 2 for 2013 Ocean Salmon Fishery Regulations* to the public. The report includes the public hearing schedule, comment instructions, alternative highlights, and tables summarizing the biological and economic impacts of the proposed management alternatives.

Mar. 25-26	Sites and dates of public hearings to review the Council's proposed regulatory options are: Westport, Washington (March 25); Coos Bay, Oregon (March 25); and Eureka, California (March 26). Comments on the options will also be taken during the April Council meeting in Portland, Oregon.
Apr. 6-11	Council and advisory entities meet to adopt final regulatory measures at the Sheraton Portland Airport Hotel, Portland, Oregon. *Preseason Report II: Proposed Alternatives and Environmental Assessment Part 2 for 2013 Ocean Salmon Fishery Regulations*, results from the public hearings, and information developed at the Council meeting is considered during the course of the week. The Council will tentatively adopt final regulatory measures for analysis by the STT on April 7. Final adoption of recommendations to NMFS is tentatively scheduled to be completed on April 11.
Apr. 12-20	The STT and Council staff completes *Preseason Report III: Analysis of Council-Adopted Management Measures for and Environmental Assessment Part 3 2013 Ocean Salmon Fishery Regulations* (April 19 print date, mailed to the Council and available to the public April 21). Council and NMFS staff completes required National Environmental Policy Act documents for submission.
Apr. 21	Council staff distributes adopted ocean salmon fishing management recommendations, and *Preseason Report III* is made available to the public.
May 1	NMFS implements Federal ocean salmon fishing regulations.

PFMC
10/15/12

2012 SALMON METHODOLOGY REVIEW

Each year, the Scientific and Statistical Committee (SSC) and Salmon Technical Team (STT) complete a methodology review to help assure new or significantly modified methodologies employed to estimate impacts of the Council's salmon management use the best available science. The Methodology Review is also used as a forum to review updated stock conservation objective proposals. This review is preparatory to the Council's adoption, at the November meeting, of all anticipated methodology and conservation objective changes to be implemented in the coming season, or in certain limited cases, of providing directions for handling any unresolved methodology problems prior to the formulation of salmon management options in March. Because there is insufficient time to review new or modified methods at the March meeting, the Council may reject their use if they have not been approved the preceding November.

This year the SSC and STT are expected to report on:

- Implementation and Assessment of Proposed Bias-Correction Methods for Mark-Selective Fisheries into Fishery Regulation Assessment Model (FRAM) for Coho (Agenda Item C.3.a, Attachment 1).
- Impacts of Mark-Selective Ocean Recreational Fisheries on Washington Coast Coho Stocks (Agenda Item C.3.a, Attachments 2).
- Technical Revision to the Oregon Coastal Natural (OCN) Coho Work Group Harvest Matrix (Agenda Item C.3.a, Attachment 3).
- Comparison of Two Methods for Estimating Coho Salmon Encounters and Release Mortalities in the Ocean Mark-selective Fishery (Agenda Item C.3.a, Attachment 4).
- Review of Modifications to Chinook FRAM Size Limit Algorithms Implemented to Allow Evaluation of Size Limit Changes (Agenda Item C.3.a, Attachment 5).

Council Action:

1. **Approve new and modified methodologies as appropriate for implementation in the 2013 salmon season.**
2. **Provide guidance, as needed, for any unresolved methodology issues.**

Reference Materials:

1. Agenda Item C.3.a, Attachment 1: Implementation and Assessment of Proposed Bias-Correction Methods for Mark-Selective Fisheries into Fishery Regulation Assessment Model (FRAM) for Coho.
2. Agenda Item C.3.a, Attachment 2: Impacts of Mark-Selective Ocean Recreational Fisheries on Washington Coast Coho Stocks.
3. Agenda Item C.3.a, Attachment 3: Technical Revision to the Oregon Coastal Natural (OCN) Coho Work Group Harvest Matrix.
4. Agenda Item C.3.a, Attachment 4: Comparison of Two Methods for Estimating Coho Salmon Encounters and Release Mortalities in the Ocean Mark-selective Fishery.

5. Agenda Item C.3.a, Attachment 5: Review of Modifications to Chinook FRAM Size Limit Algorithms Implemented to Allow Evaluation of Size Limit Changes.
6. Agenda Item C.3.b, STT Report.
7. Agenda Item C.3.b, Supplemental SSC Report.

Agenda Order:

a. Agenda Item Overview — Mike Burner
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action**: Adopt Final Methodology Changes for 2013

PFMC
10/16/12

Implementation and Assessment of Proposed Bias-Correction Methods for Mark-Selective Fisheries into FRAM for Coho

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October 12, 2012

Pacific Fisheries Management Council
Salmon Methodology Review
October 10-11, 2012

Abstract

The Fishery Regulation Assessment Model (FRAM), used in the Pacific Fishery Management Council's pre-season planning process to project mortalities during proposed coho and Chinook salmon fisheries underestimates the number of unmarked mortalities occurring in mark-selective fisheries and concurrent non-selective fisheries. The bias is caused by approximating the non-linear Baranov catch equation with a linear model. When MSF operate during a modeled time period, unmarked mortalities are underestimated because released fish that survive may encounter the fishing gear more than once during the time period.

The bias-correction methods proposed by Conrad et al. (2010, 2012) were incorporated into FRAM's computational structure and algorithms. The model was implemented with no CNR mortalities and drop-off mortalities to simplify the interpretation of results. FRAM outputs of mortality were compared to results from unbiased calculations.

FRAM produced unbiased estimates of mortalities by stock for fisheries modeled as scalars or quotas. FRAM also produced unbiased landed and non-landed mortalities.

FRAM's handling of drop-off mortality through the use of a bias correction ratio rectified most of the bias introduced by drop-off. FRAM does not address mortalities from non-retention fisheries (release of marked and unmarked) within the bias corrected equations. This resulted in a very slight underestimate of mortalities.

Introduction

Mark-selective fisheries for coho salmon (*Oncorhynchus kisutch*) were introduced as a management tool in 1998 off the Washington coast (PFMC 1999a). Regulations for mark-selective fisheries permit the retention of legal-size coho which have had their adipose fin removed (marked) and require the release of all coho salmon with an adipose fin (unmarked) that are brought to the boat. The objective of mark-selective fisheries is to provide for fisheries on abundant (marked) hatchery salmon while reducing the impact on wild salmon.

The Fishery Regulation Assessment Model (FRAM) is used by the Pacific Fishery Management Council (PFMC) during the pre-season planning process to project mortalities during proposed coho and Chinook salmon fisheries. FRAM is a single-pool, deterministic model that has discrete time steps that vary in length from one month to several months (PFMC 2008a). All fisheries during a time step are assumed to operate simultaneously on a single pool of fish. The pool of modeled fish consists of all stocks that have been caught historically in the fishery as estimated from coded-wire tag (CWT) recoveries (Nandor et al. 2010). Historical exploitation rates estimated from CWTs recovered during a base period when salmon abundances were relatively high and fisheries were widely distributed in both time and area are the basis for the FRAM predictions of fishery mortalities by stock (PSC 2005). Details for the methods and algorithms used in FRAM are presented in PFMC (2008b). PFMC (2007a and 2007b) provides a description of the base-period data used for the coho FRAM.

In FRAM, the exploitation rate on the unmarked stock is a linear function of the exploitation rate on the tagged indicator stock used to represent the unmarked stock and the release-mortality rate. Since all encountered marked fish die, the exploitation rate of the tagged indicator stock is synonymous with the exploitation rate of the marked stock. Therefore, the exploitation rate calculation for an unmarked stock in FRAM can also be described as the exploitation rate of the marked stock component (μ_M) multiplied by the release mortality rate (δ). These linear calculations produce accurate results for the marked component of the stock, as long as 100% of the marked encounters are removed. As has been demonstrated in multiple papers (Conrad and Yuen, 2009 and 2010; Lawson and Sampson, 1996), unmarked mortalities are underestimated, because unmarked fish surviving release decrease slower in abundance than marked fish and can subsequently be re-encountered (multiple encounter bias); a process that can be accurately described using exponential equations.

These equations have been tested and described in previous presentations to the council. Additionally, a method on how to evaluate and assess the bias in the existing FRAM was presented by Bob Conrad at the November 2011 council meeting (Conrad and Hagen-Breaux, 2011). At that meeting the Model Evaluation Workgroup (MEW) put forth a recommendation to investigate the feasibility of coding the bias-corrected equations into coho FRAM.

This document provides a description of the status of this project and an assessment of the accuracy of mortality reports delivered by FRAM relative to unbiased estimates generated external to the model. Table 2 summarizes the specific testing objectives associated with this evaluation.

Methods

Conrad and Yuen (2009 & 2010) described a simulation model that produced unbiased, unmarked exploitation rates for a range of fisheries with different release mortality rates. This simulation model was used to test equations computing unbiased, time step exploitation rates, unbiased fishery exploitation rates, as well as landed and non-landed mortalities for fisheries that were modeled as rates (scalars) or quotas. These calculations were presented previously to the SSC, STT and the Council.

Lawson and Sampson (1996) demonstrated that in a mark-selective fishery, the actual mortality rate of unmarked fish is an increasing function of the apparent harvest rate on the marked fish. This causes the total number of unmarked mortalities in mark-selective fisheries to be underestimated by models that compute fishery mortalities in discrete time steps using linear catch equations.

Conrad and Yuen (2010) described a bias correction method where the unbiased exploitation rate of the selectively exploited unmarked stock ($\hat{\mu}^U$) can be computed as an exponential function of the encounter rate of the corresponding marked stock component and the release mortality rate (δ) as long as all marked fish encountered die (no release of marked fish):

Basic Equations

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$$\hat{\mu}_I^U = 1 - (1 - \textstyle\sum_i \mu_i^M)^{\delta_w} \qquad (1a)$$

$$\mu_i^M = \mu_i^B = BPER_i * \propto_i \qquad (2)$$

In the absence of marked salmon releases, the marked exploitation rate (μ_i^M) is the same as the base period exploitation rate ($BPER_i$)times a fishery scalar ($\propto_i$).

Weighted Release Mortality Equations

FRAM's computational structure poses some challenges to applying the unbiased unmarked fishery mortality equations. In FRAM, all fisheries occurring in a time step operate simultaneously on a single pool of fish using different stock and fishery specific base-period exploitation rates. Therefore, $\hat{\mu}^M$ is computed as the sum of the marked exploitation rates[1] of all fisheries affecting a stock in a given time step. Additionally, these fisheries can be modeled with a range of different release mortality rates for the unmarked stock component. The bias-correction procedure used in this analysis, described in Conrad and Yuen (2010), addresses heterogeneity in encounter and release mortality rates. Specifically, the total exploitation rate in all fisheries (both non-selective and mark-selective) for the marked component of the stock is used in equation 7 of Conrad and Yuen (2010) and a weighted release-mortality rate (equations 8 and 9) is calculated using 1.00 as the release-mortality rate for non-selective fisheries (NSF).

The weighted release mortality (δ_w) is computed as:

$$\delta_w = \delta_1 * w_1 + \delta_2 * w_2 + \cdots \delta_i * w_i \qquad (3)$$

And,

[1] For a marked or unmarked stock component, a time-step specific exploitation rate uses all fishery-related mortalities occurring in the time step (harvest plus release mortalities from mark-selective fisheries) for the numerator and the cohort abundance "After Natural Mortality" for the time step as the denominator.

$$w_i = \frac{\mu_i^M}{\sum_i \mu_i^M} \quad (4)$$

Conrad, Hagen-Breaux, and Yuen (2012) determined that the weighted release mortality rate in absence of mark recognition error can simply be computed as the biased, unmarked, time step exploitation rate ($\tilde{\mu}_I^U$) divided by the marked, time step exploitation rate (μ_I^M):

$$\delta_w = \frac{\tilde{\mu}_I^U}{\mu_I^M} \quad (5)$$

where, *I = sum of all fisheries i on a stock in a time step*

Allocating Total Mortality to Fisheries

For management purposes, the unbiased, time step exploitation rate ($\hat{\mu}_I^U$)is reported on a fishery-specific basis ($\hat{\mu}_i^U$). This is accomplished by splitting the time step exploitation rate ($\hat{\mu}_I^U$) into a fishery exploitation rate using the ratio of the biased fishery rate divided by the time step sum of all the biased fishery exploitation rates ($\frac{\tilde{\mu}_i^U}{\sum_i \tilde{\mu}_i^U}$) (Conrad and Yuen, 2010).

$$\hat{\mu}_i^U = \hat{\mu}_I^U * \quad \pi_i \quad (6)$$

and

$$\pi_i = \frac{\tilde{\mu}_i^U}{\sum_i \tilde{\mu}_i^U} \quad (6a)$$

Mark Recognition Error and Allocating Fisheries Mortalities to Landed versus Released

Most mark-selective fisheries are modeled with parameters that account for mark recognition error. For marked fish, mark-recognition error occurs when a portion of the marked fish encountered are released; for unmarked fish, mark-recognition error occurs when a portion of the unmarked fish encountered are retained.

When marked fish are released they are subject to the same calculation bias as the unmarked cohort and can no longer be used to solve for $\hat{\mu}_I^U$ in equation 1.

Conrad, Hagen-Breaux, and Yuen (2012, under review) developed unbiased equations that address this estimation problem. Unbiased marked and unmarked mortalities can be computed as:

$$\hat{\mu}_I = 1 - (1 - \textstyle\sum_i \mu_i^B)^{\delta_w} \quad (1b)$$

where, μ_i^B *is calculated as in equation 2*

If it is still desired to express $\hat{\mu}_I^U$ in terms of $\hat{\mu}_I^M$ the following equation (Conrad, Hagen-Breaux, and Yuen, equation 16) applies:

$$\hat{\mu}_I^U = 1 - (1 - \hat{\mu}_I^M)^{\delta_{UI}^W/\delta_{MI}^W} \quad (1c)$$

In a single pool model δ_w can be considered the average release mortality of all fisheries affecting a stock in a time step. When marked fish are released the release mortality δ changes from 1 (100% of encounters die) to a value smaller than 1. Conversely, when unmarked fish are retained in a mark selective fishery the release mortality increases. These parameter changes can be addressed in the computation of the weighted release mortality(δ_w).

For any given fishery the weighted release mortality of the unmarked is:

$$\delta_{wi}^{U} = (1 - \zeta_i) + (\zeta_i \cdot \delta_i) \qquad (7a)$$

where ζ_i is the (correct) unmarked recognition rate

For any given fishery the weighted release mortality of the marked is:

$$\delta_{wi}^{M} = \gamma_i + [(1 - \gamma_i) \cdot \delta_i] \qquad (8a)$$

where γ_i is the (correct) marked recognition rate

In the absence of mark recognition error all marked mortalities stem from landings and all unmarked mortalities stem from releases. With mark recognition error both sources of mortality can occur for the marked and unmarked cohort. To compute mortalities by source (landed versus released) the following equations apply:

For an unmarked cohort, landed catch for fishery i ($\widehat{D}_{Li}^{U}$) is calculated as:

$$\widehat{D}_{Li}^{U} = \widehat{D}_{i}^{U} * \frac{1 - \zeta_i}{(1 - \zeta_i) + (\zeta_i \cdot \delta_i)} \qquad (7b)$$

and non-landed mortality ($\widehat{D}_{Ni}^{U}$) is calculated as:

$$\widehat{D}_{Ni}^{U} = \widehat{D}_{i}^{U} \cdot \frac{(\zeta_i \cdot \delta_i)}{(1 - \zeta_i) + (\zeta_i \cdot \delta_i)} \qquad (7c)$$

Similarly for a marked cohort:

$$\widehat{D}_{Li}^{M} = \widehat{D}_{i}^{M} \cdot \frac{\gamma_i}{\gamma_i + [(1 - \gamma_i) \cdot \delta_i]} \qquad (8b)$$

and non-landed mortality ($\widehat{D}_{Ni}^{M}$) is calculated as:

$$\widehat{D}_{Ni}^{M} = \widehat{D}_{i}^{M} \cdot \frac{(1 - \gamma_i) \cdot \delta_i}{\gamma_i + [(1 - \gamma_i) \cdot \delta_i]} \qquad (8c)$$

Compare FRAM Bias-corrected Mortalities to Mortalities from Unbiased Calculations

In 2010, for testing purposes, James Packer added unbiased exploitation rate calculations for unmarked coho to FRAM program code in Visual Studio.Net. In 2011 and 2012, as new calculations were developed to deal with a range of fisheries scenarios and FRAM's computational structure, James Packer and Peter McHugh adjusted and added to existing algorithms into the testing version of FRAM.

Conrad and Hagen-Breaux (2011) described the step-wise procedures to calculate the bias in the FRAM estimates of exploitation rates, external to the model (i.e., in a spreadsheet). Once the size of the bias and the unbiased exploitation rates were known, comparisons to biased and unbiased FRAM output of mortality were made using a “Popstat” (Population Statistics, e.g., Table 1) report, which summarizes abundance, pre- and post-fishery mortality, for all FRAM stocks for each time step. To simplify the evaluation of results, FRAM was run with drop-off mortalities and non-retention fisheries set to zero. Comparisons were made using the final 2009 pre-season model run.

Table 1. Example of a PopStat Report and Comparison of FRAM and Calculated Results

Popstat Output				Calculations		
Tstep	Starting Cohort	After Nat Mort	After Fishing	Catch	Exploitation Rate (ER)	Calculated Unbiased ER
1	1615.97	1426	1425	1	0.052%	0.052%
2		1396	1363	33	2.361%	2.411%
3		1335	1279	56	4.172%	4.352%

(note: this is an example from a FRAM run that has not been bias adjusted)

Table 2. Testing phases and criteria used to evaluate the implementation of bias-corrected calculations of fishery impacts in FRAM.

Testing objectives
Phase 1. Bias correction in the absence of mark recognition error
Testing criteria: Scalar fisheries, unmarked exploitation rates
Testing criteria: Quota fisheries, unmarked exploitation rates
Testing criteria: Time step- and stock-specific fishery impacts, by number (landed, total) and rate for a stock by fishery
Phase 2. Bias correction accounting with mark recognition error
Testing criteria: Scalar fisheries, unmarked and marked exploitation rates
Testing criteria: Quota fisheries, unmarked and marked exploitation rates
Testing criteria: Time step- and stock-specific fishery impacts, by number (landed, non-landed, total) and rate for a stock by fishery

Results

Assessment of Basic Bias Correction

In FRAM, fisheries are modeled as either rates (scalars) or as quotas. For fisheries modeled as scalars, FRAM's bias-corrected exploitation rates match exploitation rates from unbiased calculations (Figure 1, Table 3).

Figure 1. Biased FRAM, Bias-Corrected FRAM, and Unbiased Estimates of Exploitation Rates for Model Stocks when Fisheries are Modeled as Scalars

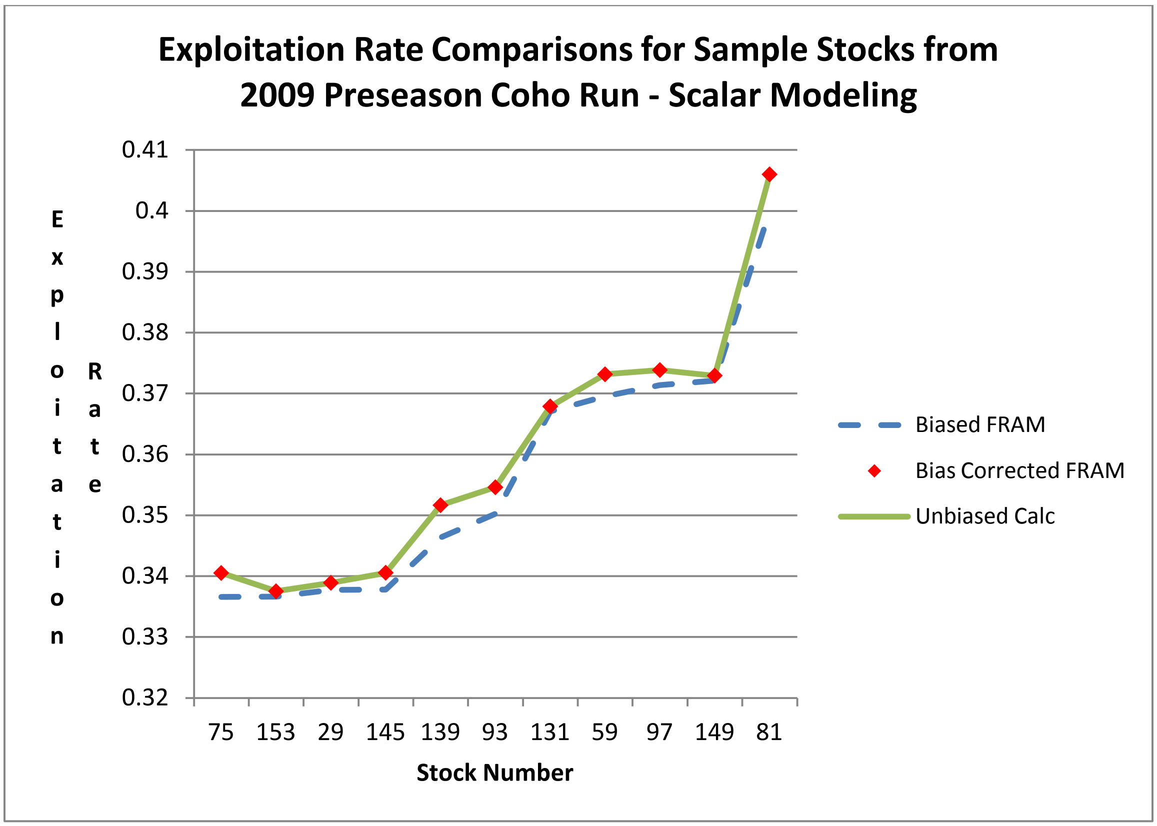

Table 3. Biased FRAM, Bias Corrected FRAM, and Unbiased Estimates of Exploitation Rates for Model Stocks when Fisheries are Modeled as Scalars

Stock #	Name	Biased FRAM ER	Bias Corrected FRAM ER	Unbiased Calculation	Initial Relative Bias
75	Area 13 Misc Wild	0.33660	0.34051	0.34051	-1.15%
153	Humptulips Wild	0.33666	0.33751	0.33751	-0.25%
29	Stillaguamish Wild	0.33776	0.33890	0.33890	-0.33%
145	Quinault Fall Nat	0.33779	0.34055	0.34055	-0.81%
139	Queets Fall Nat	0.34634	0.35165	0.35165	-1.51%
93	Area 10E Misc Wild	0.35027	0.35459	0.35459	-1.22%
131	Quillayute Fall Nat	0.36708	0.36787	0.36787	-0.21%
59	Skokomish Wild	0.36956	0.37315	0.37315	-0.96%
97	Green Wild	0.37138	0.37385	0.37385	-0.66%
149	Chehalis Wild	0.37213	0.37293	0.37293	-0.22%
81	Area 13A Misc Wild	0.39999	0.40599	0.40599	-1.48%

For fisheries modeled as quotas, FRAM's bias corrected exploitation rates match exploitation rates from unbiased calculations (Figure 2, Table 4).

Figure 2. Biased FRAM, Bias Corrected FRAM, and Unbiased Estimates of Exploitation Rates for Model Stocks when Fisheries are Modeled as Quotas

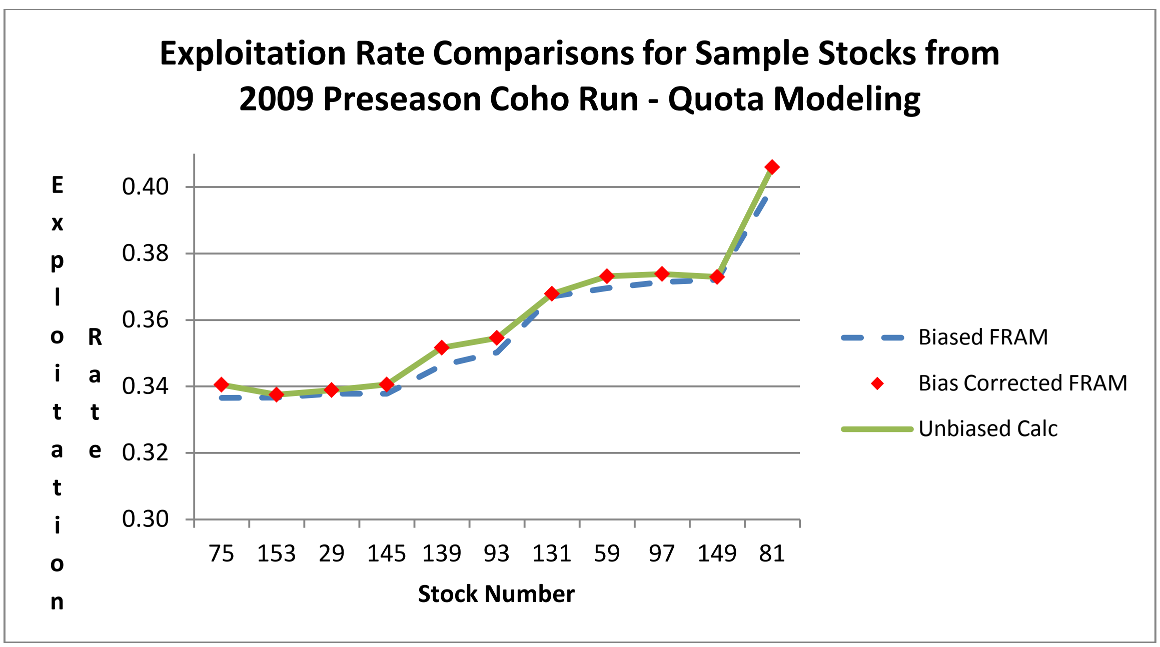

Table 4. Biased FRAM, Bias Corrected FRAM, and Unbiased Estimates of Exploitation Rates for Model Stocks when Fisheries are Modeled as Quotas

Stock #	Name	Biased FRAM ER	Bias Corrected FRAM ER	Unbiased Calculation	Initial Relative Bias
75	Area 13 Misc Wild	0.33660	0.34051	0.34051	-1.15%
153	Humptulips Wild	0.33666	0.33751	0.33751	-0.25%
29	Stillaguamish Wild	0.33776	0.33890	0.33890	-0.33%
145	Quinault Fall Nat	0.33779	0.34055	0.34055	-0.81%
139	Queets Fall Nat	0.34634	0.35165	0.35165	-1.51%
93	Area 10E Misc Wild	0.35027	0.35459	0.35459	-1.22%
131	Quillayute Fall Nat	0.36708	0.36787	0.36787	-0.21%
59	Skokomish Wild	0.36956	0.37315	0.37315	-0.96%
97	Green Wild	0.37138	0.37385	0.37385	-0.66%
149	Chehalis Wild	0.37213	0.37293	0.37293	-0.22%
81	Area 13A Misc Wild	0.39999	0.40599	0.40599	-1.48%

Allocating Total Mortality to Fisheries

In order to produce bias-corrected results that match unbiased calculations, accurate weighted release mortality rate equations have to be implemented in FRAM. Once it was established that FRAM could compute unbiased, time step exploitation rates, FRAM's output of bias-corrected mortalities by fishery were evaluated.

To apportion the time-step, bias corrected, unmarked exploitation rate of a stock to the individual fisheries, the simple (biased) unmarked exploitation rate was used as described in equation 6.

The bias-corrected fishery-specific mortalities and exploitation rates returned by FRAM match values calculated external to the model using the unbiased calculations.

Mark Recognition Error

In a mark selective fishery, mark recognition error is defined as the release of marked fish or the retention of unmarked fish. Estimates of these parameters are supplied to FRAM for each mark selective fishery, and their role in unbiased calculations is manifested within the weighted release mortality calculation of the unbiased equation (equations 7a, 8a).

In order to address the bias introduced by mark recognition error, three major changes were made to already existing bias corrected FRAM equations:

1. Discontinue use of marked exploitation rates to compute unbiased, unmarked mortalities. When marked fish are released, they also are subject to the "multiple encounter bias" and can no longer be used as a surrogate for non-selective exploitation rates. Instead, μ^B from equation 2 was used to compute unbiased unmarked exploitation rates.
2. Use unbiased equations to calculate mortalities of marked stock components.

3. To model quotas, find fisheries scalars iteratively. A quota is an unbiased estimate of marked and unmarked landed catch of all stocks in a fishery. The scalar that produces a quota is found using unbiased equations. Since these equations are exponential, the previous linear approach of computing the correct scalar, as quota catch divided by the catch that results from a scalar of 1, is no longer accurate. Instead, the correct scalar is found by iteratively repeating this calculation until a user specified precision is achieved (Conrad et al. 2012).

A comparison of FRAM output with unbiased calculations with non-zero mark recognition error (external to the model) reveals that the bias-correction algorithms correctly address mark recognition error.

For fisheries modeled as scalars or quotas, FRAM bias corrected unmarked exploitation rates match unbiased calculations.

Allocating Total Mortality to Landed and Release Mortality

FRAM bias corrected landed and non-landed mortalities match mortalities from unbiased calculations (equations 7b, 7c, 8b, 8c).

Correcting Bias Introduced by Drop-Off (DO) and Fisheries that Require Coho Non-Retention (NR)

Drop-off (the loss of a fish before it is brought on-board or on-shore) is modeled as 5% of the landed catch for the marked cohort and 5% of encounters (fish that would have been landed during a retention fishery) for the unmarked cohort. Bias corrected equations are incorporating the effects of drop-off through the use of a “Bias Corrected Ratio”. This ratio is computed as unbiased exploitation rate divided by biased exploitation rate $\frac{\hat{\mu}}{\tilde{\mu}}$.

$$DO_{bias\ corrected} = DO * Bias\ Corrected\ Ratio$$

This approach produces exploitation rates that are slightly lower than “true unbiased rates”. These unbiased rates can be computed by incorporating drop-off mortality in equation 1b.

Table 5. Influence of Drop-Off Mortality (DO) on Exploitation Rates

			Biased			Unbiased Calculations			Bias Corrected FRAM		
μ^B	δ	δ^w	Total	DO	MSF	Total	DO	MSF	Total	DO	MSF
0.05	0.14	0.181	0.0095	0.0025	0.0070	0.0097	0.0026	0.0072	0.0097	0.0026	0.0072
0.10	0.14	0.181	0.0190	0.0050	0.0140	0.0199	0.0052	0.0146	0.0199	0.0052	0.0146
0.15	0.14	0.181	0.0285	0.0075	0.0210	0.0305	0.0080	0.0225	0.0305	0.0080	0.0225
0.20	0.14	0.181	0.0380	0.0100	0.0280	0.0418	0.0110	0.0308	0.0417	0.0110	0.0308
0.25	0.14	0.181	0.0475	0.0125	0.0350	0.0536	0.0141	0.0395	0.0536	0.0141	0.0395
0.30	0.14	0.181	0.0570	0.0150	0.0420	0.0662	0.0174	0.0488	0.0661	0.0174	0.0487
0.35	0.14	0.181	0.0665	0.0175	0.0490	0.0795	0.0209	0.0586	0.0794	0.0209	0.0585
0.40	0.14	0.181	0.0760	0.0200	0.0560	0.0939	0.0247	0.0692	0.0937	0.0246	0.0690
0.45	0.14	0.181	0.0855	0.0225	0.0630	0.1093	0.0288	0.0805	0.1090	0.0287	0.0803
0.50	0.14	0.181	0.0950	0.0250	0.0700	0.1260	0.0332	0.0929	0.1255	0.0330	0.0925
0.55	0.14	0.181	0.1045	0.0275	0.0770	0.1444	0.0380	0.1064	0.1435	0.0378	0.1058

A non-retention fishery requires the release of every marked and unmarked coho encountered. Bias corrected equations are currently not incorporating the effects of non-retention fisheries[2], resulting in a slight underestimate of actual mortalities.

Table 6. Influence of Coho Non-Retention (NR) on Exploitation Rates

				Biased			Unbiased Calculations			Bias Corrected FRAM		
μ^B	μ^{NR}	δ	δ^w	Total	MSF	NR	Total	MSF	NR	Total	MSF	NR
0.050	0.039	0.14	0.5175	0.0470	0.0070	0.040	0.0472	0.0072	0.040	0.0472	0.0072	0.040
0.100	0.038	0.14	0.3778	0.0540	0.0140	0.040	0.0547	0.0147	0.040	0.0546	0.0146	0.040
0.150	0.037	0.14	0.3113	0.0610	0.0210	0.040	0.0625	0.0225	0.040	0.0625	0.0225	0.040
0.200	0.036	0.14	0.2723	0.0680	0.0280	0.040	0.0708	0.0308	0.040	0.0708	0.0308	0.040
0.250	0.035	0.14	0.2467	0.0750	0.0350	0.040	0.0795	0.0395	0.040	0.0795	0.0395	0.040
0.300	0.034	0.14	0.2285	0.0820	0.0420	0.040	0.0888	0.0488	0.040	0.0887	0.0487	0.040
0.350	0.033	0.14	0.2149	0.0890	0.0490	0.040	0.0987	0.0587	0.040	0.0985	0.0585	0.040
0.400	0.032	0.14	0.2043	0.0960	0.0560	0.040	0.1093	0.0693	0.040	0.1090	0.0690	0.040
0.450	0.031	0.14	0.1959	0.1030	0.0630	0.040	0.1206	0.0806	0.040	0.1203	0.0803	0.040
0.500	0.030	0.14	0.1889	0.1100	0.0700	0.040	0.1329	0.0929	0.040	0.1325	0.0925	0.040
0.550	0.029	0.14	0.1830	0.1170	0.0770	0.040	0.1464	0.1064	0.040	0.1458	0.1058	0.040

Summary of Results

Table 7. Summary of testing phases and criteria used to evaluate the implementation of bias-corrected calculations of fishery impacts in FRAM

Testing objectives	**Status**
Phase 1. Bias correction in the absence of mark recognition error	
Testing criteria: Scalar fisheries, unmarked exploitation rates	X
Testing criteria: Quota fisheries, unmarked exploitation rates	X
Testing criteria: Time step- and stock-specific fishery impacts, by number (landed, total) and rate for a stock by fishery	X
Phase 2. Bias correction with mark recognition error	
Testing criteria: Scalar fisheries, unmarked and marked exploitation rates	X
Testing criteria: Quota fisheries, unmarked and marked exploitation rates	X
Testing criteria: Time step- and stock-specific fishery impacts, by number (landed, non-landed, total) and rate for a stock by fishery	X

[2] For coho, non-retention fisheries are provided to FRAM as 'total dead coho'; FRAM distributes this mortality in a manner similar to a non-MSF quota fishery.

Conclusions

New FRAM code has been added to address the mark selective fishing bias in coho FRAM. This code has eliminated the mark selective fishing bias on marked and unmarked stock components with the exception of a very slight bias still remaining due to the handling of drop-off and non-retention mortalities.

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Impacts of Mark-Selective Ocean Recreational Fisheries on Washington Coast Coho Stocks.

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Introduction

In a letter dated March 23, 2012, Craig Bowhay requested an analysis of impacts occurring to Washington coast natural coho stocks from ocean recreational mark-selective fisheries for coho salmon in management areas 1-4. Specifically, that the number of Grays Harbor, Queets, Hoh and Quillayute natural coho salmon killed by this fishery each year for the past 5 years be calculated, broken down by management area and recreational component (charter boat and private boat), and be based on sampling data rather than FRAM.

Within the four watersheds above, there are coded-wire tag (CWT) programs in 3 of the basins. In Grays Harbor, the southernmost basin, there is a program at Bingham Creek Hatchery; in the Queets Basin, there is a program at the Salmon River Hatchery, and in the Quillayute basin there is a program at the Sol Duc Hatchery. All three of these CWT programs include both marked CWT releases and paired unmarked CWT, or double-index tagged (DIT), releases. Both marked and unmarked fish are sampled in ocean fisheries for all three hatchery programs, but because the bulk of the fish encountered in ocean fisheries are encountered in mark-selective fisheries, and the bulk of mortalities on the unmarked fish are in the form of release mortality and dropoff mortality, which do not provide tag recoveries, the unmarked releases are of very limited utility in terms of estimating the impacts of specific fisheries on specific stocks. Additionally, the reporting of freshwater recoveries of all CWTs differs markedly between the three hatchery programs and presents its own challenges.

Geographically, Bingham Creek is the most southerly of the three CWT stocks. The Salmon River is in the middle, and the Sol Duc is the most northerly. The Hoh River is located between the Quillayute and Queets Rivers.

Calculation of Impact Rates

The approach taken was to calculate exploitation rates on marked fish from each of the four stocks using CWT data, and then use the exploitation rates on marked fish to calculate the impact rates on unmarked fish. In order to calculate marine exploitation rates from CWTs, it is necessary to have estimates of the total number of CWTs captured in ocean fisheries, and estimates of the ocean escapement, or terminal run, of CWTed fish. Ocean catches are routinely sampled coastwide at consistently high rates, and the estimates of the numbers of CWTed fish caught in ocean fisheries reported to the Pacific States Marine Fisheries Commission (PSMFC) where they can be accessed through the Regional Mark Information System (RMIS). Recoveries from freshwater, necessary to calculate ocean escapement, are less consistently sampled and reported, and are more problematic.

Marked Fish

Terminal Run Size

In the context of this analysis, terminal run size is the number of fish returning to the river mouth, or caught in terminal area net fisheries inside Willapa Bay and Grays Harbor. It includes all freshwater catch and spawning escapement, as well as incidental mortality resulting from freshwater fisheries and pre-spawning mortality. Freshwater recoveries of CWTs include recoveries in recreational and net fisheries, as well as hatchery returns and spawning escapement to natural areas. The freshwater fisheries in Grays Harbor are well sampled, and CWT recoveries are reported to the RPMC. Coverage of CWTs from spawning escapement, both to hatcheries and to natural areas are also well reported. Within the Queets system, the freshwater net and recreational fisheries appear to be adequately reported, but CWTs reported for spawning escapement appear to be incomplete. Inriver harvest rates calculated from the reported CWT data are substantially higher than the rates reported by the Quinault Indian Nation (STT 2012, Table B-31). In the Quillayute system reporting of freshwater recoveries from both spawning escapement and from inriver fisheries appears to be far from complete. However, missing from all freshwater data are estimates of incidental fishing mortality, as well as prespawing mortality, predation, and poaching.

Table 1. Definitions of terms used in equations.

Symbol	Definition
C	Catch = landed fish
ER	Nominal exploitation rate = landed catch/(all landed catch + escapement)
T	Terminal run = freshwater catches + escapement + catches in terminal area net fisheries (Grays Harbor and Willapa Bay)
o, *r*	Superscripts denoting “ocean” and “river” respectively
m, u	Subscripts denoting “marked” and “unmarked” fish respectively
I	Index denoting fishery
h	Harvest rate = catch/(catch + escapement)
c, p	Subscripts denoting “charter” and “private” sectors of the recreational fleet
N	Initial abundance assuming no natural mortality = sum of all fishing related mortality and spawning escapement
CR	Contact rate = (catch + released fish)/initial abundance
f	Effort in angler days
γ	Recognition error = rate at which marked fish are released or unmarked fish retained.
δ	Success rate of anglers in the charter fleet relative to those in the private fleet
φ	Mortality rate of released fish as a result of being caught and released

For the sake of calculating impact rates in recreational ocean salmon fisheries, it is not necessary to separate different components of the freshwater recoveries, merely to produce an estimate of the number of the terminal run size of the tagged groups of fish. For the Bingham Creek fish, this was calculated by simply summing the freshwater CWT recoveries from fisheries, hatchery returns and natural spawning escapement, expanded for sampling rates by RMIS. Given a terminal run size, we can calculate the ocean exploitation rate on landed fish (nominal rate) as

$$ER_m^o = \frac{C_m^0}{C_m^o + T_m} \tag{1}$$

where $C_m^0 = \sum_i C_{m,i}^0$ is the sum of ocean catches of CWTed fish over all ocean fisheries

For each individual fishery we can similarly calculate a nominal exploitation rate

$$ER_{m,i}^o = \frac{C_{m,i}^0}{C_m^o + T_m} \tag{2}$$

Where *m* denotes marked fish, and *i* denotes fishery (*i* ∈ Areas 1-4 sport). For the Queets basin, the reporting of CWTs from freshwater fisheries was assumed to be complete and the reported freshwater exploitation harvest rates were used to expand freshwater catch recoveries to terminal run (terminal run = freshwater catch/freshwater harvest rate).

$$T_m = \frac{C_m^r}{h^r} \tag{3}$$

For the Quillayute system, the entire terminal run was estimated from ocean catch using the average of ocean exploitation rates from the Queets and Grays Harbor (Figure 1).

$$T_m = \frac{C_m^o}{ER_m^o} - C_m^o \tag{4}$$

For purposes of calculating exploitation rates, catches of coho salmon in other terminal net fisheries were included with terminal run rather than with ocean catches. Grays Harbor coho experience a relatively high catch rate in Willapa Bay net fisheries, while Queets and Quillayute coho do not. Because these fisheries occur after most ocean fishing, CWT recoveries in these fisheries were considered to be more appropriately included with freshwater catches and spawning escapement for the calculation of ocean impact rates. Throughout the rest of this report, terminal area net catches in marine waters outside of stock's natal basin are excluded from calculations of "ocean" impacts, but are included as "pre-terminal" in discussion of distribution of harvest impacts.

Note that the nominal ocean exploitation rates for marked fish do not include incidental mortality from dropoff or from release of legal sized marked fish that could have been retained. However, at this point it is not necessary to do so. These can be accounted for in application of rates estimated from CWTs to the unmarked natural production.

Unmarked Fish

Ocean Encounters

The encounter rate of unmarked fish in the fishery corresponds to the exploitation rate of marked fish, plus the rate at which marked fish are released. We can calculate nominal exploitation rates for Grays Harbor, Queets, and Quillayute coho, but still require rates for the Hoh stock.

Examination of the distribution of ocean fishery recoveries for marked CWT releases from the three basins reveals a great deal of similarity (Figure 2). All are caught primarily in the Westport (Area 2) and Ilwaco (Area 1) sport fisheries, the Neah Bay troll fishery (Area 4), Oregon sport fisheries, and west coast Vancouver Island fisheries. Consistent with the geographic distribution of the stocks, the Quillayute stock appears to be impacted most heavily in the WCVI sport fishery which impacts the Queets stock to a lesser extent, and the Grays Harbor stock lesser still. Similarly, recreational fisheries in Westport (Area 2) appear to have the highest proportion of impacts rate on Grays Harbor coho and their proportion of impacts on Quillayute coho are the lowest.

The impacts on all three stocks in Washington coast sport fisheries (Areas 1-4) appear to show similar patterns and it seems reasonable to use the marine exploitation rates for more data-rich systems to fill in the holes in the more data-poor ones. Because the Hoh River is located between the Queets and the Quillayute, ocean sport exploitation rates in Washington coastal recreational fisheries for the Queets and Quillayute rivers were averaged for each port in each year to represent ocean sport exploitation rates on the Hoh stock.

Incidental Mortality

Incidental mortality in ocean fisheries includes dropoff mortality and release mortality. Dropoff mortality is fish that die as a result of encountering fishing gear, but are not brought to the boat. This may include fish that are mortally wounded by contact with terminal tackle and escape to die, or fish removed from gear by predators. Management agencies have adopted a default rate of 5% of fish contacted (brought to the boat) to account for dropoff mortality in marine area hook-and-line fisheries. This rate is used for modeling Council area fisheries. Release mortality has been studied exntensively and is also quite variable. The Council has adopted a rate of 14% to account for the mortality of fish brought to the boat and released in recreational fisheries (STT 2000), and a rate of 26% for commercial troll fisheries.

In mark-selective recreational fisheries, all unmarked fish are required to be released, and legal-size marked fish are expected to be retained. However, a small fraction of unmarked fish is illegally retained, and some marked fish are released. Legal-size marked fish may be released for a number of reasons: fishermen may mistakenly identify the marked fish as unmarked, they may mistakenly believe them to be sublegal when they are actually legal. However, fishermen may also intentionally release marked fish that could be legally retained simply because they want to catch and release fish for sport, or if they intend to retain fish, they may release smaller fish in the hope of catching a larger one, or release coho in the hope of catching a Chinook when regulations permit retention both species. Whether the release of fish that could be legally retained is intentional or unintentional, the release of legal marked fish has been termed “mark recognition error”, and the illegal retention of unmarked fish has been termed “unmark recognition error” (Lawson and Sampson, 1996).

For modeling purposes, the STT models releases of legal marked fish at a uniform rate of 6% of the landed catch in mark-selective ocean recreational fisheries. However, the recreational fishery includes fishermen who fish from both private boats, and from charter boats. These two fleets behave differently. On a charter boat, the operator has an economic incentive to retain every legal fish. This serves to reduce the duration (and thus the cost) of trips when limits are being caught, and it improves the catch statistics for the fishery when limits are not being caught, which may stimulate more business. Fishermen on private boats are more likely to release legal fish, either to sort fish or simply for sport. However, they are probably less likely to release legal fish when catch rates are low and more likely to do so when catch rates are high.

Washington Department of Fish and Wildlife has been monitoring mark-selective fisheries since they were initiated in 1998. In recent years, the monitoring program has included at-sea observers on the charter boat fleet, voluntary trip reports (VTR) from the private fleet, and dockside interviews by port samplers from both sectors. The dockside sampling did not discriminate released fish by size, but the onboard observers and the VTR data did. Because the focus of this analysis is on legal-sized fish, the observer and VTR data were used. Because sampling has been more complete in the past few years, data from 2009 through 2011 were used (Appendix A). For purposes of estimating the numbers of marked fish released by each sector, the aggregate rates over all months, ports, and years were used (0.02 for the charter sector, and 0.07 for the private sector).

For each port, in each year, the contact rate of unmarked fish can be calculated from the fishery specific nominal exploitation rate for marked fish by partitioning the exploitation rate between the charter and private sectors proportional to the effort in that sector, scaled by its relative success rate. For the charter fleet, the contact rate is given by:

$$CR_{u,i,c}^{o} = (1 + \gamma_{m,c})ER_{m,i}^{o}\frac{f_{i,c}\delta_c}{f_{i,c}\delta_c + f_{i,p}} \qquad (5)$$

Where f is fishing effort in angler trips (Table 2), c denotes the charter fleet, p denotes private boat fleet, γ_m denotes the rate at which legal marked fish are released (mark recognition error), and δ_c, is the success rate of fishermen on charter boats relative to those on private boats (Table 3). For the private boat fleet, the contact rate is given by:

$$CR^{o}_{u,i,p} = (1 + \gamma_{m,p}) ER^{o}_{m,i} \frac{f_{i,p}}{f_{i,c}\delta_c + f_{i,p}} \tag{6}$$

Then the total mortality of unmarked fish in the fishery by port and sector is

$$C^{o}_{u,i,j} = N_u \left[\gamma_u + (0.05 + \varphi_i)\, CR^{o}_{u,i,j}\right] \tag{7}$$

Where j denotes sector, and γ_u denotes the rate at which unmarked fish are illegally retained (unmarked recognition error), φ_i denotes the release mortality rate for fishery *i* (0.14 for recreational fisheries and 0.26 for commercial troll fisheries), and N_u is the initial abundance of unmarked fish, given by:

$$N_u = \frac{T_u}{(1 - \sum_i CR^{o}_{m,i}\varphi_i)} \tag{8}$$

where $i \in$ pre-terminal ocean fisheries.

This method of apportioning mortalities of unmarked fish between the charter and private boat sectors on the basis of the relative success rates of anglers in terms of marked fish, assumes that both fleets are contacting marked and unmarked fish at the same rated. This requires either that both fleets have the same distribution, or that marked and unmarked fish from the same stock have the same distribution. Sample data in the form of observer data from the charter fleet and VTRs from the private fleet collected within the same month and port area indicate that the charter fleet encounters a higher proportion of marked fish than the private boat fleet (R. Conrad, personal communication). This implies that on average the fleets are fishing in different areas, AND that marked and unmarked fish have different distributions. However, the sample data are for total coho encounters and cannot be decomposed into encounters by stock. While these data do not directly inform the question of whether or not marked and unmarked fish from the same stock share the same ocean distribution, at a minimum they highlight how tenuous this assumption is.

Results and Discussion

Exploitation rates calculated here depend on the assumptions that went into estimation of the terminal run sizes of the CWT groups used in the analysis. While the analysis would have been more straightforward had there been more complete reporting of freshwater recoveries of CWTs from the Queets and Quillayute basins, the approach used here deals with the shortcomings in the CWT data and seems to be reasonably supported by inriver harvest and ocean CWT distribution data. Because of the proximity of these stocks, we would expect them to have similar ocean distributions and consequently similar ocean exploitation rates. The methods used to estimate terminal run size for the Queets stock produced ocean exploitation rates very similar to those of

Grays Harbor for all broods except the 2004 brood (Figure 1). For some reason CWTs from the Queets stock were recovered in ocean fisheries at more than 3 times the rate of CWTs from the Grays Harbor stock. Yet, there was nothing abnormal about the distributions of the ocean recoveries of either stock in that year.

While the ocean exploitation rates calculated for the Quillayute are also quite similar to those of the Queets and Grays Harbor, the method used to generate terminal runs of CWTs guaranteed that the calculated ocean exploitation rate for the Quillayute would be intermediate between those of the other two stocks in each year. However, the similarities in CWT ocean recovery patterns for all three stocks (Figure 2) support the use of surrogate data for these stocks.

The calculated mortalities for each port area, by private and charter boat sectors, are reported in Tables 4-7, and the distribution of all mortalities for both marked and unmarked coho among pre-terminal fisheries, inriver fisheries, and spawning escapement is presented in Table 8. Note that mortalities attributed to the Washington coast recreational mark-selective fishery are also included in the pre-terminal category, so the columns of pre-terminal ER, inriver ER, and escapement should sum to 100% except for rounding error. It should be noted that the hatchery and natural stocks are subject to selective harvest in freshwater, and that there is no hatchery program in the Hoho River. Marked fish in the Hoh River are dip-ins, primarily from other coastal stocks. Within the CWT broods used in this analysis, the only net fisheries that recovered any tags in marine waters were in Grays Harbor and Willapa Bay. There were no tags from the Queets or Quillayute stocks recovered in Grays Harbor net fisheries, and no tags from the Queets recovered in Willapa Bay. There were a handful of Quillayute tags and a substantial number of Grays Harbor tags recovered in Willapa Bay net fisheries. These are included in the pre-terminal ER for both stocks, while the Grays Harbor net recoveries of Grays Harbor tags were included with the inriver ER.

Calculated impact rates in the years 2006 through 2010 in mark-selective Washington recreational ocean fisheries have ranged from 0.4% to 3.7% over all years and stocks with average rates ranging from 0.8% for the Quillayute to 1.7% for the Queets. During the same time period, the impact rates in these fisheries on marked coho from the same stocks have ranged from 1.8% to 17.6%, and averaged from 4.1% to 14.5%

The average distribution of impacts for each unmarked stock is presented in Figure 3, while the distribution of impacts on marked hatchery fish is presented in Figure 4. The “other pre-terminal” impacts on Grays Harbor unmarked fish are noticeably larger than they are for the other three stocks. This is due to the inclusion of Willapa Bay net fishery, which is not mark-selective, impacts in the pre-terminal category. Nearly all other pre-terminal fisheries in which Washington coastal CWTs are recovered are mark-selective. As a result of this, pre-terminal fisheries make up a larger share of the impacts on marked fish on the same stocks. Because the terminal run is a larger fraction of the total abundance, both the terminal fishery impacts and spawning escapement comprise larger proportions of the unmarked stocks than the corresponding marked stocks.

Figure 5 compares the impacts in mark-selective Washington ocean recreational fisheries for coho relative to the pre-season prediction of impacts in these fisheries based on the final run of FRAM used each year for projecting impacts reported in Preseason Report III. Predictions have been remarkably close to post season estimates based on CWTs for Grays Harbor and Quillayute coho stocks on average. It appears that impacts to Queets coho have been consistently overpredicted, and impacts to Hoh coho have been overpredicted on average.

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STT. 2000. STT recommendations for hooking mortality rates in 2000 recreational ocean Chinook and coho fisheries. Pacific Fishery Management Council, Salmon Technical Team, Portland, OR. March, 2000. 18p.

STT. 2012. Review of 2011 Ocean Salmon Fisheries. Pacific Fishery Management Council, Salmon Technical Team, Portland, OR. Feb, 2012. 363p.

Table 2. Recreational effort (angler trips) by charter and private boat sectors in the Washington coast recreational ocean salmon fishery. Data from the Table IV-13 of the Review of 2011 Ocean Salmon Fisheries (STT 2012).

	area 1		area 2		area 3		area 4	
year	charter	private	charter	private	charter	private	charter	private
2006	8,048	13,472	15,421	9,120	534	3,609	515	12,894
2007	10,087	20,045	15,667	10,249	403	2,865	590	12,777
2008	3,747	6,272	9,942	8,788	219	1,852	301	5,287
2009	9,740	29,806	18,520	19,311	683	4,394	503	15,968
2010	6,961	20,052	18,425	20,004	630	3,206	434	11,115
2011	6,857	15,680	14,136	19,409	666	3,571	501	10,569

Table 3. Success rates of charter and private boat sectors of the Washington coast recreational ocean salmon fishery. Data from the Tables IV-10 and IV-13 of the Review of 2011 Ocean Salmon Fisheries (STT 2012).

	coastwide angler trips			catch		catch/trip		
year	charter	private	total	charter	private	charter	private	ratio
2006	24,518	39,096	63,614	16,186	19,892	0.660	0.509	1.30
2007	26,747	45,936	72,683	33,736	50,051	1.261	1.090	1.16
2008	14,209	22,199	36,408	8,265	10,464	0.582	0.471	1.23
2009	29,446	69,480	98,926	47,855	89,972	1.625	1.295	1.26
2010	26,450	54,377	80,827	14,119	22,159	0.534	0.408	1.31
2011	22,160	49,229	71,389	15,075	24,362	0.680	0.495	1.37

Table 4. Impacts on Grays Harbor unmarked natural coho in Washington coast mark-selective recreational fisheries. Numbers are mortalities by port area and recreational fleet sector. Dashes reflect no CWT recoveries of marked fish.

	Area 4	Area 3	Area 2	Area 1	total
Charter boats					
2006	1	2	136	41	181
2007	1	4	115	68	188
2008	-	-	89	30	119
2009	1	14	568	79	663
2010	-	4	356	43	403
Private boats					
2006	16	13	65	56	150
2007	27	25	68	124	243
2008	-	-	67	43	110
2009	36	78	497	204	814
2010	-	16	311	99	427
WA ocean recreational total					
2006	17	15	201	98	331
2007	28	29	183	192	432
2008	-	-	156	74	229
2009	37	92	1,064	283	1,477
2010	-	20	668	142	830

Table 5. Impacts on Queets River unmarked natural coho in Washington coast mark-selective recreational fisheries. Numbers are mortalities by port area and recreational fleet sector. Dashes reflect no CWT recoveries of marked fish.

	Area 4	Area 3	Area 2	Area 1	total
Charter boats					
2006	0	1	35	17	54
2007	4	-	51	33	88
2008	0	0	9	8	18
2009	1	3	96	12	112
2010	1	2	47	7	58
Private boats					
2006	8	3	17	24	52
2007	74	-	30	61	165
2008	4	2	7	12	24
2009	22	19	84	32	156
2010	17	10	41	17	85
WA ocean recreational total					
2006	9	4	52	41	106
2007	78	-	82	94	254
2008	4	2	16	20	42
2009	23	22	180	44	268
2010	18	12	89	24	143

Table 6. Impacts on Hoh River unmarked natural coho in Washington coast mark-selective recreational fisheries. Numbers are mortalities by port area and recreational fleet sector.

	Area 4	Area 3	Area 2	Area 1	total
Charter boats					
2006	0	0	11	6	17
2007	2	0	30	14	46
2008	0	0	5	4	10
2009	1	3	54	7	64
2010	0	1	22	6	30
Private boats					
2006	2	2	5	8	17
2007	34	0	18	25	77
2008	2	1	4	6	13
2009	14	14	48	18	93
2010	5	3	19	15	43
WA ocean recreational total					
2006	2	2	16	14	34
2007	36	0	48	39	123
2008	2	1	9	10	23
2009	14	16	102	25	157
2010	6	4	41	21	72

Table 7. Impacts on Quillayute River unmarked natural coho in Washington coast mark-selective recreational fisheries. Numbers are mortalities by port area and recreational fleet sector. Dashes reflect no CWT recoveries of marked fish.

	Area 4	Area 3	Area 2	Area 1	total
Charter boats					
2006	0	3	50	29	82
2007	1	0	38	-	39
2008	0	0	11	9	21
2009	1	7	111	14	133
2010	0	1	38	19	57
Private boats					
2006	5	14	24	40	82
2007	15	1	22	-	39
2008	4	2	9	13	28
2009	31	36	97	36	200
2010	2	3	33	43	81
WA ocean recreational total					
2006	5	16	74	70	165
2007	16	1	60	-	77
2008	5	3	20	21	49
2009	32	42	208	50	333
2010	2	4	71	62	138

Table 8. Distribution of impacts among different fisheries for marked and unmarked coho from Washington coastal stocks. The category of WA rec ER is included in the pre-terminal ER as well. Catches in terminal area net fisheries outside the basin of origin are included in the pre-terminal ER category, but net catches from marine waters inside Grays Harbor are included in the inriver ER for Grays Harbor.

	Marked Fish				Unmarked fish			
	Pre-term ER	WA rec ER	inriver ER	escapement	Pre-term ER	WA rec ER	inriver ER	escapement
Grays Harbor								
2006	19.4%	7.0%	26.5%	54.1%	11.7%	1.4%	11.6%	76.8%
2007	13.9%	6.0%	33.1%	53.0%	7.0%	1.2%	21.1%	72.0%
2008	5.8%	2.3%	34.0%	60.2%	3.0%	0.5%	26.8%	70.2%
2009	14.2%	7.7%	17.5%	68.2%	4.4%	1.6%	20.7%	74.8%
2010	6.4%	3.7%	28.1%	65.6%	2.9%	0.8%	3.1%	94.0%
average	11.9%	5.3%	27.8%	60.2%	5.8%	1.1%	16.6%	77.6%
Queets River								
2006	12.0%	7.8%	51.7%	36.3%	2.9%	1.6%	11.7%	85.4%
2007	35.2%	17.6%	21.1%	43.7%	11.2%	3.7%	20.3%	68.5%
2008	6.5%	3.2%	36.4%	57.1%	1.8%	0.7%	25.1%	73.1%
2009	13.9%	7.4%	45.7%	40.4%	3.5%	1.5%	42.8%	53.7%
2010	4.8%	3.6%	48.3%	46.9%	1.1%	0.7%	40.0%	58.9%
average	14.5%	7.9%	40.6%	44.9%	4.1%	1.7%	28.0%	67.9%
Hoh River								
2006	12.1%	7.0%	87.9%	0.0%	3.1%	1.4%	42.1%	54.8%
2007	29.9%	10.4%	71.1%	0.0%	8.8%	2.2%	36.5%	54.7%
2008	6.3%	2.5%	65.2%	28.5%	1.6%	0.5%	42.2%	56.2%
2009	13.6%	6.8%	86.4%	0.0%	3.5%	1.4%	37.1%	59.4%
2010	4.8%	3.3%	95.2%	0.0%	1.1%	0.7%	25.2%	73.8%
average	13.1%	6.0%	81.2%	5.7%	3.6%	1.2%	36.6%	59.8%
Quillayute River								
2006	12.3%	6.2%	26.5%	61.2%	3.4%	1.3%	55.6%	41.0%
2007	22.5%	3.1%	36.1%	41.3%	6.4%	0.7%	40.1%	53.5%
2008	6.0%	1.8%	64.7%	29.3%	1.3%	0.4%	45.9%	52.8%
2009	13.4%	6.0%	72.5%	14.1%	3.5%	1.3%	65.7%	30.8%
2010	4.7%	3.0%	70.5%	24.7%	1.0%	0.6%	55.5%	43.5%
average	11.8%	4.1%	54.1%	34.1%	3.1%	0.8%	52.6%	44.3%

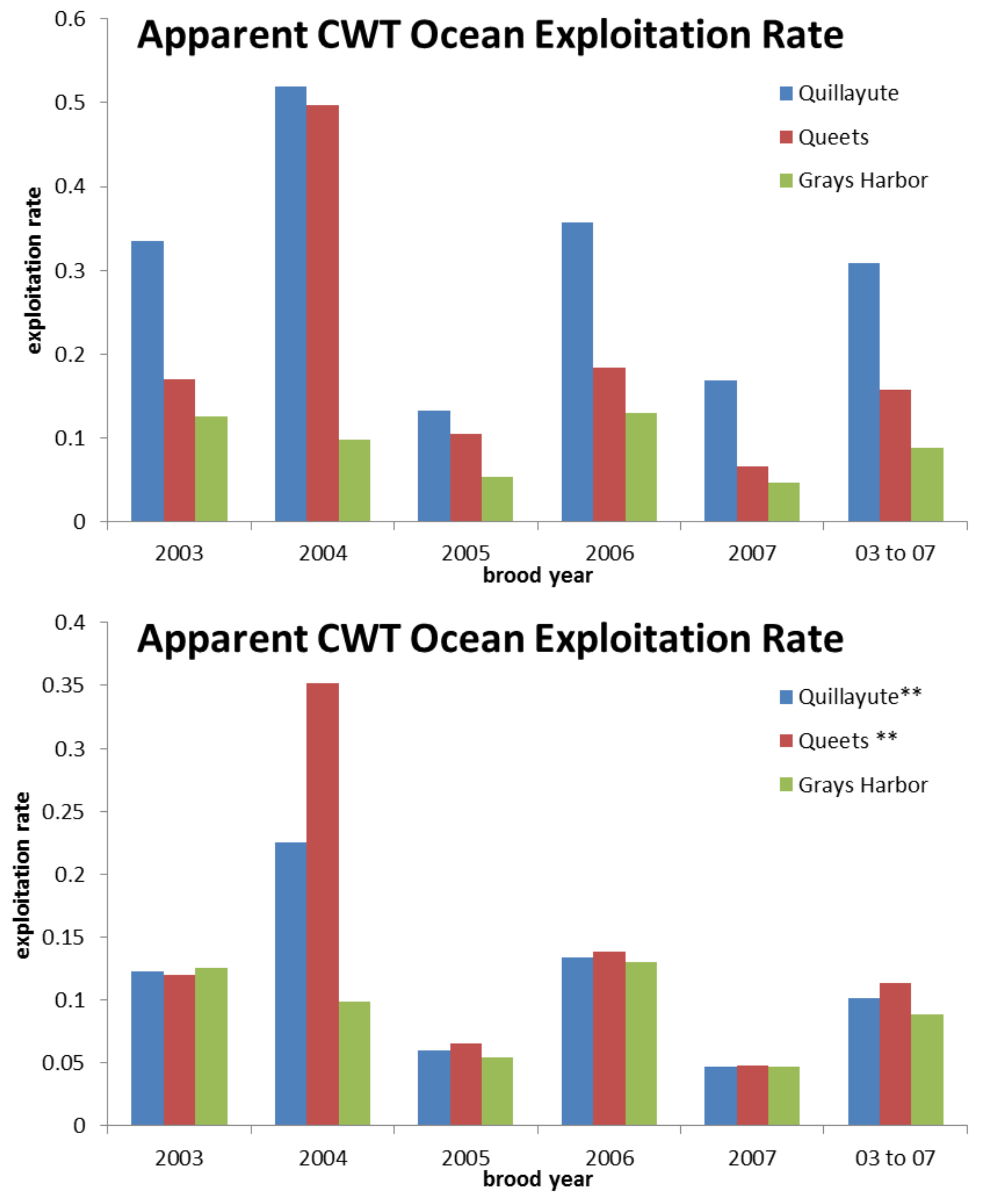


Figure 1. Ocean exploitation rates on Washington coastal coho. The upper panel is raw exploitation rates calculated from CWTs as reported to the Pacific States Marine Fisheries Commission. In the lower panel, the terminal run was calculated from reported inriver CWT recoveries and reported inriver harvest rate on hatchery fish for the Queets, and ocean exploitation rate for Quillayute was obtained by averaging those of the Queets and Grays Harbor. For the Quillayute River these ocean exploitation rates were used to calculate terminal run of tagged fish from the total ocean catch.

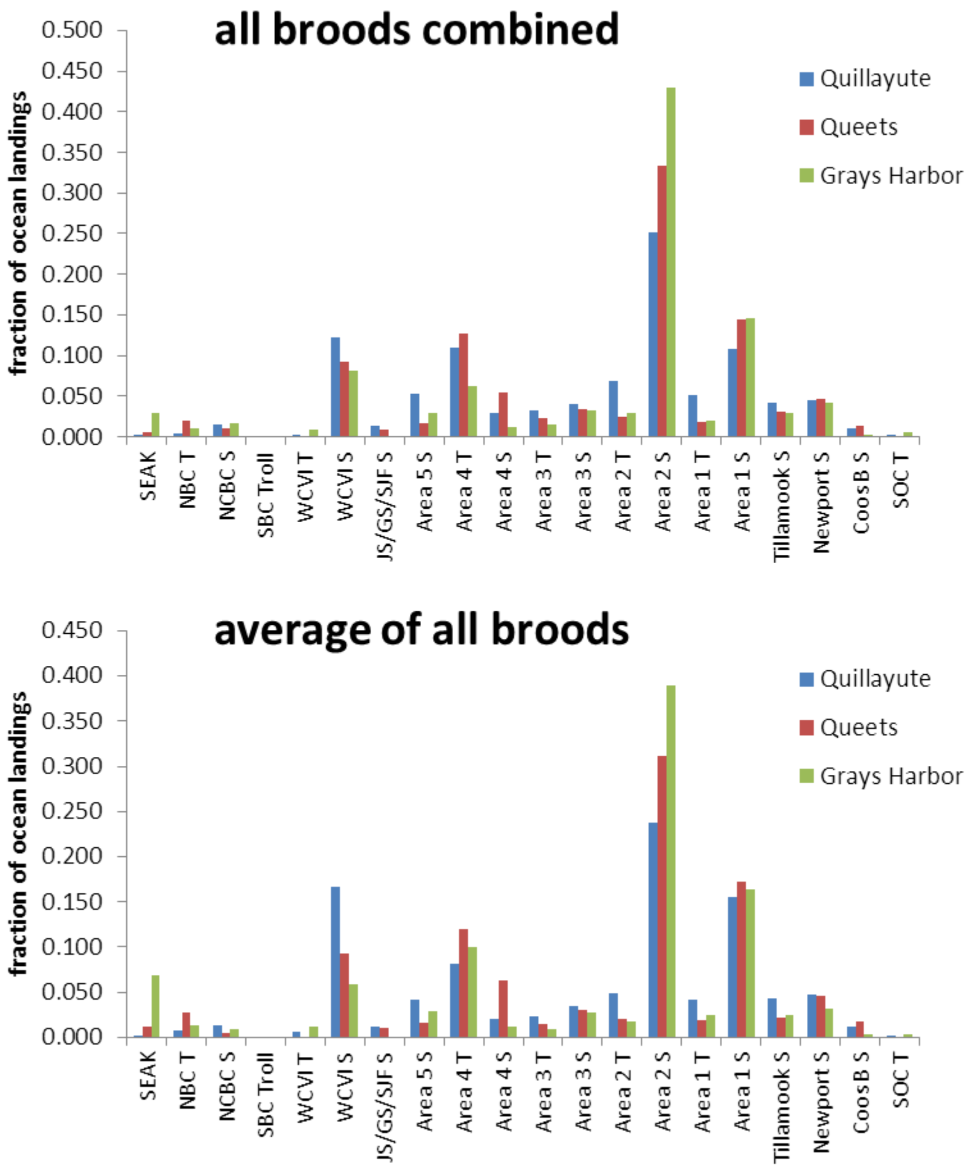


Figure 2. Distribution of ocean recoveries of CWTs from Washington coastal coho across ocean fisheries. The upper panel is the sum of all expanded CWT recoveries from the 2003 through 2008 brood year releases of marked tagged fish. The lower panel is average of the distributions from each of the six brood years.

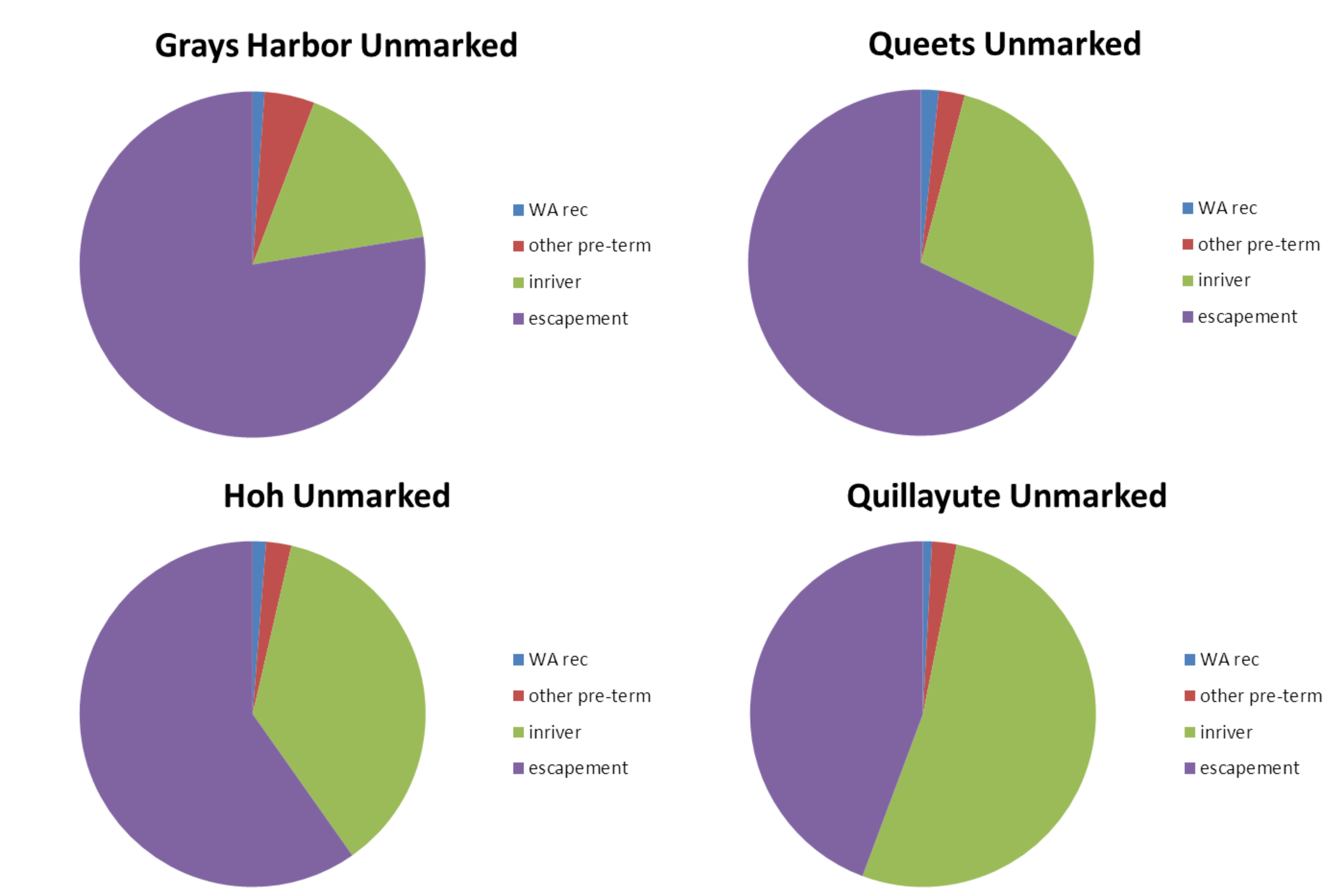


Figure 3. Average distribution of impacts on unmarked Washington coast coho stocks (1996-2010).

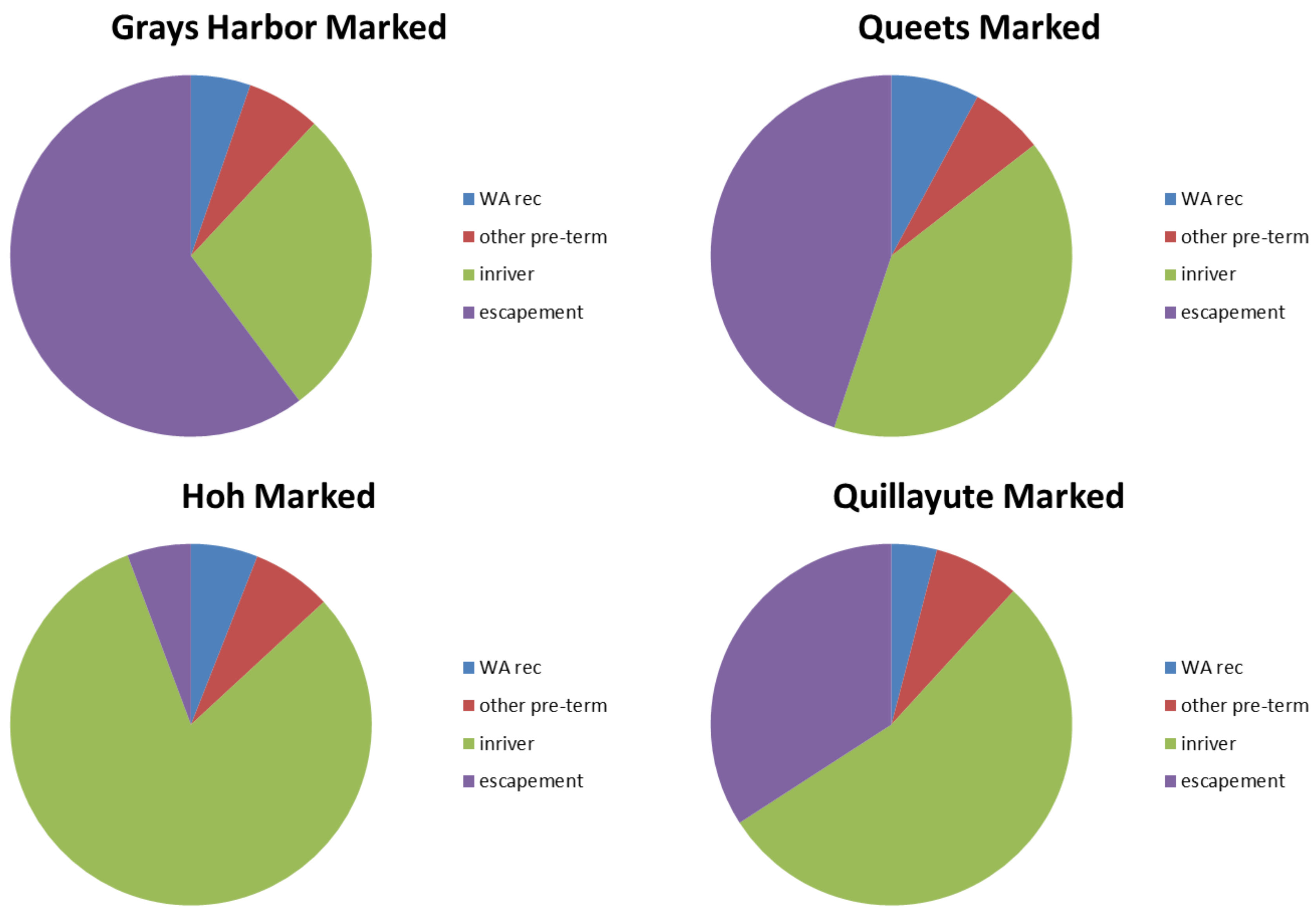
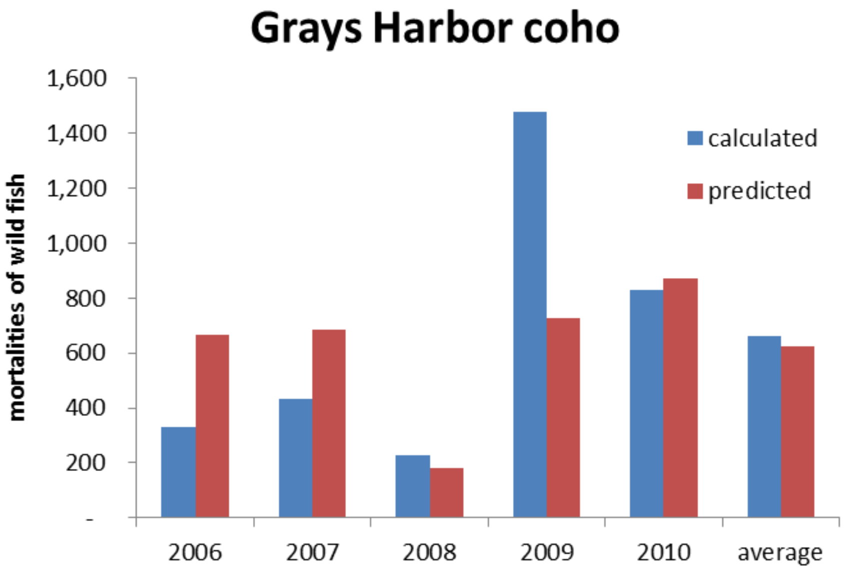
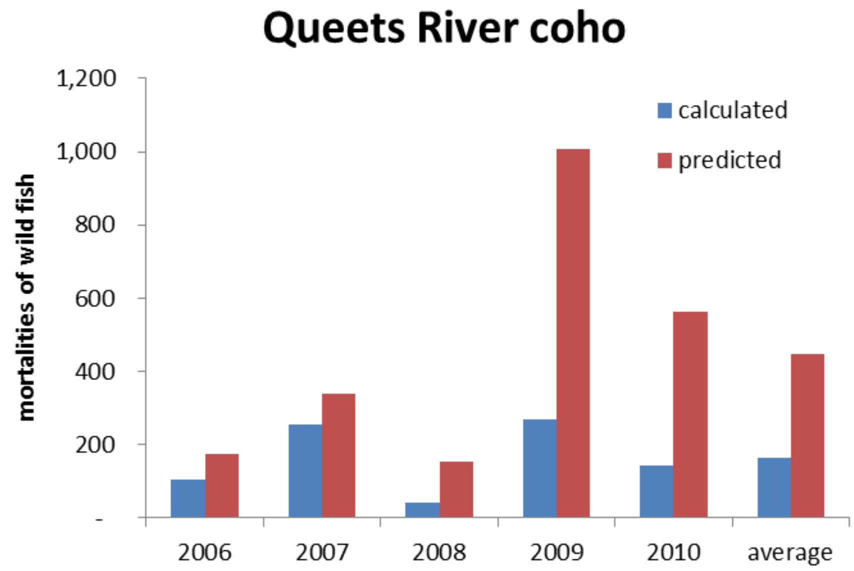
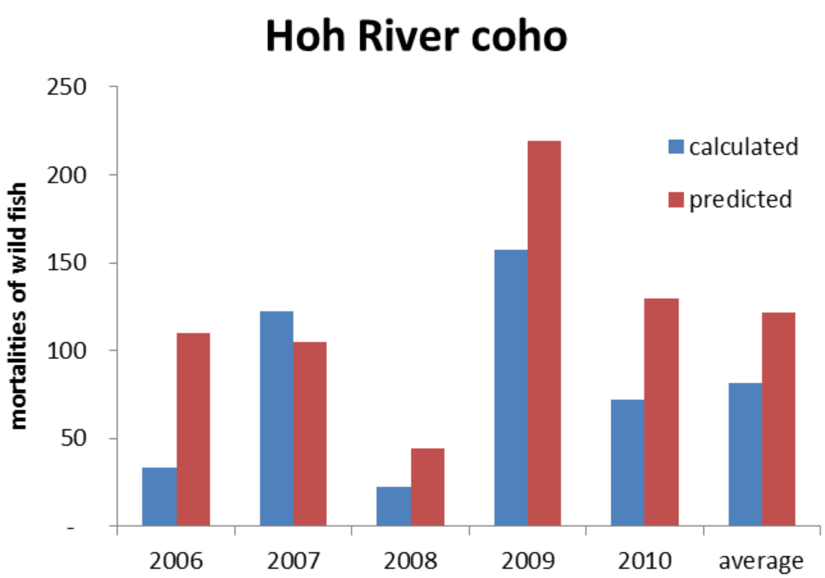


Figure 4. Average distribution of impacts on marked Washington coast coho stocks (1996-2010).


Grays Harbor coho
mortalities of wild fish
1,600
1,400
1,200
1,000
800
600
400
200
-
2006
2007
2008
2009
2010
average
calculated
predicted


Queets River coho
mortalities of wild fish
1,200
1,000
800
600
400
200
-
2006
2007
2008
2009
2010
average
calculated
predicted


Hoh River coho
mortalities of wild fish
250
200
150
100
50
-
2006
2007
2008
2009
2010
average
calculated
predicted

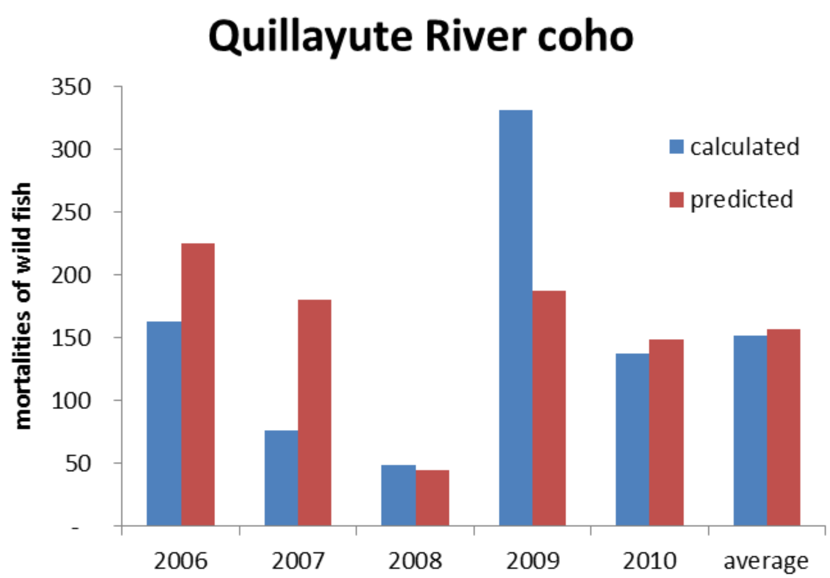

Quillayute River coho
mortalities of wild fish
350
300
250
200
150
100
50
-
2006
2007
2008
2009
2010
average
calculated
predicted

Figure 5. Comparison of pre-season prediction of impacts in Washington coastal mark-selective recreational fisheries with impacts calculated from coded-wire tag data.

Appendix A. Evaluation of differences in release rates of legal-size marked coho salmon in recreational fisheries.

Because of suspected differences in the release rates of marked fish between the charter boat and private boat recreational fleets, relationships with a number of potential factors were examined. In the charter boat fleet, the operators have an economic incentive to retain all legal fish brought to the boat. In the private fleet, fishermen may release fish that could be legally retained for a variety of reasons. Whatever the reasons, it seems likely that fishermen would be less likely to release fish that could be legally retained when catch rates are low and they are catching fewer fish, and more likely to release fish when catch rates are high. To evaluate this, marked-fish release rate were compared with CPUE in the recreational fleet. Comparisons were also made between years, months, and port areas where possible.

Data used were for legal-sized fish in mark-selective recreational fisheries (Wendy Beeghley, WDFW, personal communication). For the charter boat fleet, there data are based on at-sea observations by WDFW observers (Table A.1). For the private boat fleet, they are compiled from voluntary trip reports submitted by private recreational anglers (Table A.2). In both cases, data are recorded while fishing is taking place and do not rely on recollection by the anglers. Data are shown categorized by the different factors for the charter fleet (Figure A.1) and the private fleet (Figure A.2).

The most significant difference, by far, is the difference between the charter and private fleets. As expected, the charter fleet releases a significantly lower proportion of legal-sized marked coho during mark-selective fisheries (Table A.3). All other comparisons were made within fleets.

The relationship with CPUE is something of a surprise. There is no apparent relationship for the charter boat fleet (Figure A.1). This is not really surprising since the boats and the passengers have incentives to retain all legal fish. In the private boat fleet, the relationship is weak, but in the opposite direction one would expect. Release rate of legal fish appear to be higher when CPUE is lower.

Other relationships were not consistent or compelling. In both the charter and private fleets, there is a significant difference between the ports of Ilwaco and Westport. However, they are in opposite directions. In the charter fleet, the release rate is lower in Westport, while in the private fleet the release rate is lower in Ilwaco. The only other statistically significant difference was in the private fleet, between release rates in July and September. However, in the month of July, there were only 5 observations, and 3 of these were zeros. All three of these zeros were from samples that had fewer than 20 observations. Consequently, all potential differences, other than the difference between charter boats and private boats, were ignored in the calculations of impacts on unmarked fish.

Table A.1. Observer data for legal-sized, adipose-clipped coho salmon in the charter boat fleet during mark selective recreational fisheries. CPUE is in terms of catch per angler trip in the combined fleet. Release rates are only reported for sample sizes of at least 10.

year	month	port	CPUE	kept	released	sample size	release rate
2009	7	1	1.679	247	9	256	0.035
2009	8	1	1.495	184	7	191	0.037
2009	6	2	0.694	18	0	18	0.000
2009	7	2	1.052	286	4	290	0.014
2009	8	2	1.562	257	4	261	0.015
2009	9	2	1.679	136	1	137	0.007
2010	7	1	0.897	112	1	113	0.009
2010	8	1	0.676	121	1	122	0.008
2010	9	1	0.314	6	0	6	
2010	7	2	0.311	67	2	69	0.029
2010	8	2	0.287	53	1	54	0.019
2010	9	2	0.993	56	0	56	0.000
2010	7	4	0.338	17	1	18	0.056
2011	6	1	0.429	15	0	15	0.000
2011	7	1	0.953	152	4	156	0.026
2011	8	1	0.838	94	5	99	0.051
2011	9	1	0.715	25	1	26	0.038
2011	6	2	0.049	7	0	7	
2011	7	2	0.431	29	0	29	0.000
2011	8	2	0.449	99	1	100	0.010
2011	9	2	0.696	12	0	12	0.000

Tabel A.2. Voluntary trip report (VTR) data for legal-size, adipose-clipped coho salmon in the private boat fleet during mark-selective recreational fisheries. CPUE is in terms of catch per angler trip in the combined fleet. Release rates are only reported for sample sizes of at least 10.

year	month	port	CPUE	kept	released	sample size	release rate
2009	6	1	1.734	3	0	3	
2009	7	1	1.679	62	1	63	0.016
2009	8	1	1.495	28	1	29	0.034
2009	7	2	1.052	53	7	60	0.117
2009	8	2	1.562	111	3	114	0.026
2009	6	3	1.620	23	3	26	0.115
2009	7	3	1.329	206	5	211	0.024
2009	8	3	1.599	260	18	278	0.065
2009	9	3	0.628	10	0	10	0.000
2009	6	4	0.525	1	0	1	
2009	7	4	0.747	408	54	462	0.117
2009	8	4	0.871	323	14	337	0.042
2009	9	4	0.759	32	2	34	0.059
2010	7	1	0.897	56	6	62	0.097
2010	8	1	0.676	126	6	132	0.045
2010	9	1	0.314	2	0	2	
2010	7	2	0.311	13	3	16	0.188
2010	8	2	0.287	13	3	16	0.188
2010	9	2	0.993	4	0	4	
2010	7	3	0.252	5	0	5	
2010	8	3	0.365	6	0	6	
2010	7	4	0.338	33	6	39	0.154
2010	8	4	0.423	17	0	17	0.000
2011	6	1	0.429	19	0	19	0.000
2011	7	1	0.953	97	2	99	0.020
2011	8	1	0.838	131	5	136	0.037
2011	9	1	0.715	18	0	18	0.000
2011	6	2	0.049	1	0	1	
2011	7	2	0.431	28	4	32	0.125
2011	8	2	0.449	41	5	46	0.109
2011	9	2	0.696	11	0	11	0.000
2011	6	3	0.249	11	1	12	0.083
2011	7	3	0.407	41	2	43	0.047
2011	8	3	0.529	38	7	45	0.156
2011	9	3	0.590	42	3	45	0.067
2011	6	4	0.084	2	1	3	
2011	7	4	0.349	24	5	29	0.172
2011	8	4	0.221	21	1	22	0.045

Table A.3. Tests of significance for differences in release rates for marked coho salmon. The test for difference between the charter and private boat fleets was a one-tailed test assuming different variances. All others were 2-tailed tests assuming the same variance. Differences significant at the 0.05 probability level are bold.

	mean 1	var1	n1	mean2	var2	n2	df	t-stat	p()
Charter vs Private	0.019	0.0003	19	0.072	0.0036	30	37	-4.551	**0.000**
Charter -yr									
2009-2010	0.018	0.0002	6	0.020	0.0004	6	10	-0.194	0.850
2009-2011	0.018	0.0002	6	0.018	0.0004	7	11	0.023	0.982
2010-2011	0.020	0.0004	6	0.018	0.0004	7	11	0.195	0.849
Charter -mo									
Jul-Aug	0.024	0.0003	7	0.023	0.0003	6	11	0.081	0.937
Jul-Sep	0.024	0.0003	7	0.011	0.0003	4	9	1.085	0.306
Aug-Sep	0.023	0.0003	6	0.011	0.0003	4	8	1.048	0.325
Charter -port									
Ilwaco-Westport	0.025	0.0003	8	0.009	0.0001	10	16	2.423	**0.028**
Private -yr									
2009-2010	0.056	0.0018	11	0.112	0.0061	6	15	-1.936	0.072
2009-2011	0.056	0.0018	11	0.066	0.0035	13	22	-0.483	0.634
2010-2011	0.112	0.0061	6	0.066	0.0035	13	17	1.420	0.174
Private -mo									
Jun-Jul	0.066	0.0035	3	0.098	0.0039	11	12	-0.780	0.450
Jun-Aug	0.066	0.0035	3	0.068	0.0034	11	12	-0.043	0.967
Jun-Sep	0.066	0.0035	3	0.025	0.0012	5	6	1.268	0.252
Jul-Aug	0.098	0.0039	11	0.068	0.0034	11	20	1.162	0.259
Jul-Sep	0.098	0.0039	11	0.025	0.0012	5	14	2.408	**0.030**
Aug-Sep	0.025	0.0012	5	0.025	0.0012	5	14	1.511	0.153
Private -port									
Ilwaco-Westport	0.031	0.0010	8	0.107	0.0052	7	13	-2.716	**0.018**
Ilwaco-LaPush	0.031	0.0010	8	0.069	0.0025	8	14	-1.848	0.086
Ilwaco-Neah Bay	0.031	0.0010	8	0.084	0.0041	7	13	-2.075	0.058
Westport-LaPush	0.107	0.0052	7	0.069	0.0025	8	13	1.198	0.252
Westport-Neah Bay	0.107	0.0052	7	0.084	0.0041	7	12	0.636	0.537
LaPush-Neah Bay	0.069	0.0025	8	0.084	0.0041	7	13	-0.498	0.627

Figure A.1. Monthly release rate of legal size marked coho salmon in the charter boat fleet based on observer data, categorized by CPUE in the combined sport fleet, month, port area, and year. Only values based on sample sizes of at least 10 are shown.

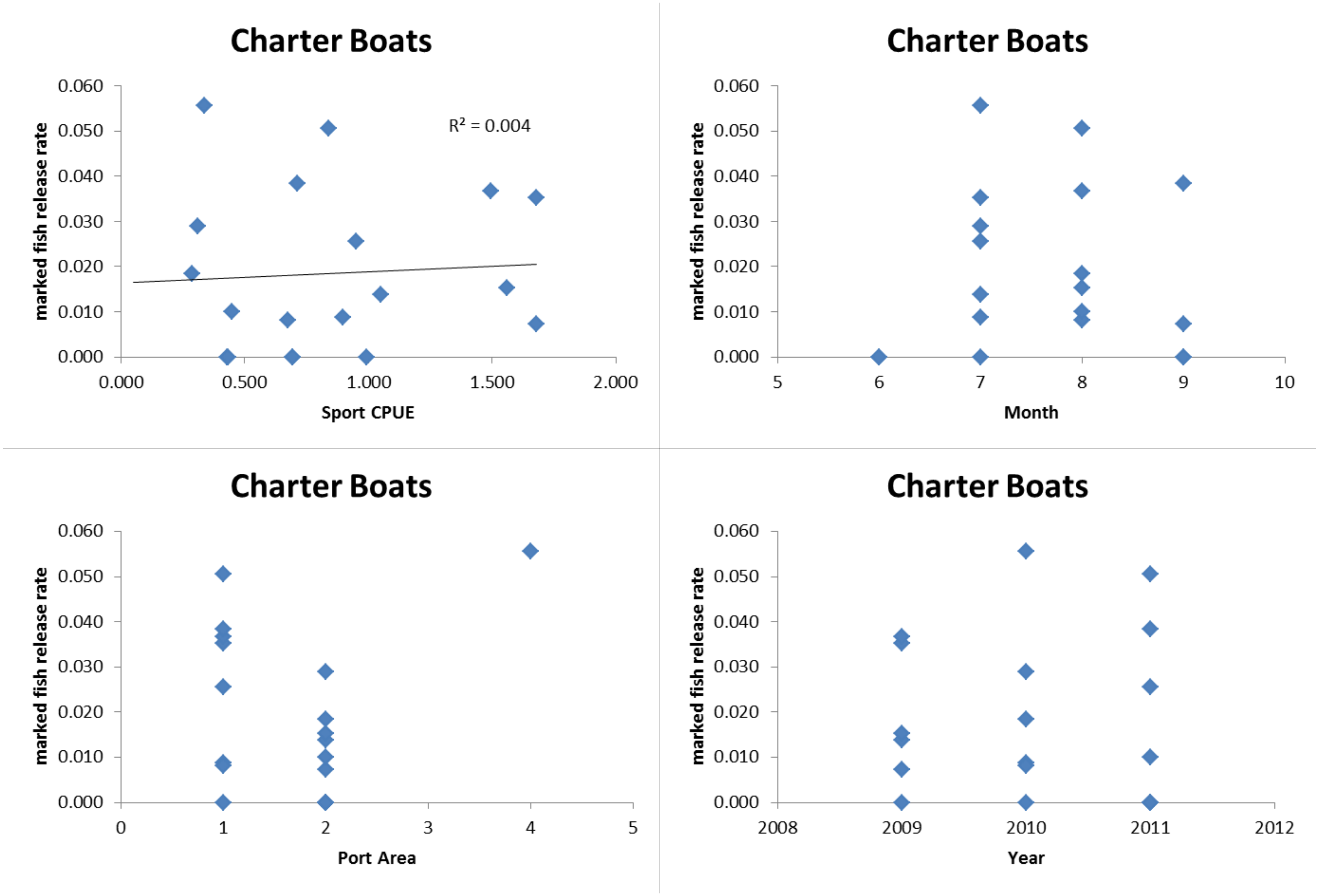
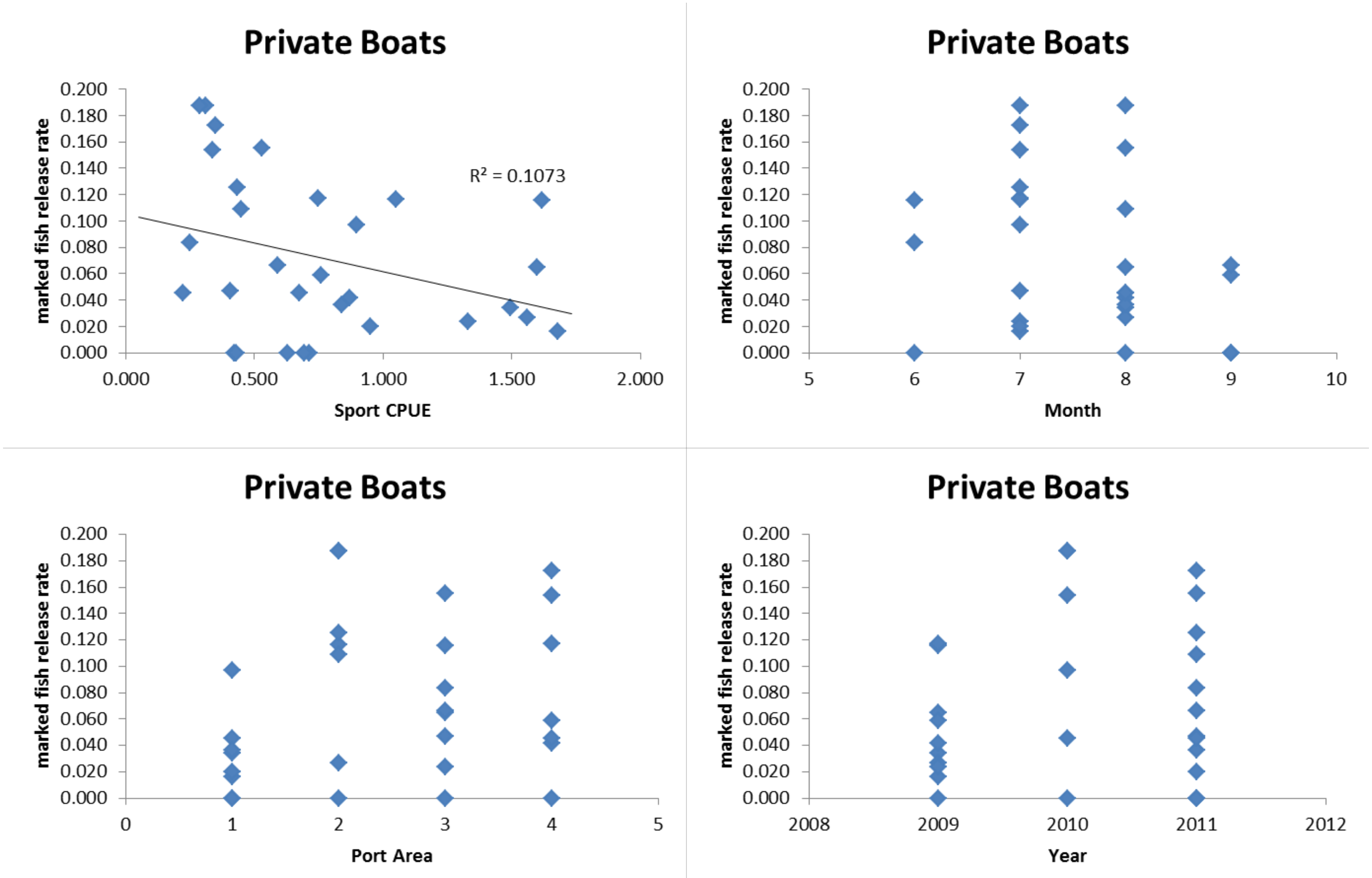


Figure A.2. Monthly release rate of legal size marked coho salmon in the private boat fleet based on voluntary trip report data, categorized by CPUE in the combined sport fleet, month, port area, and year. Only values based on sample sizes of at least 10 are shown.



2012 Technical Revision to the OCN Coho Work Group Harvest Matrix

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Abstract

Amendment 13 (A13) to the Pacific Fishery Management Council Pacific Coast Salmon Fishery Management Plan sets Oregon Coastal Natural (OCN) coho salmon harvest impact rates through a two dimensional matrix with parental status and a marine survival index as the axes. When A13 was developed available data on wild coho salmon marine survival was limited and Oregon Production Index Hatchery (OPIH) jack/smolt ratios, as a predictor of OPIH adult marine survival, was used as a proxy. Recognizing these limits the authors stipulated that the "methods of estimating the technical parameters" could be changed as a technical revision without plan amendment. We propose using the wild coho salmon jack/smolt ratios from the Mill Creek (Yaquina) Life Cycle Monitoring site as a more direct predictor of wild adult marine survival. The Oregon Department of Fish and Wildlife as part of the Oregon Plan for Salmon and Watersheds has conducted monitoring on OCN abundance, survival, and habitat since 1998. These data show that OPIH abundance and survival are not correlated with OCN abundance and survival. They also show that the forecast skill of the marine survival prediction could be increased from $r = 0.30$ to $r = 0.86$ by utilizing the proposed predictor. In a retrospective analysis from 1999 to 2011 the proposed predictor would have provided greater differentiation in impact rates between the top three recruitment years, middle seven recruitment years, and bottom three recruitment years. Allowable impact rates would have been 28%, 18%, and 10% for the high, middle, and low abundance years under the current proposal versus 15%, 13%, and 12% for the 2000 OCN Work Group matrix. The increase in forecast skill would improve the performance of the A13 matrix, appropriately limiting impact rates when survival is expected to be low but allowing harvest opportunity when it is expected to be high.

Introduction

Oregon's coastal coho salmon (*Oncorhynchus kisutch*) populations are an important ecological and cultural component of the coastal landscape and have historically contributed to significant recreational and commercial fisheries. The abundance of Oregon coastal coho salmon in the late 1800's to early 1900's was likely in the range of one to two million fish (ODFW 2007). By the 1990's the runs had declined to less than 100,000 fish a year (PFMC 2012). Oregon Coastal Natural (OCN) coho salmon have been managed as an aggregate of stocks from the Necanicum River in the north to the Winchuck River in the south. These stocks compose all of the Oregon Coast Coho Evolutionarily Significant Unit (ESU) and part of the Southern Oregon/Northern California Coasts Coho ESU. Both of these ESUs are listed as "threatened" under the Federal Endangered Species Act (National Marine Fisheries Service 2005, National Marine Fisheries Service 2011).

The majority of coho salmon in Oregon return to spawn at three years old, with a variable proportion of precocious males returning at two years old after only four to six months in the ocean (Sandercock 1991). The early marine life-stage may be a marine survival bottleneck for coho salmon (Logerwell et al. 2003; Beamish et al. 2004). Jack coho salmon also experience these early ocean conditions, so that high jack return rates indicate favorable early ocean conditions for adults of that brood cycle, and thus jack returns can be a predictor of adult marine survival (Briscoe et al. 2005). Amendment 13 (A13) currently relies on this relationship, using the Oregon Production Index Hatchery (OPIH) jack/smolt ratio to predict OCN marine survival. At the time of A13 development, data on wild adult coho salmon marine survival were unavailable and OPIH data were used as a proxy. The relationship between OPIH jack/smolt ratios and OPIH adult returns was strong (PFMC 1999), but subsequent data from multiple monitoring projects focused on wild coho salmon show that OPIH abundance and survival are not correlated to OCN abundance and survival. However, with these additional data we no longer need OPIH as a proxy and can use OCN data directly for OCN harvest management.

Harvest impacts to OCN coho salmon are managed by the Pacific Fishery Management Council (PFMC) in ocean areas beyond three miles from the coast. In the ocean within three miles of the coast, and within estuary and freshwater areas harvest management is the responsibility of the State of Oregon. Oregon has committed to manage OCN coho salmon harvest based on A13 in the 2007 Coho Conservation Plan (ODFW 2007) and in terminal areas in the Fisheries Management and Evaluation Plan (ODFW 2009). In 1997 the council adopted A13 (PFMC 1999) to the Pacific Coast Salmon Plan. A13 utilizes a matrix of OCN parental spawner status and a marine survival index to establish allowable fishery impact rates. In 2000 the OCN Work Group (Sharr et al. 2000) reviewed A13 and expanded the matrix from a 3 x 3 to a 4 x 5 matrix to address management at very low marine survival and parental abundance. The OCN Work Group matrix was adopted by PFMC and has been used as technical guidance on implementation of A13 since 2001. A13 stated a goal for harvest management of OCN coho salmon:

> *"Thus, the primary goal of the amendment is to assure that fishery related impacts will not act as a significant impediment to the recovery of depressed OCN coho and to more uniformly rebuild each component population subgroup to a higher level."*

In developing A13 the authors acknowledged the limits of the available data on OCN coho salmon and the uncertainties in the proposed management regime, and in response to these concerns A13 included a Monitoring and Evaluation section (2.2.3). This included *"…a comprehensive evaluation mechanism on a pre-determined schedule."* with the first review to occur in 2000. The 2000 OCN Work Group report is the result of that review. Section 2.2.3 of A13 also calls for a comprehensive monitoring program including: juvenile surveys, spawner surveys, habitat surveys, comprehensive monitoring sites, and fishery impact monitoring. The authors anticipated that the results of improved monitoring and periodic reviews might result in changes to the matrix. Specifically, on page 7 of A13 they state:

> *"To incorporate the best science, the methods of estimating the technical parameters used in this proposal may change without plan amendment, if approved by the Council following a technical review and recommendation for change by the Scientific and Statistical Committee."*

From 1998 to present the Oregon Department of Fish and Wildlife (ODFW) has conducted an integrated monitoring program (Firman and Jacobs 2001) as part of the implementation of the Oregon Plan for Salmon and Watersheds (OPSW). The OPSW monitoring program addresses the first four monitoring components called for by A13. The program consists of three geographically extensive monitoring projects based on a spatially balanced random site selection, and one project that intensively monitors specific sub-basins. The three geographically extensive projects are based on the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program sample design. These projects incorporate a Generalized Random Tessellation Stratified sampling design to establish a shared set of random, spatially balanced sample points (Firman and Jacobs 2001; Stevens 2002). These projects provide the juvenile surveys, adult spawner surveys, and habitat surveys called for in A13. The fourth project is the Life Cycle Monitoring (LCM) project, which determines adult and juvenile coho salmon abundance and survival at specific sub-basins, providing the comprehensive monitoring sites called for in A13.

During 2010-11 ODFW staff conducted a review of A13 and the thirteen years of OPSW monitoring data on OCN coho salmon. The results of that review showed the LCM data could provide an improvement to the method of estimating the marine survival index parameter. The analysis suggested that this change could substantially improve the performance of the A13 matrix in both restricting harvest impacts during years of low OCN abundance and allowing for greater harvest opportunities in years of higher OCN abundance.

Methods

OPSW Monitoring Data

A LCM site consists of a paired adult trap and out-migrant trap. Data presented here were collected from 1998-2012 from six sites in the Oregon Coast Coho ESU (Figure 1). Data from the East Fork Trask LCM site were not used in this analysis because it has not been operational for the entire study period. Spawner abundance at LCM sites was either a direct count from traps at complete barriers or estimated by mark-recapture methodology (Ricker 1975). Fish that entered traps were identified to species and sex and distinguished as wild or hatchery-produced based on presence or absence of an adipose fin clip. Jack coho salmon (≤ 50 cm fork length) were distinguished from adults. Downstream juvenile salmonid out-migrants were captured with rotary screw traps or motorized incline plane traps. Fish were enumerated by species and age or size class, with coho salmon identified as fry (age 0) or smolts (age 1+). Trap capture efficiency was evaluated daily and weekly out-migrant estimates were summed for season totals. Additional details on adult and juvenile estimation methods and site specific details are found in Suring et al. (2012).

The LCM smolt to adult marine survival rate was derived by dividing the female spawner abundance in year *t* by half of the smolt production, assuming a 1:1 smolt sex ratio, in year *t-1*. The OCN marine survival index was calculated by averaging the marine survival rate from all sites.

Trap design at most LCM sites does not capture jack coho salmon, but the LCM adult trap on Mill Creek (Yaquina) captures all upstream migrating fish, including jack coho salmon, as the head gate controlling flow into the trap below the Mill Creek reservoir dam creates a velocity barrier. Live fish placed above the trap represent the entire spawning population. A motorized inclined plane trap was used immediately below the fish ladder and spillway of the dam to estimate juvenile out-migrant populations each spring (Suring et al. 2012). The jack/smolt ratio was calculated by dividing the jack spawner abundance in the fall of year *t-1* by the half the smolt production, assuming a 1:1 smolt sex ratio, out-migrating in the spring of year *t-1*.

OPIH Data

Oregon production index hatchery coho salmon abundance data used in this revision are from the 2012 PFMC Preseason Report I (PFMC 2012, Table C-2). Adult marine survival was the total adult pre-harvest abundance divided by the total number of smolts released by brood year. The jack/smolt ratio was the total number of jacks divided by the total number of smolts released.

Marine Survival Categories

Matrix marine survival categories for the current proposal are unchanged from the 2000 A13 review (Sharr et al. 2000) definition of marine survival categories. The current proposal would change the metric for determining marine survival categories from the OPIH jack/smolt ratio to a forecast of wild coho salmon smolt to adult survival. The OCN Work Group described the expected wild adult coho salmon marine survival rates and an assumed ratio of wild to hatchery adult marine survival associated with each category (Sharr et al. 2000). These definitions and relationships were used to develop the proposed metric values for the marine survival axis. The OCN Work Group determined the appropriate exploitation rates for the marine survival categories using a habitat based production model (Nickelson and Lawson 1998). The current proposal does not change any of the OCN Work Group exploitation rates.

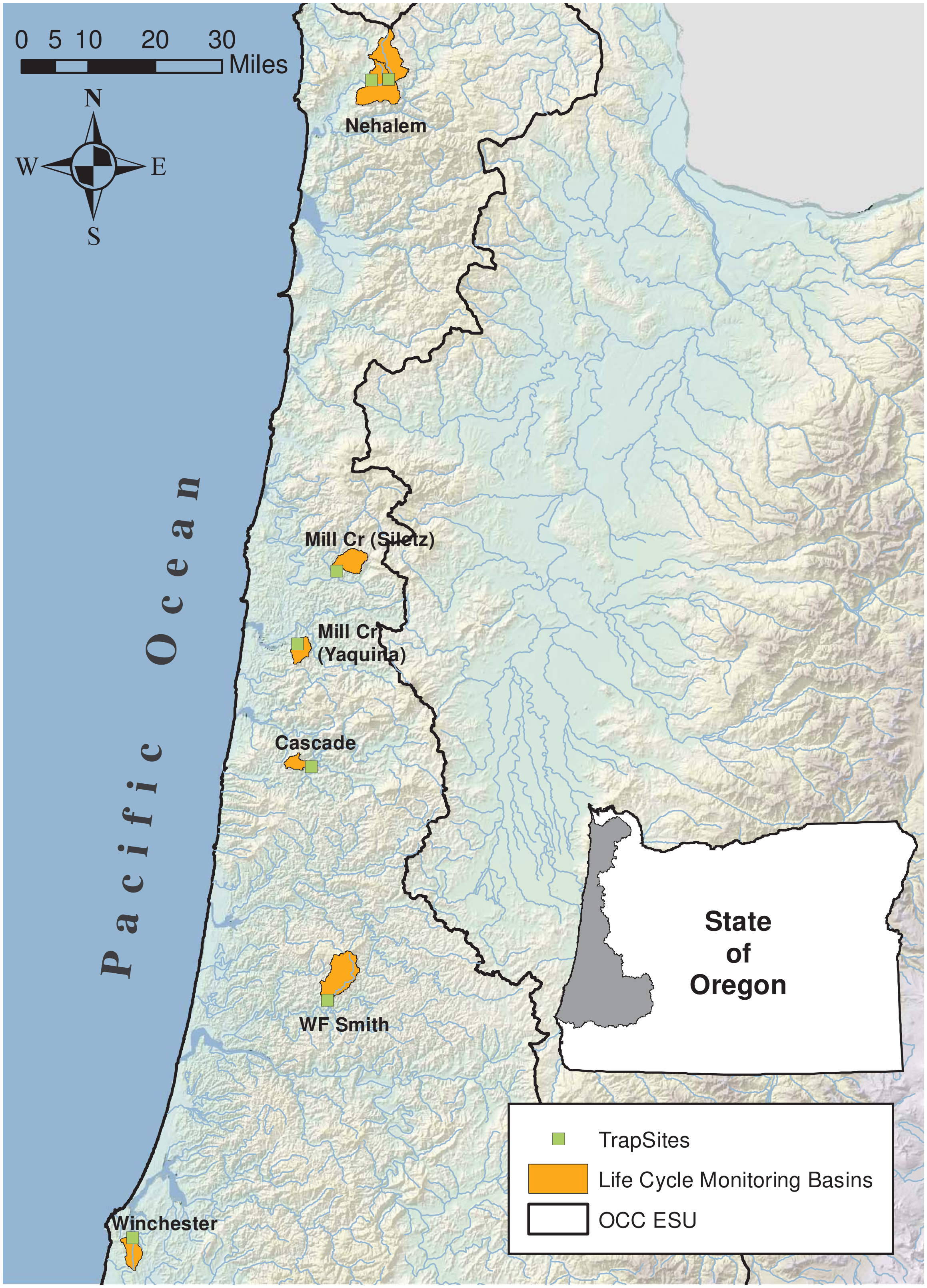

Figure 1. Oregon Department of Fish and Wildlife Life Cycle Monitoring Basins where both coho salmon adult returns and juvenile out-migrants are estimated.

Retrospective Analysis

Harvest management performance of A13 (PFMC 1999), the OCN Work Group guidance on implementation of A13 (Sharr et al. 2000), and the current proposal were compared through a retrospective analysis. The analysis used actual recent pre-season metrics for the parental spawner status and marine survival index and actual pre-harvest ocean abundance of wild adult coho salmon for the Oregon Coast Coho ESU. The allowable total fishery impact rate was determined for each management strategy (A13, OCN Work Group, current proposal) for each year in the data set, 1999 through 2011. Maximum allowable harvest impact and minimum spawning escapement were calculated for each year based on the actual pre-harvest ocean abundance of wild adult coho salmon for the Oregon Coast Coho (OCC) ESU and assumed harvest impacts at the maximum allowable rate for each management strategy. Because the goal of the analysis was to compare the three management strategies performance across a consistent set of pre-season metrics, the 2002 through 2011 parental spawner status was not adjusted for the different allowable harvest impact rates that could have been implemented under each management strategy.

Post season estimates of wild adult coho salmon spawner abundance in the OCC ESU were obtained from ODFW, and are the same numbers submitted to the Oregon Production Index Technical Team meeting each February, for inclusion in the PFMC Preseason Report I. The estimated exploitation rate on OCN coho salmon was based on the post-season MSM-FRAM coho salmon run reconstruction (PFMC 2012). The spawner abundance (spawners) and OCN exploitation rate (ER) were used to generate the actual pre-harvest ocean abundance (recruits) of wild adult coho salmon for the OCC ESU; recruits = spawners / (1 – ER). Allowable fishery impact rates under A13 and the OCN Work Group were obtained from Table V-7 in the 2012 Preseason Report I (PFMC 2012). Pre-season predictions of marine survival from the Mill Creek LCM site are available from the 1999 adult return year to present (Table 2). The allowable total fishery impact rate for the current proposal was based on these marine survival predictions and the OCN Work Group parental spawner status.

Results

OPSW Monitoring Data

An index of OCN coho salmon smolt to adult marine survival can be calculated from 14 years of complementary adult return and smolt production data at six LCM sites and jack/smolt ratios at one site (Table 1), providing information on wild coho salmon survival that was not available during the initial development of A13. The LCM sites are distributed latitudinaly but were not selected by a statistical design. The LCM sites in aggregate, however, are representative of ESU conditions based on spawner abundance and freshwater productivity as modeled by habitat surveys. Average spawner abundance at LCM sites, normalized to spawners/mile, correlates well with ESU wide escapement estimates (R^2=0.89, p<0.001, Figure 2). The relationship is linear over a wide range of abundance. The distribution of habitat quality as measured by the integrative metric of modeled winter parr/km productivity (Anlauf et al. 2009) is similar between LCM sites and the ESU as a whole (Figure 3).

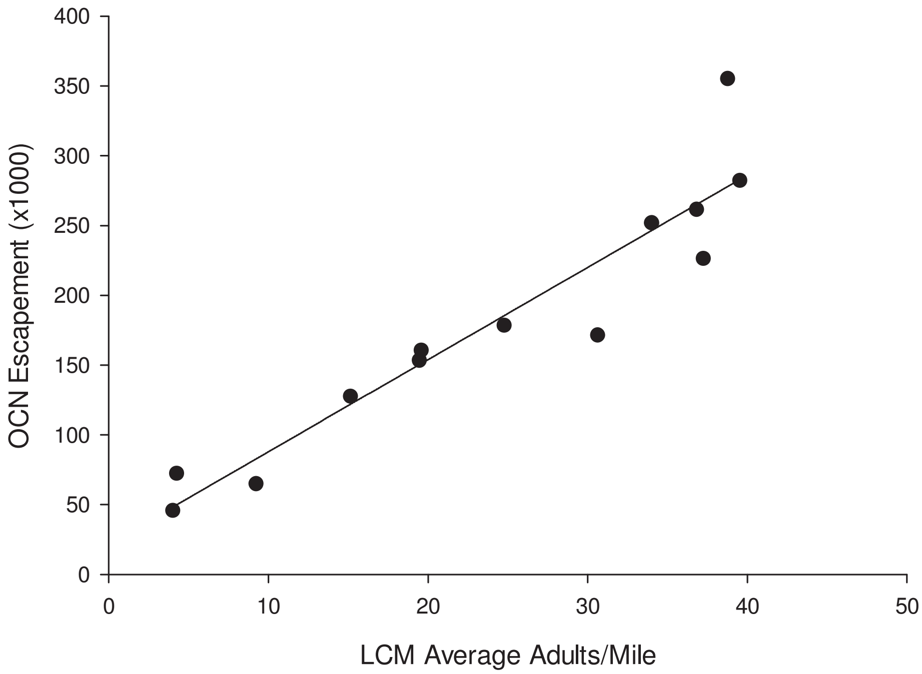

Figure 2. The relationship between adult coho salmon returns to Life Cycle Monitoring sites (n=6) and Oregon Coastal Natural escapement (R^2=0.89, p<0.001).

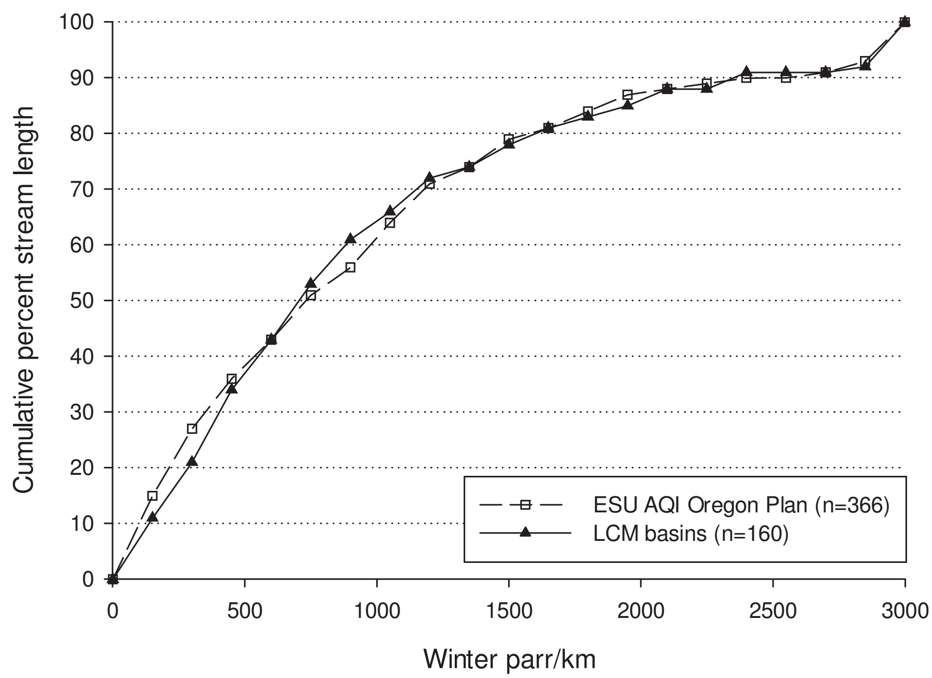

Figure 3. The cumulative distribution of modeled winter parr/km above LCM trap sites and ODFW Aquatic Inventories ESU wide probability surveys.

Table 1. Coho salmon adult marine survival and jack/smolt ratios from Life Cycle Monitoring sites and OPI hatchery returns.

Return Year	LCM adult survival	LCM Mill Cr Jacks/Smolt	OPIH adult survival	OPIH Jacks/Smolt
1998	6.0%	0.0186	1.0%	0.0004
1999	1.5%	0.0057	1.3%	0.0010
2000	3.8%	0.0459	2.1%	0.0012
2001	9.3%	0.0922	4.5%	0.0027
2002	8.7%	0.0581	2.8%	0.0009
2003	10.1%	0.0717	4.2%	0.0020
2004	5.5%	0.0415	2.8%	0.0014
2005	5.0%	0.0136	2.0%	0.0011
2006	2.8%	0.0068	2.5%	0.0012
2007	2.3%	0.0049	2.7%	0.0017
2008	6.5%	0.0385	2.6%	0.0007
2009	9.6%	0.0649	4.6%	0.0027
2010	8.3%	0.0165	2.5%	0.0012
2011	10.7%	0.1015	2.4%	0.0012
2012		0.0384		0.0009

The OPIH jack/smolt ratio remains a strong predictor of OPIH adult marine survival (R^2=0.82) as data collected since the original A13 analysis are added (1970-2011, PMFC 2012). However, there is no relationship between OPIH jack/smolt ratio and the OCN adult marine survival index measured at the LCM sites (Figure 4). Similarly, there is no relationship between OPIH and OCN adult abundance (R^2=0.02, p=0.65). The OPIH jack/smolt ratio predicted the wrong marine survival category in ten of the last thirteen years (Table 2). The jack/smolt ratio from the Mill Cr (Yaquina) LCM site has a strong relationship with wild adult coho salmon marine survival (Figure 5). The relationship with logit transformed variables is shown in Equation 1. This relationship can be used to predict adult marine survival by Equation 2.

Equation 1. $logit(\text{adult marine survival}) = -1.011 + 0.516 * logit(\text{jack/smolt})$

Equation 2. $\text{Predicted marine survival} = \dfrac{1}{1+e^{\left(-\left(-1.011+0.516*\left(ln\left(\frac{\text{jack/smolt}}{\text{1-jack/smolt}}\right)\right)\right)\right)}}$

This relationship would have predicted the correct adult OCN survival rate category in eight of the last thirteen years (Table 2). The proposed method over predicted the survival category twice and under predicted three times, one time by two categories. The OPIH method over predicted twice and under predicted eight times, four times by two categories.

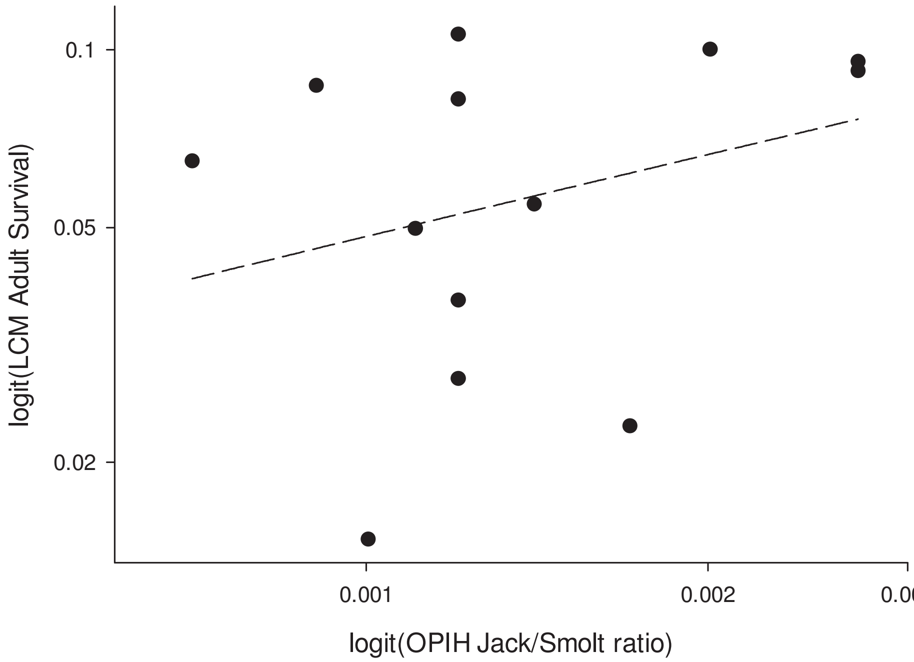

Figure 4. The relationship between the OPIH jack/smolt ratio and LCM adult marine survival (R^2=0.087, p=0.33)

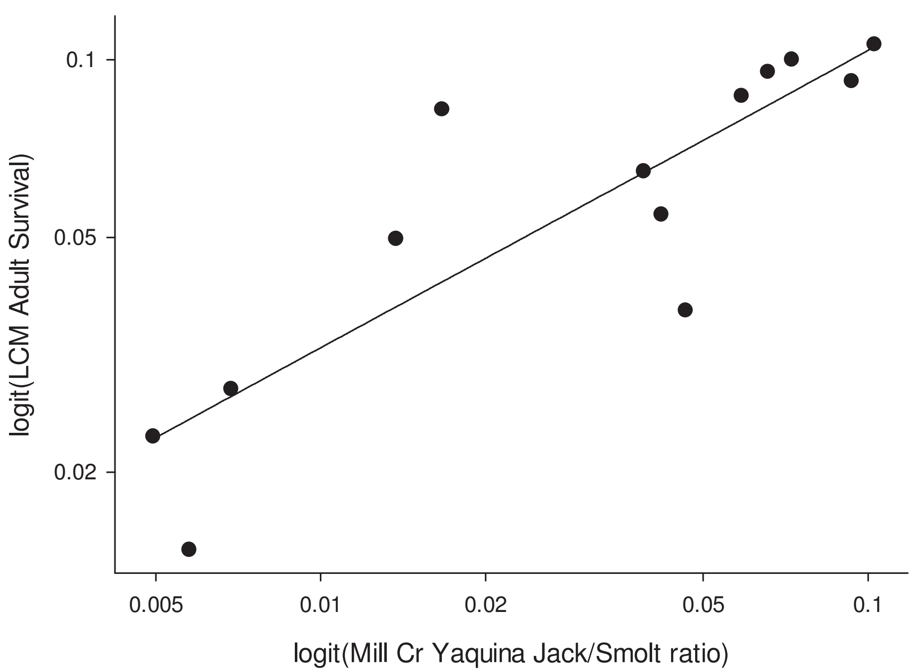

Figure 5. The relationship between the Mill Cr (Yaquina) jack/smolt ratio and LCM adult marine survival (R^2=0.74, p=0.0002)

Marine Survival Categories

This revision retains the four marine survival categories established in the 2000 review of A13 (Sharr et al. 2000) but alters the category values to be expressed as wild adult marine survival rather than OPIH jack/smolt ratios (Table 3). The proposed A13 matrix is shown in Table 4.

Table 2. Observed and predicted marine survival and marine survival categories. Incorrect predictions using OPIH and LCM jack/smolt ratios are highlighted.

Return Year	LCM observed adult survival	LCM predicted adult survival	OPIH Jacks/Smolt	LCM observed adult category	OPIH predicted category	LCM predicted category
1999	1.5%	2.5%	0.0010	Ex. Low	Low	Low
2000	3.8%	7.1%	0.0012	Low	Low	Medium
2001	9.3%	10.0%	0.0027	High	Medium	High
2002	8.7%	8.0%	0.0009	High	Low	Medium
2003	10.1%	8.9%	0.0020	High	Medium	High
2004	5.5%	6.7%	0.0014	Medium	Medium	Medium
2005	5.0%	3.8%	0.0011	Medium	Low	Low
2006	2.8%	2.7%	0.0012	Low	Low	Low
2007	2.3%	2.3%	0.0017	Low	Medium	Low
2008	6.5%	6.5%	0.0007	Medium	Ex. Low	Medium
2009	9.6%	8.4%	0.0027	High	Medium	High
2010	8.3%	4.2%	0.0012	High	Low	Low
2011	10.7%	10.6%	0.0012	High	Low	High

Table 3. Marine survival categories delineated in the OCN Work Group 2000 review of Amendment 13 harvest management matrix (Sharr et al. 2000, pg 16 & 21).

	Extremely Low	Low	Medium	High
Wild Adult Marine Survival	< 2%	2% to 4.5%	>4.5% to 8%	> 8%
OPIH Adult Marine Survival	< 1%	1% to 3%	>3% to 8%	> 8%
OPIH Jack/Smolt Ratio	<0.0008	0.0008 to 0.0014	>0.0014 to 0.0040	>0.0040

Table 4. Proposed revisions to the OCN Work Group 2000 review of Amendment 13 harvest management matrix. *Changes are highlighted and italicized*.

Parent Spawner Status[1]	**Marine Survival Index** *(Wild adult coho survival as predicted by Mill Cr (Yaquina) jack/smolt ratios)*			
	Extremely Low *<2%*	**Low** *2%-4.5%*	**Medium** *>4.5%-8%*	**High** *>8%*
High Parent Spawners > 75% of full seeding	**E** ≤ 8%	**J** ≤ 15%	**O** ≤ 30%	**T** ≤ 45%
Medium Parent Spawners > 50% & ≤ 75% of full seeding	**D** ≤ 8%	**I** ≤ 15%	**N** ≤ 20%	**S** ≤ 38%
Low Parent Spawners > 19% & ≤ 50% of full seeding	**C** ≤ 8%	**H** ≤ 15%	**M** ≤ 15%	**R** ≤ 25%
Very Low Parent Spawners > 4 fish per mile & ≤ 19% of full seeding	**B** ≤ 8%	**G** ≤ 11%	**L** ≤ 11%	**Q** ≤ 11%
Critical Parent Spawners ≤ 4 fish per mile	**A** 0 – 8%	**F** 0 – 8%	**K** 0 – 8%	**P** 0 – 8%

Sub-aggregate and Basin Specific Spawner Criteria Data

Sub-aggregate	Miles of Available Spawning Habitat	100% of Full Seeding	"Critical"		Very Low, Low, Medium & High		
			4 Fish per Mile	12% of Full Seeding	19% of Full Seeding	50% of Full Seeding	75% of Full Seeding
Northern	899	21,700	3,596	NA	4,123	10,850	16,275
North-Central	1,163	55,000	4,652	NA	10,450	27,500	41,250
South-Central	1,685	50,000	6,740	NA	9,500	25,000	37,500
Southern (*Removed per adoption of Amendment 16*)							
Coastwide Total	*3,747*	*126,700*	*14,988*		*24,073*	*63,350*	*95,025*

1 Parental spawner abundance status for the OCN aggregate assumes the status of the weakest sub-aggregate.

Retrospective Analysis

The last 13 years provides a wide range of pre-harvest OCN coho salmon ocean recruitment levels for a comparison of harvest management performance, from 51,000 in 1999 to 385,000 in 2011 (Table 5). The allowable fishery impact rates for the period 1999 through 2011 averaged 17% under A13, 13% under the OCN Work Group guidance, and would have been 18% under the current proposal (Table 5). All of these rates are well below the levels seen prior to implementation of A13 in 1998 (Table III-2 in PFMC 2012). In addition, actual fishery impact rates for the period 1999 through 2011 were consistently below the allowable rate, averaging 42% and ranging from 24% to 59% of the allowable rate. In this

Table 5. Retrospective analysis of allowable Fishery Impact Rate (FIR) under three management regimes for Oregon Coastal wild coho salmon.

	Actual Spawners, and FIR based on MSM/FRAM			Amendment 13 (Implemented 1998)			OCN Work Group (Implemented 2001)			Current Proposal		
Fishery Year	Pre-Harvest Recruits	Spawners	FIR	Harvest	Spawners	FIR	Harvest	Spawners	FIR	Harvest	Spawners	FIR
1999	50,959	47,239	0.07	7,644	43,315	0.15	4,077	46,882	0.08	4,077	46,882	0.08
2000	77,017	73,782	0.04	11,553	65,464	0.15	6,161	70,856	0.08	6,161	70,856	0.08
2001	168,606	162,705	0.04	25,291	143,315	0.15	13,488	155,118	0.08	13,488	155,118	0.08
2002	271,733	258,418	0.05	40,760	230,973	0.15	40,760	230,973	0.15	40,760	230,973	0.15
2003	249,358	229,409	0.08	37,404	211,954	0.15	37,404	211,954	0.15	62,340	187,018	0.25
2004	187,192	172,778	0.08	28,079	159,113	0.15	28,079	159,113	0.15	28,079	159,113	0.15
2005	161,170	154,595	0.04	32,342	129,368	0.20	24,257	137,453	0.15	24,257	137,453	0.15
2006	139,415	128,819	0.08	27,883	111,532	0.20	20,912	118,503	0.15	20,912	118,503	0.15
2007	75,137	66,271	0.12	15,027	60,110	0.20	15,027	60,110	0.20	11,271	63,866	0.15
2008	183,166	179,686	0.02	27,475	155,691	0.15	14,653	168,513	0.08	54,950	128,216	0.30
2009	281,602	262,735	0.07	42,240	239,362	0.15	42,240	239,362	0.15	70,401	211,201	0.25
2010	296,768	283,413	0.05	44,515	252,253	0.15	44,515	252,253	0.15	44,515	252,253	0.15
2011	385,146	356,260	0.08	77,029	308,117	0.20	57,772	327,374	0.15	173,316	211,830	0.45
2012						*0.20*			*0.15*			*0.30*
Avg.	**194,447**	**182,778**	**0.06**	**32,096**	**162,351**	**0.17**	**26,873**	**167,574**	**0.13**	**42,656**	**151,791**	**0.18**
Highest Three Recruitment Years (2009, 2010, 2011)												
Avg.	**321,172**	**300,803**	**0.06**	**54,595**	**266,577**	**0.17**	**48,176**	**272,996**	**0.15**	**96,077**	**225,095**	**0.28**
Min.		262,735			239,362			239,362			211,201	
Middle Seven Recruitment Years (2001 through 2006, 2008)												
Avg.	**194,454**	**183,773**	**0.05**	**31,319**	**163,135**	**0.16**	**25,650**	**168,804**	**0.13**	**34,969**	**159,485**	**0.18**
Min.		128,819			111,532			118,503			118,503	
Lowest Three Recruitment Years (1999, 2000, 2007)												
Avg.	**67,704**	**62,431**	**0.08**	**11,408**	**56,296**	**0.17**	**8,422**	**59,283**	**0.12**	**7,170**	**60,535**	**0.10**
Min.		47,239			43,315			46,882			46,882	

sense, all three management scenarios were successful in achieving the goal of ensuring that harvest impacts are consistent with OCN recovery needs.

The assumption inherent in the OCN harvest matrix concept is that the metrics for parental status and marine survival have a relationship with actual pre-harvest ocean recruitment levels. To evaluate this assumption, average results from the retrospective analysis were calculated for three categories: top three recruitment years, bottom three recruitment years, and middle seven recruitment years (Table 5). The A13 matrix did not provide any differentiation of high, middle, and low recruitment years with average allowable fishery impact rates of 17%, 16% and 17% respectively (Table 5). The OCN Work Group matrix had some differentiation, but the differences between high, middle, and low recruitment years were small, with average allowable fishery impact rates of 15%, 13% and 12% respectively (Table 5). The current proposal using wild jack/smolt ratios provides much more differentiation of recruitment levels than those using OPIH jack/smolt ratios, averaging 28%, 18% and 10% fishery impact rates for the high, middle and low recruitment years (Table 5).

Discussion

The goal for harvest management of OCN coho salmon is to control harvest impacts such that they do not impede recovery of OCN coho salmon while also allowing for incidental harvest of OCN coho salmon during harvest of other salmon species or stocks and the directed harvest of OCN coho salmon when appropriate. Achieving this goal is dependent on forecasts that accurately represent OCN coho salmon. ODFW, as part of the OPSW, has monitored OCN coho salmon spawner abundance (Lewis et al. 2011), freshwater habitat (Anlauf et al. 2009), and an index of marine survival and jack/smolt ratios (Suring et al. 2012) from 1998 to present, providing data directly related to OCN coho salmon that were unavailable when A13 was developed. These data show that LCM sites in aggregate are representative of OCN coho salmon in regards to both adult returns and habitat quality and that the LCM marine survival index is a reasonable index of OCN adult marine survival. The LCM jack/smolt ratio explains much more of the variation in OCN adult marine survival than the OPIH jack/smolt ratio and provides a higher forecast skill. There is no indication that the relationship between OPIH jack/smolt ratios and OPIH adult marine survival has changed since the development of A13, however, OPIH data, either abundance or survival, are not correlated with OCN data.

Revising the source of the A13 marine survival axis from OPIH jacks/smolt to LCM jacks/smolt would increase the forecast skill, as measured by Pearson's correlation coefficient r, from 0.30 to 0.86. Rupp et al. (2012) conducted a management strategy evaluation (MSE) examining the effect of forecast skill on A13 performance. While Rupp et al. (2012) did not consider a forecast skill improvement of this magnitude, their "poor" forecast skill had an $r = 0.50$ and their "good" had an $r = 0.90$, the increase in skill from 0.50 to 0.90 resulted in a 5% increase in long-term harvest and a reduction in the frequency of falling below the critical spawner density of 1%. These performance improvements would be expected to be higher given the greater increase in forecast skill in this proposal.

The potential for management improvement under this proposal has also been evaluated by comparing outcomes under the observed conditions of the last 13 years. The current proposal would have done a better job of meeting the management objectives of reducing impact rates in low recruitment years and allowing greater harvest opportunities in high recruitment years. In the lowest recruitment years the current proposal would have capped impact rates at an average of 10% versus 12% under the OCN Work Group and 17% under the original A13 (Table 5). In high recruitment years the current proposal allows harvest of 28% versus 15% and 17%. Overall the OCN Work Group and original A13 results have little or no differentiation in impact rates at different abundance levels compared to the results for the current proposal. Return year 2007 had the lowest pre-harvest coho salmon abundance of the last 12 years. However, the original A13 and OCN Work Group matrix mistakenly categorized the marine survival index as medium and allowed a 20% impact rate, the highest either method has allowed during the last 12 years. The resulting actual impact rate for OCN coho salmon in 2007 was 12%, which was the highest since A13 was adopted. The proposed predictor correctly identified 2007 as a return year with low marine survival, although an allowable harvest rate of 15% would have still been set based on parental spawner abundance.

One concern with using the Mill Creek (Yaquina) jack/smolt ratio as the basis for the marine survival axis is that it is based on a single site. If an unexpected event changes the out-migrating smolt condition such that it impacts the jack rate or early marine survival of these fish, it could disrupt the relationship between the jack/smolt ratio and the OCN marine survival index. In the springs of 2011 and 2012 smolt production has been less than expected given the number of adult spawners (Suring et al. 2012). While the level of absolute smolt production does not necessarily have an impact on the predictor, as it is normalized to the number of smolts, lower smolt production may cause higher uncertainty due to low sample sizes and may be a sign that conditions have changed at the Mill Creek site. The reliance on a single site could be ameliorated by modifying or creating new LCM sites so that jacks can be enumerated. Candidates include the North Fork Nehalem, the East Fork Trask River, and Cascade Creek. Future work will also include incorporating additional sources of information, such as ocean environmental indictors. The Mill Creek jack/smolt ratio and the OCN marine survival index relationship will be monitored annually and, if its performance deteriorates beyond that of the current predictor, the status quo of OPIH jack/smolt ratios will continue to be available as an alternative.

This proposed change to the implementation of A13 does not alter the current parental spawner axis, allowable fishery impact rates, or the categories of the marine survival axis. It changes the method of determining the OCN marine survival axis category from one based on Columbia River hatchery coho salmon to one based on wild coho salmon within the OCN area. We expect the adoption of this technical revision will result in improved management of OCN coho salmon harvest impacts. By increasing the forecast skill of the marine survival prediction fishery impact rates will better match true pre-harvest abundance levels. While the MSE conducted by Rupp et al. (2012) suggested that improvements will be moderate it also demonstrated that the risk of this proposal is relatively low.

Recommendations

Based on the results of this analysis we recommend the following technical updates to the OCN Work Group guidance on implementation of Amendment 13:

- Remove the Southern sub-aggregate from the Parental Spawner Axis criteria of the matrix as a housekeeping measure per adoption of Amendment 16.
- Change the metric for the Marine Survival Index Axis from the OPIH jack/smolt ratio to predicted wild coho salmon adult survival based on the Mill Creek (Yaquina) wild jack/smolt ratio.

Additionally ODFW and partners will continue to investigate improvements to the OCN adult marine survival predictor:

- Pursue developing jack collections at other LCM sites as additions to the Mill Creek LCM data.
- Pursue analysis of the OCN abundance predictor (ocean conditions) and other data sets as additions or alternatives to the Mill Creek LCM data as an OCN adult marine survival predictor.

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Comparison of Two Methods for Estimating Coho Salmon Encounters and Release Mortalities in the Ocean Mark-selective Fishery

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INTRODUCTION

This report compares two methods for estimating the total number of encounters with coho salmon and the number of release mortalities in the mark-selective recreational fisheries for coho conducted annually off the Washington coast (WDFW Marine Catch Areas 1, 2, 3, and 4). The starting points for both methods are estimates of the numbers of marked and unmarked legal-size coho landed (brought to the dock) in each marine catch area during each month of the fishery. The methods used to estimate landed catch and its variance are described in Lai et al. (1991). Currently, estimates of landed catch by the two components of the recreational fishing fleet (charter boats and private boats) are combined and used to estimate total encounters (and total release mortalities) for marked and unmarked coho salmon.

Four potential problems with the current estimation methods are:

a) the estimate of marked coho release mortalities is not a function of marked coho encounters but is a constant fraction of the total landed catch of marked coho salmon,
b) the estimate of total legal-size coho salmon encounters is made using the combined landed catch of the fleets,
c) the estimate of total encounters with legal-size coho salmon is based on the assumption that there is no release of legal-size marked coho salmon by either component of the recreational fleet, and
d) the proportion of all legal-size coho salmon encounters that are marked ($\hat{P}_M$), that is a component of the total encounters estimate, is estimated using sample data from each fleet that is simply combined and does not consider the proportion of total encounters occurring in each fleet.

Items c) and d) will lead to biased estimates of total encounters, including the number of unmarked (typically wild coho) encounters, if the assumptions upon which they are based are not true. The current estimation methods assume that (1) there are no differences in the behaviors of the two components of the recreational fishing fleet related to the release of legal-size marked coho and that (2) the marked-to-unmarked ratio of legal-size coho encountered by the two fleets is the same. Recent data collected from each of the fleets indicates that anglers do release legal-size marked coho salmon and that private anglers may consistently release a greater proportion of the legal-size marked coho salmon they encounter compared to the charter boat anglers.

This report describes an alternate method which estimates total encounters of legal-size coho salmon by the charter boat and private boat fleets separately and, therefore, estimates $\hat{P}_M$ (and other encounter proportions) separately for each fleet. It also incorporates fleet-specific estimates of the proportion of legal-size marked coho that are caught and released into the estimate of total encounters. The estimates of total legal-size coho salmon encounters and total release mortalities for marked and unmarked legal-size coho by each method are compared for the three most recent ocean fishing seasons (2009, 2010, and 2011).

METHODS

Current Method

For simplification, the methods used to estimate coho salmon encounters and release mortalities for a single month and area will be described and corresponding subscripts for month and area omitted from the notation. This method begins with the estimate of total landed catch (marked and unmarked coho combined) for a month and catch area (see Table 1 for definitions of the notation used). Total landed catch (C_T) is estimated as the sum of the estimates of landed marked and unmarked coho by each fleet:

$$\hat{C}_T = \left(\hat{C}_M^C + \hat{C}_U^C\right) + \left(\hat{C}_M^P + \hat{C}_U^P\right) \qquad [1]$$

with variance,

$$\hat{V}\left(\hat{C}_T\right) = \hat{V}\left(\hat{C}_M^C\right) + \hat{V}\left(\hat{C}_U^C\right) + \hat{V}\left(\hat{C}_M^P\right) + \hat{V}\left(\hat{C}_U^P\right). \qquad [2]$$

Currently the number of <u>marked</u> coho salmon released is estimated as 6% of the marked coho landed catch. The number of marked coho mortalities due to release (R_M) is estimated by applying the PFMC recommended mortality rate of 14% for coho salmon released by ocean recreational fisheries off the coast of Washington (PFMC 2000) to this estimated number released:

$$\hat{R}_M = \left(\hat{C}_M^C + \hat{C}_M^P\right) \ x \ 0.06 \ x \ 0.14 \qquad [3]$$

with variance,

$$\hat{V}\left(\hat{R}_M\right) = [0.06 \ x \ 0.14]^2 \ x \ \left[\hat{V}\left(\hat{C}_M^C\right) + \hat{V}\left(\hat{C}_M^P\right)\right]. \qquad [4]$$

Currently, the estimated number of <u>unmarked</u> coho mortalities due to release is based on an estimate of the total encounters of legal-size coho salmon (E_T) by the fishery:

$$\hat{E}_T = \frac{\hat{C}_T}{\hat{P}_M} \qquad [5]$$

where $\hat{P}_M$ is an estimate of the proportion of all legal-size coho salmon encounters[1] in the fishery that are marked based on data collected by onboard observers for the charter boat fleet and by voluntary trip reports (VTRs) for the private boat fleet. The reasoning behind using total catch in this calculation instead of total marked catch is unclear other than it will provide a somewhat larger estimate of total encounters. Also, this method assumes there is no release of legal-size marked coho salmon by anglers.

Currently, $\hat{P}_M$ is estimated by simply combining the data collected by the charter boat observer program and private-boat angler VTRs. There is no attempt to weight the data to adjust for differences in total coho salmon encounters between the two groups.

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[1] The definition of an encounter as used for management of these fisheries is a coho salmon that is brought to the boat by the angler, identified as a marked or unmarked fish, and then typically kept if a marked fish and released if an unmarked fish. Drop-offs (fish that are hooked but free themselves before being brought to the boat) are accounted for separately.

Table 1. Definitions of the notation used.

Notation		Definition
$\hat{C}_j^i$	=	the estimated landed catch of legal-size marked (*j* = *M*) or unmarked (*j* = *U*) coho by either the charter boat (*i* = *C*) or private boat (*i* = *P*) fleets. Subscript *T* indicates the estimated total landed catch of marked and unmarked coho.
$\hat{E}_T^i$	=	the estimated total number of encounters with legal-size coho salmon by anglers in fleet *i*.
$\hat{P}_M^i$	=	the estimated proportion of all legal-size coho salmon encounters by anglers in fleet *i* that were marked.
$\hat{R}_j^i$	=	the estimated number of mortalities of legal-size coho salmon of mark status *j* due to their release by anglers in fleet *i*.
$\hat{\Phi}_M^i$	=	the estimated proportion of all legal-size encounters of <u>marked</u> coho salmon that were kept by anglers in fleet *i*.
$\hat{\Omega}_M^i$	=	the estimated proportion of all legal-size coho salmon encounters (<u>both marked and unmarked</u>) that were both marked and kept by anglers in fleet *i*.
$\hat{\theta}_j^i$	=	the estimated proportion of all legal-size coho salmon encounters that were mark status *j* and released by anglers in fleet *i*.

Assuming independence between $\hat{C}_T$ and $\hat{P}_M$ and a covariance of 0, the variance of the total encounter estimate can be approximated using the delta method (Seber 1982) as:

$$\hat{V}\left(\hat{E}_T\right) \approx \frac{\hat{V}(\hat{C}_T)}{[\hat{P}_M]^2} + \frac{\hat{V}(\hat{P}_M)\ x\ \hat{C}_T^2}{[\hat{P}_M]^4}\ . \qquad [6]$$

The variance of $\hat{P}_M$ is estimated using the formula for the variance of a binomial proportion (Cochran 1977). Let N_T = the number of legal-size coho salmon recorded as brought to the boat by both charter boat observers and on VTRs and N_M = the number of those coho that were marked (missing an adipose fin). Then $\hat{P}_M = N_M / N_T$ with variance:

$$\hat{V}\left(\hat{P}_M\right) = \frac{\hat{P}_M\ x\ [1-\hat{P}_M]}{N_T - 1}\ . \qquad [7]$$

Currently, the number of unmarked coho salmon mortalities due to release is estimated as:

$$\hat{R}_U = \left(\hat{E}_T - \hat{C}_T\right)\ x\ 0.14$$

which is equivalent to:

$$\hat{R}_U = \hat{C}_T\ x\ \left(\frac{1}{\hat{P}_M} - 1\right)\ x\ 0.14. \qquad [8]$$

The variance of $\hat{R}_U$ can be estimated using Goodman's (1960) formula for the variance of the product of two independent random variables,

$$\hat{V}\left(\hat{R}_U\right) = 0.14^2\ x\ \left\{\left[\left(\frac{1}{\hat{P}_M}\right)^2\ x\ \hat{V}(\hat{C}_T)\right] + \left[\left(\hat{C}_T\right)^2\ x\ \hat{V}(\tfrac{1}{\hat{P}_M})\right] - \left[\hat{V}(\hat{C}_T)\ x\ \hat{V}(\tfrac{1}{\hat{P}_M})\right]\right\}\ . \qquad [9]$$

The variance of $1/\hat{P}_M$ can be approximated using the delta method as:

$$\hat{V}\left(\frac{1}{\hat{P}_M}\right) \approx \frac{\hat{V}(\hat{P}_M)}{[\hat{P}_M]^4}\,. \qquad [10]$$

While the release mortality rate (0.14) is acknowledged to be an estimate there is no measure of uncertainty (variance) currently associated with it. Therefore, it is treated as a known constant.

Proposed Alternate Method

The alternate method begins with an estimate of total encounters of legal-size coho by each fleet, $\hat{E}_T^i$, (where *i* is either the charter boat or private boat fleet) and is generated differently than the previous method in that it is based on the estimated total landed catch of only marked coho salmon expanded to account for the release of any legal-size marked coho by each recreational fleet:

$$\hat{E}_T^i = \frac{\hat{C}_M^i}{\hat{\Phi}_M^i} \Big/ \hat{P}_M^i \qquad [11]$$

where $\hat{P}_M^i$ is defined as for the previous method except now it is estimated separately for each fleet and $\hat{\Phi}_M^i$ is an estimate of the proportion of legal-size marked coho salmon that are brought to the boat and kept. Therefore, 1 - $\hat{\Phi}_M^i$ is an estimate of the proportion of legal-size marked coho salmon that are encountered but intentionally released by each fleet. This method is more intuitive than the previous method as it is based on the landed catch of only legal-size marked coho salmon and expands that catch to account for legal-size marked coho that were caught but released by the angler. Therefore, when expanded by $\hat{P}_M^i$ it provides an unbiased estimate of the total encounters of legal-size coho salmon by each fleet.

Equation 11 can be re-expressed as:

$$\hat{E}_T^i = \frac{\hat{C}_M^i}{(\hat{\Phi}_M^i \ x \ \hat{P}_M^i)} \qquad [12]$$

and the product in the denominator is equivalent to the estimated proportion of all legal-size coho salmon encountered that are both marked and kept by the angler based on either charter boat observer or VTR data (depending upon the fleet being analyzed - see Appendix A).

Letting $\hat{\Omega}_M^i$ represent the estimated proportion of all legal-size coho salmon encountered by anglers in a fleet that are marked coho which are kept, the variance of this total encounter estimate can be approximated using the delta method as:

$$\hat{V}\left(\hat{E}_T^i\right) \approx \frac{\hat{V}(\hat{C}_M^i)}{[\hat{\Omega}_M^i]^2} + \frac{\hat{V}(\hat{\Omega}_M^i)\, x\, [\hat{C}_M^i]^2}{[\hat{\Omega}_M^i]^4}\,. \qquad [13]$$

This assumes that the estimates of $\hat{C}_T^i$ and $\hat{\Omega}_M^i$ are independent with covariance = 0. The variance of $\hat{\Omega}_M^i$ can be estimated as the variance of a binomial proportion similarly to the variance of $\hat{P}_M$ (see Appendix A).

Letting $\hat{\theta}_M^i$ equal the estimated proportion of all legal-size coho salmon encountered by anglers from a fleet that are marked coho which are released (see Appendix A), the number of marked coho mortalities due to release by fleet *i* can then be estimated as:

$$\hat{R}_M^i = \left[\hat{E}_T^i \ x \ \hat{\theta}_M^i\right] x \ 0.14 \qquad [14]$$

with variance estimated using Goodman's (1960) formula,

$$\hat{V}\left(\hat{R}_M^i\right) = 0.14^2\ x$$

$$\left\{\left[\left(\hat{\theta}_M^i\right)^2\ x\ \hat{V}\left(\hat{E}_T^i\right)\right]\ +\ \left[\left(\hat{E}_T^i\right)^2 x\ \hat{V}\left(\hat{\theta}_M^i\right)\right] - \left[\hat{V}\left(\hat{E}_T^i\right) x\, \hat{V}\left(\hat{\theta}_M^i\right)\right]\right\}. \qquad [15]$$

The number of unmarked coho mortalities due to release can be estimated as:

$$\hat{R}_U^i\ =\ \left[\hat{E}_T^i\ x\ \hat{\theta}_U^i\right]\ x\ 0.14 \qquad [16]$$

with variance,

$$\hat{V}\left(\hat{R}_U^i\right) = 0.14^2\ x$$

$$\left\{\left[\left(\hat{\theta}_U^i\right)^2\ x\ \hat{V}\left(\hat{E}_T^i\right)\right]\ +\ \left[\left(\hat{E}_T^i\right)^2 x\ \hat{V}\left(\hat{\theta}_U^i\right)\right] - \left[\hat{V}\left(\hat{E}_T^i\right) x\, \hat{V}\left(\hat{\theta}_U^i\right)\right]\right\} \qquad [17]$$

where $\hat{\theta}_U^i$ is the estimated proportion of all legal-size coho salmon encountered by anglers from a fleet that are unmarked coho which are released (see Appendix A).

Fleet-specific Estimates of $\hat{\Omega}_M^i$

An estimate of $\hat{\Omega}_M^i$ is required for the proposed alternate method of estimating total encounters of legal-size coho salmon. If $\hat{\Omega}_M^i$ is the same for each fleet then the total number of legal-size coho salmon encounters can be estimated using a combined estimate (charter and private boat fleet) of the landed catch of legal-size marked coho and an estimate of the overall $\hat{\Omega}_M$. Data to estimate $\hat{\Omega}_M^i$ come from the onboard observer program for the charter boat fleet and the voluntary trip reporting program for the private boat fleet. If there is a difference in $\hat{\Omega}_M^i$ between the charter and private boat fleets then a separate estimate of the total encounters by each fleet is more appropriate.

As demonstrated in Appendix A, $\hat{\Omega}_M^i$ can be expressed as the product of the proportion of all encounters that are marked ($\hat{P}_M^i$) and the proportion of marked coho encountered that are kept ($\hat{\Phi}_M^i$). There are reasons to expect that these parameters may be different between the charter and private boat fleets because:

- charter boat anglers are routinely discouraged from releasing legal-size marked coho that are caught while private boat anglers are not, and
- the private boat fleet tends to be more dispersed than the charter boat fleet and fishes in some areas not heavily fished by the charter boat fleet, therefore, it may encounter a different segment of the coho salmon population at large in the ocean than the charter boat fleet.

Comparison of $\hat{\Omega}_M^i$ for charter boat and private boat fleets

Estimates of $\hat{\Omega}_M^i$ from data collected by the charter boat observer program were compared to estimates from data collected through the private boat VTR program for the same area and month strata. The three most recent years of data were analyzed (2009, 2010, and 2011). Fisher's exact test (Conover 1980) was used to test whether the estimates of $\hat{\Omega}_M^i$ for the two fleets were statistically different for month-area combinations (hereafter referred to as cells) with 10 or more total encounters with legal-size coho salmon by each sample program. We also tested whether the two fleets had similar estimates of $\hat{\Omega}_M^i$ across the entire three-year data set using ordinary least squares regression analysis to compare a line defined by the estimates to a line with a slope of 1.00 (i.e., the line of equality). Finally, the nonparametric Wilcoxon signed ranks test (Conover 1980) was used to compare the estimates across all areas and years by treating the estimates from the two data sources for a specific month-area cell as a matched pair of observations of the same parameter. The Wilcoxon test is based on the signed ranks of the differences between the paired observations and tests whether the differences between the two data sources have a median = 0 which, if accepted, indicates that the samples came from the same populations.

Estimates of $\hat{\Omega}_M^i$ from dockside interview data from charter boats were compared to dockside interview data from private anglers, also. Dockside interview data are completed-trip interview data. The sample unit for dockside interviews is a boat; therefore, the data is commonly for multiple anglers in the boat. The data collected include:

- number of coho retained regardless of mark status,
- number of marked coho retained,
- number of coho released regardless of mark status, and
- number of marked coho released.

Three major differences between the dockside interview data and the sampling program data (onboard observer and VTRs) are: (1) the unit of data collection is the boat for the dockside data compared to the encounter for the sampling program data; (2) there is no differentiation between legal and sublegal coho salmon released for the dockside data compared to a separate accounting of legal-size and sublegal-size coho for the sampling programs; and (3) the charter onboard observer and VTR data do not rely on recall (the data for an encounter is recorded shortly after it occurs) while the dockside data relies on angler recall of the number of coho salmon released and their mark-status. Therefore, the release data from dockside interviews includes a small proportion of sublegal-size coho salmon and is not directly comparable to the charter boat observer and VTR data. For the above reasons, it was not appropriate to compare the dockside data using a chi-square test. However, we examined the dockside release data to see if trends similar to those observed in the onboard observer and VTR sampling program data comparison were present in the dockside data using plots of the data, regression analysis, and the Wilcoxon test.

Evaluation of proxy estimates of $\hat{\Omega}_M^i$ when direct sampling data are lacking or insufficient

In order to estimate total encounters by fleet, an estimate of $\hat{\Omega}_M^i$ is needed for each fleet for each month-area combination[2]. Often onboard observer data for the charter boats is lacking for areas 3 and 4 (and occasionally for areas 1 and 2 in September). Similarly, VTR data for the private fleet is occasionally lacking or has a very small sample size (less than 10 total encounters with legal-size coho salmon). Usually, only a small portion of the total coho salmon catch occurs in month-area strata with missing or insufficient data. For the three years examined, 5.7%, 3.4%, and 2.2% of the total landed catch of legal-size coho salmon occurred in these type of strata in 2009, 2010, and 2011, respectively.

[2] Similarly, estimates of $\hat{\theta}_j^i$ for each fleet by area-month are needed to estimate release mortalities.

Therefore, alternate methods of estimating $\hat{\Omega}_M^i$ were sometimes needed to produce fleet-specific estimates of encounters (and subsequent release mortalities). We considered three methods of estimating $\hat{\Omega}_M^i$ when these data were missing for a month-area cell. They were:

1. estimate $\hat{\Omega}_M^i$ for either the charter boat or private boat fleet using the corresponding dockside interview data,
2. estimate $\hat{\Omega}_M^i$ using sample data for the same fleet from a neighboring area and/or month cell, and
3. estimate $\hat{\Omega}_M^i$ for the charter boat fleet using VTR data from the corresponding month-area cell.

Methods similar to those described in the previous section were used to compare data from different sources. For these analyses, data from either charter boat onboard observers or private boat VTRs were considered to provide the "best" estimate of the composition of legal-size coho salmon encounters. Analyses were conducted to determine if the alternative being evaluated consistently provided a reasonable proxy for the missing data. We considered a straight substitution of estimates, an estimate based on a ratio of means (ROM) estimator, and a regression estimate using the linear relationship between the two data sources for these analyses.

RESULTS

Analyses of $\hat{\Omega}_M^i$

The results from the comparison of $\hat{\Omega}_M^i$ between fleets are presented first since this will determine whether total encounters need to be estimated separately for each fleet. This is followed by an evaluation of proxies.

<u>Comparison of $\hat{\Omega}_M^i$ for charter boat and private boat fleets</u>

For the three years of data examined, there were 17 month-area cells that had data from both the charter boat observer and VTR data collection programs[3]. Table 2 summarizes the data collected by each program and the results of Fisher's exact test comparing $\hat{\Omega}_M$ for each fleet. There was one significant difference between the $\hat{\Omega}_M$ estimates for the fleets in each year; all three significant tests occurred in Area 2.

It can be seen from Table 2 that private boat anglers generally have a lower proportion of legal-size marked coho retained than the charter boat fleet (i.e., private boat anglers tend to release a higher proportion of legal-size marked coho salmon than charter boat anglers). The Wilcoxon signed rank test rejected the hypothesis that the median difference between the ranks of the paired estimates was 0 (P = 0.009) further indicating that the estimates of $\hat{\Omega}_M$ from the two fleets were different from one another.

A scatter plot of the estimates (Figure 1) shows that the majority of the points (11 of 17) lie above the line of equality (where the two estimates are equal). The ordinary least squares regression of these data results in significant regression coefficients (P = 0.003 for both the slope and intercept) and a slope with a 95% confidence interval that does not include 1.00 (slope = 0.570 with a 95% confidence interval of 0.231 to 0.908). This again indicates that estimates are different from one another in a consistent manner.

Appendix Table B compares the results of the dockside interview data to the sampling program data. The general trend shown by the dockside data is for retained legal-size marked coho to be a higher proportion of all coho salmon encounters by the charter fleet compared to the private fleet. If we assume equal dockside reporting accuracy as to the number of coho released by mark status for charter and private anglers and similar encounter rates of sublegal size coho then, on average, about 7% more of the total coho encounters result in a marked coho being kept by the charter fleet compared to the private fleet. This compares favorably with the results of the observer and VTR data comparison where for the same month-area cells, on average about 6% more of the total legal-size coho salmon encounters by the charter fleet consisted of marked coho that were retained compared to the private fleet. Note that the dockside encounter data include encounters with sublegal coho.

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[3] Only month-area combinations with 10 or more observations (total encounters of legal-size coho salmon recorded) for each fleet were included in this analysis.

Table 2. Summary of data and Fisher's exact test results comparing the percentage of legal-size marked coho salmon kept from all legal-size coho encounters for the charter boat observer and private boat voluntary trip report data, by month-area cell for the years 2009-2011.

			Charter Fleet Onboard Observer Data					Private Fleet Voluntary Trip Report (VTR) Data					Fisher's Exact Test (1 df)[a]	
Year	Month	Area	Marked Kept	Marked Released	Unmarked Kept	Unmarked Released	Marked Kept %	Marked Kept	Marked Released	Unmarked Kept	Unmarked Released	Marked Kept %	χ^2 Statistic	*P*
2009	July	1	247	9	0	151	60.7%	62	1	0	40	60.2%	0.008	1.000
2009	August	1	184	7	0	125	58.2%	28	1	0	26	50.9%	1.025	0.376
2009	July	2	286	4	0	236	54.4%	53	7	0	62	43.4%	**4.742**	**0.034**
2009	August	2	257	4	0	209	54.7%	111	3	1	109	49.6%	1.601	0.223
2010	July	1	112	1	0	111	50.0%	56	6	0	54	48.3%	0.091	0.819
2010	August	1	121	1	1	121	49.6%	126	6	0	163	42.7%	2.545	0.118
2010	July	2	67	2	0	78	45.6%	13	3	0	35	25.5%	**6.345**	**0.013**
2010	August	2	53	1	0	41	55.8%	13	3	0	9	52.0%	0.115	0.823
2010	Sept.	2	56	0	0	54	50.9%	4	0	0	6	40.0%	0.436	0.743
2010	July	4	17	1	0	34	32.7%	33	6	0	65	31.7%	0.015	1.000
2011	June	1	15	0	0	12	55.6%	19	0	0	12	61.3%	0.196	0.790
2011	July	1	152	4	0	124	54.3%	100	2	0	77	55.9%	0.110	0.773
2011	August	1	94	5	2	114	43.7%	133	5	0	141	47.7%	0.763	0.413
2011	Sept.	1	25	1	0	15	61.0%	18	0	0	22	45.0%	2.075	0.184
2011	July	2	29	0	0	56	34.1%	28	4	0	47	35.4%	0.032	0.871
2011	August	2	99	1	1	128	43.2%	41	5	0	94	29.3%	**7.176**	**0.008**
2011	Sept.	2	12	0	0	8	60.0%	11	0	0	14	44.0%	1.138	0.373

[a] Significant exact test results ($P \leq 0.05$) are in **bold**.

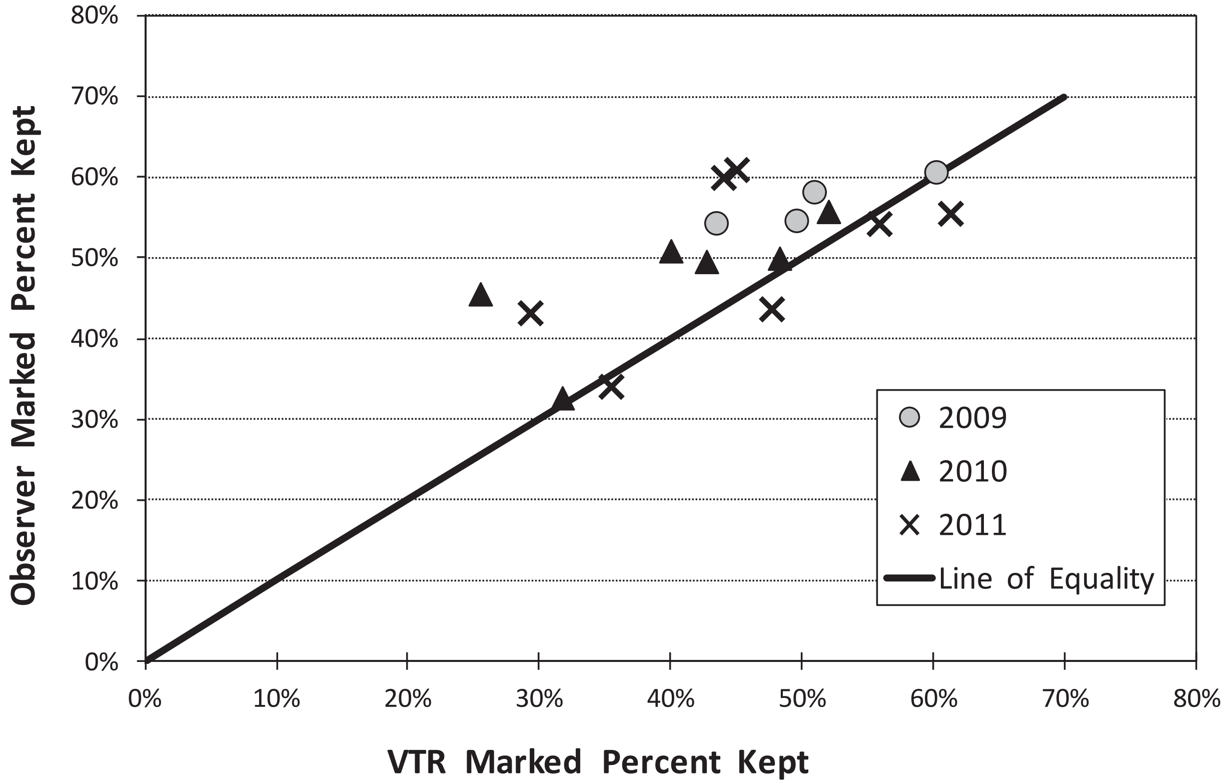

Figure 1. Comparison of estimated percentage of all legal-size coho salmon encounters which were both marked coho and retained (kept) for VTR and onboard observer data, by month-area cell.

When the dockside estimates of $\hat{\Omega}_M$ from charter boats are compared to those from private boat anglers across the 41 month-area cells sampled during the years 2009-2011, the private boat estimate of $\hat{\Omega}_M$ was less than the charter boat estimate for 76% of the comparisons (31 out of 41). The Wilcoxon signed rank test rejected the hypothesis that the median difference between the ranks of the paired estimates was 0 ($P < 0.001$) indicating that the estimates from the two data sources were significantly different from one another.

Given the above results, which consistently indicate that a higher proportion of the legal-size coho salmon encountered by the charter boat fleet are marked coho which are kept relative to the private boat fleet, total encounters should be estimated separately for the charter and private boat fleets in each month-area cell.

Evaluation of proxy estimates for $\hat{\Omega}_M^i$ when direct sampling data were lacking or insufficient

The preferred method of estimating $\hat{\Omega}_M^i$ when direct sampling data were lacking or insufficient was to use corresponding dockside sampling data because:

- corresponding dockside sampling data are almost always available for a month-area cell while corresponding VTR data are more frequently not available for missing or insufficient charter boat observer data,

- corresponding charter boat observer data are rarely available to replace missing or insufficient VTR data, and
- between-area and between-month similarities in $\hat{\Omega}_M^i$ are inconsistent.

There was not a significant linear relationship between the dockside interview and onboard charter boat observer estimates of $\hat{\Omega}_M^C$ (regression $R^2 = 0.070$ and P for slope = 0.248). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\Omega}_M^C$ when onboard observer data were not available. Figure 2A compares the line defined by the ratio estimator (ROM = 1.0798) with the line of equality.

The linear relationship between the dockside interview and VTR estimates of $\hat{\Omega}_M^P$ was significant (regression $R^2 = 0.484$ and P for slope < 0.001). However, the Y-intercept for this relationship was not significant ($P = 0.090$) indicating a line through the origin was appropriate. Since the appropriate regression line passes through the origin, for simplicity and consistency with the charter boat estimator the ROM estimator was used to estimate $\hat{\Omega}_M^P$ when VTR data were not available for the private boat fleet. Figure 2B compares the line defined by the ratio estimator (ROM = 1.1093) with the line of equality.

In order to estimate total release mortalities, estimates of the proportions of all legal-size coho salmon encounters that were marked coho that were released ($\hat{\theta}_M^i$) and unmarked coho that were released ($\hat{\theta}_U^i$) are required for each month-area cell by fleet. A ROM estimator was used to estimate these parameters when appropriate observer or VTR data were not available (see Appendix C for further ROM analysis details).

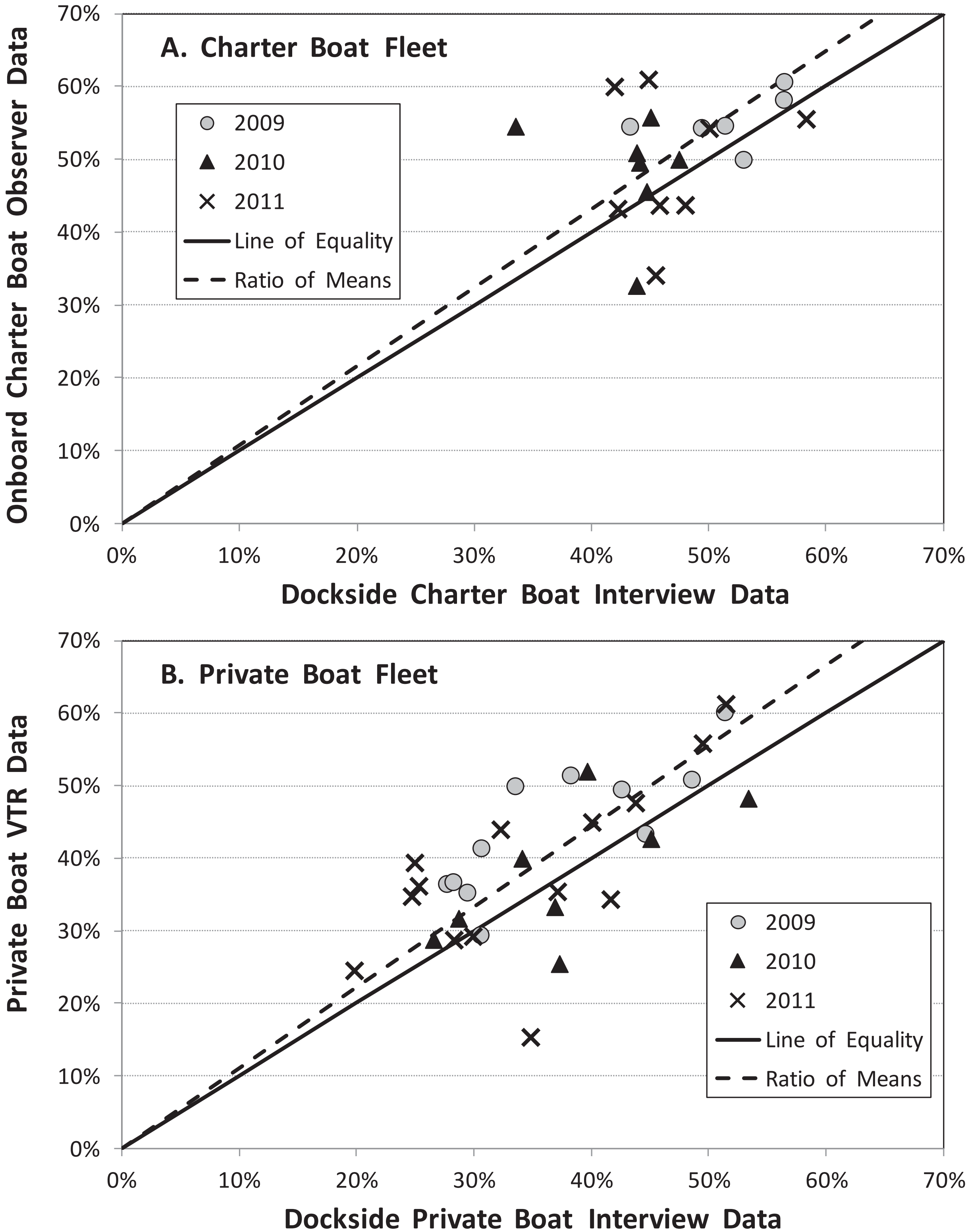

Figure 2. Comparison of dockside interview data to (A) onboard charter boat observer data and (B) private boat voluntary trip report (VTR) data for the percent of all legal-size coho encounters that were both marked coho and kept by the angler.

Comparison of Estimates of Total Encounters and Release Mortalities by the Two Methods

The procedures described for the two estimation methods (current and alternate) were applied to the 2009-2011 ocean sampling program data. Separate estimates of encounters and release mortalities were made for the charter boat and private boat fleets for the alternate method.

Compared to the current method, the alternate estimation method resulted in an increase in the estimates of total legal-size coho salmon encounters and unmarked coho release mortalities for all month-area cells during the three years of data examined (Figure 3). However, the differences between methods for the estimated number of release mortalities for marked coho were both positive and negative.

The percent differences in the estimates of total legal-size coho salmon encounters for a catch area during a year relative to the current method ranged from +3.4% to +16.4%. For the annual totals, the alternate method estimated +8.1%, +9.0%, and +7.5% more encounters compared to the current method for the years 2009, 2010, and 2011, respectively (Appendix Table D1). The relative precision of the estimates as measured by the coefficient of variation was similar for the two methods.

The percent differences in the estimates of total release mortalities for unmarked coho salmon in a catch area during a year relative to the current method ranged from 0.7% to 25.8%. For the annual totals, the alternate method estimated +14.4%, +11.6%, and +9.4% more unmarked release mortalities compared to the current method for the years 2009, 2010, and 2011, respectively (Appendix Table D2). The relative precision of the estimates as measured by the coefficient of variation was similar for the two methods.

The percent differences in the estimates of total release mortalities for marked coho salmon in a catch area during a year relative to the current method ranged from -53% to +175%. For the annual totals, the alternate method estimated -42.0%, -1.6%, and -5.7% fewer marked release mortalities compared to the current method for the years 2009, 2010, and 2011, respectively (Appendix Table D3). On a catch area by year level, the current method estimated fewer marked coho release mortalities half the time. The relative precision for the estimates of marked coho salmon release mortalities for the alternate method was considerably worse than for the current method. This is a result of the estimate for the current method being based on a constant fraction (with no associated variance) of the landed marked catch instead of using sample data from the onboard observer or VTR programs.

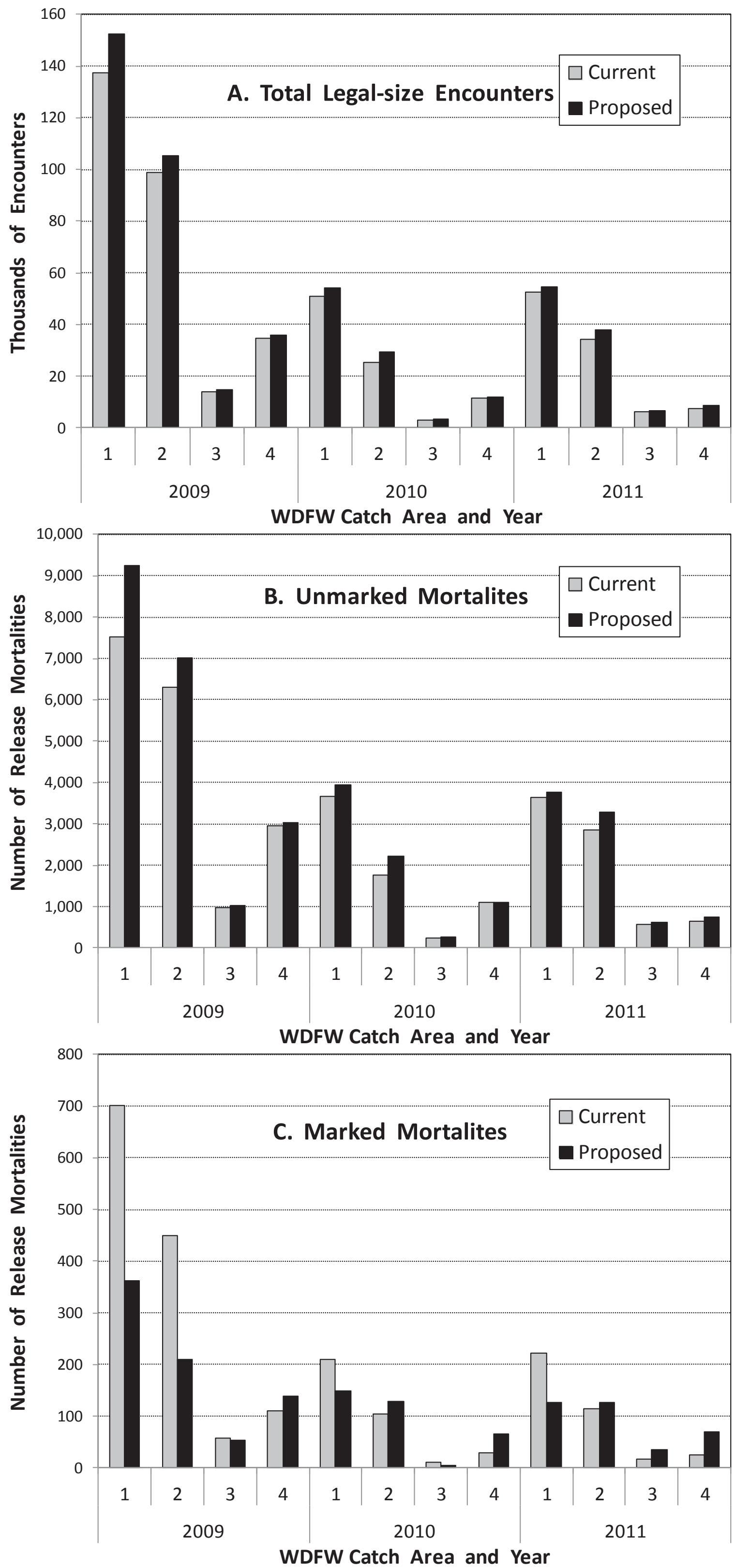

Figure 3. Comparison of estimates by current and alternate methods for (A) legal-size coho encounters, (B) unmarked coho release mortalities, and (C) marked coho release mortalities.

Discussion

The alternate method consistently estimated more total encounters with legal-size coho salmon and more release mortalities for unmarked coho than the current method. The difference between the methods in the estimated total number of legal-size coho encounters was about +8% to +9% each year. The difference between the methods in the estimated number of release mortalities of unmarked coho decreased gradually from 2009 to 2011 from +14% to +9% (Table 3).

Table 3. Summary of the annual percent difference[a] between the two methods for estimates of total legal-size coho salmon encounters and total number of unmarked coho release mortalities.

	Year		
Percent Difference in Estimates between Methods	**2009**	**2010**	**2011**
Total encounters	8.1%	9.0%	7.5%
Unmarked release mortalities	14.4%	11.6%	9.4%

[a] Percent Difference = (Alternate Method - Current Method)/Current Method.

From 2009 to 2011, there was a gradual decrease in the relative percent difference between the methods for the estimate of unmarked release mortalities. One major difference between the two estimation methods is that the alternate method estimates encounters and unmarked release mortalities separately for the charter boat and private boat fleets. A number of metrics associated with the estimates for the two fleets were examined to see if they might correspond to this trend in the data (Table 4). The metrics examined were:

- the percent of the estimated total harvest of legal-size coho taken by the charter boat fleet,
- the percent of the estimated total encounters with legal-size coho by the charter boat fleet,
- the percent of legal-size coho encounters by the charter boat fleet that are unmarked,
- the percent of legal-size coho encounters by the private boat fleet that are unmarked,
- the difference between the fleets in the percent of legal-size coho encounters that are unmarked,
- the percent of all legal-size coho encounters by the charter boat fleet that are released,
- the percent of all legal-size coho encounters by the private boat fleet that are released,
- the difference between the fleets in the percent of all legal-size coho encounters that are released,
- the percent of encounters with legal-size marked coho by the charter boat fleet that are released,
- the percent of encounters with legal-size marked coho by the private boat fleet that are released, and
- the difference between the fleets in the percent of encounters with legal-size marked coho that are released.

Table 4. Summary of metrics based on estimates from the alternate method that compare the charter boat and private boat fleets.

Metric	Year 2009	2010	2011
% difference in estimated unmarked mortalities	14.4%	11.6%	9.4%
% of total legal-size coho harvest taken by charter boat fleet	33.2%	37.0%	36.5%
% of total legal-size coho encounters by charter boat fleet	30.6%	32.1%	33.8%
% of total legal-size encounters that are unmarked - charter fleet	43.2%	50.0%	53.3%
% of total legal-size encounters that are unmarked - private fleet	49.0%	57.2%	57.1%
Difference between Fleets	-5.8%	-7.2%	-3.8%
% of all legal-size encounters that are released - charter fleet	44.4%	50.4%	54.1%
% of all legal-size encounters that are released - private fleet	50.9%	60.2%	59.9%
Difference between Fleets	-6.5%	-9.8%	-5.8%
% of all legal-size marked encounters that are released - charter fleet	2.3%	1.3%	3.0%
% of all legal-size marked encounters that are released - private fleet	3.9%	7.9%	6.7%
Difference between Fleets	-1.6%	-6.6%	-3.7%

The summary in Table 4 indicate that there are consistent annual differences between the fleets in the composition of all legal-size coho salmon encounters. Composition as defined here refers both to the mark status (mark or unmarked) and disposition (kept or released) of the encounters. Compared to the charter boat fleet, in all three years for the private boat fleet:

- a greater proportion of the total legal-size coho salmon encounters were unmarked coho,
- a greater proportion of the all legal-size coho salmon encounters were released, and
- a greater proportion of the all legal-size marked coho salmon encounters were released.

These differences between the fleets support the use of estimates stratified by fleet type.

Three of the metrics associated with the charter boat fleet have an increasing annual trend that corresponds to the decreasing annual trend in the percentage difference in the estimates of the number of unmarked release mortalities between the methods. They are:

- the percent of the estimated total encounters with legal-size coho by the charter boat fleet,
- the percent of legal-size coho encounters by the charter boat fleet that are unmarked, and
- the percent of all legal-size coho encounters by the charter boat fleet that are released.

Although the change over the three-year period is relatively minor for the percent of the estimated total encounters with legal-size coho by the charter boat fleet (3.2%), there is about a 10% change over the period for the other two metrics. Based on only three years of estimates further speculation of cause and effect is not warranted at this time, but it appears that differences between the two methods of estimation may be related to the composition of the pool of coho salmon targeted by the charter boat fleet and its differences from the pool targeted by the private boat fleet.

Relationships between the difference between the methods in the estimates of unmarked mortalities and metrics related to the two estimation methods were explored. Examining the estimates on an area and year basis indicated that the percent differences between the estimates of the number of unmarked release mortalities from the two methods were most highly correlated with P_M^W, a weighted-by-month measure of the percent of encounters that were marked for the fleets combined (Figure 4). However, the correlation coefficient for this relationship was only 0.446 so it explained less than 25% of the variation of the differences between the estimates. Current method estimates of the percentage of the total marked coho harvest taken by the charter boat fleet and the percentage of encounters that are kept (fleets combined) have similar correlations (0.419 and 0.439, respectively).

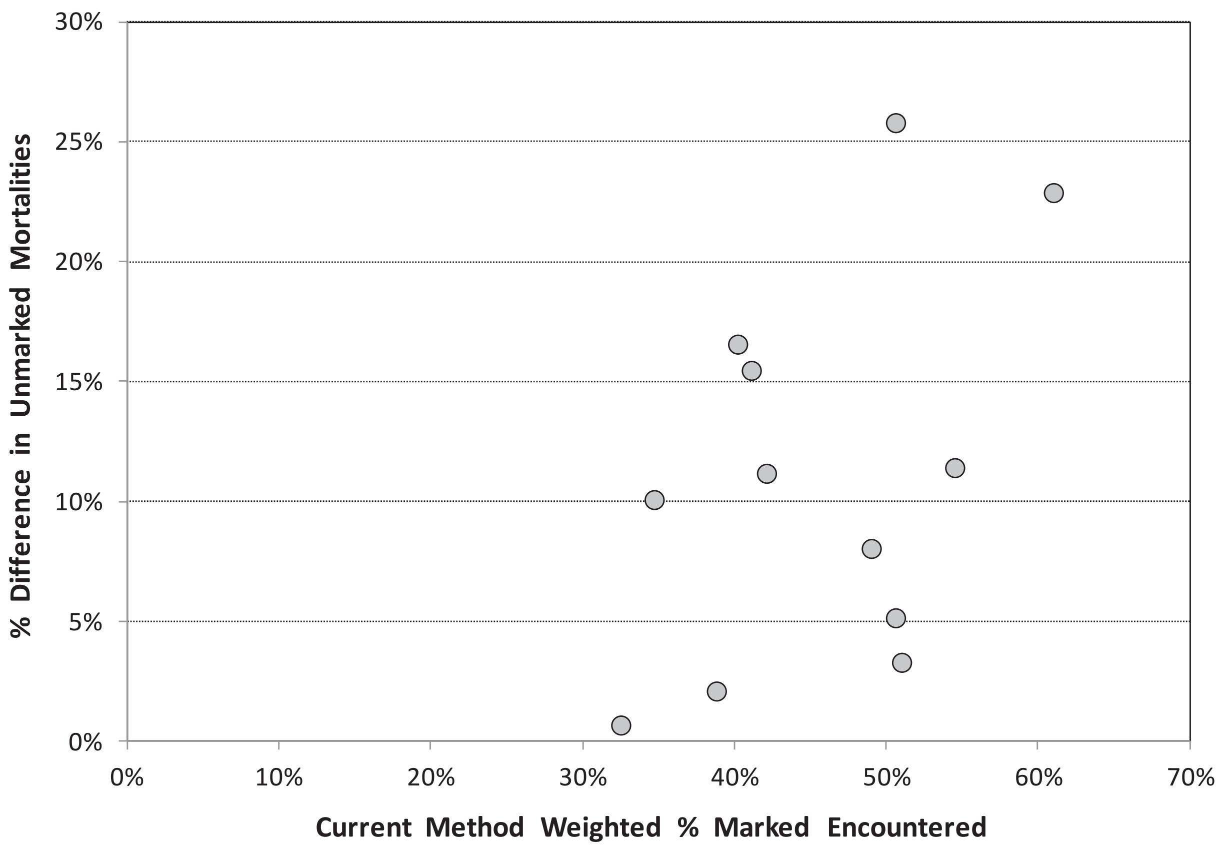

Figure 4. Relationship between the percent difference between the current and alternate estimates of the number of unmarked coho release mortalities and a weighted-by-month estimate of the overall percentage of all legal-size coho encounters that were marked for 2009-2011 data.

Finally, it should be noted that because the various components of the landed catch, number of encounters, and number of coho released are estimates based on sampling data, there is rarely perfect agreement between the estimated total encounters and the sum of its various components. I.e.,

$$\text{Total Landed Catch} + \text{Total Numbers Released} \neq \text{Total Encounters}$$

however, the differences between the two are typically small in both numbers of total encounters and as a percentage of total estimated encounters. Table 5 summarizes the annual differences for totals summed over all months for each area. Differences in the numbers of encounters range from -262 to +213 for the annual estimates by area. Differences expressed as a percentage of the total estimated encounters were all less than ±1% except for Area 3 in 2010 which was +6.4%. The Area 3 estimate was associated with the lowest estimated annual landed catch for any of the areas examined plus there was very little sample data (charter boat observer or VTR data) available for the estimates. VTR data were only available for the private fleet in August (total sample size = 18); all other encounter composition data were derived from dockside interview data. Therefore, this relatively large relative difference may result from the predominate use of the proxy estimates of disposition combined with poor estimate precision for landed catch.

Table 5. Summary of difference[a] between the total estimate of encounters and the sum of the components (landed catch estimate and total number released), by year and area.

Year	Area	Number of Coho	Percentage of Encounters[b]
2009	1	-262	-0.17%
	2	-145	-0.14%
	3	41	0.28%
	4	-208	-0.58%
Total		-574	-0.19%
2010	1	-6	-0.01%
	2	-52	-0.18%
	3	213	6.37%
	4	-73	-0.61%
Total		82	0.08%
2011	1	0	0.00%
	2	-142	-0.37%
	3	41	0.61%
	4	-60	-0.68%
Total		-161	-0.15%

[a] Difference = total encounter estimate - (total landed catch estimate + total release estimate).

[b] Percentage = (difference / total encounter estimate) x 100%.

RECOMMENDATIONS

The current method of estimating total encounters of legal-size coho salmon by the recreational fleet assumes there is no release of legal-size marked coho salmon by anglers and the proportion of marked coho salmon in all legal-size coho salmon encounters is the same for the charter boat and private boat fleets. These assumptions were not supported by the data collected in 2009, 2010, and 2011 by the charter boat observer and voluntary-trip report programs. The proposed alternate method estimates total encounters with legal-size coho salmon and the number of encounters with unmarked legal-size coho salmon separately for each fleet and does not require either assumption.

The analyses presented indicate that the current estimation method consistently underestimates both the total encounters with legal-size coho salmon and the number of encounters with unmarked legal-size coho salmon. As a consequence, the total number of unmarked (typically wild coho) legal-size coho salmon mortalities due to release is being consistently underestimated by about 10% to 15% annually.

Therefore, it is recommended that the proposed alternate methods be used to estimate total encounters of legal-size coho salmon, and release mortalities for legal-size marked and unmarked coho salmon, in the ocean mark-selective recreational fisheries in WDFW Marine Catch Areas 1, 2, 3, and 4.

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Appendix A

Estimates from Charter Boat Onboard Observers and Private Boat Voluntary Trip Reports

Onboard observers on charter boats and voluntary trip reports (VTRs) from private anglers provide data on the composition (marked or unmarked) and disposition (kept or released) of coho salmon encountered by each fleet. Although a small proportion of sublegal size coho are encountered each year[4], the following analyses use only legal-size coho salmon encounters.

For a specific data source (onboard observer or VTR), the composition and disposition of each legal-size coho salmon encounter can be categorized into one of four groups:

1. a marked coho that is kept (M_K),
2. a marked coho that is released (M_R),
3. an unmarked coho that is kept (U_K), or
4. an unmarked coho that is released (U_R).

The estimated proportion of legal-size marked coho encounters that are kept ($\widehat{\Phi}_M^i$ as previously defined) is then,

$$\widehat{\Phi}_M^i = \frac{M_K}{(M_K + M_R)}. \qquad [A1]$$

Similarly, $\widehat{P}_M$ (the estimate of the proportion of all legal-size coho encounters in the fishery that are marked as defined previously) is estimated by:

$$\widehat{P}_M^i = \frac{M_K + M_R}{(M_K + M_R + U_K + U_R)}. \qquad [A2]$$

Therefore, the product of $\widehat{\Phi}_M^i$ and $\widehat{P}_M^i$ expressed in equation 12 of the text - which estimates the proportion of all legal-size coho salmon encountered by anglers from a fleet that are marked coho which are kept ($\widehat{\Omega}_M^i$) - is equivalent to:

$$\widehat{\Omega}_M^i = \frac{M_K}{(M_K + M_R)} \; x \; \frac{M_K + M_R}{(M_K + M_R + U_K + U_R)} = \frac{M_K}{(M_K + M_R + U_K + U_R)} \qquad [A3]$$

with variance,

$$\widehat{V}\left(\widehat{\Omega}_M^i\right) = \frac{\widehat{\Omega}_M^i \; x \left(1 - \widehat{\Omega}_M^i\right)}{(M_K + M_R + U_K + U_R) - 1}. \qquad [A4]$$

The estimated proportion of marked coho encountered that are released $\widehat{\theta}_M^i$ is similarly estimated as,

$$\widehat{\theta}_M^i = \frac{M_R}{(M_K + M_R + U_K + U_R)} \qquad [A5]$$

with variance,

$$\widehat{V}\left(\widehat{\theta}_M^i\right) = \frac{\theta_M^i \; x \left(1 - \widehat{\theta}_M^i\right)}{(M_K + M_R + U_K + U_R) - 1}. \qquad [A6]$$

Corresponding estimates for the proportion of unmarked coho kept ($\widehat{\Omega}_U^i$) and released ($\widehat{\theta}_U^i$) can be estimated using U_K and U_R in the numerators of equations A3 and A5 with variances estimated similarly to the marked component.

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[4] In 2011, 5.3% of the total coho salmon encounters recorded on VTRs were sublegal in size and 2.4% of the total coho salmon encounters observed on charter boats were sublegal in size.

Appendix B

Table summarizing the estimates of the percentage of all coho salmon encounters that are marked coho which are retained (kept), by month-area cell, for onboard observer, voluntary trip report (VTR), and dockside data. Observer and VTR estimates are for the percentage of encounters with legal-size coho salmon only while dockside data is for the percentage of all coho salmon encountered.

			Onboard Observer Data			Charter Dockside Reports			Private VTR Data			Private Dockside Reports		
Year	Month	Area	Marked Kept	Total Encntrs	Marked Kept %	Marked Kept	Total Encntrs	Marked Kept %	Marked Kept	Total Encntrs	Marked Kept %	Marked Kept	Total Encntrs	Marked Kept %
2009	July	1	247	407	60.7%	5,225	9,266	56.4%	62	103	60.2%	7,046	13,726	51.3%
2009	August	1	184	316	58.2%	7,031	12,477	56.4%	28	55	50.9%	7,736	15,944	48.5%
2009	July	2	286	526	54.4%	2,854	5,783	49.4%	53	122	43.4%	1,706	3,828	44.6%
2009	August	2	257	470	54.7%	5,661	11,026	51.3%	111	224	49.6%	4,157	9,772	42.5%
		Average			57.0%			53.3%			51.0%			46.7%
2010	July	1	112	224	50.0%	1,877	3,957	47.4%	56	116	48.3%	1,454	2,725	53.4%
2010	August	1	121	244	49.6%	2,771	6,286	44.1%	126	295	42.7%	1,738	3,857	45.1%
2010	July	2	67	147	45.6%	588	1,316	44.7%	13	51	25.5%	509	1,366	37.3%
2010	August	2	53	95	55.8%	768	1,706	45.0%	13	25	52.0%	537	1,355	39.6%
2010	Sept.	2	56	110	50.9%	1,037	2,366	43.8%	4	10	40.0%	872	2,559	34.1%
2010	July	4	17	52	32.7%	85	194	43.8%	33	104	31.7%	593	2,068	28.7%
		Average			47.4%			44.8%			40.0%			39.7%
2011	June	1	15	27	55.6%	250	429	58.3%	19	31	61.3%	107	208	51.4%
2011	July	1	152	280	54.3%	2,419	4,837	50.0%	100	179	55.9%	1,017	2,056	49.5%
2011	August	1	94	215	43.7%	3,260	7,122	45.8%	133	279	47.7%	2,905	6,641	43.7%
2011	Sept.	1	25	41	61.0%	710	1,584	44.8%	18	40	45.0%	474	1,184	40.0%
2011	July	2	29	85	34.1%	662	1,457	45.4%	28	79	35.4%	807	2,176	37.1%
2011	August	2	99	229	43.2%	1,068	2,530	42.2%	41	140	29.3%	1,101	3,683	29.9%
2011	Sept.	2	12	20	60.0%	421	1,004	41.9%	11	25	44.0%	588	1,824	32.2%
		Average			50.3%			46.9%			45.5%			40.6%

Appendix C

<u>Estimation of proxy estimates for $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$</u>

When onboard observer data for the charter boat fleet or voluntary trip report (VTR) data for the private boat fleet were missing or insufficient (less than 10 total encounters with legal-size coho salmon recorded), it was necessary to provide proxy estimates for $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$ in order to estimate total legal-size coho salmon encounters and total release mortalities for marked and unmarked coho. As described in the report, ratio of means (ROM) estimators based on dockside angler interview data and sample data (onboard observer or VTR as appropriate) were used to estimate these proxies. This appendix provides further detail on the estimation methods and the data used to estimate the proxies.

There were 21 month-area cells with onboard charter boat observer data that could be compared to dockside interview data collected from charter boat anglers and 33 month-area cells with private boat VTR data that could be compared to dockside interview data collected from private boat anglers. The data used for the regressions and to estimate the ratio of means for the proxy estimates are shown in Appendix Tables C4 (charter boat fleet) and C5 (private boat fleet).

Methods:

The ratio of means was estimated as:

$$\widehat{ROM} = \frac{\textit{parameter mean for observer or VTR sample data}}{\textit{parameter mean for dockside sample data}} = \frac{\bar{Y}}{\bar{X}} \qquad \text{[C1]}$$

where the parameter is $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, or $\hat{\theta}_U^i$ for either the charter boat or private boat fleet in a specific month-area cell. The variance of $\widehat{ROM}$ was approximated by:

$$\hat{V}(\widehat{ROM}) \approx \frac{s_y^2 + (\widehat{ROM}^2 \ x \ s_x^2) - \left(2 \ x \ \widehat{ROM} \ x \ s_{yx}\right)}{n \ x \ \bar{X}^2} \qquad \text{[C2]}$$

where s_y^2 and s_x^2 are the sample variances, s_{yx} is the sample covariance, and *n* = the sample size (Cochran 1977). The proxy is used to estimate missing or insufficient data from the onboard observer or VTR sample programs ($\hat{Y}$) by,

$$\hat{Y} = \widehat{ROM} \ x \ \hat{X} \qquad \text{[C3]}$$

where $\hat{X}$ = the corresponding estimate for the parameter being estimated from the dockside sampling data corresponding to the month-area cell and fleet with missing or insufficient data. The variance of the proxy estimate is approximated by (Cochran 1977):

$$\hat{V}(\hat{Y}) \approx \frac{\hat{Y}^2}{n} \ x \left[\frac{s_y^2}{\bar{Y}^2} + \frac{s_x^2}{\bar{X}^2} - \frac{2 \ x \ s_{yx}}{\bar{Y} \ x \ \bar{X}}\right]. \qquad \text{[C4]}$$

Proxy Estimate for $\hat{\Omega}_M^i$:

Figure 2 in the report shows the relationship between the dockside interview data and the corresponding onboard observer data for the charter boat fleet (Figure 2A) and the VTR data for the private boat fleet (Figure 2B) estimates for $\hat{\Omega}_M^i$. Appendix Table C1 summarizes the ROM estimates of $\hat{\Omega}_M^i$ for the charter boat and private boat fleets.

Appendix Table C1. Summary statistics for the ROM estimators used to estimate a proxy for $\hat{\Omega}_M^i$ for the charter boat and private boat fleets.

Parameter	Statistic		
	Mean	**Variance**	**Coef. of Variation**[a]
Onboard Observer $\hat{\Omega}_M^C$	50.8%	0.006250	15.6%
Dockside Charter Interview $\hat{\Omega}_M^C$	47.1%	0.003320	12.2%
$\hat{\Omega}_M^C$ ROM	1.07981	0.001618	3.7%
VTR $\hat{\Omega}_M^P$	40.0%	0.011472	26.8%
Dockside Private Interview $\hat{\Omega}_M^P$	36.0%	0.008031	24.9%
$\hat{\Omega}_M^P$ ROM	1.10925	0.001526	3.5%

[a] Coefficient of variation = $\sqrt{\text{Variance}}$ /Mean x 100%.

Both ROM estimators were slightly greater than 1.0 indicating that the estimated proportion of coho salmon encounters that were marked coho that were kept was slightly less for the dockside interviews than observed during on-the-water sampling or reported on VTRs.

Proxy Estimate for $\hat{\theta}_U^i$:

There was not a significant linear relationship between the dockside interview and onboard charter boat observer estimates of $\hat{\theta}_U^C$ (regression R^2 = 0.060 and *P* for slope = 0.285). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\theta}_U^C$ when onboard observer data were not available. The linear relationship between the dockside interview and VTR estimates of $\hat{\theta}_U^P$ was significant (regression R^2 = 0.456 and *P* for slope < 0.001). However, the Y-intercept for this relationship was not significant (*P* = 0.092) indicating a line through the origin was appropriate. Since the appropriate regression line passes through the origin, for simplicity and consistency with the charter boat estimator we used the ROM estimator to estimate $\hat{\theta}_U^P$ when VTR data were not available for the private boat fleet.

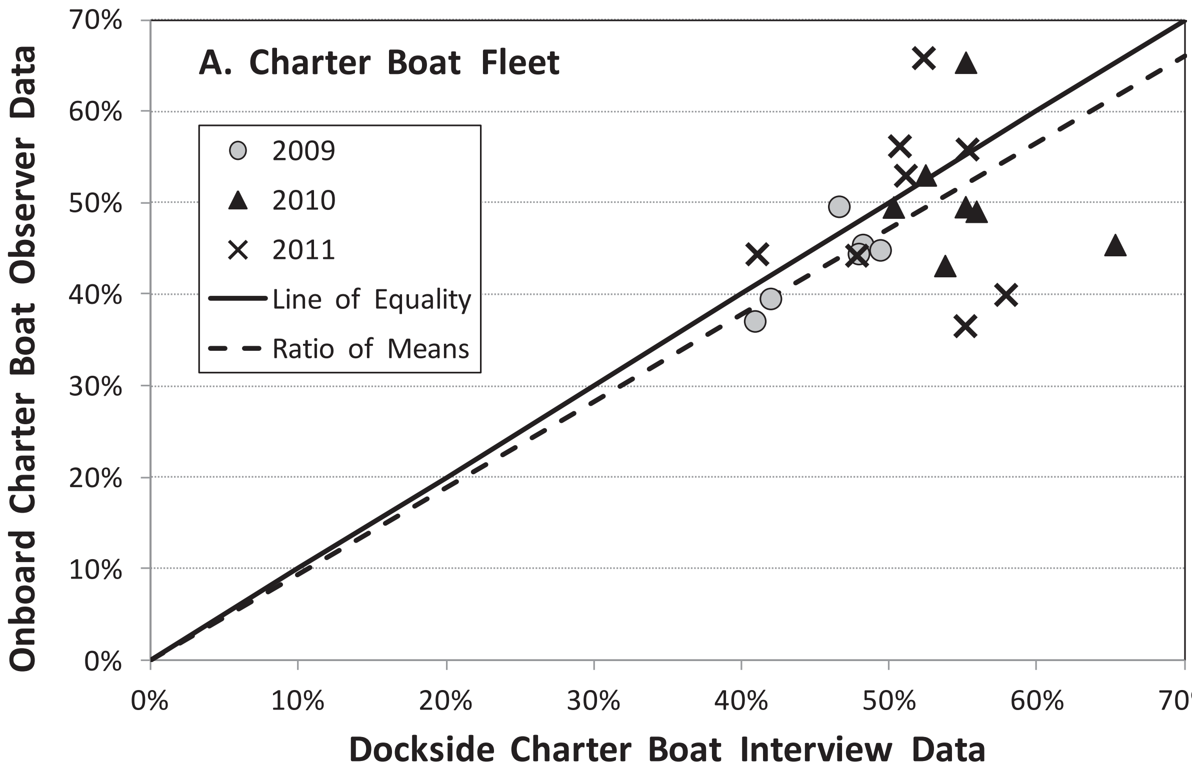
For $\hat{\theta}_U^i$, the relationship between the dockside interview data and the corresponding onboard observer data for the charter boat fleet is shown in Appendix Figure C1A and the relationship for the corresponding VTR data from the private boat fleet is shown in Appendix Figure C1B. Appendix Table C2 summarizes the ROM estimates of $\hat{\theta}_U^i$ for the charter boat and private boat fleets.

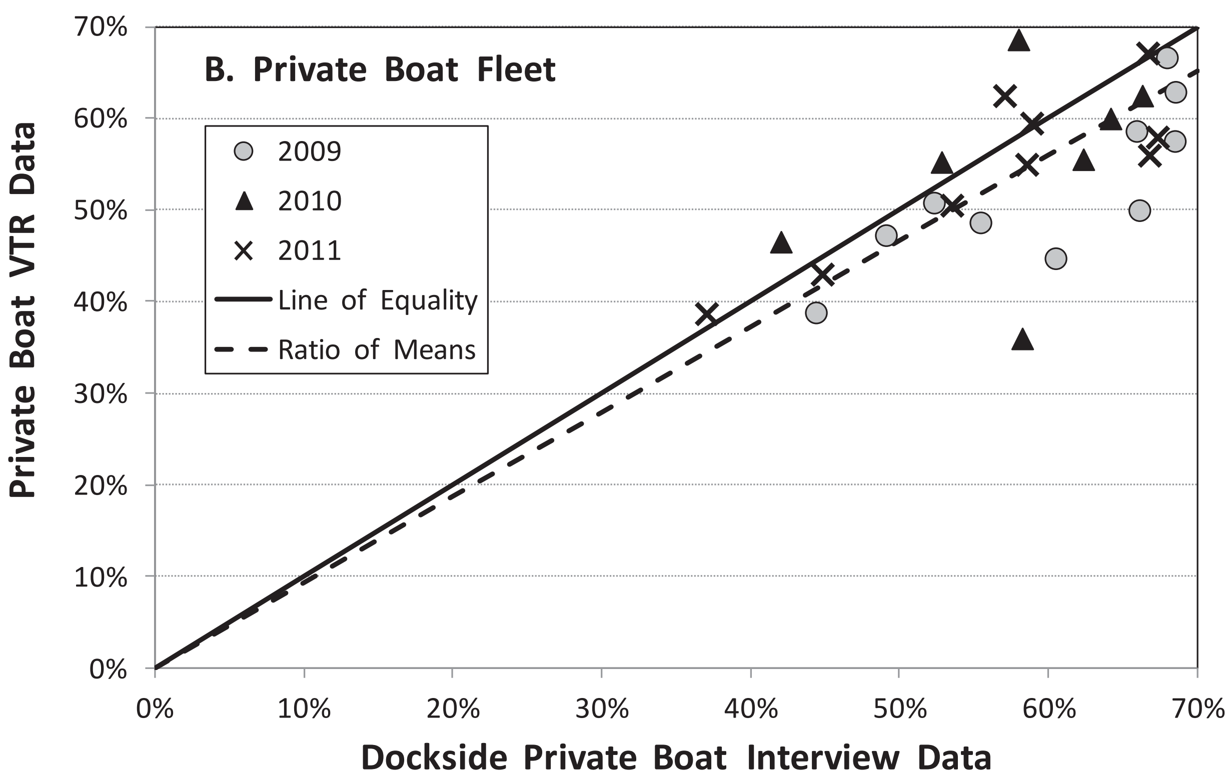
Appendix Table C2. Summary statistics for the ROM estimators used to estimate a proxy for $\hat{\theta}_U^i$ for the charter boat and private boat fleets.

Parameter	Statistic		
	Mean	Variance	Coef. of Variation[a]
Onboard Observer $\hat{\theta}_U^C$	48.2%	0.006402	16.6%
Dockside Charter Interview $\hat{\theta}_U^C$	51.4%	0.003420	11.4%
$\hat{\theta}_U^C$ ROM	0.93871	0.001311	3.9%
VTR $\hat{\theta}_U^P$	56.6%	0.010304	17.9%
Dockside Private Interview $\hat{\theta}_U^P$	60.8%	0.009796	16.3%
$\hat{\theta}_U^P$ ROM	0.93175	0.000506	2.4%

[a] Coefficient of variation = $\sqrt{\text{Variance}}$ /Mean x 100%.

Both ROM estimators were slightly less than 1.0 indicating that the estimated proportion of coho salmon encounters that were unmarked coho that were released was slightly greater for the dockside interviews than observed during on-the-water sampling or reported on VTRs.





Appendix Figure C1. Comparison of dockside interview data to (A) onboard charter boat observer data and (B) private boat voluntary trip report (VTR) data for the percent of all legal-size coho encounters that were both unmarked coho and released by the angler.

Proxy Estimate for $\hat{\theta}_M^i$:

There was not a significant linear relationship between the dockside interview and onboard charter boat observer estimates of $\hat{\theta}_M^C$ (regression R^2 = 0.044 and P for slope = 0.362). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\theta}_M^C$ when onboard observer data were not available. The linear relationship between the dockside interview and VTR estimates of $\hat{\theta}_M^P$ was not significant either (regression R^2 = 0.099 and P for slope = 0.075). Therefore, the ratio of means estimator was selected as appropriate for estimating $\hat{\theta}_M^P$ when VTR data were not available for the private boat fleet.

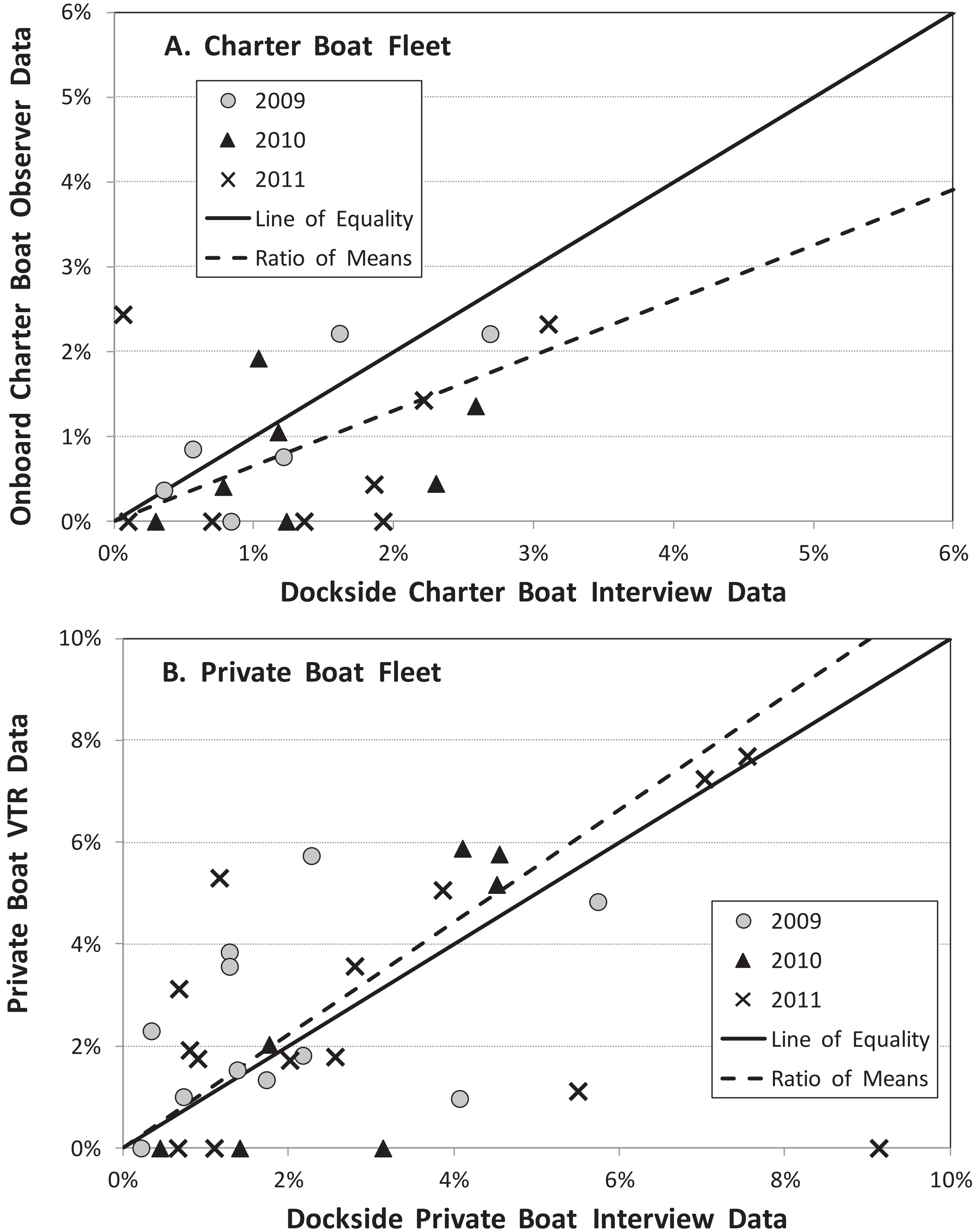
For $\hat{\theta}_M^i$, the relationship between the dockside interview data and the corresponding onboard observer data for the charter boat fleet is shown in Appendix Figure C2A and the relationship for the corresponding VTR data from the private boat fleet is shown in Appendix Figure C2B. Appendix Table C3 summarizes the ROM estimates of $\hat{\theta}_M^i$ for the charter boat and private boat fleets.

Appendix Table C3. Summary statistics for the ROM estimators used to estimate a proxy for $\hat{\theta}_M^i$ for the charter boat and private boat fleets.

Parameter	**Statistic**		
	Mean	**Variance**	**Coef. of Variation**[a]
Onboard Observer $\hat{\theta}_M^C$	0.9%	0.000080	103.1%
Dockside Charter Interview $\hat{\theta}_M^C$	1.5%	0.000102	68.9%
$\hat{\theta}_M^C$ ROM	0.59308	0.020775	24.3%
VTR $\hat{\theta}_M^P$	3.0%	0.000787	94.3%
Dockside Private Interview $\hat{\theta}_M^P$	2.7%	0.000514	84.4%
$\hat{\theta}_M^P$ ROM	1.10661	0.040873	18.3%

[a] Coefficient of variation = $\sqrt{\text{Variance}}$ /Mean x 100%.

Unlike the ROM estimates for $\hat{\Omega}_M^i$ and $\hat{\theta}_U^i$ which were very similar for the two fleets, the ROM estimates for $\hat{\theta}_M^i$ were very different for the fleets. Compared to the other ROM estimates, the ROM estimate for $\hat{\theta}_M^i$ was considerably less precise for both fleets with coefficients of variation greater than 18% compared to less than 5% for the ROM for $\hat{\Omega}_M^i$ and $\hat{\theta}_U^i$.



Appendix Figure C2. Comparison of dockside interview data to (A) onboard charter boat observer data and (B) private boat voluntary trip report (VTR) data for the percent of all legal-size coho encounters that were both marked coho and released by the angler.

Appendix Table C4. Data used for the ratio of mean proxy estimates of $\hat{\Omega}_M^i$, $\hat{\theta}_M^i$, and $\hat{\theta}_U^i$ for the charter boat fleet.

			Charter Boat Onboard Observer Data				Charter Boat Dockside Data		
Year	Month	Catch Area	Sample Size	$\hat{\Omega}_M^C$	$\hat{\theta}_M^C$	$\hat{\theta}_U^C$	$\hat{\Omega}_M^C$	$\hat{\theta}_M^C$	$\hat{\theta}_U^C$
2009	7	1	407	60.7%	2.2%	37.1%	56.4%	2.7%	40.9%
2009	8	1	316	58.2%	2.2%	39.6%	56.4%	1.6%	41.9%
2010	7	1	224	50.0%	0.4%	49.6%	47.4%	2.3%	50.3%
2010	8	1	244	49.6%	0.4%	49.6%	44.1%	0.8%	55.1%
2010	9	1	11	54.5%	0.0%	45.5%	33.5%	1.2%	65.3%
2011	6	1	27	55.6%	0.0%	44.4%	58.3%	0.7%	41.0%
2011	7	1	280	54.3%	1.4%	44.3%	50.0%	2.2%	47.8%
2011	8	1	215	43.7%	2.3%	53.0%	45.8%	3.1%	51.1%
2011	9	1	41	61.0%	2.4%	36.6%	44.8%	0.1%	55.1%
2009	6	2	33	54.5%	0.0%	45.5%	43.2%	3.6%	53.2%
2009	7	2	526	54.4%	0.8%	44.9%	49.4%	1.2%	49.4%
2009	8	2	470	54.7%	0.9%	44.5%	51.3%	0.6%	47.9%
2009	9	2	272	50.0%	0.4%	49.6%	52.9%	0.4%	46.6%
2010	7	2	147	45.6%	1.4%	53.1%	44.7%	2.6%	52.4%
2010	8	2	95	55.8%	1.1%	43.2%	45.0%	1.2%	53.8%
2010	9	2	110	50.9%	0.0%	49.1%	43.8%	0.3%	55.9%
2011	6	2	16	43.8%	0.0%	56.3%	48.0%	1.4%	50.7%
2011	7	2	85	34.1%	0.0%	65.9%	45.4%	1.9%	52.3%
2011	8	2	229	43.2%	0.4%	55.9%	42.2%	1.9%	55.3%
2011	9	2	20	60.0%	0.0%	40.0%	41.9%	0.1%	57.9%
2010	7	4	52	32.7%	1.9%	65.4%	43.8%	1.0%	55.2%

Appendix Table C5. Data used for the ratio of mean proxy estimates of $\widehat{\Omega}_M^i$, $\widehat{\theta}_M^i$, and $\widehat{\theta}_U^i$ for the private boat fleet.

Year	Month	Catch Area	Sample Size	Private Boat VTR Data $\widehat{\Omega}_M^p$	$\widehat{\theta}_M^P$	$\widehat{\theta}_U^p$	Private Boat Dockside Data $\widehat{\Omega}_M^P$	$\widehat{\theta}_M^P$	$\widehat{\theta}_U^P$
2009	7	1	103	60.2%	1.0%	38.8%	51.3%	4.1%	44.4%
2009	8	1	55	50.9%	1.8%	47.3%	48.5%	2.2%	49.1%
2010	7	1	116	48.3%	5.2%	46.6%	53.4%	4.5%	42.0%
2010	8	1	295	42.7%	2.0%	55.3%	45.1%	1.8%	52.8%
2011	6	1	31	61.3%	0.0%	38.7%	51.4%	9.1%	37.0%
2011	7	1	179	55.9%	1.1%	43.0%	49.5%	5.5%	44.8%
2011	8	1	279	47.7%	1.8%	50.5%	43.7%	2.6%	53.5%
2011	9	1	40	45.0%	0.0%	55.0%	40.0%	1.1%	58.5%
2009	7	2	122	43.4%	5.7%	50.8%	44.6%	2.3%	52.3%
2009	8	2	224	49.6%	1.3%	48.7%	42.5%	1.7%	55.4%
2010	7	2	51	25.5%	5.9%	68.6%	37.3%	4.1%	58.0%
2010	8	2	25	52.0%	12.0%	36.0%	39.6%	1.8%	58.2%
2010	9	2	10	40.0%	0.0%	60.0%	34.1%	1.4%	64.2%
2011	7	2	79	35.4%	5.1%	59.5%	37.1%	3.9%	58.9%
2011	8	2	140	29.3%	3.6%	67.1%	29.9%	2.8%	66.7%
2011	9	2	25	44.0%	0.0%	56.0%	32.2%	0.7%	66.8%
2009	6	3	78	29.5%	3.8%	66.7%	30.5%	1.3%	67.9%
2009	7	3	497	41.4%	1.0%	57.5%	30.6%	0.7%	68.5%
2009	8	3	505	51.5%	3.6%	44.8%	38.2%	1.3%	60.5%
2009	9	3	20	50.0%	0.0%	50.0%	33.5%	0.2%	66.1%
2010	8	3	18	33.3%	0.0%	55.6%	36.9%	0.4%	62.3%
2011	6	3	32	34.4%	3.1%	62.5%	41.6%	0.7%	57.0%
2011	7	3	104	39.4%	1.9%	58.7%	24.9%	0.8%	74.0%
2011	8	3	132	28.8%	5.3%	65.9%	28.3%	1.2%	70.1%
2011	9	3	171	24.6%	1.8%	73.7%	19.8%	0.9%	79.3%
2009	7	4	1,117	36.5%	4.8%	58.6%	27.6%	5.7%	65.9%
2009	8	4	914	35.3%	1.5%	62.9%	29.4%	1.4%	68.5%
2009	9	4	87	36.8%	2.3%	59.8%	28.2%	0.3%	71.1%
2010	7	4	104	31.7%	5.8%	62.5%	28.7%	4.5%	66.3%
2010	8	4	59	28.8%	0.0%	71.2%	26.5%	3.1%	69.4%
2011	6	4	13	15.4%	7.7%	76.9%	34.8%	7.5%	57.4%
2011	7	4	69	34.8%	7.2%	58.0%	24.7%	7.0%	67.3%
2011	8	4	58	36.2%	1.7%	62.1%	25.3%	2.0%	71.8%

Appendix D

Appendix Table D1. Comparison of the estimates by the current and alternate methods for the total number of legal-size coho salmon encountered, by year and catch area (2009-2011).

	Catch	Current Method		Alternate Method		Percent
Year	**Area**	**Estimate**	**CV[a]**	**Estimate**	**CV**	**Difference[b]**
2009	1	137,573	3.5%	152,206	7.4%	10.6%
	2	98,896	3.7%	105,397	3.6%	6.6%
	3	13,856	5.1%	14,628	4.9%	5.6%
	4	34,508	4.2%	35,740	4.2%	3.6%
	Total	284,832		307,970		8.1%
2010	1	50,994	4.0%	54,153	4.4%	6.2%
	2	25,174	6.0%	29,300	11.7%	16.4%
	3	2,910	25.1%	3,350	18.3%	15.1%
	4	11,570	12.2%	12,018	11.9%	3.9%
	Total	90,647		98,821		9.0%
2011	1	52,695	3.7%	54,467	4.0%	3.4%
	2	34,134	5.9%	38,039	7.2%	11.4%
	3	6,040	8.4%	6,740	8.0%	11.6%
	4	7,653	11.1%	8,839	11.8%	15.5%
	Total	100,522		108,085		7.5%

[a] CV = coefficient of variation.

[b] Percent Difference = (Alternate Method - Current Method)/Current Method x 100%.

Appendix Table D2. Comparison of the estimates by the current and alternate methods for the total number of unmarked release mortalities for legal-size coho salmon, by year and catch area (2009-2011).

	Catch	Current Method		Alternate Method		Percent
Year	Area	Estimate	CV[a]	Estimate	CV	Difference[b]
2009	1	7,527	8.9%	9,249	11.7%	22.9%
	2	6,304	8.1%	7,024	4.6%	11.4%
	3	974	10.2%	1,024	5.6%	5.2%
	4	2,964	6.8%	3,026	4.6%	2.1%
	Total	17,769		20,323		14.4%
2010	1	3,651	7.7%	3,945	5.6%	8.0%
	2	1,766	12.1%	2,222	15.0%	25.8%
	3	242	42.1%	269	20.5%	11.2%
	4	1,104	17.9%	1,112	13.2%	0.7%
	Total	6,763		7,547		11.6%
2011	1	3,643	7.6%	3,763	5.4%	3.3%
	2	2,841	10.0%	3,281	8.3%	15.5%
	3	559	12.8%	615	8.7%	10.1%
	4	643	18.4%	750	13.2%	16.6%
	Total	7,686		8,409		9.4%

[a] CV = coefficient of variation.

[b] Percent Difference = (Alternate Method - Current Method)/Current Method x 100%.

Appendix Table D3. Comparison of the estimates by the current and alternate methods for the total number of marked release mortalities for legal-size coho salmon, by year and catch area (2009-2011).

Year	Catch Area	Current Method Estimate	Current Method CV[a]	Alternate Method Estimate	Alternate Method CV	Percent Difference[b]
2009	1	702	1.4%	363	58.1%	-48.4%
	2	450	2.3%	211	23.7%	-53.1%
	3	58	4.0%	53	18.0%	-9.3%
	4	110	2.9%	139	12.6%	26.5%
	Total	1,320		765		-42.0%
2010	1	209	1.9%	150	27.3%	-28.5%
	2	105	3.8%	129	37.8%	22.8%
	3	10	4.5%	5	26.1%	-52.7%
	4	30	4.8%	65	30.2%	117.3%
	Total	354		348		-1.6%
2011	1	223	1.4%	127	26.9%	-42.9%
	2	115	2.8%	127	32.8%	10.3%
	3	17	4.0%	35	26.9%	108.2%
	4	25	4.3%	69	36.3%	175.4%
	Total	380		358		-5.7%

[a] CV = coefficient of variation.

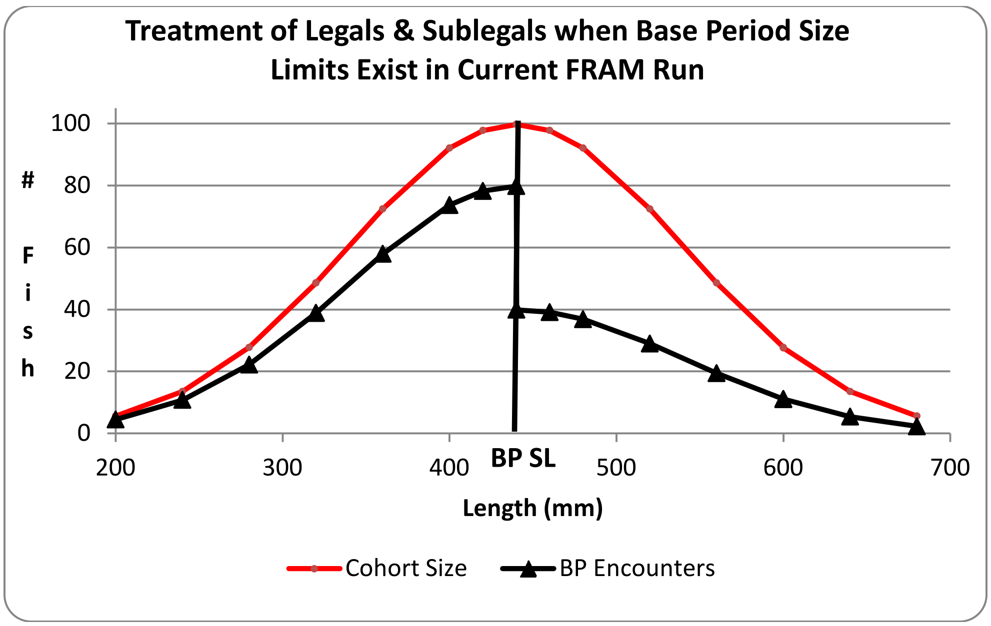
[b] Percent Difference = (Alternate Method - Current Method)/Current Method x 100%.

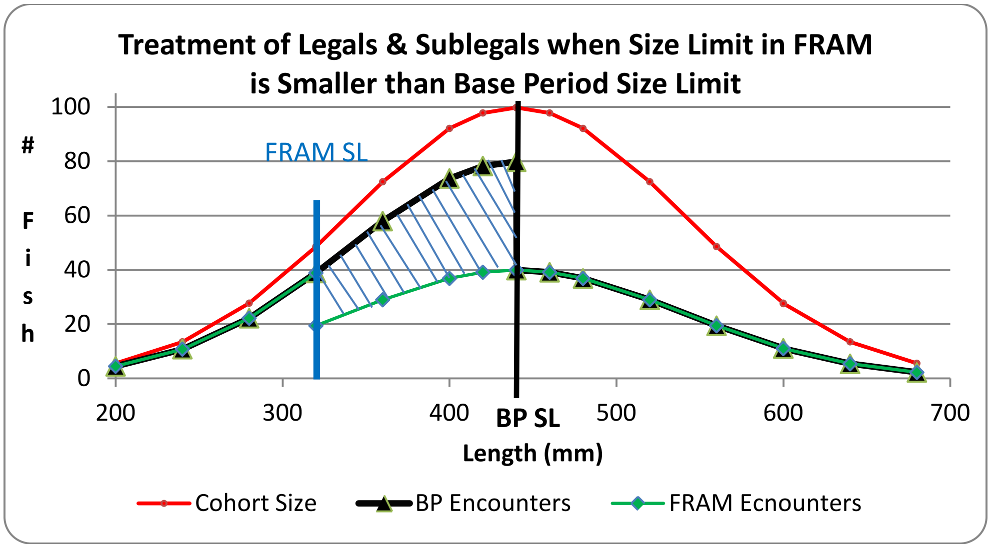
FRAM Size Limit Modeling

In recent years, Chinook FRAM hasn't been used to evaluate the effects of size limit changes, because modeling outcomes were deemed unreliable. Direct comparisons of landed catches and shaker mortalities between two FRAM runs that only differed in the minimum size limit could produce unexpected results, i.e. total mortality rising with a size limit increase.

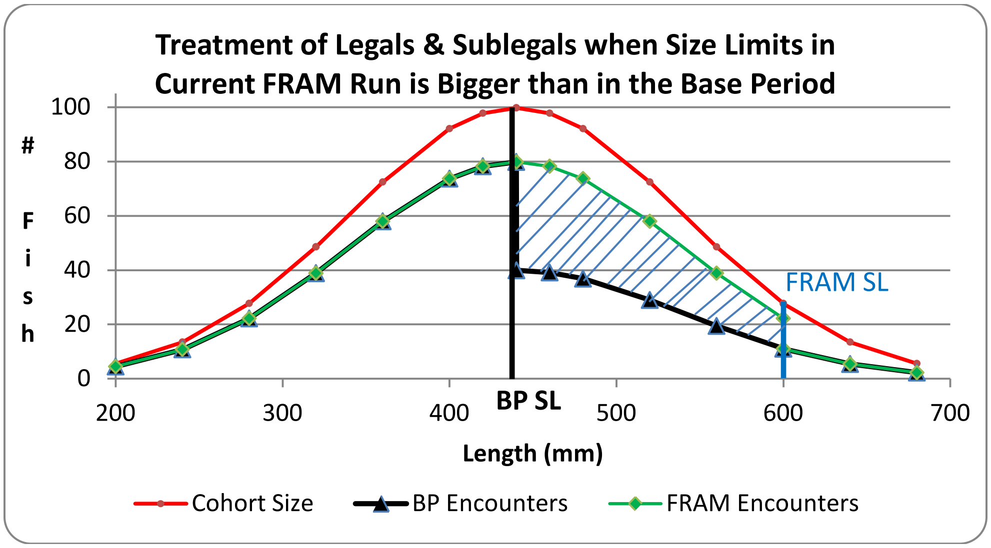
FRAM uses different rates to model encounters of legal and sub-legal fish. These rates are computed during the calibration process and are based on landed catch and encounter information during the base period years (1976-1984). As such, they reflect the size limit conditions as they existed at the time.
When size limits are modeled in FRAM, each fish smaller than the size limit is treated as a sub-legal fish. Sub-legal encounter rates are used to compute release mortalities. Conversely, each fish larger than the size limit is deemed legal and legal encounter rates are used to estimate catch. As the size limit is changed, a portion of the population (with sizes between the old and the new size limit) that previously received a sub-legal encounter rate will receive a legal encounter rate or vice versa. This leads to the total number of computed encounters varying with size limits, an incorrect outcome, if effort remains constant.

The graphs below illustrate the effects of size limit changes when the sublegal encounter rate is higher than the legal encounter rate.





The blue stripped area designates the catch that FRAM is underestimating when the size limit is lowered.



The blue stripped area designates the number of encounters that FRAM is overestimating when the size limit is increased.

FRAM Sub-Legal Shaker Mortality Algorithms

FRAM models sub-legal sized Chinook shaker mortalities through the use of the von Bertalanffy growth equation for stocks that contribute to each fishery. The mean size of each stock at the midpoint of the time step is evaluated against the stock-specific growth equation to estimate the proportion vulnerable by stock. The algorithms from the PFMC (2007) (pgs. 21-22) FRAM documentation are as follows:

$$(27)\ \ KTime_{s,a,t} = (Age_s - 1) \times 12 + \overbrace{MidTimeStep(Months)}$$

$$(28)\ \ MeanSize_{s,a,t} = \overbrace{L_s} \times (1 - (\exp(-\overbrace{K_s}) \times (\overbrace{KTime_{s,a}} - \overbrace{T0_s})))$$

$$(29)\ \ StdDev_{s,a,t} = \overbrace{CV_{s,a}} \times \overbrace{MeanSize_{s,a,t}}$$

$$(30)\ \ PV_{s,a,t} = 1 - NormalDistr(\underbrace{Minsize_{f,t}}, \overbrace{Meansize_{s,a,t}}, StdDev_{s,a})$$

where:

$KTime_{s,a}$	=	Time for estimate of growth equation for stock ***s***, age ***a***,
$PV_{s,a,t}$	=	Percent Vulnerable for stock *s*, age *a*, at time step *t*,
L_s	=	Von Bertalanffy growth parameter for stock *s (Max Size)*,
K_s	=	Von Bertalanffy growth parameter for stock *s (Slope)* ,
$T0_s$	=	Von Bertalanffy growth parameter for stock *s (Time Zero)*,
$CV_{s,a}$	=	Coefficient of Variation of size distribution at $KTime_{s,a}$ for stock *s*, age *a*,
$MinSize_{f,t}$	=	Minimum Size Limit for fishery *f*, time step *t*, and
$MeanSize_{s,a,t}$	=	Mean total length of a fish of stock *s* at age *a* at time step *t*.

The distribution of Chinook sizes by age at a particular time is assumed to be normal with a variance that was calculated using lengths from CWT recovery data. Evaluation of the normal distribution is done using a calculation method developed for the original WDF/NBS Chinook model.

$$(31)\ \ Z = (\underbrace{MinSize_{f,t}} - \overbrace{Meansize_{s,a,t}}) \Big/ StdDev_{s,a}$$

$$(32)\ A1 = Z \times (0.000005383 \times Z + 0.0000488906) + 0.0000380036$$

$$(33)\ A2 = Z \times (A1 + 0.0032776263) + 0.0211410061$$

$$(34)\ \ A3 = 1/(1 + Z \times (Z \times A2 + 0.049867347))$$

$$(35)\ \ A4 = 1 - (0.5 \times A3^{16}) = PV_{s,a,t}$$

For Chinook, the sub-legal and legal size encounters are stock- and age- specific and are calculated using the von Bertalanffy growth curves described above. The calculations for sub-legal sized Chinook (shakers) are shown below:

$$(36)\ \ SubLegProp_{s,a,t} = 1 - PV_{s,a,t}$$

$$(37)\ \ SubLegPop_{s,a,t} = Cohort_{s,a,t} \times SubLegProp_{s,a,t}$$

$$(38)\quad Shakers_{s,a,f,t} = \overbrace{SubER_{s,a,f,t}} \times SubLegPop_{s,a,t} \times \underbrace{FishScalar_{f,t}} \times \overbrace{RelRate_{f,t}}$$

where all components are defined previously and ($1\text{-}PV_{s,a,t}$) is the proportion of the cohort for stock *s*, age *a*, not vulnerable to the gear at time step *t* (for Chinook *PV* is function of von Bertalanffy growth curve.

Base Period Sub-Legal Encounter Rate Calculations

The Chinook FRAM base-period Sub-Legal Encounter Rate is calculated from the individual CWT-based stock catch estimates, externally estimated Target Sub-Legal Encounter Rates by fishery, and stock/age Sub-Legal population estimates. This methodology was used to match model estimates of sub-legal encounters with observed base-period sub-legal encounters and to estimate sub-legal encounters for stock/age cohorts that did not have CWT recoveries in a fishery because of the minimum size limit restriction. The Target Sub-Legal Encounter Rates are shown in Table 1.

The Sub-Legal Encounter Rates used in FRAM are computed in four major steps during the calibration (calibration program ChCal).

1. Compute Landed Catch by Fishery and Time Step

$$TimeCatch_{f,t} = \sum_{s,a}(BaseCWTRec_{s,a,f,t} * PEF_s)$$

2. Compute Sub-Legal Encounters by Fishery and Time Step

$$TotSubEnc_{f,t} = TimeCatch_{\,f,t} * TargetEncRate_{f,t}$$

3. Split Sub-legal Encounters into Stocks and Ages

$$SubLegEnc_{s,a,f,t} = TotSubEnc_{f,t} * PropSubPop_{s,a} * StockCatchProp_{s,f}$$

$$PropSubPop_{s,a} = \frac{SubLegalPop_{s,a}}{SubLegalPop_s}$$

$$StockCatchProp_{s,f} = \frac{LandedCatch_{s,f}}{LandedCatch_f}$$

4. Compute Sub-Legal Encounter Rates

$$SubER_{s,a,f,t} = SubLegEnc_{s,a,f,t}/(Cohort_{s,a,t} * SubLegalProp_{s,a,t})$$

Where:

$TimeCatch_{f,t} = Base\ Period\ \ Catch\ by\ Fishery\ and\ Time\ Step$
$BaseCWTRec_{s,a,f,t} = Base\ Period\ CWT\ Recoveries\ by\ Stock, Age, Fishery, Time\ Step$
$PEF_s = Base\ Period\ Production\ Expansion\ Factor$
$TotSubEnc_{s,f} = Base\ Period\ Total\ SubLegal\ Encounters\ by\ Fishery\ and\ Time\ Step$

$TargetEncRate_{f,t}$ = Base Period Target Encounter Rate Adjustment by Fishery, Time Step
$PropSubPop_{s,a}$= Proportion of the Sub-Legal Population of a Stock that is of a Given Age
$SubLegalPop_{s,a}$= Number of Sub-Legal fish of a Given Stock and Age
StockCatchProp= Proportion of the Landed Catch of a Fishery that is of a Given Stock
$BaseShaker_{s,a,f,t}$ = Base Period SubLegal Mortalities by Stock, Age, Fishery, Time Step
$SubLegEnc_{s,a,f,t}$ = Base Period SubLegal Encounters by Stock, Age, Fishery, Time Step
$SubER_{s,a,f,t}$ = Base Period SubLegal Encounter Rate by Stock, Age, Fishery, Time Step
$SubLegalProp_{s,a,t}$=Proportion of the Cohort that is Sub-Legal by Stock, Age, Time Step

Proposed Evaluation of Minimum Size Limit Change

The method for calculating the Chinook FRAM base-period Sub-Legal Encounter Rates does not allow for a simple algorithm to evaluate a change from the base-period minimum size limit. This is primarily due to the Target Sub-Legal Encounter Rate Adjustment Factor (TargetEncRate) and the Stock Fishery Catch Proportion (StockCatchProp) variables used to calculate the base-period shakers. The combination of these two variables results in an uneven distribution of legal and sub-legal sized fish by stock and age for most fisheries and time steps. The simplest approach for evaluating a size limit change from the base period is to calculate the legal and sub-legal encounters for both the base period and new minimum size limits and then adjusting the differences. Encounter differences occur in the region between the base period size limit and the new minimum size limit.

When the new size limit is less than the base-period size limit, the difference in sub-legal encounters between the base size-limit and the new size-limit becomes landed catch that is added to the calculated landed catch evaluated at the base-period size limit. Encounters are calculated by dividing the shaker estimates by the sub-legal release mortality rate. The difference in encounters is used in this case because it incorporates the base-period sub-legal encounter rates, which are always different than the base-period exploitation rates. It also allows for landed catch estimates for stock and age combinations that do not have base-period exploitation rates because of the base-period minimum size limit restriction.

When the new size limit is greater than the base-period size limit, the difference in landed catch between the new size limit and the base-period size limit becomes sub-legal encounters and is converted to sub-legal shakers by multiplying times the sub-legal mortality rate. This shaker difference is added to the calculated shakers from the base-period size limit to get total sub-legal shaker mortality. The difference in landed catch is used in this case because base-period CWT recoveries can be used to estimate an actual observed difference.

When New Size Limit is Less Than Base-Period Size Limit:

$$BaseSizeLimitShaker_{s,a,f,t} = SubER_{s,a,f,t} * BaseSubLegalPop_{s,a,t} * RelRate_{f,t} * FishScaler_{f,t}$$

$$NewSizeLimitShaker_{s,a,f,t} = SubER_{s,a,f,t} * NewSubLegalPop_{s,a,t} * RelRate_{f,t} * FishScaler_{f,t}$$

$$BaseSizeLimitEncounters_{s,a,f,t} = BaseSizeLimitShaker_{s,a,f,t}/RelRate_{f,t}$$

$$NewSizeLimitEncounters_{s,a,f,t} = NewSizeLimitShaker_{s,a,f,t}/RelRate_{f,t}$$

$$ShakerEncounterDiff_{s,a,f,t} = BaseSizeLimitEncounters_{s,a,f,t} - NewSizeLimitEncounter_{s,a,f,t}$$
$$BaseSizeLimitCatch_{s,a,f,t} = Cohort_{s,a,t} * BPER_{s,a,f,t} * FishScalar_{f,t} * BasePV_{s,a,t} * SHRS_{s,f,t}$$

$$\boxed{LandedCatch_{s,a,f,t} = BaseSizeLimitCatch_{s,a,f,t} + ShakerEncounterDiff_{s,a,f,t}}$$

Then if MSF apply MSF Calculations (PFMC-2007) by stock type (Marked and Un-Marked)

Where:

$BaseSizeLimitShaker_{s,af,t} = Shakers\ evaluated\ at\ Base\ Period\ Size\ Limit$
$NewSizeLimitShaker_{s,af,t} = Shakers\ evaluated\ at\ New\ Size\ Limit$
$BaseSubLegalPop_{s,a,t} = SubLegal\ Population\ evalauted\ at\ Base\ Period\ Size\ Limit$
$BaseSizeLimitEncounters_{s,af,t} = BaseSizeLimitShakers\ divided\ by\ Release\ Mortality\ Rate$
$NewSizeLimitEncounters_{s,af,t} = FRAM\ Shakers\ divided\ by\ Release\ Mortality\ Rate$
$ShakerEncounterDiff_{s,a,f,t} = Difference\ between\ Base\ and\ New\ Size\ Limit\ Encounters$
$BaseSizeLimitCatch_{s,a,f,t} = FRAM\ Landed\ Catch\ at\ Base\ Period\ Size\ Limit$
$BasePV_{s,a,t} = Proportion\ Vulnerable\ evaluated\ at\ Base\ Period\ Size\ Limit\ by\ Stock, Age, Time$
$RelRate_{f,,t}$ = *Release Mortality Rate*

Remaining variables are described in PFMC, 2007.

When New Size Limit is Greater Than Base-Period Size Limit:

$$BaseSizeLimitCatch_{s,a,f,t} = Cohort_{s,a,t} * BPER_{s,a,f,t} * FishScalar_{f,t} * BasePV_{s,a,t} * SHRS_{s,f,t}$$
$$NewSizeLimitCatch_{s,a,f,t} = Cohort_{s,a,t} * BPER_{s,a,f,t} * FishScalar_{f,t} * PV_{s,a,t} * SHRS_{s,f,t}$$
$$BaseSizeLimitShaker_{s,a,f,t} = SubER_{s,a,f,t} * BaseSubLegalPop_{s,a,t} * RelRate_{f,t} * FishScaler_{f,t}$$

$$\boxed{\begin{gathered} Shaker_{s,a,f,t} = BaseSizeLimitShaker_{s,a,f,t} + \\ (BaseSizeLimitCatch_{s,a,f,t} - NewSizeLimitCatch_{s,a,f,t}) * RelRate_{f,t} \end{gathered}}$$

Comparison of Model Runs with Size Limit Changes

Model runs were done for two Puget Sound sport fisheries using the old and new size limit algorithms to show the differences between the two methods. The fisheries were chosen from the 2009 PFMC final FRAM run with one using a fishery (effort) scaler (Area 5 – Sekiu, Time 1) and the other with mark-selective parameters (Area 8-1 –Port Susan, Time 1). Tables 2 and 3 show the results for the Area 5 fishery and Tables 4 and 5 for the Area 8-1 fishery. The differences between the runs are highlighted in Tables 3 and 5. When the size limit is greater than the base-period size limit the sub-legal shaker mortality is greater for the new method. When the size is less than the base-period size limit the landed catch is smaller for the new method. The magnitude of the differences between comparative runs will be relative to the Target Encounter Rate used for the fishery. The Area 5 sport fishery has a rate of 0.28 and the Area 8-1 sport fishery is 2.18. The differences by mark-type for the Area 8-1 sport fishery are shown in Tables 6 and 7 and are consistent with the previous results.

The biggest improvement for the new method is the consistency in total encounters for each of the size limits modeled. In Tables 2, 4, and 6 (New FRAM) the encounters are essentially the same with some variance for rounding error using integer numbers in the tables. The old method varied substantially between the size limits used and illustrates the problem with this method.

Pacific Fishery Management Council. 2007. *Fisheries Regulation Assessment Model (FRAM) Technical Documentation for Coho and Chinook.* (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Table 1: Chinook FRAM Base Period Target Shaker Adjustment Factors

Fishery Title	Time1	Time2	Time3	Time4
SE Alaska Troll	1.09	1.09	1.09	1.09
SE Alaska Net	-1	-1	-1	-1
SE Alaska Sport	2.62	2.62	2.62	2.62
BC No/Cent Net	-1	-1	-1	-1
BC WCVI Net	-1	-1	-1	-1
BC Georgia Strait Net	-1	-1	-1	-1
BC JDF Net	-1	-1	-1	-1
BC Outside Sport	0.78	0.78	0.78	0.78
BC No/Cent Troll	1.1	0.55	0.68	1.1
BC WCVI Troll	0.59	0.63	0.62	0.59
BC WCVI Sport	0.59	0.63	0.62	0.59
BC Georgia Strait Troll	0.34	0.34	0.34	0.34
BC N Georgia Strait Sport	0.01	0.01	0.01	0.01
BC S Georgia Strait Sport	0.01	0.01	0.01	0.01
BC JDF Sport	0.01	0.01	0.01	0.01
NT Area 3:4:4B Troll	-1	0.48	1.65	-1
Tr Area 3:4:4B Troll	0.64	0.48	1.65	0.64
NT Area 3:4 Sport	0.5	0.5	0.5	0.5
No Wash. Coastal Net	-1	-1	-1	-1
NT Area 2 Troll	0.51	0.39	1.59	0.51
Tr Area 2 Troll	-1	0.39	1.59	-1
NT Area 2 Sport	-1	0.5	0.5	-1
NrT G. Harbor Net	-1	-1	-1	-1
T G. Harbor Net	-1	-1	-1	-1
Willapa Bay Net	-1	-1	-1	-1
Area 1 Troll	0.55	1.16	4.52	0.55
Area 1 Sport	-1	0.5	0.5	-1
Columbia River Net	-1	-1	-1	-1
Buoy 10 Sport	-1	-1	-1	-1
Central OR Troll	1.05	1.05	1.05	1.05
Central OR Sport	-1	0.5	0.5	-1
KMZ Troll	-1	1.05	1.05	-1
KMZ Sport	-1	0.5	0.5	-1
So Calif. Troll	-1	1.05	1.05	-1
So Calif. Sport	0.5	0.5	0.5	0.5
NT Area 7 Sport	2.18	0.98	0.94	2.18
NT Area 6A:7:7A Net	-1	-1	-1	-1
Tr Area 6A:7:7A Net	-1	-1	-1	-1

Fishery Title	Time1	Time2	Time3	Time4
NT Area 7B-7D Net	-1	-1	-1	-1
Tr Area 7B-7D Net	-1	-1	-1	-1
Tr JDF Troll	0.28	0.24	0.44	0.28
NT Area 5 Sport	0.28	0.24	0.44	0.28
NT JDF Net	-1	-1	-1	-1
Tr JDF Net	-1	-1	-1	-1
NT Area 8-1 Sport	2.18	0.98	0.94	2.18
NT Skagit Net	-1	-1	-1	-1
Tr Skagit Net	-1	-1	-1	-1
NT Area 8D Sport	-1	-1	-1	-1
NT St/Snohomish Net	-1	-1	-1	-1
Tr St/Snohomish Net	-1	-1	-1	-1
NT Tulalip Bay Net	-1	-1	-1	-1
Tr Tulalip Bay Net	-1	-1	-1	-1
NT Area 9 Sport	2.18	0.98	0.94	2.18
NT Area 6 Sport	-1	-1	-1	-1
Tr Area 6B:9 Net	-1	-1	-1	-1
NT Area 10 Sport	2.18	0.98	0.94	2.18
NT Area 11 Sport	2.18	0.98	0.94	2.18
NT Area 10:11 Net	-1	-1	-1	-1
Tr Area 10:11 Net	-1	-1	-1	-1
NT Area 10A Sport	-1	-1	-1	-1
Tr Area 10A Net	-1	-1	-1	-1
NT Area 10E Sport	-1	-1	-1	-1
Tr Area 10E Net	-1	-1	-1	-1
NT Area 12 Sport	2.18	0.98	0.94	2.18
NT Hood Canal Net	-1	-1	-1	-1
Tr Hood Canal Net	-1	-1	-1	-1
NT Area 13 Sport	2.18	0.98	0.94	2.18
NT SPS Net	-1	-1	-1	-1
Tr SPS Net	-1	-1	-1	-1
NT Area 13A Net	-1	-1	-1	-1
Tr Area 13A Net	-1	-1	-1	-1
Freshwater Sport	-1	-1	-1	-1
Freshwater Net	-1	-1	-1	-1

Note: -1 value = no shaker adjustment used

Comparison of FRAM using Adjusted Size Limit Algorithms

PS Sport Fishery using Fishery Scaler (Area 5 Sport, Time Step 1, 2009 PFMC Run)

Table 2: New FRAM

Size Limit	Landed Catch	Sub-Legal Mortality	Total Encounters
480 mm (BP)	384	40	584
520 mm	300	57	585
425 mm	408	35	583

Table 3: Old FRAM

Size Limit	Landed Catch	Sub-Legal Mortality	Total Encounters
480 mm (BP)	384	40	584
520 mm	300	44	520
425 mm	499	35	674

PS Sport Fishery with MSF Regulations (Area 8-1 Sport, Time Step 1, 2009 PFMC Run)

Table 4: New FRAM

Size Limit	Landed Catch	Sub-Legal Mortality	Total Encounters
480 mm (BP)	1996	2012	13982
520 mm	942	2373	13984
425 mm	2651	1765	13983

Table 5: Old FRAM

Size Limit	Landed Catch	Sub-Legal Mortality	Total Encounters
480 mm (BP)	1996	2012	13982
520 mm	942	2172	12974
425 mm	3663	1765	15601

PS Sport Fishery with MSF Regulations (Area 8-1 Sport, Time Step 1, 2009 PFMC Run)

Table 6: New FRAM by Mark Type

Size Limit	Un-Mark Enc (Legal)	Un-Mark Enc (SL)	Un-Mark Enc Tot	UnMark DO Mort	Un-Mark Retained	Un-Mark Total Mort
480 mm (BP)	1747	3715	5462	87	105	738
520 mm	1108	4355	5463	55	67	668
425 mm	2264	3195	5459	113	136	795

Table 7: Old FRAM by Mark Type

Size Limit	Un-Mark Enc (Legal)	Un-Mark Enc (SL)	Un-Mark Enc Tot	Un-Mark DO Mort	Un-Mark Retained	Un-Mark Total Mort
480 mm (BP)	1747	3715	5462	87	105	738
520 mm	1108	4050	5158	55	67	638
425 mm	2756	3195	5951	138	165	898

Unmarked drop-off is computed as 5% of legal unmarked encounters.
Unmarked retained is computed as 6% of legal unmarked encounters.

SALMON TECHNICAL TEAM REPORT ON THE 2013 SALMON METHODOLOGY REVIEW

The Salmon Technical Team (STT) and Salmon Subcommittee of the Scientific and Statistical Committee (SSC) met on October 10-11, 2012, in Portland to conduct the annual Methodology Review. Five topics were reviewed at the meeting.

Ms. Angelika Hagen-Breaux presented the results of modifications to coho Fishery Regulation Assessment Model (FRAM) to correct for bias in modeling impacts to unmarked coho in mark-selective fisheries. Corrections have been incorporated in FRAM for bias caused by non-linearity in the catch equations (multiple encounters), mark recognition error, and drop-off mortality. Impacts in the bias corrected FRAM are extremely close to the unbiased values over the range of all mortality rates that would be reasonably expected to occur in pre-terminal fisheries where mark-selective fishing occurs. The STT recommends that the bias corrected coho FRAM be used in the coming year during the planning process for 2013 fisheries.

Dr. Robert Kope presented an analysis of mortalities in Washington recreational mark selective fisheries of natural coho from Grays Harbor, Queets, Hoh, and Quillayute stocks. Three of these stocks (Grays Harbor, Queets and Quillayute) have hatchery programs with coded-wire tagging (CWT) programs including double index (DIT) programs. Hatchery CWT recovery data from the Regional Mark Information System (RMIS) was used to estimate the impact rates on unmarked natural fish. Impacts were calculated for each port area, in each year from 2006 through 2010, and calculated separately for the private boat and charter boat fleets using accepted release mortality and drop-off mortality rates. Impacts included the effects of increased encounters resulting from the release of legal-sized marked fish as estimated from observer data in the charter fleet and voluntary trip reports in the private fleet. Total mortality on unmarked coho in the Washington ocean recreation fishery ranged from 0.4 percent of the Quillayute stock in 2008 to 3.7 percent of the Queets stock in 2007. Calculated mortality rates were compared to preseason predictions from the FRAM, and found to agree well for the Grays Harbor and Quillayute stocks, and to be over-predicted for the Queets and Hoh stocks. The STT does not anticipate any changes in methodology for predicting mortality of unmarked coho in mark-selective fisheries.

Messer's Mark Lewis and Eric Suring of the Oregon Department of Fish and Wildlife (ODFW) presented a proposed technical revision to the marine survival portion of the Oregon Coastal Natural (OCN) coho harvest matrix. ODFW now has 13 years of data for wild Oregon coast coho that was not available when Amendment 13 was adopted, or for the 2000 review. At that time, a hatchery jack index was used because it was the only data available. Data from life cycle monitoring (LCM) stations along the coast allow for estimation of freshwater and marine survival, and there is no significant relationship between these marine survival estimates and the hatchery jack index. At one site (Mill Creek, Yaquina system), ODFW is able to trap wild jacks to calculate a wild smolt to jack survival rate. LCM adult counts are highly correlated with the coastwide adult escapement estimates, and there is a significant relationship between Mill Creek (Yaquina) smolt to jack survival and adult survival estimated from LCM sites. Hindcasting with the Mill Creek LCM marine survival data resulted in correctly predicting the marine survival category correctly more frequently than the current methodology (8 times versus 3 times). Current methodology effectively predicts the same marine survival category (low) each year; the proposed methodology provides more variability in the marine survival category (and associated harvest rates) and for the most part gets this right. The proposed changes only impact the predictor value thresholds for each of the marine survival categories in the matrix. It does not affect the number of categories nor the ceiling exploitation rates in each cell of the matrix. This results in better forecasting, greater protection at low abundances, and more harvest opportunity when abundance is higher.

However, potential issues exist with the proposed approach, including relying on data from a single site (Mill Creek) for estimating marine survival, which could lead to location-specific effects resulting in the inability to make a prediction in a given year. However, because the design of the collection facility, problems associated with high or low water events are expected to be rare and the jack count should properly reflect returns to the basin. In addition, the number of jacks returning to Mill Creek has ranged from approximately 20 to 200, thus the index will have error associated with small sample sizes. Despite these issues, the STT recommends that the Council adopt the new predictor of smolt to adult survival for use in the coming year. The proposed method appears to offer greater protection to OCN coho when needed, increased harvest opportunity when appropriate, and increased flexibility for future improvements to the estimation of marine survival.

Mr. Bob Conrad presented a comparison of two methods for estimating coho salmon encounters in Washington recreational fisheries for purposes of post season accounting in STT reports. Estimation of encounters in recreational fisheries relies on expansion of landed catch to account for marked legal fish that are released. Currently a single rate of 6 percent is used for the entire recreational fishery to calculate release mortality, but these encounters are not accounted for in estimating release mortality of unmarked fish. Data from observers and voluntary trip reports indicate that the charter fleet retains a higher proportion of their total encounters than the private fleet, release a smaller percentage of the legal marked fish, and that they see a higher mark rate. The proposed methodology would estimate encounters independently for the charter fleet and private fleet, use the total encounter rates for estimating unmarked mortalities, and use dockside interview data to predict rates when observer data and voluntary trip reporting data are lacking or inadequate. The STT recommends the proposed methods be adopted for calculating incidental mortalities in mark-selective fisheries.

Mr. Jim Packer presented a technical modification to Chinook FRAM to forecast sublegal encounters when changes in size limits from base period have occurred. The current version of FRAM uses different rates to model sublegal encounters and legal fish exploitation rates. This can lead to different forecasts of encounters if alternative size limits are proposed, a result that led to this investigation and proposed modification. While the proposed modification does result in approximately equal forecasts of total encounters under different size limits, it does not take into account recent data collected on sublegal encounters and is a patch to a problem that should be examined in a more comprehensive manner. As a result, the STT recommends using the current FRAM methodology to model Council-area fisheries. For inside fisheries, sublegal encounters predicted by the current version of FRAM should be evaluated against modern data collected on sublegal encounters. Consideration should be given to a more extensive evaluation of new data and methods that more efficiently account for different proposed size limits in all fisheries.

In addition to the five topics reviewed at the meeting, three updates on other topics were provided. Mr. Andy Rankis provided updates on progress made to develop a user's manual for the Visual Studio version of FRAM and an evaluation of the feasibility of incorporating bias-correction methods for mark-selective fisheries into Chinook FRAM. Dr. Galen Johnson provided an update on investigations into Chinook FRAM's sensitivity to age composition forecasts.

PFMC
10/16/12

MODEL EVALUATION WORKGROUP REPORT ON 2012 SALMON METHODOLOGY REVIEW

The Model Evaluation Workgroup (MEW) offers comments on the following model related topics discussed at the Methodology Review Meeting:

For the upcoming salmon fishery planning process, the MEW endorses the use of coho Fishery Regulation Assessment Model (FRAM) as modified to account for the bias introduced by mark selective fisheries (MSF). The presentation by Angelika Hagen-Breaux (MEW/Washington Department Fish and Wildlife [WDFW]) culminates four years of MEW efforts. Over this time we have confirmed that FRAM's structure, using linear equations, was underestimating unmarked mortalities in MSF and concurrent non-MSF. Exponential equations have been added to coho FRAM that calculate the potential multiple encounters of coho released in MSF, and the subsequent additional mortality. Working with the 2009 pre-season coho model run has demonstrated that the FRAM now essentially matches independently calculated mortality estimates. Before the end of the year, the MEW will run the coho 2012 preseason model inputs through the bias corrected FRAM as an additional error checking exercise.

Chinook FRAM is currently unable to correctly model changes to minimum size limits. Presently the minimum size limits in Council fisheries are very similar to Base Period (1979-82) values; however for some fisheries outside the Council area the current size limits are different from those during the Base Period. Jim Packer (WDFW) gave a presentation on how Chinook FRAM estimates sublegal and legal-size encounters from Base Period encounter data. The algorithms for these estimates in FRAM do not correctly estimate these encounters when the size limit is changed or differs from those in the Base Period. Mr. Packer developed program code that would correct for the algorithm flaw in FRAM and thus keep total encounters (sublegal plus legal size) stable whenever a modeled size limit deviates from the Base Period size limit. This solution has merit, but doesn't address fundamental Base Period issues such as how the encounter rate of sublegal Chinook was derived, which is obsolete for some fisheries. New data needs to be incorporated into the model calibration process. Implementing a program code "fix" is not recommended at this time because of such complicating data issues. Our recommendation is to not modify minimum size limits, unless there is adequate data (current and representative) on Chinook size structure for a fishery in a time step; in such cases the sublegal and legal encounters could be calculated outside of the FRAM model and become model input.

There were three methodology tasks assigned to the MEW that were not ready for full review at the October meeting. However, Andy Rankis (MEW/Northwest Indian Fisheries Commission [NWIFC]) reported upon progress and these three tasks were then discussed with the SSC and STT. One task was to investigate Chinook FRAM's sensitivity to age composition of forecasts. Galen Johnson (NWIFC) presented her preliminary work on this topic, showing that age composition of a stock's forecast has notable effects upon model output. This again confirmed the importance of Chinook forecasts by age class.

Another task, the feasibility of incorporating MSF bias correction methodology into Chinook FRAM, was discussed by the MEW. Preliminary work indicates this would be a very challenging task. The general consensus in the MEW, which was shared by folks at the Methodology Review Meeting, is that staff time would be better used addressing other issues affecting Chinook FRAM (such as improving minimum size limit modeling and obtaining high quality forecasts).

The MEW will continue working on the third task: a User's Manual for the Visual Studio version of FRAM, for presentation at the 2013 Salmon Methodology Review Meeting.

PFMC
10/23/12

PACIFIC STATES MARINE FISHERIES COMMISSION
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PHONE (503) 595-3100 FAX (503) 595-3232

October 25, 2012

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Pacific Fishery Management Council
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Mr. Don Wolford
Chairman
Pacific Fishery Management Council
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Gentlemen:

At this year's Pacific States Marine Fisheries Commission 65th Annual Meeting there was considerable discussion concerning using a constant 16% harvest rate for ESA-listed California Coastal chinook in the Klamath River Fall Chinook Ocean Harvest Model, together with using Klamath River fall chinook as a distribution surrogate. There has been movement to abundance-based management for some listed stocks.

The Commission recognizes this comes under the Council preview. However, the PSMFC Commission went on record directing the PSMFC staff to write a letter to the Pacific Fishery Management Council, the State of California Department of Fish and Game, and the National Marine Fisheries Service to use the council forum to create a workshop on the topic.

Thank you for considering this request.

Sincerely,

Randy Fisher
Executive Director
Pacific States Marine Fisheries Commission
RFisher@psmfc.org

SALMON ADVISORY SUBPANEL REPORT ON THE 2013 SALMON METHODOLOGY REVIEW

The Salmon Advisory Subpanel (SAS) met via teleconference on October 29, 2012 to review the results of the 2012 salmon methodology review and to develop the following recommendations for Council consideration.

The SAS supports the proposed technical revision to the marine survival portion of the Oregon Coastal Natural (OCN) coho harvest matrix (Agenda Item C.3.a, Attachment 3) because it appears to outperform the existing marine survival indicator and provides improved fishery opportunity when survival is high while affording adequate protection when survival is low. The SAS shares the concerns of the Salmon Technical Team regarding the new indicator's reliance on a single site and encourages the Council to consider a fallback indicator such as the existing hatchery smolt to jack survival in the event that the single site fails to produce an estimate.

Regarding the comparison of two methods for estimating coho salmon encounters in Washington recreational fisheries (Agenda Item C.3.a, Attachment 4), the SAS supports proposed methods calculating incidental mortalities in mark-selective fisheries. The SAS encourages the Council to continue to use caution when using dock-side survey data when estimating released fish and incidental mortalities because dock-side information is often biased and subject to recollection errors.

PFMC
11/02/12

SCIENTIFC AND STATISTICAL COMMITTEE REPORT ON 2012 SALMON METHODOLOGY REVIEW

The Scientific and Statistical Committee (SSC) reviewed the five salmon methodology topics identified at the September Council meeting. Presentations were made to the Salmon Subcommittee in a joint meeting with the Salmon Technical Team and the Model Evaluation Workgroup on October 10 and 11.

Implementation and assessment of proposed bias-correction methods for mark-selective fisheries into the Fishery Regulation and Assessment Model (FRAM) for coho

Ms. Angelika Hagen-Breaux presented an analysis of the effects of implementing bias-correction methods for mark-selective fisheries into Coho FRAM (Agenda Item C.3.a, Attachment 1). She demonstrated the degree of bias reduction achieved by implementing bias-corrected methods and discussed additional potential improvements.

The most difficult technical obstacle encountered while developing bias-correction algorithms in Coho FRAM was the need for a way to model multiple simultaneous fisheries. This has been resolved with algorithms that correctly account for multiple encounters of unmarked fish in mark-selective fisheries. Effects of these improved algorithms are relatively small but potentially significant; a few fisheries showed unbiased total exploitation rate increases of about 1.5 percent compared to the biased calculation.

Mark-recognition error is another source of bias in FRAM modeling of mark-selective fisheries. Although the magnitude of this bias is small, a method has been developed and implemented to properly account for its effects. Two other sources of bias -- drop-off mortality and mortality in non-retention fisheries -- are not easily addressed in FRAM, but have effects that will be very small compared with other sources of uncertainty in the modeling. Efforts to further improve Coho FRAM would more usefully be directed to improving base-period data and run-size forecasts.

The bias testing reported to the SSC was done using simplified FRAM runs. A test with the final 2012 run comparing results with and without bias correction will provide a realistic assessment of the effects of this adjustment and help to verify that the model is running correctly. Pending the results of this comparison, the SSC recommends implementation of bias correction for multiple encounters and mark-recognition error in Coho FRAM for modeling 2013 fisheries.

Impacts of mark-selective ocean recreational fisheries on Washington Coast coho stocks

Dr. Robert Kope reported on the results of his examination of the impacts of mark-selective recreational fisheries in Washington Marine Catch Areas 1, 2, 3, and 4 on Washington Coastal natural coho salmon stocks (Agenda Item C.3.a, Attachment 2). Data from fishery years 2006 through 2010 were used for these analyses. Coded wire tag (CWT) recovery data from all ocean fisheries, pre-terminal fisheries, and escapement were available for hatchery coho stocks in the

Gray's Harbor, Queets, and Quillayute watersheds and were used to estimate stock-specific fishery impacts. Exploitation rates for Hoh River natural coho were estimated as the average of the rates for the Queets and Quillayute stocks that were based on CWTs. This is a reasonable approach for estimating exploitation rates for the Hoh natural stock for which there are no hatchery CWT data.

Anglers intentionally release legal-size marked coho salmon in these recreational fisheries. Differences in the incentives for the charter and private boat sectors lead to differences in the release rates of legal-size marked coho, with private boat anglers releasing legal-size marked coho at a higher rate than charter boat anglers. Information from observer programs and voluntary trip reports were used to estimate these rates for the charter and private boat sectors, respectively. On average, charter boat anglers released fewer legal-size marked coho than private boat anglers. The impact analyses conducted properly accounted for these differences between the fleets plus the difference in angling success between the charter and private boat fleets.

The analyses estimated relatively small impacts on Washington Coastal natural coho salmon stocks by ocean mark-selective fisheries. Annual stock-specific impact rates ranged from 0.4 percent to 3.7 percent of the total impacts on the unmarked stocks. Average impacts across years for each stock were between 0.8 percent (Quillayute) to 1.7 percent (Queets). FRAM preseason predictions of impacts by the ocean recreational fisheries have been, on average, very close to the estimates based on CWTs for Grays Harbor and Quillayute coho stocks. Impacts by these fisheries on Queets natural coho have been consistently over-predicted by FRAM and impacts on Hoh natural coho have been over-predicted on average.

The SSC endorses the methods used for these analyses and the conclusions drawn in the report.

<u>Technical revision to the Oregon Coastal Natural (OCN) coho work group harvest matrix</u>

Mr. Erik Suring and Mr. Mark Lewis reported on the analyses supporting the document "2012 Technical Revision to the OCN [Oregon Coastal Natural] Coho Work Group Harvest Matrix" (Agenda Item C.3.a, Attachment 3). Maximum allowable harvest rates for OCN coho are annually specified using a two-dimensional matrix with five levels of Parent Spawner Status (spawning density relative to full seeding) and four levels of a Marine Survival Index. Currently, the Oregon Production Index Hatchery (OPIH) jack/smolt ratio is used as a proxy for predicting OCN coho marine survival since data on wild adult coho salmon marine survival were unavailable when the matrix was developed. The authors of Amendment 13 to the PFMC Pacific Coast Salmon FMP recognized that this marine survival predictor was less than ideal and therefore stated explicitly that the methods for estimating the technical parameters of the matrix could be changed without plan amendment. The Council is currently using a modified matrix developed by Sharr et al. (2000) in their 2000 Review of Amendment 13 to the Pacific Coast Salmon Plan.

The document describes a proposed change in the basis for estimating the Marine Survival Index. A change is warranted due to the low correlation between the OPIH jack/smolt ratio and the observed OCN adult marine survival index measured at the Life Cycle Monitoring (LCM) sites from 1999 through 2011. The predicted Marine Survival Index category (i.e., the one used for management) has been different than the subsequent observed category in 10 of these 13 years (under-predicting nine times and over-predicting once).

The LCM adult trap on Mill Creek (Yaquina River) is the only LCM trap that currently captures all upstream migrating fish, including jacks. Thus Mill Creek provides the only natural jack/smolt ratio that could be used as a predictor of OCN marine survival. The LCM Mill Creek jack/smolt index has been a far better predictor of OCN marine survival over the past 13 years than the OPIH jack/smolt ratio. Had the Mill Creek index been in use, the predicted marine survival category would have been incorrect in only five of the 13 years (under-predicting four times and over-predicting once).

The SSC supports the proposed change to the OCN Harvest Matrix. However, the SSC notes that the use of a single site could be problematic if there is an event that causes this site to no longer be representative of OCN coho during a particular year. There should be a provision to revert to the OPIH jacks/smolt predictor if there are indications that the Mill Creek site might be unrepresentative in any particular year (for example, no jacks return). ODFW will investigate using other LCM sites to provide additional natural jack/smolt ratios.

In addition to Yaquina Mill Creek jacks there are other indexes that potentially could serve as marine survival estimates. In particular, the OCN abundance predictor adopted in 2011, while not a survival index, is based on a wide variety of environmental indices and is more representative of the entire stock. The SSC requests an analysis of methods that include the current OCN abundance predictor and other potential broad-scale indicators for review in October 2013. In the interim, the Yaquina Mill Creek jack/smolt ratio appears to perform substantially better than the OPIH jack/smolt ratio. The SSC approves the use of this index for setting OCN exploitation rates in 2013.

<u>Comparison of two methods for estimating coho salmon encounters and release mortalities in the ocean mark-selective fishery</u>

Mr. Robert Conrad presented an evaluation of two methods for estimating total encounters of legal-size coho salmon and release mortalities for legal-size marked and unmarked coho salmon in the ocean mark-selective recreational fisheries off the Washington coast (Washington Department of Fish and Wildlife [WDFW] Marine Catch Areas 1, 2, 3, and 4) (Agenda Item C.3.a, Attachment 4).

For estimating total encounters with legal-size coho salmon, the current method of estimation assumes:

- there is no release of legal-size marked coho salmon by anglers, and
- the proportion of marked and unmarked coho salmon in all legal-size encounters is the same for the charter boat and private boat fleets.

Data collected during the 2009, 2010, and 2011 charter boat observer and voluntary-trip report programs do not support these two key assumptions.

The proposed alternate method incorporates fleet-specific estimates of the release rate of legal-size marked coho salmon and estimates total encounters of legal-size marked and unmarked coho salmon separately for each fleet, and does not rely on either of these assumptions.

The evaluation indicated that the current methods consistently underestimate both the total encounters with legal-size coho salmon and the number of encounters with unmarked legal-size coho salmon. As a result, release mortalities for unmarked legal-size coho salmon were underestimated by about 10 percent to 15 percent in these fisheries during the years 2009 to 2011.

The SSC recommends using the proposed alternate method in 2013 to estimate total encounters of legal-size coho salmon, and release mortalities for legal-size marked and unmarked coho salmon by the ocean mark-selective recreational fisheries in WDFW Marine Catch Areas 1, 2, 3, and 4.

Review of modifications to Chinook FRAM size limit algorithms implemented to allow evaluation of size limit changes

Mr. Jim Packer presented a proposal for modifying the current size-limit algorithms in Chinook FRAM that are used to predict the number of sub-legal and legal encounters in a fishery (Agenda Item C.3.a, Attachment 5). A previous assessment evaluated a proposed change to a size limit in a recreational fishery and identified a serious problem with the way Chinook FRAM deals with size limit changes and subsequently projects total encounters. Specifically, it was determined that when a size limit different from the base period limit was entered for a FRAM fishery, the total number of encounters with a stock by the fishery with the changed size limit would increase or decrease - sometimes by a substantial amount. Obviously, this is not expected, as the total number of encounters should remain the same regardless of size limit. Only the proportion of total encounters classified as sublegal and legal should change.

The proposed modification to FRAM simply scales encounter rates to keep total encounters equal regardless of size limit. This propagates through the model to change exploitation rates in historical fisheries where size limits have changed. The changed exploitation rates are no more correct than the current rates. The fundamental problem is the lack of a valid method in the Chinook FRAM to model size at age. The SSC recommends no change to the current method until an acceptable alternative is developed. Effects of size limit changes should be evaluated outside of the FRAM model.

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