Report for the 2015 Salmon Methodology Review on the Fishery Regulation Assessment Model (FRAM) Chinook Base Period

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Introduction

The Chinook FRAM base period project began in 2014 with the investigation of the feasibility of developing a dataset that is based on analysis of coded-wire tag (CWT) recoveries from recent year releases of tag groups. The current base dataset in Chinook FRAM is derived from CWT recoveries and stock and fishery information from the late 1970s to the early 1980s. Significant changes have occurred in stock abundances, fishing seasons, and fishery structure since this time frame which have necessitated several ad hoc modifications to FRAM (and/or its inputs) to keep pace. The benefits of using contemporary data to perform a full-blown calibration thus seemed obvious. Appendix A contains a refresher on the basics of FRAM from the original FRAM Overview report (October, 2008).

A FRAM base period work group (FWG) comprised of federal, state and tribal technical staff familiar with FRAM was formed in 2014. Along the way, the FWG has been assisted on specific stock and fishery data issues by regional technical staff. The investigation began with identifying a range of recent years that could provide CWT data covering stocks and fisheries important to Council management and to 'inside' (Puget Sound) fishery management. The FWG started with the basic stock and fishery structure of the existing FRAM database. From these initial investigations, we eventually identified CWT groups from 2005-08 brood years contributing to fisheries in 2007-13 as the time frame most appropriate for developing a new base dataset. The fishery and time strata in Chinook FRAM are unchanged from the current structure. With the exception of adding fall Chinook from the mid-Oregon coast (MOC) and the need to accommodate a few out-of-base stocks, stock coverage for the new base period is the same as in the existing FRAM base period. Note, however, that a goal for future calibrations is to split stock aggregates (e.g., unmarked South Puget Sound fall fingerlings) into finer units (e.g., unmarked Nisqually wild fall fingerlings) where such resolution will benefit conservation or management.

The primary purpose of the FRAM base period project was to develop a contemporary dataset covering stocks and fisheries that could be used in the existing FRAM structure, algorithms, data processing and input/outputs. With the exception of how FRAM estimates stock-specific fishing mortality for sublegal fish and the derivation/implementation of growth functions (both discussed in detail in separate companion reports), FRAM itself is unchanged from the current version. The FRAM base period project encompasses the following tasks:

1. Identify CWT tag groups to represent FRAM stocks.
2. Compile CWT recovery dataset for the brood years identified.
3. Develop a mapping program to assign CWT recoveries from the CWT recovery dataset to FRAM stocks, fisheries and time periods (FRAMBuilder).
4. Compile datasets on base period stock abundances and fishery components (landed catch, size limits, release mortality rates, adipose mark selective fisheries, etc).
5. Develop methods to deal with data gaps in stock and fishery representation.
6. Convert the original Quick Basic calibration programs (ChDat, ChCal) to Visual Basic .NET and link them to an ACCESS database backend that can efficiently bridge calibration outputs to forward FRAM implementation.
7. Compare old vs new FRAM estimates of stock composition and exploitation rates for key stocks and fisheries.
8. Provide information on the new base period for review by comanagers.
9. Document and catalog the origin of the data components needed in the calibration and base dataset.

Base Period Data Components and Development

The base period dataset originally developed for the current Chinook FRAM was in the form of a text file that was converted to an ACCESS database in 2012. The computer programs used to process the base period dataset were originally written in Q and ran on a series of text files for input and processing. Over time, the QuickBASIC programs, and their associated text file system, have been migrated to Visual Basic and an ACCESS database platform. The initial base period project stages placed priority on this overhaul in calibration infrastructure.

CWT Recovery Database

The database of CWT recoveries is a modified version of the CWT recovery database constructed by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC). This database, called CAS (Cohort Analysis System) has most but not all of the tag recoveries for the stocks in FRAM. This database is annually updated by the CTC and has been modified to include specific adjustments or additions to the tag recoveries as reported to the Regional Mark Information System (RMIS), and is regarded as being more complete than as-is RMIS data for the stocks of interest. Added to CAS are the CWT recoveries for stocks that are not included in the annual exploitation rate analysis conducted by the CTC. This CAS derivative represents the most complete and comprehensive dataset of CWT recoveries for stocks covered in the FRAM base period, and additionally includes crosswalks between PSC model fisheries and FRAM.

The observed number of CWT recoveries in the old and new base period data is shown for fisheries (Table 1) and for FRAM stocks (Table 2) (based on September 2015 RMIS download/CWT mapping effort). The differences in the number of recoveries by fishery and time strata partially reflect the changes in magnitude and season structure that have occurred in these fisheries since the late 1970s to early 1980s. An example of this is “BC Georgia Strait Troll” where there hasn’t been a Chinook troll season since the early 1990s. In other fisheries, the number of recoveries in the new base period may be low despite adequate landed catch. The stock profile in Table 2 highlights the notable improvement between the new base period and the old base period in terms of the lower number of stocks that weren’t tagged during existing base period brood years and require adjustments to the tag recoveries. These are called the out-of-base (OOB) stocks. Fortuitously, the stocks requiring OOB adjustments for the new base period are generally small; consequently, uncertainty and/or adjustments for these stocks are unlikely to have a large carry-over effect on the estimates of fishery impacts on other stocks.

Stock and Fishery Profiles

For each FRAM stock and fishery, metadata are recorded on the associated data used in the calibration process. These stock and fishery profiles are in spreadsheet form and become the basis for eventual documentation of the data and sources for the data in the calibration. Data included, but not limited to, are list of tag codes for each stock, stock abundance estimates in the river return, landed catch and size limits in fisheries, listing of adipose mark selective fisheries. Attachment A and B are examples from DRAFT stock and fishery profile spreadsheets.

New Elements: Growth function parameters and sublegal estimates

During the early stages of updating the base period, the FWG was continuously confronted with trying to identify the sources for some of the data that were used to create the existing base period. In many cases, trying to reconstruct the original data used in the calibration could not be done. Two examples where this was especially apparent were in the data used to calculate the growth function parameters and the data used in estimating sublegal encounters and associated mortality by stock. These two examples prompted a more thorough review and a comprehensive update followed. These items are covered in separate reports and will be presented for an in-depth discussion (See companion documents 'Chinook FRAM Base Period Documentation: Sublegal Stock and Age Assignments' by Johnson et al. and 'Chinook FRAM Base Period Documentation: Growth Functions' by McHugh et al.).

Programs and Programming

FRAMBuilder

FRAMBuilder is a program coded in Visual Basic .NET that maps the CWT recoveries in CAS to FRAM stock, age, fishery (escapement) and time step. It leverages the pre-processing (mapping) of RMIS recovery locations from an initial CAS loading step, combined with location- and gear-specific rules to perform this assignment. Additionally, it contains algorithms for merging CWT datasets from across production sites within stocks and brood years, and from across brood years, into a single aggregate 'super code' tag group that can feed directly into ChCal. Lastly, FRAMBuilder processes length observations for CWT recoveries (e.g., standardizes them to fork length) so that they can be used to support the development and validation of model growth equations. This is a second generation version of FRAMBuilder, modeled after an original version coded in C; although documentation work remains, the coding phase for this program is complete and it is now fully operational.

Main Calibration Program

Two programs, originally written in Quick Basic then converted to Visual Basic .NET, were used to construct the current base period dataset. The first program ChDat is primarily a reformatting program and can also identify age-specific tag recoveries that are not expected to be of legal size using the growth function criteria. ChDat also allows for imputing recoveries based on surrogate fishery data, i.e., to cover fisheries where landings occurred but tag recoveries were sparse or absent.

The primary purpose of the second program, ChCal, is to complete cohort analyses for each stock in the FRAM model and to estimate base period exploitation rates by FRAM stock, fishery, time periods, and age. Other functions of ChCal include the estimation of the proportion of the catch in each fishery accounted for by stocks in the model (i.e., model stock proportion, MSP, discussed below), and estimating CWT recoveries that would have occurred for an OOB stock, had it been tagged during the calibration base period years, based on backwards and forwards CWT cohort reconstructions and simulation. ChCal operates in two different modes depending on whether it is doing an OOB analysis on one stock or a complete final cohort analysis during an "All-Stocks" run. The number of input files used and the type of output generated is a function of the run type (OOB or Allstocks). A brief pseudo-code description of both modes is provided below:

BACKWARDS COHORT ANALYSIS (using years with OOB recoveries)

- Perform a simple cohort reconstruction starting with age 5
- Compute incidental morality (function of abundance)
- Re-compute cohort (function of landed and non-landed mortality)
- Iterate until cohort is stable
  Goal: Get starting cohort abundance factoring in shaker mortality

FORWARDS COHORT ANALYSIS

The objective of a return to base, or OOB analysis, is to estimate the CWTs that would have been recovered from a 'current year' brood, had that brood been fished on under base period conditions. Output is OOBCatch & OOBEscapement. The key input for this exercise is the ratio of the exploitation rate by each fishery in the current year to the exploitation rate of the same fishery during the base period (i.e., a fishery scalar). This scalar is derived independently of the calibration process. Ideally, it would be estimated for each fishery using a number of CWT stocks that are similar to the stock in question and which were tagged both in the current base period years and the OOB years. The program flow is the following:

- Compute maturation rates from data derived in backwards analysis
- Compute exploitation rates in current year: recoveries*ExpFactor/(cohort * ppnVulnerable)
  ExpFactor = TotEscapement/CWTEscapement
- Conduct forward cohort analysis starting with age 2 abundance using new maturation rates, fishery scalars, exploitation rates (see above), and base period proportion vulnerable.

All ChDat and ChCal functions have been built into the new **'Main Calibration Program'**, which was programmed in Visual Basic .NET and uses ACCESS for all file inputs and outputs. In addition to doing its primary tasks, The Main Calibration Program includes new capabilities that allow it to rapidly export Base Period files that can be seamlessly imported to FRAM for implementation.

Resolving Data Gaps and Challenges

Developing datasets from CWT recoveries often involves dealing with data gaps for brood years, stocks, and/or fisheries. As in the current FRAM base period, there are cases where fisheries or stocks are not adequately represented by tag recoveries. Table 1 shows the number of CWT recoveries for the base period tag group by FRAM fishery strata. The CWT recoveries from surrogate fisheries are assigned under the following situations: 1) the number of CWT recoveries per stratum (fishery-time step) is deemed to be inadequate (N < 20 observed tags), and 2) where a fishery stratum covers a time and area where Chinook were encountered or landed (or expected to be in upcoming fisheries) in significant numbers (>100 for example) but without any affiliated tag data (e.g., due to sampling gaps). Assignment of surrogate fisheries was made by the FWG based on data proximity in space and time. That is, candidate surrogate fisheries were those that had an adequate number of recoveries and were either (a) the same fishery area but in a different (adjacent) time step, or (b) an adjacent fishery in the same time step. Local knowledge of the fishery was also used to guide the selection of surrogate fisheries.

The other case where CWT analysis can be problematic is in stock representation. The FRAM stock tag groups in Table 2 identify stocks for which there are not representative CWT groups for the brood years chosen for the proposed base period, nor are there suitable surrogate stock tag groups that have similar life histories, ocean distribution patterns, and fishery exposure. These were relegated to become OOB stocks for which CWT recoveries are adjusted to simulate the recoveries that would have occurred during the base period years. A stopgap adjustment method was selected by the FWG so that these stocks could be incorporated, albeit in a draft form, while a full-blown calibration commences; once a solid draft base emerges and post-season "validation" runs are completed, these stocks will be incorporated using the traditional OOB procedure. This preliminary OOB accommodation was achieved using a combination of approaches, including surrogate tag assignment (e.g., South Puget Sound Yearlings for University of Washington-Accelerated), tag release-recovery simulation generated using the existing base period and recent validation runs (e.g., Juan de Fuca), and/or manual OOB adjustment (i.e., OOB recs = obs'd recs * fishery scalar, where fishery scalar was estimated using independent data).

Mark selective fisheries present new challenges to development of the base period data set that were not an issue with the existing base period. The CWT groups selected included only adipose marked and CWT'd release groups. Some of the fisheries in the new base period were mark selective especially in the Puget Sound recreational fishery. The problem arises in the calibration process where the legal-size encounter rates in the CWT cohort analysis are applied to the estimate of total production from a stock unit. In mark selective fisheries, the CWT based encounter rates are estimated from the pool of fish that are adipose marked; not the total production. In fisheries that are not mark selective, the pool of fish available in the fishery is the total production. The base period calibration program and FRAM are single pool systems and are not designed to operate on different pools of fish depending on whether the fishery is mark selective or not. The calibration program must be run either in a mode where the landed catch in all fisheries and the abundances of all stocks are in terms of marked-only or where the landed catch and abundances are in terms of total production of marked and unmarked fish. In addition to this traditional "total production" perspective, the FWG has developed a set of marked-only landed catches and marked only river run sizes. The FWG has run the calibration program and created two base period data sets; a marked-only set and one from a total production perspective. Each has their attributes and shortfalls. The marked-only data set is a better representation that captures mark selective fisheries but includes more uncertainty regarding estimates of marked-only landed catch and marked-only abundance estimates. The total production perspective does not represent mark selective fisheries correctly but does have firm estimates of total landed catch and total production.

As the primary output, the calibration program produces estimates of legal-size encounter rates in FRAM fisheries and cohort abundances by stock and age prior to fishing. In simplistic terms, the base data set of legal-size encounter rates applied to the stock cohort sizes will produce an estimate of landed catch for a stock. The sum of the landed catch across all stocks will not equal the observed landed catch (though in a perfect system it would). Sometimes the summed catch is more than the observed landed catch, sometimes it is less. This factor is the Model Stock Proportion (MSP) and in the base period data set becomes a constant adjustment to the landed catch input in the model. The MSP is a fixed value from the base period calibration and does not change between years and model runs. The MSP used in the base period data set can either be from the value calculated in the calibration program or can be external values.

The FWG discussed which of the base period data sets would be the most representative. We decided that the mark-only perspective to calculate encounter rates was preferred. However, MSPs from the two runs were very different for some fisheries. We attributed part of this difference to the uncertainty surrounding the estimates of marked abundance and the marked-only landed catch in the fisheries without mark selective regulations, which is most of the fisheries. A base period data set ("beta" version) that we have used for initial evaluation have used the MSPs from the total production perspective except where we have external estimates or where we have assigned a value of 1.0 where there should not be any non-modeled stocks (eg in Puget Sound fisheries).

Appendix B contains a detailed discussion of the issue regarding marked only and total production perspective and the differences in MSP.

Results

We have begun some preliminary examination of results from FRAM using the "beta" version of the new base period. So far, this is primarily in terms of comparison of stock composition estimates from the new base period compared to the old base period using common stock abundances. This comparison, of course, is only between base period datasets without regard to which may be "best" and can only give a feel for how things have changed. We are also compiling data from Genetic Stock Identification (GSI) sampling studies to provide an independent estimate of stock composition to FRAM results. Examples of this comparison are shown in Attachment C for the Washington nontreaty troll fishery Area 2 (Westport) and Area 3 and 4 (LaPush, Neah Bay). We have not had time to evaluate these comparisons but acknowledge the variability in the stock composition estimates from FRAM and GSI.

Remaining Tasks

In addition to working through the data gaps and challenges mentioned above, the FRAM base period FWG has a number of tasks that require additional work. Of course, there is formal documentation work that needs to be completed. The FWG is well along with portions of this with the stock and fishery profiles that will provide a background record of the measure and source for many of the data pieces that are part of the base period calibration process. The FRAM documentation on the Council website will be reviewed and modified accordingly to cover the base period data development process for Chinook.

Another important task to be completed by the FWG, is further analysis of the differences in FRAM from the old and new base period regarding important FRAM outputs, such as exploitation rates for key stocks in the Pacific Coast Salmon Plan and stocks listed under the ESA. In particular, FRAM provides the data to calculate exploitation rates for ESA listed Chinook stocks in the Columbia River and in Puget Sound. (Ocean fishery impacts on Chinook stocks from the Klamath River and California are assessed using the Klamath Ocean Harvest Model, Sacramento Harvest Model, and the Winter Run Harvest Model). Comparisons of both preseason and post season exploitation rates for the key stocks from FRAM using the different base period datasets will help to better understand, refine, and modify if appropriate, management objectives for these stocks. In addition, comparisons of stock composition estimates from FRAM and other GSI studies will be expanded.

A summary report covering the effects on key stock exploitation rates and other results of the new base period will be prepared by the FWG for review by state and tribal technical staffs and comanagers. This summary report and review is tentatively expected to occur by the end of the year.

My Summary Thoughts

The task of developing a fishery model dataset is often a large undertaking and often fraught with surprises and frustration. The FWG quickly confirmed this but soldiered on knowing that the time was now to move away from 35 year old data for the foundation of FRAM. The task was to update the base data and not embark on a restructuring of FRAM. To do both could take years with completion uncertain. The primary benefits of completing this base period project for implementation in the near future are:

1. The base period dataset uses contemporary CWT data reflecting current stocks abundances and fishery seasons and structure.
2. The foundation for the base period CWT recovery data is provided in the CAS database that has been annually scrubbed and refined by the CTC.
3. The source and derivation of other data pieces such as sublegal encounters, sublegal/legal ratios, and growth parameters are known.
4. Modifying the database and calibration programs to have interchangeable linkage will greatly streamline the base period development system to facilitate updates in future years.
5. The basis for the base period data becomes much more transparent and understandable for technical staff and fishery managers.

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Table 1. Observed recoveries of CWTs in base period data sets for Chinook FRAM (Council fisheries in yellow)													
		Proposed base period				Existing base period				Ratio new/old			
FishID	FisheryName	Oct-Apr	May-Jun	Jul-Sep	Oct-Sep	Oct-Apr	May-Jun	Jul-Sep	Oct-Sep	Oct-Apr	May-Jun	Jul-Sep	Oct-Sep
1	SE Alaska Troll	722	369	2,928	4,019	70	1,436	1,557	3,063	10.31	0.26	1.88	1.31
2	SE Alaska Net	-	32	150	182	-	6	68	74		5.33	2.21	2.46
3	SE Alaska Sport	1	215	241	457	10	1,324	1,062	2,396	0.10	0.16	0.23	0.19
4	BC No/Cent Net	-	-	13	13	-	18	955	973		0.00	0.01	0.01
5	BC WCVI Net	-	1	2	3	18	158	171	347	0.00	0.01	0.01	0.01
6	BC Georgia Strait Net	-	-	-	-	48	6	452	506	0.00	0.00	0.00	0.00
7	BC JDF Net	-	-	-	-	1	-	348	349	0.00		0.00	0.00
8	BC Outside Sport	14	322	885	1,221	14	26	34	74	1.00	12.38	26.03	16.50
9	BC No/Cent Troll	-	708	955	1,663	8	846	2,039	2,893	0.00	0.84	0.47	0.57
10	BC WCVI Troll	265	1,427	763	2,455	497	1,494	2,152	4,143	0.53	0.96	0.35	0.59
11	BC WCVI Sport	36	483	1,505	2,024	12	36	139	187	3.00	13.42	10.83	10.82
12	BC Georgia Strait Troll	-	-	-	-	108	340	495	943	0.00	0.00	0.00	0.00
13	BC N Georgia Strait Sport	33	208	299	540	305	379	602	1,286	0.11	0.55	0.50	0.42
14	BC S Georgia Strait Sport	28	10	7	45	265	107	286	658	0.11	0.09	0.02	0.07
15	BC JDF Sport	115	77	226	418	336	60	177	573	0.34	1.28	1.28	0.73
16	NT Area 3:4:4B Troll	-	575	126	701	-	217	410	627		2.65	0.31	1.12
17	Tr Area 3:4:4B Troll	-	724	642	1,366	214	97	89	400	0.00	7.46	7.21	3.42
18	NT Area 3:4 Sport	1	25	234	260	-	34	73	107		0.74	3.21	2.43
19	No Wash. Coastal Net	-	-	-	-	-	-	3	3			0.00	0.00
20	NT Area 2 Troll	-	679	191	870	-	530	455	985		1.28	0.42	0.88
21	Tr Area 2 Troll	-	-	-	-	-	14	1	15		0.00	0.00	0.00
22	NT Area 2 Sport	-	240	691	931	-	246	411	657		0.98	1.68	1.42
23	NrT G. Harbor Net	1	-	5	6	-	-	14	14			0.36	0.43
24	T G. Harbor Net	-	-	-	-	-	-	-	-				
25	Willapa Bay Net	5	-	470	475	17	-	220	237	0.29		2.14	2.00
26	Area 1 Troll	-	358	77	435	-	254	58	312		1.41	1.33	1.39
27	Area 1 Sport	-	81	588	669	-	99	344	443		0.82	1.71	1.51
28	Columbia River Net	-	-	-	-	-	-	-	-				
29	Buoy 10 Sport	-	-	-	-	-	-	-	-				
30	Central OR Troll	286	661	268	1,215	53	224	347	624	5.40	2.95	0.77	1.95
31	Central OR Sport	9	26	103	138	-	15	64	79		1.73	1.61	1.75
32	KMZ Troll	-	45	84	129	1	3	14	18	0.00	15.00	6.00	7.17
33	KMZ Sport	1	151	241	393	1	14	17	32	1.00	10.79	14.18	12.28
34	So Calif. Troll	2	1,641	2,139	3,782	-	295	176	471		5.56	12.15	8.03
35	So Calif. Sport	337	496	907	1,740	72	69	104	245	4.68	7.19	8.72	7.10
36	NT Area 7 Sport	219	-	74	293	138	21	32	191	1.59	0.00	2.31	1.53
37	NT Area 6A:7:7A Net	1	-	59	60	22	-	492	514	0.05		0.12	0.12
38	Tr Area 6A:7:7A Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
39	NT Area 7B-7D Net	3	-	744	747	11	-	1,035	1,046	0.27		0.72	0.71
40	Tr Area 7B-7D Net	5	-	776	781	-	-	-	-				
41	Tr JDF Troll	100	56	1	157	398	7	3	408	0.25	8.00	0.33	0.38
42	NT Area 5 Sport	13	1	617	631	38	29	208	275	0.34	0.03	2.97	2.29
43	NT JDF Net	1	2	146	149	30	18	300	348	0.03	0.11	0.49	0.43
44	Tr JDF Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
45	NT Area 8-1 Sport	101	-	-	101	98	18	59	175	1.03	0.00	0.00	0.58
46	NT Skagit Net	-	2	6	8	7	9	87	103	0.00	0.22	0.07	0.08
47	Tr Skagit Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
48	NT Area 8D Sport	-	3	9	12	-	-	5	5			1.80	2.40
49	NT St/Snohomish Net	-	-	8	8	21	1	239	261	0.00	0.00	0.03	0.03
50	Tr St/Snohomish Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
51	NT Tulalip Bay Net	-	143	64	207	12	-	284	296	0.00		0.23	0.70
52	Tr Tulalip Bay Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
53	NT Area 9 Sport	70	-	284	354	247	68	153	468	0.28	0.00	1.86	0.76
54	NT Area 6 Sport	95	-	129	224	210	74	236	520	0.45	0.00	0.55	0.43
55	Tr Area 6B:9 Net	8	-	-	8	4	-	5	9	2.00		0.00	0.89
56	NT Area 10 Sport	50	-	261	311	182	16	88	286	0.27	0.00	2.97	1.09
57	NT Area 11 Sport	29	41	206	276	184	37	65	286	0.16	1.11	3.17	0.97
58	NT Area 10:11 Net	7	-	4	11	56	-	207	263	0.13		0.02	0.04
59	Tr Area 10:11 Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
60	NT Area 10A Sport	-	-	-	-	-	-	-	-				
61	Tr Area 10A Net	-	-	119	119	2	-	145	147	0.00		0.82	0.81
62	NT Area 10E Sport	-	-	-	-	-	-	-	-				
63	Tr Area 10E Net	-	-	30	30	-	-	-	-				
64	NT Area 12 Sport	71	-	12	83	80	11	17	108	0.89	0.00	0.71	0.77
65	NT Hood Canal Net	2	-	144	146	20	-	149	169	0.10		0.97	0.86
66	Tr Hood Canal Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
67	NT Area 13 Sport	4	6	12	22	204	35	36	275	0.02	0.17	0.33	0.08
68	NT SPS Net	-	-	14	14	11	-	39	50	0.00		0.36	0.28
69	Tr SPS Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
70	NT Area 13A Net	-	-	4	4	14	-	76	90	0.00		0.05	0.04
71	Tr Area 13A Net	NT above	NT above	NT above	NT above	NT above	NT above	NT above	NT above				
72	Freshwater Sport	-	-	-	-	-	-	-	-				
73	Freshwater Net	-	-	-	-	-	-	-	-				
74	Escapement	15,064	1,475	69,913	86,452	2,294	94	19,224	21,612	6.57	15.69	3.64	4.00
	Preterminal total tags	**2,635**	**9,808**	**18,463**	**30,906**	**4,039**	**8,691**	**17,297**	**30,027**	**0.65**	**1.13**	**1.07**	**1.03**
	Grand total tags	**17,699**	**11,283**	**88,376**	**117,358**	**6,333**	**8,785**	**36,521**	**51,639**	**2.79**	**1.28**	**2.42**	**2.27**

Table 2. Observed CWT recoveries by stock in fisheries (no escapement) in FRAM base period.													
		Proposed base period				Existing base period				Ratio new/old			
StockNum	StockName	Oct-Apr	May-Jun	Jul-Sep	Oct-Sep	Oct-Apr	May-Jun	Jul-Sep	Oct-Sep	Oct-Apr	May-Jun	Jul-Sep	Oct-Sep
2	Nooksack/Samish Fall	104	256	1742	2102	706	509	2295	3510	0.1	0.5	0.8	0.6
4	NF Nooksack Spr	90	98	156	344	OOB	OOB	OOB	OOB				
6	SF Nooksack Spr	SF NKsp	SF NKsp	SF NKsp	SF NKsp	OOB	OOB	OOB	OOB				
8	Skagit Summer/Fall Fing	80	108	228	416	328	309	755	1392	0.2	0.3	0.3	0.3
10	Skagit Summer/Fall Yrl	OOB	OOB	OOB	OOB								
12	Skagit Spring Year	54	13	50	117	OOB	OOB	OOB	OOB				
14	Snohomish Fall Fing	51	36	57	144	OOB	OOB	OOB	OOB				
16	Snohomish Fall Year	58	31	80	169	322	181	446	949	0.2	0.2	0.2	0.2
18	Stillaguamish Fall Fing	101	96	130	327	OOB	OOB	OOB	OOB				
20	Tulalip Fall Fing	54	165	116	335	OOB	OOB	OOB	OOB				
22	Mid PS Fall Fing	154	341	788	1283	367	243	737	1347	0.4	1.4	1.1	1.0
24	UW Accelerated (discontinued stock)	na	na	na	na	na	na	na	na				
26	South Puget Sound Fall Fing	66	201	385	652	84	27	128	239	0.8	7.4	3.0	2.7
28	South Puget Sound Fall Year	44	40	169	253	152	41	112	305	0.3	1.0	1.5	0.8
30	White River Spring Fing	OOB	OOB	OOB	OOB	OOB	OOB	OOB	OOB				
32	Hood Canal Fall Fing	123	276	505	904	114	63	224	401	1.1	4.4	2.3	2.3
34	Hood Canal Fall Year	70	27	139	236	14	4	20	38	5.0	6.8	7.0	6.2
36	Juan de Fuca Fall Fing	OOB	OOB	OOB	OOB	BP+OOB	BP+OOB	BP+OOB	BP+OOB				
38	CR Oregon Hatchery Tule	12	179	154	345	33	97	104	234	0.4	1.8	1.5	1.5
40	CR Washington Hatchery Tule	19	192	283	494	9	86	138	233	2.1	2.2	2.1	2.1
42	Lower Columbia River Wild	5	32	67	104	7	109	117	233	0.7	0.3	0.6	0.4
44	CR Bonneville Pool Hatchery	31	442	370	843	408	1562	1766	3736	0.1	0.3	0.2	0.2
46	Columbia R Upriver Summer	251	912	776	1939	BP+OOB	BP+OOB	BP+OOB	BP+OOB				
48	Columbia R Upriver Bright	12	124	442	578	34	970	1157	2161	0.4	0.1	0.4	0.3
50	Cowlitz River Spring	10	76	221	307	15	149	244	408	0.7	0.5	0.9	0.8
52	Willamette River Spring	202	279	230	711	60	603	590	1253	3.4	0.5	0.4	0.6
54	Snake River Fall	37	1147	1733	2917	OOB	OOB	OOB	OOB				
56	Oregon North Coast Fall	32	267	1029	1328	2	202	354	558	16.0	1.3	2.9	2.4
58	WCVI Total Fall	100	200	470	770	19	1398	1982	3399	5.3	0.1	0.2	0.2
60	Fraser River Late	51	487	870	1408	OOB	OOB	OOB	OOB				
62	Fraser River Early	50	284	481	815	OOB	OOB	OOB	OOB				
64	Lower Georgia Strait	99	249	431	779	162	324	765	1251	0.6	0.8	0.6	0.6
66	Oregon Mid Coast Fall (NEW)	164	123	336	623	0	0	0	0				
68	Lower Columbia Naturals	31	371	437	839	73	498	568	1139	0.4	0.7	0.8	0.7
70	Central Valley Fall	445	2663	3639	6747	OOB	OOB	OOB	OOB				
72	WA North Coast Fall	35	264	1034	1333	10	117	144	271	3.5	2.3	7.2	4.9
74	Willapa Bay	28	165	1224	1417	OOB	OOB	OOB	OOB				
76	Hoko River	3	35	128	166	OOB	OOB	OOB	OOB				
	Total Fishery Recoveries	2666	10179	18900	31745	2919	7492	12646	23057	0.9	1.4	1.5	1.4

BP= Base Period Stock; OOB=Out-of-Base Stock

Appendix A

Attachment A: Example of tab in Stock Profile spreadsheet

Stock profile

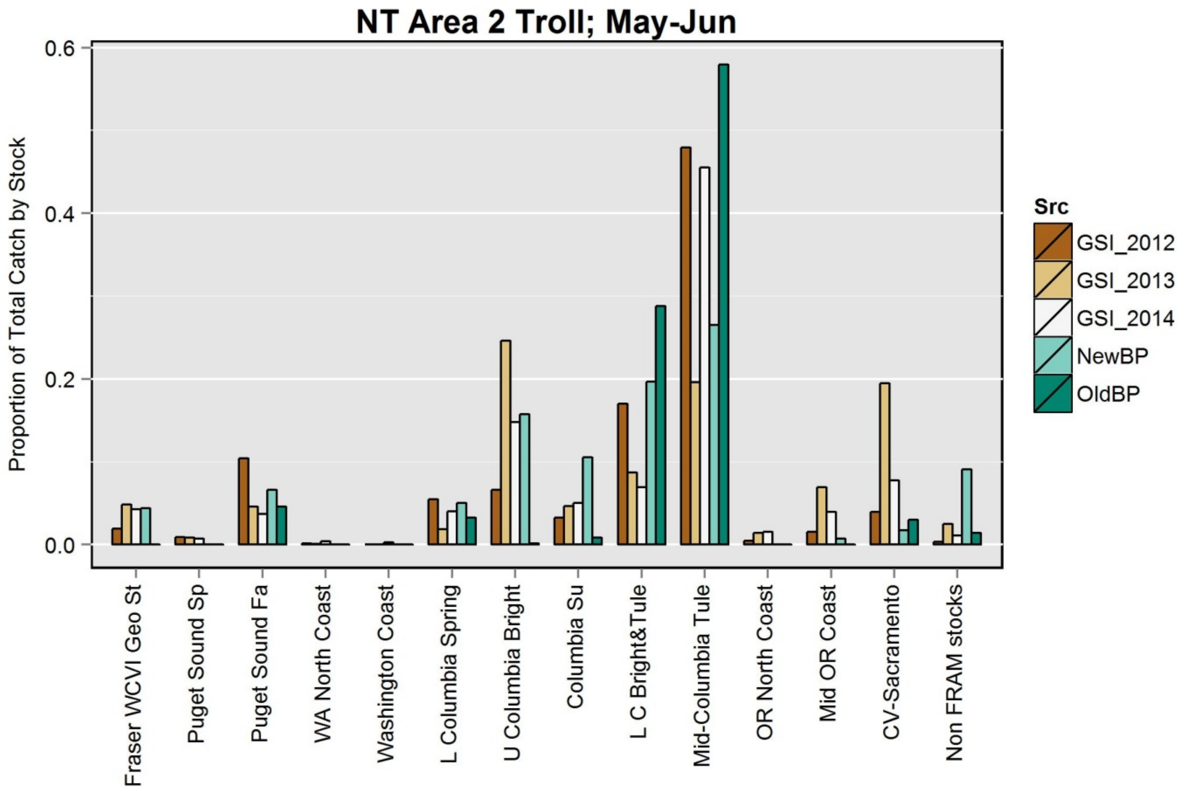
Stock Name:	Marked Columbia Upriver Summer
Aggregate Stock Abbreviation:	SUM
Management Units Represented:	Adipose-clipped Natural and hatchery summer chinook from mainstem and tributaries upstream of Priest Rapids Dam. Hatchery facilities include Wells Dam, Rocky Reach, Eastbank, Methow, Similkameen, and Chief Joseph. The production includes a mix of yearling and fingerling releases (~44% yearling for CWT releases)
Calibration CWT Groups: (by RMIS release hatchery)	WELLS HATCHERY -- BY2005: 633298, 633299, 633596; BY2006: 633385, 633386, 633799; BY2007: 633871, 633872, 634287, 634390; BY2008: 634876, 635092, 635093; [total release: 2,895,784]
Validation CWT Groups:	
Growth Function Details:	mean FL = Linf[1-exp(-k[t-t0])], where Linf = 950 k = 0.037 t0 = 7.0, and t= (Age-1)*12+timestep midpt.; CV2: 13%, CV3: 11%, CV4: 8%, CV5: 6% Estimated using marine recoveries for all Col. R. bright CWT calibration codes.
Accounted in Terminal Run (TR) (or terminal area abundance in Puget Sound):	Return to the mouth of the Columbia River of summer run Chinook destined for areas above Priest Rapids Dam.
Accounted in Extreme Terminal Run Size (ETRS):	Same as Terminal Run
Scale Data Origin:	Age composition of returns to the Columbia River from Columbia River Technical Advisory Committee, forecast database.
Supplemental Data Sources:	
Other Notes:	A variety of CWT codes are available that are not included in the BP for this stock; due to uncertain propagation (e.g., crosses) and CWT recovery histories for non-Wells codes, they are limited to Wells

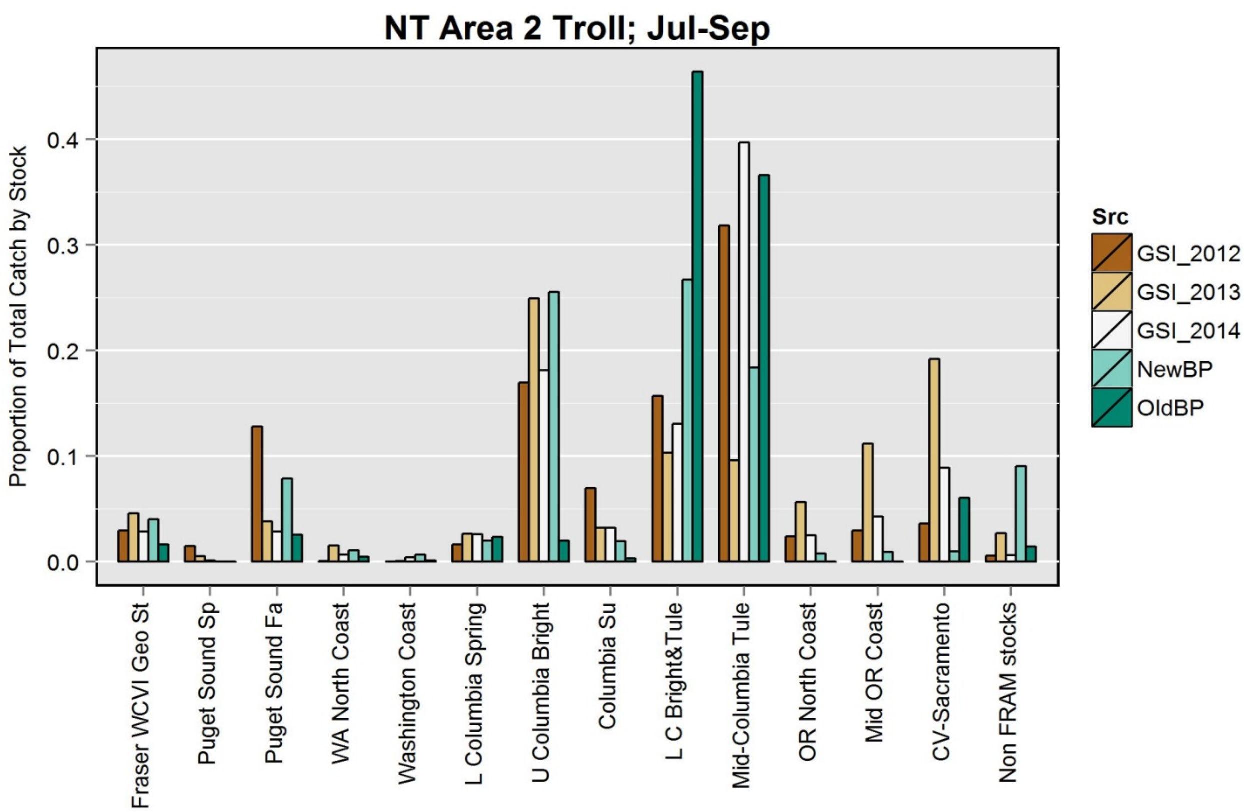
Attachment B: Example of tab in Fishery Profile spreadsheet

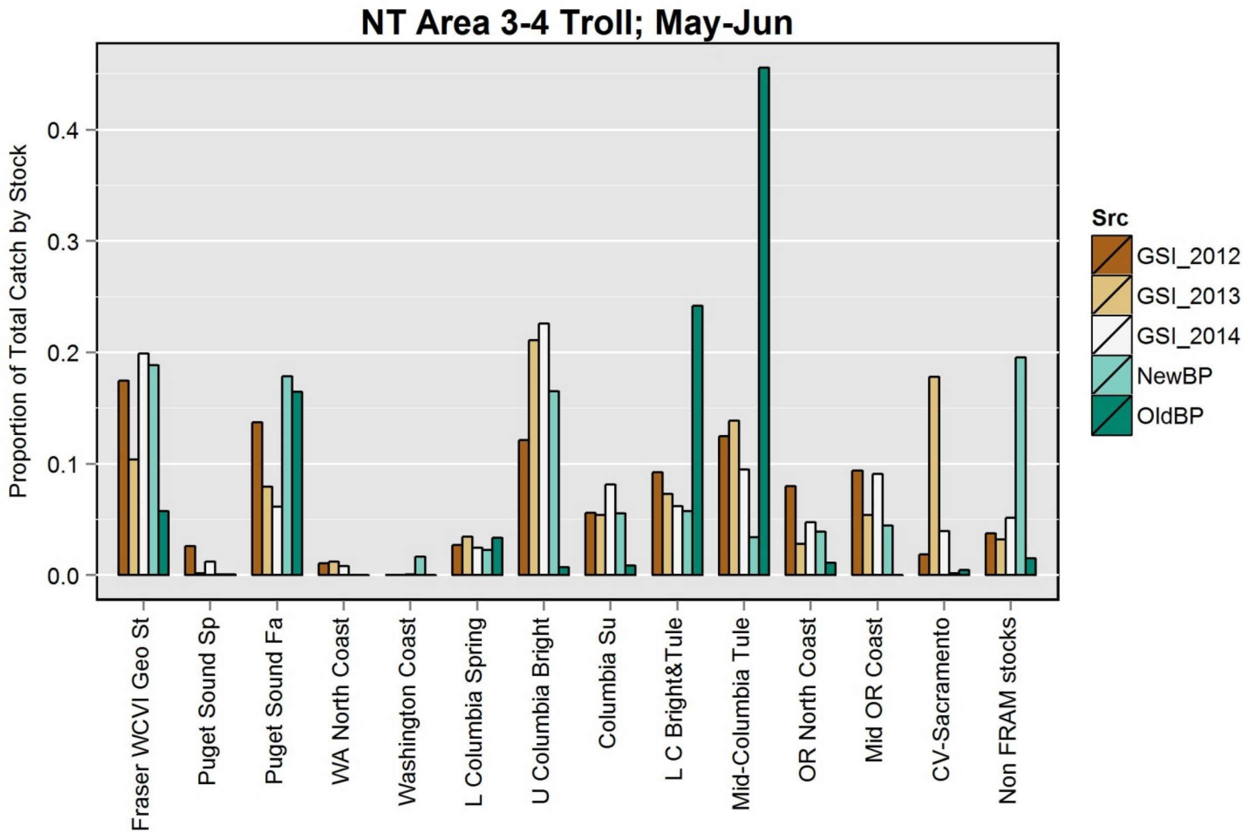
Fishery Profile

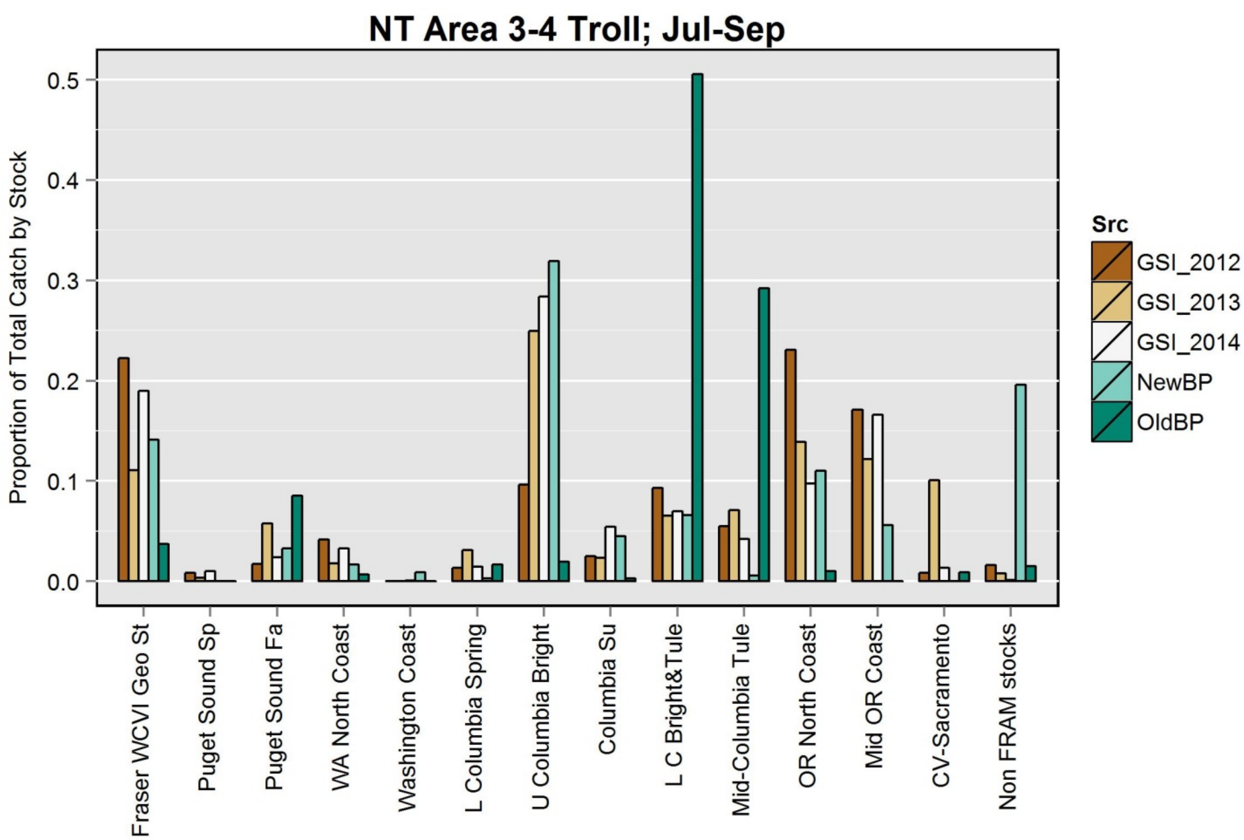
	NT Area 3:4:4B Troll
FishID/Fishery #:	16
Statistical Areas Included:	Washington Marine Areas 3-4 (4B is included in the model fishery but hasn't been opened to NT trollers for some time)
BP Min Size Limit (FL, mm):	670
BP NS Regulations:	Non-selective Chinook retention (quota dependent) during May-Jun & Jul-Sep management periods
BP MSF Regulations:	None
BP CNR Regulations:	approx. ___ vessel days on average when coho quota remains but Chinook impacts are limited
BP Catch:	0-Time 1, 6670 -Time 2, 4170 -Time 3,
BP Sublegal:Legal Ratio:	NA-Time 1, 0.925 -Time 2, 0.315 -Time 3,
Surrogate Fishery:	None
Model Stock Proportion:	80%
FRAMBuilder Mapping Rules:	-- CWTs mapped to combined Treaty+Non-treaty Areas 3:4:4B troll fishery using CAS's mapping rules and lookup; split into treaty and non-treaty components thereafter based on the 'CWDBFishery' field in CAS (10 = Non-treaty; 15 = Treaty)
References:	For sublegal encounter rates, see McHugh et al. 2013 PFMC Model Review Doc. (http://www.pcouncil.org/wp-content/uploads/C2a_ATT3_FRAM_RVW_ExternalSublegals_Oct9_NOV2013BB.pdf)
Catch Data Sources/Contacts:	Wendy Beeghley and Doug Milward, Washington Dept. of Fish & Wildlife

Attachment C: Comparison of stock composition in nontreaty troll fishery from GSI and Base Period






NT Area 3-4 Troll; May-Jun
Proportion of Total Catch by Stock
0.0
0.1
0.2
0.3
0.4
Src
GSI_2012
GSI_2013
GSI_2014
NewBP
OldBP
Fraser WCVI Geo St
Puget Sound Sp
Puget Sound Fa
WA North Coast
Washington Coast
L Columbia Spring
U Columbia Bright
Columbia Su
L C Bright&Tule
Mid-Columbia Tule
OR North Coast
Mid OR Coast
CV-Sacramento
Non FRAM stocks


NT Area 3-4 Troll; Jul-Sep
Proportion of Total Catch by Stock
0.0
0.1
0.2
0.3
0.4
0.5
Src
GSI_2012
GSI_2013
GSI_2014
NewBP
OldBP
Fraser WCVI Geo St
Puget Sound Sp
Puget Sound Fa
WA North Coast
Washington Coast
L Columbia Spring
U Columbia Bright
Columbia Su
L C Bright&Tule
Mid-Columbia Tule
OR North Coast
Mid OR Coast
CV-Sacramento
Non FRAM stocks

Appendix B

Develop the new Base Period Using Marked Landed Catches and Escapements versus Total Landed Catches and Escapements (Angelika Hagen-Breaux, August 2015)

Overview

Similar to the existing FRAM Chinook base period, the new base period uses CWT recoveries from marked Chinook to compute base period exploitation rates (ER). Therefore, marked Chinook represent both marked and unmarked components of the same stock in both base periods. Unmarked exploitation rates cannot be assessed directly, because unmarked stock components are only sporadically tagged (double index tag, DIT, groups). Even when tagged, these tags are often not recovered, because some fisheries are not electronically sampled for CWTs, or in the case of mark-selective fisheries (MSF), unmarked Chinook are not retained.

In developing the existing base period, CWT recoveries were related to total catches and total escapements to compute exploitation rates ("Total" frame of reference). Due to the influence of mark-selective fisheries in recent years, the new base period relates CWT recoveries to marked catches and marked escapement only ("Marked" frame of reference). The latter data manipulation allows for calibration under contemporary fishery conditions using the same calibration algorithms and procedures that have been used in the past; it simply views everything as a non-selective fishery (NSF) in a world populated by marked fish only. Doing otherwise (i.e., using total catches in mark-selective fisheries), would necessitate time consuming changes to calibration algorithms and infrastructure (i.e., databases, pre-processing programs/files) in order to relate recoveries to encounters rather than landed catches and to incorporate mark-selective fishing parameters.

Beyond calibration logistics, the "marked" frame of reference is preferable for at least three reasons. First, given the existence of a mix NSF and MSF regulations, the "marked" approach will yield cohort reconstruction results with considerably less bias than the "total" approach. Second, even with full-electronic sampling, sufficient DIT groups, and a means to integrate them into calibration, a "total" calibration would necessarily yield a base period built on specific MSF parameter assumptions (i.e., release mortality rates); these may or may not be consistent with future FRAM applications. Lastly, the inputs to a "marked" calibration are likely to have more certainty associated with them than those for a "total" calibration. Consider, for example, hatchery and wild escapement estimates—the former is often a census whereas the latter is an estimate with considerable imprecision and (possibly) bias.

Despite its obvious merits, the "marked" calibration approach introduces its own challenges. Most significantly, upon creation, a "marked" base period must be translated into something that can be applied on a "total" basis. Although this is straightforward for exploitation rates (i.e., ER for marked stocks become exploitation rates or encounter rates for unmarked stocks in NSF and MSF, respectively), "total" applications also require an estimate of model stock proportion (MSP). MSP is the expected fraction of a fishery's total catch that is comprised of model stocks. To decide whether to use "total" versus "marked" data, we performed a calibration using both approaches and assessed the magnitude of the difference for key outputs between the two approaches. Here, we review differences between total mortality, terminal abundance, ERs, and MSPs for the two approaches.

Assessment Approach

Two separate calibrations were conducted:

1) We performed a separate Marked and Total calibration using marked only catch and escapement and total catch and escapement, respectively. For mark selective fisheries, landed catches of marked fish were converted to total encounters of marked and unmarked fish. (Note: We did not adjusted unmarked estimates for release mortality in mark selective fisheries).
2) We developed a starting FRAM run (forward run) by first exporting parameters from the Total run. We exported base period abundances of marked and unmarked Chinook, adult equivalencies (AEQs), maturation rates, model stock proportions, and exploitation rates from the Total calibration. Fisheries were modeled at base period levels with a fishery scalar of 1.

3) For running FRAM with Marked calibration output, the Total FRAM run was copied. Fisheries were modeled using the resulting catches from the Total run by converting fishery flags from scalars to quotas. Base period exploitation rates, AEQs, and maturation rates were imported from the Marked calibration. Model stock proportions were left unchanged from the Total run.
4) Marine exploitation were computed from FRAM output of AEQ mortalities and escapements. Table 1 compares total AEQ mortalities, extreme terminal run sizes, and exploitation rates from both runs.

Relevant Calibration Algorithms

Where s = stock, a = age, f = fishery, t = time step,

- Compute a production expansion factor by stock:

$$EscExpFact_s = \frac{ActualEscapement_s}{CWTEscapement_s}$$

- Compute expanded catch for a stock, by age, fishery, time step:

$$EscExpandedCWTCatch_{s,a,f,t} = EscExpFact_s * CWT_{s,a,f,t}$$

- Compute estimated catch for a fishery and time step by summing over stocks and ages:

$$CWTCatch_{f,t} = \sum_{s,a} EscExpandedCWTCatch_{s,a,f,t}$$

- Deal with the difference between actual catch and CWT estimated catch:

$$(1) FisheryExpFact_{f,t} = \frac{ActualCatch_{f,t}}{CWTCatch_{f,t}}$$

$$(2) Fish\&EscExpandedCWTCatch_{s,a,f,t} = EscExpandedCWTCatch_{s,a,f,t} * FisheryExpFact_{f,t}$$

$$(3) NewCWTCatch_{f,t} = \sum_{s,a} Fish\&EscExpandedCWTCatch_{s,a,f,t}$$

$$ModelStockProportion_f = \frac{\sum_t CWTCatch_{f,t}}{\sum_t ActualCatch_{f,t}}$$

- For most Puget Sound fisheries, CWTCatch is scaled to match actual catch (assumption of 100% stock coverage)
- For most of the remaining fisheries, if CWTCatch < Actual Catch, CWTs are not expanded, but CWTCatch/ActualCatch becomes the model stock proportion. If CWTCatch > Actual Catch recoveries are adjusted as previously described.

Preliminary Modeling Results

Table 1. Mortalities, freshwater run sizes, and marine exploitation rates from a draft new base period model run using "Marked" versus "Total" frame of reference.

		Mortality		River Return		Marine ER	
Stock	StkName	"Marked"	"Total"	"Marked"	"Total"	"Marked"	"Total"
1	NkSm FF	1783	1798	1498	1429	54.3%	55.7%
3	NFNK Sp	733	755	1153	1128	38.9%	40.1%
7	Skag FF	5015	5305	13322	12738	27.4%	29.4%
11	SkagSpY	232	240	1081	1073	17.7%	18.3%
13	Snoh FF	1114	1152	3670	3660	23.3%	23.9%
15	SnohFYr	659	677	1335	1321	33.1%	33.9%
17	Stil FF	238	248	677	668	26.0%	27.1%
19	Tula FF	1963	1858	61	141	97.0%	92.9%
21	MidPSFF	5221	5367	10380	10271	33.5%	34.3%
23	UWAc FF	209	218	1082	1084	16.2%	16.7%
25	SPSd FF	3130	3144	6915	6835	31.2%	31.5%
27	SPS Fyr	52	52	53	52	49.8%	50.1%
31	HdCl FF	6900	7054	15318	15095	31.1%	31.8%
33	HdCl FY	56	56	90	88	38.4%	38.7%
35	SJDF FF	12095	12148	36827	35357	24.7%	25.6%
37	OR Tule	2362	2441	6581	6492	26.4%	27.3%
39	WA Tule	3667	3764	13487	13167	21.4%	22.2%
41	LCRWild	6908	6819	12541	12050	35.5%	36.1%
43	BPHTule	2146	2212	9127	9051	19.0%	19.6%
45	UpCR Su	17691	17706	39582	38339	30.9%	31.6%
47	UpCR Br	136696	131827	401785	378066	25.4%	25.9%
49	Cowl Sp	373	386	3467	3423	9.7%	10.1%
51	Will Sp	832	868	10934	10701	7.1%	7.5%
53	Snake F	6147	6307	21765	21490	22.0%	22.7%
55	OR No F	35056	33589	95823	89437	26.8%	27.3%
57	WCVI Tl	67062	66253	135809	127197	33.1%	34.2%
59	FrasRLt	31652	33214	153669	153417	17.1%	17.8%
61	FrasREr	44419	46117	174576	170250	20.3%	21.3%
63	LwGeo S	13130	13549	27703	27127	32.2%	33.3%
67	LColNat	2011	2060	6372	6222	24.0%	24.9%
69	CentVal	18725	18812	157440	157252	10.6%	10.7%
71	WA NCst	17203	15719	26298	24578	39.5%	39.0%
73	Willapa	13894	13667	14656	13635	48.7%	50.1%
75	Hoko Rv	121	122	481	460	20.1%	21.0%

Catches in the "Marked Run" were modeled as quotas to match catches in "Total Run" with fish scalars set to 1. Starting cohorts in the "Total Run" reflect base period abundances. Cohorts in "Marked Run" were set to match "Total Run". Both runs used identical model stock proportions. Mark-selective catches were converted to encounters for the "Total Run" calibration.

Table 2. Fishery Model Stock Proportions (proportion of fishery catch accounted for by model stocks) from a draft new base period model run using “Marked” versus “Total” frame of reference.

Fishery	Fishery Name	Marked %	Total %
1	SEAK Troll	208%	93%
2	SEAK Net	116%	55%
3	SEAK Sport	117%	60%
8	BCOutSport	262%	143%
9	N/C BC Trl	204%	101%
10	WCVI Troll	95%	79%
11	WCVI Sport	194%	149%
13	N GS Sport	74%	132%
15	BC JDF Spt	84%	133%
16	NT 3:4 Trl	82%	80%
17	Tr 3:4 Trl	88%	71%
18	Ar 3:4 Spt	73%	78%
20	NT 2 Troll	88%	91%
22	Ar 2 Sport	138%	162%
23	NT GHb Net	71%	23%
25	WillapaNet	202%	300%
26	NT 1 Troll	91%	100%
27	Ar 1 Sport	108%	140%
30	Cen OR Trl	104%	53%
31	Cen OR Spt	130%	52%
32	KMZ Troll	12%	5%
33	KMZ Sport	10%	5%
34	So Cal Trl	16%	9%
35	So Cal Spt	33%	24%
36	Ar 7 Sport	86%	83%
37	NT 7:7ANet	67%	69%
39	7BCDNet	90%	94%
41	Tr JDF Trl	57%	44%
42	Ar 5 Sport	144%	135%
43	JDF Net	131%	96%
45	Ar 8-1 Spt	67%	66%
46	SkagNet	3%	40%
51	TulaNet	198%	103%
53	Ar 9 Sport	131%	116%
54	Ar 6 Sport	87%	81%
56	A 10 Sport	126%	118%
57	A 11 Sport	83%	68%
61	Tr 10A Net	96%	114%
63	Tr 10E Net	15%	16%
64	A 12 Sport	113%	82%
65	HC Net	81%	94%
67	A 13 Sport	96%	68%
68	SPS Net	3%	3%
70	13A Net	2%	2%

Preliminary Observations

Errors in total or marked escapement estimates as well as errors in total or marked catch estimates are sources of exploitation rate differences when using the “marked” versus the “total” frame of reference. Evaluating the magnitude of error associated with each parameter and resulting impacts on the final exploitation rate calculation will facilitate the selection of an approach.

Model stock proportions vary widely depending on the frame of reference approach used. Again, they represent the proportion of fishery catch accounted for by model stocks. Some stocks are expected to be less than 100% accounted for in the FRAM model, such as SE Alaska Troll, which is expected to have a non-model stocks contribute to the landed catch. However, the differences from expected proportions especially in Puget Sound fisheries, with the assumption that 100% of the stocks are being represented by the model, put into question whether either approach is suitable to estimate this important modeling parameter or whether independent estimates should be pursued. They also illustrate the large variability associated with the fishery expansion factor.

Model stock proportions from the “Marked Calibration” (which used CWT's related to marked catches and escapements) should not be used in a FRAM run, because this parameter is applied to total landed catch in the model. Marked and unmarked stock components in a fishery can have very different model stock proportion; i.e. some Northern fisheries may have very high marked model stock proportions, but low unmarked model stock proportions, because the local non-model stocks are predominantly un-marked. Regardless of these issues, model stock proportions can be a valuable tool for error checking the new base period.

Exploitation rates can be calculated without the use of landed catches or escapements, simply by generating a CWT-based cohort reconstruction. The creators of the original base period calibration system must have found it beneficial to match CWT-based catches to actual observed catches. Perhaps they were seeking to address sampling biases or felt a greater comfort with base period exploitation rates that produce estimated base period catches, or they may have simply needed a method to estimate model stock proportion. However, estimates of escapements as well as catches can be associated with variances that may be larger than any biases the original method was aiming to address. Another source of variance stems from averaging the catches, as well as the escapements, over all base period years and time steps. This is especially problematic when "bookend" fishing years (i.e. those years at the very start or end of the base period time frame), that are only capturing one or two brood years of returning fish, differ significantly from the average.

In line with assessing the precision of total versus marked calibration parameters, the need for fishery expansions should also be evaluated.