Final Report to the Pacific Salmon Commission and their Southern Fund Committee - August 26th, 2014

Name(s):

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Project Number and Title:

SF-2013-I-16 B – Salish Sea Marine Survival Project – Retrospective Analysis of Marine Survival: A Proof of Concept Using Coho Salmon. Year 1

Narrative:

The coho survival workgroup completed a detailed assessment of survival patterns of wild and hatchery coho salmon using cohort reconstructions. This was considered a proof of concept because the process is being used as a template for evaluating other Salish Sea salmon species.

This research activity was a joint effort between U.S. and Canadian scientists of the Salish Sea Marine Survival Project[1]. The coho workgroup convened via web conferencing about once per month (13 times) from September 2013-August 2014, with intermittent sub-group conference calls as needed. The workgroup was facilitated by Kit Rawson (contractor) with support from Iris Kemp (Long Live the Kings employee).

Consistent with the proposal, the coho survival workgroup participants included: Mara Zimmerman, Joe Anderson and support staff (WDFW); Correigh Greene (NOAA); and Jim Irvine, Marc Trudel, Chrys Neville, and Rusty Sweeting (DFO). DFO staff hired consultants Dave Preikshot, Carol Elder, and Megan O'Neill to perform much of the data collection and analyses.

Six questions provide a framework for achieving the long-term objective of this retrospective analysis: To help narrow down the scale and possible sources of mortality, and thereby identify the most likely causes of increased mortality in the Salish Sea (described in detail in the proposal). They are:

1) What are the marine survival trends for Salish Sea salmon and steelhead populations? How do these trends compare to nearby populations outside of the Salish Sea (i. e., control group)?
2) Does survival differ for stocks entering the Salish Sea within different sub-basins (in particular, comparing oceanographic basins of Puget Sound to the Strait of Georgia)? If so, where, when, and to what degree has it varied?
3) Does marine survival more strongly predict adult returns than freshwater survival?

[1] www.marinesurvivalproject.org

4) How much does marine survival differ between hatchery stocks and naturally spawning populations?
5) Does variation in body size, smolt migration timing, or other life-history characters affect marine survival?
6) Is the production of (coho) salmon limited by the carrying capacity of the Salish Sea? What ecosystem indicators best predict marine survival?

Objectives

Per the proposal, the workgroup addressed questions 1-4 by:

A. Investigating patterns of spatial and temporal coherence in smolt-to-adult survivals for wild and hatchery populations of coho salmon within the Salish Sea, and compared these patterns to Pacific Coast reference populations outside the Salish Sea.

B. Comparing hatchery and wild smolt-to-adult (mostly marine) survival.

C. Comparing freshwater and marine survival rates in wild stocks in order to determine which has a stronger influence on population dynamics.

The workgroup also committed to: i) creating a standardized data set to perform A-C and in preparation for future studies, ii) updating the key early marine survival indices for coho salmon entering the Strait of Georgia, and iii) examining data from other regions to determine if similar early marine survival indices could be developed[2].

Deliverables

Four primary products resulted from this effort. All affiliated files are submitted to PSC with this report:

I. (Attachments Ia and Ib) A standardized, QA/QC'ed dataset that includes a data dictionary, run reconstruction data, and biological data (outmigration size and timing) for hatchery and wild coho populations. This dataset will continue to be used over the course of the Salish Sea Marine Survival Project. Biological data was collected to address question 5 of the research activity framework as a next step. An analysis script is included with the dataset.

II. (Attachment IIa) A manuscript completing objectives A and B. The manuscript, titled "Smolt Survival Patterns of Wild and Hatchery Coho Salmon in the Salish Sea" is being submitted to Marine and Coastal Fisheries (an American Fisheries Society journal). The analyses reported in this manuscript were also presented at the 2014 Salish Sea Ecosystem Conference (Attachment IIb - presentation).

III. (Attachment III) A preliminary report addressing objective C. The report is titled "Trends in coho salmon freshwater productivity and smolt-to-adult survival".

IV. (Attachment IV) A report describing the updates to the Strait of Georgia early marine survival indices. The report is titled "Coho salmon early marine survival in the Strait of Georgia".

The dataset, manuscripts, reports, and presentations are being shared among the scientists and technicians (about 150) participating in the Salish Sea Marine Survival Project via a web-based project management utility. The manuscript will also be posted to the marinesurvivalproject.com web site once published, and the dataset will ultimately be available to the general public once the data sharing

[2] See p.4 and 5, and footnotes 3 and 4 in this report for the group's considerations of an early marine survival index for Puget Sound coho.

mechanisms for the Salish Sea Marine Survival Project are complete. LLTK will make sure the published version of the manuscript is provided to PSC as well for their distribution channels.

Results

The results of the analyses are described in detail in the attached reports. From the abstract of the manuscript, "Smolt Survival Patterns of Wild and Hatchery Coho Salmon in the Salish Sea ": Cluster analyses revealed three geographic groupings of Coho Salmon: Strait of Georgia in northern Salish Sea, Puget Sound in southern Salish Sea, and Pacific Coast. A mixed effects model revealed that regional differences in smolt survival have changed over time. In the 1970s and early 1980s, smolt survival was higher for Salish Sea than reference populations. Within the Salish Sea, smolt survival was higher for Strait of Georgia than Puget Sound populations. Survivals in all regions declined in late 1980s and 1990s; however, the Salish Sea decline was more pronounced than the Pacific Coast. Populations within the Salish Sea did not rebound from this decline whereas smolt survivals of Pacific Coast populations in the last decade were similar to those observed in the 1970s. During the declining survival period (1985-1995), smolt survival was more strongly correlated at a larger spatial scale than the time period (1996-2010) following this decline. We hypothesize that the coast-wide declines in the late 1980s and 1990s were driven primarily by oceanic-scale variables. However, the greater magnitude of the decline and the continued low marine survival rates for populations within the Salish Sea as opposed to non-Salish Sea populations suggest additional, compounding regional effects. Future studies linking marine ecosystem processes and Coho Salmon smolt survival can use results from this study to select environmental variables that vary at a scale that matches the survival patterns of interest (As suspected, hatchery and wild populations followed similar trends, with hatchery stocks surviving at a lower rate overall)

The results of "Trends in coho salmon freshwater productivity and smolt-to-adult survival" analysis are less conclusive. Five wild populations with the highest freshwater and marine survival data were assessed. Adult-to-smolt (freshwater) survival was compared to smolt-to-adult survival (marine). Results show some similarities and differences in survival patterns among populations. Unfortunately though, in order to properly compare freshwater vs. marine survival, on the same scale or metric, we need adult body size data, allowing us to estimate total egg deposition from a length-fecundity relationship. Limited time to available to perform this estimate and limited data precluded it from being completed. Annual measurements of body size are available for the US populations analyzed; however, data are more sporadic for the Canadian populations (Black, Carnation). Furthermore, the role of density dependence in the freshwater environment is not accounted for here. Therefore, the workgroup considers this an initial cut at evaluating freshwater vs marine survival relative to overall productivity.

Regarding the "Coho salmon early marine survival in the Strait of Georgia" report. Catch data from the trawl surveys have been used to establish an index of early marine survival (ocean entry to September) for Coho Salmon entering the Strait of Georgia. The index has been consistent with total marine survival, and, therefore, is considered a potentially important tool for managers, providing an early indication of returns to fisheries in the subsequent year. The index, originally 1998-2007, was updated with improved estimates of hatchery production and corrected trawl survey data, and the time series was extended through 2013 under this agreement. The index model's assumptions were also reviewed, and recommendations to improve the model were provided. The updated model's results are consistent with Beamish (2010), showing a declining trend until 2007. The extension of the index to 2012 time series showed an abrupt change in the index beginning in 2009 with early marine survival increasing from 2009 to 2012 for both wild and hatchery Coho Salmon. The modelled index suggests that early marine survival has increased from about 3% in 2007 and 2008 to 15-20% in recent years. However, there is some uncertainty regarding this rate of change given potential issues with some of the current

model assumptions, including: a) an apparently high reduction in contribution of coho from Puget Sound, b) reduction in hatchery fry releases and its effects on freshwater survival estimates, and c) differences in wild and hatchery ocean entry times in recent years.

This project developed a standardized dataset (and a standardized collection and analysis approach) for coho survival. This serves as a critical component in the work set forth within the Salish Sea Marine Survival Project, and can inform management now. The survival data provides the dependent variable for correlative analyses with biological and environmental variables, for both evaluating the causative factors in the historic declining period and for continuing to isolate and prioritize the current variables driving survival, crucial for improving adult return forecasting.

For example, the dataset and analyses could improve annual preseason forecasts of coho adult returns and help coordinate forecasting methods throughout the Salish Sea. The dataset provides four decades of smolt survival information at a broad geographic scale. Analyses of these data suggest appropriate geographic scales for making predictions of smolt survival. The design of the compiled database allows population-specific information to be rolled up to more general geographic regions which can then be linked to data that are available at a broader spatial scale than individual populations (e.g., trawl data). Additionally, the compiled dataset could be used to further investigate differences in hatchery versus wild smolt survival rates and to link population survival estimates to population-specific data (e.g., migration timing, size).

This dataset provides information that can be used in conjunction with other datasets to assess survival on a broader spatial scale (e.g., around the Pacific Rim) and with other species (both salmonid and non-salmonid). Combined with additional Salish Sea datasets, this dataset gives researchers the capability to quantify the effects of various drivers on marine and freshwater coho survival (e.g., climate trends, habitat availability). The generation of these data and subsequent analyses also solidified a research collaboration between Canadian and US scientists on issues related to Salish Sea ecosystem.

Recommendations and Next Steps

The coho workgroup reviewed their own progress and suggested next steps relative to addressing the six question framework for the long-term objectives of this research. They recommend the following:

I. Identify relative contributions of freshwater versus marine processes to overall adult returns of coho salmon (continuation of this analysis)

II. (If feasible) Develop an early marine survival index for Puget Sound coho salmon using Ricker trawl data, similar to what has been done for the Strait of Georgia

III. Identify ecosystem predictors of coho salmon marine survival based on spatial patterns in survival identified in current analysis

IV. Determine the influence of inter-annual variation in life history characteristics (primarily body size and migration date) on marine survival [*Estimating total annual outmigrant abundance may be included here as an aspect of evaluating carrying capacity*]

These activities are consistent with research recommendations provided in guidance documents of the Salish Sea Marine Survival Project. They are discussed within the context of the six-question framework for this retrospective work, below:

3) Does marine (i.e. smolt) survival more strongly predict adult returns than freshwater survival?

This study provided a general assessment of freshwater versus marine contributions to overall survival. The collaborators simply did not have sufficient time to thoroughly address this question, and decided to prioritize completion of the spatial comparison analysis. Extending our initial work by completing a comprehensive analysis of freshwater survival is a high-priority study action. Specific issues that should be addressed in future analyses are incorporation of egg/fecundity data and consideration of potential density dependence of freshwater survival rates. More details on recommendations for future work are provided in the preliminary report on freshwater vs marine survival.

4) Does variation in body size, smolt migration timing, or other life-history characters affect marine survival?

This study indicated that coho populations from the Salish Sea exhibited different survival patterns from Pacific Coast populations. This supports the hypothesis that Salish Sea-specific factors affected marine survival and that there is a critical period for juvenile salmon survival, although it does not define the length or timing of the critical period. Currently, early marine survival is better described for the Strait of Georgia than for Puget Sound, which hampers attempts to understand early marine survival patterns across the Salish Sea. Development of an early marine survival index for Puget Sound and comparing this model to the existing Strait of Georgia model is considered high-priority study action. However, there are significant concerns about the consistency and extent of offshore data available for Puget Sound coho[3], and the behavior of Puget Sound coho[4] that may make this infeasible.

Assessing life-history characteristics and their relationships to coho smolt survival in the Salish Sea is a recommended study action. The dataset developed through this project includes body size and migration timing data, which could be used to address this objective. However, additional effort would be necessary to compile missing data for Canadian and US systems, particularly for wild populations. Collaborators compiled these life-history data to the extent possible, but made a decision not to fill all gaps, and rather maintain our timeline with the spatial and temporal trend analysis.

The current study did not address the potential contribution of the sub-yearling migrant coho to overall coho adult returns. A significant contribution of sub-yearling coho to adult returns could bias our survival estimates. Addressing this issue will require additional study rather than retrospective analysis. Two possible approaches for conducting this type of study are recommended: 1) otolith analysis of adults carcasses and use of Sr:Ca ratios to determine body size at marine entry or 2) tagging (passive integrated transponder) of coho parr and the use of antenna arrays to determine the timing of their outmigration and return rate as adults. The first approach could be conducted a range of watershed sizes but the second approach would be

[3] A. The offshore sampling effort (via the R/V Ricker) across years is not consistent before 2001. Since then, number of sets within Main Basin is relatively consistent each year (no data for 2003 or 2010). B. Surveys are only 2 days long (one day in Central Puget Sound, one day in Admiralty Inlet). C. Over the entire dataset, there are only 760 coho CWTs and those CWT represent 27 different hatchery populations, so sample sizes are severely limited. D. the coho stocks caught by Ricker trawls do not represent all the Puget Sound coho stocks. Stock-by-stock analysis is probably not feasible.

[4] The Ricker offshore surveys were designed for Strait of Georgia outmigration timing, and evidence suggests that coho leave Puget Sound much sooner than coho leave Strait of Georgia. Therefore, most of the coho may have left the system by the time Ricker Cruises have intercepted coho in Puget Sound.

limited to small populations where antenna arrays can be operated. The first approach is slated for implementation as a separate study in the Puget Sound research plan component of the Salish Sea Marine Survival Project.

5) Is the production of coho salmon limited by the carrying capacity of the Salish Sea? What ecosystem indicators best predict marine survival?

Identifying ecosystem indicators relevant to coho smolt survival in the Salish Sea is a recommended study action. Work on this topic has already been initiated through efforts on the Pacific coast (e.g., Rupp et al. 2012)[5] and the Strait of Georgia (Perry et al 2013)[6], as well as work on other species. Additional interest concerning ecosystem indicators of adult returns in the Salish Sea culminated in a workshop in 2012 sponsored by NMFS and Long Live the Kings, and the report summarized a number of potential indicators in both freshwater and marine systems.[7] Additional research needs to focus on both large-scale drivers affecting the entire Salish Sea as well as indicators that vary at smaller spatial scales such as oceanographic basins within Puget Sound. The research team supports continued advancements in integrating fish ecology and oceanography in order to address questions about ecosystem indicators and carrying capacity.

This study documented a decline in marine survival for both Salish Sea and non-Salish Sea stocks. The broad spatial scale of this decline suggests climate-scale oceanic drivers. However, the greater magnitude of the decline and the continued low marine survival rates for stocks within the Salish Sea as opposed to non-Salish Sea stocks suggest additional, compounding regional effects. To the extent that the data exist, a comparison of environmental conditions within the Salish Sea before and after the decline in coho smolt survival may identify variables linked to the changes in smolt survival and the currently low smolt survival rates. A study that investigates variability in environmental variables within the Salish Sea versus the Pacific Coast (California Current) would help to better explain why observed declines were of higher magnitude for Salish Sea stocks. Within the Salish Sea, there is additional variation in marine survival between the Strait of Georgia and Puget Sound which should be assessed with respect to both environmental variables and fish behavior.

Additional data are needed to assess the carrying capacity of the Salish Sea and its impact on salmon production. For example, the dataset developed through this project does not include the total number of juvenile coho entering the Salish Sea each year or the length of time coho smolts remain within the Salish Sea. This information is available and published to some extent in the Strait of Georgia, and could be compiled for Puget Sound. The question of carrying capacity is best addressed by combining information on total juvenile coho entering the Salish Sea, an early marine survival index, and overall smolt survival (as estimated by the current study). This type of analysis should provide meaningful feedback to managers on the effectiveness of existing hatchery programs to support their harvest objectives.

[5] Rupp, D.E., T.C. Wainwright, P.W. Lawson, and W.T. Peterson. 2012. Marine environment-based forecasting of coho salmon (Oncorhynchus kisutch) adult recruitment. Fisheries Oceanography 21:1, 1–19, 2012.

[6] Perry, R. I., and D. Masson. 2013. An integrated analysis of the marine social-ecological system of the Strait of Georgia, Canada, over the past four decades, and development of a regime shift index. Progress in Oceanography 115:14-27.

[7] The Results and Recommendations of the Salish Sea Marine Survival Research Planning and Ecosystem Indicators Development Workshops (2013) – available at www.marinesurvivalproject.com

Additional questions on the factors which contribute to this carrying capacity (e.g., bottom-up versus top-down processes) can be best addressed by combining information on ecosystem indicators, an early marine survival index, and overall smolt survival (as estimated by the current study). For example, appropriate variables to measure may be abundance trends in predators or proxies for ecosystem productivity (e.g., zooplankton production, lipid composition of zooplankton).

Application of this approach to other salmon species

The workgroup recommends continuing to focus on coho salmon, per the next steps above, to take advantage of the momentum and comradery established by the current work. However, the Chinook survival trends analyses must also be completed. Workgroup members in Puget Sound are responsible for both wild coho and Chinook, and they were concerned about workload. To resolve this issue, analyses of hatchery Chinook data will be prioritized in time over wild. A Chinook workgroup will be formed and will receive guidance from members of the coho workgroup, and the coho workgroup will continue.

The workgroup's guidance for applying this approach to other species is as follows. Similar analyses of Salish Sea chinook and steelhead survival are appropriate and achievable given the smolt and adult data available. Data availability for Salish Sea sockeye, pink, and chum survival is limited from the perspective of calculating smolt survival and may need to be investigated using alternate approaches (e.g., spawner or catch abundances). For each species, defining what data are necessary and planning an analytical approach to accommodate species-specific concerns prior to data compilation would reduce the amount of time and effort needed for data gathering and data assessment, especially for data sources which are not housed in a central location.

Chinook - Analyzing Salish Sea Chinook survival would be complex for two reasons: 1) multiple return ages and 2) accounting for harvest in mixed maturity fisheries. Chinook salmon are frequently harvested in non-terminal areas prior to maturation, and these fish must be discounted at some expected rate of natural mortality. The Chinook Technical Committee (CTC) has developed a series of analytical approaches to estimate survival using CWT index stocks spanning the period of declining survival from the mid 1980s to present. A detailed review of Chinook in southern BC has recently been completed by Fisheries and Oceans Canada. Thus, it will be important to use existing tools and knowledge from the harvest management arena to pursue analysis of Chinook survival trends. Existing CTC estimates can address questions of importance to the ecology of the Salish Sea. Additional calibration of estimates across the Salish Sea may be necessary, and once these issues are addressed, the analysis could follow the approach developed through the current coho survival project.

Smolt monitoring of wild populations generally occurs only in the US and not Canada. Furthermore, calculation of wild smolt survival rates will be confined to relatively recent time periods (approximately 2000 to present, depending on river). Based on our experience with coho salmon, we may have relatively little ability to identify spatial patterns in marine survival in this recent period.

Steelhead - For steelhead stocks, much of the necessary data are already compiled through another study in the Salish Sea Marine Survival Project, using this project's process as a model. The lead researcher on that study has compiled data for US stocks and established communication with Canadian scientists in British Columbia to obtain information for Canadian stocks.

Sockeye - Sockeye life history is relatively straightforward (only two major life history types), so analysis may not be complex. However, the sockeye in the Salish Sea are dominated by the Fraser River, which limits the ability to make robust spatial comparisons within the Salish Sea.

Pink and chum - Comparing pink and chum salmon survival to coho, Chinook, steelhead, and sockeye survival would be useful because of the species-specific differences in freshwater life history strategies and because return rates of pink salmon have not followed the same trends observed for the other species. However, due to a lack of hatchery production and very limited assessment of mixed stock fishery composition, determining smolt survival of individual pink salmon stocks is not possible. For chum salmon, the Pacific Salmon Commission's Chum Technical Committee is developing a genetic baseline for Salish Sea stocks and completing some mixed-stock fishery analyses, which will eventually lead to adult run reconstruction. However, these data will not be available for some period of time. Therefore, approaches to describing spatial and temporal trends in pink and chum survival will likely require alternate approaches to those developed for coho and applicable to Chinook and steelhead. In particular, spawner escapement abundances or commercial harvest information may be useful to develop indicators of survival for pink and chum salmon, building off the approach of a recent paper on that compared trends for odd- and even-year pink salmon throughout the North Pacific Ocean. Additional refinement of this information to accommodate for annual variation in freshwater survival could be obtained from a few systems where egg-to-fry survival of naturally produced fish are available and could be modeled as a function river incubation flows.

Financial Summary:

The financial summary includes two parts. Table 1. is the detailed statement of operations, summarizing expenses relative to the proposal budget. Table 2. provides a breakdown of all expenses, by date. LLTK has $2,000 of unspent income in hand, and the project ultimately was $9,503 under budget. Details regarding the variance in budget to actuals are provided below Table 1. LLTK and PSF request that PSC consider transferring these unspent funds to the next phase of this effort.

Table 1: Long Live the Kings Detailed Statement of Operations, Restricted Agreement PSC SF-2013-I-16B Final Report - August 15, 2013 - August 29, 2014

	Ref	Actual	Total 2014 Budget	Variance
Revenues				
Deferred Contribution Revenue		$67,510.00	$75,013.00	$7,503.00
Total Revenues		**$67,510.00**	**$75,013.00**	**$7,503.00**
Expenses				
Subcontractors & Consultants				
WDFW Research Biologists	1	$46,973.46	$47,000.00	$26.54
DFO Technical Consultant - Preikshot	2	$3,751.00	$5,000.00	$1,249.00
DFO Technical Consultant - Elder	3	$2,999.50	$3,000.00	$0.50
DFO Technical Consultant - Unidentified	x	$0.00	$1,563.00	$1,563.00
DFO Technical Consultant - O'Neill	4	$6,150.00	$9,450.00	$3,300.00
LLTK Facilitation Consultant - Rawson	5	$4,976.00	$9,000.00	$4,024.00
Administrative Costs				
Publication Costs	6	$660.00	$0.00	-$660.00
Total Expenses		**$65,509.96**	**$75,013.00**	**$9,503.04**
Net Surplus/(Loss)**		**$2,000.04**	**$0.00**	**$9,503.04**

Regarding the statement of operations:

- WDFW Research Biologists (**Ref #1**) were two lines "WDFW Biologist 2 (Weinheimer)" and "WDFW Research Scientist 2 (Anderson)" in the proposal budget. Ultimately, costs were spread to WDFW staff beyond Weinheimer and Anderson. Primarily, funds went to Biologist Clayton Kinsel to compile wild coho data, supporting Weinheimer, and to Research Scientist, Mara Zimmerman, who did a bulk of the manuscript writing and the presentation at the Salish Sea Ecosystem Conference in April. Zimmerman also committed more than her share of in-kind support to the project, supporting analyses and manuscript revisions (proposed 160, actual 275). Detailed information is available upon request.

- DFO Consultants Preikshot, Elder and Unidentified (**Ref # 2,3,x**) were a single line "DFO Consultant 1 early marine survival, budget $9,563" in the proposal budget, prior to identifying consultants. Only $8,000 was budgeted among the Preikshot and Elder scope of works; therefore, $1,563 was left unidentified at contract signing. Ultimately, DFO did not use the $1,563. Also, Preikshot finished his work more quickly than projected, with $1,249 remaining.
- DFO Consultant O'Neill (**Ref #4**) was listed as "DFO Consultant 2 CWT smolt survival, escapement" in proposal budget. O'Neill's original contract was for a maximum of $9,450, consistent with the proposal budget. However, her total cost was only $6,150. Reasonable hourly rates for O'Neill combined with efficiently distributing workload between U.S. and Canadian technicians working on the data collection and analyses kept costs down.
- A larger portion of project facilitator, Rawson's (**Ref #5**) work (meeting coordination, notes and task lists, reminders, project management website maintenance) was completed LLTK's Iris Kemp. 60 hours of Iris' time was listed as in-kind in the proposal; however, she ultimately contributed 109 hours (13 meetings + associated activities x 8 hours = 84, 25 hours miscellaneous).
- Publication costs (**Ref #6**) were not accounted for in the original budget. This was an oversight. However, we receive a 50% discount as AFS members which helped manage the cost.

Table 2: Long Live the Kings Detailed Revenue & Expenses
Agreement PSC SF-2013-I-16B Final Report - August 15, 2013 - August 29, 2014

Revenue:

8/23/2013	1st Advance	37,500.00
4/3/2014	2nd Advance	30,010.00
		67,510.00

Expense:

Date	Description	Ref #	Cost
9/30/2013	MEGHAN O'NEIL	4	140.00
10/2/2013	KIT RAWSON: SEPT 2013	5	1016.00
10/29/2013	STATE OF WA-WDF&W: OCTOBER 2013	1	1221.38
11/30/2013	KIT RAWSON: OCT, NOV 2013	5	944.00
12/23/2013	STATE OF WA-WDF&W: NOVEMBER 2013	1	7318.57
12/26/2013	DAVE B. PREIKSHOT PHD: DATA COLLECTION & ANALYSIS - COHO	2	1750.00
12/31/2013	STATE OF WA-WDF&W: DECEMBER 2013	1	4755.03
12/31/2013	KIT RAWSON: DEC 2013, JAN 2014	5	416.00
12/31/2013	MEGHAN O'NEIL	4	670.00
12/31/2013	CAROL ELDER: COMPASS CONTRACTING	3	637.50
1/31/2014	STATE OF WA-WDF&W: INV#141278: JAN 2014	1	3456.51
2/28/2014	STATE OF WA-WDF&W: FEBRUARY 2014	1	4011.63
3/3/2014	DAVE B. PREIKSHOT PHD: SERVICES: FEB. 24- MAR. 3, 2014	2	2001.00
3/31/2014	STATE OF WA-WDF&W: MARCH 2014	1	1354.75
3/31/2014	KIT RAWSON: FEB, MARCH 2014	5	500.00
4/11/2014	MEGHAN O'NEIL	4	3630.00
4/30/2014	STATE OF WA: DFW: INV# 141425: APRIL 2014	1	3219.88
5/31/2014	STATE OF WA DFW: INV 141441: MAY 2014	1	8600.01
6/30/2014	KIT RAWSON: APR, MAY, JUN 2014	5	1240.00
6/30/2014	MEGHAN O'NEIL INV 201408-1	4	790.00
7/22/2014	STATE OF WA-WDF&W: JUNE 2014	1	7471.05
7/22/2014	CAROL ELDER: COMPASS CONTRACTING	3	550.00
8/19/2014	KIT RAWSON: JULY-AUGUST 2014	5	860.00
8/22/2014	CAROL ELDER: COMPASS CONTRACTING:	3	1812.00
8/25/2014	MEGHAN O'NEIL INV 201408-2	4	920.00
8/26/2014	STATE OF WA-WDF&W: JULY 2014	1	3209.21
8/26/2014	STATE OF WA-WDF&W: AUGUST 2014	1	2355.44
x/xx/2014*	Taylor and Francis	6	660.00
			65,509.96

*Please note that the Taylor and Francis manuscript submission costs have not yet been incurred. The manuscript will be submitted in September after final review of the scientists once several of them return from vacation. However, the amount is known based upon posted submission costs.