Evaluating the use of commercial fishery data to inform the in-season management of salmon fisheries

March 31, 2019

Prepared for the Southern Endowment Fund

PACIFIC SALMON COMMISSION

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Prepared for:

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Cover Photo: Fishing Boats at Canfisco, Vancouver © 2018 Brian Ma

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Acknowledgements

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Acronyms

Abbreviations

PSC	Pacific Salmon Commission
SEF	Southern Endowment Fund
DFO	Fisheries and Oceans Canada
ESSA	ESSA Technologies Ltd.
ITQ	Individual Transferable Quota
TF	Test Fishery
VMS	Vessel Monitoring System
ELOG	Electronic logbook
FOS	Fishery Operations System
R^2	the coefficient of determination

Executive Summary

Return migrations of Fraser River sockeye populations overlap in space and time, which affects their vulnerability in mixed-stock fisheries. Test fisheries are key to informing reasonably accurate and timely estimates of Fraser River sockeye run strength. However, these test fisheries sample small fractions of daily abundance, and catches can be highly variable among sites and days, which limits their ability to provide abundance estimates of sufficient certainty prior to verification by lower Fraser River acoustics one week later. Previous work with commercial ITQ data established that post-season log-book information on Area B catch-per-set data is highly correlated with daily abundance estimates (Cave 2017[1]). In consultation with stakeholders, this project sought to develop and pilot a technical solution to evaluate the feasibility and use of in-season ITQ catch-per-set data to inform daily Fraser River sockeye abundance estimates.

The specific objectives of this project were to:

1. Strengthen engagement and collaboration among stakeholders to support the development of a technical solution that supports the real-time flow of information for Fraser River sockeye in-season assessment and decision-making.
2. Pilot a technical solution to facilitate the in-season transfer of data from ITQ fisheries to DFO and PSC.
3. Evaluate the feasibility of the data flow process and value of information.
4. Support the feasibility with an analytical study following on the results of Cave 2017, which demonstrated a high correlation between post-season logbook catch-per-set data and daily abundance estimates.

This project was a collaborative effort between harvesters, Fisheries and Oceans Canada, the Pacific Salmon Commission, and ESSA Technologies. The project team concluded that this project successfully demonstrated that collecting ITQ catch-per-set data in-season is both feasible and of high value for the Pacific Salmon Commission's (PSC) Fraser River sockeye salmon daily abundance estimates.

The pilot project identified and implemented vessel monitoring system (VMS) and electronic logbook (ELOG) technology to capture commercial ITQ catch-per-set data in-season. To capture the catch and set number/location data provided by the participating ITQ fleet captains, DFO staff upgraded the Fishery Operations Systems (FOS) database, DFO staff installed the VMS units and provided ELOG training to the fleet captains, DFO staff developed a query to extract data from FOS, the PSC provided daily abundance estimates to ESSA, and ESSA conducted in-season analyses between the PSC's daily abundance estimates and ITQ catch-per-set data.

The results of our analysis suggest that ITQ catch-per-set data will help improve daily abundance estimates when combined with the test fishery catch-per-set data. ITQ catch data was queried from FOS and sent to ESSA by DFO staff along with the PSC daily abundance estimates sent by the PSC immediately after each Fraser River Panel meeting. ESSA was able to provide immediate analysis of the daily abundance and catch-per-set data. The relationship between PSC daily abundance estimates and catch-per-set data was evaluated by linear regression.

The strength of the relationship was determined by the coefficient of determination (adjusted R^2 value). For the 2018 season, ITQ catch-per-set information was highly correlated to the test fishery catch-per-set data. Furthermore, the ITQ catch-per-set data was more strongly related with PSC derived daily abundance than the

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[1] Cave, J. 2017. Analysis of Catch-per-Set information from the Area B Purse seine Individual Transferable Quota Fisheries. Final Report for the Southern Endowment Fund. 39 pp.

Test Fishery catch-per-set information (R^2 of 0.70 versus 0.51). Several additional considerations warrant attention.

- The Test Fishery ensures temporal coverage throughout fishing season while subareas 13L and 13U only had ITQ catch data for 8 and 18 out of the 28-day season, respectively;
- Including the ITQ catch-per-set data increases the number of vessels reporting daily catch data (for subarea 12-3 in 2018, the mean number of daily fishers was 13.2 with a standard deviation of 9.0) compared to relying solely on data from the test fishery;
- The number of days each ITQ fishery vessel reports daily catch-per-set data is highly variable (for subarea 12-3: mean = 4.9, sd = 2.7, minimum = 1, maximum = 13), which has implications predictive power of the catch-per-set data on a given day.
- Reporting the ITQ catch data as daily total catch and total sets or by individual catch-per-set does not affect the timing of when the data are used (reporting deadline is 8am the next day). However, total daily catch from multiple subareas has to be disregarded from analysis. If daily catch reported is from multiple subareas, but reported by catch-per-set, then catch from those sets within target subareas can be retained for analysis.

Overall, this feasibility study demonstrates how promising the use of data from the Johnstone Strait ITQ fishery for sockeye salmon can be for in-season fisheries management. The ITQ data explains a larger proportion of the variation in daily abundance than test fishing catches and likely constitutes a more consistent proportion of the daily abundance across days and years when fishing occurs. One of the drawbacks of the ITQ data is that it only allows the assessment of the abundance migrating through Johnstone Strait and not through Juan de Fuca Strait. Total daily abundance estimates from both marine approaches, however, are required as input into the model to estimate the total run size. The impact of this constraint on the usefulness of the ITQ data will depend on the Northern Diversion rate; i.e., the proportion of the run migrates through Johnstone Strait. Regardless of this drawback, the ITQ catch-per-set data could be used in combination with the test fishery data within the run size model to produce in-season run size estimates and potentially contribute to improved in-season fisheries management.

We recommend the following actions to improve the pilot project implementation and to extend the potential of these results beyond the Johnstone Strait sockeye ITQ fishery:

Based on the feasibility study conducted, the following recommendations are proposed to refine and improve in-season reporting of catch-per-set data from fisheries to inform PSC daily abundance estimates:

1) More support is required for technology integration:
    a. Current support for the ELOG software and Fishery Operations System (FOS) made it challenging to implement the pilot project, in large part due to the lack of resources
    b. Captains suggested that the usability of the ELOG software could improve (which will help improve technology adoption by captains thereby increasing the amount of catch-per-set data);
2) The adoption of ELOGs and supporting technologies needs to increase
    a. The results of our simulation analysis determined that an additional 20-35 VMS units distributed throughout the ITQ fleet would be needed to capture 90% of the predictive power.
    b. Currently ELOGs and VMS units are cost prohibitive, and therefore cost-sharing options should be explored. VMS units remain costly compared to phone-ins on a per year basis, but the biggest cost is the VMS unit itself.
3) The pilot project should be extended beyond the ITQ salmon fishery to other fisheries to understand if information from multiple fisheries could provide weight-of-evidence support and increased accuracy for estimates of daily abundance

1 Introduction

This project builds on previous related efforts that established that commercial catch data could be an additional source of in-season information to inform Fraser River sockeye salmon abundance estimates. In 2015, a Southern Endowment Fund (SEF) project was funded to explore the use of catch information from the Individual Transferrable Quota (ITQ) purse seine fishery in Areas 12 and 13 to inform Fraser River sockeye abundance (Cave 2017). These analyses indicated that catch-per-set data from 2010 and 2014 ITQ sockeye salmon fisheries in these areas were highly correlated to daily abundance in the same areas. The ITQ fisheries therefore warranted consideration as an additional source of information (in addition to test fishery catch-per-set) for in-season abundance estimation in years when ITQ fisheries occur. From 2016 to 2017, the SEF funded a 2-year project to hold workshops and conduct supporting technical analyses to assess the relative costs and benefits of existing test fisheries and other possible data sources that could be used to support in-season run-size assessments (Nelitz et al. 2018). These workshops further reinforced the desire to explore the feasibility of using commercial catch data in-season. While the Cave (2017) report explored the strength of historical relationships between catch-per-set and estimates of daily abundance, it did not consider how feasible it was to access these data in-season.

The purpose of this project was to assess the feasibility of improving in-season estimates of daily abundance using commercial fishery catch-per-set data. The specific objectives of this project were to:

1. Strengthen engagement and collaboration among stakeholders to support the development of a technical solution that supports the real-time flow of information for Fraser River sockeye in-season assessment and decision-making.
2. Pilot a technical solution to facilitate the in-season transfer of data from ITQ fisheries to DFO and PSC.
3. Evaluate the feasibility of the data flow process and value of information.
4. Support the feasibility with an analytical study following on the results of Cave 2017, which demonstrated a high correlation between post-season logbook catch-per-set data and daily abundance estimates.

This project represents the first step in a longer-term process to better facilitate integration of fisheries data (beyond test fisheries) into the in-season assessment and decision-making process of the Fraser River Panel. If successful, an expected long-term outcome would be to provide an additional source of information for the Pacific Salmon Commission (PSC) to evaluate daily abundance, before making a recommendation to the Panel. For this project, the ITQ purse seine fishery for sockeye salmon in Johnstone Strait (Areas 12 and 13) was used.

The feasibility of using commercial fisheries catch data in-season is dependent on several uncertainties that this pilot project attempted to address:

(1) What technology will be used to relay catch-per-set data to Fisheries and Oceans Canada (DFO)?

(2) What is the data quality of in-season data? We measure data quality as a function of timeliness, completeness, and usefulness.

(3) What are the logistical challenges in reporting data in-season, and how can does the selected technology overcome this?

2 Methods

This project was a collaborative effort between Fisheries and Oceans Canada, the Pacific Salmon Commission, commercial harvesters in the ITQ seine fishery, and ESSA Technologies. The project benefited from the help of the individuals listed in Table 1, either through their attendance at the workshop or through their contributions to implementing the work plan.

Table 1: List of contributors and their organization.

Organization	Contributors
Fisheries and Oceans Canada (DFO)	Les Jantz, Matt Mortimer, Carmen McConnell, Lee Kearey, Shelee Hamilton, Wilf Luedke
Area B Harvesters	Rob Morley (Canfisco), Chris Cue (Canfisco), Mike Frost (Canfisco), Chris Ashton
Pacific Salmon Commission	Catherine Michielsens, Merran Hague, Mike Lapointe
ESSA	Brian Ma, Marc Nelitz, Matthew Siegle

The project followed a work plan that consisted of four major tasks:

1) Reach consensus on a technical solution and scope;
2) Implement the technical solution in-season as a pilot study;
3) Evaluate the solution in-season at predefined check-in times; and
4) Evaluate the solution post-season.

2.1 Task 1: Reach consensus on technical solution and scope

The first step involved engaging the partners to identify a suite of potential technical solutions, conduct a needs assessment to understand the challenges each partner faces, and establish both a realistic set of expectations for the 2018 pilot project and what criteria against which we should define "success". The group met on April 30th, 2018 to decide on the technical solution.

The scope of this pilot project was focused on the 2018 Area B ITQ sockeye fishery in Johnstone Strait, particularly subarea 12-3, supplemented with more limited data from PFMA 13, split into upper and lower portions (13U and 13L) following the designation in Cave (2017). The division between 13U and 13L was delineated by Chatham Point.

The group agreed that **Vessel Monitoring System (VMS) satellite technology coupled with electronic logbook (ELOG) would fulfill the requirements of this pilot project** (Figure 1). It was necessary to work with the PSC to fully define the data requirements to support in-season assessments, with DFO to understand the flow of catch data and tools utilized, and with the harvesters to understand the feasibility and cost-effectiveness of alternative reporting processes from their perspective.

VMS is a technology that uses satellites to provide near real-time positional tracking information to monitor the location of vessels and their movement. Because VMS uses satellite information, it can also be used to transmit catch reporting data to a central database provided a computer with relevant software is provided onboard the vessels. For the purposes of this project, the positional tracking information was not a necessary component, but it was deemed an incentive for participating in this pilot project as it provided a secure way for friends and family to identify their location.

Electronic Logbooks (ELOGs) can be used to enter and transmit catch reporting data via the satellite communication capabilities of the VMS units. In the Area B ITQ fishery, the Daily Catch Reporting requirement is daily catch reported at 8AM the day after fishing occurred. These requirements can be met using one of two possible technologies: (1) phone-ins via a central phone hotline, or (2) via ELOGs. For the purposes of this project, ELOGs were selected because this information could be transmitted more rapidly than with the phone-in system.

Data from Daily Catch Reports, and subsequently, catch-per-set information, are stored on DFO's Fishery Operations System (FOS), which is the central database for the Pacific Region's fishery monitoring and reporting data. Once data were on FOS, they could be provided to ESSA and PSC staff for further analyses in an anonymous form.

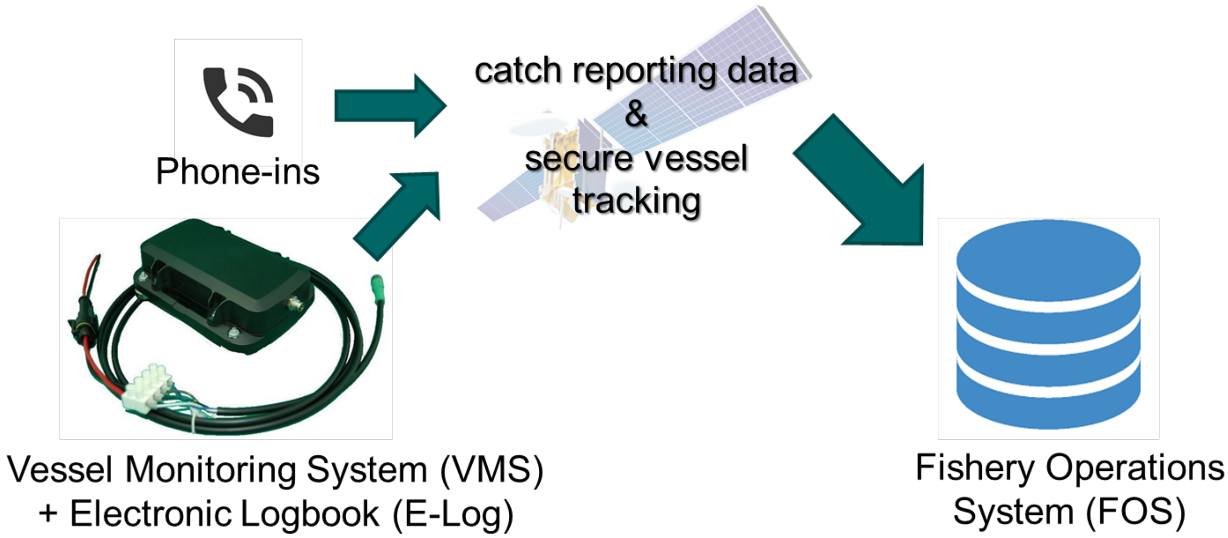


Figure 1: General schematic of how catch-per-set data are reported by harvesters and stored by DFO.

2.2 Task 2: Implement technical solutions in-season as a pilot study

The next task involved implementation of VMS and ELOGs. This required the following steps:

1) Identifying vessels to participate – Area B harvesters, including Canfisco, and DFO initially identified 17 vessels that were approached as likely participants for this pilot project, which corresponded to the number of VMS units that were available. Of the 17 vessels, 7 were test fishers that have previously used ELOG/VMS, and 10 were new potential users. Of the 7 test fishers, all 7 participated and provided catch-per-set data on days they were not participating to the test fisheries but participated to the ITQ fishery instead. Of the 10 new potential users, 5 declined participation. An often-cited reason for declining was not wanting vessel location tracked using the VMS software. Subsequently, 5 new users were identified and the desired target of 17 participants was achieved.

2) Upgrading the ELOG software – ELOG software was upgraded to allow data entry on a catch-per-set basis. This upgrade was done by MC Wright and Associates, with guidance from Carmen McConnell and Lee Kearey (DFO).

3) Upgrading FOS – FOS was upgraded to capture catch-per-set data from ELOGs. This upgrade was done by Shelee Hamilton, with guidance from Carmen McConnell and Lee Kearey (DFO).

4) Purchasing and installing VMS units and ELOG software – For all participating vessels, the VMS units and ELOG were installed by Carmen McConnell and Lee Kearey (DFO). Carmen and Lee also

provided training for the ELOG software. ESSA provided users with a "Data entry using catch-per-set" cheat sheet for the ELOG system (APPENDIX A).

5) Purchasing licences for commercial fishing (ELOG) and VMS subscription fees – The ELOG software and VMS subscription fees were paid for using SEF grant funds and in-kind contributions by DFO. The VMS units and services were purchased from ROM Communications Ltd (romcomm.com).

6) Developing a query to extract data from FOS – A query was designed to provide catch-per-set data to ESSA. The query was developed by Shelee Hamilton, with input from ESSA and insured information linking data to individual vessels or harvesters had been removed. The data were provided by Matt Mortimer, the Area B resource manager. The data provided by DFO included reporting from ELOGs *and* phone-in.

7) Developing a template to compare catch-per-set data from the ITQ and Test fisheries. This template was designed by Catherine Michielsens (PSC) with guidance from Brian Ma and Matthew Siegle (ESSA). This last step formed the basis of Task 3 – Evaluate solution in-season, discussed further in Section 2.3.

2.3 Task 3: Evaluate solution in-season

The general framework for evaluating the solution in-season is shown in Figure 2. The figure is loosely grouped into 4 main components:

1) Collect and process catch-per-set data from ITQ fisheries;
2) Collect, process and estimate daily abundance using catch-per-set data from Test Fisheries;
3) Develop statistical models to estimate daily abundances from ITQ catch-per-set data; and
4) Compare the daily abundance estimates generated by the statistical model to results from the Test Fishery and to reconstructed daily abundance estimates based on hydroacoustics (PSC) data collected at Mission and seaward catches.

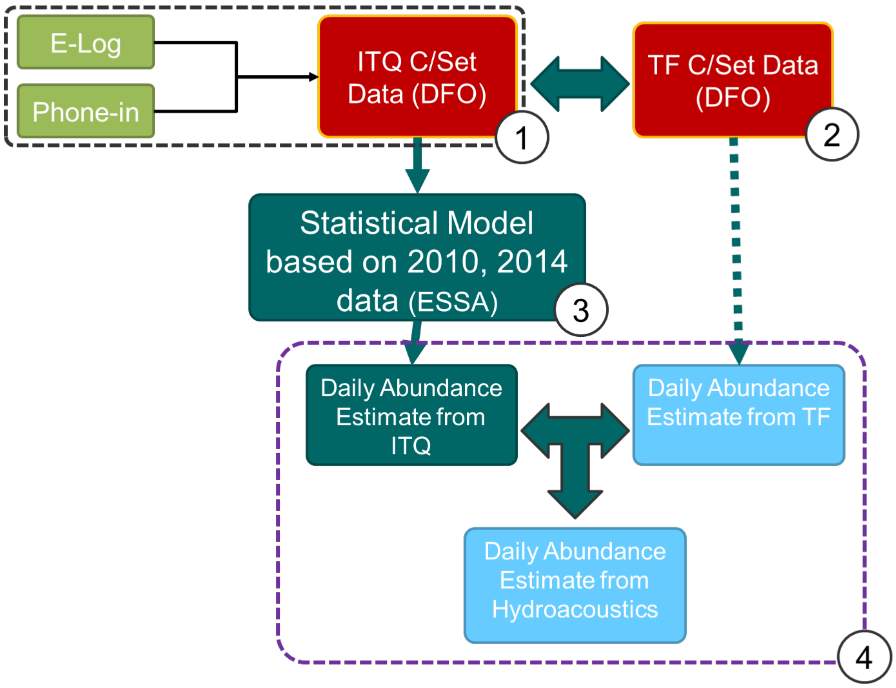


Figure 2: General framework used to evaluate the performance of ITQ Catch-per-set information in-season. Boxes are colour-coded according to the groups with primary responsibility for a component (green – harvesters, red – DFO, teal – ESSA, and light blue – PSC). Comparisons between data sources and analysis results were performed by ESSA.

Component 1: Collect and process catch-per-set data from ITQ fisheries:

Data transfers and analysis of catch-per-set data were meant to fulfill in-season requirements with all data available at 8am prior to the Fraser River Panel meetings. However, despite the data being available at 8am, the analyses were not completed until after the Fraser River Panel meetings because the goal of this project was to evaluate feasibility, and the information was not meant to be used for 2018 in-season assessments or to put extra burden on PSC and DFO staff. After each panel meeting, ESSA received the updated daily abundance estimates and test fishery catch-per-set from the PSC and the ITQ catch-per-set data from DFO. During the 2018 season, ESSA received Area B ITQ catch-per-set data on August 17th, 21st, 24th, 28th, 31st, and September 7th. Throughout the season, daily catch reports of the ITQ fishery were collected both through phone-ins and ELOGs, and ELOG only.

Component 2: Develop statistical models to estimate daily abundance from ITQ catch-per-set data

Mean daily catch-per-set estimates were calculated for 2018 by averaging the mean catch-per-set information from all individual fishers reporting on that day. Using historical data for 2010 and 2014, a linear regression was performed between daily abundance estimates for those years and corresponding ITQ mean daily catch-per-set data for each subarea (12-3, 13L, 13U). The mean daily catch-per-set and daily abundance estimates were natural-log transformed (following Cave 2017) prior to analyzing them with the linear regression. The resulting linear relationship was used to predict daily abundances using mean daily ITQ catch-per-set data for 2018. The linear regression for the 2010/2014 data is described in Appendix B.

Component 3: Collect, process, and estimate daily abundance using Test Fishery data as well as Hydroacoustic data

In a process independent of this project, the DFO and PSC use test fisheries to collect catch-per-set data, which the PSC uses to estimate daily abundances (Michielsens and Cave, 2019). In addition, the PSC also reconstructs the daily abundances for the areas 12-3, 13L and 13U using Northern Diversion rates estimates in combination with hydroacoustic data collected at Mission and seaward catches within a backwards reconstruction. The Northern Diversion Rate is an estimate of the daily proportion of fish migrating through Juan de Fuca Strait relative to Johnstone Strait. Despite being more precise than the test fishing based abundance estimates, these reconstruction-based estimates are available one week later than the test fishery or ITQ data.

Component 4: Compare the daily abundance estimates generated by the ITQ data and the statistical model to results from the Test Fishery and from hydroacoustics data

The daily abundance estimates derived from the 2018 ITQ catch-per-set data (Component 2) were compared against the corresponding daily abundance estimate generated by the PSC from test fishery data (Component 3), and against the reconstructed daily abundance estimate derived from hydroacoustics data collected at Mission (Component 3).

The comparisons are done using a series of linear regressions on natural log-transformed data to generate R^2 values. Log-transformations were done to normalize the catch-per-set data. These comparisons included:

- ITQ catch-per-set vs. TF catch-per-set;
- ITQ catch-per-set vs. reconstructed daily abundance;
- TF catch-per-set vs. reconstructed daily abundance; and
- A comparison of predicted daily abundances derived from ITQ catch-per-set data and TF catch-per-set data to the reconstructed daily abundance estimates.

2.4 Task 4: Evaluate solution post-season

The post-season evaluation was very similar to the in-season evaluation. However, the post-season analysis relied on DFO and PSC to carefully review the data and provide ESSA with a QA/QC-hardened data set. Adjustments to the data included changes to the diversion rate which will change the estimates of daily abundance based on hydroacoustics, and changes in the catch reported from the ITQ logbooks.

The post-season assessment also includes insights from collaborators and interviews with fishing vessel captains about the feasibility and ease with which the pilot project was adopted.

3 Results

The goal of the 2018 pilot project was to assess the feasibility of obtaining in-season ITQ catch-per-set data and the usefulness of these data for integration into the PSC's daily abundance estimates. The project team unanimously concluded that the pilot study was successful and demonstrates that obtaining in-season catch-per-set data from ITQ fisheries is both feasible and of high utility. The key findings for each project component are described below.

3.1 2018 In-season Assessment

For the 2018 in-season pilot project, we focused our analyses on subarea 12-3, as there were limited ITQ catch-per-set data in 13U and 13L available. For subarea 13L, only eight of the 27 days in the season had ITQ catch-per-set data composed of reports from an average of 1.4 fishers per day. For subarea 13U, only 18 of the 27 days in the season had ITQ catch-per-set data composed of reports from an average of 4.1 fishers per day. In comparison, subarea 12-3 averaged 13.2 fishers per day and had reports from all days of the season the ITQ fishery had been operational.

The ITQ and Test Fishery (TF) in-season catch-per-set data were highly correlated, with a coefficient of determination (adjusted-R^2) of 0.77 (Figure 3). In addition, the catch-per-set data were similar between the ITQ and the Test Fishery, indicating a similar efficiency at catches the available fish despite the Test Fishery fishing a strict sampling pattern and the ITQ fishery aiming to maximise catches. However, the commercial ITQ in-season catch-per-set data exhibited a stronger correlation with daily abundance estimates than the TF catch-per-set data. For Area 12-3, the R^2 value for the ITQ catch-per-set data and TF catch-per-set data were 0.70 and 0.51, respectively (Figure 4 and Figure 5). When the TF catch-per-set data were restricted to the same days as the ITQ catch-per-set data, the R^2 value increases to 0.57. The correlation between the predicted daily abundances from the ITQ catch-per-set and TF catch-per-set data varied as the season progressed and the daily abundance estimates derived by the PSC were updated. The predicted abundances from the ITQ (phone-in and ELOG reports, and ELOG only reports) and TF catch-per-set data relative to the PSC daily abundance estimate are shown in Figure 6.

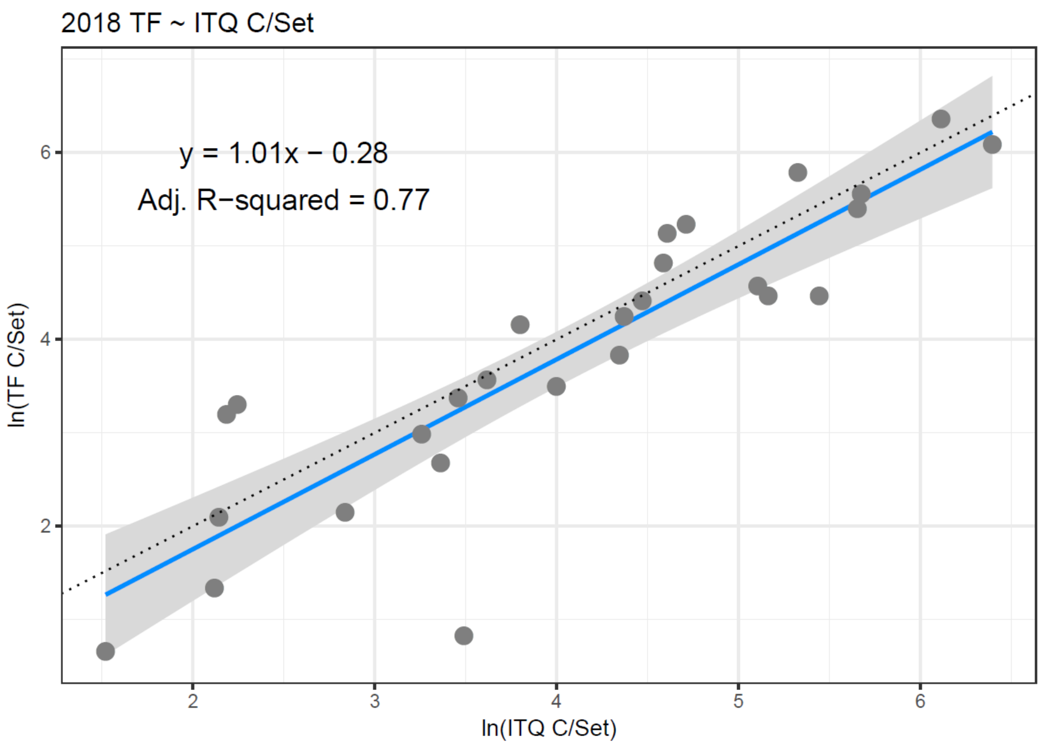


Figure 3: 2018 In-season ITQ catch-per-set and Test fishery catch-per-set (C/Set) (both natural log-transformed) data were strongly correlated with an adjusted-R^2 of 0.77. The blue line is the linear regression line, the grey shaded area is the 95% Confidence Interval, and the dotted line is the 1:1 line.

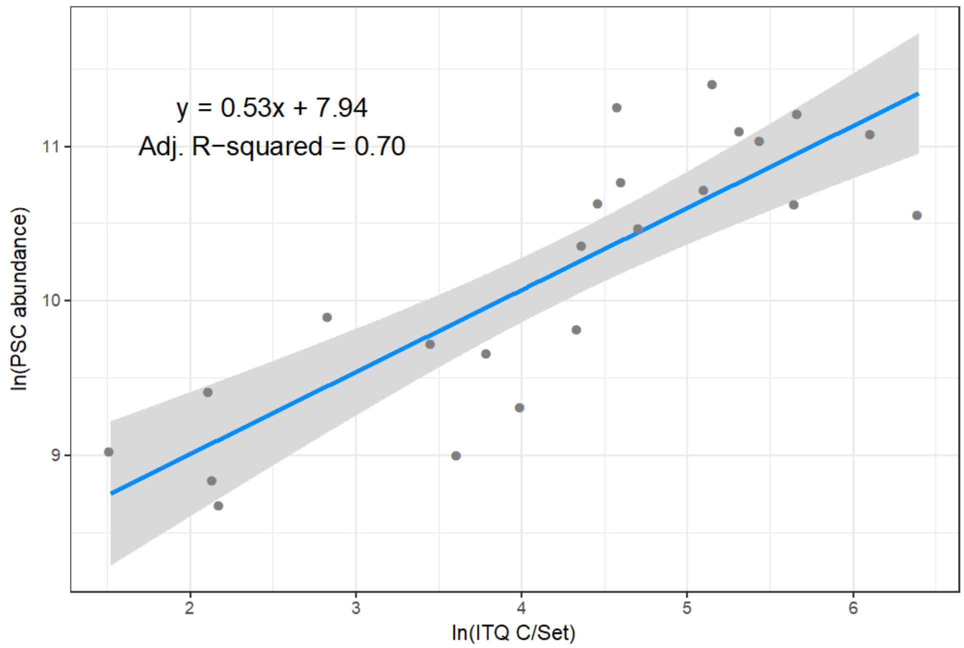


Figure 4: 2018 in-season linear regression between natural log transformed ITQ catch-per-set (C/Set) data and natural log transformed reconstructed daily abundance estimates supplied by PSC. The ITQ catch-per-set data is composed of both phone-in and ELOG reports. The blue line is the linear regression line, and the grey shaded area is the 95% Confidence Interval.

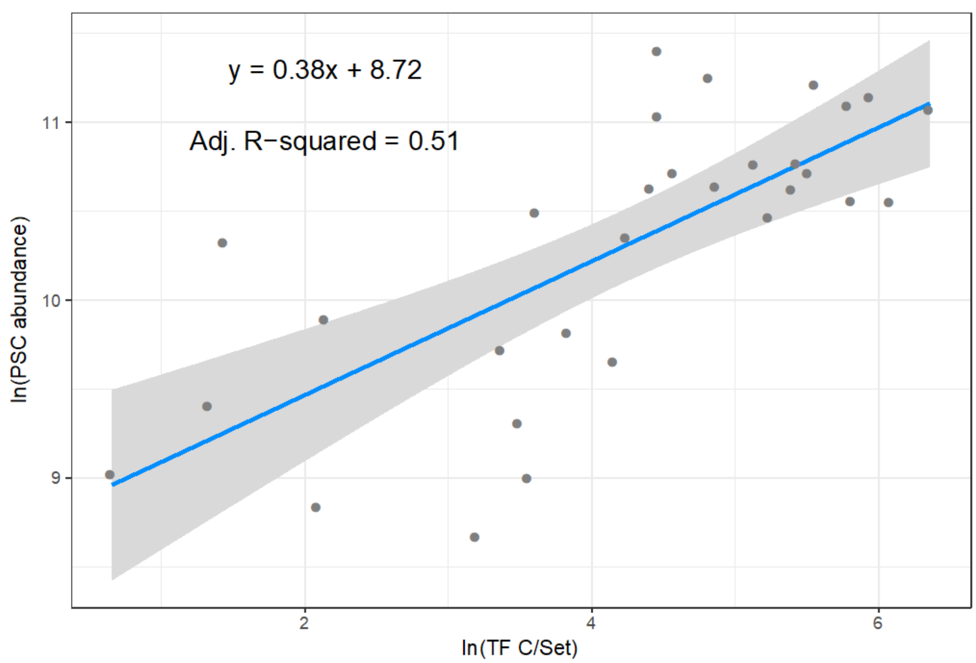


Figure 5: 2018 in-season linear regression between natural log transformed Test Fishery catch-per-set (C/set) data and natural log transformed PSC reconstructed daily abundance estimates. The Test Fishery catch-per-set data includes all available catch-per-set data. Restricting the Test Fishery catch data to the same time-frame as the ITQ catch data results in a stronger relationship (Adjusted R^2 = 0.57). The blue line is the linear regression line, and the grey shaded area is the 95% Confidence Interval.

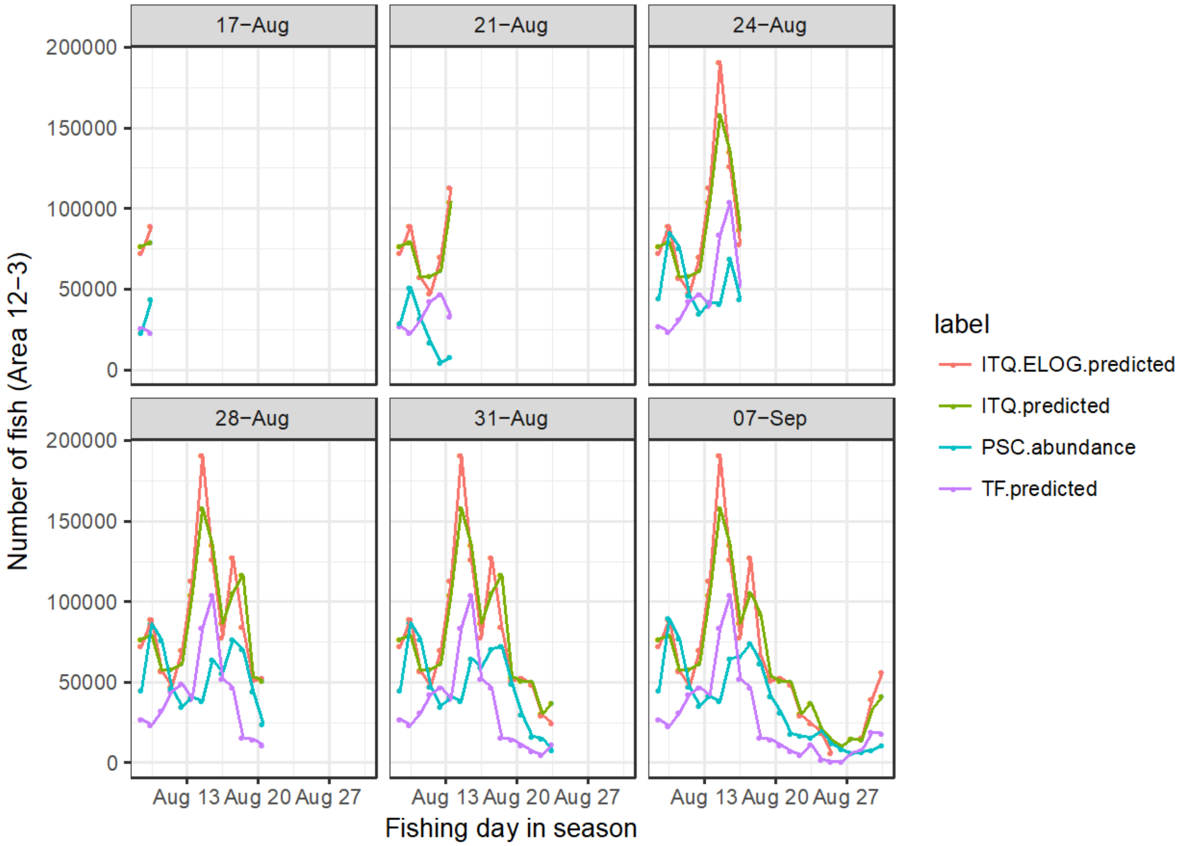


Figure 6: Predicted abundances derived from ITQ, ITQ ELOG only, and test fishery catch-per-set data along with the PSC reconstructed daily abundance estimates. Each panel reflects the daily abundance estimate for that particular assessment date.

3.2 2018 Post-season Assessment

The 2018 post-season data include updates to the ITQ catch-per-set data with higher reporting compliance rates. The differences in mean daily catch-per-set estimates for the in-season and post-season ITQ catch-per-set data are extremely small, with an R^2 value greater than 0.99. The predicted abundances derived from the in-season and post-season ITQ catch-per-set data are also highly correlated ($R^2 > 0.99$, Figure 7). The in-season ITQ and TF predicted daily abundances however vary in their correlation to the PSC reconstructed daily abundance estimates, as the predicted daily abundances estimates derived from ITQ data more closely tracks PSC's reconstructed daily abundance estimates. The R^2 value for the ITQ predicted daily abundance and PSC reconstructed daily abundance estimate and for the TF predicted daily abundance and PSC reconstructed daily abundance is 0.70 and 0.37, respectively. The PSC reconstructed daily abundance estimates and predicted abundances as of the September 7th assessment date are shown in Figure 8.

The updated post-season ITQ catch-per-set data weakens the relationship between ITQ and test fishery catch-per-set data. The R^2 value decreases from 0.70 to 0.67 when switching from the in-season to post-season ITQ catch-per-set data.

The results of the 2018 in-season assessment are similar to those observed in 2010 and 2014: ITQ catch-per-set data had a stronger relationship with PSC daily abundance estimates than the Test Fishery catch-per-set data. For the 2010 and 2014 ITQ catch-per-set data, the R^2 values were 0.61 and 0.54, respectively; compared to 0.57 and 0.40 for the TF, respectively. For the 2010 and 2014 combined data, the R^2 values for the ITQ and TF catch-per-set data were 0.69 and 0.69, respectively. For all three years combined (2010, 2014, 2018), the ITQ catch-per-set data has an R^2 of 0.77(Figure 9), and the TF catch-per-set has an R^2 of 0.69 (Figure 10).

In addition to the daily ITQ catch-per-set estimates, the PSC reconstructed daily abundance estimates in Johnstone Straight are also subject to change during the post-season, as revisions to the diversion rate occur. Updates to the 2018 diversion rate were not available at the time of preparation of this report (March 2019).

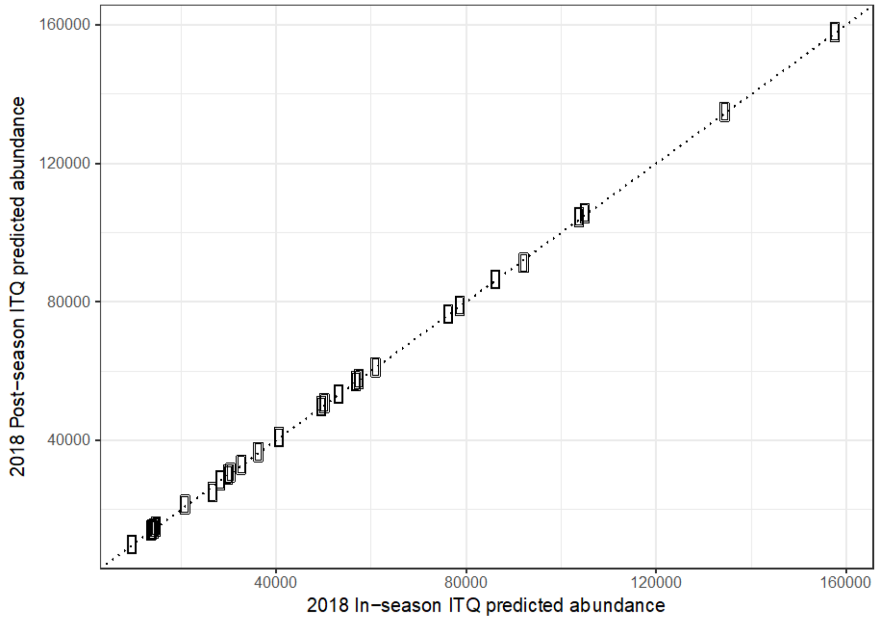


Figure 7: Predicted daily abundance estimates derived from the in-season ITQ catch-per-set data and the updated post-season ITQ catch-per-set data are extremely similar. The dotted line is the 1:1 line.

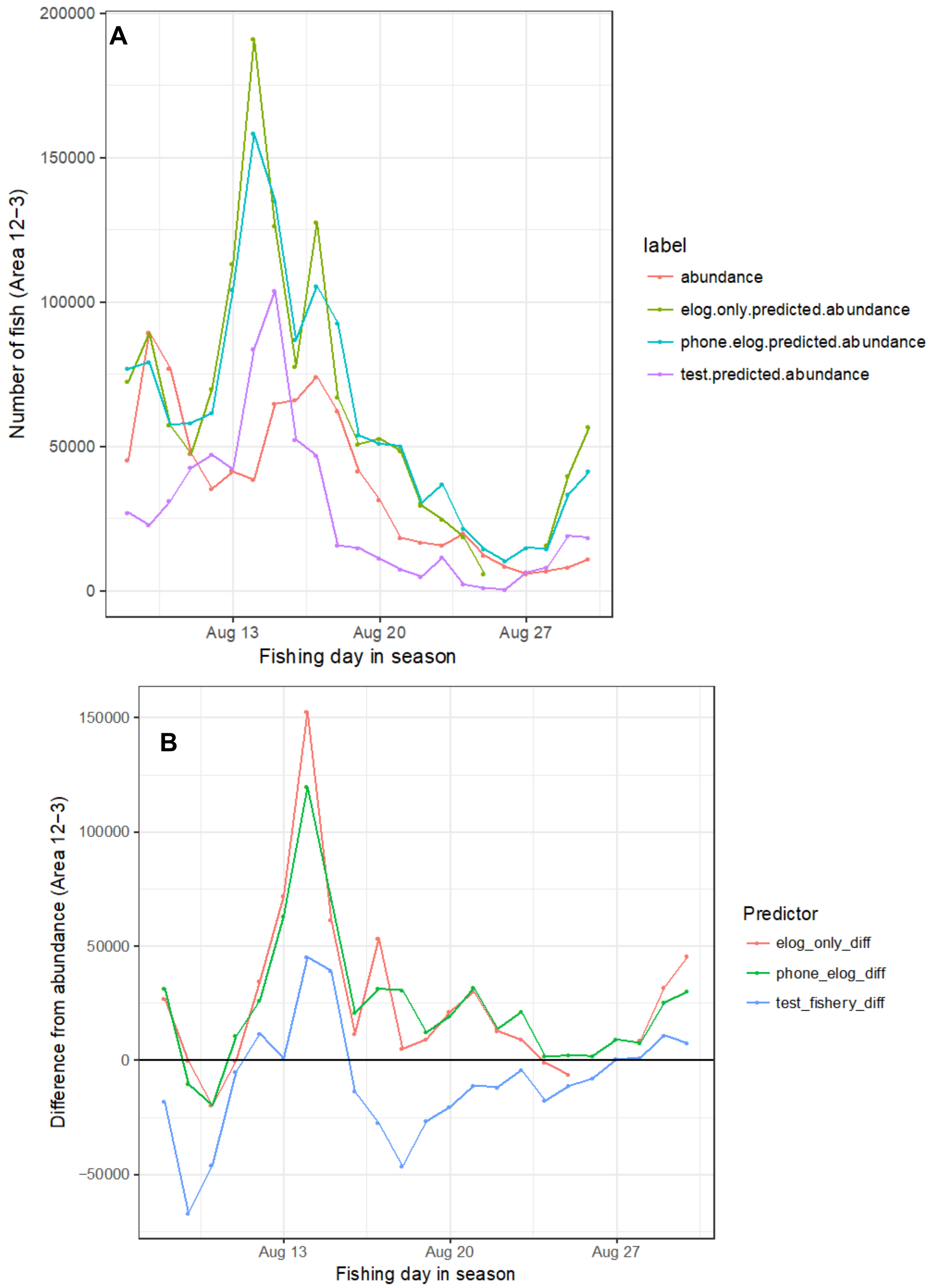


Figure 8: 2018 predicted abundances calculated from the linear regression of 2010/2014 ITQ catch-per-set and PSC reconstructed daily abundance estimates. Predicted abundances are for both ITQ phone-in and ELOG and ELOG only catch data. Panel A shows the raw predicted abundances along with the PSC daily abundance estimates as of the September 7th Assessment Date. Panel B shows the predicted abundances as the difference from the PSC reconstructed daily abundance estimates (represented as the horizontal 'zer0 line'. The R^2 values for the ITQ predicted abundance and PSC reconstructed daily abundance and for the TF predicted abundance and PSC reconstructed daily abundance are 0.70 and 0.37, respectively.

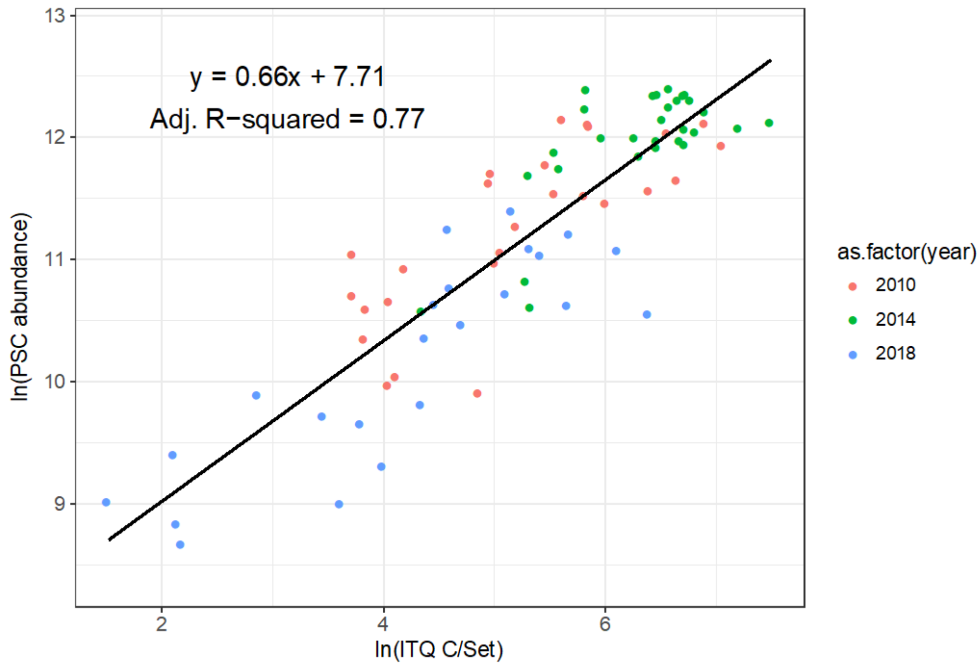


Figure 9: Linear regression for natural log transformed ITQ catch-per-set(C/Set) and PSC reconstructed daily abundances, across 2010, 2014 and 2018 fishing seasons. The black line is the regression line and the grey band is the 95% confidence interval.

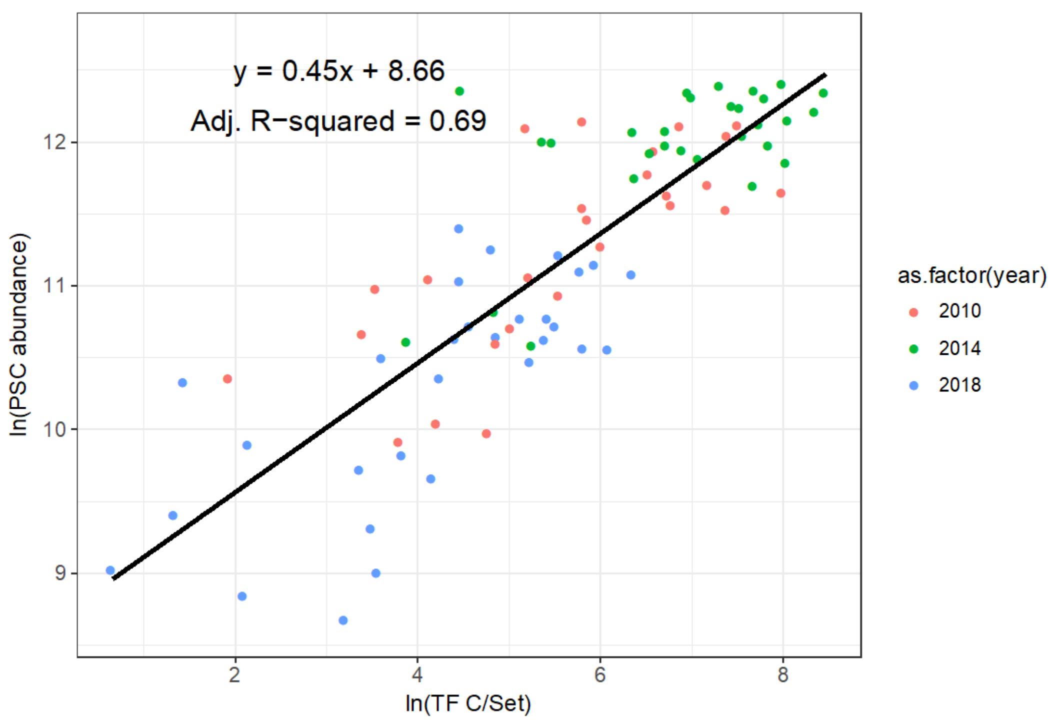


Figure 10: Linear regression for natural log transformed TF Catch-per-set (C/Set) and PSC reconstructed daily abundances, across 2010, 2014 and 2018 fishing seasons. The black line is the regression line and the grey band is the 95% confidence interval.

3.2.1 Post-season captain interviews

As part of our post-season assessment of the 2018 pilot project, ESSA interviewed several captains that participated in the pilot study to understand the barriers, successes and potential improvements that could be implemented. Four captains participated in the interview. Among the four, only one was brand new to ELOGs, and one had used ELOGs for the herring fishery (but not the ITQ purse seine fishery). The catch-per-set feature in the ELOG software was a new addition for this pilot project. Each interview lasted approximately 30 minutes and was composed of six questions:

1. How did you use the VMS/ELOG system this year?
2. What were the biggest headaches, obstacles, or barriers to using the VMS/ELOG system?
3. What specific parts of the VMS/ELOG system could be improved?
4. What specific parts of the VMS/ELOG system worked well or did you appreciate any of the benefits of the system?
5. How did the VMS/ELOG system compare to reporting catch by phone-in?
6. Is there anything else you would like to share about your experience with the VMS/ELOG system?

General notes and responses for the questions are listed in the bullet points below.

1. How did you use the VMS/ELOG system this year?
    - Only one of the four captains entered catch-per-set information after every set. The remaining three entered catch-per-set data into the ELOGs at the end of the day.
    - Majority agreed that entering catch information after every set is too burdensome and distracting when in the middle of fishing, and it would only be feasible to enter catch information at the end of the day.
    - One captain (with previous ELOG experience) switched between using VMS and a mobile broadband stick (when possible). He experienced fewer connection issues when using the mobile broadband stick compared to the VMS.

2. What were the biggest headaches, obstacles, or barriers to using the VMS/ELOG system?
    - Entering catch-per-set information (instead of total catch and total number of sets) was time consuming.
    - Technical assistance from the service provider was generally unavailable when it was needed (in the evenings outside of 9-5 business hours when fishing was completed for the day).
    - There was some hesitation about being 'tracked' by DFO with the VMS unit.
    - There were a number of issues identified by the captains regarding specific parts of the ELOG software. These include:
        - Fish transfer function was difficult to use. It was hard to find a specific vessel CFV numbers while having to scroll through the extensive list. This challenge resulted in an incomplete fish transfer entry in ELOG and an inaccurate in-season catch-per-set entry.
        - Difficulty with obtaining a new "Start Fishing" number, as the previous catch reports did not seem to be 'received'.
        - System not registering catch report was an ongoing problem.
        - Scrolling through the list of location names was burdensome.

3. What specific parts of the VMS/ELOG system could be improved?
    - More flexibility and control given to operator to move between fishing days.
    - Offload function in ELOGs seems redundant. General feeling that there is too much redundant reporting.
    - The ELOG pop-up windows can sometimes occur behind other open windows, meaning you don't see the error message window when it opens behind another window.
    - Design the system to catch mistakes and send email reminders about "ending trips" or other reporting errors/inconsistencies/incompleteness
    - General feeling that the ELOG software is clunky and could be improved to feel more like modern computer programs

- Entering the data on a per-set basis was cumbersome compared to entering the total catch and total sets per day.

4. What specific parts of the VMS/ELOG system worked well or did you appreciate any of the benefits of the system?
   - Varied use / benefit of the text messaging service noted by crew
   - Varied use / benefit of the VMS tracking service noted by crew
   - Varied use / benefit of the ELOG cheat-sheet noted by crew
   - The VMS installation and ELOG trainings generally went well and were helpful.

5. How did the VMS/ELOG system compare to reporting catch by phone-in?
   - Among the four captains, there was ***unanimous*** support for the VMS/ELOG system over the phone-in reporting.

6. Is there anything else you would like to share about your experience with the VMS/ELOG system?
   - A large part of technical trouble-shooting was conducted by DFO staff outside of business hours. This was greatly appreciated by the captains.

4 Discussion

4.1 Findings from the Feasibility Study

Based on the results reported above, the project team concluded it is feasible to collect and use in-season catch-per-set data from commercial ITQ fisheries to inform daily abundance estimates. Furthermore, the results of the data collection and analysis suggest that further exploration into the use of commercial fishery catch-per-set data is a promising avenue to explore.

With this pilot project we demonstrated for 2018 that in Johnstone Strait the in-season ITQ catch-per-set data for sockeye and the derived daily abundance estimates exhibited a strong correlation with the reconstructed daily abundance estimates. This result was consistent with post-season analyses of data for 2010 and 2014. ITQ catches represent a larger portion of the total daily available abundance than test fishing catches and are likely to constitute a more consistent proportion of the daily abundance across days and years when fishing occurs. These factors contribute to the strength of the relationship between the ITQ catch-per-set data and the daily reconstructed abundance estimates. One of the drawbacks of the ITQ data is that it only allows an assessment of the abundance migrating through Johnstone Strait and not through Juan de Fuca Strait. Total daily abundance estimates from both marine approaches are, however, required as input into the model to estimate the total run size. The impact of this constraint on the usefulness of the ITQ data will depend on the Northern Diversion rate; i.e., the proportion of the run migrates through Johnstone Strait. Regardless of this drawback, the ITQ catch-per-set data could be used in combination with the test fishery data within the run size model to produce in-season run size estimates and potentially contribute to improved in-season fisheries management.

The promising results from the Johnstone Strait sockeye salmon fishery suggest that the information can complement data from the test fishery although it should not be considered a replacement. This limitation is in part due to the lack of spatial and temporal coverage of the commercial fishery relative to the test fishery. In particular:

- The test fishery ensures temporal coverage throughout fishing season (subareas 13L and 13U only had ITQ catch data for 8 and 18 out of the 28-day season, respectively);

- ITQ catch-per-set data increases the number of vessels reporting daily catch data (for subarea 12-3 in 2018, the mean number of daily fishers was 13.2 with a standard deviation of 9.0); however, the number of days each ITQ fishery vessel reports daily catch data is highly variable (for subarea 12-3: mean = 4.9, sd = 2.7, minimum = 1, maximum = 13), which has implications for predictive power.

- Reporting the ITQ catch data as daily total catch and total sets or by individual catch-per-set does not affect the timing of when the data are used (reporting deadline is 8am the next day). However, total daily catch from multiple subareas has to be disregarded from analysis. If daily catch reported is from multiple subareas, but reported by catch-per-set, then catch from those sets within target subareas can be retained for analysis.

Vessel Monitoring Systems (VMS) and Electronic Logbooks (ELOGs) were also found to be a viable technical solution for reporting catch data to DFO's Fishery Operations System (FOS). For the purposes of data analysis, the phone-in data was just as useful as the ELOG data for analyses in the required time frame for in-season analysis. A strong indicator of the value of VMS and ELOG was that there was unanimous support for ELOGs over the phone-in Daily Catch Reports from the captains interviewed. The ELOGs facilitated faster reporting compared to the phone-ins where wait times could be upwards of 45 minutes. We were met with a generally receptive fishing community, although some worried about vessel tracking, which was an inherent feature of the VMS technology.

While the overall set up of the VMS and ELOGs was successful, there were still some challenges in the its deployment, in particular:

- Captains reported that ELOG usability was challenging, partly because the user interface was not streamlined and technical support was limited. DFO staff provided the technical support for the ELOG, largely because they installed the VMS units and installed the ELOGs on the participating vessels. In the future, support for the ELOG could shift to the service provider, who are currently paid to provide support for each ELOG licence. This support would require availability outside of 9-5 business hours that aligns with the fishing captains' work days.
- Development of the catch-per-set module was done 'just in time' for the sockeye fishery to start, which suggests that more capacity is needed to support the ELOG. Feedback from captains also suggest that the ELOG software was not as user-friendly as it could be.
- DFO support staff for FOS were limited in their time and capacity, and the improvements to FOS required for this project were challenging to support.

The VMS/ELOG system is more expensive than paper logbooks and phone-ins (Table 2). However, these costs should be balanced by the concerns around poor ease-of-use of the phone-in system identified by the fleet captains we interviewed. The VMS unit associated costs represent the largest cost differentiator. VMS units are $850 plus a $100 per unit installation fee (although there could be economies of scale if multiple units are installed concurrently). VMS activation fees are $60 per year plus the subscription-based data fees, which are a minimum of $59.95 per month for 1-hour intervals and $119.95 for 15-minute positional intervals. Aside from purchasing the VMS unit hardware, each year a captain would expect to pay about $150 more per year to use ELOGs and VMS instead of phone-in services (based on a five-month fishing season and a 1-hour positional data).

Table 2: Cost breakdown of Paper Logbooks/Phone-ins, ELOG, and VMS units.

Item	One-time cost	Annual cost	Monthly cost
ELOG		$220.50	
VMS unit	$850		
VMS activation fee		$60	
VMS installation fee	$100		
VMS Satellite data (1-hour)			$59.95
VMS Satellite data (15 min)			$119.95
Paper Logbook and Phone-in Service		$427	

Both ITQ catch-per-set data and test fishery data provide relative estimates of daily abundance that can be used to generate absolute daily abundance estimates. While this is useful, a more precise daily abundance estimate generated from multiple sources of information (ITQ and test fishery catch-per-set) does not necessarily improve total run size estimate. Other information included within the in-season run size model are estimates of migration timing and spread, and the main factor impacting improvements to the total run size estimates relate to how well those improved daily abundance estimates in combination with the other model inputs predict abundances seaward of the test fishery and ITQ fishery (Michielsens and Cave, 2019).

4.2 Next Steps

Given the success of the pilot project, there are several logical extensions to this work. Two specific considerations were discussed amongst the project partners:

(1) **Going from a pilot project to implementation** across the entire fleet. To implement this idea, and important consideration would be understanding how many VMS and ELOGs would be required to achieve high levels of precision in estimates of daily abundance.

(2) **Extending the pilot to other fisheries.** With this idea, a critical consideration is understanding if there are other fisheries that could be used to help inform daily abundance estimates.

4.2.1 Going from Pilot Project to Full Implementation

With this idea, one avenue that requires further exploration is understanding *how many* VMS and ELOGs would be required to achieve a high level of precision in the ability to estimate the daily abundance if we were to only use VMS and ELOGs without considering phone-in data. To better understand this requirement, the project team conducted an analysis to explore the issue. The full analysis can be found in Appendix C, but is summarized here.

During the 2010 and 2014 Johnstone Strait ITQ fishery for sockeye salmon in subarea 12-3, there were 61 and 66 vessels respectively participating to the fishery. Our analysis suggested that 20 to 45 vessels (2010 and 2014, respectively) would require a VMS unit to achieve R^2 values within 10% of the post-season values from the ITQ catch-per-set data compared to the derived daily abundance estimates.

4.2.2 Extending the pilot project to other fisheries

Given the success of this pilot project, the project team felt that further funding should be sought to understand whether the successes here would translate to successes in other fisheries. Further work would require a stepwise process that followed not just the work done as part of this pilot project, but also the work that preceded this project (e.g., Cave 2017 report). Fisheries that warrant consideration include Economic Opportunity (EO) fisheries, Food, Social, and Ceremonial (FSC) fisheries, recreational fisheries, and other commercial fisheries for additional species such as pink salmon.

At a high level, extensions of this pilot project to other fisheries would involve several necessary steps:

(1) Identifying fisheries that have the following characteristics - a fishery with near real-time reporting of catch data, a corresponding test fishery, and reconstructed daily abundance estimates from the PSC;

(2) Developing the statistical relationship between historical catch-per-set data from the commercial fishery and reconstructed daily abundance estimates;

(3) Understanding the statistical relationship between test fishery catch-per-set data and reconstructed daily abundance estimates;

(4) Following the methods outlined in Section 2 of this report, including reaching agreement on a technical solution, implementing the technical solution, and then evaluating it.

While the current pilot project relied on VMS units and ELOGs, the technical solution that another fishery chooses does not *necessarily* have to be the same. For example, if the fishery had excellent cellular data coverage, using computers with ELOGs tethered to a cellular phone with data could work equally as well. Any further work would require the continued collaboration between the fishing community, DFO, and the PSC.

5 Recommendations

Based on the feasibility study conducted, the following recommendations are proposed to refine and improve in-season reporting of catch-per-set data from fisheries to inform PSC daily abundance estimates:

4) More support is required for technology integration:
   a. Current support for the ELOG software and Fishery Operations System (FOS) made it challenging to implement the pilot project, in large part due to the lack of resources
   b. Captains suggested that the usability of the ELOG software could improve (which will help improve technology adoption by captains thereby increasing the amount of catch-per-set data);
5) The adoption of ELOGs and supporting technologies needs to increase
   a. The results of our simulation analysis determined that an additional 20-35 VMS units distributed throughout the ITQ fleet would be needed to capture 90% of the predictive power.
   b. Currently ELOGs and VMS units are cost prohibitive, and therefore cost-sharing options should be explored. VMS units remain costly compared to phone-ins on a per year basis, but the biggest cost is the VMS unit itself.
6) The pilot project should be extended beyond the ITQ salmon fishery to other fisheries to understand if information from multiple fisheries could provide weight-of-evidence support and increased accuracy for estimates of daily abundance

6 References

Cave, J. 2017. Analysis of Catch-per-Set information from the Area B Purse Seine Individual Transferable Quota Fisheries. Final Report for the Southern Endowment Fund. 39 p

Michielsens, C.G.J. and J.D. Cave. 2018. In-season assessment and management of salmon stocks using a Bayesian time-density model. Canadian Journal of Fisheries and Aquatic Sciences. https://doi.org/10.1139/cjfas-2018-0213

Nelitz, M., A. Hall, C. Michielsens, B. Connors, M. Lapointe, K. Forrest, and E. Jenkins. 2018. Summary of a Review of Fraser River Test Fisheries. Pacific Salmon Comm. Tech. Rep. No. 40: 155 p

Appendix A – ELOG Catch-per-set 'Cheat Sheet'

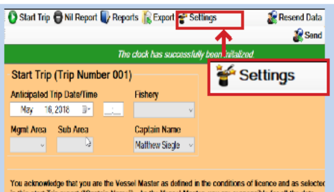
PAGE 1

DFO E-LOG MANUAL INSTRUCTIONS

THE FOLLOWING INSTRUCTIONS ARE FOR REPORTING "TOTAL DAILY CATCH" AND "DAILY SET BY SET" CATCH. NOTE THAT "SET BY SET" CATCH IS ONLY FOR THE ITQ PILOT PROJECT IN AREA B OF JOHNSTONE STRAIT

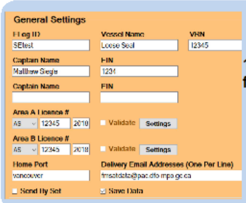
STEP 1: START TRIP
START TRIP must be ON or AFTER the Fishery Opening date (not the date leaving port).

From the HOME PAGE, select the appropriate fisery fr om the drop-down menu.



From START TRIP click "SETTINGS."

TOTAL DAILY CATCH OPTION



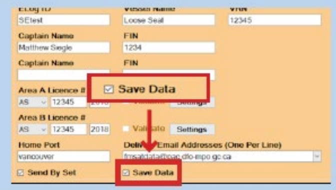
1) Fill-in box fieds.

DAILY SET BY SET OPTION

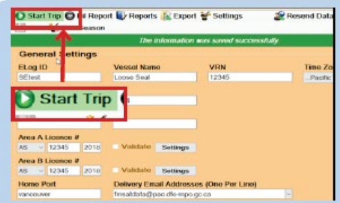
1) Fill-in box fieds.

2) Check "set-by-set."

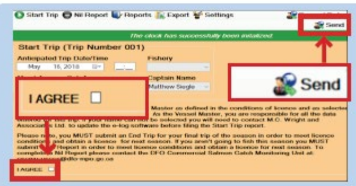
PAGE 2



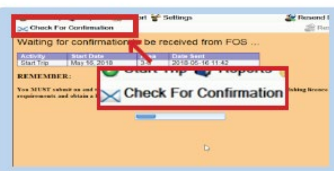
Check "SAVE DATA."



Click "START TRIP."



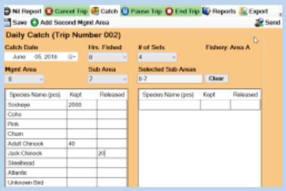
1. Fill out box fields.
2. Click "I AGREE."
3. Click "SEND."
4. Click "YES" to confirm.



Confirmation takes about 5 minutes. You do not need to wait for confirmation. Click "CHECK FOR CONFIRMATION" to begin recording set catch.

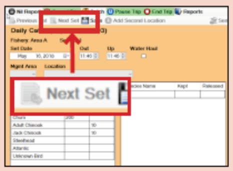
PAGE 3

STEP 2: RECORDING CATCH INFORMATION

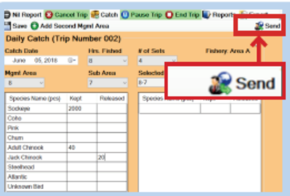


Fill out catch information.

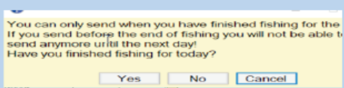
DAILY SET BY SET OPTION



After filling in catch information for first set, click "NEXT STEP" to continue entering additional sets. Repeat for every set.

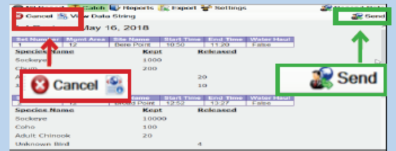


Click "SEND" after entering Daily Catch or after entering final set-by-set catch.

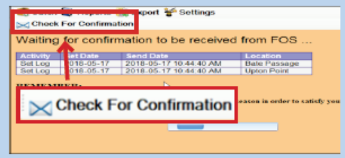


Confirm if you are done fishing for the day and want to send catch report.

PAGE 4

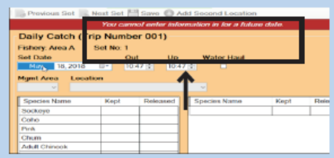


1) Review set catches for the day (Total Daily Catch OR set-by-set catch).
2) If correct, click "SEND".
3) If incorrect, click "CANCEL"



Confirmation takes about 5 minutes. You do not need to wait for confirmation.

Check "CHECK FOR CONFIRMATION"

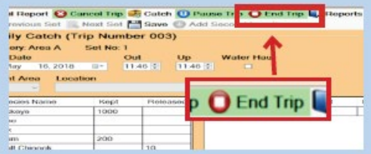


If the send is successful, you will be directed to catch report for the following day. The error message does not apply to the successfully sent catch report.

PAGE 5

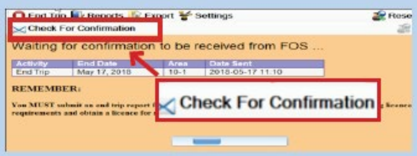
STEP 3: ENDING A TRIP

End the trip after reviewing DAILY CATCH REPORT and receiving FOS confirmation number.



Click "END TRIP"

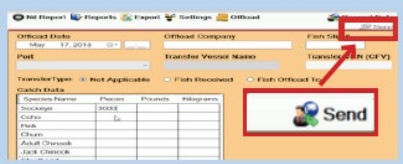
1. Fill out END TRIP information.
2. Click "SEND"



Click "CHECK CONFIRMATION"

STEP 4: OFFLOAD REPORT

For every **START TRIP** report submitted, one **OFFLOAD** report must be submitted.
You can submit an **OFFLOAD** report before or after submitting the **END TRIP** report, but it must be submitted ***BEFORE*** a new **START TRIP** report.

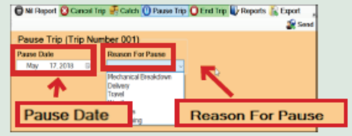


1. Enter the offload and transfer information
2. Click "SEND"

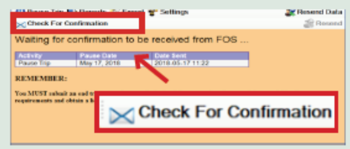
PAGE 6

PAUSING A TRIP

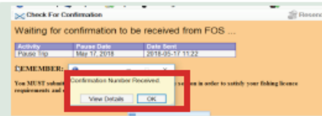
Click **PAUSE TRIP** if you are **NOT** finished for the day but do not want to cancel a trip
PAUSE TRIP report notifies DFO that you have suspended fishing effort ***FOR A PARTICULAR DAY***



1. Select date
2. Select reason for pause (can be left blanlk)
3. Click "SEND"



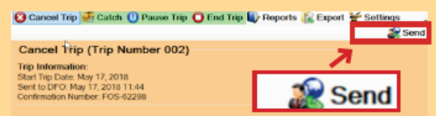
Click "CHECK FOR CONFIRMATION"



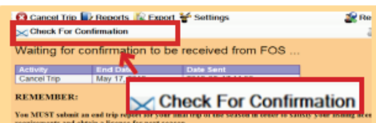
Click"OK"

CANCELLING A TRIP

Click CANCEL TRIP if you need to cancel a trip after a trip has already started.
You CANNOT cancel a trip if fishing has already occurred.



Click "SEND"



Click "CHECK FOR CONFIRMATION"

WHO DO I CONTACT IF I EXPERIENCE A PROBLEM?: M.C. WRIGHT AND ASSOCIATES LTD.: (250) 591 - 1056

Appendix B – Figures for the linear regression of daily abundance and catch-per-set

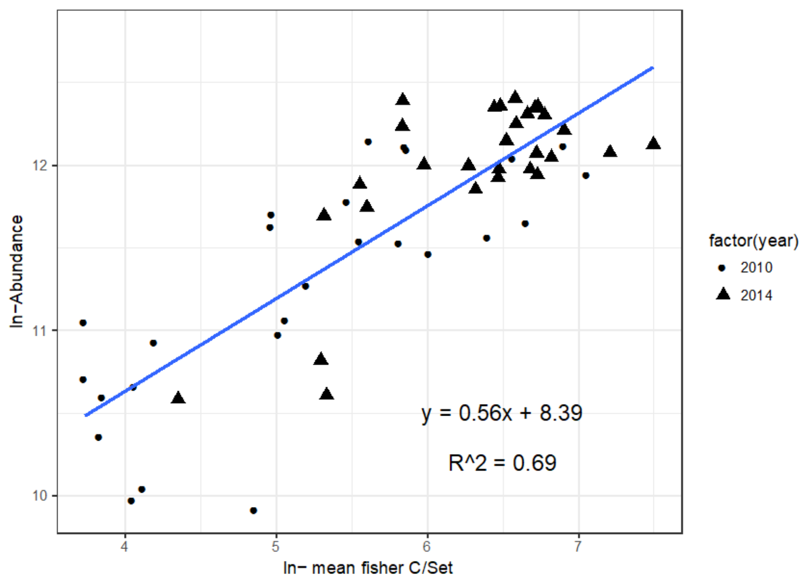


Figure B1: Area 12-3 linear regression for the combined 2010 and 2014 catch-per-set (C/Set) data. The straight line is the prediction line, and the grey band is the 95% confidence interval.

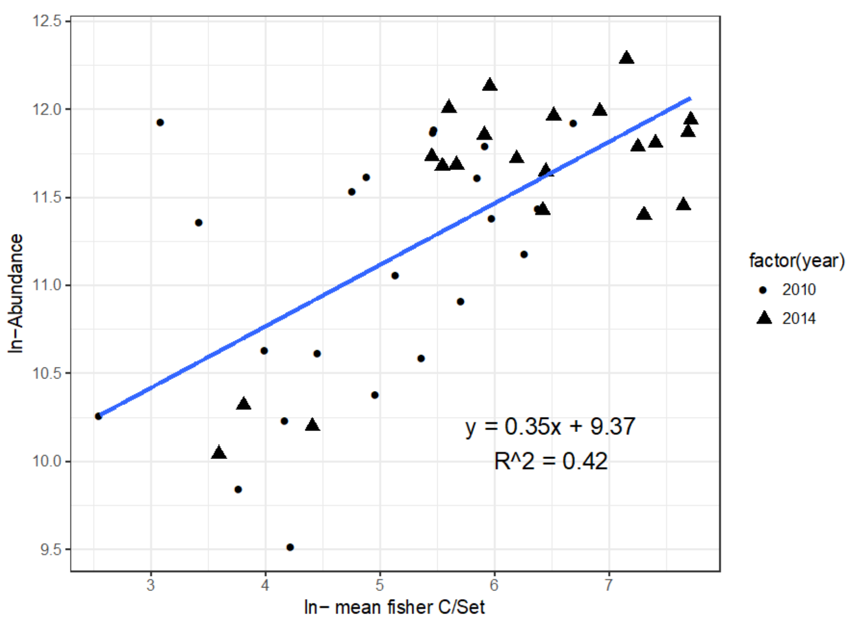


Figure B2: Area 13L linear regression for the combined 2010 and 2014 catch-per-set (C/Set) data. The straight line is the prediction line, and the grey band is the 95% confidence interval.

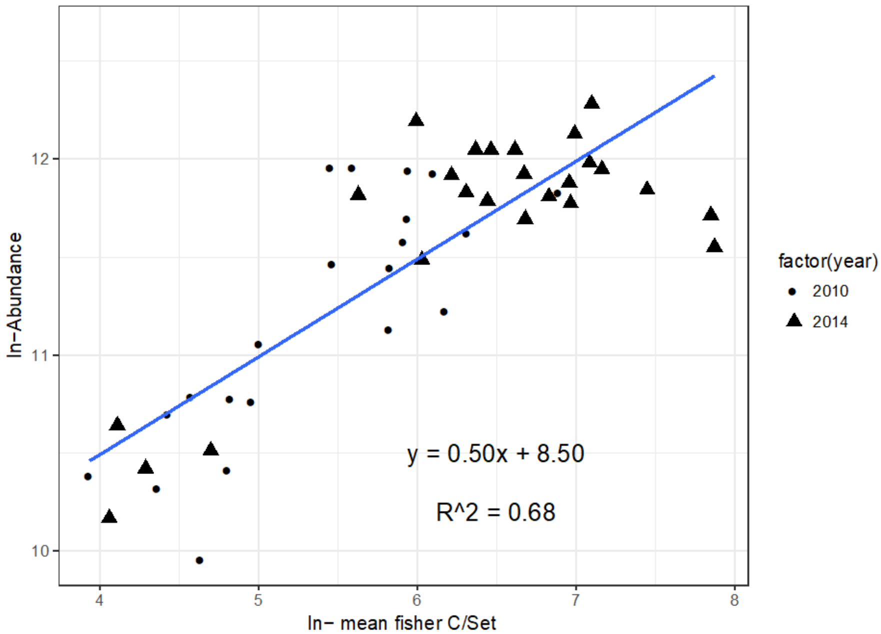


Figure B3: Area 13U linear regression for the combined 2010 and 2014 catch-per-set (C/Set) data. The straight line is the prediction line, and the grey band is the 95% confidence interval.

Appendix C – Sample Size Simulation Study

How does the number of fishing vessels reporting daily catch-per-set data affect the relationship between daily catch-per-set and daily abundance?

Appendix Authors: Matthew Siegle[1*], Brian Ma[1] and Catherine Michielsens[2]

[1] – ESSA Technologies Ltd, [2] – Pacific Salmon Commission

Background

A strong relationship between daily catch-per-set information from post-season logbook data and estimates of daily abundance of summer-run sockeye salmon was established by a previous study using information from the Individual Transferrable Quota (ITQ) fishery for sockeye salmon in Johnstone Strait, Area B (ITQ fishery) (Cave 2017). The work presented here is an extension of this analysis.

A pilot project on the feasibility of collecting daily Catch-per-set data from the ITQ fishery in real-time using VMS units is planned for the 2018 ITQ fishery. Real-time data collection will pose its own set of challenges, from logistical challenges to a smaller set of data collected. In this analysis, we explored the effect of changing the availability of daily catch-per-set data on the relationship between catch-per-set and daily abundance estimates of summer-run sockeye salmon. Instead of the 'perfect' information from post-season logbook data, we sub-sampled the data, thereby treating it as if it were in-season data collected under -

(1) different scenarios of catch reporting compliance (i.e., variation in the number of fishers reporting daily catch-per-set data on time), and

(2) different time points throughout the season as the season progresses.

Importantly, for the purpose of our analysis, we can consider the boats that are sampled as having the ability to report catch-per-set information in real-time via VMS units. Therefore, the 'number of fishing vessels sampled is analogous to the 'number of unique fishing vessels that use VMS and ELOGs'. This is important to consider because VMS units cannot be moved from boat to boat within the season, and there is a large number of unique fishing vessels fishing throughout the season and high variation in the total number of days each vessel is actively fishing. For example, there were 61 and 66 unique fishing vessels in Area 12-3 for the 2010 and 2014 fishing seasons, respectively. Out of a total 26 and 29-day seasons for 2010 and 2014, the number of days a fisher reported daily Catch-per-set data ranged from 1 to 13 for the 2010 season, and 1 to 12 for the 2014 season.

Ideally, the findings from this report will help us better understand -

(1) how data availability will impact the relationship between catch-per-set and estimates of abundance of Summer-run sockeye salmon, and
(2) the number of vessels that have VMS units + ELOGs and report on time for the data to be useful to the PSC.

Approach

We used post-season logbook data from the ITQ fishery from 2010 and 2014 to understand this relationship. For each fishing season, we asked the question, "if we only consider a subset of fishing vessels reporting daily catch-per-set data, how would that change our understanding of the relationship between daily catch-per-set and daily abundance from the relationship derived from the complete post-season logbook data?" To answer this question, only catch-per-set data from Area 12-3 was used. We also investigated the effect of combining 2010 and 2014 data on the relationship between daily catch-per-set and daily abundance for Areas 12-3, 13U, and 13L.

For the 2010 and 2014 seasons in Area 12-3, there were 61 and 66 unique fishing vessels, respectively. We created different sample size categories that increased in increments of five (13 categories for 2010 and 14 categories for 2014) ranging from 5 fishing vessels to 61 (for 2010) or 66 (for 2014). Each sample size category was populated with a random selection of unique fishing vessels, and this procedure was repeated 100 times. Following Cave (2017), daily catch-per-set data were adjusted by the stock ID composition and mean daily catch-per-set and daily abundance data were ln-transformed. To ensure a ln-transformation was not performed on a value of zero (which is not mathematically possible), 0.001 was added to each mean daily catch-per-set value. This entails a ln-transformation is not attempted on a zero value and is small enough to not affect the interpretation of the model results. Linear regression was used to model the relationship between daily catch-per-set and daily abundance.

We conducted two analyses to understand the effect of fishing vessel sample size on -

(1) the temporal coverage across the fishing season that would be used to construct the relationship between daily catch-per-set and daily abundance, and
(2) the overall relationship between daily catch-per-set and daily abundance

and two analyses to address -

(3) how the relationship between daily catch-per-set and daily abundance changes as the fishing season progresses (for Area 12-3, 2010 and 2014 seasons)
(4) how the relationship between daily catch-per-set and daily abundance changes if the 2010 and 2014 data are combined (for Areas 12-3, 13U, and 13L).

Results

(1) Sample size and temporal coverage for Area 12-3

The 2010 and 2014 fishing seasons lasted for 26 and 29 days, respectively. In both years there was considerable variation in the number of days fished by each unique vessel (ranged from 1-13 and 1-12 for 2010 and 2014, respectively). Given this variation, the amount of temporal coverage across the fishing season that would be used to construct the relationship between daily Catch-per-set and abundance data varies by sample size. The number of fishing days across the fishing season that are represented by the different sample sizes increases as the sample size of vessels increases for both the 2010 and 2014 seasons (Figure C1 and Figure C2, respectively).

Based on the mean number of fishing days represented across the sample size category simulations:

- For the 2010 season, a sample size of 10 and 20 vessels leads to 80% and 90% fishing day representation of the 26-day season, respectively.
- For the 2014 season, a sample size of 20 and 35 vessels leads to 80% and 90% fishing day representation of the 29-day season, respectively.

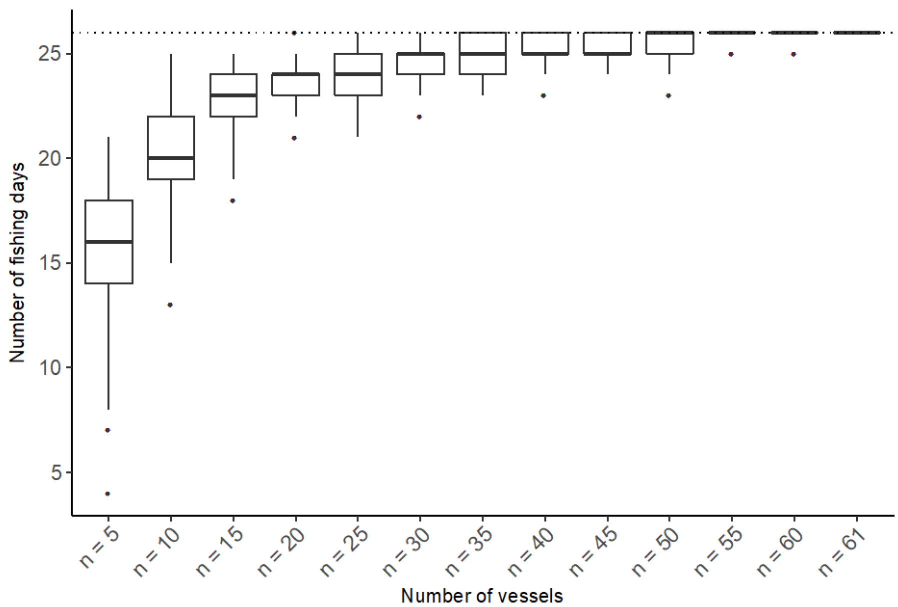


*Figure C1: For the 2010 season, the number of fishing days with daily catch-per-set information increases as the number of vessels reporting increases. The dotted line is at the full 26-day season. Each boxplot corresponds to 100 runs for each sample size category. Within each boxplot, the horizontal line is the median value, the top and bottom of the box are the 25% and 75% quartile, the ends of the whiskers are the respective interquartile range (ITQ)*1.5, and the dots are outliers.*

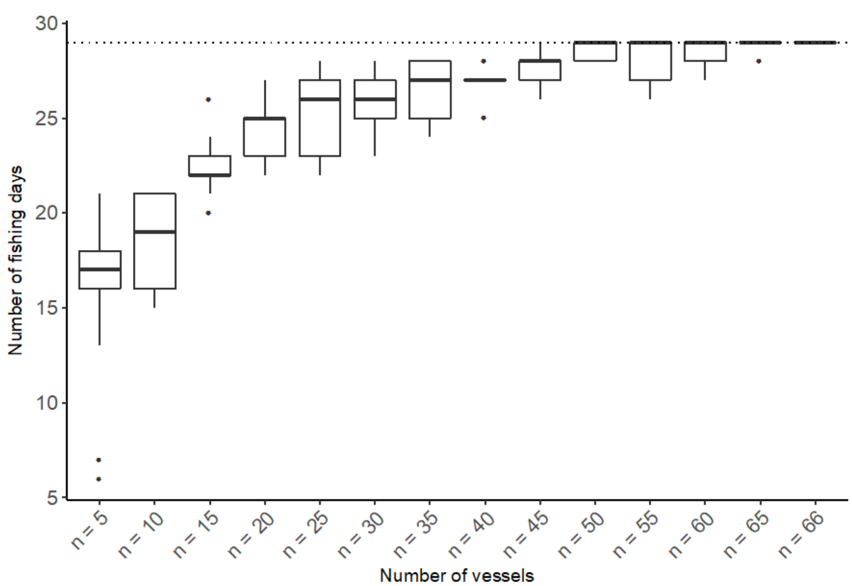


*Figure C2: For the 2014 season, the number of fishing days with daily Catch-per-set information increases as the number of vessels reporting increases. The dotted line corresponds to the full 29-day season. Each boxplot corresponds to 100 runs for each sample size category. Within each boxplot, the horizontal line is the median value, the top and bottom of the box are the 25% and 75% quartile, the ends of the whiskers are the respective interquartile range (ITQ)*1.5, and the dots are outliers.*

(2) Sample size and the relationship between daily catch-per-set and daily abundance

For both the 2010 and 2014 seasons, the precision of R^2 values between the ln-transformed daily catch-per-set and ln-transformed daily abundance data increases as the fishing vessel sample size category increases. This trend is more pronounced for the 2014 season. The range of R^2 values observed for each sample size category across the 2010 and 2014 seasons are shown in Figures C3 and C4, respectively.

Based on the mean R^2 value across the simulations, there is substantial variation between seasons in how many vessels are needed to achieve an R^2 value close to that observed with the full post-season logbook data (Table C1).

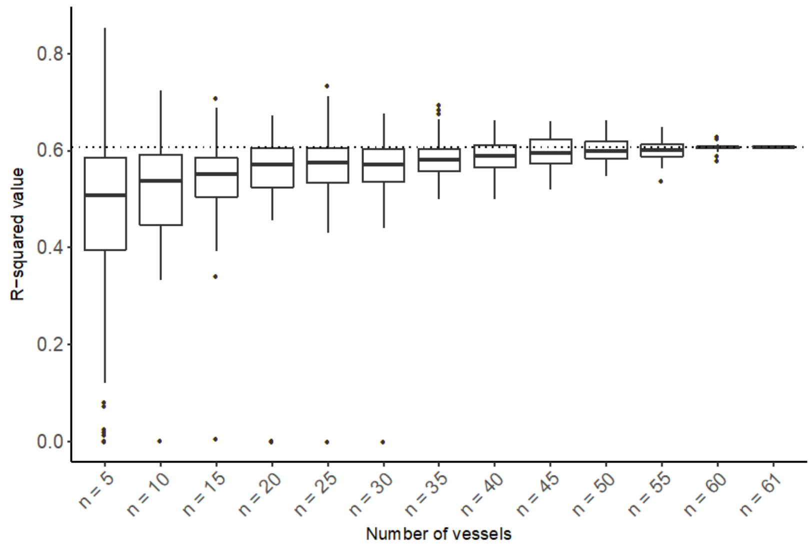


Figure C3: For the 2010 season, the precision of R2 values between the adjusted daily catch-per-set reporting and reconstructed daily abundance increases as the total number of vessels reporting catch-per-set information increases. the dotted line indicates the R2 value from the full logbook data.

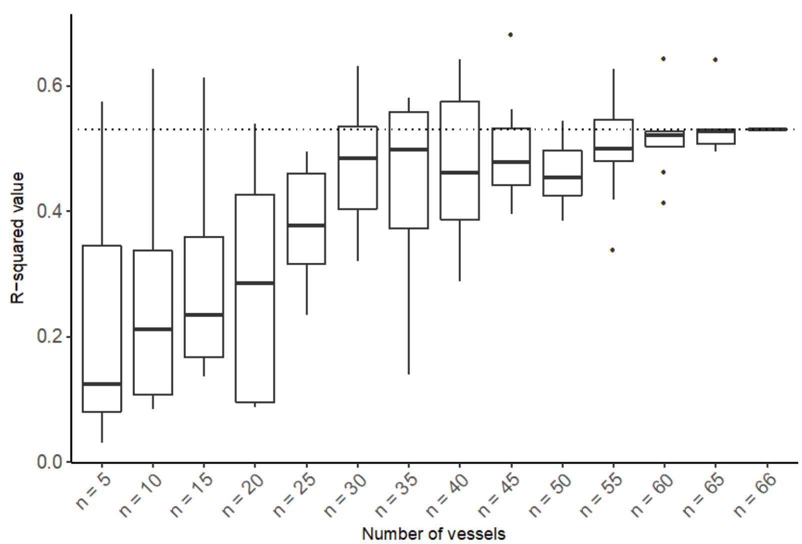


Figure C4: For the 2014 season, the precision of R2 values between the adjusted daily catch-per-set reporting and reconstructed daily abundance increases as the total number of vessels reporting catch-per-set information increases. the dotted line indicates the R2 value from the full logbook data.

Table C1: Number of vessels reporting daily catch-per-set data to ensure an R2 value within a target approximation of the R2 value from the full post-season logbook data.

Season	Total number of unique vessels	Number of reporting vessels needed for R^2 value to be within '*x%*' of the post-season logbook R^2		
		Within 5%	Within 10%	Within 15%
2010	61	30 vessels	20 vessels	10 vessels
2014	66	55 vessels	45 vessels	25 vessels

(3) The relationship between daily catch-per-set and reconstructed daily abundance as the season progresses

The relationship between daily catch per set and daily abundance changes as the fishing season progresses. For the 2010 season, the R^2 values do not consistently improve as the fishing season progresses, while the R^2 values generally increase as the 2014 season progresses, albeit at lower values. While the R^2 value for the full 2010 and 2014 seasons are similar (0.61 and 0.55), the R^2 value across the 2010 season fluctuates between 0.44 and 0.68, and the R^2 value for the 2014 season fluctuates between 0.03 and 0.55 (Figure C5). The linear models at day 7, 13, 20, and 26/29 (full post-season) for the 2010 and 2014 seasons are shown in Figure C6. While all four regression models at day 7, 13, 20 and 26 for the 2010 season are significant ($p < 0.05$), only the full 29-day model is significant for the 2014 season.

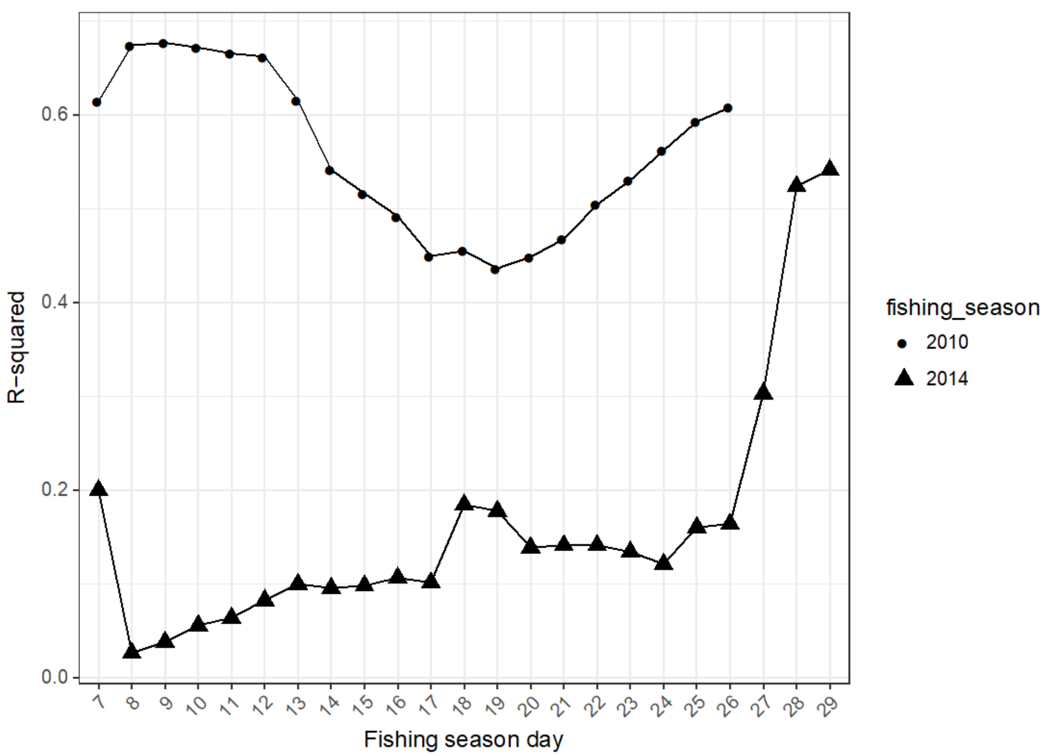


Figure C5: R2 values obtained from ln-ln-transformed Catch-per-set and reconstructed abundance data fluctuate as the season progresses for both the 2010 and 2014 seasons in Area 12-3.

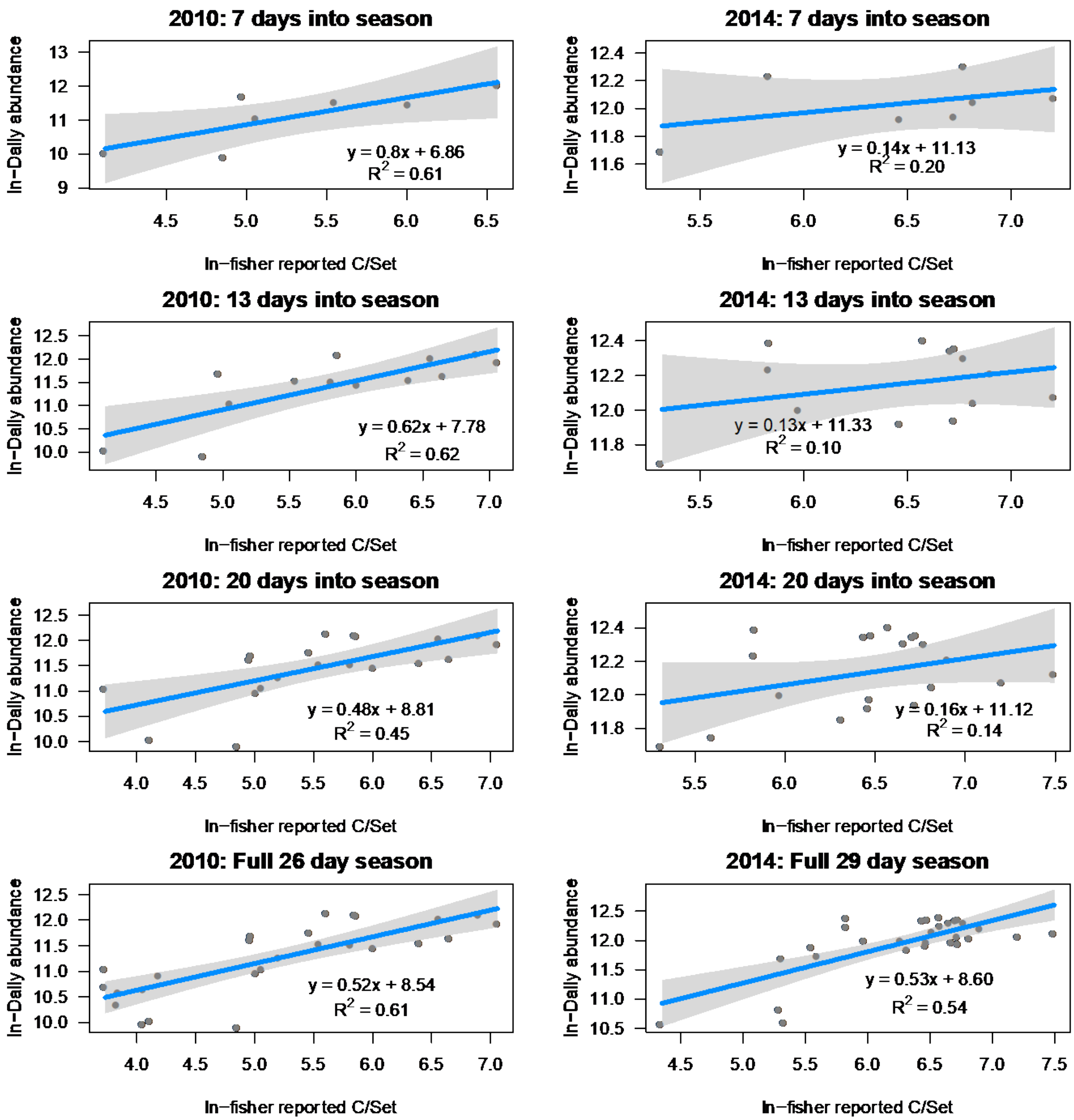


Figure C6. Relationship as the season progresses. Linear models of ln-ln transformed mean daily fisher reported Catch-per-sets and reconstructed daily abundance. The fit does not consistently improve linearly as the fishing season progresses. However, for all time frames except the 20 days into the fishing season, the fit does improve if the daily Catch-per-set data is adjusted for summer stock composition. Each row is a time frame, the left column includes the 2010 data and the right column includes the 2014 data. The straight line is the prediction line, and the grey band is the 95% confidence interval. All linear models for 2010 are significant ($p < 0.05$) while only the full 29-day model is significant for the 2014 season.

(4) Relationship between daily catch-per-set and abundance with combined 2010 and 2014 data for Areas 12-3, 13L, and 13U

For Area 12-3, when the data are pooled across both fishing seasons the R^2 value increases to 0.69 (Figure C7).

For Area 13L, an R^2 value of 0.22 and 0.53 are observed for 2010 and 2014, respectively. When the data are combined for both years, an R^2 value of 0.42 is observed (Figure C8).

For Area 13U, an R^2 value of 0.69 and 0.63 are observed for 2010 and 2014, respectively. When the data are combined for both years, an R^2 value of 0.68 is observed (Figure C9).

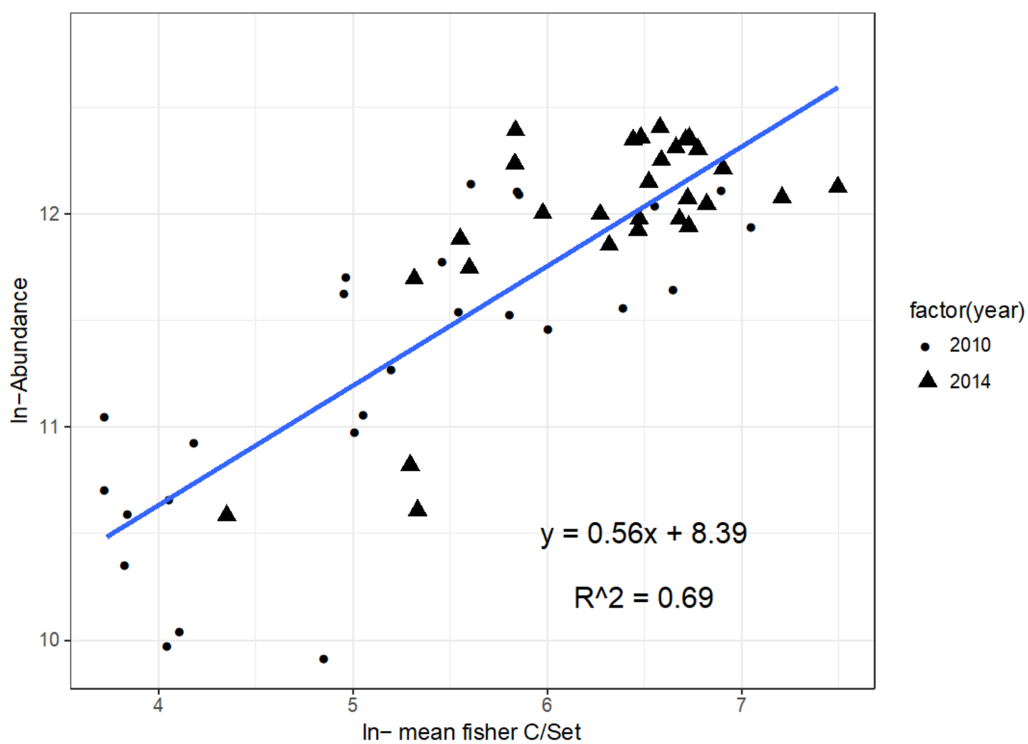


Figure C7: Area 12-3. A stronger relationship between daily abundance and mean catch-per-set data is observed when the data is pooled across the 2010 and 2014 seasons. The straight line is the prediction line, and the grey band is the 95% confidence interval.

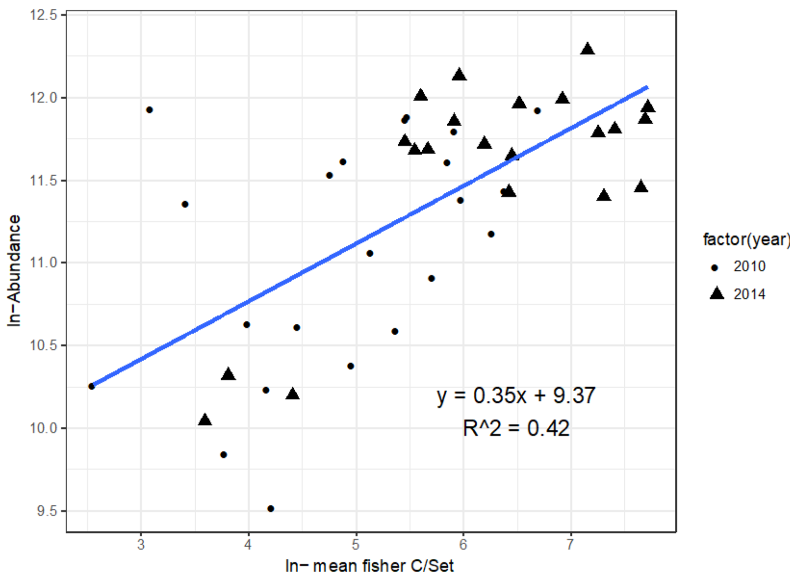


Figure C8: Area 13L. An intermediate relationship between daily abundance and mean catch-per-set data is observed when the data is pooled across the 2010 and 2014 seasons. The straight line is the prediction line, and the grey band is the 95% confidence interval.

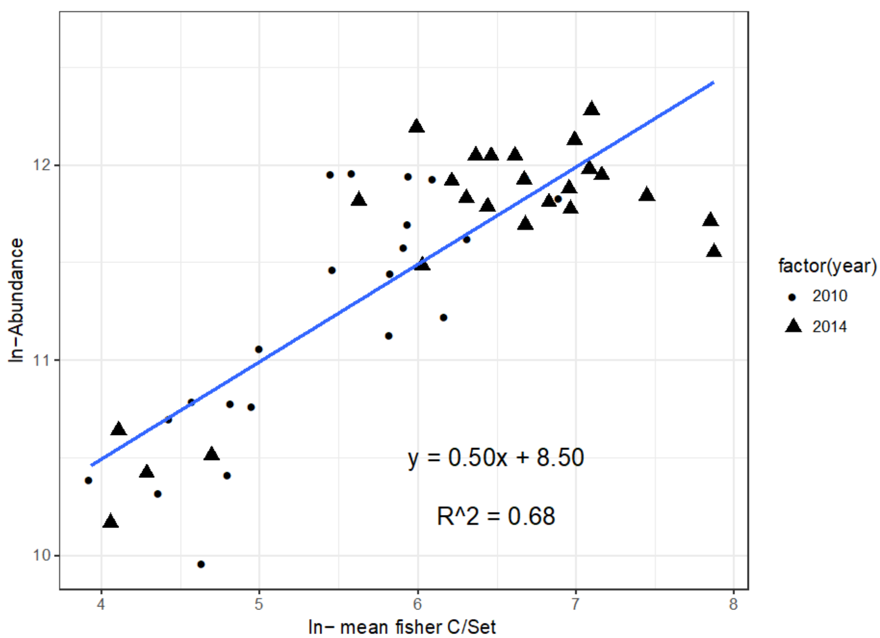


Figure C9: Area 13U. The relationship between daily abundance and mean catch-per-set data observed when the data is pooled across the 2010 and 2014 seasons is just slightly lower than for 2010 alone, but higher than 2014 alone. The straight line is the prediction line, and the grey band is the 95% confidence interval.

Conclusions

This document follows up on the analysis by Cave (2017) and describes the effect of fishing vessel sample size on the relationship between daily Catch-per-set and daily abundance data. The motivation for this analysis is to help understand how increasing the number of vessels in the ITQ fishery reporting daily catch-per-set data may improve daily abundance estimates of summer-run sockeye. The inability to move VMS units between vessels, and the high variation in fishing effort observed between each unique fishing vessel across season presents a logistical challenge for obtaining meaningful Catch-per-set data from a relatively small number of fishers. It is the goal of this analysis to help understand potential cost/benefit trade-offs for installing VMS units and fishers using the ELOG system to report daily Catch-per-set data.

We found that the relationship between daily Catch-per-set and abundance is sensitive to the sample size of unique fishers in Area 12-3. Specifically,

1. Based on the mean values of the simulations:
    - For the 2010 season, a sample size of 10 and 20 vessels (out of 61 unique vessels) were needed to ensure a temporal coverage of 80% and 90% of the 26-day season, respectively.
    - For the 2014 season, a sample size of 20 and 35 vessels (out of 66 vessels) were needed to ensure a temporal coverage of 80% and 90% of the 29-day season, respectively.
    - For the 2010 season, ~20 actively fishing vessels needed to report daily Catch-per-set data in order to achieve an R^2 within 10% of that obtained from the full post-season logbook data.
    - For the 2014 season, ~45 actively fishing vessels needed to report daily Catch-per-set data in order to achieve an R^2 within 10% of that obtained from the full post-season logbook data.

2. While similar R^2 values for the 2010 and 2014 seasons are observed from the full post-season logbook data, these values exhibit substantial variation when compared at different time points across the fishing season.

3. All four linear regressions for 2010 data (Day 7, Day 13, Day 20 and full post-season) were significant, while only the full post-season model was significant for 2014 data.

4. Combining the 2010 and 2014 data improved the R^2 value for Area 12-3, but resulted in an intermediate R^2 value for area 13L and 13U.

References

Cave, J. 2017. Analysis of Catch-per-Set information from the Area B Purse Seine Individual Transferable Quota Fisheries. Final Report for the Southern Endowment Fund. 39 pp.