**Estimation of potential impacts on Interior Fraser Steelhead during Fraser River Commercial Chum Gillnet Fisheries**

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Mike Hawkshaw

## Introduction

The Southern BC Salmon Integrated Fisheries Management Plan sets out an objective to minimize the impact of Canadian fisheries on Interior Fraser River (IFR) steelhead to increase spawner abundance. For Fraser river commercial gill net fisheries, the strategy is to protect 80% of the IFR steelhead run with a high degree of certainty. Steelhead are not targeted by gillnet fisheries but are a bycatch in some chum salmon targeted gill net fisheries, including Area E commercial, Musqueam First Nation, and Tsawwassen First Nation economic opportunity gill net fisheries (collectively referred to hereafter as commercial gill net (CGN) fisheries). The main management tool used to protect IFR steelhead from CGN is to allow only a small window for chum fisheries such that 80% of the steelhead run can migrate through the fishing areas without being intercepted in CGN fisheries. **An analysis of historic return patterns and the 2015 fishery plan suggests that the current fishing plan meets this goal.** The methods and results are described below.

## Method

In order to estimate the certainty with which 80% of the run is protected an analysis was undertaken using a Monte Carlo method to generate estimates of the proportion of the IFR steelhead run protected with different assumptions about migration rate and historic information about return timing. A three step analysis was done and is briefly outlined below:

1. Characterize the Steelhead run in terms of return timing to Albion test fishery

It is standard practice to use a normal distribution to represent the pattern of migrating salmon past a fixed point. To characterize IFR steelhead migration, normal distributions were fit to 20 years of steelhead catch at the Albion test fishery to estimate 50% dates and distribution of the migration (Fig 1). The historic information from the Albion test fishery allows us to characterize the variability of the run timing of steelhead from year to year.

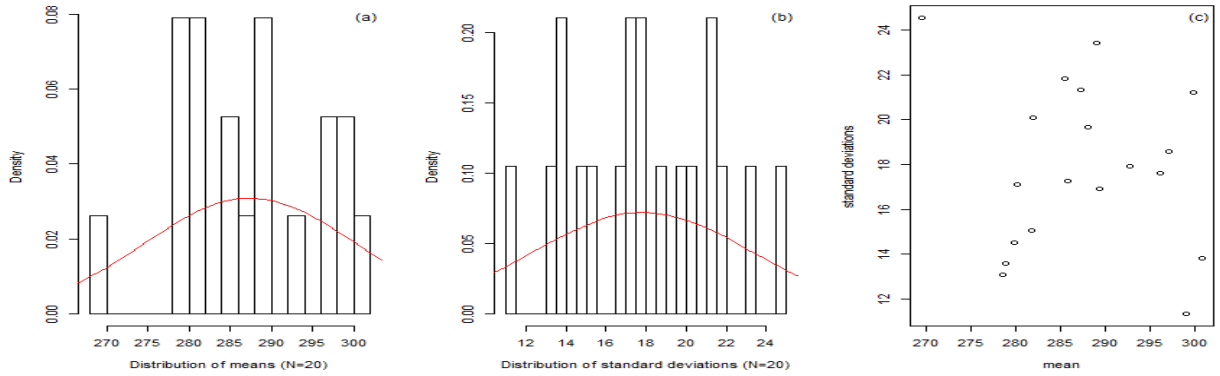


Figure 1: The distribution of calculated 50% dates (a) and the distribution of the widths of the reconstructed returns (b) to Albion are shown as both histograms (bars) and normal approximations of the distribution (red line). The 50% dates plotted against the spread of the runs (c) demonstrating no relationship between 50% date and spread of the return. Data provided for 1995 to 2013.

2. Characterize the fishing area and migration speed

The fishing area used by the CGN fisheries extends ~81.6 km from the mouth of the Fraser River to Mission. The reference point for IFR steelhead migration is the Albion test fishery 60.4 km from the mouth of the Fraser River. A variety of methods and sources provide migration speeds for steelhead, and rather than an exhaustive review of different estimates migration speeds, a range of hypotheses about swimming speed (from 8 km/day to 40 km/day) were used to estimate the expected protection provided by limiting CGN fisheries. Using a variety of swimming speeds results in a range of possible residence times for IFR steelhead in the fishing area; residence time was determined by the length of the fishing area (km) divided by the migration speed. The effect of the residence time is that a fishery that is open on one day will affect several days of steelhead migration.

3. Estimate the proportion of overlap between migrating timing distribution for interior Fraser River steelhead and commercial gillnet fisheries

CGN fisheries for 2015 are scheduled to be held on October 22$^{nd}$, 23$^{rd}$, 25$^{th}$, and 27$^{th}$, these fisheries will impact between 6 and 14 days of steelhead migration (depending on assumptions about residence time in the fishing area). Because of uncertainty in the migration of the IFR steelhead run it is impossible to say exactly what proportion of the run is protected by restricting the fisheries to this limited window. However, because we have characterized the IFR steelhead run past the Albion fishery, we can use a Monte Carlo procedure to estimate the likely proportion protected, and, our confidence around achieving the 80% protected with a high degree of certainty goal. In this case, we assume a migration pattern drawn from the historical distribution of run spread and the October 10$^{th}$ estimate of 50% return date (Robert Bison Thompson steelhead update 26 Oct 2015) to generate 10,000 simulated patterns of IFR steelhead migration distribution. Each hypothesis about residence time is then evaluated in terms of these 10,000 simulated returns and the proportion of the run protected is recorded (Fig 2). Because we are simulating a large number of possible IFR steelhead return distributions we can estimate a range of

the proportion of IFR steelhead protected, but also the distribution of the proportion protected and thus the confidence with which we have protected 80% of the return (Fig 3).

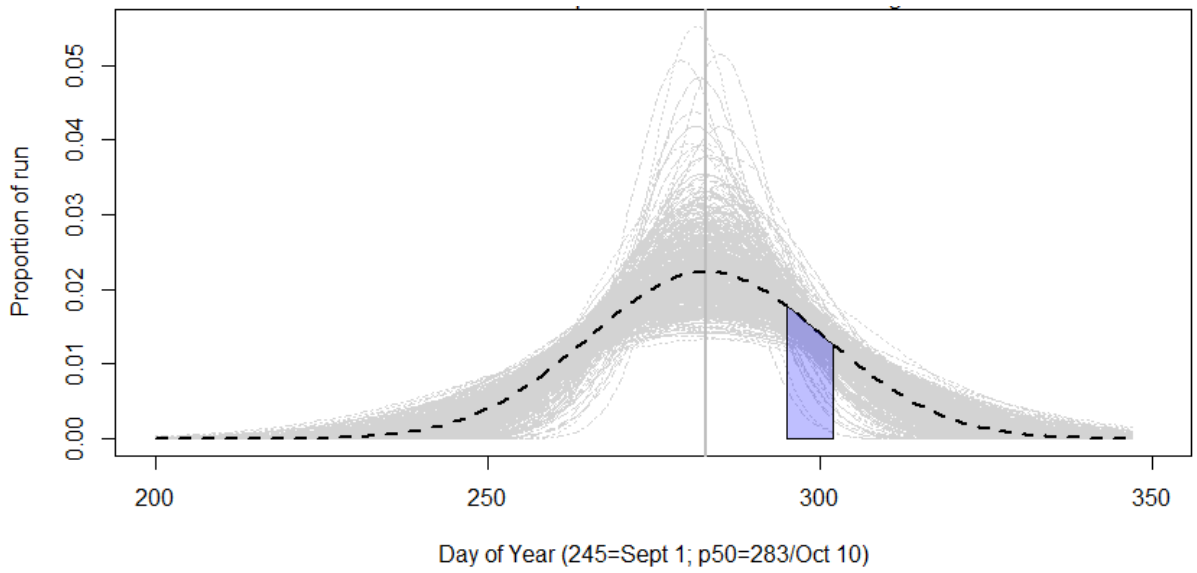


Figure 2: Monte Carlo simulations of IFR steelhead return to Albion and proportion of return exposed to CGN fisheries. The grey lines represent individual simulations of the IFR steelhead return, and the heavy dashed line represents the mean return pattern expected for 2015, the blue polygon represents the proportion of the run exposed to CGN fisheries. For this example a residence time of two days was assumed. In this example 89.64 % of the steelhead return is protected from CGN fisheries with a 95% confidence interval of 86.72%-92.55%.

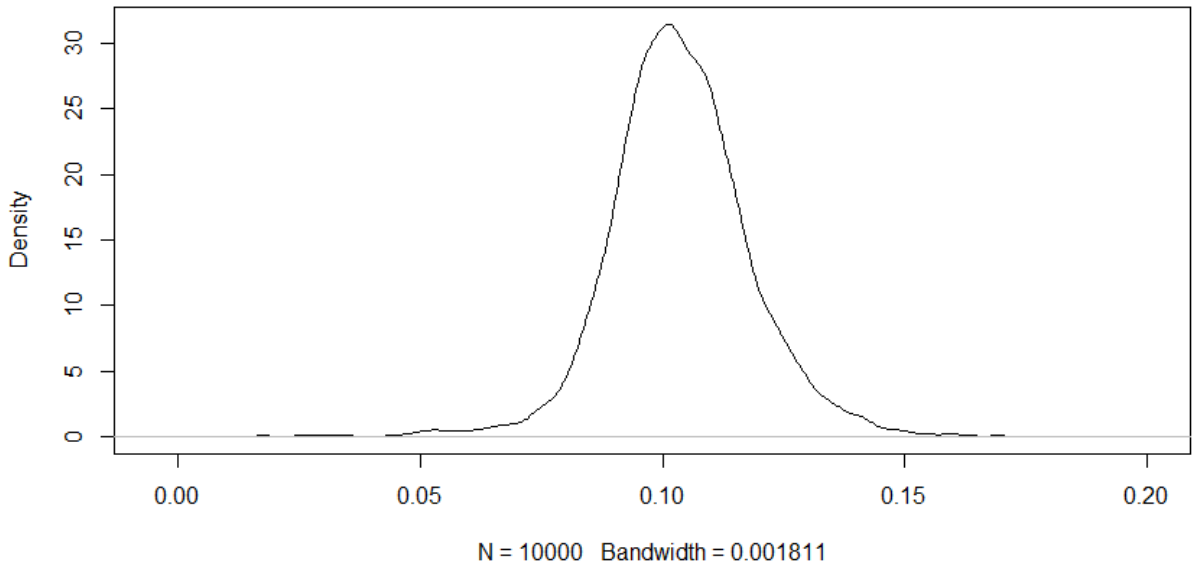


Figure 3: Predictive density of steelhead exposed to fisheries assuming 2 day residence time in fishing area and 2015 fishery openings. Notice that the distribution falls below 0.2 on the x-axis which means <20% of the run is exposed to CGN fisheries and that >80% of the run is protected () with a very high degree of certainty.

**Results**

This method estimates the impact of CGN fisheries on Interior Fraser River steelhead, by estimating the protection that they are afforded by controlling the CGN openings. For a variety of assumptions about swimming speed we are able to predict that 80% of the Interior Fraser River steelhead are protected from CGN with a high degree of certainty.

Table 1: Estimates of proportion of IFR steelhead protected by limiting Area E, MFN and TFN Economic Opportunity fisheries. The final column in the table is an estimate of the degree of confidence with which 80% of the run is protected from these fisheries.

| Assuming an Oct 10th 50% date (Steelhead Update) | | | | | |
|---|---|---|---|---|---|
| Residence Time in fishing Area | ~swimming speed(km/day) | Proportion of IFR protected mean | upper | lower | "confidence" of 80% protection |
| 10 | 8.0 | 82.3% | 76.5% | 88.0% | 77.95% |
| 9 | 8.9 | 83.0% | 77.6% | 88.4% | 85.82% |
| 8 | 10.0 | 83.7% | 78.7% | 88.8% | 92.51% |
| 7 | 11.4 | 84.5% | 79.8% | 89.2% | 97.06% |
| 6 | 13.3 | 85.4% | 81.0% | 89.8% | 99.27% |
| 5 | 16.0 | 86.4% | 82.4% | 90.3% | 99.91% |
| 4 | 20.0 | 87.4% | 83.8% | 91.0% | 99.99% |
| 3 | 26.7 | 88.5% | 85.2% | 91.7% | 99.99% |
| 2 | 40.0 | 89.6% | 86.8% | 92.5% | 100.0% |