INCORPORATING RESEARCH INTO MANAGEMENT:
ESTIMATING TOTAL MORTALITIES ON ENDANGERED CHINOOK

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Abstract

Fisheries managers, First Nations, and stakeholders are becoming more aware that Fisheries Related Incidental Mortality (FRIM) can contribute significantly to Total Mortalities (TM) in fisheries. As a case study on one fishery, we examine potential FRIM and TMs in Spring and Summer Fraser River Chinook populations designated as 'Endangered' by *the Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) (Table 1).

The South Coast Juan de Fuca recreational fishery encounters Spring and Summer Fraser River (4_2 and 5_2) Chinook from Southwest Vancouver Island to the mouth of the Fraser River (DFO fishery management areas 18,19,20,29,121). As the largest and oldest Chinook that return to the Fraser River, these fish are important to endangered Southern Resident killer whales and as a source of food for interior First Nations.

We apply the guidance provided in Patterson et al. (2017b) and interviews with anglers to identify risk factor ranges for Capture, Injury, Handling, and Predation Mortality. These are combined with drop-out mortality and a Monte Carlo simulation to estimate a range of FRIM. Other factors that may affect estimates of FRIM, such as the stock composition of releases, are also investigated.

Our results suggest that current methods for estimating FRIM employed by both DFO (15% x releases) and the Pacific Salmon Commission (PSC) Chinook Technical Committee (15% drop-out mortality on catch and 10% immediate mortality on releases) likely underestimate FRIM when compared to the Patterson et al. (2017b) approach.

In conclusion, we discuss management recommendations for improved monitoring and identify information needs in both this fishery and others that effect endangered chinook.

Introduction

In an effort to improve low spawner abundance of Fraser Spring and Summer 4_2 and 5_2 stream-type Chinook, fishery regulations introduced in 2010 require the release of Chinook greater than either 67 or 85 cm (slot size limits vary by date depending on the populations likely present). Understanding the potential long-term fate of the released fish is critical to estimate total fishery related mortalities for the populations of concern.

Fisheries managers with DFO employ estimates of immediate post-release mortality listed in the Integrated Fisheries Management Plans (IFMP). The Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC 2004) and Patterson et al. (2017a,b) both recognize and describe the limitations of DFO's current approach. Managing populations of concern using a total mortality cap requires proper consideration of FRIM, as these elements have a significant implications for the estimates of total mortalities used in making fishery management and allocation decisions.

Data limitations mean many assumptions are required for this analysis. Further, this is not an effort to ascribe definitive numbers of FRIM from specific fisheries to sub-stocks of Fraser River chinook, but an introductory look into the range of impacts that might be expected using the guidance provided in Patterson et al. (2017a,b).

Lack of defensible estimates of fishery related mortality in endangered Fraser River Spring and Summer Chinook may compromise our understanding of total abundance, productivity, and recovery potential in these populations.

Spring and Summer Fraser Chinook migrate through several marine and freshwater fisheries on their way to spawning grounds. In conventional fisheries management, evaluating losses to fisheries is a simple matter of summing retained catch. However, managing endangered Chinook in mixed-stock fisheries often calls for regulations requiring all Chinook, or those under a certain size, to be discarded. Estimating losses of endangered Chinook across all fisheries therefore requires defensible cumulative estimates of retained catch and fishery related incidental mortalities.

Spring and Summer Fraser River Chinook are encountered in Canadian fisheries in Northern British Columbia (BC), the west and east coasts of Vancouver Island, Juan de Fuca Strait, the Gulf Islands, Georgia Strait, the Fraser River (marine approaches and in-river). They are also encountered in US fisheries in Southeast Alaska, Juan de Fuca Strait, and Puget Sound. FRIM could be estimated using catch and release data from each of the fisheries shown in Figure 1, however this is hampered by a lack of stock composition information in many of these fisheries.

Table 1: *In 2018, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identified 11 populations of spring and summer stream-type Chinook as threatened or endangered.*

Conservation Unit	Run Timing Aggregate	COSEWIC Status
South Thompson – Bessette Summer 1.2	Spring 4_2	Endangered
Upper Fraser – Spring 1.3	Spring 5_2	Endangered
North Thompson – Spring 1.3	Spring 5_2	Endangered
North Thompson – Summer 1.3	Summer 5_2	Endangered
Lower Fraser River – Upper Pitt Summer 1.3	Summer 5_2	Endangered
South Thompson – Summer 1.3	Summer 5_2	Endangered
Middle Fraser – Portage Fall 1.3	Fall 5_2	Endangered
Middle Fraser – Spring 1.3	Spring 5_2	Threatened
Middle Fraser – Fraser Canyon	Spring 5_2	Threatened
Middle Fraser – Summer 1.3	Summer 5_2	Threatened
Lower Fraser – Fall	Fall 4_1	Threatened
Lower Fraser – Spring 1.3	Spring 5_2	Special Concern
South Thompson – Summer 0.3	Summer 4_1	Not at Risk

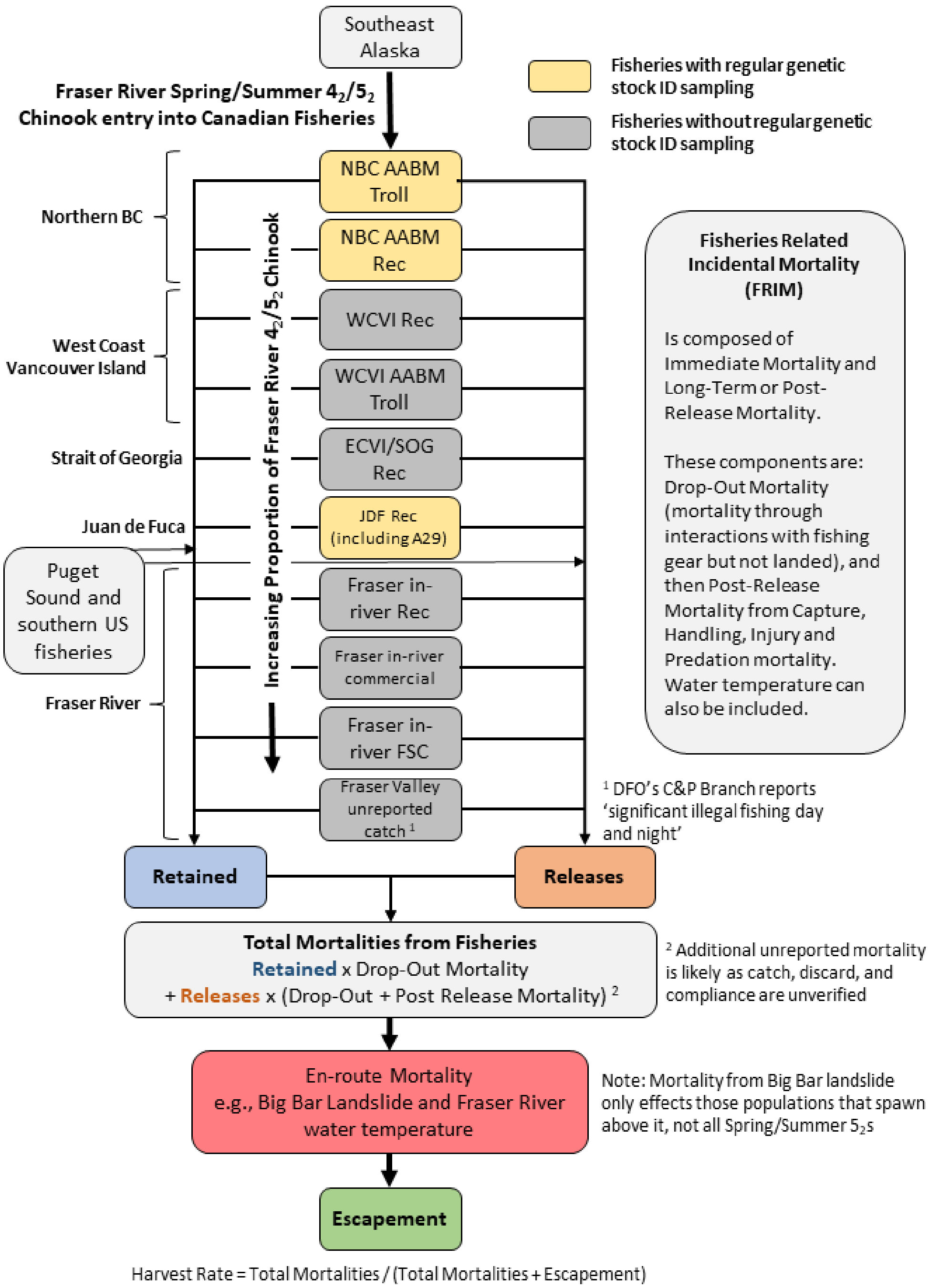

Figure 1: *A flow chart of vulnerability for threatened and endangered (4_2 and 5_2) Fraser Chinook in Canadian and US fisheries. Total mortalities are the sum of retained catch, FRIM (an estimate of the proportion of fish that dropped off or were released and didn't survive to spawn), and unreported retained catch or releases. Only those fisheries in yellow have consistent DNA sampling that would allow the total mortalities of endangered chinook to be calculated.*

Methods

Data

Catch and release data for 2019, and genetic stock composition data (GSI) for various years in the recreational fishery were provided by DFO. This analysis used catch and release data from Management Areas 18,19,20,29, and 121, aggregated by month for May, June, July and August.

DNA data provided by DFO from Area 19/20 creel surveys was used to determine the number of retained and released Fraser River $4_2/5_2$ Chinook by month. DNA percentages from the UPFR, MUFR, NOTH, LWTH, LWFR-sp and LWFR-su (Fraser 4_2 and 5_2) groups were summed to determine the percent composition of these stocks per month and the number of retained and released Fraser $4_2/5_2$ Chinook from all areas. For 2019, an average stock composition was calculated from all DNA data years (2009, 2010, 2014, 2016, 2017, 2018) and used.

Risk Factors

Patterson et al. (2017b) provides guidance through risk factor scoring tables. We used these tables as well as local knowledge of recreational fisheries to inform our selection of FRIM mortality ranges for the stochastic modelling work. The chosen Mortality Risk Range was based on three 10-15 minute interviews with experienced anglers: an experienced guide, a retired biologist who fishes non-guided, and an experienced guide/scientist (Table 2). Selection of risk factor ranges is biased by area (e.g. higher pinniped predation in some areas versus others), thus these risk factor ranges are guidelines only. Where additional field information is available, risk factor ranges could be varied by strata within fisheries, temporally and spatially.

***Table 2**: Risk factor ranges presented by different anglers*

Risk Factor	Group 1	Group 2	Rationale
Capture	5-15%	5-15%	Between 3 and 10 minutes play on average
Handling	0-25%	0-20%	Released in water without netting to spending < 2 minutes in air
Injury	0-5%	0-5%	Very minor injuries generally reported
Predators	15-25%	0-5%	Very few to daily observations of some predators, larger fish less vulnerable?

We used the following formula to calculate FRIM (Patterson et al. 2017b):

$$FRIM = (Kept\ Catch\ x\ P(NCM) + [Released\ Catch\ x\ \left(P(NCM) + P(PRM)\right)]$$
(1)

Where Non-Capture Mortality (*NCM*) is the Drop-Out Mortality and Post-Release Mortality (*PRM*) is the sum of the four-risk factors (Figure 2).

Model

A simple model was developed in R (R Core Team 2017) that uses catch and release data, GSI data, and randomly generated probability distributions (10,000 draws from 100,000 random variates – Figure 2 left panel) for each of the four risk factor ranges, and drop-out mortality to estimate FRIM. Uniform distributions were based on the assumption that it was equally likely to have values at the lower and upper tails for each range. The results were not highly sensitive to the distribution type (normal, triangular, or uniform). Example distributions are shown in Figure 2, as well as the combined distribution for Post-Release Mortality.

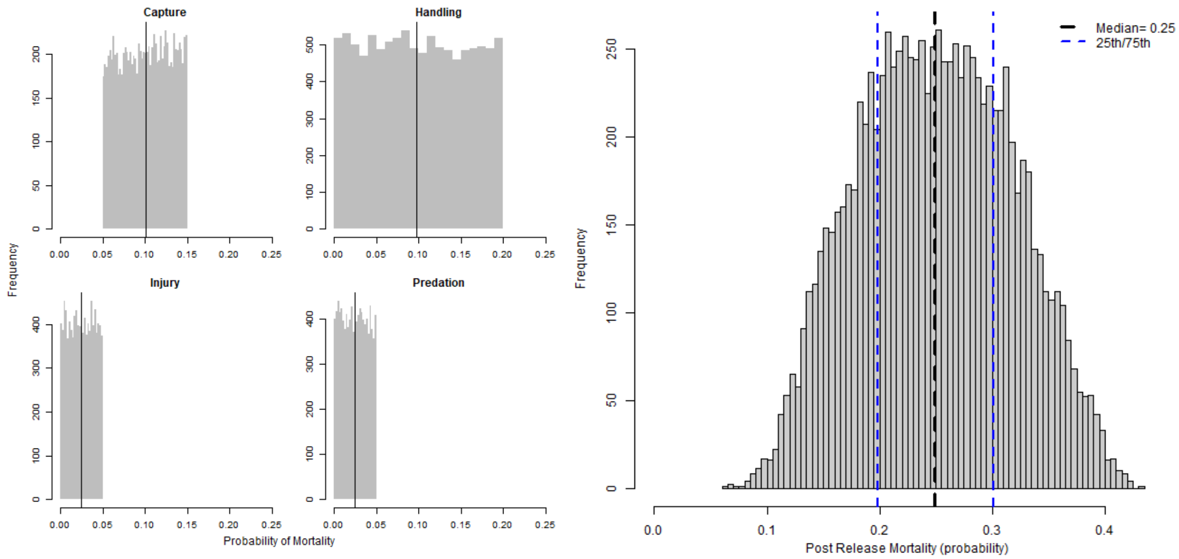

Figure 2: *Sample parameter distributions generated from the risk factors provided by Group 2 (left) and combined distribution showing the resultant total probability of PRM used in Eqn 1 (right).*

Results and Discussion

Overall, our results suggest that the DFO methodology likely under-estimates FRIM and Total Mortalities by 2-4 times (Table 3, Figures 3 and 4). PSC CTC methodology, which includes Drop-Out Mortality, may also under-estimate FRIM and Total Mortalities.

Figure 3 illustrates that fishers (recreational and commercial), will likely have varying perspectives on the risk factor ranges, risk factors will vary with area, gear and fishing techniques, experience, and profession (guide/outfitter versus recreational angler).

Table 3: *Estimates of Total Mortalities from the three scenarios*

Scenario	DFO	PSC CTC	Our Estimates (median)	Our Estimates (10th percentile)	Our Estimates (90th percentile)
Group 1	2455	3154	4349	3826	4874
Group 2			3494	3044	3944
Group 1: Releases + 30%			3942	3369	4517

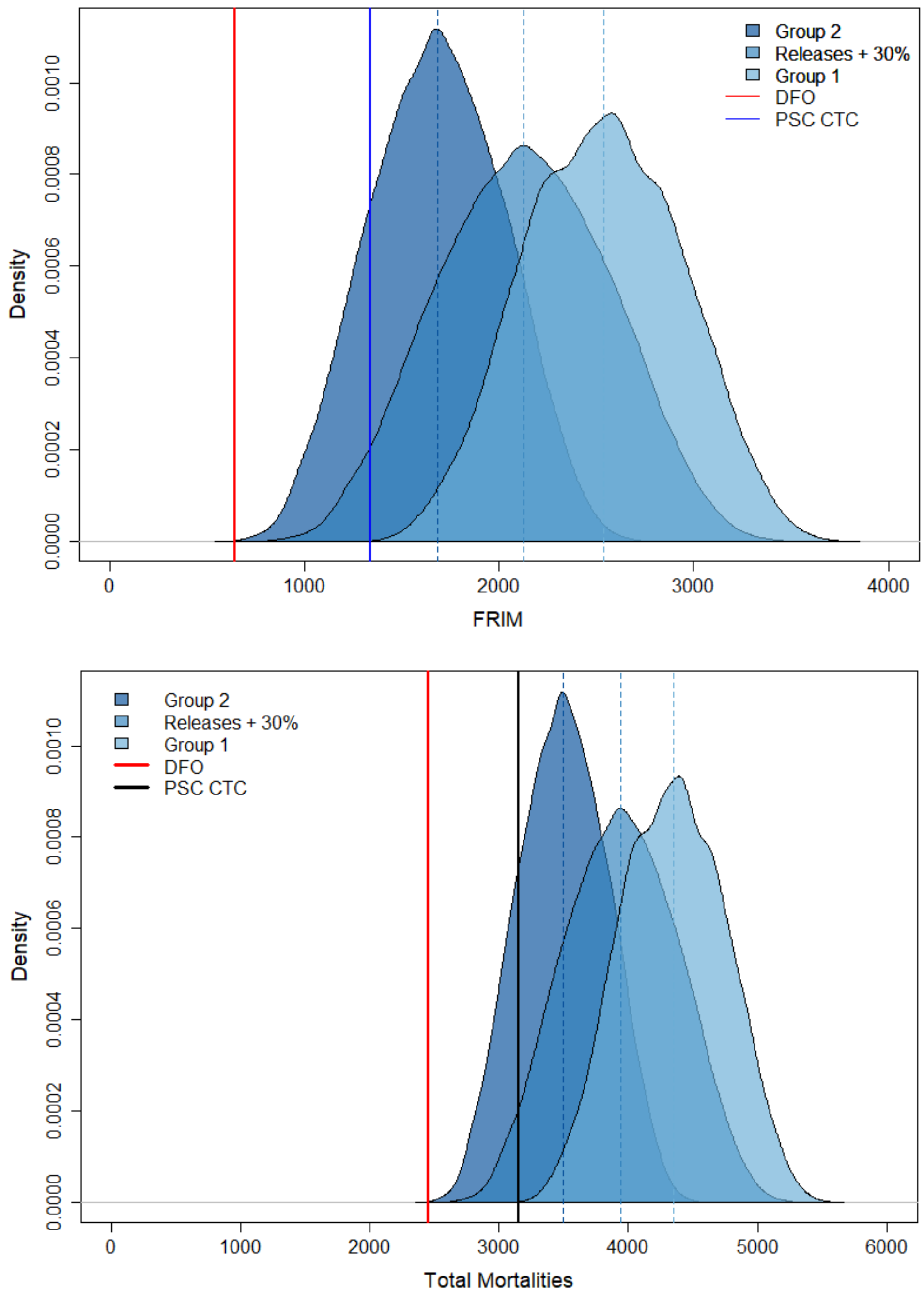

Figure 3: *Distributions of FRIM (top) and Total Mortalities (bottom) of Fraser River $4_2/5_2$ Chinook in the Juan de Fuca recreational fishery as estimated following Patterson et al. 2017b guidance using the risk factors provided by Groups 1 and 2 (Group 1 in light blue, Group 2 in dark blue). Additional analysis increased stock composition of Fraser $4_2/5_2$ Chinook by 30% to reflect management measures (Chinook > than 67cm or 80cm are released), and the uncertainty in the stock composition of discarded catch (likely > than in kept catch samples). The thick red vertical line is the FRIM/TM estimated using DFO methodology, the thick vertical black line is the FRIM/TM estimated using PSC CTC methodology, and the blue dashed lines are the median FRIM/TM as estimated following Patterson et al. 2017b for each of the three scenarios.*

The work presented is not meant to be prescriptive, but to demonstrate how improved estimates of total mortalities might be incorporated into management and recovery planning for endangered and threatened populations.

While there is considerable uncertainty in the extent of endangered Chinook mortality due to FRIM in 2019 south coast recreational fisheries, this mortality could be significant relative to escapement estimates. If extended to the other fisheries in Figure 1, the number of Chinook killed through FRIM could be an important component of total fisheries and environmental mortality.

If unaccounted for mortality such as FRIM was included in productivity calculations, it might indicate that these populations are more productive than currently thought. This would have implications for recovery planning and modeling as it relates to Population Viability Analyses for both Chinook and Southern Resident killer whales.

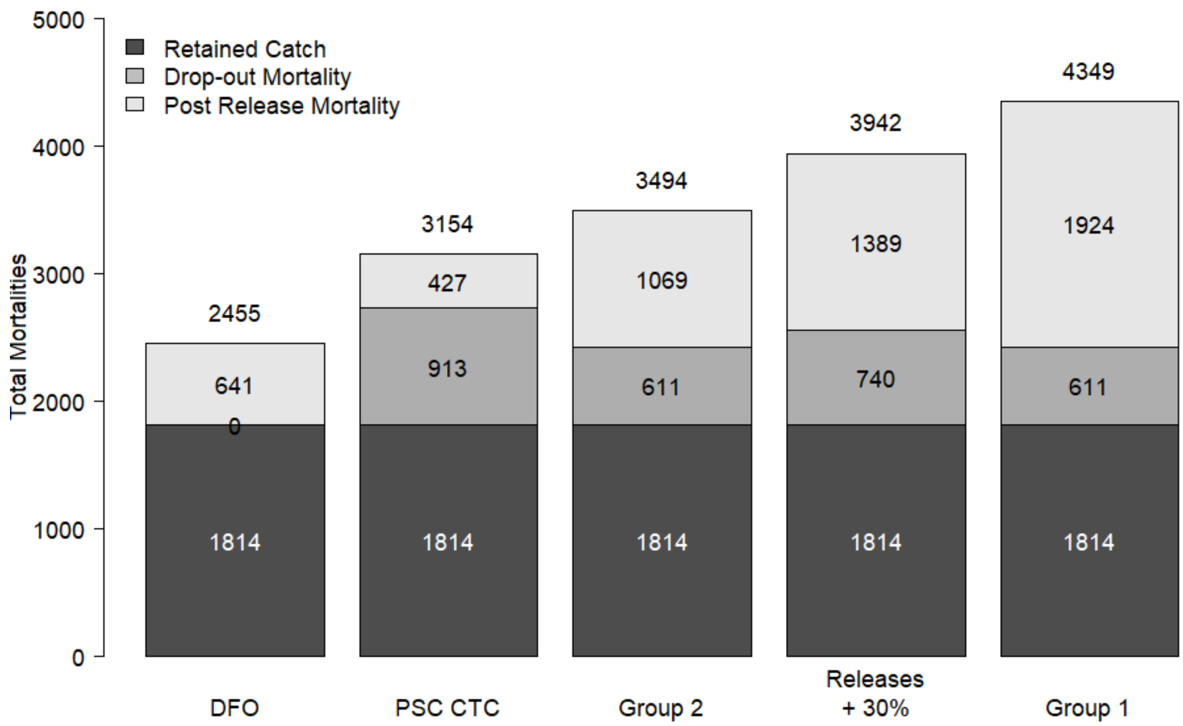

Figure 4: *Estimated Total Mortalities of Fraser River $4_2/5_2$ Chinook in the Juan De Fuca recreational fishery in 2019, broken apart into the various components. Dark shading is the kept catch (same in all groups). Medium grey shading is the mortality component due to Drop-Out Mortality. Light grey shading is the component due to Post-Release Mortality. Numbers in columns provide estimates for each component, and numbers at the top provide the estimate of total mortalities.*

Information Gaps and Recommendations

Gaps in information and monitoring:

Important information and monitoring gaps that hamper robust FRIM estimates include:

- Verification of retained catch and discards, and compliance with fishery regulations.

- Characterization of each fishery and potential sources of discard mortality.
- In-season GSI monitoring of stock composition in retained catch and releases.
- The effects of Fraser River water temperatures and flows on Chinook migration in July and August, including increased FRIM
- Cumulative effects, and effects of multiple re-captures on spawning success & survival**.**
- Survival rates of Chinook from Albion to the spawning grounds, including FRIM.

Recommendations:

Many assumptions are required to complete numerical FRIM estimates. Our recommendations for future work to inform and incorporate improved estimates of FRIM in Canadian fisheries include:

- Continue and expand work on survival of tagged Chinook caught in south coast fisheries; this should include smaller fish as well as different handling treatments.
- Implement a genetic stock ID sampling program on discarded catch to inform release composition of Spring and Summer Fraser River $4_2/5_2$ Chinook.
- Engage with social scientists to develop methodologies to solicit and integrate fisher interviews from a wide variety of fisheries and areas.
- Examine the influence of Fraser River water temperatures on spawning success of Chinook, especially those from endangered or threatened populations.
- Examine effects of Chinook gillnet Drop-Out Mortality in Lower Fraser River fisheries.
- Examine the influence of pinniped abundance on FRIM.

This project demonstrates that working together, management agencies, fishers, and stakeholders can put this type of work into practice to inform fisheries management and aid in the protection & recovery of at risk salmon populations.

Literature Cited

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