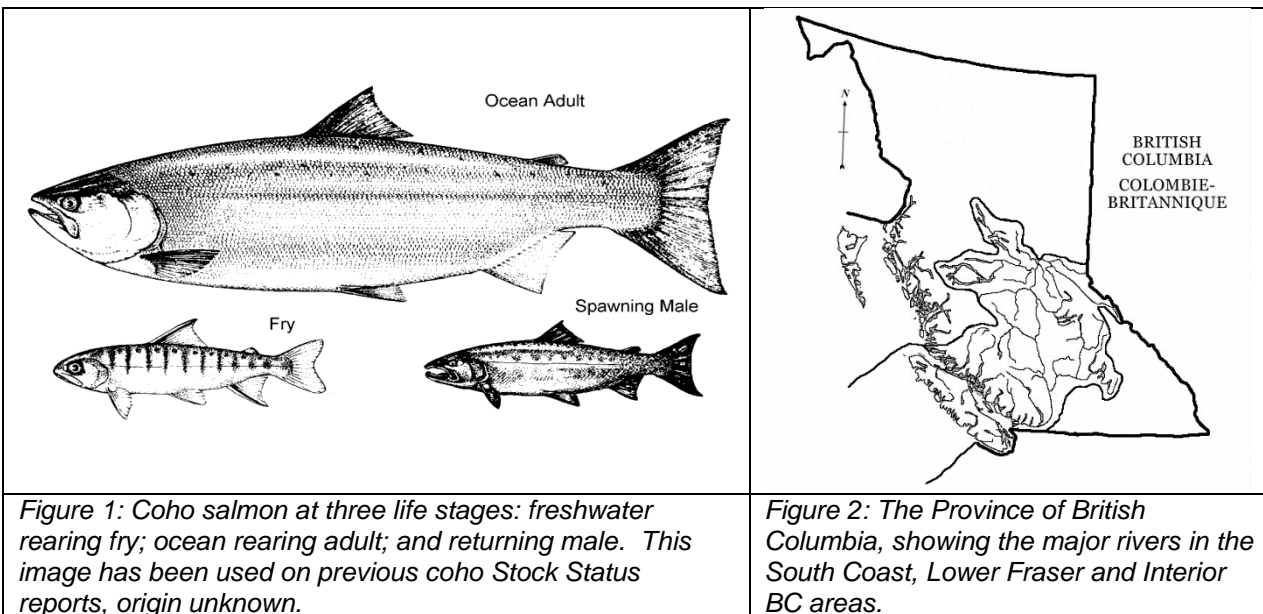


2019 MARINE SURVIVAL FORECAST OF SOUTHERN BRITISH COLUMBIA COHO



SUMMARY

The observed indicator marine survivals and aggregate abundances from 2018 were generally higher than the previous year with the exception of the Area 12 Aggregate and Robertson (Stamp) Hatchery. All but the Area 12 Aggregate were higher than the forecast, and the Georgia Basin – West indicators were much higher than the forecast. This suggests that the best performing model failed to forecast the large increase for these three indicators.

The 2019 forecast for coho indicator marine survivals is showing a decrease from 2018 levels (minus 13% - 82%) and a return to levels similar to 2017 observations. The exception is the Area 12 Aggregate which is forecast to increase from the 2018 observation, but less than the 2017 observation, and the Upper Fraser Aggregate which is forecast to remain similar to the 2018 return.

The Chrome Island salinity Distribution Index suggests a moderately outside distribution for coho.

INTRODUCTION

Coho marine survival and aggregate abundances for Indicator stocks in southern British Columbia and the Fraser River have been forecast annually since 1996. The estimates from these Indicators are used in International stock management processes and domestically for informing fishery management, while the forecasts are used for shaping future fisheries.

The changes in indicator marine survivals from 2017 to 2018 were mostly higher than both the previous year and the forecast level. The exception was the Area 12 Aggregate indicator that decreased from both the previous year and the forecast, and the Robertson (Stamp) Hatchery indicator that was slightly lower than the previous year but slightly higher than the forecast. Specifically, the observed marine survivals of the three Georgia Basin – West indicators (two hatchery stocks and one wild stock) were higher than the previous year and much higher than their respective forecasts.

Starting with the 2015 forecast, the Ocean Climate Indices was incorporated into the suite of models examined for the two WCVI indicators. In the following year, these indices were included as possible forecast models for the rest of the marine survival indicators. These models were not considered for the Aggregate Indicators.

Previously, marine survival or aggregate abundance forecasts for southern BC coho stock groups have been published as Science Advisory Reports. Starting in 2012, this information is set out in an unpublished document for use in domestic and international coho stock management processes.

Descriptions of the assessment methods, data sets, forecast models and sources of uncertainty have been documented in previous papers and will not be described herein. For more information see Simpson *et al.* (2004), DFO (2006), DFO (2008), DFO (2009) and DFO (2012). Baillie *et al.* (2005), DFO (2010), DFO (2011), DFO (2013), DFO (2014), DFO (2015), DFO (2016), DFO (2017) and DFO (2018) are similar reports that are unpublished but are available from Wilf Luedke, StAD Chief, South Coast Area, DFO.

Exploitation Rate

A change in the methodology used to estimate the exploitation rate for adipose fin clipped coho indicators was incorporated into the 2015 forecast exercise and has been continued with the current forecast. Please see the 2015 forecast for further information.

Directed commercial and recreational fisheries on coho were severely restricted in the late 1990s in response to decreasing stock abundances. Until recently most exploitation of coho was incidental catch in commercial fisheries that targeted other species. Generally, non-retention of unmarked coho is in effect in most areas except for Food, Social and Ceremonial fisheries for First Nations in specific areas where local abundances allow for retention of unmarked coho (PSC 2013).

Data Sources

The data set used for the Area 12/13 aggregates is based on a subset of coho populations from each Area. The forecast is based on the expected total return to the average stream in the area (derived via the P_{max} methodology to standardize escapements in the aggregate area). For the Interior Fraser aggregate, the data represents the estimated total abundance for that aggregate. Each datum includes Natural Spawners, Broodstock removals and Fishery catches, both recreational and commercial. All other indicators in this forecast

use the survival rate between release of smolts and the resulting return of adult coho, which includes coho caught in commercial, sport and First Nation fisheries, and entering freshwater to spawn. There are four hatchery stocks used, Robertson Creek Hatchery, Quinsam Hatchery, Big Qualicum Hatchery and Inch Creek Hatchery. Additionally, there are two wild stocks used, at Black Creek and Carnation Creek.

For several years a CPUE model was used but discontinued in 2014. This model is based on the catch-per-unit-effort of adipose clipped coho that were caught using mid-water trawl surveys in the Strait of Georgia in July and September of the smolting year (return year minus one). The data from this model is regressed against the average marine survival for the three Strait of Georgia hatcheries (Quinsam, Big Qualicum and Inch Creek Hatcheries) although there may be other stocks present at this time. Work is under way to reinstate this model into the forecast process, incorporating new information on stock composition.

Forecast Models

The forecast is chosen from a variety of both time-series and biologically based methods which are evaluated and selected based on performance criteria. See Simpson *et al.* (2004) for a description of the times series models.

Climate Indicators

Large scale climate indicators have been shown to be correlated to biological processes, including marine survival of Pacific salmon (Trudel *et al.*, 2015). In addition, the odd\even year has been shown to be a co-variable in association with the climate indicators. This was used in developing the forecast model regressions.

The marine survival forecast models in this report use direct data input from the specific populations and a marine survival forecast is generated in a naïve manner with respect to climate trends. Specifically, marine climate indicators such as the Pacific Decadal Oscillation (PDO), North Pacific Gyre Oscillation (NPGO), El Nino Southern Oscillation (ENSO), and Sea Surface Temperature (SST) will be included. In this year's annual report the marine climate indices will be included in the forecast model comparison for all the marine survival indicators.

The data for the climate indicators was obtained from:

PDO: <http://jisao.washington.edu/pdo/PDO.latest>

NPGO: <http://www.o3d.org/npgo/data/NPGO.txt>

ENSO: <http://www.esrl.noaa.gov/psd/enso/mei/table.html>

Amphitrite SST: <http://www.pac.dfo-mpo.gc.ca/science/oceans/data-donnees/lighthouses-phares/data/AmphitriteMonthlyTemp.txt>

RESULTS

Graphical depictions of the observed marine survival or aggregate abundance for all coho indicators used in this forecast are shown in Appendix 1 while Appendix 2 is a table that shows the observed 2017 and 2018 values, and the forecast for 2019 returns.

Johnstone Strait/Mainland Inlets

In 2018 the observed return in Area 12 was 66% lower than forecast and the Area 13 return was about 40% higher than forecast. The Area 12 return saw 28% of the 2015 brood return and about 26% of what was estimated for the previous year return (2017). The Area 13 return demonstrated similar abundance relative to the brood year (2014) and 126% improvements over the return from the previous year (2017). For the indicator systems at Keogh, smolt production in 2017 was above average (82,000). Based on the observed 2018 returns at those and other system in the area, marine survival had declined significantly in Area 12 and improved slightly in Area 13 relative to the 2017 return. This reduction in marine survival in Area 12 was also observed in many of the local pink salmon stocks that out-migrated in 2017 similar to the coho salmon.

The Area 12 forecast for 2019 is 12 % lower than the brood returns in 2016. The Area 13 forecast is 75% higher than the 2016 observed indices. Coho abundance in this region is varied and can be characterized as ‘well below average’ for both Area 12 stocks and for Area 13 stocks. See Simpson et al., 2004 for description of characterizations. Smolt production in 2018 was average for Keogh River (65,000). Keep in mind that these more recent year returns do not have the high levels of exploitation as in the past and these forecasts are highly uncertain. These forecasts should be viewed with caution due to the continued decline of contributing index streams further exacerbating the uncertainty in the expectations.

Georgia Basin – West

The observed 2018 marine survival rate of Quinsam and Big Qualicum Hatcheries were 2.0% and 3.3%, respectively, and the marine survival at the wild indicator at Black Creek was 1.8%. All three indicators had observed marine survival levels that were higher than the previous year, and much higher than the forecast. This suggests that the forecast model that had been used (NPGO) failed to predict this level of increase.

After a retrospective analysis with the addition of the 2018 return, the best performing forecast model over the last 21 years is still the North Pacific Gyre Oscillation index. The 2019 forecast for the three indicators is for a continuation of the low marine survival levels seen in recent years. The model forecasts a marine survival of 0.9%, 0.6% and 0.5 % for Quinsam Hatchery, Big Qualicum Hatchery and Black Creek, respectively. Smolt production in 2018 (40,000) was well below average for Black Creek.

Lower Fraser

The observed 2018 marine survival from the Inch Creek Hatchery indicator was 5.0% which was higher than the previous year and, like the other indicators in the Strait of Georgia, was much higher than the forecast level.

The retrospective analysis showed that the best performing model is still the El Nino Southern Oscillation climate index. The 2019 forecast for marine survival for this indicator is 1.9%, a decrease from the observed level in 2018.

Interior Fraser

The Thompson River Aggregate, which is encompassed within the Interior Fraser Aggregate, is no longer required for domestic management purposes and therefore it will no longer be part of the Coho Forecast.

The observed 2018 abundance for the Interior Fraser Aggregate was 43% higher than the previous year, and 11% higher than the forecast.

The forecast model selected for the 2019 return is the 3 Year Average model, which is the same model used in 2018. The 2019 forecast of abundance for the Interior Fraser Aggregate is 40,533 coho with an 80% forecast range of 28,422 to 58,342. Please note that the confidence interval was changed from 50% to 80%. This forecast is 25% less than the observed escapement in 2018.

Southwest Vancouver Island

The two indicators in this Management Unit are Robertson Creek Hatchery and Carnation Creek, both located in Barkley Sound. For the Robertson indicator the estimate of coho escapement is based on the estimated abundance from the Stamp Falls fishway project.

The observed 2018 marine survival for Robertson (Stamp) Indicator was slightly lower from the previous year (decrease of 8%), and the marine survival for Carnation Creek (Wild) was much higher (+150%) than the previous year. Both indicators were higher than the forecast (Robertson (Stamp): +17%, Carnation: +67%).

For the 2019 forecast, the best performing model for the Robertson (Stamp) Indicator was the North Pacific Gyre Oscillation index while the best performing model for the Carnation Wild Indicator was the 3 Year Average time series model. The 2019 marine survivals are forecast to decrease to 5.9% (Robertson), and to 0.6% (Carnation) from the 2018 observed values.

Distribution

The distribution Index is a metric that uses salinity in the Strait of Georgia to forecast whether coho will be present in the Strait during their final summer (“inside”) or wait until fall to re-enter the Strait (“outside”). In Figure 4, the central red line indicates the base period average distribution of coho catches between Strait of Georgia and WCVI fisheries. Deviations from this line suggest a greater ‘Inside’ or ‘Outside’ catches of coho, if the same fisheries regimes were in place.

This model is based on the relationship between salinity and the relative quantity of coho that were harvested, using data from a base period (1975-1997). As fisheries have been restricted since the late 1990’s the relationship is fixed and cannot be updated or have a retrospective analysis.

The average salinity as measured at Chrome Island lighthouse was 28.07 ppt, which results in a P_{inside} statistic of 0.326, suggesting a moderately outside distribution of coho.

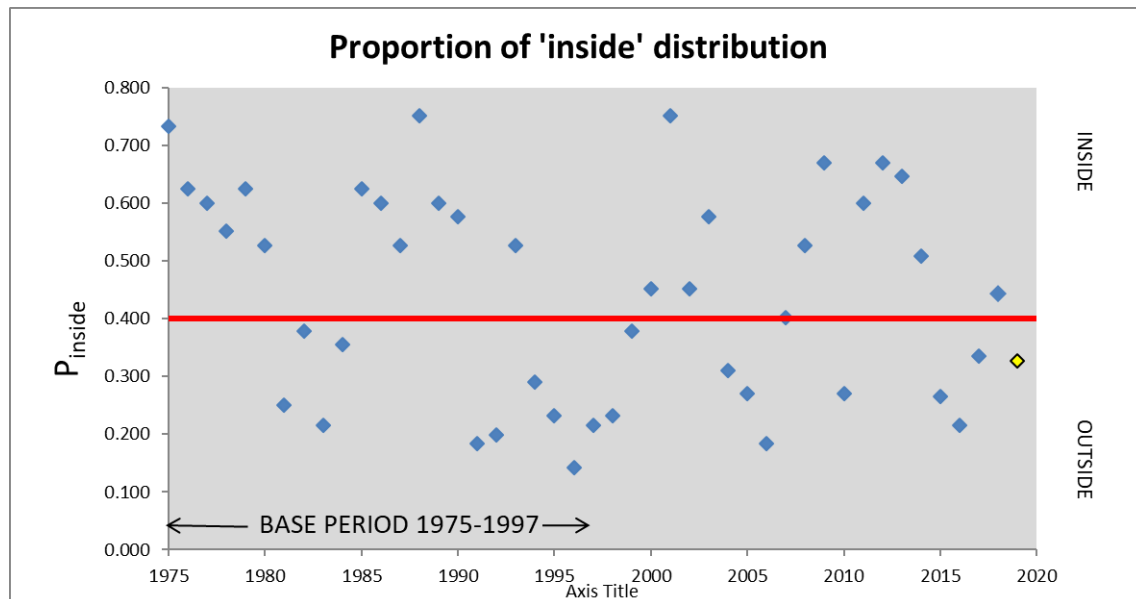


Figure 4. Distributional index for Strait of Georgia Coho, with observed data from 1975-1997, and results from the salinity based model for 1998-2019. The red line indicates the division between an ‘inside’ year and an ‘outside’ year. The yellow datum represents the current year.

ACKNOWLEDGEMENTS

The coho forecast for southern British Columbia requires data from many sources and is very much a collaborative document. All sources are DFO staff except where noted. Steve Baillie (ret., DFO) completed analysis of WCVI and Strait of Georgia indicators. Data analysis of the Interior Fraser Management Unit was completed by Lynda Ritchie, and the Johnstone Strait Aggregates by Pieter Van Will.

Fresh water creel survey data were provided by Joan Bennett (Strait of Georgia) and Joe Tadey (Lower Fraser). Coho data from the WCVI indicators was collated by Erin Porszt and Mike Spence. Cheryl Lynch provided escapement data from the hatcheries. Wild coho data were provided by Andrew Pereboom - Black Creek) and Dr. Peter Tschaplinski (BC Ministry of Environment - Carnation Creek). Chrome Island salinities were collected by the lighthouse keeper and provided by Peter Chandler, Institute of Ocean Sciences.

Ocean Climate indices were obtained from various internet sources noted in the text.

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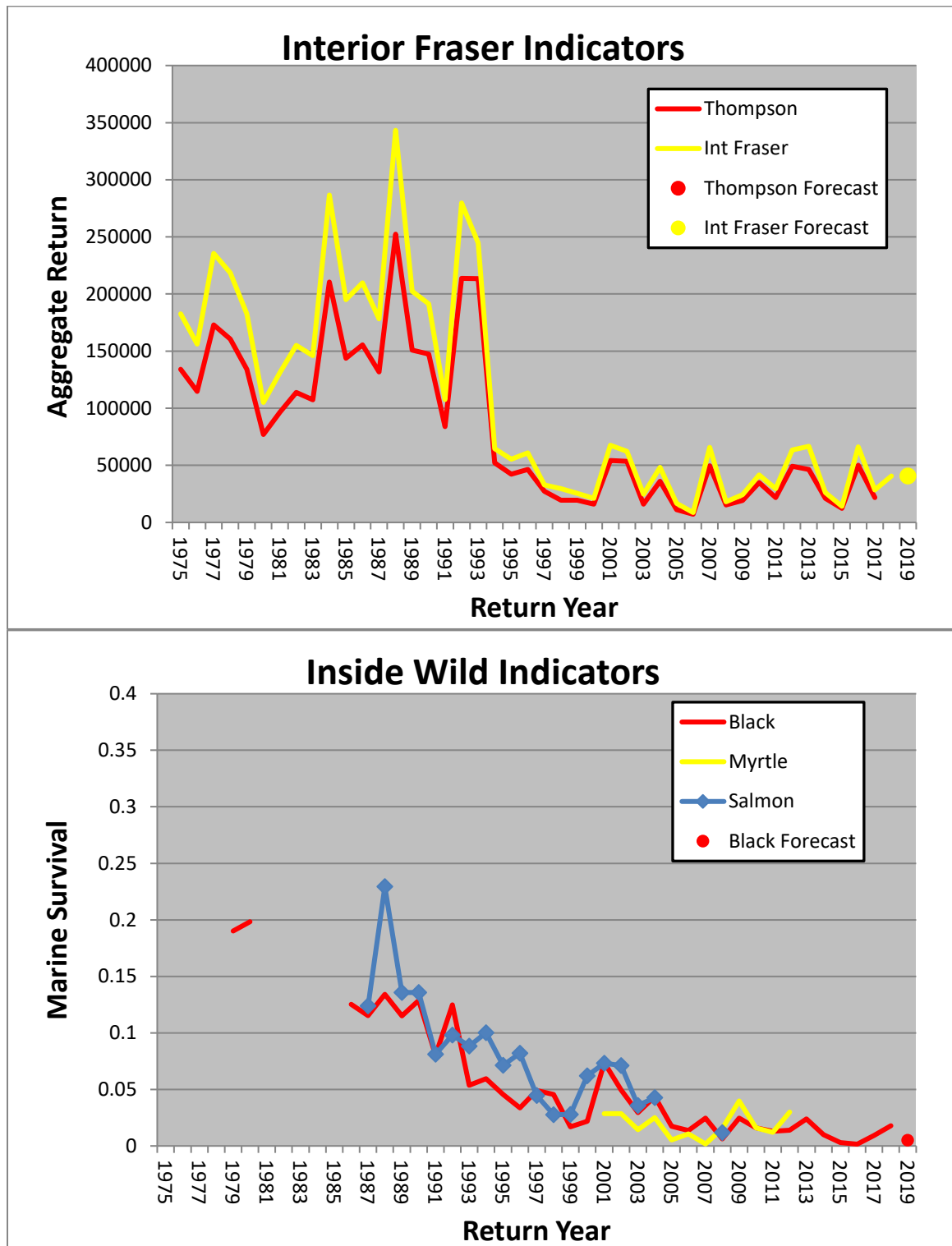
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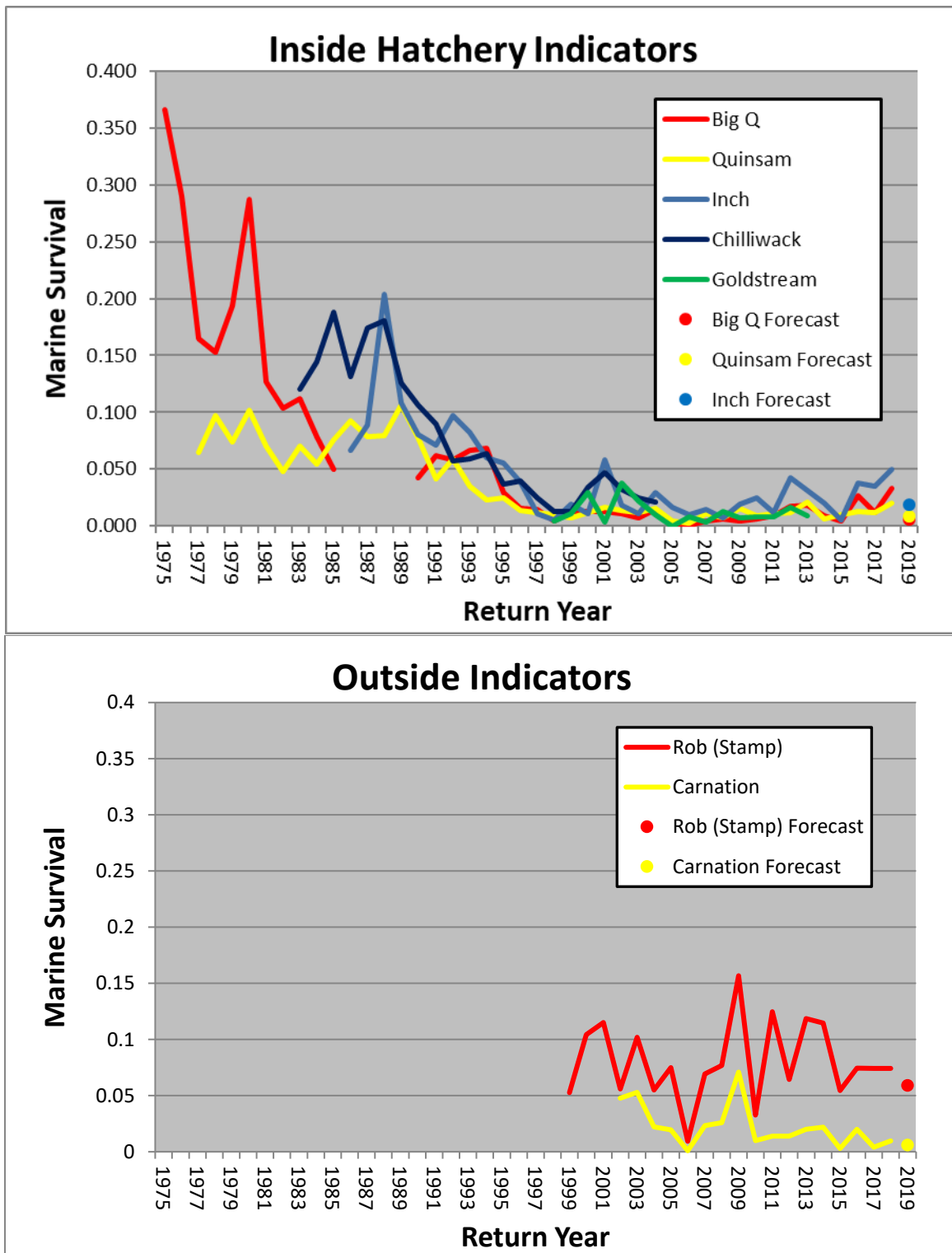
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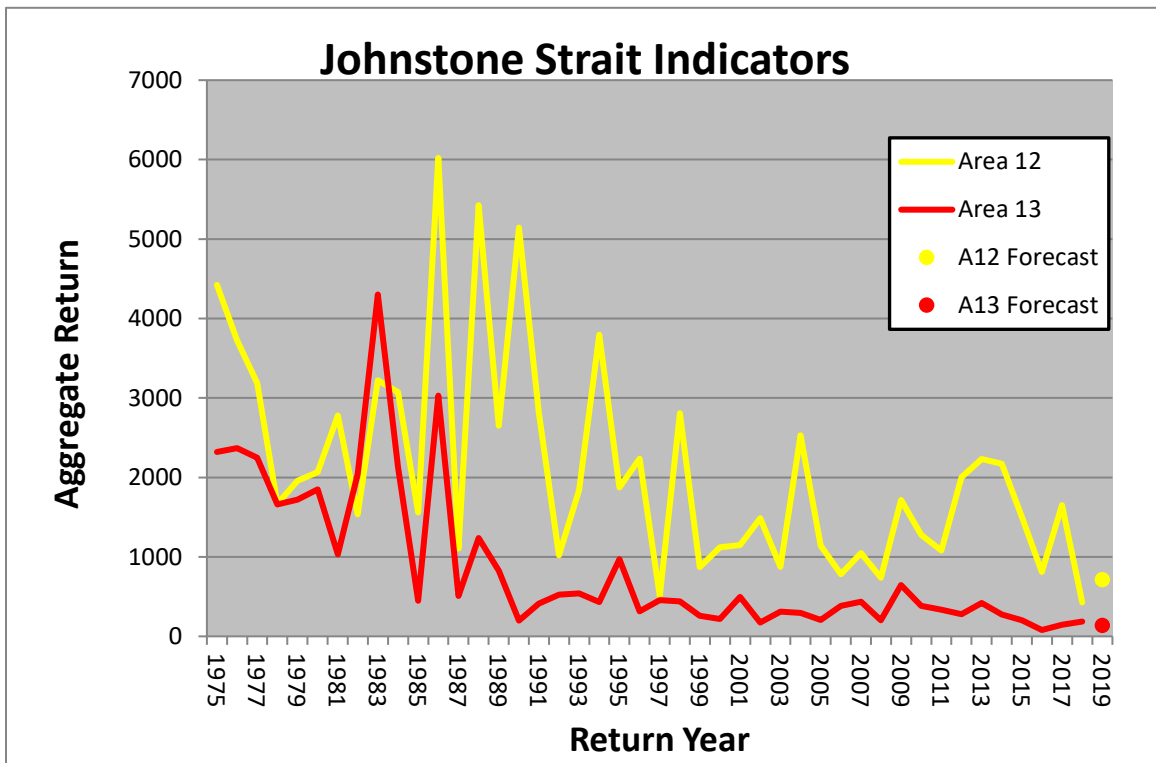
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Appendix 1. Marine survival or aggregate abundances for southern BC coho indicators, including the 2019 forecast.







Appendix 2. Observed and forecast marine survival and aggregate abundance indicators from southern BC coho indicator stocks.

Column Headings

Stock: The name of the Management Unit in **Bold**, followed by the individual indicator or stock grouping within that Management Unit.

2017 Observed: The values in this column represent either the aggregate value (whole numbers) or the estimated marine survival (decimal numbers), from the 2017 return year.

2018 Forecast, 50% CI, and Model refer to the forecast for the 2018 return year. The actual forecasted value is given first, followed by the 50% confidence interval, then the forecasting model used.

2018 Observed, Change from forecast and Change from 2017 refer to the estimated values for each indicator, then the % change from the forecasted value and from the observed value in the previous year. The % change is in relation to the base value so a marine survival of 1.5% in year one increasing to 2.0% in the next year is expressed as a plus 33% change and is highlighted in green. A decrease of 2.0% to 1.5% is expressed as a minus 25% change and is highlighted in pink.

2019 Forecast, 50% CI and Model refer to the forecast for the current year.

Change from 2018 is the change in value from the observed 2018 value to the 2019 forecast. Each change is highlighted in green or pink, depending on whether the change is up, or down.

Distribution Index (P_{inside}) does not have an annual inside/outside measure so there are no Observed data to report or compare to.

2019 Marine Survival Forecast of Southern British Columbia Coho

Stock	2017		2018		2018	Change from forecast	Change from 2017		2019		Change from 2018
	Observed	Forecast	50% CI	Model	Observed			Forecast	50% CI	Model	
Johnstone Strait/Mainland Inlets											
Area 12 Aggregate	1,653	1,249	864 - 1,805	3YRA	427	-66%	-74%	712	494 - 1047	3YRA	69%
Area 13 Aggregate	146	132	90 - 193	3YRA	185	40%	27%	140	95 - 204	3YRA	-24%
Georgia Basin - West											
Quinsam Hatchery	0.012	0.008	0.006 - 0.011	NPGO	0.020	150%	65%	0.009	0.006 - 0.012	NPGO	-55%
Big Qualicum Hatchery	0.012	0.005	0.003 - 0.009	NPGO	0.033	560%	170%	0.006	0.003 - 0.010	NPGO	-82%
Black Creek (wild)	0.009	0.004	0.003 - 0.009	NPGO	0.018	350%	96%	0.005	0.003 - 0.008	NPGO	-72%
Lower Fraser											
Inch Hatchery	0.035	0.019	0.013 - 0.029	ENSO	0.050	163%	44%	0.019	0.012 - 0.029	ENSO	-62%
Interior Fraser											
Interior Fraser Aggregate	28,418	36,538	27,704 - 46,605	3YRA	40,533	11%	43%	40,533	28422 - 58342*	LLY	0%
Thompson River Aggregate	21,500	28,521	20,111 - 41,205	3YRA							
South-west Vancouver Island											
Robertson (Stamp Falls) Hatchery	0.074	0.058	0.043 - 0.079	NPGO	0.068	17%	-8%	0.059	0.043 - 0.081	NPGO	-13%
Carnation Creek (wild)	0.004	0.006	0.003 - 0.012	3YRA	0.010	67%	150%	0.006	0.003 - 0.011	3YRA	-40%
Distribution Index (P_{inside})		0.442	0.345 - 0.542	Salinity				0.326	0.244 - 0.420	Salinity	
* Interior Fraser Aggregate used an 80% CI for 2019 forecast											