# 2018 MARINE SURVIVAL FORECAST OF SOUTHERN BRITISH COLUMBIA COHO

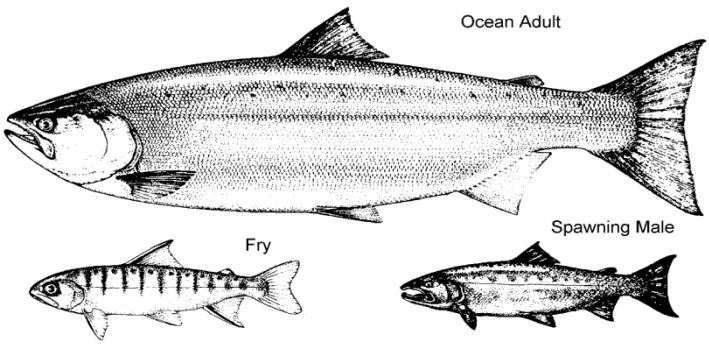


*Figure 1: Coho salmon at three life stages: freshwater rearing fry; ocean rearing adult; and returning male. This image has been used on previous coho Stock Status reports, origin unknown.*


*Figure 2: The Province of British Columbia, showing the major rivers in the South Coast, Lower Fraser and Interior BC areas.*

## SUMMARY

The observed indicator marine survivals and aggregate abundances from 2017 did not show a directional pattern from the previously year as some were higher and some were lower. There was no consistent pattern in area, or hatchery/wild status.

The 2018 forecast for coho indicators are showing a decrease from 2017 levels (minus 10% - 59%). The exceptions are the two Interior Fraser aggregates and the Carnation Creek wild indicator which suggests increases of approximately 33% and 50%, respectively.

The Distribution Index indicates a weak inside distribution of 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 for internal informing fishery management, while the forecasts are used for shaping future fisheries.

The changes in indicator marine survivals and returns from 2016 to 2017 were mixed. On the West Coast of Vancouver Island Robertson (Stamp) increased but Carnation Creek decreased from the previous year. In contrast, the Strait of Georgia hatchery stocks decreased and Black Creek increased from the previous year. Both Johnstone Strait

aggregates increased and both Interior Fraser aggregates decreased from the previous year.

Starting with the 2015 forecast, the Ocean Climate Indices and the Growth model were 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 (2007), DFO (2008), DFO (2009) and DFO (2012). Baillie *et al.* (2005), DFO (2011), DFO (2013), DFO (2014), DFO (2015), DFO (2016) and DFO (2017) 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 aggregates, the data represents the estimated total abundance for those areas. 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.

Escapement to Robertson River, as enumerated at Stamp Falls, for return years 2016 and 2014 was adjusted to reflect recent changes to data analysis.

**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.

The Growth Model (Trudel *et al.*, 2008) is no longer included as a marine survival index model. In recent years the relationship has become statistically invalid, and stock composition analysis has shown that the fish that were sampled were not of BC origin. Although there may have been value in the Growth Model as a general gauge of productivity levels in the marine waters previously, this relationship no longer exists with current indicators.

**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 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/amphitriteDailySalTemp.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 2016 and 2017 values, and the forecast for 2018 returns.

**Johnstone Strait/Mainland Inlets**
In 2017 the observed return in Area 12 was 20% higher than forecast and the Area 13 return was about 10% lower than forecast. The Area 12 return saw 76% of the 2014 brood return and a doubling (2X) what was estimated for the previous year return (2016). The Area 13 return demonstrated a 53% decrease in abundance relative to the brood year (2014) and 180% improvements over the previous year's return (2016). For the indicator

systems at Keogh, smolt production in 2016 was above average (92,000). Based on the observed 2017 returns at those and other system in the area, marine survival had declined in both Area 12 and Area 13 relative to the 2016 return. This reduction in marine survival was also observed in many of the Area 12 and 13 pink salmon stocks that out-migrated in 2016 similar to the coho salmon.

The Area 12 and 13 2018 forecasts are lower than the brood returns in 2015. The Area 12 and 13 forecasts are respectively 16% and 35% lower than the 2015 observed indices. Coho abundance in this region is varied and can be characterized as 'below average' for Area 12 stocks and 'well below average' for Area 13 stocks. See Simpson et al., 2004 for description of characterizations. Smolt production in 2017 was well below average (34,000) for Black Creek and above average for Keogh River (82,000). 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.

**Georgia Basin – West**

The Hatchery indicators for this Management Unit are Quinsam and Big Qualicum Hatcheries and the Wild indicator is Black Creek. In 2016 the smolt production at Black Creek (25,000) was well below average.

The observed 2017 marine survival rate of Quinsam and Big Qualicum hatcheries were both 1.2%, a decrease of 7% and 55%, respectively, from the observed 2016 values but surpassed the forecasted levels. These data show a continuation of the low marine survival levels that have existed since the late 1990's. The Wild indicator, Black Creek, had an improved marine survival of 0.9% over the last two years, but still below short term (10 year) average of 1.2%.

The best performing model for the Big Qualicum Hatchery indicator previously was the Growth Model which is no longer available. The best performing forecast model for this stock, and the Quinsam Hatchery and Black Creek Wild stocks, is the North Pacific Gyre Oscillation index. The 2018 forecast for the Quinsam and Big Qualicum Hatchery indicators is for an increase from the 2017 levels to 1.2% for both hatcheries. The best performing model for Black Creek wild indicator is the North Pacific Gyre Oscillation index, which forecasts a marine survival of 0.4%. Smolt production in 2017 (34,000) was well below average for Black Creek.

**Lower Fraser**

The 2017 marine survival from the Inch Creek Hatchery indicator was very similar to the previous year and, like the other indicators in the Strait of Georgia, was higher than the forecast level.

The retrospective analysis showed that the best performing model is now the El Nino Southern Oscillation climate index, switching from the Pacific Decadal Oscillation that was used previously. The 2018 forecast for marine survival for this indicator is 1.9%, a decrease from the observed level in 2017.

**Interior Fraser**
The observed 2017 abundances for both the Thompson River and Interior Fraser Aggregates were slightly less than half of the previous year, but only about 11-13% less than the forecast.

The forecast model selected for the 2018 return is the 3 Year Average model, which is the same model used in 2017. The 2018 forecast of abundance for the Interior Fraser Aggregate is 36,528 coho with a 50% forecast range: 27,704 to 46,605. Similarly, the 2018 forecast for Upper Thompson Aggregate is 28,521 with a range of 20,111 to 41,205. Both aggregates are forecast to increase by a third over the 2017 levels.

**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 2017 marine survival for Robertson (Stamp) Indicator was 20% higher, and the marine survival for Carnation Creek (Wild) was 50% lower, than the previous year. Similarly, both indicators were higher and lower than the forecast (Robertson (Stamp): +37%, Carnation: -80%).

For the 2018 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 2018 marine survivals are forecast to decrease to 5.8% (Robertson), and increase to 0.6% (Carnation) from the 2017 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 28.56 ppt, which results in a $P_{inside}$ statistic of 0.442, suggesting a weak inside distribution of coho.

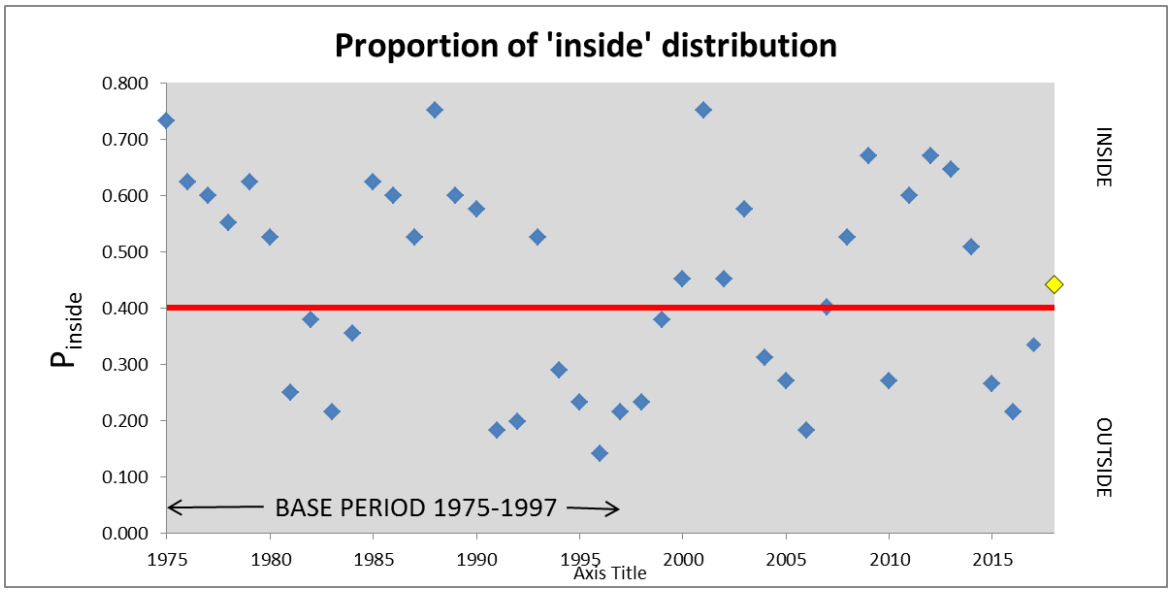


Figure 4. Distributional index for Strait of Georgia Coho, with observed data from 1975-1997, and results from the salinity based model for 1998-2018. The yellow datum represents the current year.

## ACKNOWLEDGEMENTS

The coho forecast for southern British Columbia requires data from many sources and is very much a collaborative document. Steve Baillie, Erin Porszt and Kevin Pellett completed analysis of WCVI and Strait of Georgia indicators. Data analysis of the Interior Fraser Management Units was completed by Lynda Ritchie and Johnstone Strait by Pieter Van Will.

Fresh water creel survey data were provided by Joan Bennett (Strait of Georgia). Coho data from the WCVI indicators was collated by Roger Dunlop (Nuu-Chal-Nulth Tribal Council). Cheryl Lynch provided escapement data from the hatcheries. Wild coho data were provided by Jim Meldrum (A'tlegay First Nation - Black Creek) and Dr. Peter Tschaplinski (BC Ministry of Environment - Carnation Creek). Ocean Climate indices were obtained from various internet sources noted in the text.

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## *FOR MORE INFORMATION*

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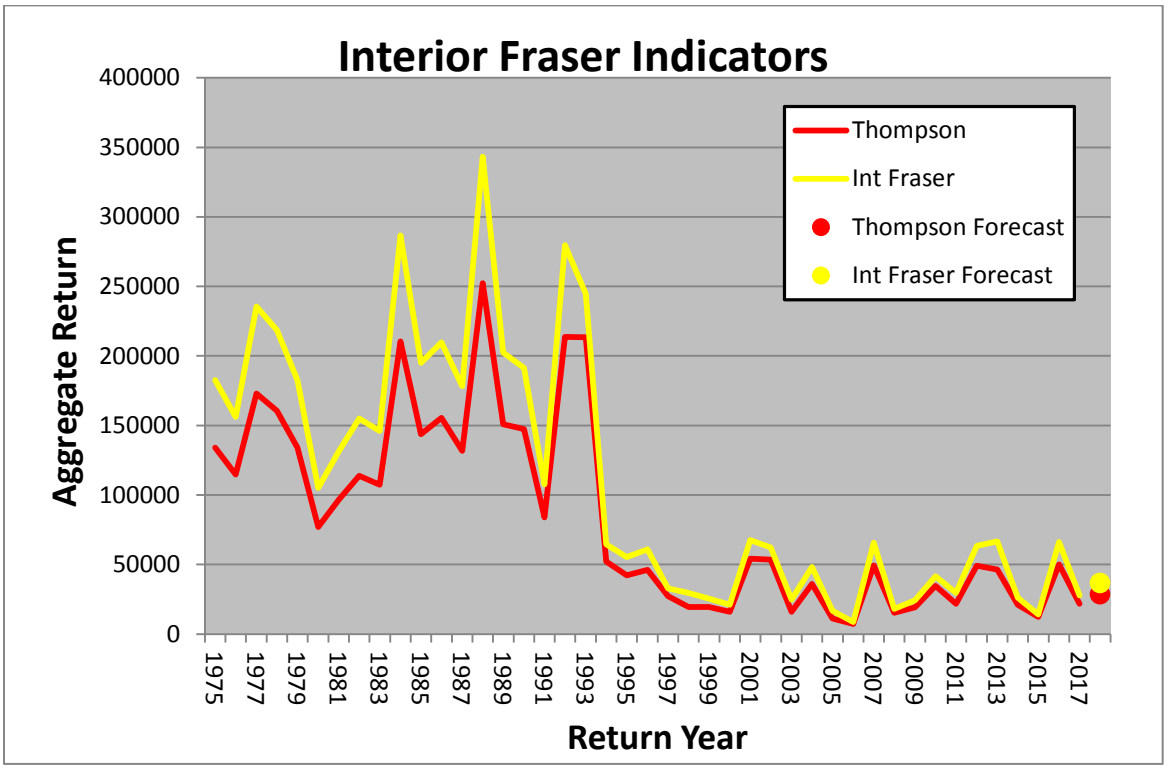
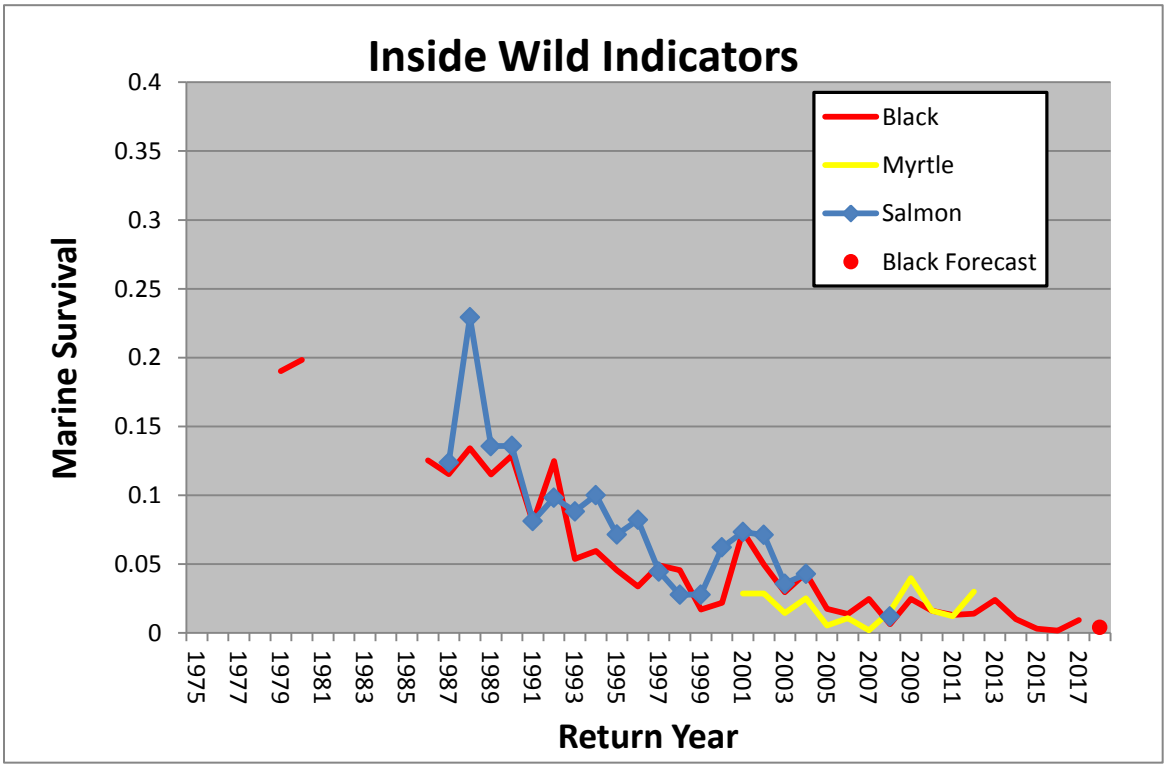
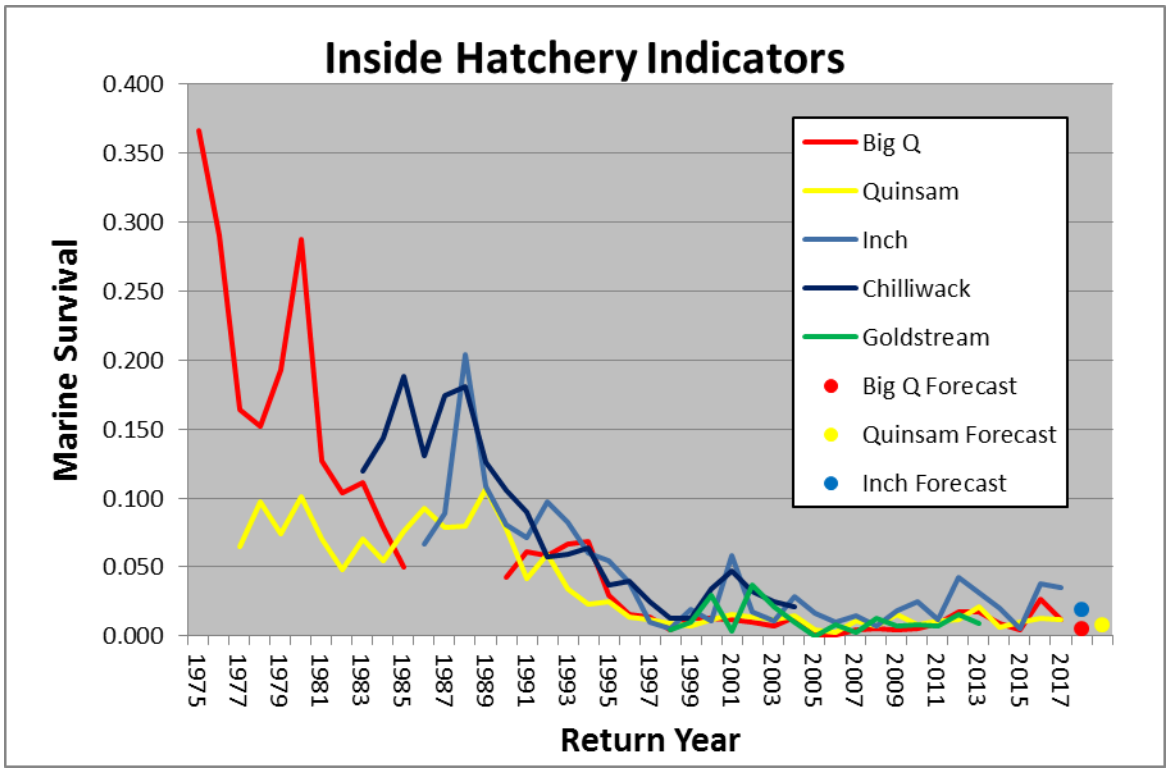
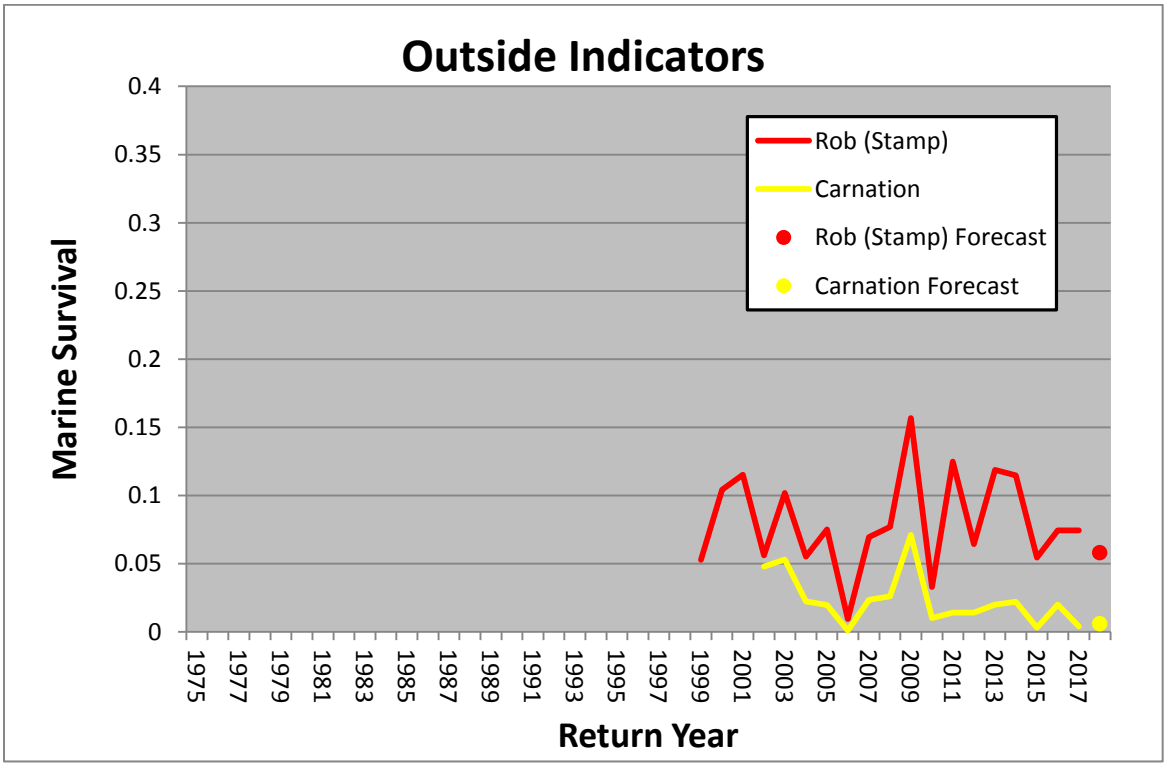
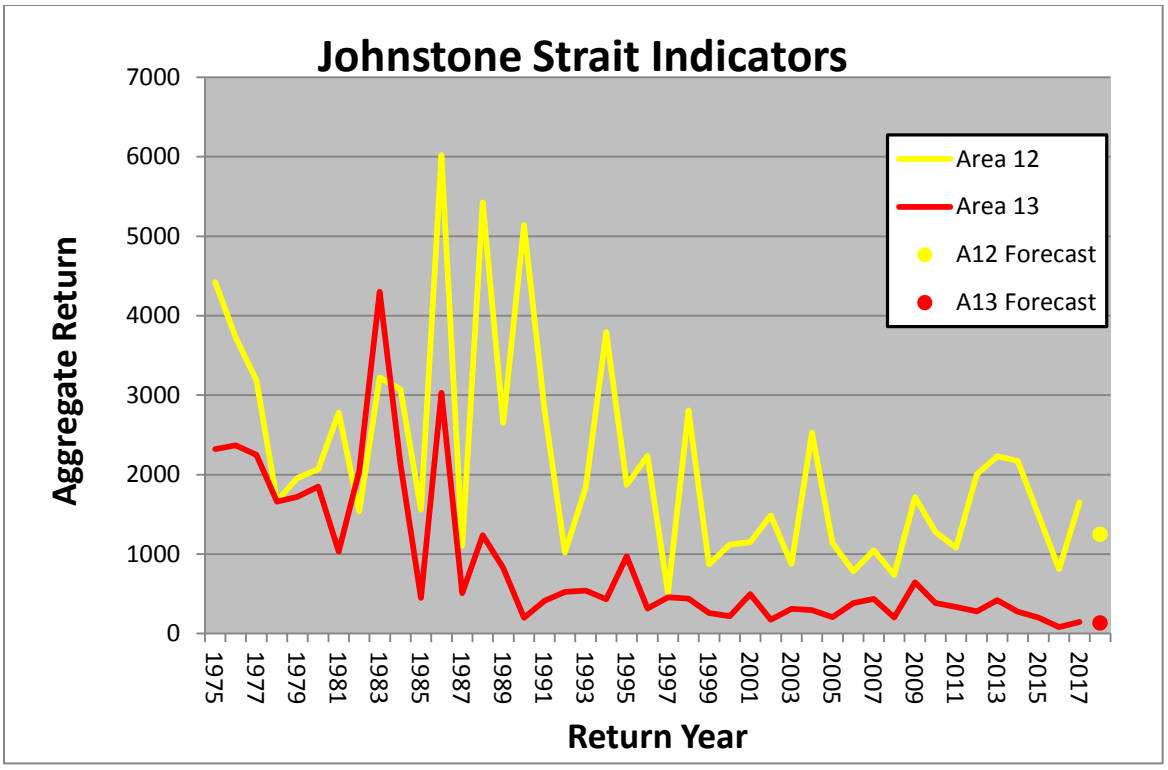
Appendix 1. Marine survival or aggregate abundances for southern BC coho indicators, including the 2018 forecast. The Quinsam forecast datum is offset for clarity.




Inside Hatchery Indicators
Marine Survival
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Return Year
Big Q
Quinsam
Inch
Chilliwack
Goldstream
Big Q Forecast
Quinsam Forecast
Inch Forecast


Outside Indicators
Marine Survival
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Return Year
Rob (Stamp)
Carnation
Rob (Stamp) Forecast
Carnation Forecast


Johnstone Strait Indicators
Aggregate Return
Return Year
Area 12
Area 13
A12 Forecast
A13 Forecast
7000
6000
5000
4000
3000
2000
1000
0
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017

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.

**2016 Observed**: The values in this column represent either the aggregate value (whole numbers) or the estimated marine survival (decimal numbers), from the 2016 return year.

**2017 Forecast, 50% CI, and Model** refer to the forecast for the 2017 return year. The actual forecasted value is given first, followed by the 50% confidence interval, then the forecasting model used.

**2017 Observed, Change from forecast and Change from 2016** 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.

**2018 Forecast, 50% CI and Model** refer to the forecast for the current year.

**Change from 2017** is the change in value from the observed 2017 value to the 2018 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.

| Stock | 2016 | 2017 | | | 2017 | Change from forecast | Change from 2016 | 2018 | | | Change from 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Observed | Forecast | 50% CI | Model | Observed | | | Forecast | 50% CI | Model | |
| **Johnstone Strait/Mainland Inlets** | | | | | | | | | | | |
| Area 12 Aggregate | 811 | 1,367 | 944 - 1981 | 3YRA | 1,653 | **21%** | **104%** | 1,249 | 864 - 1,805 | 3YRA | **-22%** |
| Area 13 Aggregate | 80 | 162 | 110 - 239 | 3YRA | 146 | **-10%** | **83%** | 132 | 90 - 193 | 3YRA | **-10%** |
| **Georgia Basin - West** | | | | | | | | | | | |
| Quinsam Hatchery | 0.013 | 0.008 | 0.006 - 0.010 | NPGO | 0.012 | **51%** | **-7%** | 0.008 | 0.006 - 0.011 | NPGO | **-34%** |
| Big Qualicum Hatchery | 0.027 | 0.004 | 0.003 - 0.007 | Growth | 0.012 | **205%** | **-55%** | 0.005 | 0.003 - 0.009 | NPGO | **-59%** |
| Black Creek (wild) | 0.002 | 0.007 | .0.005 - 0.012 | NPGO | 0.009 | **31%** | **496%** | 0.004 | 0.003 - 0.009 | NPGO | **-57%** |
| **Lower Fraser** | | | | | | | | | | | |
| Inch Hatchery | 0.038 | 0.012 | 0.008 - 0.018 | PDO | 0.035 | **190%** | **-8%** | 0.019 | 0.013 - 0.029 | ENSO | **-45%** |
| **Interior Fraser** | | | | | | | | | | | |
| Interior Fraser Aggregate | 66,202 | 31,212 | 19,309 - 50,453 | 3YRA | 27,682 | **-11%** | **-58%** | 36,538 | 27,704 - 46,605 | 3YRA | **32%** |
| Thompson River Aggregate | 49,971 | 24,752 | 15,119 - 40,525 | 3YRA | 21,500 | **-13%** | **-57%** | 28,521 | 20,111 - 41,205 | 3YRA | **33%** |
| **South-west Vancouver Island** | | | | | | | | | | | |
| Robertson (Stamp Falls) Hatchery | 0.054 | 0.062 | 0.048 - 0.079 | NPGO | 0.074 | **20%** | **37%** | 0.058 | 0.043 - 0.079 | NPGO | **-22%** |
| Carnation Creek (wild) | 0.020 | 0.008 | 0.004 - 0.015 | 3YRA | 0.004 | **-50%** | **-80%** | 0.006 | 0.003 - 0.012 | 3YRA | **50%** |
| **Distribution Index ($P_{inside}$)** | | 0.335 | 0.430 - 0.252 | Salinity | | | | 0.442 | 0.345 - 0.542 | Salinity | |