# 2007 MARINE SURVIVAL FORECAST OF SOUTHERN BRITISH COLUMBIA COHO

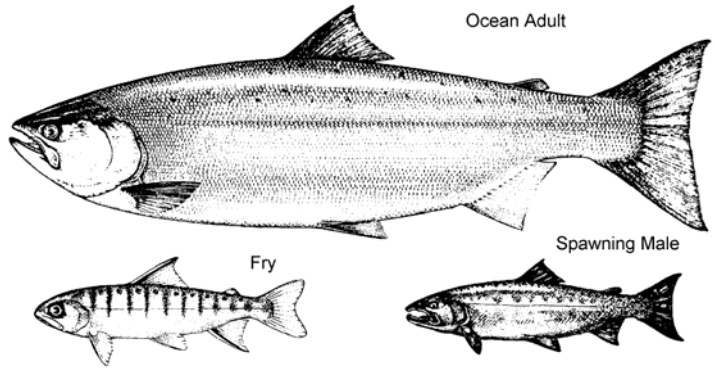


*Figure 1: Coho salmon at three life stages: freshwater rearing fry; ocean rearing adult; and returning male in spawning colours. This image has been used on previous coho Stock Status reports, origin unknown.*


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

**Context**

*This report presents a forecast for southern British Columbia coho returning in 2007. Stock assessment and forecast documents on southern BC coho have been submitted to the Pacific Scientific Advice Review Committee (PSARC) since 1995. Simpson et al. (2004) represents the most recent full treatment of the forecast process and should be referred to for more information on the in-depth details. Since 2005, the forecast report was requested as a SAR document, which does not include the detailed description of the data sources, their assumptions and uncertainties, and the models. This forecast report relies on identical methods reviewed by PSARC on this subject.*

## SUMMARY


- 2006 marine survival and abundance observations were generally lower than forecast, and in some cases much lower than forecast. Since the early 1970s the marine survivals have been decreasing from the 10% to 20% range down to less than 2%.
- Forecast models predict extremely low marine survivals and abundances for 2007, similar to the last two years. Interior Fraser, Georgia Basin East and Georgia Basin West Management Units in particular are coho stocks of concern. Although the biological based models are more optimistic than the time series models, the abundance would still be considered low.
- The distributional forecast is for a weaker outside distribution than 2005 and 2006, and similar to the long term average.
- Monitoring programs for coded-wire tagged, adipose fin clipped coho must be maintained or strengthened to continue to monitor southern British Columbia coho populations.

# INTRODUCTION

During the 1990s DFO Fisheries Management and Stock Assessment divisions observed an unprecedented decrease in the marine survival of southern British Columbia coho populations. Hatchery indicator stocks decreased from a mean survival of 6.6% (Brood Year (BY) 1983-1992) to 2.5% (BY 1993-2001) and wild indicator stocks from 10.2% to 4.4% during the same time period. In response, all directed coho fisheries were curtailed to protect weaker stocks such as Thompson River and Strait of Georgia coho. This management action resulted in a decrease of the total exploitation rate (all sectors) from a mean of 67% (BY 1983-1994) down to 17% (adipose fin clip (AFC) coho, BY 1995-2001) and 4% (non-AFC coho).

These measures allowed more coho salmon to return to natal creeks. Bradford et al. (2000) found that a minimum rate of 3% marine survival is required for a wild, coastal population to sustain itself. Hatchery indicators can withstand lower levels of marine survival because of the higher egg to fry survival rates of these stocks.

The scope for this forecast is southern British Columbia (sBC), which comprises seven Management Units (MU):

**Johnstone Strait/Mainland Inlets (JST):** Johnstone Str., Queen Charlotte Str., and adjacent inlets (Areas 11, 12 and the northern portion of Area 13). The indicator data consists of the return (catch plus escapement) of a group of monitored streams.

**North-west Vancouver Island (NWVI):** Estevan Pt. to Cape Scott (Areas 25-27). There are no indicators in this MU.

**South-west Vancouver Island (SWVI):** Victoria to Estevan Pt. (the remaining part of Area 19 and Areas 20-24). There is one wild indicator (Carnation Creek) and one hatchery indicator (Robertson Hatchery).

**Georgia Basin – East (GBE):** east side of the Str. of Georgia, excluding the Fraser R. system (Areas 15, 16, 28 and the coastal foreshore streams in Area 29). Currently there are no indicators used for this MU, however a wild indicator (Myrtle Creek) should be included next year.

**Georgia Basin – West (GBW):** west side of the Str. of Georgia (Areas 13 (southern portion), 14, 18 and the Str. of Georgia portion of Area 19. There is one wild indicator (Black Creek) and three hatchery indicators (Quinsam, Big Qualicum and Goldstream Hatcheries).

**Lower Fraser (LowFr):** Lower Fraser R. system as far upstream as Hell's Gate (Area 29). There is one hatchery indicator (Inch Hatchery) and a wild indicator that was discontinued in 2004 but restarted in 2006, and will be included next year.

**Interior Fraser (IntFr):** upstream from Hell's Gate, including the Thompson R. system (Area 29). The indicator data used for this MU is the estimated total escapement into the MU, including North Thompson, South Thompson, Lower Thompson and non-Thompson Fraser coho.

# ASSESSMENT

For the hatchery indicators and a wild indicator, Black Creek, a cohort of smolts is coded-wire tagged and released. This group of tagged coho is followed through the fisheries (where possible) and is enumerated when they return to their natal creeks. Any freshwater fisheries are monitored and included as escapement so that the calculated marine survival can be applied to the entire MU.

For the wild indicator, Carnation Creek, the smolts have been tagged since 2001 (brood 1999). For this indicator we used the adult escapement abundance rather than marine survival as this data series extends back to 1972. Similarly, abundance is used in the JST and IntFr management units.

The process of developing the sBC coho forecast is as follows:

1. Gather data on coded-wire tagged / adipose fin clipped (CWT/AFC) coho from marine and freshwater fishing mortality and escapement from the previous forecast year for indicator stocks. For Interior Fraser River (Thompson) and Area 12/13 coho populations escapement and exploitation information is collected. Finally, salinities from February and March of the current year from Chrome and Sisters Islets are collected.
2. Add the data to the forecast models' data sets.
3. Examine the predictive power of each model and select the one that best fits the past data to use for the next forecast year.

## Forecast models

1. Time Series Models.

The following four models were applied in all abundance and survival forecasts:

- '**Like last year' (LLY):** the forecasted survival or abundance will remain the same as that observed in the previous year;
- **Three year average (3YRA):** the forecasted survival or abundance will equal the mean of the previous three years of observed values;
- **One year trend (RAT1):** the change in survival or abundance from last years observed to this years forecast will equal the previous change (from that observed two years ago to that observed last year); and,
- **Average three year trend (RAT3):** the change in survival or abundance from last years observed value to this years forecast will equal the mean of the previous three changes.

2. Sibling Model.

This forecasts the adult return to an indicator using a regression that relates past adult returns to the escapement of jacks one year prior. Forecast returns to hatcheries are converted to forecasts of survival by dividing returns by the smolt releases.

3. Euphausiid Model.

This model forecasts the return to Carnation Creek using a regression that relates past adult returns to the abundance of a euphausiid species in Barkley Sound one year prior. This species is an important prey for coho in Barkley Sound.

4. CPUE Model.

This is a forecast of the total return of CWT/AFC coho for the three hatchery indicators in the Georgia Basin: Quinsam, Big Qualicum and Inch. A research vessel is used to sample juvenile coho in July of their first year in the Strait of Georgia. The catch of AFC coho is related in a regression to the CWT/AFC return to these hatcheries the following year. The catches are from a standard trawl survey conducted annually. The return forecast is then divided by the total CWT/AFC release from the hatcheries to provide a marine survival forecast. There are other sources of AFC coho that can be found in the Strait including Puget Sound however the releases from the hatcheries are used as an index of the AFC coho population in the Strait of Georgia.

5. Stock-Recruit Model.

The time series of standardized escapements and returns to Area 12 and Area 13 streams were used as inputs to Ricker stock-recruitment analyses, which were then used to forecast recruitment and returns using observed spawner indices in the brood year.

6. Distribution Forecast.

Young coho originating in the Georgia Basin are thought to rear in the Strait of Georgia until the fall, when they primarily migrate to the west coast of Vancouver Island. A varying proportion return to the Strait soon after, in late winter, and are available to 'inside' fisheries in their last year at sea. This proportion has been related to salinity in the strait in this late winter period: low salinities are associated with few coho returning early. The salinity model predicts the proportion of catch taken in the strait if pre-1997 fishing regimes were in place and this proportion, $P_{inside}$, is now used as an index of inside distribution. $P_{inside}$ should not be interpreted as the proportion that is occupying the strait in their last year.

A retrospective analysis is done for each model to choose the one with the best fit to the observed data using common time periods. The model that best fits the past data was used to forecast the following year return either as marine survival or adult return.

## Changes from previous reports

Exploitation rates of sBC coho indicator stocks have been previously estimated by comparing the Catch-Per-Unit-Effort (CPUE) of coho by-catch in non-targeted fisheries from a base period (1987-1997) to efforts during the fishing season for the past year. This has been considered to be unreliable as a surrogate for measuring exploitation rate. Without an alternative, the rate from the previous year was assumed for 2006 for Quinsam, Big Qualicum and Inch Hatchery indicators, and Black Creek and Salmon River wild indicators. Estimation of the exploitation rate for Robertson Hatchery and Carnation Creek coho was not changed from previous years. Exploitation rates on Interior Fraser River coho were based on the post season analysis of the Fisheries Regulation Allocation Model (FRAM).

Goldstream Hatchery (GBW), which was included for the 2006 forecast, was not included in the current document. The escapement enumeration was hampered by higher than normal water levels and the estimate could not be calculated.

Salmon River (LowFr) restarted field operations in 2006 and will be included as a wild indicator again.

## Sources of uncertainty

### Commercial by-catch of coho

Exploitation rates were estimated by using the by-catch of coho in non-targeted commercial fisheries from a base period of return years 1987 – 1997 and comparing the effort from this base period to 2006 to estimate the by-catch of coho. For the current forecast the exploitation rates were assumed to be the same as in 2006.

### Sport catch

CWT-based estimates of sport fishing mortality have become less certain due to changes in creel survey study designs and calculations of CWT recoveries.

Freshwater creel surveys were limited to Quinsam River, Nicomen Slough (Inch Creek Hatchery) and the Fraser River.

### Predictive power of the time series models

The time series models used in this forecast can only forecast continuing trends therefore they have no predictive power for changes to that trend.

## Stock trends

Since the early 1970's, marine survival of coho salmon has decreased from a range of 10% - 20% down to less than 2%. The majority of the observed marine survival for the 2006 return continued to be at the bottom of this range (see Table 1. – 2006 Observed column). With the exception of the Area 13 Aggregate the observed survivals in 2006 were all less than or equal to the forecast of the time series models, and most were less than the lower 50% confidence interval bound.

*Table 1. Forecasted 2006 coho marine survival and abundance values with 50% confidence intervals and values observed in 2006.*

| | 2006 | | | 2006 | Change |
|---|---|---|---|---|---|
| | Forecast | 50% CI | Model | Observed | from forecast |
| **Johnstone Strait/Mainland Inlets** | | | | | |
| Area 12 | 1446 | 952 - 2196 | 3YRA | 766 | -47% |
| Area 13 | 261 | 170 - 400 | 3YRA | 540 | 107% |
| **Georgia Basin - West** | | | | | |
| Big Qualicum | 0.001 | 0.001 - 0.002 | LLY | 0.001 | 0% |
| Quinsam | 0.007 | 0.005 - 0.010 | 3YRA | 0.002 | -71% |
| Goldstream | 0.012 | 0.006 - 0.023 | 3YRA | N/A | |
| Black (wild) | 0.026 | 0.018 - 0.038 | 3YRA | 0.015 | -42% |
| **Lower Fraser** | | | | | |
| Inch | 0.015 | 0.009 - 0.026 | LLY | 0.008 | -47% |
| Salmon (wild) | | | | 0.014 | |
| **Str. Of Geo. Hatcheries** | 0.007 | 0.005 - 0.009 | CPUE | 0.004 | -43% |
| **Interior Fraser** | | | | | |
| Thompson aggregate | 18,341 | 11,759 - 28,608 | 3YRA | 7,079 | -61% |
| **South-west Vancouver Island** | | | | | |
| Robertson | 0.045 | 0.021 - 0.095 | LLY | 0.005 | -89% |
| Carnation (wild) | 31 | 17 - 59 | Euphausiid | 7 | -77% |
| **Distribution Index ($P_{inside}$)** | 0.195 | 0.138 - 0.268 | Salinity | | |

## Johnstone Strait/Mainland Inlets

In 2006 the observed return in Area 12 was 47% less than forecast and the Area 13 return was 106% above forecast. The Area 12 return was slightly less than the brood and approximately 65% of what was estimated for the previous year's return. The Area 13 return was a significant improvement over the brood year (2003) and to the 2005 return. However returns to individual systems were variable with the majority of streams failing to reach expected returns. Average smolt production was encountered in 2005 in Keogh River. Low smolt production and the region wide drop in marine survival (evident in both pink and coho returns in 2006 which entered the marine environment in 2005) resulted in the continued low returns to the Johnstone Strait areas.

## North-west and South-west Vancouver Island

The observed 2006 Robertson Creek Hatchery coho survival (0.5%) and Carnation Creek return (7) were both much lower than forecast and less than the lower 50% CI bound. The Carnation Creek return was substantially less that the 2003 brood of 468 and less than the previous low escapement of 9 (1994). The Robertson Creek Hatchery coho marine survival was the second lowest on record. The other occurrence when the marine survival was below 1% was in 1994. The 2006 forecast for Robertson Creek Hatchery coho was based on the LLY model which had a slightly better retrospective performance statistic however the Sibling model would have forecast a marine survival of 0.9%, much closer to the observed value.

Figure 3 shows the marine survival for wild (Carnation Creek) and hatchery (Robertson Hatchery) indicators, and the 2007 marine survival forecast including 50% confidence intervals. The data has been smoothed by plotting a running three year average.

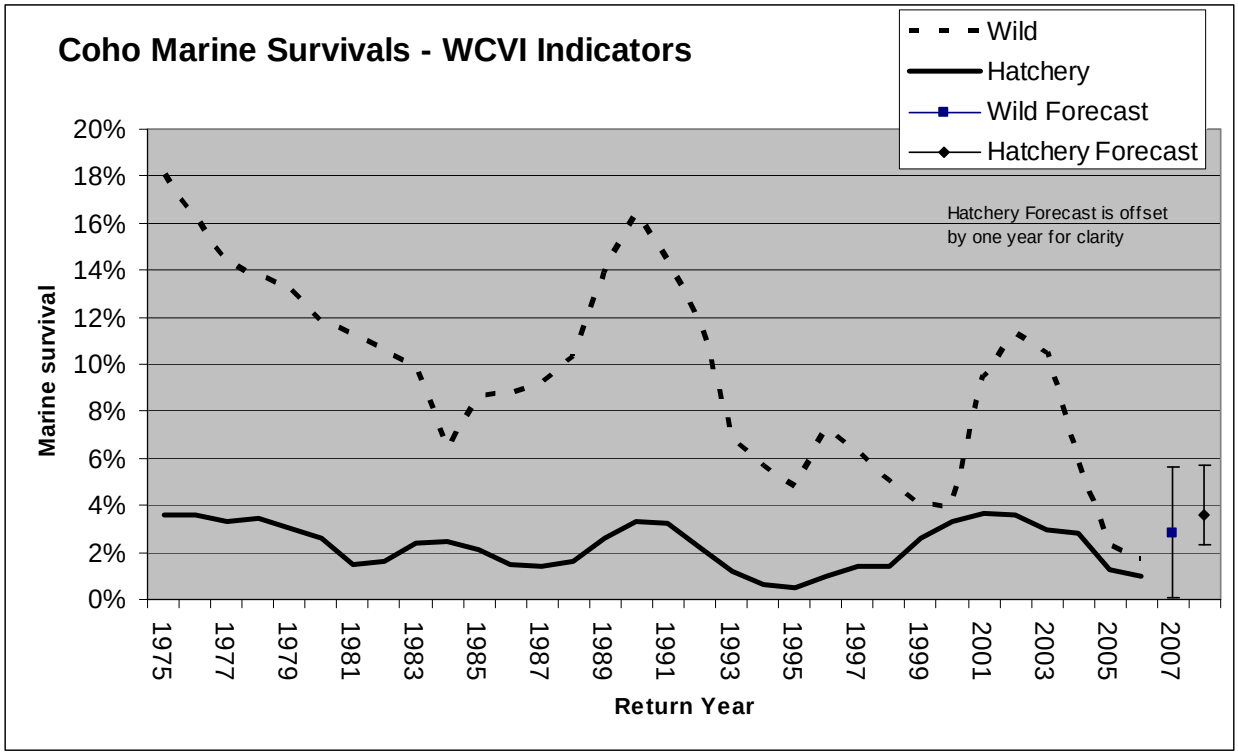


*Figure 3. Coho marine survivals for West Coast Vancouver Island indicators (SWVI and NWVI).*

## Georgia Basin West and Georgia Basin East

Coho returns to the Georgia Basin continued to decline in 2006, and except for Big Qualicum Hatchery, were less than the forecast and less than the lower 50% CI. Big Qualicum Hatchery coho continued to be extremely low at 0.1% marine survival.

The wild indicator at Black Creek continues to have better marine survival than the hatchery stocks but is still low at 1.5%. The 2006 return was substantially less than the brood year. This is the second consecutive year that the marine survival has been less than replacement levels.

## Lower Fraser

The 2006 observed marine survival of Inch Creek hatchery coho (0.8%) was less than the forecast of 1.5%, and was just outside the 50% CI range. This is the second lowest marine survival for this stock on record (1998 return was 0.5%).

The wild indicator for the Lower Fraser is the Salmon River (Langley, B.C.). This project was discontinued in the Fall of 2005 however it was restarted in the Fall of 2006 and a marine survival of 1.4% was observed for the return from the 2003 brood year. This is the lowest marine survival on record.

Figure 4 shows the marine survival for wild (Black Creek and Salmon River) and hatchery (Quinsam, Big Qualicum, Inch, Chilliwack and Goldstream Hatcheries) indicators, and the 2007 marine survival forecast including 50% confidence intervals. The data has been smoothed by plotting a running three year average of the annual means.

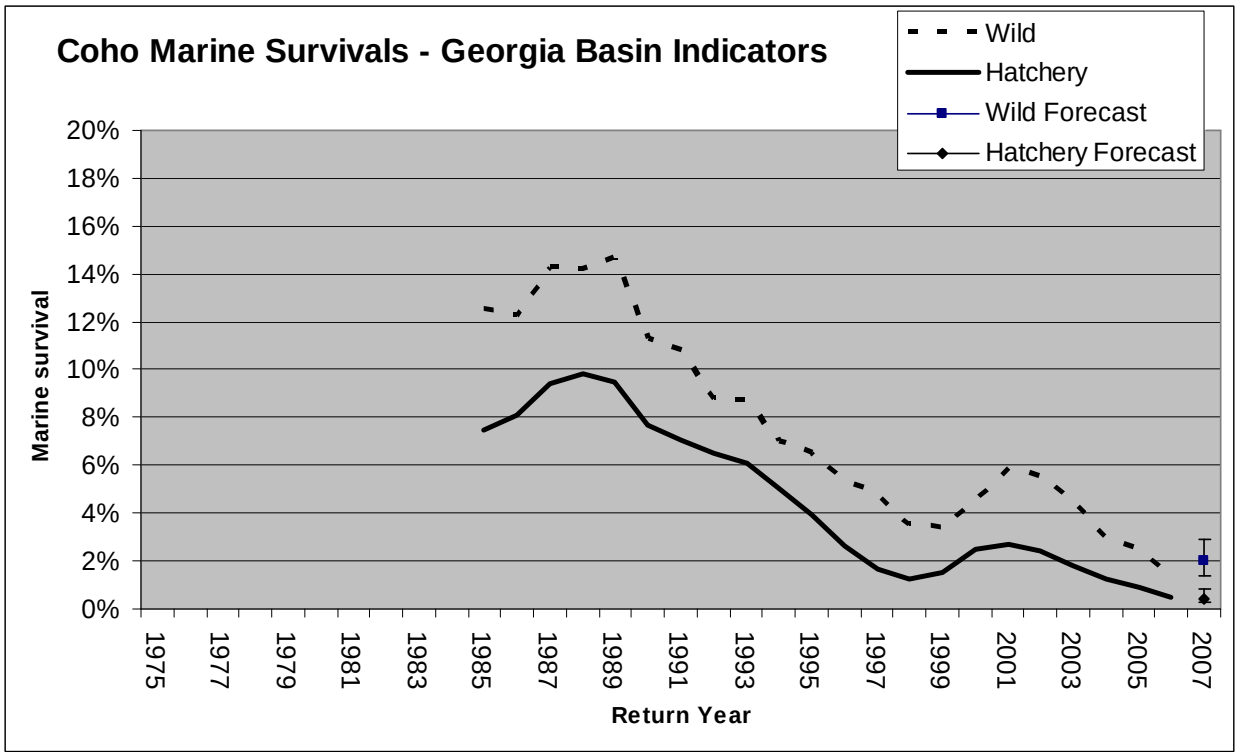


*Figure 4. Coho marine survivals for Georgia Basin indicators (GBE, GBW and LowFr).*

## Interior Fraser

The total abundance of Thompson River watershed coho in 2006 was approximately 7,079, which was far below the forecasted abundance of 18,341 animals. The abundance in 2006 was lower than the abundance observed in 2005 (11,261), and just 45% of the brood year abundance of 15,903. The estimated spawning escapement (including brood removals) of coho in the Thompson River drainage in 2006 was 6,337.

The total abundance and spawning escapement observed for the entire Interior Fraser River Management Unit was approximately 8,565 and 7,077 coho salmon, respectively.

Exploitation rates on Interior Fraser River coho were derived from the post-season estimates generated from the Fisheries Regulation Allocation Model (FRAM) and the post-season Fraser River fisheries ER rate calculation. The estimated exploitation rate for IFR coho in 2006 was approximately 7.8%. Total Canadian exploitation was estimated at 2.5%.

# 2007 Forecasts

*Table 2. Observed 2006 coho marine survival and abundance values and 2007 forecasts with 50% confidence intervals.*

| | 2006 | 2007 | | | Change (2007 forecast minus |
|---|---|---|---|---|---|
| | Observed | Forecast | 50% CI | Model | 2006 observed) |
| **Johnstone Strait/Mainland Inlets** | | | | | |
| Area 12 | 766 | 1331 | 876 - 2021 | 3YRA | 74% |
| Area 13 | 540 | 317 | 204 - 491 | 3YRA | -41% |
| **Georgia Basin - West** | | | | | |
| Big Qualicum | 0.001 | 0.001 | 0.001 - 0.001 | LLY | 0% |
| Quinsam | 0.002 | 0.004 | 0.003 - 0.006 | 3YRA | 100% |
| Goldstream | N/A | 0.003 | 0.001 - 0.010 | 3YRA | N/A |
| Black (wild) | 0.015 | 0.020 | 0.014 - 0.029 | 3YRA | 33% |
| **Lower Fraser** | | | | | |
| Inch | 0.008 | 0.008 | 0.005 - 0.014 | LLY | 0% |
| Salmon (wild) | 0.014 | | | | |
| **Str. Of Geo. Hatcheries** | 0.004 | 0.025 | 0.023 - 0.027 | CPUE | 525% |
| **Interior Fraser** | | | | | |
| Thompson aggregate | 7,079 | 14,183 | 9,065 - 22,192 | 3YRA | 100% |
| **South-west Vancouver Island** | | | | | |
| Robertson | 0.005 | 0.036 | 0.023 - 0.057 | Sibling | 620% |
| Carnation (wild) | 7 | 63 | 2 - 124 | Euphausiid | 800% |
| **Distribution Index ($P_{inside}$)** | | 0.39 | 0.300 - 0.490 | Salinity | |

## Johnstone Strait/Mainland Inlets

The Area 12 and 13 Aggregate forecasts are lower than the brood and slightly better than the brood returns, respectively. The Area 12 forecast is 74% higher and the Area 13 forecast is 41% lower than the estimated observed indices in 2006. Coho abundance in this region remains poor and can be characterized as 'below average' (Area 12) and 'well below average' (Area 13). See Simpson et al. (2004) for description of characterizations.

## North-west and South-west Vancouver Island

The euphausiid model predicts a low return of Carnation Creek coho of 63 adults. This will be from a smolt enumeration of 2248, indicating a marine survival of 2.8%. The Robertson Creek Hatchery coho forecast is for a marine survival of 3.6% using the sibling model. Both of these forecasts suggest a large increase in 2007 return from the 2006 return, however these are still considered low.

## Georgia Basin West and Georgia Basin East

The marine survival forecast for hatchery stocks, using the LLY and 3YRA models, is slightly better than observed in the previous year but is continuing to be extremely low at 0.1% - 0.3%. The wild indicator at Black Creek is forecast to improve slightly to 2.0% using the 3YRA model.

The CPUE forecast for aggregate Strait of Georgia hatchery stocks is more optimistic than the individual hatchery forecasts, which are based on time series.

### Lower Fraser

The forecast model used for 2007 is the LLY model which was also used to forecast the 2006 survival. The forecast is for 0.8% marine survival. This will be a continuation of the very low survivals that have been observed over the last 10 years.

The wild indicator at Salmon River has been restarted and will be part of the suite of indicators next year.

### Interior Fraser

Based on the 3YRA abundance model, the forecast of total abundance of Thompson River coho for 2007 is estimated to be 14,183. The forecasted return to the Thompson River watershed is approximately 21% of the mean abundance of the time series, and would represent a decrease below the brood abundance of 35,792 animals.

It should be noted that the last three years of Thompson River coho abundances have failed to meet the abundances of their corresponding brood years. The 2007 forecasted abundance is again below the abundances observed in the brood year.

Additionally, the forecasted abundance is below the lower threshold escapement suggested in the IFR Coho Recovery Strategy required to ensure genetic and demographic concerns are maintained in the entire Management Unit

In light of the abundance trend, coupled with the further decline of marine survival rates of Southern B.C. coho stocks observed in 2006, the low forecasted abundance of Thompson coho should be viewed with caution when planning fisheries or activities which may impact the survival of Thompson and Interior Fraser River coho

### Distribution

The final $P_{inside}$ statistic for 2006 was 0.195. The final 2007 $P_{inside}$ statistic is 0.390, indicating a weaker 'outside' distribution of coho than the last two years. This level is similar to the long term mean of 0.412 and indicates that coho should return to the Strait of George earlier than the last two years.

## CONCLUSIONS

The 2006 returns of coho to southern British Columbia continued to decline to extremely low levels, particularly within the Strait of Georgia. Although the 2007 forecast of some stocks predict an improvement over the 2006 returns, this must be viewed with caution as the abundance of coho stocks would still be considered low.

Noteworthy is an apparent dichotomy between time series based forecasts (LLY and 3YRA), and biologically based forecasts (Sibling, Euphausiid, and CPUE). The time series models are forecasting a range of annual increases of 0% to 100%, and the biological models are forecasting a range of annual increases of 525% to 800% from the previous year.

In light of the abundance trend, coupled with the continuing decline of marine survival rates of southern B.C. coho stocks, the forecast of marine survival and abundance should be characterized as extremely low and caution should be exercised when planning fisheries or activities which may exploit these stocks.

Monitoring of CWT/AFC coho catch in all sources of mortality should be maintained or improved and be responsive to shifting fishing pressures. Commercial catch in particular should be monitored as previous estimation models are no longer reliable.

## SOURCES OF INFORMATION

The data, models and treatments that were used in this report are fully documented in Simpson et al. (2004). Refer to that document for descriptions and background information.

The coho forecast for southern British Columbia requires data from many sources and is very much a collaborative document. Data analysis of Thompson River and Johnstone Strait coho was completed by Michael Chamberlain and Pieter Van Will, respectively. Ron Tanasichuk provided euphausiid data and analysis. The CPUE data were collected and analyzed by Ruston Sweeting. Creel survey data were provided by Joe Tadey (Lower Fraser), James Patterson (West Coast Vancouver Island) and Shawn Stenhouse (Strait of Georgia). Roberta Cook provided escapement data from the hatcheries. Wild coho data were provided by Eamon Miyagi (Black Creek) and Dr. Peter Tschaplinski (BC Ministry of Forests - Carnation Creek).

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