2008 MARINE SURVIVAL FORECAST OF SOUTHERN BRITISH COLUMBIA COHO

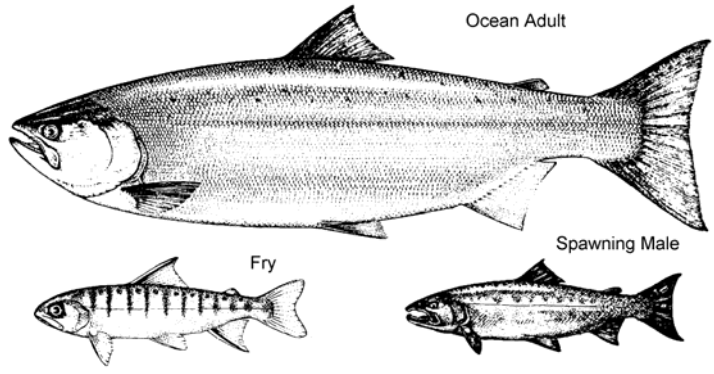

Figure 1: Coho salmon at three life stages: freshwater rearing fry; ocean rearing adult; and returning male in spawning colours. This image has been used on previous coho Stock Status reports, origin unknown.

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 2008. 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 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

- 2007 marine survival and abundance observations were higher than 2006 with the exception of Area 13 Index streams. Also, they were generally higher than forecast, except for west coast Vancouver Island, Area 12 and the Strait of Georgia Hatchery CPUE model.
- All of the biological based model forecasts were lower than the observed values in 2007 and 7 of 8 of the time series based model forecasts were higher than the observed values.
- Marine survivals have decreased from the 10% to 20% range in the early 1970s to less than 2%.
- Forecast models predict extremely low marine survivals and abundances for 2008, similar to the last three years. Interior Fraser, Georgia Basin East and Georgia Basin West Management Units in particular are coho stocks of concern.
- The distributional forecast is for a stronger outside distribution than 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. (part of Area 19 (sub-areas 1 to 4) 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, 17, 18 and the Str. of Georgia portion of Area 19 (sub-areas 5 to 12)). 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 one wild indicator (Salmon River), which discontinued operations after spring 2005 and restarted in fall 2006. This indicator will be included in next year's forecast when coded-wire tagged adults are returning to the system.

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 modeled. For the Goldstream Hatchery indicator there are no coded-wire tag catch data from this stock available for the baseline period so exploitation information must be based on tag recoveries. 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. Biological Models

- **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.
- **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.

- **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.
- **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.
- **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

Goldstream Hatchery (GBW) has been included for the 2008 forecast. It was not included in the 2007 document as 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 fall 2006 and will be included as a wild indicator again next year.

The Carnation Euphausiid model can be based on either adult return or marine survival. For the 2008 forecast the adult return regression was used to produce a forecast.

Sources of uncertainty

Commercial by-catch of coho

Exploitation rates are 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 the effort in 2007 to estimate the exploitation rate of coho.

Sport catch

CWT-based estimates of sport fishing mortality have become less certain due to decreased participation by sport fishers in submitting adipose clipped head samples.

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 estimates for the 2007 return continued to be at the bottom of this range (see Table 1. – 2007 Observed column). Returns of coho in 2007 improved over the previous year and were generally higher than forecast. The returns were well above most of the time series models (3YRA, LLY) forecasts (average 101% greater than forecast) and less than the biological model forecasts (average 45% less than forecast).

Table 1. Forecasted 2007 coho marine survival and abundance values with 50% confidence intervals and values observed in 2007.

	2006	2007			2007	Change	Change
	Observed	Forecast	50% CI	Model	Observed	from forecast	from 2006
Johnstone Strait/Mainland Inlets							
Area 12	766	1331	876 - 2021	3YRA	1,274	-4%	66%
Area 13	540	317	204 - 491	3YRA	509	61%	-6%
Georgia Basin - West							
Big Qualicum	0.001	0.001	0.001 - 0.001	LLY	0.003	217%	217%
Quinsam	0.002	0.004	0.003 - 0.006	3YRA	0.007	75%	250%
Goldstream	N/A	0.003	0.001 - 0.010	3YRA	0.007	120%	
Black (wild)	0.015	0.020	0.014 - 0.029	3YRA	0.026	30%	73%
Lower Fraser							
Inch	0.008	0.008	0.005 - 0.014	LLY	0.013	62%	62%
Salmon (wild)	0.014						
Str. Of Geo. Hatcheries	0.004	0.025	0.023 - 0.027	CPUE	0.008	-68%	100%
Interior Fraser							
Thompson aggregate	7,079	14,183	9,065 - 22,192	3YRA	49367	248%	597%
South-west Vancouver Island							
Robertson	0.005	0.036	0.023 - 0.057	Sibling	0.020	-46%	290%
Carnation (wild)	7	63	2 - 124	Euphausiid	50	-21%	610%
Distribution Index (P_{inside})		0.39	0.300 - 0.490	Salinity			

Johnstone Strait/Mainland Inlets

In 2007 the observed return in Area 12 was 4% less than forecast and the Area 13 return was about 60% above forecast. The Area 12 return was 50% lower than the 2004 brood return and approximately 45% improvement on what was estimated for the previous year's return (2006). The Area 13 return demonstrated a significant improvement over the brood year (2004) and slightly better than the previous year's return. Above average to just below average smolt production was encountered in 2006 in the Black Creek and Keogh River coho indicators, respectively. This increased production and the improvement in marine survival during the 2006 juvenile out-migration resulted in the 2007 improvement over 2006 returns to the Johnstone Strait areas.

North-west and South-west Vancouver Island

Coho returns to the west coast of Vancouver Island improved from the previous year. The observed 2007 Robertson Creek Hatchery coho survival (2.0%) and Carnation Creek return (50) were both lower than forecast but higher than the very low returns observed in 2006. The Robertson coho survival was outside the lower 50% CI and the Carnation Creek return was within the 50% CI.

Figure 3 shows the marine survival for wild (Carnation Creek) and hatchery (Robertson Hatchery) indicators, and the 2008 marine survival forecast including 50% confidence intervals. The data has been smoothed by plotting a running three year average.

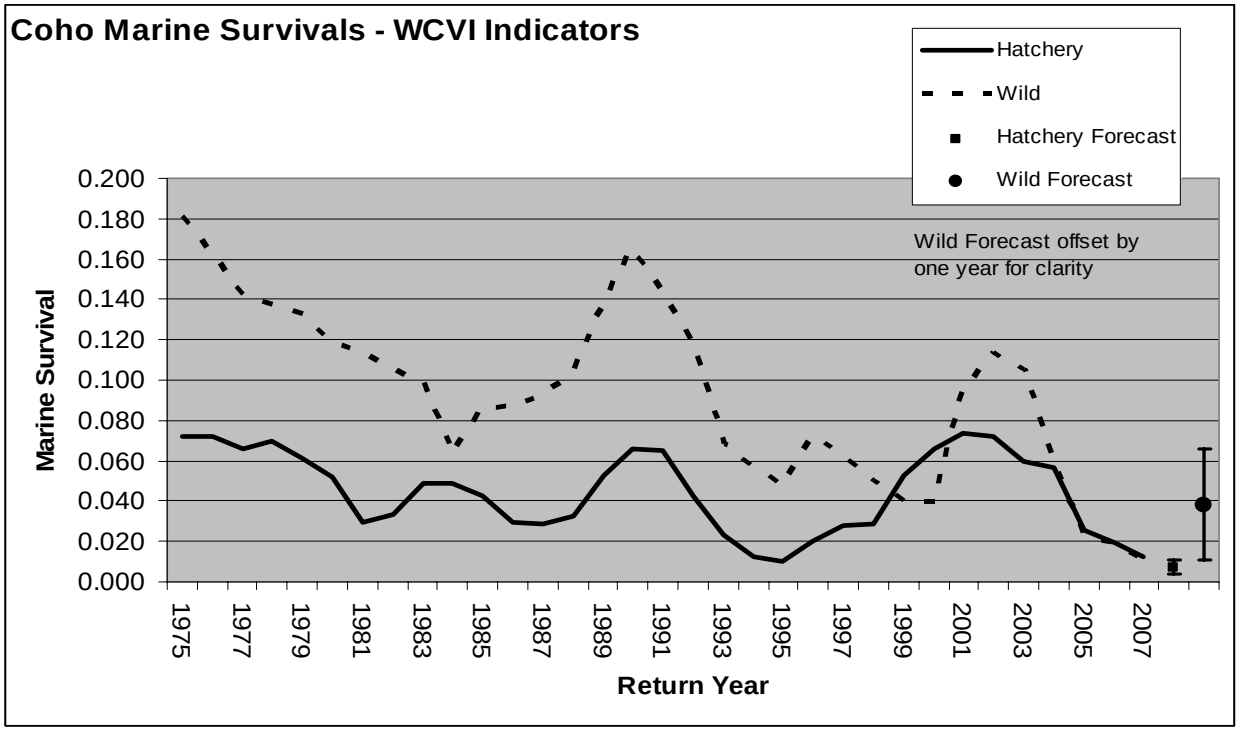

Figure 3. Coho marine survivals for South West Vancouver Island indicators.

Georgia Basin West and Georgia Basin East

Coho returns to the Georgia Basin improved in 2007 as forecast and outperformed the time series modeled predictions. Both Quinsam and Big Qualicum Hatchery stocks were higher than the 50% CI and Goldstream Hatchery and Black Creek (wild) were within the 50% CI. Big Qualicum Hatchery coho continued to be extremely low at 0.3% marine survival.

The biologically based CPUE model that uses the population levels in the early ocean stage as a forecast model, provided an over-forecast of 2007 returns. This model forecast an average marine survival of 2.5% and the observed average was only 0.8%.

The wild indicator at Black Creek continues to have better marine survival than the hatchery stocks but is still low at 2.6%. The 2007 return was a slight increase over the brood year.

Lower Fraser

The 2007 observed marine survival of Inch Creek hatchery coho (1.3%) was higher than the forecast of 0.8%, and was just within the upper 50% CI range.

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. Marine survival data will continue when the Spring 2007 smolts return in Fall 2008.

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 2008 marine survival forecast including 50% confidence intervals. The data has been smoothed by plotting a running three year average of the annual means.

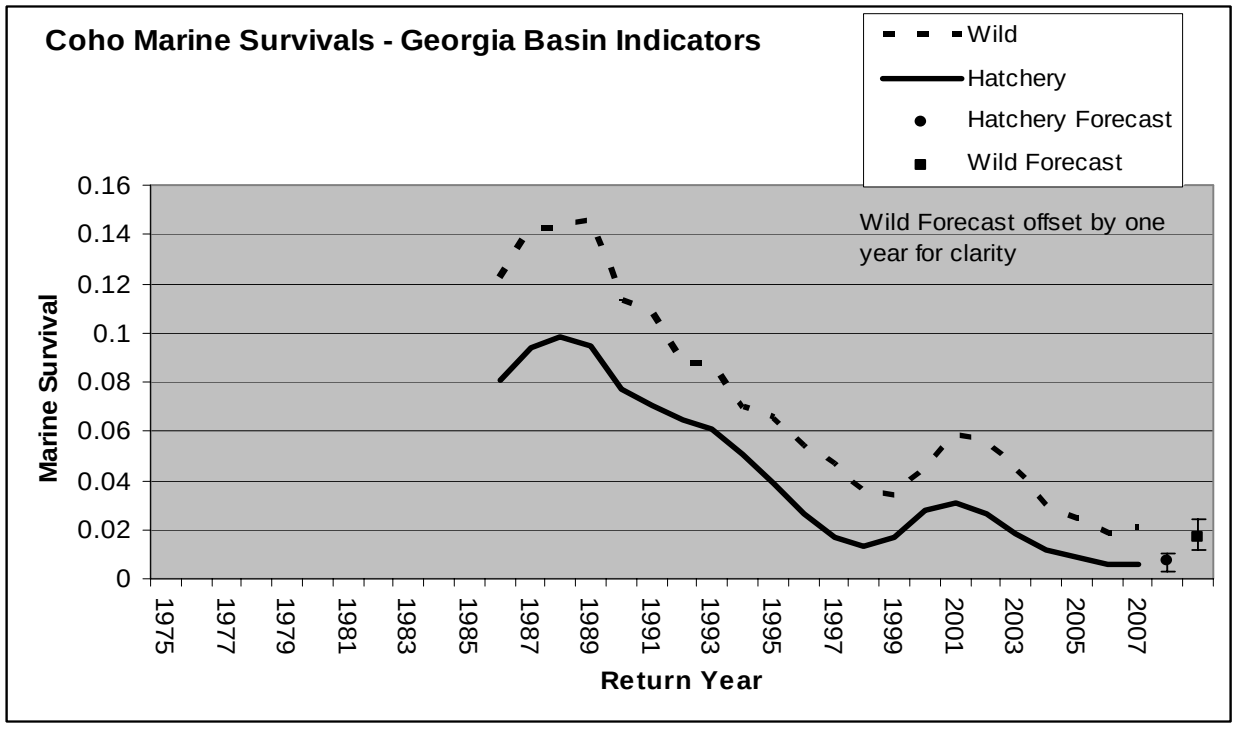

Figure 4. Coho marine survivals for Georgia Basin indicators (GBE, GBW and LowFr).

Interior Fraser

The total abundance of Thompson River watershed coho in 2007 was approximately 49,367 animals which was far above the forecasted abundance of 14,183 animals. The abundance in 2007 was higher than the abundance observed in 2006 (7,079), and 39% higher than the brood year abundance of 35,792. The estimated spawning escapement (including brood removals) of coho in the Thompson River drainage in 2007 was 43,838.

The total abundance and spawning escapement observed for the entire Interior Fraser River Management Unit was approximately 65,558 and 58,097 coho salmon, respectively.

Exploitation rates on Interior Fraser River coho from Canadian fisheries were derived from the post-season estimates generated from the CDFO coho fisheries effort model and the post-season Fraser River fisheries ER rate calculation. United States impacts were estimated from a first-run of the post season FRAM model. The estimated exploitation rate for IFR coho in 2007 was approximately 11.2%. Total Canadian exploitation was estimated at 1.8%.

2008 Forecasts

Table 2. Observed 2007 coho marine survival and abundance values and 2008 forecasts with 50% confidence intervals.

	2006	2007	2008			Change (2008 forecast minus
	Observed	Observed	Forecast	50% CI	Model	2007 observed)
Johnstone Strait/Mainland Inlets						
Area 12	766	1,274	1,114	694 - 1,787	3YRA	-13%
Area 13	540	509	393	254 - 608	3YRA	-23%
Georgia Basin - West						
Big Qualicum	0.001	0.003	0.003	0.002 - 0.005	LLY	0%
Quinsam	0.002	0.007	0.003	0.002 - 0.005	3YRA	-57%
Goldstream	N/A	0.007	0.002	0.001 - 0.007	3YRA	-70%
Black (wild)	0.015	0.026	0.017	0.012 - 0.024	3YRA	-35%
Lower Fraser						
Inch	0.008	0.013	0.013	0.008 - 0.022	LLY	0%
Salmon (wild)	0.014					
Str. Of Geo. Hatcheries	0.004	0.008	0.008	0.005 - 0.011	CPUE	0%
Interior Fraser						
Thompson aggregate	7,079	49367	15,586	9,511 - 25,541	3YRA	-68%
South-west Vancouver Island						
Robertson	0.005	0.020	0.007	0.004 - 0.011	Sibling	-64%
Carnation (wild)	7	50	42	12 - 73	Euphausiid	-15%
Distribution Index (P_{inside})			0.091	0.060 - 0.135	Salinity	

Johnstone Strait/Mainland Inlets

The Area 12 and 13 forecasts are less than the brood and better than the brood returns, respectively. The Area 12 forecast is 13% lower and the Area 13 forecast in 23% lower than the estimated observed indices in 2007. 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. Smolt production in 2007 was half of the long term

average (35,000 vs. 63,000) for Black Creek and slightly above average for Keogh River (56,000 vs. 55,000).

North-west and South-west Vancouver Island

The euphausiid model predicts a marine survival of 3.8% for Carnation Creek coho. This will be from a smolt enumeration of 1106, indicating a return of 42 adults. The forecast marine survival is higher than the observed value in 2007 however the lower smolt production results in a lower return than 2007. The Robertson Creek Hatchery coho forecast is for a marine survival of 0.7% using the sibling model. Both of these forecasts suggest a decrease in 2008 return from the 2007 return.

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 0.3% - 0.7%. The wild indicator at Black Creek is forecast to decrease slightly to 1.7% using the 3YRA model.

The CPUE model forecasts a marine survival of 0.8%, which is within the range of time series based forecasts for the Big Qualicum, Quinsam and Inch hatcheries (0.3% - 1.3%).

Lower Fraser

The forecast model used for 2008 is the LLY model which was also used to forecast the 2007 survival. The forecast is for 1.3% 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 2008 is estimated to be 15,586. The forecasted return to the Thompson River watershed is approximately 27% of the mean abundance of the time series, and would represent an increase above the brood abundance of 9,239 animals.

2007 was the first year out of the last four in which Thompson River coho abundances met and exceeded the brood year abundances. The 2008 forecasted abundance while above the observed brood abundance is still 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

Distribution

The P_{inside} statistic for 2008 is 0.091, indicating a strong ‘outside’ distribution of coho, similar to 1991 and 1995-1997. This indicates that coho should return to the Strait of George later than average.

CONCLUSIONS

The 2007 returns of coho to southern British Columbia improved over the previous year but are still at extremely low levels.

The 2008 forecasts show decreasing marine survivals relative to 2007.

In light of the abundance trend, coupled with the continuing low 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 exploitation rate 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. Fresh water creel survey data were provided by Sue Grant (Lower Fraser), and Dawn Lewis (Strait of Georgia). Roberta Cook provided escapement data from the hatcheries. Wild coho data were provided by Pieter Van Will (Black Creek) and Dr. Peter Tschaplinski (BC Ministry of Forests - Carnation Creek).

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FOR MORE INFORMATION

Contact: Steve Baillie
South Coast Area, Fisheries and Oceans Canada
3225 Stephenson Point Road
Nanaimo, BC V9T 1K3

Tel: (250) 756-7227
Fax: (250) 756-7020
E-Mail: steve.baillie@dfo-mpo.gc.ca

This report is available from the:

Pacific Scientific Advice Review Committee
Pacific Region
Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, BC V9T 6N7

Telephone: (250) 756-7208
Fax: (250) 756-7209
E-Mail: psarc@pac.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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