2009 MARINE SURVIVAL FORECAST OF SOUTHERN BRITISH COLUMBIA COHO

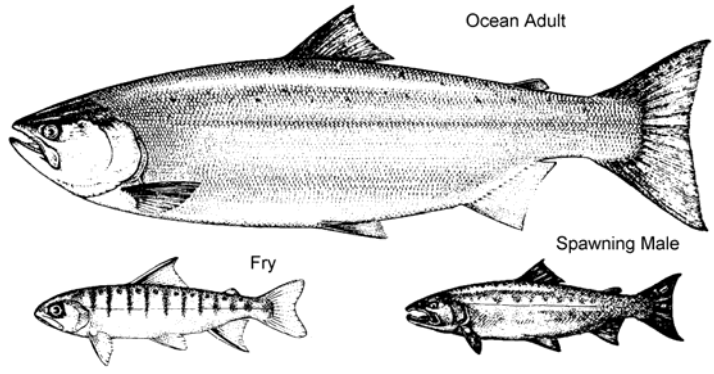

Figure 1: Coho salmon at three life stages: freshwater rearing fry; ocean rearing adult; and returning spawning male.

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 2009. 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 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. Since 2005 the forecast report has been published as a Science Advisory Report.

SUMMARY

- 2008 marine survival and abundance observations were higher than the 2007 observations on the West Coast of Vancouver Island. In other areas covered by this forecast the 2008 marine survival and abundance observations were, except for Big Qualicum Hatchery (GBW), lower than the 2007 observations.
- 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 2009, similar to the last four years. Interior Fraser, Georgia Basin East and Georgia Basin West Management Units in particular are stocks of concern.
- The distributional forecast is for a stronger inside distribution than the long term average.
- Maintaining or strengthening programs for monitoring coded-wire tagged, adipose fin clipped coho in catches, particularly the recreational catch, are important for forecasting marine survival of 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 (MUs):

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. In addition, a hatchery indicator (Lang Creek) has started releasing coded-wire tagged coho smolts in 2009.

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.

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 two wild indicators, Black Creek and Salmon River, 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, the estimate of adult escapement is used rather than marine survival as this data series extends back to 1972. Similarly, abundance is used in the JST and IntFr MUs.

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

1. Compile data on coded-wire tagged / adipose fin clipped (CWT/AFC) coho from the catch 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 used to estimate survival. For the Goldstream Hatchery indicator there are no coded-wire tag catch data from this stock for the baseline period so exploitation information is based on tag recoveries. Finally, salinities from February and March of the current year from Chrome and Sisters Islets are collected for predicting coho distribution.
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 candidate model to choose the one with the best fit to the observed data using common time periods. The model that best fits the historical data was used to forecast the following year return either as marine survival or adult return.

Changes from previous reports

In previous years the escapement of Robertson Creek Hatchery CWT coho was based on an estimate of the number of adipose clipped coho returning back to the hatchery. It was known that this estimate was incomplete due to an unknown number of coho that did not return to the hatchery but remained in freshwater to spawn naturally. This error was addressed by initiating an enumeration project at Stamp Falls Fishway, which is located downstream from the hatchery. A fishway was first constructed here in the 1920's to allow anadromous salmon to bypass the falls. This structure was rebuilt in 1955. The monitoring project was started in 2000 with a viewing facility and video monitoring system installed to allow accurate counts of all species of salmon moving past this point. An estimate of the number of adipose clipped coho from this project is used in conjunction with the observed coded-wire tag incidence in clipped coho at the hatchery to estimate the number of CWT/AFC coho in the escapement.

Salmon River (LowFr) was dropped as a wild indicator in 2004 and has been reinstated for this 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 has decreased from a range of 10% - 20% down to less than 2%. The majority of the observed marine survival estimates for the 2008 return continued to be at the low end of the range (Table 1). Returns of coho in 2008 in all areas but the SWVI and NWVI MUs were at or below the previous year and the deviation from the forecast varied depending on the area.

Table 1. Forecasted 2008 coho marine survival and abundance values with 50% confidence intervals and values observed in 2008.

	2007	2008			2008	Change	Change
	Observed	Forecast	50% CI	Model	Observed	from forecast	from 2007
Johnstone Strait/Mainland Inlets							
Area 12	1,274	1,114	694 - 1,787	3YRA	829	-26%	-35%
Area 13	509	393	254 - 608	3YRA	221	-44%	-57%
Georgia Basin - West							
Big Qualicum	0.0032	0.0032	0.002 - 0.005	LLY	0.0054	70%	70%
Quinsam	0.0070	0.0030	0.002 - 0.005	3YRA	0.0068	127%	-3%
Goldstream	0.0066	0.0020	0.001 - 0.007	3YRA	0.0036	78%	-46%
Black (wild)	0.0260	0.0170	0.012 - 0.024	3YRA	0.0065	-62%	-75%
Lower Fraser							
Inch	0.0130	0.0130	0.008 - 0.022	LLY	0.0074	-43%	-43%
Salmon (wild)					0.0119		
Str. Of Geo. Hatcheries	0.0080	0.0080	0.005 - 0.011	CPUE	0.0065	-19%	-19%
Interior Fraser							
Thompson aggregate	49367	15,586	9,511 - 25,541	3YRA	15683	1%	-68%
South-west Vancouver Island							
Robertson	0.0195	0.0070	0.004 - 0.011	Sibling	0.0310	343%	59%
Stamp Falls					0.0861		
Carnation (wild)	50	42	12 - 73	Euphausiid	163	288%	228%
Distribution Index (P_{inside})		0.091	0.060 - 0.135	Salinity			

Johnstone Strait/Mainland Inlets

In 2008 the estimated return in Area 12 was 25% less than forecast and the Area 13 return was about 44% below forecast. The Area 12 return was 33% lower than the 2005 brood return and approximately 35% lower than what was estimated for the previous year's return (2007). The Area 13 return showed a slight improvement over the brood year (2005) and was significantly lower than the previous year's return (approx. 50% of 2007 return abundance). Below average smolt production was encountered in 2007 in the Keogh River coho indicator. This level of production and a reduction in marine survival during the 2007 juvenile out-migration resulted in the lower than expected returns to the Johnstone Strait areas in 2008.

North-west and South-west Vancouver Island

Returns of wild coho in 2008 to the west coast of Vancouver Island increased substantially from the previous year. The Carnation Creek return (163 coho) was 288% above the forecast (42

coho). Higher numbers of coho spawners was observed in 2008 in other monitored rivers in the MU. The Robertson Hatchery coho survival estimate was 343% above the forecast.

Figure 3 shows the marine survival (three year running average) for wild (Carnation Creek) and hatchery (Robertson Hatchery) indicators, and the 2009 marine survival forecast including the 50% confidence interval (CI).

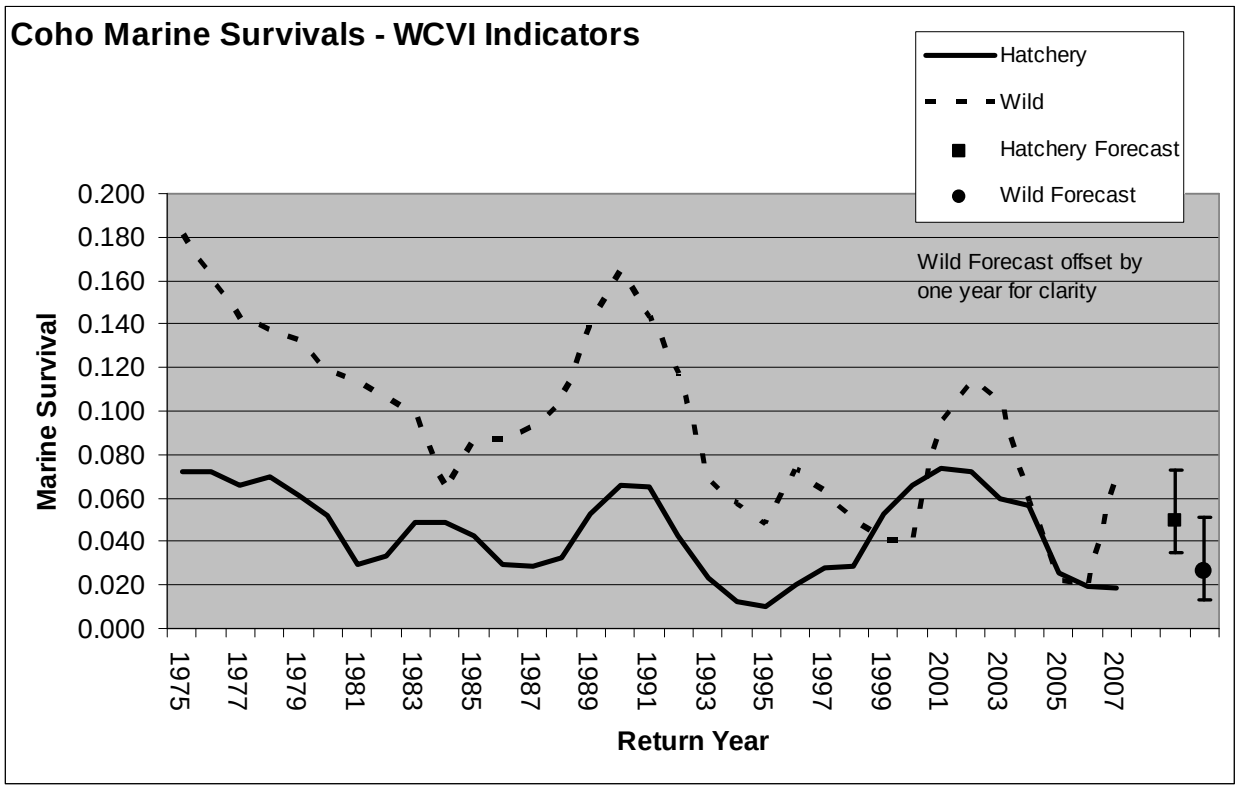

Figure 3. Coho marine survivals for South West Vancouver Island indicators.

Georgia Basin West and Georgia Basin East

Coho returns to the Georgia Basin in 2008 varied depending on the specific stock and area. The hatchery stocks were higher than the point estimate of the forecast and near the upper 50% CI. The combined marine survival was very similar to the biologically based CPUE model forecast that uses the hatchery release abundance in the early ocean stage and was well within the 50% CI.

The wild indicator, Black Creek, was much lower than forecast and below the lower 50% CI. The marine survival of this wild stock is normally higher than the hatchery stocks but in 2008 it was near the same level.

Lower Fraser

The estimated 2008 marine survival of Inch Creek hatchery coho was lower than forecast, unlike the Georgia Basin hatchery stocks. It was slightly below the 50% CI.

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.

Figure 4 shows the marine survival (three year running average) for wild (Black Creek and Salmon River) and hatchery (Quinsam, Big Qualicum, Inch, Chilliwack and Goldstream Hatcheries) indicators, and the 2009 marine survival forecast including the 50% CI.

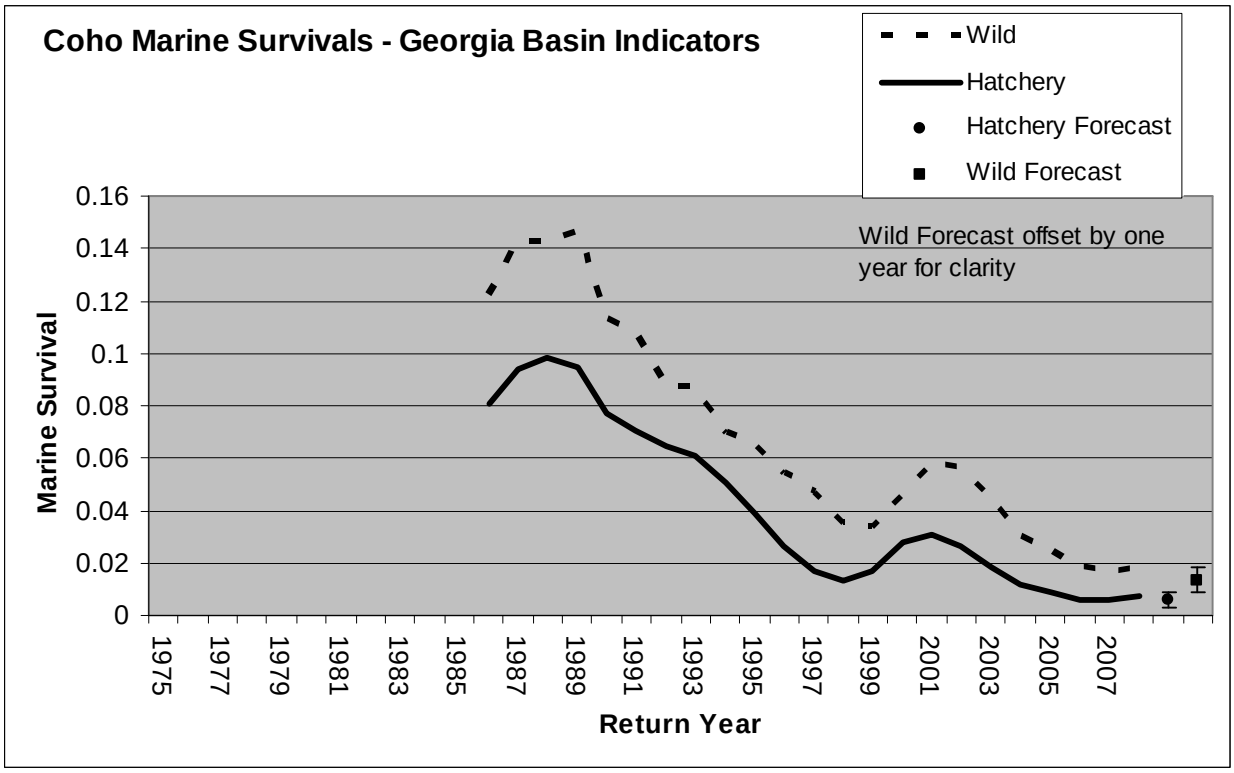

Figure 4. Coho marine survivals for Georgia Basin indicators (GBE, GBW and LowFr).

Interior Fraser

The total abundance of Thompson River watershed coho in 2008 was approximately 15,700 coho which was near the forecasted abundance of 15,600 coho. The abundance in 2008 was lower then the abundance observed in 2007 (49,400), and 39% higher than the brood year abundance of 11,000. The estimated spawning escapement (including brood removals) of coho in the Thompson River drainage in 2008 was 13,400.

The estimated total abundance and spawning escapement for the entire Interior Fraser River MU was approximately 18,600 and 16,000 coho, respectively.

Exploitation rates on Interior Fraser River coho from Canadian fisheries were derived from the post-season estimates generated from the DFO coho fisheries effort model and the post-season Fraser River fisheries exploitation rate calculation. United States impacts were estimated to be 10%. The estimated exploitation rate for the MU in 2008 was approximately 11.8%. Total Canadian exploitation was estimated at 1.8%.

2009 Forecasts

Table 2. Observed 2008 coho marine survival and abundance values and 2009 forecasts with 50% confidence intervals.

	2007	2008	2009			Change (2009 forecast minus
	Observed	Observed	Forecast	50% CI	Model	2008 observed)
Johnstone Strait/Mainland Inlets						
Area 12	1,274	829	975	650 - 1459	3YRA	18%
Area 13	509	221	349	231 - 529	3YRA	58%
Georgia Basin - West						
Big Qualicum	0.0032	0.0054	0.005	0.003 - 0.009	LLY	0%
Quinsam	0.0070	0.0068	0.004	0.003 - 0.006	3YRA	-37%
Goldstream	0.0066	0.0036	0.002	0.001 - 0.006	3YRA	-32%
Black (wild)	0.0260	0.0065	0.014	0.009 - 0.020	3YRA	109%
Lower Fraser						
Inch	0.0130	0.0074	0.007	0.004 - 0.013	LLY	0%
Salmon (wild)		0.0119	0.012	0.009 - 0.016	LLY	
Str. Of Geo. Hatcheries	0.0080	0.0065	0.007	0.004 - 0.010	CPUE	8%
Interior Fraser						
Thompson aggregate	49367	15683	17,405	10,743 - 28,200	3YRA	11%
South-west Vancouver Island						
Robertson	0.0195	0.0310				
Stamp Falls		0.0861	0.050	0.035 - 0.073	Sibling	-42%
Carnation (wild)	50	163	18	9 - 35	Euphausiid	-89%
Distribution Index (P_{inside})			0.667	0.568 - 0.753	Salinity	

Johnstone Strait/Mainland Inlets

The Area 12 forecast is higher than the brood return and 18% higher than the return in 2008 (Table 2). The Area 13 forecast is less than the brood return and 58% higher than the estimated indices in 2008. Coho abundance in this MU 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 2008 was well above average for Keogh River (72,000 vs. 55,000).

North-west and South-west Vancouver Island

The euphausiid model predicts an adult return of 18 coho to Carnation Creek. This will be from a smolt enumeration of 682, indicating a marine survival of 2.6%. The Robertson Hatchery stock is forecast to survive at 5.0% based on the sibling model. Both of these forecasts suggest a decrease in 2009 return from 2008.

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 2009 is the LLY model for both wild and hatchery indicators. The forecast is for 1.2% and 0.7% marine survival, respectively. This will be a continuation of the very low survivals that have been observed over the last 10 years.

Interior Fraser

Based on the 3YRA abundance model, the forecast of total abundance of Thompson River coho for 2009 is estimated to be 17,400. The forecasted return to the Thompson River watershed is approximately 20% of the mean abundance of the time series, and would represent an increase above the brood abundance of 6,800 coho.

2008 was the second year in a row in which Thompson River coho abundances met and exceeded the brood year abundances. The 2009 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 that genetic integrity and demographic concerns are maintained in the entire MU. The 2006 brood year from which the 2009 adults are produced was the lowest observed in the time series.

Distribution

The P_{inside} statistic for 2009 is 0.667, indicating a strong 'inside' distribution of coho, similar to 1985-1990 and 1993. This indicates that coho should return to the Strait of George earlier than average.

CONCLUSIONS

The 2008 returns of coho to southern British Columbia improved on the West Coast of Vancouver Island over the previous year but are still at extremely low levels. Elsewhere, the returns generally decreased.

The 2009 forecasts represent decreasing marine survival compared to 2008 for the west coast of Vancouver Island, and consistently low elsewhere.

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.

Maintaining or strengthening programs for monitoring coded-wire tagged, adipose fin clipped coho in catches, particularly the recreational catch, are important for forecasting marine survival of southern British Columbia coho populations. More emphasis on monitoring coho by-catch in commercial fisheries is recommended as exploitation rate estimation models are no longer reliable.

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