

# Sockeye Salmon Recruitment Variations, Ocean State Changes, Year 2008 Forecasts and Performance

Kim Hyatt, Margot Stockwell & Paul Rankin

Salmon in Regional Ecosystems Program, Fisheries and Oceans Canada

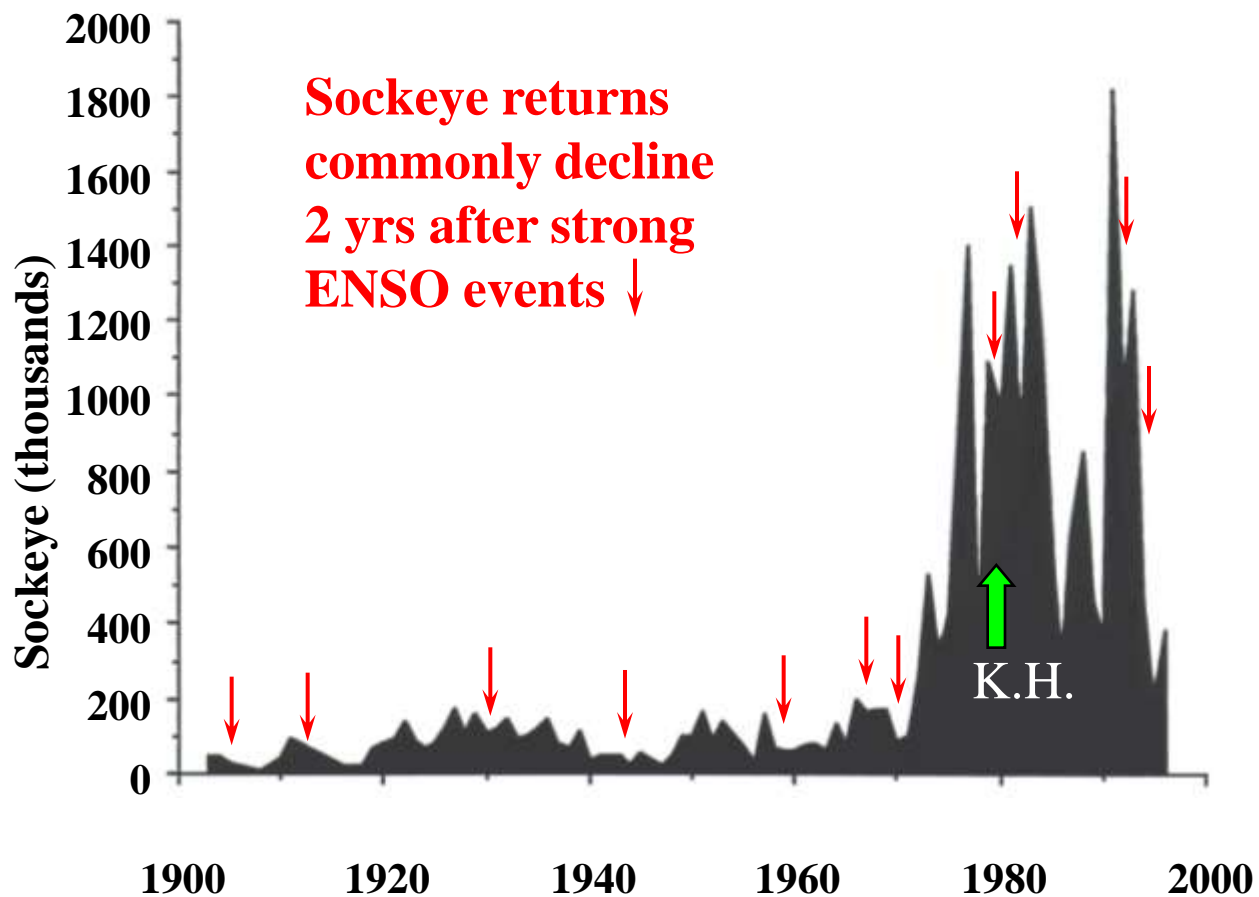
FOWG Annual Meeting - Feb. 17, 2009 - IOS, B.C.



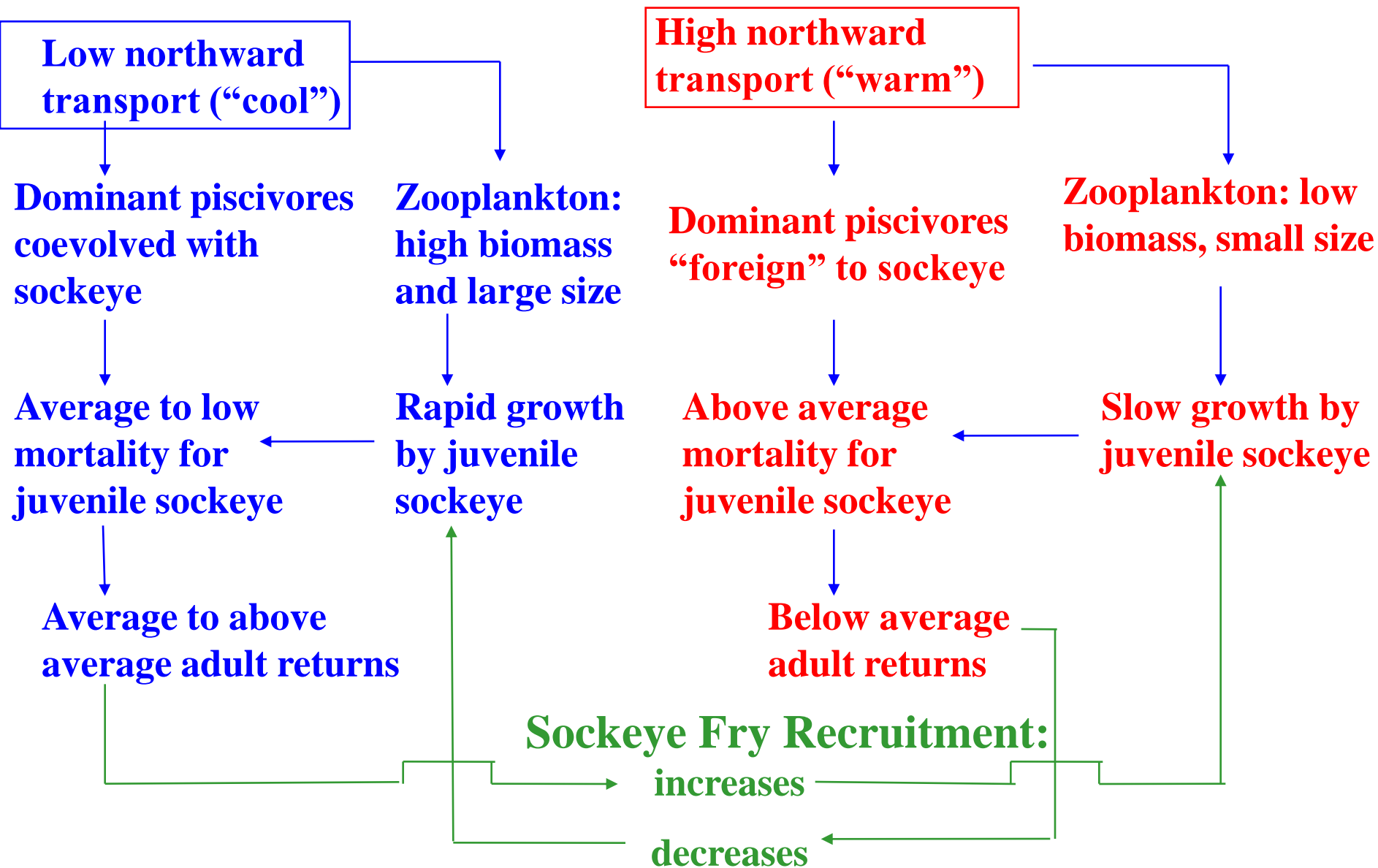
Fisheries and Oceans  
Canada

Pêches et Océans  
Canada

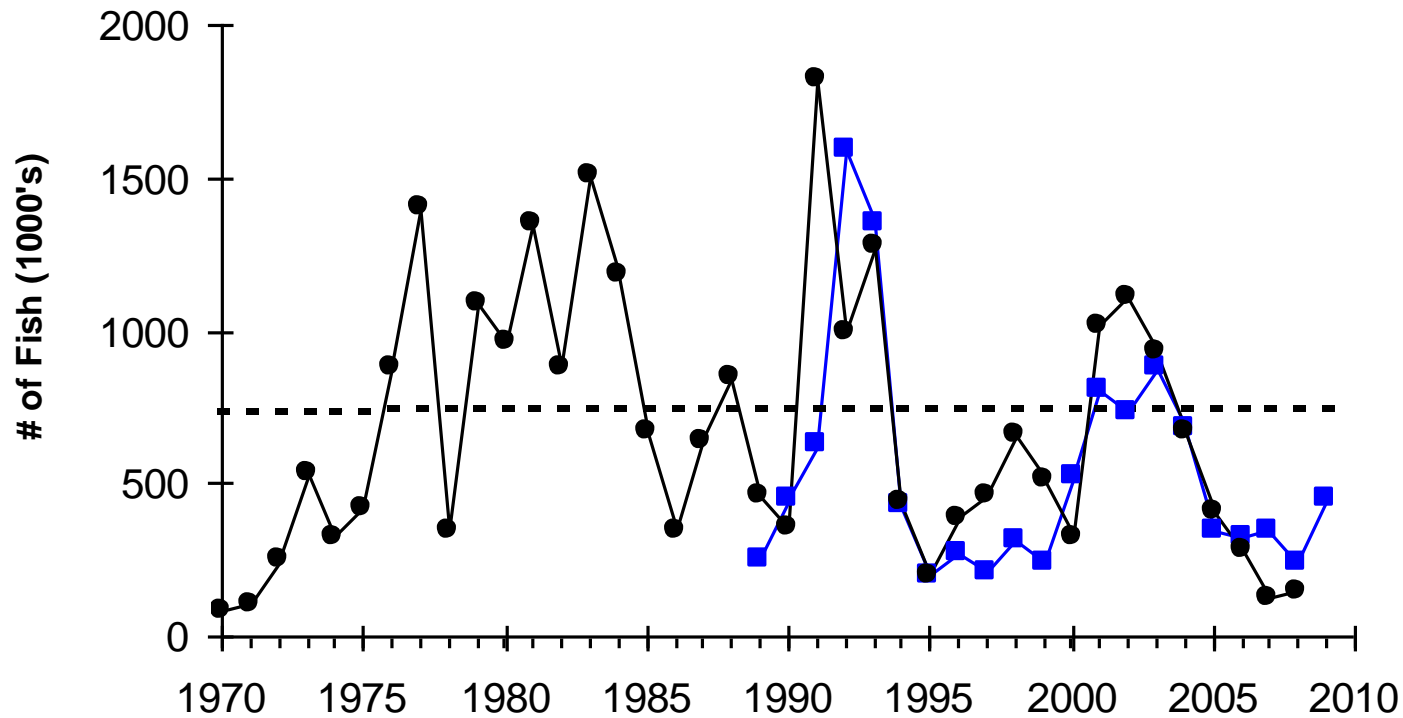
# Barkley Sound Sockeye Return Variations



# Two-State Model of El Nino – La Nina Mediated Production Responses of Barkley Sd. Sockeye (Hyatt et al. 1989)



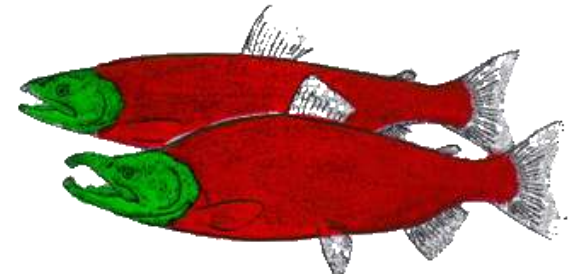
# Predicted (SStM) versus Returns of Sockeye to Barkley Sound in 2008 plus Comments on Returns for 2009-10.



- Barkley Sd sockeye returns fell well below the all-year average in 2005-2008 as predicted (i.e. positive SST & ENSO in 2002-2005 sea-entry).
- SST & ENSO indices shifted to average or negative (la Nina) in 2006-2008 so WCVI salmon return rates should improve in 2009-2010. Return of 160,000 in 2008 was close to expectation based on higher return rate but a sub-average escapement.
- Improvements in marine survival will permit a period of stock rebuilding but total returns are likely to remain sub-average until depressed escapements are rebuilt.

# Conclusions from WCVI Sockeye Work

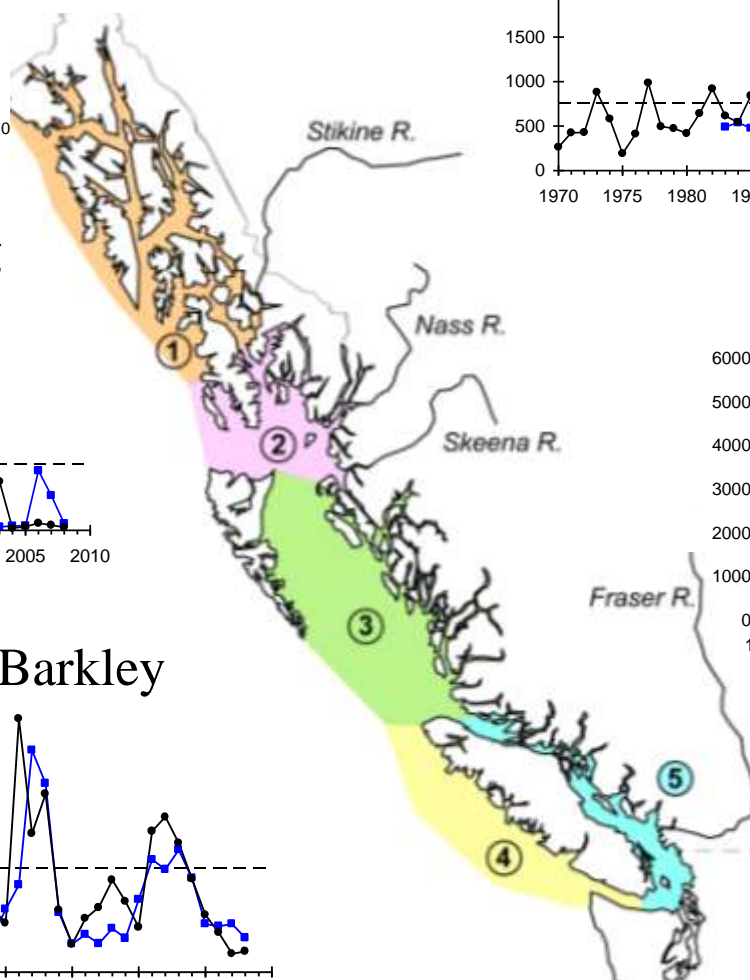
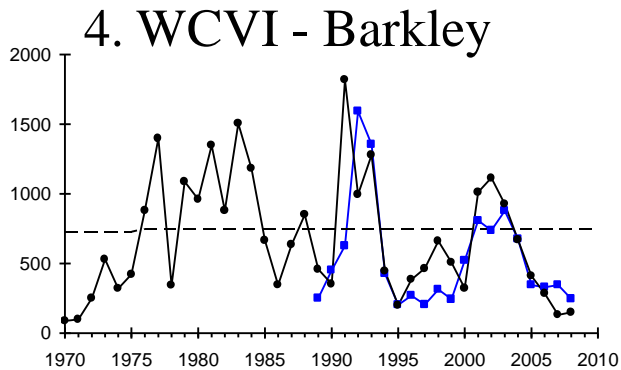
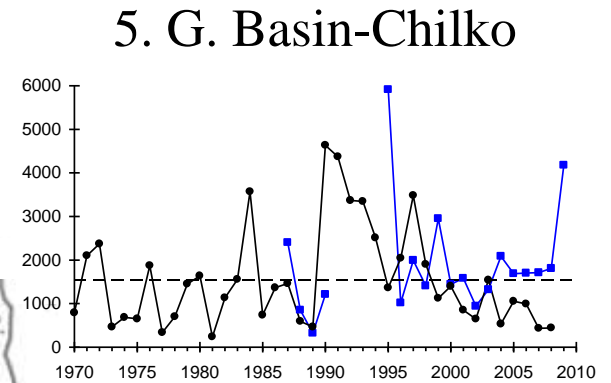
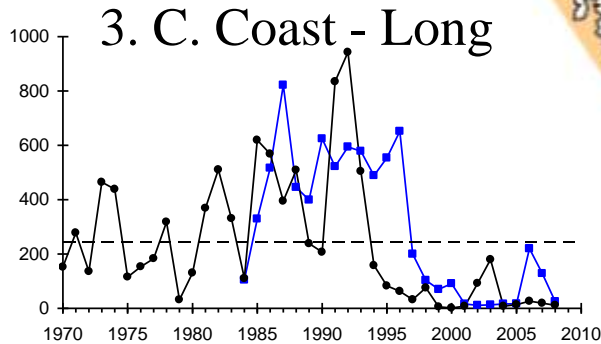
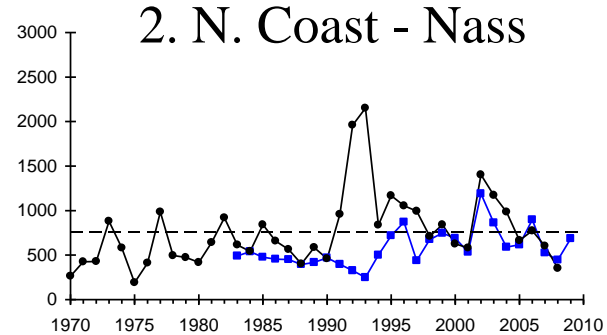
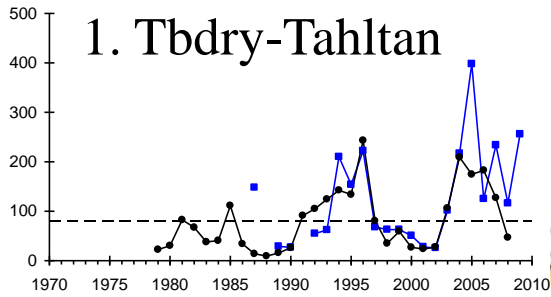
- life history events & production variations of WCVI salmon populations co-vary with short (ENSO) & longer term (PDO) climate “regime” changes.
- changes to dominant predator and prey communities that Barkley Sd sockeye & WCVI salmon encounter on the continental shelf during early seaward migration drive major changes in survival (ranges from .01 % to 26 %).
- a simple two-state, “survival stanza”, model (SStM, Hyatt & Steer, 1988) in which smolt-to-adult survival rates alternate between a high mean level (5 %) given favourable ocean conditions (SST < 30 year mean during smolt migration *i.e.* March-May) and a lower mean level (2.5 %) when ocean conditions are unfavourable (SST > 30 year mean) has been used since 1988 to successfully predict stock collapses & recoveries associated with strong El Nino & La Nina events respectively.



# Annual Report Card for Factors Influencing Salmon Survival in the Northern California Current - Northwest Fisheries Science Center - NOAA

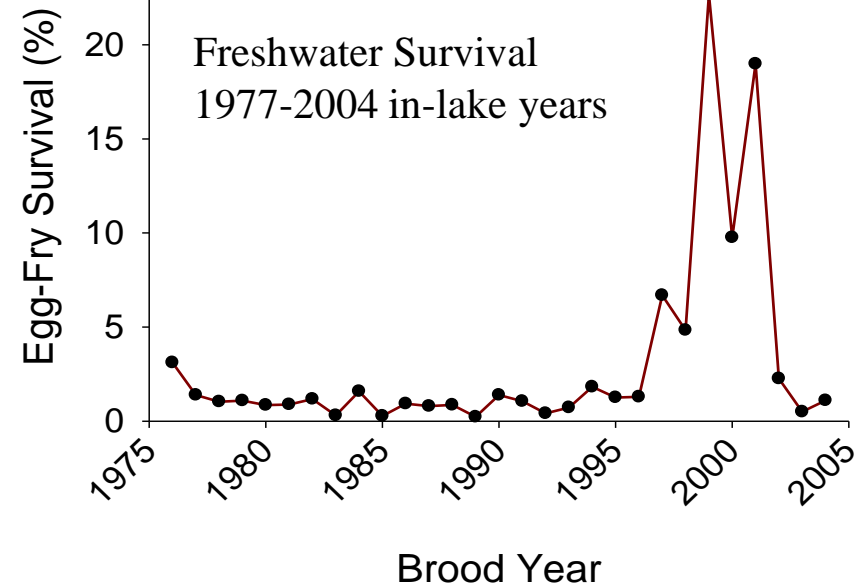
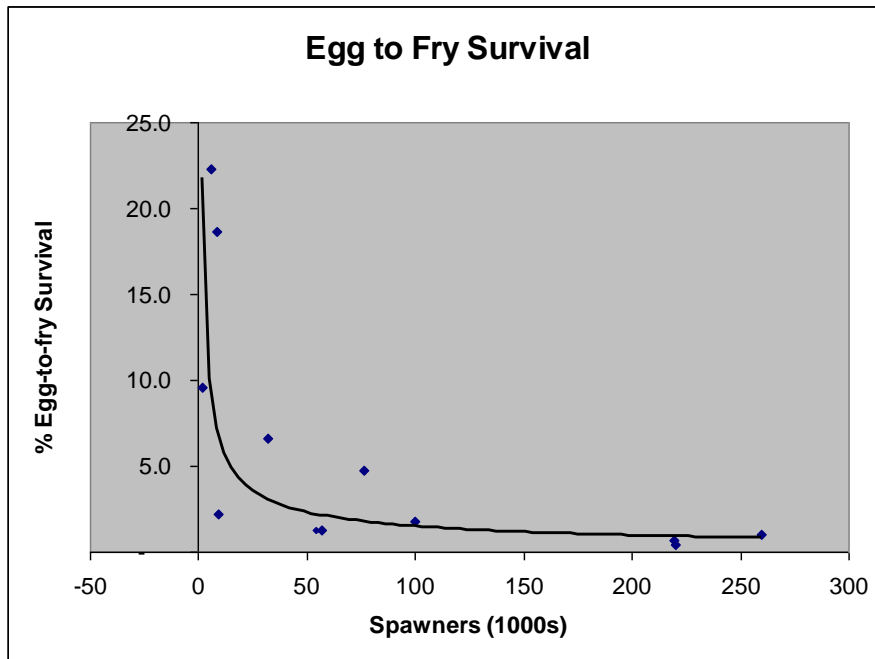
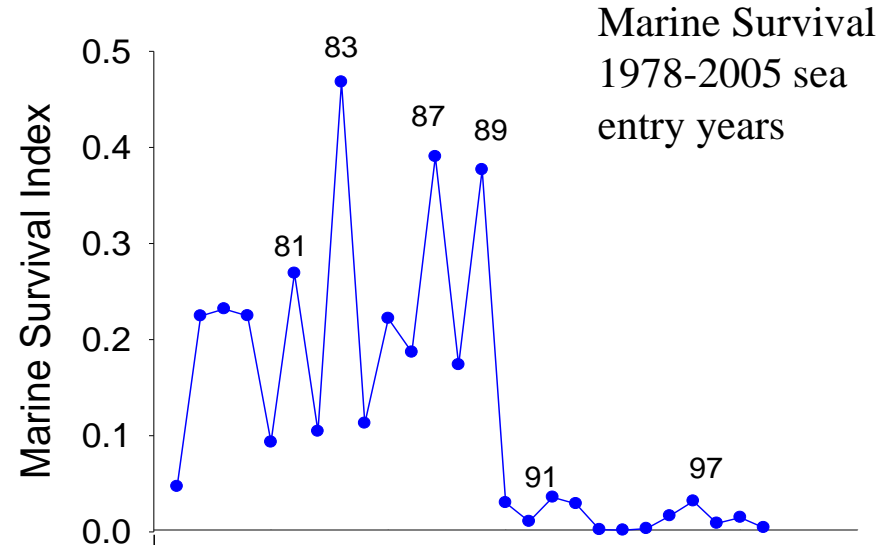
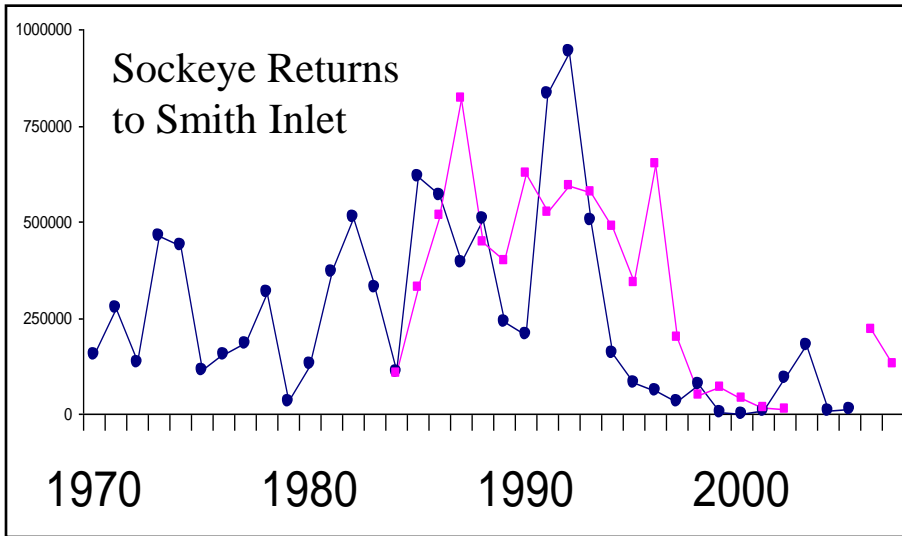
Sea Entry Year	98	99	00	01	02	03	04	05	06	07	08
Pacific Decadal Oscillation											
December–March	10	4	1	7	3	11	6	9	8	5	2
May–September	5	2	4	3	6	10	9	11	7	8	1
Multivariate El Niño Southern Oscillation Index											
MEI Annual	11	1	3	5	10	9	7	8	6	4	2
MEI Jan–Jun	11	2	3	5	7	9	6	10	4	8	1
Sea surface temperature											
Buoy 46050 (May–Sep mean)	9	2	4	5	1	7	11	8	6	10	2
NH 05 (May–Sep mean)	8	2	1	4	7	6	11	10	5	9	3
<b>Winter prior to ocean entry</b>	11	6	4	5	3	7	10	9	8	2	1
Physical spring transition (Logerwell)	7	6	2	1	4	9	8	11	9	3	5
Coastal upwelling April–May	6	1	10	3	5	9	8	11	6	2	4
Deep water at NH 05 (May–Sep)											
Temperature	11	4	6	2	2	7	8	10	9	5	1
Salinity	11	3	3	5	8	9	10	7	6	1	1
Upwelling season length (d)	7	4	3	9	1	10	8	11	6	5	2
Copepod biodiversity	11	2	1	5	3	8	7	10	9	6	4
N Copepod anomalies	11	8	3	5	2	9	6	10	7	4	1
Biol. spring transition	11	6	3	5	4	9	7	10	8	2	1
Spring Chinook (Jun)	10	2	3	8	5	7	9	11	6	4	1
Coho (Sep)	9	2	1	4	3	5	10	11	7	8	6
Overall Ranking											
Mean of ranks	9.5	3.5	3.2	4.6	4.3	8.6	8.0	9.7	6.9	5.1	2.4
Rank of mean ranks	10	3	2	5	4	9	8	11	7	6	1

# Trends in predicted versus observed trends for sockeye index stocks (1970-2008)

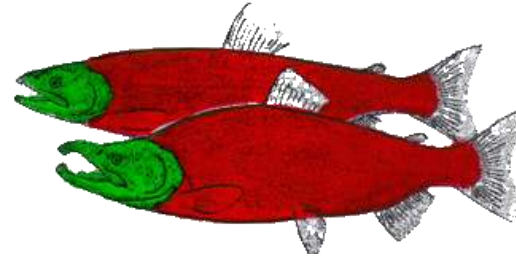


- Observed Returns
- Forecast Returns
- - - All Year Average

# Partitioned survival observations verify ocean origins for Smith Inlet Sockeye collapse but also reveal a density dependent “buffering” effect of freshwater survival on stock size.



# Average & Range of Returns per Spawner Associated With a Set of Above (90-93) and Below (97-00) Average Return Intervals for South, Central and North Coast Sockeye (“Gnats & Camels”)

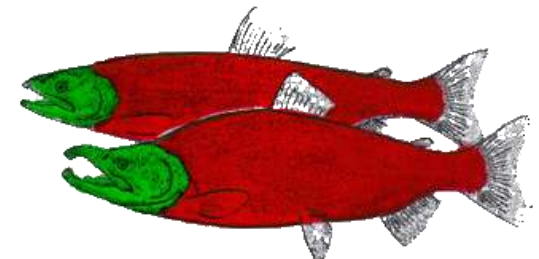
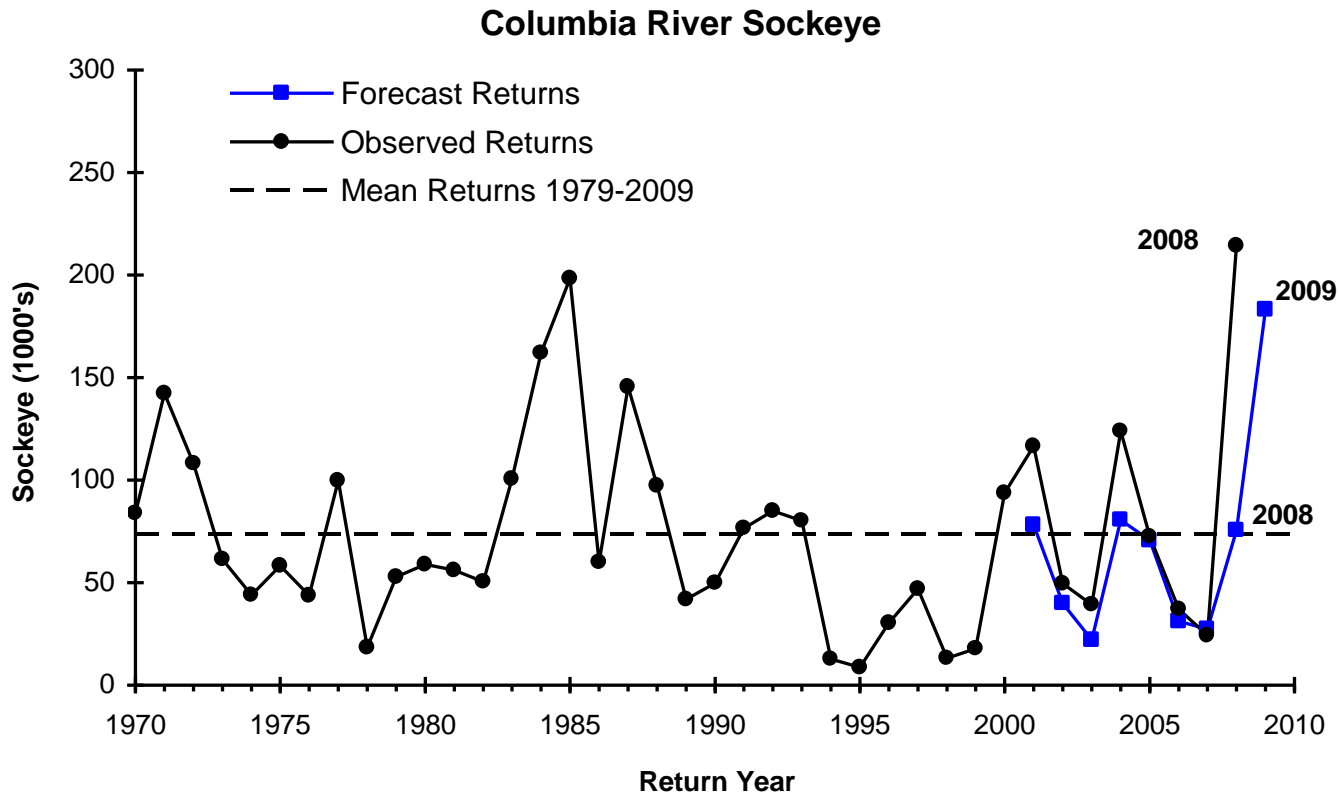


<b>Stock</b>	<b>R/S 90-93</b>	<b>Range</b>	<b>R/S 99-02</b>	<b>Range</b>
Chilko	<b>26.78</b>	<i>(12.9 - 58.8)</i>	<b>1.31</b>	<i>(.61 - 2.34)</i>
Barkley	<b>3.1</b>	<i>(1.5 - 5.3)</i>	<b>0.14</b>	<i>(.08 - .36)</i>
Smith Inlet	<b>3.1</b>	<i>(.93 - 6.1)</i>	<b>1.17</b>	<i>(.04 - 2.7)</i>
Meziadin	<b>11.84</b>	<i>(4.23 - 17.97)</i>	<b>1.9</b>	<i>(.16 - 5.41)</i>
Tahltan	<b>16.19</b>	<i>(4.61 - 25.88)</i>	<b>1.71</b>	<i>(0.41 - 4.52)</i>

# Annual Report Card for Factors Influencing Salmon Survival in the Northern California Current - Northwest Fisheries Science Center - NOAA

Sea Entry Year	98	99	00	01	02	03	04	05	06	07	08
Pacific Decadal Oscillation											
December–March	10	4	1	7	3	11	6	9	8	5	2
May–September	5	2	4	3	6	10	9	11	7	8	1
Multivariate El Niño Southern Oscillation Index											
MEI Annual	11	1	3	5	10	9	7	8	6	4	2
MEI Jan–Jun	11	2	3	5	7	9	6	10	4	8	1
Sea surface temperature											
Buoy 46050 (May–Sep mean)	9	2	4	5	1	7	11	8	6	10	2
NH 05 (May–Sep mean)	8	2	1	4	7	6	11	10	5	9	3
<b>Winter prior to ocean entry</b>											
Physical spring transition (Logerwell)	11	6	4	5	3	7	10	9	8	2	1
Coastal upwelling April–May	7	6	2	1	4	9	8	11	9	3	5
Deep water at NH 05 (May–Sep)	6	1	10	3	5	9	8	11	6	2	4
Temperature	11	4	6	2	2	7	8	10	9	5	1
Salinity	11	3	3	5	8	9	10	7	6	1	1
Upwelling season length (d)	7	4	3	9	1	10	8	11	6	5	2
Copepod biodiversity	11	2	1	5	3	8	7	10	9	6	4
N Copepod anomalies	11	8	3	5	2	9	6	10	7	4	1
Biol. spring transition	11	6	3	5	4	9	7	10	8	2	1
Spring Chinook (Jun)	10	2	3	8	5	7	9	11	6	4	1
Coho (Sep)	9	2	1	4	3	5	10	11	7	8	6
Overall Ranking											
Mean of ranks	9.5	3.5	3.2	4.6	4.3	8.6	8.0	9.7	6.9	5.1	2.4
Rank of mean ranks	10	3	2	5	4	9	8	11	7	6	1

# Anomalous Returns of Columbia River Sockeye in 2008



# Summary of Trends and 2008 Returns

- “All” sockeye index returns were sub-average in 2008. This was anticipated for outer coast stocks in the south but not for Fraser, N. Coast or N. Tbdry
- Outer-coast sockeye from Barkley Sd in the south and Rivers and Smith Inlets on the central coast display a persistent pattern (> 10 years) of strongly sub-average returns from 1994 (1992 sea entry) to present. Low marine survival and now depressed escapements are responsible.
- Major south and central coast stocks (Chilko, Barkley, Smiths, Rivers, Skeena-Babine) continued to exhibit sub-average returns reflecting variable to poor survival during the 2002-2006 freshwater rearing and ocean entry years.
- High returns of Columbia R. sockeye in 2008 were a surprise.
- Classification of marine survival expectations based on a “weight of indicators” approach shows promise (e.g. 20 yr experience with BkSd. Sockeye) & suggest we should expect positive anomalies on 4-casts in 2010.

