Appendix C (Part 1 of 2): Background Speakers' Presentations

An appendix to the report:

Peterman R.M., D. Marmorek, B. Beckman, M. Bradford, N. Mantua, B. Riddell, M. Scheuerell, M. Staley, K. Wieckowski, J. Winton, C. Wood. 2010. Synthesis of evidence from a workshop on the decline of Fraser River Sockeye. June 15-17, 2010. Vancouver Island Conference Centre, Nanaimo B.C., 123 pp + 35 pp. appendices.

Names of the two presenters who provided introductory background talks are hypertext linked to their slide presentations.

Session: Overview of the Fraser Sockeye Situation

1. Mike Lapointe, PSC
2. Timber Whitehouse and Arlene Tompkins, DFO

Overview of Fraser sockeye situation

Mike Lapointe
Pacific Salmon Commission

Topics

1. 2009 – What happened?
2. Longer term trends in returns
3. Productivity indices and trends
4. Where and when to look for causes?

2009 Fraser River Forecasts

- 10.5 million sockeye
- 17.5 million pink salmon… BUT

Forecasts are very uncertain!

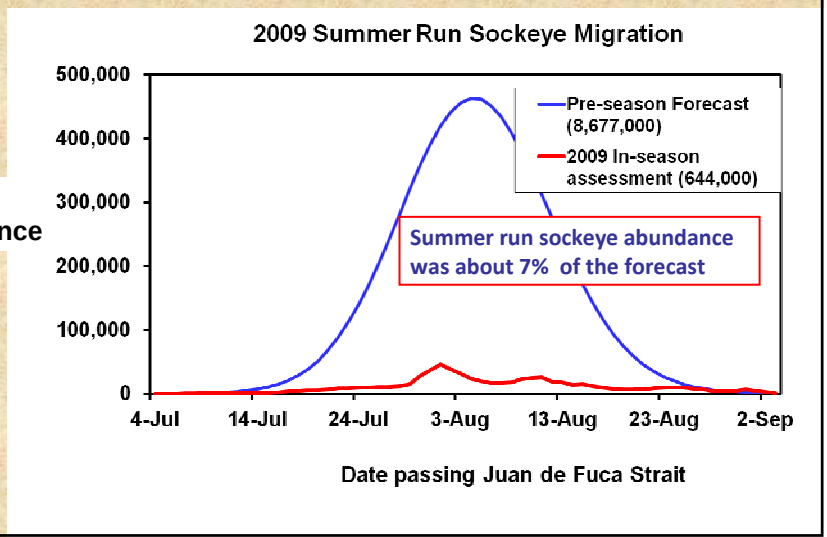
Sockeye in 2009

1 in 4 chance of return *less than* 6M

1 in 4 chance of return *greater than* 19M

Fishery Managers plan for range of returns

Fisheries are ***NOT*** opened based on Forecasts.



2009 Sockeye return

- Pre-season forecast 10.5M

  (Range 3.5M-37.6M)

- Preliminary post-season: 1.5M (lowest since 1947)

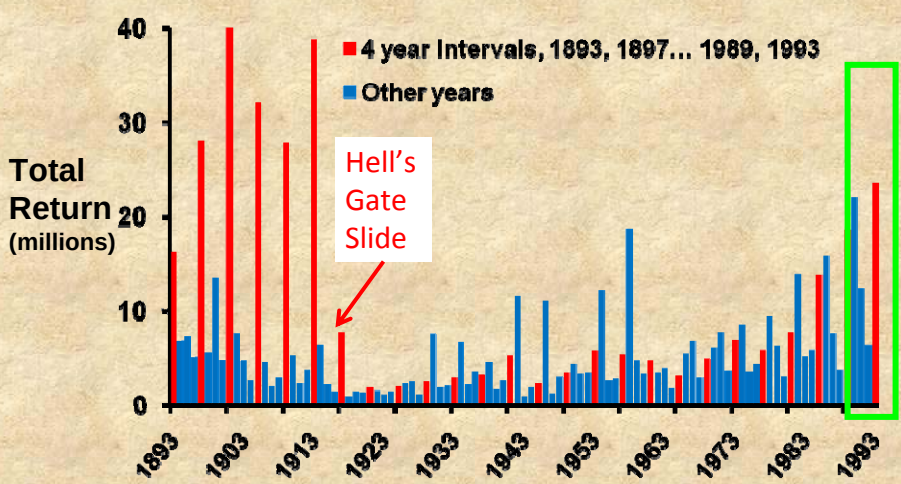
2009 Sockeye catch

- Total catch 124,000
- 8% of the run was harvested leaving 92% of the run available for spawning escapement

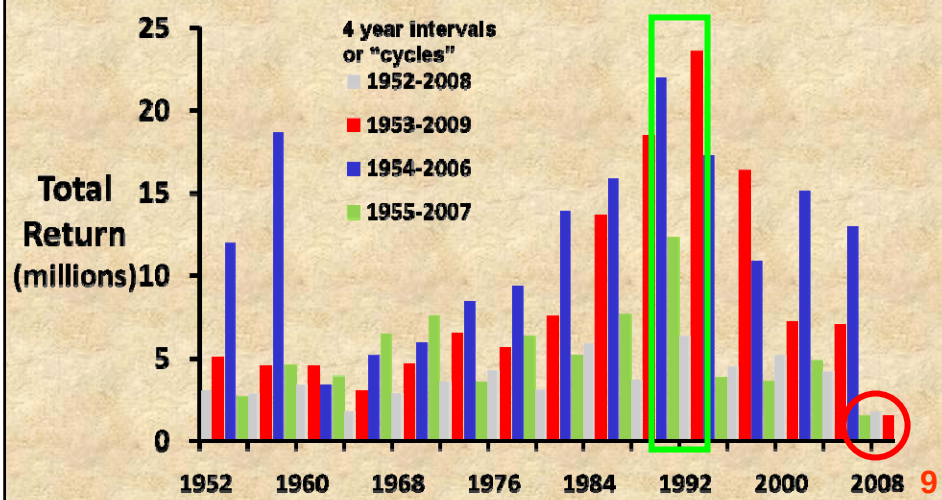
2009 Sockeye Spawning escapements

Management group	2009 escapement (adults)	Average escapement (2009 cycle; 1953,57,61,…2005)
Early Stuart	45,000	222,000
Early Summer	92,000	100,000
Summer	478,000	1,853,000
Late	441,000	139,000
Total	1,056,000	2,314,000

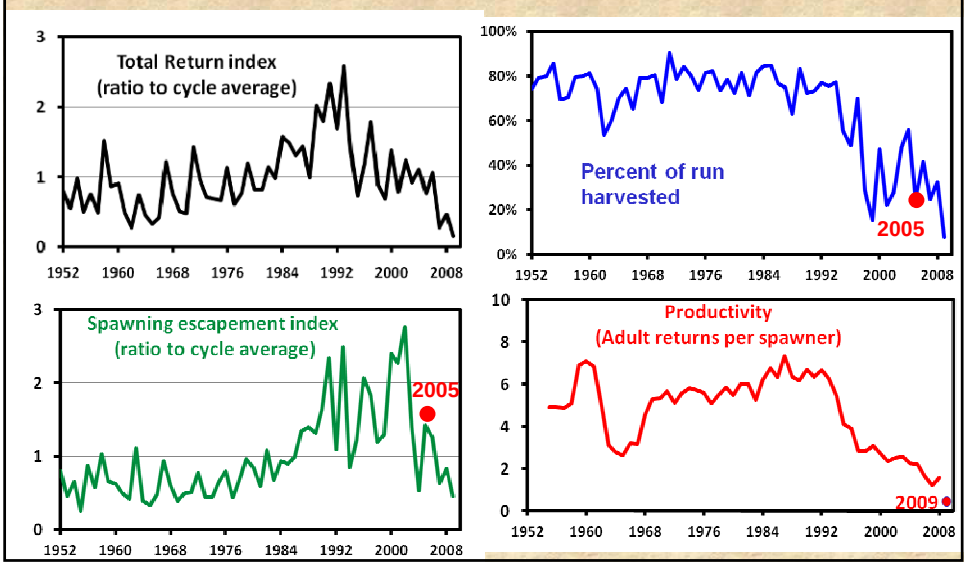
Long term patterns in Fraser Sockeye returns



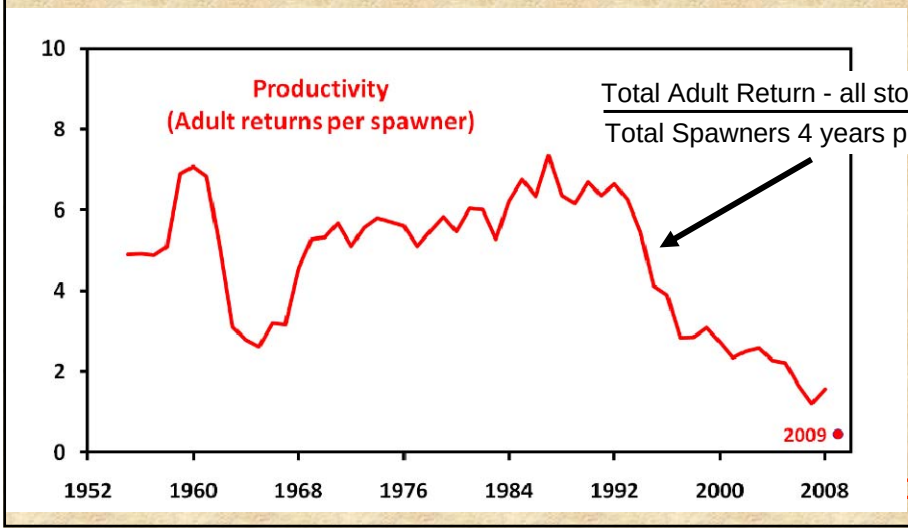
Long term patterns in Fraser Sockeye returns



Long term trends
Total Fraser

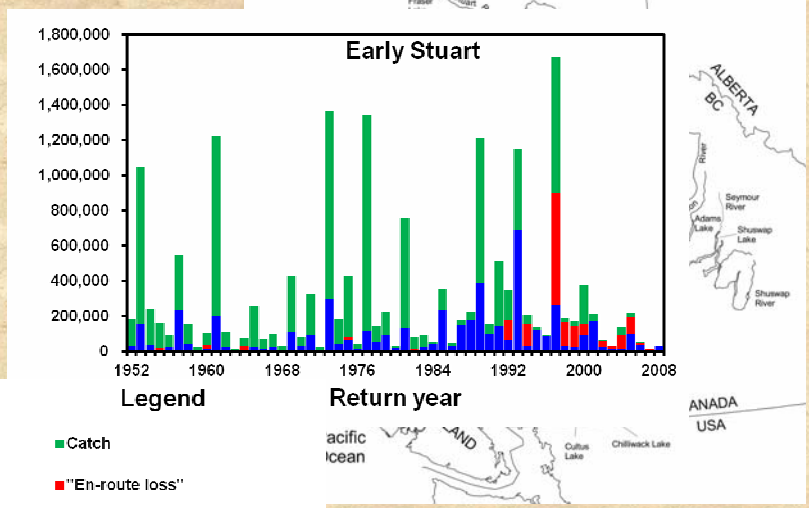


Productivity
Total Fraser



Early Stuart Run

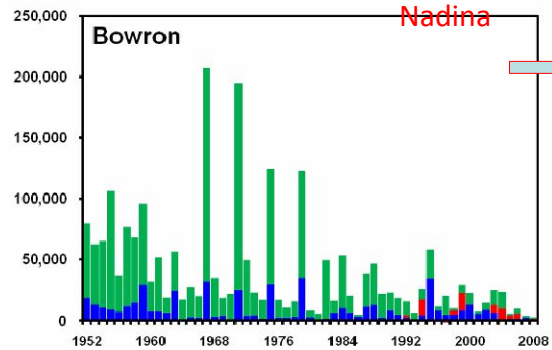
43 spawning sites,
3 rearing lakes

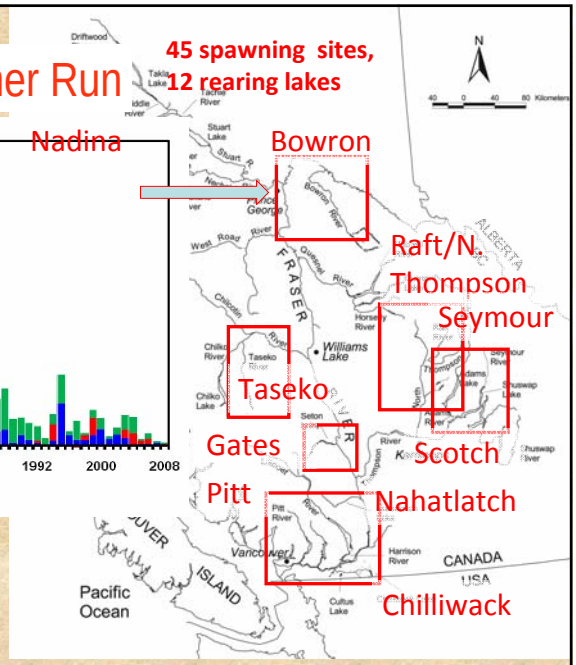


Fraser Sockeye Stocks

Early Summer Run

45 spawning sites,
12 rearing lakes





Legend

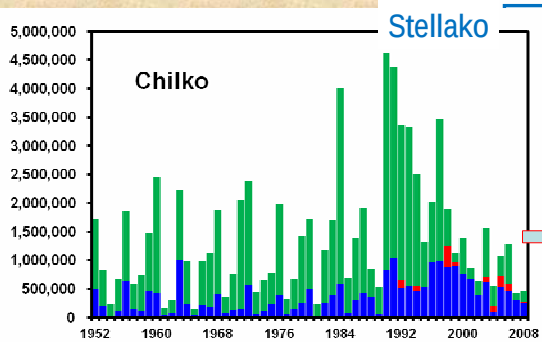
- Catch
- "En-route loss"
- Spawning escapement

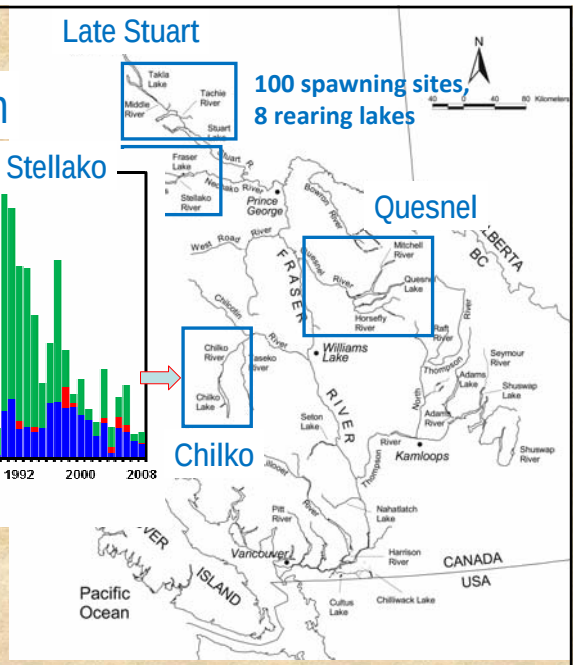
Fraser Sockeye Stocks 13

Summer Run

Late Stuart

100 spawning sites,
8 rearing lakes

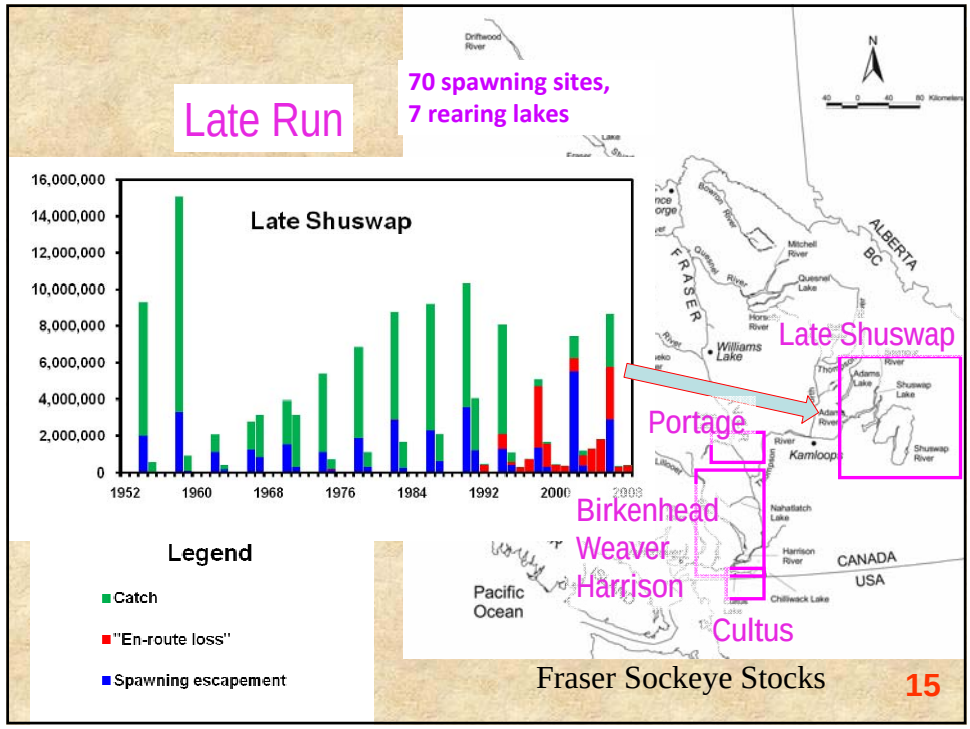




Legend

- Catch
- "En-route loss"
- Spawning escapement

Fraser Sockeye Stocks 14



Productivity indices

- [Returns (or recruits)]/spawner
- Recruits/(<u>effective female spawners</u>)
- Residuals Ricker model

$$Ln(R/S)= a – bS + v$$

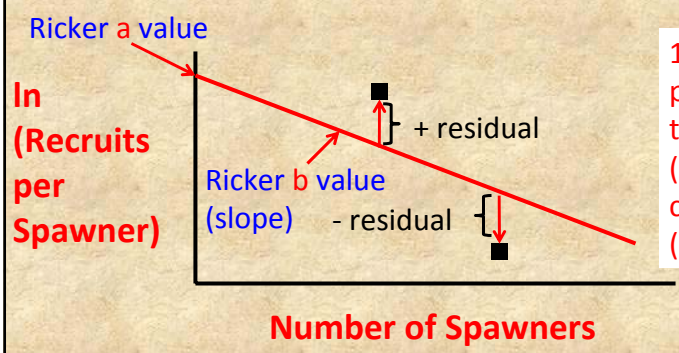
- Deviations of time varying a_t from average a $Ln(R/S)= a_t – bS + w$
- Residuals from Larkin model

$$Ln(R/S_t)= a – b_0S_t + b_1S_{t-1} + b_2S_{t-2} + b_3S_{t-3} +v$$

Effects of prior brood years' spawner abundances on productivity

Productivity indices
Why residuals?

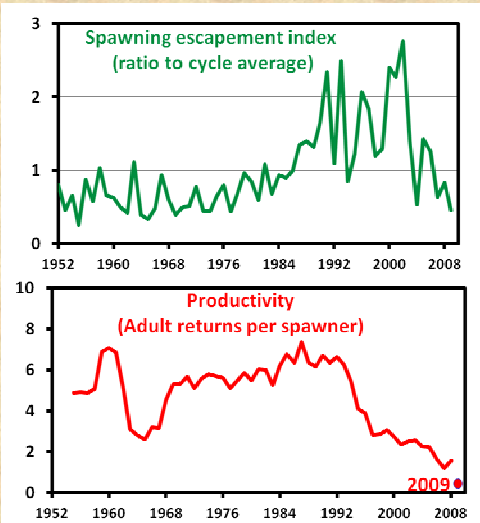
- Expect productivity to decline with increasing spawner abundance (Ricker model)



17/18 Fraser populations show this pattern (exception Scotch creek), but r^2 is low (mean 16%) [1]

Notes: 1 Based on regressions of Ln(age 4 Recruits/effective female) vs. eff females)

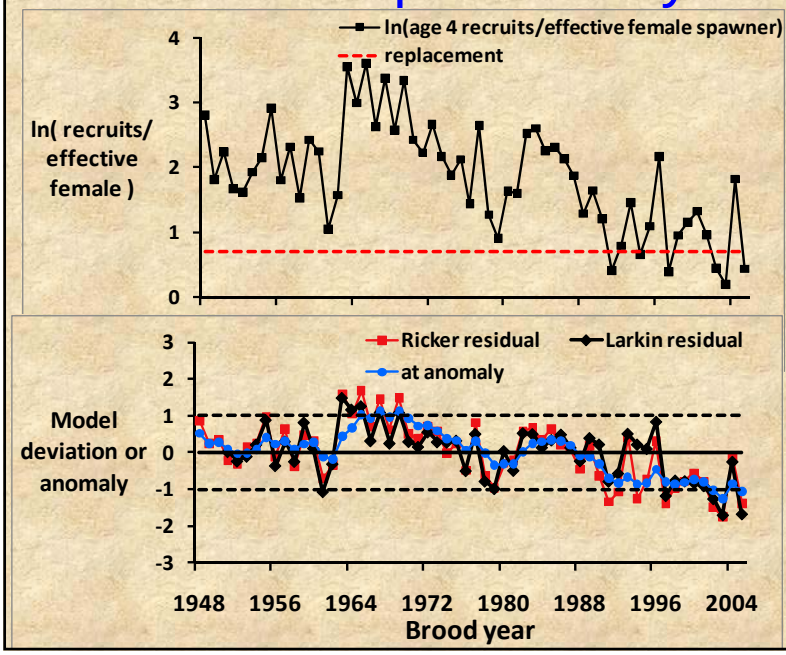
Productivity indices
Why residuals?



Trends in residuals used to examine productivity patterns remaining after removing effects related to changes in spawner abundance

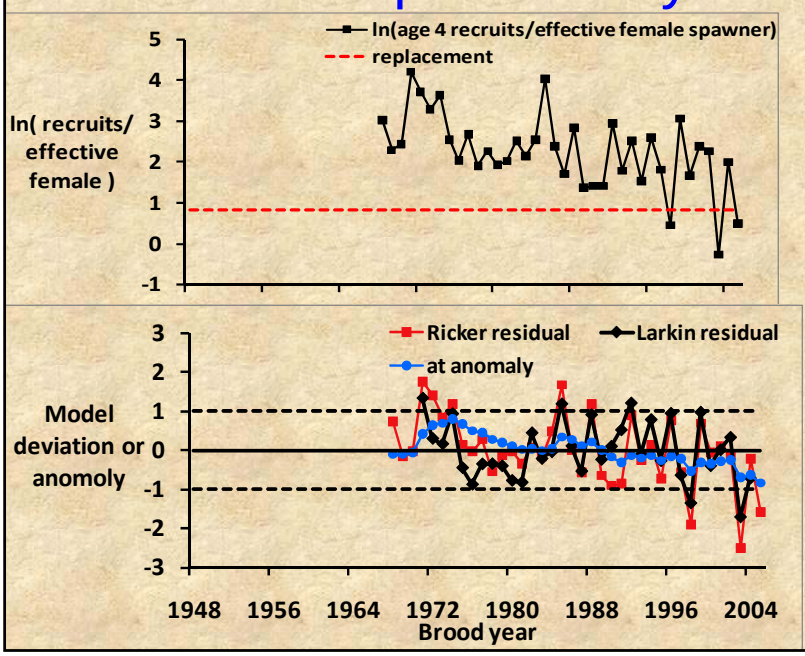
Productivity measure	Spawner abundance effects
Ricker residual	Brood year
a_t anomaly	Brood year
Larkin residual	Brood &prior yrs

Trends in productivity



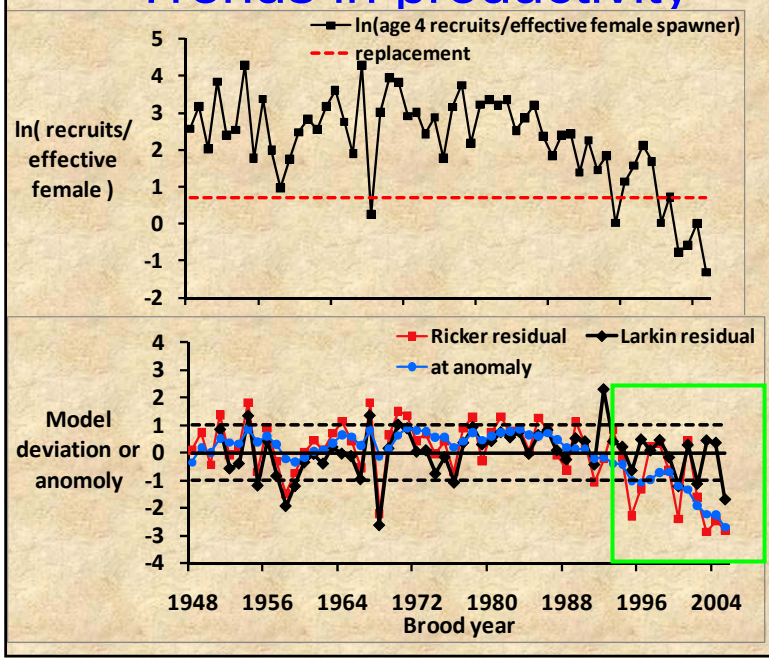
Early Stuart

Trends in productivity



Gates Creek

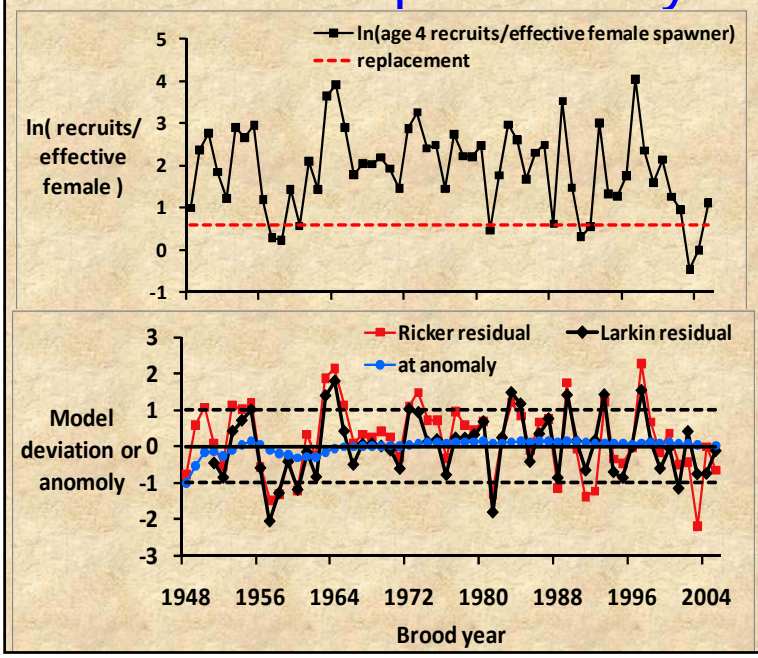
Trends in productivity



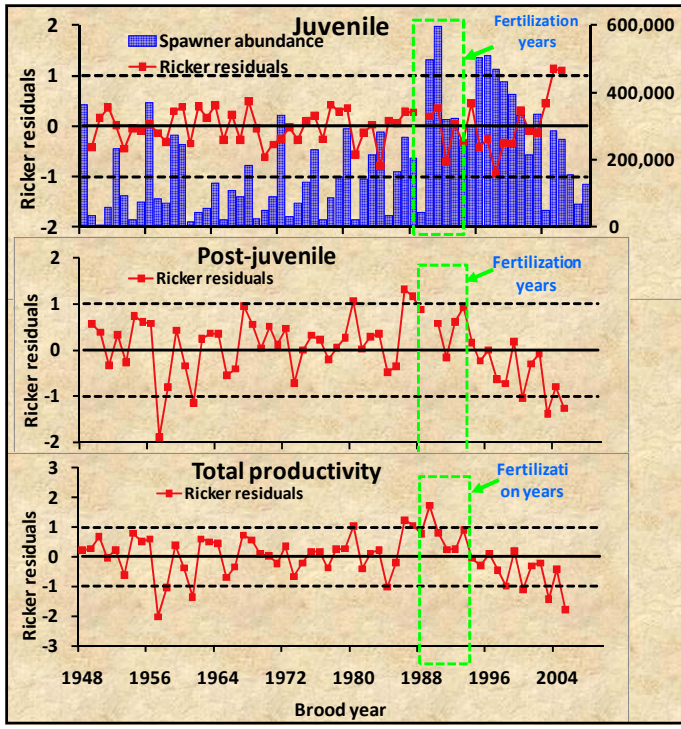
Quesnel

(Horsefly, Mitchell, lake tribs)

Trends in productivity



Late Shuswap

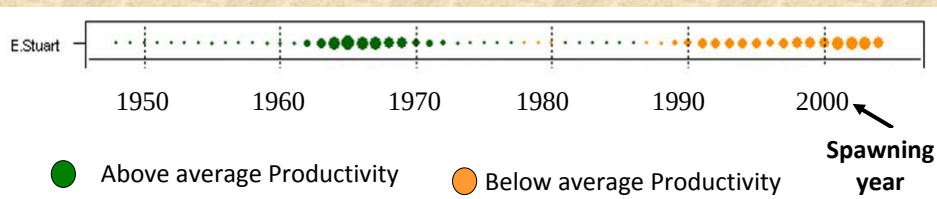


Trends in productivity

Chilko

Stock specific trends in productivity

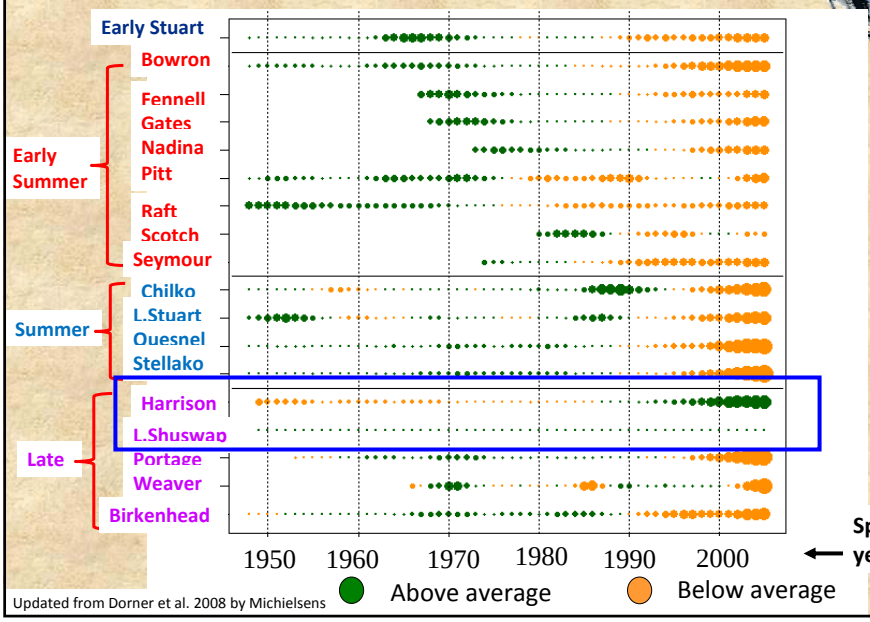
Early Stuart



Smoothed Ricker a_t parameter values estimated by Kalman Filter – (standard deviation units).

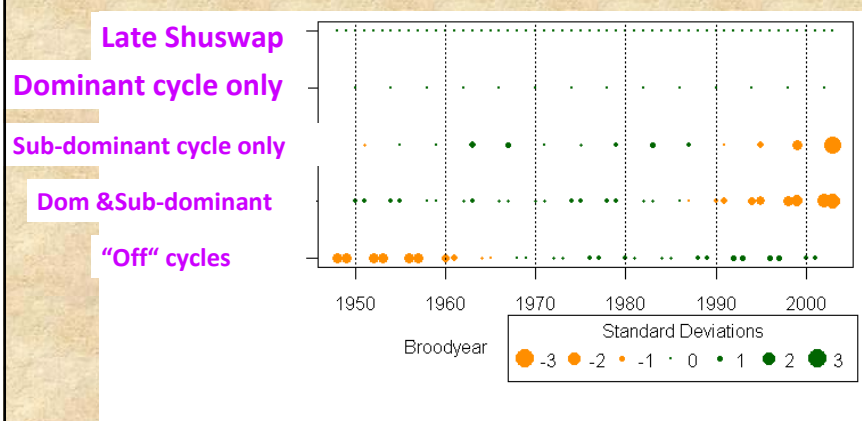
Updated from Dorner et al. 2008 by Michielsens

Stock specific trends in productivity



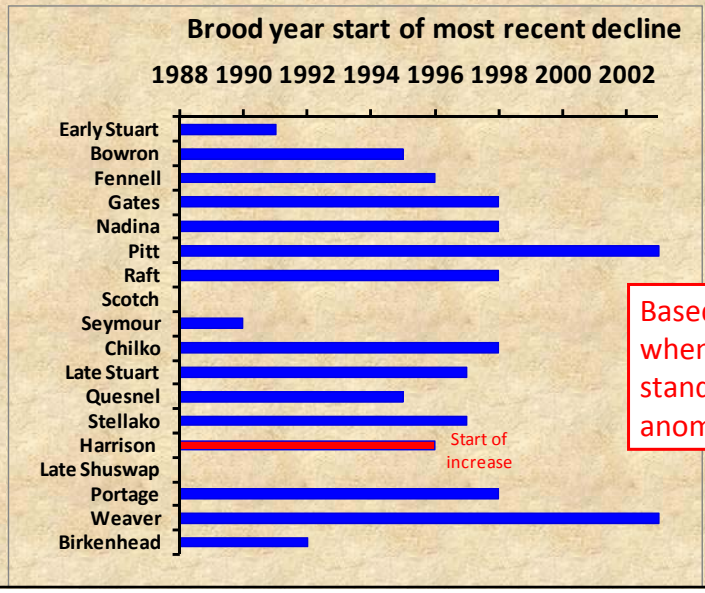
Updated from Dorner et al. 2008 by Michielsens

Late Shuswap trend not detected; model or data issue?



Stock specific trends in productivity

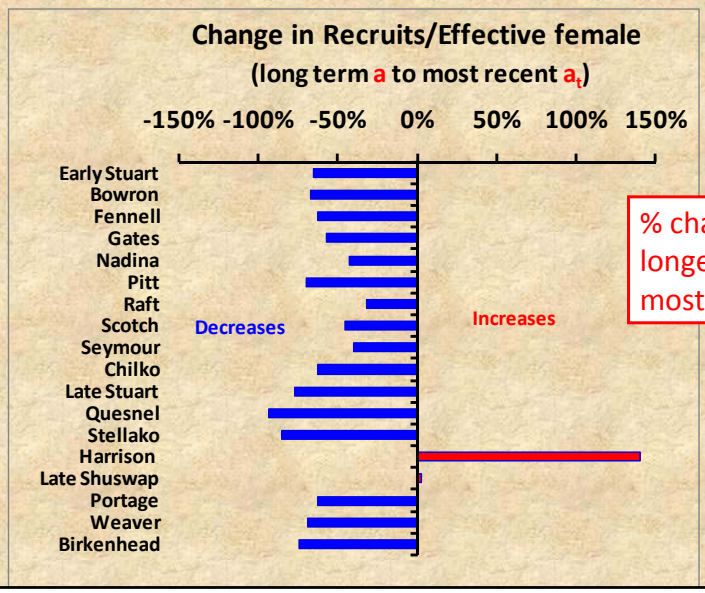
When did most recent declines begin?



Based on year when standardized a_t anomaly < -1

Stock specific trends in productivity

How much has productivity declined?



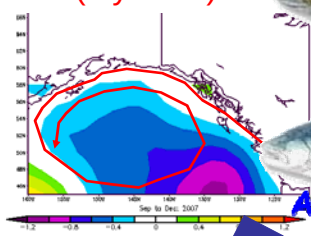
% change from longer term a to most recent a_t

Where and when to look for causes of low productivity?

Fraser Sockeye life cycle

Typical pattern

Smolts exit Fraser, migrate north along coast, after 2 yrs at sea (Gulf of Alaska), most adults return in fall 2009 (4 yrs old)



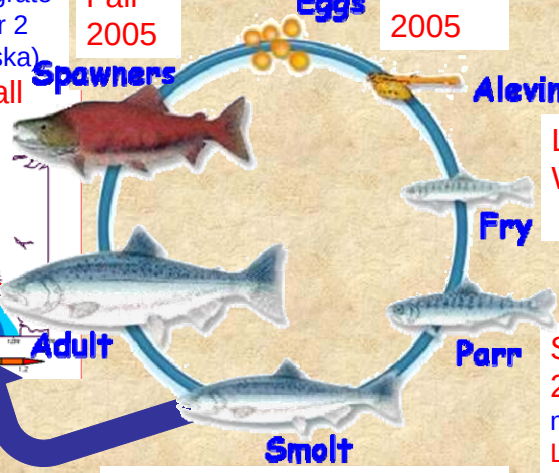
Fall 2005

Winter 2005

Late Winter 2006

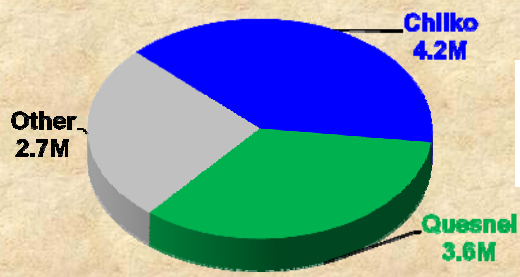
Spring 2006, fry migrate to LAKE

Spring 2007 smolts leave lakes, migrate to seas



2009 Fraser River sockeye forecasts

Total Forecast 10.5M



75% of the return in two stocks

- 77 million smolts left Chilko Lake in 2007 (nearly 2 times 50 yr max)!
- 52 million fry were estimated in Quesnel lake in the fall of 2006 (slightly below average for the 2009 cycle)
- Good signals for freshwater survival from the 2005 spawning

2009 Returns

Stock-group	Pre-season Forecast	Post-season estimate (prel).
Chilko	4,175,000	270,000
Quesnel	3,575,000	220,000
Total Sockeye	10,488,000	1,505,000

Sherlock's Theory!

Colonel Mustard did it in the ocean with a _____?

Ocean mortality hypothesis
Some caveats

1. For Chilko smolts, can't rule out mortality during downstream migration (650 km).

2. For Quesnel fall fry can't rule out addition mortality in lake (9 months) or mortality during downstream migration.

Spatial scale of covariation among stock in productivity

- **Positive correlation in productivity among stocks within species -- pinks, chum, sockeye <u>at regional-scale</u> (~ 500 to 800 km)**

- **Environmental processes that drive this biological variation should have this same spatial scale**

Mueter et al. (2002) *Fish. Oceanog.*

Mechanisms for covariation

At which life stage does most covariation arise?

Late freshwater or early ocean life stages

What is driving spatial covariation in productivity?

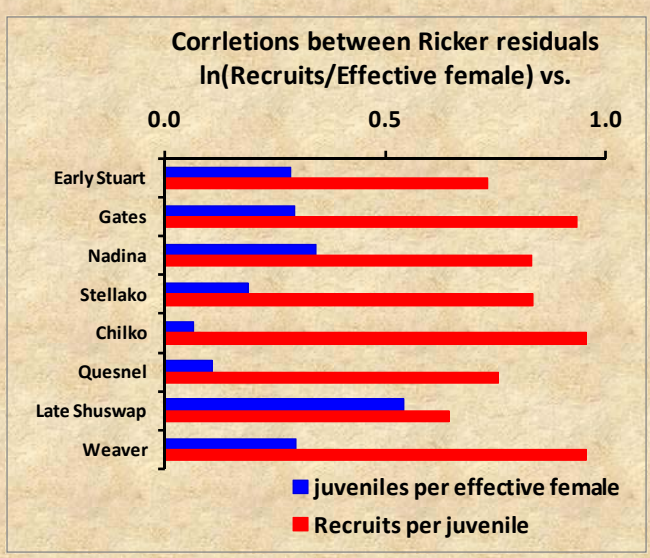
- **Upwelling?**
- **Coastal sea-surface temperature (SST)?**
- **Coastal sea-surface salinity?**

spatial scale of covariation~ 500 km, same as salmon productivity

Asked same question:
Is there positive correlation across locations?

Mueter et al. (2002a)

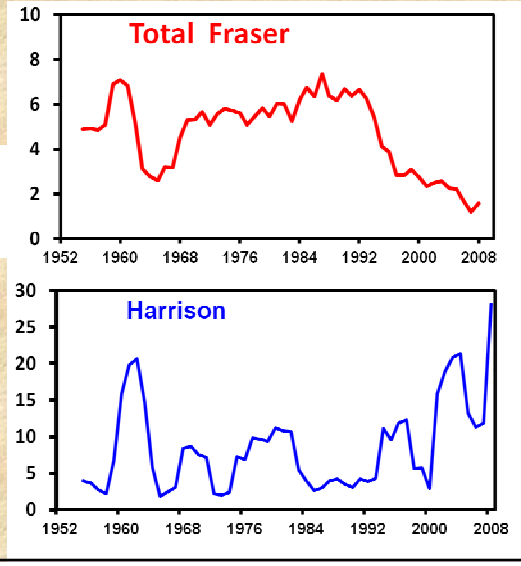
Post-juvenile stage has highest correlations with overall productivity



Life history clues?

Harrison sockeye Productivity

Productivity
(Adult returns per spawner)



Harrison sockeye Life history

Life history	Most Sockeye	Harrison
Fry rearing	Lake (1 year)	Sloughs, estuary (few months)
Ocean entry	2 years after spawning	< 1 year after spawning
Ocean residence	2 years	2 *and* 3 years
Age at return	4 years	3 *and* 4 years
Ocean entry of 2009 return	2007	2007 for age 3 fish 2006 for age 4 fish

Harrison sockeye
Productivity of 2009 return

Year	Total Fraser Sockeye	Harrison
2007 Ocean entry	0.5 returns/spawner	1.8 (age 3 fish from 2009 return)
Smolt migration route	**Most use Johnstone Strait**	**Some, perhaps most use Juan de Fuca Strait**
2006 Ocean entry	**3.0 returns/spawner**	**0.04 returns/spawner (age 4 from 2009 return & age 3 from 2008 return)** **400,000 spawners (2005;33 times average!)**

Multi-year clues?

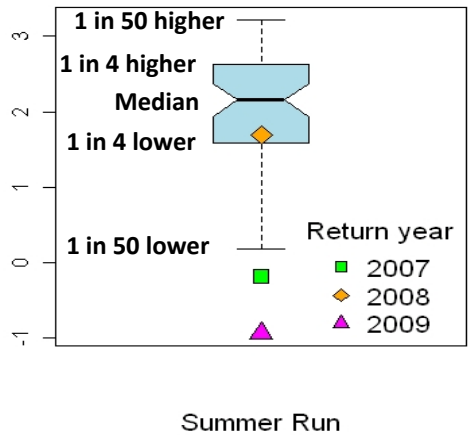
low returns in 2009,2008 & 2007

Shared causes?

Return rates not equally anomalous

Productivity index

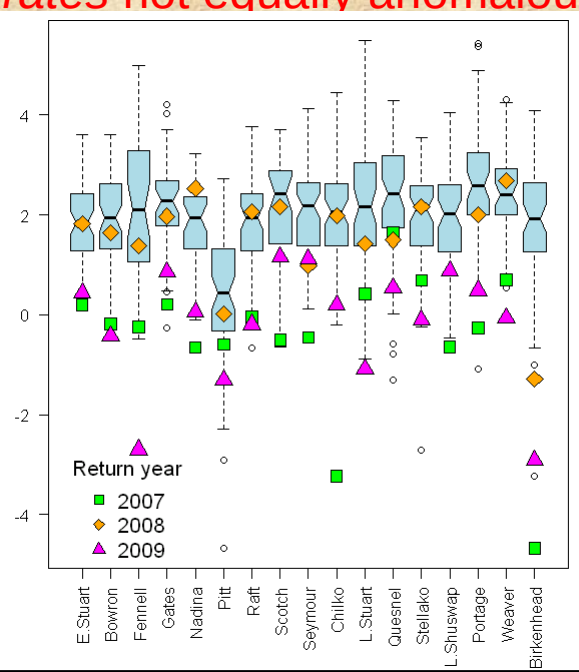
(ln (age 4 return per female spawner)

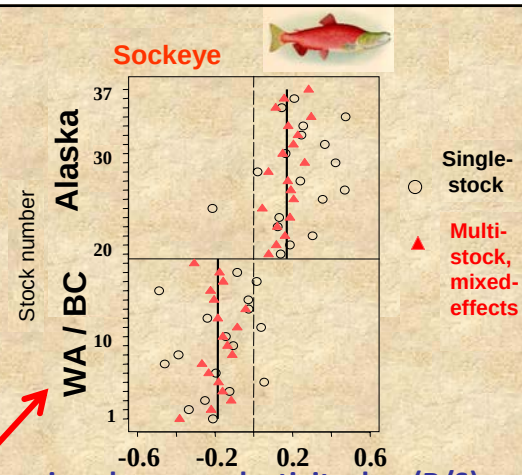


Return rates not equally anomalous

Productivity index

(ln (age 4 return per female spawner)





Change in salmon productivity, $\log_e(R/S)$, per °C increase in summer sea-surface temperature (SST coefficient)

WA and BC Sockeye productivity decreases with increasing sea surface temperature

Mueter et al. (2002a)

Different Coastal Ocean conditions Fraser revelant?

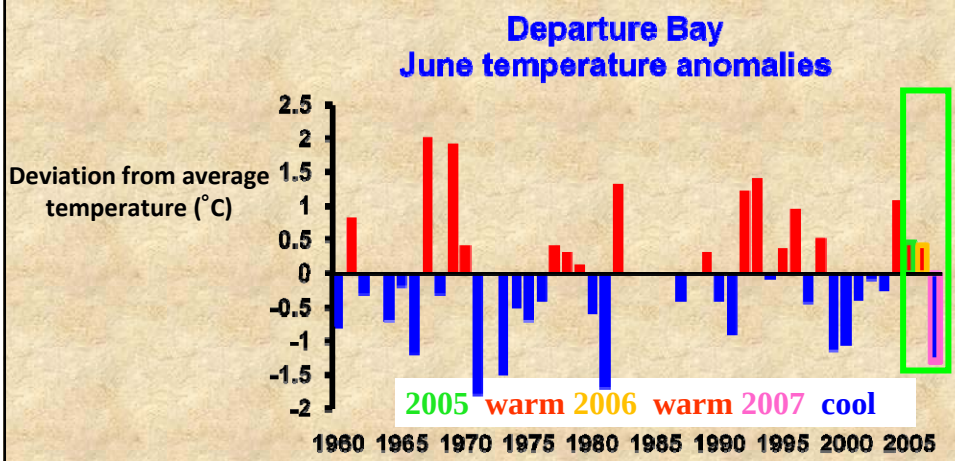
Ocean entry year / Return year	2005 / 2007	2006 / 2008	2007 / 2009
Ocean Indices			
1 PDO (Jan-March average)	R		
2 ALPI		G	G
Physical Conditions			
3 SST (Entrance Island)	R		
4 SST (Pine Island)	R		G
5 Upwelling index (48°N)	R		G
6 Spring transition timing (48°N)	R		
Biological Conditions			
7 Southern Copepods (SVI)	R	R	G
8 Boreal Shelf Copepods (SVI)	R	R	G
9 Southern Copepods (NVI)	R	R	G
10 Boreal Shelf Copepods (NVI)	R		G

Peterson's ranking method, NFSC, NOAA

Mantua et al. (2007); Beamish et al. (1997); Bakun (1973); Mackas (data)

Georgia Strait conditions different (

More Fraser relevant?)



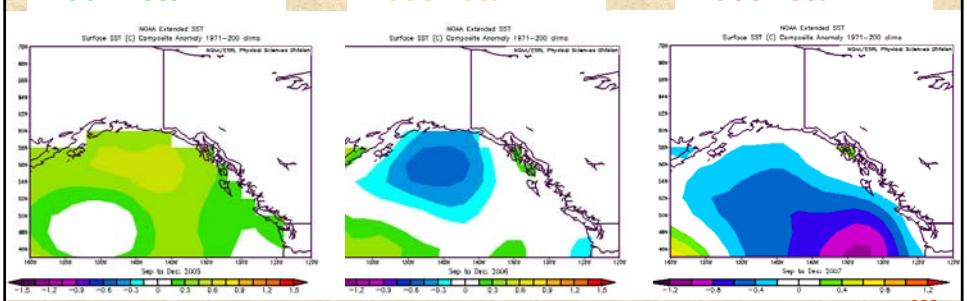
Different conditions in Gulf of Alaska

Sept-December SST anomalies year of arrival

Blue = cold, Green Yellow = warmer

Significant to fish?

2007 return **2008 return** **2009 return**



Summary of multi-year comparisons

1. 2008 productivity was below average for most stocks but much higher than 2007 and 2009.

2. Readily available data on environmental factors *do not show* a common pattern even among the most anomalous years (2007 & 2009).

Summary of multi-year comparisons

3. The extremely low productivity in 2007 (2005 ocean entry) was consistent with warm coastal and open ocean conditions that have been linked to poor marine survival of salmon.

4. However the productivity in 2009 similar (in some cases lower) to 2007 despite cooler than average ocean temperatures and *seemingly* more favorable conditions.

Underscores the futility of these broad comparisons and the need for Fraser specific indicators.

Data on ocean life stages lacking!

Smolts exit Fraser, migrate north along coast, after 2 years at sea (Gulf of AK), 4 yr old adults return in fall

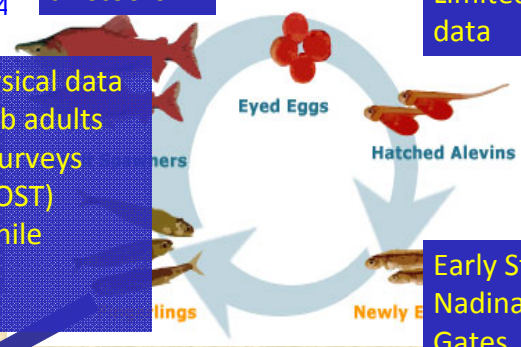
Excellent monitoring, all stocks

Winter 2005

Limited data

Winter 2006

Limited Biological & Physical data
Old high seas tagging sub adults
Georgia Strait juvenile surveys
Cultus smolt tagging (POST)
Discovery passage juvenile sampling



Early Stuart, Nadina, Gates, Weaver

Chilko last seen spring 2007

Spring 2007 fingerlings leave lake, migrate down the Fraser River, entering ocean as smolts

Quesnel last seen fall 2006

Spring 2006, fry migrate to lake

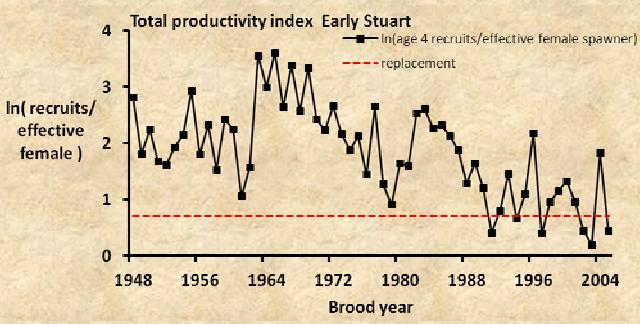
I had help!!

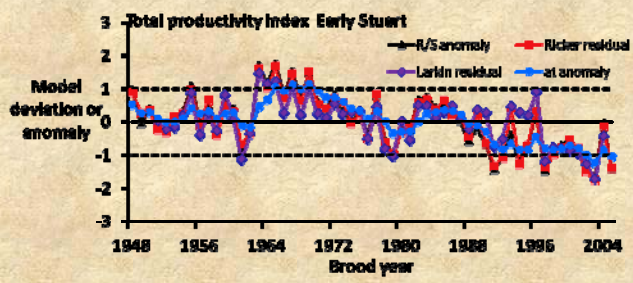
Catherine Michielsens
Steve Latham
Sue Grant
Randall Peterman

Thanks!

The End

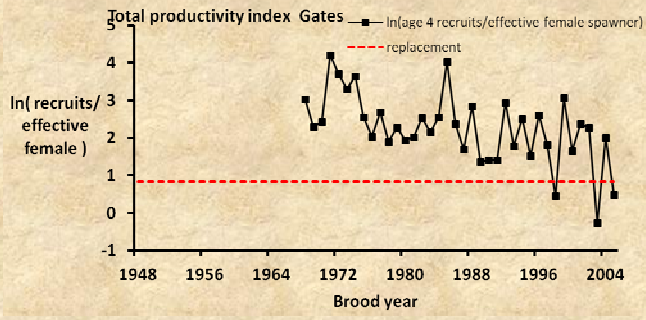
Trends in productivity

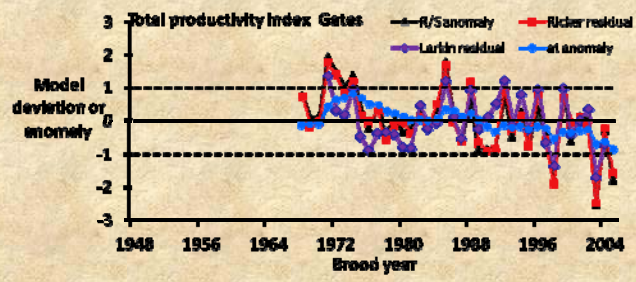




Early Stuart

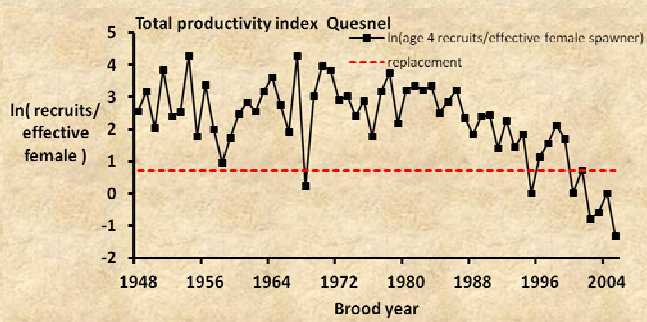
Trends in productivity

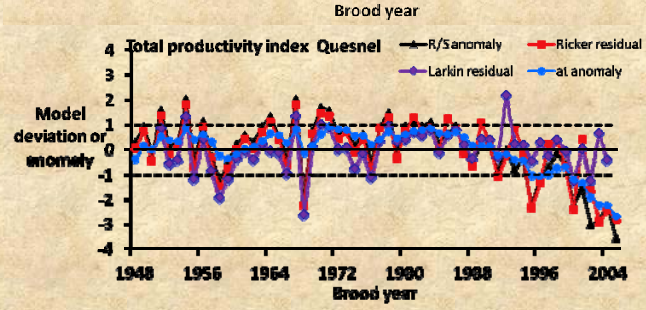




Gates Creek

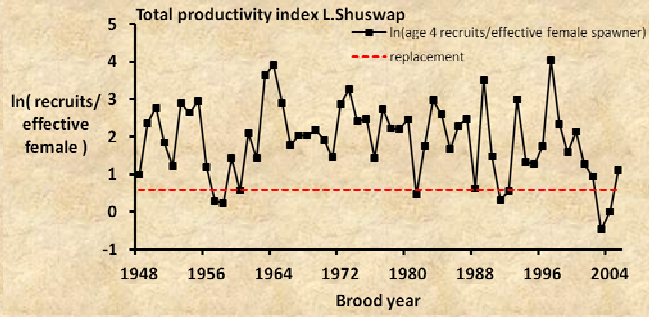
Trends in productivity

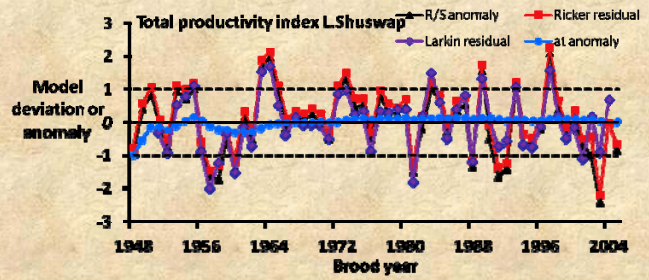




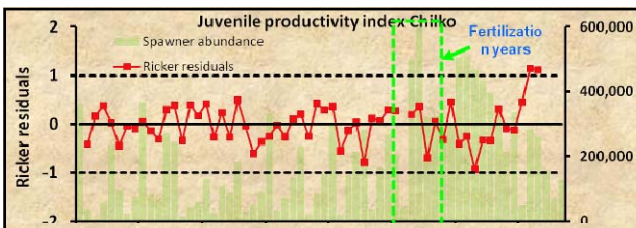
Quesnel
(Horsefly, Mitchell, lake tribs)

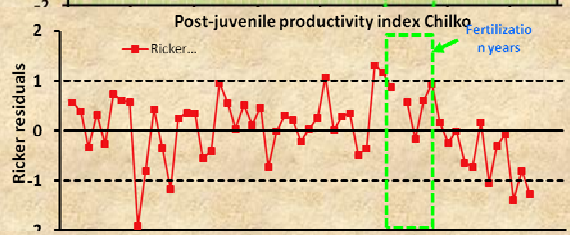
Trends in productivity

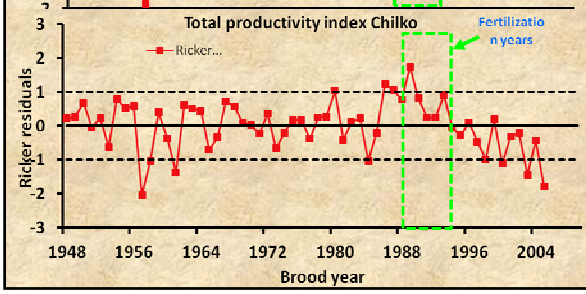




Late Shuswap







Trends in productivity

Chilko

Supplemental slides

Productivity

Indices of productivity

- Recruits/(effective female spawners)
  a. Carcasses are examined in spawning areas for sex ratio
  b. a sample of females is scored: 100% (none of few eggs left in carcass), 50% (some eggs left in carcass), 0% (most or many eggs left in carcass)
  c. Weighted average % spawned calculated from b.
  d. effective females = females X % spawned
  e. (1 - %spawned) often referred to as pre-spawn mortality

Indices of productivity

Ricker model residuals

- Ricker model
- $R_t = S_t e^{(a-bSt) + v}$; $\ln(R_t S_t) = a - bS_t + v_t$
- a (intercept), b(slope) estimated by regression,
- Residual = v_t observed productivity – model predicted productivity
- $v_t = \ln(R_t S_t) - a - bS_t$
- for Fraser sockeye if S_t is spawing stock in year t, R is recuitment of age 4 in year t+4 and age 5 in year t+5

Indices of productivity

Time varying a_t values

- Ricker model with time varying a value
- $R=Se^{(a_t-bS)+v}$;$\ln(R/S) = a_t - bS + vt$
- $a_t = a_{t-1} + w$ (Random walk model)
- analogous to trying to detect a trend the Ricker model residuals resulting from a mode with constant a parameter
- See Dorner et al. 2008 (Can. J. Fish. Aquatic Sci. 65:1842:1866)

Stock specific trends in productivity

	Brood year that most recent decline began[1]	Long term average a	Most recent a_t	long term average R/EFS from a	Most recent R/EFS from a_t	% change in R/EFS
Early Stuart	1991	1.90	0.84	6.7	2.3	-65%
Bowron	1995	2.38	1.28	10.8	3.6	-67%
Fennell	1996	2.75	1.77	15.7	5.9	-62%
Gates	1998	2.40	1.56	11.0	4.8	-57%
Nadina	1998	1.97	1.42	7.2	4.1	-42%
Pitt	2003	1.10	-0.11	3.0	0.9	-70%
Raft	1998	2.06	1.68	7.8	5.4	-31%
Scotch	na since 97 [2]	1.76	1.15	5.8	3.2	-46%
Seymour	1990	2.05	1.54	7.7	4.7	-40%
Chilko	1998	2.70	1.73	14.8	5.6	-62%
Late Stuart	1997	2.38	0.90	10.9	2.5	-77%
Quesnel	1995	2.32	-0.38	10.2	0.7	-93%
Stellako	1997	2.26	0.37	9.6	1.4	-85%
Harrison [3]	1996	2.12	2.99	8.3	19.9	140%
Late Shuswap	na sa =0.1[4]	1.99	2.02	7.4	7.5	3%
Portage	1998	3.13	2.15	23.0	8.6	-63%
Weaver	2003	2.71	1.54	15.1	4.7	-69%
Birkenhead	1992	2.30	0.95	10.0	2.6	-74%

Notes: 1 last year when smoothed anomoly > -1
2 smooth anomoly has not been < -1 since 1997
3 Harrison start of increase - smoothed anomoly > +1
4 method did not detect trend in a for Late Shuswap

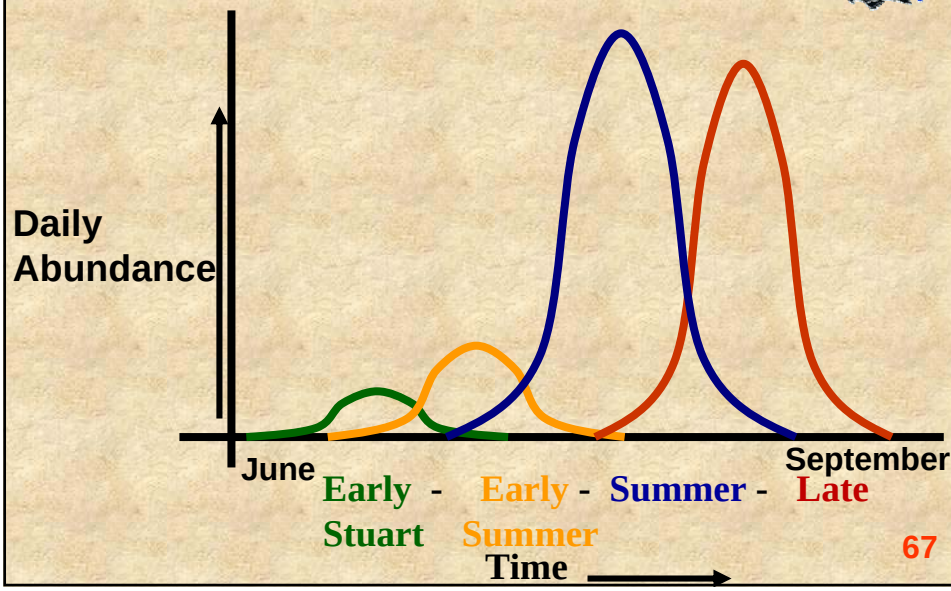
Post-juvenile stage has highest correlations with overall productivity

Correlations between Ricker model residuals

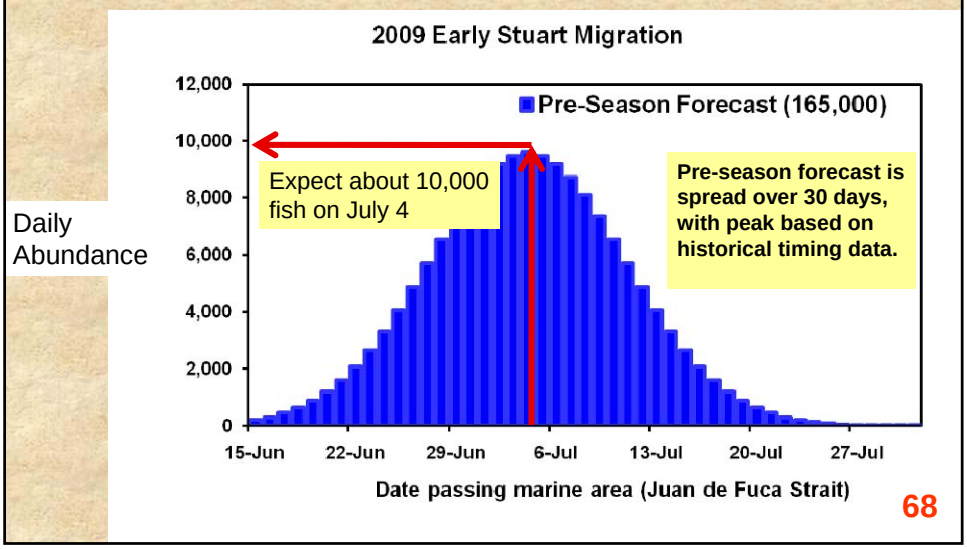
Recruits per effective female vs.

	n years	Juveniles per effective female	Recruits per juvenile
Early Stuart	16	0.29	0.73
Gates	38	0.30	0.93
Nadina	33	0.34	0.83
Stellako	13	0.19	0.83
Chilko	56	0.07	0.95
Quesnel	19	0.11	0.76
Late Shuswap	15	0.54	0.64
Weaver	38	0.30	0.96

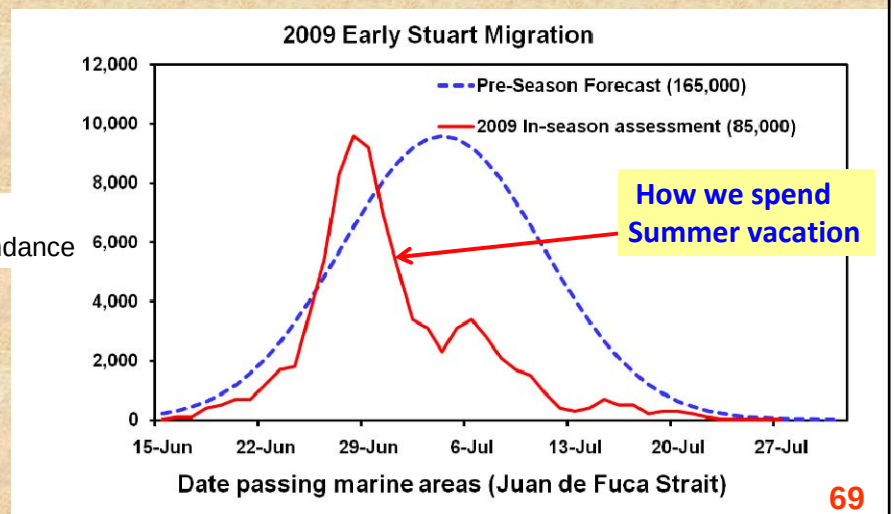
Migration timing of management groups



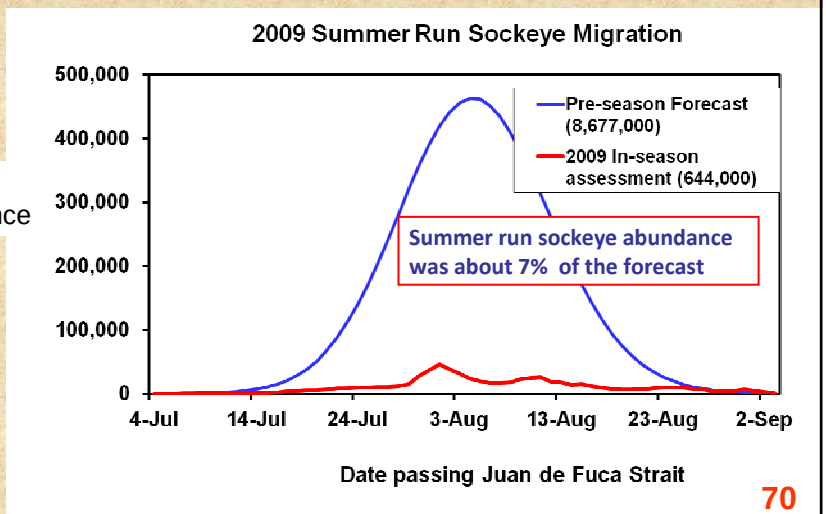
Pre-season expectations timing and abundance



In-season assessments



In-season assessments



- Result:

Summer sea-surface temperature: spatial scale ~ 500 km, same as salmon productivity

- Models including stock-specific summer SST
  - Fit data much better than models without SST

- How much change in salmon productivity has occurred in past for each ^{o}C increase in SST?

Causal factors concepts
Critical period hypothesis

- variation in productivity/survival rates is caused by events/factors during a particular time (and location) in the salmon life cycle

e.g. food in first few months at sea in Georgia Strait

Principle Data/model needs:

- knowledge of space/time locations of salmon and causal agents
- quantitative data on relative abundance of salmon and magnitude of factors
- model relating salmon and factor with some explanatory mechanism

Causal factors concepts
Critical period hypothesis

Challenges/Assumptions:

- Identification of period/location; Fraser sockeye at sea for more than 24 months, pass through area of more than 1 million km^2
- correlation between critical period survival and overall survival depends on both relative magnitude ***and*** variation in subsequent survival periods.
- (e.g. see Bradford 1992;Fish. Bull (US) 90:439-453.)

Causal factors concepts
Whole life cycle hypothesis

- variation in productivity/survival rates is caused by the cumulative effects of a whole series of events/factors across the whole fishes life cycle.

e.g.

Principle Data/model needs:

- knowledge of space/time locations of salmon and causal agents
- measurements of multiple factors and relative abundance along the migration path
- complex model relating salmon survival and the multiple factors with some explanatory mechanism

Causal factors concepts
Whole life cycle hypothesis

Challenges/Assumptions:

- Self evident, but testable? (i.e. hard to reject without proof of critical period)
- Collection of data over entire life cycle is expensive
- Precision of survey data vs. model complexity and number of parameters.
- models break down due to complexity and non-stationarity

Fraser sockeye example

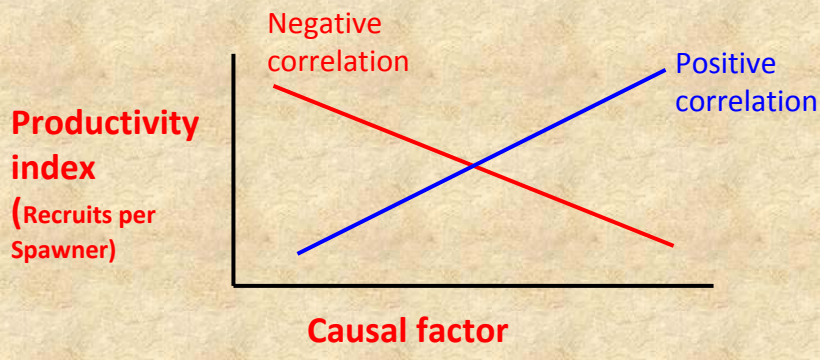
- correlations of productivity indices at different life stages

Positive correlation

Causal factors concepts

Types of relationships

1. Correlation analyses



Causal factors concepts
Types of relationships

2. Model Co-variate analyses

Model

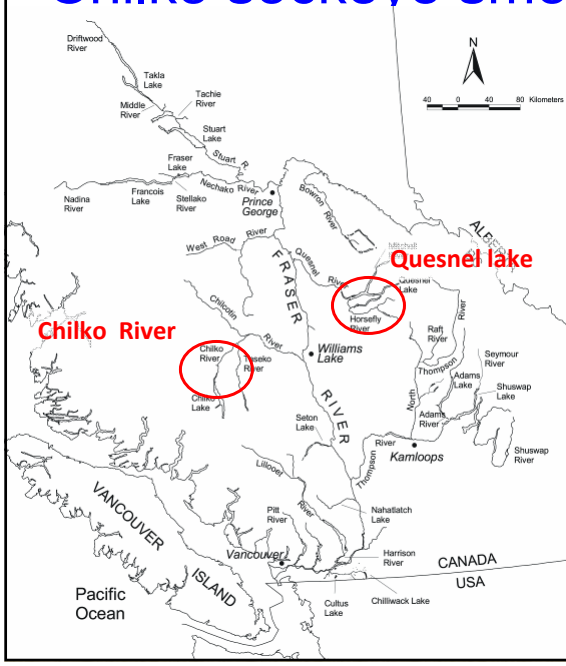
Ln (R/S) = a +bS +cfactor

- parameter c quantifies relationship between factor and residual
- model could be linear or non-linear
- multiple factors could be added/tested
- does inclusion of factor improve the fit of model?

Methods for estimating juvenile abundance

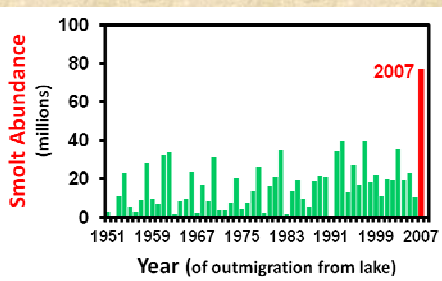
1. Fry traps (Nadina, Gates, Weaver, Early Stuart)
2. Acoustic lake surveys (fry; Shuswap, Quesnel)
3. Smolt Weir (Chilko)

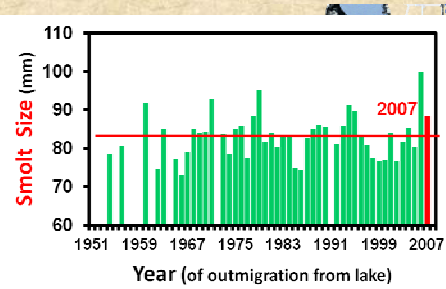
Chilko sockeye smolt program



Chilko sockeye smolt data

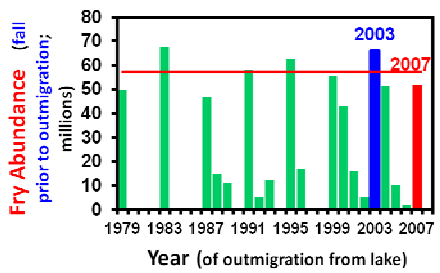
Source: DFO stock assessment

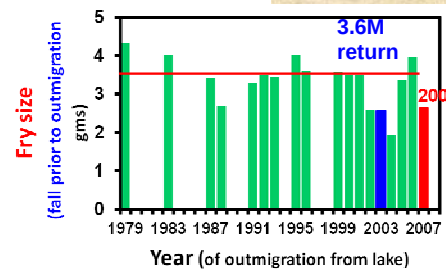




Quesnel lake sockeye fry data

Source: DFO Lake program





2009 Productivity relative to average

Freshwater (fry or smolt / female)

Below average:

Early Stuart, Gates

Near average:

Quesnel, Weaver

Above average:

Nadina, Chilko

No Juvenile data for other stocks

"Post Fry" (returns/fry or smolt)

Below average:

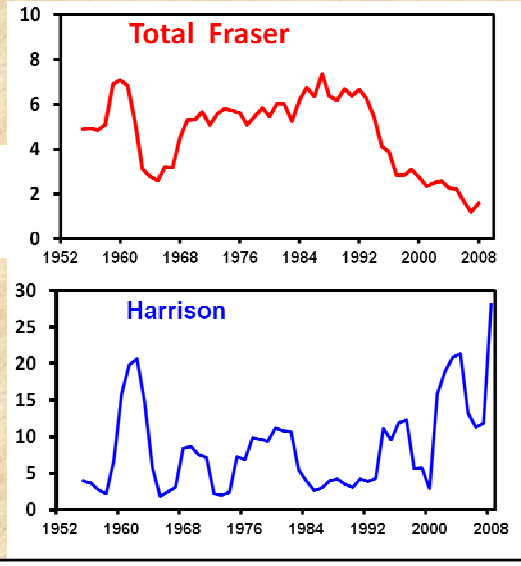
Early Stuart, Chilko, Quesnel, Weaver, Nadina, and Gates

Note: DFO concerns about fry data quality for E. Stuart, Gates?

Life history clues?

Harrison sockeye Productivity

Productivity
(Adult returns per spawner)



Harrison sockeye Life history

Life history	Most Sockeye	Harrison
Fry rearing	Lake (1 year)	Sloughs, estuary (few months)
Ocean entry	2 years after spawning	1 year after spawning
Ocean residence	2 years	2 *and* 3 years
Age at return	4 years	3 *and* 4 years
Ocean entry of 2009 return	2007	2007 for age 3 fish 2006 for age 4 fish

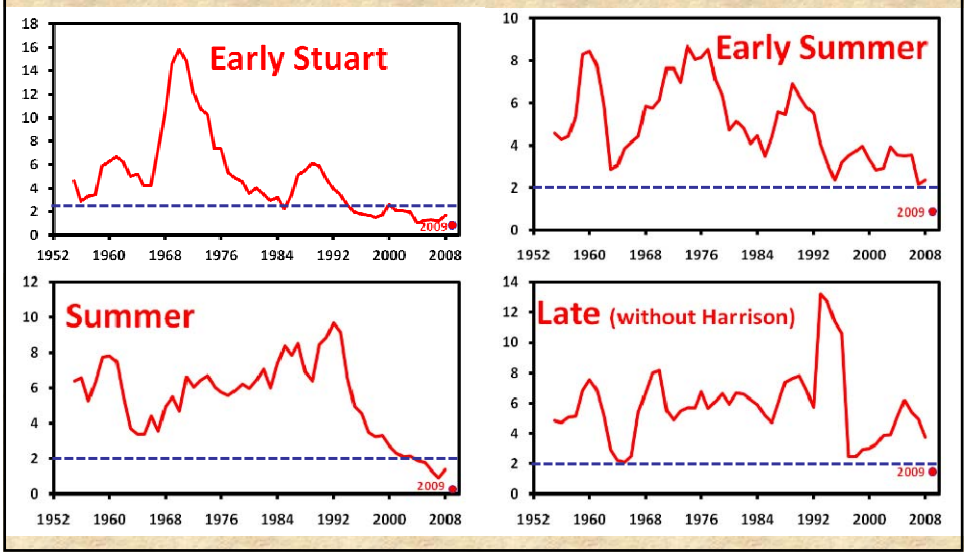
Harrison sockeye Productivity of 2009 return

Year	Total Fraser Sockeye	Harrison
2007 Ocean entry	0.5 returns/spawner	1.8 (age 3 fish from 2009 return)
Smolt migration route	**Most use Johnstone Strait**	**Some, perhaps most use Juan de Fuca Strait**
2006 Ocean entry	**3.0 returns/spawner**	**0.04 returns/spawner (age 4 from 2009 return & age 3 from 2008 return)** **400,000 spawners (2005;33 times average!)**

Potential candidate weapons

a. Poor food – the fish starved?
b. Predators – something ate them?
c. Disease - they got lethally ill
d. Parasites – those pesky sea lice?
e. Contaminants – poisoned on outmigration in Fraser estuary?
f. Other
g. All of the above, some of above, none of the above?

Productivity
by Management group

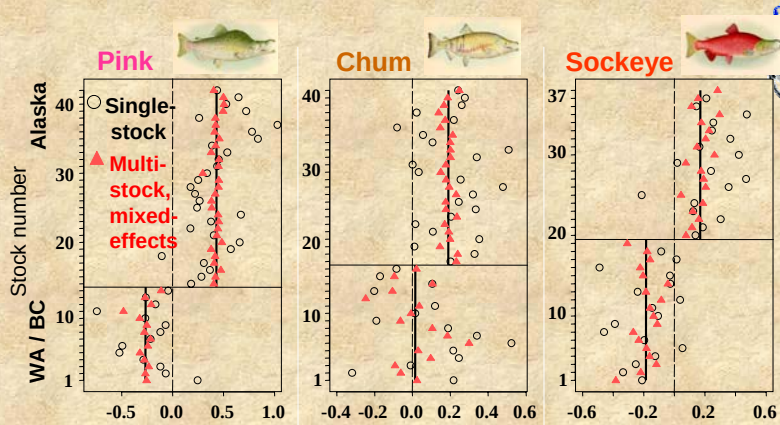


Start of productive declines not coincident – different mechanisms? time or stock effect?

- Some plots here from Forecast document comparing R/EFS, Ricker residuals and Kalman a values converted to R/EFS
- Stocks that show declines starting in different time periods

Productivity metrics and interpretations here

- Influence of time period on Kalman a trends
- Influence of spawning escapements on Kalman a trend



Change in salmon productivity, $\log_e$(R/S), per °C increase in summer sea-surface temperature (SST coefficient)

WA and BC Sockeye productivity (R/S) decreases with increasing sea surface temperature

Mueter et al. (2002a)

Mechanisms, part 2

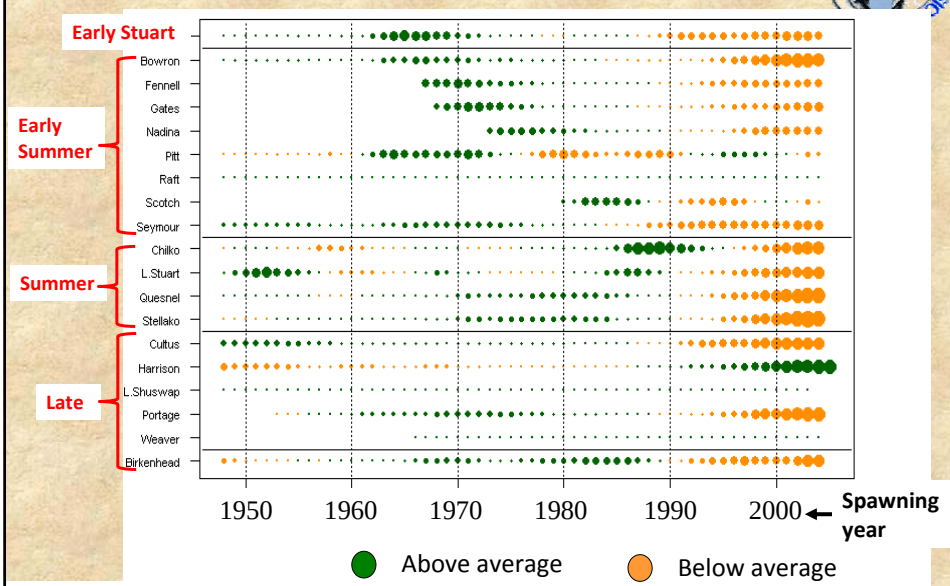
What is driving spatial covariation in productivity?

- Upwelling?
- Coastal sea-surface temperature (SST)?
- Coastal sea-surface salinity?

Asked same question:

Is there positive correlation across locations?

Stock specific trends in productivity



Updated from Dorner et al. 2008 by Michielsens

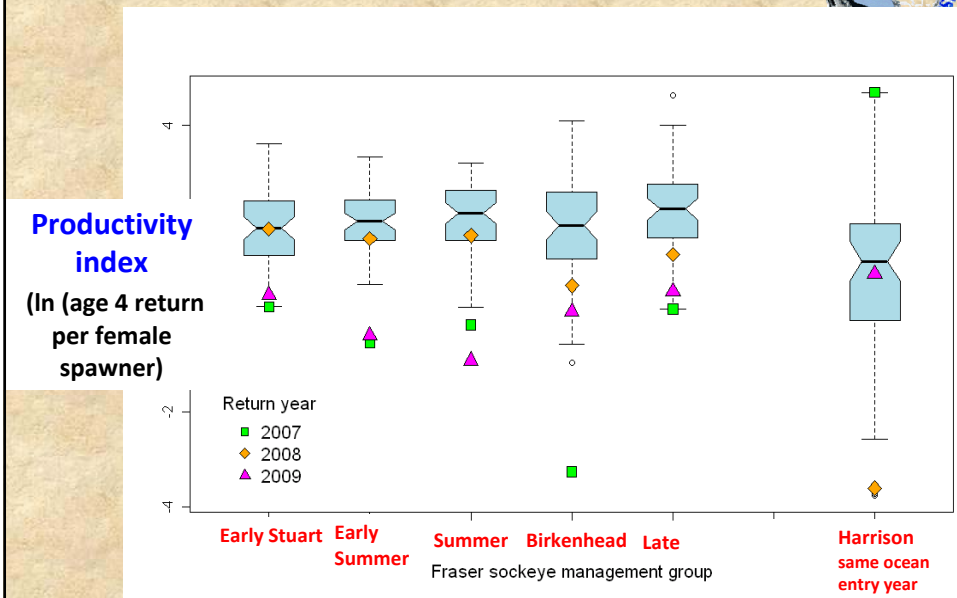
Return rates not equally anomalous

Summer Run 58 years of historical data

Brood year	Effective Females	Age 4 Recruits (thousands)	Age 4 recruits/ Effective female	Productivity ln(Age 4 recruits/ Effective female)	
1948	374	1829	4.9	1.6	
1949	132	2724	20.7	3.0	
1950	86	1126	13.1	2.6	
1951	110	1055	9.6	2.3	
1952	254	1862	7.3	2.0	
1953	241	2823	11.7	2.5	
1954	96	1918	19.9	3.0	
.	.	.	.	.	
.	.	.	.	.	
.	.	.	.	.	
2000	854	1979	2.3	0.8	
2001	2313	5197	2.2	0.8	
2002	1723	2069	1.2	0.2	
2003	547	455	0.8	-0.2	2007 return
2004	161	872	5.4	1.7	2008 return
2005	1033	408	0.4	-0.9	2009 return

Productivity Quantiles	
1 in 50 higher	3.2
1 in 4 higher	2.6
Median	2.2
1 in 4 lower	1.6
1 in 50 lower	0.2

Return rates not equally anomalous



Was the 2009 return a rare event?

- Probability of a 1.5M return given the pre-season forecast <<1%!
- Chilko marine survival implied by 2009 return is 3/1000, about ¼ of the previous 50 year minimum!!

Pacific Salmon Commission
Bilateral Scientific Workshop to Examine the Decline in Fraser River Sockeye

Overview of the Issue:
Review Historical Data on Other Salmon Populations

Timber Whitehouse and Arlene Tompkins

June 15, 2010

Objectives

- Compare coast-wide performance of other stocks/ species relative to year of spawning, sea entry, and return relative to Fraser sockeye
- Examine apparent similarities or divergences in life history, survival, productivity, distribution in both marine and freshwater environments.

Use Signals From Other Salmon Stocks

Salmon characterized by complex life history strategies

- Variable Freshwater Residence (1 -18 months)
  - Lake or stream type (sockeye)
  - Ocean or stream type (Chinook)
- Variable Ocean Residence
  - Pink & Coho, adults return after 1 year
  - Chinook, Chum, & Sockeye, adults return at multiple ages, 2-4 years later

Stock & Species Comparisons

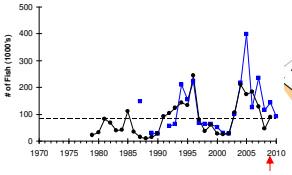
- Patterns of similarities / divergence as indicators
  - Species / stocks within Fraser watershed
  - Species / stocks coast wide
- Forecast Performance
- Comparisons (survival, return, productivity) relative to:
  - 2009 Return Year
  - 2007 Ocean Entry Year
  - 2005 Brood Year

Cross Species Comparison

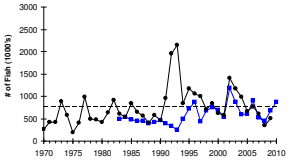
Species	Year		
	Brood (Spawn)	**Ocean Entry**	Return
FR Sockeye	**2005**	**2007**	**2009**
Sockeye	2005, 2006	**2007**	2009-10
Chinook	2005, 2006	**2007**	2008-11
Coho	2005	**2007**	2008
Chum	2006	**2007**	2010
Pink	2006	**2007**	2008

Coast Wide Sockeye Forecast Performance: Returns versus Predicted

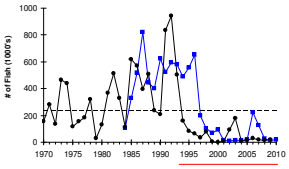
1. **Alaska - Transboundary**

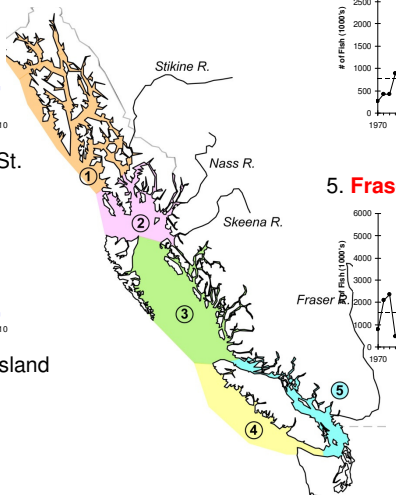


2. North Coast – Dixon Entrance

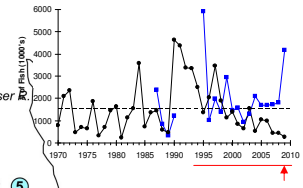


3. Central Coast – Hecate St.

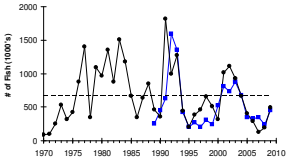




5. **Fraser R. – Georgia Basin**



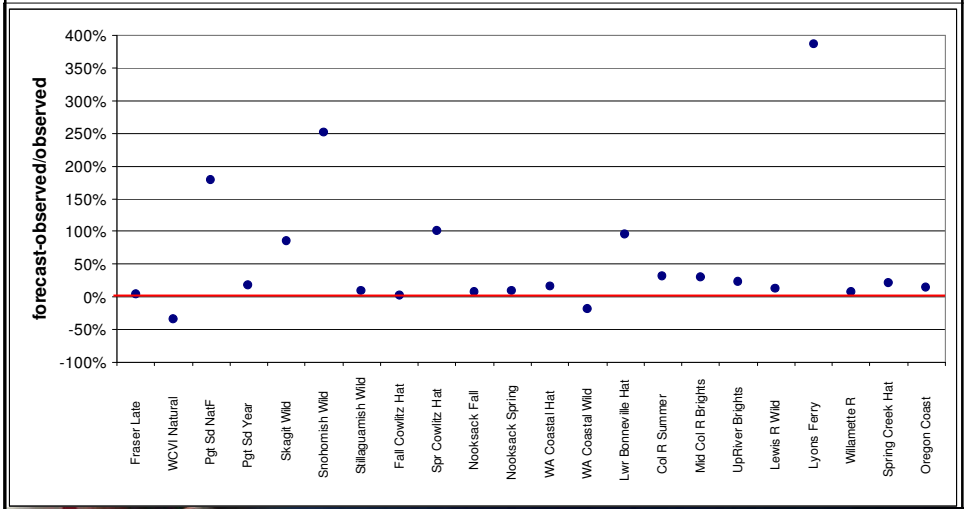
4. West Coast Vancouver Island



Observed Returns
Forecast Returns
All Year Average

Fisheries and Oceans Canada | Pêches et Océans Canada

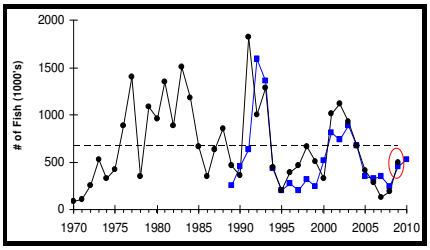
2009 Chinook Forecast Compared to Observed Return



Canada

Fisheries and Oceans Canada | Pêches et Océans Canada

Forecast Performance: Exceptions to Fraser SX



2009 **Barkley Sound** sockeye returned below average but as predicted.

2009 Return within **10%** of the prediction.

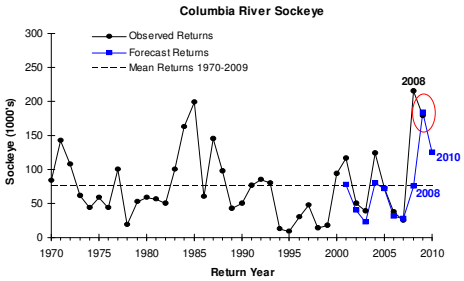
Survival Stanza Method (Hyatt et al., 1989).

2009 **Columbia River** sockeye returns above average (as predicted).

2009 Return within **3%** of the prediction.

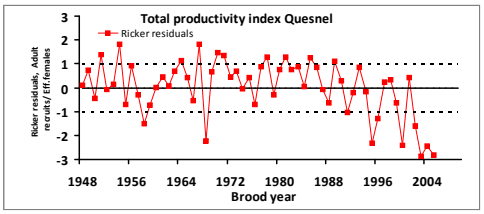
Other returns > forecast:

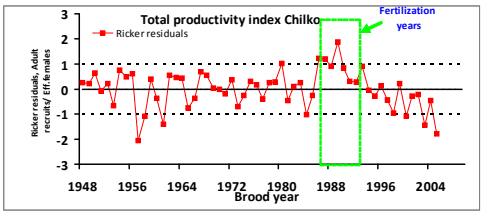
- Bristol Bay, Ak
- Smiths Inlet, BC
- Okanagan, BC

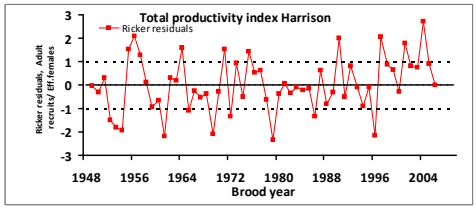


Canada

Comparison Productivity Within Fraser Sockeye Stocks







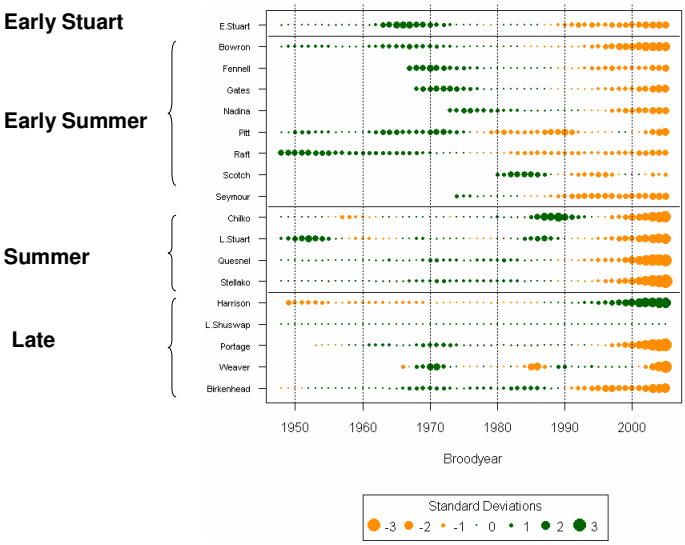
Summer run stocks

Comprised 82% total preseason forecast
Actual return 10% forecast

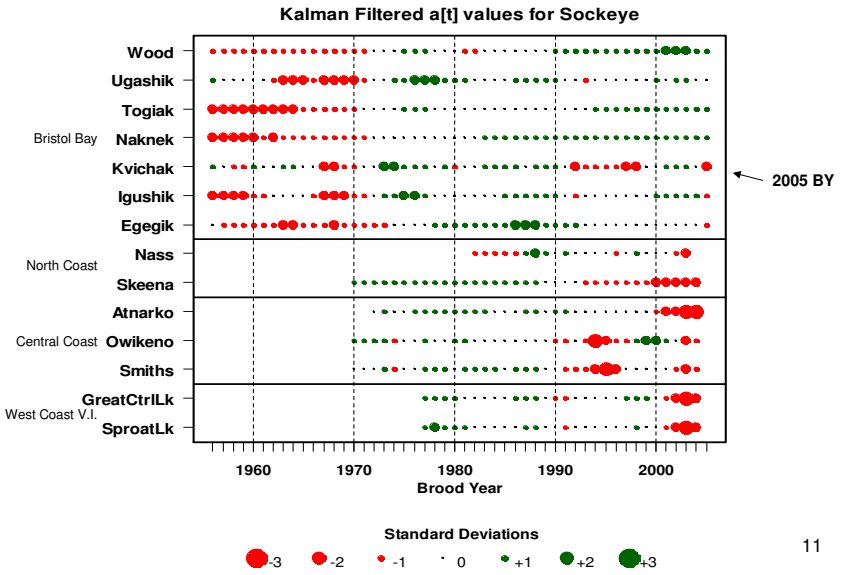
Late run stock

Comprised 9% total preseason forecast
Actual return 300% forecast

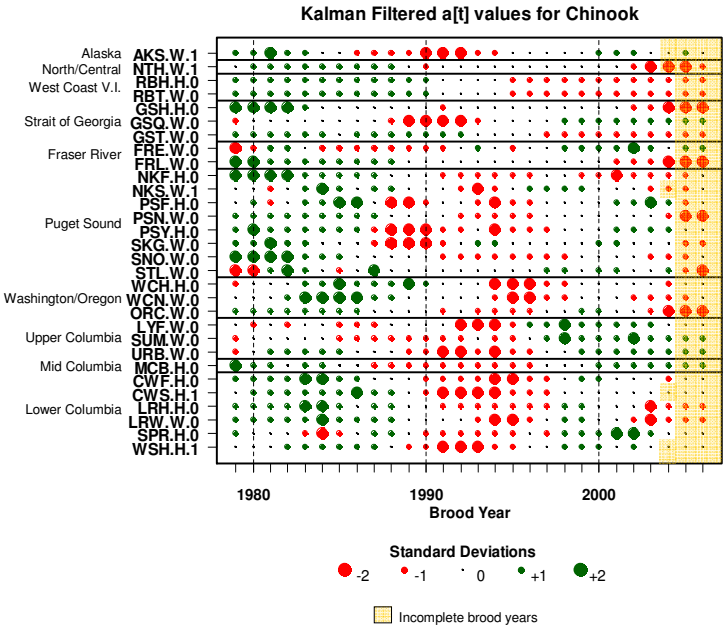
Comparison of Fraser Sockeye Productivity



Comparison of Sockeye Productivity Outside Fraser

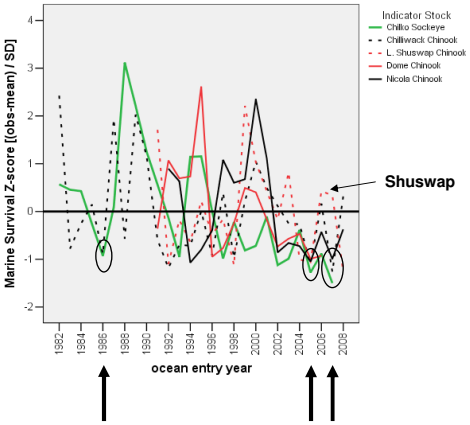


Comparison Productivity Across Chinook Stocks

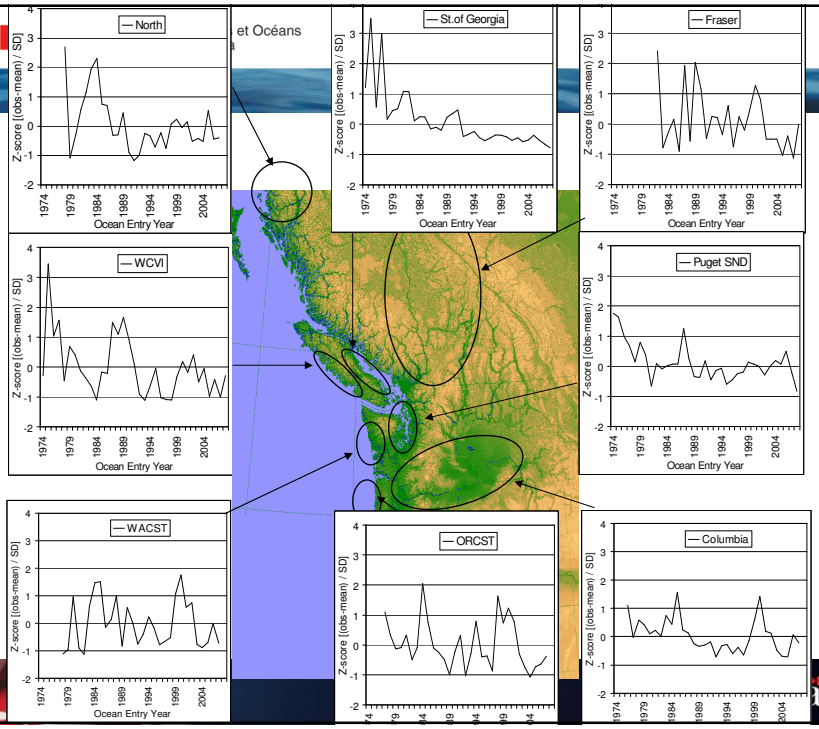


Comparison Marine Survival: Fraser Chinook

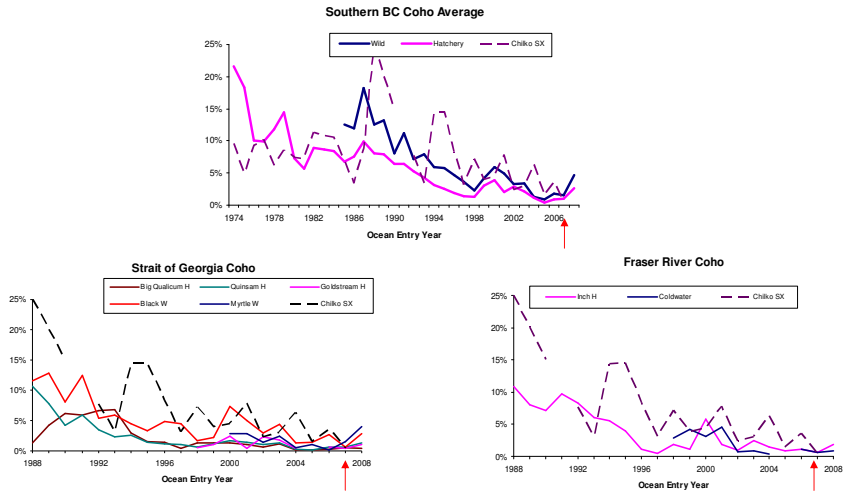
- Poor marine survival events coincided for Chilko Sockeye and Fraser Chinook in OEY 1986, 2005, & 2007
- As with Chilko Sockeye, Chilliwack Chinook survival was extremely low for OEY 2007
  - 92% below average & about 40% less than lowest measured over 27 years



Chinook Marine Survival



Comparison Marine Survival :Southern BC Coho



Observations Consistent with Fraser Sockeye:

Other salmon populations experienced poor performance related to 2009 return year or 2007 Ocean Entry Year:

- 2009 Sockeye returns to SEAK were lower than forecast
- 2009 Skeena Sockeye returns half of forecast
- 2009 Lake Washington Sockeye returns were lowest on record <u>but predicted</u>, declining trend since 2006
- 2009 return Fraser late ocean type Chinook were 92% below average
- 2007 OEY (2005 BY, 2009 RY) Fraser stream type Chinook performed poorly
- 2007 OEY (2005 BY, 2008 RY) GSTR Coho performed poorly (marine survival < 1%)
- 2007 OEY (2006 BY, 2008 RY) Pink performed poorly coast wide

Observations Inconsistent with Fraser Sockeye:

Response observed in Fraser Sockeye in 2009 was not a coast wide phenomenon similar to 2005 Ocean Entry Year:

- 2009 returns to other sockeye populations were as forecast or greater (Bristol Bay, Smith Inlet-Long Lake, Harrison, Barkley Sd, & Okanagan Lake)
- 2007 OEY survival & 2009 returns of Fraser summer run ocean type Chinook (Shuswap indicator) were good
- 2009 Fraser pink salmon & other pink stocks had large returns

Summary

- Comparison among stock & species aggregates did not identify a uniform response based on geographic location of natal stream or utilization of Strait of Georgia
- However coincidental poor ocean survival among several, but not all, Fraser Sockeye, Fraser Chinook & southern BC Coho stocks for OEY 2007
- Time & location-specific factors need to be considered (e.g. time of estuary residence, time of ocean entry, & migration path)
- Likely multiple factors operating at various scales that account for varied responses in salmon populations
- Stock specific data (commonalities, signals) can be used to inform hypotheses & identify areas for further monitoring & investigation

END