Pre-Season Run Size Forecasts:
Fraser River Pink and Sockeye Salmon in 2015

Fisheries and Oceans Canada   Pêches et Océans Canada

S. Grant & B. MacDonald

FRAFS March 10 2015

Fraser Pink Forecast

Fry Abundance
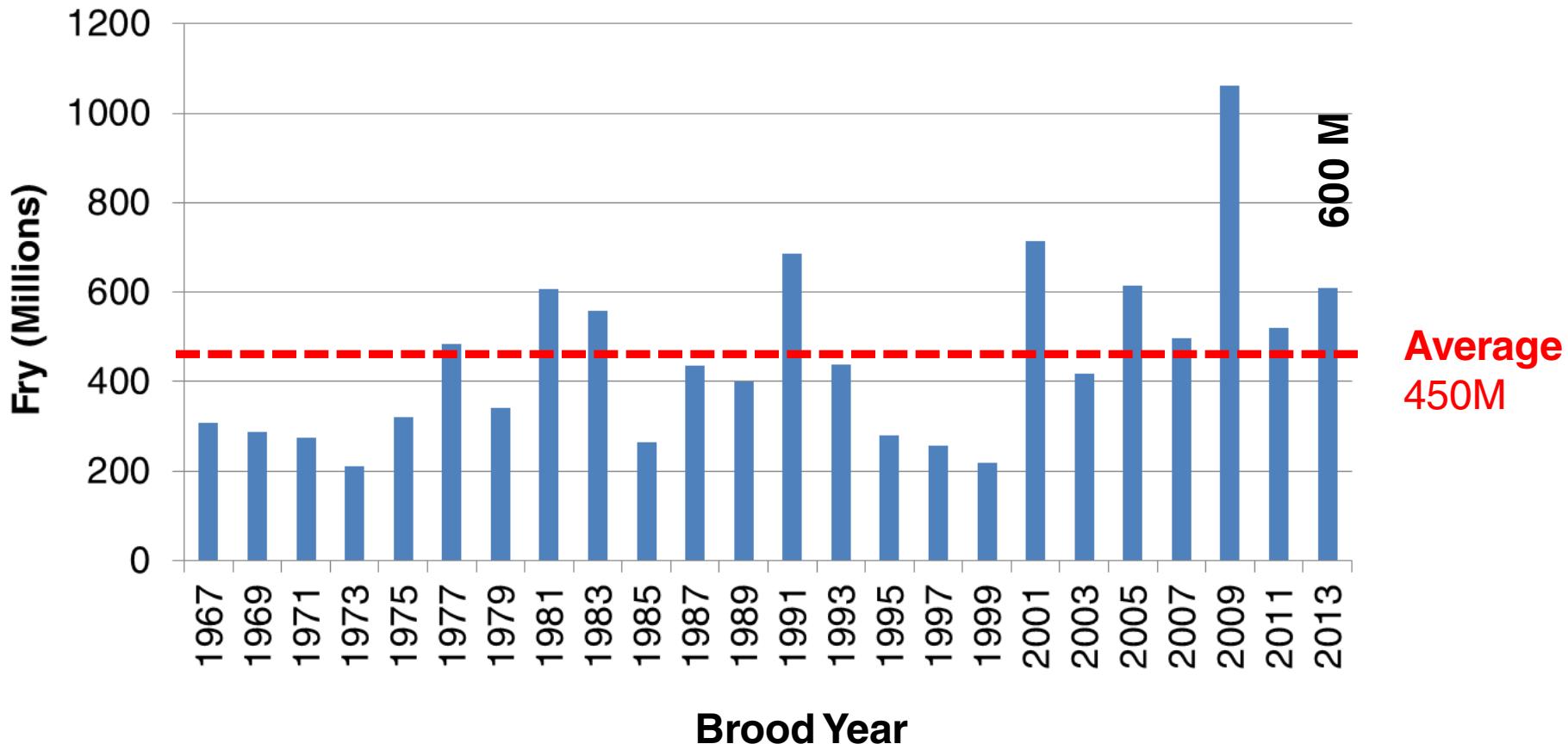
Adult Returns (Escapement + Catch)
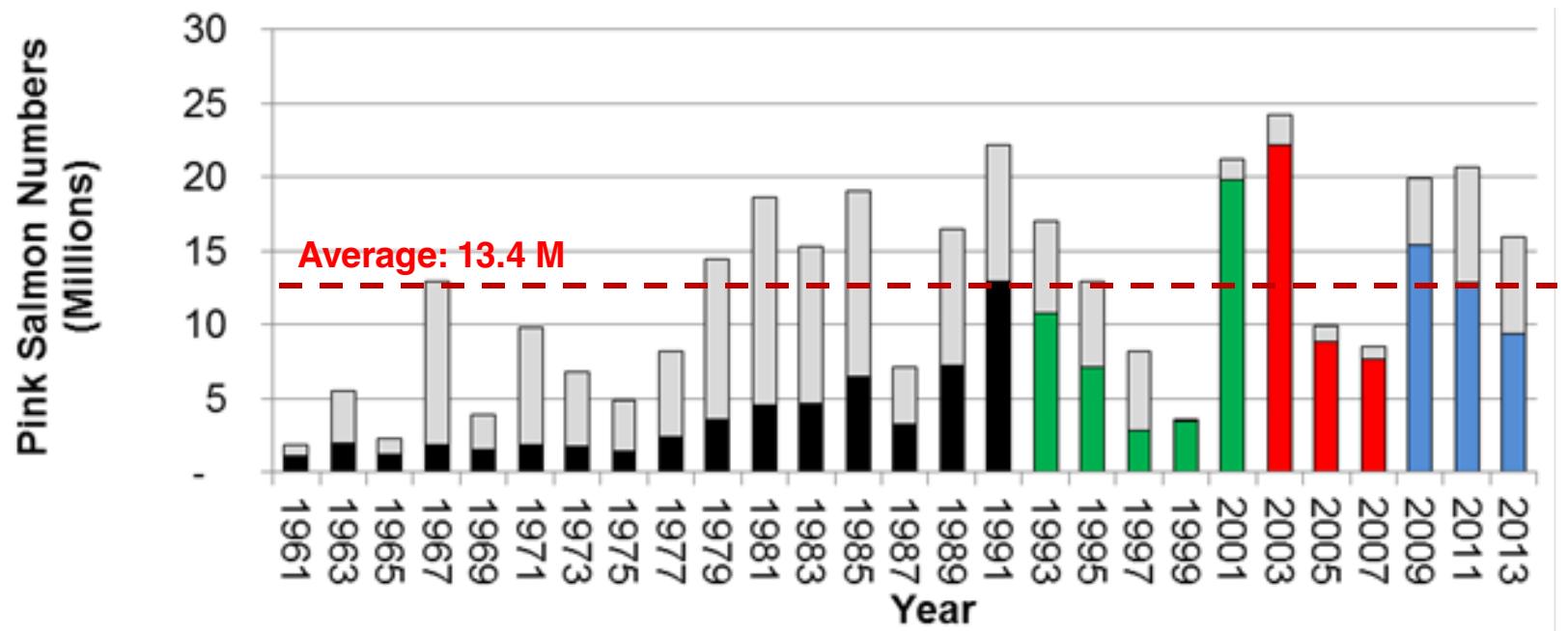
**System-specific
(various methods)**

**System-Wide Assessments
MR   Test-   Hydro-
      Fishery acoustic**

Jacknife Analysis (2015 Update)

| | MRE | | MAE | | MPE | | RMSE | | Average |
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	**Rank**
Power	-0.946	5	4.323	3	-0.003	1	5.773	2	**3**
Power (SSS)	-0.794	4	4.023	1	0.1261	3	5.498	1	**1**
TSA	-1.708	7	6.008	5	0.2021	6	6.734	4	**5**
R1C	-0.128	1	6.056	6	0.2235	7	7.374	5	**6**
R2C	-1.199	6	6.584	7	0.1461	4	7.913	7	**7**
MRS	-0.606	3	4.206	2	0.1091	2	5.865	3	**3**
RS1	2.714	8	9.079	8	0.2939	8	13.545	8	**8**
RS2	0.429	2	5.527	4	0.1682	5	7.377	6	**5**

Amphitrite Point
Race Rocks
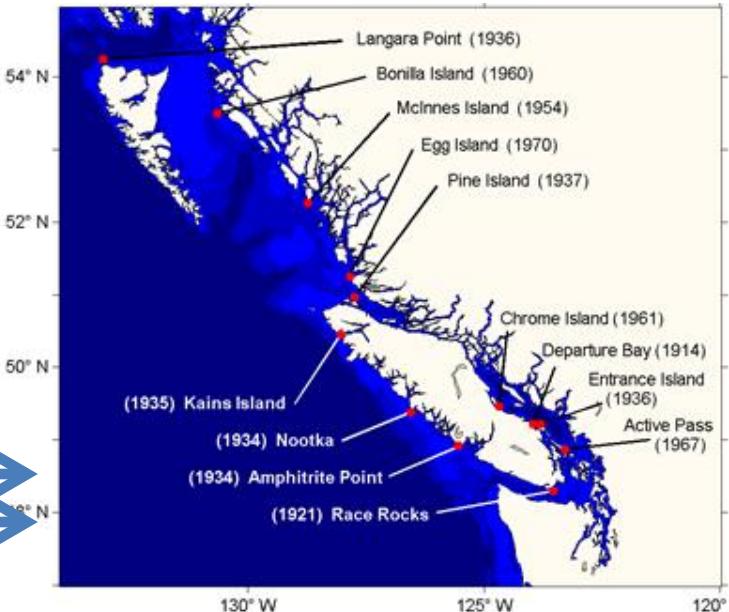
Sea-Surface Salinity
Avg from July-September

Fraser Pink Forecast

Probability Levels

	25%	50%	75%
Power (fry)-SSS	**10,385,000**	**14,455,000**	**20,450,000**

Average: 13.4 M

Fraser Pink Conclusions

- Forecasts are extremely uncertain given changes in escapement and catch estimation methods over time and Pink fry abundance is an index of abundance only;

- Returns are expected to be average based on the 2015 forecast

Fraser Sockeye Forecast
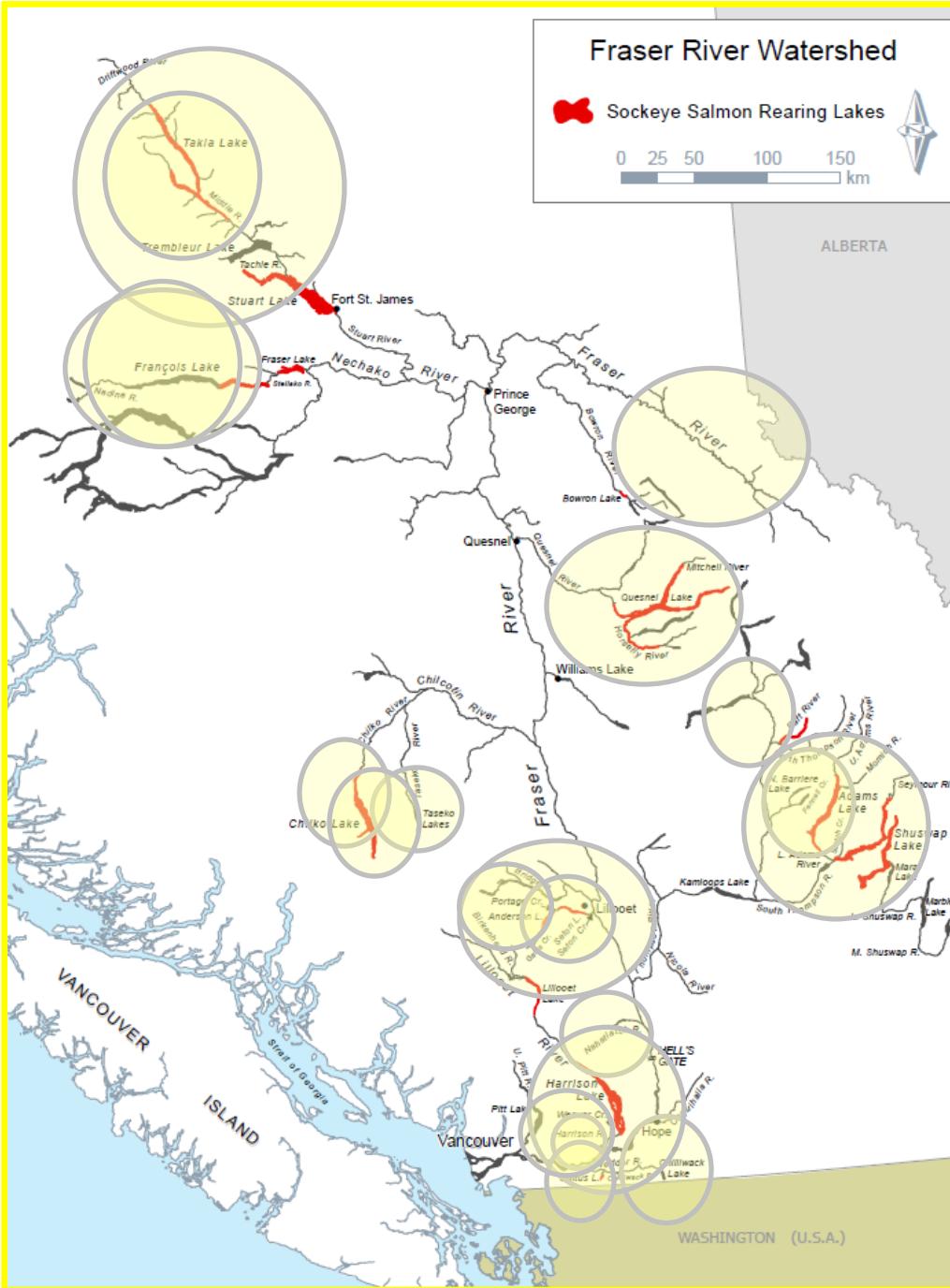
Early Stuart
Early Stuart

Early Summer
Bowron
Fennell
Gates
Nadina
Pitt
Scotch
Seymour

Early Shuswap Miscellaneous
Taseko Miscellaneous**
Chilliwack miscellaneous
Nahatlach miscellaneous

Summer
Chilko
Late Stuart
Quesnel
Stellako
Raft
Harrison
North Thompson River Miscellaneous
North Thompson Tributaries Miscellaneous
Widgeon miscellaneous

Late
Cultus

**Late Shuswap (Adams River)**
Portage
Weaver
Birkenhead
Non-Shuswap miscellaneous

Fraser Sockeye Aggregate: Returns
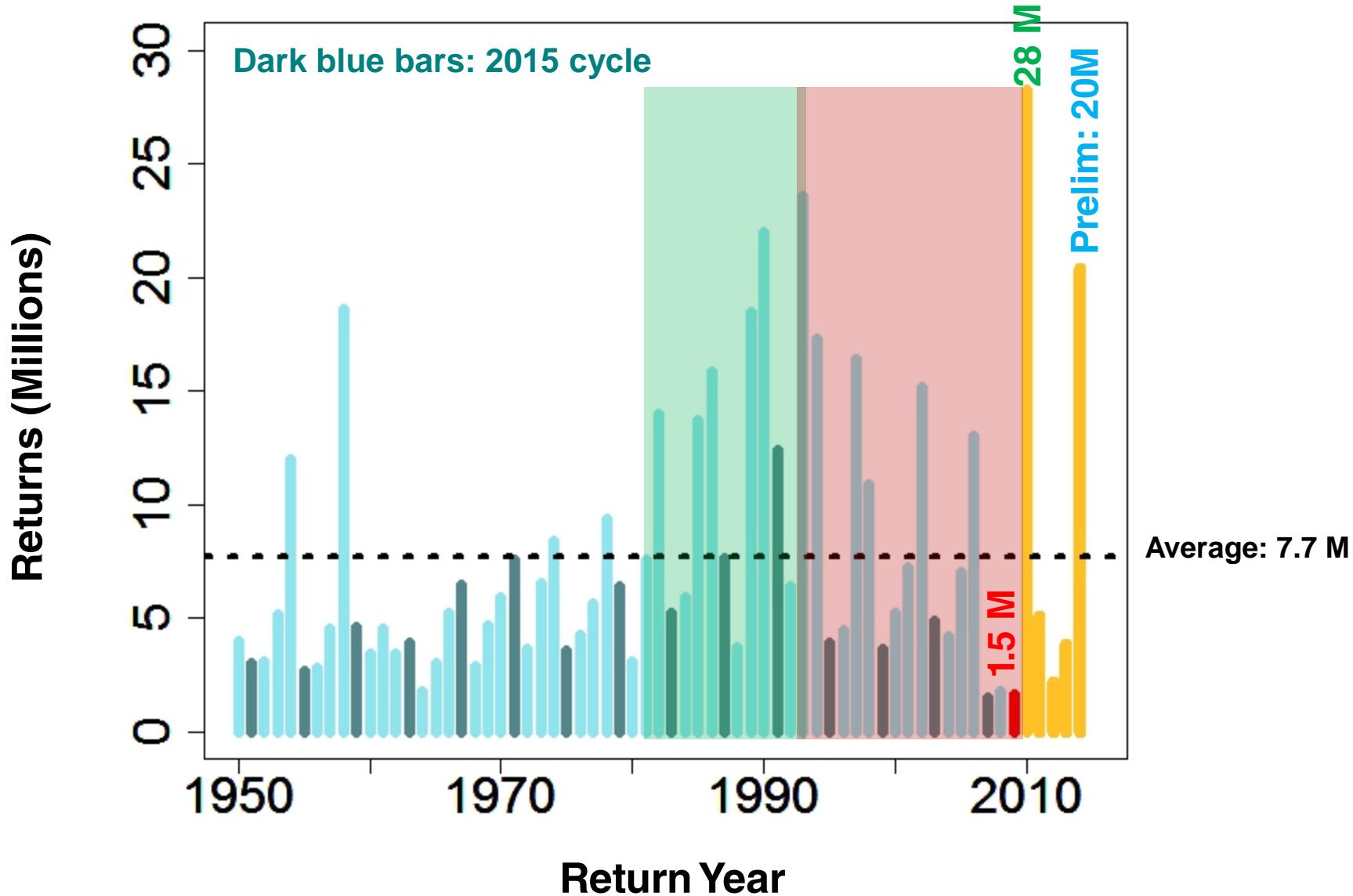
Fraser Sockeye Aggregate: Productivity
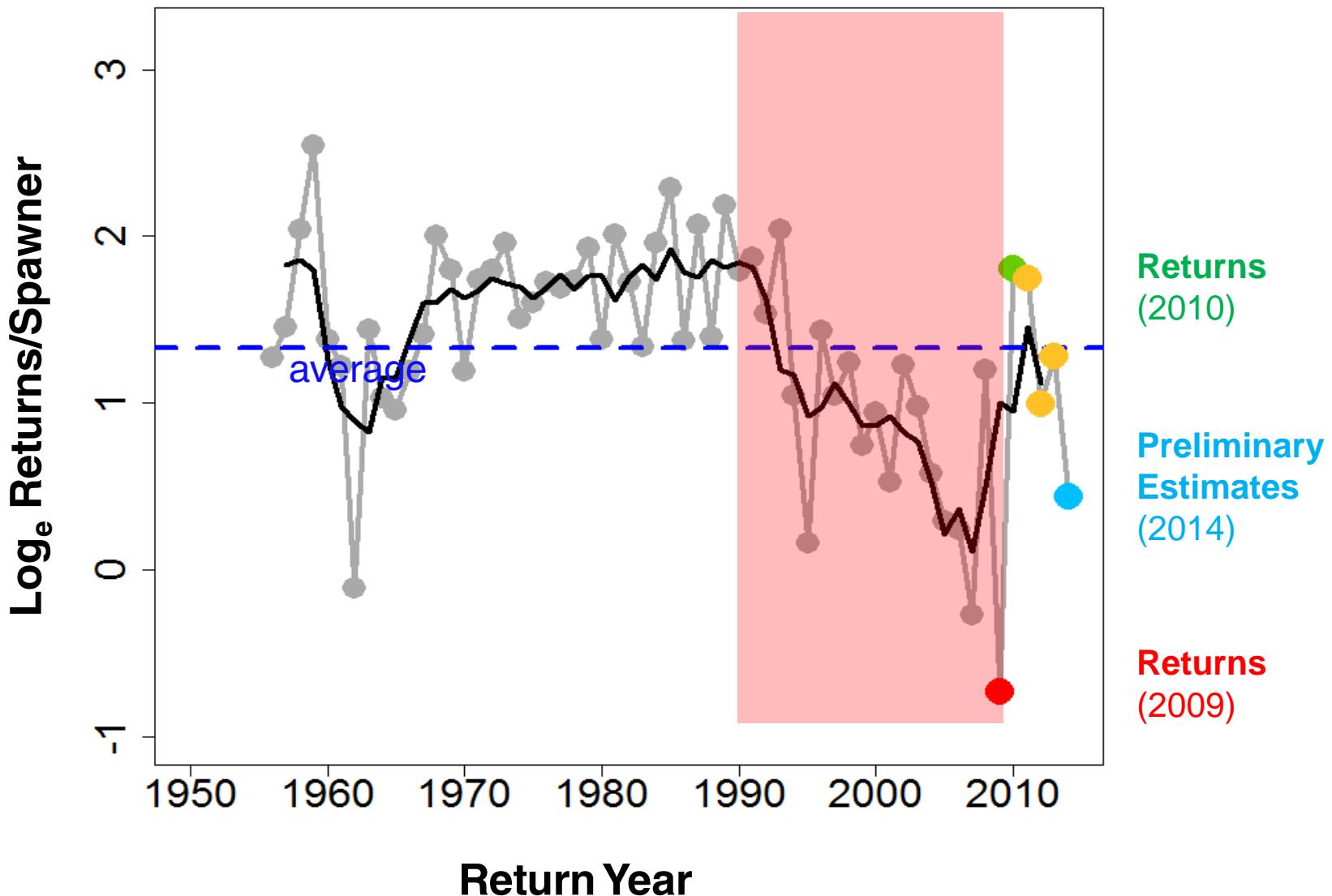
Total Survival: Harrison
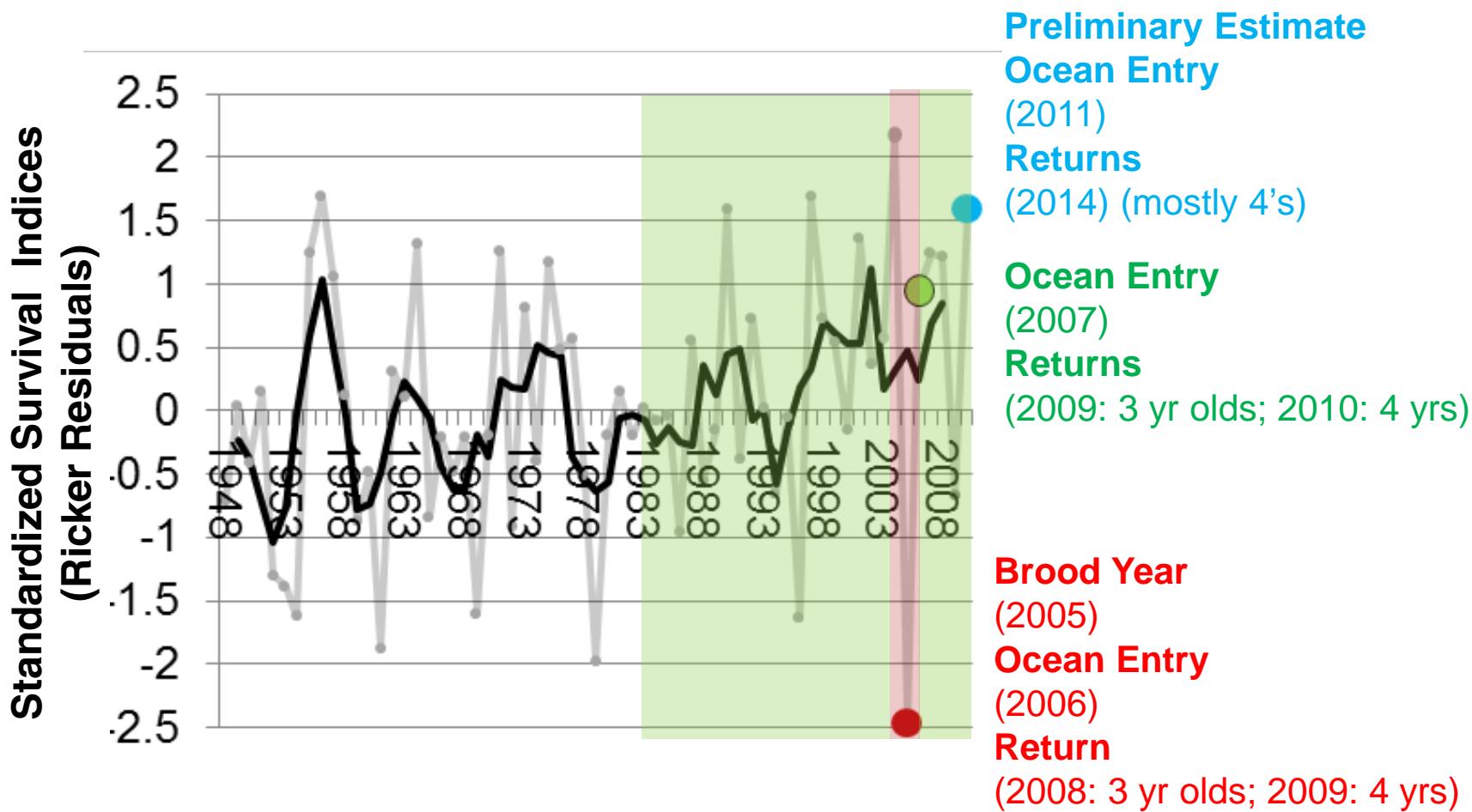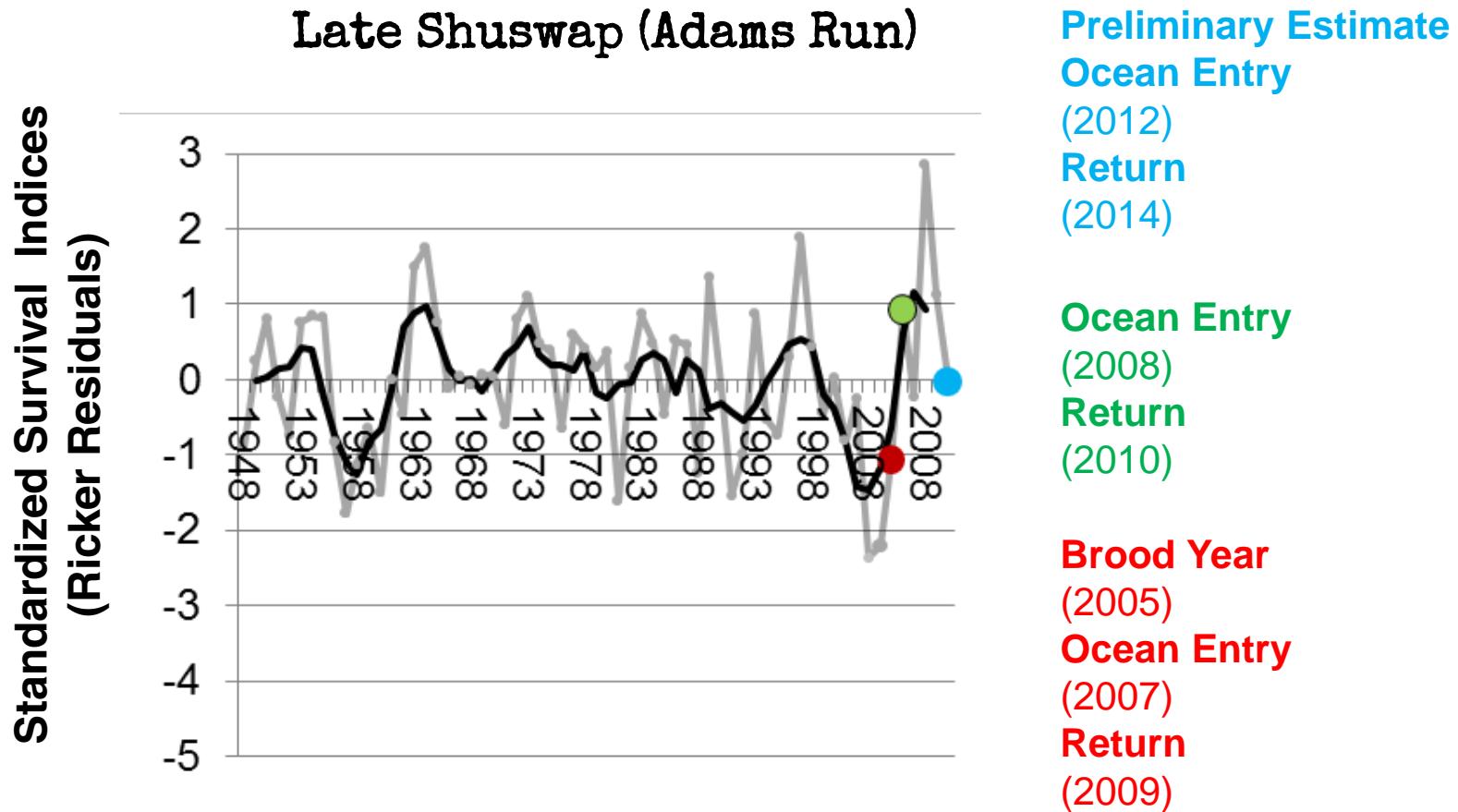

Preliminary Estimate
Ocean Entry
(2011)
Returns
(2014) (mostly 4's)

Ocean Entry
(2007)
Returns
(2009: 3 yr olds; 2010: 4 yrs)

Brood Year
(2005)
Ocean Entry
(2006)
Return
(2008: 3 yr olds; 2009: 4 yrs)

Total Survival: Late Run

Late Shuswap (Adams Run)

Preliminary Estimate
Ocean Entry
(2012)
Return
(2014)

Ocean Entry
(2008)
Return
(2010)

Brood Year
(2005)
Ocean Entry
(2007)
Return
(2009)

Brood Year Escapement

Average age: 4_2

Marine: 2 Winters

Freshwater: 2 Winters

Returns
2015

Juveniles
2013-2015

Spawn (eggs):
2011

Fry emergence:
2012

Freshwater

Ocean

Meg Anderson
Alaska State Parks
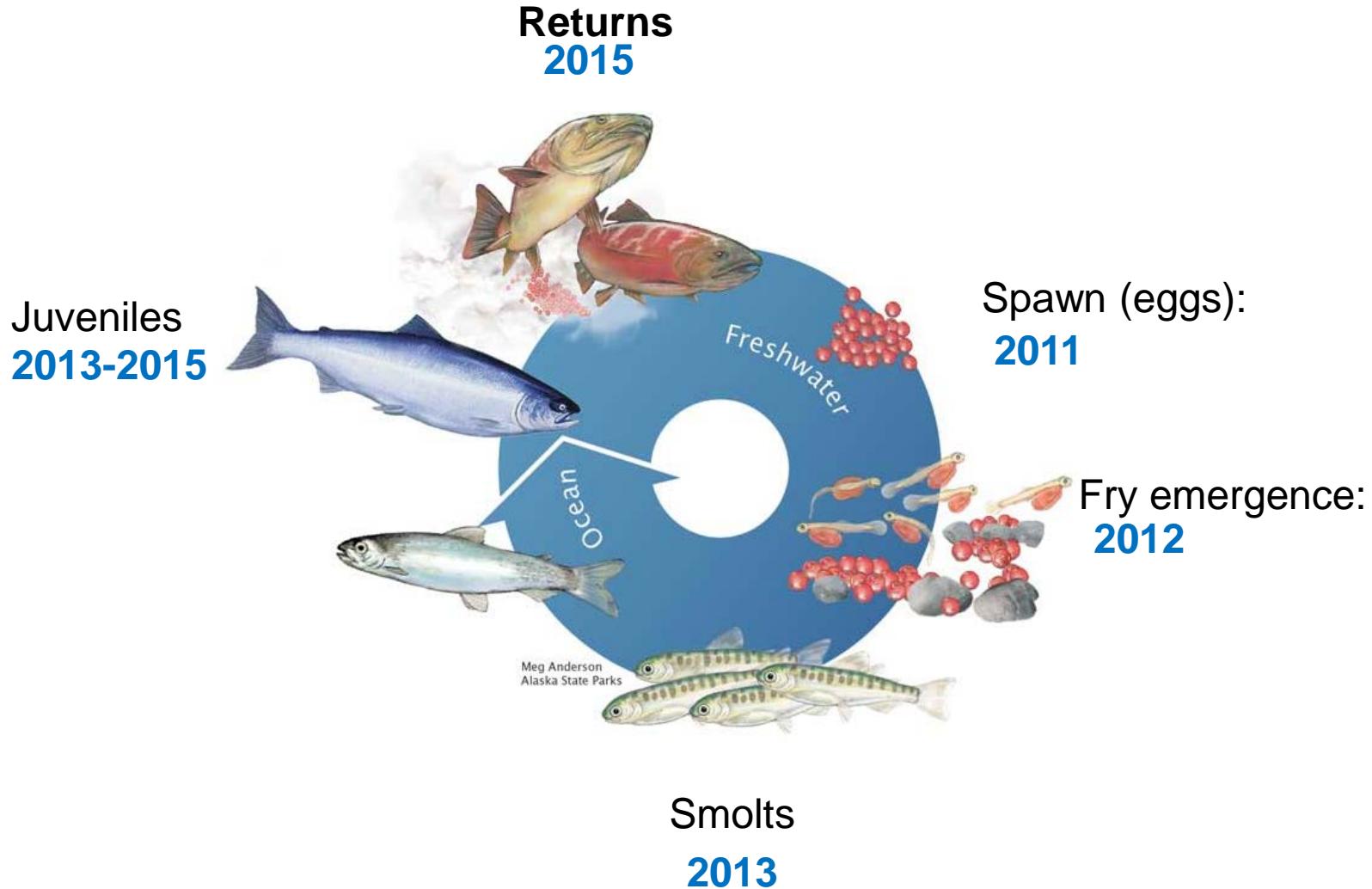
Smolts
2013

Four Year Old Brood Year

Four Year Old Brood Year

effective female spawners

smolts

Run timing group Stocks	2011 Brood Year (Age-4)
Early Stuart	200
Early Summer	
Bowron	2,000
Fennell	4,500
Gates	26,400
Nadina	1,200
Pitt	30,400
Scotch	12,500
Seymour	8,000
Summer	
Chilko [j]	44.2 M
Late Stuart	800
Quesnel	17,000
Stellako	26,000
Raft	4,400
Harrison	387,100
Late	
Cultus	119,800
Late Shuswap	46000
Portage	300
Weaver	24,500
Birkenhead	92,400

Chilko: 40%

Harrison: 34%

74%

Birkenhead **8%**

16

Four Year Old

Run timing group / Stocks	2011 Brood Year (Age-4)
Early Stuart	
Early Stuart	200
Early Summer	
Bowron	2,000
Fennell	4,500
Gates	26,400
Nadina	1,200
Pitt	30,400
Scotch	12,500
Seymour	8,000
Summer	
Chilko [j]	44.2 M
Late Stuart	800
Quesnel	17,000
Stellako	26,000
Raft	4,400
Harrison	387,100
Late	
Cultus	119,800
Late Shuswap	46000
Portage	300
Weaver	24,500
Birkenhead	92,400

Five Year Old (Harrison-Three)

Run timing group / Stocks	2010 Brood Year (Age-4)
Early Stuart	
Early Stuart	34,200
Early Summer	
Bowron	4,400
Fennell	5,500
Gates	5,900
Nadina	11,900
Pitt	8,800
Scotch	273,900
Seymour	284,500
Summer	127,367
Chilko [j]	54.9 M
Late Stuart	43,500
Quesnel	133,000
Stellako	110,300
Raft	2,400
Harrison	32,900
Late	
Cultus	318,400
Late Shuswap	3.1 M
Portage	26,700
Weaver	25,300
Birkenhead	67,800

Left labels (red): Early Stuart, Bowron, Nadina, Seymour, Late Stuart, Stellako, Cultus, Late Shuswap, Portage

Right labels (green): Early Stuart, Bowron, Nadina, Scotch, Seymour, Late Stuart, Quesnel, Stellako, Cultus, Late Shuswap

Fraser Sockeye Forecasts

Pre-season

forecasts distributions are used to frame out the range of fishing opportunities over different stock survival conditions

in-season

Forecast distributions are used as Bayesian priors for in-season run size estimation models. Diminishing influence as more stock-specific in-season data become available

Run timing group Stocks	Forecast Model [b]
Early Stuart	*Ricker (Ei)*
Early Summer	
(total excluding miscellaneous)	
Bowron	*MRS*
Fennell	*power*
*Gates	*Larkin*
Nadina	*MRJ*
Pitt	*Larkin*
*Scotch	*Ricker*
*Seymour	*Ricker*
Summer	
(total excluding miscellaneous)	
Chilko [g]	*power (juv) (Pi)*
Late Stuart	*power*
Quesnel	*Ricker-cyc*
Stellako	*Larkin*
Raft [h]	*Ricker (PDO)*
***Harrison [h & j]	*Adjusted RS1*
Late	
(total exlcuding miscellaneous)	
Cultus [g]	*MRJ*
*Late Shuswap	*Ricker-cyc*
*Portage	*Larkin*
Weaver	*MRS*
xxBirkenhead	*4-Ricker (Ei); 5-sibling*

19

Forecast Models
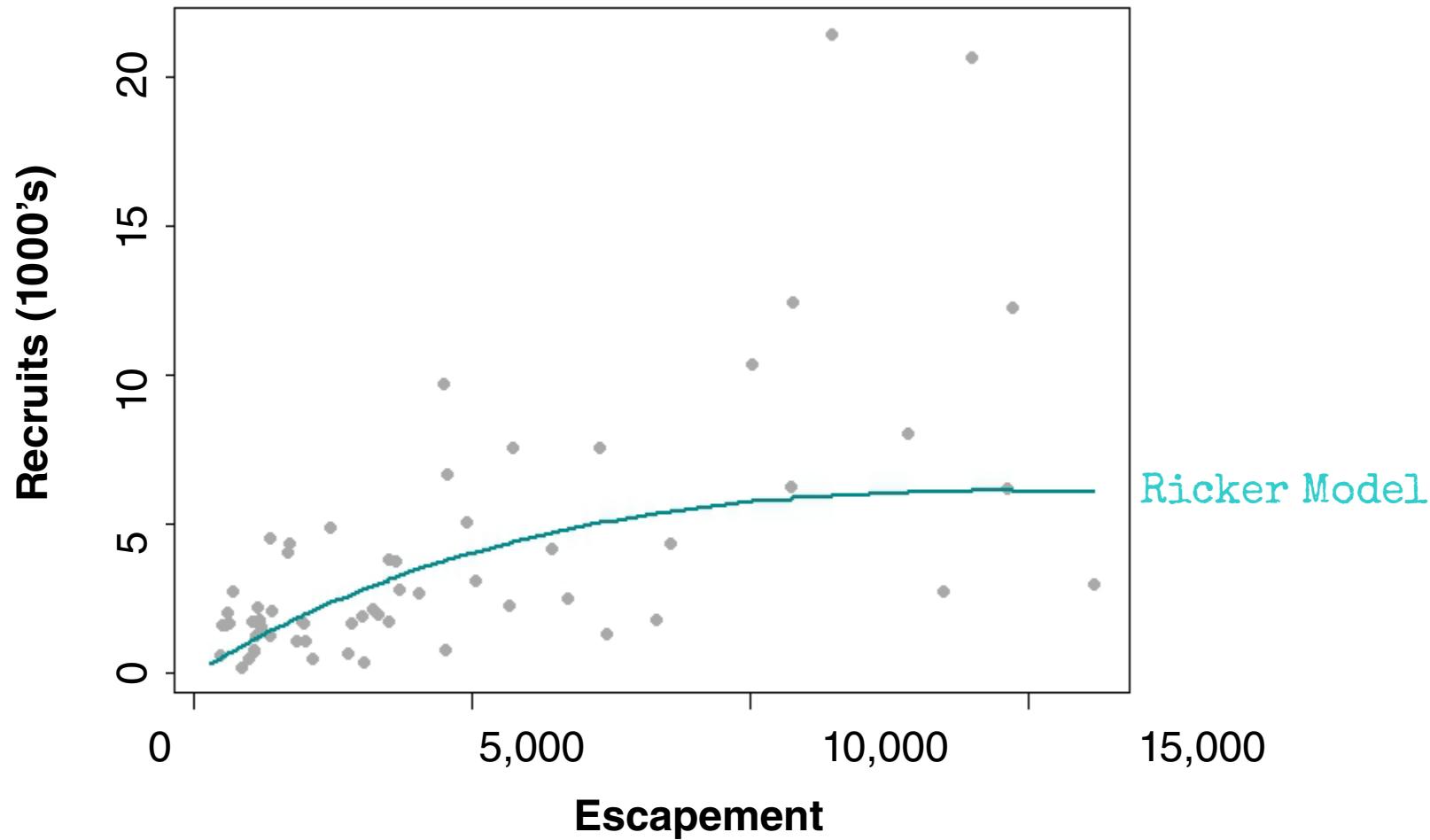
Forecasts are probability distributions

Stock	25%	50%	75%
Hypothetical	48,000	75,000	98,000

Cumulative Probability (Percent) of Smaller Run Sizes

75% Probability
50% Probability
25% Probability

Uncertainty

Total Return Size

2015 Fraser Sockeye Forecasts

10% 25%   50%   75%   90%

2.4 M 3.9 M   7 M   12.9 M   24 M

Early Stuart

0   5,000,000   10,000,000   15,000,000
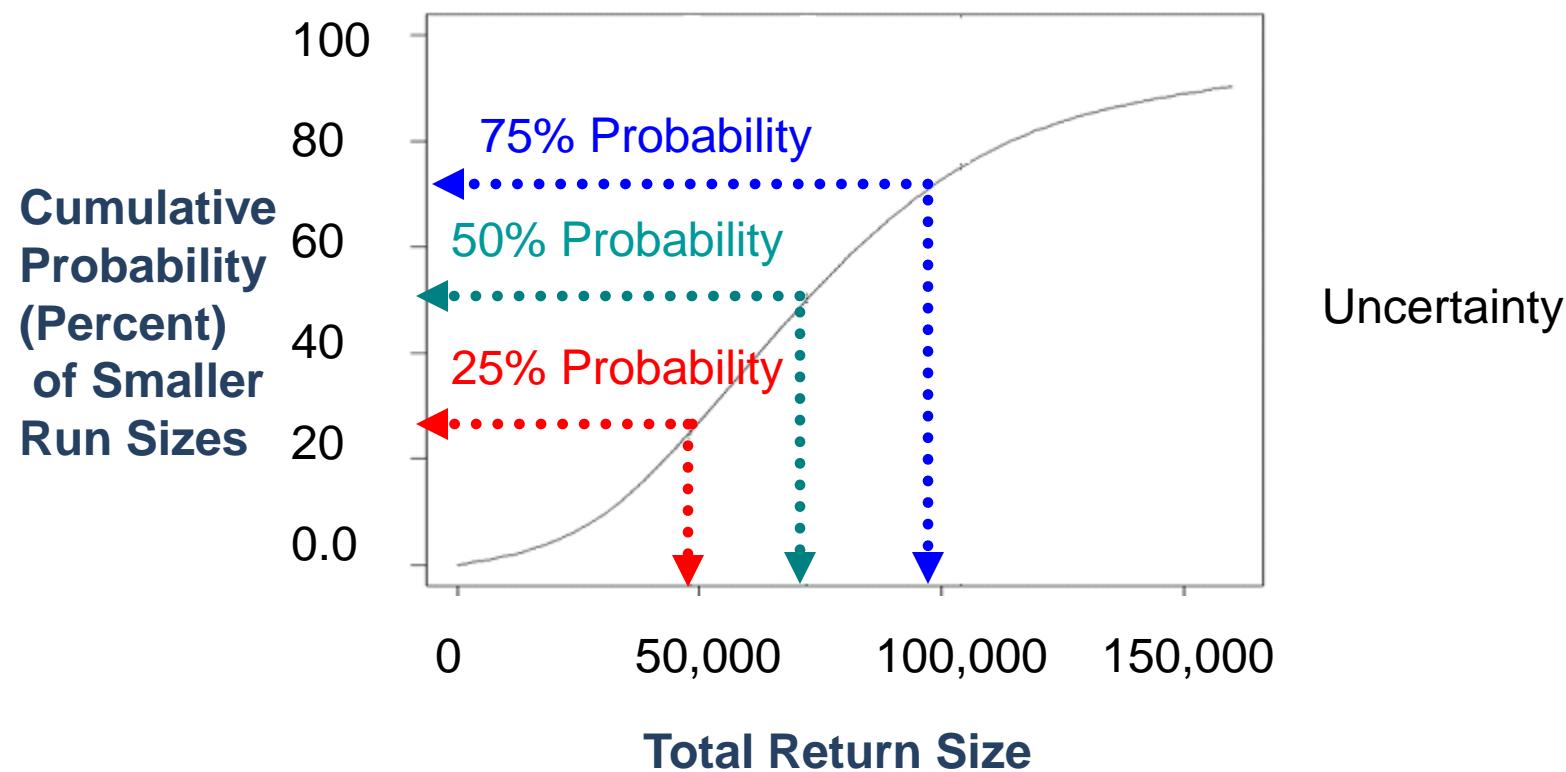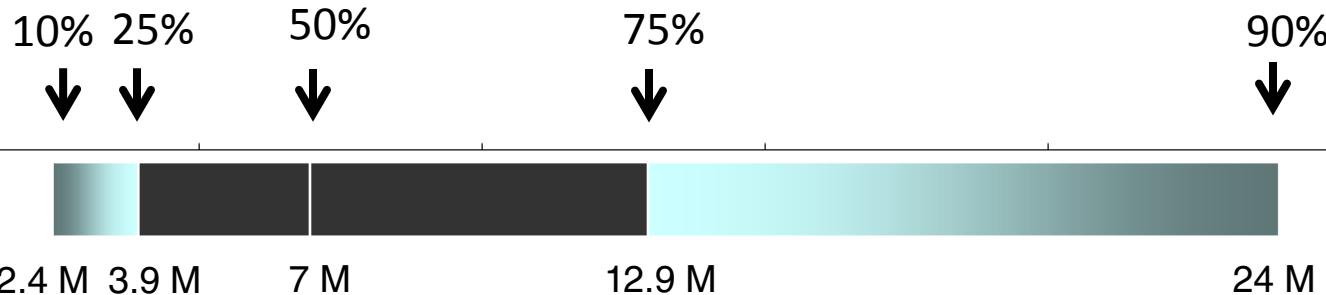
8 K – 108 K
(<1% of total forecast)
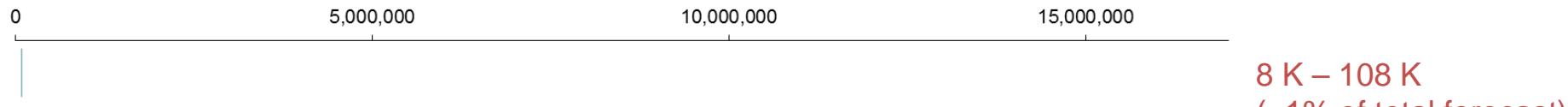
Early Summer   Scotch: 2%   Seymour: 2%

0   5,000,000   10,000,000   15,000,000

236 K – 3.0 M
(12% of total forecast)
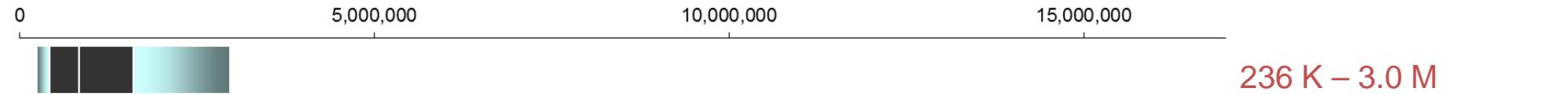
Summer   Chilko: 35%   Harrison: 20%   Stellako: 6%   Quesnel: 5%

0   5,000,000   10,000,000   15,000,000

1.7 M – 16.5 M
(69% of total forecast)

Late

0   5,000,000   10,000,000   15,000,000

489 K – 4.5 M
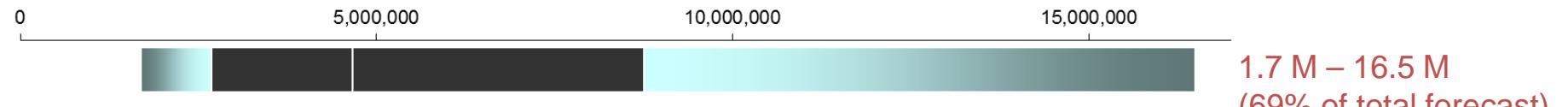
Late Shuswap: 7%   Birkenhd: 7% Weaver: 5% (18% of total forecast)

Harrison Sockeye

Harrison (uncertain forecast)

Return Abundances vs. year (1952–2014)

2005-2014 average: 600,000

1952-2004 average: 30,000
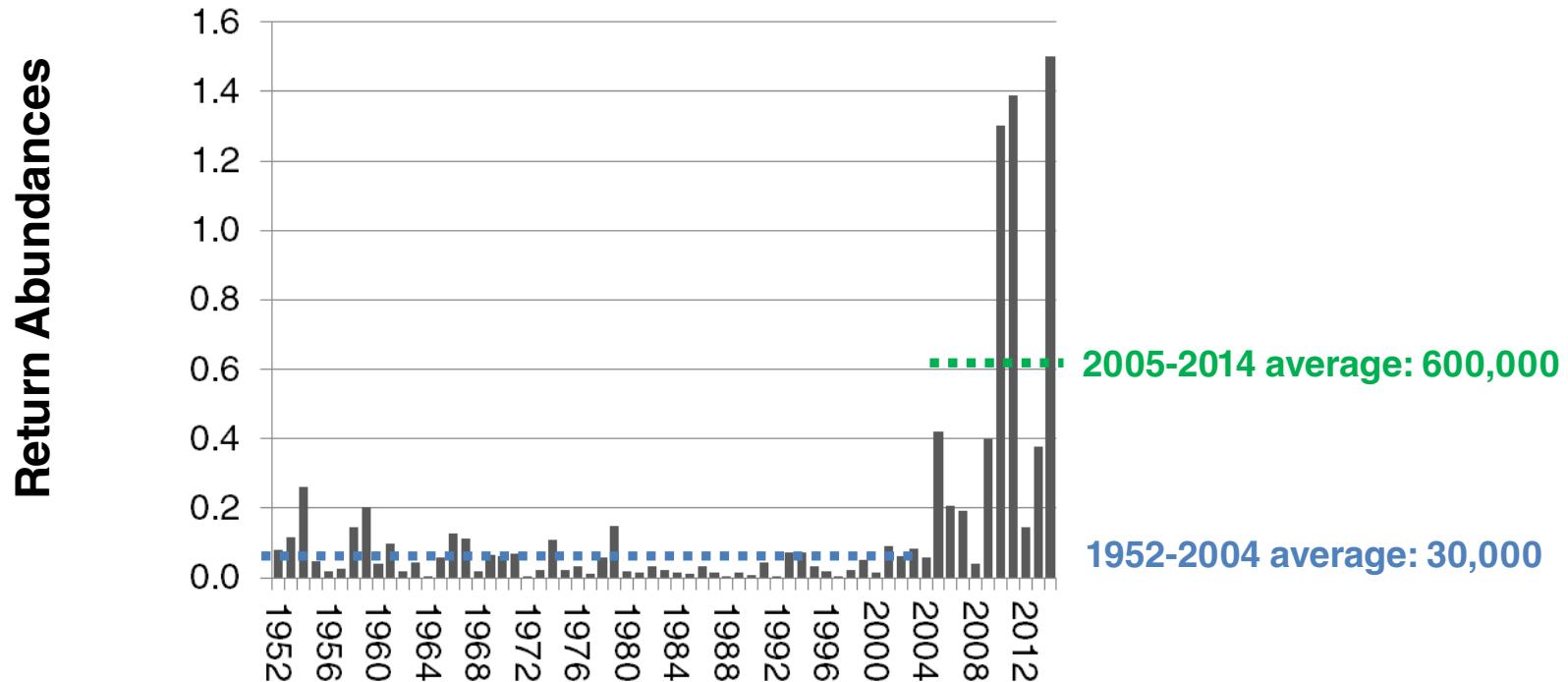
Sibling Models

Chilko

Log$_e$4 year old recruits

$$y = 0.3494x + 2.1022$$
$$R^2 = 0.3441$$

(Y-axis label: **Log$_e$3 year old recruits**)
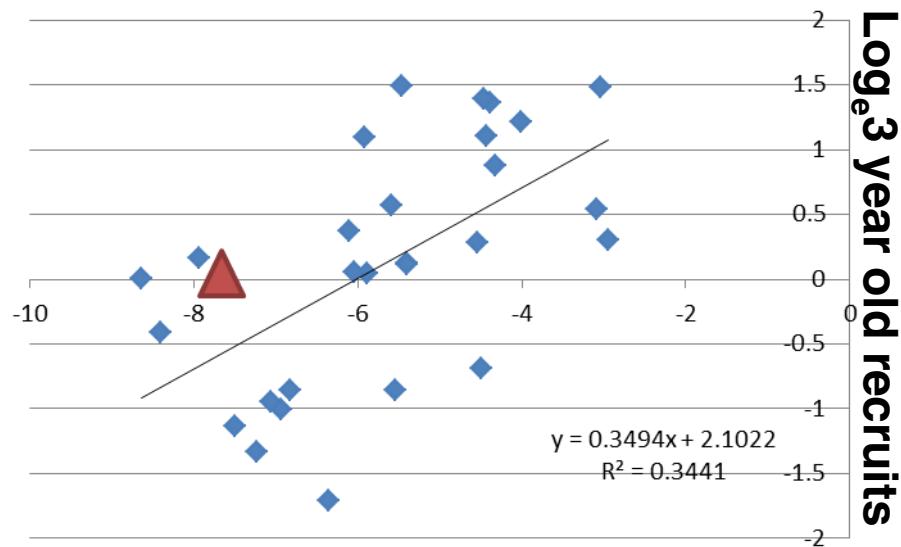
Sibling four year old forecast

(used three year olds (jacks) from 2014 returns as predictor variable)

50% p-level five year old forecast

Power(juv)-Pi   2.4 M
Sibling   1.2 M

Brood Year Escapements

Four Year Olds

Run timing group Stocks	2011 Brood Year (Age-4)
Early Stuart	200
Early Summer	
Bowron	2,000
Fennell	4,500
Gates	26,400
Nadina	1,200
Pitt	30,400
Scotch	12,500
Seymour	8,000
Summer	
Chilko [j]	44.2 M
Late Stuart	800
Quesnel	17,000
Stellako	26,000
Raft	4,400
Harrison	387,100
Late	
Cultus	119,800
Late Shuswap	46000
Portage	300
Weaver	24,500
Birkenhead	92,400

Five Year Olds

Run timing group Stocks	2010 Brood Year (Age-5)
Early Stuart	34,200
Early Summer	
Bowron	4,400
Fennell	5,500
Gates	5,900
Nadina	11,900
Pitt	8,800
Scotch	273,900
Seymour	284,500
Summer	
Chilko [j]	54.9 M
Late Stuart	43,500
Quesnel	133,000
Stellako	110,300
Raft	2,400
Harrison	399,700
Late	
Cultus	318,400
Late Shuswap	3.1 M
Portage	26,700
Weaver	25,300
Birkenhead	67,800

	Percent 5-yr olds returns	5 yr old returns
Early Stuart	95%	(29,000)
Bowron	35%	(8,000)
Nadina	78%	(24,000)
Pitt	63%	(50,000)
Scotch	18%	(33,000)
Seymour	31%	(44,000)
Chilko	11%	(265,000)
Late Stuart	52%	(28,000)
Quesnel	56%	(207,000)
Stellako	52%	(204,000)
Late Shuswap	32%	(167,000)
Portage	37%	(3,000)

Late Stuart: productivity

	Brood Year EFS	4 yr Rec Forecasts	Productivity (4 yr R/EFS)	
ACTUAL	778	17,000	22	**Green > 18**
Half	389	10,000	26	
Quarter	195	7,000	36	
Double	1,556	28,000	18	
6x	5,000	61,000	12	**Amber: >4 & <= 18**
13x	10,000	99,000	10	

GeoAvg: 12K   **Avg: 9K**
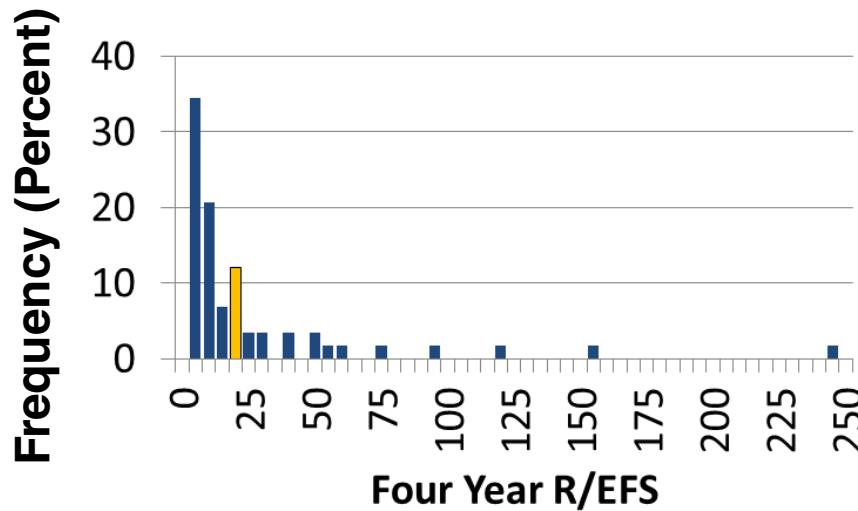
Run timing group	Probability that Return will be at/or Below Specified Run Size [a]				
Stocks	10%	25%	50%	75%	90%
Early Stuart	**8,000**	**16,000**	**30,000**	**58,000**	**108,000**
Early Summer	**236,000**	**424,000**	**837,000**	**1,603,000**	**2,963,000**
(total excluding miscellaneous	*192,000*	*325,000*	*624,000*	*1,256,000*	*2,342,000*
Bowron	6,000	11,000	21,000	40,000	72,000
Fennell	10,000	16,000	27,000	47,000	78,000
Gates	46,000	79,000	141,000	280,000	502,000
Nadina	8,000	15,000	31,000	65,000	126,000
Pitt	33,000	51,000	79,000	120,000	190,000
Scotch	48,000	85,000	185,000	430,000	845,000
Seymour	41,000	68,000	140,000	274,000	529,000
Misc (Early Shuswp)	33,000	74,000	164,000	258,000	459,000
Misc (Taseko)	1,000	2,000	4,000	7,000	9,000
Misc (Chilliwack) [f]	4,000	9,000	18,000	33,000	61,000
Misc (Nahatlatch) [f]	6,000	14,000	27,000	49,000	92,000
Summer	**1,701,000**	**2,681,000**	**4,675,000**	**8,764,000**	**16,511,000**
(total excluding miscellaneous	*1,693,000*	*2,666,000*	*4,648,000*	*8,710,000*	*16,406,000*
Chilko [g]	1,117,000	1,587,000	2,387,000	3,813,000	5,972,000
Late Stuart	12,000	25,000	54,000	118,000	245,000
Quesnel	108,000	197,000	367,000	684,000	1,421,000
Stellako	186,000	261,000	390,000	552,000	823,000
Raft [h]	15,000	23,000	36,000	56,000	87,000
**Harrison [h & i]	255,000	573,000	1,414,000	3,487,000	7,858,000
Misc (N. Thomp. Tribs) [h & j]	1,000	2,000	3,000	7,000	14,000
Misc (N. Thomp River) [h & j]	5,000	10,000	18,000	37,000	74,000
Misc (Widgeon) [k]	2,000	3,000	6,000	10,000	17,000
Late	**419,000**	**703,000**	**1,236,000**	**2,210,000**	**3,998,000**
(total exlcuding miscellaneous	*400,000*	*671,000*	*1,176,000*	*2,103,000*	*3,809,000*
Cultus [g]	1,000	3,000	6,000	12,000	22,000
**Late Shuswap	168,000	293,000	517,000	924,000	1,758,000
Portage	1,000	3,000	8,000	19,000	55,000
Weaver	110,000	189,000	346,000	635,000	1,095,000
xxBirkenhead	120,000	183,000	299,000	513,000	879,000
Misc non-Shuswap [k]	19,000	32,000	60,000	107,000	189,000
TOTAL SOCKEYE SALMON	**2,364,000**	**3,824,000**	**6,778,000**	**12,635,000**	**23,580,000**
(TOTAL excluding miscellane	*2,293,000*	*3,678,000*	*6,478,000*	*12,127,000*	*22,665,000*

(10% p-level) (25% p-level) (50% p-level) (75% p-level) (90% p-level)

90% p-level

50% p-level

10% p-level
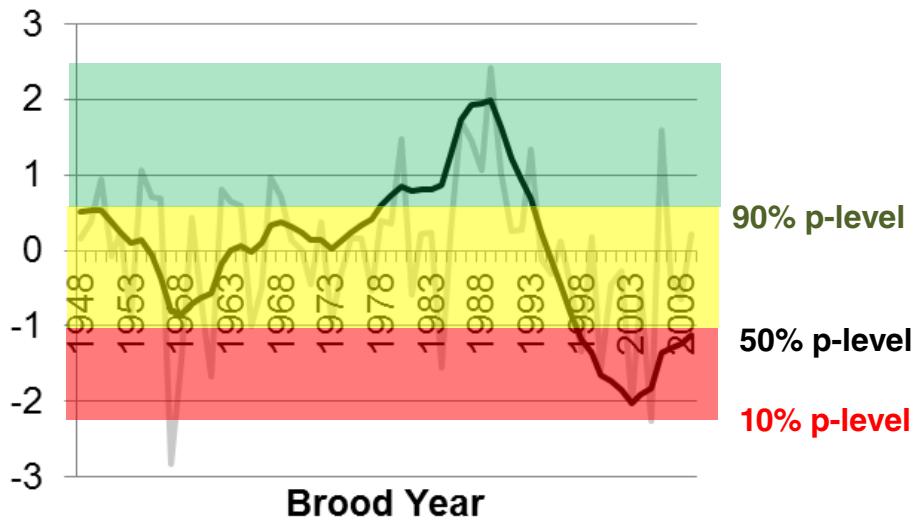
Survival Overview

Most Fraser Sockeye Return as Four Year Olds

Marine
2 Winters

May-June 2013

June-October 2013

First Winter 2014

Second Winter 2015

July-Oct 2015
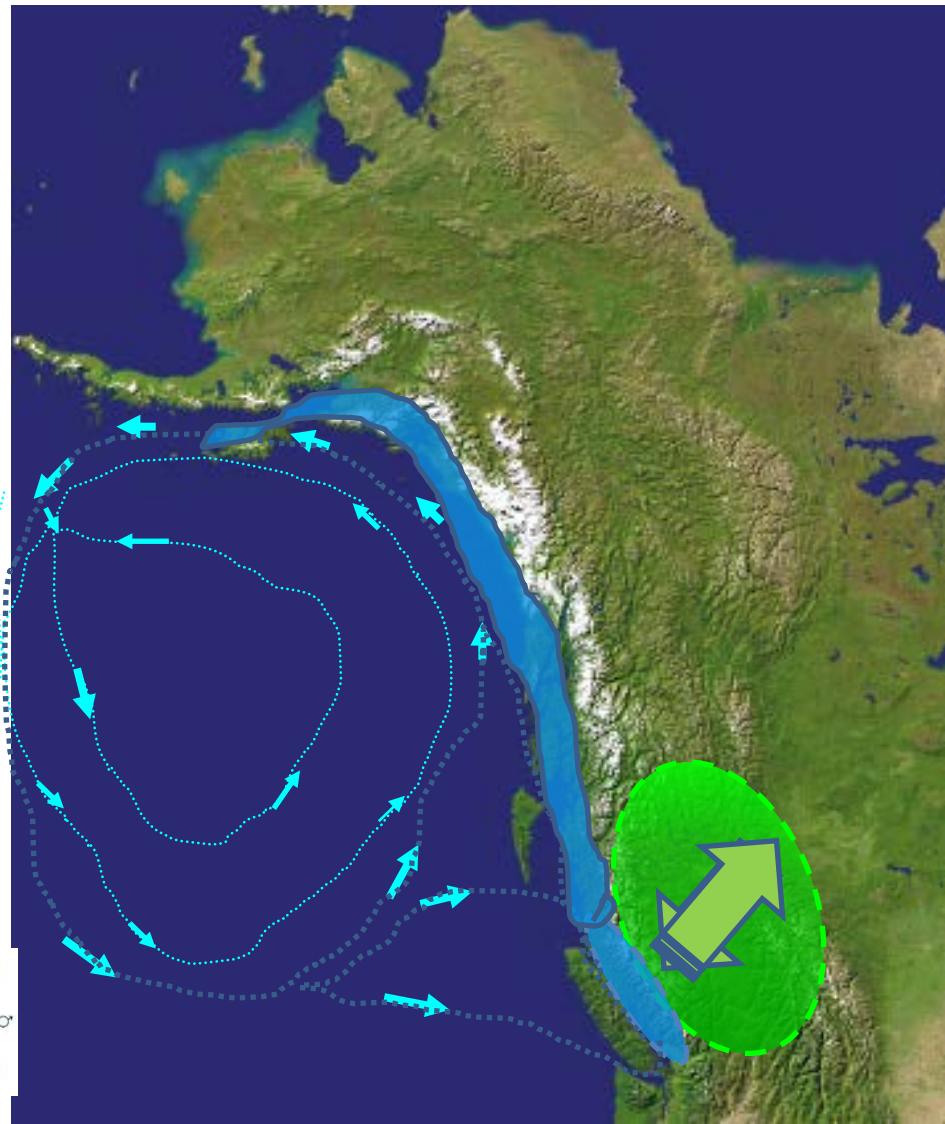
Freshwater
**2 Winters**

Brood Year
July-Oct 2011

April-May 2012

April-May 2013

Spawning Ground Escapements
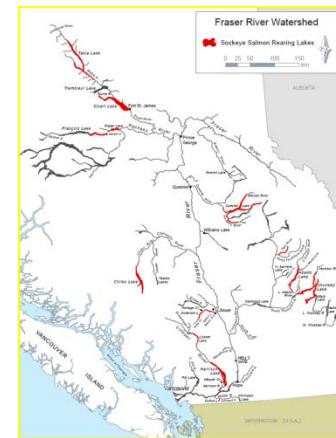
Mission Smolts

Aerial image of the sampling site near Mission, BC, outlining the location of the sampling Bays used in the lower Fraser River juvenile sockeye salmon assessment project. (image: Google Earth).

Strait of Georgia Juveniles
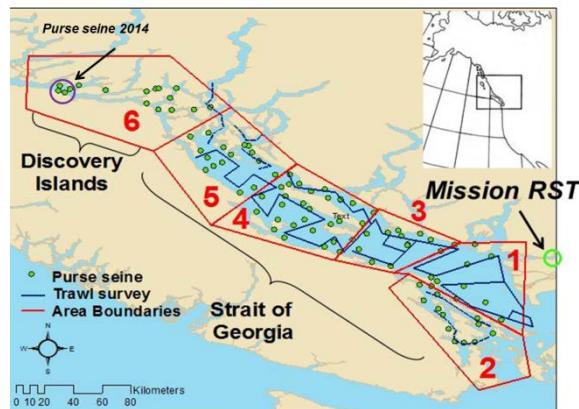
Preliminary Proportions
(Does not include Harrison: unique life-history and ocean distribution)

Legend:
- Effective Female Escapement
- Mission Smolts
- SOG Juveniles
- Four Year Old Forecasts

Categories (x-axis): Chilko, Late Shuswap, Early Shuswap, Weaver, Birkenhead, Stellako, Quesnel, Gates
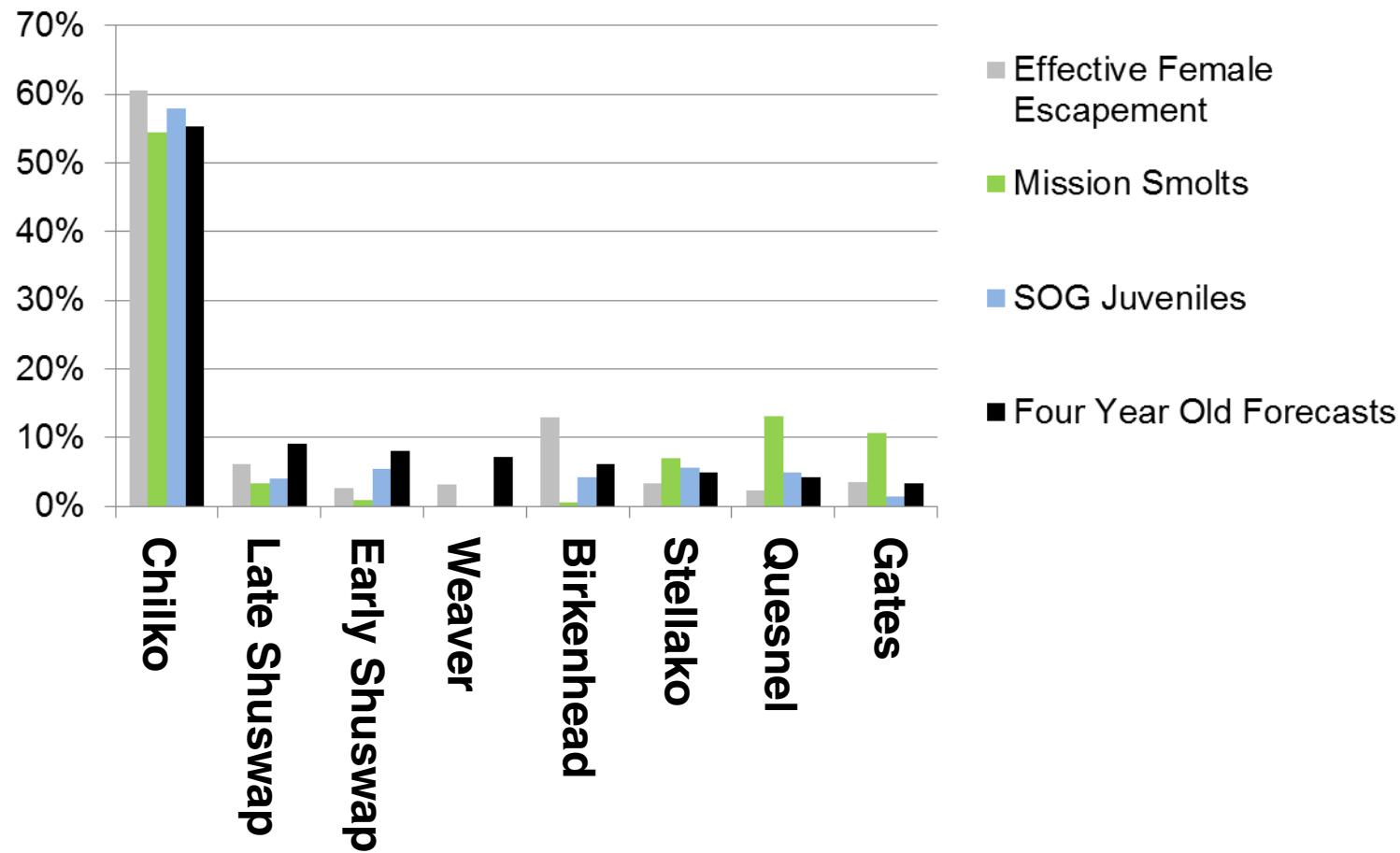
Only n=15 in QSC (Trudel surveys in 2013)

Preliminary Proportions
(Does not include Harrison: unique life-history and ocean distribution)

Legend:
- Effective Female Escapement
- SOG Juveniles
- Four Year Old Forecasts

Categories: Chilko, Late Shuswap, Early Shuswap, Weaver, Birkenhead, Stellako, Quesnel, Gates
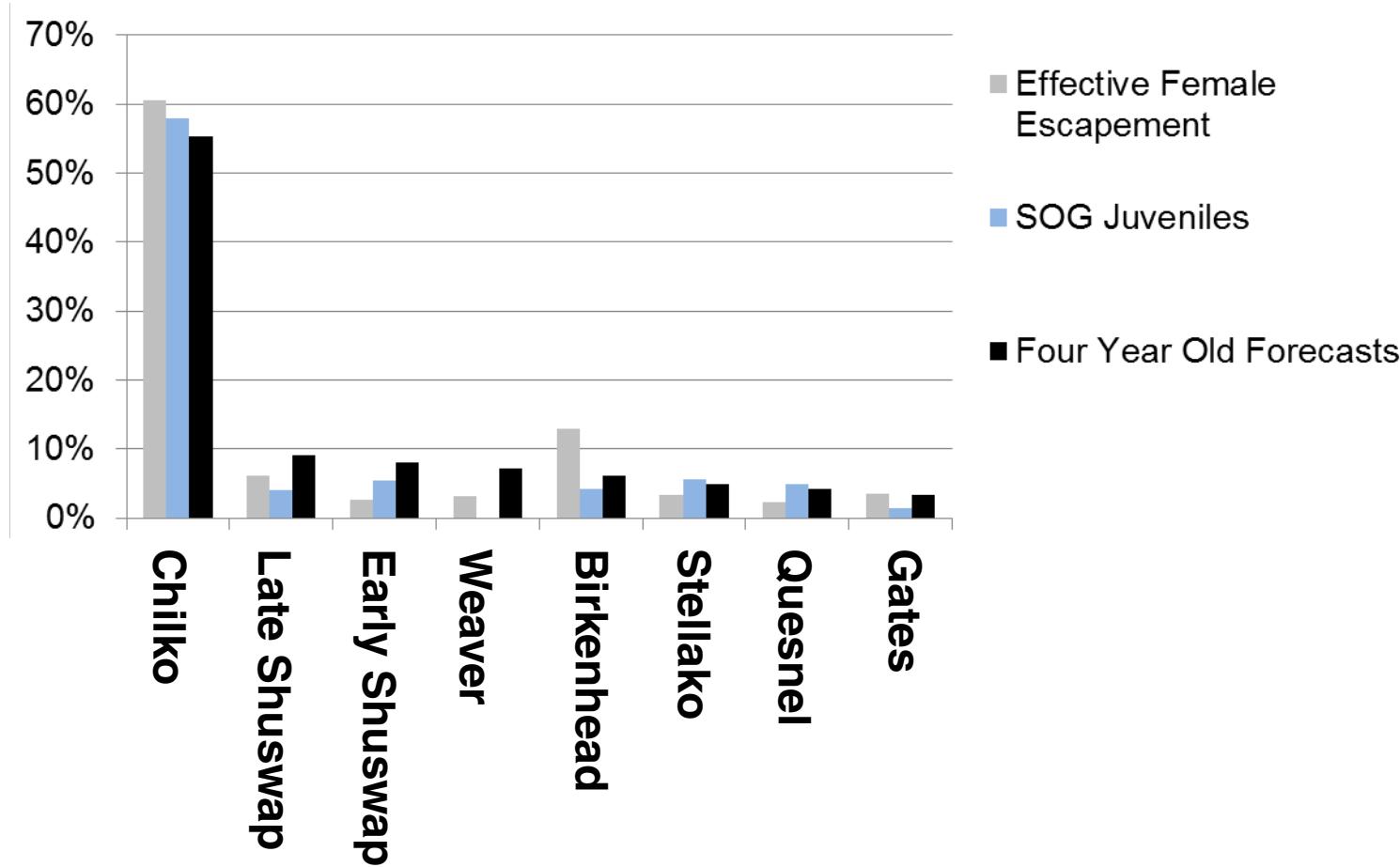
Ocean Conditions

**State of the Ocean
DFO Tech Report 3102
Editor: Ian Perry**

Monthly sea surface temperature anomalies (Argo data), 2013
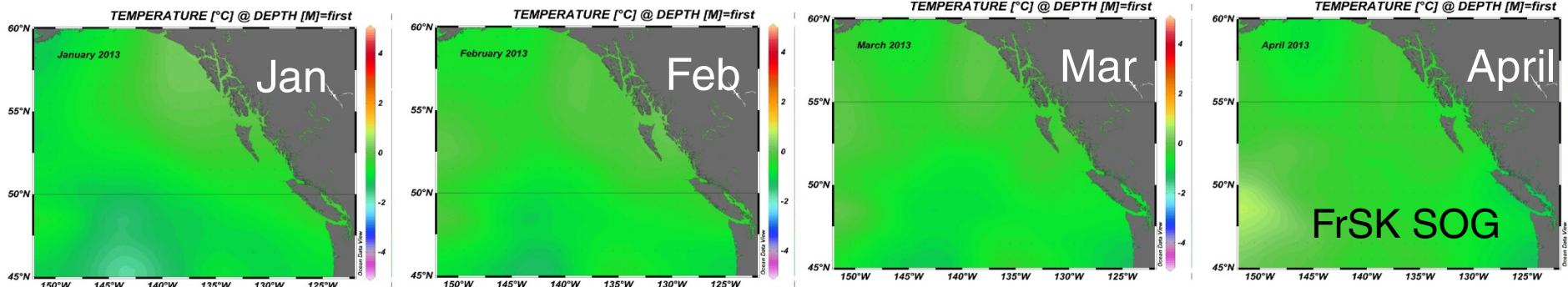
Returns in 2015 start ocean migration (May-July)

Jan | Feb | Mar | April

FrSK SOG

May | June | July | Aug

FrSK SOG | FrSK SOG/Shelf | Shelf | Shelf

Sep | Oct | Nov | Dec

Shelf/GOA | Shelf/GOA | Shelf/GOA | Shelf/GOA (1st winter at sea)
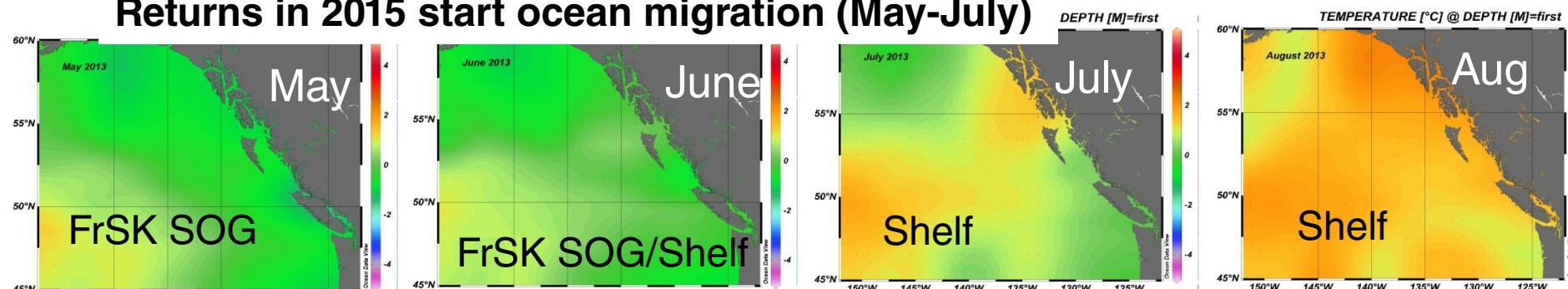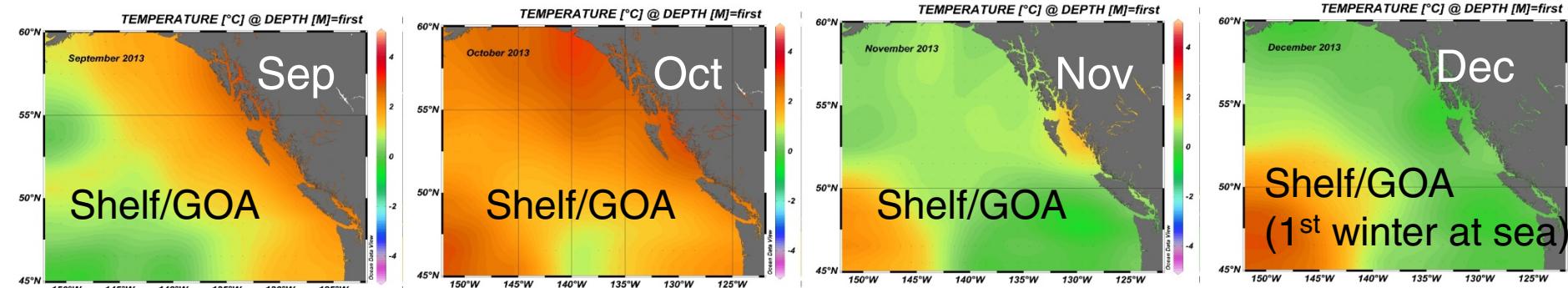
Base Period: 2000-present
Prepared by I. Perry, DFO, for supplement meeting 2015

Monthly sea surface temperature anomalies (Argo data), 2014

Land & Ocean Temperature Percentiles Sep 2014–Nov 2014
NOAA's National Climatic Data Center
Data Source: GHCN–M version 3.2.2 & ERSST version 3b

| Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest |

Fri Dec 12 08:16:58 EST 2014
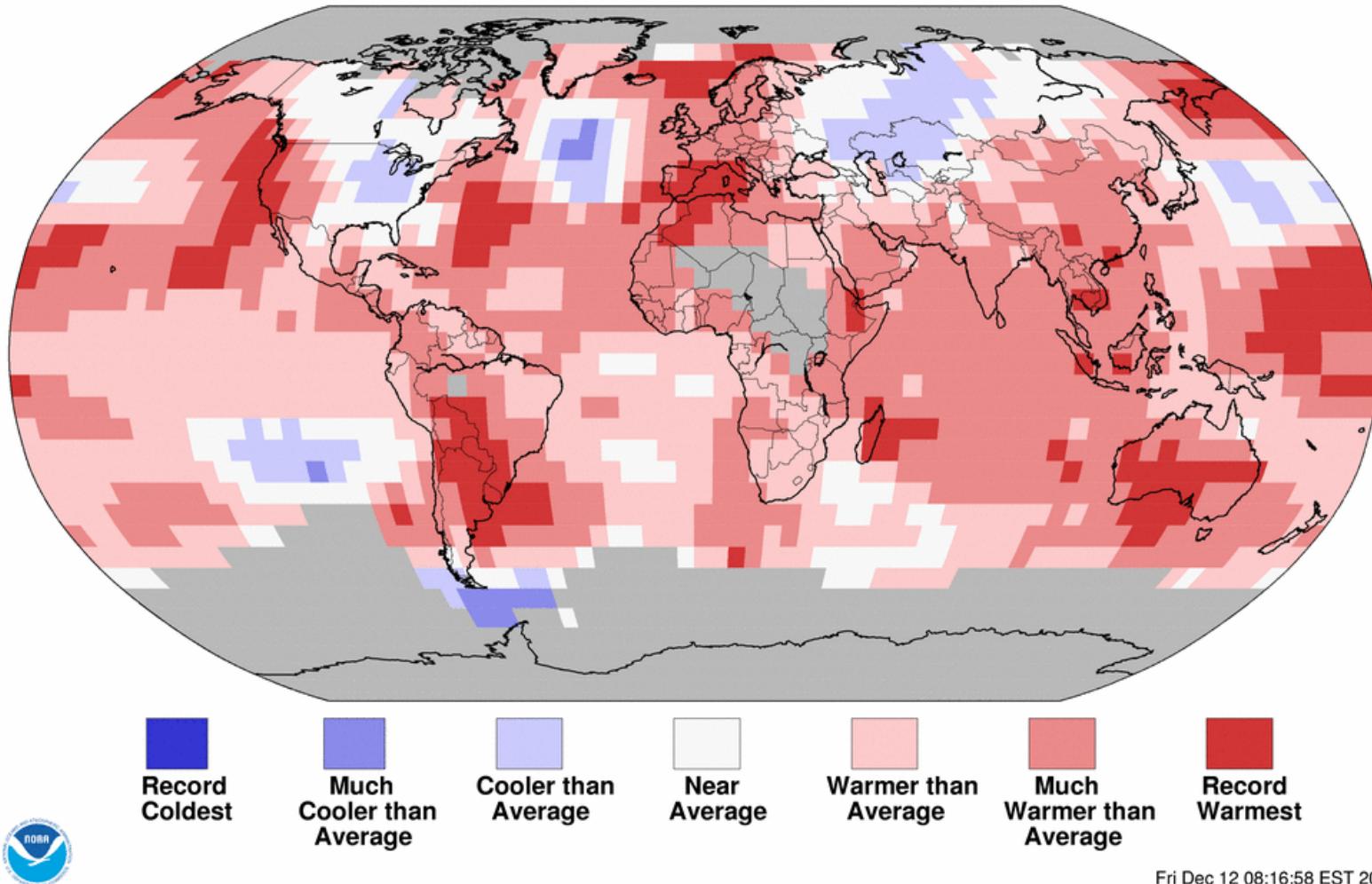
1981-2010 base period

source: www.ncdc.noaa.gov/sotc/

Prepared by I. Perry, DFO, for supplement meeting 2015

Fisheries and Oceans Canada   Pêches et Océans Canada
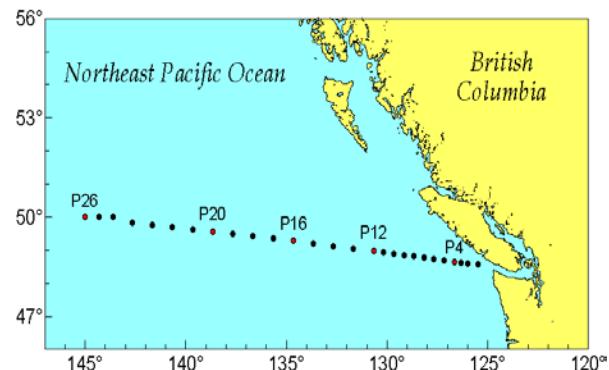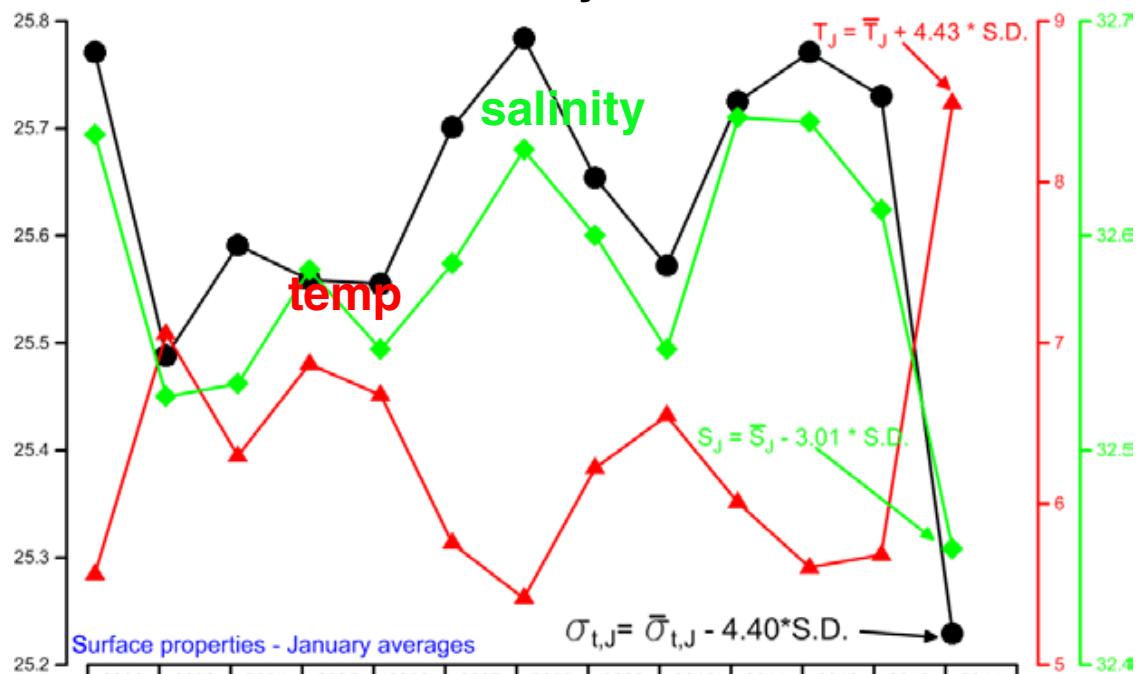
Surface properties:

- Averaged over January at Ocean Station Papa;

- Shows low variability from 2002 to 2013;

- Huge change in January 2014; surface water with very low density has reduced vertical mixing, and reduced resupply of nutrients;

Prepared by I. Perry, DFO, for supplement meeting 2015
From Can. Tech. Rep. Fish. Aquat. Sci. 3102

Fisheries and Oceans Canada Pêches et Océans Canada

Potential consequences of reduced vertical mixing in NE Pacific on Chlorophyll (representing the base of the food web)
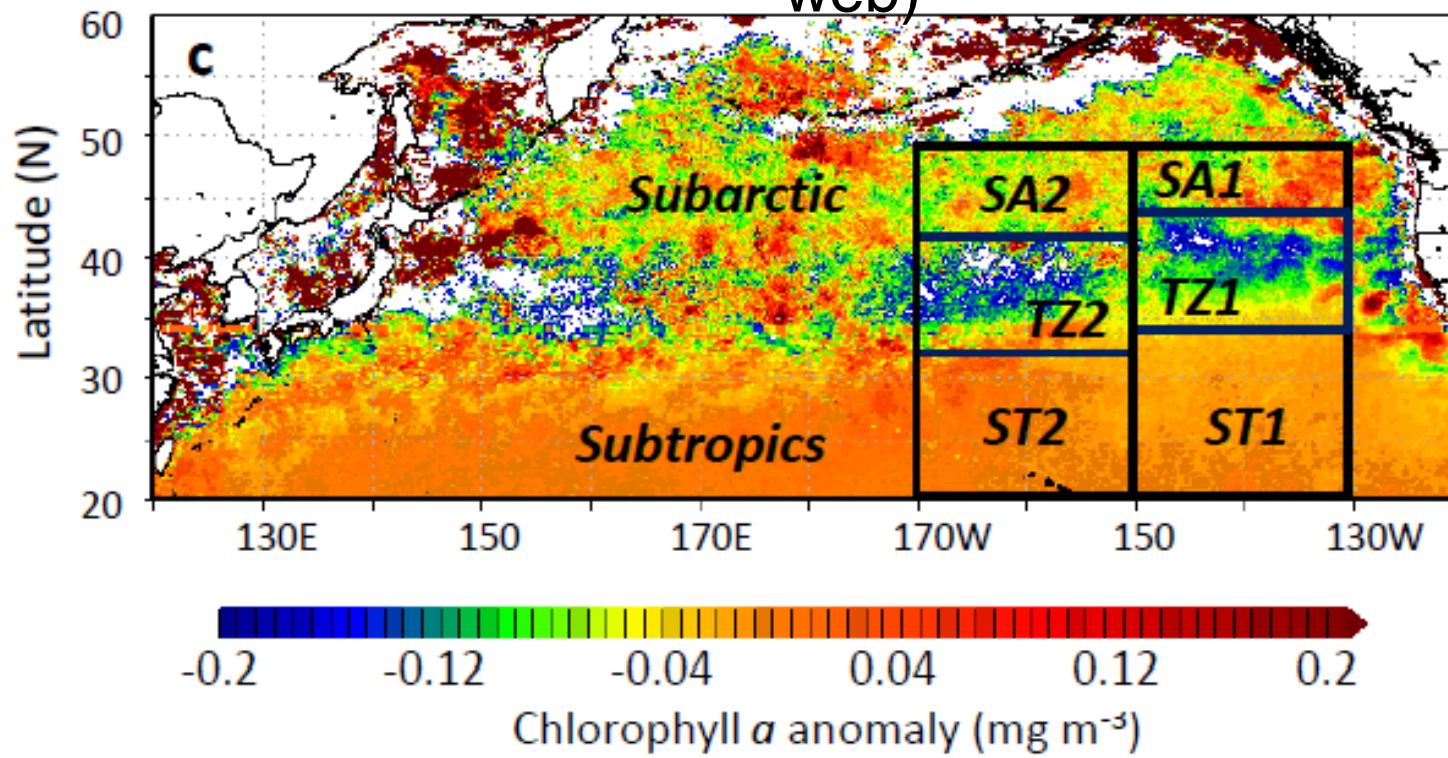
Chlorophyll *a* anomaly for Jan-May 2014, over the subtropical and subarctic North Pacific . Shows unusually low chlorophyll in the Transition Zone region (TZ1, TZ2). This low chlorophyll anomaly progressed north into the Subarctic Pacific by June 2014

Prepared by I. Perry, DFO, for supplement meeting 2015
From F. Whitney. Geophys. Res. Letters (in press)

Zooplankton on WCVI, 2013 biomass anomalies
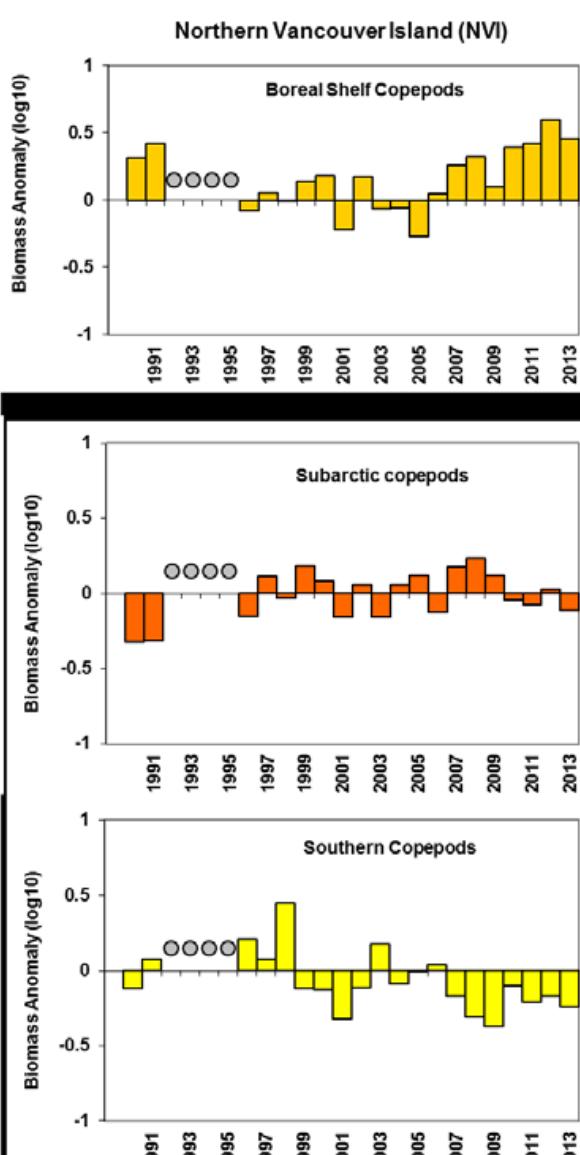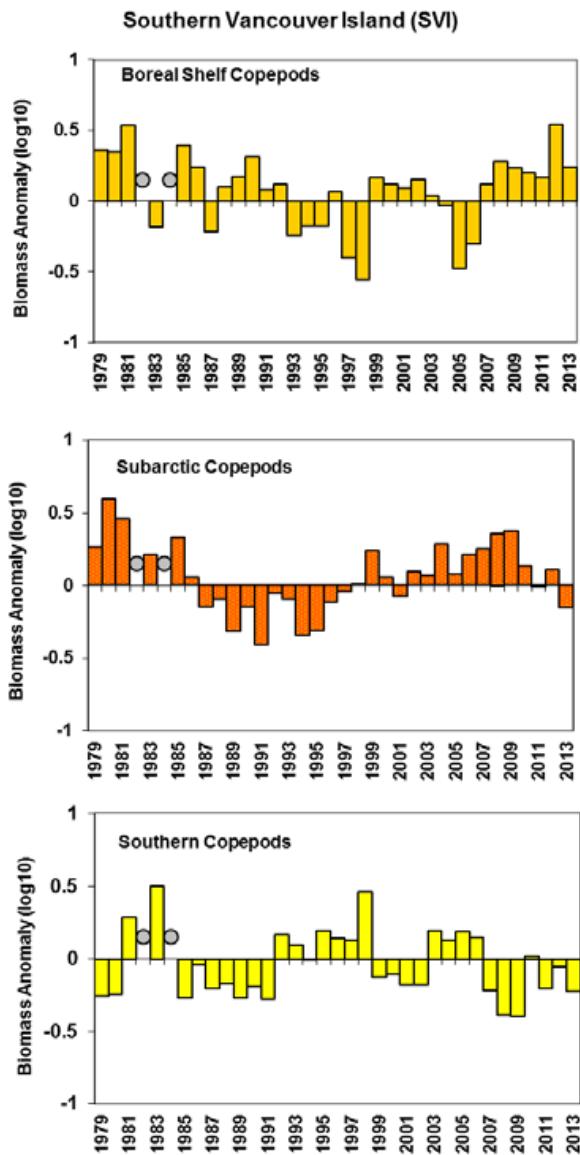
Greater abundances of warm water zooplankton in summer and fall 2013 than earlier in the year

Galbraith et al. 2014. Can. Tech. Rep. Fish. Aquat. Sci. 3102: 52.
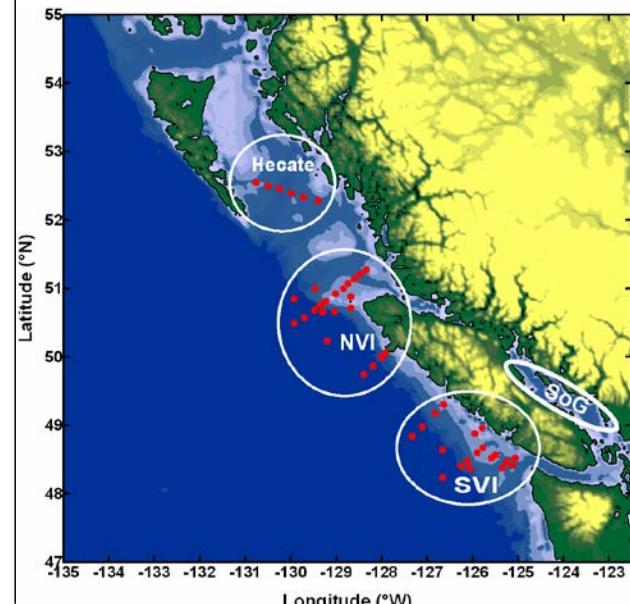
Prepared by I. Perry, DFO, for supplement meeting 2015
From M.Galbraith. In Perry (Ed). Can. Tech. Rep. Fish. Aquat. Sci. 3102: p52

Juvenile Fish Size

Mission Smolts
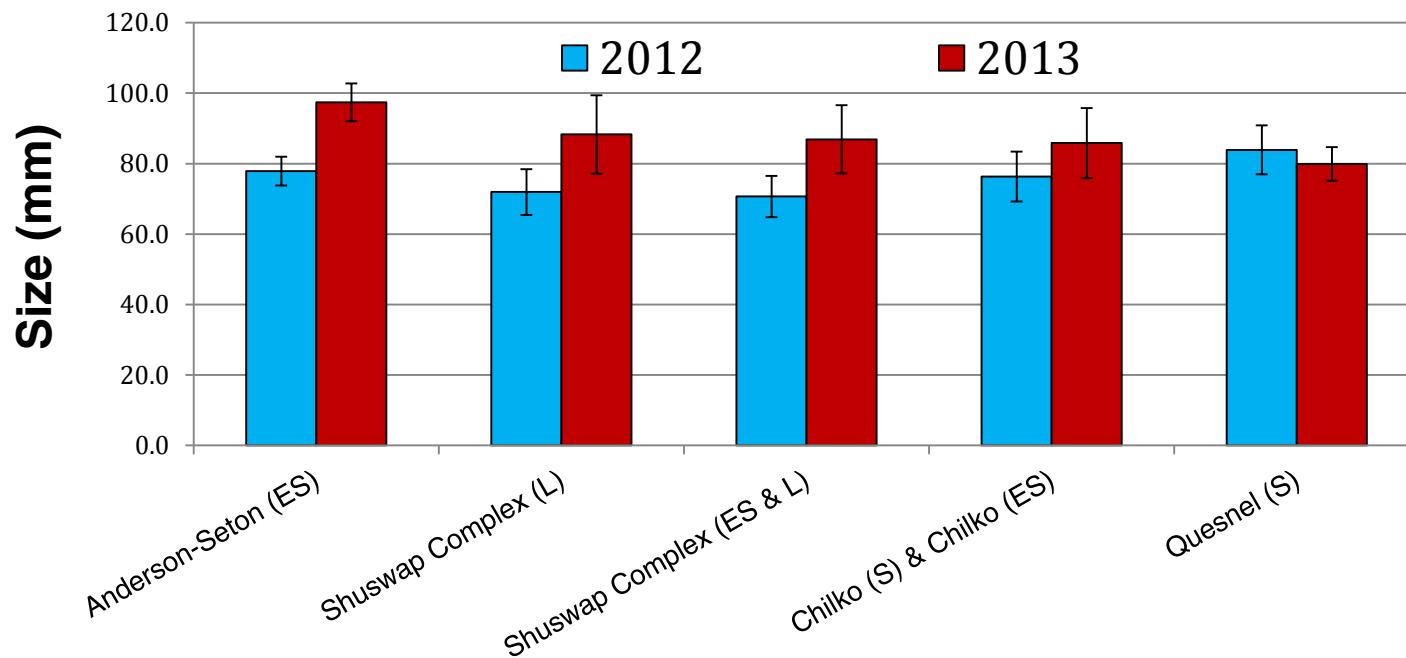
SOG Smolts (late June surveys)

**2012
(2014 Return)**
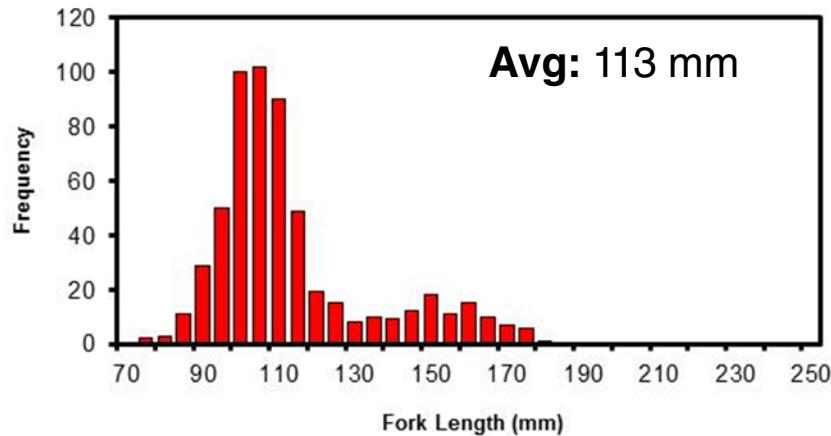
**2013
(2015 Return)**
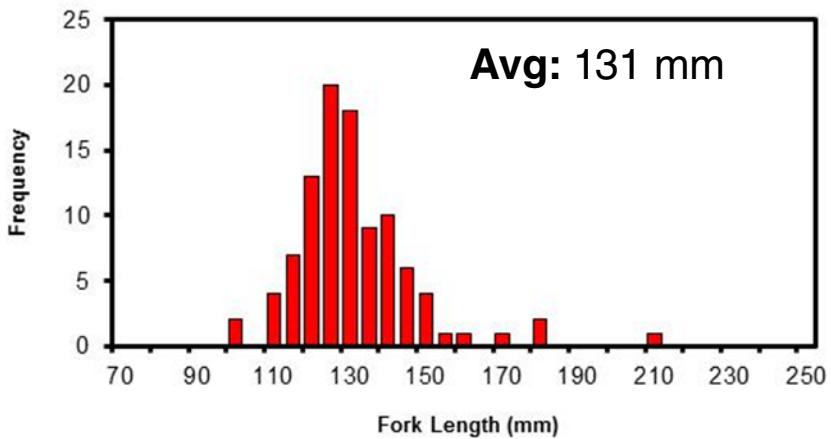
On-going work on forecasts and understanding mechanisms influencing Fraser Sockeye Survival

On-going DFO Fraser Sockeye projects: Fraser Sockeye Supplement that is pulling together information on the Mission smolt program; SOG juvenile salmon surveys; High Seas Salmon Program; Escapement and Catch monitoring; oceanographic research and monitoring, etc.;

Akenhead, Irvine, Hyatt, Johnson, Grant, Michielsens (and many more): Fraser Sockeye survival mechanisms, metadata, and capacity parameters;

Ye, Beamish, Glaser, Grant, Richards, Schnute, Hsieh, Sugihara: Empirical Dynamic Modelling approach applied to Fraser Sockeye forecasts (publication in PNAS);

Martins et al. (Post-Doc collaboration with DFO's Patterson and Bradford): life-history stanza approach to understanding mechanisms influencing Fraser Sockeye survival;

Key Messages

Chilko, Harrison, and Late Shuswap: 63% of the forecasted return

Chilko additional uncertainty: sibling model indicates lower return than forecast

Harrison is particularly uncertain: given exceptional production in 2011, which contributes 90% to total Harrison forecast; very low return of 3 yr olds in 2014

Ocean has been anomalously warm for the past 2 winters: not certain how this will influence survival

For a number of stocks a higher proportion of five year olds is expected Sibling models provide support for the official five year old (or four year old in the case of Cultus) forecast with some exceptions (generally stocks with lower proportion of five year olds expected)

A number of on-going projects to improve our understanding of survival mechanisms for Fraser Sockeye

DFO CSAS Science Response

Contributors: Official Forecast

Bronwyn MacDonald	DFO
Sue Grant	DFO
Mike Lapointe	PSC
Catherine Michielsens	PSC
Bob Conrad	Fraser Panel Technical Committee US
Mike Staley	Fraser Panel Technical Committee CDN
Aaron Dufault	Fraser Panel Technical Committee US
Jamie Scroggie	Fraser Panel Technical Committee CDN

Contributors: Supplement

Sue Grant	DFO
Bronwyn MacDonald	DFO
Keri Benner	DFO
David Patterson/Jayme Hills	DFO
Timber Whitehouse	DFO
Joe Tadey	DFO
Dan Selbie	DFO
Lucas Pon	DFO
Chrys Neville	DFO
Marc Trudel	DFO
Ian Perry	DFO