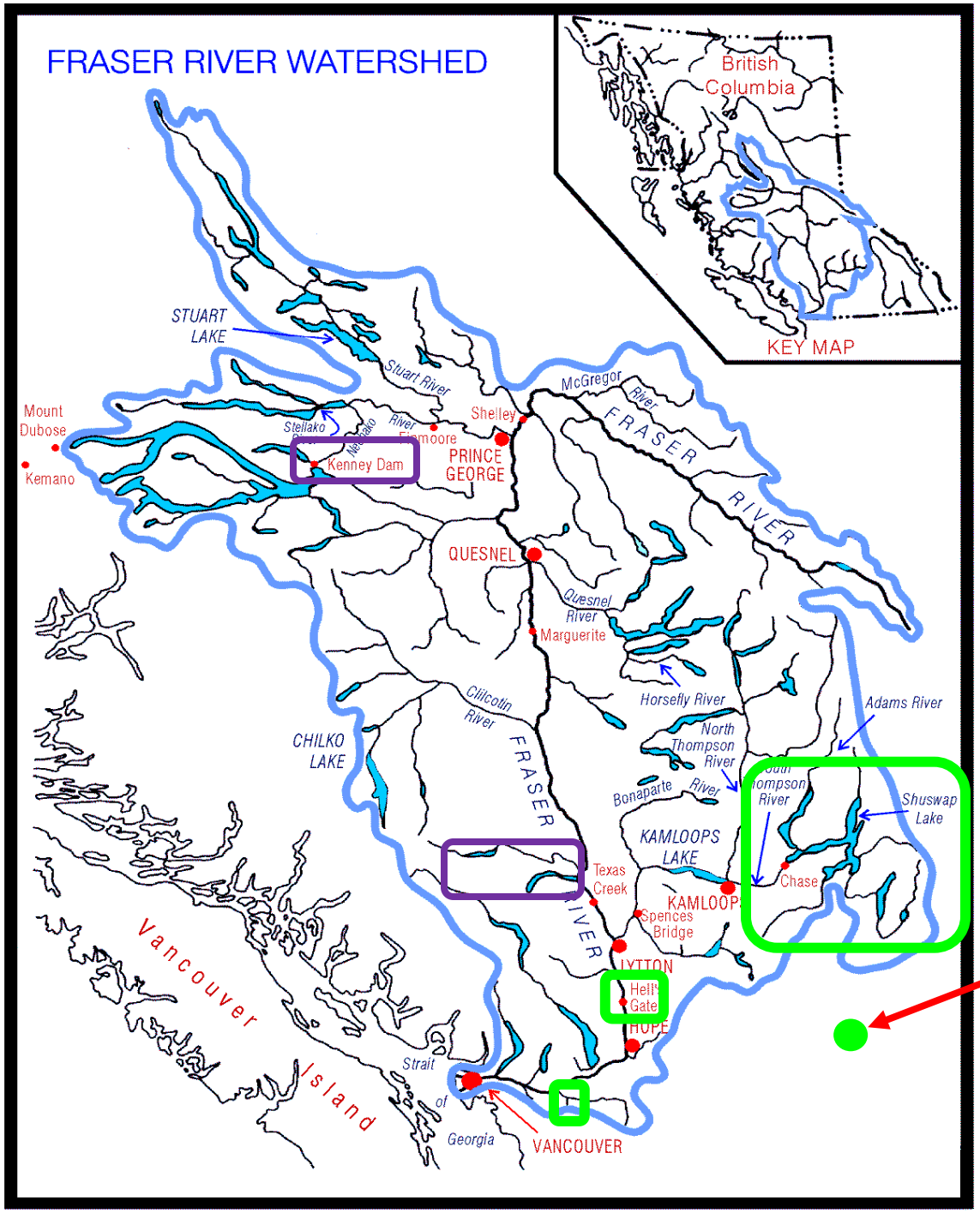
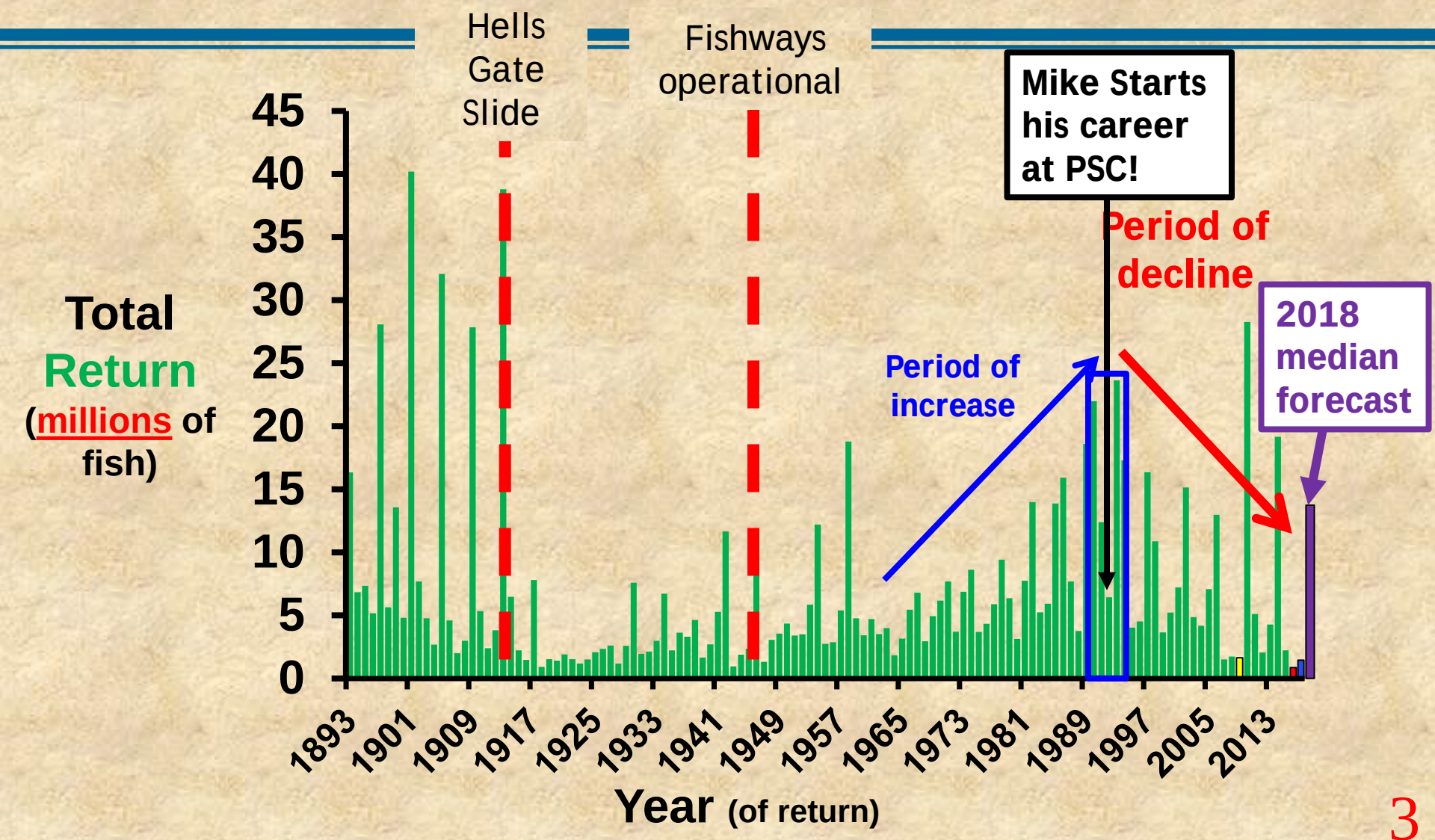
What is causing declines in the annual returns of Fraser River sockeye salmon?

Mike Lapointe, Catherine Michielsens; Pacific Salmon Commission Secretariat
Sue Grant, Bronwyn MacDonald; Fisheries and Oceans Canada


FRASER RIVER WATERSHED
British Columbia
KEY MAP
STUART LAKE
Stuart River
McGregor River
FRASER RIVER
Mount Dubose
Kemano
Stellako River
Nechako River
Fraser Fort George
Shelley
Kenney Dam
PRINCE GEORGE
QUESNEL
Quesnel River
Marguerite
Horsefly River
Adams River
Clilcotin River
CHILKO LAKE
FRASER RIVER
North Thompson River
Bonaparte River
South Thompson River
Shuswap Lake
KAMLOOPS LAKE
Chase
Texas Creek
KAMLOOPS
Spences Bridge
LYTTON
Hell's Gate
HOPE
Vancouver Island
Strait of Georgia
VANCOUVER
We are here!

“Long-term” History of Returns

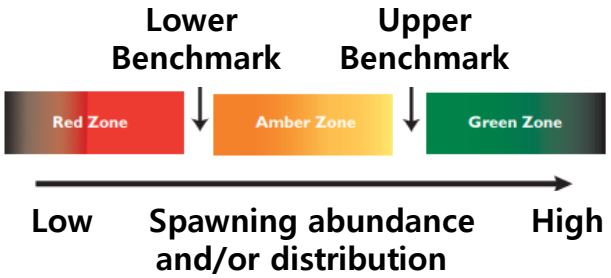


Recent Status assessments

Run timing or Stock group	Wild Salmon Policy (DFO 2017)	COSEWIC (2018)
Early Stuart		EN
Early Summer run		
Bowron		EN
Upper Barriere (Fennell)		THR
Gates		NAR
Nadina		NAR
Pitt		NAR
Scotch		NAR
Seymour		NAR
Summer run		
Chilko		NAR
Late Stuart		EN
Quesnel		EN
Stellako		SC
Harrison		NAR
Raft		SC
Late run		
Cultus		EN
Late Shuswap		NAR
Portage		EN
Weaver		EN
Birkenhead		SC

Legend

Wild Salmon Policy

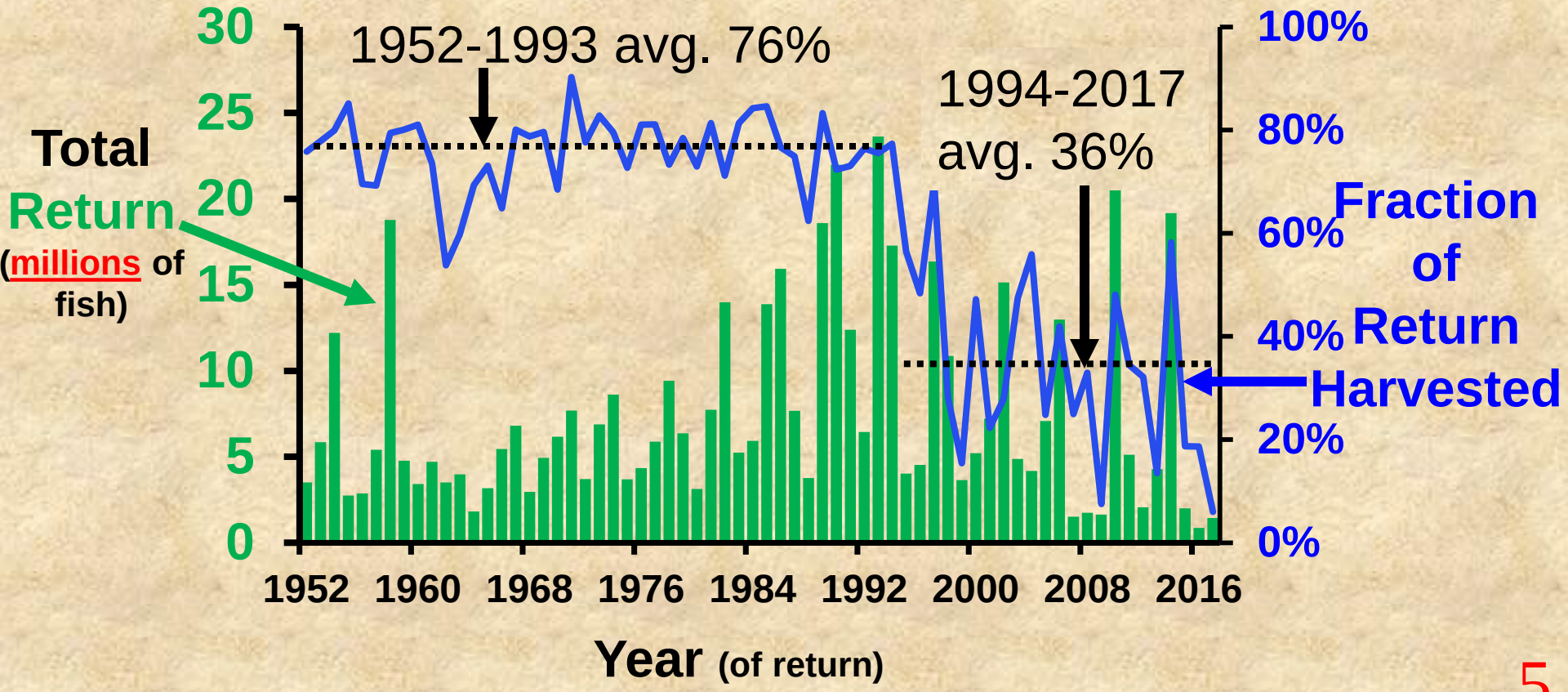


COSEWIC

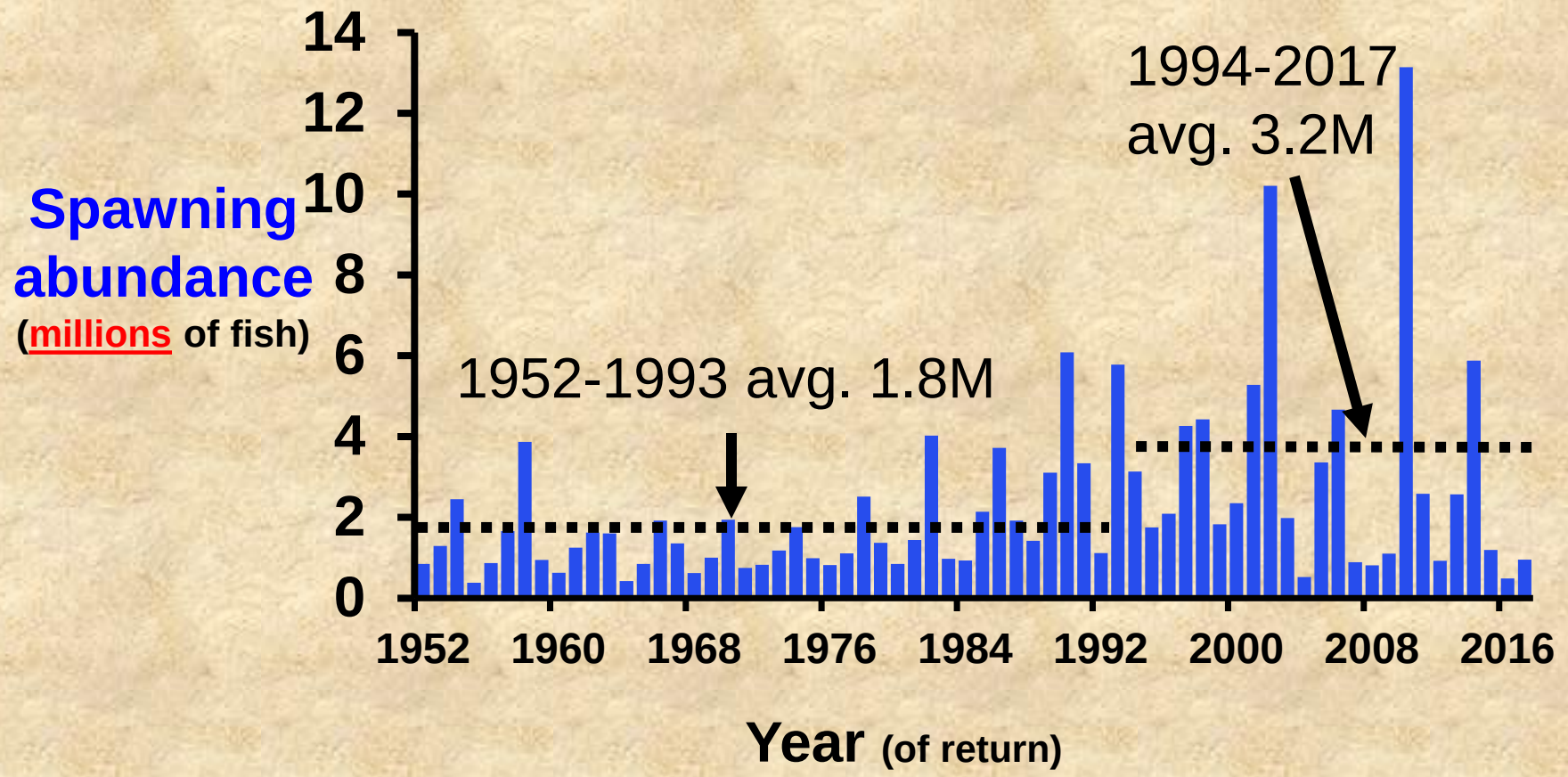
EN	Endangered
THR	Threatened
NAR	Not At Risk
SC	Special Concern

Management response to declining returns

Exploitation rates have decreased



Declining exploitation rates have increased spawning abundance

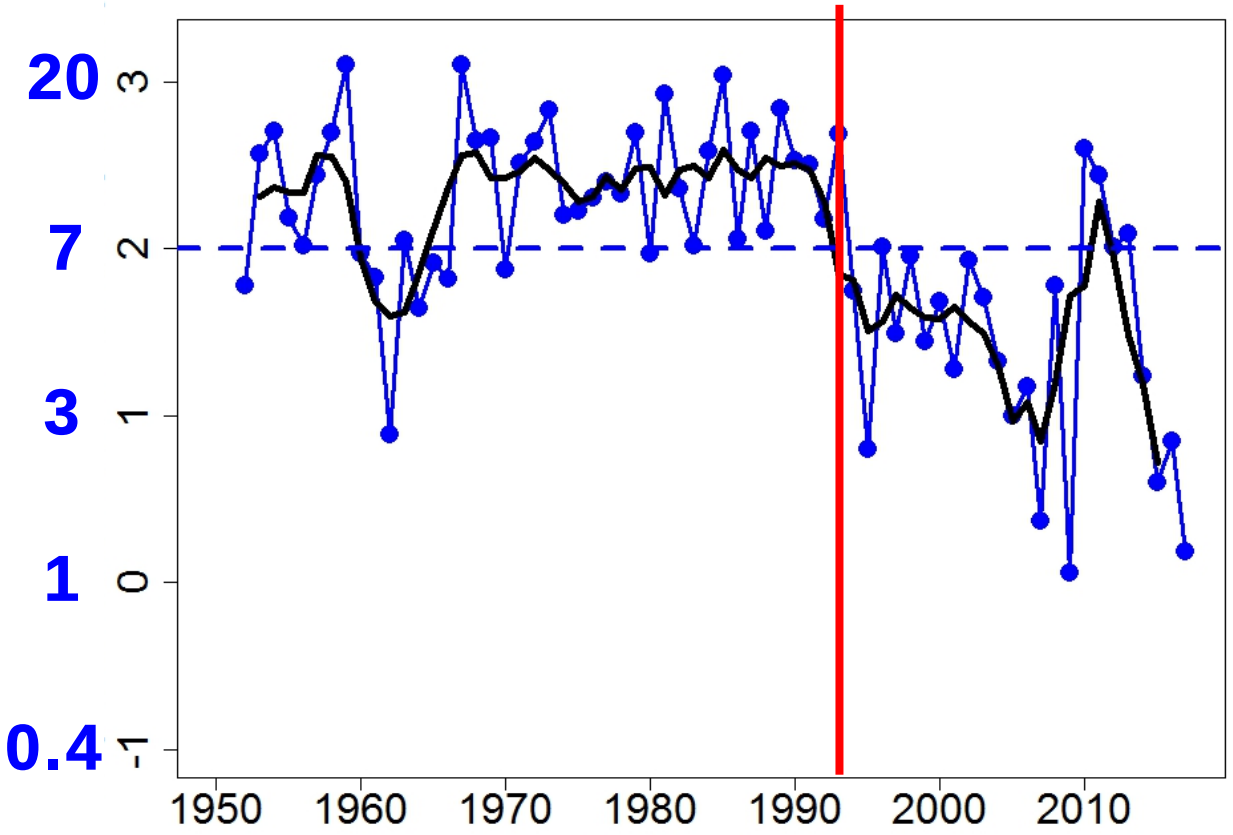


Fraser sockeye productivity has declined!

Index of Total productivity

Mature offspring produced per female spawner

Log_e(Return per EFS)

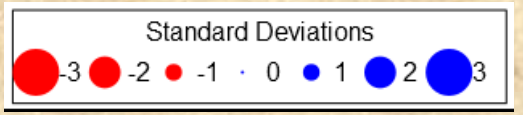


Modified from Grant et al. 2018

Productivity varies among stocks

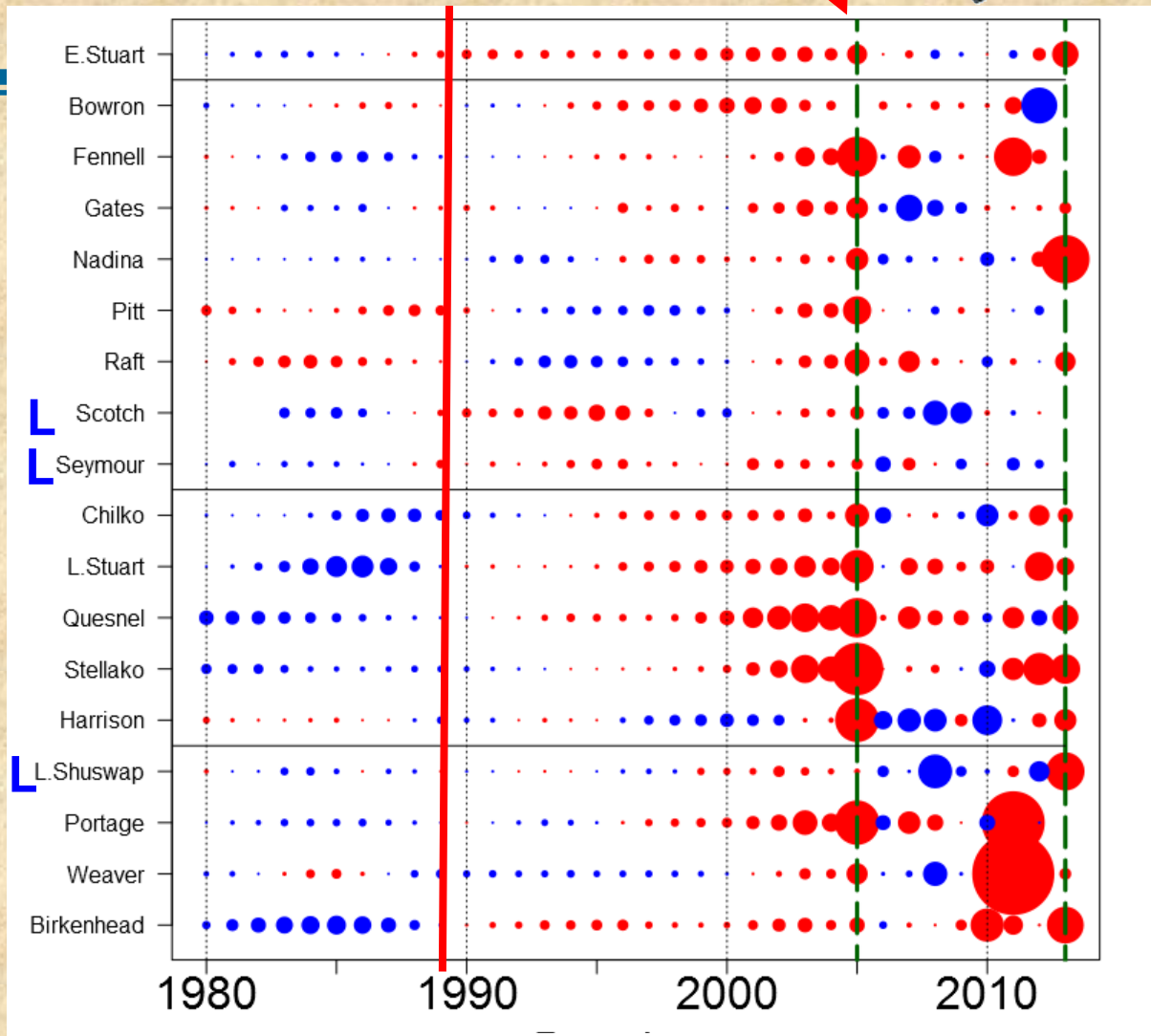
Index of Total productivity

(deviations from Ricker or Larkin (L) Stock-Recruit models)



Below average productivity

Above average productivity

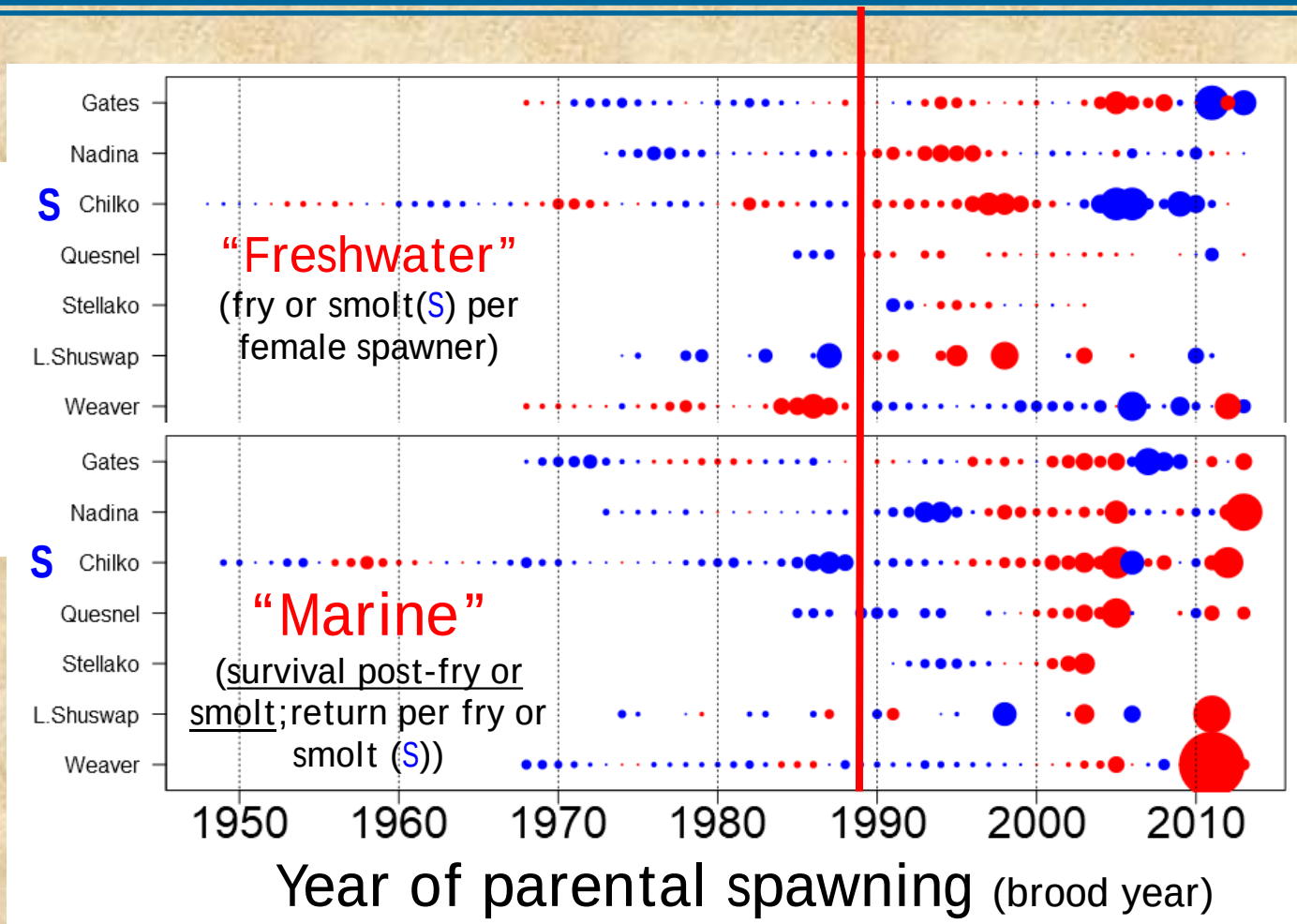


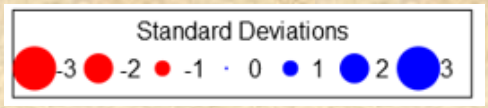
Updated from Grant et al. 2017

Productivity varies among stocks and life stage

Index of productivity

(deviations from Ricker Stock-Recruit model)





Below average productivity

Above average productivity

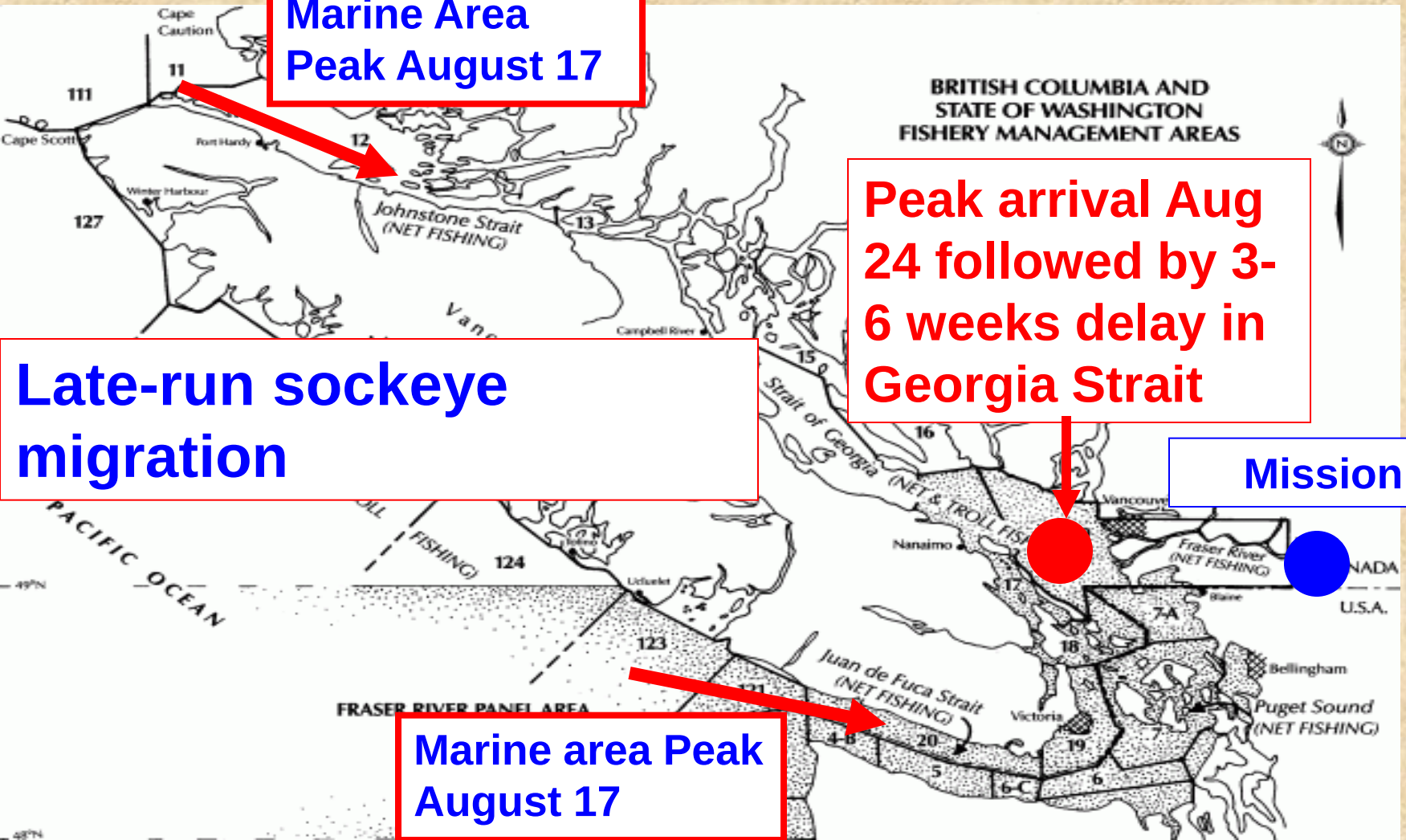
C. Michielsens pers comm.

Two factors are adding to productivity declines

1. **Early Upstream migration of one Fraser sockeye stock group (Late run)**

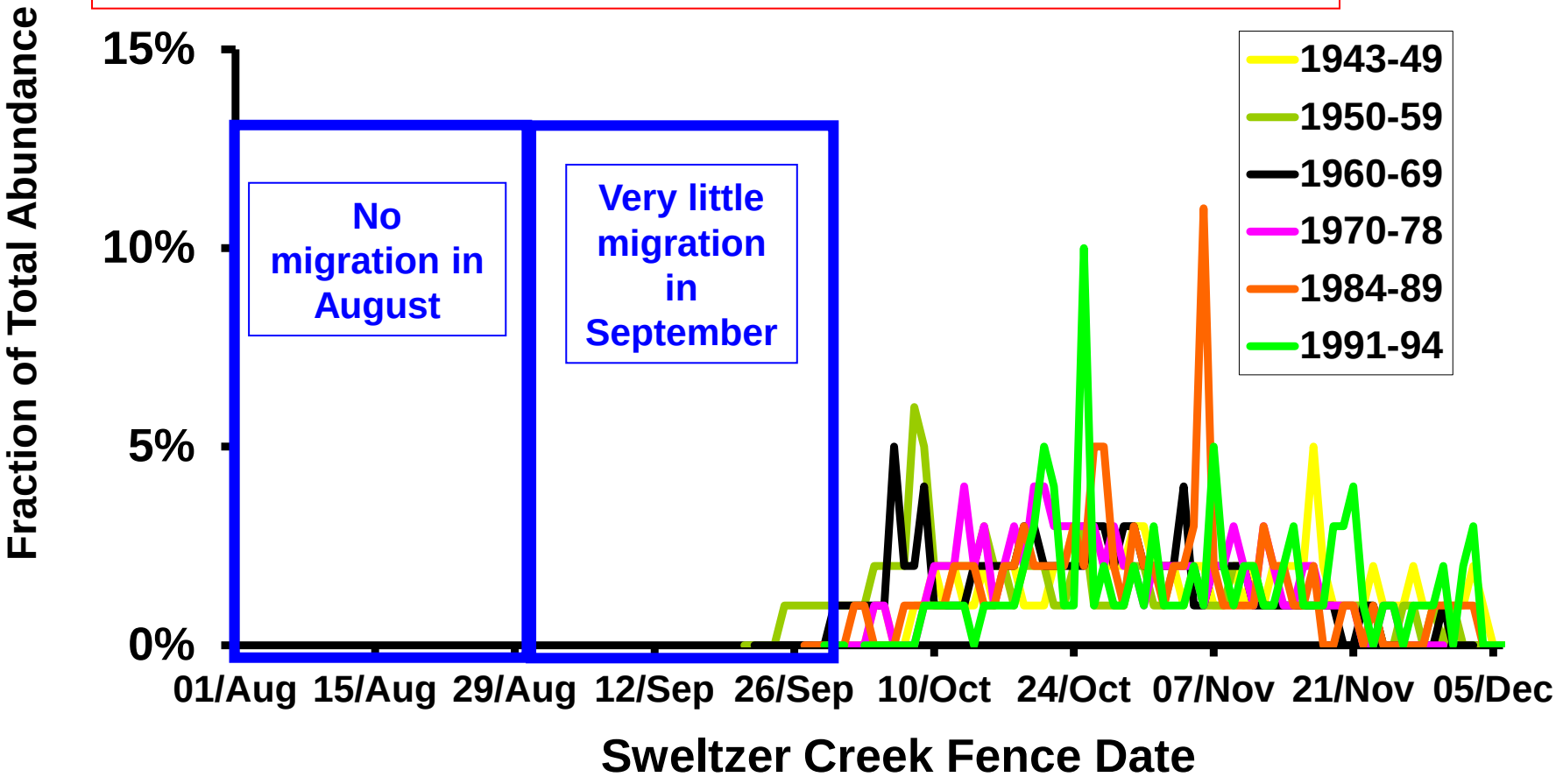
2. **Impacts of warming Fraser River**

Historical "normal" migration behavior of Late-run sockeye



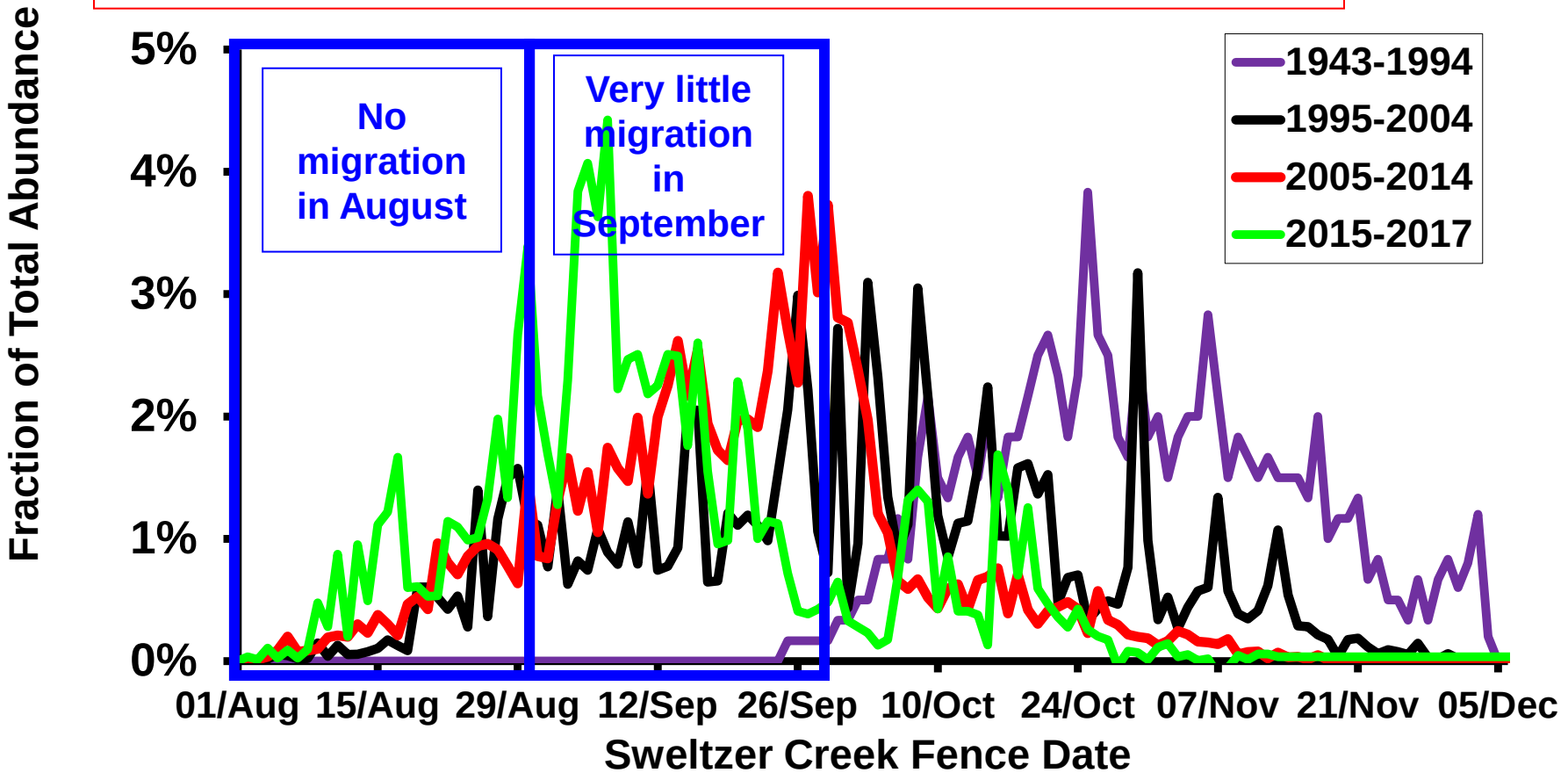
Historical "normal" upstream migration of Late-run sockeye

Cultus Sockeye

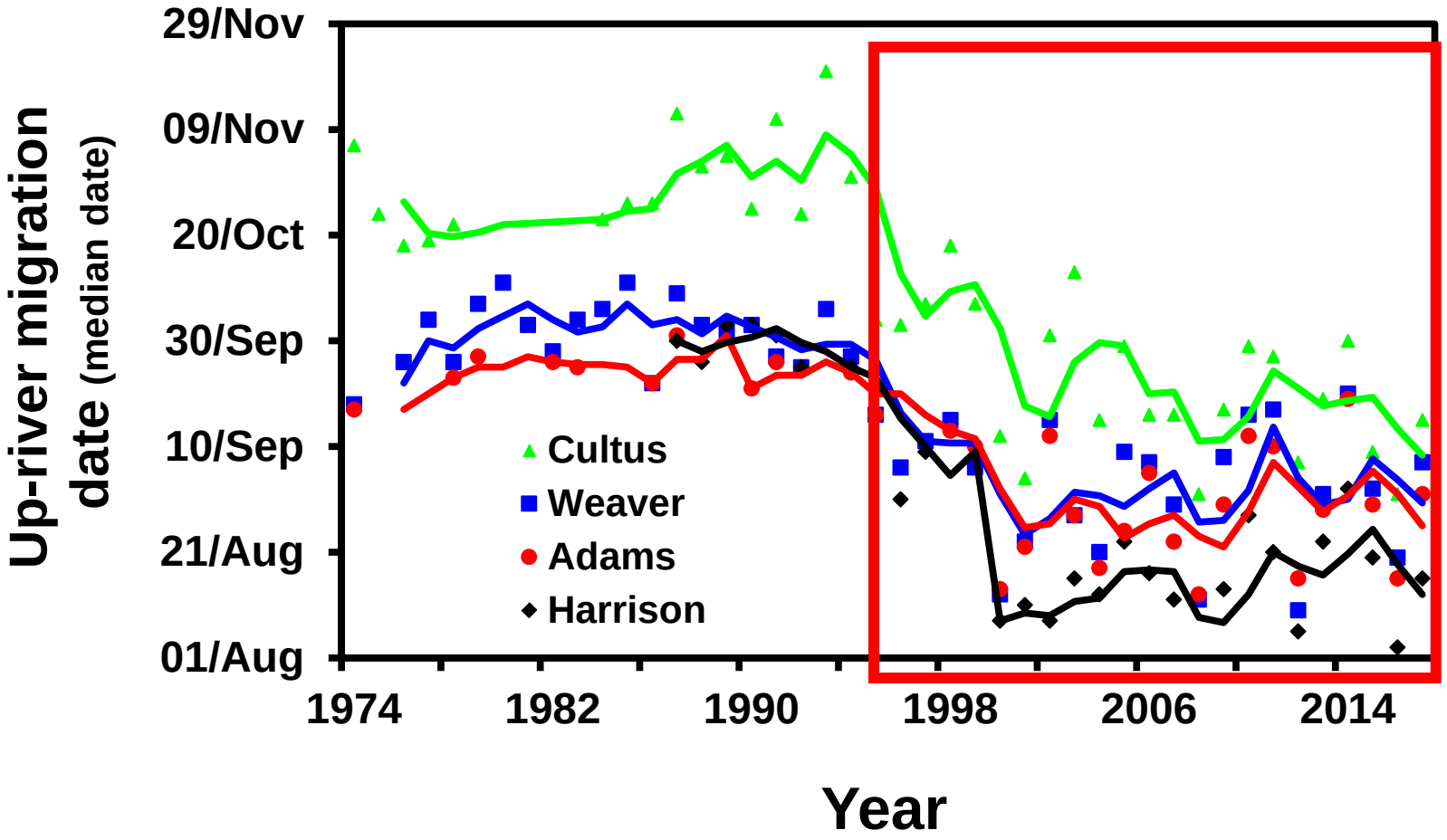


Early upstream migration of Late-run sockeye

Cultus Sockeye



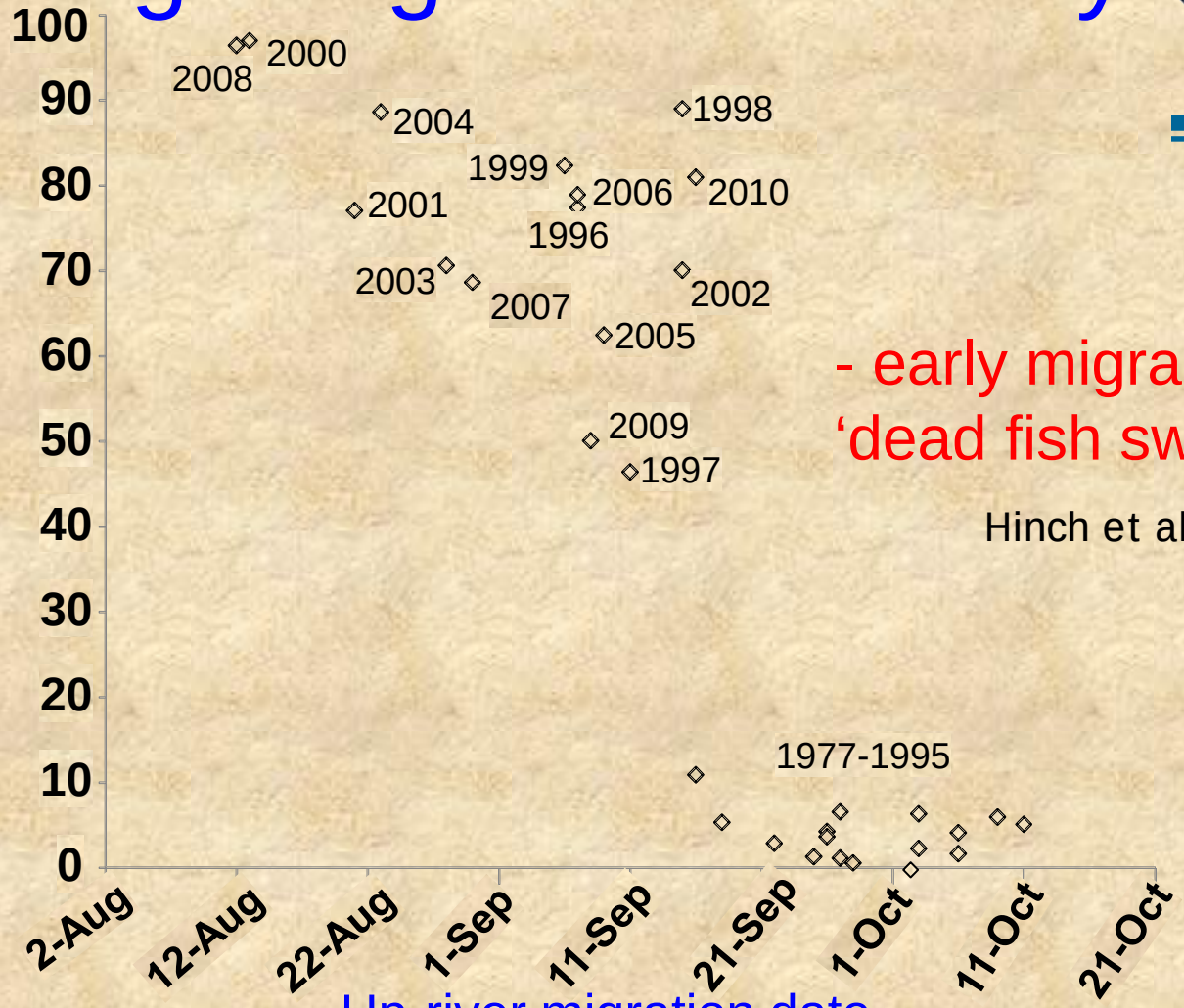
Recent “abnormal” upstream migration pattern is consistent among stocks



Updated from Lapointe 2009

Early migration correlated with extremely high migration mortality

Index of Migration Mortality[1]
(% of the run)

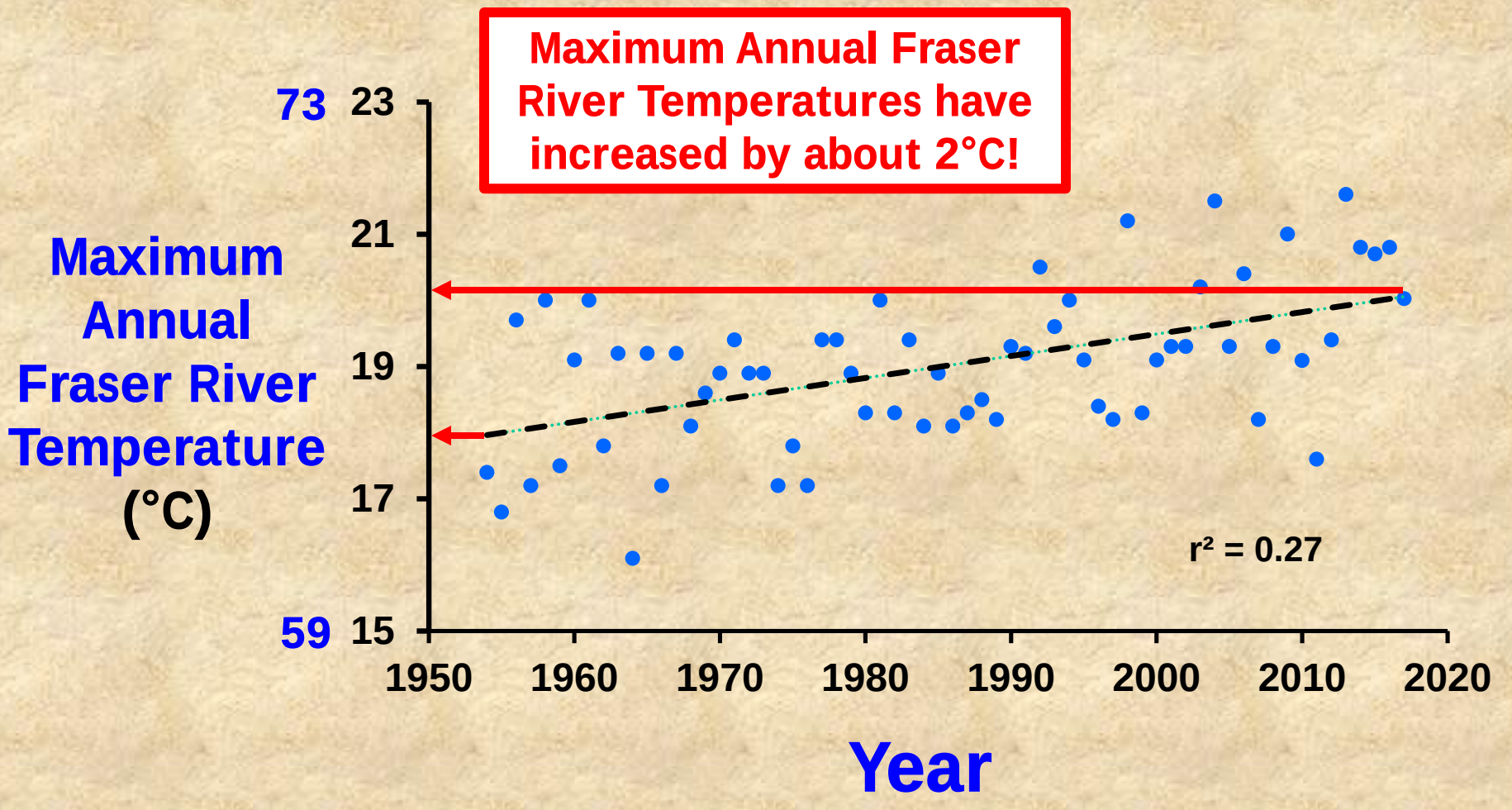


- early migrants are 'dead fish swimming'

Hinch et al. 2012

1 Discrepancy between lower and upper river estimates

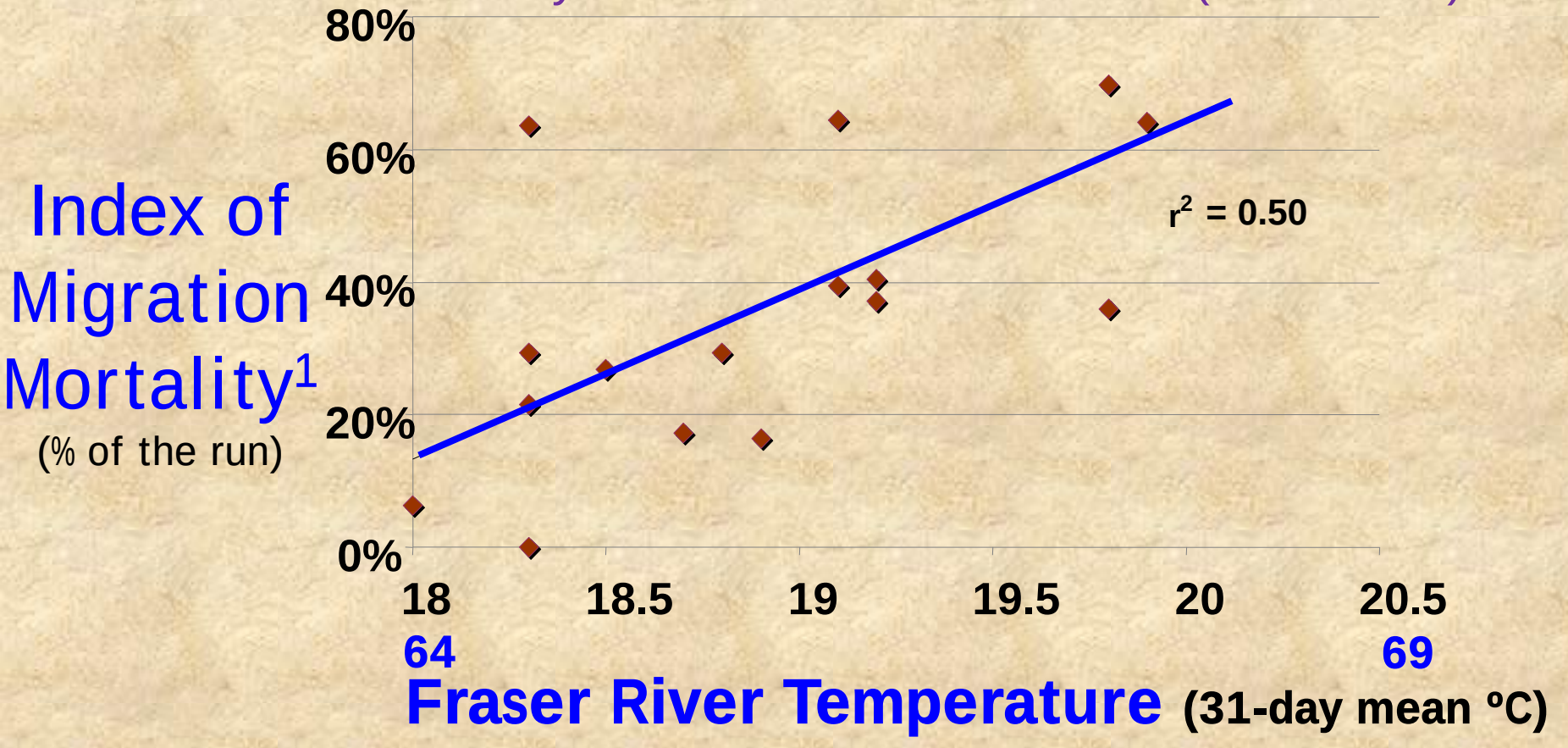
The Fraser River is getting warmer



Updated from Eliason et al. 2011

Consequences of warming Fraser River

Migration Mortality during thermally stressful years
for Early summer and Summer runs (1992-2008)



1 Discrepancy between lower and upper river estimates

Hinch and Martins 2011

Conclusions

1. Fraser River sockeye returns have declined since 1993 as a consequence of decreased productivity (across the total life cycle).

2. Decreased total productivity cannot be attributed to any single causal factor; productivity has varied at both freshwater and “marine” stages.

Conclusions

3. Abnormal migration behavior and a warming Fraser River are leading to migration mortality; thus despite decreased harvests, fewer fish are reaching spawning areas.

Acknowledgements

Co-Authors

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