26 March 2013

# "Production dynamics of Fraser River sockeye salmon compared to other west coast populations"

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Cohen Commission Science Workshop (Dave Levy)
27 March 2013

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## ***Outline***

- Changes over time in sockeye productivity
  - Fraser River
  - Non-Fraser stocks
- Patterns we need to explain
- Possible causes

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## Background

Since early 1990s, most Fraser River sockeye populations have decreased in:

- Abundance (adult returns)
- Productivity (adult returns **per spawner**)
  ["productivity" analogous to "cars produced per year per worker"]

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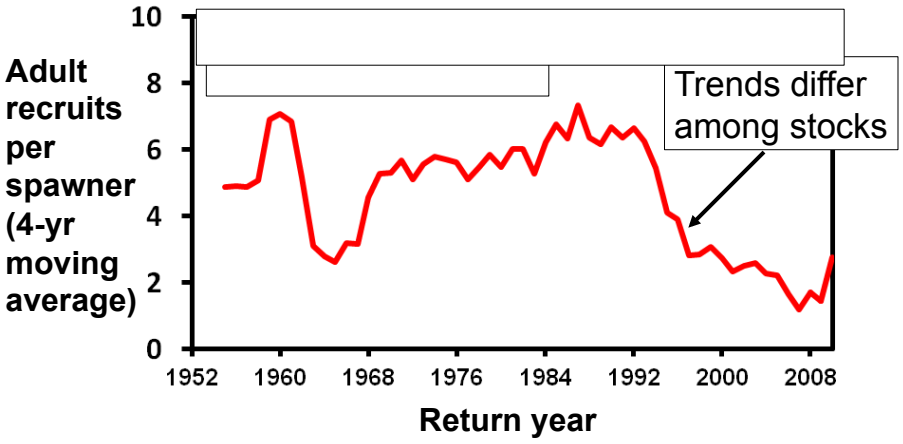
## All Fraser sockeye populations combined




M. Lapointe, PSC

**Research objective**

How widespread has **decreasing productivity** been across west-coast sockeye populations?

**Relevant because ...**

- If decreases only occurred in Fraser stocks, this implies that local factors caused declines.
- Large spatial extent implies large-scale factors

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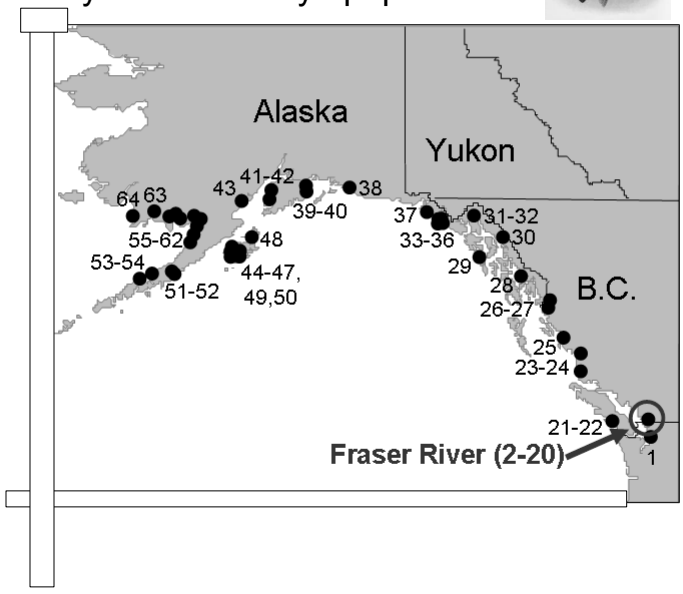
Productivity for 64 sockeye populations




Peterman and Dorner 2012

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## Methods

**Measures of productivity**

1. Annual adult returns per spawner
2. "Kalman filter" smoothed estimates that show "signal" amid "noise"

**Analyses**

- Correlations
- Other methods (same conclusions)

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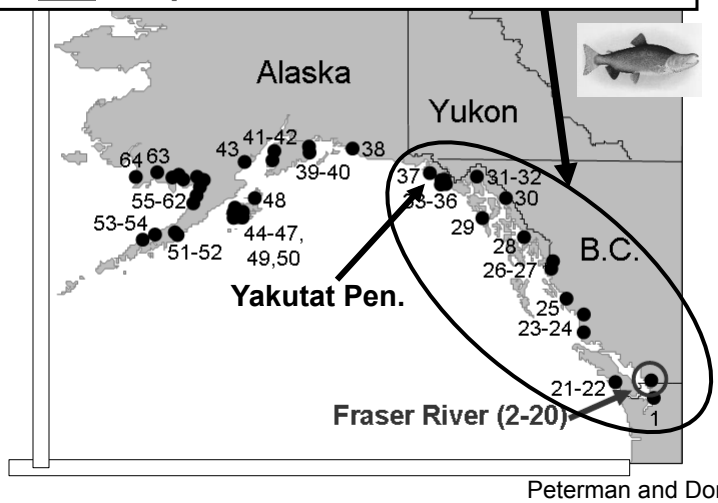
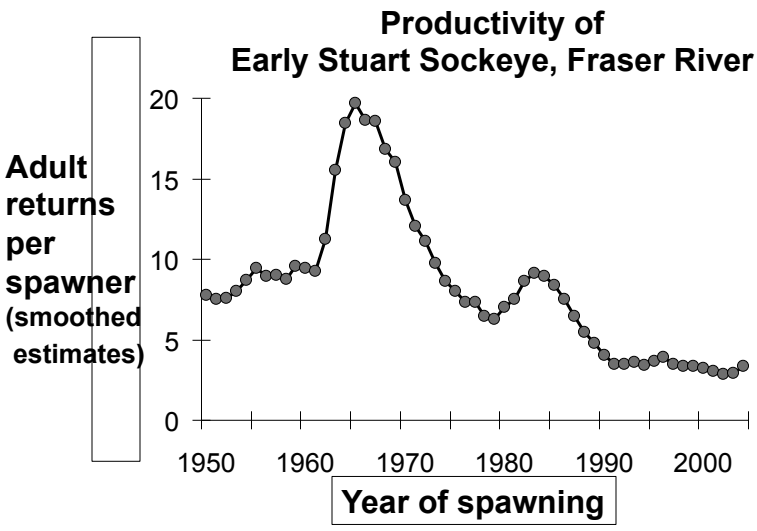
## Results

**1. Widespread decreases in productivity (24 of 37 stocks), especially since 1990s - Not unique to Fraser River**




Peterman and Dorner 2012




To compare trends across stocks, we then used "standardized" time series (same mean and variability)

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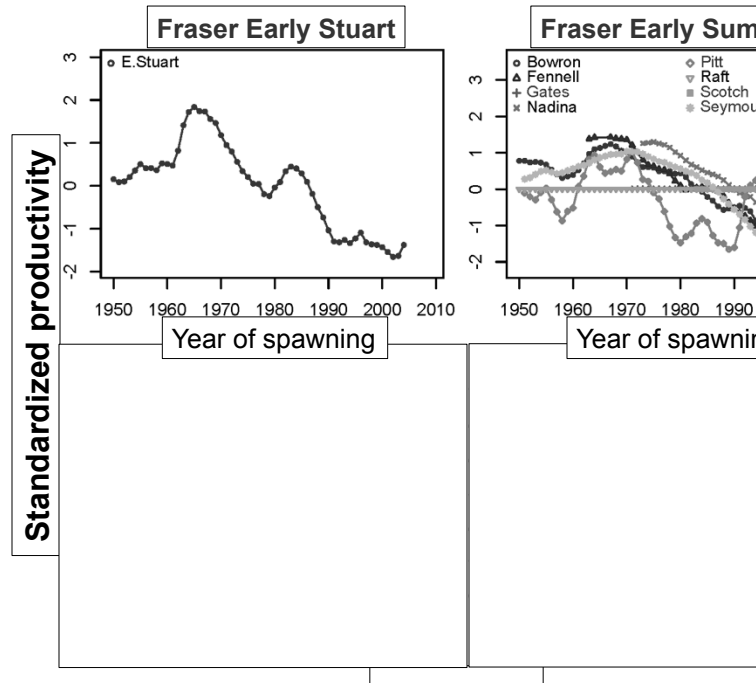
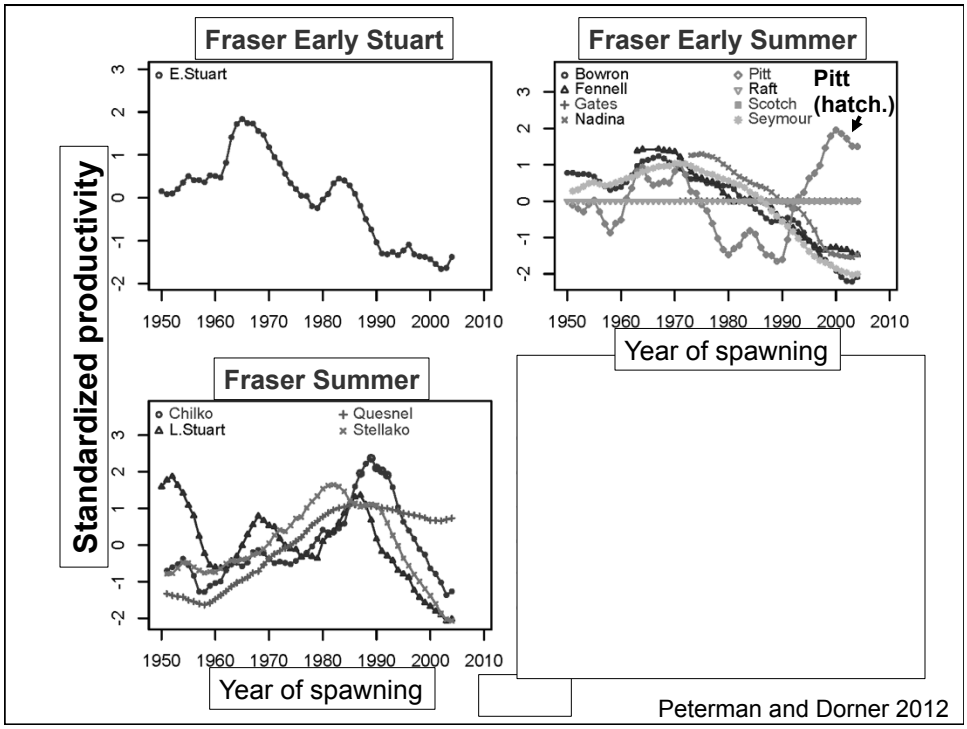
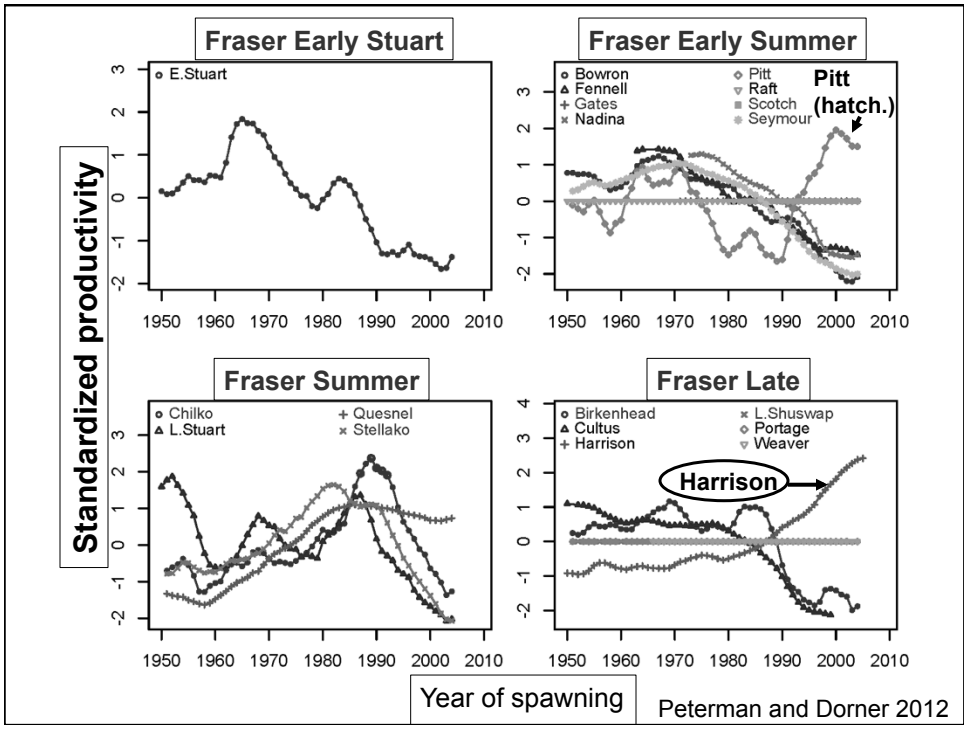
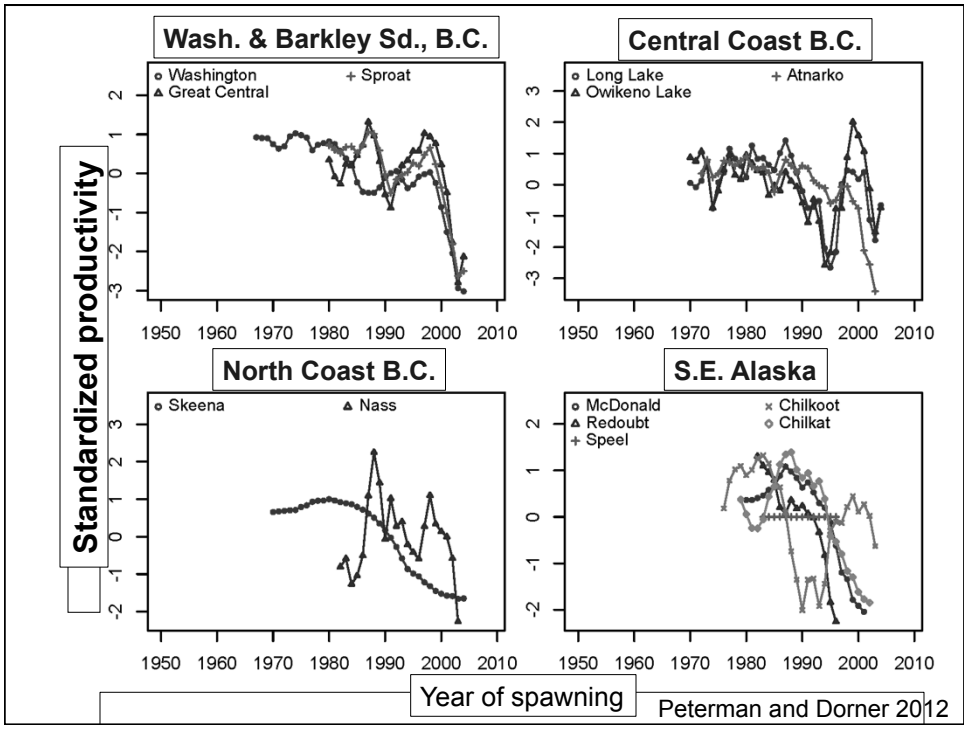
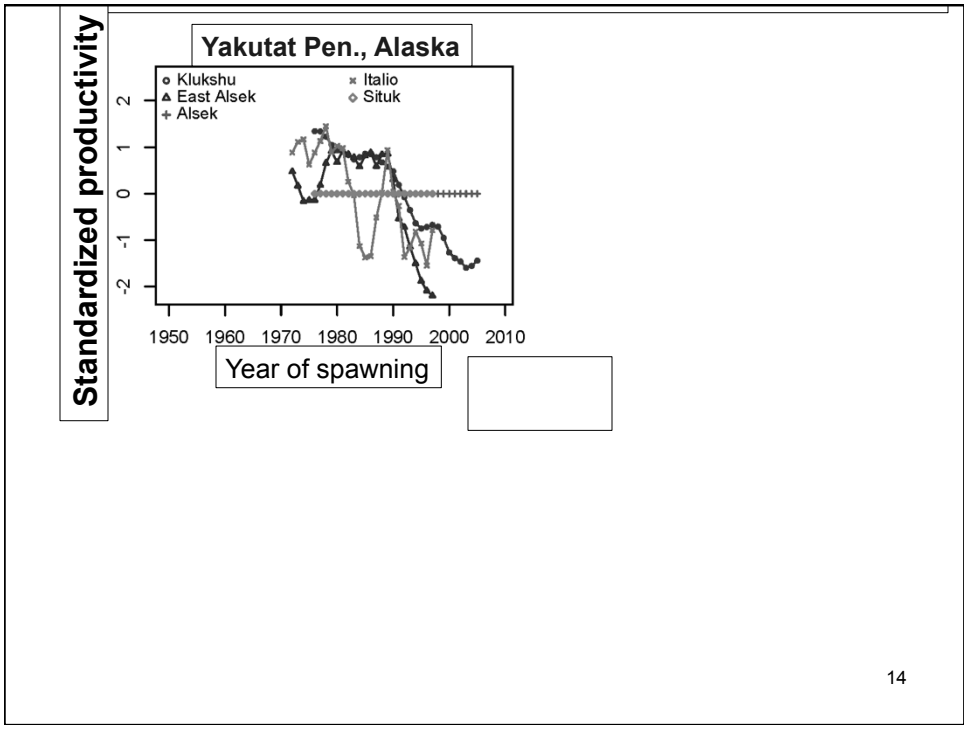


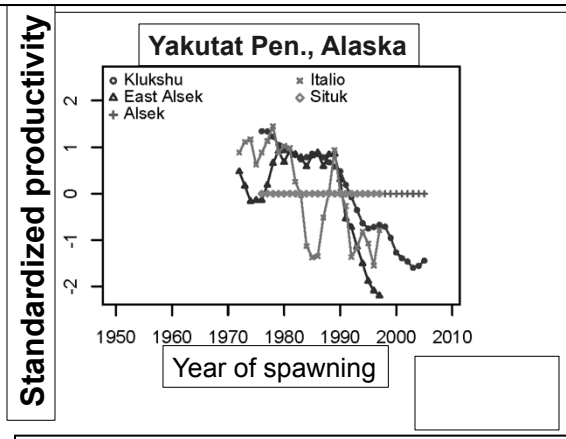

Peterman and Dorner 2012


Fraser Early Stuart
E.Stuart
Fraser Early Summer
Bowron
Fennell
Gates
Nadina
Pitt
Raft
Scotch
Seymour
Pitt
(hatch.)
Fraser Summer
Chilko
L.Stuart
Quesnel
Stellako
Standardized productivity
Year of spawning
Year of spawning
Peterman and Dorner 2012


Fraser Early Stuart
E.Stuart
Fraser Early Summer
Bowron
Fennell
Gates
Nadina
Pitt
Raft
Scotch
Seymour
Pitt
(hatch.)
Fraser Summer
Chilko
L.Stuart
Quesnel
Stellako
Fraser Late
Birkenhead
Cultus
Harrison
L.Shuswap
Portage
Weaver
Harrison
Standardized productivity
Year of spawning
Peterman and Dorner 2012


Wash. & Barkley Sd., B.C.
Washington
Great Central
Sproat
Central Coast B.C.
Long Lake
Owikeno Lake
Atnarko
North Coast B.C.
Skeena
Nass
S.E. Alaska
McDonald
Redoubt
Speel
Chilkoot
Chilkat
Standardized productivity
Year of spawning
Peterman and Dorner 2012


Yakutat Pen., Alaska
Klukshu
East Alsek
Alsek
Italio
Situk
Standardized productivity
Year of spawning
14




**In contrast, central and western Alaskan sockeye populations show <u>increasing</u> or relatively stable productivity in same period.**

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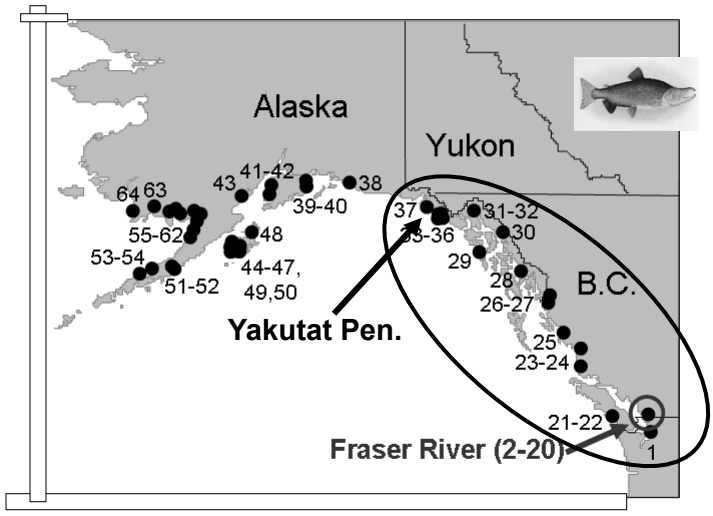


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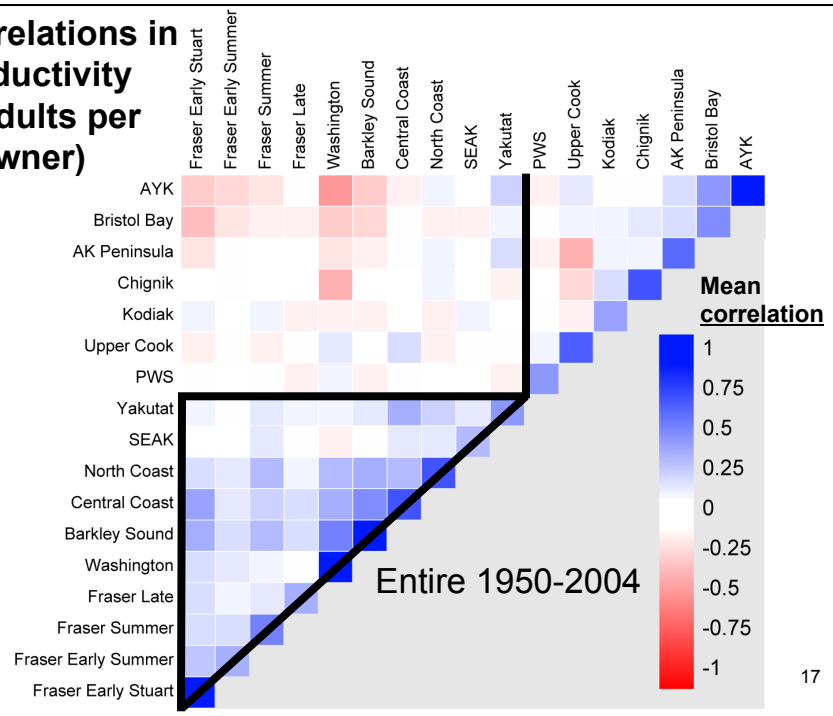
Peterman and Dorner 2012

**Correlations in productivity (~ adults per spawner)**

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## Results (continued)

**1. Similar downward productivity trends exist in 27 of 34 stocks from Washington and the Fraser R. up through Yakutat, Alaska.**

**Implication:**

- Shared causes?

- Different causes in different places (coincidental)
  -- Unlikely coincidental
  (quite different watersheds, pressures)

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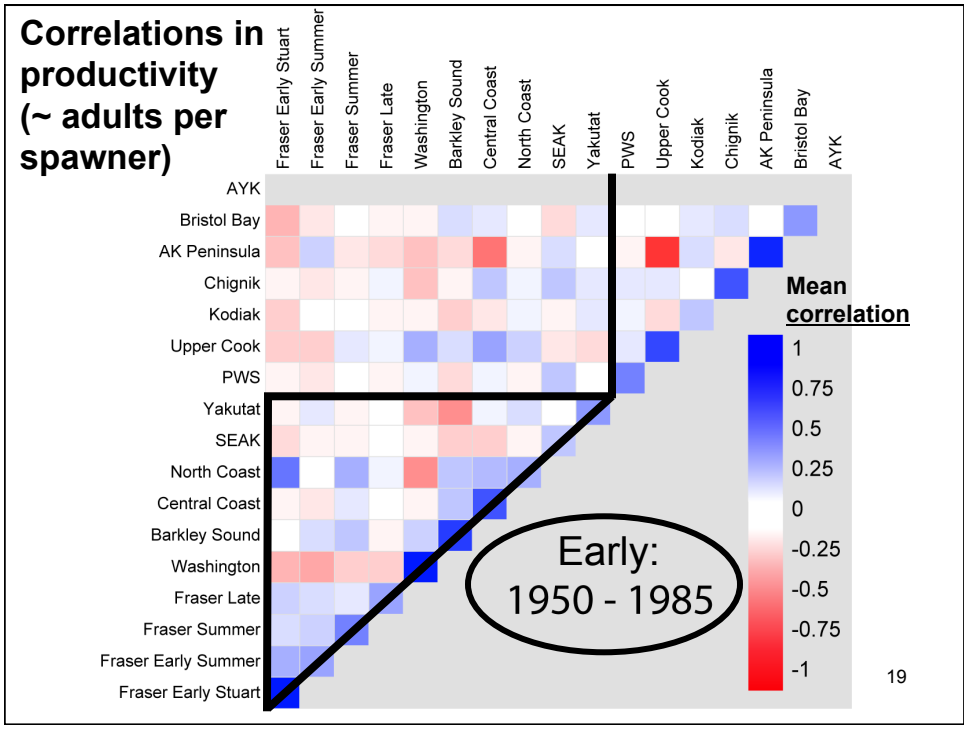
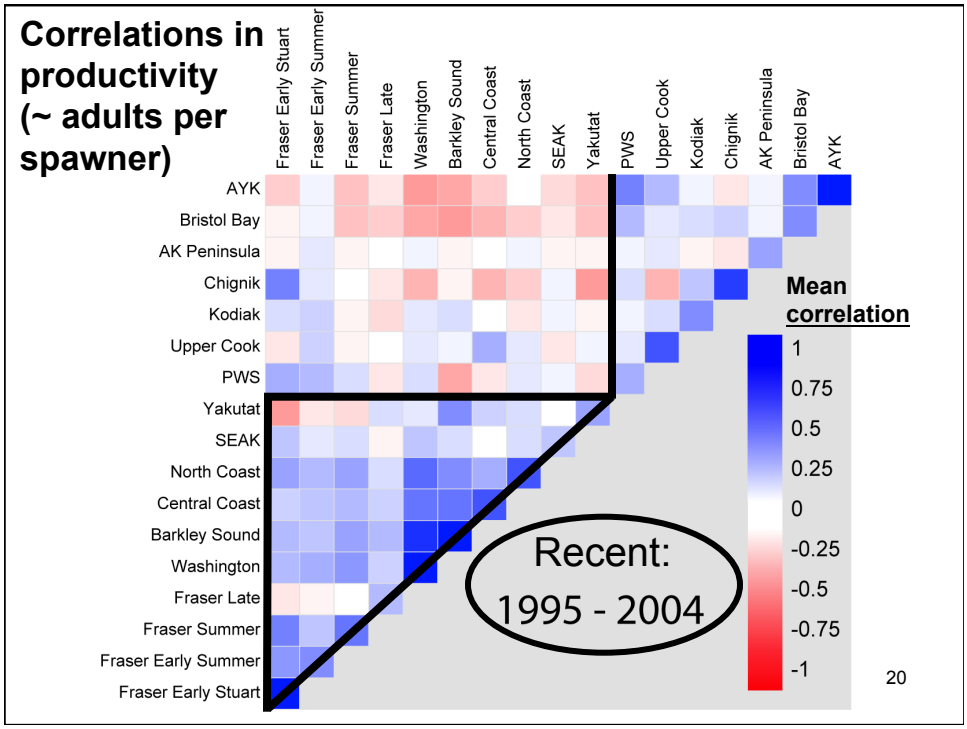

Correlations in productivity (~ adults per spawner)
Fraser Early Stuart
Fraser Early Summer
Fraser Summer
Fraser Late
Washington
Barkley Sound
Central Coast
North Coast
SEAK
Yakutat
PWS
Upper Cook
Kodiak
Chignik
AK Peninsula
Bristol Bay
AYK
Mean correlation
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
Early: 1950 - 1985
19


Correlations in productivity (~ adults per spawner)
Fraser Early Stuart
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Fraser Summer
Fraser Late
Washington
Barkley Sound
Central Coast
North Coast
SEAK
Yakutat
PWS
Upper Cook
Kodiak
Chignik
AK Peninsula
Bristol Bay
AYK
Mean correlation
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
Recent: 1995 - 2004
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## Results (continued)

**2. Positive correlations among "southern" stocks have recently become stronger or more synchronized.**

**Implication:**
Causes of decreasing productivity are increasing in strength.

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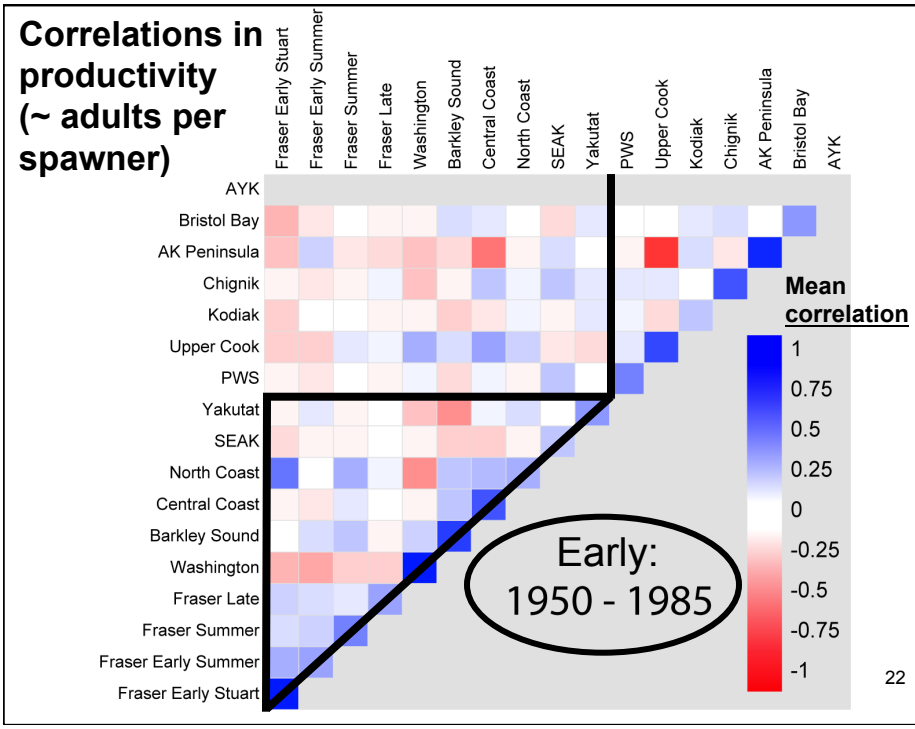
**Correlations in productivity (~ adults per spawner)**

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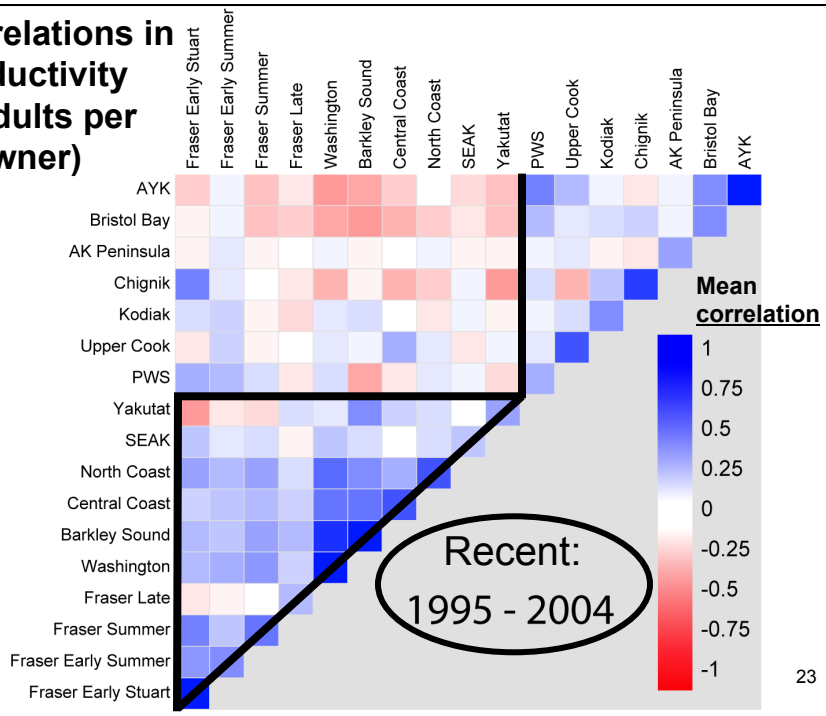
**Correlations in productivity (~ adults per spawner)**

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## Results (continued)

**3. The spatial extent of the positively correlated southern area appears to have spread further north over time.**

**Implication:**

Suggests northward-moving, large-scale processes such as:

- Spread of pathogens
- Increases in predators of salmon
- Climate-driven changes in ocean productivity

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## "Over-escapement"

Hypothesis:
Large number of sockeye spawners (escapements) reduce productivity (adults per spawner).

Evidence:
1. Only 70 out of 977 cases (7%) for Fraser sockeye show fewer adult recruits than parental spawners.

- **None** of those cases came after an extremely large spawner abundance that subsequently led to chronic low abundance.

Peterman and Dorner 2011

## "Over-escapement" (continued)

2. Only Quesnel data are described best by the Larkin model (delayed density dependence)

**Implication:**
"Over-escapement" or "delayed density dependence" has contributed very little to the widespread decreases in productivity and abundance of Fraser R. sockeye.

Peterman and Dorner 2011

## Conclusions

1. Similar decreases in productivity along west coast; main causes are likely shared across stocks.
2. From juvenile data (not shown today):
   - Most of mortality that caused decreases of Fraser River sockeye ***occurred after*** the juvenile stage (still possibly freshwater ***origin***)
3. Over-escapement does not explain the decreased productivity of most Fraser R. sockeye or other west-coast sockeye populations.

Peterman and Dorner 2012

## Recommendations

1. Research priority on large-scale processes or the ocean where correlated sockeye stocks overlap
2. Create Canada-U.S. sockeye working group
   - Multi-disciplinary research program
     -- Life history of juveniles (Harrison vs. others)
     -- Oceanography
     -- Food, predators, pathogens, harmful algae, ...
   - Shared data base for entire west coast
3. Estimate juvenile abundance on more stocks

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Details in:

Peterman, R.M. and B. Dorner. 2011. Fraser River Sockeye Production Dynamics. Tech. Rept. #10, Cohen Commission.

and

Peterman, R.M. and B. Dorner. 2012. A widespread decrease in productivity of sockeye salmon populations in western North America. Canadian Journal of Fisheries and Aquatic Science 69:1255-1260.

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