King of Fish
The Thousand Year Fall of Salmon

David R. Montgomery
Classical Hypothesis for Pacific Salmon Evolution and Diversification

- Isolation during glacial advances
- **Problem:** Fossil salmon pre-date Pleistocene glaciations!
Evolution of the Pacific Salmon

• Pacific salmon evolved between 20 million and 6 million years ago (Miocene).

• Radiation of Pacific salmon into distinct species coincides with uplift of Pacific Rim topography.
The Skokomish River fossil salmon locality is just upstream of the gorge of the South Fork at the edge of the Puget Lowland.
Skokomish River, Sockeye Salmon
4 year old, spawning population

Major life history traits established by 1 million years ago
Salmon & Natural Disturbances

For millions of years, salmon thrived in a landscape shaped by floods, volcanic eruptions and natural disturbances.
Archaeological excavations along the Columbia River confirm extensive salmon fishing for >9300 years...

Butler and O’Connor, Quaternary Research, v 62, p 1-8, 2004
### Status of Salmon Populations Today

<table>
<thead>
<tr>
<th>Region</th>
<th>Percent of Historical Run Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>106</td>
</tr>
<tr>
<td>British Columbia</td>
<td>36</td>
</tr>
<tr>
<td>Puget Sound</td>
<td>8</td>
</tr>
<tr>
<td>Washington</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Columbia Basin</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Oregon</td>
<td>7</td>
</tr>
<tr>
<td>California</td>
<td>5</td>
</tr>
<tr>
<td>California, Oregon, Washington, Idaho</td>
<td>5</td>
</tr>
</tbody>
</table>
Salmon

Harvest

Habitat

Hydropower

Hatcheries
History, The 5th H

Strikingly similar pattern of changes to river systems and salmon crises in Great Britain, New England and now the Pacific Northwest.
The earliest recorded salmon-fishing legislation was an edict issued by King Malcolm II of Scotland in 1030 that established a closed season for taking “old salmon.”
Habitat

A statute dating from the reign of Richard the Lionheart declared that rivers must be kept free of obstructions so as to permit a well-fed three-year-old pig, standing sideways in the stream, not to touch either side.
Hydro (dams)

An act passed in the reign of King Robert the First, in 1318, forbade the erection of fixtures of any size or dimensions that would prevent the progress of salmon up and down a river.
In 1714, George I enacted a law to prevent blocking salmon from their spawning grounds in 17 English rivers.

By 1868, all 17 rivers protected by George I were either blocked or poisoned by pollution. [habitat and hydro]
Alexander Fraser proposed steps to increase the number of salmon in Scottish rivers (1833):

(1) don’t block the ability of salmon to migrate up or down stream [hydro];
(2) limit fishing intensity so as to not take the majority of the spawners [harvest];
(3) prevent habitat degradation that could damage the fishery [habitat].
New World Salmon

“If the Pigeons plagued us by their abundance, the Salmon gave us even more trouble. So large a quantity of them enters into this river that at night one is unable to sleep, so great is the noise they make in falling upon the water after having thrown or darted themselves in to the air.”

— N. Denys (1672, p. 199).
The proliferation of small dams gradually blocked salmon from New England’s rivers.
First laws outlawing salmon-blocking dams date from 1709.

Between 1820 and 1880, the State of Maine passed more than 150 fishery laws relating to salmon.

Enforcement, provided for at the local level, was virtually nonexistent.
Key factors in British and New England salmon declines

- Local control and lax enforcement
- Gradual accumulation of many individual habitat impacts
- Over-reliance on hatcheries at the expense of habitat
- Lack of long-term planning and understanding of habitat-fish linkages...
Have we learned any of these lessons? Are we really doing anything any different in the Pacific Northwest?
Harvest
Hydro
Habitat
The supply and transport of water, sediment and wood interact to structure salmon habitat.
Army Corps of Engineers aggressively “de-snagged” American Rivers

Collins et al. (2002)
Nisqually River Floodplain

Collins et al. (2001)

Numerous floodplain channels with inlets controlled by log jams
Big Trees Influenced Big Rivers
Stillaguamish River, Washington

Single floodplain channel with evidence of remnant side channels

Collins et al. (2001)
Historical changes in salmon habitat along the Skagit River
Huge losses of side channels and valley bottom wetlands along most major Puget Sound rivers, yet the story for each river is unique.

Collins et al. (2001)
Seasonal water depths from GLO field notes help describe historical wetland habitat

Descriptions of wetlands in Skagit Flats:

“The water was 2 ½ feet deep and appeared to be deeper northward, we therefore consider it unfit for cultivation and impracticable to now survey it” --November 2, 1866

“Through marsh Covered with Hard Hack Willow and scattering firs. Standing water from 6 in to two feet deep” --August 30, 1872

Seasonal inundation (> 1 ft for most of season):
W: winter   W&S: winter & summer
Change to wetland area in four North Sound estuaries/deltas

EEM=estuarine emergent; ESS=estuarine scrub-shrub; RT=riverine-tidal; P=palustrine
Provide some refuge for the salmon, and provide it quickly, before complications arise which may make it impracticable, or at least very difficult. ... If we procrastinate and put off our rescuing mission too long, it may be too late to do any good. After the rivers are ruined and the salmon gone they cannot be reclaimed ... all the power of the United States cannot restore salmon to the rivers after the work of destruction has been completed.

— Livingston Stone (1892)
One of the few strategies that might work over the long run would be to create a network of Salmon Sanctuaries by restoring forested river corridors along river floodplains.
Urbanization changes the way that water moves across and off the land, resulting in increased high flows, and often turning the pre-urbanization 10 year flood into a post-urbanization annual flood.
Most Moscrip and Montgomery, JAWRA, 1997

Recurrence interval

Discharge (cfs)

Juanita Creek

after

before

Moscrip and Montgomery, JAWRA, 1997
Puget Sound Partnership recommendations essentially ignore the adverse impacts likely to occur due to future development.
On October 26, 2006, 14 so-called “experts” sent a letter to the Puget Sound Partnership expressing concern over failure to adequately address management of stormwater runoff from future development.

Doug Beyerlein
Susan Bolton
Derek Booth
Tom Holz
Thom Hooper
Richard Horner
James Karr
DeeAnne Kirkpatrick
John Lombard
Chris May
Gary Minton
David Montgomery
David Somers
Cleve Steward
“The strategies listed are not likely to be sufficient to achieve ecosystem goals...”

Puget Sound Parternship, Page 43, Appendix A, report of scientific working group.
NPDES permits only require adherence to the state stormwater manual, which itself states:

“Land development as practiced today is incompatible with the achievement of sustainable ecosystems.”
When a key industry group threatened to pull out of the Partnership, the effort to re-examine stormwater runoff recommendations apparently was abandoned, despite the acknowledged failure to adequately address impacts from future development.
“Forest practices had no effect on landsliding”
- WA State DNR

Stillman Creek, Washington

Photo: Seattle Times
Site was inspected and found to have “no potentially unstable slopes.”

- Timber Company Forest practice application

Stillman Creek, Washington

Photo: Seattle Times
“Who could have predicted it?”
- WA State DNR

Stillman Creek, Washington

Photo: Seattle Times
History

KING OF FISH
THE THOUSAND YEAR FALL OF SALMON
DAVID R. MONTGOMERY

Process

Inputs
- Water
- Fine sediment
- Coarse sediment
- Large woody debris

Process
- Floodplain inundation
- Sediment transport
- Bank erosion

Form
- Floodplain morphology
  - Side channels
- Channel morphology
  - Bars
  - Pools
  - Riffles

Habitat
- Floodplain & riparian habitat
- Rearing habitat
  - Summer
  - Winter
- Spawning habitat
- Salmon