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Origins of the Salmon Crisis in the Columbia River Basin and Prospects for Sustainable Long-Term Solutions

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Origins of the Salmon Crisis in the Columbia River Basin and Prospects for Sustainable Long-Term Solutions

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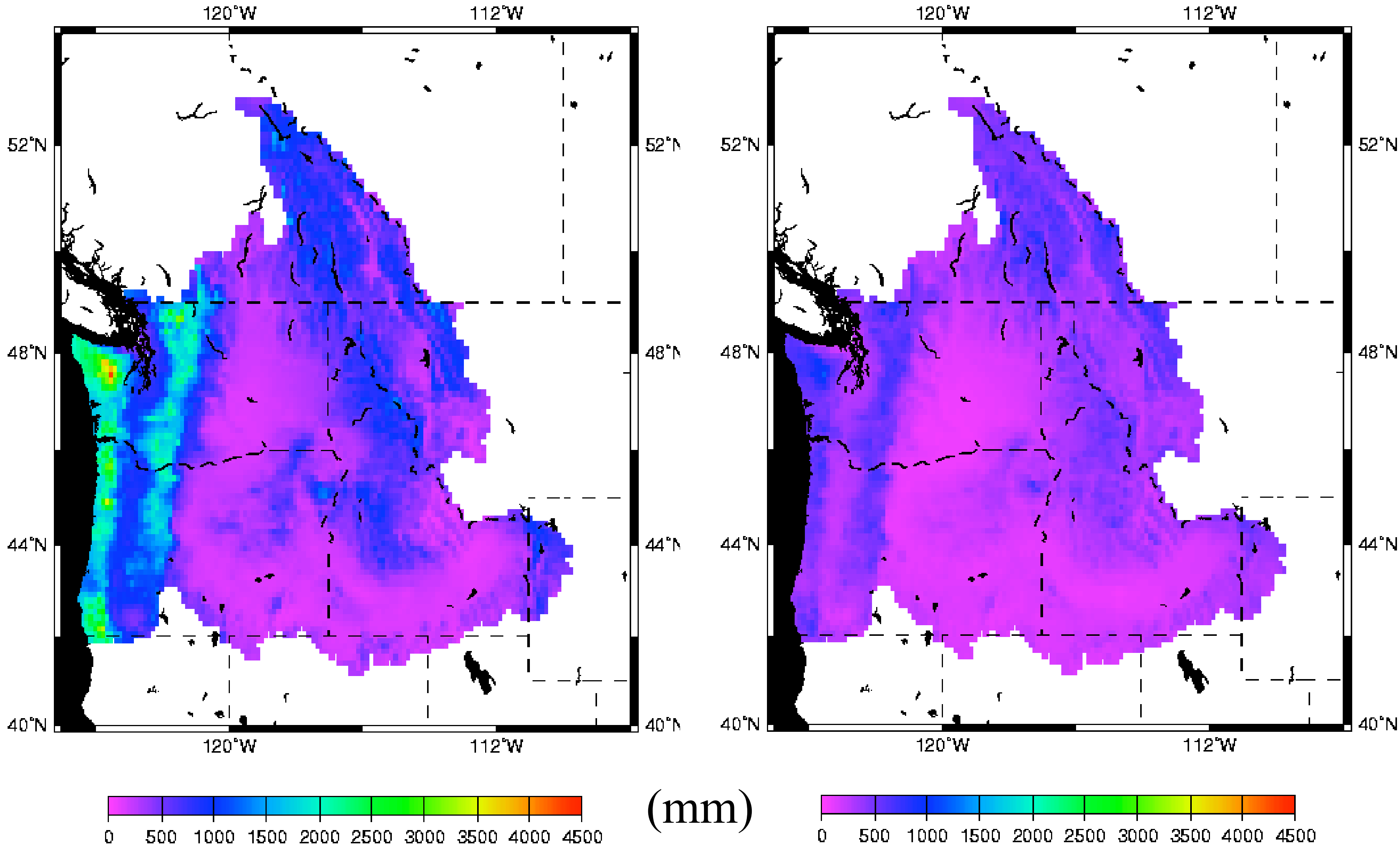
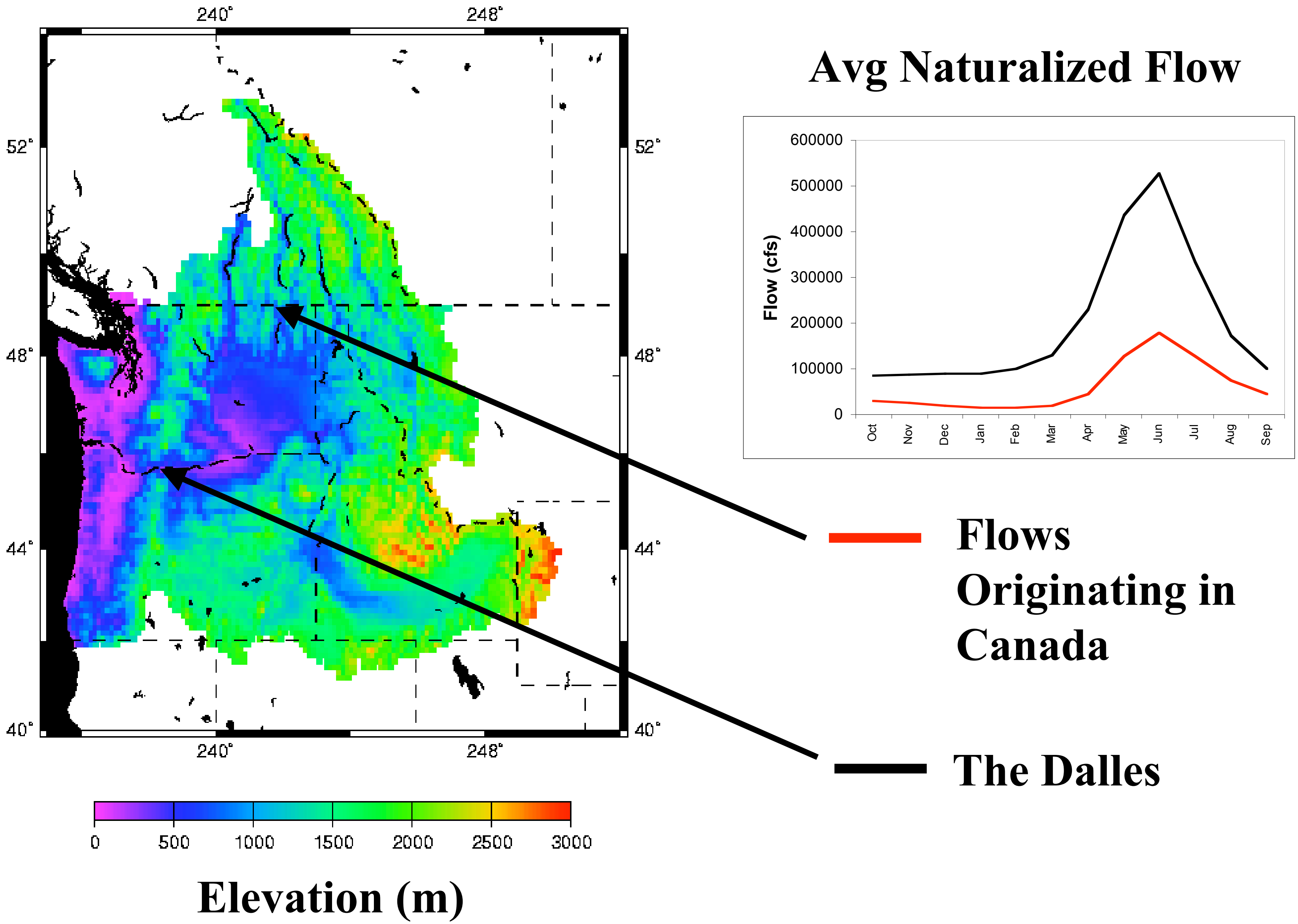
Hydroclimatology of the Pacific Northwest



Winter Precipitation

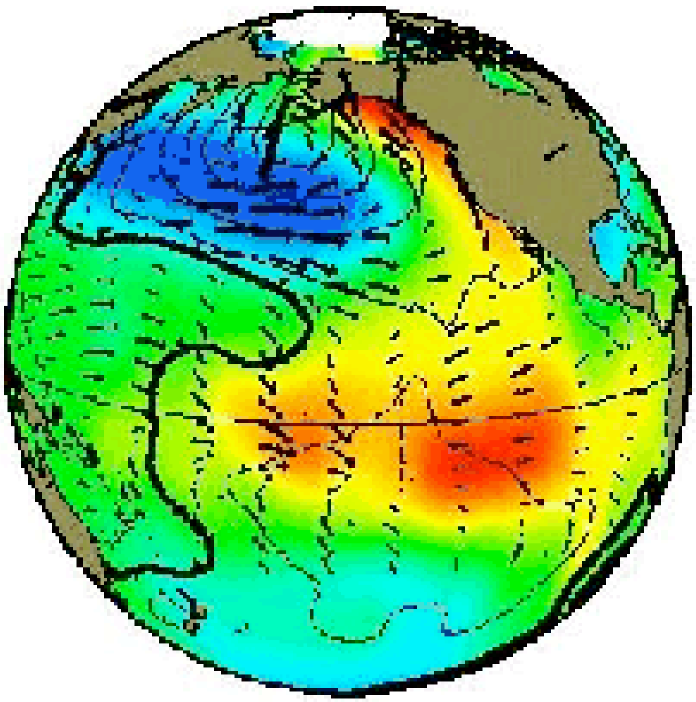
Summer Precipitation

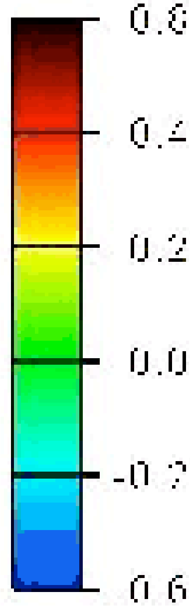
Hydrologic Characteristics of the Columbia Basin

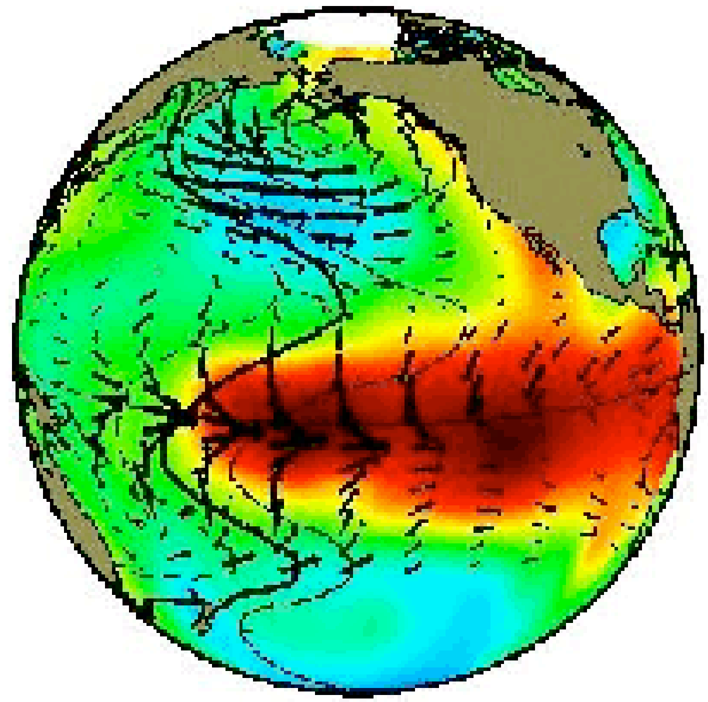


Pacific Decadal Oscillation

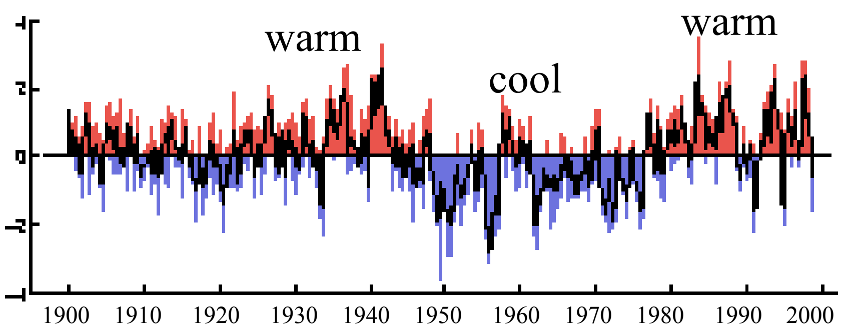
El Niño Southern Oscillation



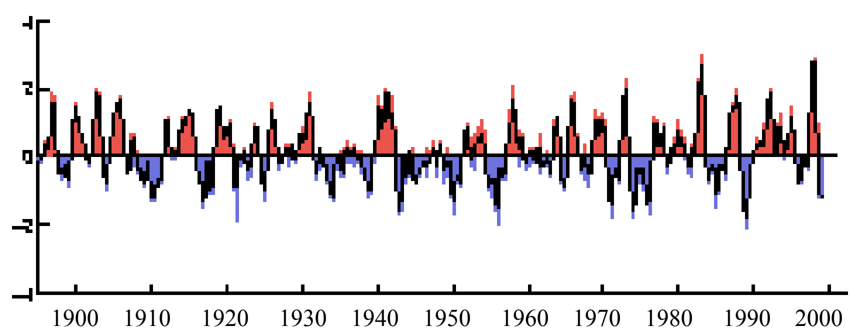




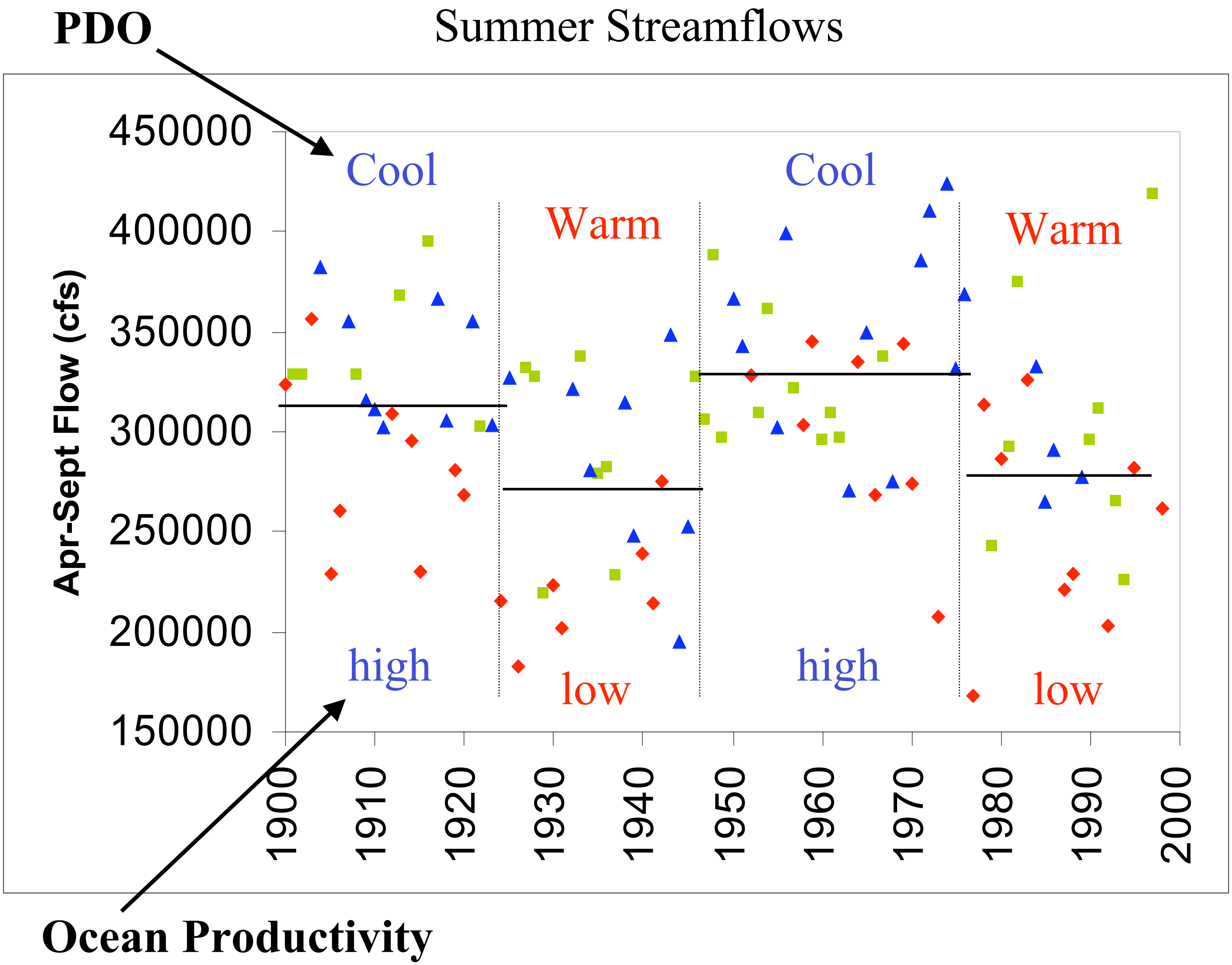
A history of the PDO



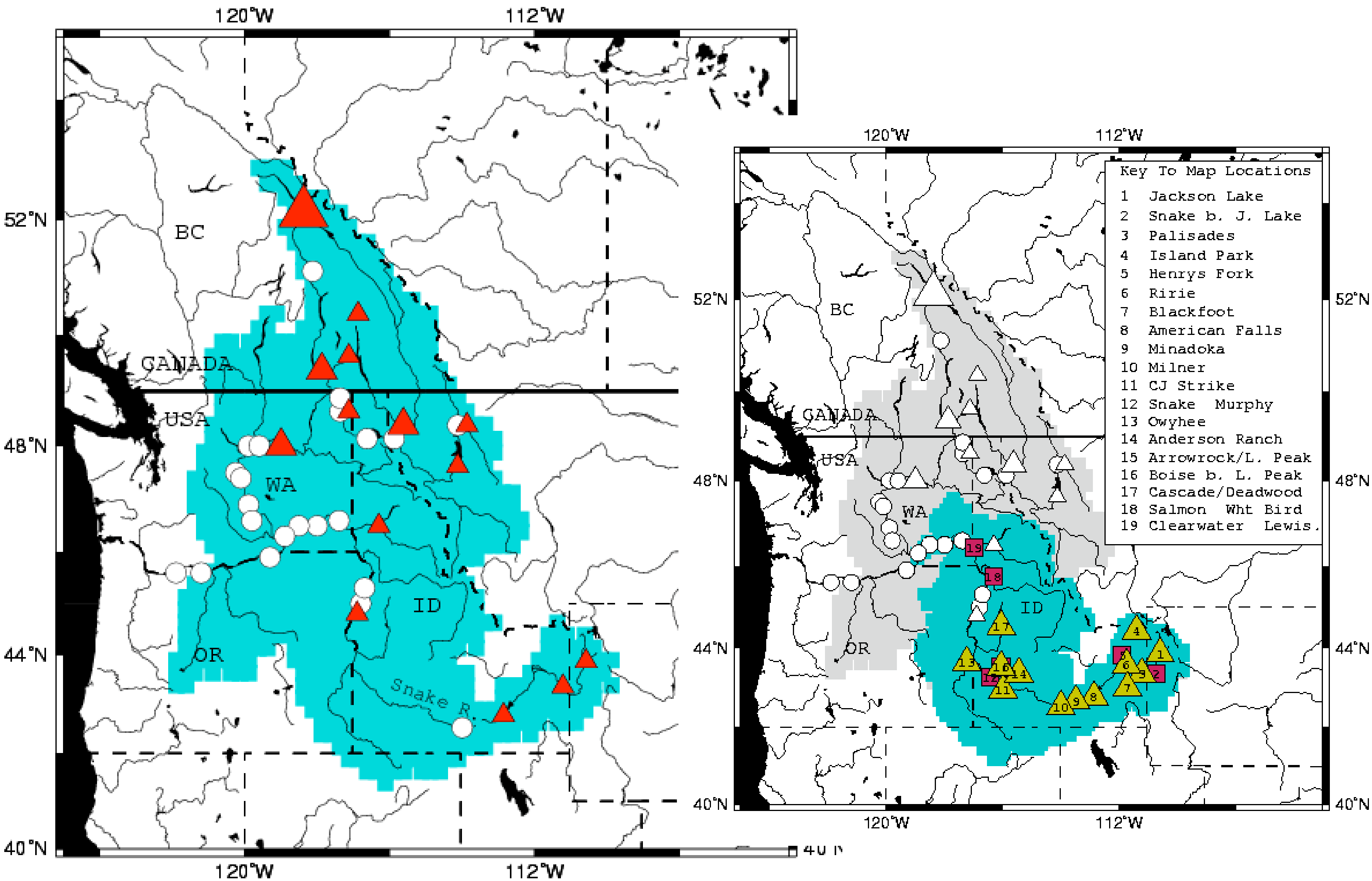
A history of ENSO



Effects of the PDO and ENSO on Columbia River Summer Streamflows



Columbia Basin Water Resources System



120°W
112°W
52°N
48°N
44°N
40°N
BC
CANADA
USA
WA
ID
OR
Snake R.
Key To Map Locations
1 Jackson Lake
2 Snake b. J. Lake
3 Palisades
4 Island Park
5 Henrys Fork
6 Ririe
7 Blackfoot
8 American Falls
9 Minadoka
10 Milner
11 CJ Strike
12 Snake Murphy
13 Owyhee
14 Anderson Ranch
15 Arrowrock/L. Peak
16 Boise b. L. Peak
17 Cascade/Deadwood
18 Salmon Wht Bird
19 Clearwater Lewis.

A Timeline for the Columbia's Development

1935 · 1940 · 1945 · 1950 · 1955 · 1960 · 1965 · 1970 · 1975 · 1980 · 1985 · 1990 · 1995 · 2000

Bonneville Dam completed 1938

Grand Coulee Dam completed 1941

Columbia River Treaty Ratified 1964

Duncan Dam completed 1967

Keenleyside Dam completed 1968

Dworshak and Mica Dams completed 1973

Libby Dam completed 1976

4 Snake River Dams:

Ice Harbor (1962)
Lower Monumental (1970)
Little Goose (1970)
Lower Granite (1975)

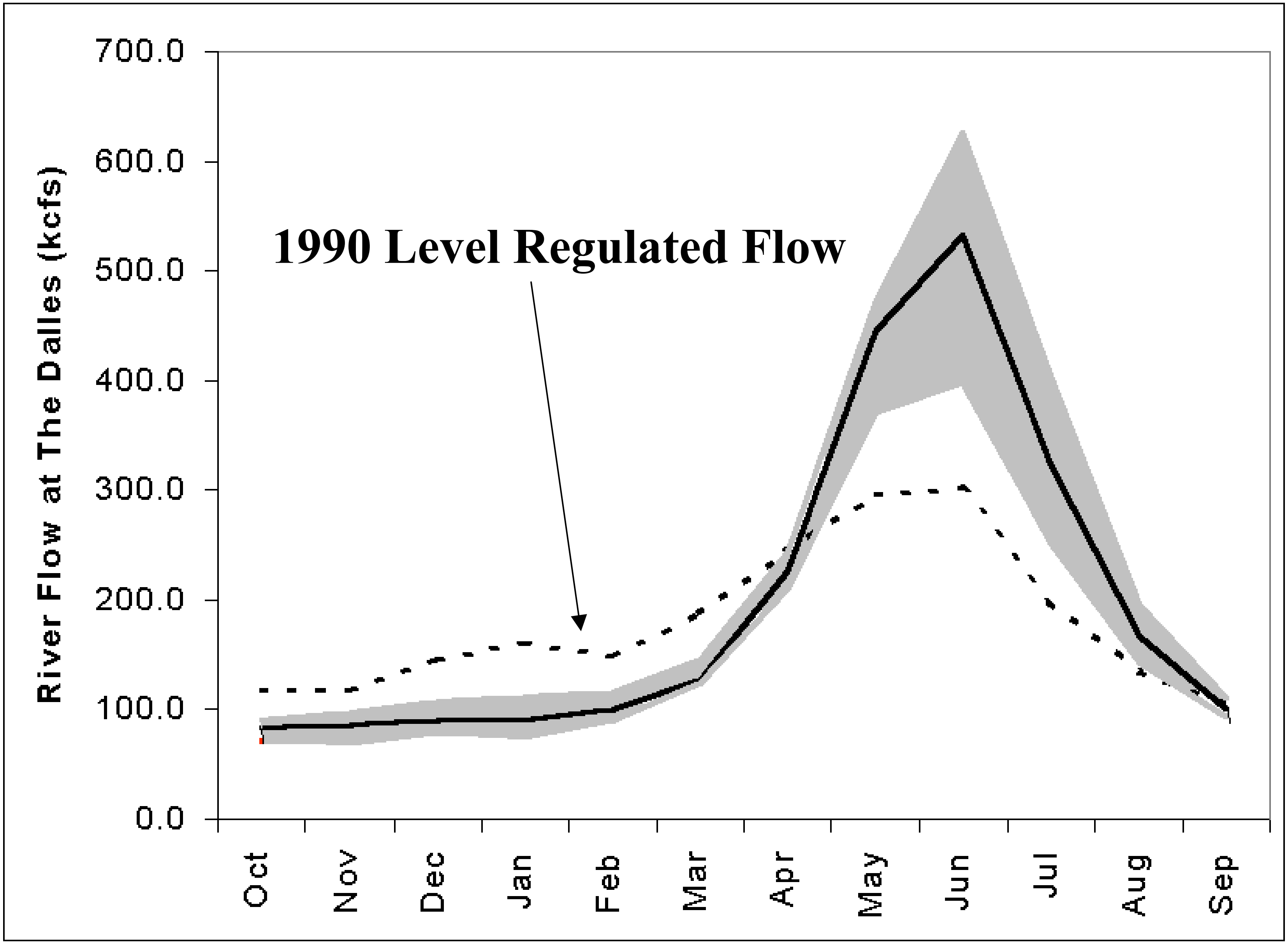
PNW Power Planning and Conservation Act 1980

Snake River Sockeye and Chinook and Kootenai River Sturgeon listed under ESA 1991-1994

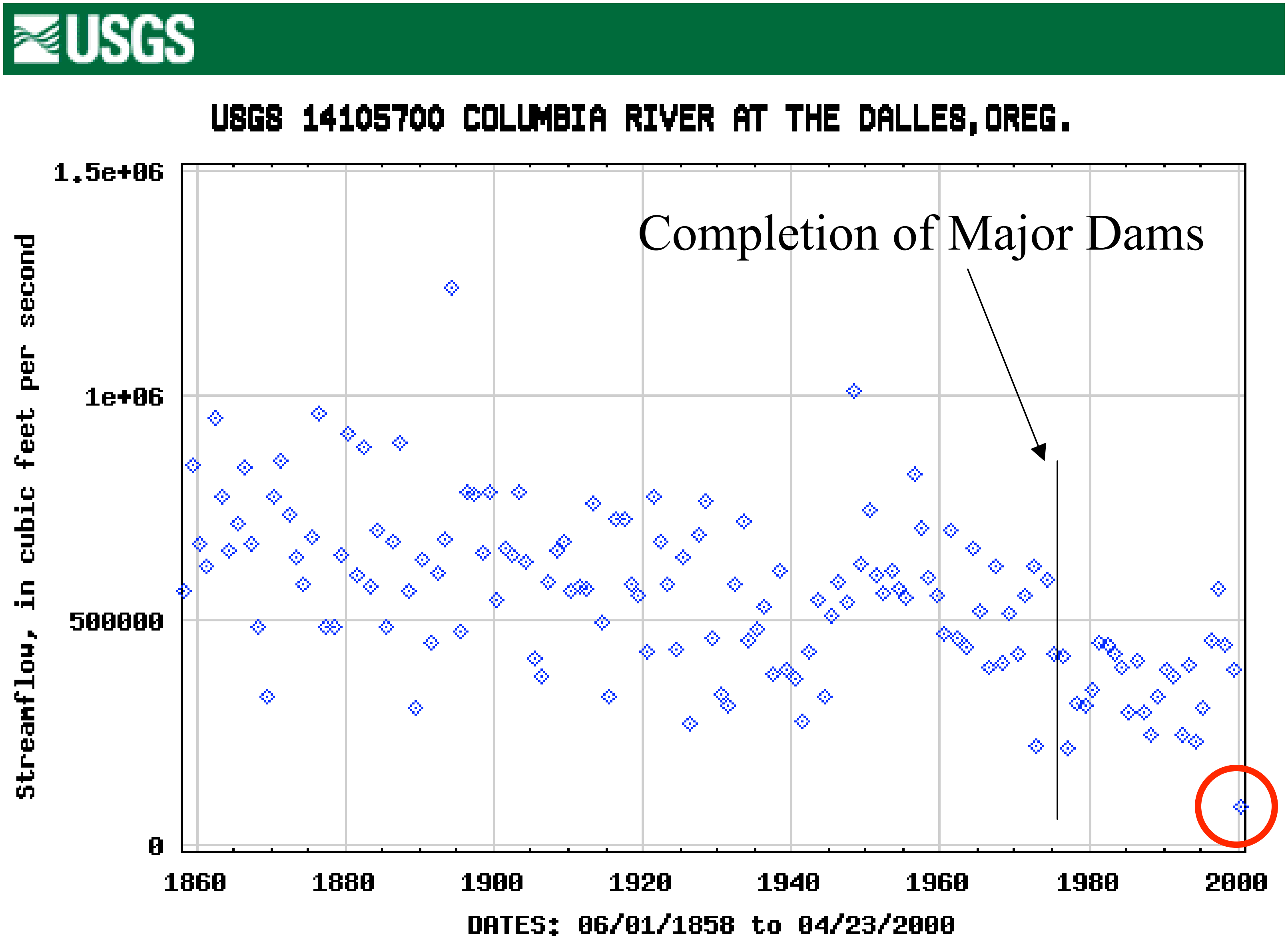
NMFS Biological Opinion 1995

Eight additional ESA listings for Sockeye, Chum, Chinook and Steelhead throughout the PNW 1999

Natural Variability Compared to Effects of Regulation



Peak Regulated Flow at The Dalles



Major Operational Objectives for the Columbia River Dam System

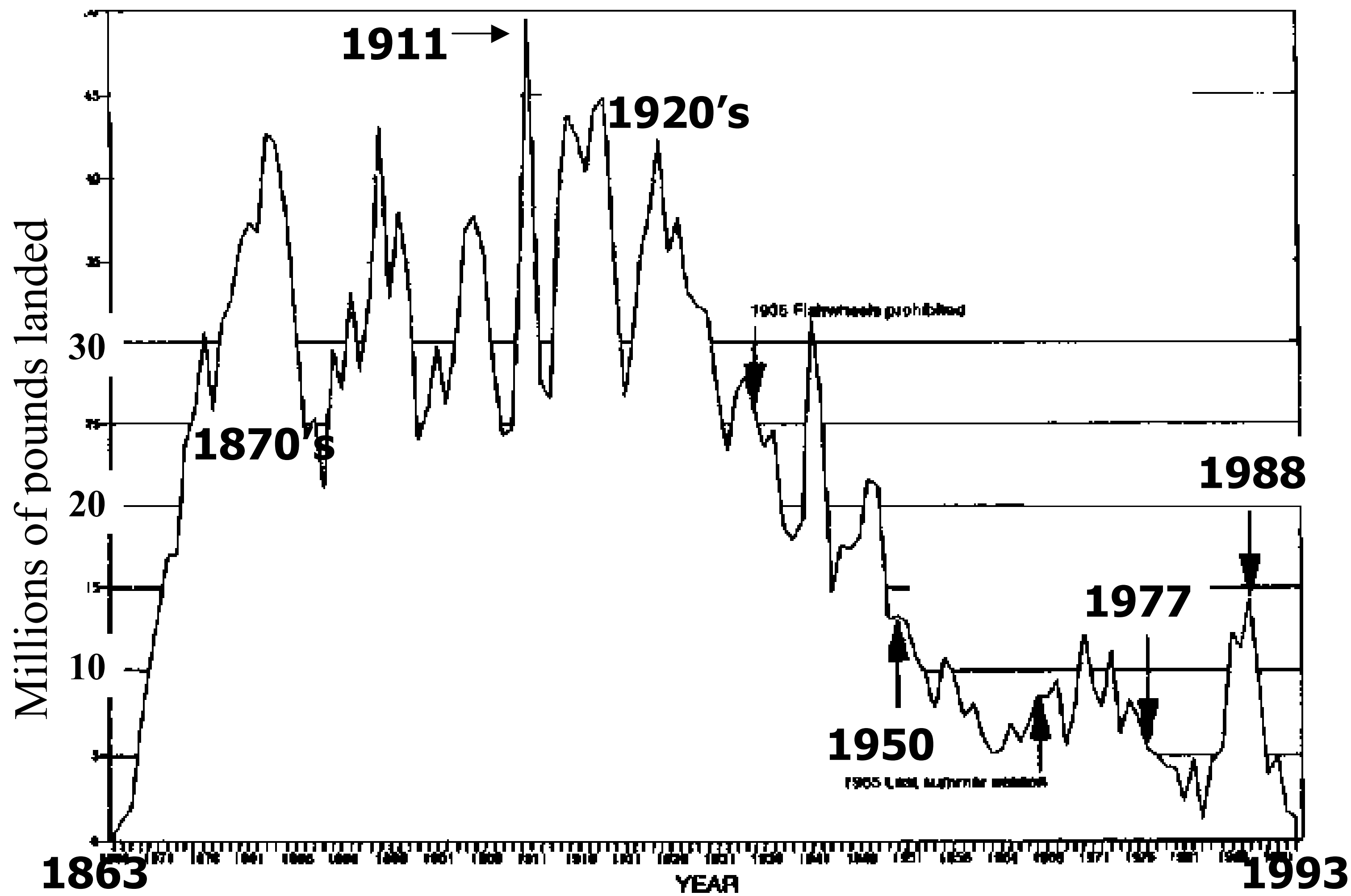
Dominant objectives:

- Flood Control
- Hydropower Production
- Irrigation
- Navigation

More recently an increasing emphasis on:

- Maintenance of summer flow for fish
- Recreation

The Northwest Salmon Crisis: commercial landings in the Columbia River 1863-1993



****Instream habitat and flow are only one factor in the decline****

Some Important Aspects of the Columbia River Treaty

Built about 50% of the Columbia's present storage most of it in Canada (step change in regulated flow regime as above)

Intentional design linkage between flood control and winter hydropower (no attempt to make flood control efficient)

Flood control guaranteed in perpetuity (protects US hydropower in winter)

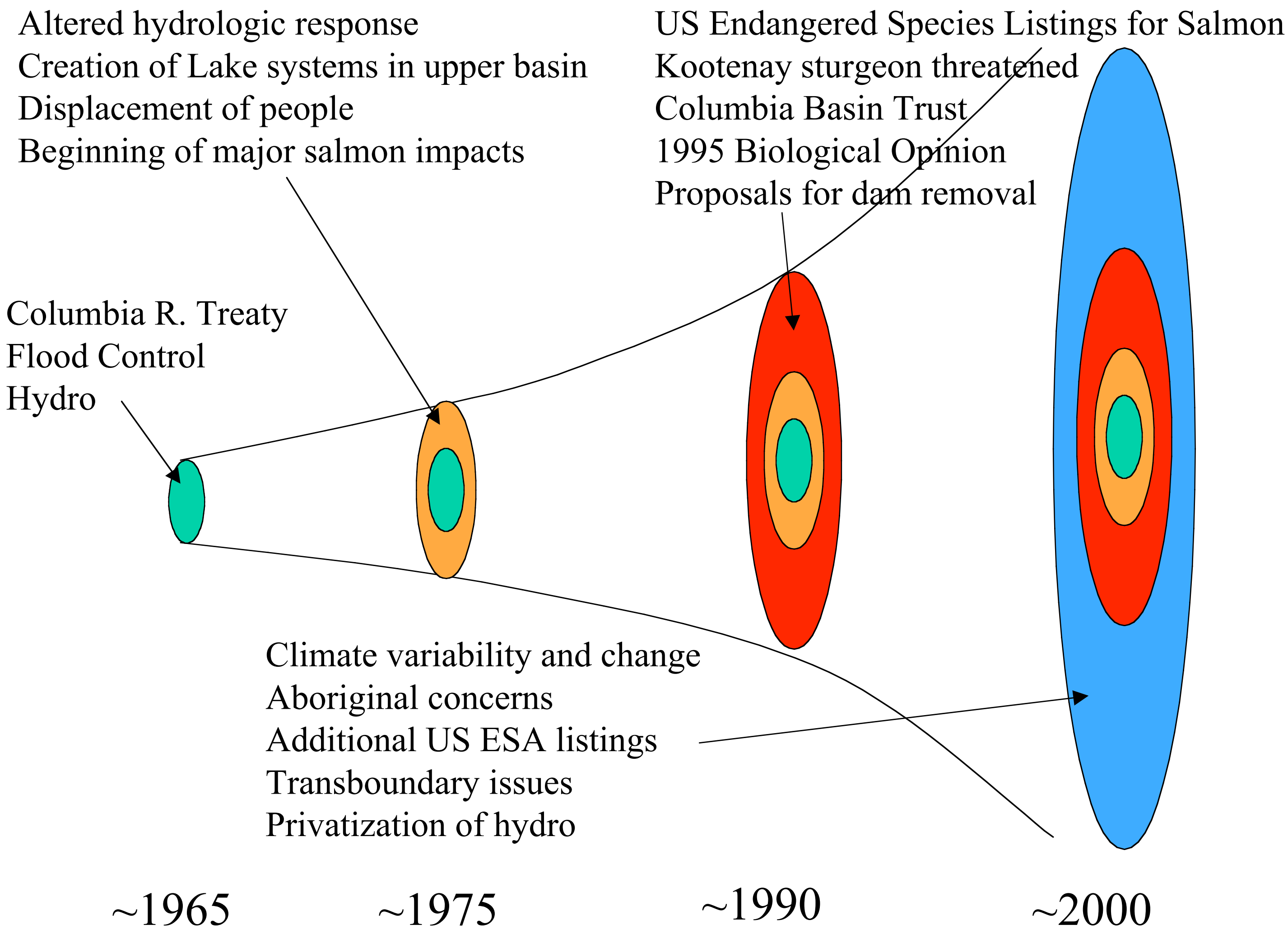
No explicit provisions for instream flows in summer (vulnerability to changing circumstances such as climate and endangered species)

"Closed-door" oversight of the Treaty by a committee high-level of engineers comprising the Permanent Engineering Board (2 from US, 2 from Canada). (Operations connected to the CRT have been very difficult to change)

Conflicting goals between Canada and US regarding fish--(Canada lake fish/US anadromous fish)

Revision of downstream power benefits to Canada (Duncan 1997, Keenleyside 1998, Mica 2003)

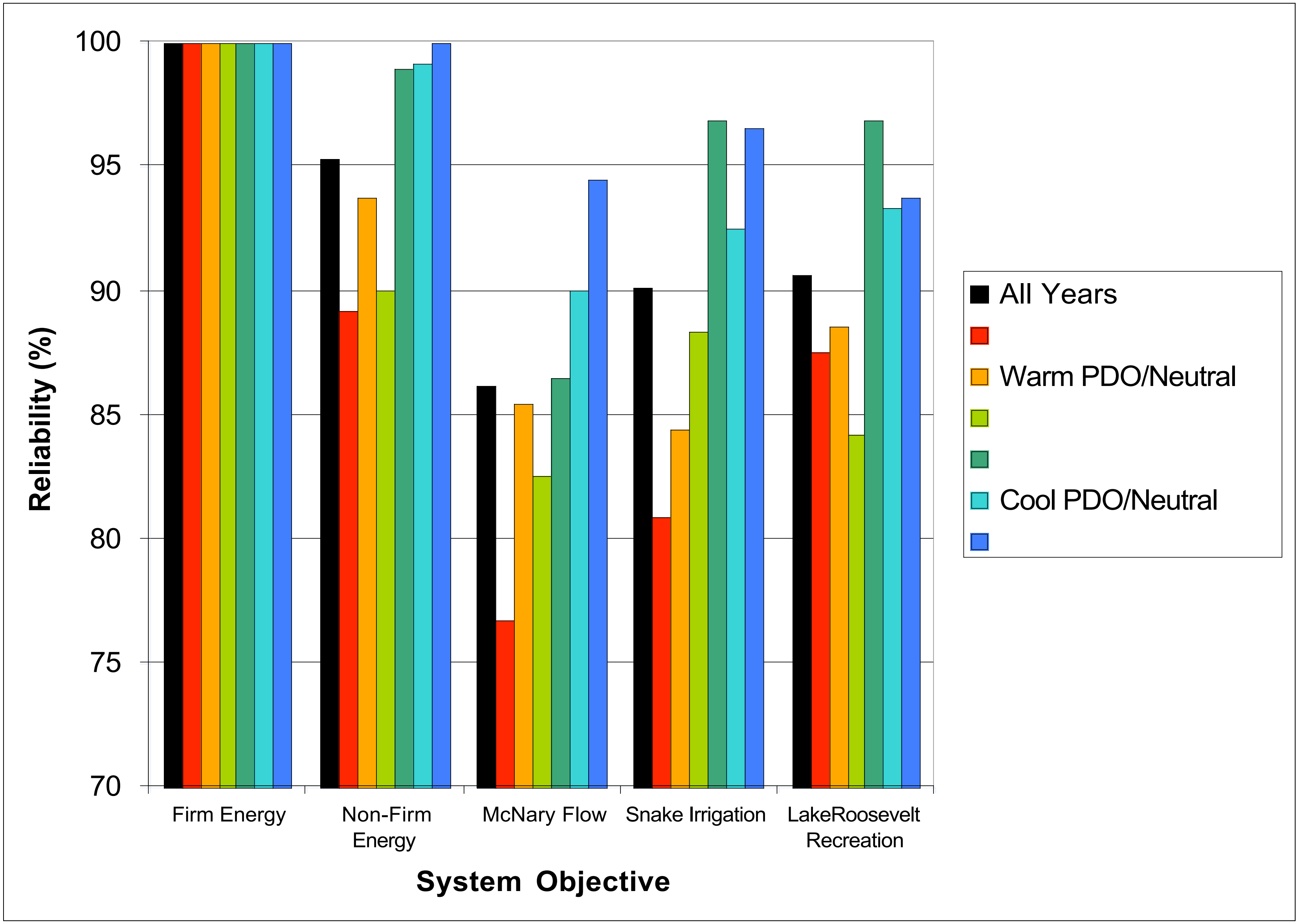
Evolution of Columbia Basin Integration Boundaries



Conflicts in the Columbia Main Stem

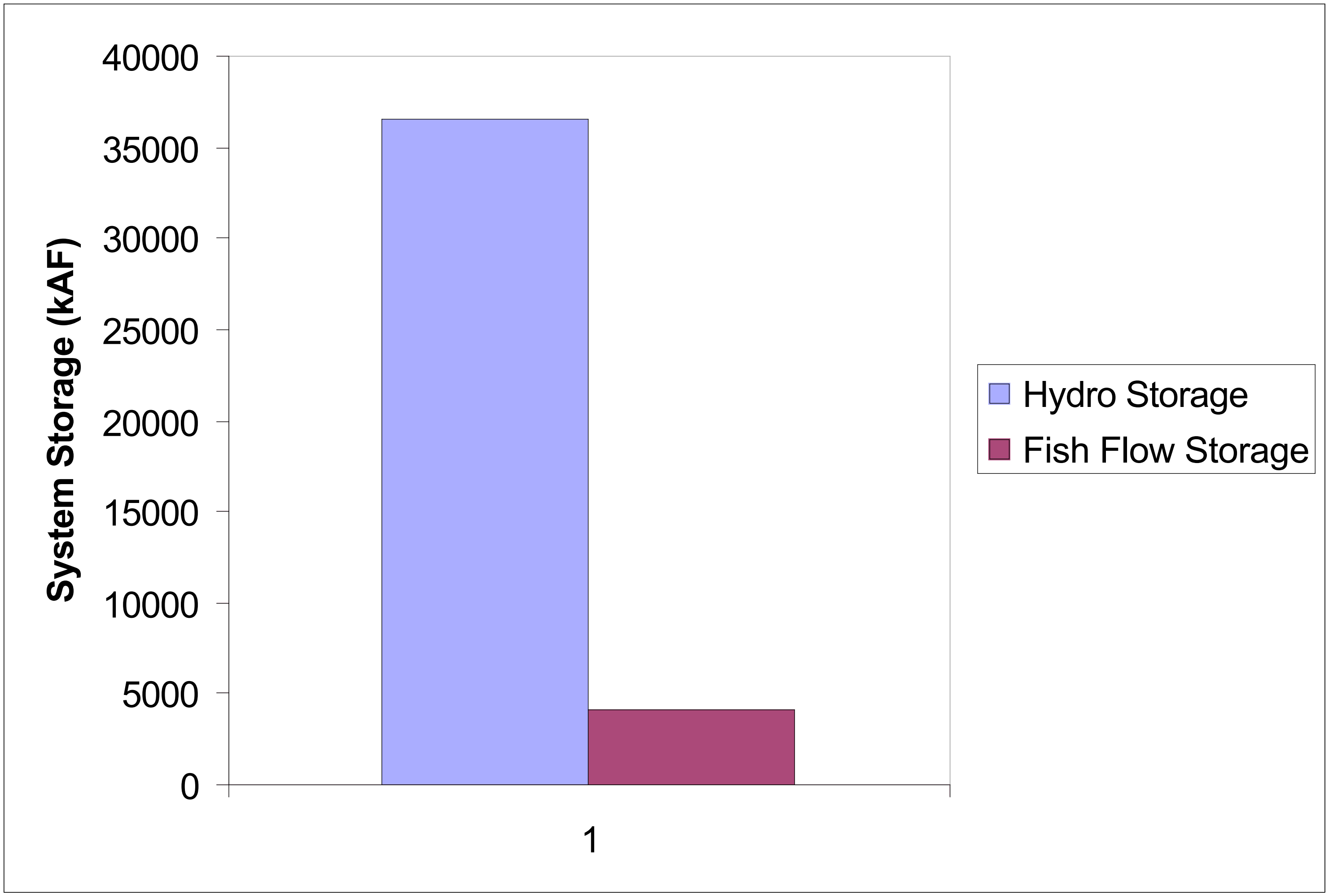
Salmon vs Hydro and Flood Control

Effects of Natural Variability for Status Quo

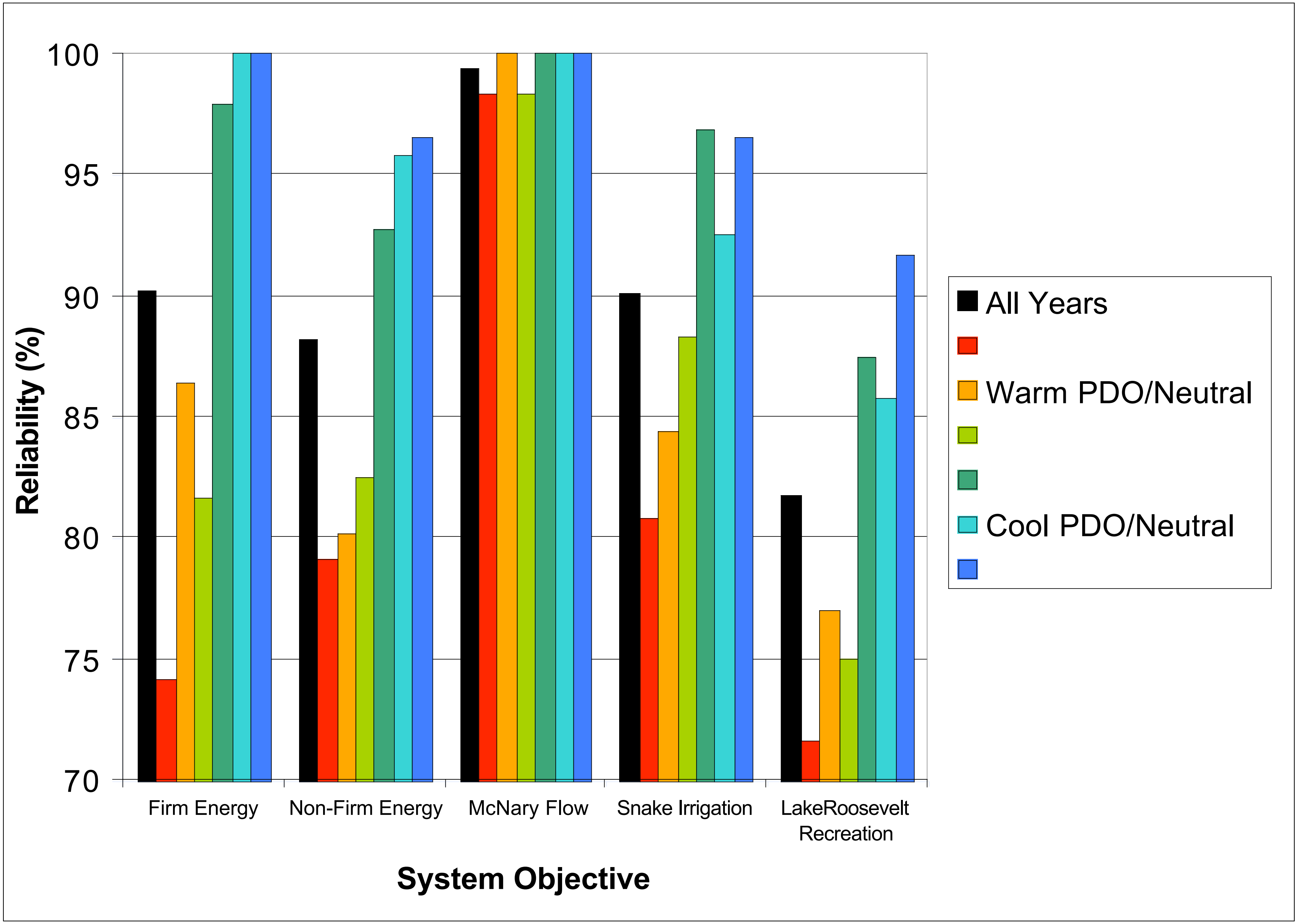


Why does the system behave like this:

Storage allocation for fish flows = 4150 kAF
Storage allocation for hydro = 36500 kAF



Effects of Natural Variability for Fish Flow Alternative



What Would be Required to Implement the Hypothetical Fish Alternative?

Replacement Energy Sources in the Winter

e.g. interchange with CA, natural gas, wind, solar, nuclear(?)

Some Access to Canadian Storage in Summer

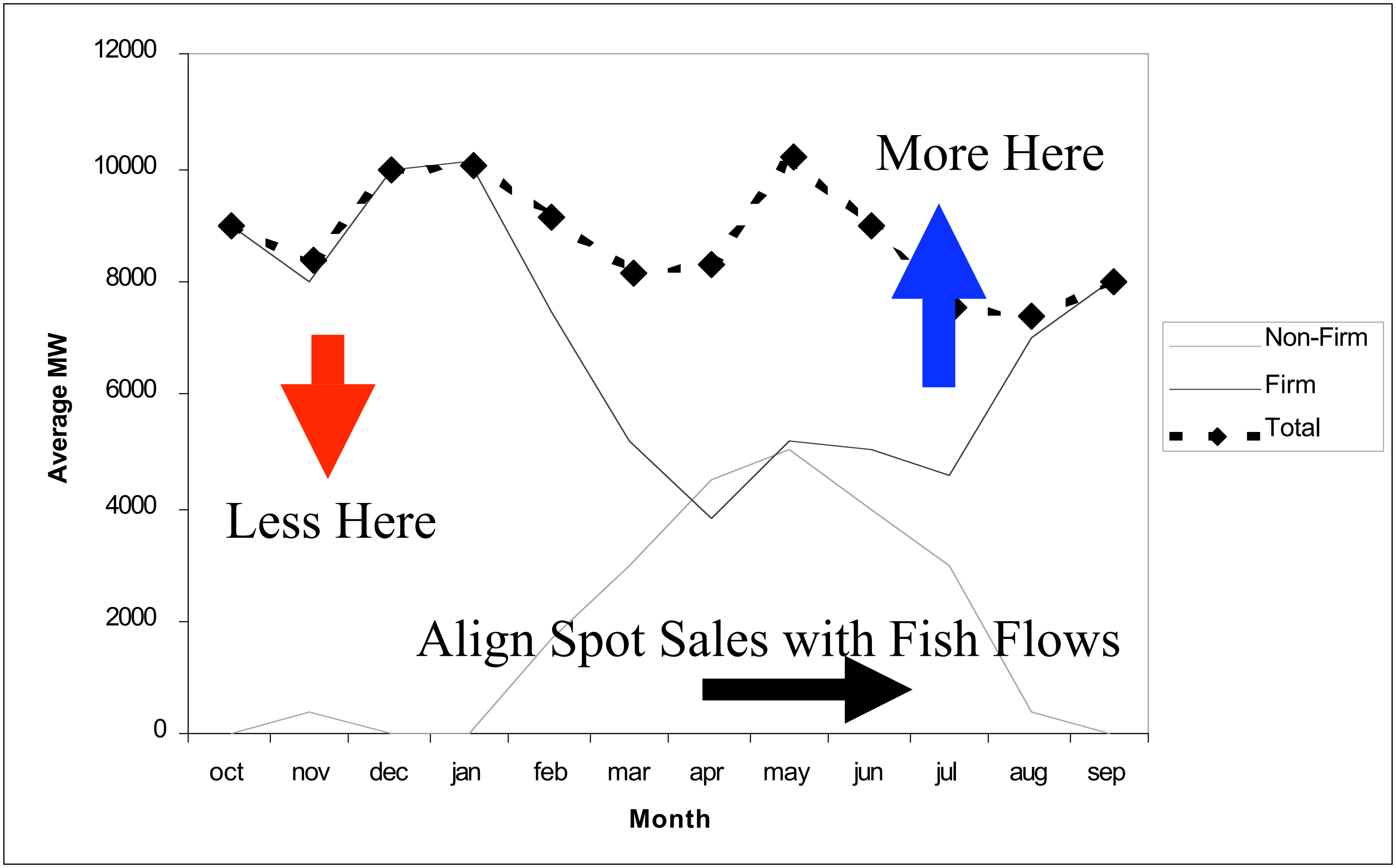
Columbia River Treaty

Conflicting objectives in Canada & US

Loss of Some Lake Recreation Benefits at Storage Reservoirs

Problems with Irrigation (?)

Typical Energy Load Shape Prior to Wholesale Deregulation and Proposed Changes to Benefit Fish



Cost Estimates Assuming Reliable Supply of 70% of Current "Firm" Energy Targets

Increased Hydro Revenue = $65 million per year

Cost of Winter Replacement Energy = $250 million per year

Net Cost = $185 million per year

Estimate of Required Replacement Capacity = 5000 MW

Potential Role of Technological Innovations in the Energy Sector

Short Term

- Wind Turbines

- Larger CA capacity (source of winter capacity for PNW)

- Photovoltaics (grass roots potential)

- Demand side innovations (e.g. high efficiency lighting)

Medium Term

- Fuel Cell and Hydrogen Storage (cogeneration potential with hydropower)

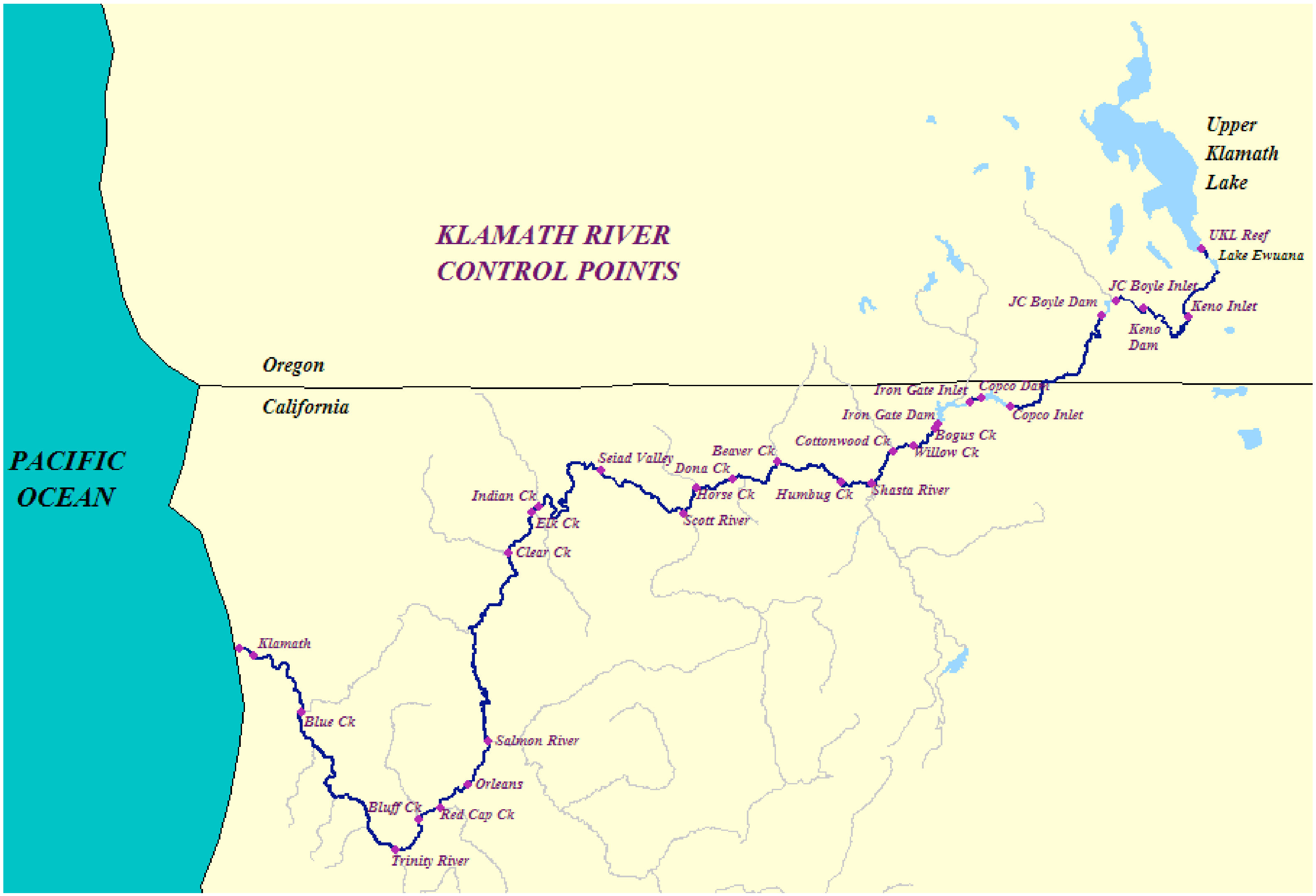
Long Term

- Nuclear (solve existing waste disposal problems or fusion ?)

Conflicts in Heavily Allocated Irrigation Systems

Salmon vs Irrigation

Case Study: Klamath Basin in 2001 and 2002
Political Polarization and Oscillating Extremes



What happened in 2001?

2001 was the first serious test of water allocation policy informed by the ESA listings in the basin. A drought in 1992 had tested the system to a limited extent, but conditions were not nearly as bad as in 2001. Flows in the Klamath system in 2001 were at record low levels.

Attempts were made to alter the ESA water allocation rules during the drought (July, 2001), but they were overruled by congress. The USBR enforced the ESA requirements.

Equity between different kinds of water users was not handled well. The USBR cut off water impounded by federal storage projects, impacting a large number of farmers with junior water rights, while nearby non-federal projects continued to deliver water to their stakeholders. (Issues of trust)

What happened in 2002?

The science behind the fish flow targets was criticized by the National Academy of Sciences review as “inconclusive”.

Under intense criticism of its actions in 2001, the USBR (aided by farm interests in the current administration and the above) revised it’s water allocation policies for instream flow augmentation for 2002 in a new 10-year plan (57% of fish flows guaranteed, 43% voluntary).

Water year 2002 was a moderately low flow year in the Klamath basin.

In 2002, based on the new water allocation plan, the USBR reportedly delivered about 60% of the flow they provided in 2001.

There were large salmon kills (both juveniles and adults) in the lower basin in summer 2002 believed to be caused by low flows and/or high water temperatures.

Potential Role of Water Markets and Water Banks in Solving Problems of Over Allocation

Water markets and water banks can help to facilitate the orderly transfer of water between different uses and users on both short and longer time scales. Such systems have been implemented on a limited basis in some areas.

Problems:

Current water law and the expectations of current water rights holders.

Equity in the transfer process. Who owns the water? Is the water right a license to use or more like personal property that can be bought and sold?

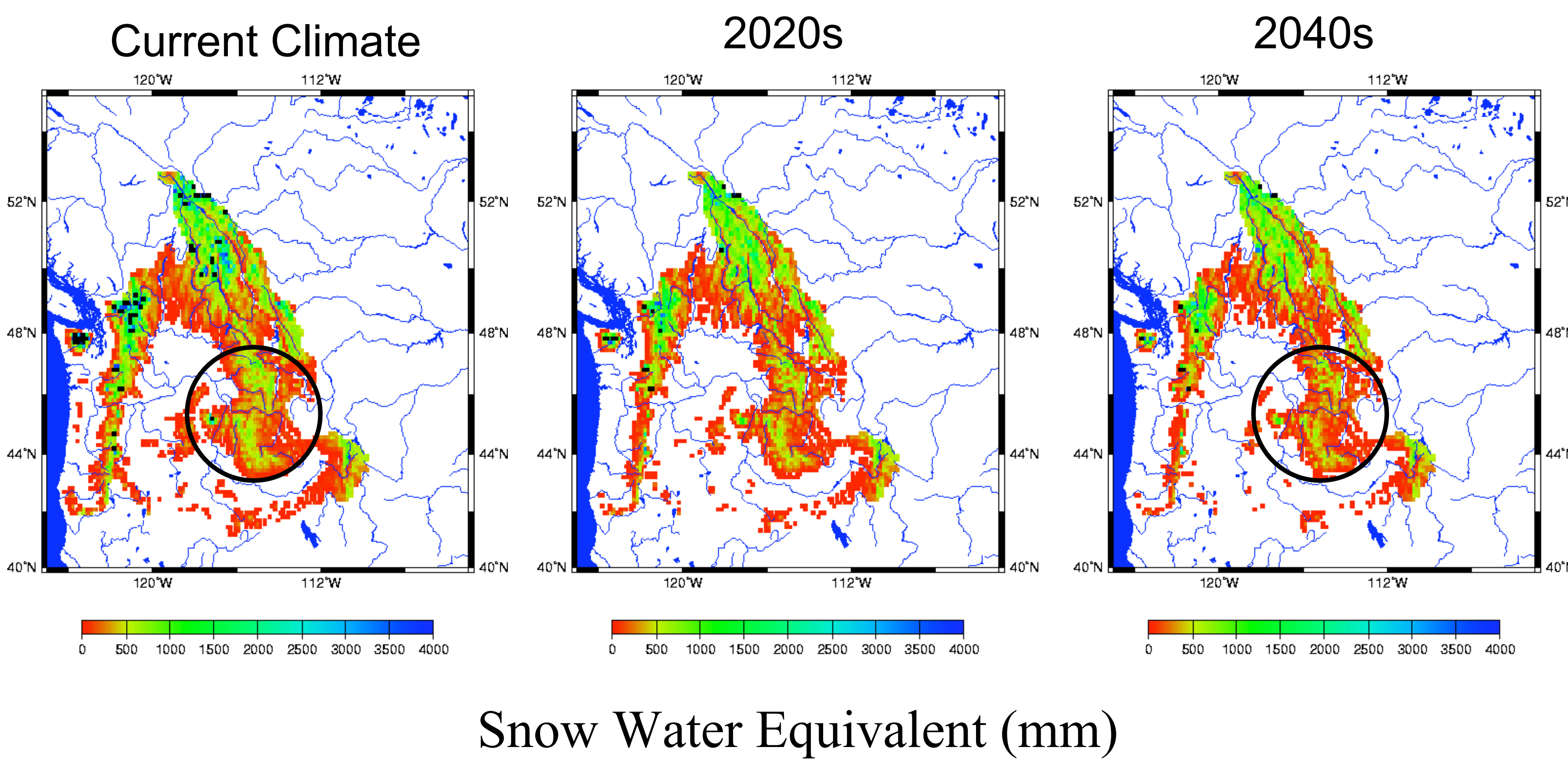
Ground water/surface water interactions and long-term impacts to downstream users.

Potential misalignment of market forces with specific water management objectives (e. g. transfers of water right from irrigation to hydro as opposed to transfers from irrigation to M&I use)

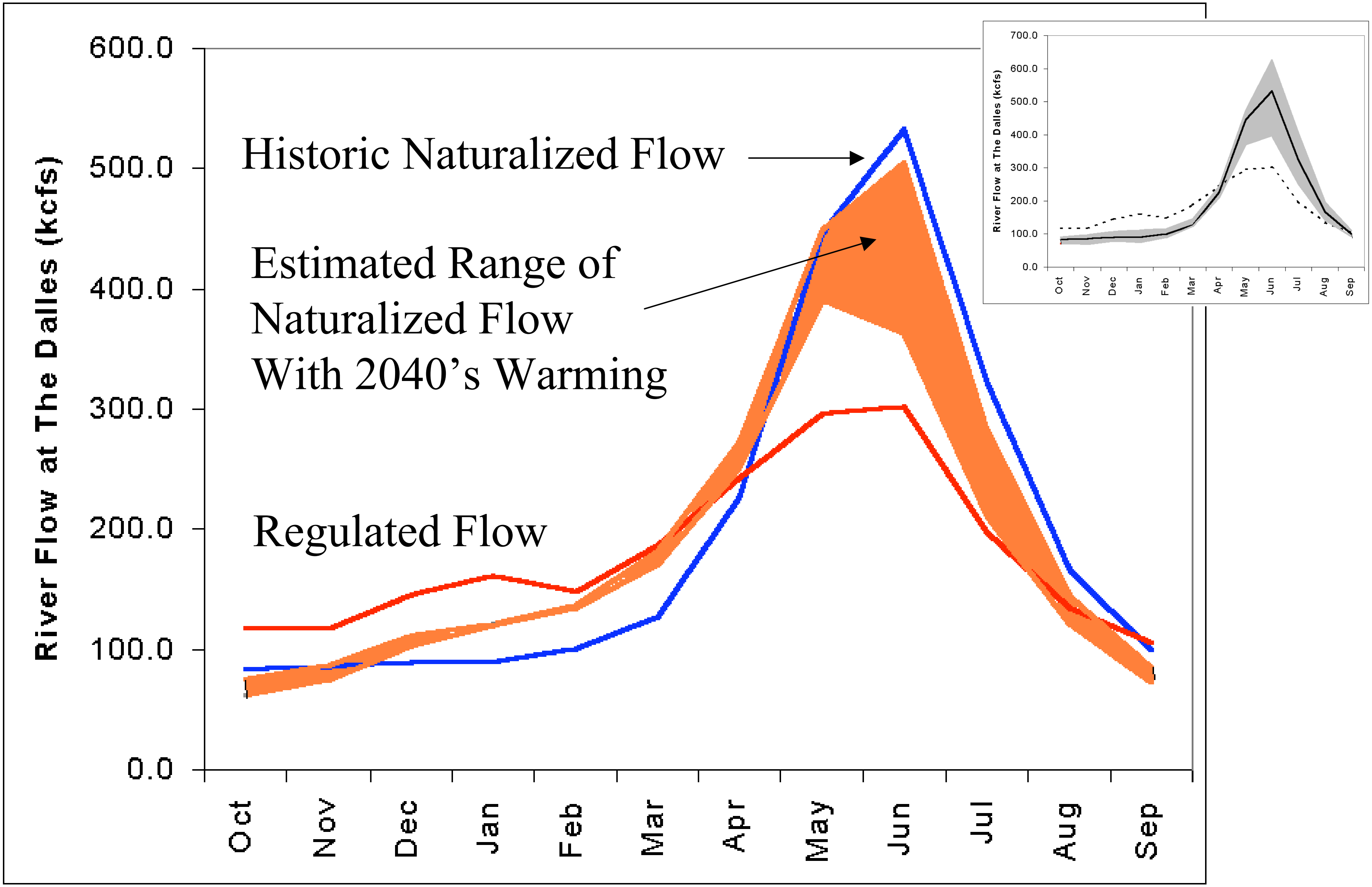
“External” Stressors

Climate Change

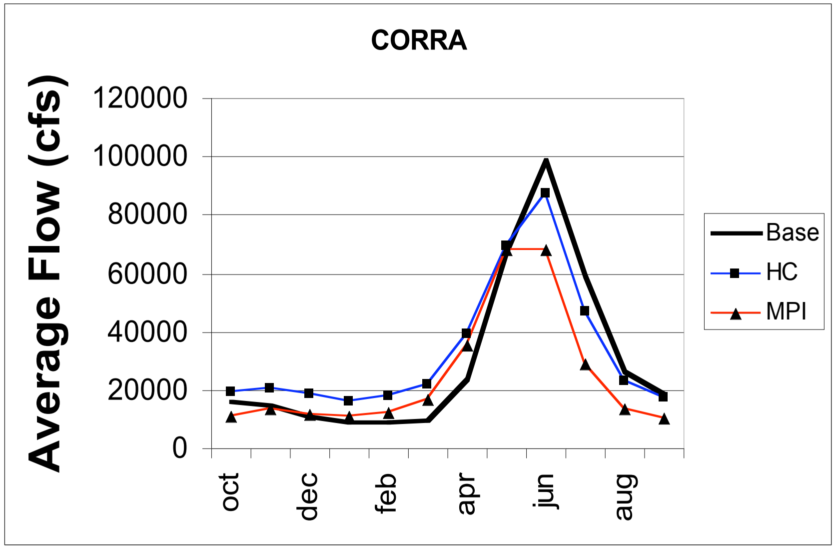
VIC Simulations of April 1 Average Snow Water Equivalent for Composite Scenarios (average of four GCM scenarios)

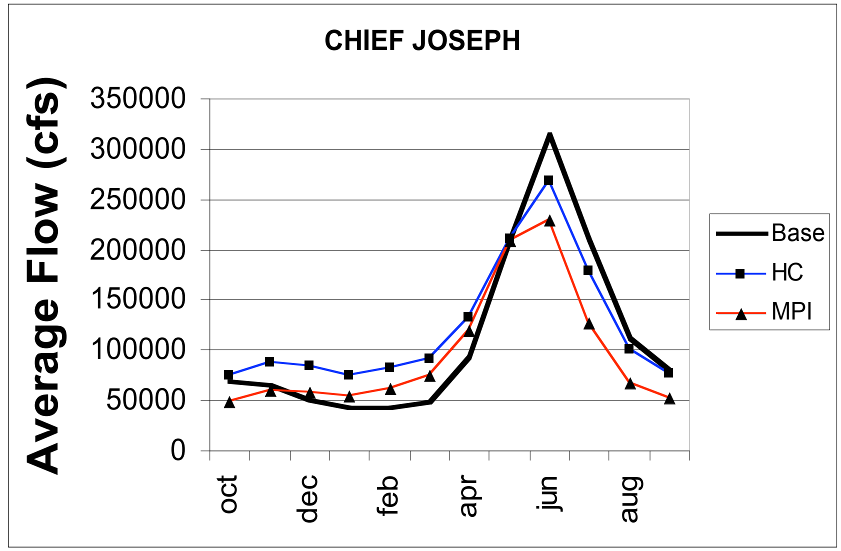


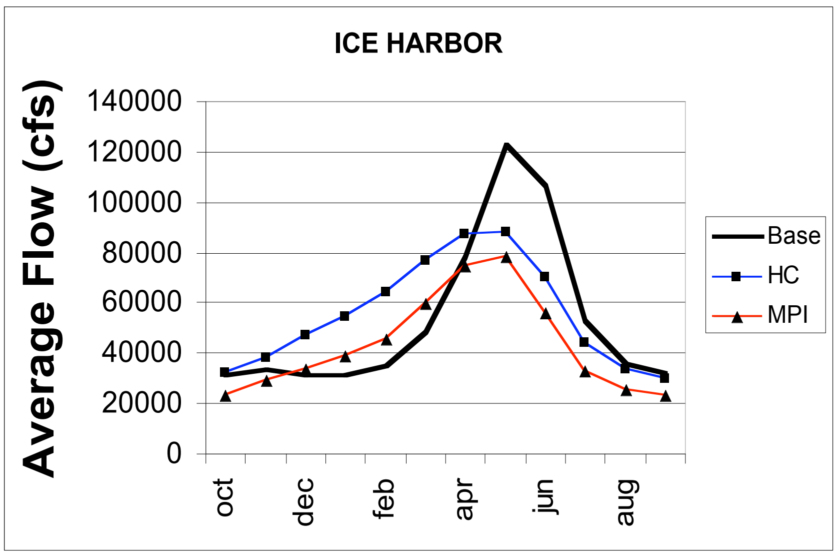
Naturalized Flow for Historic and Global Warming Scenarios Compared to Effects of Regulation at 1990 Level Development

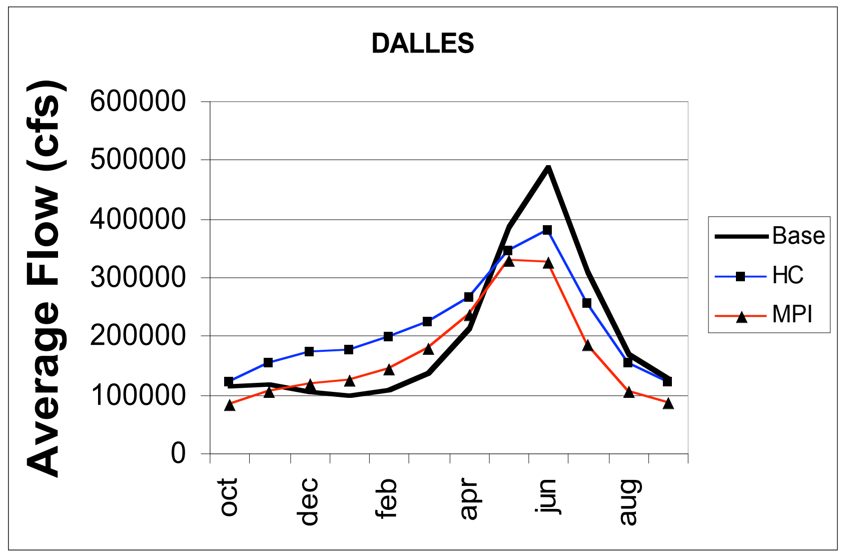


Changes to Mean Hydrographs Columbia Basin 2045









Special Issues Regarding Adaptation to Climate Change

Impacts to summer streamflow may be incremental or may occur in “jumps”.

Complex interactions with patterns of natural variability may produce periods with reduced impacts. A cool PDO epoch in the next 20 years could delay adaptive measures in the PNW.

Current water management and planning are based primarily on the variability of the past, and are not particularly well suited to coping with gradual and systematic changes in water availability.

Contingency planning provides an avenue for coping with climate uncertainty, but how will the plans be “triggered”?

Transboundary Issues Associated with Climate Change

Summer streamflows in the lower Columbia basin are strongly influenced in by streamflows originating in Canada.

The importance of streamflows originating in Canada is likely to increase with climate change because an increasing proportion of the snowpack will be in the Canadian snowfields in spring for warmer climate.

Current treaties between the U.S. and Canada have no explicit provisions for the maintenance of lower basin instream flows in summer.

Because of conflicting summer water objectives in Canada and the United States, the Columbia River Treaty may have increased the US's vulnerability to climate change. (Flow across the border is not guaranteed in summer.)

Conclusions

Threats to salmon survival and sustainable ecosystem management in the Columbia River basin have been physically diverse and cumulative in nature. Fixing any one of these threats probably won't solve the problem. Need for integrated planning.

Existing water management institutions and traditional water allocation practices have been an obstacle in making substantive changes in the Columbia's operating policies. Most changes have been incremental in nature, have emphasized "engineering" solutions, and have remained centered on the basic water management framework established by the CRT in 1964.

Cost effective alternate water management policies that are capable of providing a more sustainable balance between human systems and ecosystems have been proposed (some are being tested in practice on a limited basis), but many require institutional, legal, and political changes to function effectively.

Conclusions (cont.)

The potential impacts of other stressors such as increasing human populations, land use changes, and climate change highlight the need for effective monitoring and flexible water management systems that can adapt to evolving conditions without recursive policy intervention.

Integration Questions Related to Sustainability

How sustainable are the PNW's groundwater and surface water resources in the context of the past 250 years of climate variability and potential changes in climate expected in the next 100 years? How do we measure sustainability?

How (and on what basis -- e.g., economic, social considerations) can water best be allocated between competing uses and users of water?

How should instream flow requirements be determined and managed? (tradeoffs between ecological considerations and human needs)

How can more flexible water management institutions be developed that can respond to changing conditions without recursive policy intervention as unanticipated problems emerge?

How can issues of governance be addressed in water managment to ensure that institutional fragmentation does not dominate response capability to changing conditions?

What role can technological innovations play in coping with increasing demand and limited supplies? Where will different technologies find their best application and at what cost?

What formal linkages between water resources planning and land use planning are needed to ensure sustainability on a local, regional, and national scale?