Independent Scientific Advisory Board
for the Northwest Power and Conservation Council,
Columbia River Basin Indian Tribes,
and NOAA Fisheries
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204
ISAB@nwcouncil.org

January 4, 2011

ISAB Presentation - Columbia River Food Webs: Developing a Broader Scientific Foundation for Fish and Wildlife Restoration

Robert Naiman, review lead, will present the ISAB's Columbia River Food Webs Report. Co-authors Bruce Rieman, Richard Alldredge, and Pete Bisson will also attend to help field questions. The report will be released before the meeting but not in time for an in-depth understanding of the contents. Consequently, the presentation will highlight the report's key findings and give a general overview to help guide reading and use of the report.

The report is the culmination of a two-year undertaking that provides a fundamental understanding of aquatic food webs in the Columbia River Basin and their effects on native fish restoration efforts. The report's scope includes the tributaries, impoundments and mainstem Columbia and Snake rivers, as well as the estuary. To complete the report the ISAB compiled and reviewed the diverse literature to produce a coherent summary; identified future food web-related research directions for improving restoration of fish and wildlife in the Basin; and presented current scientific understanding in a form that can be used by policy makers.

To guide the review, the ISAB considered a number of fundamental questions concerning aquatic food webs that, if adequately addressed, could inform ongoing and future restoration efforts:

- What are the quantifiable, system-scale impacts of sea lions and birds?
- What are the ecological consequences of changing the river from a primarily benthic-based production system to one that is now predominantly pelagic-based?
- How do intensive and selective fisheries (e.g., Northern pikeminnow) reverberate through food webs?
- What are the ecological consequences of the large numbers and consistent annual levels of salmonid hatchery releases?
- Are the preferred foods of migrating juvenile salmon available in sufficient quantities, and at the right times?

- How vulnerable are existing salmonid food webs to near term climate-induced changes?

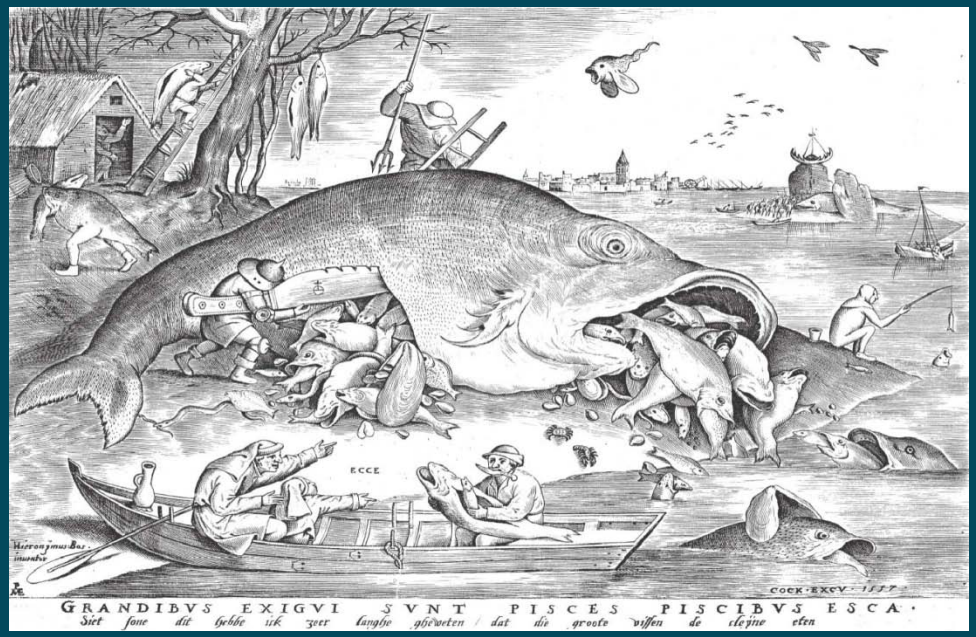
- Do marine-derived nutrients released from the bodies of spawning salmon contribute to the survivorship and productivity of the subsequent generation as well as enhance the productivity of the entire biotic community?

- How might projected changes in agricultural land use and water withdrawals impact food web structure?

- Can a general model be developed to predict the food web consequences of proliferating non-native species (e.g., shad, bivalves) on the foods of native species?

The ISAB looks forward to presenting its findings to the Council and the public in Missoula.

Food Webs:
Developing a Broader Scientific Foundation for Fish and Wildlife Restoration



ISAB – Presentation to Northwest Power and Conservation Council

Missoula, Montana January 11, 2011

J. Richard Alldredge, Ph.D., Professor of Statistics at Washington State University.

*David Beauchamp, Ph.D., Cooperative Fish Research Unit at U of Washington

Peter A. Bisson, Ph.D., Senior Scientist at the Olympia (Washington) Forestry Sciences Laboratory of the U.S. Forest Service's Pacific Northwest Research Station

James Congleton, Ph.D., Emeritus Fisheries Professor, University of Idaho

*Charles Henny, Ph.D., Emeritus Scientist, USGS

Nancy Huntly, Ph.D., Professor of Wildlife Biology at Idaho State University.

Roland Lamberson, Ph.D., Professor of Mathematics and Director of Environmental Systems Graduate Program at Humboldt State University.

Colin Levings, Ph.D., Scientist Emeritus and Sessional Researcher at Centre for Aquaculture and Environmental Research, Department of Fisheries and Oceans, Canada.

Robert J. Naiman, Ph.D., Professor of Aquatic and Fishery Sciences at U of Washington

William Pearcy, Ph.D., Professor Emeritus of Oceanography at Oregon State University.

Bruce Rieman, PhD, Research Scientist Emeritus, U.S. Forest Service, Rocky Mountain Research Station

Greg Ruggerone, Ph.D., Fisheries Scientist for Natural Resources Consultants, Affiliated Research Scientist Alaska Salmon Program, U of Washington

Dennis Scarnecchia, Ph. D., Professor of Fish and Wildlife Resources at University of Idaho.

Peter Smouse, Ph.D., Professor of Ecology, Evolution, and Natural Resources at Rutgers University.

Chris Wood, Ph.D., Head of Conservation Biology Section at Department of Fisheries and Oceans, Canada.

Review Objective & Approach

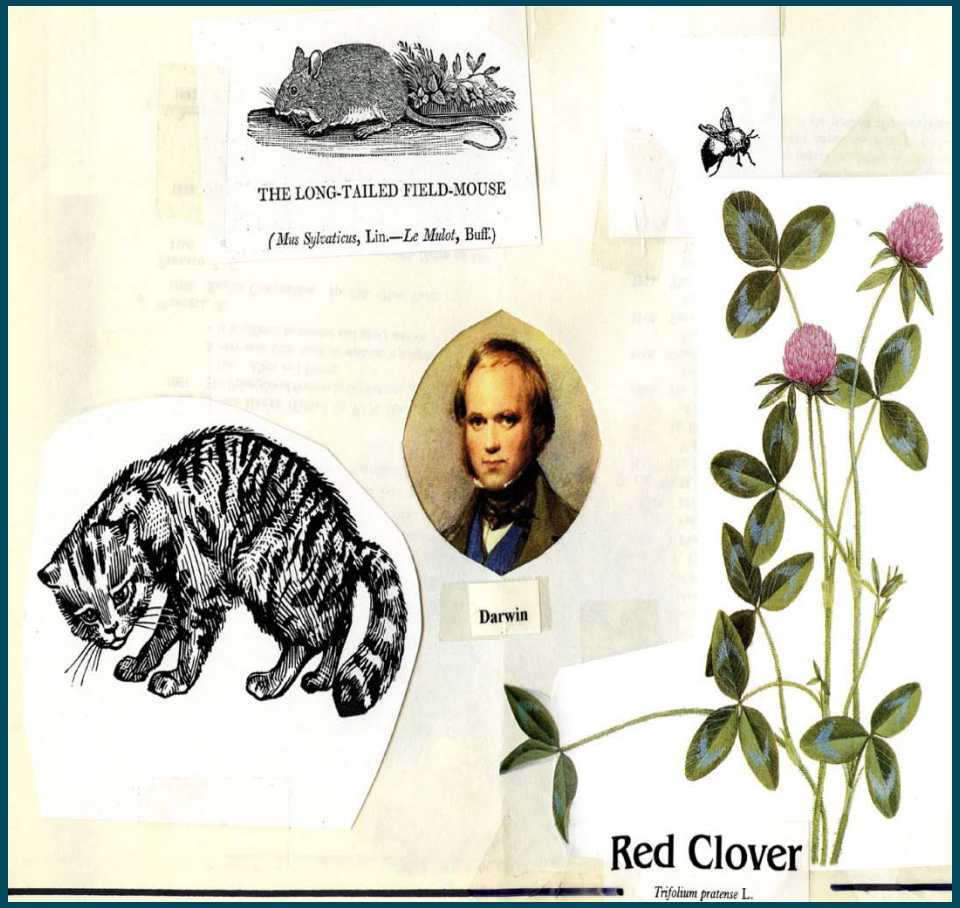
- Provide a fundamental understanding of aquatic food webs in the Columbia River Basin and their effects on native fish restoration efforts

- Compile and review the diverse literature to produce a coherent summary
- Identify future food web-related research directions for improving restoration of fish and wildlife in the Basin
- Present current scientific understanding in a form that can be used by policy makers

Food Webs are the Foundation for Fish Production

It is through the food relation that animals touch each other and the surrounding world at the greatest number of points, …. the struggle for existence becomes sharpest and most deadly; and, finally, it is through the food relation ….. that animals are brought in contact with the material interests of man.

Stephen A. Forbes,
The Food of Fishes, 1880



Relation to the Council's Fish and Wildlife Program

…. which seeks to establish and maintain an ecosystem that sustains an abundant, productive and diverse community of fish and wildlife (NPCC 2009-09).

Food webs fuel that ecosystem ….

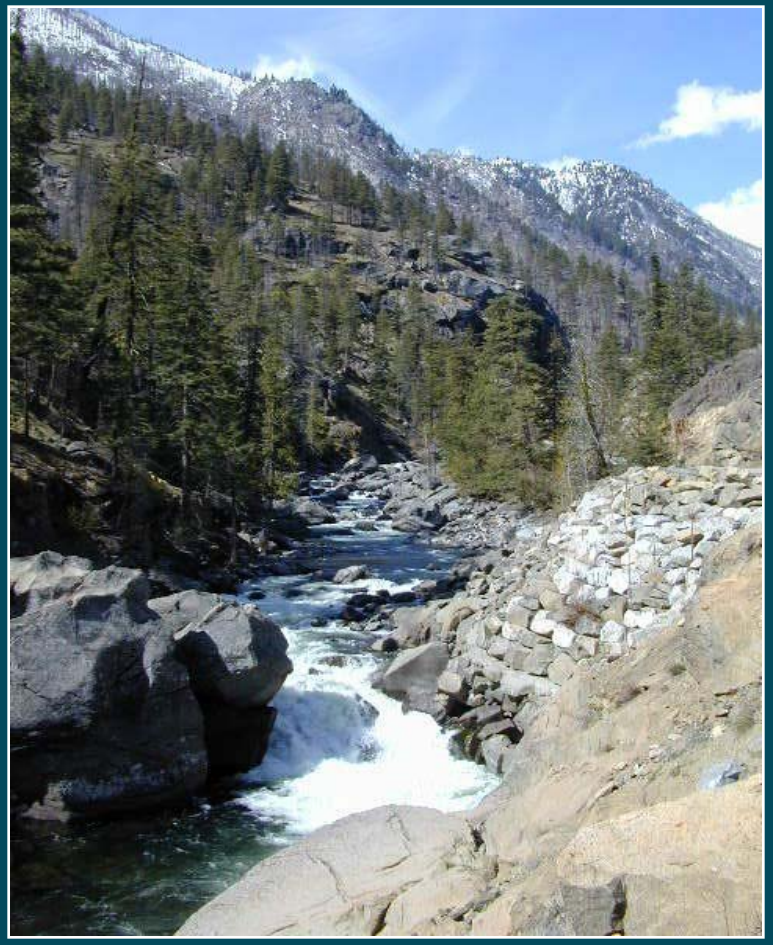
Why Focus on Food Webs? Five Reasons:

Reveal insights into basic properties underpinning productivity and resilience

These cannot be obtained from an exclusive focus on hydrosystem, habitat, hatcheries and harvest (the four H's)

Why Focus on Food Webs? Five Reasons:

Considerable food comes from external sources — including subsidies from MDN, fishless headwater tributaries, and adjacent riparian and terrestrial habitats



Restoration focusing on physical habitat assumes local characteristics dictate fish production while tradition conveys the notion that most fish food is produced within the local aquatic habitat

Why Focus on Food Webs? Five Reasons:

Important trophic pathways and food sources vary over time and space

When restoration is not successful, it is often because a sufficiently broad view of drivers is not taken, including food webs and processes regulating food availability

Why Focus on Food Webs? Five Reasons:

Fishes use an array of habitat types to complete their life cycles

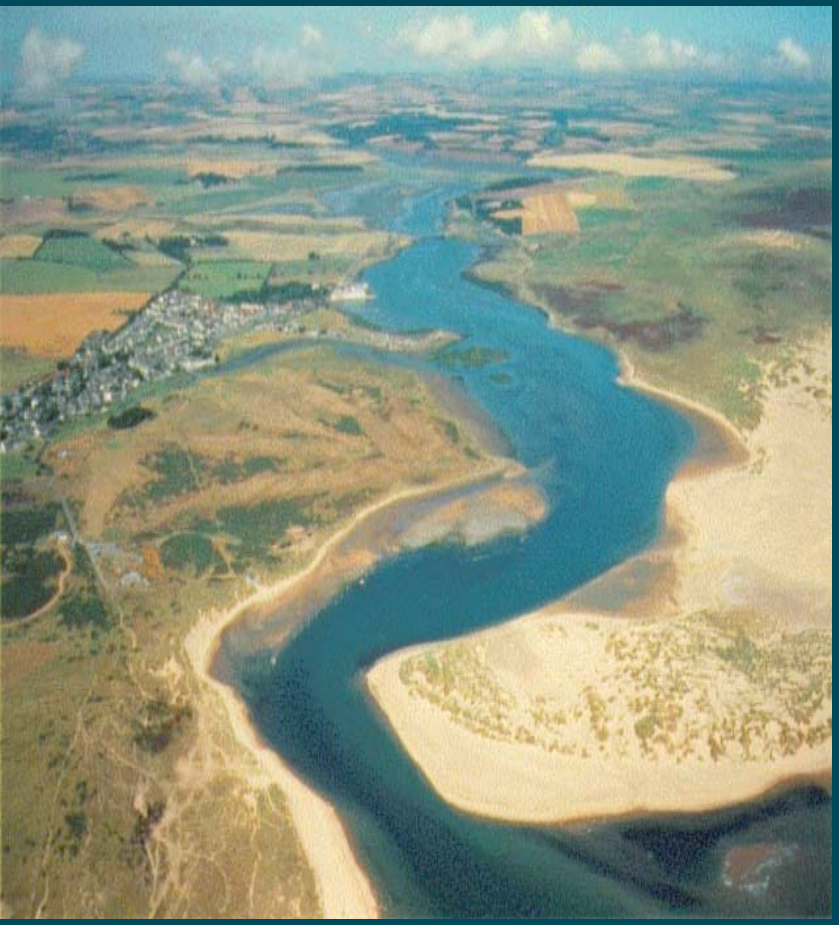
They encounter a diverse array of important prey resources – and this is fundamental to effective restoration

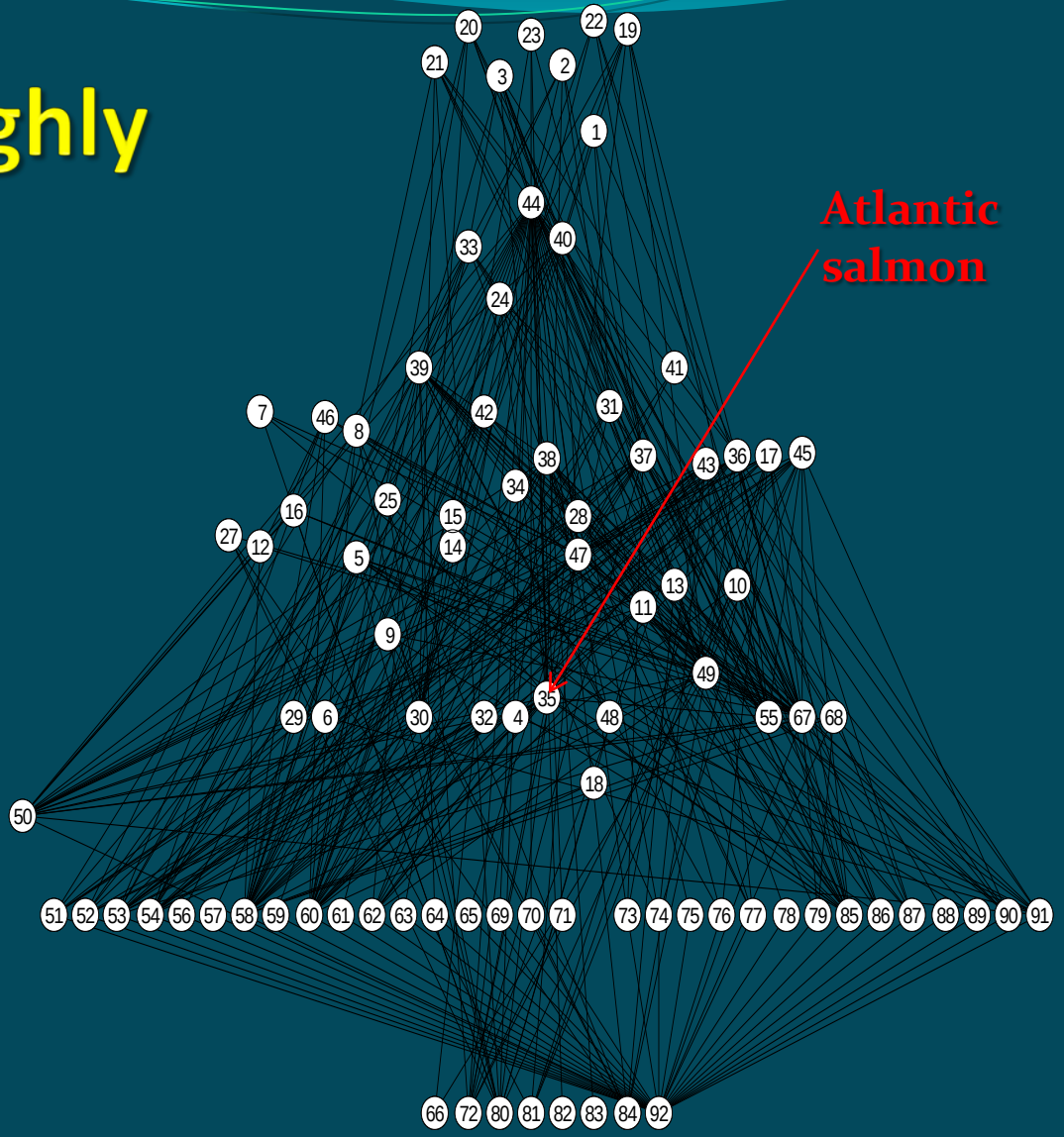
Why Focus on Food Webs? Five Reasons:

Food webs reflect how ecosystem components act collectively – sometimes synergistically – to underpin resilience and productivity

Each food web component (e.g., algae, leaf, microbe) responds to changes in environmental conditions and interactions. Some changes reverberate throughout the entire food web as a "cascading trophic interaction"

Food webs are highly complex





Ythan Estuary, Scotland

Important Information Gaps for Columbia Food Webs

- Historical Baselines
- Taxonomy
- Abundance, including Spatial and Temporal Trends
- Physical Controls on Structure and Processes, including Plume Dynamics
- Growth of Juvenile Fishes
- Effects of Hatcheries
- Chemical Contaminants
- Apex Predators (Birds, Seals, Humans)
- Land-Water Interactions
- Water, Energy and Nutrient Fluxes at the System Scale
- Quantifying Ecological Networks

Scope & Organization of ISAB Review

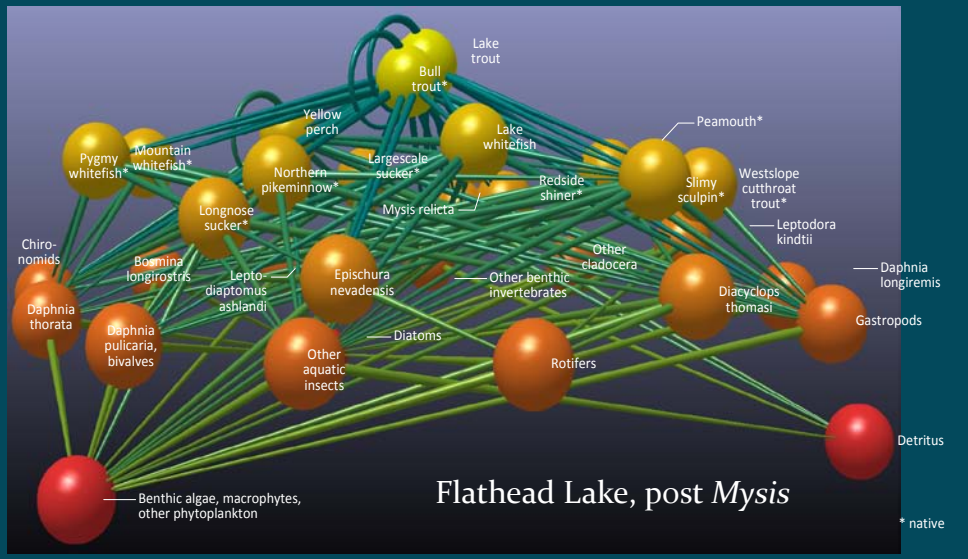
- Spatial scope: tributaries, riparian zones, lakes, impoundments and the mainstem Columbia and Snake rivers, as well as the estuary and plume

- **The review has five sections:**
  - General concepts and applications
  - Description of the physical settings
  - Key environmental processes affecting food web characteristics
  - Food webs in typical habitats
  - System perspective re: contemporary and emerging issues

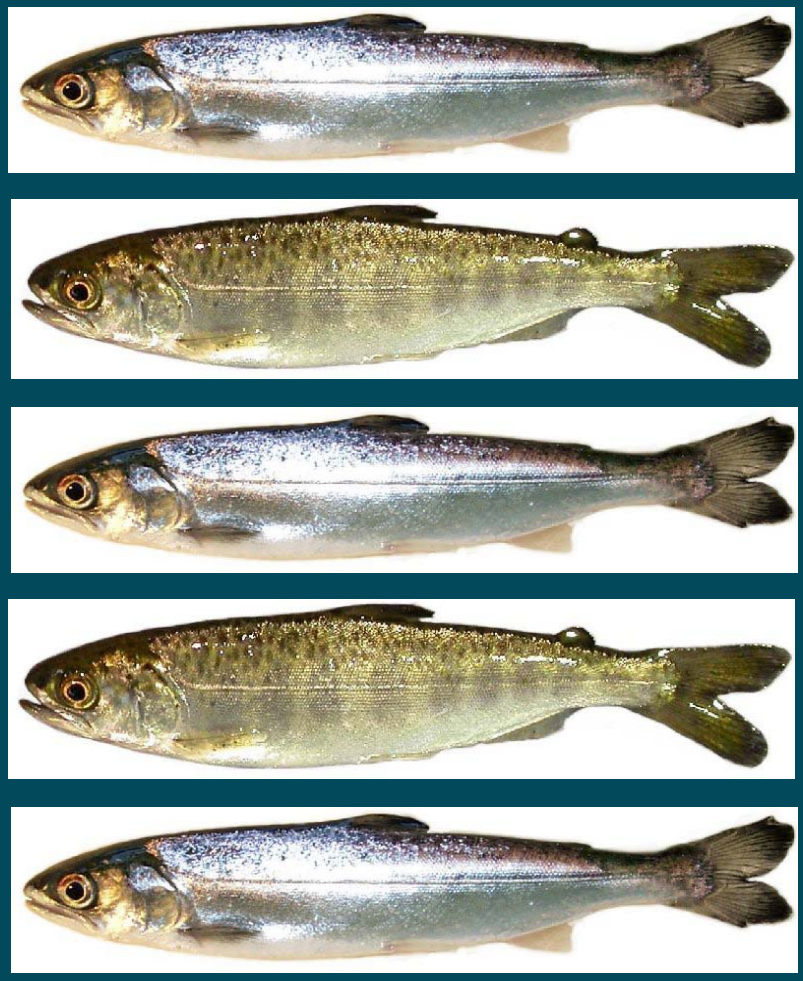
Food Webs

Highly Critical Issues:

- *Uncertainty about the Aggregate Carrying Capacity of the Basin*
- *Proliferation of Chemicals and Contaminants*
- *Consequences of Non-native Species: Hybrid Food Webs*



Carrying Capacity



- Most anadromous salmonids in the Basin originate from hatcheries; well over half total smolt abundance
- Hatchery-reared fish interact trophically with wild salmon and other native species as predators, competitors or prey
- Surprisingly little is known about the impact of hatchery releases on natural food webs in the Basin

Carrying Capacity

Food demand of spring-summer Chinook salmon smolts

Lower Granite Dam to Bonneville, 461 km
~9 million hatchery and wild yearling Chinook, May 2008
~13 day migration

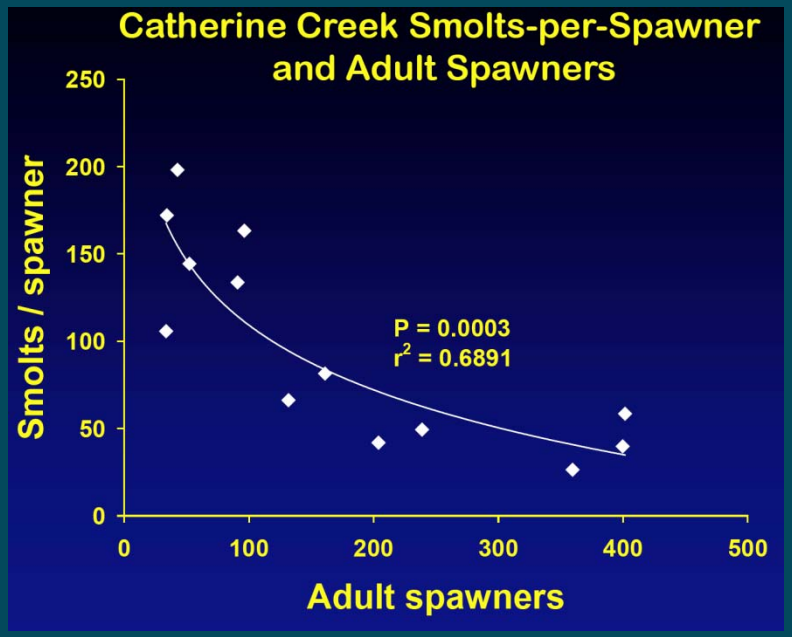
Total food required: 166.5 metric tons (mt)

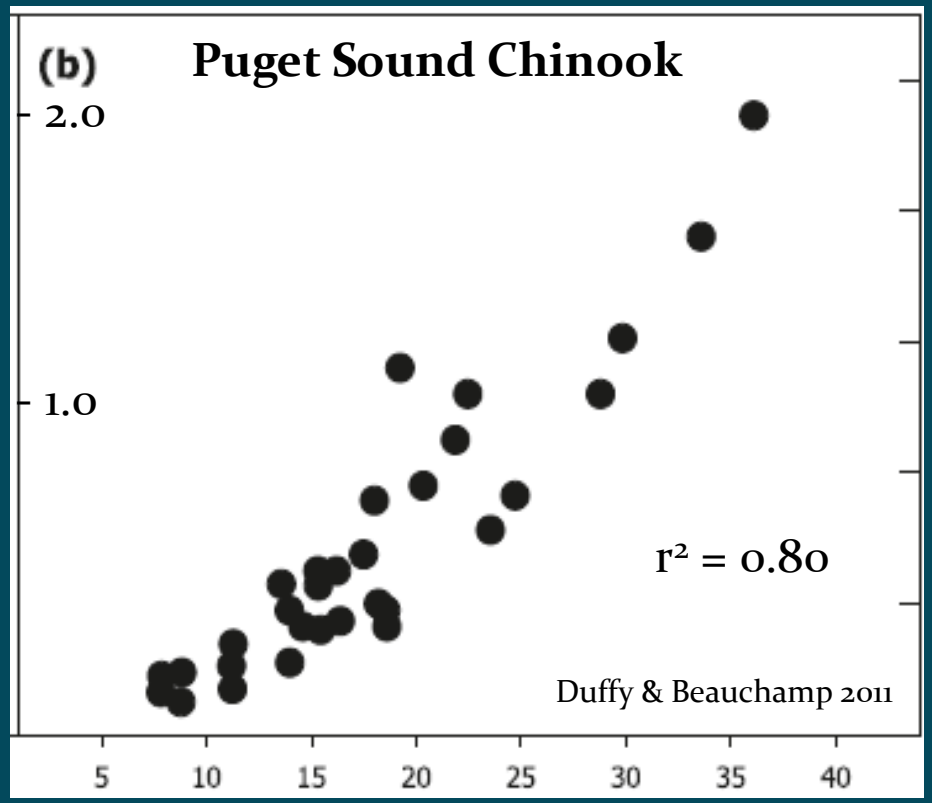
33.3 mt dipterans
52.1 mt other insects
38.8 mt Daphnia
42.2 mt amphipods

Each million juvenile shad consume 25-52 mt of food during July-September

Density Dependence and Survival

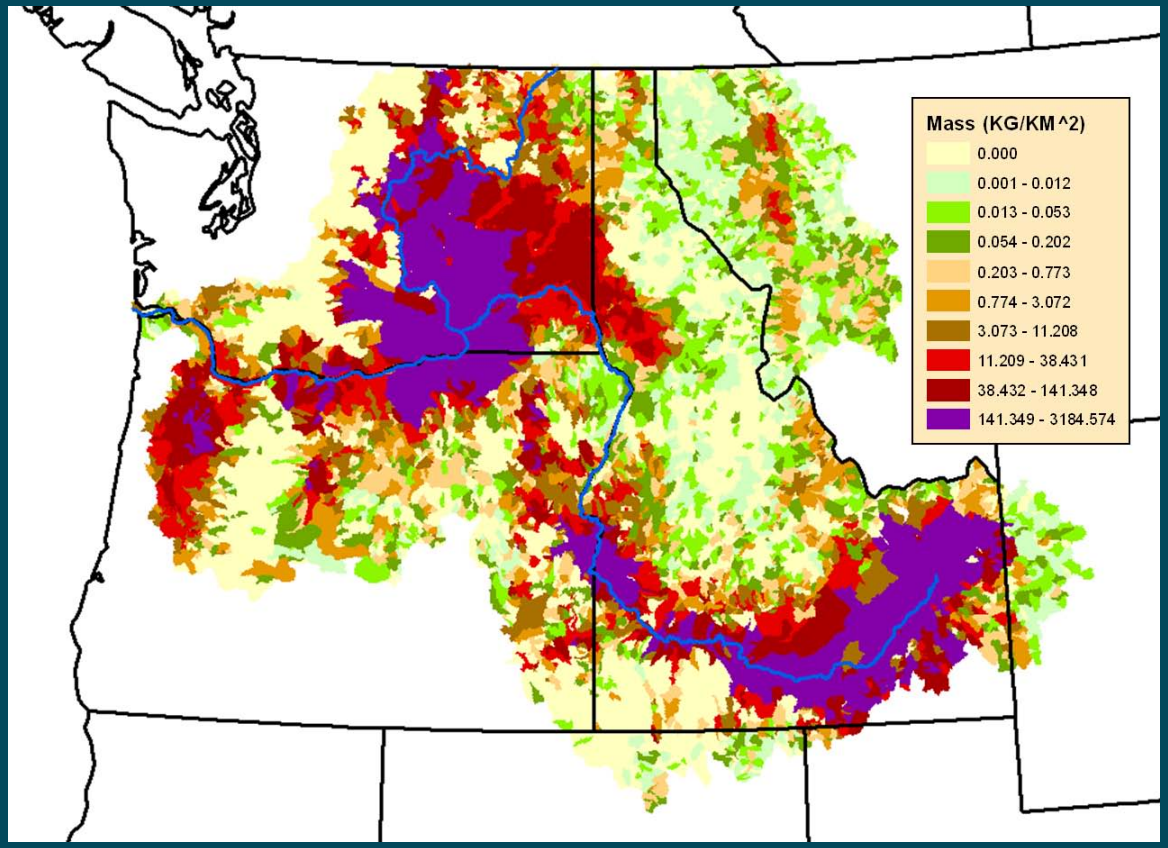
A focus on size and condition of fish at different life stages, and understanding conditions that contribute to growth, are essential for improving survival





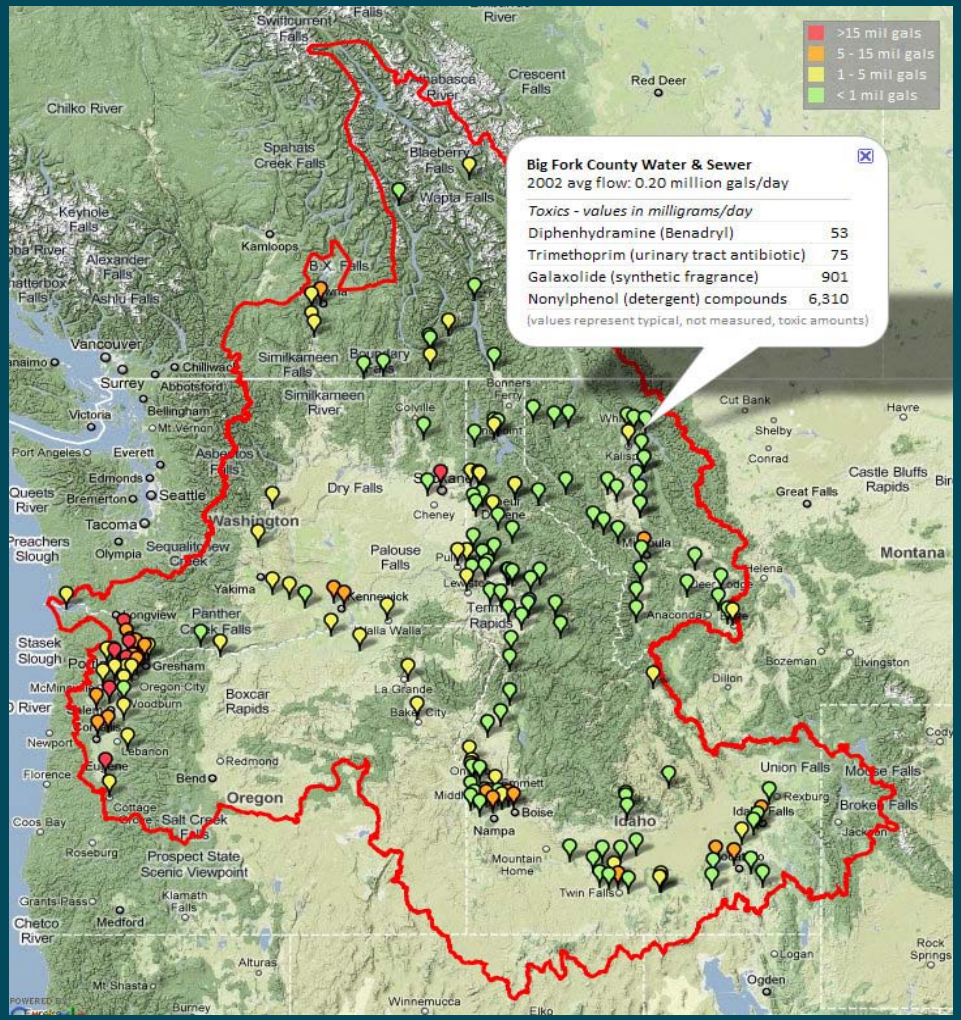
Contaminants & Bioaccumulation

- ~182 pesticides (herbicides & insecticides) in use
- 45,939 mt of active ingredients applied annually

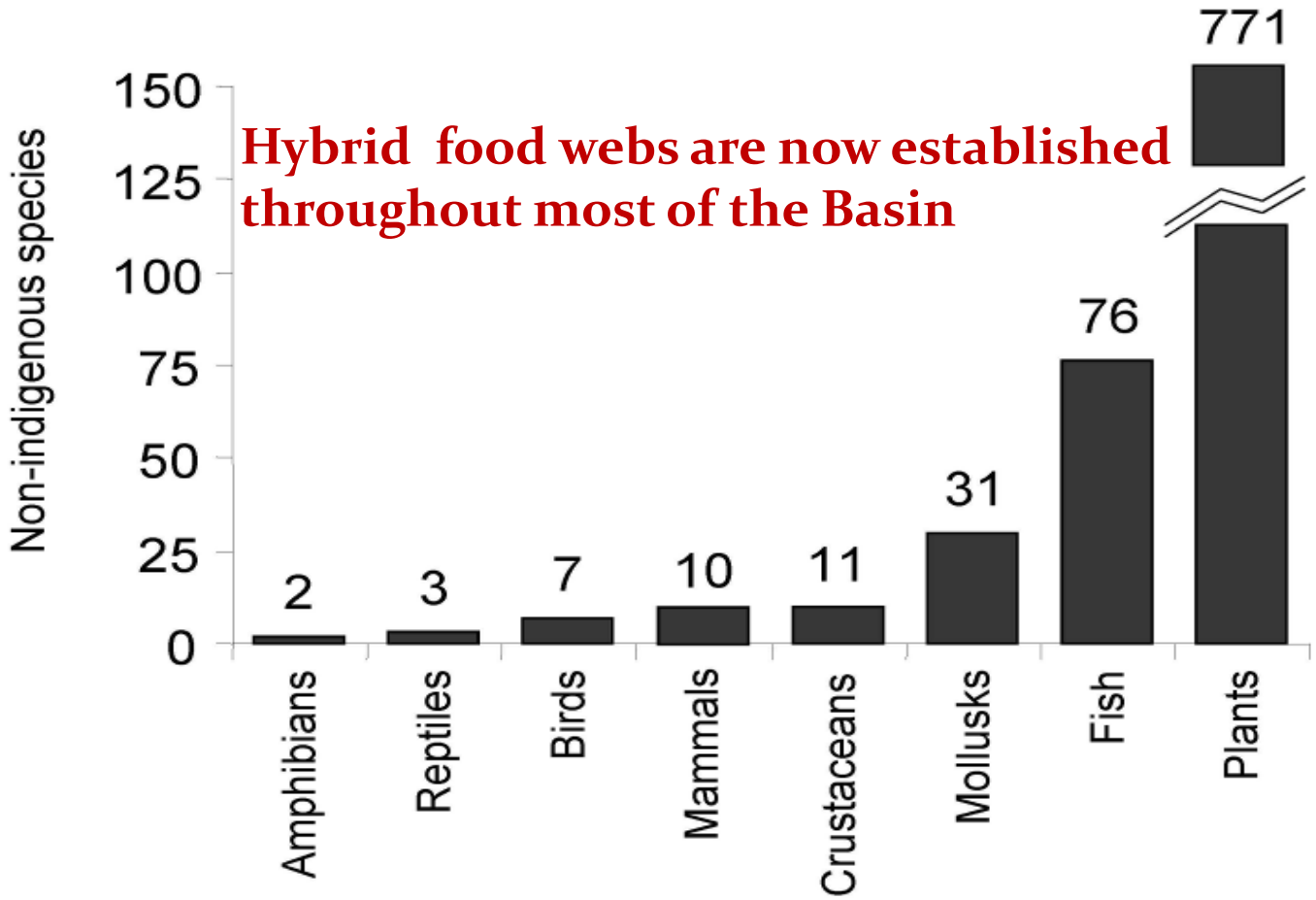


Contaminants & Bioaccumulation

- 169 US and 18 Canadian wastewater treatment plants
- Contributions from current and emerging industrial contaminants (e.g., PAHs, PBDEs, pharmaceuticals and personal care products) remain largely unknown



Non-Native Species



Sanderson et al. 2009

Other Critical Aspects

Altered Nutrient, Organic Matter (Energy), Water, and Thermal Sources and Flows

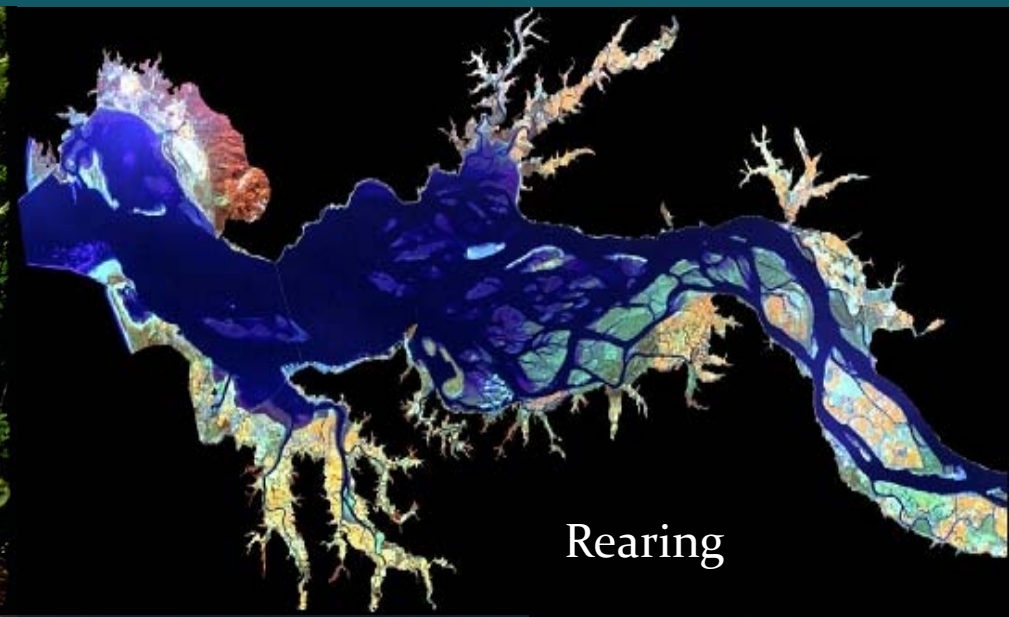
Reconnecting Critical Habitats and their Food Webs

Humans as Predators

Strategic Planning for Environmental Change; Expect Some Surprises

Reconnecting Critical Habitats & Foods

Spawning



Rearing

Key Foods

Humans as Predators

People kill more large fish than any other predator in the Basin

Each year, on average, fisheries take ~500,000 Pacific salmon and steelhead, ~47,000 sturgeon, ~51,000 American shad, ~200,000 northern pikeminnow (bounty program), plus other fishes

These removals imply a fishing mortality rate of ~30% for salmonids (of both hatchery and wild origin) but only ~1% for the non-native shad population

In comparison, total predation mortality on anadromous salmonids by bird and mammal predators is unlikely to exceed 20%.

Filling Specific Knowledge Gaps

Data Gathering and Synthesis

Modeling

Restoration Actions and Experiments to Test Model Predictions and Assumptions

Evaluation of Alternative Policies, with Models

Implications for Restoration

Identify Properties Maintaining Desired Ecosystem States

Sustain Resilient Communities

Accept Hybrid Food Webs as Legitimate Targets, while Maintaining Productivity

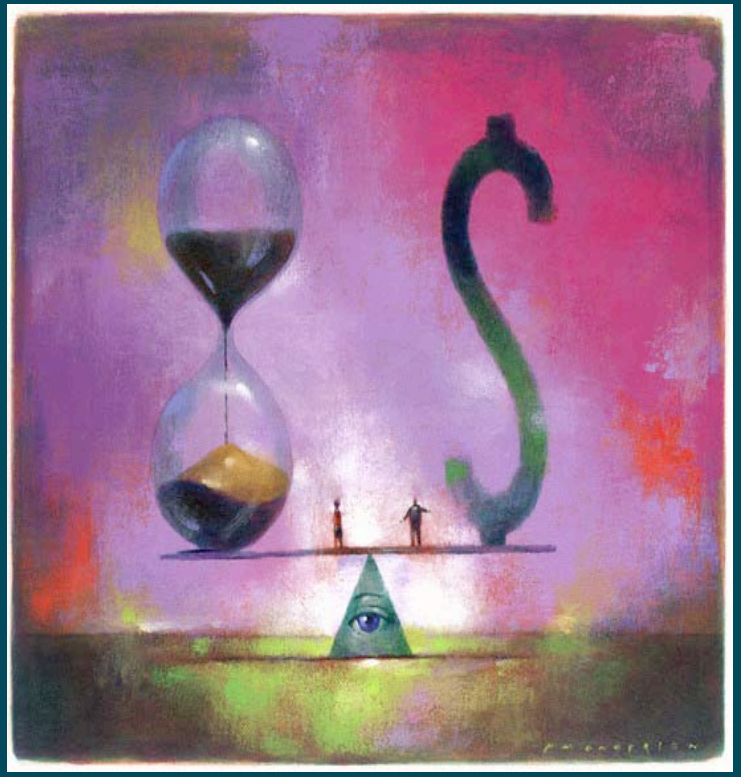
Restore for a Changing World

The Case for a Comprehensive Food Web Model

Implementing An Action Plan

Since the "food web" issue is so complex, the ISAB provides an estimated cost. The cost is ***only*** intended to give an initial sense of the scope and scale of the focus needed:

A 12-year effort with an estimated ***total*** cost of $20-25 M (~1% of annual budget)



Implementing An Action Plan

ISAB provides suggestions on implementation within the F&W Program. Some projects fall under:

Monitoring, as they involve determination of the state of the system

Habitat, as they involve efforts at habitat manipulation and/or restoration / reclamation

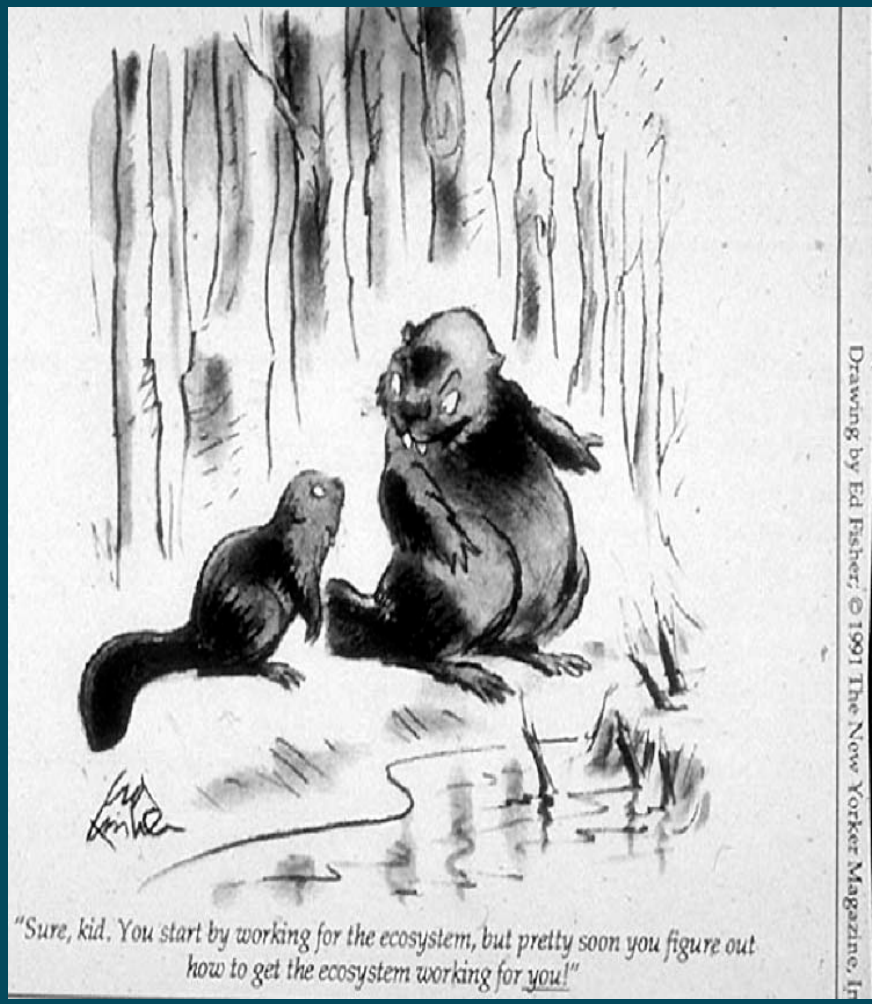
Production, as they may involve adjustments to which fish are reared and released, in what numbers, and where

Research, particularly those aimed at filling information gaps

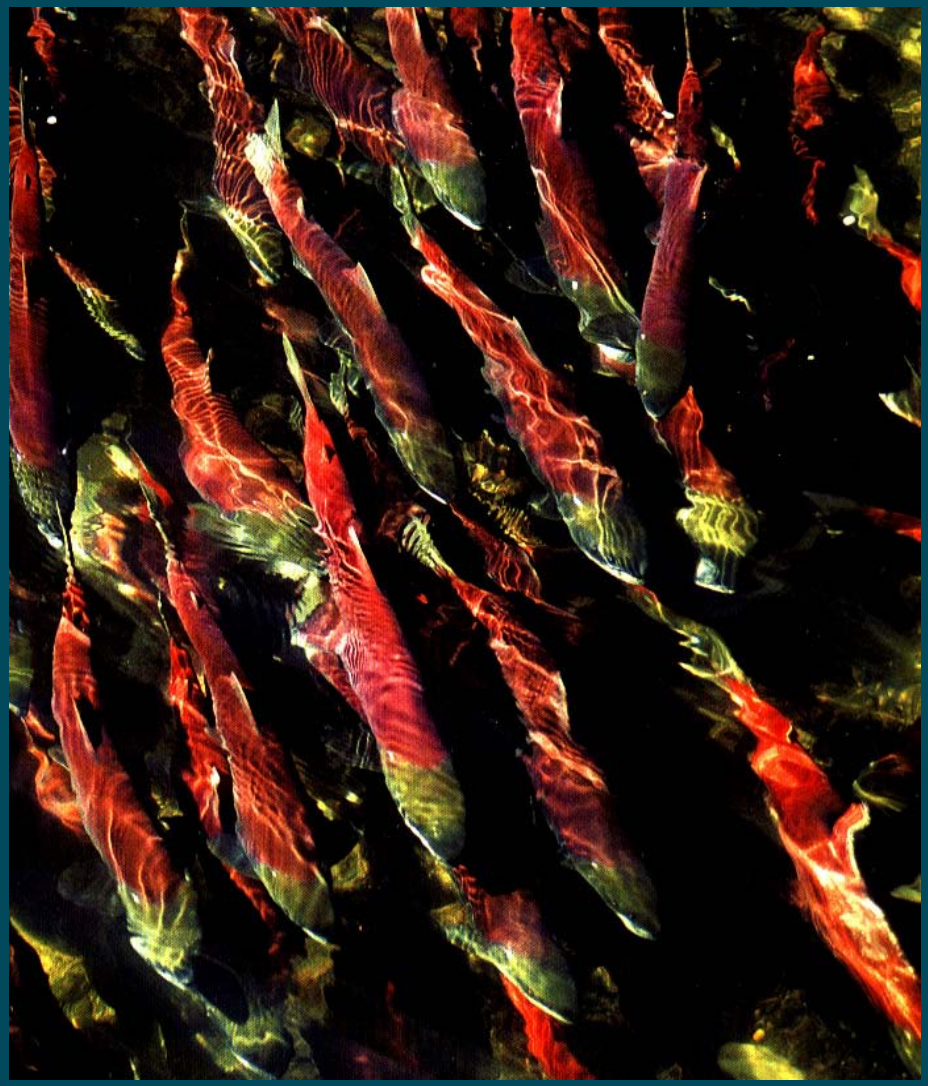
Concluding Remarks

A food web perspective provides a necessary complement to ongoing emphases on hydrosystem, habitat, hatcheries and harvest (the four H's)

While important to recognize that the Columbia Basin is an ever changing 'hybrid' system with an inherently limited capacity to produce fish –these also present great management challenges and opportunities for coordination



Acknowledgments



- ISAB colleagues
- Council staff
- NOAA
- Columbia River Tribes
- Other contributors

END