PATHWAYS TO RESILIENCE

APRIL 3-5, 2007 • PORTLAND, OREGON

Conference Steering Committee

Xan Augerot
Pangaea Environmental, LLC

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Northwest Fisheries Science Center, NOAA Fisheries

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Court Smith
Oregon State University, Anthropology (Emeritus)

A Special Thanks to:

Sea Grant Oregon

Oregon State University OSU

Conference Program

Tuesday, April 3: The Management Problem

07:30-12:00 **Registration**

09:00 **Welcome and Objectives**
(Robert Malouf: Director, Oregon Sea Grant)

09:15 **Background and Conference Agenda**
(Dan Bottom: NOAA Fisheries, Northwest Fisheries Science Center)

09:30 **Overview: Perspectives on Social and Ecological Resilience**
(The Honorable John Kitzhaber)

10:10 **The Problem: Where We are Today with Salmon Conservation**
(convener: Dan Bottom)

- A Manager's Perspective (Daniel Edge: Department Head, Department of Fisheries and Wildlife, Oregon State University; member, Oregon Fish and Wildlife Commission)

10:30 **Break**

10:50 **The Problem: Where We are Today with Salmon Conservation (cont.)**

- A Fisher's Perspective (Jeff Feldner: Sea Grant Extension, Oregon State University)
- A Tribal Perspective (Terry Williams: Tulalip Tribe Fish and Natural Resource Coordinator, Tulalip, Washington)
- A Community Perspective (Mike Dickerson: Executive Vice President, ShoreBank Enterprise Cascadia, Ilwaco, Washington)

11:50 **Lunch** (provided)

12:45 **How Did We Get Here in Fisheries Management?**
(convener: Gordon Reeves, Pacific Northwest Research Station)

- How Did We Get Here in Fisheries Management. . . A Century of Learning? (Brian Riddell: Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.)
- Freshwater Ecosystems of Pacific Salmon: Implications of Managing from a Resilience Perspective (Pete Bisson and Gordon Reeves: Pacific Northwest Research Station)
- The Concept of Resilience and Implications for Conservation (Fikret Berkes: Natural Resources Institute, University of Manitoba)

14:15 **Break**

14:35 **A Natural and Cultural History of Pacific Salmon**
(convener: Court Smith: Department of Anthropology, Oregon State University)

- Evolutionary History of Pacific Salmon in Variable Environments (Robin Waples: NOAA Fisheries, Northwest Fisheries Science Center)
- Co-evolution of People, Salmon and Place: Forming a Future Course of Resilience Modeled from Multi-millennial Relationships between Indigenous Peoples and Pacific Salmon (Frank Lake: Pacific Southwest Research Station)
- Concept of Resilience and Implications for Communities: Resilience in Lower Columbia River Salmon Fishing Communities (Irene Martin: Salmon For All and St. James Episcopal Church, Cathlamet, Washington)

17:00 **Poster Session and Social** (no-host bar)
Dinner on your own

Wednesday, April 4: Managing for Resilience

08:00 **Introduction/Overview of Day's Activities**

08:05 **Properties and Measures of Resilient Ecosystems**
(convener: Xan Augerot: Pangaea Environmental, LLC)

- The Social Construction of Fishing, 1949 (Mary Finley: University of California, San Diego)
- Resilience in Coupled Social-ecological Systems as a Vehicle for Exploring Human Dimensions of Global Change in the Marine Environment (Thomas M. Leschine: School of Marine Affairs, University of Washington)
- Resilience as a Guide for Salmon Management (Michael Healey: University of British Columbia)
- Exploring the Interplay Between Fishing and Resilience Using Ecosystem Models: Historical and Cross-system Comparisons in Three Ecosystems of the Pacific (J. E. Little: School of Aquatic and Fisheries Sciences, University of Washington)

09:30 **Break**

09:50 **Case Studies in Ecosystem Resilience**
(convener: Kim Jones: Oregon Department of Fish and Wildlife)

- Paleoseismicity, Alluvial Conditions, and the Archeology of Anadromous Fish Use in Salmon River Basin, Idaho (Loren Davis: Department of Anthropology, Oregon State University)
- Should Climate Change Change the Way We Conserve Species? An Example with Bull Trout (Dan Isaak: Rocky Mountain Research Station)
- Mechanisms of Resilience and Management of Fish in Headwater Streams (Jason B. Dunham: U.S.G.S. Forest and Rangelands Ecosystem Science Center)
- Effects of Fire on Native and Nonnative Salmonids in Western Montana: A Tale of Two Responses (Michael K. Young: Rocky Mountain Research Station)
- Cultural and Ecological Resilience in a Temperate Rainforest Ecosystem (Aaron C. Hill: University of Montana)

11:30 **Lunch** (provided)

12:30 **Case Studies in Ecosystem Resilience**
(convener: Charles Simenstad: School of Fisheries and Aquatic Sciences, University of Washington)

- Resilience in Pacific Northwest Salmon Populations over the last ~7500 Years: Insights from Archeological Fishbone Records (Virginia L. Butler: Department of Anthropology, Portland State University)
- Comparing Juvenile Life Histories of Northwest Salmon Species and Stocks: Marine Survival under Varying Ocean Conditions and Habitats (Robert Emmett: NOAA Fisheries, Northwest Fisheries Science Center)
- The Effect of Life History Diversity on Bristol Bay Sockeye Salmon Populations (Correigh Greene: NOAA Fisheries, Northwest Fisheries Science Center)
- Life History Strategy of Coho Salmon in an Alaskan Stream Demonstrates Resiliency (K.V. Koski: The Nature Conservancy, Juneau, Alaska)

14:15 **Break**

14:35 **Implications of Resilience for Management – contributed session**
(convener: Sarah Greene: Pacific Northwest Research Station)

- Global Constraints on Rural Fishing Communities: Whose Resilience is it, anyway? (Martin D. Robards: University of Alaska, Fairbanks)
- Achieving Normative Flow: Increasing Resilience in Flowing Water Ecosystems (Robert R. Fuerstenberg: King County Department of Natural Resources, Seattle)
- Prespawning Loss of Adult Sockeye Salmon in the Fraser River—Implications of a Changing Environment and Managing for Resilience (Jeffery Young: David Suzuki Foundation, Vancouver, B.C.)

16:05-17:30 **Facilitated "Town Hall" Meetings and Discussions**
How can we incorporate ecosystem resilience into salmon conservation? What changes would be necessary?

Participants will be assigned to one of six multidisciplinary "Town Hall" sessions.

18:00 **Conference Banquet**
Speaker: Johnny Sundstrom (President, The Siuslaw Institute, Inc.): "Do It Anyway"

Thursday, April 5: Pathways to Resilience

08:00 **Introduction/Overview of Day's Activities**

08:05 **Management Approaches to Support Ecosystem Resilience**
(convener: Susan Hanna: Department of Agricultural and Resource Economics, Oregon State University)

<u>Overview</u>: Integrating Science and Social Learning: Ecology and Values (Bryan Norton: School of Public Policy, Georgia Institute of Technology)

- Harnessing the Hydrologic Disturbance Regime: Sustaining Multiple Benefits in large River Floodplains in the Pacific Northwest (Stan Gregory: Department of Fisheries and Wildlife, Oregon State University)
- Instream Flow Restoration in the Columbia Basin through Water Transactions (Andrew Purkey: National Fish and Wildlife Foundation/Columbia Basin Water Transactions Program)
- Intrinsic Potential, Disturbance, and Resilience of Streams (Kelly M. Burnett: Pacific Northwest Research Station)
- Uncertain Future: Climate Change Impacts on Salmon in the Ocean (Nathan Mantua: School of Aquatic and Fishery Sciences, University of Washington)

10:00 **Break**

10:15 **Panel Discussion I: Integrative Perspectives on Managing for Resilience**
(convener: Xan Augerot: Pangaea Environmental, LLC)

Panelists will synthesize results from the conference and town hall meetings, and offer suggestions for further incorporating these ideas into a new management paradigm.

Panelists
Fikret Berkes: Natural Resources Institute, University of Manitoba
Susan Hanna: Oregon State University, Agricultural and Resource Economics
Bryan Norton: School of Public Policy, Georgia Institute of Technology
Gordon Reeves: Pacific Northwest Research Station
Phil Mundy: NOAA Fisheries, Alaska Fisheries Science Center

12:00 **Lunch** (provided) News media invited to attend.

13:00 **Panel Discussion II: What Policy and Administrative Changes are Needed to Support Salmon Ecosystem Reslience?**
(convener: Joe Cone, Oregon Sea Grant)

Further analysis and discussion of first steps required to incorporate a resilience perspective in salmon management: Questions and group discussion from the audience.

Panelists
Jim Lichatowich: Alder Fork Consulting
Angus Duncan: Bonneville Environmental Foundation
Paula Burgess: Wild Salmon Center
Margaret Davidson: NOAA Coastal Services Center, South Carolina

15:00 **Presentation and Discussion of Conference Recommendations: Where Do We Go from Here?**
Dan Bottom and conference steering committee

15:30 **Adjourn**

The concept of resilience and implications for management

Fikret Berkes
University of Manitoba
Winnipeg, MB Canada

Resilience is the capacity of a system to absorb recurrent disturbances, including shocks and stresses, so as to retain essential structures, processes and feedbacks. It developed out of the observations that ecological change is not continuous and gradual but episodic; spatial attributes of ecosystems are not uniform but patchy and discontinuous at all scales; and ecosystems typically have not a single equilibrium but multiple equilibria. As argued in a classic paper by Holling and Meffe, these observations have profound management implications: management that applies fixed rules for achieving constant yields erodes resilience in the long run, and management should strive to retain critical types and ranges of natural variation in ecosystems. Current work in resilience has emphasized the importance of considering the linked social-ecological system as a unit, and paying special attention to thresholds and system flips (e.g., sardine-anchovy), social traps (e.g., dependence on hatcheries), and external drivers (e.g., impact of market forces). Resilience thinking is not a cure-all but can help frame a dynamic concept of conservation and management that matches the dynamics of ecosystems and social systems. It has a number of significant policy implications: (1) it provides a framework to evaluate management options holistically, (2) it puts the emphasis on the ability of a system to absorb disturbance and deal with shocks and stresses, and (3) it is forward-looking and helps explore policy options for dealing with uncertainty and future change.

ORAL PRESENTATION

Freshwater ecosystems of Pacific salmon: Implications of managing from a resilience perspective

Peter A. Bisson*
USDA Forest Service
Pacific Northwest Research Station
Olympia, Washington

Gordon H. Reeves
USDA Forest Service
Pacific Northwest Research Station
Corvallis, Oregon

The application of recent concepts of resilience to the management of freshwater ecosystems of Pacific salmonids challenges scientists, managers, and policy makers to think about goals and objectives in a different way. Traditional goals of maintaining the stability of freshwater habitats and of fish populations have often proved unattainable and are gradually being replaced with management strategies that accommodate natural and anthropogenic variability. Central to this evolution has been a shift from viewing ecosystems as tending toward a single equilibrium condition to a view based on non-equilibrium dynamics, in which multiple states are possible depending on a system's disturbance regime and its capacity for recovery. For anadromous species such as Pacific salmon, life cycle complexity and wide-ranging migratory paths expose populations to enormous environmental diversity. Not surprisingly, salmon have evolved a variety of genotypic and phenotypic mechanisms to cope with this variability. However, the decline of salmon over the last century suggests that our management choices have overwhelmed even these fishes' impressive capacity to adapt. We leave the discussion of policies relating to the artificial propagation and salmon harvesting to others, but here we argue that attempts to homogenize stream habitats and to resist disturbance are part of the problem and in any case are doomed to failure. Current ecological paradigms emphasize the importance of periodic disturbances in maintaining long-term ecosystem productivity. Managing for resilience will require a better appreciation of significant environmental constraints, including long-term trends in climate and human population development, as well as a better understanding of how disturbances (natural and otherwise) play out at various spatial and temporal scales. This will have important policy and regulatory consequences that involve a reduced dependence on habitat standards and a lessening of reliance on refuges to bolster fish populations. But it will also increase the need to (1) identify locations on the landscape where disturbances can produce the diversity of habitats needed by salmon, i.e., those locations where watershed processes are currently, or could become, reasonably functional, and (2) take steps to ensure that those processes are not truncated. Managing for resilience does not mean abandoning the environmental protections of the past, but it does force us to think in terms of large-scale, long-term watershed objectives that include disturbance as an essential element in conserving Pacific salmon and other aquatic resources.

ORAL PRESENTATION

Intrinsic potential, disturbance, and resilience in streams

Kelly Burnett
USDA Forest Service
Pacific Northwest Research Station
Corvallis, Oregon

We explore resilience in terms of the capacity of streams in the Oregon Coast Range to provide habitats for Pacific salmonids in the face of anthropogenic disturbance. Thus, the spatial distribution of areas with high intrinsic potential is compared for coho salmon and steelhead relative to likely sources of natural and human disturbance. Intrinsic potential expresses the capacity of a stream to support high-quality habitat for a species and is based on attributes of stream gradient, constraint, and size. For channel networks in the study area, debris flows are important natural disturbances. Stream reaches with high intrinsic potential for coho tend to be larger, less confined, and of lower gradient than those for steelhead. Such characteristics are more consistent with sediment deposition than transport; consequently recovery after debris flows may be slower in high-intrinsic potential reaches for coho than for steelhead. Forestry-related activities are the most wide-spread cause of human disturbance in reaches with high-intrinsic potential for both species. However, a larger percentage of the area adjacent to high intrinsic potential reaches for coho than for steelhead is managed by private landowners for short-rotation industrial forestry, agriculture, and urban uses. These uses can alter floodplain characteristics and increase sediment delivery rates to stream channels. This and the fact that high-intrinsic-potential reaches for coho are depositional areas have coupled to reduce the resilience of streams to provide habitat for this species across the study area. Focusing conservation on watersheds where high-intrinsic potential reaches are concentrated may help recover habitat resilience.

ORAL PRESENTATION

Resilience in Pacific Northwest salmon populations over the last ~ 7500 Years: Insights from archaeological fishbone records

Virginia L. Butler* & Sarah K. Campbell
Portland State University
Portland, Oregon

Animal bones and teeth recovered from archaeological sites provide a record of long-term human-animal relationships and indicate the extent to which human use of animals was sustainable or not. To examine trends in Pacific Northwest salmon and other fish populations, we synthesized the ~7500 year long fish bone record from two sub-regions of the Pacific Northwest: the South-Central Northwest Coast and the upper Columbia River. Over 170,000 remains from 52 archaeological sites and 124 dated components were included in the study.

Most patterns in fish representation are explained by site location and access to resources. For the Northwest Coast samples, every time period shows a range in salmon abundance values, suggesting salmon was the focus of fishing in some locations and only a minor constituent in others. Salmon dominates all components on coastal rivers while sites located on coastlines are dominated by marine fish. In upper Columbia River samples, salmon dominates all assemblages except for a set dating between 5000 and 3800 years ago, that may reflect reduced salmon abundance due to environmental factors.

While minor changes in fish use are evident, the overall record is characterized by stability. Explanations for resilience in salmon populations across this lengthy period include intrinsic aspects of fish biology and reproductive strategy, human population size and exploitation intensity, traditional cultural practices, and environmental change that improved salmon habitat allowing for increased salmon production and off-take. Approaches to testing these explanations are outlined as well as implications for current and future management practices.

ORAL PRESENTATION

Paleoseismicity, alluvial conditions, and the archaeology of anadromous fish use in the Salmon River basin, Idaho

Loren G. Davis
Oregon State University
Corvallis, Oregon

Archaeological records show that by ca. 6,000 years ago, Native American groups began to develop intensive salmon fisheries in many parts of the Columbia River basin. Intensive exploitation of productive salmon fisheries allowed native groups to support semi-sedentary village settlements and solve problems of seasonal resource shortfalls. In the lower Salmon River canyon of western Idaho, however, evidence of semi-sedentary pit house villages does not appear until after 2,000 BP. Studies of Salmon River alluvial geochronology reveals that channel incision and terrace formation occurred abruptly at ca. 2,000 BP. This event is interpreted as signalling fluvial adjustment in response to neotectonic displacement along a local normal fault. The delayed appearance of pit house village sites in the canyon is thought to be directly related to dramatic neotectonically-induced changes in fluvial conditions after 2,000 BP, which are hypothesized to have improved aquatic habitats for anadromous fishes and led to the development of a predictable, productive salmon fishery. This case study offers a unique perspective on the resilience of anadromous fishes in the context of significant ecosystemic reorganization.

ORAL PRESENTATION

Mechanisms of resilience and management of fish in headwater streams

J.B. Dunham*
USGS FRESC Corvallis Research Group
Corvallis, Oregon

Gordon Reeves
USDA Forest Service
Pacific Northwest Research Station
Corvallis, Oregon

Dan Isaak and Bruce Rieman
USDA Forest Service
Rocky Mountain Research Station
Boise, Idaho

Fish in headwater streams are ideal subjects for the study of resilience. Headwater streams are highly dynamic with episodes of catastrophic disturbance, yet fish persist in these systems. Early work on fishes in headwater streams emphasized influences of these stochastic influences at smaller scales. Few generalized patterns or explanations for long-term persistence were apparent. Subsequent research at larger scales revealed the general importance of the spatial structure of stream networks and life history to resilience. Much of this has been learned through the study of disruption of connectivity and loss of habitats caused by human activities. Whereas habitat restoration is actively underway to reverse these past influences, present and future influences of invasive species, climate change, and other changes will provide novel and significant challenges. In some cases, present actions may actually prevent opportunities or exacerbate threats that are likely to be important in the future. Whereas the future is difficult to predict with great precision, a forward-looking view of resilience is needed to ensure that present-day efforts are successful in the long-term.

ORAL PRESENTATION

Comparing juvenile life histories of northwest salmon species and stocks: marine survival under varying ocean conditions and habitats

Robert Emmett*, William Peterson, Rick Brodeur, Edmundo Casillias, David Teel,
Brian Beckman, Susan Hinton, Paul Bentley, Laurie Weitkamp, Jen Zamon
NOAA Fisheries, Northwest Fisheries Science Center
Seattle, Washington

Cheryl Morgan, Joe Fisher, Troy Guy
Oregon State University, Cooperative Institute for Marine Resource Studies
Newport, Oregon

Northwest salmon species and stocks utilize the ocean on a variety of temporal and spatial scales, which may ultimately influence their survival. Salmon species/stocks have evolved different strategies to deal with spatio-temporal fluctuations in the marine environment, such as juveniles migrating to the ocean at different times and at variety of sizes, thus utilizing different ocean habitats, eating different prey resources, and encountering different suites of predators. We now have over 20 years of ocean research that we can use to explore seasonal, interannual and spatial differences in distributions, growth, feeding and predation. We have established that the time lag between major changes in ocean conditions and juvenile salmon marine survival is no more than one year. Strong correlations between zooplankton biomass and composition, growth and juvenile coho salmon marine survival suggest that bottom-up food chain processes influence survival. However, strong correlations between salmon predators and forage fish abundances and juvenile salmon marine survival suggests that top-down processes influence survival as well. Both processes operate in all years, with bottom-up forcing perhaps more important in cold productive years and top-down forcing in warm low productive years. These data show that differences in the ability of Northwest salmon stocks to rebound from low abundance levels is tightly linked to their ability to survive variable and changing marine conditions. Managers developing salmon recovery plans need to be aware that the resilience of salmon populations is dependent on both freshwater and marine habitats.

ORAL PRESENTATION

The social construction of fishing, 1949

Mary Finley
University of California, San Diego
San Diego, California

In 1949, an American scientist named Wilbert M. Chapman, a fisheries attaché in the State Department, announced the U.S. policy for high seas fisheries, grounded in the concept of Maximum Sustained Yield, or MSY. Chapman defined MSY as making possible "the maximum production of food from the sea on a sustained basis year after year." In 1955, MSY was adopted as the goal of international fisheries management, and it remains at the heart of current American management. Post-war fishing policies were grounded in humanitarian goals of easing world hunger. This paper examines Chapman's scientific understanding of fish populations, ocean processes, and the role of fishing in 1949. Chapman, an ichthyologist trained at the University of Washington, believed that human fishing played a productive role in fish populations, removing older individuals so that younger fish would have more opportunity to grow. He also believed that fish populations were essentially robust and could recover quickly if too many fish were harvested.

ORAL PRESENTATION

Achieving normative flow:
Increasing resilience in flowing water ecosystems

Robert R. Fuerstenberg
King County Department of Natural Resources and Parks
Seattle, Washington

The restoration and maintenance of salmon populations depends upon the integrity and resilience of the ecosystems they inhabit. The characteristics of stream and river ecosystems—disturbance patterns, distribution and abundance of habitats, and species composition—vary over space and time, the result of interactions among physical and biological processes and the physical and biological structure of the ecosystem. Salmonids have become adapted to these patterns over many thousands of years and the apparent attributes of salmon populations—abundance, productivity, diversity and spatial structure—reflect this ecological and evolutionary history. The continuity of these patterns over time reflects the resilience of the ecosystem. In flow-modified stream and river ecosystems, the continuity of these patterns has been largely lost; the greater the modification, the less resilience the ecosystem possesses. Normative flow principles assume that flow (over many spatial and temporal scales) is a major forcer of critical processes occurring in riverine ecosystems and that a pattern of flow attributes reflective of the historic flow regime must be restored if salmon recovery is to be successful. Furthermore, the principles suggest that the restored flow attributes need not replicate the historic flow attributes exactly but must address certain critical characteristics of the flow regime; among these are the frequency of floods and droughts, temporal distribution, especially the timing of seasonal flow pulses, and the spatial distribution of the flow regime.

ORAL PRESENTATION

The effect of life history diversity on population dynamics in Chinook salmon

Correigh Greene*, Eric Beamer, and Kurt Fresh
NOAA Fisheries, Northwest Fisheries Science Center
Seattle, Washington

The concept of resilience is often linked to the importance of diverse biological assemblages that buffer a system in the face of environmental variation. When the system is a population, scientists often argue that life history diversity spreads risk, thereby protecting a species from stochastic events. While this argument is persuasive, it has largely remained untested. We use a stochastic matrix model to test how diversity of life history types during juvenile and adult life stages of Skagit River Chinook salmon influence population dynamics. We test this using four conceptual extremes of the Chinook salmon life cycle, by assuming one or three juvenile life history pathways and one or five adult life histories. We examined these four scenarios using a stochastic model that included empirically validated variation during both freshwater and marine life stages, run 1000 times to test for extinction thresholds and patterns in productivity. Our analysis indicated that juvenile life history variation increased population growth rate, but that adult life history variation reduced it. However, adult life history variation reduced the variance in population growth rate. Hence, the overall influence of life history diversity will depend upon both whether diversity occurs within or among year classes, and what temporal scales changes in productivity are measured.

ORAL PRESENTATION

Harnessing the hydrologic disturbance regime: Sustaining multiple benefits in large river floodplains in the Pacific Northwest

Dr. Stan Gregory*
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon

Professor Dave Hulse
Department of Landscape Architecture
University of Oregon
Eugene, Oregon

More than 11,000 miles of streams and rivers in Oregon have been listed as impaired based on temperatures that exceed the water quality standard. Concerns over elevated water temperature have led to questions about creating cold water refuges for native biota through floodplain restoration, particularly where these habitats could provide multiple ecosystem and social benefits. Efforts are underway to establish ecosystem marketplace trading, using thermal trading credits in the Willamette River as a pilot study. We have integrated a study of thermal patterns in the Willamette River, development of a model of hyporheic influence on water temperature, creation of dynamic visualizations of technical concepts and research results. We have used this information and informatics tools to work with regional decision makers and state agencies to simultaneously 1) derive water temperature reductions, 2) terrestrial and aquatic habitat enhancements, 3) increased recreation, and 4) improved non-structural flood storage in large river floodplains. These ecosystem services may be conserved or restored while meeting the requirements of the Clean Water Act Total Maximum Daily Load (TMDL) for temperature and Endangered Species Act concerns. We held two workshops in 2006 with the Oregon Department of Environmental Quality and citizen groups and municipalities in the Willamette Valley. We identified approaches for achieving and sustaining multiple benefits, including but not limited to thermal modification, in prioritized locations. We also worked with the Willamette Partnership to develop market-based approaches to accomplish these goals and find solutions to comply with regulations while maximizing and sustaining the benefits to communities along the Willamette River. We will illustrate the use of alternative futures, dynamic models of land use change based on ecological and economic values, and market-based alternatives to identify resilient properties of river ecosystems and the human systems that depend on them for ecosystem services.

ORAL PRESENTATION

Resilience as a guide for salmon management

Michael Healey
Calfed Bay-Delta Program
University of British Columbia
Vancouver, BC Canada

Pacific salmon have existed in North America for approximately 10 million years. During that time they have survived prolonged periods of warm temperatures and, over the past 2 million years, multiple periods of glaciation. Whether they will survive much longer as naturally reproducing populations in Washington, Oregon, California and southern British Columbia is an open question. As humans continue to alter freshwater and marine habitats of salmon on both small and large scales, the survival of the various species will depend a great deal on their inherent resilience to rapid change. The resilience of salmon populations derives from a number of population and life history traits including multiple life history tactics that are expressed in relation to environmental cues (e.g., age of maturity, choice of spawning site, choice of reproductive tactic) and metapopulation structure. Traditional harvest management has focused on taking maximum yields from dominant life history types and most abundant population components while conservation has come to focus on so called “critical” habitats of these same population components. This management approach has narrowed significantly the spectrum of population and life history traits expressed by each species and has, thereby, reduced the resilience of salmon populations. Management to sustain and, hopefully, restore productive capacity of Pacific salmon populations should be based on providing the opportunity for salmon to regain some of the variability and resilience that has been lost over the years. Reduced harvests, habitat restructuring that reconnects rivers and floodplains and promotes natural fluvial processes, greater emphasis on retaining so called “marginal habitats” and an aggressive strategy to combat invasive species will all be part of such a management regime.

ORAL PRESENTATION

Cultural and ecological resilience in a temperate rainforest ecosystem

Aaron C. Hill*, Jack A. Stanford, Niels Maumanee, Diane C. Whited
University of Montana
Missoula, Montana

Gerald Amos,
Headwaters Initiative
Terrace, BC Canada

Peter R. Leavitt
University of Regina
Regina, SK Canada

The Kitlope River drains 400,000 hectares in the north coastal area of British Columbia and is entirely protected and pristine from headwaters to estuary. The physical and oral history and traditional knowledge of the Haisla First Nation form a cornerstone for continuing educational, scientific, spiritual, and tourism activities within the conservancy. Seven wild *Oncorhynchus* species exist in the Kitlope, some of which exhibit multiple life history strategies; but populations are depressed based on historic escapement estimates, analysis of proxy salmon metrics in lake sediments and riparian vegetation, and local and traditional knowledge (LTK). In spite of intensive harvests since the 1890s, Kitlope salmon populations continue to support commercial and sport fisheries and a range of natural consumers including Haisla people. Physical habitat for salmon appears robust and potential salmon productivity in the Kitlope is high, based on a comparative analysis of Pacific Rim salmon rivers using calibrated satellite imagery. Empirical and LKT data show a clear warming trend in the last 50 years that is coherent with increasing total nitrogen, algal pigments and $\delta^{15}N$ in the lake core, suggesting that ecosystem productivity is naturally increasing. These interpretations infer high resilience: barring unforeseen deleterious consequences of climate change, salmon productivity and salmon-dependent biodiversity likely will substantially recover if harvest of returning spawners can be reduced. This could be achieved with no net economic loss by using sorted, in-river fisheries and by adding value to commercial catches through product marketing that emphasizes the outstanding natural qualities of the ecosystem.

ORAL PRESENTATION

Should climate change change the way we conserve species? An example with bull trout

Dan Isaak
USDA Forest Service
Rocky Mountain Research Station
Boise, Idaho

Climate change is imparting dramatic shifts to stream environments across the western US. Changes in the timing and magnitude of fire-related disturbance and stream hydrology are already apparent and are predicted to increase during this century. The spatial and temporal distribution of habitats and resources will change for most stream fishes, which will result in broad distributional adjustments or lost resilience and even local extinctions. We illustrate this by modeling the distributional response of bull trout to predicted changes in mean annual air temperature across the interior Columbia River Basin. The most likely scenario representing a 1.5°C increase by 2050 suggests the areal extent of bull trout habitat will decrease by about 40%, but a larger decline is apparent (60%) if the results are filtered for a patch size large enough to buffer small population effects. The predicted response is not spatially uniform due to interactions with local topography and climate, suggesting that some areas within the Columbia River Basin are more vulnerable to climate change. Management implications may be the acceptance of the loss of bull trout from large portions of the current range so that limited conservation resources can be effectively prioritized. A non-intuitive approach of focusing conservation resources in areas currently supporting strong bull trout populations may be important to ensure maximum resilience. Bull trout may be especially vulnerable to climate change given their strong dependence on cold water and isolation in headwater systems, but changes in stream systems are likely to be profound and will affect all aquatic organisms to some degree. Research is needed to better identify how streams will change and which species are most at risk.

ORAL PRESENTATION

Life history strategy of Coho salmon in an Alaskan stream demonstrates resiliency.

Dr. K V. Koski
The Nature Conservancy
Juneau, Alaska

Coho salmon utilizing an urbanized stream in southeast Alaska demonstrated resiliency by an obscure life history strategy that exploits habitats generally not recognized as important. Duck Creek is a small stream flowing through the Mendenhall Valley near Juneau. The stream has been impacted by most of the activities typically found in an urban residential watershed. Coho escapement numbered about 600 fish in the1960s and is currently less than 100 fish. Because of degraded habitat, coho reproduction does not occur. Smolt yield, however, has ranged from about 1,000 to 4,000 fish annually as a result of a fall immigration to the stream from the estuarine salt marsh. These coho of apparently nomadic origin rear in the salt marsh in summer and then with an innate sense migrate to a freshwater stream for overwintering. Streams with groundwater-fed ponds (e.g., beaver ponds, or wall-base channels) or deeper water habitats attract these fish and provide them refuge in winter. The strategy of utilizing salt marshes for summer rearing and freshwater ponds for overwintering has been observed in neighboring Jordan Creek, Kake Bake Creek (a tributary to Big John Bay on Kupreanof Island), and Porcupine Creek, on Etolin Island. Unlike chinook or sockeye juveniles that can migrate to sea as age-0s, coho nomads apparently need to overwinter in freshwater habitats. Perhaps recovery efforts for coho salmon should examine the role and availability of estuarine salt marshes and suitable freshwater overwintering habitat for coho production.

ORAL PRESENTATION

Co-evolution of people, salmon, and place: Forming a future course of resilience modeled from multi-millennial relationships between indigenous people and Pacific salmon

Frank K. Lake
USDA Forest Service
Pacific Southwest Research Station
Arcata, California

Pacific salmon and indigenous people of the Pacific Northwest have cohabitated the same watersheds for thousands of years. Pleistocene-Holocene ice free areas of the coastal Pacific Northwest and California were refugium for salmonids and people. Changing climate and rising sea levels affected environmental conditions which directly impacted Indigenous people and salmonid populations. Anadromous salmonids were an energetic currency that connected terrestrial, aquatic and marine environments. Marine, estuarine and riverine food resources, particularly salmonids, were critical to the early formation of northwest indigenous cultures. Careless human impacts to the initial fragility of salmonid populations could have reduced or extirpated salmonids from established refugium or from colonizing interior riverine habitats. Such impacts would have reduced human and salmon fitness. So how did indigenous people learn to live with salmon? What constitutes co-evolution between indigenous peoples, salmon and place?

Over thousands of years indigenous people developed sophisticated harvesting methods, and culturally instituted beliefs and laws which served to conserve and maintain viable salmon populations. Other land use practices of indigenous people, such as burning for a multitude of purposes across the landscape, influenced ecosystem processes which affected salmon habitat quality. Some of these cultural practices increased salmon reproductive fitness at the population level. Traditional ecological knowledge and ethnographic data provide details of how indigenous people developed cultural management systems allowing for a sustainable harvest of salmonids under variable environmental conditions. What were/are these systems and how can they be used today to model future pathways to human-salmon resilience in the Pacific Northwest?

ORAL PRESENTATION

Resilience in coupled social-ecological systems as a vehicle for exploring human dimensions of global change in the marine environment

Thomas M. Leschine
School of Marine Affairs
University of Washington
Seattle, Washington

Humans are now affecting the Earth's ecosystems at planetary scales through the burning of fossil fuels, species introductions and other activities. Similarly, the forces of globalization are having social and economic impacts, both positive and negative, that reverberate through societies and economies around the world in complex and difficult-to-predict ways. The UW School of Marine Affairs is currently revising its masters' curriculum to better prepare marine affairs practitioners to address these growing challenges. The training emphasizes both knowledge and understanding and analytic and practitioners' skills necessary for dealing with problems of global change. Among key concepts are resilience and vulnerability in coupled social-ecological systems, emphasizing human dimensions of global change in the marine environment (HDGCME).

This presentation reviews briefly the utility of viewing social and ecological systems as coupled interacting systems in a way that facilitates application of the concepts of resilience and vulnerability within that framework. Examples of resilience theory applied to marine and coastal systems, both from published literature and the author's own work, are reviewed. Relevant examples explored in recent literature include recovery following the South Asian tsunami of late 2004, mangrove conversion in Vietnam and in Indonesia, traditional fisheries affected by forces of globalization in South India, and environmental and social change in the Arctic due to climate change. The author's own work and the work of students permits exploration of the capacity of Marshal Islanders to resettle Pacific Islands that were used for nuclear weapons testing during the Cold War and the case of the Bristol Bay, Alaska, salmon fishery in the face of price competition from farm-raised salmon. The strengths and limitations of resilience theory to inform both analysis and policy remedies are explored, together with implications for a new marine affairs pedagogy aimed at instilling future resource managers with the capacity to apply tools derived from an HDGCME framework built around to the emerging marine and coastal problems of the coming decades.

ORAL PRESENTATION

Exploring the interplay between fishing and resilience using ecosystem models: Historical and cross-system comparisons in three ecosystems of the Pacific

J.E. Little* and R.C. Francis, School of Aquatic and Fishery Sciences
University of Washington, Seattle, Washington
I.C. Kaplan, NOAA Fisheries, NWFSC, S. Gaichas and J.C. Field, NOAA Fisheries, AFSC,
J.C. Field, NOAA Fisheries, SWFSC

How does fishing shape the structure, function, or resilience of an ecosystem? Does response vary when viewed from ecological and economic perspectives? To address these questions, we evaluated responses of three ecosystem models to sustained increases and decreases in fishing pressure. Here, we highlight results from two exercises. First is a contrast of past (1960s) and present (1990s) using a model of the Northern California Current (NCC) ecosystem. Second, a cross-system comparison between the NCC, Eastern Bering Sea and Central North Pacific ecosystems. In all cases, we assess short-term (decadal) and long-term (100 years) system response to sustained fishing pressure changes of different magnitudes; responses are expressed in both ecological (biomass) and economic (fleet revenue) terms. Stark differences arose between systems as did strong, temporally distinct tradeoffs between fleets from both ecological and economic perspectives. More heavily exploited systems showed higher levels of reorganization when subjected to increased fishing pressure. We discuss these results as they apply to ecosystem-based fishery management as well as focus attention to strengths and shortcomings of studying resilience using these types of ecosystem models.

ORAL PRESENTATION

Uncertain future: climate change impacts on salmon in the ocean

Nathan Mantua
Center for Science in the Earth System and Climate Impacts Group
School of Aquatic and Fishery Sciences
University of Washington
Seattle, Washington

What will global warming mean for Pacific Northwest salmon in the 21st century? Addressing this question requires connecting scenarios for future climate and ocean conditions with an understanding for climate impacts on marine ecosystems, and how ecosystem changes influence salmon survivals and growth. Direct and indirect observations from recent decades show a clear association between warm ocean temperatures and poor growth and survival for many northwest coho and chinook populations. Upper ocean temperature changes in the past have come with sometimes dramatic changes in the forage and predator communities that are part of salmon ecosystems. Because the regional impacts of global warming are projected to include a general warming of the upper ocean, this factor alone points to a reduced quality of ocean habitat for some NW salmon populations. However, the wind-driven coastal upwelling process that makes our coastal ocean productive will continue to play a prominent role in shaping biophysical processes in our coastal ocean, and uncertainty in the future behavior of these winds leads to substantial uncertainty in future ocean conditions for NW salmon.

ORAL PRESENTATION

Resilience in lower Columbia River salmon fishing communities

Irene Martin
Salmon for All
St. James Episcopal Church
Cathlamet, Washington

Irene Martin's research indicates widespread poverty in the lower Columbia River region, coupled with high rates of juvenile alcohol and drug abuse, suicide rates, and child abuse rates. Columbia River gillnetters, who live in four main counties (Wahkiakum, Pacific and Grays Harbor, Washington, and Clatsop County in Oregon) have developed strategies for dealing with declining fisheries income from the Columbia River, while maintaining their presence in the gillnet fishery. Their resilience is based on strategies that include developing portfolios of permits that enable them to move rapidly from one fishery to another; taking part in distant water fisheries, particularly in Alaska, which not only provides income but also provides a perspective on what kind of abundance is achievable with good habitat; maintaining customs, folkways and networks; forming alliances with groups that have interests in common, such as Save our Wild Salmon; supporting fishermen's organizations, such as Salmon For All, and a heavy emphasis on oral tradition (exemplified in the Fisher Poets gathering each February in Astoria). Discussion of environmental issues that affect salmon and salmon fishing communities, and fishermen's responses and adaptations over the past century will illustrate their long-term resilience.

ORAL PRESENTATION

Overview of metrics of resilience for monitoring and evaluating results of management in salmon bearing ecosystems

Phil Mundy
Auke Bay Laboratories/AFSC/NOAA Fisheries
Juneau, Alaska

Metrics of resilience for monitoring and evaluating results of management in salmon bearing ecosystems must start with the number of salmon on a time interval, but numbers of salmon are essentially meaningless without metrics of the competencies and magnitudes of critical habitats within which the salmon completes its life cycle. The types and numbers of metrics of resilience will be different for each life cycle stage, but the numbers of salmon is an essential metric for all life cycle stages. Metrics of resilience are also determined by the biology of the individual species, its metapopulations and the nature of its habitats. The three ideal properties of any metric of resilience are its range, its present value and its (time) rate of change. The rate of change of a metric is one of the most important pieces of information for managers, since they must know how fast resilience is changing, and in what direction. Developing monitoring programs that provide consistent estimates of metrics of resilience at a meaningful levels of spatial and temporal resolution requires a series of four activities; 1) defining the measurable attributes (metrics) of the populations and habitats, 2) discovering the functional relationships among these attributes, 3) picking the most important attributes that society can afford to measure, and 4) communicating the state of resilience, as defined by steps 1 – 3, to an interdisciplinary audience. Possible metrics of resilience for salmon recovery planning and approaches to monitoring are examined.

ORAL PRESENTATION

Integrating science and social learning: Ecology and values

Bryan Norton
School of Public Policy
Georgia Institute of Technology
Atlanta, Georgia

While it is possible to get agreement from many that good environmental management must be "scientific management," that agreement only highlights the need for a re-examination of what we mean by "science" in an adaptive, scientific management process. Many scientists still cling to an outdated, positivistic model, whereby science consists of value-neutral descriptions of objective events in nature. Recent developments in the philosophy of science have established the importance of analogy, metaphor, models, and other types of "representations" in the development of ecological theory, for example. Steward Pickett and colleagues have built upon these ideas of philosophers of science and have shown that, while ecology cannot provide a complete model of any environmental problem, nor can it specify the "correct" spatio-temporal scale at which to model a problem, it can propose and build upon new and illuminating metaphors that can help people to re-model the problem and move toward cooperative behavior.

This work on the role of analogies in ecology has the potential to turn our view of science and value on its head. Through the positivist period it was always thought that science should be completed before values are injected into a policy decision context. If Pickett and colleagues are right, the search for management wisdom starts with the search for an appropriate metaphor for a particular situation, which must be guided by core values and communal concerns that constitute "the problem" at hand. Consider the term "resilience"—as scientists have shown, it can be defined in terms of particular system dynamics, but if the term resilience is to be useful in management, it will be made useful when it "connects" to a management story about how to protect something of value to the community that is in danger, and provides scientists and lay participants a new metaphor for the functioning of ecological systems.

If it is more realistic to think of metaphors and models as shaping science, then we should re-think the way we evaluate anthropogenic change. Rather than trying to "commodify" nature as is done by economic, willingness-to-pay analysis, which builds narrowly upon a single nature-as-productive-system metaphor, ecologists could be experimenting with multiple and varied models and metaphors, and helping managers and the public to develop plausible scenarios, and evaluate these as possible "development paths" associated with various policy approaches. Such an approach to the evaluation of change would be more holistic and pluralistic, but that is what seems to be demanded if we recognize the metaphorical roots of ecology. Relying upon the creative approach that searches for better metaphors by which to "model" a problem, it seems to me that "resilience" might, for example, be connected to a "medical" model of management. It is impossible, however, to treat the decision as to which model we use to articulate environmental problems, and to apply appropriate ecological models, as an exercise in positivistic "science".

ORAL PRESENTATION

Instream flow restoration in the Columbia basin through water right transactions

Andrew Purkey
National Fish & Wildlife Foundation
Portland, Oregon

The Columbia Basin Water Transactions Program (CBWTP) was established in 2002 to fund and support innovative, voluntary grassroots strategies that improve flow for anadromous and resident fish populations in Columbia Basin streams and rivers. The CBWTP philosophy is to improve flow for fish and wildlife habitat in a manner that respects the value of irrigated agriculture and the water rights held by agricultural producers. The CBWTP is administered by the National Fish and Wildlife Foundation and is primarily funded by the Bonneville Power Administration.

The four Pacific Northwest states in the Columbia Basin (Idaho, Montana, Oregon and Washington) have allocated water rights to agricultural producers through a system of legal water rights first established in the nineteenth-century when it seemed there was no end to land or water. Now, though, in many places, more rights have been assigned than there is water to meet them. During a typical growing season, stretches of many streams and rivers in the Columbia Basin run of anadromous and resident fish in the basin.

Since 2002, the CBWTP has supported 11 entities (8 NGOs and 3 state water agencies) and funded over 100 water right transactions that have restored ecologically-significant flow to critical streams in the basin. The partners, including the Deschutes River Conservancy and Oregon Water Trust in Oregon, link with irrigation districts, landowners and producers in local communities to put water in streams.

Andrew Purkey, CBWTP program director, will highlight the CBWTP's challenges, efforts and results since its inception 5 years ago.

ORAL PRESENTATION

How did we get here in fisheries management … A century of learning?

Brian Riddell
Canadian Department of Fisheries and Oceans
Pacific Biological Station
Nanaimo, BC Canada

Daniel Pauly's note on the "shifting baseline syndrome" drew attention to the progressive loss of longer term perspectives in stock size and species compositions with the beginning of each new generation of resource managers. As this conference begins to discuss how we have gotten to this state of the Pacific salmon resource, Dr. Pauly's syndrome is a useful analogy to consider in a broader context. The state of salmon today reflects an evolution, since the late 1800s, in knowledge about salmon biology, of capabilities in fisheries management, and of changing environmental conditions. Before fishery scientists developed an understanding of salmon biology and stocks, the distribution of salmon in ocean fisheries, or an empirical basis for assessment of Pacific salmon status (circa 1950); the basis for most of today's debates in salmon management were already well established. Habitat impacts, competitive ocean fisheries, and hatchery programs were extensive and the economic importance of salmon fisheries seriously challenged management agencies to implement change. Within the context of rapid economic development of the Pacific coast in those early years, the impacts on Pacific salmon might be easily rationalized, but how do we explain the present of state of many salmon populations given the explosion of information through the twentieth century?

This talk will provide a retrospective on factors that have contributed to their current state, including past narrow perspectives on limiting factors to salmon production, the definition of salmon stocks in management, this isolation of salmon from their ecosystems, and institutional issues. In looking forward though, we must recognize our past (i.e., the syndrome), set realistic goals, and critically identify past lessons. An objective of this talk is to stimulate discussion on the lessons (biological and management) and the ecological and genetic conditions necessary to sustain or restore resilience in the salmon resource. Pacific salmon face an increasingly uncertain future; sustaining them will be a challenge for scientists, managers, and society.

Pauly, D. 1996. Anecdotes and the shifting baseline syndrome of fisheries. TREE 10(10):430.

ORAL PRESENTATION

Global constraints on rural fishing communities: Whose resilience is it anyway?

Martin D. Robards* and Joshua A. Greenberg
University of Alaska, Fairbanks
Fairbanks, Alaska

Sustaining natural resources is regarded as an important component of ecological resilience and commonly assumed to be of similar importance to social and economic vitality for resource-dependent communities. However, communities may be prevented from benefiting from healthy local resources due to constrained economic or political opportunities. In the case of Alaskan wild salmon, the fisheries are in crisis due to declining economic revenues driven by the proliferation of reliable and increasingly high-quality products from fish farms around the world. Conventional responses to reduced revenues by the wild-capture industry have been to increase economic efficiency through implementing a range of entry entitlement and quota allocation schemes. However, while these mechanisms may improve economic efficiency at a broad scale, they may not benefit local community interests, and in Alaska have precipitated declines in local ownership of the fishery. To be viable, economic efficiency remains a relevant consideration, but in a directionally changing environment (biological, social, or economic), communities unable to procure livelihoods from their local resources (through access or value) are likely to seek alternative economic opportunities. The adopted strategies, although logical for communities seeking viability through transformation in a changing world, may not be conducive to resilience of a "fishing community" or the sustainability of their wild fish resources. We use a theoretically grounded systems approach and data from Alaska's Bristol Bay salmon fishery to demonstrate feedbacks between global preferences toward salmon and the trade-offs inherent when managing for the resilience of wild salmon populations and human communities at different scales.

ORAL PRESENTATION

Evolutionary history of Pacific salmon in variable environments

Robin Waples
NOAA Fisheries
Northwest Fisheries Science Center
Seattle, Washington

The species of Pacific salmon diverged several million years ago, and recurrent episodes of glaciation in the Pleistocene forged the major ancestral lineages that are found within each of the species. Following the most recent glacial maximum about 15,000 years ago, large areas (e.g., Puget Sound and most of British Columbia) were opened up for recolonization by salmon. Current diversity within each species is thus the product of recent evolution overlayed onto divergent historical lineages. Although some of the more extreme environmental conditions (e.g., the recurrent glacial floods associated with Lake Missoula) have abated since the end of the Pleistocene, the ecosystems that Pacific salmon inhabit remain dynamic to the present day. A conundrum regarding Pacific salmon (they can evolve relatively quickly and can show considerable phenotypic plasticity, but most populations are not ecologically exchangeable on human time frames) poses challenges to those concerned with long-term sustainability of the resource. A key topic of current research is to elucidate the relative importance of genetic and environmental factors in producing observed levels of diversity. A recent survey shows that in the Pacific Northwest and California, about 30% of historic populations are extinct, and estimated losses of major components of ecological, life history, and genetic diversity range from 15-33%. Nevertheless, substantial diversity remains at all levels, and (provided that adequate conservation measures are implemented) this diversity could provide the resilience for the species to adapt to new natural and anthropogenic challenges in the future.

ORAL PRESENTATION

Prespawning loss of adult sockeye salmon in the Fraser River – implications of a changing environment and managing for resilience

Jeffery Young*
David Suzuki Foundation
Vancouver, BC Canada

Scott Hinch and Tony Farrell
University of British Columbia
Vancouver, BC Canada

Steven Cooke
Carleton University
Ottawa, ON Canada

Recent research, conducted by the University of British Columbia and Fisheries and Oceans Canada, has identified environmental, physiological and behavioural correlates of en route and prespawning mortality in migratory adult Fraser River sockeye salmon. Environmental conditions, such as elevated freshwater temperatures and altered flows, have been identified as important factors in mortality. Climate change is predicted to increase the frequency and severity of these difficult conditions. Overall, this research shows that Fraser River sockeye salmon are facing challenges through the entire range of their migration, from the coastal marine environment to spawning grounds, which can result in the loss of a large proportion of salmon before they spawn. Better understanding of the vulnerability of salmon to environmental change, such as the phenotypic plasticity and stock specific tolerances to elevated water temperature, and a reaffirmed commitment to precautionary biodiversity protection is necessary to protect sockeye salmon resilience. This presentation will summarize current scientific research on Fraser River sockeye salmon migration and will present the David Suzuki Foundation's perspectives on further research priorities and potential policy reforms to support sockeye salmon resilience in a changing environment.

ORAL PRESENTATION

Effects of fire on native and non-native salmonids in western Montana: A tale of two responses

Clint M. Sestrich and Thomas E. McMahon
Department of Ecology, Montana State University
Bozeman, Montana

Michael K. Young*
USDA Forest Service, Rocky Mountain Research Station
Missoula, Montana

Wildfire is perceived as a dramatic disturbance capable of causing fish kills or degrading habitat. Less often recognized is the potential role of non-native fishes in altering the responses of native species to environmental disturbances. Using a before-after control-impact design, we examined the changes in absolute and relative abundance of westslope cutthroat trout, bull trout, and brook trout in 18 western Montana streams following a large wildfire in 2000. In many basins, there was little or no apparent change in the abundance of westslope cutthroat trout or bull trout. In others where abundance initially declined, particularly in reaches that experienced debris torrents, these native species rapidly returned to levels near or above those observed before the fire. In contrast, non-native brook trout often recovered more slowly than did either native species in burned areas. Brook trout did not appear to have a substantial effect on native salmonids, although they replaced bull trout in one reach. We believe resiliency in these salmonid populations is related to connectivity to other populations or population segments and to inherent differences in their responses to habitat alteration and the degree of environmental disturbance, particularly during incubation and emergence.

ORAL PRESENTATION

Stable isotope indicators of life history diversity of juvenile Chinook salmon in the Columbia River estuary: metrics of resilience?

Greer Anderson and Charles Simenstad*
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University of Washington, Seattle, Washington

Dan Bottom
NOAA Fisheries, Northwest Fisheries Science Center,
Newport, Oregon

One of the hypothesized contributors to resilience in Pacific Salmon populations is life history diversity. As a part of our on-going research on juvenile salmon ecology in the Columbia River estuary, we are using stable isotopes to delineate life histories of juvenile Chinook (*O. tshawytscha*). We used $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ in muscle and liver tissues of fish captured over three years (2003-2005) along ~60 km of the lower estuarine gradient to identify organic matter sources, migratory pathways, residency times, and food-web linkages. We documented isotopically-distinct groups of juvenile Chinook that we interpreted to reflect temporal, spatial (habitat, estuarine region) and size-specific life history patterns as the fish migrated and reared in the estuary. We are presently accruing corroborative information on individual fish genetic, parasite and otolith microstructure/chemistry to further verify whether these represent discrete life histories, and thereby provide insight into historic and contemporary salmon resilience.

POSTER PRESENTATION

Salmon MALBEC: Model for Assessing Links Between Ecosystems

Xan Augerot[1], Ray Hilborn[2], Nate Mantua*[2], Kate Myers[2], Randall Peterman[3], Dave Preikshot[4], Greg Ruggerone[5], Daniel Schindler[2], Jack Stanford[6], Nathan Taylor[2], Trey Walker[2], Carl Walters[4]

[1]Pangaea Environmental, LLC, [2]University of Washington, [3]Simon Fraser University, [4]University of British Columbia, [5]Natural Resources Consultants, Inc., [6]University of Montana

We built a spatially explicit model of North Pacific salmon stocks (Model for Assessing Links Between Ecosystems) that predicts abundance and growth to vary with total abundance of fish sharing the same habitats during 6 month stanzas. We fit it to data from 135 North Pacific chum, pink and sockeye salmon (*Onchorhynchus spp.*) stocks. We show that models parameterized with density-dependent effects on marine survival fit the data better than without, but that there is large uncertainty about the magnitude of these effects. Reconstructions made using marine density dependence show that current biomass is less than would have been predicted assuming no marine density dependence and a higher proportion of hatchery to total salmon biomass in the Pacific. Simulations predict that reducing hatchery output would have little impact on the total biomass.

MALBEC is designed to allow users to test hypotheses about aspects of salmon ecology like: competition within and between salmon stocks (and species) in the North Pacific, resilience in Pacific salmon ecosystems in the face of climate change and possible impacts of large hatchery releases on stocks from other regions, risk assessments of different conservation, hatchery policy, and/or harvest management strategies. We have developed a North Pacific data base with annual run-sizes, harvests, spawning escapements, and hatchery releases for major pink, chum, and sockeye population groups around the Pacific rim for the period 1950-2000.

POSTER PRESENTATION

Diversity and resilience of Chinook salmon and estuarine wetlands in the Salmon River estuary (Oregon)

Trevan J. Cornwell*[1], Kim K. Jones[1], Daniel L. Bottom[2], Ayesha Gray[3], Charles A. Simenstad[3], and Eric Volk[4]

[1]Oregon Department of Fish and Wildlife, Corvallis, Oregon,
[2]Northwest Fisheries Science Center, NOAA Fisheries, Newport, Oregon,
[3]Wetland Ecosystem Team, School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington,
[4]Washington Department of Fisheries and Wildlife, Olympia, Washington

We examined variations in the juvenile life history of fall-spawning Chinook salmon, *Oncorhynchus tshawytscha*, for evidence of change in estuarine residency and migration patterns following the removal of dikes from 145 ha of former salt-marsh habitat in the Salmon River estuary (Oregon). The absence of fry migrants in the estuary during spring and early summer in 1975-77—a period that preceded restoration of any of the diked marshes—and the extensive use of marsh habitats by fry and fingerlings April–July, 2000-02 indicate that wetland restoration has increased estuarine rearing opportunities for juvenile Chinook salmon. Although few of the earliest migrants survived to the river mouth, many fry and fingerlings from mid- and upper-basin spawning areas distributed throughout a greater portion of the estuary during the spring and summer and migrated to the ocean over a broader range of sizes and time periods than thirty years ago. Wild adult spawners and ocean entry juveniles comprised similar proportions of life history types, dominated by summer migrants entering at 60-95 mm. The findings support the linkage between estuarine wetlands, juvenile life histories, and spawning adults. The results suggest that wetland recovery has expanded life history variation in the Salmon River population by allowing greater expression of estuarine-resident behaviors. The overall improvement in resilience of the habitat and populations in the estuary may not be fully realized because of competing interests in the watershed. The dichotomy of management philosophies concerning wild and hatchery fish, and upriver versus estuarine habitat highlights the challenges of managing an entire salmon ecosystem (fish and habitat) for resilience.

POSTER PRESENTATION

The effect of life history diversity on Bristol Bay Sockeye salmon populations

Correigh Greene*, Jason Hall, and Kim Guilbault
NOAA Fisheries, Northwest Fisheries Science Center
Seattle, Washington

Tom Quinn
University of Washington
Seattle, Washington

Resilience in populations is often linked life history diversity, under the assumption that diversity spreads risk across different segments of the population. Diversity in turn has been linked to habitat complexity. We examined the potential causes and consequences of life history diversity in sockeye salmon spawning in nine Bristol Bay watersheds over the last 50 years by relating the diversity of freshwater/marine age groups to trends in population productivity. The nine Bristol Bay watersheds vary greatly in the complexity of their lake systems, with some watersheds dominated by a few large lakes, and others having many small lakes or a mix of both large and small lakes. This complexity, represented by the skew coefficient of the size spectrum of lakes in each watershed, had a strong unimodal relationship with life history diversity. Because medium values of skew represent higher habitat complexity than the tails, the unimodal relationship between lake area skew and life history diversity indicates that the highest values of diversity were associated with the highest habitat complexity. This relationship persisted in different regimes of the PDO, even though levels of diversity strongly fluctuated between regimes, especially at the tail ends of the skew relationship. In turn, life history diversity showed both positive and negative correlations with productivity as measured by recruits per spawner, indicating that elucidating the effect of diversity on population dynamics will depend upon the temporal scale of these analyses.

POSTER PRESENTATION

Achieving resiliency in salmon and their ecosystems through a common process-based view of habitat and fisheries management

Gino Lucchetti*, Hans B. Berge, Robert Fuerstenberg, and Raymond K. Timm
King County Department of Natural Resources and Parks
Seattle, Washington

A new paradigm for aquatic and riparian ecosystem management emerged during the latter part of the 20th century. Rather than aiming to restore particular habitats, current habitat management approaches increasingly recognize the need to protect and restore the fundamental processes that shape and form habitats and biological complexes and that create the resiliency necessary for long-term sustainability. This change resulted from the view that ecological processes operate over a spatial and temporal continuum that establishes specific ecosystem structures (habitats and biological communities) and functions important for the fitness, local adaptation and, ultimately, the resiliency of species and populations within specific watersheds. Furthermore, this approach embraces variability in process, structure and function consistent with the evolutionary experience of aquatic organisms, such as Pacific salmon (*Oncorhynchus spp.*). In contrast the fishery management paradigm of selecting for the highest and most efficient rates of production, e.g., maximum sustained yield, remains dominant and is inconsistent with the view of resilient populations operating within the context of the ecosystem processes that sustain habitats and allow for full expression of phenotypic and population level variation and evolutionary potential. Having two such distinctly different views of salmon management and restoration creates less resilient populations and uncertainty and conflict in efforts to recover salmon populations. A natural selection-based salmon management paradigm would help ensure a common language and basis for common ecological goals among hatchery, harvest, and habitat managers working toward recovery of resilient salmon populations and ecosystems in the Pacific Northwest.

POSTER PRESENTATION

Abundance, length, stock origin, and pathogen infection in marked and unmarked juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the nearshore surface waters of Puget Sound

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S. Gezahegne, C. Durkin, and K. Fresh
NOAA Fisheries, Northwest Fisheries Science Center
Seattle, Washington

E. Beamer
Skagit River System Cooperative
La Conner, Washington

R. Reisenbichler
USGS, Biological Resources Division, Sand Point Campus
Seattle, Washington

To better understand major anthropogenic influences on wild Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), we studied seasonal and geographic patterns in the abundance, size, stock origin, and pathogen infection prevalence in marked (known hatchery) and unmarked (majority natural origin) juvenile Chinook. Monthly surface trawl sampling was conducted from April to October in 2003 at 52 sites in Eastern Puget Sound ranging from Bellingham Bay to the Nisqually Reach. Unmarked Chinook in the northern regions of the study area showed broader seasonal distributions of abundance and length than both marked Chinook from all areas and unmarked Chinook in central and southern Puget Sound. Unmarked fish tended to be smaller than marked fish. For genetic analysis, data from 13 standardized microsatellite DNA loci surveyed in over 60 spawning populations in Washington and British Columbia were used as a baseline to estimate the stock composition of a subset of 424 unmarked individuals. The genetic results, combined with coded wire tag (CWT) data from 283 fish, showed that juveniles in all sampling areas included individuals from a wide range of populations, and that fish from different source populations vary in terms of movement patterns and apparent residence time. Prevalence of infection by *Renibacterium salmoninarum* was related to capture location rather than stock origin. These results demonstrate that juvenile Chinook use neritic waters in Puget Sound during much of the year, but suggest more extensive use of estuarine environments by wild than hatchery Chinook, and differential use of various geographic regions of greater Puget Sound by all Chinook. In addition, length differences and infection associations have implications for interactions between hatchery and wild Chinook throughout Puget Sound.

POSTER PRESENTATION

Austin Ranch Case Study in Water Management for Economics and Salmon

Kimberly Schonek
Oregon Water Trust
Portland, Oregon

The Oregon Water Trust (OWT) mission is to restore surface water flows for healthier streams in Oregon using cooperative, free-market solutions. OWT was the first water trust in the nation, founded in 1993 by a group with diverse water interests. Since settlers arrived in Oregon in the mid-1800's, the right to use water has been given out liberally often resulting in more water being allocated than what is naturally available. This results in streams without water during summer and fall when it is needed for salmon and steelhead. OWT utilizes a broad range of innovative transaction tools to increase streamflow throughout streams.

The Austin Ranch project, completed in 2006, is a perfect example of OWT's success. Historically, irrigation withdrawals for pasture and hay on the ranch dewatered the upper Middle Fork John Day River and one of its tributaries. The water taken out of the river was used inefficiently to flood irrigate and delivered to the fields through long, leaky ditches. Spring Chinook salmon attempting to spawn in September were limited by the low flows resulting from these practices. Juvenile Chinook and steelhead were also deprived of cool water and their passage into tributaries was limited by flow barriers.

OWT worked with the landowner to craft a unique agreement to shorten his irrigation season so that water withdrawals now end on July 20^{th} of each year. For the landowner, this allowed him to maintain irrigation in the early season and then utilize the land for pasture in late summer. The landowner anticipates this agreement reduces the carrying capacity of the ranch by about 30%. One way to regain this loss in profit has been to improve the quality of the stock and to sell through a natural beef co-op.

For OWT, this project provides needed habitat for Chinook and steelhead when it is most needed—late in the summer after July 20^{th}. The project complements other ongoing restoration efforts in the watershed. To evaluate the benefits of flow restoration in the Middle Fork, OWT has under taken a 10 year monitoring program. Preliminary results indicate that minor changes in flow significantly increase habitat.

POSTER PRESENTATION

Modeling policy choices to maintain aquatic resilience with rapid urban expansion

Courtland L. Smith*, John P. Bolte, and Stanley V. Gregory
Oregon State University
Corvallis, Oregon

David W. Hulse, University of Oregon
Eugene, Oregon

A spatially-explicit, agent-based, multi-objective, multi-year, landscape model enables experiments about the resilience of aquatic resources at the agricultural-urban interface. The model, Evoland, produces alternative future landscapes resulting from different policy approaches as a growing urban population competes for agricultural and forest land, while also seeking to protect aquatic resources. Model runs suggest that urban containment, agricultural reserves, and best-practice conservation policies work to accommodate urban expansion and maintain the resilience of aquatic resources. The landscape analyzed is at the junction of the McKenzie and Willamette Rivers adjacent to the cities of Eugene and Springfield in Lane County, Oregon. Results indicate that if societal goals allow for urban growth boundaries and paying landowners to grow habitat, then scarcities in aquatic populations and ecosystem health can be avoided. Without urban containment policies, then urban expansion is more likely to fragment landscapes and aquatic resources loose their resilience.

POSTER PRESENTATION

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