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Where Are We? Resources at the Brink

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The population dynamics of anadromous fishes reflect the influences of biological, social, economic, and political factors. As a result, the management, restoration, and conservation of these organisms is unusually complex and challenging. In addition, a poorly developed informational network between researchers, managers, and user groups makes maintaining the vitality of these fishes difficult, especially at this critical juncture in the fate of salmon populations. Linkages need to be established among those who conduct basic research on anadromous fishes and their ecosystems, those who manage resources for recreation and commercial interests, and those who ultimately make legal decisions on the future of natural resources.

Along the Pacific coast of western North America, salmonids (*Oncorhynchus* spp.) are extremely important resources for several reasons. First, they are an important food source, not only for the region, but worldwide. Second, because salmonids migrate through thousands of kilometers, moving from streams and rivers through estuaries to the ocean and back, they provide a valuable indication of environmental conditions in those habitats. Finally, there is a strong cultural bond associated with salmonids among the peoples of this region (Schoonmaker and von Hagen 1996). Thus, these fishes provide a complicated natural resource with which to synthesize information on the complex of management, political, social, and biological factors influencing the maintenance of aquatic biodiversity.

The choices available require difficult decisions. Many salmonid stocks have been driven to or near the point of extinction, and there is little time left to make effective decisions before the options disappear. If salmonid populations are to remain healthy, then human life styles will have to change. In other words, continued land development (habitat destruction), inexpensive power (dams), inexpensive water (diversions), and extensive fisheries (unlimited harvest) are not compatible with sustained populations of salmonids and unlimited numbers of humans. A broad-based view of important factors influencing salmonids is needed. Integrating information and the desire to work across scientific and social boundaries may help select suitable options. The interaction and cooperation of separate disciplines remain critical to future management and restoration.

Salmonids in the Pacific Northwest have been widely studied. Much is known about their life history (see Groot and Margolis 1991) as well as their genetics and the importance of freshwater and estuarine habitat quality (Meehan 1991, Naiman et al. 1992, Nielsen and Lisle 1994, Naiman and Anderson 1996, National Research Council 1996) and ocean productivity (Pearcy 1992, Lawson 1993). Using salmonids as an example, this book provides a case study that integrates basic and applied sciences. In general, this case study stresses the importance of working across many disciplines and spatiotemporal scales for salmonids as well as humans. In the following text, we present a brief overview of each section of the book.

Introduction to a Complex Problem

This section introduces the complexity of the problem, discusses the regional importance of salmonids, and provides background information on salmonid biology, conservation, and management. Smitch (1996) describes the importance of salmon in the Pacific Northwest and how this further extends to a national concern. Many organizations (e.g., academic, state, federal, nonprofit, tribal) consider salmon vital to the health of the region. Regier (1996) then discusses the bases upon which conservation and management of salmonids have been set. Maintaining old traditions as foundations from which to address current issues only exacerbates the crisis for salmonids. McPhail (1996) presents the geologic history of this region, showing how it has influenced the evolutionary biology of salmonids. Because of the young geologic history of the region, as well as long periods of isolation resulting from glaciation, salmonids have uniquely responded to a suite of environmental conditions. Using the foundation provided in the introduction, the following sections address specifics associated with the regional status of salmonids.

Status of Pacific Northwest Salmonids

In this section, the authors describe the data available as well as the information needed to interpret changes in population strength, the status of salmonid populations in different regions, and factors contributing to salmonid declines. In an earlier review, Nehlsen et al. (1991) outlined the decline of salmonid populations; ~47% of the native-spawning populations in California, Oregon, Idaho, and Washington were at high risk of extinction. More recent studies have identified healthy stocks in the same region (e.g., Huntington et al. 1996) that provide opportunities for the rehabilitation and maintenance of stocks. Nehlsen (1996) sets the stage by providing an updated perspective describing stocks at risk throughout the Pacific Northwest.

Analyzing Trends: Data and Variability

Data collected by resource managers vary temporally as well as in quality and consistency. This variability creates complexity and inconsistency in evaluating changes in long-term population patterns. Nicholas (1996) presents an analysis of the types of information that scientists and managers have available to them. Characteristically, some of the available data are collected as verbal and written observations while others are collected with specific goals in mind (e.g., escapement, survival). Thus, not only are the data limited but their uses beyond original goals also are restricted. Given the limitations managers have on the quantity and quality of data, Walters (1996) describes the types of data that would be most useful. Managers and those charged with species conservation need specific kinds of data to address an array of urgent questions such as "How does one determine at what point population numbers have been impacted so that restoration is necessary, critical, or beyond hope?" Lichatowich (1996) continues the evaluation of data to present a provocative discussion on how baselines for comparing stocks today with those in the past influence the determination of the magnitude of changing population sizes. Largely dependent upon the group or organization, the baseline may be historical (>100 years) or within the past 20 years. Thus, interpretation with respect to the magnitude of population change will depend on the time scale evaluated. When we evaluate long-term population fluctuations, incorporating several data types over long temporal scales becomes critical in targeting resources for management, conservation, and rehabilitation.

Regional Trends

For Alaska, California, Idaho, Oregon, Washington, and British Columbia authors from each region briefly describe the respective assessment programs and how each defines a "population" (e.g., wild, natural, hatchery populations). The authors also discuss the tools and methods used, the kinds of available data, and the individual definitions of "baseline." The authors then examine temporal and spatial trends in chinook (*O. tshawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*), chum (*O. keta*), and sockeye (*O. nerka*) salmon, and steelhead (*O. mykiss*). Overall, it is vividly apparent that stocks in California (Mills et al. 1996) and Idaho (Hassemer et al. 1996) are most threatened, largely resulting from habitat loss (e.g., water diversion, urbanization) and habitat inaccessibility (e.g., migratory corridors blocked by dams). Salmon and steelhead in coastal regions of Washington (Johnson et al. 1996) and Oregon (Kostow 1996) are doing considerably better than stocks in the interior regions of these states (see also Huntington et al. 1996). Salmonid populations in Alaska (Wertheimer 1996) and British Columbia (Northcote and Atagi 1996) appear more stable and productive although the population numbers within some stocks are decreasing. Much of the relative success of the Alaska and British Columbia populations may be attributed to productive oceanic current regimes and the presence of intact freshwater habitats. Each regional perspective also provides suggestions for the future of salmonid stocks that incorporate responsive management regimes, habitat rehabilitation, and habitat conservation.

Factors Contributing to Stock Declines

The factors contributing to stock declines are diverse but also related. Factors include both direct (e.g., habitat degradation, harvest, predation) as well as indirect influences (e.g., oceanic cycles, hydrologic alterations). In total, these factors impact salmonid populations cumulatively, with the strength of interaction varying in a complicated manner. In other words, impacts are rarely additive and linear. One cannot remove one factor and see a direct and corresponding decrease in impact. Initially, the factors contributing to stock declines showed minimal impact. However, as the number, magnitude, and duration of these factors increased, the ecosystem and its salmonid residents could no longer successfully accommodate the accompanying environmental changes. As salmon and steelhead populations declined, populations became isolated, and artificial propagation of salmonid stocks began. In cases where few individuals contribute to the gene pool, there is a strong potential for decreased heterozygosity and changes in life-history traits (Reisenbichler 1996). As populations become more homozygous, they may become more susceptible to disease, may lose their ability to compete successfully against conspecifics and heterospecifics, and may fail to accommodate minor alterations in their habitats. Fresh (1996) examines the role of biological interactions, such as competition and predation, in the decline of salmonids. There is both direct and indirect evidence that biological interactions have become more important owing to anthropogenic environmental changes. Some of these changes include the introduction of nonnative species to habitats previously dominated by salmonids. Salmon and steelhead now encounter a different array of habitats and co-inhabitants thereby shifting the outcome of biological interactions.

Salmonid habitat has been altered by urbanization, channelization, timber practices, and a suite of other factors. Gregory and Bisson (1996) present information on how these changes influence the complex life history of these fishes. Nineteenth century human colonization and habitat development in the Pacific Northwest occurred largely along waterways; current urbanization follows a similar template. As land adjacent to streams, rivers, estuaries, and the ocean is developed, the natural inputs of sediment, woody debris, and nutrients are modified, and much of the water is diverted for other needs. Collectively, these alterations have severe impacts on salmonids.

Salmonids traverse habitats from freshwater to the ocean throughout their life, thus encountering different fisheries (commercial, recreational, and tribal) as well as different management regimes (state or provincial, national, and international). The Pacific Northwest has faced extremes in salmonid harvest; fishers of all varieties have experienced bountiful and non-existent harvests. In concert with salmonid population declines and concerns about estimating potential return, Mundy (1996) describes the difficulty in balancing preservation of the fish and the fishers.

Finally, salmonids encounter a major influence beyond human intervention—ocean productivity. Pearcy (1996) discusses the oceanography and productivity (primary and secondary) of the subarctic Pacific Ocean. Contrasting the fluctuations between the California and Alaskan currents and the associated El Niño Southern Oscillation events facilitates the association of decadal trends with salmon survival. This element of variability cannot be predicted precisely but must be anticipated for the evaluation of stock fluctuations and implementation in management policies.

Salmon Policies and Politics

The vitality of salmonid stocks is intimately related to policies and politics that influence management. Management decisions (e.g., harvest, habitat, water, and hatcheries) are often made independently whereas the fishes are influenced by all these factors throughout the various life-history stages. If salmonid management is to become more successful, it will require coordination with policy and politics.

Rutter (1996) contrasts the processes by which federal, state, and provincial harvest decisions are made. In addition, he includes information on the role of science and politics in the decision-making process and outlines the consequences of the current situation. Salmon harvest decisions include myriad users (recreational, aboriginal, and commercial) across state, provincial, and national borders (United States [US] and Canada), which creates a complex and tedious process. Similarly, Sedell et al. (1996) discuss the fractured nature of habitat management and describe an attempt by the US federal agencies to develop watershed-based management plans. Often terrestrial (e.g., owls) and aquatic organisms (e.g., fish and invertebrates) have overlapping requirements, yet management decisions are made independently. New approaches to resource management (e.g., Forest Ecosystem Management Assessment Team [FEMAT]) attempt to incorporate the full array of biodiversity into future plans.

Complications also arise when one considers how water-management and water-quality decisions are made. Gauvin (1996) provides insights into the processes of water management—how management has proceeded in the past and how it can be improved. In the past, water has been managed with little or no consideration for aquatic organisms or the importance of natural inputs (e.g., woody debris, nutrients) to the overall integrity and productivity of aquatic systems (Naiman et al. 1995a, b).

The absence of a paper on hatchery policy reflects the delicate and controversial nature of this issue. Several potential authors attempted to write papers but were either prevented from or unsuccessful in providing accurate information because of the regional and political pressures to continue using hatcheries as a means to replace lost stocks. Hatchery policies currently remain a topic of considerable debate and concern (Hilborn 1992, Meffe 1992, Stickney 1994). Some of the concern is based on salmonid biology (e.g., genetic diversity) while other aspects are based on the belief that stocks can be rehabilitated through artificial technology rather than through complex and integrative processes incorporating fish ecology with anthropogenic impacts (e.g., habitat loss, urbanization). Hatcheries must be able to provide an adequate mechanism to facilitate recovery, enabling the rehabilitation of stocks. However, it will require a coherent policy facilitated by professionally responsible personnel. This includes shifting hatchery policy from production and augmentation to a policy of the hatchery as a repository for genetic information.

Policy and management decisions are currently made in a fragmented manner. Viewing decisions as separate is dangerous because, in reality, each is intimately connected. What are the consequences of a lack of management coordination? Frissell et al. (1996) examine how to measure the performance of decisions. If the goals are to sustain healthy wild populations, then critical ecological and cultural measures need to be included.

Technological Solutions: Cost-effective Restoration

Given the fragmented nature of salmon policy and a need for integrated management, can technology and science provide us with additional tools for cost-effective restoration? Bisson et al. (1996) propose an ecological framework for setting habitat goals based on the range of conditions generated by natural disturbances. Goals center on watershed management, which includes riparian buffers, presence of large woody debris in streams and rivers, and adequate spawning and rearing habitat. By incorporating a larger-scale view of habitat restoration, the authors suggest including natural spatial and temporal change (e.g., seasonal fluctuations, climatic variation). Beschta (1996) specifically addresses the importance of riparian restoration as a critical step for improving freshwater habitat for salmonids in the Columbia River basin. While waiting for many of the habitat-related problems to be resolved, artificial propagation programs help conserve at-risk stocks. Kapuscinski (1996) evaluates how hatchery programs have functioned, whether they have been successful, and what the future holds.

As resource managers grapple with variability and its inherent uncertainty, methods are needed to assess successes and failures. Fundamental technical problems exist when managing renewable resources with "incomplete information." This somehow implies that the problems would be solved if there was "complete information." Francis (1996) stresses that resources are dynamic; chance and change are becoming regarded as fundamental aspects of the natural world. The future of salmon assessment and management includes explicitly recognizing and dealing with uncertainty. Lackey (1996) further evaluates ecological risk assessment in protecting anadromous salmonid stocks. He suggests that it may be essential to isolate the scientific basis for decision making from the policy-making arena to eliminate real or perceived biases. Using a team approach, scientists examine the risks associated with stocks of interest (i.e., those at or near extinction). Not only can risks be identified, but options available to change activities or to reduce threats to particular stocks can be made available.

In conclusion, Williams and Williams (1996) describe the development of an ecosystem-based management strategy (FEMAT 1993) that was designed to restore and maintain natural production of anadromous salmonids on public lands. This approach consists of sets of goals and objectives that provide guidelines to protect and restore watersheds. It also includes a key component, monitoring, which has been previously lacking in many restoration plans.

Institutional Solutions: Effective Long-Term Planning and Management

The fifth part of this book addresses socioeconomic factors and institutional solutions to planning and management problems. Hughes (1996) introduces this section with an overview of the philosophical basis of values (i.e., contrasting economic and ecological views), development of organizational systems, the integration of information at different scales, and using different values. The fundamental basis for institutional change is the need for resource users and managers to understand past motivations, goals, and agreements. Bottom (1996) presents a thorough review of the ideas inherent in salmonid conservation. A diverse group of people have been involved (e.g., managers, scientists, policy makers) with different motives (e.g., fish as "crops," exploitation). Understanding where salmonid management has been will allow a better evaluation of where future management and conservation should go.

Societal values, organizational systems, and institutional constraints present opposing forces to be reconciled and integrated in order to improve resource condition. Smith and Steel (1996) present the view that where our values lie—in an economic or ecological realm—will influence how resource decisions are made. Little concern is placed on ecosystem or biological preservation when resources are valued primarily for their economic value. Ecological value, however, is difficult to quantify. The problem is further complicated when one considers organizational systems and the burden of proof. Bella's (1996) premise is that organizations incorporate operational failure into the system. These systems are not structured to succeed or to resolve problems; otherwise the organizations might no longer be necessary. This is especially so in the case of providing evidence of harm. The burden of proof currently lies in proving damage after the fact rather than before an alteration or change is made to the system. The situation appears bleak for salmonids if this remains the case.

The science of salmonid ecology requires a perspective that includes the bottom of a stream (or the ocean) as well as the top of a ridge and all the physical, biological, social, and economic components in between. How do we integrate salmon, land and water stewardship, and human values? Robert Lee (1996) proposes a solution that integrates organisms and environment into society without altering our existing life-style quality. Philosophically, society should be able to accomplish this; however, reality includes cross-disciplinary awareness, interaction, and compromise.

Where Do We Go from Here?

This book's organization steps from the basic biology of salmonids to an understanding of the population trends and factors (physical, biological, political, and social) influencing them, and incorporates an attempt to understand options available for restoration and long-term survival. The last two chapters present views for the future of salmonids in the Pacific Northwest. Kitchell (1996) examines the salmon resource from the viewpoint of an "outsider," one who has been actively involved in fishery resources in other regions. He suggests accomplishment of the following: accept humans as components of ecosystems, work with allies in the political arena, and conduct small, potentially successful restoration projects. Success in any of these areas will translate into support and encouragement by the public. Kai Lee (1996), presents three similar principles for sustaining salmon from his own experience in meandering along the challenging path of salmonid restoration, rehabilitation, and conservation. He maintains that sustaining salmon will involve cooperation when conflict is inevitable, incorporation of appropriate spatial and temporal scales into action plans, and learning by experimentation (adaptive management).

In summary, if one may judge by salmonids as an example of resources at the brink, we as a society have been poor stewards. If these resources are an indication of our stewardship, natural resources in the US are at risk. However, if we use their example as a call to consider the complexity of the problem, the critical need for integration across organizations and disciplines, and a willingness to adapt and compromise as resource users, then genuine progress is possible. We hope resource management and conservation will change in such a manner that the health and biodiversity of this planet will be sustained for future generations.

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