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Disease as a Factor in the Adaptive Management of Park Aquatic Resources

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Disease concerns in fishery management

Emerging diseases along with a suite of known and persistent diseases can present management challenges for native species management and restoration, can influence biodiversity, or may cause losses of recreational fishing opportunities. Disease is "any impairment that interferes with or modifies the performance of normal functions, including responses to environmental factors such as toxicants and climate, nutrition, infectious agents; inherent or congenital defects, or any combination of these factors" (Wobester 1981). An understanding of the prevalence and role of disease in wild populations of fish and other aquatic organisms should be important criteria in fishery management. Likewise, it has been well documented that diseases can affect survival, reproduction and performance of host fishes. However, as pointed out by Hedrick (1998), the implications of disease are most often overlooked in fishery management. It is not until disease becomes epizootic and dead or dying fish become evident that managers begin to pay attention to the implications of disease in wild fish management. These concerns are particularly relevant when disease is complicated by environmental contaminants, degraded ecosystems, or the result of the introduction of some exotic pathogen.

Disease as a factor in wild fish populations is poorly understood or ignored for a variety of reasons. Certainly, one of the most common reasons is the difficulty of describing the etiology of disease and attributing any cause-and-effect relationships. This is largely due to the complexities of the host–pathogen–environment relationship and the spatial and temporal frameworks within which this association exists. Disease causality in wild populations can be influenced by multiple factors such as changes in population density, loss of habitat, nutritional status, and other biotic or environmental factors that result in stress and changes in immune functions. Some of the more common host-level effects of disease include poor growth or condition, increased susceptibility to predation, altered behavior, altered food conversion, reduced reproductive fitness, and poor survival (Hedrick 1998). These effects can occur singularly or in combination, affecting various life stages, and have cumulative and problematic consequences for wild fish populations (Nehring and Walker 1996).

The effects of disease at the population level are of the greatest concern for fishery managers. In general, diseases that have long incubation periods and where hosts are infected but not infectious have less impact on population growth, while diseases that affect reproductive functions are most likely to suppress population growth (Anderson and May 1979). The spread of disease at the population level is usually directly proportional to the density of susceptible and infectious hosts. Rapid increases in the prevalence of infection in a host population can result in epizootic disease and mass mortality. However, the more common cir-

cumstance is for enzootic disease with a low prevalence of infection or pathogenicity. In these later cases, the prevalence of a pathogen alone provides little information of the impact of the disease on the population. Successful management depends on the ability of fishery managers to clearly understand the relationships of disease, fecundity, and survival of infected and uninfected hosts within the population (McCallum and Dobson 1995). Such data can be obtained through carefully designed mark-recapture studies in which infected and uninfected hosts could be determined by serological techniques.

Some diseases in national parks

There have been very few direct investigations of fish diseases in national parks. However, fishes and other aquatic organisms in parks are just as likely to harbor pathogens and parasites as fishes found outside of the parks and at times, these pathogens can result in disease. This is particularly true in parks where present or past fish stockings have occurred, or parks in which exotic aquatic organisms have been introduced. Some examples of diseases affecting fishes in parks are included in Table 1. Some of these diseases are persistent and have been documented in fish for quite some time, while others are just emerging as new problems for resource managers. Whirling disease has been present in North American trout populations since its introduction from Europe in the 1950s. However, it was not until the 1990s that significant declines in wild rainbow trout were noted in the Intermountain West. These declines were eventually attributed to whirling disease. Damselfish neurofibromatosis (DNF) is an emerging disease of fish in national park units in South Florida and the Caribbean. It is a transmissible cancer that is caused by a retrovirus that is known to affect bicolor damselfish (Campbell et al. 2001). It tends to affect larger damselfish more than smaller ones. The effects of the disease on damselfish populations on South Florida reefs are unknown.

In addition to fishes, pathogens are responsible for several other diseases affecting aquatic resources in parks. Examples include amphibian ranaviruses which are suspected of causing population declines of several amphibian species in the northeast and Rocky Mountains and several coral diseases affecting reefs in South Florida, the Virgin Islands, and in the Pacific.

Fish diseases with zoonotic potential

In addition to causing disease in fish there are a few pathogens that are known to be zoonotic, that is, to cause disease in humans. The Centers for Disease Control and Prevention have identified several common fish pathogens that can cause disease in humans. These include *Mycobacterium marinum*, *Streptococcus iniae*, *Aeromonas hydrophila*, *Photobacterium damsela piscida*, and *Edwardsiella tarda.* For instance, the handling of fish infected with *Mycobacterium marinum* by anglers may cause localized skin lesions that can be very difficult to treat. Immuno-compromised individuals, infants, and children can be especially at risk of infection. In 2001, the Maryland State Public Health Laboratory reported 34 positive cases of mycobacteriosis, or fish-handler's disease, in people having handled striped bass in Chesapeake Bay (Blankenship 2002). Likewise, the careless handling of fish infected with *Streptococcus iniae* could result in invasive bacteremic illness. Symptoms of this illness

Disease	Pathogen	Parks affected	Characteristics
whirling disease	*Myxobolus cerebralis*	Yellowstone	Chronic, debilitating parasitic disease known to occur in at least 21 states. Generally considered a disease of cultured trout, but now threatening several "blue ribbon" trout streams in Colorado and Montana (Potera 1997). May represent a threat to native cutthroat trout restoration.
damselfish neurofibromatosis	DNFX retrovirus	Biscayne, Virgin Islands	A transmissible cancer that affects bicolor damselfish on South Florida and Caribbean reefs (Schmale and Kemerer 1996).
striped bass mycobacteriosis	*Mycobacterium* spp.	Lower Delaware	A subacute to chronic wasting disease known to affect 167 species of freshwater and saltwater fishes and occurring in all coastal waters of the U.S. *Mycobacterium marinum* is considered the primary causative agent although several other species may be involved (Rhodes et al. 2001).
bacterial kidney disease (BKD)	*Renibacterium salmoninarium*	Shenandoah	Bacterial kidney disease (BKD) is a serious systemic infection that causes high mortality in populations of wild and cultured salmonids. The disease can be transmitted both horizontally (from fish to fish) and vertically (from parent to offspring; Bullock and Herman 1988). It is also known to be transmitted between wild and stocked fish (Elliot et al. 1997).
Asian fish tapeworm	*Bothriocephalus acheilognathi*	Glen Canyon, Grand Canyon	A serious exotic and parasitic cestode that affects many native cyprinids and some catfish species in the Colorado River basin. Probably introduced along with exotic carp.

Table 1. Some common fish diseases in the national park system.

include cellulitis, infective endarcarditis, meningitis, and/or systemic arthritis. While the risk of contracting infection or disease from fish pathogens is generally low, an awareness of the potential risks should be an important consideration for park managers.

The role of adaptive management

The application of new knowledge of fish disease processes, fish disease defense mechanisms, and ecology is important to the development of fishery management strategies in parks. This is especially true where either epizootic disease or chronic disease influence fish at the population level. In such instances, successful resource management will depend on the ability of park managers to properly diagnosis disease, to predict population- and ecosystem-level risks, and to take appropriate actions for containment and control of the disease. To accomplish park fishery management goals, managers should employ adaptive management techniques that incorporate aquatic animal health concerns whenever disease is implicated as a factor. Adaptive management is a process from which scientific knowledge is generated on an issue or resource and this knowledge is subsequently translated into management strategies that change, or adapt, to new information and changing resource conditions (Wilhere 2002).

Table 2 provides a summary of seven components required to address the adaptive management of fish in parks. The high degree of uncertainty and the general lack of ability to control the system make adaptive management a challenge. To employ active adaptive management in such situations requires the coordination and cooperation of all the responsible authorities and the full integration of aquatic animal health specialists or veterinarians in strategic planning and monitoring. Addressing disease issues in wild populations also requires consultations with the policy makers who regulate the fishery and those that utilize the resource, namely anglers and other park users. When zoonotic risks exist this process should involve not only aquatic animal health specialists but also those responsible for public health decisions. All these actions are predicated on an understanding of the etiology of the infectious disease and having effective communication networks in place for sharing information, making decisions, and getting scientifically valid information to park managers and visitors.

References

Anderson, R.M., and R.M. May. 1979. Population biology of infectious disease: Part I. *Nature* 280:2, 361–367.

Blankenship, K. 2002. Mycobacteriosis poses no major threat to humans if treated in time. *Bay Journal* 12:2 (April).

Bullock, G.L., and R. L. Herman. 1988. Bacterial kidney disease of salmonid fishes caused by *Renibacterium salmoninerum*. Fish Disease Leaflet no. 78. Kearneysville, W.Va.: U.S. Fish and Wildlife Service, National Fisheries Research Center-Leetown, National Fish Health Research Laboratory.

Campbell, C.E., D.P.L. Gibbs, and M.C. Schmale. 2001 Progression of infection and tumor development in damselfish. *Marine Biotechnology* 3:7,107–114.

Elliot, D.G., R.J. Pascho, L.M. Jackson, G.M. Matthews, and J.R. Harmon. 1997. *Reni-*

Component	Primary focus areas
Monitoring	Diagnose disease and determine patterns, trends, and geographic distributions
Reporting	Develop real-time awareness, data summaries, and analysis
Field response	Initiate and evaluate disease management and control activities
Disease etiology	Provide science support for describing host–pathogen–environment relationships and for finding the weak links
Technology development	Provide science support for the development of new tools and methodologies for disease detection, diagnosis, and control including the development of nonlethal sampling techniques
Interagency coordination	Communicate and coordinate to maximize the benefits of jurisdiction/agency involvement and shared responsibilities
Education and outreach	Enhance resource manager, societal, and park visitor awareness, addressing disease issues and park user/public health concerns

Table 2. Components of adaptive management required to address fish disease.

baecterium salmoninarum in spring–summer Chinook smolts at dams on the Columbia and Snake Rivers. *Journal of Aquatic Animal Health* 9:2,114–126.

Hedrick, R.P. 1998. Relationships of host, pathogen and environment: Implications for diseases of cultured and wild fish populations. *Journal of Aquatic Animal Health* 10, 107–111.

McCallum, H., and A. Dodson. 1995. Detecting disease and parasite threats to endangered species and ecosystems. *Trends in Ecology and Evolution* 10:5, 190–194.

Nehring, R.B., and P.G. Walker. 1996. Whirling disease in the wild: the new reality in the Intermountain West. *Fisheries* 21:6, 28–32.

Potera, C. 1997. Fishing for answers to whirling disease. *Science* 278, 225–226.

Rhodes, M.W., H. Kator, S. Kotob, P. van Berkum, I. Kaatari, W. Vogelbein, M.M. Floyd, W.R. Butler, F.D. Quinn, C. Ottinger, and E. Shotts. 2001. A unique Mycobacterium species isolated from an epizootic of striped bass *(Morone saxatilis). Emerging Infectious Diseases* 7:5, 896–899.

Schmale, M.C., and T.W. Kemerer. 1996. Melanophores in damselfish neurofibromatosis: Alterations in morphology and melanosome aggregation responses. *Journal of Aquatic Animal Health* 8, 1–12.

Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. *Conservation Biology* 16:1, 20–29.

Wobester, G.A. 1981. *Diseases of Wild Waterfowl.* New York: Plenum.