APPENDIX C. PATHOGENS AND DISEASES OF SPRING CHINOOK SALMON AT LEAVENWORTH NATIONAL FISH HATCHERY[1]

The following diseases have been regularly diagnosed in Spring Chinook Salmon at Leavenworth NFH. These diseases are of increasing concern with warming water.

A. Background.

In general, a fine balance exists among fish stress, pathogen exposure, and the onset of clinical disease. Salmonid fishes become stressed at temperatures beyond their preferred thermal zone and experience profound decrease in immune system competence. Additionally, warmer water favors replication and enhanced pathogenicity of many salmonid pathogens. This combination of fish stress and enhanced pathogenicity can create dangerous disease epizootics that become increasingly more severe and difficult to treat as water temperature increases.

B. Diseases of concern

1. Ich.

"Ich" is a disease caused by the ciliated parasite *Ichthyophthirius multifilis*. Ich burrows into the skin and gills of fish causing severe electrolyte and osmotic imbalance, secondary infections, and impaired respiratory function. This disease is a seasonal summer concern at Leavenworth NFH and routinely causes morbidity and mortality among Spring Chinook at the hatchery. As water warms, the duration of the life cycle of the parasite decreases allowing the parasite to proliferate more quickly (e.g., the life cycle is approximately 13 – 14 days at 7.8 °C but only 7 days at 21 °C). Because of this more rapid life cycle, more formalin treatments over a defined time period are required to control the parasite.

In addition to more rapid proliferation of the parasite, salmonid fishes become stressed physiologically at water temperatures above their optimal temperature range and develop profound immune suppression. This suppression impedes the ability of the fish to mount the strong immune response necessary to defend themselves against parasites like Ich. In short, warm water temperatures above the optimum range of the fish species can tip the host-parasite balance in favor of the parasite resulting in more frequent, severe, and difficult-to-treat ich outbreaks.

2. Bacterial kidney disease.

Bacterial kidney disease (BKD) is caused by *Renibacterium salmoninarum*, a pathogen present in many salmonid fish populations in North America. BKD can be transmitted vertically from female parent to offspring via their eggs and also horizontally among individual fish. Infections with R. salmoninarum can occur at any life stage, and clinical signs are often varied and non-specific. While disease can occur at a variety of water temperatures and mortality can be seen at temperatures as low at 4 °C, clinical disease progresses more rapidly at higher water temperatures (15 – 20.5 °C). No effective treatment

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exists currently for BKD, and control measures focus on (a) reducing the likelihood of vertical transmission of R. salmoninarum through broodstock testing and exclusion (or isolation) of fertilized eggs from female parents with high pathogen loads and (b) reducing stress on juvenile fish during the rearing period. As with ich, warm water temperatures promote progression of disease in both adults and juveniles by accelerating replication of the bacteria and diminishing immune response of the fish. Warmer water temperatures most likely increase the probability of vertical transmission from adults to juveniles via the eggs.

3. Columnaris disease

Columnaris disease is caused by infection with the bacterium, *Flavobacterium columnare*. Most freshwater fish species, including Pacific Salmon juveniles and adults, are susceptible to Columnaris disease. Infection typically occurs in fish raised in stressful conditions or with injuries to the skin and mucosa, and mortality can be high. Columnaris disease can occur at lower water temperatures (12 – 15 °C), but most severe outbreaks in salmon are strongly correlated with higher water temperatures of 20 °C and greater. Treatment of Columnaris disease typically includes medicated antimicrobial feed and/or immersion treatments. As described previously, warm temperatures increase the rate of proliferation of Columnaris bacteria and decrease the immune response of salmon hosts.

4. Furunculosis

Furunculosis is caused by infection with the bacterium, *Aeromonas salmonicida*. All salmonid fish species are susceptible to this pathogen with disease occurring at all life stages over a wide range of water temperatures. Exposure to the pathogen typically results in systemic infection, and clinical disease can range from acute septicemia to chronic skin lesions. Like BKD, the clinical course and duration of furunculosis are longer at cooler water temperatures (e.g., ≤13 °C) with incubation of *A. salmonicida* lasting several weeks. At water temperatures ≥20 °C, the clinical course and duration of disease are significantly shortened, and fish can develop disease within 4 to 12 days following initial exposure to *Aeromonas salmonicida.* At that point, diseased fish become a point source for shedding infectious bacteria into the environment. Treatment for furunculosis is medicated antimicrobial feed. As with most other bacterial-caused diseases, warm temperatures increase the speed of bacterial replication and decrease host immunity thereby tipping the balance strongly in favor of severe disease.

5. Other

Several pathogens and diseases of salmonid fishes have not been diagnosed historically at Leavenworth NFH but are a concern under future conditions. For example, the parasite *Ceratonova shasta* and the bacterium *Lactococcus garviae* are of particular concern because they have wider thermal ranges than salmonid fishes and can quickly establish virulent populations in watersheds where the intermediate host is present (*C. shasta*) and water temperatures exceed 18 °C, respectively.