**Relationship between dams and disease in salmon**
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Salmon runs in the Klamath River , once among the largest in the PNW, have declined since the construction of six dams between 1908 and 1962, which blocked hundreds of miles of spawning habitat and significantly modified the ecosystem. Although salmon may encounter a variety of pathogens, in recent decades the parasite *Ceratonova shasta (C. shasta)*, been shown to have had a consistent presence in the Klamath River. The parasite infects outmigrating juvenile salmon causing enteronecrosis and death, and has been linked with Chinook salmon population declines in this system. *C. shasta* is present in most large rivers of the PNW, but its effects in the Klamath have been the most dramatic and consequently has received the most study. Completing the life cycle of the parasite involves not only the salmon, but an invertebrate polychate worm, which plays a large role in where and when the parasite occurs and how abundant it becomes – in other words, this worm drives the life cycle.

We now have good data to support the following links between the river alterations that occur as a result of dams the risk of disease in salmon.

- Blockage of adult salmon migration has several effects in addition to the loss of upriver spawning habitat
    - adult salmon once migrated into upper river tributaries where parasite spores were unlikely to encounter their invertebrate host, thus ending the parasite life cycle. Now large numbers of these fish spawn in the mainstem river below Iron Gate dam, providing direct spore input
    - adult salmon, and thus *C. shasta* spores, become concentrated in a small area of the river, creating "hot zones" for infection of juvenile salmon
    - mitigation for loss of spawning habitat resulted in the need for hatcheries to maintain production. The large numbers of juvenile salmon released from Iron Gate hatchery enter the river just above the infectious zone during a period when parasite abundance is high, resulting in high infection among these fish.

- Alteration of river hydrology affects *C. shasta*'s invertebrate hosts and in turn, disease risk to salmon.
    - Years where there has been flushing flow events also have low disease risk.
    - Dams result in stabilized river flows , allowing polychaete populations to build up to millions per square meter. While historically this likely occurred during years of drought, it is now an annual occurrence without a management intervention to provide flushing flows.
    - At the other end of the flow spectrum, historically river flows in summer were lower, drying out polychaete habitat that occurs along the river margins.

- Reservoir modification of the thermal regimes affects disease prevalence
    - Disease risk is highly correlated with temperature – at higher temperatures the parasite replicates more rapidly in both the salmon and polychaete host.

    - During the fall, reservoirs keeps water temperatures higher, which likely affects the progress of the infection in the returning adult salmon and may increase the transmission of the parasite to the polychaete host.
    - In spring, reservoir temperatures are slightly cooler, which may delay development of the parasite and result in more overlap between the parasite and outmigrating juvenile salmon.
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- Reservoirs modify the food web, which supports polychaete populations
    - The production of diatoms and other phytoplankton that serve as food for polychaete worms is affected by nutrient cycles in the reservoirs.
    - Increased nutrients allow polychaete populations levels to increase to very high levels and may allow them to overwinter, and thus rebound more rapidly in spring.