US Army Corps of Engineers
Alaska District
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Black Lake Ecosystem Restoration Study
Section 206
Continuing Authorities Program

Problem Identification:

The concern of the local sponsor is related to increased competition between two sockeye salmon stocks during their juvenile life history. Previous studies have found evidence that when Black Lake was deeper, juvenile sockeye spent the winter in Black Lake. Today, indications are that most of the juvenile sockeye migrate to Chignik Lake by August. Reductions in the depth and volume of Black Lake attributable to lower long-term water surface elevations (WSEs) have been published in various reports and journal articles since the early 1990s. It is feared that under the future without project conditions, increased competition from Black Lake fry fleeing degraded habitat in Black Lake may result in lower abundance of the late-run Chignik Lake stock contributing to an overall loss of productivity in the entire Chignik system. The Chignik sockeye fishery is of critical importance to local subsistence and commercial fishers. Also, the two Chignik sockeye runs there are important to area wildlife, in particular brown bears, seals, and Stellar sea lions. If no action is taken, the following possibilities are of particular concern:

- **Continued loss of the water volume of Black Lake** will further diminish the quality and quantity of rearing habitat, further reducing the utilization of the lake by sockeye fry. In particular, increased water temperatures due to reduced volumes and depths are a concern.
- **Further, and potentially complete, extension of the spit across Black Lake** threatens to impair water circulation and sediment and nutrient transport processes, especially in the upper, principal basin of the lake. This may make it difficult for fish to utilize the lake's upper basin.
- **Greater proportion of flows enter Black Lake from the south fork of the Alec River** reducing salmon utilization of Black Lake. With greater flows from the south fork, critical rearing habitat within Black Lake could be greatly reduced.

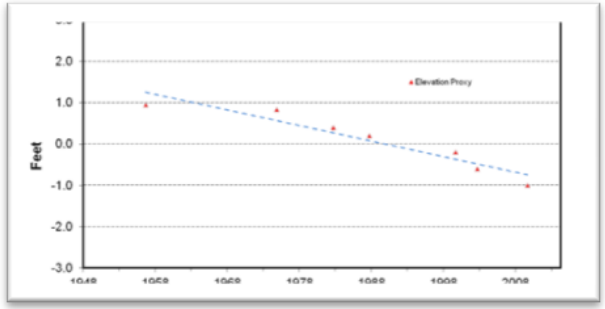
USACE Study Efforts:

With the funds provided for this study, the following activities were performed:

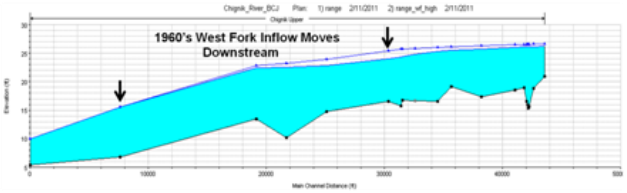
- Continuous monitoring of water levels in Black Lake.
- Cross section surveys of the outlet of Black Lake and Black River, with accurate vertical and horizontal control monuments, allowing for comparison between historical measurements and present conditions.
- A bathymetric survey of Black Lake in 2011.
- Core sampling to document sedimentation rates occurring in Black Lake for the past 50 years.
- Development of a hydraulic model to better understand the flow characteristics of Black River.
- Creation of a thermal model to simulate various lake volumes and the associated impacts on water temperature.
- Monitoring of the Chignik River sockeye salmon smolt outmigration and limnology assessments of Black and Chignik lakes.

Findings from the Study:

- Over the past 50 years, the average surface elevation of Black Lake has decreased by approximately 1 to 2 feet. The average volume of the lake has decreased by an estimated 25 percent due to the lowering of the average lake water surface elevation and 1 to 5 percent due to lake sedimentation over the past 50 years. Lower lake water surface elevations are attributed to the shift in the location where the West Fork River enters the Black River. Based on data collected to date, it is estimated that, while the trend in lower average lake water surface elevations may continue, the rate of change may be decreasing with the Black River approaching an equilibrium following the shift in the West Fork. While further reductions in the volume of Black Lake may occur, no major change is projected for the near term.



Water Level Trends over past 50 years



Hydraulic modeling of impact to water surface of Black River by West fork migration downstream

- It has been determined that Black Lake depths have been reduced by 1 to 4 inches due to sedimentation over the past 50 years. Therefore, sedimentation accounts for only a small proportion of the depth reductions observed at Black Lake.

- This analysis has concluded that under existing conditions, water entering Black Lake within its north basin will be sufficient to ensure that the spit remains open for the foreseeable future. This will ensure that. favorable habitat located in the north basin will continue to be accessible to salmon.
- Thermal modeling (Griffiths 2011) showed that increases in lake depth as deep as 6.5 feet would have no appreciable impact upon water temperatures in Black Lake. The thermal model confirmed that air temperature, not lake morphology, was the predominant influence upon water temperatures in Black Lake. With recent warming trends experienced in the region and expected to continue into the near future, it is likely that Black Lake will experience further increases in water temperature.
- Structural measures are predicted to have a minimal impact upon the thermal regime of Black Lake and hence are not expected to increase the utilization of Black Lake habitat. Future anticipated increases in air temperature are likely to have a larger impact.
- There is no definitive correlation between the changes documented at Black Lake and the fisheries resources of the Black Lake/Chignik system. No sustained downward trend in the fishery attributable to the reduction in depth and volume has been documented.

What is recommended:

The Corps recommends continued monitoring of smolt outmigration and limnology in the Chignik system to detect changes in the early life history strategies that may detrimentally impact the overall resources of the watershed. Such data are not impacted by variable ocean conditions and hence are essential for linking changes in freshwater life stages and the overall health of sockeye salmon stocks. Annual collection of water surface elevations of Black Lake, combined with periodic collection of cross section data from the Black River and satellite imagery of the region, will allow early identification of any geomorphic forcings that could result in a harmful loss of rearing habitat in Black Lake. Continued study under Section 206 of the Water Resources Development Act of 1996 is not warranted at this time because the Authority does not facilitate monitoring efforts prior to project construction.

Monitoring Plan:

A monitoring plan such as the following, in addition to continuing ongoing smolt emigration, limnological, and genetics monitoring, would provide the necessary information to allow the early identification of any potential stressors to the health of the sockeye salmon resources of the Chignik system.

Year-round, continuous lake level measurements

- It is important to monitor the level of Black Lake on a continuous basis throughout the year to establish rates and direction of WSE changes.
- These measurements should consist of a simple water level recorder installed and retrieved each year. A second redundant sensor is also recommended.
- Biweekly lake water surface measurements should be performed during the typical summer field season. These measurements should consist of a simple level loop that begins and ends at a stable COE benchmark. An inexpensive digital level is recommended for this work. All future elevation data should be collected using this consistent, GPS established, vertical datum.
- Data should be reduced and quality controlled on an annual basis with comparisons performed against prior years.

Acquire satellite imagery

- On a 2 to 5-year interval, acquire satellite imagery of Black Lake that includes the confluence of Chiaktuak Creek on the Black River.
- Examine each image for qualitative and quantitative changes in Black Lake, the Alec Delta, and the Black River.

Repeated cross section surveys

On a minimum 5-year interval, perform repeated cross section surveys. The priority should be cross sections located with the upper Black River.