

History, Mythology, and Limnology of Lake Crescent, Olympic NP

By Bryan E. Pierce

Editor's note: Following is a synopsis of a limnological study that introduces, explores, and in some cases explodes the local myths that surround many such deep lakes as Crescent. These extra-limnological observations are included as source material for park interpreters.

Lake Crescent in Olympic National Park is one of very few large oligotrophic (unproductive) coastal lakes in western North America. Its pristine natural beauty makes it an important tourist attraction and its clear waters are home to endemic forms of extraordinarily large rainbow trout (*Salmo gairdneri irideus*, to 20 lbs.) and cutthroat trout (*Salmo clarki clarki*, to 12 pounds). Myths often accompany large, deep lakes and Lake Crescent is no exception. Discrepancies in this mythology exist in local opinion, as well as in the popular and scientific literature; however, many of these conflicting beliefs were examined and clarified in a recent study of the lake, which was undertaken to enhance and facilitate the management of this fragile limnological system.

Lake Crescent is situated between the coastal foothills and the main range of the Olympic Mountains at an elevation of 176.5m (579 feet). Although numerous inholdings exist along the shores, this ecosystem remains largely natural. One and a half meters (60 inches) of rain annually (Walken 1955) coupled with a mean annual temperature of 5.9°C (42.6°F) places the lake in the Transition Zone (e.g., climax western hemlock and western red cedar forests). The watershed is predominately Canadian Zone.

The Lake Crescent area was covered most recently by Vancouver Island origin cordilleran glaciers during the Vashon Stage of the Late Wisconsin (Fraser) Glaciation (Alley & Chatwin 1979). Final deglaciation probably occurred prior to 13,000 BP which suggests that the lake is 1-2 thousand years older than is stated in most literature (i.e., Scheffer 1935, Hagen 1961).

Lake cross-sections from echosounder transects show the typical steep sided U-shape of a glaciated valley. Eocene basalt is found on the northeast shore of Lake Crescent while the balance of the basin consists of suboceanic origin sandstone, shale, and conglomerate (Tabor 1975). There is a longstanding belief that the lake is actually a drowned portion of the adjacent Soleduck River channel, but the presence of a long natural bedrock ramp across the west end of the lake where such a channel should continue refutes this hypothesis.

Just after deglaciation, Lake Crescent included the present sister lake, Lake Sutherland, and emptied to the east through Indian Creek and the Elwha River drainage. A landslide along the northeastern shore, the scar of which is still clearly visible, divided the two lakes and forced the current Lake Crescent to rise approximately 16.8m (55 feet) before spilling into its new north-flowing outlet, the Lyre River. Anadromous fish passage up this outlet is currently blocked by a natural barrier falls about 2.4km (1.5 miles) downstream from the lake. Some literature (Kemmerer et al. 1923, Mausolf 1969) suggests that this block (a log jam, cascade, narrow raceway and 3m overhanging falls) was passable during recorded time; however, there is no evidence to support this suggestion. The unusual upstream migratory behavior of fry of the outlet spawning trout (Pierce 1984a) appears to be an

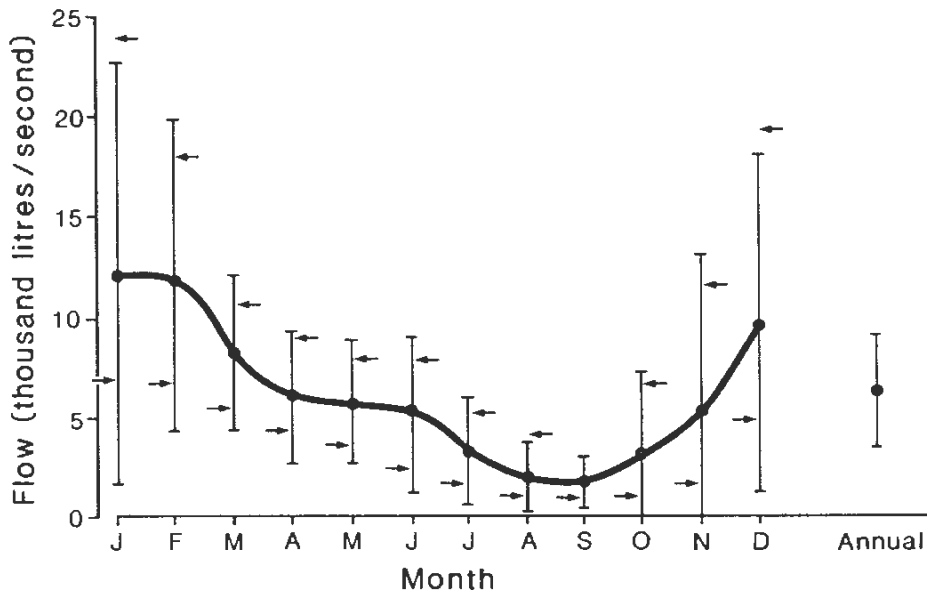


Fig. 1. Outlet mean monthly flows, 1917-1927 (Walken 1955). Bars indicate 95 percent confidence intervals about the grand mean; arrows show the actual maximum and minimum mean monthly flows measured during the period.

adaptation to the long-term isolating effects of this barrier to seaward migration.

Proposals to remove or bypass this obstacle are unjustified, as such a modification would greatly alter the composition of the Lake Crescent fish community while the low productivity of the system would contribute little to anadromous fish runs.

The Lake Crescent watershed encompasses about 12,000 hectares (30,000 acres), of which 1,800 hectares (4,650 acres) constitutes the lake itself. About

8.7 percent of the terrestrial watershed lies outside Olympic NP and is potentially susceptible to logging or other modification.

Barnes Creek is the major tributary to the lake with 37.7 percent of the watershed area, of which 11.6 percent lies outside the National Park. Other tributaries are relatively minor and may dry up during summer, especially along the northern shore. These small streams are subject to short, intense winter floods.

Continued on page 22

Location: 123 50' West Longitude, 48 6' North Latitude R. 8-10 W., T. 30 N.
Age: 13000 years
Substrate: primarily sandstone, shale and conglomerate. Northeast shore: Eocene basalt.
Elevation: 176.5m (579 feet)
Rainfall: 1.5m (60 inches)
Mean Annual Temperature: 5.9 C (42.6 F)
Biome: Lake Crescent - Transition Zone. Watershed - Canadian Zone
Anadromous fish passage: blocked
Lake Area: 1880 hectares (4650 acres)
Watershed Area: 12100 hectares (30000 acres) (including the lake)
Watershed Outside Olympic National Park: 8.7% of total
Barnes Creek Watershed: 37.7% of total
Lake Level Fluctuations: 0.94m (37 inches) in 1984
Depth: 190m (624 feet) in mid-western basin
Mean Depth (Z): 101m (332 feet)
Volume: 1,906,000,000 cubic meters (1,545,000 acre feet)
Shoreline Length: 35.2 km (21.9 miles)
Shoreline Development: 2.29
Water Exchange Rate: 9.8 years per cycle
Trophic Status: Oligotrophic
Trophic State Index: 18
Stratification Pattern: warm monomictic
Secchi Disc Visibility: 15-18.3m (49-60 feet)
Oxygenation: fully oxygenated at all levels all year
pH: 7.9 (1976); 7.3 (1982)
Alkalinity (as HCO₃): 49.5 mg/l
Limiting Nutrient: nitrate

Table 1. Vital statistics of Lake Crescent, Olympic NP, Washington.

Maximum flows usually occur in January with minimum flows in August and September. Spring snow melt has relatively little impact on flows. Based on the 10-year mean Lyre River discharge rate and the volume of the lake basin, the flushing exchange rate is about 10 years.

During 1982 the lake level fluctuated 0.94m (37 inches). This is considered historically "normal" except in years when debris dams block the outlet causing levels to increase up to an additional meter. Past and ongoing proposals to dam the lake outlet for hydro-electric power generation would greatly exceed this gradual level fluctuation and deleteriously alter the existing macro-invertebrate communities, as well as eliminate the sole spawning grounds for the endemic rainbow trout stock.

While some local residents believe Lake Crescent to be "bottomless" it actually descends 190m (624 feet) to 13.5m (45 feet) below sea level in the middle of the western half of the lake basin (Peterson 1957, reconfirmed during the present study). The average depth is 101m (332 feet), which is remarkably deep for a coastal lake. The sharp drop-off along most of the 35.2 km (21.9 mile) shoreline of Lake Crescent results in a minimal littoral zone.

Shoreline development was relatively low (2.29) for this lake, indicating that, while the basin is elongate, the shoreline is quite straight with few large coves. A low shoreline development again reflects less potential for the development of littoral communities (Wetzel 1975). Construction of a highway and railroad grade directly adjacent to most of the lake's shore originally resulted in much timber falling into the lake, but will hinder natural rates of input in the future. With relatively little littoral habitat to support invertebrate production, it is important that new snags, which support invertebrate communities and shelter juvenile fish, be allowed to enter the lake (or be artificially introduced) to replace older degenerating logs and woody debris.

The Trophic State Index (TSI) of Carlson (1977) provides a measure of the trophic status of the lake, using Secchi disk visibility as an index of productivity. Secchi disk visibility for Lake Crescent was given as 15m (49 feet) by Kemmerer et al. (1923), as 17.5m (57 feet) during a June 1976 water quality assessment by Olympic NP, and as 18.3m (60 feet) during August 1982. The earliest readings may reflect silt input from timber harvest in the basin or higher nutrient influxes from private dwellings which were more numerous during the first half of this century than at present. The most recent Secchi disk rating yielded a TSI value of 18, an oligotrophic rating.

Assuming phytoplankton requirements of seven units of nitrate to one of phosphate (Wetzel 1975), extant values indicate that Lake Crescent is a nitrate limited system (Pierce 1984b). After destratification, both nitrate and phosphate values initially increased by a factor of approximately 2.5 in 1982 as unutilized nutrients in the hypolimnion (cold, deep water layer) became available. Nitrogenous pollutants would increase plankton production and therefore reduce the lake's normal high water clarity.

Few data exist concerning the water chemistry of Lake Crescent. Dissolved oxygen data by Kemmerer et al. (1923) indicate near-saturation levels at water depths to 175m (575 feet), the maximum depth sampled. An NPS analysis in June 1976 indicated a surface pH of 7.9 and alkalinity of 49.5mg per liter (as HCO_3). The 1982 surface pH value of 7.3 is less alkaline than the value reported in 1976. It is important

that this parameter be monitored in future to detect potential acid rain effects on this relatively unbuffered water body.

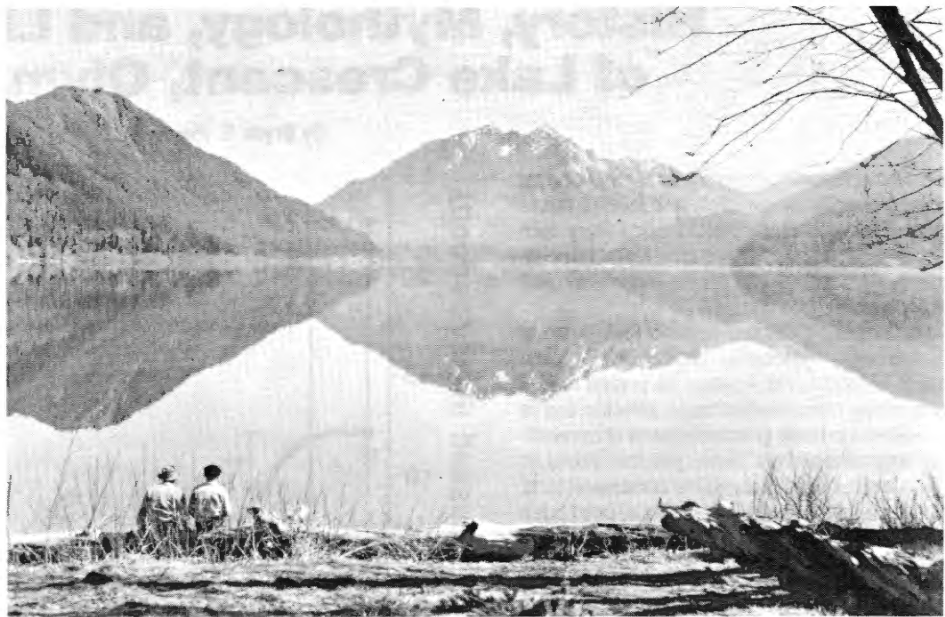
Thermal stratification of Lake Crescent had not been studied prior to my work in 1982. Many local residents believed that the lake was permanently stratified. Depth-time isotherms obtained from March 3, 1982 to Feb. 28, 1983 proved this not to be true. The lake waters mixed in mid-winter, but quickly began to warm and stratify again in early spring. While the gradient did not meet strict requirements for a "true" metalimnion (i.e., temperature change $>1^{\circ}\text{C}/\text{m}$), there is no doubt that stratification occurred in summer. As the winter of 1982/1983 was one of the warmest on record, it is quite likely that the destratified period is longer than most years. The temperature during mixing (initially) and of the hypolimnion (the stratum of lake water below the thermocline) during summer was 6.4°C (43.5°F). Thus, Lake Crescent may be classified as a warm monomictic lake; "warm" meaning never cooling to 4°C , and monomictic meaning one water circulation period per year.

An analysis of these limnological aspects reveals that the key features of this lake are its extreme depth, low productivity and isolation. The full impact of these combined factors has not always been recognized. For instance, attempts to introduce a run of sockeye salmon (*Oncorhynchus nerka*) to the lake (1927-1931) failed because returning adults could not pass the barrier falls (Pierce 1984b). If the physical and biological integrity of Lake Crescent is to be preserved, future management strategies must carefully consider the overall interplay of the limnological features that determine the character of this unique system.

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Lake Crescent, in Olympic National Park, is an important tourist attraction.