Recent Origin of **Lahar Lakes**

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The catastrophic eruption of Washington's Mount St. Helens on May 18, 1980 had a devastating effect on nearly all 35 to 40 subalpine lakes surrounding the volcano (Dahm et al. 2005). The eruption was not entirely destructive, however. Among its powerful aftereffects were volcanic mudflows (named "lahars" by Cotton 1944) that formed obstructive basins (Davis 1882) in which several new lakes arose. Although the newly formed lakes have mostly disappeared – their loss attributed largely to drainage and evaporation – two of the lakes, named Coldwater and Castle, remain as prominent bodies of water (Figure 1).

Lahar Lakes

During the eruption, runoff from melting glaciers and snowfields on the flanks of the volcano generated enormous lahars intermixed with avalanche debris. Quickly gathering momentum, the lahars surged into river valleys radiating out from the volcano's base (Figure 2). The largest and most impactful lahar swept down the North Fork Toutle River, blocking tributary streams on either side of the valley with an estimated 2.5 cubic kilometers of water-saturated sediment (Figure 3). Dammed near their confluence with the main stem of the river, tributary valleys filled with water and formed new lakes.

Coldwater Lake and Castle Lake owe their existence to the lahar's impoundment of North Coldwater Creek and South Castle Creek, respectively. The earliest signs of lake formation were the emergence of ponds on the valley floors (Figures 4 and 5), indicating that the creeks were beginning to back up and flood the valleys.

Figure 1. Lakes in the blast area north of Mount St. Helens. Coldwater and Castle lakes are located about 8-9 km northwest of the volcano. Map courtesy of Dianne McDonnell and James Thibault of the University of New Mexico.

Lacking outlets, the lakes continued to rise behind the lahar blocking tributary flow to the North Fork Toutle River. As the lakes increased in volume, they threatened to breach or overtop the lahar blockage and surge destructively downstream. Beginning in early 1981, the U.S. Army Corps of Engineers constructed outlets, or overflow channels, to draw the lakes down and stabilize surface elevations. Release flows from Coldwater Lake commenced in July 1981 and from Castle Lake five months later. Within a few weeks, the lakes had reached their maximum capacities determined by outlet elevations (Figure 6).

Spirit Lake, located about 7 kilometers east of Coldwater Lake also threatened to breach or overtop the material (avalanche debris) blocking the lake's outlet, the North Fork Toutle River (refer back to Figure 3). Beginning

Figure 2. A lahar (mudflow) emanating from the western slopes of Mount St. Helens inundates the South Fork Toutle River valley, summer 1980. Photo courtesy of Robert Heims, U.S. Army Corps of Engineers.

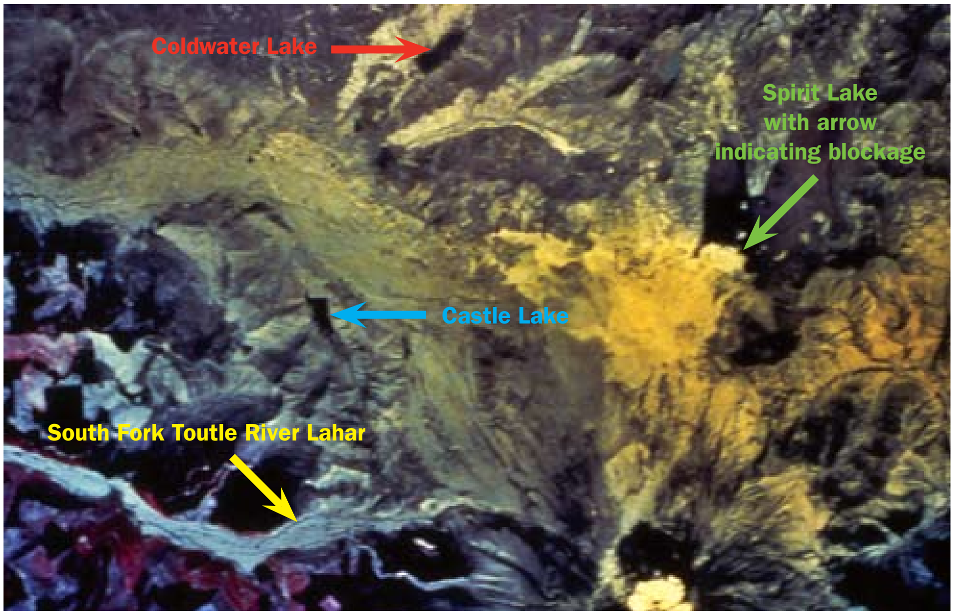

Figure 3. Billowing clouds of smoke and ash rise from the crater of Mount St. Helens (bottom right-center of photo), summer 1980. A huge deposit of light-colored avalanche debris lies directly north of the volcano, blocking the outlet of Spirit Lake (green marker). The North Fork Toutle River valley, completely inundated by a lahar, angles northwestward (toward the upper left-hand corner of the photo). Early stages of Coldwater Lake (red marker) and Castle Lake (blue marker) lie at the upper reaches of the tributary valleys impounded by the lahar. The much smaller lahar in the South Fork Toutle River valley (yellow marker) is also shown in Figure 1. Source: U.S. Army Corps of Engineers.

in June 1984, the Corps of Engineers constructed a tunnel outlet connecting Spirit Lake to the North Fork Toutle River via South Coldwater Creek (Figure 7). South Coldwater Creek, also a tributary of the mainstem North Fork Toutle River, had been diverted by the lahar into the Coldwater Lake basin. Subsequently, countless tons of sediment, eroded and transported by the creek, were deposited in the lake, forming a large fan-shaped delta that has filled a sizeable portion of the lake's lower end (Figures 8 and 9).

By all reasonable considerations, Coldwater and Castle lakes can be loosely defined as "drowned-valley" lakes. Technically, however, this definition applies only to coastal lakes that were formerly river valleys flooded by a postglacial rise in sea level (Thornbury 1954; Kalff 2002). In that case, basin enclosure was completed not by a volcanic mudflow but by the coastline buildup of eroded rock and soil materials derived from either inland or offshore sources, or both. Nevertheless, the basins in which Coldwater and Castle lakes now reside are indeed drowned valleys.

Limnological Genesis

During the summer of 1980, investigators (Wissmar et al. 1982; Ward et al. 1983) began to probe the primeval waters of Coldwater and Castle lakes ponding on the valley floors. They described the lakes as being blackish and essentially opaque, evidenced by vertical light-extinction coefficients of 7.2/meter and 12.4/meter for Coldwater Lake and Castle Lake, respectively. [*Author's note:* Kalff (2002) referred to a light-extinction coefficient of 2.2/meter as "large."] Secchi-disk visibility was reduced to only a few centimeters due to (1) relatively high concentrations of suspended particulate matter and (2) extreme discoloration by organic leachates derived from an overabundance of blown-in forest debris.

Organic loading from forest debris, and hence organic leaching, contributed to the lakes' relatively high concentrations of dissolved organic carbon (DOC), a major derivative of the leaching process. DOC concentrations in Coldwater Lake (114 mg/liter) and Castle Lake (149 mg/liter) were among the highest ever reported for natural lakes (Wissmar et al. 1982). Considerably greater amounts of DOC may have originated from nearby geothermal springs, however. Baross et al. (1982) reported that geothermal waters entering Coldwater Lake had temperatures as high as 80˚C and DOC concentrations exceeding 4,000 mg carbon/liter.

Waters below lake surface were anoxic and highly concentrated with hydrogen sulfide, soluble iron and

Figure 4. Isolated ponds scattered across the valley floor of North Coldwater Creek represent the beginnings of Coldwater Lake, summer 1980. Initial investigators (Wissmar et al. 1982) obtained water samples from the large pond in the foreground. Photo courtesy of Robert Heims, U.S. Army Corps of Engineers.

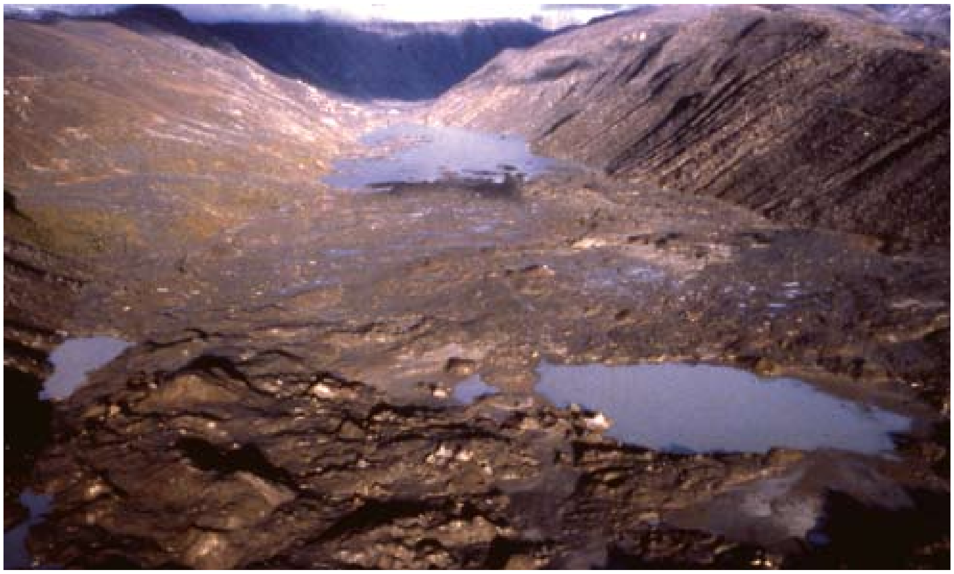

Figure 5. Early stage of Castle Lake, summer 1980. Trees blown down during the eruption cover the valley's steep slopes. The lake will eventually flood the entire valley floor shown in the photo. Photo courtesy of Robert Heims, U.S. Army Corps of Engineers.

manganese, methane, ammonia, and other reduced chemicals. Ionic concentrations in surface waters were vastly higher than preeruption values for riverine waters in the North Fork Toutle River Basin (Table 1).

Total bacteria densities were extraordinarily high, ranging from 7 x 10^{6}/ milliliter in Coldwater Lake to 2 x 10^{7}/ milliliter in Castle. Pathogenic bacteria were commonly present, including *Legionella* sp. and *Klebsiella pneumonia.* Protozoans (ciliated and nonciliated) were observed in both lakes, but were not quantified.

Algal remnants were found in Castle Lake including a blue-green genus (*Gomphosphaeria* sp.), a diatom (*Gomphonema* sp.) and diatom fragments identified as *Meridion* sp., and *Melosira* sp. Estimated total density was 500 algal units/milliliter (Ward et al. 1983). Presumably, the phytoplankton community in Coldwater Lake was similarly depleted, although there are no known data to confirm this. Both lakes were "devoid" of zooplankton and other invertebrates. Fish and amphibians were not observed.

Coldwater and Castle Lakes: One Year Later

Starting in late October 1980, winter storms typical for the Pacific Northwest brought heavy precipitation to the watersheds surrounding Coldwater and Castle lakes. By September 1981, precipitation runoff had been sufficient to increase the volume of Coldwater Lake to 68,000 acre-feet (Figure 10) and that of Castle Lake to 17,500 acre-feet (Figure 11). Due to the regulating outlets, lake volumes and other morphometric characteristics (Table 2) would remain constant, more or less, to the present day.

Limnological surveys of Coldwater and Castle lakes were resumed in April and June 1981. Dahm et al. (1981) found that lake-water clarity had barely improved, reporting that all but 1 percent of surface light intensity in Coldwater Lake had disappeared at a depth of 1.3 meters. Vertical light-extinction rates were similar for Castle Lake. Secchi disk readings taken in September and October 1981 ranged from 1.0 meters in Coldwater Lake to 3.1 meters in Castle (Dahm et al. 2005).

The increase in lake volumes greatly diluted lake waters, causing significant reductions in alkalinity and ion concentrations (Table 3). Concentrations varied little throughout the water column. DOC concentrations fell to 6.3 mg/liter in Coldwater Lake and 8.4 mg/liter in Castle. Algal photosynthesis and a reduction in microbial oxygen demand contributed to a buildup of dissolved oxygen (DO) in the water column: DO concentrations in Coldwater Lake during June 1981 ranged from 7.2 mg/liter at the surface to 4.0 mg/liter at 37 meters. Castle Lake was less oxygenated, with 6.6 mg/liter at the surface, 0.3 mg/liter at 15 meters, and zero oxygen at lake bottom. By September and October, however, the hypolimnetic regions in both lakes were anoxic due to persistently strong microbial

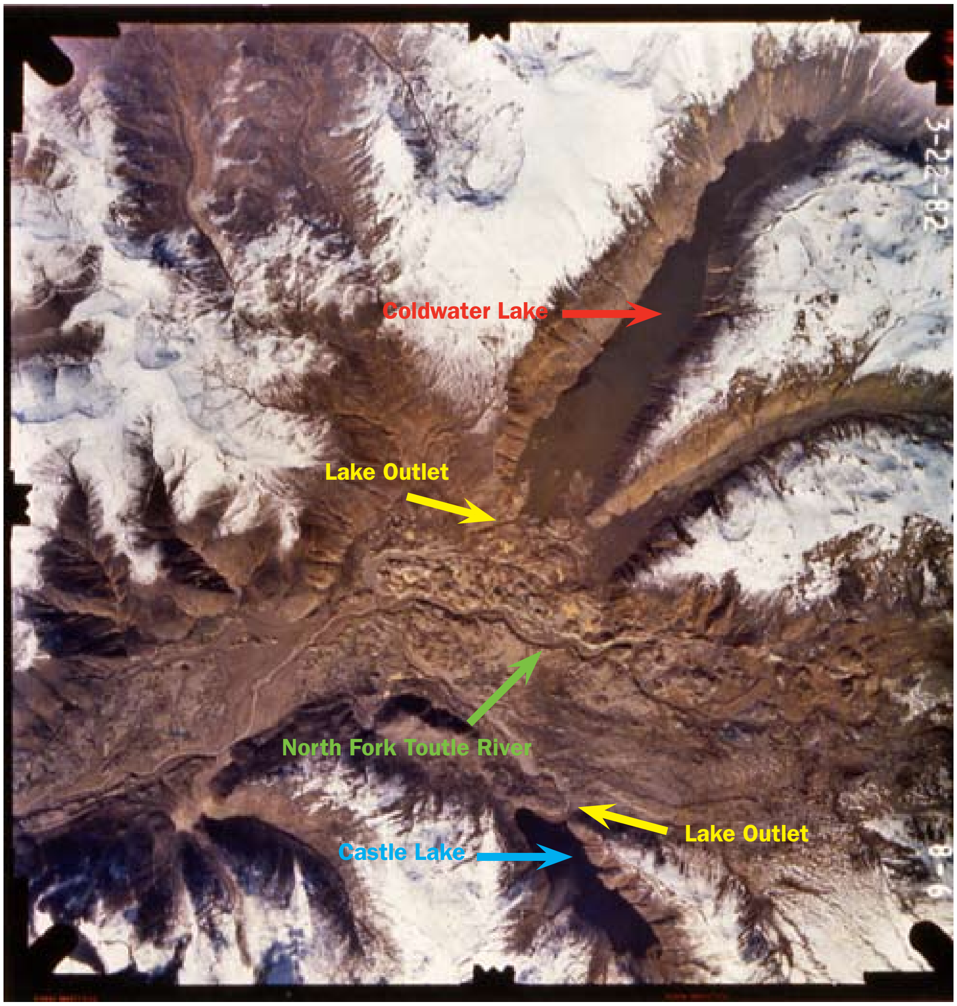

Figure 6. Aerial view of Coldwater Lake (red marker) and Castle Lake (blue marker), March 22, 1982. Corps of Engineers outlets (yellow markers) release lake water into the North Fork Toutle River meandering over the lahar surface (green marker). Source: U.S. Army Corps of Engineers.

oxygen demand in lake sediments and hypolimnetic waters.

Total bacteria increased in density throughout the summer, approaching 10^8 organisms/milliliter by mid-summer. Bacteria were predominantly manganese- and sulfur-oxidizing bacteria, as well as nitrifying bacteria, all of which developed in response to (1) higher oxygen levels and (2) high output of chemically reduced manganese, sulfide, and ammonia while the lakes were largely anoxic.

Evidence of phytoplankton colonization appeared in 1981, although taxa diversity was relatively small and individuals were scarce in number. June samples from Castle Lake yielded flagellates (cryptomonads) and pennate diatoms totaling 280 algal units/milliliter (Ward et al. 1983). By late October, due to suboptimal light and temperature conditions, densities in both lakes had diminished to fewer than 2.0 algal units/milliliter. But 17 different genera representing seven algal divisions had been identified over the preceding six months. Numerous flagellates and coccoids were observed but were not identified (Dahm et al. 2005).

Zooplankton was similarly scarce, with maximum densities of 60 and 130 individuals/meter^3 reported for Coldwater Lake and Castle Lake, respectively. Cladocerans, copepods, and rotifers comprised the lakes' zooplankton assemblages, but only two species were identified, *Ceriodaphnia reticulata* (cladoceran) and *Keratella quadrata* (rotifer). Among cladocerans, three taxa were identified to genus (*Ceriodaphnia* sp., *Daphnia* sp., *Alona* sp.). Copepods consisted of cyclopoid copepodids and nauplii. Rotifers identified to genus included *Asplanchna* sp. and *Keratella* sp. (Dahm et al. 2005).

Ecological Transformations: 1982-1986

After 1981, as lake environments became more ecologically favorable, typical lake biological communities began to develop. Zooplankton, in particular, had become more abundant and diverse. Zooplankton densities increased dramatically in 1982, reaching maximum observed levels of 8,850 individuals/meter^3 in Coldwater Lake and 5,710

Figure 7. Map of the Spirit Lake tunnel outlet. The tunnel, 2.6 kilometers in length and 3.4 meters in diameter, was constructed between June 1984 and April 1985 at a cost of about $14 million. The tunnel extends under Harry's Ridge, the summit of which is at elevation 1,463 meters (above msl), or about 400 meters above the surface of Spirit Lake. Source: U.S. Army Corps of Engineers.

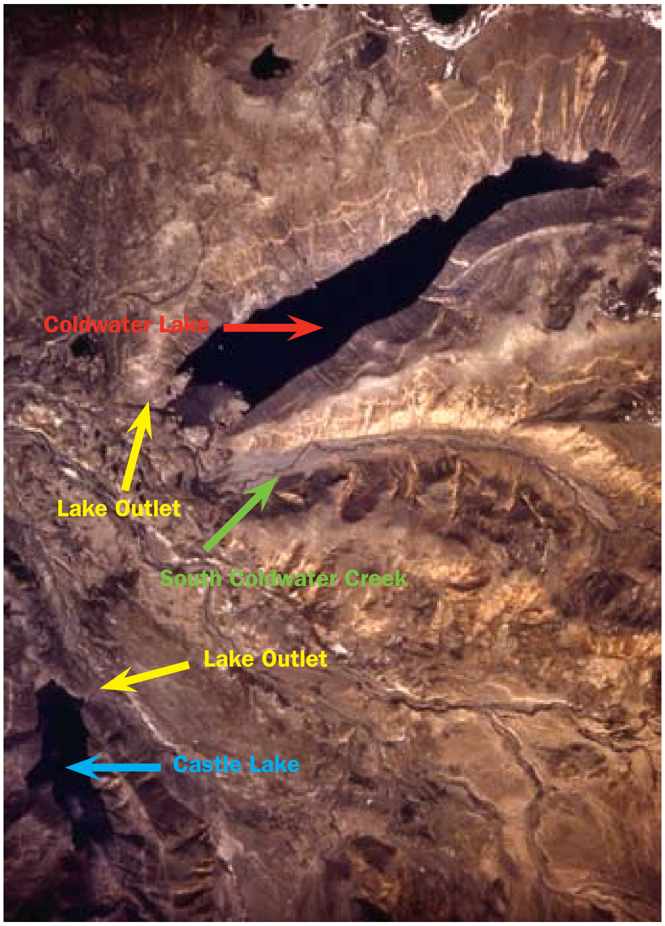

Figure 8. Aerial view of Coldwater Lake (red marker) and Castle Lake (blue marker), April 27, 1987. Corps of Engineers outlets indicated by yellow markers. South Coldwater Creek (green marker) flows into Coldwater Lake. Source: U.S. Army Corps of Engineers.

Figure 9. Researchers approach the delta in Coldwater Lake while collecting water samples, June 1990. Mount St. Helens looms in the far background. Photo by the author.

Table 1. Water Chemistry, Coldwater and Castle Lakes, Mount St. Helens, WA, June 30, 1980.[1, 2, 3]

Variable	*Coldwater*	*Castle*	*NFTR*[4]
Alkalinity, mg/liter as $CaCO_3$	76	225	8.0
Ca, dissolved, mg/liter	91	94	2.8
Mg, dissolved , mg/liter	15	21	0.6
Na, dissolved, mg/liter	88	112	2.0
K, dissolved, mg/liter	17	40	0.6
Mn, dissolved, µg/liter	3,350	5,399	6.0
Fe, dissolved, µg/liter	180	15,703	<10
Si, dissolved, mg/liter	8.0	18	12
Cl, dissolved, mg/liter	115	142	1.5
SO_4, dissolved, mg/liter	312	120	ND[5]
PO_4-P, dissolved, µg/liter	6.7	43	0.09
NO_2-N + NO_3-N, diss., µg/liter	16	256	<0.06

[1] Surface-water samples.
[2] Source: Wissmar et al. (1982).
[3] Values of 10.0 or greater are rounded off to whole numbers.
[4] North Fork Toutle River; pre-eruption data collected March 28, 1980 and reported by Dethier et al. (1980); pre-eruption data for NFTR tributaries (North Coldwater Creek, South Castle Creek) not available.
[5] Not detected.

individuals/meter^3 in Castle during August and September. Approximately 80 percent of the zooplankton in Coldwater Lake consisted of *Daphnia* sp., with rotifers (*Asplanchna* sp.) comprising an additional 18 percent. The predominant taxa in Castle Lake were *Alona* sp. (68 percent) and unidentified rotifers (23 percent). Calanoid copepods and cyclopoid nauplii were present but scarce.

Zooplankton were considerably fewer during summer 1983 (maximum observed: 4,380 individuals/meter^3 in Coldwater Lake, 4,300 in Castle), but taxa were similar to those reported for 1982. *Daphnia* sp. was predominant in both lakes, constituting 73 percent of the assemblage in Coldwater Lake and 70 percent in Castle (Dahm et al. 2005).

Phytoplankton was far less prolific, although samples were not collected until midsummer 1986. Then, densities averaged 255 and 224 algal units/milliliter for Coldwater Lake and Castle Lake,

Figure 10. Coldwater Lake, September 14, 1981. Washington's Mount Rainier (summit elevation: 14,411 feet) appears on the horizon. The North Fork Toutle River flows from right to left through the middle of the lahar (foreground). Photo by the author.

Figure 11. Mount St. Helens towers over Castle Lake, September 14, 1981. A raft of blown-down forest debris covers the lake's lower end. Photo by the author.

respectively. Chrysophytes (*Dinobryon bavaricum, Chrysochromulina* sp.) and small, motile cryptophytes (*Rhodomonas* sp., *Cryptomonas* sp.) dominated the total assemblage, comprising 74 percent of the phytoplankton community in Coldwater Lake and 90 percent in Castle. The diatom *Cyclotella stelligera* was the most common species, but was found only in Coldwater Lake (Dahm et al. 2005).

Coldwater Lake's thermal gradient ranged from 16.8˚C at the surface to 5.6˚C near bottom at 50 meters. Castle Lake was warmer at the surface (20.9˚C) but similarly cold (5.7˚C) near bottom at 29 meters. Dissolved-oxygen had improved to some extent since 1981, as indicated by DO concentrations of between 6 and 8 mg/liter extending down to 40 meters (or about 10 meters from the bottom) in Coldwater Lake. Castle Lake was well-oxygenated (8.3 mg/liter) in the upper five meters, but was increasingly oxygen-deficient toward the bottom where DO was 1.0 mg/liter or less. Evidence of improved water clarity was demonstrated by Secchi disk, which was visible to depths of 10 meters in both lakes (D.W. Larson, unpub. data).

Limnological Stabilization

Scientists who first visited the septic, muddy ponds that would become Coldwater and Castle lakes asked the question: How long will it take for the ponds to develop into "typical" subalpine lakes found in the Cascade Range? Based on water transparency and plankton data, Petersen (1993) concluded that by 1991 all lakes located inside the blast zone, including Coldwater and Castle, were "similar" to other subalpine lakes in the Pacific Northwest. Vogel et al. (2000), after analyzing data collected during years 1989 through 1997, reported that by 1989 the zooplankton assemblage in Coldwater Lake was "normal" for the Cascade ecoregion, and that the Castle Lake assemblage "appeared to be missing only one or two species." This was not unusual, they claimed, citing a case of complete zooplankton recolonization in several acid-polluted Canadian lakes over a period of just 12 years (Keller et al. 1992).

Petersen and Vogel were probably correct, given that by 1989 the physical and chemical properties of the two lakes were more or less typical of subalpine, mesotrophic/oligotrophic lakes located outside the blast zone (Kelly 1992). Those conditions would have been favorable for the existence of typical lake biological communities. During 1989-1990, for example, lake waters were highly transparent, as indicated by vertical light-extinction coefficients of 0.30/meter in Coldwater Lake and 0.34/meter in Castle. Summertime epilimnetic waters were well-oxygenated (65 to 100 percent oxygen-saturated), although by late summer and fall dissolved-oxygen in near-bottom waters was depleted due to continued microbial oxygen demand. Concentrations of most ionic constituents had diminished significantly (Tables 3 and 4), some of which by 1993 had nearly fallen to levels reported for oligotrophic

Table 2. Lake Morphometry, Coldwater and Castle Lakes,1990, Mount St. Helens, WA.

Variable	*Coldwater*	*Castle*
Surface elevation, m	762	796
Maximum length, km	5.11	2.37
Maximum breadth, km	0.985	0.744
Area, km^2	3.10	1.07
Volume, km^3	0.0838	0.0216
Maximum depth, m	62	32
Mean depth, m	27	20
Relative depth, percent	3.1	2.8
Shoal area, percent less than 3 m	9.5	5.8
Shoreline, km	14.1	6.2
Shoreline development	2.26	1.70
Volume development	1.31	1.88
Watershed area, km^2	49.45	8.67
Retention time, years	1.7	2.5

Source: Kelly (1992).

Table 3. Water Chemistry, Coldwater and Castle Lakes, Mount St. Helens, WA, 1980-1981. [1, 2]

	Coldwater		*Castle*	
Variable	*June 80*[3]	*June 81*[4]	*June 80*[3]	*June 81*[4]
Alkalinity, mg/liter as $CaCO_3$	76	18	225	24
Ca, dissolved, mg/liter	91	25	94	21
Mg, dissolved , mg/liter	15	5.5	21	4.7
Na, dissolved, mg/liter	88	30	112	19
K, dissolved, mg/liter	17	3.5	40	3.3
Mn, dissolved, µg/liter	3,350	981	5,399	936
Fe, dissolved, µg/liter	180	73	15,703	1,350
Si, dissolved, mg/l	8.0	5.4[5]	18	6.2[5]
Cl, dissolved, mg/liter	115	NA[6]	142	NA
SO_4, dissolved, mg/liter	312	15	120	5.2
PO_4-P, dissolved, µg/liter	6.7	2.0	43	4.0
NO_2-N + NO_3-N, diss., µg/liter	16	28	256	192

[1] Surface-water samples.
[2] Values of 10.0 or greater are rounded off to whole numbers.
[3] Wissmar et al. (1982).
[4] Dahm et al. (1981).
[5] Si reported as SiO_2.
[6] Not available.

Cascade Range lakes located outside the blast zone (Menting 1995).

Trophic Dynamics

While Coldwater and Castle lakes were developing typical limnological characteristics, they were also becoming less productive biologically (Kelly 1992). This process, dubbed "reverse eutrophication," is what normally occurs in newly created reservoirs as they age. Unlike most natural lakes, which evolve from oligotrophic to eutrophic systems, reservoirs usually begin their existence in a highly eutrophic state due to the abundant availability of nutrients and organic matter derived from flooded lands. This "trophic upsurge" is eventually followed by a "trophic depression" in which productivity declines as nutrient and organic supplies diminish and the reservoir's ecological structure and energy flow stabilize (Kalff 2002).

Likewise, initial biological production in Coldwater and Castle lakes was extremely high due to (1) massive organic loading, causing proliferation of heterotrophic bacteria, and (2) equally prolific chemosynthetic bacteria capable of deriving energy by oxidizing reduced metals (iron and manganese) and sulfides. But as lake conditions improved, particularly water transparency allowing greater light penetration, algal photosynthesis largely replaced bacteriological activity as the lakes' means of production.

Although phytoplankton and other algae have become the principal producers in the two lakes, phytoplankton data collected in 1989 (Table 5) indicated that density and diversity had remained fairly stable since 1986, and, with some exceptions, had not changed significantly since 1981 when phytoplankton colonization was first observed. Petersen (1993) reported that phytoplankton abundance during 1991 was "low and indicated oligotrophic conditions," especially in Castle Lake where abundance was described as being "very low." Phytoplankton characteristics were similar in 1993, the year that the lakes' phytoplankton communities were last surveyed (Menting 1995).

Zooplankton, barely evident in 1981, suddenly mushroomed in 1982. Since then, however, their abundance and diversity have also stabilized more or less. Average densities during summer 1989 ranged from 326 to 8,749 individuals/meter^3 (n=27 vertical tows) in Coldwater Lake, and from 922 to 4,072 individuals/meter^3 (16 tows) in Castle. Maximum observed densities (individuals/meter^3) were 15,906 for Coldwater and 6,244 for Castle (Kelly 1992). Seven cladocerans, four copepods, and 15 rotifers comprised the 26 species identified from the two lakes during years 1989 through 1997 (Vogel et al. 2000). Scharnberg (1995) suggested that zooplankton abundance and diversity was the strongest indicator of the lakes' trophic status. On this basis he considered the lakes oligotrophic but approaching a mesotrophic state.

Considerable uncertainty surrounds the question of how zooplankton first

Table 4. Water Chemistry, Coldwater and Castle Lakes, Mount St. Helens, WA, 1989 and 1993.[1, 2]

Variable	Coldwater		Castle	
	Aug 89[3]	*Aug 93*[4]	*Aug 89*[3]	*Sep 93*[4]
Alkalinity, mg/liter as $CaCO_3$	NA[5]	20	NA	23
Ca, dissolved, mg/liter	19	8.8	8.0	8.0
Mg, dissolved , mg/liter	3.8	1.9	1.4	1.3
Na, dissolved, mg/liter	26	5.1	2.3	2.2
K, dissolved, mg/liter	2.3	0.75	0.4	0.3
Mn, dissolved, µg/liter	NA	NA	NA	NA
Fe, dissolved, µg/liter	40	NA	70	NA
Si, dissolved, mg/l	15[6]	14[7]	11[6]	15[7]
Cl, dissolved, mg/liter	17	2.6	1.6	0.9
SO_4, dissolved, mg/liter	66	22	8.2	6.0
PO_4-P, dissolved, µg/liter	3.1	0.9	1.2[8]	3.1
NO_2-N + NO_3-N, diss., µg/liter	2.7	47	0.23	2.4

[1] Surface-water samples.

[2] Values of 10.0 or greater are rounded off to whole numbers.

[3] Kelly (1992).

[4] Menting (1995).

[5] Not available.

[6] Si reported as SiO_2

[7] Si reported as SiO_4

[8] Sample collected from 5-meter depth; no data for surface.

Table 5. Phytoplankton, Coldwater and CastleLakes, Mount St. Helens, WA, May-September 1989.

Variable	*Coldwater*	*Castle*
Species identified	15[1]	18[2]
Genera only identified[3]	11	3
Density range, algal units/milliliter	108-599	174-9,525
Mean density, algal units/milliliter	317	1,824
Number of samples	45	29

[1] Diatoms were dominant in Coldwater Lake, with *Cyclotella meneghiniana* being most abundant among all species identified.

[2] Flagellates and the dinoflagellate *Glenodinium pulvis* dominated the phytoplankton in Castle Lake.

[3] Collections from both lakes contained unidentified "green algae," flagellated chrysophytes and pennate diatoms.

Source: Kelly (1992).

arrived in the two lakes. Vogel et al. (2000) attributed their arrival mostly to wind and larger animals (insects such as dragonflies and waterfowl) capable of dispersing eggs and ephippia. The authors also believed that release flows from nearby Spirit Lake (refer back to Figure 7), via the tunnel outlet, introduced zooplankton into Coldwater Lake, a wry example perhaps of invasive species.

Limnological Intervention

In August 1985, fishery biologists with the Washington Department of Fish and Wildlife (WDFW) set out for the first time to determine if any fish existed in Coldwater and Castle lakes. Deploying gill nets and electrofishing equipment, the biologists came up empty-handed. They concluded tentatively that the lakes were fishless.

Coldwater Lake

In 1989, the agency stocked Coldwater Lake with about 30,000 fingerling rainbow trout. Following this introduction, the fingerlings grew rapidly, reaching a mean fork length of about 278 millimeters within a year. Rainbow fry were observed in 1992, indicating that the stocked fish had matured and were spawning. This precluded further fish introductions, making 1989 the only year that the lake was stocked.

Gill-netting by WDFW in 2001 produced 61 fish, including 35 rainbow trout, 18 cutthroat trout, and 8 rainbow/cutthroat hybrids. Finding cutthroat was probably unexpected, although two possible explanations were given for their presence: (1) The 1989 introduction of rainbows included a few cutthroats, which had somehow been added unintentionally to the rainbow stock at the fish hatchery; and (2) some sea-run cutthroats survived the 1980 eruption after being trapped behind the lahar blocking North Coldwater Creek.

During the early 1990s, the U.S. Forest Service, managers of the Mount St. Helens National Volcanic Monument in which Coldwater and Castle lakes are located, constructed a fish-cleaning facility and a paved boat launch and parking lot at Coldwater Lake. The lake was opened to sport fishing in July 1993 (Lucas and Weinheimer 2007).

Castle Lake

Rumors circulated during the early 1990s that anglers were catching fish in supposedly fishless Castle Lake, some weighing up to ten pounds. If true, biologists suggested that the fish may have inhabited South Castle Creek and survived the 1980 eruption. A survey by WDFW in 1991 yielded fish, but all were hatchery-bred rainbow trout. Biologists were probably surprised, given that the lake had never been stocked. They concluded that the fish had originally been stocked in Coldwater Lake in 1989, but had migrated to Castle Lake.

Further investigations found that the fish were spawning successfully, as evidenced by fry captured in 1991. Growth rates were described as "amazing," averaging 386 millimeters in length among three age II+ rainbow trout caught in 1993 (Lucas and Weinheimer 2007).

The Future

The life expectancy of lakes located near active volcanoes is understandably shorter than that of lakes in less geologically volatile regions. Although new lakes may emerge in the wake of violent eruptions and accompanying earthquakes, existing lakes lying within the volcano's explosive range are usually altered beyond recognition or blasted to near-extinction.

Mount St. Helens was dormant for about 120 years before it erupted catastrophically in 1980. Over the past 4,000 years, the volcano has erupted about 20 times, or about once every 200 years on average. Given the close proximity of Coldwater and Castle lakes to Mount St. Helens' eruptive epicenter, the next eruption could be life-threatening. Until then, the two young lakes will grace the volcano's devastated landscape (Figures 12 and 13), but always on the edge of disaster.

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Figure 12. Coldwater Lake, September 27, 2004. Flowing across the delta, South Coldwater Creek divides into several channels, or "distributaries"(Thornbury 1954). Thick vegetation and a marshy soil covers the delta. Mount Rainier rises in the background. Photo by the author.

Figure 13. Castle Lake, September 27, 2004. Photo by the author.

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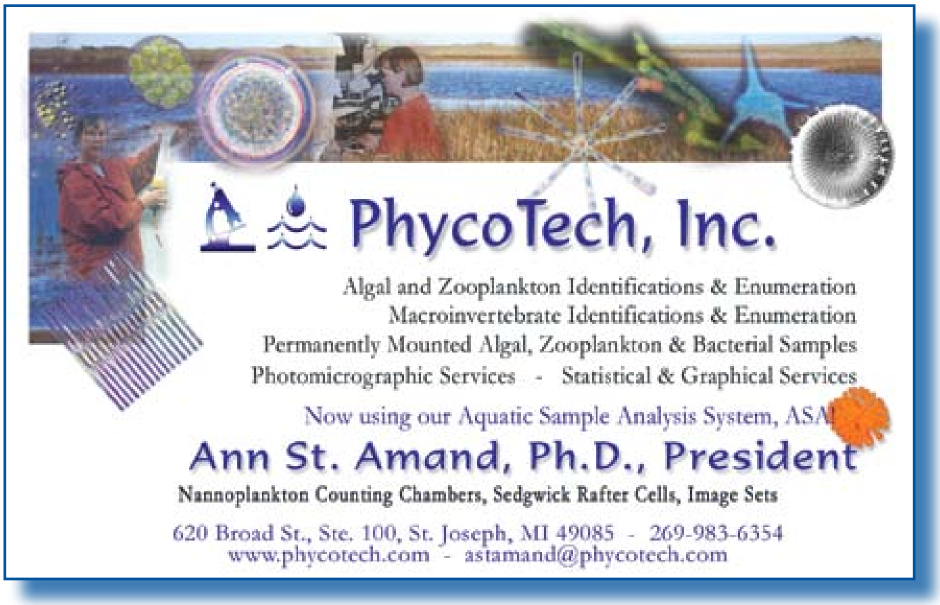

In Memoriam

On December 30th, 2010, long-time NALMS members, Tom and Elinor Eberhardt tragically died in a plane crash. Tom was piloting his airplane to a family gathering in Texas.

Tom and Elinor were proud supporters of NALMS, dedicated and dependable corporate members, and good friends to all of us in the NALMS family. They will be deeply missed.

The Sweetwater Exhibit Booth and the Alum Workshop will be Tom and Elinor's lasting legacy. Not only did Tom and Elinor make a positive difference for NALMS, they made a positive difference for many lakes.

The Eberhardts were the owners of TeeMark Corp. of Aitkin, MN. The business has three divisions and produces foundry products, can crushers, and a lake restoration operation called Sweetwater Technology. Tom and Elinor were givers. They truly believed in public service as Tom was the first president of the Aitkin Lakes Area Rotary Club, served on the Aitkin Airport Commission, and they were also assisting the Magengo Orphanage in Tanzania.

The family feels that the best way to honor their memory would be to support the Susan G. Komen Foundation that gave Elinor, a breast cancer survivor, her health back and so many precious moments with her friends and family.