Recovery of Fish Populations in Lakes Affected by the May 18, 1980 Eruption of Mount St. Helens

by

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Washington Department of Fish and Wildlife

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EXECUTIVE SUMMARY

The May 18, 1980, eruption of Mount St. Helens severely impacted a number of lakes in the vicinity of the mountain. Intense heat, tephra deposits, and a pressure wave that blew trees into these lakes appeared to doom fish populations; however, trout survived in most waters. Many lakes were covered with ice on May 18, which reduced thermal warming and protected resident fish. This report documents trout population changes in the 22 years since the eruption.

Nineteen of the 24 lakes studied had self-reproducing trout populations in 2001. Four lakes were barren of fish, but current Mount St. Helens Monument policies preclude stocking of these lakes. Two new lakes, Coldwater and Castle, were created when material from the debris avalanche blocked stream drainages. These relatively large lakes have provided new recreational opportunities.

Although eruption effects were often devastating to fish populations, inorganic volcanic material and organic debris from surrounding forests added nutrients to these lakes. Since many spawning streams were buried in ash, presumably fish recruitment was limited. With fewer fish to compete for food, substantial fish growth occurred in many lakes. Likely, increased productivity from nutrient enhancement also accelerated fish growth. As spawning areas recovered, populations expanded and growth rates generally declined. After the initial influx of nutrients, productivity in many lakes decreased.

Debris avalanche material in Coldwater, Castle, and Spirit lakes greatly enhanced productivity. Anaerobic conditions in Spirit Lake were due to bacterial decomposition of organic material. By 1986, phytoplankton photosynthesis in Spirit Lake had nearly replaced bacterial chemosynthesis.

Zooplankton diversity and abundance declined in most lakes immediately after the eruption. Turbid conditions from ashfall and erosion curtailed phytoplankton production. As water clarity improved, primary production increased, enhancing zooplankton communities.

INTRODUCTION

Mount St. Helens is located in the Cascade Mountains. It is surrounded by numerous lakes of glacial, landslide, and volcanic origin. Before 1980, lakes in the vicinity of Mount St. Helens provided outstanding recreational opportunities for hiking, camping, and fishing. Anglers could catch a variety of species including rainbow (*Oncorhynchus mykiss*), cutthroat *(Oncorhynchus clarki)*, eastern brook (*Salvelinus fontinalis*), and lake trout (*Salvelinus namaycush*). Most of the lakes managed by the Forest Service were in a roadless area and in pristine condition, discounting trails and campsites. Many lake basins on private land were logged.

The eruption on May 18, 1980, instantly transformed this mecca for outdoor recreation into a stark-gray landscape. When the north face of Mount St. Helens collapsed, trapped gases and fluids exploded with a blast directed to the north. This mixture of expanding gases, rock, and ice moved at speeds estimated at 220-250 miles per hour (354-402 km/hr) and reached a temperature of 680EF (360EC) (U.S. Forest Service 1984). Trees in the path of this shock wave were blown over or shattered. At the edge of the blast, temperatures were still high enough to kill standing trees. Approximately 215 square miles (557 km^2) were affected.

Debris avalanches swept down the mountain. One lobe barreled over a 985-1,250 foot (300-381 m) ridge into South Coldwater Creek; another crashed into Spirit Lake causing a wave more than 850 feet (259 m) high (U.S. Forest Service 1984). The main avalanche traveled down the North Fork Toutle valley for about 13.5 miles (22 km) with deposits averaging 150 feet (46 m) in depth.

One look was enough to convince any sane biologist that nothing could survive the individual or synergistic effects of blast, heat, pumice, and ash. Because of floating pumice and massive ash deposition, from the air it appeared that some lakes had been completely buried. We surmised that all fish were dead. We were wrong.

Initial helicopter surveys on July 1 and 31, 1980, found zooplankton and larval insects (Crawford 1986). Crayfish were observed at Hanaford Lake and Meta Lake, but no live fish. A gill net set in Meta Lake in late September 1980 provided the first direct evidence of fish survival; 35 fish were caught (Crawford 1986).

A report by Crawford (1986) summarized eruption impacts and recovery of lakes affected by the May 18, 1980 eruption. The purpose of this report is to investigate many of the same lakes initially studied and document changes in fish populations since our first surveys. Management recommendations for specific lakes are offered based on the results of our sampling.

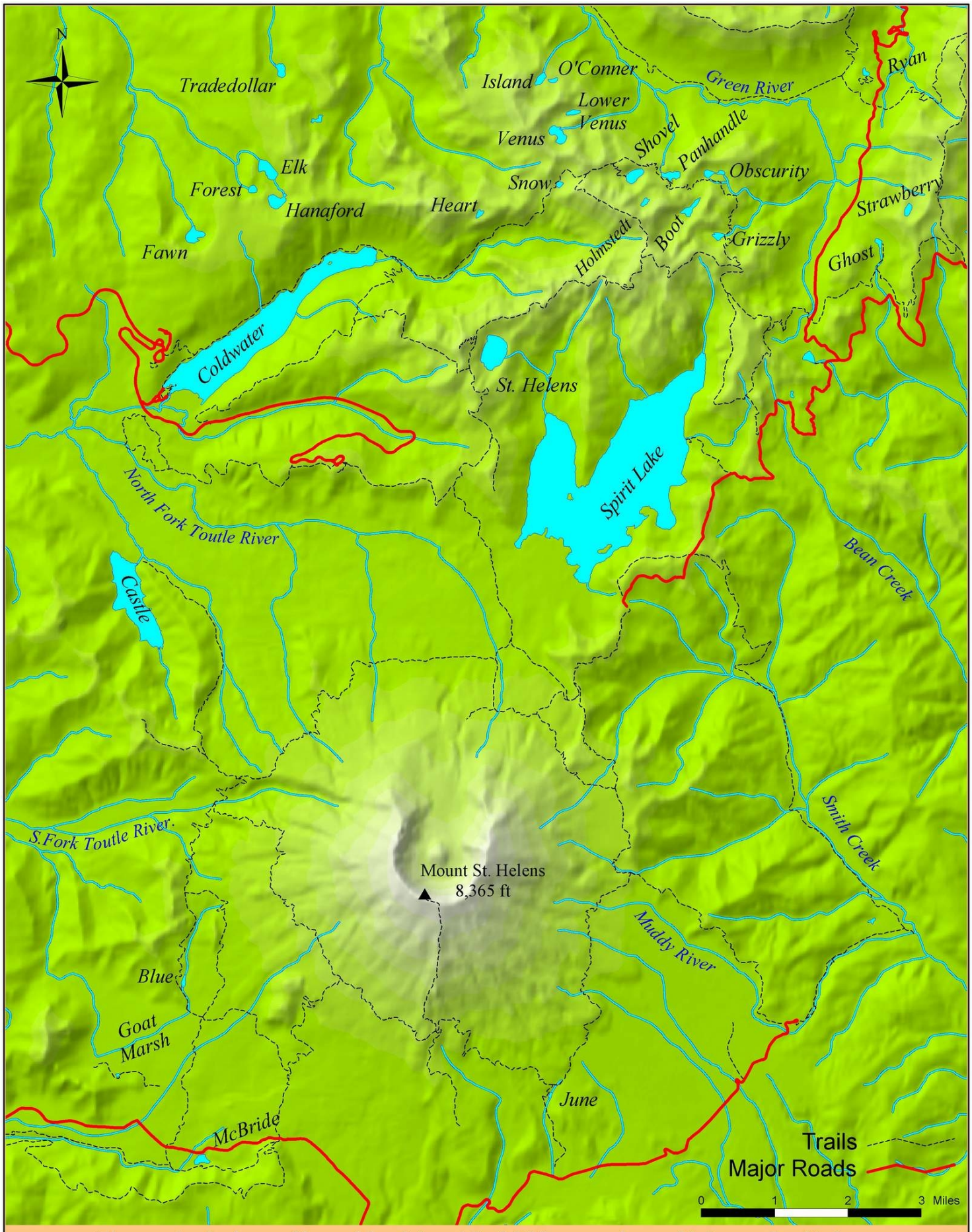

Figure 1. Lakes affected by May 18, 1980, eruption of Mount St. Helens.

METHODS

Since these follow-up studies were completed over a 16-year time period, sampling methods varied depending on survey objectives and individuals involved. The following method descriptions apply to most of the lakes studied.

Physical Characteristics

A drainage was defined as the stream network a lake drains into. Surface area for most lakes was derived from Wolcott (1961). As the water level in many lakes fluctuate throughout the year, areas given were approximations. Most maximum depths were from Crawford (1986). Lake elevations were taken from Wolcott (1961), unless more current information was available from USGS quads. Kelly (1992) provided elevations for Coldwater and Castle lakes. Inlet and outlet stream information was normally based on cursory visual surveys. Bottom composition was inspected at several locations near shore. Ice-free periods were determined by personal communication (Charlie Crisafulli and Hans Castren, Mount St. Helens Monument staff 2002).

Water Quality

In the 1980s, most water quality measurements were taken by the Washington Department of Fish and Wildlife using a Hach kit. For 2000 and 2001 sampling, water quality data (temperature, specific conductivity, dissolved oxygen, and pH) were measured with a calibrated Quanta Hydrolab.

Fishery Resources

Hatchery plants provided in this document were as accurate as possible. However, records were gleaned from archived data, and we recognize that some data might be incomplete or erroneous. Information after 1980 should be fairly accurate. Pre-eruption fish surveys were nearly non-existent and consisted primarily of creel checks from archived files. Abbreviations for species were as follows: EB (eastern brook), RB (rainbow), CT (cutthroat), BT (brown trout), and TLCT (Twin Lakes cutthroat).

We traveled by foot, truck, and helicopter to sample lakes. Surveys were brief snapshots, as there wasn't sufficient time to complete a thorough inventory.

Inlet and outlet streams were inspected visually for trout; however, a Smith-Root Type VII shocker was used occasionally to check for fish.

Most gill nets used for sampling were 17-30 meters with variable mesh panels. They were usually set perpendicular to shore. Many nets were baited with canned tuna fish. Hook-and-line sampling occurred on many lakes. Unless otherwise specified, surveys were by the Washington Department of Fish and Wildlife.

Fish were measured to the nearest millimeter (fork length) and weighed to the nearest gram. Condition factor was determined using the following equation: weight x 100,000/length^3. Usually, scales or otoliths were taken. Scales were read with a GAF microfiche reader, while otoliths were aged with a binocular dissecting scope. Fish were visually inspected for visceral fat and parasites. Stomachs contents were taken from a subsample of the fish collected. Gut contents were extracted, combined, preserved in alcohol, and keyed out using a binocular dissecting scope.

Recreational Use

The only estimates of recreational use were from permits issued for Obscurity, Panhandle, Shovel, and Snow lakes (Castren 2002). Trail distances were approximated from maps.

INDIVIDUAL LAKE SUMMARIES

Boot Lake

County: Skamania
Location: NE 1/4, Sec. 25, T. 10N, R. 5E; SE 1/4, Sec. 24, T. 10N, R. 5E, SW 1/4, Sec. 19, T. 10N, R. 6E.
Drainage: Obscurity Lake to Grizzly Creek to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 6.5 ha (16.1 acres)
Elevation: 1,375 m (4,512 ft)
Aspect: Northeastern
Maximum Depth: 21 m
Inlet Streams: (7/25/01)

The main inlet stream at the southwest end of Boot Lake was 2-3 m wide. The moderate gradient zone near the lake had predominantly ash substrate. When the gradient increased (approximately 100 m from the lake), there was fairly decent spawning gravel mixed with ash. No blockages were visible for at least 400 m.

Outlet: (7/19/94; Crisafulli 2002)

The outlet width was 6.0 m and percent slope 3.0. Sand was the dominant substrate with some limited spawning gravel. A log jam spanned the outlet channel, but was not a barrier.

Lake Bottom Composition: Sand, ash, and organic ooze
Normally Ice-free: Mid-July through November
Eruption Impacts:

Boot Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 2. Boot Lake-1980.(Photo by Crawford)

Figure 3. Boot Lake-2001.

Water Quality

Table 1. Boot Lake water quality data.

	8/15/93*		7/25/01	
	Surface	**3 m**	**Surface**	**3 m**
Temperature (C)	**12**	**12**	**14.34**	**12.06**
Specific Conductivity(µS/cm)	**29**	**--**	**21**	**21**
Dissolved Oxygen (mg/l)	**9.4**	**9.2**	**9.14**	**9.75**
pH	**--**	**--**	**6.59**	**6.58**

***Frenzen (1995)**

Invertebrates

Scharnberg (1995) found extreme invertebrate predation in Boot Lake during sampling from 1992-94. *Chaoborus* was a top predator and abundant during all sampling periods. Zooplankton communities were dominated by rotifers, cyclopoids, and *Holopedium gibberum*, which are relatively unpalatable.

Fishery Resources

Table 2. Boot Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	1934	Unknown			Unknown
EB	1940	13000			Unknown
EB	Jul-57	5,040			Unknown
TLCT	08/27/63	2,466			Unknown
TLCT	09/15/70	1,372	1.5	915	Mossyrock
TLCT	08/21/73	3,010	7	430	Mossyrock
Tokul Cr. CT	09/13/76	3,060	18	170	Mossyrock
TLCT	09/18/79	1,600	8.5	188	Mossyrock

Pre-eruption Fish Populations

Brook trout stocked in 1934, 1940, and 1957 were self sustaining up until the eruption. Cutthroat were occasionally planted, but likely could not compete with the brook trout.

Post-eruption Fish Populations

Gill nets set in 1981, 1993 (Hollen 1993), and 2001 found no fish in Boot Lake. No fish were observed by Crisafulli (2002) during perimeter snorkel surveys in 1994 and 1995, nor while minnow trapping in 1997. Boot was one of the few lakes with total fish mortality.

Recreation Access and Use

There is no trail to Boot Lake, and public access is not allowed.

Future Management

The Mount St. Helens National Volcanic Monument (MSHNVM) Fish and Wildlife Plan designated Boot Lake for research use; no fish should be stocked. Prior to the eruption, Boot Lake was managed for self-sustaining brook trout and was occasionally planted with Twin Lakes cutthroat. With its favorable water quality and existence of fish in nearby lakes, there is no question that Boot could again support fish. The inlet and outlet streams have some spawning habitat.

Castle Lake

County: Cowlitz
Location: SW1/4, Sec. 14, T. 9N, R. 4E; Sec. 23, T. 9N, R. 4E
Drainage: Castle Creek to North Fork Toutle River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 107 ha (264 acres) (Kelly 1992)
Elevation: 796 m (2,612 ft) (Kelly 1992)
Aspect: Northern
Maximum Depth: 32 m (Kelly 1992)
Inlet Streams:

The main inlet, Castle Creek, is at the southeastern end of Castle Lake. It is a relatively large stream (width normally 5-6 m). Although temporary debris barriers form, most years spawning fish can penetrate upstream at least 300 m to where the gradient steepens at the end of the flood plain. The stream channel was relatively unstable, but suitable spawning gravel was available along with considerable ash. Fry were found during every survey from 1995-1999.

A few rainbow trout spawn in two small tributaries along the western shore of Castle Lake.

Outlet Stream:

A debris jam where Castle Creek left the lake did not block fish access. Numerous rainbow fry and yearlings were first found during electrofishing surveys in 1993.

Bottom Composition: Tephra, woody debris, and detritus
Normally Ice-free: Castle Lake rarely freezes.
Eruption Impacts:

Castle Creek was blocked by the massive debris avalanche from the 1980 eruption. The resulting impoundment was Castle Lake. The entire basin was in the blast zone. Shock waves blew over standing timber, heat seared vegetation, and tephra was deposited. Because of the relatively small watershed and limited shoal areas, Kelly (1992) speculated that Castle Lake will eventually be oligotrophic. Also, it will likely be more productive than Coldwater, as Castle has a higher surface area to volume ratio.

Figure 4. Castle Lake-1981. (Photo by Bruce Crawford) Figure 5. Castle Lake-2002.

Water Quality

Table 3. Castle Lake water quality data.

	9/22/98*		7/2/01	
	Surface	**3 m**	**Surface**	**3 m**
Temperature (C)	**18.0**	**17.4**	**18.85**	**16.14**
Specific Conductivity (µS/cm)	**43.7**	**--**	**51**	**51**
Dissolved Oxygen (mg/l)	**8.40**	**8.20**	**9.33**	**9.29**
pH	**7.32**	**--**	**7.29**	**7.27**
Secchi Disc (m)	**--**	**--**	**--**	**--**
Nitrate-Nitrate (mg/l)	**0.032**	**--**	**--**	**--**
Phosphorous (mg/l)	**0.011**	**--**	**--**	**--**
Alkalinity-$CaCO^3$ (ueq/l)	**415.9**	**--**	**--**	**--**

*Hodges (1998)

Temperature monitoring by Kelly (1992) in 1989 and 1990 found warmer maximum surface temperatures in Castle Lake (22.8EC) than Coldwater (18.8EC). She speculated that higher dissolved organic matter (DOM) in Castle might explain these differences, as the DOM tends to absorb infrared wave lengths of light and increase lake temperatures.

Although Castle Lake was slightly more productive than Coldwater, overall water quality values still pointed toward oligotrophy (Kelly 1992). Salinity (52.2 mg/l) and conductivity (67 mhos/cm) were lower than Coldwater, but still indicative of a moderately productive lake. Oxygen deficits found in both 1989 and 1990 were likely caused by substantial decomposition of organic material. Productivity will likely decrease over time.

Invertebrates

Cladocerans dominated zooplankton populations in Castle Lake during sampling in 1992 (Scharnberg 1995). *Bosmina longirostris* numbers peaked in early spring, while *Daphnia pulex* prevailed in the fall. There was no evidence of excessive predation by fish or invertebrates. Many of the organisms available rated high in palatability. Reduced *Daphnia* in spring samples could indicate heavy predation by rainbow trout. Typically, fish switch to juvenile and adult insects as the year progresses, allowing *Daphnia* to recover.

Zooplankton surveys by Hodges (1998) indicated that Cladocerans were predominate (2,314 m^3) followed by rotifers (622 m^3).

Fishery Resources

Planting History

Castle Lake has never been stocked. However, stubbed-dorsal, hatchery rainbow trout found in Castle in 1991 indicated that some of the rainbow planted into Coldwater Lake in 1989 apparently immigrated to Castle Lake.

Pre-eruption Fish Population

Prior to the eruption, Castle Creek supported anadromous coho and steelhead, as well as resident rainbow and cutthroat.

Post-eruption Fish Population

No fish were found during initial gill net sampling in 1985. However, in the early 1990s, there were unverified reports of anglers catching fish up to ten pounds. It is possible that a few fish residing in Castle Creek might have survived the eruption. Adult fish collected in 1991 were age II and appeared to be hatchery fish. These rainbow jump-started the fishery in Castle Lake. Fry found in the outlet area in 1991 substantiated successful spawning. Likely, some of the spawners were wild origin. Initial growth rates were amazing; age II+ rainbow averaged 386 mm. As the rainbow population began to increase through natural production, growth rates and condition factors declined (Table 4).

The high catch rate and low condition factor of rainbow collected in 2001 were likely indicative of over population. Mean condition factor of rainbow declined from 1.2 (1995-97) to 0.96 (1999-2001). Many fish collected in 2001 were spawn-outs, which contributed to their poor condition. Post-spawning rainbow sampled at Coldwater Lake during the same period, however, were in much better condition. Growth to age III+ and IV+ of rainbow collected in 2001 were nearly identical to rainbow taken in 1999 (Table 5).

Figure 6. Castle Lake rainbow trout-1999.

Table 4. Castle Lake rainbow trout fishery surveys.

Date	**8/29/85**	**7/18, 19, 24, & 25/91**	**6/30/93 & 7/27/93**	**6/17/95**	**7/2/96**
Sampling Method	**Gill Net**	**Angling/ Gill Net**	**Angling**	**Angling**	**Angling**
Number Collected	**0**	**25**	**12**	**6**	**60**
Mean Fork Length (mm)	**--**	**368**	**370**	**241**	**287**
Range	**--**	**219-419**	**219-490**	**165-370**	**150-377**
Mean Weight (g)	**--**	**--**	**692**	**155**	**305**
Mean Condition Factor (K)	**--**	**--**	**1.16**	**1.32**	**1.20**
Catch/hr	**--**	**--**	**--**	**--**	**3.3**

Table 4. Castle Lake rainbow trout fishery surveys (cont).

Date	7/29/97	7/2/98	7/30/99	7/2/01
Sampling Method	Angling	Angling	Angling	Angling/ Gill Net
Number Collected	36	40	85	74
Mean Fork Length (mm)	268	306	264	285
Range	155-385	135-398	125-375	142-378
Mean Weight (g)	279	302	197	288
Mean Condition Factor (K)	1.12	0.98	1.02	0.88
Catch/hr	2.0	1.8	3.5	4.4

Table 5. Castle Lake rainbow trout growth rates.

	Age							
	I+		II+		III+		IV+	
Year	Mean Length (mm)	n	Mean Length (mm)	n	Mean Length (mm)	n	Mean Length (mm)	n
1993	295	1	386	3	394	3	--	-
1995	193	3	249	2	371	1	--	-
1996	323	2	305	9	343	1	--	-
1997	198	7	257	3	351	12	305	1
1998	191	3	287	5	320	11	--	-
1999	165	7	264	11	328	11	373	2
2001	191	1	229	4	323	4	371	3

Recreational Use

In the early 1990s, many anglers drove to Castle Lake. Although the Forest Service gated the road, fishermen either had keys or pulled out the gate. In 1999, the road was dug out by the Department of Natural Resources. Currently, access is directly downhill from the 3000 road; there is no developed trail. The distance is approximately 1.6 km (1 mile) and the elevation drop about 425 m (1,394 feet).

Future Management

Because of the apparent scarcity of large fish, the 16-inch minimum size limit serves the same function as a catch-and-release regulation. More fish could be harvested in Castle without adversely affecting the fishery. It is doubtful, however, that lowering the minimum size limit would reduce abundance enough to influence condition factors. Probably, limited angler access has had far more influence on harvest than any regulation. Since most anglers seem to be satisfied with the Castle Lake fishery, no change in regulation is recommended.

The rainbow population is self-sustaining, and no stocking is necessary. Access by anadromous fish from the North Fork Toutle into Castle Creek is a possibility depending on the location of the stream mouth, which often changes. Sometimes, when the mouth of Castle Creek nearly parallels the Toutle, there is no blockage to migration.

Coldwater Lake

Location: N1/2, Sec. 1, T. 9N, R. 4E,
NE1/4, Sec. 2, T.9N, R.4E,
S1/2, Sec. 36, T. 10N, R. 4E,
Sec. 31, T. 10N, R. 5E,
SE1/4, Sec. 30, T. 10N, R. 5E,
County: Cowlitz and Skamania
Drainage: Coldwater Creek to North Fork Toutle River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 310 ha (766 acres) (Kelly 1992)
Elevation: 762 m (2,500 ft) (Kelly 1992)
Aspect:: Southwestern
Maximum Depth: 62 m (Kelly 1992)
Inlet Streams:

Coldwater Lake has a number of tributaries, but most are small and steep with very little to offer for spawning. The first evidence of trout reproduction was in 1992 when fry were found in Upper Coldwater Creek. Erosion in the upper watershed still contributes a significant bedload of fine material. Coldwater Creek wanders across an extensive, flat floodplain. Without channel stability, gravels in the streambed continue to be heavily impacted by fine material. Fish can negotiate up to where Coldwater Creek enters a narrow, steep canyon, a distance of at least 400 m.

South Coldwater Creek has some suitable spawning gravel. Fry were first found in 1992, and spawning adults electroshocked in 1993. Overflow from Spirit Lake was diverted via tunnel into South Coldwater Creek by the Corps of Engineers. Although this stream originally entered Coldwater Lake directly, the channel now flows into the outlet stream.

Outlet Stream:

Modified by the U.S. Army Corps of Engineers to reduce the potential failure of the debris plug, the outlet flows only a short distance before plunging over a waterfall. The channel is fairly stable. Some spawning occurs in this short stream section.

Bottom Composition: Sand, ash, organic debris and logs, and organics. Some

Eurasian milfoil has established in shallow areas.

Ice-free Period: Coldwater Lake rarely freezes.

Eruption Impacts:

North Coldwater Creek was blocked by the massive debris avalanche from the 1980 eruption. The resulting impoundment was Coldwater Lake. The entire basin was in the blow-down zone. Lateral blast over standing timber, heat seared vegetation, and tephra was deposited.

Figure 7. Coldwater Lake-1980.

(Photo by Bruce Crawford)

Figure 8. Coldwater Lake-2002.

Water Quality

Table 6. Coldwater Lake water quality data.

	10/3/93*	6/29/01	
	Surface	**Surface**	**3 m**
Temperature (C)	**16.1**	**15.92**	**14.96**
Specific Conductivity (µS/cm)	**85**	**54**	**53**
Dissolved Oxygen (mg/l)	**--**	**9.24**	**9.20**
pH	**--**	**7.12**	**7.18**
Secchi Disk (m)	**5.8**	**--**	**--**

***Haapala (1993)**

Due to steep valley walls, shoal areas are less than 10% of the lake (Kelly 1992). This limits lake productivity. The hypolimnion volume closely matched the epilimnion indicating reduced nutrient recycling. These characteristics are normally associated with oligotrophic lakes. Mean chlorophyll *a* for 1990 was 2.03 ug/l, which was within the mesotrophic range.

Easily eroded soil in the watershed, coupled with rich nutrient loading from Spirit Lake, contributed to the high salinity (184.8 mg/l) and conductivity (307.5 mhos/cm) found by Kelly (1992). These values align more closely with eutrophic lakes.

As time passes, the trophic level of Coldwater will likely continue to decline.

Invertebrates

Zooplankton collections by Kelly (1992) in 1989 found *Daphnia pulicaria* as the dominant species, with substantial contributions by *Diaptomus tyrelli* and several rotifers.

From 1992-93, Coldwater had a relatively balanced zooplankton community dominated by *Daphnia pulex* and *Diaptomus tyrelli* (Scharnberg 1995). The diverse zooplankton available indicated a relatively productive lake for the Mount St. Helens area. The high percentage of larger daphnids probably reflected low to moderate fish predation.

Fishery Resources

Table 7. Coldwater Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	08/23/89	10,050	750	13.4	Mossyrock
RB	08/30/89	9,860	850	11.6	Mossyrock
RB	09/12/89	10,502	890	11.8	Mossyrock

Pre-eruption Fish Populations

Prior to the eruption, Coldwater Creek supported anadromous runs of winter steelhead and coho, as well as resident cutthroat and rainbow.

Post-eruption Fish Populations

Initial gill net sampling of Coldwater Lake and electrofishing of Coldwater Creek on August 29, 1985, yielded no fish. A total of 30,412 fingerling rainbow

were planted in 1989. By the following summer, these fish grew substantially to a mean fork length of nearly 278 mm (Table 8). These rainbow quickly reached maturity and successfully spawned, as fry were observed in 1992.

No fish have been stocked since 1989; Coldwater is managed for self-sustaining stocks. In 2001, species composition (n=61) was 57.4% rainbow, 24.6% Twin Lakes cutthroat, 13.1% rainbow/cutthroat hybrid, 3.3% coastal/Twin Lake cross, and 1.6% coastal cutthroat. The presence of Twin Lakes cutthroat in Coldwater Lake indicated that likely some cutthroat were inadvertently mixed at the hatchery with rainbow. The only plausible explanation for the coastal cutthroat is that a few survived the eruption.

Figure 9. Coldwater Lake rainbow trout-7/9/98.

Comparisons between Coldwater and Castle lakes were interesting. Because of the abundance of younger fish in the catch, the mean length of Coldwater rainbow collected in 2001 was actually less than Castle, 267 mm versus 284 mm, respectively. However, 34.3 % of the rainbow exceeded 330 mm in Coldwater compared to only 14.9 % in Castle. Coldwater rainbow had a healthy mean condition factor of 1.24, while fish in Castle were a paltry 0.88.

Table 8. Coldwater Lake rainbow trout fishery surveys.

Date	8/29/85	6/27/90	6/13/91	6/3/92	6/17/93	7/2/97
Sampling Method	Gill Net	Angling	Angling	Angling	Angling	Angling/ Gill Net
Number Collected	0	10	10	36	22	15
Mean Fork Length (mm)		278	344	377	391	312
Range		258-321	330-361	210-410	170-480	175-420
Mean Weight (g)		276	500	514	--	444
Mean Condition Factor (K)		1.28	1.23	1.01	--	1.03
Catch/hr		--	--	--	--	--

Date	7/9/98	7/7/99	6/30/00	6/29/01
Sampling Method	Angling	Angling	Angling	Angling
Number Collected	11	19	44	35
Mean Fork Length (mm)	237	331	255	267
Range	131-420	194-425	140-456	157-438
Mean Weight (g)	223	468	368	300
Mean Condition Factor (K)	1.21	1.24	1.30	1.24
Catch/hr	0.61	1.21	2.28	2.44

Growth rates have remained relatively stable through time. Twin Lakes cutthroat, which are increasing in abundance, potentially could compete for food resources and retard growth of rainbow trout. If this were the case, however, condition factors would likely decline. Since 1998, rainbow condition factors have held steady within the 1.21-1.30 range.

Table 9. Coldwater Lake rainbow trout growth rates.

	Age									
	I+		II+		III+		IV+		V+	
Year	Mean Length (mm)	n	Mean Length (mm)	n	Mean Length (mm)	n	Mean Length (mm)	n	Mean Length (mm)	n
1997	198	5	257	1	368	6	404	3	--	--
1998	188	8	--	--	305	1	378	1	419	1
1999	211	3	318	5	348	6	414	3	--	--
2000	160	4	251	7	368	9	404	4	--	--
2001	178	5	231	11	343	2	404	3	409	1

Recreational Use

Fishing was first allowed at the lake on July 15, 1993. Daily permits were issued to reduce crowding. As pressure declined, permits were discontinued. A paved boat launch and parking lot were first opened in April of 1994. Although trail #211 parallels the western shore, anglers are only allowed to use three shoreline access points.

Future Management

Coldwater is managed as a quality trout fishery. Anglers are allowed to take one fish more than 16 inches. No bait is allowed and single, barbless hooks are required. Currently, Coldwater Lake provides a first-class trout fishery. Angling pressure is relatively light, as the lake is not located near a large population center. Recruitment is at a level where growth rates have not been measurably affected. In all probability, as spawning habitat improves, increased recruitment will reduce rainbow growth. Until that occurs, no change in management is recommended.

Elk Lake

County: Skamania
Location: NW 1/4, Sec. 19, T. 10N, R. 5E.
Drainage: Schultz Creek to Green River
Ownership: Weyerhaeuser Company

Physical Characteristics

Surface Area: 12.3 ha (30.5 acres)
Elevation: 1,212 m (3,978 ft)
Aspect: Northwest
Maximum Depth: 14 m
Inlet Stream:

The inlet provides only marginal spawning habitat. During a survey on August 9, 2001, the width was about one meter. There was minimal flow, with standing water near the lake. Steeper gradient areas yielded marginal spawning gravel. Dense willow thickets grew along the stream. Access was blocked by debris piles approximately 75 m upstream. Moderate numbers of brook trout fry were observed.

Outlet:

Heavy willow canopy covered the outlet. Gradient was moderate and spawning gravel was available. The outlet was choked with debris at the lake and there were several 0.6 m falls just below the logjam. An estimated 25-30 spawning brook trout were observed August 9, 2001.

Bottom composition: Sand, mud, detritus, and organic debris
Normally Ice-free: June through November
Eruption Impacts:

Elk Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 10. Elk Lake-1981.
(Photo by Bruce Crawford)

Figure 11. Elk Lake-2001.

Water Quality

Table 10. Elk Lake water quality data-8/12/00.

	Surface	3 m
Temperature (C)	**15.55**	**14.79**
Specific Conductivity (µS/cm)	**44**	**44**
Dissolved Oxygen (mg/l)	**8.41**	**8.6**
pH	**7.24**	**7.18**

Fishery Resources

Table 11. Elk Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	1942	22,500			
RB	1950	10,000			
EB	08/01/51	7,345			
EB	08/18/53	3,000			
EB	08/12/60	1,000			
TCLT	08/27/63	2,466			
TCLT	09/15/70	1,830	2	915	Mossyrock
TLCT	08/18/73	5,160	12	430	Mossyrock
TLCT	09/13/76	5,015	29.5	170	Mossyrock
TLCT	10/05/78	1,387	3.8	370	Mossyrock
TLCT	09/18/79	3,000	16	188	Mossyrock
TLCT	08/26/82	1,107	3	369	Mossyrock
TLCT	08/22/84	1,039	2.1	495	Mossyrock
TLCT	08/23/85	975	1.9	513	Mossyrock
TLCT	08/27/87	512	1.6	320	Mossyrock
TLCT	09/25/89	2,320	10	232	Mossyrock
BT	07/28/92	300	120	2.5	Mossyrock
BT	09/14/98	752	32	23.5	Mossyrock

Pre-eruption Fish Populations

Although Elk Lake was planted frequently with Twin Lakes cutthroat, creel checks before the eruption found primarily brook trout.

Post-eruption Fish Surveys

The first survey after the eruption was August 19, 1981; only one brook was taken, obviously a survivor of the eruption. To replenish fish populations, Twin Lakes cutthroat were stocked from 1982 to 1989. Initially, the cutthroat trout thrived and provided an excellent fishery, but gradually the brook trout took control. Gill net sampling in 1991, 1992, 1996, and 2000 yielded predominantly eastern brook with a few rainbow trout.

Brook trout collected by gill net on July 12, 2000, averaged 219 mm. The mean condition factor was a relatively robust 1.16. Average growth per year of 64 mm (2.5") was about average for brook trout in sub-alpine lakes in the southern Cascades (Lucas 1989). Fish were feeding almost exclusively on larval chironomids.

Figure 12. Elk Lake brook and rainbow trout-7/12/00.

In an attempt to control the burgeoning brook trout, and also provide a trophy fishery, brown trout were planted in 1992 and 1998. One brown trout (275 mm) from the 1998 plant was collected on July 12, 2000.

Table 12 . Elk Lake brook trout fishery surveys.

Date	8/19/81	7/10/91	7/6/92	7/16/96	7/12/00
Sampling Method	Gill Net	Gill Net/ Angling	Gill Net/ Angling	Gill Net	Gill Net
Number Collected	1	23	3	4	18
Mean Fork Length (mm)	285	193	193	254	219
Range	--	156-212	166-217	148-348	160-316
Mean Weight (g)	122	--	86	246	129
Mean Condition Factor (K)	0.94	--	1.19	1.22	1.16
Catch/hr	--	--	--	0.20	0.87

Table 13. Elk Lake brook trout growth rates-7/12/00.

Age	Mean Length (mm)	Range	n
III+	189	163-226	3
IV+	225	224-225	2
V+	262	240-305	3

Table 14. Elk Lake rainbow trout fishery surveys.

Date	8/19/81	7/10/91	7/6/92	7/16/96	7/12/00
Sampling Method	Gill Net	Gill Net/ Angling	Gill Net/ Angling	Gill Net	Gill Net
Number Collected	0	6	1	3	1
Mean Fork Length (mm)	--	224	176	241	370
Range	--	190-240	--	215-267	--
Mean Weight (g)	--	--	55	158	320
Mean Condition Factor (K)	--	--	1.01	1.08	--
Catch/hr	--	--	--	0.15	0.05

Recreational Use

Some maps reverse Elk and Forest Lakes. In this report, Elk is the larger of the two lakes. Because of the relatively easy access provided by Weyerhaeuser logging roads, Elk Lake was a popular destination both before and after the eruption. Unfortunately, trash and vandalism forced Weyerhaeuser to block vehicle access in 2001. Anglers now hike or ride bikes from the Coldwater Visitor Center, a distance of about 11.5 km (7.2 miles). Reduced pressure provides a better quality fishing experience.

Future Management

The few rainbow in Elk Lake seem to be persisting. Brown trout have been stocked twice with limited success. If brown trout aren't collected in future sampling, additional stocking is unnecessary. The brook and rainbow trout provide relatively high catch rates with the opportunity to land fish up to 370 mm. The length distribution and condition factor of brook trout indicate a relatively healthy population. No further stocking is warranted.

Fawn Lake

Location: NW1/4, Sec. 25, T.10N, R. 4E
County: Cowlitz
Drainage: Schultz Creek to Green River
Ownership: Weyerhaeuser Company

Physical Characteristics

Surface Area: 9.6 ha (23.6 acres)
Elevation: 1,128 m (3,700 ft)
Aspect: Northern
Maximum Depth: 14 m
Inlet Streams:

Several dry creek beds were located at the east end of Fawn Lake on August 10, 2001. These were about 0.7 m wide with minimal spawning potential.

Outlet (8/10/01):

The outlet had a mud bottom with low gradient and likely would not support much spawning.

Bottom Composition: The bottom is mostly sand with a thin organic layer on top.
Normally Ice-free: May through November
Eruption Impacts: Fawn is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

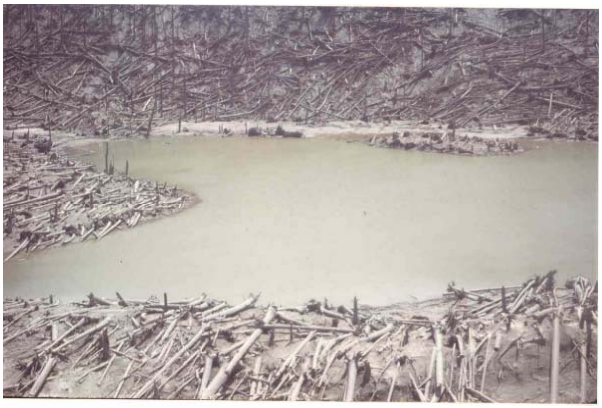

Figure 13. Fawn Lake-7/1/80.

Figure 14. Fawn Lake-7/11/00.

(Photo by Bruce Crawford)

Water Quality

Dion and Embrey (1981) reported a substantial increase in specific conductivity from 30 to 666 µS/cm in 1974 and 1980, respectively. By 2000 conductivity had dropped to nearly pre-eruption levels.

Table 15. Fawn Lake water quality data.

	9/14/74*	8/27/80*	7/11/00	7/11/00
	Surface	Surface	Surface	3 m
Temperature (C)	**14.8**	**15.7**	**16.24**	**16.21**
Specific Conductivity (µS/cm)	**30**	**666**	**53**	**53**
Dissolved Oxygen (mg/l)	**8.8**	**9.2**	**8.23**	**8.02**
pH	**--**	**6.5**	**7.73**	**7.70**
Secchi Disk (m)	**6.4**	**2.1**	**--**	**--**

***Dion and Embrey (1981)**

Invertebrates:

Scharnberg (1995) reported that the large number and biovolume of zooplankton in Fawn Lake (1992-93), despite the high number of predators (both fish and zooplankton), was an indicator of high productivity. Rotifers tended to dominate in the spring, while cladoceran abundance increased in the fall. Fish predation was moderate as most *Daphnia* were rather small in size.

Fishery Resources

Table 16. Fawn Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	07/24/57	7,560			Unknown
CT	08/27/63	2,466			Unknown
TLCT	09/15/70	1,830	2	915	Unknown
TLCT	08/18/73	5,160	12	430	Unknown
TLCT	09/01/76	5,130	27	190	Mossyrock
TLCT	08/22/85	2,001	3.9	513	Mossyrock
TLCT	09/25/89	2,306	9.3	248	Mossyrock

Pre-eruption Fish Populations

Before 1980, Fawn Lake had a self-sustaining population of brook trout. Twin Lakes cutthroat were stocked every three years from 1970 to 1976.

Post-eruption Fish Populations

A gill net set May 4, 1981, verified that many brook trout in Fawn Lake survived the eruption. Subsequent sampling in 1982, 1985, and 1992 also yielded brook trout. Twin Lakes cutthroat stocked in 1985 and 1989 likely were unsuccessful because of competition from existing brook trout.

An overnight gill net set in July 2000 collected 18 brook trout averaging 252 mm. The growth rate of approximately 51 mm a year was slightly below average for Region Five brook trout lakes (Lucas 1989). Currently, Fawn Lake provides an excellent fishery for brook trout with above average size and condition factor.

Figure 15. Processing brook trout from Fawn Lake-7/11/00.

On July 11, 2000, Chironomidae pupae were most common food item in the stomachs analyzed, followed by nymph Ephemeroptera, larval and adult Coleoptera, adult Diptera, pupal Trichoptera, and adult Decapoda.

Although the inlet and outlet provide minimal spawning habitat, obviously brook trout had been reproducing, possibly using small upwelling areas.

Table 17. Fawn Lake brook trout fishery surveys.

Date	5/4/81	8/12/82	7/3/85	7/6/92	7/11/00
Sampling Method	Gill Net	Gill Net	Angling	Angling	Gill Net
Number Collected	23	7	9	11	18
Mean Fork Length (mm)	237	283	203	243	252
Range	190-298	--	170-280	226-269	164-371
Mean Weight (g)	117	261	--	148	199
Mean Condition Factor (K)	0.88	1.15	--	1.00	1.10
Catch/hr	--	--	--	--	0.96

Table 18. Fawn Lake brook trout growth rates-7/11/2000.

Age	Mean Length (mm)	Range	n
III+	164	--	1
IV+	221	188-255	3
V+	283	270-295	2
VI+	259	237-275	3
VII+	--	--	0
VIII+	371	--	1

Recreational Use

Because of the relatively easy access provided by Weyerhaeuser logging roads, Fawn Lake was a popular destination both before and after the eruption. Unfortunately, trash and vandalism forced Weyerhaeuser to block vehicle access in 2001. Anglers now hike or ride bikes into the lake. From the Coldwater Visitor Center, the distance is about 10.4 km (6.5 miles). Reduced pressure provides a better quality fishing experience.

Future Management

Fawn Lake provides a respectable fishery for brook trout, with the opportunity to catch fish larger than one pound. Although brook trout populations often seem to be unaffected by fishing pressure, it is possible that reduced harvest will cause further stunting of fish growth. No stocking is recommended.

Forest Lake

Location: SW1/4, Sec. 19, T.10N, R. 5E
SE1/4, Sec. 24, T.10N, R. 4E
County: Cowlitz and Skamania
Drainage: Schultz Creek to Green River
Ownership: Weyerhaeuser Company

Physical Characteristics

Surface Area: 3.2 ha (8.0 acres)
Elevation: 1,189 m (3,900 ft)
Aspect: Northwest
Maximum Depth: 4 m
Inlet Streams: (8/9/01)

A number of small springs flowed into the lake along the eastern shore. The bottoms were mostly mud, but one had a little gravel. Despite the marginal conditions, fry were observed in a stagnant pool.

Outlet: (8/9/01)

The outlet was quite steep, with a bedrock chute from the lake. It was about one meter wide with heavy willow canopy and low flow. Spawning success would be minimal.

Bottom Composition: Ash with a thin organic layer. Beds of Eurasian milfoil were found in shallow areas.
Ice-free Period: June through November

Figure 16. Forest Lake-1981.
(Photo by Bruce Crawford)

Figure 17. Forest Lake-2001.

Eruption Impacts: Forest is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Water Quality

No data were available.

Fishery Resources

Table 19. Forest Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	07/01/57	11,340	45	252	Unknown
TLCT	09/17/73	2,240	7	320	Unknown
TLCT	09/01/76	2,042	10.7	190	Mossyrock
TLCT	09/17/78	2,240	7	320	Mossyrock
TLCT	09/25/79	800	4.6	175	Mossyrock
TLCT	08/26/82	184	0.5	369	Mossyrock
TLCT	08/22/84	198	0.4	495	Mossyrock
TLCT	09/25/89	603	2.6	232	Mossyrock
TLCT	09/18/91	609	2.1	290	Mossyrock
TLCT	10/05/94	486	4.5	108	Mossyrock

Pre-eruption Fish Populations

Although cutthroat were stocked in the 1970s, brook trout dominated the fishery in Forest Lake.

Post-eruption Fish Surveys

No fish were collected in the first gill net set (August 19, 1981) after the eruption. Crawford (1986) speculated that high temperature from the blast superheated this shallow lake, or that heavy ash fall and debris depleted oxygen levels causing fish mortality. In 1993, however, brook trout were discovered in Forest Lake. Either trout did survive and were missed during the 1981 survey, or anglers could have transported fish from nearby Elk Lake.

Twin Lakes cutthroat were stocked on a number of occasions after the eruption. It was difficult to determine if these were successful, as there were no follow-up surveys until 1993. Likely, the cutthroat met the same fate as those stocked in Elk Lake and lost in the battle for lake supremacy to the brook trout.

Six brook trout collected by angling on July 12, 2000, averaged 223 mm. These fish were slightly smaller than brook trout taken in 1996, and their mean condition factor was lower. Dense beds of milfoil reduced available habitat for fish.

Figure 17. Brook trout collected at Forest Lake-7/12/00.

Table 20. Forest Lake brook trout fishery surveys.

Date	8/19/81	9/2/93	7/16/96	7/12/00
Sampling Method	Gill Net	Angling	Gill Net	Angling
Number Collected	0	1	17	6
Mean Fork Length (mm)	--	125	243	223
Range	--	--	194-296	184-250
Mean Weight (g)	--	25	214	131
Mean Condition Factor (K)	--	1.28	1.37	1.16
Catch/hr	--	--	0.88	--

Recreational Use

Some maps reverse Forest and Elk Lakes. In this report, Forest is the smaller lake. (See Elk Lake for access information.) Anglers skirt the shore of Elk Lake to fish Forest, which receives relatively low fishing pressure compared to Elk.

Future Management

It appears that brook trout have reestablished and provide an adequate fishery. Since stocked cutthroat have not been successful, Forest Lake should be managed for brook trout. No further stocking is recommended.

Ghost Lake

Location: Sec.28, T.10N, R.6E
County: Skamania
Drainage: Clearwater Creek tributary to Muddy River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area:

Wolcott (1961) reported surface area of 2.0 ha which might be accurate at full pool. During a 1998 survey, the lake had already dropped considerably and appeared to be about 1.2 ha. With no observable inlet, Ghost Lake could drop even more throughout the summer.

Elevation: 1,148 m (3,767 ft)
Aspect: Southern
Maximum Depth: 2.1 m
Inlet Streams:

Ghost Lake is the source of Clearwater Creek and very close to the divide between Clearwater Creek and the Green River. There is no visible inlet, although Crisafulli (2002) indicated that landslides in 1996 and 1997 buried the existing inlet. Flow into the lake is now subterranean.

Outlet:

The outlet was fairly stagnant for the first 10 m, but the gradient gradually increased. Dense willow lined the one meter wide channel. The bottom was composed of small gravel mixed with some fine material.

Bottom Composition:

The bottom was composed of pumice, ash, and organics. A landslide originating from a steep hillside east of the lake filled in the edge of the lake with pumice.

Ice-free Period: June through November
Eruption Impacts:

Ghost Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 19. Ghost Lake-2002.

Water Quality

Table 21. Ghost Lake water quality data-6/30/98.

	Surface
Temperature (C)	**17.8**
Specific Conductivity (µS/cm)	**39.5**
Dissolved Oxygen (mg/l)	**8.3**
pH	**7.1**

Note: values are means for several locations.

Fishery Resources

Planting History

No early Department records could be located, but Wolcott (1961) reported that cutthroat were stocked in 1940 and brook trout in 1957.

Table 22. Ghost Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
SRCT	08/08/74	450	3	150	Cowlitz
TLCT	09/01/76	1,045	5.5	190	Mossyrock
TLCT	09/18/79	500	2.7	188	Mossyrock

Pre-eruption Fish Populations

No information could be found.

Post-eruption Fish Populations

There were no documented surveys of Ghost Lake prior to our trip on June 30, 1998. More than 30 coastal cutthroat were caught, but only 13 were measured; the mean fork length was 237 mm. The average length of age II+ fish was 201 mm. These cutthroat were rather slender with moderate visceral fat. Growth to age II+ was comparable to coastal cutthroat in Deep Lake in Skamania County (Lucas 1989). Fish had orange flesh and no parasites were observed. Stomachs contained Decapoda, Chironomidae pupae, Trichoptera larvae, and adult Ephemeroptera.

It is likely that these cutthroat were descendants of either the 1940 cutthroat plant or the coastal cutthroat stocked in 1974. Fish were observed in 1982 by Crisafulli (2002). Brook trout planted in 1957 had apparently disappeared, which is unusual for a lake with available spawning habitat. Winterkill might have eliminated the brook trout.

Table 23. Ghost Lake cutthroat trout fishery survey.

Date	**6/30/98**
Sampling Method	**Angling**
Number Collected	**13**
Mean Fork Length (mm)	**237**
Range	**191-290**
Mean Weight (g)	**--**
Mean Condition Factor (K)	**--**
Catch/hr	**–**

Table 24. Ghost Lake cutthroat trout growth rates- 6/30/98.

Age	Mean Length (mm)	Range	n
II+	**235**	**191-267**	**6**
III+	**290**	**--**	**1**

Spawning could occur in the outlet and several upwelling areas along the northern shore. No fry were observed, but there were numerous yearling and older fish.

Recreation Access and Use

From the Norway Pass trail head, hiking distance is approximately 3.2 km (2 miles). Cutting across to the trail just past the 99 Rd crossing of Clearwater Creek reduces the hike to about 1.6 km (1 mile).

The shoreline was relatively undisturbed with little evidence of use.

Future Management

Coastal cutthroat in Ghost Lake are self sustaining and appear healthy. One particular concern is the drop in lake volume and surface area during warm summer months. By the end of August, fish could be concentrated into a very small area. As fish could be extremely vulnerable to angling, catch-and-release regulations might be warranted. Follow up monitoring is suggested. It would be interesting to revisit the lake in mid September to observe changes in water level. No stocking is necessary not is it allowed under the MSHNVM Fish and Wildlife Plan. Ghost Lake should be managed for natural production of coastal cutthroat.

Grizzly Lake

Location: NW1/4, Sec. 30, T.10N, R. 6E
County: Skamania
Drainage: Grizzly Creek to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 3.2 ha (8.0 acres)
Elevation: 1,309 m (4,296 ft)
Aspect: Northeastern
Maximum Depth: 17.1 m
Inlet Stream: (7/25/01)

The inlet was 2-3 m wide and accessible to fish for several hundred meters. Suitable gravel was available, mixed with a high percentage of fines. The gradient was 2-5 percent.

Outlet:

A brief helicopter inspection of the outlet found a debris plug at the source with relatively low gradient until the stream dropped over a steep rock face.

Bottom Composition: Ash mixed with small pumice and some organic ooze
Ice-free Period: July-mid November
Eruption Impacts: Grizzly Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 20. Grizzly Lake-1980.

Figure 21. Grizzly Lake-7/25/01.

(Photo by Bruce Crawford)

Water Quality

Table 25. Grizzly Lake water quality data-7/25/01.

	Surface	3 m
Temperature (C)	**15.68**	**10.52**
Specific Conductivity (µS/cm)	**23**	**28**
Dissolved Oxygen (mg/l)	**8.84**	**9.2**
pH	**6.40**	**6.27**

Invertebrates:

During sampling in 1994, Scharnberg (1995) reported that *Chaoborus* and *Keratella quadrata* were most common. Zooplankton populations were extremely imbalanced, possibly due to high *Chaoborus* biomass.

Fishery Resources

Table 26. Grizzly Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB?	1934	Unknown			Unknown
RB	1940	12,930			Unknown
CT	08/27/63	1,228			Unknown
TLCT	09/15/70	1,372	1.5	915	Mossyrock
TLCT	09/17/73	1,280	4	320	Mossyrock
TLCT	09/01/76	1,045	5.5	190	Mossyrock
TLCT	09/18/79	800	4.3	188	Mossyrock

Pre-eruption Fish Populations

Since the only pre-eruption fishery data were creel checks in 1941 and 1954, the status of fish populations before the eruption was unknown.

Post-eruption Fish Surveys

Gill nets were set during surveys on August 29, 1984, and July 25-26, 2001. No fish were collected. Surveys were unavailable to determine if the Twin Lakes cutthroat planted in the 1970s were successful, but likely some of these fish were alive at the time of the eruption. Therefore, Grizzly was one of the few lakes with complete fish mortality.

Recreational Use

Day use is allowed. From the Norway Pass Trailhead, hiking distance is approximately 6.4 km (4 miles).

Future Management

The MSHNVM Fish and Wildlife Plan designated Grizzly Lake for research use; no fish should be stocked. Prior to the eruption, Grizzly Lake was managed for brook trout and was planted with Twin Lakes cutthroat every third year during the 1970s. Grizzly has suitable water quality and spawning habitat to again support trout. Currently, it is closed to fishing.

Hanaford Lake

Location: SW1/4, Sec. 19, T.10N, R. 5E
County: Skamania
Drainage: Elk Lake to Schultz Creek to Green River
Ownership: Weyerhaeuser Company

Physical Characteristics

Surface Area: 9.6 ha (23.6 acres)
Elevation: 1,247 m (4,090 ft)
Aspect: Northern
Maximum Depth: 15.2 m
Inlet Stream (8/9/01):

The inlet was small, dry, and had minimal potential for spawning.

Outlet:

Choked with debris with no flow, the outlet likely had little spawning use.

Bottom Composition: Ash with a thin organic layer
Ice-free Period: June through November
Eruption Impacts:

Hanaford Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 22. Hanaford Lake-7/01.

Water Quality

Table 27. Hanaford Lake water quality data-7/11/00.

	Surface	3 m
Temperature (C)	**15.56**	**15.15**
Specific Conductivity (µS/cm)	**38**	**38**
Dissolved Oxygen (mg/l)	**8.45**	**8.31**
pH	**7.16**	**7.14**

Invertebrates

Over 20 species of zooplankton were found during sampling of Hanaford Lake from 1992-93 (Scharnberg 1995). Most common was *Holopedium gibberum*, followed by *Daphnia*, and *Keratella cochlearis*. Length frequency analysis of *Daphnia* found most individuals from 1-2 mm, indicative of moderate fish predation. High zooplankton diversity provided evidence of excellent productivity.

Fishery Resources

Table 28. Hanaford Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	Jul-34		Eggs		Unknown
RB	1950	10,000			Unknown
EB	Jul-57	7,560			Unknown
TLCT	08/27/63	4,932			Unknown
TLCT	09/15/70	1,830	2	915	Unknown
TLCT	08/18/73	5,160	12	430	Mossyrock
TLCT	09/13/76	5,015	29.5	170	Mossyrock
TLCT	09/18/79	2,300	12	188	Mossyrock
TLCT	08/26/82	1,476	4	369	Mossyrock
TLCT	08/22/84	1,386	2.8	495	Mossyrock
TLCT	08/27/87	1,696	5.3	320	Mossyrock
TLCT	09/25/89	1,809	7.8	232	Mossyrock
TLCT	09/18/91	1,218	4.2	290	Mossyrock
TLCT	09/02/93	1,197	4.4	272	Mossyrock
TLCT	11/02/95	1,187	10.6	112	Mossyrock
TLCT	09/01/97	1,201	4.9	245	Mossyrock
TLCT	09/01/99	1,197	4.5	266	Mossyrock
TLCT	10/01/01	1,184	7.4	160	Mossyrock

Pre-eruption Fish Populations

A 1976 creel check of Hanaford found one rainbow and eight eastern brook up to 46 cm.

Post-eruption Fish Surveys

Gill nets set after the eruption in 1980 and 1982 verified that brook trout had survived the eruption. Interestingly, no brookies were caught in nets set in 1991, 1992, and 1996, but were caught again July 12, 2000. It is possible that their numbers were so depressed that our nets missed them. Another scenario is that brook trout were stocked illegally from nearby Elk or Forest Lakes. Brook trout in Hanaford were among the largest and fastest growing in the region primarily due to the availability of *Gammarus* and crayfish. Stomachs examined contained primarily *Gammarus*, with some Decapoda and larval Coleoptera.

Figure 23. Hanaford Lake brook trout-7/12/00.

Figure 24. Hanaford Lake Twin Lakes cutthroat-7/12/00.

Normally, Twin Lakes cutthroat have been stocked every other year since 1982 and have provided superior fishing. Attaining 194-215 mm by age I+ is exceptional growth (Lucas 1989). Due to the absence of a quality inlet or outlet stream, spawning success is limited in Hanaford. This prevents brook trout from overpopulating the lake.

Table 29. Hanaford Lake brook trout fishery surveys.

Date	9/30/80	8/12/82	7/10/91	7/7/92	7/16/96	7/12/00
Sampling Method	Gill Net	Gill Net	Gill Net	Gill Net	Gill Net	Gill Net
Number Collected	6	1	0	0	0	9
Mean Fork Length (mm)	319	425	--	--	--	331
Range	--	--	--	--	--	190-395
Mean Weight (g)	322	1000	--	--	--	452
Mean Condition Factor (K)	0.99	1.30	--	--	--	1.16
Catch/hr	--	--	--	--	--	0.42

Table 30. Hanaford Lake brook trout growth rates-7/12/00.

Age	Mean Length (mm)	Range	n
III+	285	--	1
IV+	--	--	0
V+	354	300-385	4
VI+	330		1

Table 31. Hanaford Lake Twin Lakes cutthroat trout fishery surveys.

Date	9/30/80	8/12/82	7/10/91	7/7/92	7/16/96	7/12/00
Sampling Method	Gill Net	Gill Net	Gill Net	Gill Net/ Angling	Gill Net	Gill Net
Number Collected	1	0	0	12	2	4
Mean Fork Length (mm)	381	--	--	215 Age I+	194 Age I+	287
Range	--	--	--	203-230	--	152-347
Mean Weight (g)	625	--	--	124	--	322
Mean Condition Factor (K)	1.13	--	--	1.24	--	1.18
Catch/hr	--	--	--	--	0.10	0.19

Recreational Use:

Weyerhaeuser roads provide direct vehicle access to Hanaford Lake; however, litter and vandalism forced Weyerhaeuser to gate their roads. Anglers need to hike or bike past the gate, a distance of approximately 10.5 km (6.5 miles). A concessionaire providing tent lodging, meals, and volcano tours often set up on the shore of Hanaford Lake. Undoubtedly, fishing pressure was higher during the years he operated.

Future Management:

Managing for both brook and cutthroat trout is difficult. Because of the expanding brook trout population, Twin Lakes cutthroat should be stocked every three years at 50/acre. It might be possible to provide a quality fishery for both species. If condition and growth of cutthroat are reduced substantially, planting should be curtailed and Hanaford managed for natural production of brook trout. This management strategy could still provide trophy trout, as brook trout have limited spawning success in Hanaford.

Holmstedt Lake

Location:	SW1/4, Sec. 24, T.10N, R. 5E NW1/4, Sec.25, T.10N, R. 5E
County:	Skamania
Drainage:	Unnamed tributary to Panhandle Lake to Green River
Ownership:	U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area:	2.0 ha (5.0 acres)
Elevation:	1,554 m (5,100 ft)
Aspect:	Northern
Maximum Depth:	Unknown

Inlet Streams: (7/25/01)

A small inlet offered some spawning habitat, but was subterranean at the lake.

Outlet: (7/25/01)

The outlet (1 m wide) was surveyed by air. There was no canopy and the bottom mostly ash and small pumice. Stream gradient was low and there was no debris blockage.

Bottom Composition:	Predominantly sand
Ice-free Period:	July through October
Eruption Impacts:	Holmstedt Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 25. Holmstedt Lake-7/26/00.

Water Quality

Table 32. Holmstedt Lake water quality data-7/25/01.

	Surface	3 m
Temperature (C)	**14.39**	**8.15**
Specific Conductivity (µS/cm)	**19**	**24**
Dissolved Oxygen (mg/l)	**8.94**	**9.58**
pH	**6.64**	**6.42**

Fishery Resources

Table 33. Holmstedt Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
TLCT	09/18/79	500	2.7	188	Mossyrock
TLCT	09/25/89	302	1.3	232	Mossyrock

Pre-eruption Fish Populations

No surveys were completed.

Post-eruption Fish Populations

Holmstedt was only surveyed once; a gill net was set July 25-26, 2001, but no fish were collected.

Recreational Use

There is no public access to Holmstedt Lake.

Future Management

The MSHNVM Fish and Wildlife Plan designated Holmstedt Lake for research use; no fish should be stocked. The lake was inadvertently stocked in 1989 with Twin Lakes cutthroat; however, apparently these fish disappeared. Holmstedt has suitable water quality and spawning habitat to again support trout.

Island Lake

Location: NE1/4, Sec.15, T.10N, R. 5E
County: Skamania
Drainage: Unnamed Tributary to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 4.5 ha (11.0 acres)
Elevation: 1,475 m (4,840 ft)
Aspect: Northern
Maximum Depth: 10.7 m (estimated)
Inlet Streams: (7/25/01)

A small, low-gradient stream with some spawning gravel was only accessible for about 10 m. No fry were observed.

Outlet: Steep with minimal spawning potential.
Bottom Composition: Predominantly ash
Ice-free Period: July through mid-November
Eruption Impacts:

Island Lake is in a zone of standing green timber. Heavy tephra fall was the only volcanic impact.

Figure 26. Island Lake-1980.
(Photo by Bruce Crawford)

Figure 27. Island Lake-7/25/01.

Water Quality

Table 34. Island Lake water quality data-7/25/01.

	Surface	3 m
Temperature (C)	**15.09**	**11.14**
Specific Conductivity (µS/cm)	**14**	**14**
Dissolved Oxygen (mg/l)	**8.54**	**9.61**
pH	**6.55**	**6.53**

Fishery Resources

Table 35. Island Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
TLCT	09/18/79	900	4.8	188	Mossyrock

Pre-eruption Fish Populations

Although no fish stocking records could be located prior to 1979, creel checks in 1972 and 1973 found rainbow trout, and Crawford (1986) caught cutthroat trout in 1977. Obviously, some reproduction was occurring.

Post-eruption Fish Surveys

The first post-eruption survey was July 27, 1983; seven Twin Lakes cutthroat averaging 256 mm were caught. These were probably survivors from the plant in 1979. Although no fish have been stocked since the eruption, cutthroat apparently spawn successfully in the short inlet stream, as cutthroat were found both in 1992 and 2001. The outlet is steep without spawning habitat.

Fish collected in 2001 were feeding predominantly on Trichoptera larvae and some pupal chironomids. Mean length of 326 mm at age III+ was excellent.

Figure 28. Island Lake Twin Lakes cutthroat-7/25/01.

Table 36. Island Lake Twin Lakes cutthroat trout fishery surveys.

Date	**7/27/83**	**7/30/92**	**7/26/01**
Sampling Method	**Gill Net**	**Angling**	**Gill Net/Angling**
Number Collected	**7**	**2**	**3**
Mean Fork Length (mm)	**256**	**236**	**326***
Range	**--**	**221-250**	**285-352**
Mean Weight (g)	**197**	**151**	**395**
Mean Condition Factor (K)	**1.17**	**1.15**	**1.09**
Catch/hr	**--**	**--**	**0.1**

*Age III+

Recreational Use

A well-used campsite on the southeast end of the lake indicated some recreational use before 1980. No overnight camping is allowed with 200 feet of the lake and campfires are illegal. This is a popular destination for anglers. There is no official trail to the Island Lake, but visitors take off from the Lakes Trail (#211) first to Venus Lake and then to Island.

Future Management

The MSHNVM Fish and Wildlife Plan designated Island Lake for research use; no fish should be stocked. Since the cutthroat in Island Lake are reproducing, no future planting is necessary.

Little (Lower) Venus Lake

Location: SW1/4, Sec. 14, T.10N, R. 5E
County: Skamania
Drainage: Venus Creek to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 3.2 ha (8.0 acres)
Elevation: 1,402 m (4,600 ft)
Aspect: Northeastern
Maximum Depth: 9.1 m
Inlet Stream (outlet for Venus Lake):

A low gradient reach near the lake provides some adequate gravel, mixed with small pumice and ash. Several fish about 150 mm were observed in 2001.

Outlet:

The outlet is very low gradient and choked with logs. Spawning use is unlikely.

Bottom Composition: Predominantly ash with some bedrock
Ice-free Period: July through mid-November
Eruption Impacts: Little Venus Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 29. Little Venus Lake-7/29/01.

Water Quality

Table 37. Little Venus Lake water quality data-7/29/01.

	Surface	3 m
Temperature (C)	**15.60**	**15.52**
Specific Conductivity (µS/cm)	**14**	**14**
Dissolved Oxygen (mg/l)	**8.13**	**8.04**
pH	**6.51**	**6.61**

Fishery Resources

Table 38. Little Venus Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
TLCT	09/17/79	800	4.3	188	Mossyrock
TLCT	09/25/89	510	2.2	232	Mossyrock

Pre-eruption Fish Populations

A creel survey in 1973 checked 13 rainbow trout.

Post-eruption Fish Surveys

An angling survey on July 26, 1983, provided the first evidence that fish survived in Little Venus Lake. Five Twin Lakes cutthroat averaging 273 mm were collected. Both rainbow and cutthroat were taken by angling in 1989. These rainbow were either survivors missed in 1983 or emigrants from Venus Lake. Only one of the 21 fish collected in 2001 was a cutthroat.

The mean length of rainbow collected in 2001 was 181 mm; the average condition factor was 1.03. Growth was slow, as age IV+ averaged 221 mm. Stomachs contained adult Coleoptera, larval Chironomidae, and Formicidae.

Although the inlet had some spawning habitat, no fry were observed during the 2001 survey.

Table 39. Little Venus Lake Twin Lakes cutthroat trout fishery surveys.

Date	7/26/83	9/25/89	7/31/01
Sampling Method	Angling	Angling	Gill Net
Number Collected	5	1	1
Mean Fork Length (mm)	273	295	170
Range	--	--	--
Mean Weight (g)	--	--	48
Mean Condition Factor (K)	1.05	--	0.98
Catch/hr	2.5	--	0.02

Table 40. Little Venus Lake rainbow trout fishery surveys.

Date	7/26/83	9/25/89	7/31/01
Sampling Method	Angling	Angling	Gill Net
Number Collected	0	3	20
Mean Fork Length (mm)	--	219	181
Range	--	200-238	158-248
Mean Weight (g)	--	--	66
Mean Condition Factor (K)	--	--	1.03
Catch/hr	--	--	0.42

Figure 30. Little Venus Lake rainbow trout-7/31/01.

Table 41. Little Venus Lake rainbow trout growth rates-7/31/01.

Age	Mean Length (mm)	Range	n
II+	163	158-175	5
III+	183	171-226	7
IV+	221	220-221	2
V+	248	--	1

Recreational Use

There is an unestablished trail leading from Venus Lake to Little Venus, but most anglers target Venus Lake. No camping is permitted. (See Venus Lake for access information.)

Future Management

Stunted rainbow trout have taken over Little Venus Lake, out competing Twin Lakes cutthroat. Management options are limited. The most reasonable option is to manage both Venus lakes in tandem. Trophy rainbow would be available in Venus, while anglers would find higher catch rates and smaller size rainbow in Lower Venus.

Meta Lake

Location: NE1/4, Sec. 5, T.9N, R. 6E
County: Skamania
Drainage: Clearwater Creek to Muddy River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 3.6 ha (9.0 acres)
Elevation: 1,091 m (3,580 ft)
Aspect: Southeastern
Maximum Depth: Unknown
Inlet Streams:

The inlet on the north shore is about one meter wide and has suitable spawning gravel.

Outlet:

Crisafulli (2002) reported that since 1983 at least seven beaver dams had been constructed within the first 150 m of the outlet. Adult and fry brook trout were abundant in the impoundments. The substrate was mostly fines. Stream widths varied from 3-15 m.

Bottom Composition: Organic ooze with some ash
Ice-free Period: June through November
Eruption Impacts: Meta Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 31. Meta Lake-7/80.
(Photo by Bruce Crawford)

Figure 32. Meta Lake-8/23/02.

Water Quality: Not taken

Invertebrates:

Meta was classified as a moderately productive lake by Scharnberg (1995). During collections in 1993, there was significant abundance of cladoceran and rotifers. The zooplankton populations were balanced and there was moderate fish predation.

Fishery Resources

Table 42. Meta Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	07/24/57	1,764			Unknown
TLCT	08/21/73	1,290	3		Unknown
TLCT	08/08/74	450	3	150	Unknown
Beaver Cr. CT	09/01/76	1,045	5.5	190	Mossyrock
TLCT	09/18/79	900	4.8	188	Mossyrock

Pre-eruption Fish Populations

Eastern brook and rainbow were found during creel surveys in 1937, while an angler check in 1953 found only rainbow. With existing brook trout populations, cutthroat plants in the 1970s were probably unsuccessful.

Post-eruption Fish Populations

A gill net set in September of 1980 found a stunted population of brook trout. As 35 fish were collected, there was no evidence of high mortality due to the eruption. However, eruption impacts limited recruitment. With fewer individual trout competing for food, the mean length of brook trout increased accordingly. Brookies sampled in 1983 averaged 300 mm, with fish up to 415 mm. The condition of these fish was extraordinary; most were feeding on what we believed were *Ambystoma gracile* (Northwest salamanders). Subsequent sampling from 1997-99 indicated that, with improved recruitment, the brook trout had reverted back to a stunted population.

Table 43. Meta Lake brook trout fishery surveys.

Date	9/30/80	8/26/81	6/16/83	5/27/97*	5/97*	5/98 & 6/98*
Sampling Method	Gill Net	Gill Net	Gill Net	Gill Net	Angling	Gill Net
Number Collected	35	7	?	11	32	19
Mean Fork Length (mm)	193	276	300	257	239	178
Range	165-229	260-317	182-415	232-277	189-302	105-321
Mean Weight (g)	--	--	--	--	115	76
Mean Condition Factor (k)	1.14	1.21	--	--	0.80	0.91
Catch/hr	--	--	--	--	--	--

Date	5/26 & 27/98	6/99*
Sampling Method	Angling	Angling
Number Collected	75	100
Mean Fork Length (mm)	218	208
Range	170-336	165-350
Mean Weight (g)	95	74
Mean Condition Factor (k)	0.83	0.81
Catch/hr	--	--

***Crisafulli (2002)**

Figure 33. Meta Lake brook trout-6/16/83.

Recreational Use

Meta Lake is a day-use interpretative site and located just a few hundred meters from the Forest Service 99 road. Visitor use is high, but very few are anglers.

Future Management

Meta Lake provided a brief glimpse of a fishery with very limited recruitment. Brook trout growth and size was exceptional. Improved spawning success increased competition for food and growth was stunted. Although zooplankton populations in 1993 showed only moderate predation, currently consumption is likely much higher. Once brook trout overpopulate a lake, management options are limited. No stocking is warranted nor is it allowed under the MSHNVM Fish and Wildlife Plan.

Obscurity Lake

Location: W1/2, Sec.19, T.10N, R.6E
County: Skamania
Drainage: Grizzly Creek to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 4.1 ha (10.2 acres)
Elevation: 1,325 m (4,348 ft)
Aspect: Southeasterly
Maximum Depth: 16.8 m
Inlet Streams: 7/17/91 (Hollen 1993)

The inlet was approximately 4 m wide with gravel/sand substrate. It was accessible for 210 m up to a waterfall. Small brook trout were observed. Also, fry were found during the 8/23/02 survey.

Outlet: 7/17/91 (Hollen 1993)

Small brook trout were found in the outlet, which was 5-6 m in width and accessible for 150 m. The substrate was gravel/sand.

Bottom Composition: Sand with some ash and pumice
Ice-free Period: July through mid-November
Eruption Impacts: Obscurity Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 34. Obscurity Lake-7/80.
(Photo by Bruce Crawford)

Figure 35. Obscurity Lake-7/25/01.

Water Quality:

Table 44. Obscurity Lake water quality data-8/24/02.

	Surface	3 m
Temperature (C)	**14.22**	**13.39**
Specific Conductivity (µS/cm)	**20**	**19**
Dissolved Oxygen (mg/l)	**9.35**	**9.14**
pH	**7.30**	**7.15**

Invertebrates

Scharnberg (1995) described zooplankton populations in Obscurity Lake as simplified. Only eight species were collected in 1994. *Cyclops vernalis*, *Kellicottia longispina*, and *Keratella quadrata* dominated, which was evidence of extreme brook trout predation.

Fishery Resources

Table 45. Obscurity Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	1934	Unknown			Unknown
RB	1950	10,000			Unknown
TLCT	09/15/70	1,372	1.5	915	Mossyrock
TLCT	08/21/73	3,010	7	430	Mossyrock
TLCT	10/06/78	765	2.3	340	Mossyrock

Pre-eruption Fish Populations

Apparently, a few rainbow spawned successfully as one rainbow was creeled in 1961, 11 years after stocking. All other creel surveys from 1954 to 1973 yielded brook trout.

Post-eruption Fish Populations

Since only three brook trout were collected during gill net sampling in 1984, likely few fish were successfully spawning after the eruption. The mean length of fish taken was 271 mm, quite respectable for brook trout. Sampling in 1993, 1997, and 2002 indicated that recruitment had increased substantially, as mostly small, emaciated fish were taken. Zooplankton collections in 1994 showed evidence of heavy fish predation.

Fish examined on August 24, 2002, were feeding exclusively on terrestrials including Hymenoptera (ants) and Acrididae (short-horned grasshoppers).

Table 46. Obscurity brook trout fishery surveys.

Date	8/29/84	8/13/93[a]	7/9/97[b]	8/24/02
Sampling Method	Gill Net	Gill Net	Angling	Gill Net
Number Collected	3	16	12	12
Mean Fork Length (mm)	271	175 (total length)	179	189
Range	--	159-190	126-237	161-275
Mean Weight (g)	197	52	56	64
Mean Condition Factor (K)	0.98	0.97	0.91	0.88
Catch/hr	0.1	0.62	--	0.64

[a]Hollen (1993)
[b]Crisafulli (2002)

Figure 36. Obscurity Lake brook trout-8/24/02.

Recreational Use

Overnight camping is allowed at Obscurity by permit. Based on permits issued, 39 individuals visited Obscurity Lake in 2001. As not all visitors obtain the

required permit, use could easily be doubled (Hans Castren, Mount St. Helens Monument staff, personal communication, 2002). Hiking distance from the Norway Pass Trailhead is approximately 8.3 km (5.1 miles).

Future Management

Brook trout numbers declined after the eruption probably due to limited spawning success. The remaining trout flourished, but by 1993 had lapsed back to the stunted populations that normally occur in alpine lakes. Changes in regulation would likely have little impact on fish size, and fish stocking is prohibited by the MSHNVM Fish and Wildlife Plan.

O'Conner Lake

Location: NW1/4, Sec. 14, T.10N, R. 5E
County: Skamania
Drainage: Unnamed tributary to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area:	1.6 ha (4.0 acres)
Elevation:	1,466 m (4,810 ft)
Aspect:	Northern
Maximum Depth:	6 m (estimated)
Inlet Streams:	Several intermittent streams flow into the lake
Outlet:	Not surveyed
Bottom Composition:	Predominantly ash
Ice-free Period:	July through mid-November

Eruption Impacts:

O'Conner Lake is in a zone of standing green timber. Heavy tephra fall was the only volcanic impact.

Figure 37. O'Conner Lake-7/80.
(Photo by Bruce Crawford)

Figure 38. O'Conner Lake-7/26/01.
(background)

Water Quality

Table 47. O'Conner Lake water quality data-7/25/01.

	Surface	3 m
Temperature (C)	**18.41**	**12.92**
Specific Conductivity (µS/cm)	**20**	**20**
Dissolved Oxygen (mg/l)	**7.93**	**8.22**
pH	**6.50**	**6.34**

Fishery Resources

Table 48. O'Conner Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
TLCT	09/18/79	400	2.1	188	Mossyrock
TLCT	09/25/89	162	0.7	232	Mossyrock
TLCT	08/31/92	151	0.3	504	Mossyrock
TLCT	08/27/95	108	0.3	360	Mossyrock
TLCT	09/21/98	110	0.5	220	Mossyrock
TLCT	09/12/00	101	0.4	252	Mossyrock

Pre-eruption Fish Populations

No pre-eruption surveys could be found for O'Conner Lake.

Post-eruption Fish Populations

The first confirmed stocking was when Twin Lakes cutthroat were planted in 1979. Surviving cutthroat were found in 1983 and 1992. A gill net set July 25-26, 2001, collected 14 Twin Lakes cutthroat. Larval Trichoptera were predominant in stomachs examined followed by adult Coleoptera, Odonata nymphs, and Chironomidae larvae. Their flesh was pale orange and substantial visceral fat indicated that these fish were in excellent condition. Mean length for age I+ cutthroat was 280 mm, well above average for Region Five sub-alpine lakes (Lucas 1989). There was no evidence of reproduction.

Table 49. O'Conner Lake Twin Lakes cutthroat trout fishery surveys.

Date	7/27/83	7/30/92	7/26/01
Sampling Method	Angling	Angling	Gill Net
Number Collected	5	1	14
Mean Fork Length (mm)	283*	430	284
Range	--	--	242-335
Mean Weight (g)	--	980	248
Mean Condition Factor (K)	--	1.23	1.08
Catch/hr	--	--	0.71

***Age IV+**

Table 50. O'Conner Lake cutthroat trout growth rates-7/26/01.

Age	Mean Length (mm)	Range	n
I+	280	260-300	8
III+	313	290-335	2

Recreational Use

Since O'Conner Lake is only a few hundred meters from Island, many anglers probably fish both lakes. There were no developed campsites at O'Conner and use appeared to be less than at Island. (See Island Lake for access information.)

Future Management

Growth of stocked Twin Lakes cutthroat in O'Conner was excellent. Stocking should continue every third year at 40 fish per acre.

Panhandle Lake

Location: Sec. 24, T.10N, R. 5E
County: Skamania
Drainage: Panhandle Creek to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 6.1 ha (15.1 acres)
Elevation: 1,369 m (4,492 ft)
Aspect: Northern
Maximum Depth: 21.6 m
Inlet Streams: (7/26/01)

The inlet on the west end of the lake was 3-4 meters wide. It had excellent gravel and flow and was accessible for about 70 meters with willow canopy over part of the stream. Numerous brook trout fry were observed.

A second stream on the southern shore was not surveyed.

Outlet: Not surveyed
Bottom Composition: Predominantly ash
Ice-free Period: July to late-November

Eruption Impacts: Panhandle Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 39. Panhandle Lake-7/26/01.

Water Quality

Table 51. Panhandle Lake water quality data.

	8/14/93*		7/25/01	
	Surface	**3 m**	**Surface**	**3 m**
Temperature (C)	**13.5**	**13.0**	**14.45**	**13.32**
Specific Conductivity (µS/cm)	**32**	**--**	**17**	**17**
Dissolved Oxygen (mg/l)	**9.0**	**9.1**	**9.2**	**9.7**
pH	**--**	**--**	**6.67**	**6.73**

***Frenzen et al. (1995)**

Invertebrates:

Collections from 1992-94 by Scharnberg (1995) found zooplankton dominated by *Cyclops vernalis*, *Holopedium gibberum*, *Kellicottia longispina*, and *Keratella quadrata.* Similar to Obscurity Lake, Scharnberg (1995) surmised that most palatable species were nearly eliminated by brook trout.

Fishery Resources

Table 52. Panhandle Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	1940	19,800			Unknown
RB	1948	6,945			Unknown
RB	1949	20,775			Unknown
RB	1950	15,000			Unknown
CT	08/27/63	2,466			Unknown
TLCT	09/15/70	1,377	1.5	915	Unknown
TLCT	08/18/73	5,160	12.0	430	Mossyrock
TCLT	09/13/76	5,015	29.5	170	Mossyrock
TLCT	09/17/79	1,500	8.0	188	Mossyrock

Note: Eastern brook trout were obviously planted, but no stocking records could be found. Brook trout stocked in nearby Boot, Obscurity, or Shovel Lakes could have been transported by anglers to Panhandle Lake.

Pre-eruption Fish Populations

Cutthroat, rainbow and brook trout were caught in the 1940s and 1950s; however, creel checks in 1972 and 1973 found only small brook trout. Twin

Lakes cutthroat stocked in the 1970s probably did not fare well with competition from brook trout.

Post-eruption Fish Populations

Brook trout survivors of the Mount St. Helens eruption were first collected June 2, 1981. While trout caught in 1981 were relatively small, brook trout caught during an angling survey in 1993 averaged 363 mm. Growth rates apparently declined, as a follow-up gill net set on July 26, 2001, caught 33 eastern brook trout averaging 177 mm. The largest fish was only 193 mm. Brook trout were feeding on Orthoptera adults, Formicidae adults, and Chaoborinae larvae. Interestingly, there were small pumice stones in several stomachs. Growth was quite slow with age V and VI+ brook trout measuring only 179 and 174 mm, respectively.

The inlet provides good spawning gravel and numerous fry were observed during the 2001 survey.

Table 53. Panhandle Lake brook trout fishery surveys.

Date	6/2/81	1993*	7/26/01
Sampling Method	Gill Net	Angling	Gill Net
Number Collected	2	7	33
Mean Fork Length (mm)	171	363 total length	177
Range	--	254-406	165-193
Mean Weight (g)	48	--	56
Mean Condition Factor (K)	0.95	--	1.00
Catch/hr	--	3.5	1.71

***Hollen (1993)**

Table 54. Panhandle Lake brook trout growth rates-7/26/01.

Age	Mean Length (mm)	Range	n
V+	179	165-193	5
VI+	174	165-183	2
VII+	190	--	1

Figure 40. Panhandle Lake brook trout-7/26/01.

Recreational Use:

Panhandle has two designated campsites and receives moderate to heavy use. Visitors are required to have a permit. In 2001, 90 permitted visitors hiked to Panhandle Lake (Castren 2002). Actual use could be up to 180 visitors, as a number of people don't obtain permits. Hiking distance from the Norway Pass Trailhead on Trail #211 is approximately 11 km (6.9 miles).

Future Management

Although brook trout collected by Frenzen et al. (1995) in 1993 were sizable, the population in 2001 was very stunted with numerous small fish. Brook trout populations in both Panhandle and Shovel were quite similar. The MSHNVM Fish and Wildlife Plan designated Panhandle Lake for research use; no fish should be stocked.

Ryan Lake

Location: NW1/4, Sec. 16, T.10N, R. 6E
County: Skamania
Drainage: Unnamed tributary to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 1.6 ha (4.0 acres)
Elevation: 1,008 m (3,307 ft)
Aspect: Southeastern
Maximum Depth: 4.9 m
Inlet Streams: No defined inlet could be found
Outlet: (8/22/01)

There was standing water up to an impassable beaver dam which was about 10 meters from the lake. No spawning gravel was available.

Bottom Composition: Predominantly ash with some organic ooze
Ice-free Period: Mid-May through November

Eruption Impacts: Ryan Lake is located in the blast zone. Shock waves blew over standing timber. The heat wave temperature at Ryan Lake was estimated to be over 121C (Dahm et al. 1983). The area received heavy tephra deposits. It was assumed to be ice-free at the time of the eruption.

Figure 41. Ryan Lake-7/80.
(Photo by Bruce Crawford)

Figure 42. Ryan Lake-8/22/01.

Water Quality

Table 55. Ryan Lake water quality data-8/22/01.

	Surface	3 m
Temperature (C)	**18.14**	**18.13**
Specific Conductivity (µS/cm)	**45**	**45**
Dissolved Oxygen (mg/l)	**7.53**	**7.40**
pH	**6.77**	**6.97**

Invertebrates:

The top predator, *Chaoborus,* was abundant in 1993 plankton tows (Scharnberg 1995). *Diaptomus franciscanus* dominated zooplankton communities. Cladoceran numbers were low. Despite the high numbers of *Chaoborus*, only moderate predator pressure was evident.

Fishery Resources

Table 56. Ryan Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	1934	Unknown			Unknown
RB	1940	17,425			Unknown
EB	07/24/57	1,764			Unknown
CT	09/11/65	1,780	4	445	Mossyrock

Pre-eruption Fish Populations

No records could be found.

Post-eruption Fish Populations

The first survey of Ryan Lake was July 1, 1980. No nets were set, but one dead brook trout was found. On November 12-13, 1980, two gill nets yielded no fish. It was assumed there were no fish survivors, because Ryan Lake was shallow and directly in the path of the blast. Also, oxygen depletion due to massive organic input was a concern. Extensive sampling in 1997 with snorkeling, minnow traps, and dip nets found no fish (Crisafulli 2002).

Therefore, the two brook trout collected in a gill net set August 22, 2001, were quite a surprise. These fish were in excellent condition with bright orange flesh and had excellent visceral fat. One fish fed exclusively on Chaoborinae larvae and the other stomach contained both Chaoborinae larvae and Odanata nymphs.

The source of these fish is somewhat of a mystery. One possibility is that a few fish survived the blast and were simply missed during sampling in 1980. Also, fish could have possibly survived in the outlet stream and moved back into the lake; there is no defined inlet stream. Finally, brook trout might have been illegally transported from nearby Meta Lake. The 260 mm trout was age VI.

Because only two fish in excellent condition were taken in the gill net, it was likely that only a moderate number of brook trout inhabited Ryan Lake. A beaver dam blockage of the outlet, coupled with the absence of a defined inlet channel, limit reproductive success.

Table 57. Ryan Lake brook trout fishery surveys.

Date	**11/13/80**	**8/22/01**
Sampling Method	**Gill Net**	**Gill Net**
Number Collected	**0**	**2**
Mean Fork Length (mm)	**--**	**251**
Range	**--**	**242-260**
Mean Weight (g)	**--**	**199**
Mean Condition Factor (K)	**--**	**1.23**
Catch/hr	**--**	**0.11**

Figure 43. Ryan Lake brook trout-8/22/01.

Recreational Use

The lake receives considerable use as it can be accessed by road, and there is a small interpretative site with restrooms. Anglers may not have yet discovered the brook trout in Ryan Lake.

Future Management

After the eruption, Ryan Lake was designated as a research lake, but was not included in the lakes set aside by the Scientific Advisory Board. Brook trout in Ryan Lake should be monitored to determine changes in fish abundance and condition. Although stocking of fish is allowed, likely the lake will be managed for self-sustaining brook trout.

St. Helens Lake

Location: SW1/4, Sec. 34, T. 10N, R. 5E
NW1/4, Sec. 3, T. 9N, R. 5E
County: Skamania
Drainage: Spirit Lake to South Coldwater Creek to North Fork Toutle River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 32 ha (79 acres)
Elevation: 1,394 m (4,575 ft)
Aspect: Southeastern
Maximum Depth: 78.6 m
Inlet Streams: No defined inlet could be found
Outlet:

A short, low-gradient section drops over a steep ridge. Likely, there is no spawning use.

Bottom Composition: Bedrock, rubble, and ash
Ice-free Period: Mid July through October
Eruption Impacts:

With the exception of Spirit Lake, St. Helens was the closest lake north of Mount St. Helens and suffered considerable damage. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 44. St. Helens Lake-6/81.
(Photo by Bruce Crawford)

Figure 45. St. Helens Lake-9/11/00.

Water Quality

St. Helens Lake is extremely deep with a low surface area to volume ratio. Initially, after the eruption productivity spiked, as indicated by specific conductivity of 154 µS/cm (8/28/80). Much lower conductivity, 46 µS/cm, on September 11, 2000, was evidence of declining productivity.

Table 58. St. Helens Lake water quality data.

	8/28/80*	**9/11/00**	
	Surface	**Surface**	**3 m**
Temperature (C)	**11.0**	**11.54**	**11.31**
Specific Conductivity (µS/cm)	**154**	**46**	**46**
Dissolved Oxygen (mg/l)	**7.0**	**8.66**	**9.02**
pH	**6.6**	**7.08**	**6.96**
Secchi Disk (m)	**0.3**	**--**	**--**

***Dion and Embrey (1981)**

Invertebrates:

Scharnberg (1995) collected 19 species of zooplankton from 1992-94. *Diaptomus kenai* was the dominant species during summer sampling, while *Daphnia pulex* was most common in the fall. Many of the zooplankton species were palatable. The abundance and biovolume of zooplankton were moderate.

Fishery Resources

Table 59. St. Helens Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	08/28/14	400			US Bureau Fisheries
EB	Jul-34	20,000			Unknown
CT	1941	41,500			Unknown
RB	1947	60,900			Unknown
RB	1948	18,800			Unknown
RB	08/20/51	40,000			Unknown
EB	07/09/52	4,900			Barnes
EB	07/24/57	23,080			Unknown
EB	07/31/62	21,543			Unknown
TLCT	08/27/63	19,648			Twin Lakes
TLCT	09/15/70	4,575	5	915	Mossyrock
TLCT	08/18/73	30,100	70	430	Mossyrock
TLCT	09/13/76	30,090	177	170	Mossyrock
TLCT	09/17/79	7,900	42	188	Mossyrock

Note: No records of lake trout stocking could be found.

Pre-eruption Fish Populations

Anglers checked in the 1970s had creeled eastern brook, cutthroat and lake trout.

Post-eruption Fish Populations

No fish were taken during the first post-eruption survey in 1981; however, two lake trout were collected in 1984. Fifteen lake trout caught in nets pulled on September 11, 2000, averaged 430 mm and ranged from 337-511 mm. Otoliths were extremely difficult to read, but it appeared most fish were at least seven years old. Stomachs contained Decapoda, Chironomidae larvae and pupae, and Orthoptera adults.

Interestingly, brook trout apparently disappeared from St. Helens Lake after the eruption. As brookies are more surface oriented than lake trout, the blast could have selectively killed brook trout. Another possible reason for the survival of lake trout is their spawning adaptability. Although preferring rubble and gravel bottoms, they can be successful in mud and sand.

Figure 46. Lake trout from St. Helens Lake-9/11/00.

Table 60. St. Helens lake trout fishery surveys.

Date	6/1/81	6/30/84	8/13/93*	9/11/00
Sampling Method	Gill Net	Gill Net	Gill Net	Gill Net
Number Collected	0	2	0	15
Mean Fork Length (mm)	--	380	--	430
Range	--	360-400	--	337-511
Mean Weight (g)	--	--	--	884
Mean Condition Factor (K)	--	0.82	--	1.06
Catch/hr	--	--	--	0.07

***Hollen (1993)**

Recreational Use

St. Helens Lake basin was set aside for long-term research. It remains closed to the public.

Future Management

The lake trout appear to be persisting in St. Helens Lake. No stocking is necessary nor allowed by the MSHNVM Fish and Wildlife Plan.

Shovel Lake

Location: W1/2, Sec. 24, T.10N, R. 5E
County: Skamania
Drainage: Panhandle Lake to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 8.4 ha (20.8 acres)
Elevation: 1,418 m (4,653 ft)
Aspect: Eastern
Maximum Depth: >30 m
Inlet Streams:

Crisafulli (2002) found two inlets during a July 20, 1994 survey. Both inlets were at the southwest end of the lake. One stream was 1.4 m wide with a mean depth of 4 cm. The substrate was predominantly fine pebbles and sand; no spawning gravel was present nor were fish observed. A barrier falls was approximately 43 m from the lake. The other inlet was 2.5 m wide and had a depth of 5 cm. The dominant substrate was fine pebbles with some fine sand. Fish access was blocked by a falls located about 100 m from Shovel Lake.

Outlet:

The outlet was inventoried by Crisafulli (2002) on July 20, 1994. It was 5 m wide, and the channel gradient was 10 percent. No spawning gravel was evident. Although a large log jam at the entrance to the outlet channel appeared to block fish, six adult brook trout were observed in the stream.

Bottom Composition: Organic/ooze and ash
Ice-free Period: July through mid-November

Eruption Impacts: Shovel Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 47. Shovel Lake-7/80.
(Photo by Bruce Crawford)

Figure 48. Shovel Lake-8/24/02.

Water Quality

Table 61. Shovel Lake water quality data-7/26/01.

	Surface	3 m
Temperature (C)	**15.04**	**12.63**
Specific Conductivity (µS/cm)	**18**	**18**
Dissolved Oxygen (mg/l)	**8.87**	**9.61**
pH	**6.64**	**6.64**

Invertebrates:

Sampling during the summer of 1994 by Scharnberg (1995) found zooplankton populations dominated by *Cyclops vernalis*. Very few of the invertebrates found were palatable. Most of the nutrients were probably bound within the brook trout population (Scharnberg 1995).

Fishery Resources

Table 62. Shovel Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	1950	10,000			Unknown
EB	07/24/57	5,000			Unknown
TLCT	09/15/70	1,372	1.5	915	Mossyrock
TLCT	08/21/73	3,010	7	430	Mossyrock
TCLT	09/13/76	3,060	18	170	Mossyrock
TLCT	09/17/79	2,100	11.2	188	Mossyrock

Pre-eruption Fish Populations

Both rainbow and cutthroat were creeled in 1954, but the brook trout stocked in 1957 appeared to have taken over. Cutthroat planted in 1970 and 1973 did not show up in a 1976 angler check.

Post-eruption Fish Populations

Gill net sets in 1984, 1993, and 2001 documented survival and persistence of brook trout. High catch per hour, along with the limited size range of small fish, indicate a stunted population. In 2001, age V+ and VI+ trout were only 189 and 199 mm, respectively. Stomachs contained predominantly Chironomidae larvae and pupae with a few adult Coleoptera.

Table 63. Shovel Lake brook trout fishery surveys.

Date	8/30/84	8/13/93[a]	7/26/01
Sampling Method	Gill Net	Gill Net	Gill Net
Number Collected	21	7	19
Mean Fork Length (mm)	171[b] 302[c]	185 (total length)	185
Range	150-320	165-197	169-212
Mean Weight (g)	--	53	66
Mean Condition Factor (K)	1.03	0.85	1.03
Catch/hr	--	0.25	0.98

[a]Hollen (1993)
[b]Age I+
[c]Age V+

Table 64. Shovel Lake brook trout growth rates-7/26/01.

Age	Mean Length (mm)	Range	n
IV+	172	--	1
V+	189	175-210	5
VI+	199	184-212	3

The inlet and outlet streams were not inventoried, but the self-sustaining, brook trout population indicated that spawning was occurring either in these streams or in upwelling areas of the lake.

Recreational Use

Hiking distance on from the Norway Pass Trailhead is approximately 12.5 km (7.9 miles) (Trail #211 to 211C). Overnight camping is allowed at two designated sites. A permit is required to camp at Shovel Lake. Fifty-one permitted visitors camped at Shovel Lake in 2001 (Castren 2002). Total use, including day visitors, could be as high as 100 people.

Future Management

Although the brook trout population is stunted, management options are limited. Stocking other species on existing brook trout is rarely successful. Besides, stocking is precluded according to the provisions of the MSHNVM Fish and Wildlife Plan. No change in current management is advocated.

Snow Lake

Location: SW1/4, Sec. 23, T.10N, R. 5E
County: Skamania
Drainage: Coldwater Creek to North Fork Toutle River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 1.9 ha (4.8 acres)
Elevation: 1,433 m (4,700 ft)
Exposure: Southern
Maximum Depth: 6.1 m
Inlet Streams: (7/25/01)

The small inlet was about one meter wide with minimal flow. It was accessible for about 100 m. Small pockets of gravel, mixed with a high percentage of fines, offered marginal spawning habitat. Sections of the channel were dry during a September 16, 1994 survey (Crisafulli 2002).

Outlet:

No fish were discovered by Crisafulli (2002) during a survey on September 16, 1994. The outlet was 5.6 m wide with a gradient of 1.0 %. It was accessible for approximately 40 m.

Bottom Composition: Predominantly sand
Ice-free Period: July through mid-November

Eruption Impacts: Snow Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 49. Snow Lake-1984. (Photo by Crawford)

Figure 50. Snow Lake-8/24/02.

Water Quality

Table 65. Snow Lake water quality data-7/25/01.

	Surface	3 m
Temperature (C)	**16.36**	**13.85**
Specific Conductivity (µS/cm)	**27**	**26**
Dissolved Oxygen (mg/l)	**8.69**	**9.06**
pH	**6.83**	**6.94**

Invertebrates:

As was typically found in Mount Margaret lakes within the National Volcanic Monument, abundant *Chaoborus* was linked to fishless environments (Scharnberg 1995). Most of the zooplankton present in September of 1994 were not palatable.

Fishery Resources

Table 66. Snow Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	1950	10,000			Unknown
TLCT	09/17/73	960	3	320	Mossyrock
CT	09/18/76	1,045	5.5	190	Mossyrock
TLCT	09/18/78	812	12	290	Mossyrock
TLCT	09/17/79	500	2.7	188	Mossyrock

Pre-eruption Fish Populations

Planting records are incomplete, as both rainbow and cutthroat trout were caught prior to 1950, the first record of stocking. Also brook trout were creeled in 1951, yet there were no reported brook trout plants. It was likely that rainbow reproduced in Snow Lake, as they were creeled in 1961 and 1973.

Post-eruption Fish Populations

Gill nets set August 29-30, 1984, August 12-13, 1993 Hollen (1993), and July 25-26, 2001, yielded no fish. Either the lake was barren prior to the eruption or fish were killed by eruption impacts.

The inlet provided some marginal spawning habitat.

Recreational Access

Hiking distance from the Norway Pass Trailhead is approximately 11.7 km (7.3 miles) (Trail #211 to #1 to #214 to #211). A permit is required to camp. In 2001, 49 individuals obtained permits to camp at Snow Lake (Castren 2002).

Future Management

The MSHNVM Fish and Wildlife Plan designated Snow Lake for research use; no fish should be stocked. With its favorable water quality, there is no question that Snow could again support fish.

Spirit Lake

Location: NW1/4, Sec. 6, T. 9N, R. 6E
Sec. 1; S1/2, Sec. 2; SE1/4, Sec. 3; E1/2, Sec. 10;
Sec. 11; Sec. 12; N1/2, Sec. 13; Sec. 14; E1/2, Sec. 15;
N1/2, Sec. 23; T. 9N, R. 5E
County: Skamania
Drainage: South Fork Coldwater Creek to North Fork Toutle
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area: 1,100 ha* (2,717 acres)
Elevation: 1,048 m* (3,440 ft)
Exposure: Southern
Maximum Depth: 34 m*
*U.S. Army Corps Engineer (1987)

Inlet Streams:

Numerous small inlet streams flow into Spirit Lake. In lower gradient areas near the lake, streams along the southern shore had no defined channel. As gradients increased, stream channels were more stable. Stream bottoms were composed primarily of fine material near the lake, with more cobble upstream. These streams were visually surveyed for fry in 1983, 1993, 1994, 2000, and 2001; no fish or redds were observed.

Bear Creek electrofishing on September 11, 2000, yielded no fish. The mouth was choked with logs, but above this area, there were sections with suitable gravel. Another stream entering the large bay below Windy Ridge was visually inspected by Crisafulli (2002) and shocked July 26, 2001, by Washington Department of Fish and Wildlife; no fish or redds were found.

The Donny Brook inlet stream network was surveyed during June of 2001, and no fish or redds were observed (Crisafulli 2002).

Outlet:

There is no natural outlet. Spirit Lake drains through a tunnel constructed by the Corps of Engineers in 1985. No spawning habitat is available.

Bottom Composition: Primarily sands, pumice, and fines with some Eurasian milfoil first observed in 1991.
Ice-free Period: Spirit Lake rarely freezes

Eruption Impacts:

When the north face of Mount St. Helens collapsed, a huge debris avalanche swept into Spirit Lake. The lake surface was elevated by about 60 meters and the surface area increased by 80 percent (Larson 1993). Huge rafts of logs covered much of the lake surface.

Figure 51. Spirit Lake-1977. (Photo by Crawford)

Figure 52. Spirit Lake-7/80.

Figure 53. Spirit Lake-8/23/01.

Water Quality:

Prior to the eruption, Spirit Lake was classified by Larson (1994) as ultra oligotrophic. In 1974, specific conductivity was only 27 µS/cm (Bortleson et al. 1976), fairly typical for sub-alpine lakes.

Table **67.** Spirit Lake water quality data.

	6/27/74[a]	7/28/80[b]	7/5/83[c]		7/26/00	
	Surface	**Surface**	**Surface**	**35 m**	**Surface**	**3 m**
Temperature (C)	**10.0**	**20.6**	**12.5**	**5.0**	**17.93**	**17.16**
Specific Conductivity (µS/cm	**27**	**860**	**560**	**580**	**243**	**259**
Dissolved Oxygen (mg/l)	**10.4**	**--**	**7.6**	**2.9**	**8.42**	**8.53**
pH	**6.9**	**6.8**	**7.8**	**7.4**	**7.87**	**8.03**

[a]Bortleson et al. (1976)
[b]Dion and Embrey (1981)
[c]US Army (1983)

On May 19, 1980, one day after the eruption, Dion and Emory (1981) reported the surface temperature was 32.7EC. The massive influx of organic and inorganic matter from the eruption allowed bacteria to proliferate (Larson 1994). Shallow water bacteria counts in June of 1980 were more than one-half billion cells per milliliter, a level Larson (1994) speculated was likely unprecedented in fresh water. Due to bacterial decomposition of organic material, Spirit Lake remained anoxic from early July through fall of 1980. Dion and Emery (1981) stated that Spirit Lake "looks and smells very much like the effluent liquor from a pulp mill." Dissolved oxygen levels in the epilimnion layer were only 0.8 mg/l on October 16, 1980. Because of the eruption, there were substantial increases in dissolved solids, specific conductivity, hardness, and alkalinity. Lake productivity was enhanced by a 33-fold increase in phosphorus after 1980 (Larson 1994).

With the absence of green plants, there was no photosynthesis and bacterial processes dominated. Water quality in the lake improved substantially by 1982, as much of the lake was saturated with oxygen. By 1986, phytoplankton photosynthesis "had all but replaced bacterial chemosynthesis" (Larson 1994). In fact, a total of 138 species of phytoplankton were identified in 1986 (Larson 1993).

Specific conductivity peaked at 860 µS/cm immediately after the eruption; by July 26, 2000, surface conductivity declined to 243 µS/cm. Surface pH increased from 6.9 (1974) to 7.9 (2000).

Invertebrates

Most scientists assumed that zooplankton were destroyed by the superheated water caused by the eruption or the anoxic conditions of Spirit Lake afterwards. However, by 1986 *Daphnia pulex* and *Bosmina longirostris* were abundant.

Fishery Resources

Table 68. Spirit Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	1913	Unknown			Unknown
RB	1933	Unknown			Unknown
RB	1934	Unknown			Unknown
EB	1936	Unknown			Unknown
RB	1951-1979	Various	legals		

Pre-eruption Fish Populations

Before the 1980 eruption, anadromous coho, steelhead, and sea-run cutthroat spawned in tributaries of Spirit Lake. Hatchery rainbow trout were stocked annually to supplement the small population of resident cutthroat and rainbow.

Post-eruption Fish Populations

Gill nets were first set in 1983 and yielded no fish. Finally, in 1993, one rainbow (affectionately known as Harry) was caught. We speculated that with the incredibly rich food base in Spirit Lake, the population would expand rapidly. Our prediction was correct; it just took longer than anticipated. Another rainbow was caught during gill net sets in 1994; this age III fish was 440 mm. Nets set in 1997 yielded a 330 mm rainbow.

As we approached our sampling in 2000, we didn't have high expectations. The first cast into Spirit Lake appeared to have hooked bottom, but when a huge rainbow exploded on the surface, we knew Spirit Lake had finally turned the corner.

The mean length of 32 rainbow collected by gill net and angling on July 25 and 26, 2000 was 511 mm; the range was 368-686 mm. All fish were age II+ and III+, indicating that some rainbow spawned successfully in 1997 and 1998. Apparently, spawning conditions were less suitable in 1999, as no age I+ were caught.

Figures 54 & 55. Spirit Lake rainbow-7/26/00.

We surveyed numerous lake tributaries from 1993 to 2001 and found no fry or redds. Many of these stream channels had not yet stabilized. Obviously, rainbow trout successfully spawned either in inlet streams or upwelling areas along the shore.

So far, low recruitment has limited rainbow abundance. The relatively few rainbow in Spirit Lake are thriving in a nutrient-rich environment. Growth to age II far exceeded established standards for western Washington rainbow, especially in a sub-alpine environment with shorter growing seasons (Lucas 1989). Remarkably, the fish were attaining this growth apparently consuming relatively small food organisms. Stomachs from fish collected in 2000 contained predominantly small gastropods and Ephemeroptera nymphs, along with Chironomidae larvae and pupae, and larval Coleoptera.

Scales were difficult to analyze, as only subtle seasonal changes in circuli width were apparent. Relatively wide spacing of winter circuli indicated that growth continued during the winter, probably accounting for the extraordinary increase in size. One explanation for this unusual winter growth was that thermal venting might have warmed the lake and allowed fish to grow during the normally dormant winter period.

As the 1997 and 1998 year classes aged, there was a declining percent of age II fish during collections in 2001 and 2002. A few age IV rainbow were collected. There could be several explanations for the relatively low number of age IV fish. Many females collected on July 31, 2002, still had not spawned. Milt was not running from the males. Late July is extremely late for rainbow spawning. If these females were reabsorbing their eggs, mortality of mature females could be higher

than normal. Also, life spans of faster growing fish are often less than fish with slower growth. Interestingly, few age I rainbow have been caught during our sampling. Since fish were collected with both angling and gill nets, probably gear selectivity was not a factor. One explanation is that proportionately fewer young fish inhabit the areas we have sampled.

The rainbow population in Spirit Lake is rapidly expanding, but has not reached carrying capacity. Lakes with higher productivity normally support a higher biomass of fish. Lake productivity in Spirit Lake has already started to decline. Another factor is spawning conditions. As streams stabilize and spawning survival improves, recruitment will increase. With more fish in the lake and fewer nutrients fueling their food supply, growth rates will eventually decrease.

Where did these fish come from? It was very unlikely fish survived the eruption. Even if they weathered the initial blast, Spirit Lake was not a hospitable environment for a considerable period of time afterwards. Leaching of organic debris caused anoxic conditions. Another source could be fish moving down from St. Helens Lake, but it only has lake trout. The most plausible explanation is that the fish were stocked illegally, and there have been persistent rumors that unauthorized planting occurred. Genetic samples were taken to determine the origin of Spirit Lake rainbow. These samples have not yet been analyzed.

Table 69. Spirit Lake rainbow trout fishery surveys.

Date	**6/15/83**	**11/7/93**	**8/11/94**	**8/6/97**	**7/25/00**	**7/26/00**
Sampling Method	**Gill Net**	**Gill Net**	**Gill Net**	**Gill Net**	**Angling**	**Gill Net**
Number Collected	**0**	**1**	**1**	**1**	**18**	**14**
Mean Fork Length (mm)	**--**	**202 Age I**	**440 Age III**	**330**	**529**	**488**
Range	**--**	**--**	**--**	**--**	**368-686**	**347-582**
Mean Weight (g)	**--**	**--**	**--**	**--**	**--**	**1,342**
Mean Condition Factor (K)	**--**	**--**	**--**	**--**	**--**	**1.10**
Catch/hr	**--**	**--**	**--**	**--**	**2.83**	**0.38**

Table 69. Spirit Lake rainbow trout fishery surveys (cont.).

Date	Oct-Nov/00*	6/22/01	7/31/02
Sampling Method	Angling	Angling	Angling
Number Collected	30	32	60
Mean Fork Length (mm)	528	531	553
Range	343-592	406-591	300-660
Mean Weight (g)	1,804	2,503	2,140
Mean Condition Factor (K)	1.20	1.66	1.21
Catch/hr	--	--	3.93

*Crisafulli (2002)

Table 70. Spirit Lake rainbow trout growth rates.

	Age							
	I+		II+		III+		IV+	
	Mean Length	n	Mean Length	n	Mean Length	n	Mean Length	n
2000	--	0	417	7	559	14	--	0
2001	--	0	456	5	550	16	533	1
2002	333	2	538	4	562	28	592	3

Recreation Use

The only legal public access to Spirit Lake is via the Harmony Falls Trail #224. The lake is closed to fishing.

Future Management

Currently, Spirit Lake offers an incredible fishery with high catch rates for large fish. The expanding rainbow population will eventually strike a balance with available nutrients. Growth rates will decline. The window of opportunity for the public to enjoy this fishery could be short lived. The National Volcanic Monument staff is understandably reluctant to open Spirit Lake to the general public. Other options, such as a permit system, should be considered.

Strawberry Lake

Location: NW1/4, Sec.27, T.10N,R6E
NE1/4, Sec.28, T.10N, R.6E
County: Skamania
Drainage: Tributary to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area:	4.0 ha (10 acres)
Elevation:	1,451 m (4,760 ft)
Aspect:	Westerly
Maximum Depth:	Unknown
Inlet Streams:	No inlets were found.
Outlet: (8/23/02)	The outlet had standing water and a mud bottom. It had no spawning habitat.
Bottom Composition:	Organic ooze over ash
Ice-free Period:	Mid-July through October

Eruption Impacts: Strawberry is located on the edge of the blast zone. Trees were still standing, but many were killed by the heat. Tephra was deposited.

Figure 56. Strawberry Lake-8/23/02.

Water Quality:

Table 71. Strawberry Lake water quality data-8/23/02.

	Surface	3 m
Temperature (C)	**18.56**	**17.00**
Specific Conductivity (µS/cm)	**26**	**26**
Dissolved Oxygen (mg/l)	**8.83**	**8.55**
pH	**8.27**	**7.95**

Fishery Resources

Table 72. Strawberry Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
EB	07/09/52	4,900			Unknown

Pre-eruption Fish Populations

A creel check in 1934 found rainbow. The brookies stocked in 1952 likely out-competed the rainbow.

Post-eruption Fish Populations

Surveys of Strawberry Lake in 1981 and 2002 by Washington Department of Fish and Wildlife and Crisafulli (2002) in 1995 and 1997 found stunted brook trout with no evidence of reduced population from the eruption. Unfortunately, with a 14-year span between surveys, it was difficult to determine if there was a time of declining recruitment.

Brook trout collected on 8/24/02 were feeding almost exclusively on Hymenoptera (ants).

Figure 57. Strawberry Lake brook trout 6/3/81.

Figure 58. Strawberry Lake brook trout 8/24/02.

Table 73. Strawberry Lake brook trout fishery surveys.

Date	6/3/81	8/24/02
Sampling Method	Gill Net	Gill Net
Number Collected	28	15
Mean Fork Length (mm)	189	199
Range	159-210	140-221
Mean Weight (g)	69	73
Mean Condition Factor (K)	1.02	0.89
Catch/hr	--	0.79

Recreational Use

There is no official trail to Strawberry Lake; however, a party of 11 was camped at the lake during our 2002 survey.

Future Management

Strawberry Lake is a typical, sub-alpine lake with a brook trout population severely cropping the food supply. Management options are limited. No stocking or regulation change is warranted.

Tradedollar Lake

Location: NW1/4, Sec. 18, T.10N, R. 5E
County: Skamania
Drainage: Tradedollar Creek to Green River
Ownership: Weyerhaeuser Company

Physical Characteristics

Surface Area:	4.9 ha (12.1 acres)
Elevation:	1,083 m (3,552 ft)
Aspect:	Northern
Maximum Depth:	12.2 m
Inlet Streams:	The southern inlet was predominantly beaver ponds with not much spawning potential. No fry were found. Another small (25 cm) inlet on the eastern shore offered no habitat.
Outlet:	A large beaver pond was at the beginning of the outlet. There was not much spawning habitat below the pond. No fry were observed.
Bottom Composition:	Organic ooze with some ash
Ice-free Period:	Mid-May through November
Eruption Impacts:	Tradedollar Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 59. Tradedollar Lake-7/80.
(Photo by Bruce Crawford)

Figure 60. Tradedollar Lake-7/11/00.

Water Quality

Table 74. Tradedollar lake water quality data-7/11/00.

	Surface	3 m
Temperature (C)	**16.77**	**14.15**
Specific Conductivity (µS/cm)	**40**	**40**
Dissolved Oxygen (mg/l)	**8.27**	**8.41**
pH	**7.17**	**6.47**

Fishery Resources

Table 75. Tradedollar Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
RB	Jul-34		Eggs		
RB	1940	35,900			
TLCT	08/27/63	1,842			Mossyrock
TLCT	09/15/70	1,830	2	915	Mossyrock
TLCT	08/21/73	5,160	12	430	Mossyrock
Tokul Cr. CT	09/13/76	5,015	29.5	170	Mossyrock
TLCT	09/17/79	1,200	6.4	188	Mossyrock
TLCT	08/19/83	824	1.9	434	Mossyrock
TLCT	08/22/85	1,194	3.2	373	Mossyrock
TLCT	08/27/87	896	2.8	320	Mossyrock
TLCT	09/25/89	742	3.2	232	Mossyrock
TLCT	09/18/91	725	2.5	290	Mossyrock
TLCT	09/02/93	598	2.2	272	Mossyrock
TLCT	11/02/95	616	5.5	112	Mossyrock
TLCT	09/09/97	613	2.5	245	Mossyrock
TLCT	09/27/99	266	1.0	266	Mossyrock
TLCT	10/01/01	608	3.8	160	Mossyrock

Pre-eruption Fish Populations

Prior to the 1980 eruption, Tradedollar Lake was managed for both self-sustaining rainbow and planted cutthroat.

Post-eruption Fish Populations

Gill nets set in 1980 and 1981 yielded rainbow, but no cutthroat. Since 1983, Tradedollar has been stocked with Twin Lakes cutthroat, usually every other year. Angling surveys from 1992-93 found a higher percentage of cutthroat than rainbow.

An overnight gill net on July 11, 2000, caught a total of 15 rainbow

averaging 235 mm. Only one small Twin Lakes cutthroat was collected. The size of age III rainbow (259 mm) exceeded the mean for Region Five sub-alpine lakes (Lucas 1989). Rainbow were feeding primarily on Chironomidae larvae, followed by Cladocera, pupal Trichoptera, and larval Coleoptera.

Table 76. Tradedollar Lake rainbow trout fishery surveys.

Date	11/6/80	4/7/81	7/11/91	7/7/92	9/2/93	7/11/00
Sampling Method	Gill Net	Gill Net	Angling	Angling Gill Net	Angling	Gill Net
Number Collected	2	1	6	1	0	15
Mean Fork Length (mm)	238	290		156	--	235
Range	216-260	--	largest 161 mm	--	--	162-304
Mean Weight (g)	483	250	--	37	--	157
Mean Condition Factor (K)	1.08	--	--	0.97	--	1.08
Catch/hr	--	--	--	--	--	0.78

Table 77. Tradedollar Twin Lakes cutthroat trout fishery surveys.

Date	11/6/80	4/7/81	7/11/91	7/7/92	9/2/93	7/11/00
Sampling Method	Gill Net	Gill Net	Angling	Angling Gill Net	Angling	Gill Net
Number Collected	0	0	1	4	7	1
Mean Fork Length (mm)	--	--	220	177[a]	233[b]	155
Range	--	--	--	165-196	205-258	--
Mean Weight (g)	--	--	--	51	138	35
Mean Condition Factor (K)	--	--	--	0.93	1.07	0.94
Catch/hr	--	--	--		--	0.05

[a]Age I+

[b]Age II+

Table 78. Tradedollar rainbow trout growth rates-7/12/00.

Age	Mean Length (mm)	Range	n
II+	**191**	**162-225**	**5**
III+	**259**	**235-304**	**8**
IV+	**252**	**--**	**1**

Recreational Use

Because of the relatively easy access provided by Weyerhaeuser logging roads, Tradedollar Lake was a popular destination both before and after the eruption. Unfortunately, trash and vandalism forced Weyerhaeuser to block vehicle access in 2001. Anglers now hike or ride bikes into the lake. From the Coldwater Visitor Center, the distance is about 17 km (10.5 miles). Very few fishermen will travel that far.

Future Management

Although Twin Lakes cutthroat planted in 1991 provided some excellent fishing, the rainbow have established a viable population. No future stocking is recommended.

Venus Lake

Location: SW1/4, Sec.14, T.10N, R. 5E
NW1/4, Sec.23, T.10N, R. 5E
County: Skamania
Drainage: Venus Creek to Green River
Ownership: U. S. Forest Service, Mount St. Helens National Volcanic Monument

Physical Characteristics

Surface Area:	8.5 ha (21 acres)
Elevation:	1,500 m (4,920 ft)
Aspect:	Northeastern
Maximum Depth:	42.7 m
Inlet Streams: (7/29/01)	Several very small streams along the northern shore area did not have much spawning potential.
Outlet:	Fish use was unlikely due to a debris blockage at its origin and steep gradient.
Bottom Composition:	Rock, rubble, and ash
Ice-free Period:	July through mid-November
Eruption Impacts:	Venus Lake is located in the blow-down zone. Lateral blast blew over standing timber, heat seared vegetation, and tephra was deposited.

Figure 61. Venus Lake-7/80.
(Photo by Bruce Crawford)

Figure 62. Venus Lake-7/29/01.

Water Quality

Venus Lake water quality measurements offer rather dramatic evidence of the nutrient loading from the eruption. Specific conductivity jumped from 9 µS/cm in 1974 to 233 several months after to eruption. Interestingly, conductivity had dropped down to 13 µS/cm on July 29, 2001.

Table 79. Venus Lake water quality data.

	9/14/74[a]	7/28/80[b]	8/12/93[c]		7/29/01	
	Surface	Surface	Surface	3 m	Surface	3 m
Temperature (C)	**9.4**	**17.8**	**14**	**13**	**13.04**	**13.01**
Specific Conductivity (µS/cm)	**9**	**233**	**24**	**--**	**13**	**13**
Dissolved Oxygen (mg/l)	**9.5**	**--**	**8.4**	**8.8**	**8.74**	**8.48**
pH	**--**	**6.3**	**--**	**--**	**6.33**	**6.53**
Secchi Disk (m)	**6.2**	**--**	**16.5**	**--**	**--**	**--**

[a]Bortleson et al. (1976)
[b]Dion and Embrey (1981)
[c]Frenzen et al. (1995)

Invertebrates:

Scharnberg (1995) sampled Venus Lake from 1992-94 and found zooplankton communities dominated by *Holopedium gibberum* and rotifers. He attributed the high percentage of non-palatable species to heavy predation by fish. With the few fish in Venus Lake in 2001, zooplankton populations likely had changed substantially since sampling in 1992-94.

Fishery Resources

Table 80 . Venus Lake fish plants.

SPECIES	DATE	NO.	LBS.	NO./LB.	HATCHERY
TLCT	09/17/79	2,100	11.2	188	Mossyrock
RB	09/25/89	1,505	43	35	Mossyrock

Pre-eruption Fish Populations

Prior to the eruption, Venus was primarily a rainbow fishery occasionally producing a trophy fish such as the 533 mm fish checked in 1975. The rainbow were self sustaining.

Post-eruption Fish Populations

The first post-eruption survey on July 26, 1983, found seven Twin Lakes cutthroat from the 1979 plant, but no rainbow. After stocking rainbow fingerlings in 1989, six rainbow were collected in a July 30, 1992 gill net. These fish were likely age III+ and averaged 274 mm. A two-day gill net set (July 29-30) in 2001 yielded only one rainbow, but it was huge. This age VI+ fish was 600 mm and weighed 2,950 g.

A catch rate of 0.02 fish/hour indicated that few rainbow were left in Venus and that spawning success was quite limited. Two small inlet streams offered minimal habitat, and the outlet was blocked with debris.

Table 81. Venus Lake Twin Lakes cutthroat trout fishery surveys.

Date	**7/26/83**	**7/30/92**	**7/18/95***	**9/19-22/95[a]**	**7/31/01**
Sampling Method	**Gill Net**	**Angling**	**Gill Net**	**Gill Net**	**Gill Net**
Number Collected	**7**	**0**	**0**	**0**	**0**
Mean Fork Length (mm)	**296[b]**	**--**	**--**	**--**	**--**
Range	**--**	**--**	**--**	**--**	**--**
Mean Weight (g)	**275**	**--**	**--**	**--**	**--**
Mean Condition Factor (K)	**0.98**	**--**	**--**	**--**	**--**
Catch/hr	**--**	**--**	**--**	**--**	**--**

[a] Crisafulli (2002)

[b] Age IV+

Table 82. Venus Lake rainbow trout fishery surveys.

Date	7/26/83	7/30/92	7/18/95*	9/19-22/95[a]	7/31/01
Sampling Method	Gill Net	Angling	Gill Net	Gill Net	Gill Net
Number Collected	0	6	0	0	1
Mean Fork Length (mm)	--	274	--	--	600[b]
Range	--	252-294	--	--	--
Mean Weight (g)	--	227	--	--	2950
Mean Condition Factor (K)	--	1.09	--	--	1.37
Catch/hr	--	--	--	--	0.02

[a] Crisafulli (2002)
[b] Age VI+

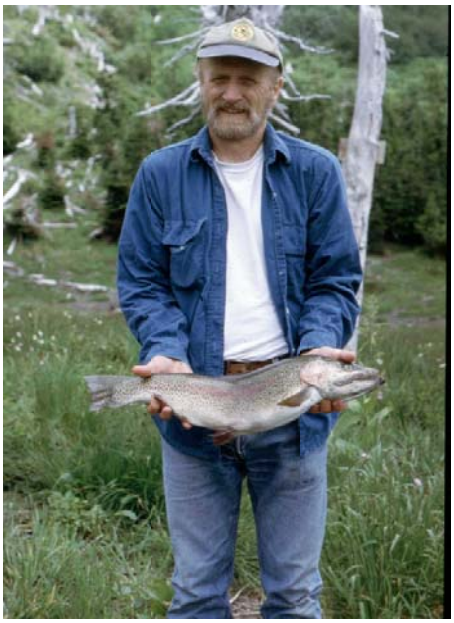

Figure 63. Venus Lake rainbow trout-7/31/01.

Recreational Use

Venus is open for day use only. No trailed access is provided; visitors cut off the Lakes Trail (#211) to access Venus Lake. Several tents were observed during our visit in 2001.

Future Management

Because of limited spawning success in Venus, it should be restocked with rainbow. As Venus can grow large trout, a low planting rate of 30 fish per acre is recommended. Follow-up surveys are necessary to determine the appropriate planting frequency.

DISCUSSION

Water Chemistry

Organic and inorganic inputs from the eruption greatly enhanced nutrient loads for lakes within the area affected by the May 18, 1980, eruption of Mount St. Helens. Direct tephra fall into lakes provided immediate loading, and subsequent hillside erosion continued to bring nutrients to these lakes. Dissolution of these inorganic materials increased concentration of minerals.

The blast wave fell trees directly into many lakes increasing organic input. Even 20 years after the eruption, Castle, Spirit, St. Helens, and Grizzly still had large log rafts which were a source of nutrients. Spirit Lake received substantially more nutrients from the eruption than other lakes. These nutrients were derived from massive inputs of pyroclastic material, ash, and organic material blasted into the lake. Coldwater and Castle Lakes were formed when their stream drainages were blocked by debris avalanche material. Because the area flooded by these lakes contained topsoil and logs, they received comparably more nutrients than many other lakes in the area. This phenomenon was similar to initial productivity increases when reservoirs are created by damming rivers.

Some lakes were transformed from oligotrophic before the eruption to eutrophic afterwards. There were long time gaps between our measurements, and detailed analysis was not possible for most lakes. Still, it appeared that nutrient loading peaked in most lakes within a year or two after the eruption. Generally, productivity in these lakes has gradually declined and eventually will likely drop to pre-eruption levels.

Other than normal oxygen deficits in the hypolimnion, anoxic conditions in epilimnion zones were only found in Spirit Lake. Oxygen depletion was not a problem in Spirit Lake after 1981.

Table 83. Water quality data summary.

	Temperature (C)		Specific Conductivity (µS/cm)		Dissolved Oxygen (mg/l)		pH	
	Surface	3 m	Surface	3 m	Surface	3 m	Surface	3 m
Boot (7/25/01)	14.34	12.06	21	21	9.14	9.75	6.59	6.58
Castle (7/2/01)	18.85	16.14	51	51	9.33	9.29	7.29	7.27
Coldwater (7/29/01)	15.92	14.96	54	53	9.24	9.20	7.12	7.18
Elk (7/11/00)	15.55	14.79	44	44	8.41	8.60	7.24	7.18
Fawn (7/11/00)	16.24	16.21	53	53	8.23	8.02	7.73	7.70
Ghost (6/30/98)*	17.8	–	39	–	8.3	–	7.1	--
Grizzly (7/25/01)	15.68	10.52	23	28	8.84	9.20	6.40	6.27
Hanaford (7/11/00)	15.56	15.15	38	38	8.45	8.31	7.16	7.14
Holmstedt (7/25/01)	14.39	8.15	19	24	8.94	9.58	6.64	6.42
Island (7/25/01)	15.09	11.14	14	14	8.54	9.61	6.55	6.53
Little Venus(7/29/01)	15.60	15.52	14	14	8.13	8.04	6.51	6.61
Obscurity (8/23/02)	14.22	13.39	20	19	9.35	9.14	7.30	7.15
O'Conner (7/25/01)	18.41	12.92	20	20	7.93	8.22	6.50	6.34
Panhandle (7/25/01)	14.45	13.32	17	17	9.22	9.69	6.67	6.73
Ryan (8/22/01)	18.14	18.13	45	45	7.53	7.40	6.77	6.97
St. Helens (9/9/00)	11.54	11.31	46	46	8.66	9.02	7.08	6.96
Shovel (7/25/01)	15.04	12.63	18	18	8.87	9.61	6.64	6.64
Snow (7/25/01)	16.36	13.85	27	26	8.69	9.06	6.83	6.94
Spirit (7/26/00)	17.93	17.16	243	243	8.42	8.53	7.87	8.03
Strawberry (8/23/02)	18.56	17.00	26	26	8.83	8.55	8.27	7.95
Tradedollar (7/11/00)	16.77	14.15	40	40	8.27	8.41	7.17	6.47
Venus (7/29/01)	13.04	13.01	13	13	8.74	8.48	6.33	6.53

***mean values from several locations**

Zooplankton

Initially, zooplankton diversity and abundance in many lakes declined after the eruption (Scharnberg 1995). Turbid water from tephra fall and erosion curtailed phytoplankton production. As water clarity improved, primary production increased, bolstering zooplankton communities.

Trophic status and predation were significant factors influencing zooplankton communities for 18 lakes in the Mount St. Helens area studied by Scharnberg (1995). Extreme predation caused distressed zooplankton communities. Shovel, Panhandle, and Obscurity had stunted brook trout that severely cropped zooplankton numbers. Snow, Boot, and Grizzly were fishless, but predatory *Chaoborus* substantially reduced palatable zooplankton. Generally, lakes with moderate numbers of fish, e.g., Venus and St. Helens, had a more balanced zooplankton community.

Hanaford, Fawn, Castle, Coldwater, and Spirit Lakes were classified as productive lakes. Zooplankton populations in these lakes usually were more diverse and abundant than in less productive lakes.

Fish Populations

Initial concerns that fish were destroyed in most blast zone lakes were unfounded. Many lakes were covered with ice which protected them from eruption impacts. Even though St. Helens Lake was severely impacted by the eruption, lake trout survived due to the low surface area to volume ratio in the lake. Fish in Spirit Lake disappeared because of high temperatures from the blast and anoxic conditions throughout summer and fall of 1980. Although no survey data were available to verify fish presence in Grizzly or Snow Lakes before 1980, these lakes were planted in 1979 and possibly supported fish. Since both lakes were first surveyed in 1984, absence of fish did not necessarily indicate mortality from the eruption. Without reproduction, five years is a long time for Twin Lakes cutthroat to maintain a viable population. Also winterkill might have been a factor. Brook trout in Boot Lake were killed by the eruption. Why fish were destroyed in Boot, while fish survived in lakes within a mile radius remains a mystery. Possibly blast and heat effects were inconsistent, and some lakes received disproportionately more damage. Also, basin morphology was likely a factor.

Brook Trout

Brook trout populations survived in all lakes except Boot and possibly Ryan (Table 84). In general, limited recruitment due to ash in spawning areas and turbid water reduced populations. It was difficult to chart changes through time, as often more than ten years elapsed between surveys. Inventories of Meta, Panhandle, Obscurity, and Shovel indicated that lower recruitment and increased lake productivity resulted in better growth and larger size. As populations expanded due to improved spawning success, brook trout in these lakes reverted back to stunted populations. Brook trout in relatively productive lakes, such as Fawn and Hanaford Lakes, were larger with better condition factors.

Rainbow Trout

Rainbow trout in Tradedollar Lake survived the eruption and maintained a viable population (Table 85). Venus Lake rainbow had been maintained by periodic stocking. Initially planted in 1989, Coldwater Lake rainbow were self sustaining. Some planted rainbow in Coldwater Lake emigrated out and moved upstream into Castle Lake. Coldwater and Castle Lakes were extremely productive due to nutrient inputs from the eruption and leaching of drowned and floating organic material. Rainbow thrived in these lakes, and growth rates were much higher than observed in many western Washington lakes. No rainbow trout were found in Little Venus Lake during sampling in 1983, but a few were collected in 1989. By 2001, rainbow in Little Venus were quite small and emaciated due to over population.

The first rainbow in Spirit Lake was collected in 1993. High water temperature during the eruption and long periods of anoxic conditions undoubtedly killed all fish in Spirit Lake. Therefore, this rainbow was likely directly planted or progeny of fish illegally planted in the lake. We received several reports of fish stocked during tunnel construction in 1985. It would have been difficult to bring in large numbers of fish, so likely few fish were stocked. With limited spawning opportunities, fish numbers remained low until around 2000 when the population expanded rapidly. Growth rates of rainbow in Spirit Lake were exceptional, as age III fish collected in 2002 averaged 562 mm.

Table 84. Fish survey summary for eastern brook trout.

Date	Elk 7/12/00	Fawn 7/11/00	Forest 7/12/00	Hanaford 7/12/00	Meta 6/99	Obscurity 8/24/02	Panhandle 7/26/01	Ryan 8/22/01	Shovel 7/26/01	Straw-berry 9/24/02
Sampling Method	Gill Net	Gill Net	Angling	Gill Net	Angling	Gill net	Gill Net	Gill Net	Gill Net	Gill Net
Number Collected	18	18	6	9	100	12	33	2	19	15
Mean Fork Length (mm)	219	252	223	331	208	189	177	251	185	199
Range	160-316	164-371	184-250	190-395	165-350	161-275	165-193	242-260	169-212	140-221
Mean Weight (g)	129	199	131	452	74	64	56	199	66	73
Mean Condition Factor (K)	1.16	1.10	1.16	1.16	0.81	0.88	1.00	1.23	1.03	0.89
Catch/Hour	0.87	0.96	--	0.42	--	0.64	1.71	0.11	0.98	0.79

Table 85. Fish survey summary for rainbow trout.

Date	Castle 7/2/01	Coldwater 6/29/01	Little Venus 7/31/01	Spirit 7/31/02	Tradedollar 7/11/00	Venus 7/31/01
Sampling Method	Angling	Angling	Gill Net	Angling	Gill Net	Gill Net
Number Collected	74	35	20	60	15	1
Mean Fork Length (mm)	285	267	181	553	235	600
Range	142-378	157-438	158-248	300-660	162-304	--
Mean Weight (g)	228	300	66	2,140	157	2,950
Mean Condition Factor (K)	0.88	1.24	1.03	1.20	1.08	1.37
Catch/Hour	4.40	2.44	0.42	3.93	0.78	0.02

Cutthroat Trout

Twin Lakes cutthroat were stocked in a number of alpine lakes in the Mount Margaret backcounty area before the eruption. Cutthroat survived eruption impacts in Hanaford, Fawn, Island, Venus, Little Venus, O'Conner, and Tradedollar Lakes (Table 86). Even though Twin Lakes fish were planted in Boot, Elk, Forest, Meta, Panhandle, and Shovel lakes during the 1970s, likely these cutthroat plants were unsuccessful due to intense competition with brook trout. Holmstedt, Snow, and Grizzly were stocked with cutthroat in 1979; no fish were found after the eruption. Mortality in these three lakes could be from factors other than the eruption.

Hanaford and O'Conner were the only lakes stocked with Twin Lakes cutthroat on a regular basis. Twin Lakes stock were reproducing in Island Lake, and self-sustaining rainbow crowded out cutthroat in Little Venus and Tradedollar. Ghost Lake had coastal cutthroat which were reproducing successfully.

Table 86. Fish survey summary for Twin Lakes cutthroat trout.

Date	Hanaford 7/12/00	Island 7/26/01	Little Venus 7/31/01	O'Conner 7/26/01	Tradedollar 7/11/00
Sampling Method	Gill Net	Gill Net/ Angling	Gill Net	Gill Net	Gill Net
Number Collected	4	3	1	14	1
Mean Fork Length (mm)	287	326 Age III+	170	284	155
Range	152-347	285-352	--	242-335	--
Mean Weight (g)	322	395	48	248	35
Mean Condition Factor (K)	1.18	1.09	0.98	1.08	0.94
Catch/Hour	0.19	0.10	0.02	0.71	0.05

Future Management

Most lakes within the area affected by the May 18, 1980, eruption of Mount St. Helens have self-sustaining trout populations including brook, cutthroat (coastal and Twin Lakes), rainbow, and lake trout. Angling opportunity in several lakes is maintained by stocking. When the Mount St. Helens National Monument Fish and Wildlife Plan (1989) was signed by US Forest Service, Washington Department of Fisheries, and Washington Department of Wildlife, the intent was to strike a balance between providing recreational opportunities and protecting natural recovery.

It has been 22 years since the eruption. Agencies need to review the Fish and Wildlife Plan to discuss new issues, such as the unanticipated presence of fish in Spirit Lake. Also, the moratorium on fish stocking of lakes needs to be revisited to determine if there are still valid reasons to preclude stocking.

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