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Management of Washington's High Lakes

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1.0 EXECUTIVE SUMMARY

The purpose of this report is to document Washington Department of Fish and Wildlife's (WDFW) high lakes management goal, objectives, and strategies, and guidelines for management. For specific details of facts or figures contained within this report see *Washington Department of Fish and Wildlife's High Lakes Fishery – Final Report* (Pfeifer et al. 2001). A copy of this report can found on-line at: www.wa.gov/wdfw/fish/high_lakes.

The management goal for fish populations in Washington's high lakes is to:

> ***Protect, restore, and enhance fish populations and their habitats in high lakes while maximizing recreational opportunities consistent with natural resource protection guidelines***.

Washington Department of Fish and Wildlife's (WDFW) high lakes program is an integral part of the Agency's overall trout program. People have been traveling to the high elevations of the Olympic Peninsula and Cascade mountain ranges for over 100 years to take part in this extraordinary recreational experience. An estimated 128,000 license-buying anglers use Washington's high lakes annually. This equates to over a million angler days per year. This activity has an estimated annual worth of nearly $34 million while WDFW's cost associated with managing the program is estimated to be around $40,000. Because many of the high lakes support self-sustaining fish populations, and because many of the lakes are stocked by organized volunteers groups, the program is one of the most cost-effective program administered by WDFW.

Lake Management Strategies.

WDFW manages each high lake with one of following three basic management strategies. Fishless lakes are managed for native wildlife species only, with no trout stocking. These lakes are found across the landscape especially in designated wilderness areas and the state's national parks. Quality Fisheries are lakes where the local manager regulates fish stocking frequency and density to produce fish of high quality, but not necessarily quantity. Production water are lakes that have no native wildlife species preservation concerns, are regularly stocked or have self reproducing fish populations, have high angler use levels, and easy access.

The result of these strategies provide:

1. Protection of native species,
2. A diversity of fishing opportunities,
3. Consideration for ecological impacts of fisheries and fish presence, and
4. Avoids the development of self reproducing populations.

Of the more than 4,700 high lakes and ponds in Washington, at least 2,940 (62%) are fishless, an estimated 1,000 of the lakes have self-sustaining populations and only about 800 (17%) are periodically stocked.

Management Guidelines.

Fish Stocking. As a general fish stocking guideline, high lakes should be managed for a total standing trout density of no more than 50 to 100 fish per surface acre. Fish stocks which have demonstrated an inability to successfully reproduce in Washington's high lakes should be considered first. Management of high lakes is not driven by catch rates, instead stocking strategies (densities and species) are used to address ecological issues such as impacts to native fauna, down stream impacts, and the general overall productivity of the lake. However, within the confines of stocking densities guidelines, and frequency at which lakes are stocked, there are opportunities to refine lake management to meet a desired catch rate. For lakes that are managed for quality fisheries the catch rate objective should be three 11-13inch fish per day. For lakes that are managed for production fisheries an expected catch rate is five fish per day. This includes those waters with self-sustaining populations at undesirable levels.

Field Investigations. Inventory Methods for information on certain physical, chemical, and biological parameters is essential to any management approach for high lakes trout fisheries. For consistency among data sets, the following forms are suggested for use: High Lake Fishing Report Form: Appendix A, and the Alpine Lake Field Survey Form Appendix B.

Ecological Considerations. WDFW local managers will practice continued diligence managing high lakes to be certain that fish species and stocks do not pose any realistic chance of hybridizing or competing with native fish in downstream receiving waters, and avoid unacceptable ecological impacts.

2.0 INTRODUCTION

Washington Department of Fish and Wildlife's (WDFW) high lakes program is an integral part of the Agency's overall trout program. People have been traveling to the high elevations of the Olympic Peninsula and Cascade mountain ranges for over 100 years to take part in this extraordinary recreational experience. An estimated 128,000 license-buying anglers use Washington's high lakes annually (Michael, 2004) and has an estimated worth of nearly $34 million (U.S. Department of Interior, et al., 2003). WDFW's cost associated with managing the program is estimated to be around $40,000 (Pfeifer et. al. 2001). Because many of the high lakes support self-sustaining fish populations, and because many of the lakes are stocked with low-cost small fry by organized volunteers groups (Trailblazers, Highlakers, and Backcountry Horsemen), the program is one the most cost-effective program administered by WDFW.

WDFW's high lake fishery program includes those lakes in western Washington above 2,500 feet mean sea level and above 3,500 feet in eastern Washington. These elevations encompasses the sub-alpine and alpine habitat zones. Since the alpine zone is defined as above the timberline and lies well above 2,500 feet in western Washington the term "high" lake is preferred to alpine lake.

The water bodies in the high lakes program vary in size and may be categorized using terms such as "lake" and "pond" or "tarn". The overwhelming majority of alpine and subalpine waters being maintained for trout fisheries in Washington are at least large enough to appear on standard 7.5 minute U.S. Geological Survey (USGS) topographic maps. Smaller waters (between 0.1 to 0.2 acres) tend to be omitted from these 1:24,000 scale maps. Most of these do not support fish, but do provide important, or critical habitat for amphibians and invertebrates (Kezer and Farner 1955; Anderson 1967; Fukumoto and Herrero 1998). Of the more than 4,700 high lakes and ponds in Washington, at least 2,940 (62%) are fishless, an estimated 1,000 of the lakes have self-sustaining populations and only about 800 (17%) are periodically stocked.

The purpose of this report is to document WDFW's high lakes management goal and objectives, and the strategies for their implementation and evaluation.

Management Goal and Objectives. Washington Department of Fish and Wildlife's mission statement of "*Sound Stewardship of Washington's Fish and Wildlife Resources"* has as one of it's goals to "Maximum fishing, hunting and non-consumptive recreational opportunities compatible with healthy, diverse fish and wildlife populations". Goals specific to fish management include providing for significant recreation opportunities through artificial propagation programs and providing a diversity of fishing opportunities. The management goal of fish populations in Washington's high lakes is to:

> ***Protect, restore, and enhance fish populations and their habitats in high lakes while maximizing recreational opportunities consistent with natural resource protection guidelines***.

Objectives: The fish resources in high lakes will be managed with objectives that when met will achieve the high lakes management goal. They are:

- Maintain the productivity and diversity of native fish and wildlife populations and their habitat in high lakes at healthy levels,
- Maintain introduced fish stocks at desired levels in high lakes consistent with native resource needs (protection from hybridization, and significant interspecific competition),
- Provide a diversity of recreational fishing opportunities in high lakes that are desired by the public and consistent with native resource needs,
- Promote a conservation ethic associated with the high lakes fishing experience, and
- Promote effective coordination and communication of management objectives and actions with land managers, constituents, and other agencies.

3.0 MANAGEMENT HISTORY

Prior to the formation of the Washington Department of Game (WDG) in 1933, fish and wildlife resources were managed by county governments. At that time many high lakes in the Cascades and Olympics had already received their initial fish introductions from U.S. Fish and Wildlife Service (USFWS) and counties. Significant negative ecological impacts associated with excessive trout abundance in some high lakes today are the direct result of unknowing mistakes made by early non-governmental parties, as well as federal, county, and state agency staff. Many of the stunted eastern brook populations in Washington high lakes were established through fish introductions made at that time.

Beginning in 1933 WDG assumed control of the high lakes fish stocking programs. Examination of the historical stocking records shows that relatively high stocking densities were the rule more than the exception, with levels of more than 1,000 trout per surface acre occurring frequently.

Over the next 35-40 years WDFW's progress in development and management of the fishery closely paralleled that seen in other states. The performance of various strains and species of trout and char were empirically tested in waters of varying productivity and setting. Methods were developed and refined for stocking fry using backpack and aircraft to replace the old U.S. Forest Service (USFS) pack strings or miners lugging milk cans. More rigorous methods were developed for surveying the lakes and their fisheries beginning in the early 1970s. Initial chemical treatments were made on high lakes to replace stunted, excessively abundant brook trout. They were replaced with a controlled population of trout that were compatible with the alpine lake ecosystem. Methods were

developed for more complete and error-free data collection, monitoring, database management, and reports.

A lengthy list of fish species and stocks have been introduced into Washington high lakes since the early 1900s (Table 1). The earliest introductions used the most commonly-available salmonid game species. Since many of the earliest introductions were made by federal agencies, fish were commonly obtained from federal hatcheries.

Eastern brook trout may have been the first species officially stocked, but cutthroat and kokanee were also available between 1911 and 1915 from early local hatcheries such as Lake Whatcom (Whatcom County), Tokul Creek (Snohomish County), and Twin Lakes (Chelan county near Leavenworth)(Crawford 1979).

A wide variety of rainbow trout, including winter-run steelhead, have been stocked. Several other varieties (Entiat, Shasta) were obtained from federal hatcheries between 1970 and 1990, and were experimentally stocked to evaluate their growth and performance in a limited number of lakes.

Millions of westslope cutthroat fry (*Oncorhynchus clarki lewsi*) have been stocked into scores of different high lakes, most of which originated from Twin Lakes. As a result, the range of this strain has been artificially extended in Washington (Behnke 1992; Williams 1999). Coastal cutthroat (*O. clarki clarki*), generally from Tokul Creek (originally from Lake Whatcom), are the second most-stocked strain. A small number of lakes were planted with Yellowstone Lake and Henry's Lake cutthroat (*O. clarki bouvieri* sometimes called Montana Blackspots); a few lakes have developed naturalized populations of this strain.

Brown trout (*Salmo trutta*) have been stocked on a very limited, experimental basis, primarily to test their ability to serve as a top predator, and control stunted fish populations. The Ford Hatchery stock (Scottish Loch Levan variety) is believed to be the only one that has been used.

Table 1. Fish species used in Washington high lakes programs.

Species	Stock	Year Introduced	Sponsoring Agency
Eastern Brook	Unknown	1914	USFS
Rainbow	Unknown	1917	USFS
Rainbow	Kamloops	1932	Unknown
Rainbow	Mount Whitney	1946	WDG
Kokanee	(Lake Whatcom presumed)	1917	USFS
Cutthroat	Unknown	1909	NPS
Cutthroat	Coastal (Tokul Creek)	1957	WDG
Cutthroat	Lahontan	1954	Unknown
Cutthroat	Westslope (Twin Lakes)	1915	USFS
Cutthroat	Yellowstone (MBS)	1914	USFS

Lake Trout	Unknown	1920	Unknown[1]
Golden Trout	(California)	1936	WDG
Grayling	Unknown	1945	WDG
Steelhead	Coastal / Puget Sound	1916	Unknown[2]
Atlantic Salmon	Unknown	1975	WDG
Brown Trout	Unknown	1935	WDG
Coho Salmon	(Coastal/P. Snd. presumed)	1918	USFS
Chinook Salmon	Wallace (Skykomish) River	1999	WDFW

[1] Source: Piper & Taft (1925); probably USFS.

2 Source: Trail Blazers, Inc. database; probably USFS.

Lake trout (*Salvelinus namaycush*) were introduced into Washington high lakes very early, with the first introduction to Lake Isobell [sic] in Snohomish County apparently occurring in 1920 (Piper & Taft, Inc. 1925). Another naturalized population exists in Eightmile Lake in Chelan County. They have been tested on an extremely limited basis (two lakes) since 1980 for biological control purposes.

Grayling (*Thymallus arcticus*) were stocked in a number of locations as early as the 1920s, but only survive in one (high) lake in Skagit County. Attempts were made in the late 1980s to develop a high lake near North Bend as a grayling brood stock lake, and several fry introductions were made. The effort failed due to predation by the wild rainbow reproducing in the lake. There is currently no brood stock in Washington, nor plans to develop one.

Kokanee (*O. nerka*) were stocked in numerous high lakes in the early 20th century, but their use essentially ceased by 1950. They established reproducing populations in many lakes. They are only occasionally stocked now, primarily to augment forage for lake trout in one or two lakes.

Atlantic salmon *(Salmo salar*) have been tested in a number of high lakes. Results have either been spectacular, or dismal failures. When stocked into barren waters, they exhibit excellent growth, and superb sporting qualities. However, when forced to compete with other species, particularly rainbow, they tend to do very poorly.

Golden trout *(O. aquabonita*) have been stocked intermittently since 1938. Inconsistent availability of eggs from other western states, particularly after 1970, was recognized as a major problem with this species. When eggs were available, up to 27 lakes are stocked in as many as 10 counties.

Though many fish species have been tried in the past, golden trout, Mt. Whitney rainbows, Westslope cutthroat, coastal cutthroat and in a few places eastern brook trout are the only fish species used in the current high lakes program. Fish species not native to the drainages are only allowed in waters where they cannot emigrate from the lake they are stocked, to downstream receiving waters.

4.0 CURRENT MANAGEMENT STRATIGES

WDFW generally manages each high lake with one of three basic management approaches: Fishless lakes, quality fishing waters, and production waters.

4.1 Fishless Lakes (ponds and tarns) – or "Special Protection Waters"

- are managed for native wildlife species only, with no trout stocking. These lakes are found across the landscape especially in designated wilderness areas, and the state's national parks. These waters may or may not have historically contained fish. With the exception of 15 lakes in North Cascades National Park, no trout stocking occurs in lakes and ponds in the state's national parks (Olympic, Mt. Rainier, North Cascades), or in a number of waters in Natural Resource Conservation Areas managed by the Washington Department of Natural Resources (Class 3 and 4 waters). This results in literally thousands of lakes and small tarns that have no fish and can be managed and studied for their natural condition and ecological communities. This management approach also provides many lakes and ponds across the landscape that can serve as habitat or refugia for various species of invertebrates or amphibians. Although the percentages vary from region to region, an average of 62 percent of ponds and lakes larger than 0.1 acre are managed for a fishless condition.

4.2 Quality Fishing Lakes-

are lakes where the local manager regulates fish stocking frequency and density to produce fish of high quality, but not necessarily quantity. Fishing may range from fast to slow, depending on factors such as weather, insect hatches, etc. Most waters in this class are on a periodic stocking cycle, so fish abundance is low in some years, leading to slow fishing. This is offset by the important objectives of preservation of all invertebrate taxa in the lake, and production of consistently high quality trout. There are a very few high lakes in this classification that have naturally-reproducing fish that alone can support a recreational fishery, most require some level of stocking.

4.3 Production Fishery Waters –

Include all lakes that have naturally-reproducing trout or char populations where fish are excessively abundant. This is not a desirable situation and WDFW will work to correct this wherever possible. Other lakes managed with this approach include those having all of the following characteristics: regularly stocked, high angler use levels, and easy access. These lakes have no special native wildlife species preservation concerns.

5.0 MANAGEMENT GUIDELINES

This section identifies the current highlake management guidelines. These guidelines should be considered WDFW expectations and standards for: Record keeping, Field sampling methods, Data management, Fish Stocking, Catch Rates, Ecological Considerations such as species conflicts and population control, Diversity of opportunity, and Public Outreach.

5.1 Record Maintenance –

Experience has shown that information on certain physical, chemical, and biological parameters is essential to development of a successful management plan for high lakes or ponds supporting trout fisheries. This basic information can help determine if a lake needs to be stocked, what species may be appropriate, and give a preliminary estimate of the stocking density.

Guideline 1: Record Maintenance - Highlakes that are actively managed for fishing should have some basic information on file. At the very least the file should have the name of the lake (if available), a map of the lake (for sources see 7.5 min. U.S.G.S. quad or Topozone http://www.topozone.com/default.asp), and geographic location using the MUCODE or latitude and longitude in degrees, minutes, and seconds (GPS reading), Section, Township, and Range, or, county name, any stocking history, known fish species presence, and any results of past fisheries.

5.2 Field Investigations--

The following section sets guidelines regarding field sampling requirements and methodologies, and reporting. There are three levels of surveys:

Level 1 surveys – Standard annual monitoring includes fishery monitoring parameters and temperature information. (Section 5.2.1)

Level 2 surveys – Level 1 monitoring plus physical description and water chemistry parameters. This level is generally collected for lakes that do not have the existing baseline data (Section 5.2.2).

Level 3 surveys or baseline data collection – Level 2 surveys plus those parameters included in the baseline data section (Section 5.2.3). Level 3 surveys will be required on lakes proposed for rehabilitation through the use of chemical pesticides.

5.2.1 Fishery Monitoring Methods - Monitoring includes periodic or annual collection of information on trout growth rates, angler use, angler catch success, quality of fishing (angler satisfaction), and environmental impacts at lakes for which a fishery has been established. Monitoring typically occurs on lakes which have long histories of fish presence and angler use, but also includes waters that are visited by only a few individuals annually. It does not include the data collection required to catalogue the existing habitat and fish population conditions when a "baseline" survey is first completed. (There are still numerous fish-bearing high lakes in Washington that have not yet received a baseline survey.).

5.2.2 Physical Description and Water Chemistry - Information includes location, GPS reading, lake area and maximum depth; an estimate (or calculation) of

mean depth; location and character of tributaries and outlet/s, length accessible to trout, and the amount of spawnable habitat; and the nature of the nearshore lake bottom (littoral zone). Water chemistry parameters include pH, hardness, total alkalinity, and conductivity.

5.2.3 Baseline data – Map of lake bathymetry, nearshore and bottom composition, spawning area, shoreline development, geomorphic lake type, number of inlet and outlet streams, the presence of any toxic elements, such as heavy metals. Biological information includes presence or absence of fish; the age structure of any population found; growth and condition of fish; and any evidence of successful reproduction, such as fry in spawning areas, or a population age structure that does not correlate with the water's stocking history. Additional biological information is the diversity and relative abundance of invertebrate food resources, and the presence of rooted aquatic plants. Other valuable information that does not fit neatly into these three categories includes access difficulty, and evidence of the level of human use of the lake vicinity

Guideline 2:Number of Annual surveys - A goal of 10 lakes per year should be surveyed for each region (excluding Region 1) with one of the three survey levels above.

Guideline 3: Report Forms - For consistency use the High Lake Fishing Report Form (Appendix A). Key information includes the survival of the previous fish introduction (relative abundance and catch rates), fish growth and condition, evidence of reproduction, the number of anglers and other users at the lake, use/campsite impacts, and access conditions.

Guideline 4: Field Survey Forms - For consistency among data sets use Alpine Lake Field Survey Form for items 5.2.1 and 5.2.3. in Appendix B. For methods see Pfeifer 2002, Lind 1985, or Methods from Bahls 1989.

Guideline 5: Reports from volunteers - For consistency volunteers should use the same forms cited above. Periodic training of volunteers may be necessary to ensure quality control. Storage of data from these groups must identify source individual and affiliated club.

Guideline 6: Because of the key role volunteer groups play in WDFW's high lake stocking and monitoring programs, and the link they provide to the public at-large, time should be spent each year by local fishery management biologists, to maintain an adequate amount of coordination/communication with them.

5.3 Data Base Management-

While most of the local WDFW high lake management biologists retain the original field data forms, lake sketch maps, and notebooks from baseline surveys, few have converted much of the field data to electronic databases. The degree to which these summary files, or lake by lake management plans have been completed varies from region to region. Most of the other biologists are using spreadsheets to catalogue lake-by-lake data and brief management recommendations.

Guideline 7: Data storage - High lake management biologists need to make every effort to record any existing field data forms to electronic databases. The format is shown in Appendix C of this report. If this cannot be accomplished at the regional level hard-copies of the files should be made and sent to Olympia Resident Fish Management for entry. A statewide data base will be maintained at headquarters.

5.4 Fish Stocking –

All available fish stocking records back to 1901 have been entered into an Access database in WDFW's Olympia headquarters. Old unrecorded files are added to the data base as they are discovered. New stocking information is entered into the database on a monthly basis as the hatcheries submit their stocking summaries at the end of the month. High lake stocking generally begins in June, and ends in October, although some unusual introductions have occurred as late as mid-December.

High lake stocking data management varies among the regional offices. Some district biologists maintain records in databases or spreadsheets on their office PCs. Some regions continue to update the "Record of Planting" cards. A general problem is lack of a consistent, standardized approach to management of these data among the regions, and between the regions and agency headquarters. Some regions rely on the Hatchery Program (which dispenses the fish to volunteers and sponsors) to follow the allotments, and to track and make an accurate accounting of what gets stocked. This is then recorded in the central database, an updated electronic copy which is annually sent to the regions for review. Other regions check stocking data accuracy earlier in the process by reviewing hatchery stocking sheets which are submitted to the central database.

Inconsistency problems regarding hatchery stocking information exist between regional records, and those logged in the WDFW central database. While the inconsistencies are not large (affecting many records, or involving large value errors), they are chronic. Most relate to problems of identification of the specific lake or pond actually stocked. This problem is almost always limited to small, unnamed lakes or potholes where a location descriptor such as a quarter Section is insufficiently precise to eliminate confusion with a nearby water body. The second most frequent problem is confusion over the name of a stocked water. Both of these problems can be corrected by local fishery managers if they review

the hatchery stocking sheets. Headquarters data entry staff do not have the intimate knowledge of the lakes, or the regional fry stocking allotments, to catch errors of naming or location that occasionally occur on the monthly hatchery stocking summary.

Guideline 8: Stocking Plans - High lakes fish stocking plans should be finalized annually by June 1 to facilitate coordination and logistics for the stocking season.

Guideline 9: Review of Hatchery Plants - High lake fishery managers should review hatchery stocking sheets for errors and provide corrections when the annual stocking summary is mailed to the regions for review. It is important to include the MUCODE or WBID number of each water stocked. If the MUCODE or WBID number is not known, use the latitude and longitude in degrees, minutes, and seconds from a GPS unit. Corrections should be sent, in a timely manner, to the Hatchery Data Unit in Olympia for inclusion in the stocking data base.

5.5 Stocking Considerations –

The following section describes the managerial, biological, and logistical considerations that WDFW district fishery biologists assess when making first-time, or annual decisions to stock high lakes in Washington.

5.5.1 Assessment of existing natural trout reproduction - Most, if not all of the district fish biologists determine the presence of natural reproduction through one or more of the following means:

- Reconciliation of the observed age or size composition of the population with the stocking record,
- Observation of fry in the lake or in spawning areas;
- Angler reports of the above kinds of information (preferably with follow-up field verification).

In many cases a determination of reproduction hinges on the accuracy of the stocking record. Multiple age groups in the fish population, and equivocal information on spawning habitat shift the evidentiary dependence to the stocking record. This is probably the most important reason for rigorous accuracy in annual stocking records, and the need to ferret out errors from the historical record as much as possible. It is easy to see how illegal or unauthorized stocking can make the determination of reproduction more difficult. The presence of young fish, or fish whose age does not agree with the official stocking record, can lead an inexperienced biologist to assume they were the result of reproduction.

Most of the lakes being managed for trout fisheries have long stocking histories, and many years of angler reports which may often provide sufficient information to verify active reproduction. If a gill net set or two, and multiple hours of lake observation and angling fail to produce any sign of fish, especially on a second or third trip, it is a fairly safe conclusion that if any reproduction exists, it is at a very low level. This can be supported by a habitat survey that shows little or no available spawning habitat.

5.5.2 Stocking Frequency and Density- Although stocking frequency and density are two of the most important aspects of high lake fisheries management, there has been relatively little rigorous research in Washington on the underlying factors which determine them, such as natural and angling mortality of trout in high lakes, or angling effort (trips or cumulative hours spent fishing). WDFW has not prepared a thorough analysis or theoretical models which would effectively prescribe stocking levels and frequencies on individual lakes. Although this would be a valuable management tool, it is questionable whether this is even feasible, given the changes that occur in angler use levels, access conditions, and climate, all of which affect trout survival in lakes, even if a lake's basic productivity potential is fairly constant.

Most WDFW local managers adjust their stocking frequencies (cycles) and fish densities to provide "quality" fishing in those lakes where they have the ability to do so (little or no natural reproduction is occurring). Though not the preferred management strategy, there are lakes where trout or non-native char natural reproduction provide an opportunity for "fast" fishing on smaller fish, and thereby offer a consistent fishery for those users who expect to find fish in the lakes. These are often categorized as production type waters. While management objectives definitely vary among lakes, with remote wilderness lakes often being managed differently than high lakes that are heavily visited. Managers should try to strike a balance between consistent opportunity (a minimum average catch rate) and overstocking, with the latter's resultant impacts on fish size and the lake ecology.

Most biologists endeavor to match stocking frequency and fish density with some assessment of angling effort, so as to provide a reasonable expectation of catch success on quality trout, while allowing the fish populations to dwindle to a low level before re-stocking. Stocking frequencies range from annually on lakes that are accessible by roads, or are easily accessible and heavily fished, to once in 10 or more years on remote, seldom-visited wilderness lakes. The statewide mean number of years between stocking is currently about 4 years, although this varies between regions, and is largely dictated by lake access and fishing pressure.

Year to year decisions on fry stocking density and frequency should be based primarily on the historic stocking record on each lake, subsequent trout growth and condition, evidence of survival of vulnerable trout prey, the most up-to-date angler reports from the monitoring program, and if the management strategy is appropriate for the lake.

Guideline 10: Fish Stocking Density - Manage for a single age class and a total standing trout density of no more than 50 to 100 fish per surface acre.

Guideline 11: Stocking Frequency - Stocked once every 3-4 years.
Exception: It is recognized that this varies greatly, with target densities ranging from 10/ac to several hundred/ac. Local managers should never stock at more than 100/ac unless:

1. The lake has received a level 3 survey, and its physical, chemical, and biological characteristics indicate it can support higher densities without unacceptable long term ecological impacts,
2. The manager can demonstrate no long term negative impacts, or
3. The manager can demonstrate that the lake does not have native wildlife concerns.

5.5.3 Species and Stock Selection - To maintain program diversity, strains that are not having a significant negative effect on native biota (e.g. golden trout) can continue to be stocked. Species should not be stocked into lakes where they have not been stocked before; without completing a full SEPA review process. Exotic species such as brown trout, lake trout, Atlantic salmon, tiger muskies, and grayling can be stocked where special circumstances make sound biological sense to do so. Many lakes with stunted trout and non-native char populations cannot be treated with piscicides. They must either remain as is, or receive benefits from a biological control such as a top predator or use blockage of spawning areas. Unusual species that attract high angler interest (golden trout, grayling) can be expanded to a low number of lakes lacking surface outlets if their introduction does not result in unacceptable impacts from increased recreational use.

Guideline 12: Species and Stock Selection –

a) Species should be stocked that are native to the lake's drainage basin (e.g. rainbow, cutthroat), or
b) Fish species and strains should be stocked which have a demonstrated inability to successfully reproduce in Washington's high lakes.
c) New species or stocks should never be planted into a lake that has not received a complete survey and SEPA review.

Exceptions to this rule could include lakes that do not have surface outlets and have no spawning habitat, or lakes where limited reproduction by a top predator may be desired for long term biological control. Even this exception must undergo a SEPA review.

5.5.4 Catch Rate – Management of high lakes are not necessarily driven by catch rates, instead stocking strategies (densities and species) address ecological issues such as impacts to native fauna, down stream impacts, and the general overall productivity of the lake. However, within the confines of stocking densities guidelines, and frequency at which lakes are stocked, there are opportunities to refine lake management to meet a desired catch rate.

Guideline 13: Catch Rates - For lakes that are managed for quality fisheries a reasonable catch rate should be three 11-inch fish per day. For lakes that are managed as production waters an expected catch rate should be at least five fish per day.

5.6 Ecological Considerations -

Strictly speaking, virtually all fish stocked into Washington's high lakes are exotic to the lakes themselves since the vast majority of the lakes were fishless since the last glaciation. The next level of concern is whether the fish stocked are native to the lake basin, or watershed to which it drains. Some stocks, like Twin Lakes cutthroat stocked into lakes that drain to the mid-to-upper Columbia River or, Tokul Creek coastal cutthroat stocked into western Cascade high lakes, are native species in those watersheds and pose no downstream threats to local fish populations. However, these concerns are largely academic unless there is reason to believe the fish will either find their way out of the lakes into which they are stocked, or careless individuals transfer them into other systems supporting native fish.

5.6.1. Use of High Risk Species - Fish species and stock diversity is a very important attribute of the WDFW high lake program. Diversity in the program was identified as a goal in earlier planning (WDG 1981). Recent use of exotic species and strains in carefully selected lakes has not been shown to have adverse effects, but on the contrary, have either added diversity to the catch, or had varying levels of effectiveness in controlling stunted fish populations.

Potential genetic impacts on native fish populations from trout or non-native char stocked into high lakes is one of the most controversial issues stemming from the high lakes program. The presence of some species (eastern brook trout) or stocks (westslope cutthroat) in streams below stocked high lakes may be evidence of dropout. The long history of stocking of various species and stocks into headwater streams in the early part of the 20th century makes this determination problematic in most cases.

Nevertheless, WDFW managers do not want stocked fish interacting with downstream native fish populations.

Guideline 14: Use of High Risk Species - Species that pose the most risk (e.g., eastern brook trout or westslope cutthroat) should be stocked only in lakes where they do not present conflicts with native fish populations downstream, or where they physically cannot migrate or be washed out of the lake.

5.6.3. Population Control Methods - Stocking functionally sterile fish, Guideline 12 (b), is the primary method to control fish populations. This strategy can provide a quality fishing experience while addressing many of the ecological considerations of native biota. Functionally sterile fish are either unable to effectively reproduce due to life history incompatibility with the high lakes environment (e.g. Mount Whitney rainbows), or are unable to produce functional gametes (e.g. triploid trout). The production of sterile triploid trout is a top priority for WDFW's triploid trout program, and the use of these fish will be an integral part of high lakes management.

Sterile triploid trout may not only be an effective population control measure through the lack of recruitment, they may also affect reproduction of undesirable fish populations through the sterile male technique. In this scenario, a sterile triploid trout male spawns with viable females resulting in zero recruitment from those female. Over time, recruitment to the population is reduced. While common in management of insect populations, this technique has not been used on fish. More conventional means of population control employs the use of piscicides or mechanical methods.

Only chemical treatment with rotenone has been shown to eliminate stunted, excessively abundant fish in Washington high lakes. Antimycin is much less toxic to non-target species such as invertebrates and zooplankton, and should be used in lieu of rotenone whenever possible. However, many lakes will remain overburdened by excessive fish production because for one reason or another they cannot be treated with piscicides. Ongoing work in an Idaho high lake with tiger muskellunge has shown great promise in dramatically reducing the abundance of brook trout. A pilot project using the same hybrids was initiated Washington in the spring of 2005.

The use of non-sterile top predators should be limited to lakes where they have no potential for having significant negative interactions with native fish and wildlife, and where they have measurable success in improving the overall condition and quality of stunted trout or char. Brown trout and lake trout should not be expected to effect significant changes in stunted fish abundance in less than 10 years (or more). Monitoring should continue on

the lakes where test introductions have been made, and where initial results show potential for further measurable improvements.

The use of a spawning area exclosure should be tested in a few lakes where the spawning habitat is limited to a few inlets where natural materials can be placed that create barriers to the only effective spawning substrate. In general, this option would be used only if other methods, particularly chemical methods, could not be used, or would likely be ineffective.

Limnological data should be gathered on lakes that have received test introductions of top predators. Although the pre-test conditions are not known, current or final invertebrate species diversity and abundance can be compared to data from other similar vicinity lakes which do not have excessive fish populations. Lakes proposed for new top predator introductions should have their invertebrate communities thoroughly surveyed prior to the predator introduction to enable a better evaluation of the potential benefits of this technique.

Liberalized fishing regulations should not be relied upon to make any significant or lasting reduction in overabundant or stunted fish populations.

Guideline 15: Population Control Methods –

- **a) Highlakes managers should use population control measures only when practical and where resources allow.**
- **b) A list of prioritized lakes needing control of excessive fish populations should be prepared by each region. For each lake, one or more potential control methods should be identified; potential control methods include chemical treatment (Antimycin or rotenone), top predators, spawning habitat exclosure (barriers), or intensive netting or trapping. For lakes to be treated using chemical treatments see procedures and timeline in: Lake and Stream Rehabilitation Project Leader's Handbook (Hisata 2003). For other methods a complete SEPA review will be required.**

5.6.4. Diversity of Recreational Activity – There is no evidence or expectation that the number of users of Washington's high lake fishery is going anywhere but up. "People management" is in many ways a larger issue than fish or fishery management, particularly with respect to meeting the terms and intent of the Wilderness Act of 1964 (Public Law 88-577). Many lakes, particularly those that are off-trail destinations, are largely self-limiting on use, depending on access difficulty. WDFW local managers face the challenge of balancing angler effort with trout abundance, growth rates, and ecological impact, while at the same time considering the effect of the fishery on the land and wilderness values.

Most high lakes in Washington are stocked to provide a consumptive recreational fishery. However, many lakes with reproducing trout, char, or grayling populations provide viewing opportunities for salmonids in their natural environment. Many high lakes have exceptional water quality and transparency, enhancing the ability to view fish. This unquestionably adds to the enjoyment, wilderness experience, and wildlife appreciation of many users, particularly children. Stocks used in the Washington high lake fishery program often attain their most dramatic coloration or condition in well-managed high lakes.

Guideline 16: Diversity in Recreational Activity - Local managers will strive for a diversity of opportunities given the available resources and production potential of lakes.

5.7 Interagency and Landowner Coordination –

WDFW has a long history of coordination and cooperation with other land managers. Cooperative projects have yielded many highly beneficial work products. Most of the problems in recent years stem from the burgeoning human population in Washington, and difficulty in meeting the terms of earlier legislation. Inconsiderate dumping and vandalism on state and private timberlands from a small minority has prompted Department of Natural Resources (DNR) and private timber growers to erect gates on roads that lead to high lakes. USFS wilderness managers have greater and greater difficulty in meeting the standards set forth in the Wilderness Act due to ever-increasing levels of use. For example, special interest groups, unfamiliar with the issues at the time the North Cascades National Park was created, exert pressure on NPS administrators to eliminate historic high lake fishing in NCNP.

Guideline 17: Interagency Coordination - WDFW must continue to coordinate and cooperate with other land managers and agencies. Annual or biannual workshops with federal land managers have historically been the most productive, and significantly increased communication and understanding.

5.8 Outreach –

Numerous articles have appeared in newspaper, magazine, and special interest group newsletters in recent years that suggest that trout stocking in high lakes leads, to amphibian declines. Differing points of view or hypotheses are rarely, if ever mentioned by those who would ban trout stocking. The most recent research has in fact, revealed that the situation is far from simple, and that amphibian declines may be the result of complex environmental interactions. These groups also believe that trout should be banned from wilderness areas in which they are not native even though fishing and fish stocking is a permitted activity in wilderness areas under state and federal laws.

Because of the misunderstanding of biological and ecological issues surrounding the high lake fishery in Washington**,** it is essential that the public be better informed and educated about the benefits and impacts of the program. Apart from these policy issues, there is always a need for basic education of the public about how the agency manages its high lake fishery resource.

5.8.1 Information to the Public - Local WDFW managers routinely get calls from the public asking where they can go to fish a high lake; often a majority of these are asking about specific species, such as golden trout. In part to meet this information need, a pamphlet on the high lake fishery was written by Washington State Hi-Lakers member Gerry Ring Erickson, and WDFW Fish Biologist Bob Pfeifer in the mid-1980s. The authors recognized the sensitive nature of the high country, and the potential conflict with wilderness management by USFS staff. A carefully selected list of lakes was chosen for the "Suggested Lakes" section. In general, the lakes are ones which have had high numbers of users for many years, have well-maintained trails and camping areas, and are large lakes, with fish populations that can withstand fairly heavy fishing pressure. Also included was a section on the "**Leave No Trace**" wilderness ethic. The primer was renamed and can be found on the agency website renamed as a Fishing Guide entitled "Trout Fishing in Washington's High Lakes".

Guideline 18: Stocking information - The "Trout Fishing in Washington's High Lakes" pamphlet will be reviewed and updated periodically to provide up to date information on the suggested list of lakes.

Guideline 19: Public Information Requests. High lake management biologists will provide specific stocking information upon request.

6.0 SUMMARY

The fish resources in high lakes will be managed to achieve the high lakes management goal of protecting, restoring, and enhancing fish populations and their habitats in high lakes while maximizing recreational opportunities consistent with natural resource protection guidelines. This will be accomplished by:

1. Maintaining the productivity and diversity of native fish and wildlife populations and their habitat at healthy levels,

2. Maintaining introduced fish stocks at levels that does not result in significant negative interactions with native resources needs (protection from hybridization, and significant interspecific competition) and avoiding the development of self reproducing populations,

3. Providing a diversity of recreational fishing opportunities that are desired by the public and consistent with native resource needs,

4. Promoting a conservation ethic associated with the high lakes fishing experience, and

5. Promote effective coordination and communication of management objectives and actions with constituents, and other agencies.

Guidelines for High Lakes management are summarized in Appendix E.

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Appendix A. Highlakes Fishing Report.

HIGH LAKE FISHING REPORT

Please fill in the blanks, check all appropriate boxes that apply, and add comments when necessary.
This information is used by the Department of Wildlife to help obtain quality fishing in the high lakes.

Name of lake_____ **Date of trip**_____

County_____ **Township**____ **Range**____ **Section**____ **Subsection**____

Latitude_____ **Longitude**_____

Name of reporter_____ Hi-Laker☐ Trail Blazer☐

	RAINBOW	CUTTHROAT	GOLDEN	E. BROOK	BROWN	ATL SALMON	GRAYLING	MACKINAW	
QUANTITY									
SIZE RANGE									
AVERAGE SIZE									

QUALITY OF FISHING: Zilch☐ Poor☐ Fair☐ Good☐ Excellent☐

FISH ACTIVITY: **Rising** None☐ Few☐ Lots☐ **Cruising** None☐ **Few**☐ Lots☐

FISH CONDITION: Fat☐ Normal☐ Thin☐ Big head☐ Spawning☐ Dead fish seen☐ Fry seen☐

Other/Comments_____

SUCCESSFUL LURES: Bait☐ Dry Flies☐ Wet Flies☐ Spoons☐ Spinners☐ Flatfish☐

Other_____

STOMACH CONTENTS: Empty☐ Copepods☐ Shrimp☐ Snails☐ Larvae☐ Surface Insects☐ Debris☐

Other_____

SENSITIVE SPECIES: Red copepods☐ Gammarus☐ Large Aquatic Insects☐ Salamanders (NW☐, LT☐)

Other_____

TIME AT LAKE: Days____ Hours____ **TIME FISHING:** (Nearest 1/4 Hour)_____

#Anglers in party_____ #Other anglers at lake_____ #Non-Anglers at lake_____

LAKE CONDITION: Clear☐ Glacial☐ Dark☐ % Frozen_____

Comments_____

CAMP USAGE: Heavy☐ Moderate☐ Light☐ #of camp sites_____

WEATHER: Partly Cloudy☐ Cloudy☐ Clear☐ Cold☐ Warm☐ Hot☐ Windy☐ Calm☐

Snowing☐ Raining☐ Foggy☐ Other_____

COMMENTS:_____

If confidential, check all boxes indicating who may see this report, check no boxes if all right to put in summary report:

Co-reporters☐ Hi-Lakers☐ Trail Blazers☐ Department of Wildlife☐

List Co-reporters here:_____

WEIGHT LENGTH DATA: As a general guideline, take weights only on fish that have been killed to take home, are part of a sample to be worked up for biological management purposes, or died for some other reason. Please be as accurate as possible.

Species	Weight	Length

Indicate units used

weight
- ☐ pounds
- ☐ ounces
- ☐ lb, oz
- ☐ grams

length
- ☐ inches
- ☐ centimeters

Species	Weight	Length

Appendix B. Alpine Lake Survey Form

WDF&W 830 (4/95) ALPINE LAKE FIED SURVEY FORM
HABITAT PARAMETERS

LAKE _____ LOCATION: S _____ T _____ R _____ MUCODE _____

SURVEY DATE _____ SURFACE ACRES _____ ELEVATION _____ EXPOSURE _____

WATER COLOR _____ GEOMORPHIC LK TYPE _____ DRAINAGE _____

MAX DEPTH _____ MEAN DEPTH _____ % < 10' DEEP _____ % < 20' DEEP _____

AVG. ANNUAL FLUCTUATION _____ MEAN DATE ICE-OUT _____

SURFACE TEMPERATURE _____ pH _____ TOT. ALK _____ TOT. HDNSS _____

NITRATES _____ NITRITES _____ TOT. SOL. P _____ CONDUCT _____

% BOTTOM COMPOSITION SHOREWARD OF 10' CONTOUR: BEDROCK _____ SILT _____

RUBBLE _____ GRAVEL _____ SAND _____ BOULDERS _____ WOODY DEBRIS _____ DETRITUS _____

AQUATIC VEGETATION _____

_____

POTENTIAL IN-LAKE SPAWNING AREAS:

TYPES(S) _____ Total area (yd2) _____

MAJOR INLETS AND OUTLET(S):

Inlet (1) / Outlet(s) (O) Stream and ID Number						
Width (ft)						
Depth (in)						
Velocity (L, M, H)						
Dominant stream substr. Types (BR,BO,RU,GR,SA,SI)						
Fish access length (yd)						
Barrier type (w'fall WF; logjam LJ; steep slope SS; shallow SH)						
Potential instream spawning are (yd2)						
Potential alluvial fan spawning area (yd2)						
Alluvial fan total area (max width/max length)						

Appendix B. Alpine Lake Survey Form

LAKE _____ MUCODE/GPS _____ DATE _____

No./location of minor streams _____ No./location of inlet seeps _____

REMARKS ON IN/OUTLETS: _____

_____

_____

BIOLOGICAL PARAMETERS

TERRESTRIAL LAKESHORE CHARACTER (10m wide strip around the lake):

Forest % coverage _____ Open ground % coverage _____

Dominant types _____ Dominant types _____

AQUATIC INVERTS. OBSERVED _____

_____

COPEPODS _____ SCUDS _____ DEAD FISH? _____

FISH POPULATION DATA

FISH SAMPLING: #FM _____ TOT. HRS. _____ TOT. CATCH _____

GILL NET SET(S): Set Number _____ Type _____ Location _____ Total hours Effort/Net _____

Set Number _____ Type _____ Location _____ Total hours Effort/Net _____

FISH SPECIES AND RELETIVE ## PRESENT _____

_____

LENGTHS BY SPECIES _____

FISH CONDITION _____ EVIDENCE OF SUCCESSFUL SP'G _____

FISH < 6"? _____ FISH < 3"? _____ FRY IN INLET/OUTLET? _____

TOTAL SPAWNING HABITAT ESTIMATE (none, very low, low, mod, high): _____

NATURAL REPRODUCTION SUMMARY (none, low, moderate, high): _____

STOMACH CONTS. IN ORDER OF DECR'G VOL. _____

ANGLING PRESSURE

POSSIBLE TO WALK AROUND LAKE TO FISH? _____ DVLPD TRAIL? _____

HRS RQD TO HIKE _____ MILES FROM NRST ROAD _____

CAMPS _____ # FIRE RINGS _____ EST'D ANN. ANG-DAYS _____

OF NON-SURVEYING FM DATE _____ # NON-FM DATE _____

COMMENTS:

Appendix C. High Lake Table field definitions

The attached High Lakes File was used as the basis for several figures and tables in this report. Not all the detailed data used for the report is included in the file. However, the lake names, identification numbers, size, location, administrative areas are included. The lakes are ordered by County, Township, Range, Section and Lake Name in memory of Ernest Wolcott who used that ordering in his Lakes of Washington volumes.

HIGH LAKE Table field definitions

Field Name	Type	Comment
CountyName	Text	County name
Township	Text	Public Land Survey Township
Range	Text	Public Land Survey Range
PSection	Long Integer	Public Land Survey Section
PSectionSuffix	Text	Section subdivision using Wolcott method
Lake Name	Text	Primary lake name. Unnamed lakes use Unnamed-Elevation for a name
Other Names	Text	Other lake names in use
HighLakeFlagWDFW	Yes/No	Flag identifying a high lake or pond based on WDFW criteria
HighLakeException	Yes/No	Flag identifying lake that does not meet WDFW high lake criteria but is being managed as a high lake by regional biologist.
FishStocked	Yes/No	Flag identifying that the lake has ever been stocked with fish
FishSeen	Yes/No	Flag identifying that a fish has ever been observed in the lake
Organization	Text	The organization managing or owning lake property
Admin	Text	Administrative area name if any
CU	Text	USGS basin (hydrologic unit) code
FSWatershed	Text	Forest Service 5^{th} and 6^{th} level watershed code
LakeBasin(Acres)	Single	Lake basin drainage area (acres)
Reach	Text	Reach identifier imported form USGS/EPA Reach File or assigned by Mike Swayne Trail Blazer Librarian using Reach File identification methodology
DownReach	Text	Downstream lake or stream name
RDOWCode	Text	Regional WDFW biologist lake code
SDOWCode	Text	State WDFW lake MUCODE
Lake2k	Long Integer	State WDFW GIS lake code

NPSCode	Text	North Cascade National Park lake code
Wolcode	Text	Wolcott code (Volume.Page.Item.subitem)
CurtisID	Integer	Lake code developed by Walt and Brian Curtis used in Hi-Laker High Lake database
Location	Text	Lake location description, distance and direction from named feature
SurfaceArea	Single	Lake area (acres)
AvgDepth	Single	Average lake depth (feet)
MaxDepth	Single	Maximum lake depth (feet)
MaxDepthQual	Text	Maximum depth qualifier
Outlet	Yes/No	Outlet exists flag
Shoreline	Single	Shoreline length (miles)
Elevation	Integer	Elevation above mean sea level (feet)
DLat	Double	Latitude decimal degrees NAD27
DLong	Double	Longitude decimal degrees NAD27
LLPosition	Text	Lat/Long position (Center, drainage outlet)
MapCode	Text	USGS Map code
MapName	Text	USGS Map name

Appendix D. Survey Methods from Bahls 1989

HABITAT DATA

1. Physical Data

a. Lake surface area (acres) - computer-assisted digitizer or polar palinimeter is used to obtain area reading from the lake perimeter map (see Survey Preparation section).

b. Shallow littoral (acres and % of total lake surface acres) - lake depths are measured along at least six transects across the lake using an inflatable raft and weighted line. Location of depths sounded along the transect lines are recorded on the field map and three meter contour intervals are drawn. Two to six hours are required for making a bathymetric map, depending upon the complexity of the bathymetry and size of the lake. However, if time is limited, a full bathymetric survey is not necessary for large, deep lakes, since only measurements of three and six meter contour intervals and maximum depth are used to derive specific habitat parameters. A digitizer or polar palimineter is later used on the bathymetric map to determine the surface acres between the shoreline and the three meter contour line.

c. Deep littoral (acres and % of total lake surface acres) - the same method is used to determine the surface acres between the three and six meter contour intervals.

d. Maximum depth (meters) - measured during the course of taking depth soundings, with the region of maximum depth marked on the lake map.

e. Lake elevation (feet) - taken from USGS 7.5 minute topographic maps.

f. Lake exposure direction (degrees) - usually in line with
the major direction of past glacial scouring, exposure direction is measured by first orienting a USGS 7.5 minute topographic map to the magnetic field, then lining the edge of a compass up with a line running from the center of the lake to the direction of least blockage by mountain slopes surrounding the lake (usually directly opposite of the direction of the glacial headwall). The compass bearing is then recorded.

g. Shoreline development ratio - measure perimeter of lake with digitizer or polar palinimeter and calculate using formula in Appendix C.

h. Geomorphic lake type - topographic maps and field observations are used to classify lakes into one of five types - cirque (a single lake formed by rotational pluck and scour action of mountain glacier with lake position usually resting in a cup under a peak and flanked on three sides by steep walls), cirque-scour (located down valley of the headwall and usually occupying basins scoured of less resistant bedrock), paternoster (a chain of at least three cirque--scour lakes), upland (a lake basin scoured by an ice cap on a gently rolling old upland surface), and other (a variety of lakes included here, such as beaver and landslide formed).

i. Watershed area (acres) - lake watershed perimeter is traced onto a transparent overlay of a USGS 7.5 minute topographic map and the area measured with polar palinimeter or digitizer.

j. Percent bottom composition of the lake shoreward of the three meter contour interval - percentages of lake bottom substrate types visible from the shoreline and estimated to lie under 3 meters in depth are visually estimated and mapped at stops made about every twenty meters around the lake shore (in conjunction with invertebrate sampling) and at a minimum of six locations. Substrate types and definitions are given in Appendix D. An estimate of the percentage

substrate types in the littoral for the entire lake is based on averaging sample station estimates and summarizing the lake map.

k. Sediment type in the shallow littoral zone - dominant colors (grey, grey-brown, brown, and dark-brown) and textures (silt, sand, organic matter) of lake sediments in the shallow littoral are recorded at each location. Also, the extent of silt coverage of rocks in the littoral is estimated for a one meter size patch of substrate one meter from shore, where 0 = no silt, 1 = partial silt coverage, 2 = complete coverage by thin (<1 cm) silt layer, 3 = complete coverage by moderate silt layer (1-2 cm), 4 = complete coverage by thick (>2 cm) silt layer.

l. Potential spawning areas in lake proper (types and total area in square meters) - "types" refers to either sand, gravel or both and to either an isolated patch or the alluvial fan of an inlet stream. Type and size of potential spawning areas is estimated during the walk around the lakeshore.

m. Major lake inlets and outlets - a "major" stream is defined as having a bank width of at least 30 cm that is liberally estimated to be accessible to trout during periods of high flow. Only characteristics of major streams, not minor streams or seeps. (defined below), are surveyed. Stream flow and bank width measurements are made 5 meters from the lake inlet or outlet. Stream substrate estimates are made after walking along the stream from the lake to a fish passage barrier on the stream or a distance of 50 meters. Stream characteristics are measured as follows.
Inlet(I)/Outlet(O) stream and ID number (such as 0-1) - Identification code for each major inlet and outlet stream,
also recorded on lake map.

Bank width (cm) - width of active stream channel during high water as measured by distance between stabilized banks.

Stream width (cm) - width of stream between wetted perimeters.

Stream depth (cm) - maximum depth along width crosssection.

Gradient (low, moderate, high) relative rating of estimated stream gradient where low = 0-10 percent slope typical of streams located in meadows and with silt or gravel/ rubble substrates, mod = 10-30 percent slope typical of riffles and pool streams with gravel and rubble substrates and few waterfalls greater than .5 meters high, high = 30 - 90 percent slope characterized by frequent waterfalls over .5 meters high and boulder or bedrock substrate.

Dominant stream substrate types (same types and definition as for lake substrates, Appendix D) - a rough estimate of the two dominant substrate types occurring between lake and barrier.

Fish access length (m) -on an inlet stream, the distance from the lake to a definite barrier preventing further upstream travel. On an outlet stream, the distance from the lake to a barrier preventing re-access to the stream and lake from below the barrier.

Barrier type (waterfall [WF], logjam [U] , steep slope [SS], shallow [SH] - the large seasonal fluctuation in
stream flow, large variation in types of potential barriers and largely unknown ability of trout to surmount them, makes barrier identification difficult. Barriers which may be passable should be marked with a "?". Usually only rock waterfalls with more than a two meter drop are considered barriers. Logjams can float during periods of high water and are usually not effective barriers.

Potential in-stream spawning substrate (total area (square meters) of sand and/or gravel) - a visual estimate of the total sand and/or gravel substrate in the accessible stream section.

Potential alluvial fan spawning substrate -- only alluvial fans with some sand or gravel are considered. A maximum of two substrate types are recorded (such as SA/SI).

Potential alluvial fan spawning area (maximum width/maximum length in meters) - width is visually estimated parallel to the shoreline and is usually at a maximum close to shore, maximum length is estimated in a perpendicular direction to the shoreline.

n. Number of minor inlet streams - "minor" streams are defined as having a bank width of less than 20 cm or are definitely inaccessible to trout.

o. Number of inlet seeps - "seeps" are defined as having a bank width of less than 10 cm or an undefined stream channel, but do flow above ground for at least one meter.

p. Air temperature (C) - reading taken one meter above water surface from inflatable raft and immediately receding measurement of surface water temperature. Thermometer must be dry for accurate reading.

q. Surface water temperature (C) - reading taken from inflatable raft while located over deepest region of lake. Thermometer tip should be five cm under water surface for least 30 seconds and reading taken immediately upon retrieval.

r. Shallow water temperature (C at 1.5 m) - reading taken from inflatable raft while located over deepest region of lake. Temperature measured and recorded immediately upon collection of water sample from 1.5 m depth using Modified Larson sampler (see Equipment List, Appendix A).

s. Deep water temperature (C at 1.5 m above lake bottom) - reading taken from inflatable raft while located over deepest region of the lake. Temperature measured and recorded immediately upon collection of water sample collected from 1.5 m above the lake bottom in region where the lake bottom is within 3 meters of maximum depth.

2. Water Chemistry Data

a. Shoreline pH - probe of pH meter is dipped in region of the lake that is about 1 meter from shore and .3 to 1 meter deep. Probe is slowly stirred through water to allow circulation. Three measurements, at least 10 meters apart and 20 meters from major stream inlets, are made at each lake.

b. Shoreline conductivity (U'S cm-l) - same procedure as for pH measurement.

c. Shallow water pH - water sample from 1.5 meters deep and collected for shallow water temperature reading (see above) is transferred while in the raft to a second 250 ml sample bottle for measurement on shore within one-half hour. For lakes less than three meters in maximum depth, the shallow water sample is taken mid-way between the surface and bottom in the region of maximum depth.

d. Deep water pH - same as above for deep water sample collected for deep water temperature reading.

e. Shallow water conductivity (us cm-1) - measurement is taken in the same_ sample bottle and immediately following shallow water pH measurement.

f. Deep water conductivity (us cm-1)- measurement is taken in same sample bottle and immediately following deep water pH measurement.

g. Shallow water alkalinity (ueq L-l) - Immediately following pH and conductivity measurements from the shallow water sample bottle, a 100 ml water sample is transferred (using a syringe flushed with water from the sample) into a 250 ml beaker. The Gran-titration method is used, whereby at least ten additions of one to two drops of .02 M H_2SO_4 are added to the sample with a 2 ml microburette. PH and amount of acid added are recorded with each addition until the sample is titrated to below 3.5 pH. Alkalinity is then calculated after the field season (see Alkalinity, Summary section).

h. Deep water alkalinity (ueq L-l) - Same procedure as for shallow water alkalinity.

3. Biological Data

a. Aquatic vascular macrophytes (genera present and relative abundance of each genera- and group) - Genera (and species if feasible) of vascular plants observed in the littoral zone during a survey around the lake shore are recorded. Representative unknown types are collected in a plant press (see Appendix A, equipment) for later identification. Relative abundance (rare, common, abundant) is estimated for each type. A relative abundance index for aquatic plants as a group (low, moderate, high) is determined (Appendix C).

b. Seasonally emergent or submerged sedges. (Group relative abundance) - only unusual or especially prevalent species are collected for identification due to the large number of species and difficulty in identification. A group relative abundance indice is determined (Appendix C).

c. Deep zooplankton (species sampled) - two vertical zooplankton hauls are made in the deepest region of the lake. The open net is allowed to sink with open mouth to one meter above the bottom and then is retrieved at a moderate rate. Zooplankton samples are drained into a 60 ml sample bottle. On shore, 95% ethanol is added to achieve an estimated 70% ethanol solution to preserve zooplankton for later identification.

d. Shallow zooplankton (species sampled) - two horizontal hauls are made from two locations along the shore at least 10 meters apart. While standing on shore, the surveyor throws the net 5 to 7 meters out into the lake and quickly retrieves the net, keeping the net mouth just below the lake surface until one-half meter from shore. The first zooplankton sample is drained into one 30 ml sample bottle, then returned to the net after obtaining the second sample to drain excess water. Both. samples are then drained into the -sample bottle together and 95% ethanol is added to achieve an estimated 70% ethanol solution.

e. Aquatic invertebrates (genera sampled and group relative abundance) - The surveyor walks the entire lake perimeter, stopping every 10 meters to visually scan the near-shore zone for aquatic invertebrates. At least two of every type of aquatic insect (species and life-stage) observed are collected with the aid of a long handled sampling net (see equipment, Appendix B) and preserved for later identification in one 30 mm sample bottle filled with about 5 ml of lake water and 15 ml of 95% ethanol (dilution to 70% ethanol). Every twenty meters, the bottom substrate and submerged vegetation are searched for insects by manually sifting through silt and/or vegetation dredged up by the sampling net. Rubble substrate is searched by turning over rocks with by hand. The surveyor records the common names of each type of invertebrate observed, its life-stage and relative abundance.

f. Freshwater shrimp (species present) - Usually found in rubble or silt substrates, near shore and surveyed and collected in conjunction with the aquatic invertebrate survey.

g. Terrestrial lakeshore vegetation (percent coverage of vegetation types in a 10 m wide strip around lake) - a visual estimate of forest and open ground percent coverage is made based on four vantage points taken during the walk around the lakeshore. Within the forest percent coverage, - the percent coverage of each tree species is estimated. Under open ground percent coverage, the dominant plants (common names) and rock types (bedrock, talus) are recorded.

h. Animal observations (species, relative abundance or number, behavior and habitat) - observations of all vertebrates (not including humans) seen at or near the lake are recorded here. Specimens of unknown species, such as salamanders, are collected and preserved in ethanol for later identification.

B. FISH POPULATION DATA

a. Fish species present in lake - surveyors are trained prior to the field survey to identify planted and native fish species and stocks that may be encountered, as well as potential hybrid forms. All fish sampled are identified as to species, native or planted, and particular strain if possible. Fish are obtained for sampling by both gill-netting and angling. A specially designed lightweight - compact and variable mesh gill-met (see Equipment List, Appendix A) is tied to shore at the small mesh end and laid out perpendicular to the shoreline using the raft. The set is made over a gentle to moderate sloping area of the lake bottom containing few logs or boulders to snag the net. The set location is marked on the lake map. A twelve hour overnight set is made. The next morning surveyors either pull the net in from shore or retrieve the net with the raft if there is a danger of snagging it on bottom obstructions. Fish are untangled from the net and sampled immediately. After use, the gill-net is carefully re-piled and put in a stuff sack so that it can be laid out without tangling at the next lake. The gill-net will obtain a much better representation of the smaller size ranges of fish (8 cm - 15 cm) that represent the previous year's reproduction or stocking of fry than will angling methods. However, angling is used instead of gill-netting to sample lakes with abundant, naturally reproducing populations, such as usually occur in lakes containing brook trout.

b. Stocking record for the lake (date of stocking, species and fish size stocked, total number stocked, and stocking rate (number per total surface acres and number per shallow littoral surface acres)) - this information is usually obtained from the state fisheries management agency responsible for stocking the lakes.

c. Catch ratio - ratio of the numbers of each strain or species of fish obtained by gill-netting and angling.

d. Relative abundance (very low, low, moderate, high, very high) Abundance estimate for the total trout population in a lake, base on gill-net catch/hour and angling catch/hour (Appendix C).

e. Fish size, and condition (for each discernable stock or species) - fish sampling is done by one person, while the other records data. Data summary is conducted after the field season. The following population characteristics are measured in the field or calculated after the field season.

*total length (range and mean in mm) - each fish is measured by placing on a nylon sewing tape pinned to a flat log or the insect sampling handle (Appendix A).

*weight (range and mean in g) - each fish is weighed on a Pescola 1000 g spring balance (Appendix A).

*condition (range and mean in g) - a condition factor is calculated based on a length/weight ratio (Appendix C).

*visceral fat percentage - a visual estimate of the relative percentage of surface area of pyloric seccae "fingers" on the intestines covered which are covered with fat. Presence of a fat lobe attached to the lower intestine is also recorded.

*fish condition summary (very poor, poor, fair, good, excellent) and notes - a summary of fish condition for each discernable stock or species is determined after the field season based on a combination of the condition factor and visceral fat percentage estimate (Appendix C). Notes are occasionally needed here to record unusual observations.

f. Fish stomach content data (orders and some families of prey species present and relative abundance) - Stomach contents from all fish sampled are grouped by order (and some by family) of the organism and a visual estimate is used to rank orders by relative volume. If more lab time then field time is available, samples are preserved in one or two 60 ml sample bottles flooded with 95% ethanol for later analysis.

g. Otolith collection - otoliths are obtained from at least five trout in populations where interpretation of other data is inconclusive in terms of determining the level of natural reproduction and correlation to stocking records. To obtain otoliths, the fish head is bent back, exposing the underside of the head above the gills. A shallow lateral cut through the head exposes the two otoliths, which are pried out carefully and stored in a scale envelope (or folded piece of paper) with the sample number of the fish recorded on it.

h. Natural reproduction - various characteristics of the fish population and habitat are measured, as listed below. These measures are used in combination to obtain an estimate of the level of natural reproduction of the trout population occurring in a lake.

*correlation of length/age frequency and stocking records (summary notes) - distinct size or age classes of species and stocks of trout that correspond to stocking records and a lack of intermediate or smaller sizes (especially sizes ranging between 50-150 mm) and hybrid forms is a good indication of a lack of natural reproduction.

*relative abundance of fish smaller than 150 mm observed in inlet/outlet streams, or 'lake (none, low, moderate, high), fish size range and location (inlet/outlet ID code or lakeshore) - during stream habitat surveys of major inlets and outlets, numbers and size ranges of fish are observed and recorded for each stream. Small fish are surveyed in the littoral area during the insect survey. Total relative abundance of small fish observed is then determined (Appendix C) and unusual findings noted.
*Total spawning habitat estimate (very low, low, moderate, high) - the relative abundance classification is based on stream/shoreline data (Appendix_ C).

*Natural reproduction summary (none, low, moderate, high) at present a subjective estimate based on consideration of all of the factors listed above (Appendix C).

C. HUMAN USE AND IMPACT

a. Number of anglers and non-anglers observed at lake - surveyors record the total number of individuals observed at the lake, the number camping at the lake during a one-night period and the number observed fishing in the lake.

b. Campsite impact (ID number, size and degree of impact) - each discernable camping area within 100 m of the lake perimeter is given an ID number and mapped on the lake map. Size of impact of each distinct area is estimated in meters along the maximum axis of impact and then perpendicular to the first axis Degree of impact (low, moderate, high) uses a visual estimation of the percentage of duff and vegetation coverage remaining at the site (Appendix C).

c. Access difficulty rating (F.S. miles) - ratings are determined after the field season based on distance measurements made between the road and lake, using a 1:100,000 scale wilderness trail map. Measurements are made in one-half mile straight line increments along main trails, minor trails (blackline man-way trails or a trail not appearing on wilderness maps) and bushwack routes (no trail). (Appendix C).

d. Angling pressure summary - objective criteria are used to classify the relative extent or size of the total impact of campsites (none, low, moderate, high), total access difficulty (low, moderate, high), and lake size (small, medium, large) and used in combination with knowledge of the existing trout population estimate total angling pressure (low, moderate, high) as detailed in Appendix B.

D. PHOTO-DOCUMENTATION

A 35 mm camera with 50 mm lens using Kodachrome 64 or Fuji 100 color slide film is used to take a series of standard photographs at each lake as detailed below.

a. Lake from above (1-2 photos) - usually possible to obtain a good photo of the lake and watershed from a peak or ridge above the lake. (This is also a good opportunity to map lake perimeter landmarks on the lake map for later use as reference points for bathymetric mapping).

b. Lake shoreline (2 photos) - two separate stretches of lake shoreline are photographed from the shore.

c. Fish sampled (0-6 photos) - fish caught by gill-netting or angling are photographed separately. Fish are arranged by species and size on a flat rock or barren ground, with, a hand or foot and measuring tape included for size reference. Additional photos of unidentified, native or unusual looking fish are also obtained.

d. Animal observations - all vertebrates observed are photographed if feasible, especially unknown species of amphibians and reptiles.

e. Human use - photographs of people camping and fishing at lakes are obtained if feasible.

f. Human impact - severe campsite and trail impacts are photographed.

g. Survey methods - photographs of the survey team involved in various survey activities are obtained.

h. Other - photographs are taken of unusual lake color, rock types or biological phenomena.

E. NOTES

One of the surveyors takes responsibility for writing summary notes immediately after surveying each lake. Notes are written in a 5x8.5 water-resistant notebook. Notes reflect the surveyor's best intuitive interpretation and summary of various aspects of the lake ecosystem, as listed below.

a. Lake name, arrival and departure time and date.
b. Daily weather conditions.
c. Fish species, discernable strains and hybrids present.
d. Fish condition for each discernable strain and species. e. Fish size range and relation to past stocking.
f. Evidence for and estimated level of natural reproduction.
g. Relative abundance of the trout population.
h. Aquatic invertebrate prey bate condition.
i. Potential lake productivity for fish (assuming an appropriate stocking rate).
j. Angling pressure and human impact estimate.
k. General interpretation of fish population dynamics.
l. Unique or unusual observations.
m. Management concerns and recommendations.

Appendix E. Summary: Guidelines for Managing Washington's High Lakes