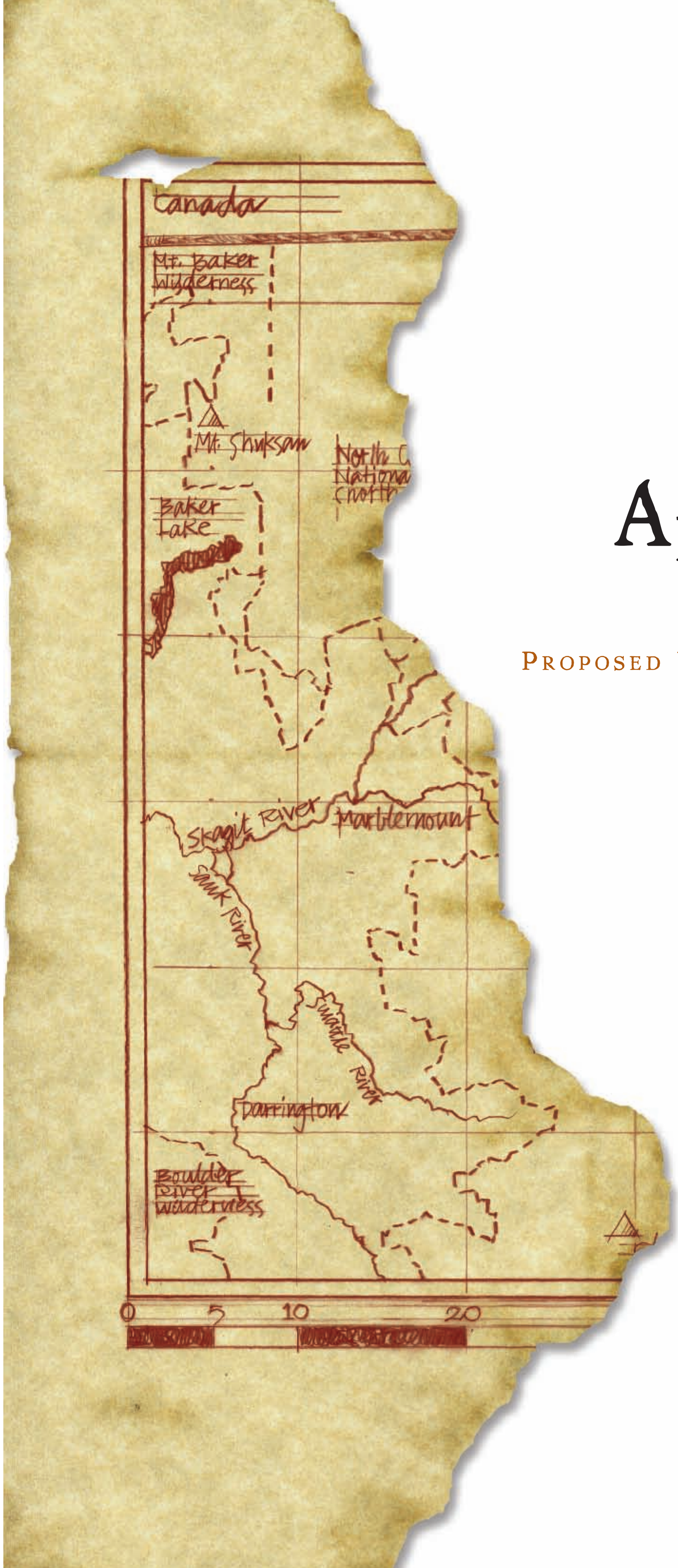

Appendix F

Proposed Mountain Lakes Fishery Monitoring Plan

APPENDIX F: PROPOSED MOUNTAIN LAKES FISHERY MONITORING PLAN

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INTRODUCTION

Adaptive management is a central theme of the three action alternatives analyzed in this *Draft Mountain Lakes Fishery Management Plan / Environmental Impact Statement* for the 91 naturally formed mountain lakes in the North Cascades National Park Service Complex (North Cascades Complex). Monitoring of the 91 lakes is a key component of adaptive management. Adaptive management is based on the continuing, iterative process of applying management actions, monitoring consequences, evaluating monitoring results against objectives, adjusting management actions, and using feedback to make future management decisions. The adaptive management process for the 91 lakes in the study area would include evaluating the effects of management actions (for example, management of low densities of nonreproducing fish) on biological resources at individual lakes and identifying whether and how these practices should be modified to meet the objectives of the selected management action for the lakes. Monitoring activities would be selected and designed to test the success and effectiveness of management actions at each lake. This proposed mountain lakes fishery monitoring plan (monitoring plan) for the North Cascades Complex would provide the basis for the monitoring activities.

The specific objectives of the monitoring plan are listed below.

Reduce uncertainty of current conditions by gathering additional information where data are lacking.

Develop, if needed, and implement standardized protocols for data collection that are cost effective, efficient, and explicitly linked to management actions. Also, develop thresholds/criteria for data evaluation that will facilitate the adaptive management process.

Perform adaptive management by evaluating the success or failure of management actions to conserve/improve biological integrity and provide quality fishing opportunities.

Sampling under the proposed monitoring plan is not intended to replace monitoring that has been or is currently being performed under other programs in the North Cascades Complex (such as long-term monitoring). Instead, monitoring would use data already collected and implement sampling protocols developed and applied within the North Cascades Complex lakes. One notable example of established sampling methods is the set of sampling protocols prepared by Hoffman et al. (2003). Other aquatic monitoring efforts include

Long-term research by the National Park Service (NPS) that was initiated following the 1988 Supplemental Agreement. The research was performed with the support of the U.S. Geological Survey (USGS)-Biological Resources Division and Oregon State University and completed in 2002. Results of this research are summarized in the “Purpose of and Need for Action” chapter in the section titled “Summary of Existing Research.”

Management by the Washington Department of Fish and Wildlife (WDFW) of fishery resources in 17 stocked lakes and 23 lakes with self-sustaining (reproducing) fish populations in North Cascades National Park and all lakes in the Ross Lake and Lake Chelan National Recreation Areas. Two private groups, the Washington State Hi-Lakers and the Trail Blazers Inc., assist the WDFW in collecting fishery data.

This proposed monitoring plan is organized as follows:

Past Monitoring: Existing Data, Reliability of Data, Protocols Used—provides a summary of the known physical, chemical, and biological data collected at the 91 lakes in the North Cascades Complex that are the subject of the *Draft Mountain Lakes Fishery Management Plan / Environmental Impact Statement* (plan/EIS).

Management Actions and Associated Monitoring Needs—for each management action, provides the needed monitoring efforts and objectives in table and flowchart formats.

Key Data Categories and Selection of Methods/Protocols for Monitoring—describes *key data* to be used during monitoring and recommends methods best suited for use in monitoring the results of the selected management actions.

Decision Support Framework—describes the basic elements in the process by which the Technical Advisory Committee (TAC) would make lake management decisions.

Adaptive Management Framework—discusses how the key data for each lake would be evaluated and interpreted to determine if a change in management direction would be needed.

Priorities for Monitoring—describes considerations that would be used when setting priorities as to which lakes would be monitored and which data are key to monitoring management activities.

References Cited

PAST MONITORING: EXISTING DATA, RELIABILITY OF DATA, PROTOCOLS USED

A variety of data have been collected from many of the 91 lakes in the North Cascades Complex. The most common physical characteristics, water temperature and depth, have been measured for approximately 75 of the 91 lakes. Outlet habitat type has only been estimated from Geographic Information System (GIS) data but not confirmed in the field. The 21 types of data (abiotic and biotic) collected from the 91 study area lakes are provided in table F-1. For each data type, the method used to collect the data and the reliability of the data are listed in the table, with additional explanation provided in footnotes. In most cases, fishless lakes have less data available than do lakes that currently have fish.

MANAGEMENT ACTIONS AND ASSOCIATED MONITORING NEEDS

The 91 lakes in the North Cascades Complex have been placed into one of four categories according to the fishery population found in the lake. The four categories are

1. Lakes that are currently fishless
2. Likes with high densities of reproducing fish
3. Lakes with low densities of reproducing fish
4. Lakes with nonreproducing fish.

TABLE F-1: NORTH CASCADES COMPLEX SURVEYS FOR 91 LAKES IN THE STUDY AREA—PROTOCOLS, DATA CATEGORIES, AND RELIABILITY OF DATA[a]

Lake Information		Abiotic Data Categories						Biotic Data Categories: Fish					Biotic Data Categories: Amphibian			Biotic Data Categories: Benthic Macroinvertebrates		Biotic Data Categories: Zooplankton			Biotic Data Categories: Vegetation	
Lake Name	NPS Lake Code	TKN (mg/l)	Surface Water Temperature	Lake Depth	Substrate	Available Spawning Habitat	Outlet Habitat Type	Fish Presence	Fish Reproductive Status	Fish Species Present	Density of Reproducing Fish	Status of Fish Population in Outlet	Snorkel Survey	Visual Survey	Trap Survey	OSU BMI Survey	NOCA BMI Survey	NOCA Presence Survey	OSU Presence Survey	OSU Density Survey	Riparian Vegetation	Aquatic Vegetation
Azure	MP-09-01		1	X				Fishless													P	
Battalion	MLY-02-01	2	1	X				1	2	2	2	3	2	1	1	X			X		P	
Bear	MC-12-01	2	1	X				1	1	1	2	3				X			X		P	
Berdeen	M-08-01		2	X				1	1	2	2	2									P	
Berdeen (Lower)	M-07-01	2	2	X				1	1	2	2	3	2	3							P	
Berdeen (Upper)	M-09-01		2					2	2	2	3	2									P	
Blum (Largest/Middle, No. 3)	M-11-01		2		X			1	2	1	2	3						X			P	
Blum (Lower/West, No. 4)	LS-07-01	2	1	X	X			1	1	1	1	3	2					X			P	
Blum (Small/North, No. 2)	MC-01-01	2	2	X	X			Fishless					2					X			P	
Blum (Vista/Northwest, No. 1)	MC-02-01	2	1	X	X			Fishless					2				X	X			X	X
Bouck, Lower	DD-04-01	2	2	X				1	1	1	3	3				X			X		P	
Bouck, Upper	DD-05-01	1	1	X				1					2				X				X	X
Bowan	MR-12-01	1		X				1					2						X	X	P	
Coon	MM-10-01	1	1	X	X			1					2	2		X		X	X		P	
Copper	MC-06-01	1	1	X				1					2				X		X		X	X
Dagger	MR-04-01	1	1	X	X			1	1	2	1	3	2	2	2			X	X	X	P	
Dee Dee, Upper	MR-15-01	1	1	X				1	2	1	2		2				X		X		X	X
Dee Dee/Tamarack, Lower	MR-15-02	1	1	X				1					2	3	3		X		X	X	X	X
Despair, Lower	M-14-01							Fishless													P	
Despair, Upper	M-13-01							Fishless													P	
Diobsud No. 1	LS-01-01	1	1	X				1	1	1	2	2	1	3		X	X		X	X	X	X
Diobsud No. 2, Lower	LS-02-01	1	1	X				1	1	1	2	3	1	3		X			X	X	P	
Diobsud No. 3, Upper	LS-03-01	1	1	X				1					2	3		X			X		P	
Doubtful	CP-01-01	1	1	X	X			1	1	2	3	2	2			X	X	X	X		X	X
Doug's Tarn	M-21-01	2	2	X				1	1	1	2	3	2								P	
East, Lower	MC-14-02		2					Fishless						3			X				X	X
East, Upper	MC-14-01							Fishless									X				X	X
Firn	MP-02-01		2	X				1	1	2	3	3		3	3		X				X	X
Green	M-04-01		2	X				1	1	2	2	3									P	
Green Bench	LS-04-01		2	X				Fishless								X	X				X	X
Hanging	MC-08-01							1													P	
Hidden	SB-01-01		1	X	X			1	3	2	2	3				X		X			P	
Hidden Lake Tarn	EP-14-01		1	X				1									X				X	X
Hi-Yu	M-01-01	1	1	X				1					2	1			X				X	X
Hozomeen	HM-02-01	1	1	X	X			1	1	1	2	2	2			X	X	X	X		X	X
Ipsoot	LS-06-01		1	X			No outlet	1	1	2	2	No outlet		1							P	
Jeanita	DD-01-01	1	1	X	X		No outlet	1	2	1	2	No outlet	2	1		X		X			P	

TABLE F-1: NORTH CASCADES COMPLEX MOUNTAIN LAKES SURVEYS—PROTOCOLS, DATA CATEGORIES, AND RELIABILITY OF DATA (CONTINUED)

Lake Information		Abiotic Data Categories						Biotic Data Categories														
								Fish					Amphibian			Benthic Macroinvertebrates		Zooplankton			Vegetation	
Lake Name	NPS Lake Code	TKN (mg/l)	Surface Water Temperature	Lake Depth	Substrate	Available Spawning Habitat	Outlet Habitat Type	Fish Presence	Fish Reproductive Status	Fish Species Present	Density of Reproducing Fish	Status of Fish Population in Outlet	Snorkel Survey	Visual Survey	Trap Survey	OSU BMI Survey	NOCA BMI Survey	NOCA Presence Survey	OSU Presence Survey	OSU Density Survey	Riparian Vegetation	Aquatic Vegetation
Kettling	MR-05-01	2	2	X				1	1	2	1	3	2	1					X	X	P	
Kwahnesum	MC-07-01	2	1	X	X			1					2	1			X	X			X	X
McAlester	MR-10-01	2	1	X	X			1	1	1	1	1	1	1	1	X	X	X	X	X	X	X
Middle, Lower	MC-16-02		2	X				Fishless						3			X				X	X
Middle, Upper	MC-16-01		2	X				Fishless													P	
Monogram	M-23-01	1	1	X	X			1	1	1	2	3	2	1	3	X	X	X	X		X	X
Monogram Tarn	M-23-11							2						3	3						P	
Nert	M-05-01	1	1	X				2					2	1		X	X		X		X	X
Noisy Creek, Upper	LS-14-01							Fishless													P	
No Name	PM-01-01	2	1	X				1													P	
Panther Potholes, Lower	RD-05-02	1	1	X	X			2					1	1		X	X	X	X	X	X	X
Panther Potholes, Upper	RD-05-01	1	1	X	X			Fishless					1	1		X	X	X	X	X	X	X
Pegasus	EP-10-01							Fishless													P	
Pond SE of Kettling Lakes	MR-09-01	2		X				1					2				X		X	X	X	X
Quill, Lower	M-24-02						No outlet	1	3	2	3	No outlet									P	
Quill, Upper	M-24-01		2	X			No outlet	1	3	2	3	No outlet									P	
Rainbow	MR-14-01	2	1	X				1	1	1	1	3	1			X	X		X	X	X	X
Rainbow, Upper (North)	MR-13-01	1	1	X	X			Fishless					2	1		X		X	X	X	P	
Rainbow, Upper (South)	MR-13-02	1	1	X	X			1					1			X		X	X	X	P	
Rainbow, Upper (West)	MM-11-01	1	1	X				1					2						X		P	
Redoubt	MC-11-01	2	2	X				Fishless					2			X	X				X	X
Reveille, Lower	MC-21-02	2	2	X				Fishless								X	X		X		X	X
Reveille, Upper	MC-21-01	2	1	X				Fishless					2			X	X		X		X	X
Ridley	HM-03-01	1	1	X	X			1					2	1		X	X	X	X		X	X
Sky	EP-13-01							Fishless													P	
Skymo	PM-03-01	2	1	X				1	1	1	2	3	2	2	2	X	X		X		X	X
Sourdough	PM-12-01		2	X				1	1	1	2	3									P	
Sourpuss	ML-01-01	1	1	X				Fishless					2	3			X				X	X
Stiletto	MR-01-01	2	1	X				1									X				X	X
Stout	EP-09-02			X				1	1	1	2	2									P	
Stout, Lower	EP-09-01	2	2	X				1	1	1	2	3	2								P	
Sweet Pea	ML-02-01	1	1	X	X			1					2	3	3		X	X	X		X	X
Talus Tarn	M-06-01	1	1	X				Fishless					2	3		X					P	
Tapto, Lower	MC-17-03							Fishless													P	
Tapto, Middle	MC-17-02	1	1	X				Fishless								X			X	X	P	
Tapto, Upper	MC-17-01	2		X				Fishless								X	X		X	X	X	X
Tapto, West	MC-17-04	1	2	X				Fishless								X	X		X	X	X	X
Thornton, Lower	M-20-01	2	1	X				1	3	3	3	3	2	1			X		X		X	X
Thornton, Middle	M-19-01	2	1	X	X			1					2				X	X	X		X	X

TABLE F-1: NORTH CASCADES COMPLEX MOUNTAIN LAKES SURVEYS—PROTOCOLS, DATA CATEGORIES, AND RELIABILITY OF DATA (CONTINUED)

Lake Information		Abiotic Data Categories						Biotic Data Categories														
								Fish					Amphibian			Benthic Macroinvertebrates		Zooplankton			Vegetation	
Lake Name	NPS Lake Code	TKN (mg/l)	Surface Water Temperature	Lake Depth	Substrate	Available Spawning Habitat	Outlet Habitat Type	Fish Presence	Fish Reproductive Status	Fish Species Present	Density of Reproducing Fish	Status of Fish Population in Outlet	Snorkel Survey	Visual Survey	Trap Survey	OSU BMI Survey	NOCA BMI Survey	NOCA Presence Survey	OSU Presence Survey	OSU Density Survey	Riparian Vegetation	Aquatic Vegetation
Thunder	RD-02-01	1	1	X	X			Fishless					2	3	1	X	X	X	X		X	X
Tiny	MC-15-01		2	X				Fishless						3			X				X	X
Torment	ML-03-01	2	1	X	X			1					2	3				X			P	
Trapper	GM-01-01	1	1	X	X			1	1	2	2	2	2			X		X	X		P	
Triplet, Lower	SM-02-01	1	2	X				1	1	1	1	3	2	3		X	X		X	X	X	X
Triplet, Upper	SM-02-02	2	2	X				1	1	1	1	3	2	3		X	X		X	X	X	X
Triumph	M-17-01		2	X				1						1		X					P	
Unnamed	FP-01-01							Fishless													P	
Unnamed	MR-11-01	1	1	X	X			1					2	3	1	X	X	X	X	X	X	X
Unnamed	MR-16-01	2		X				2	3	2	1	3	2						X	X	P	
Vulcan	ML-04-01	1	1	X				Fishless					2	3	3	X	X		X		X	X
Wilcox/Lillie, Upper	EP-06-01	1	1	X				1	1	1	3	2				X			X		P	
Wilcox/Sandie, Lower	EP-05-01	2	1	X				1	1	1	3	3	2				X				X	X
Wild	MC-27-01	1	1	X				Fishless					2			X			X		P	
Willow	HM-04-01	1	1	X	X			1					2	2		X	X	X	X		X	X

Notes:
a. The presence/absence of data and its reliability are presented as a "snapshot" of the data available in April 2004. Additional lake surveys may have been performed, and conditions may change prior to baseline surveys conducted as part of the proposed monitoring plan.

Cells marked by an "X" indicate that a reliable survey has been conducted; blank cells indicate that no survey has been conducted.

Data Categories:

TKN (mg/l): Total Kjeldahl nitrogen determined using OSU protocols for collecting water samples in the field.
1 = High confidence in number because surveys on multiple dates were conducted, the mean has a low standard deviation, or few outliers were present.
2 = Low confidence in number because surveys were only conducted on one date, the mean had a high standard deviation, or two or more values were both higher and lower than 0.045 mg/l.

Surface Water Temperature: Surface water taken during thermal maxima (warmest period of day) over deepest portion of lake using OSU Protocols.
1 = High confidence in number because surveys were conducted on multiple dates, the mean has a low standard deviation, or few outliers were present.
2 = Low confidence in number because surveys were only conducted on one date, the mean had a high standard deviation, or the range of values was unusually high.

Lake Depth: Lake depth measured in feet at deepest portion of lake, depth is usually measured with a weighted line, but can be measured with electronic depth finders. Reliable measurements exist for most lakes.

Substrate (percentage by type: silt, sand, gravel, cobble, coarse woody debris, etc.): Percentage of substrate types is visually estimated for individual measured segments of shoreline during a survey of perimeter of lakeshore, and the percentages by type are totaled.

Available Spawning Habitat (spawning area and type of spawning habitat): No spawning habitat surveys have been conducted. The percentage of available (accessible) spawning gravel in inlet and outlet streams is visually estimated for measured stream areas. If available beach spawning habitat needs to be determined, gravel areas can be measured by snorkel surveys in areas where upwelling through gravel is measured or assumed.

Outlet Habitat Type (surface, subsurface, none): Outlet surveyed in field to determine if a surface connection exists part of the season so that fish can physically migrate out from a lake into downstream basin. Currently, the only available information is if a lake does or does not have an outlet.

Fish Presence: Fish presence is measured by setting funnel traps, visual observation of shallow areas of lake (by wading or snorkeling), observation of surface feeding activity, hook-and-line fishing, or gillnets. Since this information is to be gathered after a fish removal treatment, young of the year are the target of surveys. Visual observation and trapping are likely to be the most successful methods of surveying.
Fishless = Lake is currently fishless. This information has been determined by either survey or historic information (no reports of observed fish or lake with no recorded reproduction and has not been stocked in over 10 years).
1 = High confidence that fish are present in lake because (1) reproduction well documented, (2) lake has been recently stocked, or (3) recent reports exist of fish observed or caught.
2 = Low confidence in presence of fish because of lack of confidence in available records.

Fish Reproductive Status (by species/subspecies/hatchery stock): Fish have continued to persist in multiple year classes with no documented stocking occurring. Fish have been observed spawning, and fry have been documented during years when documented stocking is not known to have occurred.
1 = Lakes with known reproduction at adequate levels to sustain population.
2 = Lakes where limited levels of reproduction are known to occur.
3 = Lakes where limited levels of reproduction are thought to occur.

Fish Species Present (species/subspecies/hatchery stock): Fish species have been determined through historic records of stocking and examination of catch records. In one case (McAlester Lake), a genetic analysis of the fish population is available.
1 = Fish species/strain/hatchery stock is well documented.
2 = Fish species/subspecies/strain is not fully documented or level of introgression is suspected.
3 = Species of fish that is reproducing is not known.

Density of Reproducing Fish: The only reliable estimates are from mark-and-recapture studies conducted by OSU.

1 = Density of reproducing fish population has been documented through mark-and-recapture study (OSU protocols).
2 = Density of reproducing fish has not been quantified but estimated based on subjective data and best professional judgment.
3 = Density of reproducing fish has not been documented, and no data other than presence and a general idea of species is available.

Status of Fish Population in Outlet: The outlet stream of McAlester Lake is the only stream where an assessment of downstream migration of trout introduced into mountain lakes has been documented. Outlet streams of lakes with reproducing populations of trout should be surveyed by visual means (assessment of availability of suitable habitat and visual signs of trout) to determine where fish occur. Backpack electrofishers should be used to confirm the upstream extent of native fish (usually at a barrier falls) and the presence of introduced fish above and below the upstream maximum extent of native fish.

1 = Outlet has been surveyed for presence and type of fish downstream to native fish populations.
2 = Outlet has not been surveyed, but some evidence of downstream migration and colonization is available.
3 = Outlet has not been surveyed.
No outlet; No surface outlet is known to exist.

Amphibian Snorkel Survey: OSU protocol was used to determine salamander nearshore population densities by conducting nearshore snorkel transects of randomly selected 100-meter segments of lake shorelines.

1 = High confidence in data because more than 2 surveys were conducted.
2 = Moderate confidence in data because 1–2 surveys were conducted. The probability of detection of populations was still good, but density data may reflect low recruitment years (weather and other causes).

Amphibian Visual Survey: Visual surveys of amphibians conducted utilizing methodologies outlined in Olson et al. 1997. Surveys are not quantitative (number/time, area, or distance). Amphibians usually identified without capture, but where identification is questionable, individuals are captured by hand or dipnet and voucher specimens collected if necessary.

1 = High confidence in presence because amphibians were observed.
2 = Moderate confidence in presence data because more than one survey was conducted.
3 = Low confidence in presence data because only one survey was conducted.

Amphibian Trapping Survey: Trapping surveys conducted with funnel traps utilizing methodologies outlined in Olson et al. 1997. Some surveys were quantitative (number/time), but it is unlikely that enough traps were set to achieve the level of detection available from a snorkel survey. No mark-and-recapture surveys were conducted, so densities were not determined.

1 = High confidence in presence because amphibians were observed.
2 = Moderate confidence in presence data because more than one survey was conducted.
3 = Low confidence in presence data because only one survey was conducted.

OSU Benthic Macroinvertebrate Survey: Survey used OSU sampling protocols. BMI were collected with kicknets. No habitat data (substrate, riparian vegetation, and aquatic vegetation) were collected.

NOCA Benthic Macroinvertebrate Survey: Survey used NOCA sampling protocols. More intensive sampling of BMI occurred using kicknets for sampling. This protocol is more likely to detect presence of all species present than OSU protocols. In addition, habitat data (substrate, riparian vegetation, and aquatic vegetation) were collected.

NOCA Zooplankton Presence Survey (to document the presence of large copepod species)**:** Surveys used vertical net tows, but information has not been quantified and methodology or equipment documented.

OSU Zooplankton Presence Survey (to document the presence of large copepod species)**:** Surveys used OSU protocol for vertical (deeper lakes) or horizontal (shallow lakes) net tows. Samples were not quantified by volume of water sampled, but proportions of taxa were measured to determine dominant/subdominant taxa. Reliability of presence data is good, but sparse populations may not be documented.

OSU Zooplankton Density Survey (to document the presence and density of large copepod species)**:** Surveys used OSU protocol in vertical or horizontal net tows. Data were quantified by determining the volume of water sampled to approximate zooplankton densities by species.

Riparian Vegetation: Percentage of riparian vegetation by type (shrub, forest, talus, forbes) was visually estimated for measured segments of shoreline during surveys of lake perimeters. The total breakdown by percentage for each vegetation type was calculated from this data. Cells marked with an "X" indicate that a survey was performed. Cells marked with a "P" indicate that this information has been approximated through aerial photo interpretation.

Aquatic Vegetation: The percentage of shoreline with aquatic vegetation present has been visually estimated for measured segments of shoreline during a survey of lake perimeters. The total percentage of shoreline with aquatic vegetation was calculated from this data.

Management actions for each of the four categories of lakes are described in table F-2. Management actions and their associated monitoring requirements would differ for many lakes according to the action alternative (B, C, or D) chosen. A list of all 91 lakes and their management actions under each alternative are shown in table F-3. Under alternative B, up to 42 lakes may be available for fishing; under alternative C, up to 11 lakes may be available for fishing; and under alternative D, all 91 lakes would either remain fishless or be returned to a fishless condition. Under the no-action alternative (alternative A), current lake management practices would continue.

For each management action, the monitoring actions and objectives would remain the same, regardless of the alternative chosen, such as under management action 2A—remove all reproducing fish. Monitoring the recovery of native organisms and maintaining the lake in a fishless state would be the same under alternatives B and C. Under management action 2A, four monitoring actions are indicated:

Monitor effects of chemical fish removal on nontarget organisms (if applicable)

Monitor effectiveness of fish removal or die off (if applicable)

Monitor recovery of indicators after fish removal or die off (never restock)

Monitor riparian vegetation impacts/recovery (if present)

These monitoring actions are the same for all lakes that fall under management action 2A.

The various management actions and their monitoring requirements and objectives are listed in table F-4. Monitoring actions are shown in the main body of the table, and the monitoring objectives are described in footnotes. The process for deciding what monitoring should be performed is illustrated in the monitoring flowchart (figure F-1).

KEY DATA CATEGORIES AND SELECTION OF METHODS/PROTOCOLS FOR MONITORING

Key data are needed in order to determine into what category to place each lake and to monitor the effects of the various management actions. These data include such parameters as presence/absence of fish, density of fish, fish reproductive status, zooplankton species and abundance, benthic (bottom dwelling) macroinvertebrate community composition, lake productivity, lake depth, and lake location relative to the Cascade Crest (west or east side). Data already collected or needed to be collected are separated into abiotic (physical and chemical) and biotic (fish, amphibians) categories. Within each of these categories, data are further identified as either *key data* or *additional data* that may be useful but are not critical to monitoring the management actions.

TABLE F-2: MANAGEMENT ACTIONS FOR THE 91 LAKES

This table presents a standard set of fishery management actions for implementation under alternatives B and C. Note that management actions under alternative A would not change from current management, and management actions under alternative D only involve discontinuing stocking and removing all fish. The standard management actions in this table are broken down into classes 1-4, based on the Technical Advisory Committee's current understanding of the presence, reproductive status, and density of fish in the lakes. These standard management actions would require periodic monitoring and evaluation to facilitate adaptive management.	
For a lake that is currently fishless:	
1	The lake would remain fishless.
For a lake with high densities of reproducing fish, apply one of the following management actions:	
2A	Remove all reproducing fish. Monitor the recovery of native organisms and keep the lake fishless.
2B	Remove all reproducing fish. Monitor lake conditions and use the results to determine whether or not to restock the lake with nonreproducing fish. If the lake is restocked and monitoring results indicate fish are causing major adverse impacts, then fish densities would be reduced by changing stocking densities, stocking cycles or the species of stocked fish. If these management changes do not work, then discontinue stocking.
2C	Remove all reproducing fish. Implement a resting period (that is, keep the lake fishless for a period of time) to foster recovery of native organisms, The duration of the resting period will be determined on a lake-by-lake basis based upon monitoring results. If monitoring results indicate favorable recovery of native organisms, then restock the lake with low densities of nonreproducing fish and monitor lake conditions. If monitoring results indicate fish are causing major adverse impacts, then reduce stocking densities, stocking cycles, or the species of stocked fish. If these management changes do not work, then discontinue stocking.
For a lake with low densities of reproducing fish, apply one of the following management actions:	
3A	Remove all reproducing fish. Monitor the recovery of native organisms, and keep the lake fishless.
3B	Evaluate the reproductive status of fish and the status of indicator taxa. If fish density is high enough that impacts on indicator taxa may be major, apply prescription 2A, 2B, or 2C. If fish densities and impacts to indicator taxa are low, maintain the low fish densities. If monitoring data indicate fish are causing major adverse impacts, then completely remove fish.
3C	For lakes with extremely low densities of fish, augment the population with supplemental stocking and monitor indicator taxa. If monitoring results indicate fish are causing major adverse impacts, then stop stocking and remove all fish.
For a lake that has been stocked and does not contain a reproducing population of fish, apply one of the following management actions:	
4A	Discontinue stocking. Monitor the recovery of native organisms.
4B	Lack of data for decision-making. Discontinue stocking and monitor lake conditions. If the lake is restocked and monitoring results indicate fish are causing major adverse impacts, then discontinue stocking.
4C	Continue stocking with low densities of fish expected not to reproduce in the lake. If monitoring results indicate fish are causing major adverse impacts, then reduce stocking densities, stocking cycles or the species of stocked fish. If these management changes do not work, then discontinue stocking.

TABLE F-3: MANAGEMENT ACTION FOR EACH OF THE 91 LAKES

Note: Shaded rows indicate lakes that are in Ross Lake and Lake Chelan National Recreation Areas; the other lakes are in the national park portion of the North Cascades Complex.

Lake Name	NPS Lake Code	Current Condition of Lake (as represented under alternative A)	Management Action		
			Alternative B	Alternative C	Alternative D
Azure	MP-09-01	Fishless	1	1	1
Battalion	MLY-02-01	High density reproducing fish	2B	2B	2A
Bear	MC-12-1	High density reproducing fish	2C	2A	2A
Berdeen	M-08-01	High density reproducing fish	2C	2A	2A
Berdeen, Lower	M-07-01	High density reproducing fish	2A	2A	2A
Berdeen, Upper	M-09-01	High density reproducing fish	2A	2A	2A
Blum (Largest/Middle, No. 3)	M-11-01	High density reproducing fish	2B	2A	2A
Blum (Lower/West, No. 4)	LS-07-01	High density reproducing fish	2C	2A	2A
Blum (Small/North, No. 2)	MC-01-01	Fishless	1	1	1
Blum (Vista/Northwest, No. 1)	MC-02-01	Fishless	1	1	1
Bouck, Lower	DD-04-01	High density reproducing fish	2C	2C	2A
Bouck, Upper	DD-05-01	Stocked with nonreproducing fish	4A	4A	4A
Bowan	MR-12-01	Stocked with nonreproducing fish	4A	4A	4A
Coon	MM-10-01	Stocked with nonreproducing fish	4C	4C	4A
Copper[a]	MC-06-01	Stocked with nonreproducing fish	4B	4A	4A
Dagger	MR-04-01	High density reproducing fish	2B	2A	2A
Dee Dee, Upper	MR-15-01	High density reproducing fish	2B	2A	2A
Dee Dee/Tamarack, Lower	MR-15-02	Stocked with nonreproducing fish	4A	4A	4A
Despair, Lower	M-14-01	Fishless	1	1	1
Despair, Upper	M-13-01	Fishless	1	1	1
Diobsud No. 1	LS-01-01	High density reproducing fish	2A	2A	2A
Diobsud No. 2, Lower	LS-02-01	High density reproducing fish	2B	2A	2A
Diobsud No. 3, Upper	LS-03-01	Stocked with nonreproducing fish	4A	4A	4A
Doubtful	CP-01-01	High density reproducing fish	2C	2A	2A
Doug's Tarn	M-21-01	High density reproducing fish	2C	2A	2A
East, Lower	MC-14-02	Fishless	1	1	1
East, Upper	MC-14-01	Fishless	1	1	1
Firn	MP-02-01	Low density reproducing fish	3B	3A	3A
Green	M-04-01	High density reproducing fish	2B	2A	2A
Green Bench	LS-04-01	Fishless	1	1	1
Hanging	MC-08-01	High density reproducing fish	2A[b]	2A[b]	2A[b]
Hidden	SB-01-01	Low density reproducing fish	3C	3A	3A
Hidden Lake Tarn	EP-14-01	Stocked with nonreproducing fish	4A	4A	4A
Hi-Yu	M-01-01	Stocked with nonreproducing fish	4B	4A	4A
Hozomeen	HM-02-01	High density reproducing fish	2A	2A	2A
Ipsoot	LS-06-01	Low density reproducing fish	3B	3A	3A
Jeanita	DD-01-01	Low density reproducing fish	3B	3A	3A
Kettling	MR-05-01	High density reproducing fish	2A	2A	2A
Kwahnesum	MC-07-01	Stocked with nonreproducing fish	4A	4A	4A
McAlester	MR-10-01	High density reproducing fish	2B	2B	2A
Middle, Lower	MC-16-02	Fishless	1	1	1
Middle, Upper	MC-16-01	Fishless	1	1	1
Monogram	M-23-01	High density reproducing fish	2C	2A	2A
Monogram Tarn	M-23-11	Stocked with nonreproducing fish	4A	4A	4A
Nert	M-05-01	Stocked with nonreproducing fish	4A	4A	4A
Noisy Creek, Upper	LS-14-01	Fishless	1	1	1
No Name	PM-01-01	Stocked with nonreproducing fish	4C	4A	4A

TABLE F-3: MANAGEMENT ACTION FOR EACH OF THE 91 LAKES (CONTINUED)

Lake Name	NPS Lake Code	Current Condition of Lake (as represented under Alternative A)	Management Action		
			Alternative B	Alternative C	Alternative D
Panther Potholes, Lower	RD-05-02	Stocked with nonreproducing fish	4A	4A	4A
Panther Potholes, Upper	RD-05-01	Fishless	1	1	1
Pegasus	EP-10-01	Fishless	1	1	1
Pond SE of Kettling Lakes	MR-09-01	Stocked with nonreproducing fish	4C	4C	4A
Quill, Lower	M-24-02	Stocked with nonreproducing fish	4B	4A	4A
Quill, Upper	M-24-01	Stocked with nonreproducing fish	4B	4A	4A
Rainbow	MR-14-01	High density reproducing fish	2C	2C	2A
Rainbow, Upper (North)	MR-13-01	Fishless	1	1	1
Rainbow, Upper (South)	MR-13-02	Stocked with nonreproducing fish	4A	4A	4A
Rainbow, Upper (West)	MM-11-01	Stocked with nonreproducing fish	4A	4A	4A
Redoubt	MC-11-01	Fishless	1	1	1
Reveille, Lower	MC-21-02	Fishless	1	1	1
Reveille, Upper	MC-21-01	Fishless	1	1	1
Ridley	HM-03-01	Stocked with nonreproducing fish	4C	4C	4A
Sky	EP-13-01	Fishless	1	1	1
Skymo	PM-03-01	High density reproducing fish	2C	2A	2A
Sourdough	PM-12-01	High density reproducing fish	2B	2A	2A
Sourpuss	ML-01-01	Fishless	1	1	1
Stiletto	MR-01-01	Stocked with nonreproducing fish	4B	4A	4A
Stout	EP-09-02	Low density reproducing fish	3B	3A	3A
Stout, Lower	EP-09-01	Low density reproducing fish	3B	3A	3A
Sweet Pea	ML-02-01	Stocked with nonreproducing fish	4C	4A	4A
Talus Tarn	M-06-01	Fishless	1	1	1
Tapto, Lower	MC-17-03	Fishless	1	1	1
Tapto, Middle	MC-17-02	Fishless	1	1	1
Tapto, Upper	MC-17-01	Fishless	1	1	1
Tapto, West	MC-17-04	Fishless	1	1	1
Thornton, Lower	M-20-01	Low density reproducing fish	3C	3A	3A
Thornton, Middle	M-19-01	Stocked with nonreproducing fish	4C	4A	4A
Thunder	RD-02-01	Fishless	1	1	1
Tiny	MC-15-01	Fishless	1	1	1
Torment	ML-03-01	Stocked with nonreproducing fish	4A	4A	4A
Trapper	GM-01-01	Low density reproducing fish	3B	3A	3A
Triplet, Lower	SM-02-01	High density reproducing fish	2C	2C	2A
Triplet, Upper	SM-02-02	High density reproducing fish	2A	2A	2A
Triumph	M-17-01	Stocked with nonreproducing fish	4C	4A	4A
Unnamed	FP-01-01	Fishless	1	1	1
Unnamed	MR-11-01	Stocked with nonreproducing fish	4C	4C	4A
Unnamed	MR-16-01	Low density reproducing fish	3B	3B	3A
Vulcan	ML-04-01	Fishless	1	1	1
Wilcox/Lillie, Upper	EP-06-01	High density reproducing fish	2A	2A	2A
Wilcox/Sandie, Lower	EP-05-01	High density reproducing fish	2C	2A	2A
Wild	MC-27-01	Fishless	1	1	1
Willow	HM-04-01	Stocked with nonreproducing fish	4C	4C	4A

Notes:

a. In August 2004, a large fish kill was observed in Copper Lake, possibly due to disease. Further surveys are needed to confirm that the lake is fishless.

b. Remove all reproducing fish pending agreement with British Columbia.

TABLE F-4: MANAGEMENT ACTIONS AND MONITORING OBJECTIVES

Monitoring Objectives: (see below for descriptions)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Monitoring Actions: Management Actions [(a)]	**Perform Baseline Measurements**	**Monitor Effects of Chemical Fish Removal on Nontarget Organisms (if applicable)**	**Monitor Effectiveness of Fish Removal or Die Off (if applicable)**	**Monitor Recovery of Indicators After Fish Removal or Die Off (never restock) [(b)]**	**Monitor Indicators to Determine Restocking After Fish Removal or Die Off**	**Monitor Effects of (Re)Stocked Fish on Indicators [(c)]**	**Determine Characteristics of Fish Population**	**Improve Knowledge of Recreational Fishing Levels**	**Survey Riparian Vegetation Impacts/Recovery (if present) [(2)]**
Lakes that are Currently Fishless									
1 (Lakes to remain fishless) [29,29]	X[d] (for selected lakes)								
Lakes with High Densities of Reproducing Fish									
2A (Treat lakes to remove high-density reproducing fish) [8,22]	X (as needed)	X	X	X					X
2B (Remove reproducing fish, gather information, determine if lake should be restocked) [8,2]	X (as needed)	X	X		X	X	X	X	X
2C (Remove reproducing fish, allow lake to rest, restock with nonreproducing fish) [11,3]	X (as needed)	X	X			X	X	X	X
Lakes with Low Densities of Reproducing Fish									
3A (Treat lakes to remove low density reproducing fish) [0,8]	X (as needed)	X	X	X					X
3B (Evaluate reproductive status of fish, allow low densities of fish) [7,1]	X (as needed)	X (if needed)	X (if needed)			X	X	X	X
3C (Supplement low densities of reproducing fish with stocked nonreproducing fish) [2,0]	X (as needed)	X (if needed)	X (if needed)			X	X	X	X
Lakes with Nonreproducing Fish									
4A (Discontinue stocking of lake [nonreproducing fish]) [12,21]	X (as needed)		X	X					X
4B (Discontinue stocking of lake, gather information, determine if lake should be restocked) [5,0]	X (as needed)	X (if needed)	X (if needed)		X	X	X	X	X
4C (Continue to stock with nonreproducing fish) [9,5]	X (as needed)	X (if needed)	X (if needed)			X	X	X	X

Notes:

a. See table F-2 for full descriptions of the management actions. Numbers in brackets [B,C] are estimated numbers of lakes within each management action under alternatives B and C (see table F-3).

b. If needed as input to adaptive management decisions.

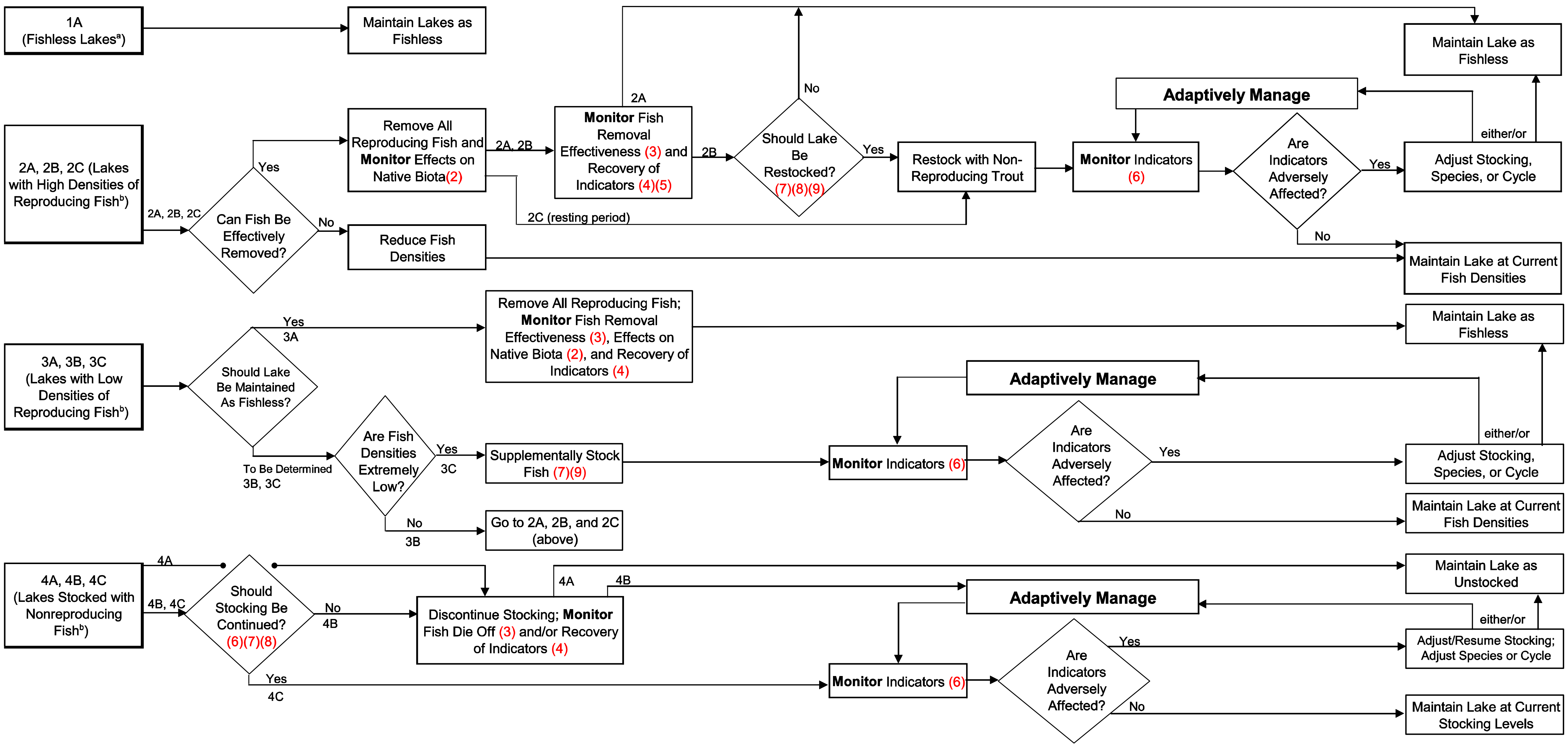
c. If unacceptable effects occur, a different management action (e.g., fish removal) would be applied.

d. X = possible monitoring could occur for each management action.

MONITORING OBJECTIVES:

1. To supplement existing data with key biological and physical/chemical data as needed for use as baseline in the monitoring program.
2. To evaluate the degree of adverse impact of antimycin on native biota in order to minimize impacts of future antimycin applications.
3. To determine the effectiveness of fish removal and to evaluate if all fish (reproducing or nonreproducing) have been eliminated or if population levels have been reduced, and if additional/different fish removal should be performed.
4. In lakes that would be maintained as fishless, to determine recovery of indicators after fish removal or die-off — never restock. Use the monitoring data as input for possible adjustments to thresholds or future adaptive management decisions.
5. Prior to any restocking, use the data to determine whether indicators are satisfactorily recovering to permit restocking at an appropriate level. Use the data as input to adaptive management decisions.
6. To determine the impacts of nonnative fish on the native biota. Use the data as input to future adaptive management decisions.
7. To improve knowledge of recreational fishing activity. To understand relative demand for fishing and focus mitigation measures where needed.
8. To determine fish population characteristics. Data would serve as one indicator of the biological condition of the lake and as an indicator of recreational fishing opportunities/experience and the need for stocking/restocking with nonreproducing fish.
9. If riparian-zone vegetation is present along shoreline, determine the impacts of trampling of vegetation by anglers. Data on degree of trampling and recovery would be used as input to management decisions.

FIGURE F-1: MOUNTAIN LAKES FISHERY MANAGEMENT MONITORING FLOW CHART



NOTES:

a. Selected lakes may be surveyed for baseline measurements of key data (1).

b. It is assumed that these lakes have adequate baseline aquatic data to support decision making. If data are found to be inadequate, the missing/inadequate key data sets would be supplemented with baseline sampling and analysis (1) as described in the monitoring plan and in "Table F-4: Management Actions and Monitoring Objectives."

Red numbers (1, 2, 3, 4, 5, 6, 7, 8, 9) indicate monitoring objectives (see "Table F-4: Management Actions and Monitoring Objectives").

ABIOTIC CATEGORIES—KEY DATA

Water temperature—required to accurately classify lakes for analysis of biotic data and is also used in determining fish removal methodology.

Water conductivity—required to determine effectiveness of electrofishing for use in removing fish.

Lake depth—required to accurately classify lakes for analysis of biotic data and to evaluate best methodology to effectively remove fish. Lake depth data is available for most lakes.

Total Kjeldahl nitrogen (TKN)—serves as a general indicator of lake nutrient levels and is needed to classify lakes for analysis of biotic data. TKN data is available for a moderate number of lakes, but the data is from many lakes and is questionable due to the extreme range of values recorded or the limited number of data points.

Substrate percentage by type (silt, sand, gravel, coarse woody debris, etc.)—needed to classify lakes by type when analyzing benthic macroinvertebrate (BMI) survey data and may be useful in evaluating the biotic integrity of assemblages of other groups of organisms.

Available spawning area (ASA or available spawning gravel) and spawning habitat (inlet, outlet, or beach) type—needed to evaluate the feasibility of fish removal and determine the best methodology for fish removal.

Outlet habitat type (surface, subsurface, none)—needed to determine if it is physically possible for fish in mountain lakes to migrate out of lakes into downstream basins.

Inlet and outlet water flows—needed to determine proper amount of the piscicide antimycin needed to eliminate fish, yet not impact other aquatic biota.

ABIOTIC CATEGORIES—ADDITIONAL DATA POTENTIALLY USEFUL

In addition to TKN, other basic water chemistry/water quality data (pH, water hardness, turbidity, basic nutrients) may be available or could be gathered while collecting water samples for TKN measurements. This information probably should be collected if additional TKN measurements are needed from individual lakes, but may not be necessary for the purposes of monitoring under the plan/EIS. Also, water samples for analysis of anthropogenic pollutants (such as methyl-mercury and persistent organic pollutants could be collected. Results of these analyses would be used to help understand any observed long-term trends in the monitored aquatic communities.

BIOTIC CATEGORIES—KEY DATA

Fish

Fish Presence—information has already been collected for the 91 lakes; however, after fish removal treatments, it would be necessary to survey lakes for fish presence to determine the success of removal treatments. If stocking were continued, fishing mortalities may have to be monitored to determine suitable stocking rates (densities) of nonreproducing fish.

Reproductive status of fish in lakes by species/subspecies/hatchery stock—needed in order to place each lake into one of the three categories used in the monitoring plan. It would also be used to classify lake by type for the analysis of survey data; that is, fish reproductive status would be required for analysis of BMI survey data under the protocol for the North Cascades Complex.

Species of trout present in lakes—needed in conjunction with reproductive status. This also includes examining suspect populations for hybridization. In some cases, genotypes would probably have to be determined by USGS biological survey. Tissue samples should be collected where fish cannot be identified by physical appearance (phenotype).

Density of reproducing fish—required in order to place each lake into one of the three categories used in the monitoring plan. Also, in lakes where gillnets would be used to reduce fish density, the success of treatment would need to be monitored.

Status of fish population in outlet—needed to assess the potential for escape or extent of escape of stocked populations of trout in mountain lakes to downstream water bodies.

Fishery health—needed as an indication of the quality of sport fishing in lakes that are currently stocked or would be stocked. Elements used to determine overall fishery health would include growth rates, condition factors, and parasite loads.

Amphibians

Three amphibian protocols (snorkel, visual, and trapping) have been utilized during amphibian surveys. Since larvae population densities are required for lake management, it is recommended that snorkel surveys be used for both presence and density information. All three methodologies could be used to determine salamander presence, with snorkeling providing the most reliable presence information. Although trapping may be used for mark-and-recapture estimates of population densities, snorkeling would be the most practical method of determining population densities of amphibian larvae. Amphibian surveys would focus on salamanders, but the presence/abundance of Columbia spotted frogs (*Rana luteiventris*) should also be noted.

Presence of salamander larvae by species—needed to document the presence of either of the two salamander species found in the North Cascades Complex: long-toed salamander (*Ambystoma macrodactylum*) or Northwestern salamander (*A. gracile*). Although the extended rearing period of salamander larvae in lakes (more than one year) increases the probability of detection, how appealing larvae are to fish can vary with weather and climate conditions.

Density of salamander larvae by species—needed to evaluate potential impacts of fish to salamander populations; same problems as described above.

Benthic Macroinvertebrates

Two protocols were used for benthic (bottom dwelling) macroinvertebrate (BMI) surveys. An OSU protocol was used for a provisional inventory of species composition at each lake; however, the methodology developed by staff at the North Cascades Complex has a greater probability of detecting less common or difficult to detect species, and when combined with substrate and vegetation surveys, enables a more detailed analysis and better predictions of species assemblages in the study area lakes.

Although there is some overlap in the lakes surveyed by the two different protocols, coverage is not complete. If the protocol at the North Cascades Complex were used for BMI surveys, additional surveys may be required in lakes that have only been surveyed under the OSU protocol.

Presence and frequency of occurrence of benthic macroinvertebrates by species—needed to determine the biodiversity index for BMI, which can be used to evaluate direct fish impacts to macroinvertebrates. The season of the year when lakes are surveyed, and the fragmented distribution of some species populations, may create issues with the BMI data, which may need compensation.

Zooplankton

Data describing the presence and density of large copepods are needed to evaluate direct fish impacts on zooplankton. Because the presence and densities of individual zooplankton species vary dramatically during the ice-free season, the timing of surveys can create an issue with the comparability of these data between lakes and from year to year.

Three protocols have been used for zooplankton surveys.

Earlier surveys were conducted by the NPS at the North Cascades Complex. Information about the survey methodology is not available, but it does not appear to have been quantitative and appears to have been used only for identification of a few species (large copepods and a few other important taxa).

Zooplankton surveys were also conducted by OSU using more intensive searches. Most of the surveys were not quantitative but only intended to determine presence of each species that were the dominant and subdominant species.

Additional surveys were conducted by OSU using essentially the same protocols used for their initial surveys but with the sampled water volume quantified. It was recommended that this latter OSU protocol be used to quantitatively measure the presence and density of large copepods during lake monitoring.

BIOTIC CATEGORIES—ADDITIONAL DATA POTENTIALLY USEFUL

Surveys of riparian and aquatic vegetation may be required in conjunction with the BMI surveys at the North Cascades Complex to determine the biodiversity index for individual lakes. Other vegetation data would be useful in assessing habitat quality for salamanders or the presence of sensitive plant species:

Riparian vegetation (percent by type: talus, shrub, forbes, forest)—information may be needed to classify lakes by type when analyzing BMI survey data and may be useful in evaluating the biological integrity of assemblages of other groups of organisms.

Presence and status of state-listed plant species or other vegetation that is unique or particularly sensitive to trampling—information would be useful in deciding whether to mitigate for angler use or whether a lake should be closed to restocking.

Aquatic Vegetation (percent of shoreline with aquatic vegetation)—information also may be needed to classify lakes by type when analyzing BMI survey data and may be useful in evaluating the biotic integrity of assemblages of other groups of organisms.

Width of emergent vegetation—useful in determining the survivability of adult salamanders during the breeding season. This could be collected during assessments of the percentage of aquatic vegetation.

Distance to closed-canopy forest—helpful is assessing the availability of adult salamander habitat for pond-breeding salamanders. This information has been evaluated through interpretation of ortho-photographs, actual field measurements of interpretation of better-quality aerial photographs would provide a better assessment.

Descriptions of monitoring protocols for each data category are provided in appendix F-1. The descriptions include a brief explanation of the protocol itself, the number of lakes where it has been performed, and the reason for collecting the data.

ADAPTIVE MANAGEMENT FRAMEWORK

Once the monitoring program has been initiated and *key data* collected, as needed, for each lake in the program, the data would be evaluated and interpreted to determine if a change in management direction would be needed, based on the management objectives. This could be done in a variety of ways, including the development and use of a formal decision support model, such as what is used in the *Northwest Forest Aquatic and Riparian Effectiveness Monitoring Plan* (Reeves et al. 2004) or by the establishment of a decision support framework that would use a designated Technical Advisory Committee to evaluate the data, based on a set of criteria or thresholds that would be developed to guide the decision. The committee would be charged with

establishing priorities as to which lakes to monitor and which physical/chemical/biological parameters to monitor

developing and refining evaluation thresholds/criteria

assessing whether the data indicate that some thresholds have been exceeded or that biological integrity of the system is being compromised

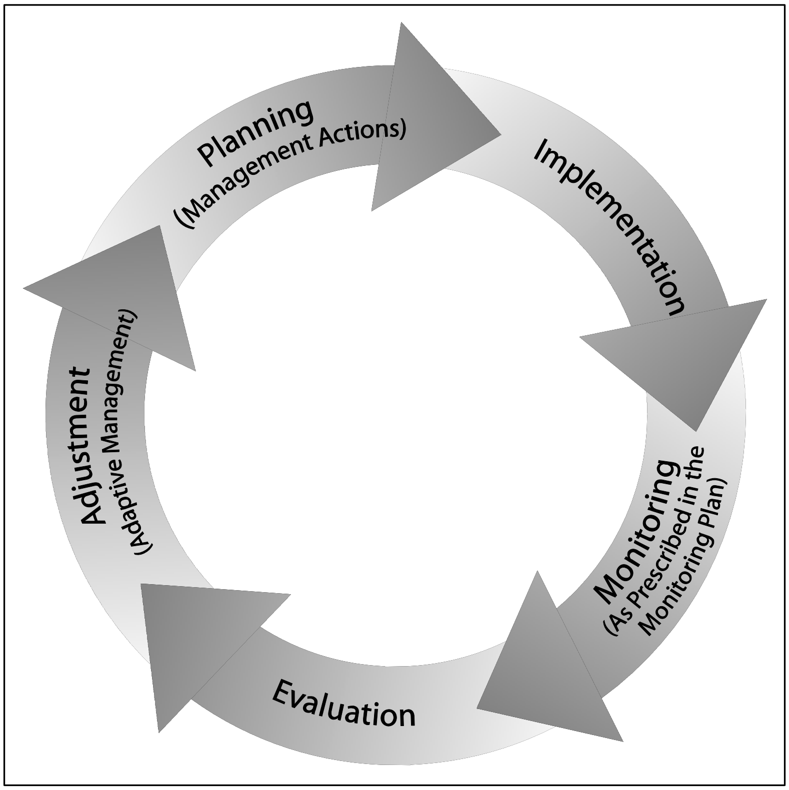
deciding if a change in management actions may be necessary

making other lake management decisions, as needed

At this point in time, a formal decision support model has not been developed for use in this proposed monitoring plan; rather, the following outlines a decision support framework, or decision protocol, that has been developed to provide for a consistent, integrated interpretation of the data, using the best science available. The interpretation would drive future adaptive management decisions, as indicated in figure F-2.

Integral to the adaptive management component of the framework, is continued monitoring and evaluation, as needed, to ensure the management objectives for the lake(s) are being met.

FIGURE F-2: FUTURE ADAPTIVE MANAGEMENT DECISIONS



TECHNICAL ADVISORY COMMITTEE COMPOSITION

A necessary component of this decision protocol is the establishment of a technical advisory committee (TAC) that would review the *key data* categories and validate reference sites and values; define the evaluation factors and criteria; adjust the decision support protocol, as needed, to take into account different indicator weights and relations; apply the criteria; and verify the results. This committee must include regional and provincial experts who represent interagency and interdisciplinary skills and who can draw upon the expertise and knowledge of local research and field staffs, as necessary. The TAC for the monitoring plan would consist of key researchers in the NPS, WDFW, and USGS who have been involved in past monitoring in the North Cascades Complex. In addition, other TAC members who would be familiar with the North Cascades Complex and the ecology of high mountain lakes may include informed citizens or the scientific community associated with local universities, the U.S. Environmental Protection Agency, and U.S. Forest Service.

Initially, TAC members could include the following: Roy Zipp (Natural Resource Specialist—North Cascades Complex), Reed Glesne (Aquatic Ecologist—North Cascades Complex), Bob Pfeifer (Inland Fisheries Management Biologist, Habitat Biologist—WDFW), Mark Downen (Inland Fisheries Biologist—WDFW), and John Wullschleger (Fisheries Biologist—NPS, Fort Collins, CO). Roy Zipp would serve as chairman of the TAC. Bob Hoffman (OSU Research Professor/USGS) would serve as technical advisor to the committee. The specific individuals on the TAC would likely change as the monitoring program evolves.

FRAMEWORK FOR DECISIONS

The basic framework would initially involve the TAC examining a suite of physical and biological indicators (the *key data* categories discussed above) to evaluate the condition of the subject lake (the "observed"), relative to a selected baseline (the "expected"). For each lake, the TAC would examine all the key data or indicator values that would be monitored under that lake's designated management action (see table F-3). Then, the TAC would use a multiple-lines-of-evidence approach to determine what level of change in the data would indicate a need for a change in management. Biological assemblages would be assessed in combination with physical and chemical attributes. The TAC would then interpret the suite of data as a whole, examining the indicator values, the amount of difference between "observed" and 'expected" values, and the interdependence among various factors to evaluate a lake's condition and condition of shoreline vegetation.

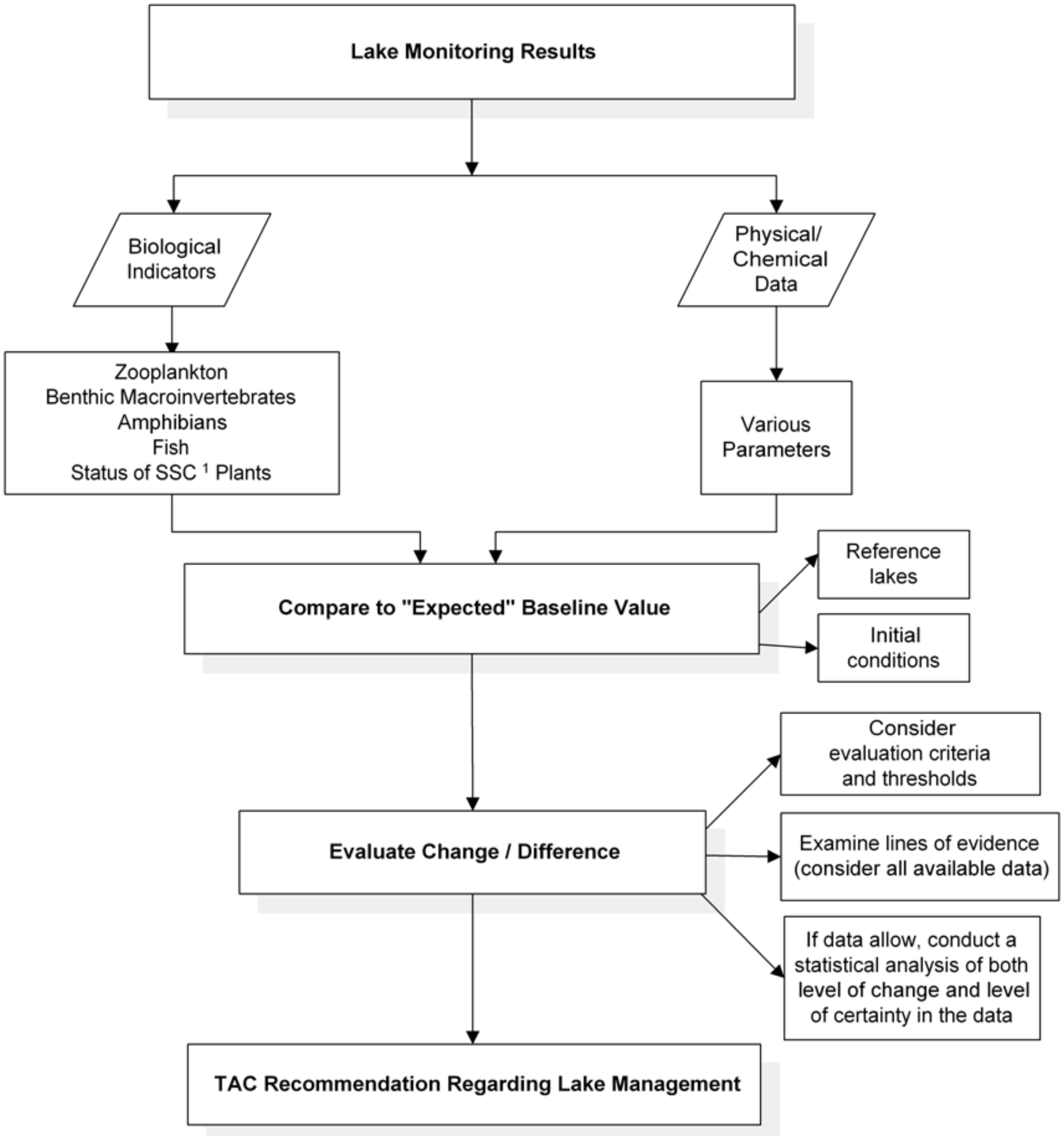
In general, the "expected" baseline would consist of similar data from a reference lake or lakes—generally historically fishless lakes of the same or similar class. General lake classes would be assigned based on work performed by Lomnicky et al. (1989). The first level of classification would separate the lakes into two major geographic regions with large-scale differences in climate, aspect, and vegetation, based on location east or west of the hydrological divide (Cascade Crest) of the Cascade Mountains. The second level of classification, representing smaller variations in ecological habitat, would also be considered.

Where distribution, habitat requirements, or species assemblages of indicator species or species assemblages are better known, reference lakes could be grouped by data specific to the indicator taxa. A predictive model for BMI species assemblages has been developed where mountain lakes in the North Cascades Complex are classified into six biologically similar groups based on location west (four groups) or east (two groups) of the hydrological divide and similarity of their BMI species composition (species assemblages), using ordination or clustering methods. Lake classes for predicting presence, species, and relative abundance of salamander larvae could be grouped by side of hydrologic divide, range of salamander distribution, lake fertility (measured by TKN value), and distance from other known or potential breeding lakes. The dominant large copepod (*Diaptomus kenai*) are strongly associated with lakes that have temperatures greater than 50ºF, while small copepods (*D. tyrrelli*) are strongly associated with shallow (less than 33 feet in depth) lakes with higher TKN values (Liss et al. 2002). Lake depth and TKN values are not correlated with the presence of large copepods, but their relative abundance in lakes with high densities of reproducing trout tends to be much higher in lakes greater than 33 feet in depth.

Data from the subject lake could also be compared with the initial conditions of the lake, or previously obtained monitoring results, to see what changes have occurred in the lake over time. Using this as a baseline would not imply that this would serve as the desired condition for the lake. It would, however, provide a baseline from which it would be possible to determine if application of the management actions are resulting in the desired change and the conditions in the lake are moving in the desired direction (in other words, is the observed change meeting the management objectives).

If the TAC agrees (by a consensus decision) that the observed change (such as reduction in fish density and reestablishment of indicator taxa) is meeting management objectives, management actions for the lake would not be changed. If, however, there has been no change or a significant change from the expected/desired value, and this cannot be explained by variables other than fish density or fish condition, a change in the management action would be indicated. Figure F-3 provides an illustration of the basic decision framework.

FIGURE F-3: BASIC DECISION FRAMEWORK



Note: 1. Species of Special Concern

EVALUATION THRESHOLDS

Absent a formal model, the TAC would be charged with evaluating the levels of change and their implication for lake management. The actual thresholds/criteria for each biotic and abiotic parameter cannot be defined at this time but would be defined initially by the TAC based on previously collected data. Thresholds for each data type would include the actual measurements/observations plus the associated data variability. The thresholds would be refined by the TAC as the monitoring program progresses. Park- or region-wide trends, as monitored in reference lakes, would be factored into all management decisions. Any changes in fishery management would require consideration of all appropriate data in a line-of-evidence approach and would require consensus of the TAC. The types of thresholds/criteria to be considered by the TAC would include, at a minimum, the following:

If the data for a parameter are statistically adequate, a change based on one or two standard deviations from expected would be applied.

If the data for a parameter are quantitative, but could not support a statistical evaluation, thresholds based on a percent change from baseline would be applied.

If the data for a parameter are qualitative, the observed changes would be classified as minor, moderate, or major and considered in conjunction with the quantifiable data.

PRIORITIES FOR MONITORING

Monitoring priorities must be set to determine which lakes should be monitored and which monitoring data types should be collected for each lake monitored. As described earlier, one of the initial activities for the TAC would be to establish priorities as to which lakes to monitor and the *key data* required for monitoring. Both prioritization activities would have to consider budget and schedule constraints. The following are the factors that would be considered when prioritizing lakes for monitoring:

Highest Priority—lakes requiring evaluation before a management action could be selected and implemented. These lakes would require further inventories of baseline conditions; the inventories would provide the basis for longer-term monitoring.

High Priority—lakes with management actions identified based upon sufficient baseline information. These lakes would be monitored to evaluate the success of management actions.

Low Priority—lakes with management actions identified but no current plans for implementation. These lakes would include the larger, deeper lakes in the North Cascades Complex that are targeted for fish removal. Also, fishless lakes selected to act as reference lakes would be categorized as either low- or high-priority lakes, depending on data needs and budget/schedule constraints. Data needs on trends in the North Cascades Complex may be satisfied using information compiled from higher-priority lakes or from other monitoring programs.

The factors to consider when prioritizing data types would include

Highest Priority—data that are considered *key data*. These data must be collected during baseline studies and monitoring in order to make management decisions.

High Priority—data that would help interpret the *key data*. These data, while not considered *key*, would help to interpret the consequences of management actions if the *key data* could not be conclusively interpreted. Should be considered for collection if funding and schedule permit.

Low Priority—data that would be nice to gather while a lake is being sampled but would not be used directly or indirectly by the NPS to make lake management decisions. Because these data may be useful to other researchers or fishery managers, the data may be collected if incremental costs and effort would not be excessive and if other sources of funding could be identified.

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APPENDIX F-1
SUGGESTED SURVEY PROTOCOLS

APPENDIX F-1: SURVEY PROTOCOLS

The categories listed below cover data categories that must be collected in the field, rather than by analysis of Geographic Information System (GIS) data and interpretation of aerial photographs. Where data (zooplankton presence and relative densities, amphibian presence and densities, water temperature, total Kjeldahl nitrogen [TKN]) would be expected to vary significantly over the ice-free season or from year to year, multiple samples (three or more) may be required to increase confidence in the collected data.

ABIOTIC CATEGORIES

PROTOCOLS FOR OBTAINING KEY DATA

Surface (epilimnetic) water temperature—from Hoffman et al. (2003). Temperature is measured in centigrade over the deepest spot in lakes at 1 meter (3.28 feet) from the surface and again half way to the bottom using a hand-held thermometer and a remote thermistor (thermocouple). Temperatures are recorded on warm summer days during the warmest period of the day (thermal maxima)—around 2:00 P.M.

Surface water temperature has been determined for 74 lakes. Mid-depth temperatures have not been taken but are useful in determining if thermal stratification occurs in a lake. Water temperatures are needed in the monitoring program to assess lake productivity and characterize lake habitat and expected biotic community.

Lake depth—from Hoffman et al. (2003). A handheld sonar device or calibrated line is used to determine a lake's deepest point. At a minimum, two perpendicular depth transects intersecting at the deepest point of the lake are conducted. When determined, the maximum depth and the UTM (Universal Transverse Mercator) coordinates of its location are recorded.

Maximum depths have been determined for 77 lakes. Maximum depths are needed in the monitoring program to help determine the most appropriate methods to use to remove fish and to characterize the basic lake habitat and expected biotic community. Transect depth profile data are needed to calculate the lake volume for use in estimating the volume of antimycin needed to remove fish.

Total Kjeldahl nitrogen (TKN)—from Hoffman et al. (2003). Water samples are collected for measuring TKN and a suite of water chemistry variables. A minimum of 1 liter sample of filtered lake water and 250 milliliters (ml) sample of unfiltered lake water should be collected at the deepest point of each lake and processed in the field by methods described in Hoffman et al. (2003). Samples will be transported out of the field and stored in a refrigerator for laboratory analysis. Additional samples (field duplicates) may be collected to ensure confidence in the repeatability of the data.

TKN values have been determined for 62 lakes. TKN values are needed in the monitoring program to help determine lake productivity and characterize lake habitat and expected biotic community. Additional water chemistry variables, including pH, alkalinity, conductivity, total dissolved solids, ammonia, nitrate-N, total phosphorus (and cations [positive ions] and anions [negative ions] if desired) may also be determined during laboratory analysis of the water samples. Samples for anthrogenic pollutants (e.g., persistent organic pollutants [POPs] or methyl-mercury) may also be collected at the same time as other water quality sampling.

Chlorophyll-a concentration—from Hoffman et al. 2003. Water samples may be collected for measuring Chlorophyll-a. A minimum 500 milliliter (ml) sample of filtered lake water should be collected at the deepest point of each lake and processed in the field by methods described in Hoffman et al. (2003). Samples will be transported out of the field and stored in a freezer until the sample is processed in the laboratory. Additional samples may be collected to ensure confidence in the repeatability of the data.

Chlorophyll-a values have not been determined for any of the lakes. Chlorophyll-a values are needed in the monitoring program as an indication (in addition to TKN) of lake productivity.

Dominant littoral substrate. The dominant littoral (near shore) zone substrate is estimated within 10% categories (silt, sand, gravel, cobble, coarse woody debris, etc.) during a visual examination of the perimeter of the lake.

Dominant littoral zone substrates have been determined for 25 lakes. Dominant littoral substrates measured in 10% increments is needed to characterize lake habitat and expected biotic community.

Available spawning area (ASA or available spawning gravel) and spawning habitat (inlet, outlet, or beach) type. Stream spawning gravels are assessed by walking all tributary and outlet streams until a barrier to upstream migration is reached. The percent of available spawning gravel in each segment is estimated and recorded. This data is used to calculate the amount of available stream spawning habitat. Available lake spawning gravel can be located by snorkel surveys of the littoral zones of mountain lakes during salmonid spawning periods. Generally, this area can be mapped accurately by recording redds (spawning areas) or surveying extent of upwelling area with flow metering devices. The recruitment new-year classes of trout fry in most lakes is limited by the available area of spawning gravel, rather than the number of available spawning females.

Field surveys indicate that limited spawning habitat is available at Wilcox/Lillie, Upper Lake (EP-06-01). Available spawning area has not been determined for any of the other study area lakes. Data describing available spawning habitat are needed as input for determination of the most effective fish removal technique and as an indication of the sustainability of trout populations in lakes with low levels of trout reproduction.

Outlet habitat type (surface, subsurface, none). Lake outlets where reproducing trout are present should be surveyed to determine if an accessible surface outlet exists that trout can utilize to migrate downstream from lakes into downstream basins. Although some lakes have been determined to have no outlets based on available mapping data, this should be confirmed in the field. In many cases, mapped outlets do not actually flow on the surface or do not receive water from mountain lakes. In other cases, an outlet stream may cease to have a surface channel and will flow subsurface for a considerable distance. For these reasons, it is recommended that, where there is concern that nonnative fish may enter stream basins through mountain lake outlet streams, the outlet stream be surveyed to determine if there is a complete surface connection to downstream basins. Surveys should extend to known perennial streams and preferably to the upstream limit of native fish distribution. Document any falls considered to be barriers to upstream fish migration for the native species in the downstream lake/pond.

Outlet habitat type has been estimated for all lakes from GIS data, but not confirmed in the field. An accurate assessment of outlet habitat type is needed in the monitoring program to assess the potential of nonnative trout in mountain lakes colonizing downstream basins.

Inlet and outlet flows. Inlet and outlet flows would be measured using a propeller flow meter in a measured flow channel (width and depth). By counting the number of revolutions over one minute, the flow in cubic feet per second can be calculated.

Inlet and outlet flows have not been measured at any lakes. These data are needed as input to the estimate of the volume of antimycin needed to remove fish.

BIOTIC CATEGORIES

PROTOCOLS FOR OBTAINING KEY DATA

Fish Surveys

Fish presence. Rod-and-reel angling, gillnet fishing, visual-encounter surveys, snorkel surveys, seining, electrofishing, or trapping can be used to determine fish presence or absence and species present, and with the exception of visual-encounter surveys and snorkel surveys, to collect meristic data (e.g., total and fork lengths, weight, sex, and age) and tissue samples for genetic analysis or analysis for methyl-mercury or persistent organic pollutants. Fish presence has been evaluated for all study area lakes, but data from several lakes are not considered reliable. A combination of gillnet and rod-and-reel angling gives the best combination of presence by species, meristic data, and tissue samples. Where it is necessary to determine the presence of fry (when determining if reproduction is occurring or if fish have been successfully removed from a lake), a combination of seining, trapping, snorkel surveys, and visual-encounter surveys may be required.

Where it is necessary to confirm the removal of reproducing populations of fish, a lake should be surveyed annually for the presence of fish. A period of at least 3 years with no detection of fish should pass before fish removal is considered a success. In lakes where reproduction has not been documented, and fish are to be removed through the cessation of stocking, the lake should be surveyed for fish approximately 10 years after the last stocking. If fish are observed, but numbers appear to be few, and fish are from the age class of the last stocking, the lake should be surveyed for fish presence periodically until no fish can be detected. If young fish are observed, the lake should be evaluated for the presence of natural reproduction.

Fish-presence surveys are necessary to confirm the presence or absence of fish, determine species of fish present, and to collect meristic data and tissue samples. Confirming the absence of fish requires a more intensive effort over a greater period of time than confirming presence and visual means of surveying. (Note: visual-encounter surveys and snorkel surveys do not allow the collection of any data other than confirmation of the presence of fish, although population densities can be estimated from quantified snorkel surveys.)

Species of trout present in lakes. Fish should be collected by one of the methods listed above under fish presence. Bias in sampling should be avoided by using multiple methods of collection to obtain as complete a collection of age classes and species present as possible. Fish should be field identified by specimen, but photographs and tissue samples (in 95% ethanol) should also be collected for verification of the species of fish that are present in the lake.

The trout species present in lakes have been determined to various degrees of accuracy for all lakes, but several lakes need additional data to confirm the identity of species/subspecies/hatchery stock. This information is needed to determine if reproducing fish in lakes are not native to the stream basin into which the lakes drain.

Indices of condition of fish. Fish should be collected by one of the methods listed above (except for snorkel surveys and visual-encounter surveys) under “Fish Presence.” Meristic data can be collected and recorded from the sampled fish. Indices of condition (such as Fulton Condition Factors), relative condition factor, or relative weight can be calculated from measurements of length and weight. The sex, species, and time of year that data is collected should be recorded along with meristic data. These factors can have a strong bearing on how the data is evaluated (condition can vary by sex, species, age, spawning period, and time of year).

Condition factors have not been collected for the *Draft Mountain Lakes Fishery Management Plan / Environmental Impact Statement* (plan/EIS), but data may be available for some of the 91 study area lakes. Indices of fish condition are needed to manage the fishery in lakes where the effects of fish stocking are evaluated. Condition factors also may be used as an indication if fish densities have exceeded the carrying capacity of a lake, providing a rough approximation of effects on native biota.

Growth rate of fish. Fish should be collected by one of the methods listed above (except for snorkel surveys and visual-encounter surveys) under “Fish Presence.” Meristic data can be collected and recorded from the sampled fish. Samples of fish scales and otoliths (particles of calcium carbonate found in the inner ear of vertebrates) should also be collected to age fish so that growth rates by length and weight can be calculated. The sex, species, and time of year should be recorded along with meristic data. These factors can have a strong bearing on how the data is evaluated (condition can vary by sex, species, age, spawning period, and time of year).

Growth rates of fish have not been collected for this plan/EIS, but data may be available for some of the lakes. Growth rates are needed to manage the fishery in lakes where fish stocking would continue. Growth rates also may be used as an indication if fish densities are having effects on native biota. Growth rates can also provide a good approximation of lake productivity.

Parasite load of fish. Fish should be collected by one of the methods listed above (except for snorkel surveys and visual-encounter surveys) under “Fish Presence.” Sampled fish can be dressed in the field and the gills, skin, viscera, and muscle tissue examined for the presence of parasites. Sampling of live fish is mandatory for parasite examination because many external parasites leave fish within minutes after the host’s death. As a result, when using gillnets to sample fish, nets should be sampled frequently. An external examination and necropsy (autopsy) conducted in the field may provide useful general information, but a complete parasite examination requires at least a good dissection microscope and a person with fish health training for a definitive inventory of parasites. This would require transport of living fish from the field. As a result, parasite examinations in the field would be limited to judgments of the severity of infections by an experienced biologist or technician. Methods described in Murphy and Willis (1996) should be used for the examination of fish parasite loads.

Parasite load data have not been collected for this plan/EIS, but this data may be available for some of the lakes. Estimates of fish parasite loads are needed to manage the fishery in lakes where fish stocking would continue. Fish parasite loads may be used as an indication if fish densities have exceeded the carrying capacity of a lake, providing a rough approximation of effects on native biota. High loads of parasites can be a sign of environmental stress, such as low levels of available forage organisms and organic and inorganic pollutants.

Reproductive status of fish in lakes by species/subspecies/hatchery stock. Fish should be collected by one of the methods listed above (except for snorkel surveys and visual-encounter surveys) under “Fish Presence.” The age of the specimens should be verified through the collection of scales and otoliths as described below under the section on density of reproducing fish. Length frequency distributions should not be used to distinguish different stocking efforts or year classes (Nelson 1988). Bias in sampling should be avoided by using multiple methods of collection to obtain a complete a collection of age classes and species present. At least 20–30 individuals should be collected, if possible. After the ages of collected fish are determined by examination in a laboratory, this information should be compared to documented fish stocking. The presence of many age classes of fish that were not documented in stocking records can be considered documentation of reproduction, with confidence increasing with the number of reproducing fish of various age classes present. A single age class, not the product of a documented stocking, may represent an undocumented stock and should be regarded as suspect (although many lakes may have reproduction only in years with favorable climate and water level conditions). Photographs and tissue samples (in 95% ethanol) should also be collected for verification of the species of fish that is reproducing in the lake.

The reproductive status of fish in lakes has been determined to various degrees of accuracy for all lakes, but several lakes need additional data to confirm determinations as to reproductive status and the identity of species/subspecies/hatchery stock that are reproducing. This information is needed to determine if a reproducing population exists in a lake and if the reproducing fish are not native to the stream basin into which the lake drains.

Density of reproducing fish. Mark-recapture methods (Gresswell et al. 1997) and gillnet sampling (Nelson 1964, 1972, 1984, 1988) can be used to determine the density of reproducing fish in lakes. Snorkel surveys similar to those for salamander larvae (Hoffman et al. 2003) can be used.

The density of reproducing fish has been determined through mark-and-recapture for 8 lakes and population densities based on average densities in the literature for the reproducing species have been estimated for an additional 18 lakes. This information is needed to assess the level of effect trout populations have on native biota, such as zooplankton (relative abundance of larger copepods), and salamander larvae (density and presence).

Status of fish population in outlet streams. Fish populations in outlet streams may be assessed to determine if nonnative fish stocked in mountain lakes are migrating downstream from lakes and either hybridizing or replacing native fish populations in downstream basins. In addition, nonnative fish may be colonizing reaches of streams above the range of native fish with possible effects on native biota.

The historic distribution of native fish in streams should be determined as accurately as possible from the available literature and fish inventory reports. Fish distribution is usually limited to the first major barrier falls on tributary streams, but sometimes there is a gradual loss of fish species diversity as successive barrier falls are encountered, while moving upstream. Where there is concern about the escape of reproducing trout from mountain lakes into downstream basins, or a need to prioritize lakes for fish removal by their effects to native fish populations in downstream basins, the upper limit of fish distribution should be approached by the most direct (or easiest route) available. At least two crewmen should participate in field surveys. The presence of fish should be determined by a combination of habitat evaluation (gradient and pool structure), visual encounter (using Polaroid glasses to more easily observe movements of fish in stream pools), and a backpack electrofisher and dip net. If fish cannot be found, survey downstream until the upstream limit of native fish distribution is found. Document any falls considered barriers to upstream fish migration. (Note: different fish species have different abilities to navigate barrier falls.) Sample 20–40 fish (if available) to determine species composition. If nonnative fish do not appear to be present, stop downstream survey; however, collect meristic information and tissue samples from sampled fish for later analysis of possible hybridization. Take photographs of sampled fish.

Survey either upstream to barrier for native fish or downstream from lake outlet, noting physical barriers to upstream movement. If no fish habitat (lower gradient reaches with pools) exists between the lake outlet and upper limit of fish distribution, it is only necessary to survey downstream from the lake until a reach of 100 meters (328 feet) of stream is surveyed with no fish encountered. When surveying upstream from the limit of native fish distribution, the survey can stop when nonnative fish are first encountered.

The colonization of a lake's outlet stream by nonnative trout stocked in the lake has only been documented for McAlester Lake. There is some evidence of downstream migration and colonization with reproducing populations of trout for 8 lakes. Densities of reproducing fish have been determined through mark-and-recapture for 8 lakes, and population densities based on average densities in the literature for the reproducing species have been estimated for an additional 18 lakes. This information is needed in the monitoring program to assess the extent of colonization of outlet streams and downstream basins by nonnative trout stocked in mountain lakes and its effect on native fish and other taxa.

Amphibian Surveys

Three amphibian protocols (snorkel, visual, and trapping) have been utilized during amphibian surveys. All three methodologies can be used to determine salamander presence, with snorkeling (Hoffman et al. 2003) providing the most reliable presence information. Trapping (Adams et al. 1997) can also provide highly reliable presence information, but the number of traps necessary to approximate detection abilities of snorkel surveys may be prohibitive at most mountain lakes.

Since larvae population densities are required for lake management, it is recommended that snorkel surveys be used for both presence and density information when surveying for salamander larvae. In addition to snorkel surveys for the determination of salamander larvae presence and densities, a visual-encounter survey should be conducted for frogs and toads using protocols outlined in Olson et al. (1997), Tyler et al. (1998), Brokes (2000), Hoffman et al. 2003, Thoms et al. (1997), Bury and Major (1997), and Crisafulli (1997). If frogs or toads (adults) are documented during visual-encounter survey, dipnets should be used to capture specimens, which can either be used for field identification (with photographs), as voucher specimens, or as sources of tissue samples for genetic analysis and identification.

Snorkel surveys for salamander larvae (along with visual-encounter surveys for other amphibians) have been conducted in 53 lakes. An additional 7 lakes have had visual-encounter surveys for amphibians. This information (presence and abundance of salamander larvae and presence of any other amphibians) will provide an estimate of effects of fish on native biota.

Benthic Macroinvertebrate Surveys

Two protocols have been used for benthic (bottom dwelling) macroinvertebrate (BMI) surveys. An Oregon State University (OSU) protocol was used for a provisional inventory of species composition at each lake; however, the methodology developed by personnel at the North Cascades Complex has a greater probability of detecting less common or difficult-to-detect species and was combined with substrate and vegetations surveys that enable a more detailed analysis and better predictions of species assemblages in the study area lakes. BMI survey data from the North Cascades Complex was used to develop a BMI index of water quality and biological integrity. Samples are collected using kick-and-sweep techniques for approximately 6 minutes at each of five randomly located sites at each lake, within the 1 meter (3.28 feet) depth contour.

BMI data using the North Cascades Complex protocol has been collected at 43 lakes (OSU BMI data is available for 23 of these lakes), with BMI data using the OSU protocol collected at an additional 16 lakes. The information is needed for the monitoring program to assess the biotic integrity of the BMI data in lakes by determining if the BMI assemblages of lakes fall within the their expected range of biodiversity or if the assemblages are being affected by high densities of fish.

Zooplankton Surveys

Three protocols were used for zooplankton surveys. Earlier surveys were conducted by personnel at the North Cascades Complex using protocols similar to those used by OSU during later surveys (Hoffman et al. 2003). These surveys primarily documented the taxa present in lakes and grouped them as dominant or subdominant in the zooplankton species assemblages. Zooplankton surveys also were conducted by OSU using essentially the same protocols but with the volume of sampled lake water quantified, so relative densities of large copepods and *D. tyrrelli*/volume of water surveyed could be determined for each lake. It is recommended that the quantitative OSU protocols be used to measure for the presence and density of large copepods and other zooplankton species. Both vertical and horizontal tows should be used in deeper lakes, with only horizontal tows 25 meters (82 feet) in length used in lakes less than 2 meters (6.5 feet) in maximum depth. In lakes that are greater than or equal to (≥) 2 meters maximum depth, at least three replicate vertical tows and one horizontal tow of approximately 25 meters in length should be performed.

Zooplankton presence data has been collected at 53 lakes, with relative abundance data collected at 20 of the 53 lakes. Zooplankton presence and relative abundance (at least for large copepods) is needed for the monitoring program to assess the effects of trout populations on zooplankton communities.

Vegetation Surveys

Surveys of riparian and aquatic vegetation may be useful (but not required) in conjunction with the BMI surveys and surveys for other taxa to characterize lake habitat and expected biotic communities.

Riparian vegetation (percent by type: talus, shrub, meadow, forest). The riparian vegetation is estimated within 10% cover categories (shrub, forest, meadow, talus) during a visual examination of the perimeter of the lake. Meadow species include both forbs (broad-leaf plants) and graminoids (grasses and sedges).

Riparian vegetation percent by type has been determined through field observation for 43 lakes. Riparian vegetation for the remaining lakes has been assessed through interpretation of aerial photographs, but the estimates have not been checked through ground observations. Riparian vegetation measured in 10% increments may be used to characterize lake habitat and expected biotic community. Both data types provide rough cover estimates, but they cannot be used to identify the specific types of vegetation that may be present in the riparian communities. The status (trampled or healthy) of the riparian vegetation can also be used to estimate usage by recreational anglers.

Aquatic vegetation (percent of shoreline with aquatic vegetation). The percentage of shoreline with aquatic vegetation present in the littoral zone is estimated within 10% categories during a visual examination of the perimeter of the lake.

Aquatic vegetation percentage has been determined for 43 lakes. The percent of shoreline littoral zone with aquatic vegetation may be used to characterize lake habitat and expected biotic community.

Additional vegetation data potentially available, but not necessarily needed, include

> *Width of emergent vegetation*—This information, which is useful in determining the survivability of adult salamanders during the breeding season, could be collected during assessments of the percentage of aquatic vegetation. Up to 30% of the breeding adult Northwestern salamanders leaving lakes in the Mt. St. Helens Volcanic Monument without emergent shoreline vegetation have been observed to be visibly maimed by feeding trout (Dr. Crisafulli, pers. comm., 2003).

Distance to closed canopy forest—This information has been evaluated through interpretation of ortho-photographs; however, actual field measurements of interpretation of better-quality aerial photographs would provide a better assessment of the availability of adult habitat for pond-breeding salamanders.

Additional vegetation data not currently available that should be collected include

Specific types of vegetation present in the riparian zone—The cover categories used to characterize the riparian and aquatic vegetation types are very general and do not indicate the specific types of vegetation present in those communities. Low, woody shrubs (such as *Phyllodoce* spp.), seedlings, and forbs are more sensitive to trampling and take longer to recover than do tall, woody shrubs (such as *Salix* spp.) and graminoids (Cole and Trull 1992). Assessments of the status of riparian vegetation should take into account the types of vegetation impacted. Recreational users should be informed to avoid heavily impacted areas, especially those communities sensitive to the effects of trampling.

Presence of state special status species—None of the lakes have been surveyed for the presence of riparian or aquatic state special status plant species. Because state special status species are rare and often occur in small populations, any trampling of those populations has the potential to have a major impact on the species. As resources and funds allow, surveys for special status species should be conducted by a qualified plant biologist in conjunction with surveys for other biota.

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