Appendix D

Lake Chelan Fishery Management Plan

Washington Department of Fish and Wildlife

2002

LAKE CHELAN FISHERY MANAGEMENT PLAN

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ACKNOWLEDGEMENTS

The ideas, understanding and direction in this plan are a direct result of a coordinated effort by many. In 1999 the Chelan Public Utility District (PUD) began the process of relicensing the Chelan Dam Hydro project. This forum allowed the subsequent meeting coordination and exchange of ideas by biologists from many agencies, sportsman and other local groups. Without the forum supported by the PUD this degree of coordination and the creation of this plan would have been very difficult. Therefore, we wish to thanks the Chelan PUD for their support.

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Abstract

In an effort to balance the biology of the current assemblage of native and non native populations of fish species in Lake Chelan, with the sometimes overlapping authorities and responsibilities of state and federal agencies and local sportsman's groups, the Chelan Public Utility District and other social interests, the Washington Department of Fish and Wildlife (WDFW), has created this up to date fishery management plan for lake Chelan. The plan emphasizes protection and restoration of indigenous fishes and natural reproduction, while maintaining as many sport fisheries as possible directed primarily on non-native species. Recommendations will be based primarily on the biological needs, of the lake fish populations and the fishery management directives of the WDFW. The wishes of involved sportsman groups and federal agencies have been seriously considered and included in the plan where possible.

Cutthroat trout (*Oncorhynchus clarki*) are indigenous to, and were once abundant in Lake Chelan. During the 1900s, hatchery removal of adult cutthroat spawners without replacement of young, interactions with nonnative fishes, lake level fluctuations and habitat changes devastated the cutthroat population. WDFW will attempt to increase cutthroat abundance in the lake and lake tributaries. Lake Chelan endemic Twin Lakes stock cutthroat are being hatchery reared and released in the lake. To establish spawning runs, eyed eggs are also being stocked in tributaries. Sport harvest of naturally reproduced cutthroat will be prohibited, eighty percent of the hatchery-reared fish will be adipose clipped and available for harvest.

Rainbow Trout (*Onchorynchus mykiss*) were introduced into Lake Chelan in the early 1900s. Rainbows compete and hybridize with cutthroat; eventually cutthroat numbers dwindle. Current stocking of rainbow into the lake will be replaced by ever increasing numbers of cutthroat until only cutthroat are stocked.

Bull trout (*Salvelinus confluentus*) were indigenous to Lake Chelan and lake tributaries, but are believed to have been extirpated about 1951. WDFW is considering the possibility of an attempt to reintroduce bull trout to the lake and the Stehekin River. We decided that restoring bull trout into Lake Chelan is currently problematic due to the presence of lake trout and should not be attempted at this time. However, we feel that efforts to reintroduce bull trout to various waters in the Lake Chelan basin are justifiable. This could include tributaries and small mountain lakes that drain into the Stehekin River or directly into Lake Chelan.

Burbot (*Lota lota*) and the pygmy whitefish (*Prosopium coulteri*) are indigenous to Lake Chelan. Very little is known about abundance, locations during various life stages, and interactions between these fishes and other species present in the lake, or how sport angling affects these fish. The management plan outlines methods designed to gather this information.

Kokanee (*Onchorynchus nerka*) were introduced to the lake in the early 1900s. Currently kokanee numbers and their size are acceptable to anglers. Landlocked chinook salmon (*Oncorhynchus tschawytscha*) were first introduced to the lake in the 1970s. Since 1995-chinook abundance has dwindled compared to earlier years. Floodwaters in the Stehekin River during 1995 severely impeded natural production of juvenile chinook, and WDFW hatchery supplementation efforts with juvenile chinook have failed during recent years. WDFW recognizes that chinook prey upon kokanee. Therefore, we plan to balance the chinook and kokanee abundance. The Fish Management Plan includes the tasks of annual monitoring of both species and the adjustment of hatchery stocks, supplementation numbers, rearing and release strategies and sports harvest accordingly.

According to records from local guides, annual salmon derby results, and comments from anglers, the landlocked chinook (*Oncorhynchus tschawytscha*) harvest since 1996 until the present has been dismal compared to earlier years. Some of the more vocal sportsmen are asking WDFW to increase numbers of chinook in the lake. Alternatives for management are presented.

Lake Trout (*Salvelinus namaycush*) were introduced to Lake Chelan in the 1980s and have been stocked in the lake until the year 2000. Any decision concerning the management of lake trout in Lake Chelan needs to be made with two considerations in mind. 1) Based on information from other systems, if the population of lake trout becomes abundant enough they will have the potential to substantially reduce the numbers of kokanee, landlocked chinook, cutthroat and other species in the lake. 2) Recently lake trout have contributed substantially to the fishery on Lake Chelan both in numbers and size. Alternatives for management are presented.

Brook trout (*Salvelinus fontinalis*) were introduced to Lake Chelan and its tributaries in the 1900s. Brook trout compete for rearing space and forage with cutthroat and bull trout. Interbreeding of bull with brook trout has been proven to eventually eliminate bull trout. Consequently, the presence of book trout will interfere with our attempts to restore both cutthroat and bull trout. The Draft Management Plan calls for the removal of angling limits for brook trout and possibly the use of electrofishing gear to physically remove brook trout from tributaries.

An evaluation of smallmouth bass (*Micropterus dolomieui*) abundance and their effect upon other species in the Lake needs to be conducted.

INTRODUCTION

Purpose

The purpose of this effort is to create an up to date comprehensive fishery management plan for lake Chelan that balances the biology of the current assemblage of native and non-native populations of fish species with the sometimes overlapping authorities and responsibilities of the Washington Department of Fish and Wildlife with the U.S. Forest Service, the National Park Service, the U.S. Fish and Wildlife Service, the Washington Department of Ecology, the National Marine Fishery Service, and the Yakima Indian Nation. The plan also considers the interests of the Chelan Sportsman Association, the Chelan Public Utility District and other social interests

The plan emphasizes protection and restoration of indigenous fishes and natural reproduction, while maintaining as many sport fisheries as possible, directed primarily on non-native species. Recommendations will be based on the biological needs, of the lake fish populations and the fishery management directives of the Washington department of Fish and Wildlife (WDFW). The wishes of involved sportsman groups and federal agencies have been seriously considered and included in the plan where possible. Proposals for future management for each game species in the lake are presented. Where management direction is unclear, alternative management strategies are presented. The plan provides methods designed to meet selected fishery management goals that were developed based on information available at this time. However, WDFW understands that fishery management is a dynamic process and expects that as new information becomes available the strategies and methods presented in this plan will change accordingly.

The geological characteristics, limnology of the lake, historical accounts of fish populations, past and present sport fisheries, hydroelectric manipulations of water levels and the implications of early and present day fish management is presented to give the reader an understanding of why we have chosen the particular fish management goals and recommendations in this plan. A comparison between the results from Brown (1984) and Duke Engineering (2000) studies funded by the Chelan Public Utility District (PUD) in response to the Federal Energy Regulatory Commission (FERC) re-licensing requirements will be emphasized.

Lake Chelan is located in northern Chelan County in Washington State. The lake was formed approximately 18,000 years ago during the Wisconsin glacial period. During this

time the Chelan Glacier moved down the valley from the north and the Okanogan - Columbia Valley lobe of the Cordilleran ice sheet extended upward from the south. The two glaciers approached each other and nearly met at Wapato Point and the narrows, respectively. The approach and recession of these two glaciers caused erosion to occur in the mid and upper portion of the lake, and geologic moraine depositions to form at the lower end of the lake. Together these effects created Lake Chelan (Freeman 1944; Whetten 1967; Kendra and Singleton 1987). Due to the effects of the two glaciers the lake now consists of two basins with differing topography. A shallow sill at a constriction known as the narrows separates the two basins. The Lucerne basin extends from the narrows northerly for 38.4 miles and is deep and fjord like; maximum depth is 1500 feet. The Wapato basin extends for 12 miles south of the narrows and is relatively wide and shallow in comparison, with a maximum depth of 400 feet. The glaciers left a deeply incised valley with extremely steep slopes plus a deep cold clear water lake described as ultraoligotrophic (Brown 1984). Lake Chelan is the largest natural lake in Washington and one of the deepest in the Untied Sates. This lake extends 51 miles from Chelan to Stehekin with 110 miles of shoreline and 32,980 surface acres of water (Figure 1). A maximum depth of approximately 1500 feet occurs off the mouth of Big Goat Creek. Mean width is about 1 mile. The Stehekin River and Railroad Creek supply 75% inflowing water. These two tributaries as well as numerous other steep gradient streams carry water to the lake from melting snow and glaciers in the high mountains of the Cascade Range. The lake is bordered on the south by the Entiat and Chelan mountains and the Glacier Peak complex and on the north by the Saw Tooth Mountain range (Duke Engineering 2000). North of Twenty Five-Mile Creek is rugged, mountainous, public land that is mostly managed by the U.S. Forest Service. The extreme upper portion of the lake near Stehekin is surrounded by mountainous public land managed by the National Park Service. From Twenty Five-Mile Creek down lake the terrain gradient becomes less precipitous and contains a substantial amount of developed private land.

Water from Lake Chelan flows from the outlet, located at the southern end, into the shortest river in Washington, the 4.1-mile long Chelan River. This river falls 400 feet in a four-mile descent through a steep rocky gorge to the Columbia River (Duke Engineering 2000). Early on Lake Chelan and the Chelan River were considered ideal for hydroelectric development. A small power plant was constructed between 1899 and 1903. This power plant had very little effect upon lake level. At least two other timber crib dams were built to improve commercial water traffic and hydropower production (Eldred personnel comm.). Between 1926 and 1928 the larger present day dam was constructed to facilitate electric power production. Prior to construction of this dam the lake level was normally at 1,080 feet above sea level. Lake levels post dam construction is annually varied from 1079 - 1,100 feet (normal max is 1,098) according to Federal Energy Regulatory Commission (FERC) jurisdiction to meet the needs primarily of power generation, and also of recreation, irrigation and flood control (Brown 1984; Duke Engineering 2000). The lowest lake elevations occur in March or April. The lake remains between 1098 - 1100 feet, from July 1 - September. Lake water is used for power production between October and April (Duke Engineering 2000). As a result

of dam operations flows in the Chelan River ranged from zero during some summer months too near 20,000 CFS during flood events (Eldred personnel comm.).

LIMNOLOGY

Historical productivity

Lake Chelan is the textbook example of an oligotrophic body of water. These bodies of water tend to be relatively deep, nutrient poor, clear, light transmission is high and the euphotic zone is deep. Even though light penetrates to a considerable depth, primary production of phytoplankton is limited by the lack of nutrients, all of which results in a biologically limited body of water. An orthograde oxygen curve where the entire water column is well oxygenated is common in these types of lakes. Brown (1984) reported, "Most of the time dissolved oxygen was at or near saturation levels at all depths and times sampled". This likely occurs in Lake Chelan because in most years stratification does not occur due to prevailing northwesterly winds causing mixing and oxygenation of the entire water column. Also, as a result of low productivity, only sparse amounts biological material reaches the hypolimnion thus, little oxidation occurs in that layer. Consequently, during years when the lake stratifies, the hypolimnion remains oxygen rich.

Measures of nitrates and phosphorus concentration in Lake Chelan, parameters indicative of lake productivity, were relatively low and correspond to what would be expected in an oligotrophic lake (Brown 1984). Because of low productivity it must be recognized that the fish carrying capacity of the lake is clearly limited. In its present condition Lake Chelan cannot support high densities of fish.

Fishery status Review:

Fish indigenous to lake Chelan include cutthroat trout (*Oncorhynchus clarki*), bulltrout (*Salvelinus confluentus*), burbot (*Lota lota*) and pygmy whitefish (*Prosopium coulteri*), northern pike minnow (*Ptychocheilus oregonensis*), bridge lip sucker (*Catostomus columbianus*), three-spine stickleback (*Gasterosteus aculeatus*), peamouth chub (Mylocheilus caurinus), and chiselmouth (Acrocheilus alutaceus).

Presently cutthroat trout numbers are very low, bull trout are extirpated, and burbot and pygmy whitefish still exist in an unknown abundance. The present day assemblage of fish in the lake includes all the above indigenous fish except bull trout, plus introduced rainbow trout (*Oncorhynchus mykiss*), lake trout (*Salvelinus namaycush*), kokanee (*Oncorhynchus nerka*) land-locked chinook (*Oncorhynchus tschawytscha*) small mouth bass (*Micropterus dolomieui)* and brook trout (*Salvelinus fontinalis*), primarily found in Twentyfive Mile Creek and the Stehekin River.

CUTTHROAT TROUT

A change in management direction is needed to restore the once abundant cutthroat trout (*Oncorhynchus clarki*) population in Lake Chelan. A comparison of creel survey results from 1981, 1982 (Brown 1984) and 1999 (Duke Engineering 2000) resulted in a sample of approximately 351, exactly 352 and 3 cutthroat trout, respectively. The lack of cutthroat in the 1999 survey is reason to be concerned about the cutthroat population.

Cutthroat trout are one of the few indigenous fish that presently reside in the lake. Early reports in the late 1800's and early 1900's documents an abundant population of cutthroat trout, which at that time provided excellent sport fishing (Brown 1984). Articles from the Chelan Valley Mirror contain statements such as: The fishing on the lake is fine and such large, speckled beauties. At the mouths of creeks, they would bite as fast as we could pull them out (Volume 1, No. 10, October 8, 1891); we had fishing until we were tired of it, and more fish than we could make use of. Then we quit. One morning before breakfast, I took nine 2-pound trout, all gamy fellows. Most of the fishing was at Pine Creek, Lake Chelan (Volume 3, No. 1, August 3, 1893); Four Manson fishermen returned from a fishing tour Sunday with a hundred and five of the biggest and best trout ever caught in Lake Chelan (Volume 28, No. 16, April 18, 1918). The average fish harvested was about one and three quarter pounds, most were caught off the mouth of lake tributaries.

During this period, Lake Chelan was in pristine condition. The angling was superb for those few who had the opportunity to fish the lake. However, this quality of angling was soon to change. Throughout the 1900's a combination of events took place that led to the demise of the cutthroat trout population. The effects of hatchery mining of cutthroat spawners without replacement, the introduction of nonnative fishes, logging in watersheds, mining in Railroad Creek (with its subsequent toxic contamination of the

creek and lake), tributary habitat degradation caused by the development of roads and houses in the Wapato basin, lake level fluctuations and habitat changes resulting from hydroelectric production, and possibly over fishing, collectively took their toll on the once abundant cutthroat.

In 1909 the first fish hatchery in Washington was constructed on Boulder Creek at the head of Lake Chelan. The hatchery was moved from this location in 1915 to Bear Trap Springs and moved again in 1927 to Rainbow Creek. Annually between mid April and mid June, up to thirteen traps were used to capture spawning cutthroat. Eggs were taken from these fish, fertilized, water hardened and shipped throughout the state. None of the fish produced from these egg takes were returned to the lake until 1924. From 1924-1927 sac fry were released back into the lake in numbers equal to eggs shipped. The hatchery was in operation from 1909 through 1927. Records from 1909-1915 have not been found. However, records from 1916-1927 show that the number of adult fish that could be trapped declined from 1,697 in 1916 to only nine in 1927 (Brown 1984). The hatchery was closed after 1927 because of lack of fish. The state of Washington fishery workers began introducing rainbow trout between1906 and 1913 and kokanee salmon to the lake in 1917. Cutthroat now had to compete for forage (in a very unproductive lake) with two exotic species. Cutthroat also hybridized with rainbows.

In 1928 the Chelan Electric Company built a dam at the outlet of the Lake and began lake level manipulation for hydroelectric production (Lake Chelan Fishery Problems 19??). The Initial rising of the lake flooded some spawning areas at the upper end (Lake Chelan Fishery Problems 1967). This was partially corrected when spawning gravel was enhanced in the lower Stehekin River basin in the mid 1950s and in 1965 with an artificial spawning channel constructed in Twenty Five Mile Creek as mitigation for Rocky Reach Dam's effect upon the whitefish fishery in the Columbia River (Eldred WDFW, personal communications). Currently, this channel is not functional, but plans are being made for cleaning and remodeling of the structure. Another artificial spawning channel was planned for construction in Company Creek but was never built

Early pre-hydro project records of hatchery cutthroat trapping in Lake Chelan show that the cutthroat spawning runs historically occurred between mid April and mid June. Of concern are the findings from a study in 1999, Duke Engineering (2000), who captured fry in the tributaries and by back calculating was able to determine that cutthroat spawning took place only in July and August. Recent on going work by the U.S. Forest Service (USFS) and WDFW has shown that deposits of alluvial gravels in the lake at the mouths of most lake tributaries, coupled with the current mode of lake level management is preventing spring spawning fish, which includes cutthroat trout and rainbow trout, from ascending these tributaries to spawn until June or July Consequently, in recent years only the latest spawning remnants of the original cutthroat and rainbow trout spawning run have been able to enter tributaries and spawn. This greatly delayed spawning is of tremendous importance, because it results in late emergence of fry. These fry loose the early rearing months of growth. Consequently, these progeny are smaller and thus

more vulnerable to predation, less able to compete for forage, and enter the winter at a size and weight that may compromise their survival.

Restoring access to tributaries for spring spawning fish will be a responsibility charged to the Chelan Public Utility District (PUD) as a requirement of relicensing the Chelan Hydro-power project in 2004; this will be accomplished by removing deposits of alluvial gravels in the lake at the mouths of most lake tributaries and changing the current mode of lake level management.

In addition to the lack of spring access to tributaries, WDFW current regulations allow angling at the mouth of lake tributaries on July 1. The current regulation allow anglers to catch late spawners prior to their entry into the tributaries and furthers the continuing decline in cutthroat and naturally reared rainbows in Lake Chelan.

RAINBOW TROUT

Competition for forage and spawning habitat between rainbow trout and cutthroat needs to be minimized and hybridization between the two species needs to be eliminated. Hatchery reared rainbows stocked into Lake Chelan have been exiting the lake and entering the Columbia River when the PUD spills water over the dam (Steele and Viola WDFW, 1999, personal observations). Hatchery rainbow presence in the Columbia River creates potential competition between rainbows and endangered juvenile steelhead and potential breeding with adult Upper Columbia steelhead. The latter will potentially infuse un-desirable characteristics into the steelhead population.

Wild resident rainbow populations did not inhabit Lake Chelan prior to 1908 (Brown. WDFW, personnel communications, 2002). Early records show that rainbows from Packwood Lake were first introduced into Lake Chelan in 1916 (Chelan News Leader, June 13, 1916. Rainbows have been stocked into the lake ever since. In recent times about 100,000 3-5-fish/lb. rainbows annually have been released into the lake to satisfy Chelan PUD mitigation agreements. A naturally reproducing population of rainbows that were derived from the hatchery-stocking program currently exists in the Lake.

Ever since rainbow trout were first introduced, they have contributed to sport harvest in the lake. However, Brown 1984 concluded that hatchery rainbows provided little benefit to the fishery. He based this conclusion on the fact that few of the rainbows sampled in 1981 and 1982 showed any signs of hatchery origin (stubbed dorsal fins, etc.). In contrast, 97 percent of rainbows in the 1999 creel survey were of hatchery origin (Duke Engineering 2000).

Proposed changes in cutthroat and rainbow trout management:
Changes in cutthroat and rainbow trout management including monitoring and evaluation of these two species are, interrelated and must be considered together. Replacing the stocked catchable size rainbows with catchable size cutthroat (Twin Lakes Stock) will

supplement the present cutthroat population. Reduction and eventual discontinuance of rainbow trout stocking will diminish hybridization and other negative interactions between rainbows and cutthroat. We must proceed deliberately and with caution, the change from rainbow to cutthroat must occur over five years. Rigorous annual monitoring is necessary to ensure adequate information is collected to evaluate the success of this program change.

Management recommendations for cutthroat and rainbow trout management.

Over a four-year period, with careful monitoring and evaluation, replace the 100,000 rainbows (3 -5 fish/lb) that are customarily stocked with 100,000 Twin Lake cutthroat of the same size. Eighty percent of the catchable size cutthroat stocked in the lake will have their adipose fin clipped off to identify them as legal “keepers”. Simultaneously, WDFW will establish regulations that allow the legal harvest of only adipose clipped cutthroat. These efforts in combination will ensure that a significant portion of the stocked cutthroat is protected from harvest and escape to spawn. We realize that some of the unclipped fish will be lost to accidental hooking and natural mortality. The optimum percent to clip in order to balance harvest and adequate spawning escapement will have to be determined from monitoring and evaluation efforts.

Twin Lakes cutthroat eggs

Twin lakes cutthroat brood fish may not be capable of providing all the eggs needed for the many hatchery programs throughout Washington and Idaho that are currently supplied these eggs. Twin Lakes stock cutthroat originated from Lake Chelan (Brown 1984); and are the appropriate stock to use in Lake Chelan; this does not apply to the other waters currently stocked with these fish. Accordingly, during years when an insufficient amount of eggs cannot be supplied for all programs, Twin Lake cutthroat eggs should be automatically allotted for Lake Chelan. Alternative sources of cutthroat eggs should be located for other hatchery programs. To partially alleviate the potential for a Twin lakes egg shortage problem we propose to shift Twin Lakes cutthroat eggs presently assigned to the Lake Chelan fry-stocking program, to the new Lake Chelan catchable size cutthroat program. Since 1993 WDFW has annually stocked about 65,000 cutthroat fry into the lake, nevertheless, the cutthroat population has continued to decline. Evidentially, the fry-stocking program has not been successful and the eggs would be used more efficiently used in the catchable size cutthroat program

Cutthroat eggs from Twin Lakes are not taken until May and will need to be reared at the hatchery until August of the next year to get them to catchable size. In 2002 the WDFW reared approximately 16,000 catchable cutthroat trout and released them in to Lake Chelan in lieu of 16,000 catchable rainbows. Our plans for the next four years are to increase the number of cutthroat stocked into the lake while simultaneous reducing an equal number of rainbows stocked. In the year 2002, 2003, 2004 and 2005 we plan to replace 35,000, 60,000, 80,000 and 100,000 catchable rainbows, respectively with equal numbers of catchable size cutthroat.

2) During 2001 the WDFW stocked 60,000-eyed Twin lakes cutthroat eggs, in each of First and Twenty-five mile creeks, using on site incubators. We plan to annually duplicate this effort in 2002 – 2005. This purpose of this endeavor is not to produce a great number of fish, but to establish spawning runs of cutthroat in these tributaries, thus contributing to the effort to restore cutthroat to Lake Chelan. Success of this effort will be monitored for at least 6 years. If this effort proves successful, stocking of eyed eggs into First and Twenty-five mile creek will continue past 2005 and other tributaries may also be stocked wisely with cutthroat eggs.

MONITOURING CHANGES IN CUTTHROAT AND RAINBOW TROUT MANAGEMENT

This management plan is designed to alter the abundance and composition of fish species in Lake Chelan. The plan outlines many methods to accomplish this goal. The purpose of a creel survey on Lake Chelan is to collect the necessary information that will be used to evaluate the success of those methods. To ensure that the results from any future creel surveys on Lake Chelan are useful and relevant, the methods used need to be comparable to those used in the past by Duke 2000, Hagen 1997 and Brown 1984; the methods outlined here are designed with this in mind.

Creel survey methods:

Conduct annual creel surveys designed to monitor and determine the contribution of cutthroat and rainbow trout to the sport fishery; annual creel surveys should begin in 2002 and continue until 2005.

The main purpose of the survey is to: 1) determine the relative composition of fish species and origin (naturally produced or hatchery released) contributing to the sport fishery; and 2) determine what species of fish anglers prefer to catch. To obtain effort and harvest information the survey should use aerial boat counts, and roving on–lake angler interviews beginning in April and continue until mid October. Both aerial boat counts and the angler interviews should be on a stratified random basis. Strata should include weekdays, weekends; A.M. (0700 –1400 hours) and P.M. (1400 – 1100 hours) time periods, upper-lake (up-lake from Safety Harbor) and lower- lake (down-lake from Safety Harbor). At least two randomly chosen weekdays and one non-random weekend day, alternating between Saturday and Sunday, should be sampled per week. Aerial surveys will count and record the date and time of the survey and the number of boats observed (independently for the upper and lower portions of the lake). Angler interviews should be designed to collect information on angler effort (hours fished), fish caught and kept (or released) by species, fish length, weight, scales samples; (otoliths from burbot) for age analysis; all fin clips or other identifying marks should be recorded. Stomach samples can be obtained by offering to clean angler's fish. Stomachs should be preserved in a 10% solution of formalin for future analysis. A questionnaire

designed to learn angler species preference and satisfaction can be handed out during interviews with a self addressed envelope. Anglers will be asked to answer the questions when they have time and return the questionnaire by mail. Results from this survey will yield the information needed to determine if the catchable size cutthroat are replacing the catchable size rainbows in the sport harvest and information to evaluate angler's reaction to the change in species.

Spawning ground survey methods:

In year 2002 and in future years estimate adult spawning cutthroat and rainbow trout abundance in First Creek and Twenty-five Mile Creek.

We will walk First Creek and Twenty-five Mile Creek each week beginning in early April through July. Each adult cutthroat and rainbow trout observed will be documented. In addition, each redd observed will be given a unique alpha numeric code; F1, F2 and T1, T2 and so on to identify the first, second and subsequent redds observed in First Creek and Twentyfive Mile Creek, respectively. This code, along with the date and the surveyor initials, will be written with a permanent marker on flagging tape and attached to the riparian vegetation to mark the location of the redd. This information, along with any other pertinent information, will be recorded. Each week we will survey the exact same sections of each creek and attempt to locate and describe the condition of all the previously located redds and to locate any newly constructed redds. All new redds located will be marked with flagging tape and the appropriate information will be recorded. Both rainbow and cutthroat trout can be expected to construct redds in both of these creeks at approximately the same time of year. An effort to observe and document the actual species that constructed each redd will be made by hiding for at least 5 minutes in the hopes the spawning fish will return. Over the years increases or decreases in the number of adult cutthroat observed and the number of redds that can be identified as being constructed by cutthroat will give us the means to evaluate the success of our efforts to restore the cutthroat population, both with eyed eggs and the stocking of catchable size cutthroat.

If spawning surveys document an increase spawning by cutthroat trout future fishing regulations for First and Twentyfive Mile creeks may be altered to protect spawning cutthroat.

Fishing regulations:

By altering the current fishing regulations WDFW will protect, from harvest, a portion of the stocked cutthroat trout and all naturally produced cutthroat. These fish will then be available to spawn naturally. A portion (20% to begin with) of the stocked catchable size cutthroat will not be adipose fin clipped. The new regulations (Table 1) will allow harvest of only adipose clipped cutthroat, and also prohibit angling near the mouths of tributaries where cutthroat typically concentrate. The new regulations will also encourage anglers

to harvest rainbow trout that interbreed and compete with cutthroat, and to harvest lake trout, which are notorious cutthroat predators.

Table 1. The proposed regulation for Lake Chelan, 2002

Water	Species	Season	Min size	Daily Limit	Additional rules
CHELAN LAKE (Chelan Co.) south of a line between Purple Point (at Stehekin) and Painted Rocks to Chelan Dam, except **CLOSED** within 400' of the mouth of all tributaries.	TROUT	Year-round	None	5	TROUT- Wild CUTTHROAT **(adipose fin present)** release. Kokanee and Lake Trout (Mackinaw) are not included in the TROUT daily limit. Burbot one setline with up to 5 hooks may be used. **Salmon are NOT included in the TROUT daily limit.**
	LAKE TROUT	Year-round	None	No limit	
	KOKANEE	Year-round	None	5	
	BURBOT	Year-round	None	5	
	Other Game Fish	Year-round	Statewide	rules	
	SALMON	May 1 - 30	15"	1	
North of a line between Purple Point (at Stehekin) and Painted Rocks.	TROUT	Aug 1- Mar 31	None	5	TROUT- Wild CUTTHROAT **(adipose fin present)** release. Kokanee and Lake Trout (Mackinaw) are not included in the TROUT daily limit. Burbot one setline with up to 5 hooks may be used.
	LAKE TROUT	Aug 1- Mar 31	None	No limit	
	KOKANEE	Aug 1- Mar 31	None	5	
	BURBOT	Aug 1- Mar 31	None	5	
	Other Game Fish	Aug 1- Mar 31	Statewide	rules	
	SALMON	**CLOSED**			**CLOSED to fishing for salmon year-round**

Evaluation:

To be considered successful the following four main objectives should be met.

1) The catchable size cutthroat must eventually replace the catchable size rainbows in the sport fishery. Results from annual creel surveys will provide catch per unit effort, total all effort and harvest of cutthroat and rainbow trout. A comparison of these values to results of creel surveys from previous years should allow us to evaluate how successfully the cutthroat are replacing the rainbow trout in the sport fishery.

2) A majority of anglers fishing Lake Chelan need to accept the change in species; questions designed to learn angler preference, included in the creel surveys, should allow us to determine how well anglers have accepted the change from rainbow to cutthroat trout.

3) A sufficient number of the catchable size cutthroat must escape harvest and recruit to the spawning run in order to substantially increase natural production.

4) Cutthroat hatched from eyed egg stocking must survive to maturity, spawn and contribute to increased natural production. A comparison of annual cutthroats redd construction as observed during annual spawning ground surveys will provide the information needed to determine the success of increasing natural reproduction of cutthroat trout.

KOKANEE

Kokanee are the most sought after fish in Lake Chelan (Brown 1984; DES 2000). Maintaining a popular kokanee sport fishery in Lake Chelan is a high priority. However, kokanee should be managed to maintain an abundance of kokanee at a size acceptable to anglers, but at the same time at a level of abundance that does not substantially hinder our efforts to restore native species.

Kokanee were first stocked into Lake Chelan in 1917 (Brown 1984). Three years later the Chelan Valley Mirror wrote: “Professor E. Victor of the University of Washington advises me that he has received information from one of the University Professors who is sojourning on the shores of Lake Chelan that he observed silver trout (Oncorhynchus nerka kennerlyi) in great quantities ascending some of the inlets of Lake Chelan, but that these are being taken by residents in large numbers without regard for bag limits. He says they are being salted, preserved or otherwise cured” (Volume 30, No. 42, 1920).

Early kokanee egg taking operations began at Twenty Five Mile Creek, Railroad Creek and Prince Creek, but were moved in 1942 to the Stehekin River (Johansen 1961). Johansen described the 1941 kokanee spawning run as “hundreds of thousands of kokanee literally cramming the Stehekin and what appear to be the principle-spawning tributary, Spring Creek” now known as Company Creek. Eggs were taken from Lake Chelan runs and hatched at Chelan Falls and Chiwaukum hatcheries. WDFW stocked only Lake Chelan stock kokanee fry into the lake from the early 1940's until about 1957. In 1957 Kootenay Lake stock kokanee were introduced into the lake as eyed eggs, and in 1966 Whatcom stock kokanee plus, Kootenay stock kokanee began to be stocked as eyed eggs and in later years as fry. Currently only Whatcom stock fry are being stocked. Kokanee stocking records earlier than 1933 are missing.

Prior to 1976 natural recruitment of kokanee was so successful that eventually they became over-populated and exhibited poor growth. Anglers were dissatisfied with the size of these fish. In an effort to alleviate this problem WDFW stocked mysis shrimp (M*ysis relicta*) into the lake in 1968 to provide forage for kokanee. At that time it was believed that an introduction of Mysis into Waterton and Kootenay lakes in British Columbia was the cause of the greatly increased size of the small kokanee previously populating these lakes. WDFW biologists believed an introduction of Mysis would have similar beneficial results in Lake Chelan. Unfortunately, history would prove the introduction of mysis into Lake Chelan, and elsewhere, to be a mistake. In general, both young Kokanee (i.e. less than 10 inches in length) and Mysis compete for zooplankton species. Larger kokanee are capable of foraging on mysis shrimp, but unfortunately the diurnal migrations of Mysis shrimp do not correlate with the feeding habits of kokanee. Consequently Mysis shrimp are mostly unavailable to the fish.

Annual kokanee spawning surveys on Company Creek are presently the most reliable measure of kokanee egg to spawner survival, and relative abundance (Brown 1984). The results from annual spawning surveys show that kokanee survival decreased substantially between 1976 and 1981. This decline in kokanee spawners is believed to be a result of competition for food following introduction of mysis shrimp in 1968 and/or predation by chinook salmon that were first introduced in 1974. Results from the 1999 study (DES 2000) showed a four-fold increase in mysis shrimp abundance when compared to the study that brown and crew conducted in 1984.

Management recommendations

Kokanee spawn in the Stehekin River drainage and also in tributaries of the lake; in some years spawning kokanee numbers are very high in these tributaries, other years numbers are reduced compared to historical accounts (Brown1984; Fielder 2000). Yet, we have continued to stock approximately the same number of juvenile kokanee in the lake each year. Hatchery stocking numbers and frequency of stocking need to be examined in comparison to natural spawning potential. Do we need to stock each year? Can natural reproduction provide enough fish for both harvest and natural escapement to maintain the population? What is the number of kokanee that will provide an acceptable sport fishery and yet not substantially hinder our attempts to restore native fishes? Answering these questions will be difficult. A food web/species interaction and bioenergetics study such as David Beauchamp from the University of Washington proposed (Appendix B) would provide much of the information needed for timely management adjustments. Unfortunately, a continuous shortage of funds seems to have precluded this a study at this time. Finding funding for this type of study in the future will be very difficult. However, if we determine the contribution of the fish we stock to both sport harvest and the spawning run, we may be able to determine if we need to continue stocking kokanee on an annual basis. If we determine that stocking should continue in the future, even on an as needed basis, a stock needs to be chosen that provides the greatest potential for success, and to make the most efficient use of the hatchery program.

Continual monitoring of population size is needed to indicate either excess harvest or predation that would reduce the over all quantity of kokanee, or population explosion that would result in stunted fish. Since kokanee are a prey species of chinook and lake trout, an attempt should be made to balance these three species, to obtain an optimum number and size. A balance among species may be accomplished by adjusting the number of kokanee; chinook and lake trout stocked relative to abundance of naturally produced fish of both species. Also, adjusting harvest of all three species should provide a way to maintain a balance between numbers of kokanee chinook and lake trout.

Although the kokanee population is currently doing very well, some of the tributaries, which historically supported substantial, spawning runs, recently have had very insignificant numbers of spawners; notably First and Twentyfive Mile creeks. In general, the decline of kokanee spawners in these tributaries is caused by barriers at the mouth

of each creek, and also by deterioration of the spawning channel, in Twenty Five Mile Creek. On First Creek the barrier has been removed; approximately 100 spawners were observed there during the fall of 1999. The removal of the barrier, as well a restoration of the spawning channel in Twenty Five Mile Creek, is planned for the near future. Presently the gravel in Twentyfive Mile Creek spawning channel is choked with a heavy load of silt. In 2001 we observed many kokanee attempting to spawn in this mix of gravel and mud. The silt would have most likely suffocated any eggs deposited. If, by August1 2002, the heavy load of silt in the spawning channel has not been cleaned out, we should block the entrance and water intake of the channel.

Monitoring

1) Annual spawning surveys as described in Brown (1984) and Fielder (1998) should be continued. In addition, during these surveys genetic samples should be taken from adult spawning kokanee to determine the percent of hatchery-reared kokanee versus those that were naturally reared.

2) WDFW will mark all kokanee released in the lake starting in 2003. The methods of marking are discussed below.

3) During the annual creel survey, as described earlier, we will examine all kokanee possible for the presence of a mark that indicates the fish is of hatchery origin. We will also collect scale samples and genetic samples from these fish that also will allow an identification of origin. To facilitate this effort Juvenile hatchery-reared kokanee must be marked to allow identification after two to four years.

Marking methods for juvenile kokanee:

Tetracycline, oxytetracycline and calcein have been used to produce a mark that can be seen under a florescent light on the sagittal otoliths, dorsal fin rays, vertebrae and opercula of juvenile fishes (Babaluk et.al. 1987, Bilton 1986, Choate 1964, Hendricks et. al. 1991, Mohler, 1997, Wilson et.al. 1987).

Bilton 1986, fed oxytetracycline in a diet of Oregon moist pellet to three different groups of chum salmon (Oncorhynchus keta) fry for 7, 14 and 21 days; after two years 60.4%, 98% and 100% had a clear mark on the vertebrae, respectively. Single, double and triple marks were produced in shad (Alosa sapidissima) fry immersed in a 200mg of tetracycline or oxytetracycline for 6 hours, at 4 day intervals, or by feeding 88 grams of tetracycline of food for three consecutive days, at 5 – or 7 day intervals (Hendricks et. al. 1991). Mohler 1997 tested the persistence of marks induced by calcein and oxytetracycline. Each of four groups of sixty day post hatch larval Atlantic salmon (Salmo salar) were immersed in a solution of 125 mg/l of calcein, or 250 mg/l of calcein or 250 mg/l oxytetracycline or in untreated water for 48 hours. Chemical marks were produced in the fish treated with calcein but not in fish treated with oxytetracycline or in

fish immersed in un-treated water. Fish treated in a solution of 250mg/l of calcein had a significantly higher mortality 10.5%, (P is less than or equal to 0.05) than in a solution of 125mg/l of calcein where mortality was <1.0%. Two hundred and thirty four days after post immersion the calcein-produced marks could be non-lethally observed.

Since the kokanee must retain visible marks for at least two years post release, and because to date I have not been able to locate any information concerning the longevity of marks produced by calcein beyond that reported by Mohler 1997, I suggest we use tetracycline or oxytetracycline to mark juvenile kokanee. To ensure the greatest retention of marks these fish need to be held at the hatchery out of direct sun light. Lorson et. al. found that mark retention in shad fry treated by immersion with 50mg oxytetracycline-hydrochloride/L was 85% in fish held outside in direct sunlight as compared to 94% mark retention in fish held indoors.

Kokanee maturity can be reached in 2–5 years, with most stocks maturing at 3 – 4 years of age. Therefore, it is important that any kokanee we mark as juvenile retain that mark for up to five years; otherwise we will not be able to identify hatchery-produced fish sampled from the spawning run. Chemical marking has not been shown to endure for this length of time, however physical marking of fry is impractical. To identify the origin of kokanee spawners (hatchery vs. naturally produced) a method of electrophoresis that examines the many individual loci of genes (Allendorf e. al. 1975) will have to be used. We will take tissue from a sample of spawning kokanee and send them to a genetics lab for analysis. The WDFW genetics division will be able to recommend an appropriate sample size.

Lake Chelan kokanee:

If we determine that stocking should continue in the future (based on the contribution of hatchery kokanee to the sport fishery and the spawning run), we would make more efficient use of the hatchery if we used a broodstock that was better adapted to Lake Chelan than the Whatcom kokanee that we are presently using. That is, assuming that kokanee adapted to the lake would have a higher fry to adult survival; we would be able to release fewer juvenile fish and still provide enough adults for both the sport fishery and the spawning run. The benefits would be that less space and feed would be needed at the hatchery and most importantly competition between hatchery reared kokanee and native fishes would be reduced.
Annually (if needed) collect eggs from Lake Chelan Kokanee spawners in the wild to be used as the source of eggs for our hatchery program.

If needed we should consider annual trapping at Company Creek and taking eggs from about 10% of the spawners. At present, 10% of the spawning run in Company Creek will provide enough eggs to rear the same number of fry that are currently being released into the lake. However, the actual number of eggs that will need to be collected will be determined by how many kokanee, if any, are needed to be reared and released to

support a sport fishery and a desirable run of naturally spawning fish. Monitoring and evaluation results from methods 1 and 2 above should give us a way to determine this.

Kokanee trapping and spawning methods:

We need egg collecting and spawning methods that will not compromise the current natural adaptation to Lake Chelan. This requires that we preserve the variability of both physical and behavioral traits that make them successful. To maintain run timing, gametes will need to be taken from kokanee spawners from the entire run, which begins in August and lasts into October. The best way to accomplish this is with a trap that is monitored daily. All fish collected each day should be held in a live box or similar enclosure in the creek until they are spawned during one day each week. In addition, the number of fish spawned each week needs to be correlated with the size of the run reaching the spawning grounds. The quantity of fish reaching the spawning grounds by date is well represented in the results from earlier spawning ground surveys this information will allow us to determine how many fish need to be spawned per week. A trap would be most effective method to collect spawners. But the cost of construction, operation and maintenance of a trap, coupled with the possibility that the Park Service may not let us construct a trap on Company Creek, requires an alternate method to collect broodstock. A crew of at least four people could use seines one day a week, or at least one day every two weeks to collect fish for spawning.

Spawning protocol:

To ensure that as much genetic variability is maintained, kokanee eggs should be stripped from individual females into a wire strainer to drain off ovarian fluid, then these eggs should be transferred to a small bowl, the eggs should then be fertilized by one male and then again by a back up male. Male spawners should be used only once. Obviously this will require us to have at least twice as many males on hand than females Even better would be to have 2.5 times as many males as needed since all the males we hold may not be ripe. All males that are used should be held in a live box to be used again, only in the event that an insufficient amount of male fish are available to maintain the one female and two males spawning ratio. A small amount of creek water should be added to the mixture of eggs and sperm. The eggs, sperm and water need to be mixed by gently swirling the bowl and allowed to stand for at least one minute. To reduce the chance of disease transfer, after at least one minute, the eggs should be rinsed in a wire mesh container with100mg/l solution of iodophor (Piper et. al. 1982) and then gently poured into a container with at least three times the volume of 100mg/l iodophor solution to be “hardened” for one hour. After water hardening all eggs from each mating should rinsed and placed together in the same container. The container can then be placed in an insulated cooler containing ice and transported to the hatchery for incubation.

Evaluation:

1) To consider our management efforts as successful we must maintain the kokanee population in the numbers and at a size acceptable to anglers. The 2000 kokanee sport fishery provided the number of fish at a size that was desirable to anglers. A comparison of catch per unit effort from earlier creel surveys and future creel surveys should provide the information to determine if we are continuing to provide an acceptable kokanee sport fishery.

2) We also must simultaneously keep kokanee numbers low enough to not substantially hinder our native species restoration efforts. Determining the optimum number of kokanee to meet both of these objectives will be difficult without contracting someone to conduct a food web/species interaction bioenergetics study such as proposed by David Beauchamp from the University of Washington (Appendix B).

LAND LOCKED CHINOOK

According to the records of local guides, annual salmon derby results, and comments from anglers, the landlocked chinook (*Oncorhynchus tschawytscha*) harvest since 1996 until the present has been dismal compared to earlier years. Some of the more vocal sportsmen are asking WDFW to increase numbers of chinook in the lake.

The recent decline in sport-caught chinook from the lake can be understood by reviewing the history of fish stocking in the lake, the changing success of natural reproduction of chinook in the Stehekin River and its tributaries, and advances in angler effectiveness.

The Washington Department of Fisheries (WDF) introduced chinook into Lake Chelan in 1974. An early-unpublished report written by the WDF states that: “In the spring of 1974, the Washington Department of Fisheries instigated a new salmon program in Eastern Washington. With much public support, the Fisheries Department started freshwater pen rearing in Chelan, Banks and Sprague lakes, with the idea of rearing chinook beyond their migration stage, thus land locking them in the lakes.” Note the emphasis at this time was to rear these fish past the smolting stage and land lock them.

The chinook program in Lake Chelan started in 1974. Spring Creek fall chinook at 10 fish per pound were placed into a 20 x 20 foot net pen at the Cove Marina. These fish were reared until August 12, when 16,500 fish, at 3.5 fish per pound, were released. It is imperative to understand that these fish were about 19 - 20 months old when released. In 1975 a second net pen was added at Twenty Five-Mile Creek. Both net pens were used to rear and release fish until 1978. Stocks used during these years were Spring Creek fall, Skykomise fall, and Deschutes fall chinook. Size at release ranged from 3.5 - 50 fish per pound. For reasons that are now unclear, no chinook were released from 1979 - 1990. From 1990 - 1993, chinook were again pen-reared and released into Lake Chelan at Fields Point. Washougal and Wells fall chinook stocks were used during this

latter period. Size at release ranged from 21-38 fish per pound. From 1994 to present, Wells stock summer/fall chinook were reared for about 8 - 9 months at the Wells Hatchery, trucked to the lake and released at either Twenty Five-Mile Creek, or barged and released near Fields Point. The main point is that juvenile chinook were not reared to as large a size or for as long a time prior to release, as they were before to 1978.

All hatchery chinook released into the lake in recent years have been fin clipped. Unfortunately, none have ever been caught as adults during the annual salmon derby. Also, very few fin clipped adult chinook are ever sport caught. No chinook were stocked from 1979 – 1990, and fishing continued to be good through 1996. Combined this information allows us to conclude that natural reproduction is supporting the fishery.

In November of 1995 the Stehekin River and its tributaries experienced the largest flood ever recorded between 1911 and 1998; peak flows equaled 20,900 cfs (DES 2000). This occurred just after chinook salmon completed spawning. A flood of this magnitude could have destroyed a complete year class of fish. The result of this loss in natural reproduction of chinook was experienced in the 1997 - 1999 sport fisheries. Compared to earlier years, the catch per unit effort declined catastrophically.

We began stocking lake trout from 1980 –1983, then again from 1990 until 2000. Lake trout are apex predators, as are chinook, and compete with chinook for food. This competition would reduce the number of chinook surviving to adult size.

Simultaneously, during the 1990s major advances and increased availability of angling technology, such as improved depth finders, more efficient down riggers, etc occurred. Coupled with an increasing knowledge of anglers on how to catch chinook, and the advent of a number of guide services that routinely targeted chinook, it is reasonable to suspect that increased harvest of adult chinook was and is presently reducing the number of fish escaping to spawn.

From 1994 to 1998 fish were reared at the Wells Hatchery and released into Lake Chelan in July as a pre-smolts, because water temperatures at the hatchery became too high. July is when the PUD is actively spilling water at the Chelan Dam. This spill may create an attraction flow that stimulates emigration of chinook from the lake. It is possible, though unproven, that these pre-smolt fish eventually left the lake.

The chinook released into the Lake were never screened for bacterial kidney disease, so common to chinook. It is also possible that the fish we released were sick and could not survive.

Management Alternatives:

WDFW has two alternatives for managing landlocked chinook in Lake Chelan. Our decision concerning future management of chinook must be guided by two considerations. 1) This plan outlines methods to restore native fish populations to the

lake; to a certain extent chinook prey upon and compete with these species. 2) Landlocked chinook are considered a trophy fish and have historically supported a very popular sport fishery and salmon derby that is a significant economic event for the City of Chelan and the Lake Chelan Sportsman Club.

Alternative 1. Manage the landlocked chinook salmon population in Lake Chelan at a level of abundance that allows adequate numbers of fish to sustain a viable sport fishery but in low enough numbers to preclude any significant hindrance to efforts to build numbers of cutthroat trout. Also since chinook prey upon and compete for food and spawning area with kokanee we will attempt to balance chinook and kokanee population numbers to provide a generous number of kokanee of an acceptable size and an acceptable number of land locked chinook salmon for sport harvest.

Anglers are happy at catching one or two salmon per day and expect to have to work hard to accomplish this. For that reason the number of landlocked chinook salmon needed to provide a fishery is relatively few when compared to the number of cutthroat trout and kokanee needed to provide sport fisheries. This makes it feasible to maintain a land locked chinook population for sport harvest in Lake Chelan.

Methods:

1) Beginning in 2002, replace the100,000 diploid chinook presently being stocked with 100,000 triploid chinook. The triploid fish should be reared at Wells Hatchery to approximately 10 fish per pound (all fish should be adipose fin clipped and coded wire tagged for identification) and then placed into a 20 x 20 foot net pen located in Lake Chelan where they should be reared to approximately 3.5 fish per pound and released in August or September. In total these fish should be reared for at least 19 months. Triploid chinook have been shown to retain similar emigration characteristic as their normal counterparts (Vanderhagen WDFW Personal Communication). Holding the fish in the hatchery and then in the net pens until they are at least 19 months old should ensure that the smolting stage and the tendency to emigrate has past. Consequently these fish should become landlocked, plus the increase in size at release will improve survival.

The fact that triploid fish are sterile provides two, and possibly three, very important benefits to fish management: 1) these salmon will not compete for spawning habitat with fall spawning kokanee; 2) since triploids do not reproduce, WDFW will have better control of the number of salmon in the lake, which will assist with balancing their numbers with other fish species; and 3) triploid fish have been known to grow to exceptional sizes, there is potential for this to occur with triploid chinook.

Alternative 2. Supplement the abundance of naturally reproducing chinook in the Lake.

Methods:

1) If stocking triploid chinook does not successfully increase the abundance of salmon in the lake, a second option would be to rear and release a natural diploid Lake Chelan Stock of landlocked chinook by the same methods as describe in alternative 1. This would require collecting eggs from a portion of the salmon spawning naturally in the Stehekin River and its tributaries.

2) In addition natural reproducing runs of chinook may be able to be established by stocking eyed diploid chinook eggs in various tributaries and in the alluvial deposits in the lake located at the mouths of most tributaries.

3) Protect the limited number of landlocked chinook that now populate the lake from harvest so more fish escape to spawn. Alter the current fishing regulations to reduce the daily limit from two fish to one fish per day, reduce the season length and close the area at the mouth of the Stehekin River to chinook angling (Table 1). This area is an important rearing area for juvenile chinook.

Discussion of alternatives:

Alternative 1, if successful would establish a number of triploid landlocked chinook in the lake that would provide angling opportunity, but not produce significant negative interactions between chinook and all other fish species

Alternative 2, if successful would reestablish an abundant population of diploid landlocked chinook in the Lake. This would provide considerable angling opportunity, but negative interactions between chinook and all other fish species would increase. Also we would set up a situation where natural reproducing chinook could result in a population explosion that would substantially interfere with efforts to reintroduce cutthroat. Also Alternative 2 requires eggs taken from naturally spawning salmon in the Stehekin River. Currently the adult population of landlocked chinook in the lake is so low that the population may not be able to provide enough fish to spawn or to maintain genetic diversity of the population.

Management recommendations:

Each alternative has pros and cons; my recommendation is that we combine the first portion of Alternative 1, (Hatchery and net pen rear and release triploid chinook) with method 2 under Alternative 2. (Establish regulations that protect the limited number of landlocked chinook that now populate the lake from harvest so more fish escape to spawn).

Consider that we are not sure that releasing triploid chinook will result in enough landlocked fish to provide a sport fishery. Also consider that If we protect and increase the number of self-reproducing salmon that has proven themselves adapted and

successful in Lake Chelan we will have the opportunity to use some of the gametes produced by these fish to develop a program of supplementation as described in Alternative 2. If in the future the need arises we can always reduce the number of naturally reproducing salmon by allowing unlimited harvest and destroying redds.

Monitoring and evaluation:

Methods to produce triploid chinook:

Induced triploidy (the production of individual sterile fish with an extra sets of chromosomes) can be accomplished by applying a shock to fish eggs in the form of heat, hydrostatic pressure or chemicals, shortly after fertilization (Thorgaard 1986). This method has been proven to be sensible way to produce sterile salmonids (Bye and Lincoln, 1983; Donaldson, 1986). Of the three methods for inducing triploidy, hydrostatic pressure produces the highest proportion of triploid fish per number of eggs treated (Johnstone, 1985; Benfey and Sutterlin, 1984). However, the apparatus needed to pressure treat eggs often does not hold large quantities of eggs. As an example, Tillman et.al 1987 placed coho eggs 15 minutes after they were fertilized, into a to a stainless steel basket; which was then lowered into the pressure vessel. The vessel was then filled with water to remove all air and sealed. Eggs were then treated with 9,000 or 10,000 psi for 15 minutes. This study suggests that two operators working together could pressure treat 5,000 coho eggs every 10 minutes, 30,000 coho eggs per hour or 250,000 eggs per day. This method is time consuming but may produce enough treated chinook eggs in one day to provide the 100,000 triploid chinook that we have proposed be stocked in Lake Chelan.

The methods of treating eggs with hydrostatic pressure seems to have two drawbacks, it is time consuming and requires the purchase of the appropriate equipment. As an alternative, heat treatment has proved to a reliable and effective method to produce high proportions of triploid individuals when large quantities of eggs need to be treated (Chourrout and Quillet, 1982). The basic procedure is to immerse eggs shortly after fertilization (10 minutes) into heated water (29 degrees C) for 10 minutes.

Methods to check for polyploidy

The methods used to check for triploidy seems to be complex. We most likely will have to contract a lab for this analysis. A list of methods includes: The measurement of erythrocyte nuclear volumes (Allen et.al. 1978); The use of flow cytometry by measuring deoxyribonucleic-acid fluorescence in erythrocytes; (Allen et.al. 1983; Benfey et. al. 1986, Ewing et. al. 1991).
Harrell et al. al 1998 cross-validated the most common methods to check for triploids; they state, “The most common verification techniques are DNA staining and fluorescence quantification with a flow cytometer, erythrocyte nuclear nucleolar organizer regions, and cytological karyotyping. “Cytological karyotyping is the most accurate”.

Methods:

1) We propose to annually mark, with fin clips, any hatchery-reared chinook released in the lake, triploid or otherwise; this will allow us to evaluate the contribution to the sport fishery, identify any Lake Chelan fish that may have left the lake and are collected in the Columbia River, or returning to Wells Hatchery. Furthermore, a comparison of annual results of spawning ground surveys will assist in monitoring trends in numbers of diploid chinook in the lake and aid in evaluating the success of our management efforts.

2) During the annual creel survey (described earlier in this plan), under monitoring and evaluation of cutthroat and rainbow trout, we will collect biological information including marks from sport caught landlocked chinook.

3) Examine all fish encountered and record both biological information including marks from sport-caught chinook at the annual salmon Derby.

4) Continue annual spawning surveys, as described in (Brown 1984) and (Fielder (2000).

BULL TROUT

Bull trout (*Salvelinus confluentus*) were indigenous to Lake Chelan and the Stehekin River but were extirpated about 1951(Brown 1984). The USFWS determination of Threatened Status for the Columbia River Distinct Population Segment of Bull Trout final rule (Federal Register/Vol. 63, No. 111/June 10, 1998) stated that bull trout are thought to have been extirpated in 10 streams within the Mid-Columbia River geographical area including Lake Chelan (p. 31651).

WDFW biologists have discussed the possibility of an attempt to reintroduce bull trout to the Lake and the Stehekin River. Due to the presence of a abundant population of lake trout (Salvelinus namaycush), reintroduction of bull trout into lake Chelan is problematic and should not be attempted at this time. However, we feel that efforts to reintroduce bull trout to various waters in the Lake Chelan basin are justifiable and sound. This could include tributaries and small mountain lakes that drain into the Stehekin River or directly into Lake Chelan.

During the early 1900's bull trout were an important game fish in the lake (Campbell 1974). Prior to the introduction of kokanee, bull trout averaged 3 pounds. After kokanee were established in the lake, bull trout average size increased to 9 pounds. Evidently, the bull trout took advantage of this introduced forage. Bull trout continued to provide sport fishing until about 1951. Randy Morse of Morse Resort states, “the fish almost completely disappeared from the waters of Lake Chelan”. They were seen in great numbers along the shores at Stehekin, covered with gray fungus, sick and dying. Relatively few have been caught since that time (Chelan PUD (1968). Brown (1984) states that some have suggested that the severe floods occurring in 1948 and 1949 were the cause of extinction, but goes on to say that a more plausible theory is that a pathogen, foreign to any that bull trout had encountered before could have been

introduced along with WDFW hatchery stocking, resulting in an epizootic that wiped out the population. Also Brown states that some resident creek populations of bull trout still exist in the Stehekin River drainage.

Study results of intentional introductions of lake trout to waters containing bull trout, show that the lake trout out-compete and deplete or completely eliminated populations of bull trout (Donald and Alger 1992). Lake trout stocking would have to be eliminated, natural reproduction of lake trout, if any, would have to be exterminated, before we can expect an introduction of bull trout to be successful in Lake Chelan.

A less contentious approach would be to introduce fluvial bull trout to the tributaries and small mountain lakes that drain into the Stehekin River or directly into Lake Chelan. If successful, fluvial fish may eventually attempt to enter the lake and become adfluvial. This alterative may mitigate sport fishery losses in Lake Chelan.

Management recommendations

There should be a dedicated attempt to reintroduce and increase the abundance of fluvial bull trout to the tributaries and small mountain lakes that drain into the Stehekin River or directly into Lake Chelan.

Methods:

1) Our first effort should be a survey to locate any bull trout population that might still exists in this system.
2) If a fluvial bull trout population is found, determine if habitat conditions limit their re-colonization of the Stehekin River system. Correct or lessen the factor(s) that have been limiting bull trout or determine if enough fish exist to use as an appropriate brood stock, so we might avail them the survival advantage of the hatchery system.

4) If no bull trout population is found, then an appropriate donor stock of fluvial fish from another river should be chosen for reintroduction.

LAKE TROUT

Twenty-two thousand fingerling Lake trout (Salvelinus namaycush) were first introduced to the lake between 1980 and 1982. Lake trout fingerlings were again stocked beginning in 1990 and have continued until 2000 (Appendix A). After a decline in the land locked chinook population occurred WDFW chose to stock lake trout to provide a more stable trophy fishery. At that time WDFW made this choice based on the perceived desirable interactions among lake trout, kokanee and mysis shrimp in Priest and Pend Oreille lakes, in Idaho and Lake Tahoe in California/Nevada (Brown 1984). However, in time biologists found that lake trout, through competition and predation, began to threaten the

abundance of kokanee and cutthroat trout populations in these and other western lakes where lake trout have been introduced. Lake trout have contributed to the decline of other salmonid populations via predation (Beauchamp 1999, Donald and Alger 1992, Marnell 1985, M. Liter IDF&G personal communication, February 2002).

Historically, Flathead Lake in Montana supported the largest kokanee fishery in North America. After the introduction of mysis shrimp in the 1980's the population of kokanee crashed according to Beattie and Clancey (1991). In addition the lake trout population increased and the bull trout population declined. An attempt to restore the kokanee population by stocking 800,000 – 1,000,000 yearling kokanee failed because predation losses, primarily by lake trout, accounted for almost all the kokanee stocked. The kokanee restoration project was terminated because of expense and limited space to rear enough kokanee to offset predation losses (Beauchamp 1996).

If we lose the kokanee population in Lake Chelan due to predation from lake trout, or for any other reason, the lake trout population will survive because they forage on other species as well. Without abundant forage, over time they, most likely will grow slower and obtain a smaller size per age. The opportunity to produce trophy size lake trout will be lost, and most importantly an abundance of lake trout will make recovery of the kokanee population impossible.

Lake Trout were discovered in Yellowstone Lake in 1994. Based on population age structure and bioenergetics simulations, Ruzycki and Beauchamp (1997) estimated that 59,000 cutthroat trout (100 –300 mm FL) were consumed for every 1,000 lake trout $\geq$ 270 mm FL, per year. Should this level of predation occur in Lake Chelan we will have almost no chance to restore native cutthroat.

Any decision concerning the management of lake trout in Lake Chelan needs to be made with two considerations in mind.

1) Based on information from other systems, if the population of lake trout becomes sufficiently abundant they will have the biological momentum to substantially reduce the numbers of kokanee, landlocked chinook, cutthroat and other species in the lake. Results from the 2001 chinook derby and information from anglers and guides suggest that we are currently experiencing a considerable increase in lake trout abundance. Snorkeling surveys in 1999 and 2000 associated with Lake Chelan Hydropower relicensing may have identified a 32 mm lake trout fry near the mouth of First Creek, and three other lake trout fry ranging in length from 75 – 100 mm in a side channel in the lower Stehekin River, respectively. Although this evidence of natural production is antidotal and not officially verified, the coincidental increase in lake trout harvest and the possible presence of naturally produced juvenile fish supports our concern that we may be facing a rapid and sudden increase in lake trout numbers. Consequently, it is critical that we determine if lake trout are reproducing naturally, and if the population is

increasing and at what rate. If such a condition exists, competition and predation by lake trout represents a serious threat to kokanee and other fishes in lake.

2) Recently lake trout have contributed substantially to the fishery on Lake Chelan both in numbers and size. During recent years lake trout have been filling a void left as the landlocked chinook fishery has declined. Three state record lake trout have been caught since 1999; a 31lbs, 2.75-ounce fish was caught in May 1999, a 33lbs., 6.5-ounce fish was caught in August 2001 and a 35lb., 7-ounce fish was caught in December 2001. As a result, this fishery is gaining increasing support from the local sportsman club, guides and other sport anglers.

In addition, it has been estimated that the Mysis population has increased four fold since 1992 (DES 2000). Competition for zooplankton between Mysis and kokanee is believed to be one of the factors that resulted in a past crash in kokanee numbers in Lake Chelan. Lake trout inhabit the same deep-water habitats as Mysis during the daylight hours, and samples of lake trout stomach contents indicate these fish prey extensively on mysis. Lake trout may be the only species of fish in the lake that may able to control the mysis population.

Management alternatives:

Alternative 1) Maintain status quo, continue stocking and continue with the current regulations. During the annual creel survey, we will collect information on lake trout that may provide trend information of population dynamics and allow us to evaluate if natural reproduction is occurring

Alternative 2) WDFW can temporarily discontinue stocking lake trout into Lake Chelan for five years. We can change present regulations to allow unlimited harvest opportunity for lake trout. This alternative should partly guard against uncontrolled increases in lake trout numbers. In combination these changes will provide an opportunity to determine if naturally production of lake trout is occurring, and to evaluate the potential for natural reproduced lake trout to substantially populate the lake. The annual creel survey over several years can collect information that will allow us to evaluate if natural reproduction of lake trout is occurring and provide information on population dynamics of lake trout and other species of concern.

Alternative 3) Temporarily discontinue stocking lake trout into Lake Chelan for five years, but continue with the current lake trout harvest regulation.

Discussion of alternatives and management recommendations:

My recommendation would be to implement alternative 2. Discontinue stocking lake trout for five years and implement regulations to allow unlimited harvest of lake trout. Monitoring the results may allow us to determine if the lake trout population is increasing, at what rate, and if natural reproduction is occurring. If the lake trout population is

currently increasing in abundance, regulations that allow unlimited harvest may provide the control to the population that may be appropriate.

If, after five years or sooner, the information we collect from the creel surveys shows that a population explosion is not occurring, we can always change the regulations back to an appropriate recovery mode (two fish per day, 15 inches minimum size) and we can begin stocking lake trout again.

The only decisions that may result in a damaging change to kokanee, rainbow and cutthroat trout and other species, and be **irrevocable**, is to continue stocking lake trout, and continue with the current restrictive regulations. If the lake trout population is on the verge of an explosion, and we wait into the future to try to control it, lake trout may become so abundant that control will no longer be possible. Bruce Rieman of the Idaho Fish and Game, when discussing a similar situation in Idaho, summed up the situation very well he states" **We may be cussed by some for being to conservative and saying the sky is falling. However, the alternative is to let the sky fall and be cussed by all".**

Monitoring

Methods:

1) During the annual creel survey we will collect information on lake trout harvest and biological information including scales and branchiostegal rays from sport caught lake trout.

2) We will examine lake trout brought in at the annual salmon derby and collect biological information including scales and branchiostegal rays.

3) An analysis of scales and branchiostegal rays will provide information on population age structure, and an indication of the proportion of fish that were reared in the hatchery versus those that were produced naturally.

Evaluation:

The annual creel survey will provide information about the lake trout population that can be compared both annually and also within years. We will be able to compare the annual harvest, catch per unit effort, age and the relative proportions of hatchery and wild lake trout. We will test the null hypothesis that natural reproduction is not occurring in the lake to any substantial extent. An analysis of lake trout scales collected during future creel surveys will show that naturally produced fish are not recruiting to the fishery. Should this occur, the relative change in the proportion of hatchery-reared lake trout recruiting to the sport fishery should decline in five years.

BURBOT

Burbot or ling (*Lota lota*) are indigenous to Lake Chelan. These fish are the only representative of the codfish family (Gadidae) that resides in freshwater. Only a small group of anglers fish for burbot, mostly in late winter and early spring, and do so because of the burbot's reputation as excellent table fare. Angling is done primarily with setlines. However, jigging in deep water for burbot is becoming increasingly popular.

Very little is known about burbot in Lake Chelan. However, Brown in 1984 reported that because of their natural fecundity (about 180,000 eggs per pound of female) is so high that angling mortality is unlikely to have any measurable effect on their population in a lake the size of Lake Chelan, with the intensity of the present fisheries.
Burbot were sampled with set lines in 1999 by the WDFW. Many of the fish in these samples had infected gonads. Samples were examined both by a WDFW pathologist and the University of Washington's fish health lab. Ovaries and testes contained moderate to severe multi-focal granulomas, which generally are caused by a mycobacterial fungus infection.

Management recommendations

Presently the only management that WDFW does for burbot is the regulation of harvest. Until more is learned about the population status of burbot we should continue with this present management. More effort is needed to ascertain the status of the burbot population. We need to develop a sampling method that can be used annually to provide trend information about burbot population abundance and age class structure**.**

Monitoring

1) A combination of setlines placed in the same locations each year, and creel checks may provide a way to sample burbot consistently enough to provide trend information.

2) Use age determination from otoliths compared to length to examine age class structure of the population.

3) Physical and histological examination of burbot that are annually sampled may allow us to determine why some burbot sampled in 1999 were infected.

PYGMY WHITEFISH

Pygmy whitefish (*Prosopium coulteri*) in Lake Chelan was documented during deep water netting in 1996 (Hallock and Mongillo 1998). Pygmy whitefish are listed as a Priority Species under WDFW Priority Species and Habitat Program (PHS). The status of the pygmy whitefish populations in Lake Chelan, and possibly the tributaries, needs to be established. Populations of this species must be protected from extirpation. Pygmy whitefish in Washington have been extirpated from six of the fifteen lakes where

they historically occurred by the introduction of exotic fishes and/or deteriorating water quality and in one case by the use of a piscicide (Hallock and Mongillo 1998). The limited distribution of these fish in Washington makes this species vulnerable to extirpation.

The pygmy whitefish, is a remnant of the last ice age, typically resides in deep, cold, oligotrophic lakes and streams of mountainous regions. In lakes, during late-summer to early winter, pygmy whitefish enter shallow littoral zones to spawn. Throughout most of the year pygmy whitefish inhabit deep-water areas. These small, delicate fish in Lake Chelan are therefore at risk of being consumed in deep water by lake trout and landlocked chinook. A substantial reduction in the predation of pygmy whitefish in deep-water habitat could be achieved by reducing the number of lake trout.

During late summer to early winter when, pygmy whitefish enter shallow littoral zones to spawn they are at risk of being consumed by small mouth bass, adult rainbow trout, cutthroat trout and northern pike minnow. In shallow water, a shoreline predator such as smallmouth bass may or may not be beneficial to the pygmy whitefish populations. The northern pike minnow population, lacking predation by small mouth bass may consume more whitefish than would be consumed by a combination of small mouth bass and northern pike minnow.

Management Recommendations:

1) Discontinue Lake Trout stocking:

2) We should support all efforts to protect Lake Chelan from accelerated eutrophication and siltation of shallow water habitat that would occur due to heavy shore line development and increased nutrient input that typically accompany development.

Monitoring and Evaluation:

1) Set up locations for sampling with vertical gill nets. Compare presence/absence results once every five years. This sampling should be kept at a minimum to reduce added mortality and avoid increasing the risk of extirpation. Minimum sampling coupled with the size of the lake will preclude a reliable quantitative estimate of the pygmy whitefish population only. Is this worth doing at all?

2) Pygmy whitefish, if any, encountered during annual electrofishing surveys conducted to monitor other species in the tributaries may provide trend information and ascertain the presence or absence of pygmy whitefish.

SMALLMOUTH BASS

An evaluation of smallmouth bass (*Micropterus dolomieui*) abundance and the effect of their interactions with other species in the Lake need to be conducted.

Smallmouth bass were illegally stocked into Lake Chelan sometime in the 1990s. Since then these fish have responded well to conditions in the lake and a population of bass is now present in the shallow littoral area of southerly Wapato Basin. Smallmouth bass, a species favoring rocky shorelines are likely limited by the steep topography and colder water temperatures of the Lucerne basin. The lake also has abundant populations of coarse fish northern pike minnow (*Ptychocheilus oregonensis*), red side shiner (*Richardsonius balteatus*) and peamouth (*Mylocheilus caurinus*). During summer, fish biomass in the lower basin is most likely greater than 90 percent coarse fish (Brown 1984). A shoreline predator such as smallmouth bass may be beneficial to the salmonid populations if they prey upon the coarse fish that compete for food with salmonids. Anglers actively seek out and fish for these bass. Many bass are in the 4 -6 pound size range, (personal observations). At this time the bass population is adding to the list of species that anglers find appealing in Lake Chelan. However, this population needs to be monitored to ensure against overpopulation and potential negative interactions among bass and the other game fish.

Management recommendations

At this time WDFW does not have enough evidence to suggest any management strategy for smallmouth bass. Monitoring of smallmouth bass population numbers, age composition, distribution, food habitats and the interactions among bass and other game species needs to be conducted.

Angling regulations are the only management tool currently used to manage bass in Lake Chelan. We recommend no change in current regulations.

BROOK TROUT

Competition and interbreeding of bull trout with brook trout have been proven to displace and eventually eliminate bull trout populations. Brook trout will also compete for rearing space and forage with cutthroat, thus interfering with our attempts to rebuild the cutthroat population. An effort should be conducted to completely eliminate or reduce brook trout from the tributaries to Lake Chelan.

Management Recommendations:

1) Electrofishing gear could be used to physically remove brook trout from tributaries.

Monitoring and Evaluation:

1) Annually conduct electrofishing surveys in the lake tributaries and estimate brook trout abundance. A comparison of annual abundance should allow us to evaluate if our management efforts are successful in reducing the number of brook trout in the lake tributaries.

SCHEDULE OF NECESSARY TASKS	DATE
Replace 16,000 catchable size rainbow trout with 16,000 catchable size Twin Lake cutthroats. None of these fish will be adipose fin clipped.	Sept. 2001
Replace 35,000 catchable size rainbow trout with 35,000 catchable size Twin Lake cutthroats; 15,000 will be adipose fin clipped.	July, 2002
Replace 60,000 catchable size rainbow trout with 60,000 catchable size Twin Lake cutthroats; 48,000 will be adipose fin clipped.	July, 2003
Replace 80,000 catchable size rainbow trout with 80,000 catchable size Twin Lake cutthroats; 64,000 will be adipose fin clipped.	July 2004
Replace 100,000 catchable size rainbow trout with 100,000 catchable size Twin Lake cutthroats; 80,000 will be adipose fin clipped.	July 2005
Protect cutthroat trout by changing the current regulations for Lake Chelan.	May 2002
Stock 50,000 eyed twin lake cutthroat eggs using on site incubators, into each of First and Twentyfive mile creeks for a total of 100,000 eggs.	June, 2002 – 2005
Conduct annual creel surveys	April – Oct. 2003 -5
Annually estimate cutthroat and rainbow spawning escapement in First and Twentyfive Mile creeks.	April –July Annually starting in 2002

Treat juvenile kokanee at the Chelan Hatchery with Tetracycline, oxytetracycline or calcein to produce a mark that can be seen under a florescent light.	Spring 2002 -2005
If by August1 2002, theTwentyfive Mile Creek spawning channel has not been cleaned of silt, we should block the entrance of the channel so the fall run of kokanee can spawn in the creek itself.	August 1, 2002
Annually (if needed) collect eggs from Lake Chelan Kokanee spawners in the wild to be used as the source of eggs for our hatchery program.	If needed, this could begin in 2006, or sooner.
Induced triploidy to enough fall chinook eggs to produce at least100,000 triploid juvenile chinook. Samples should be sent to a lab to check the percent of eggs that were successfully induced into a triploid condition.	Annually in the fall
Hatchery and net pen rear and release 100,000 triploid chinook for a total of 20 months.	Annually, release fish in August
Conduct annual surveys designed to locate any bull trout population that might still exists in the Stehekin River. Use electrofishing, snorkeling, trapping and angling methods to search for bulltrout.	July or August, 2002 - 2003
If no bull trout population is found, then an appropriate stock of fluvial fish from another river should be trapped and spawned to use for hatchery rearing and release of these fish into the Stehekin River above high bridge.	Rearing can begin in 2004, release in 2005
Discontinue stocking lake trout for five years.	2001 -2005
Implement regulations to allow unlimited harvest of lake trout	2002

During the annual creel survey, as described earlier in this plan, we will collect information on lake trout harvest and biological information including scales and branchiostegal rays from sport caught lake trout. An analysis of scales and branchiostegal rays will provide ages as well as an indication of the proportion of fish that were reared in the hatchery versus those that were produced naturally.	April – Oct. 2003 -5
Sample the burbot population with a combination of setlines placed in the same locations each year, and creel survey checks. This may provide a way to sample burbot consistently enough to provide trend information.	March – April Annually
Use age determination from otoliths compared to length to examine age class structure of the burbot population.	Annually
Physical and histological examination of burbot that are annually sampled may allow us to determine why some burbot sampled in 1999 were infected.	Annually
An evaluation of smallmouth bass abundance and the effect of their interactions with other species in the Lake need to be conducted.	When ever the funds become available for bioenergetics study on the lake.
Use electro fishing gear to remove and estimate the brook trout populations in Twentyfive mile creek.	August – September Annually

LITERATURE CITED

Allen, S. K., Jr. and J.G. Stanley. 1978. Reproductive sterility in polyploid brook trout, Savelinus fontinalis. Transactions of the American Fishery Society. 107:473- 478.

Allen, S. K., Jr. and J.G. Stanley. 1983. Ploidy of hybrid grass carp x bighead carp determined by flow cytometry. Transactions of the American Fishery Society. 12:431-435.

Allendorf, F.W., F. M. Utter, and B.P. May. 1975. Gene duplication within the family Salmonidae: Detection and determination of genetic control of duplicate loci through inheritance studies and examination of populations. Page 415-432 *in* C.L Markert, Editor. *Isozymes. IV. Genetics and Evolution*. Academic Press, New York, New York, USA.

Babaluk, J. A. and J.S. Campbell. 1987. Preliminary results of tetracycline labeling for validating annual growth increments in opercula of walleyes. North American Journal of Fisheries Management 7:138-141.

Beattie, W.D., and P.T. Clancy. Effects of *Mysis relicta* on the zooplankton community and kokanee population of Flathead Lake, Montana. American Fisheries Society Symposium 9:39-48.

Beauchamp, D.A. 1996. Estimating predation losses under different lake trout population sizes and kokanee stocking scenarios in Flathead Lake. Final Report to Montana Fish, Wildlife and Parks. Journal of Animal Ecology. 47:977-991.

Beauchamp, D.A. 1999. Modeling Food Web Interactions: A Conceptual Framework and Applications for Managing Native-Nonnative Assemblages. Utah Cooperative Fisheries and Wildlife Research Unit and Berryman Institute, Department of Fisheries and Wildlife, Utah State Univ., Logan, UT 84322.

Benfey, T. J. and Sutterland, A.M. 1984. Growth and gonadal development in triploid landlocked Atlantic salmon (Salmo salar) Canadian journal of Fish and Aquatic Science, 41: 1387-1392.

Benfey, T. J., I. I. Solar, G.Dejong, and E. M. Donaldson. 1986. Flow-cytometeric confirmation of aneuploidy in sperm from triploid rainbow trout. Transactions of the American Fishery Society 115:838-840.

Bilton, H.T. 1986. Marking chum salmon fry vertebrae with oxytetracycline. North American Journal of Fisheries Management 6:126-128.

Brown, L.G. 1984. Lake Chelan Fishery Investigations. Technical Report of the Washington State Fish and Game and Chelan County Public Utility District No. 1.

Brown, L.G. 1984. Washington Department of Fish and Wildlife, Personal Communications.

Donald, D.B., and Agler. D.J. 1983. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology. 71:238-247.

Chelan County Mirror. 1974. Volume 1, No. 10, October 8,1891.

Chelan County Mirror. 1974. Volume 3, No. 1, August 3,1893.

Chelan County Mirror. 1974. Volume 28, No. 16, April 18,1918

Chelan News Leader, June 13, 1916.

Chelan Public Utility District. 1968. Lake Chelan Fishery Problems.

Chelan Valley Mirror. 1920. Volume 30, No. 42.

Choate, J. 1964. Use of tetracycline drugs to mark advanced fry and fingerling brook trout (Salvelinus fontinalis). Transactions of the American Fishery Society 93:309-311.

Chourrout, D. and Quillet, E. 1982. Induced gynogenisis in rainbow trout: sex and survival of progenies. Production of all- triploid populations. Theory and Applied Genetics, 63:201-205

Donaldson, E. M. 1986. The integrated development and application of controlled reproduction techniques in pacific salmonid aquaculture. Fish Physiology, biochemistry, 2: 9-24.

Duke Engineering and Services, (DES). 2000. Lake Chelan Fisheries Investigation Final, Lake Chelan Hydroelectric Project No. 637.

Eldred D., 2000. Washington Department of Fish and Wildlife. Personal Communications.

Ewing, R.R., C.G. Scalet, and D.P. Evenson. 1991. Flow cytometeric identification of larval triploid walleyes. Progressive Fish-Culturist 53:177-180.

Fielder P.C., 1998. Lake Chelan Spawning Surveys. Chelan County Public Utility District, Fish and Wildlife Operations, P.O. Box 1231, Wenatchee Washington 98807.

Freeman, O.W. 1944. Glaciation and some human relationships at Lake Chelan.
North West Science 18:59-62.

Hagen, J.E. 1997. An evaluation of the trout fisheries enhancement program in Lake Chelan. M.S. Thesis. School of Fisheries. University of Washington, Seattle WA. 53 p. plus appendices.

Hendricks, M.L., T.R. Bender, Jr., and V.A. Murdrak. 1991. Multiple marking of American shad otoliths with tetracycline antibiotics. Transactions of the American Fishery Society 11:212-219.

Johansen, J. 1961. Interoffice memo. Washington Department of Game

Johnstone, R. and Lincoln, R.F. 1986. Polyploidy estimation using erythrocytes from formalin–fixed salmonid fry. Aquaculture, 55:145-8.

Kendra, W. and L. Singleton. 1987. Morphology of Lake Chelan. Ecology Report No. 87 –1, Water Quality Investigations Section, Washington State Department of
Ecology, Olympia WA.

Lincoln, R. F. and Scott, A.P. 1983. Production of all-female rainbow trout, Aquaculture, 30,375-80. *Change Page 28 Lincoln 1986 to 1983*

Liter, M. 2002. Idaho Fish and Game, personal communication.

Marnell, L.F. 1985. Bull trout investigations in Glacier National Park, Montana. Pages 33-35 *in*: D.D. MacDonald, Editor. Proceedings of the Flathead River Basin bull trout biology and population dynamics modeling information exchange. Fisheries Branch, British Columbia Ministry of Environment, Cranbrook, B.C., Canada.

Mohler, J.W. 1997. Immersion of larval Atlantic salmon (Salmo salar) in calcein solutions to induce a non-lethal detectable mark. North American Journal of Fisheries Management 17:751-756.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard
1982. Fish Hatchery Management. Unites States Department of the Interior. Fish and Wildlife Service, Washington, D.C.

Ruzycki, J.R., and D.A. Beauchamp. 1977. A bioenergetics modeling assessment of the Lake Trout impact in Yellowstone Lake. Proceedings from the Wild Trout Symposium, Bozeman Montana.

Steele R. and A.E. Viola, 1999. Washington Department of Fish and Wildlife. Personal Observations.

Thorgaard, G. H. 1986. Ploidy manipulations and performance. *Aquaculture*, 57,57-64.

Tillman J., Benfey, T. J. Bosa, P. G., Richardson, N.L. and E. M. Donaldson. 1997. Effectiveness of a commercial-scale pressure shocking devise for producing triploid salmonids. Aquaculture Engineering, 0144-8609/88/So3.50.

Whetten, J.T. 1967. Lake Chelan, Washington: Bottom and sub-bottom topography. Limnology and Oceanography 12:253-259.

Wilson, C. A., D. W. Beckman, and J. M. Dean. 1987. Calcein as a fluorescent marker of otoliths of larval and juvenile fish. Transactions of the American Fishery Society 116:668-670.

Vander Hagen, G. 1999. Washington Department of Fish and Wildlife. Personal Observations.