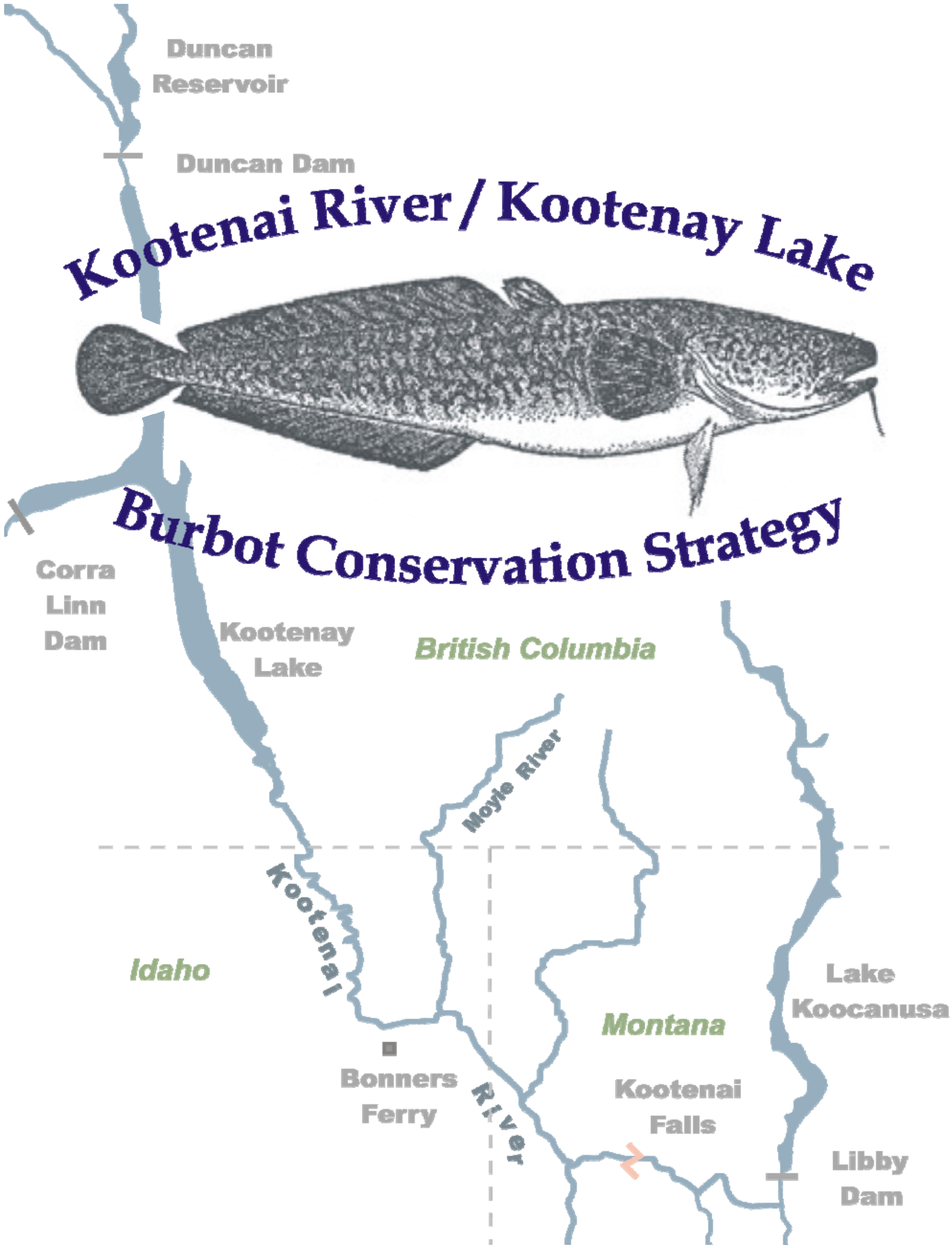
Kootenai River / Kootenay Lake Burbot Conservation Strategy



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Conservation strategies delineate reasonable actions that are believed necessary to protect, rehabilitate, and maintain species and populations that have been recognized as imperiled, but not federally listed as threatened or endangered under the US Endangered Species Act. This Strategy resulted from cooperative efforts of U.S. and Canadian Federal, Provincial, and State agencies, Native American Tribes, First Nations, local Elected Officials, Congressional and Governor's staff, and other important resource stakeholders, including members of the Kootenai Valley Resource Initiative. This Conservation Strategy does not necessarily represent the views or the official positions or approval of all individuals or agencies involved with its formulation. This Conservation Strategy is subject to modification as dictated by new findings, changes in species status, and the completion of conservation tasks.

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Conservation Plan Acronyms, Abbreviations, and Definitions

Cfs	cubic feet per second (water flow rate)
Cm/s	Centimeters per second (water velocity)
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
e.g.	"for example"
ESA	U. S. Endangered Species Act
et al.	"and others"
i.e.	"in other words"
kcfs	thousand cubic feet per second
km	kilometers
km/d	kilometers per day (regarding fish movement)
mps	meters per second (water velocity)
rkm	river kilometer
SOR	system operation request

Agencies and Institutions

BEF	Bonneville Environmental Foundation
BPA	Bonneville Power Administration
CBT	Columbia Basin Trust (British Columbia)
USACE	U.S. Army Corps of Engineers
DEQ	Idaho Department of Environmental Quality
FWS	U.S. Fish and Wildlife Service
IDFG	Idaho Department of Fish and Game
ICL	Idaho Conservation League
IDL	Idaho Department of Lands
IKERT	International Kootenai River Ecosystem Restoration Team
KRBCC	Kootenai/y River Basin Burbot Conservation Committee
KTOI	Kootenai Tribe of Idaho
KVRI	Kootenai Valley Resource Initiative
MFWP	Montana Department of Fish, Wildlife and Parks
NOAA	National Oceanic and Atmospheric Association (US; formerly National Marine Fisheries Service)
NPCC	Northwest Power and Conservation Council (formerly Northwest Power Planning Council)
NRCS	
SPC&A	S.P. Cramer and Associates
UI-ARI	University of Idaho, Aquaculture Research Institute
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WLAP	British Columbia Ministry of Water, Land, and Air Protection

EXECUTIVE SUMMARY

Currently, the healthiest populations of burbot (*Lota lota*) in the Kootenai/y Basin inhabit three separate lake or reservoir systems: Lake Koocanusa in Montana, and Duncan Reservoir and Trout Lake in British Columbia (BC). The West Arm Kootenay Lake burbot stock has been extirpated (Ahrens and Korman 2002). Little is currently known about the distribution and abundance of burbot in Lake Koocanusa and in the upper Kootenai River upstream from Lake Koocanusa. After decades of sampling, demographic analysis of Lower Kootenai River burbot indicated that approximately 50 fish remain in this population; the 95% confidence interval on this estimate ranged from 25-100 fish (Pyper et al. 2004). A total of 300 burbot were caught from 1993 through 2004, and many were recaptured. Although small fish were represented in the catch throughout this time period, data exhibited an aging population, increasing numbers of recaptures, increasing annual mean fish lengths, and decreasing annual recruitment, catch rates, and population abundance estimates (Pyper et al. 2004). Without immediate, substantive management actions, native riverine burbot in the Kootenai Basin will likely share the fate of the West Arm Kootenay Lake population and disappear completely.

A series of factors appears responsible for the collapse of riverine burbot populations in the Kootenai/y Basin, including: habitat alteration and loss (increased winter discharge and winter water temperatures, reduced primary and secondary productivity, hydro impoundment and operations, Kootenay Lake flood control), harvest, reduction in mysid availability, and resulting ecological community composition shifts (Paragamian et al. 2000; Ahrens and Korman 2002, Paragamian 2002, Anders et al. 2002, Paragamian et al. 2000, Hammond and Anders 2003).

The goal of this Conservation Strategy is to restore and maintain a viable and ultimately harvestable burbot population in the Kootenai River and in the South Arm of Kootenay Lake.
Three objectives address this goal: 1) maintain at least 2,500 adults in a burbot population in the Kootenai River and the South Arm of Kootenay Lake; 2) provide consistent natural recruitment in at least three different spawning areas, with net recruitment and juvenile population size sufficient to support at least 2,500 adult fish. Recruitment for burbot recovery may come from natural production, from conservation aquaculture, or from some combination of the two, and 3) produce stable size and age class distributions.

Five complementary conservation and restoration strategies are provided to meet the above objectives: 1) implement an aggressive adaptive program of experimental recovery measures, 2) develop a broad-based habitat restoration program to address altered ecosystem problems that contribute to the burbot collapse, 3) employ hydro operations and conservation aquaculture as key components of near-term burbot protection and restoration, 4) maintain a strong scientific monitoring and evaluation program to guide implementation of conservation activities, and success of recovery, and 5) ensure that burbot recovery measures strike a fair balance between the needs of fish and the needs of people. Complete restoration will be achieved when monitoring and evaluation indicate a sufficient surplus of fish to support self sustained harvest subsistence and recreational fisheries.

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1.0 INTRODUCTION

Burbot are widespread throughout their circumpolar, holoarctic distribution. Despite their wide distribution, burbot populations are in decline or have been extirpated in many European countries. Distribution and stock status have been investigated throughout the burbot's geographical range. Specific assessments have occurred in Asia (Nelichik 1979, Nikiforov et al. 1993), Canada (Lindsey 1956, Hatfield et al. 1972, Paragamian et al. 2001), Alaska (Hallberg 1986, Peckham 1986, Parker et al. 1987, Parker et al. 1988, Lafferty et al. 1990), and the northern United States (Robins and Deubler 1955, Muth 1973, Clady 1976, Edsall et al. 1993). McPhail and Lindsey (1970) indicated that burbot were relatively abundant in many drainages of western Canada. Burbot are described as common throughout the upstream reaches of the Columbia River Basin in the northwestern US, and in much of Canada (Scott and Crossman 1973; Paragamian et al. 2001). In Idaho, burbot are endemic only to the Kootenai River (Wydowski and Whitney 1979, Simpson and Wallace 1982). They also inhabit the Kootenay River and Kootenay Lake (Canadian spelling) in British Columbia (McPhail and Paragamian 2000).

The Kootenai River and Kootenay Lake once provided popular and important sport, subsistence, and commercial burbot fisheries, and may have provided one of the most robust burbot fisheries in North America (Paragamian and Hoyle In Press). Many large-scale ecological changes have occurred on the Kootenai River that negatively affected native burbot stocks. Two of the most serious impacts are thought to be loss of the natural Kootenai River floodplain, and operation of Libby Dam, constructed by the U.S. Army Corps of Engineers for hydropower production and flood control management (Northcote 1973, Ashley et al. 1994, 1997, 1999, Anders et al. 2002, 2003). The burbot fishery in Kootenay Lake's West Arm rapidly diminished from an annual harvest of over 26,000 burbot in 1969 to none in 1987. Annual harvest rates in the West Arm fishery during the early to mid 1970s more than doubled the recommended annual harvest quotas (Martin 1976), and post-dam reductions in productivity reduced productivity and food availability (Paragamian 1995a, 1995b; Ahrens and Korman 2002). Angling regulations for burbot fishing became more restrictive as environmental changes to the river and lake were occurring (e.g. nutrient trapping, flow changes through the West Arm, high winter flows, and power peaking). Assessment of the population size structure during the decline of the burbot fishery indicated that the stock was recruitment limited because the proportion of large burbot increased during the period of decline (Paragamian et al. 2000). However, subsequent harvest restriction may have been too late because the fisheries did not improve and were soon closed. Harvest resulting from overestimated burbot abundance due to hyper-stability of catch rates (Longhurst 1998, Ahrens and Korman 2002), may have accelerated an eminent decline because of habitat loss and alteration, and reductions in system productivity likely contributed to decline of Kootenai/y Basin burbot stocks (Paragamian et al. 2000, Ahrens and Korman 2002, Anders et al. 2003, Hammond and Anders 2003).

Across the Kootenai/y River Basin, no single factor appears responsible for the collapse of burbot stocks or populations. Increased winter discharge and winter water temperatures, environmental degradation, reduced primary and secondary productivity, Kootenay Lake flood control, harvest, reduced mysid availability as burbot forage, and ecological community composition shifts have been cited as possible contributing factors to decline of Kootenai/y Basin burbot (Paragamian et al. 2000, Ahrens and Korman 2002, Hammond and Anders 2003, Paragamian et al. in Press).

In response to the loss of these valuable and popular burbot fisheries, fish and river managers, researchers, and concerned stakeholders formed the Kootenai Valley Resource Initiative (KVRI) Burbot Committee to formulate this Conservation Strategy to: 1) prevent further burbot losses, 2) identify actions needed to rehabilitate the burbot population, and 3) avoid extinction of additional local burbot stocks. This Conservation Strategy represents the collective contribution of the Burbot Committee to conserve and restore burbot in the Kootenai/y Basin.

2.0 BIOLOGY

2.1 Species Description

The burbot (*Lota lota*) is the only true freshwater representative of the cod family, Gadidae (McPhail and Paragamian 2000). It normally completes its lifecycle in freshwater and rarely enters the sea (Figure 1), however, burbot have been documented in estuaries and brackish lagoons (Preble 1908, Percy 1975, Pulliainen et al. 1992). Residence in saltwater appears transitory and a high proportion of adult burbot are either sterile or fail to mature under brackish conditions (Pulliainen and Korhonen 1990).

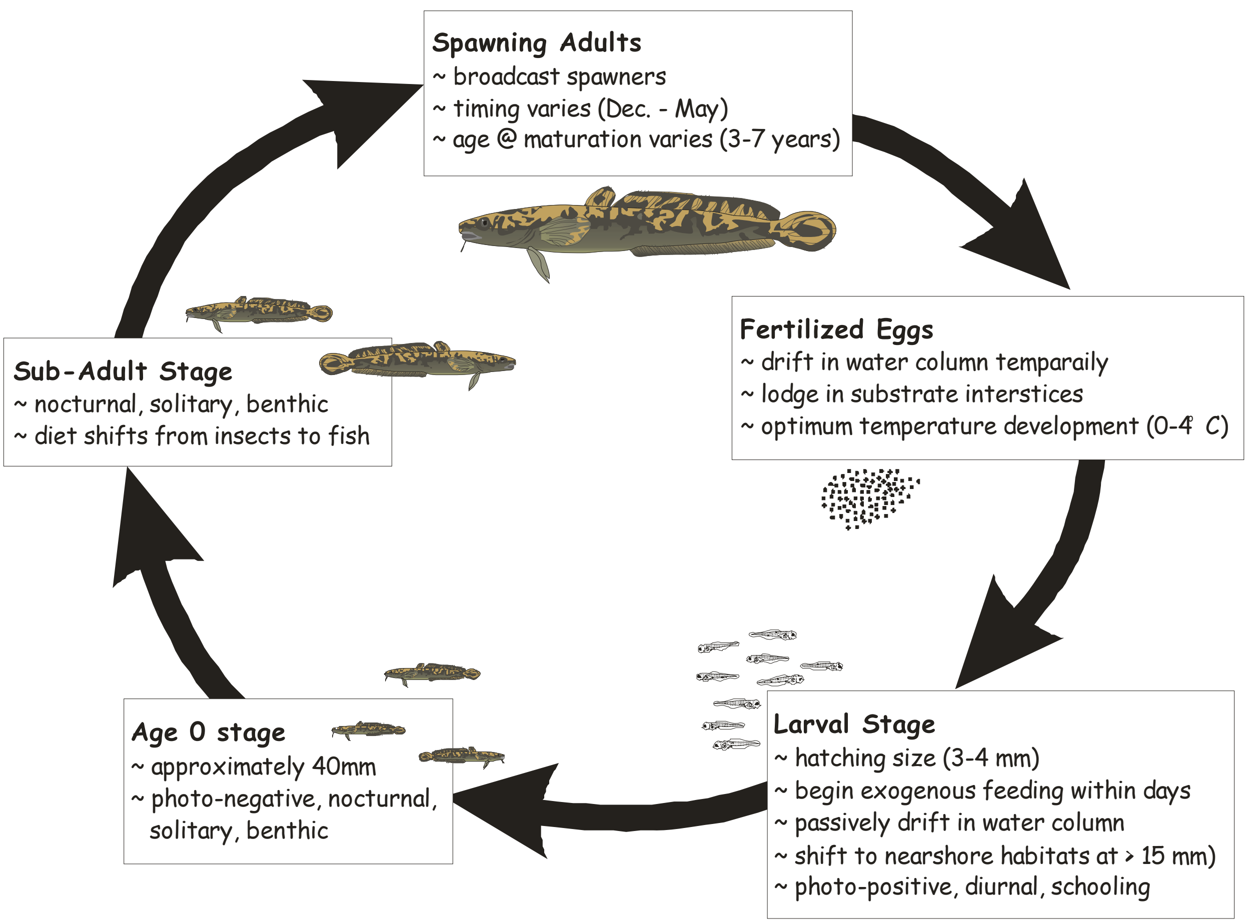

Figure 1. A schematic diagram of burbot life history.

Burbot are easily distinguished from other Northern Hemisphere freshwater fish (McPhail and Paragamian 2000). They are elongate, laterally compressed, the head is slightly flattened, there is a single barbel at the tip of the chin, and each nostril has a small single tube-like projection (Figure 2). The mouth is wide and both jaws contain many small teeth. Burbot have two low, soft dorsal fins: the first is short and the second is much longer. The anal fin is also low and approximately the same length as the second dorsal fin. The pectoral fins are fan-shaped and the pelvic fins are narrow, with elongate second fin rays (Figure 2). The pelvic fins are placed well forward and are located slightly anterior to the pectoral fins. Adult burbot vary in color; dorsally, they usually have olive to brown or black vermiculations and the belly is crème to white (Figure 2). Scales are cycloid, small, and difficult to age.

Figure 2. The burbot (Lota lota) (Scientific drawing by Emily Damstra).

Most burbot attain lengths of 300 to 600 mm with weights of 1 to 3 kg; however, much larger burbot have been documented (Muus and Dahlstrom 1971). The elongate cylindrical body shape limits swimming performance. In one study adult burbot did not maintain water column position for more than 10 min in current velocity that exceeded 25 centimeters per second (Jones et al. 1974). However, burbot in the Kootenai/y Basin and elsewhere exist upstream from higher velocity areas, likely due to use of low velocity upstream migration paths around turbulent and higher velocity areas.

Burbot life span varies geographically. Northern populations generally contain older fish than southern populations (McPhail and Paragamian 2000). Maximum ages recorded in northern populations ranged from 20 to 22 years (Hatfield et al. 1972, Nelichik 1978, Guinn and Hallberg 1990). In Quebec, Magnin and Fradette (1977) noted that burbot older than 7 years were uncommon at latitude 45 °N, however, adults ranged from 8-12 years at latitude 55 °N.

2.2 Distribution and Movements

Burbot exhibit a circumpolar holoarctic distribution extending from the British Isles eastward across Europe and Asia to the Bering Strait (Berg 1949). In North America, burbot range from the Seward Peninsula in Alaska (McPhail and Lindsay 1970) eastward to New Brunswick (Scott and Crossman 1973) and south across the northern United States.

Burbot inhabit cold rivers and lakes throughout their range. Burbot exhibit fluvial (riverine) or adfluvial (live in lakes but migrate to rivers to spawn) life histories (Sorokin 1971). Adult burbot are thought to be relatively sedentary (McPhail and Paragamian 2000). However, burbot are reported to migrate over a wide range of distances. Lengthy migrations have been documented in the late fall/early winter and again in late winter/early spring that coincide with spawning (Robins and Deubler 1955, McCrimmon 1959, Percy 1975, Morrow 1980, Johnson 1981, Breeser et al. 1988, Evenson 2000, Paragamian 2000, Schram 2000). These migrations were often temporally correlated with changes in water temperatures, although movement appeared to be minimal immediately prior to spawning (Evenson 2000). Spawning migrations have been documented at travel rates of 1.5 to 2.0 km/day, assuming constant travel rate.

Burbot inhabit many major rivers and lakes within the Columbia Basin except the Kettle, Flathead, Coeur d'Alene, and Similkameen (McPhail and Carveth 1992). In Idaho, burbot are native only to the Kootenai River (Simpson and Wallace 1982). Burbot are also native to the Kootenay River and to Kootenay Lake in British Columbia (Figure 3). Historically, burbot were distributed throughout the Kootenai/y Basin. The largest concentrations were believed to be in the Balfour area at the mouth of the West Arm of Kootenay Lake, and in the Kootenai River from Kootenay Lake to Kootenai Falls (Figure 3). Based on temporal and spatial reproductive isolation, at least two distinct burbot stocks appeared to exist in the Kootenay Lake watershed (a lacusterine population in Kootenay Lake and a fluvial population in Kootenai River). Empirical confirmation of late reproductive timing of West Arm Kootenay Lake fish (May thru June), based on several years of monitoring the west Arm burbot fishery (Martin 1976) suggested that this group was likely reproductively (temporally and spatially) isolated from historic burbot spawning populations upstream in the Kootenai River in Idaho, and in the Goat River in BC, or in any upstream Kootenai River tributaries in Idaho or Montana (Hammond and Anders 2003).

Currently, most burbot in the Kootenai/y Basin inhabit three separate lake systems: Lake Koocanusa in Montana, and Duncan Reservoir and Trout Lake, both in BC (Figure 3). Little is known about the distribution of burbot in Lake Koocanusa and the upstream Kootenay River in BC. Distribution of burbot in Duncan Reservoir and Trout Lake are addressed in Spence (2000), Neufeld and Spence (2001), Spence and Neufeld (2002), and Baxter et al. (2002a, 2002b). Bissett and Cope (2002) indicated that a viable burbot population exists in Moyie River/Lake based on a 2002 creel survey. However, no other mention of this population was found elsewhere in the regional burbot literature. Burbot also inhabit regional waters of the Upper Columbia River Basin in BC, including its headwaters, Columbia Lake.

Burbot have recently been observed in the North Arm of Kootenay Lake (Spence 1999), at the confluence of the Goat and Kootenai Rivers (Paragamian 1995, Bissett and Cope 2002), and in the mainstem Kootenai River, primarily at Ambush Rock just downstream from Bonners Ferry, Idaho (rkm 244; Paragamian et al. 2001)(Figure 3). Population size in these locations is believed to be a fraction of historic levels. In most cases, insufficient numbers of burbot have been captured to meaningfully estimate their abundance despite years of sampling for this purpose (Pyper et al. 2004). Only two burbot have been captured in the Balfour area of the West Arm of Kootenay Lake during recent years: one in 1997 and one in 1998 (Spence 1999).

Figure 3. Distribution of burbot (*Lota lota*) in the Kootenai River/ Kootenay Lake basin. Symbols indicate general locations and status of existing burbot populations.

2.3 Taxonomy and Genetics

Burbot sub-specific taxonomy is unclear, and little agreement exists among researchers on the classification of the species. Morphological traits traditionally used to characterize subspecific taxonomy are unreliable at large geographic scales and across variable environmental templates.

Historically, burbot were considered two separate species: *Lota lota* (Linnaeus) in Europe and *Lota lacustris* (Walbaum) in North America (McPhail and Paragamian 2000). By the latter part of the 19th century, burbot were recognized as one species, possessing a circumpolar holoarctic distribution (Gunther 1862). By the mid 20th century, some researchers argued that three burbot subspecies existed: *L. l. lota* in Eurasia, *L. l. leptura* in eastern Siberia and Northwestern North America, and *L. l. lacustris* (= *maculosa*) in central and northeastern North America (Hubbs and Schultz 1941, Chen 1969). Pivnicka (1970) provided additional evidence that *L. l. lota* could be distinguished from *L. l. lacustris* but *L. l. lota* and *L. l. leptura* were synonymous. Other studies reported morphological differences among localized burbot populations (Nelichik 1978, Nikiforov et al. 1993). Snyder (1979) suggested that larval burbot may provide additional evidence for subspecies designations. However, subspecific designations based on larval morphology may differ from those based on morphological traits of adult burbot. Many other authors have not used subspecific designations (Lindsey 1956, Lawler 1963, McPhail and Lindsey 1970, Scott and Crossman 1973, Morrow 1980, Simpson and Wallace 1978, Wydoski and Whitney 1979, Nelson and Paetz 1992), although this does not suggest that burbot are morphologically or genetically uniform throughout their range (McPhail and Paragamian 2000). The burbot literature suggests considerable morphological variation in *Lota lota* across geography. It may be inappropriate to treat all burbot as a single taxon (McPhail and Paragamian 2000), or such morphological variation could exist within common genotypes across geography. Burbot phylogenetic or phylogeographic studies are needed to address this uncertainty.

In the case of burbot, difficulty resolving taxonomic uncertainty involves making subspecies decisions/conclusions with inconclusive or incomplete empirical data at various geographic scales. Additional difficulty exists in determining whether variation across geography represents phenotypic or behavioral plasticity within genotypes or lineages, or whether morphological differences are genetically or evolutionarily informative. Such uncertainties could be resolved or at least addressed by comprehensive phylogeographic studies. However, to date, such studies have not been performed.

Burbot in the Kootenai/y Basin region are believed to have recolonized after the most recent Pleistocene glacial retreat 10,000 to 15,000 years ago. One would expect that burbot in the Kootenai/y Basin would be closely related, compared to taxa that did not undergo post-glacial recolonization. However, the number of contributing evolutionary lineages and colonizing events for burbot in the Kootenai basin is currently unknown. Recent fragmentation and physical isolation mechanisms in the Basin include: Cora Linn Dam (completed in 1930s; formerly the natural Bonnington Falls), Duncan Dam (completed in 1967), Kootenai Falls, and Libby Dam (completed in 1972). furthermore, spatial and temporal reproductive isolation may have existed between burbot in the West Arm of Kootenay Lake and burbot in the upstream tributaries of the Kootenai/y River in Idaho and BC (Martin 1976, Ahrens and Korman 2002, Hammond and Anders 2003).

The only population genetic analysis of Kootenai/y Basin burbot performed to date was reported by Paragamian et al. (1999). In this work, several coauthors performed mitochondrial DNA analysis of burbot captured in four different areas within the Basin: Kootenay Lake, B.C., Kootenai River in B.C. and Idaho, Kootenai River at the base of Libby Dam, Montana, and Lake Koocanusa, Montana (Figure 3). Resulting data suggested that burbot could be divided into two distinct groups or populations: those above and below Kootenai Falls, Montana (Figure 3). Paragamian et al. (1999) reported that sequence divergence among observed haplotypes and the significant geographic heterogeneity observed in haplotype frequency distributions supported the conclusion of two genetically dissimilar burbot populations. However, future population genetic study of Kootenai/y Basin burbot may fail to fully reconstruct historical population structure and genetic variability because certain population components have been extirpated (Hammond and Anders 2003) (Figure 3).

2.4 Habitat Requirements and Behaviors

2.4.1 Larvae

In lakes, burbot larvae are limnetic (Clady 1976, Ghan and Sprules 1991, Ryder and Pesendorfer 1992, Wang and Appenzeller 1998, Fischer 1999) and drift passively in the water column. As they grow, improved swimming performance allows larvae to become more mobile. As their mobility increases with larval development, they appear to use shallower water depths, and can be found feeding near the top of the water column. In early summer, larval burbot (< 15 mm, TL) exhibited a habitat shift to near-shore areas (Clady 1976, Ghan and Sprules 1991, Ghan and Sprules 1993).

Little is known of habitat use patterns and the general fate of larval burbot in rivers. However, it is assumed, as common with many larval fishes in rivers that burbot larvae drift downstream. The rate of downstream drift would likely decrease in backwater areas or at physical obstructions that reduce water column velocity. As their swimming performance improves, burbot may be better able to maintain position in low velocity areas of the river. One larval burbot was captured in the Goat River, BC (Fredricks and Fleck 1995).

2.4.2 Juveniles

In lakes, age-0 burbot are found in near shore areas with adequate cover. Lawler (1963) and Boag (1989) observed age-0 burbot sheltered under stones and debris in shallow bays and along rocky shorelines. Fischer and Eckmann (1997) documented a strong positive correlation between juvenile burbot presence in the littoral zone and the presence of gravel substrate and large stones. Ryder and Pesendorfer (1992) noted that burbot fingerlings sheltered under rocks and debris where they excavated small burrows. In rivers, similar habitat use shifts by burbot were reported. Age-0 burbot sought shelter in weed beds and under rocks, debris, and cut banks (Robins and Deubler 1955, Hanson and Qadri 1980). Subadult burbot were reported to occupy similar habitats as age-0 burbot (Clemens 1951a, Beeton 1956, Bishop 1975, Nagy 1985, Sandlund et al. 1985, Guthruf et al. 1990).

Little is known regarding larval and juvenile burbot habitat use in the Kootenai River because no larvae and very few juvenile burbot have ever been captured. Although most sampling focused on capturing adults, extensive juvenile sampling occurred with very little success (Fredericks and Fleck 1995, Spence 1999, Paragamian et al. 2001). One YOY burbot (40 mm) was caught in the Lower Kootenai River at the mouth of Trout Creek along the bottom at about 4 m depth.

However, no habitat description was provided other than the benthic association (Fredericks and Fleck 1995). Spence (1999) captured one YOY burbot at the north end of Kootenay Lake's North Arm. This fish was found in a small pile of cobble and boulders in about 30 cm of water.

During night observations of adult burbot, Spence (1999) and Baxter et al. (2002b) observed subadult burbot (<250 mm) at the north end of the North Arm of Kootenay Lake. Although detailed habitat descriptions were not provided, substrate associated with these sightings consisted primarily of fines, in close proximity woody cover.

2.4.3 Adults

Throughout their range, adult burbot prefer cool water. At the southern edges of their range, they typically inhabit deep lakes or cool rivers and reservoirs associated with mountainous areas (McPhail and Paragamian 2000). In lakes, burbot are strongly associated with the substrate, and are usually found below the thermocline during the summer months (Sandlund et al. 1985, Kirillov 1988, Carl 1992, Edsall et al. 1993). Hackney (1973) reported a preferred summer temperature range of 10 to 12 °C. Adult burbot habitat use in rivers is poorly understood, but burbot are a common fluvial species in northern rivers where temperatures rarely exceed 18 °C. Adult burbot are associated with main channels and seem to prefer turbid water in such systems although they often enter tributaries in the fall (Chen 1969, Hatfield et al. 1972, Breeser et al. 1988). Burbot have also been known to enter brackish water in the summer and return to rivers in the fall (Preble 1908, Percy 1975, Mueller 1982). Burbot are fairly uncommon in southern rivers where temperatures normally exceed 20 °C; in these areas, they are restricted to higher elevation, cooler systems (McPhail and Paragamian 2000).

Burbot are believed to have low swimming endurance and are commonly found in low flow riverine habitats. Jones et al. (1974) determined that burbot did not have the ability to swim 100 m upstream in 10 min at water velocities greater than 20 to 25 cm/s. Of the 17 species studied, burbot appeared to have the lowest swimming stamina (Jones et al. 1974). Paragamian (2000) reported an empirical relationship between burbot downstream movement and increasing water velocity in the Kootenai River. He reported downstream movement when burbot were assumed to travel upstream to spawning areas. British Columbia researchers have observed burbot avoid high velocities during a study of spawning migrations in the Duncan River (Spence and Neufeld 2002). However, burbot in the Kootenai/y Basin and elsewhere exist upstream from higher velocity areas, likely due to potential use of low velocity upstream migration paths around turbulent or high velocity areas.

Adult burbot habitat use information from the Kootenai River Basin must be inferred from habitat descriptions of locations where burbot have been captured, and from telemetry studies. Paragamian (1994) captured adult burbot in the mainstem Kootenai River near Ambush Rock (rkm 244, Figure 3) at depths ranging from 3-20 m in association with boulder cobble substrate in the outside bend of the river, and in the mainstem Kootenay River from rkm 147-170, over sand or silt substrate (Paragamian 1995b). Adult burbot were also captured in the mouth of the Goat River over sand or silt substrate (Paragamian et al. 1997). Spence and Neufeld (2002) observed a clear preference for deep-water habitat use by burbot in Duncan Reservoir. No fish were caught at depths <16 m and the CPUE was considerably higher for the deepest depth interval sampled (26-30 m). Spence and Neufeld (2002) also investigated Duncan River habitat conditions occupied by adult burbot after a presumed spawning migration to the upper Duncan River; mean depths were 63.2 cm and water velocity averaged 0.132 mps.

2.5 Food and Feeding

Food items consumed by exogenously feeding larval burbot varied by location and availability. Ghan and Sprules (1993) reported the first food taken was rotifers, Ryder and Pesendorfer (1992) found that copepods and cladocerans were the first foods, and Wang and Appenzeller (1998) observed that copepod nauplii were positively selected by burbot larvae. Once they begin feeding, larvae selected the largest prey items they could engulf (Ghan and Sprules 1993). Hartmann (1983) indicated that small larvae (5-14 mm) increased the number of items they consumed as they grew, whereas larger larvae (15-30 mm) consumed approximately the same number of prey items but switched to larger prey as fish size increased. In general, larval growth is rapid in spring and early summer but slows later in the summer (Ryder and Pesendorfer 1992).

Like many fishes, as burbot grow, they exhibit ontogenic shifts in prey selection, which may be due to reduced gape limitation, ontogenic shifts in habitat use, or both. For example, larvae 3-10 mm long fed primarily on copepods and cladocerans, burbot 11-20 mm in length also consumed dipterans, burbot 21-30 mm contained 60% zooplankton and 30% amphipods, burbot 31-40 mm contained 85% amphipods, and larger fingerlings ate mostly amphipods and insects (Ryder and Pesendorfer 1992). A similar shift in burbot prey items occurs in rivers: age-0 burbot fed on amphipods, insects, and young of other fish (Robins and Deubler 1955, Bishop 1975, Hanson and Qadri 1980), and diet of subadults progressively shifts from insects to fish as burbot grow (Clemens 1951a, Beeton 1956, Bishop 1975, Nagy 1985, Sandlund et al. 1985, Guthruf et al. 1990).

Adult burbot are piscivorous, with fish comprising more than 80% of the diet (Clemens 1951a, Rawson 1951, Nikolsky 1954, Hewson 1955, Bonde and Maloney 1960, Lawler 1963, Bailey 1972, Hatfield et al. 1972, Bishop 1975, Magnin and Fradette 1977, Nelichik 1978, Chisholm et al. 1989). Although the proportion of fish in the diet is positively related to fish size, large burbot still consumed some insects and macroinvertebrates (McPhail and Paragamian 2000). Burbot diet can also shift seasonally, depending on available prey items (Bailey 1972).

The only report of stomach contents from adult burbot in the Kootenai River Basin came from night surveys for spawning burbot at the north end of the north arm of Kootenay Lake. Baxter et al. (2002a) reported that a dead female burbot had recently eaten Mysid shrimp (*Mysis relicta*); although a detailed stomach content analysis was not performed.

2.6 Spawning

2.6.1 Onset of Sexual Maturity

Burbot size and age at onset of sexual maturity varies by sex and by region (latitude). Robins and Deubler (1955) reported standard lengths of 19.5 to 23.5 cm and ages 2 and 3 at the onset of sexual maturity in the Susquehanna River, N.Y., whereas Chen (1969) documented that burbot were 40-50 cm in total length and 6 to 7 years old at onset of sexual maturity in Interior Alaska. There is general agreement that males mature about a year before females (Bjorn 1940, Clemens 1951b, Sandlund et al. 1985, Kirillov 1988, Boag 1989). In Europe and North America, individual burbot in northern populations generally matured later (4 to 7 years old; Chen 1969, Kirillov 1988, Evenson 1990, Evenson 2000) than those in southern populations (3 to 4 years old; Robins and Duebler 1955, Lelek 1980, Boag 1989).

Migrations

Lengthy burbot migrations have occurred during late fall/early winter, and again during late winter/early spring that coincide with spawning with some of over 100 km (Robins and Deubler 1955, McCrimmon 1959, Percy 1975, Morrow 1980, Johnson 1981, Breeser et al. 1988, Evenson 2000, Paragamian 2000, Schram 2000, Paragamian et al., in press). These migrations are also temporally correlated with changing water temperatures, and appeared to be minimal immediately prior to spawning (Evenson 2000). Spawning migrations have been documented at travel rates of 1.5-2.0 km/day, and appear to vary among populations. Burbot movement rates in the Kootenai River rates ranged as high as 8 to 11 km/day (Paragamian et al., in press).

Telemetry data suggested that most burbot in the Kootenai River moved only a few km during the presumed pre-spawning period (Paragamian 1995b) and some fish are very sedentary (Paragamian, unpublished data). However, one fish was tracked from the Crawford Bay area of Kootenay Lake (rkm 85) to rkm 197 (Kerr Lake outlet) of the Kootenay River over a period of several months. An additional burbot originally tagged and released at rkm 244.5 near Bonners Ferry was captured the following year during the spawning season near the Goat River (rkm 152; Paragamian 1995b). Although only one fish could be tracked during the pre-spawning period, Paragamian and Whitman (1997) documented this burbot moving from the Kootenay River delta at rkm 119 to Ambush Rock at rkm 244 during the fall months where it remained until the presumed spawning season during January and February. Paragamian et al. (2001) tracked a burbot from rkm 166.5 to 150.5 near the Goat River during a 20-day period in late December/early January; it is unknown how far this fish had migrated prior to its capture at rkm 166.5. Bisset and Cope (2002) captured a burbot during the spawning migration into the Goat River that was captured in the Kootenay River at rkm 152.7 during the previous year; this is consistent with little movement observed in the Goat River area for most fish (Paragamian 1995b, Paragamian and Whitman 1997, Paragamian et al. 2001).

Spence (1999) observed minimal movement of burbot in Kootenay Lake tagged during the spawning period (late February to March); all fish remained in the north end of the North Arm of Kootenay Lake. Males traveled farther than females and the mean rate of travel for males and females was 0.46 and 0.10 km/d respectively, based on assumed constant migration rates (Spence 1999). Spence and Neufeld (2002) tagged fish in November and December at the south end of Duncan Reservoir; most fish remained near the site of capture throughout the spawning season (through March). The few fish that migrated to the north end of Duncan Reservoir gradually migrated downstream along the southern edge of the river-reservoir interface as it subsided during winter drawdown; this downstream migration occurred during the presumed spawning period (Spence and Neufeld 2002).

2.6.2 Habitat Characteristics

Burbot spawn in rivers, streams, and lakes. In rivers, burbot spawn in low velocity areas, in main channels, or in side channels behind deposition bars (Breeser at al. 1988, Sorokin 1971). Preferred river substrate appears to be fine silt, sand, or gravel. In lakes, spawning usually occurs over near-shore shallows (1.5-10 m deep) or over shallow offshore reefs and shoals (Clemens 1951b, McCrimmon 1959, Johnson 1981, Boag 1989). However, there is some indication of spawning in deep water in the Great Lakes (Clemens 1951b). Lake substrate is usually sand, gravel, or cobbles and is relatively free of silt (McCrimmon and Devitt 1954, Chen 1969, Sorokin 1971, Boag 1989).

Paragamian (1995) described habitat in the Kootenai and Goat rivers used during the spawning period. In the Kootenai River, burbot were rarely found in less than 6 m of water, but maximum depth ranged from 1-30 m where fish were sampled. Substrate in most locations was composed of silt or sand. In the lower Goat River, where spawning was thought to have occurred, the habitat was described as silt and sand substrate with water depths less than 3 m. In the North Arm of Kootenay Lake, burbot spawning was associated with cobble and boulder substrate in 0.5 to 1.5m depths (Spence 1999). In Duncan Reservoir, Spence and Neufeld (2002) observed a concentration of burbot during the spawning period at the mouth of Glacier Creek. In Trout Lake, Baxter et al. (2002b) observed fish concentrations at the mouths of small creeks entering the lake; there was no observed utilization of the larger tributaries entering the lake. During winter and early spring when Trout Lake was frozen, these creek mouths were the only ice-free areas.

2.6.3 Timing

Burbot typically spawn during winter or early spring, often under the ice, during a relatively short (2-3 weeks) and highly synchronized spawning season (Bjorn 1940, Clemens 1951b, McCrimmon and Devitt 1954, Lawler 1963, Meshkov 1967, Chen 1969, Johnson 1981, Kouril et al. 1985, Sandlund et al. 1985, Breeser et al. 1988, Boag 1989, Arndt and Hutchison 2000, Evenson 2000, Paragamian 2000). However, Martin (1976) reported that historical burbot spawning in the West Arm of Kootenay Lake, B.C. began in early April and continued into late May or early June. Paragamian (1995) described spawning migrations in the Kootenay River toward the Goat River in late January and suggested that the spawning period ended in mid-February because no activity indicative of spawning behavior was observed after this time. Bisset and Cope (2002) reported that burbot spawned in the Goat River during February, but indicated that spawning fish may have been in that system before late January. Spence and Neufeld (2002) documented burbot spawning during March in Duncan Reservoir. Baxter et al. (2002a) tracked burbot in Trout Lake and estimated that they spawned from late February to late April.

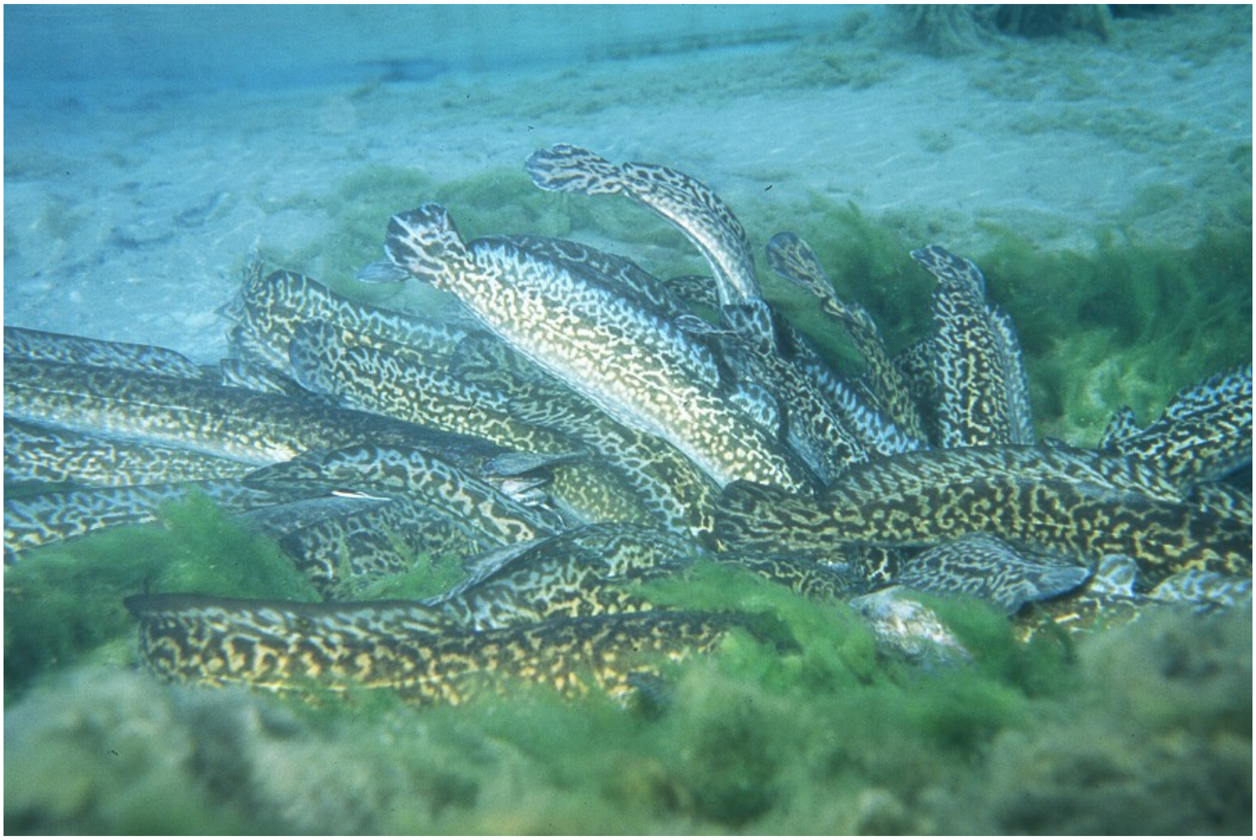

Figure 4. Spawning aggregation of male and female burbot in an unnamed tributary to Columbia Lake, British Columbia. (Photo courtesy of Ernest Keeley, Idaho State University).

2.6.4 Behavior

On the spawning grounds, burbot do not prepare the substrate and eggs are broadcast into the water column well above the substrate (Fabricius 1954). However, more recently, Arndt and Hutchison (2000) noted that movements of dense congregations of burbot in deep pools prior to spawning displaced the silt layer and exposed a clean cobble substrate over which spawning likely occurs. Depending on water column velocity, the eggs may initially drift but eventually settle into the substrate interstices (Sorokin 1971). There appear to be differences in the time of day when burbot spawn that may be related to geographic region. Fabricius (1954) observed spawning in the morning and evening in an experimental tank, whereas others reported that burbot spawned at night (Carl et al. 1959, Scott and Crossman 1973, Simpson and Wallace 1978, Morrow 1980). Because spawning usually occurs under ice, observations of spawning activity and gamete release are rare. Field observations of burbot spawning suggest spawning aggregations (Figure 4). Cahn (1936) observed a large 'ball' of males with one or two females at the center. Gametes are released as the 'ball' writhes about in the water column. McCrimmon (1959) observed a 'milling around' of spawning burbot with a release of a quantity of eggs; many of the eggs remained in temporary suspension by the water movements created by the fish activity. In contrast, experimental observation revealed spawning of a single male and single female releasing multiple gametes at 5- to 20-min intervals (Fabricius 1954).

Burbot do not appear to be obligate annual spawners. Evenson (1990) estimated that approximately 15% of females and 17% of males collected in the Tanana River, Alaska, would not have spawned during the year they were sampled. Pulliainen and Korhonen (1990) estimated that 30% of adult burbot did not spawn every year and Pulliainen and Korhonen (1993) reported that 29 to 49% of adult burbot off the coast of the Simo River, Finland, did not spawn annually. Arndt and Hutchison (2000) reported that 3.1 to 18.2% returned to the spawning area in consecutive years to spawn; other fish either did not spawn or spawned in a different location. Pulliainen and Korhonen (1993) were unable to explain the rest year phenomenon using condition indices, and determined that sexual maturation was not accurately predicted by the extent of liver fat stores.

2.6.5 Water Temperature

Burbot spawn at very low water temperatures (1-4 °C; McCrimmon and Devitt 1954, Hewson 1955, Lawler 1963, Meshkov 1967). Kouril et al. (1985) indicated that a change in temperature from 0 to 2.5 °C can delay spawning up to 14 days, suggesting that burbot eggs are adapted for greatest survival at temperatures between 0 and 2 °C. Taylor and McPhail (2000) demonstrated that survival from fertilization to hatching was highest at 3 °C, and that all embryos died at temperature above 6 °C. Jager et al. (1981) indicated that optimal embryo development temperatures were between 4 and 7 °C, and that mortality increased below 4 °C. Variation in observed thermal optima for embryo development and hatching success may be due in part to local adaptation across latitudes. Water temperature regimes and their possible effects on burbot brood stock maturation, spawning, and incubating embryos held and reared in captivity were recently reported by Cain and Jensen (2004).

In the North Arm of Kootenay Lake, spawning burbot were associated with a surface water temperature of 4.3°C (Spence 1999). In the confluence of the Kootenay and Goat rivers, Paragamian (1995) observed burbot staging in cooler portions of the river (2-3 °C) and documented suspected spawning movements to 1 or 2 °C water in the Goat River. Paragamian and Whitman (1997) tracked burbot during the spawning period that remained in <1 to 3 °C water at the confluence of the Goat and Kootenay Rivers. Bissett and Cope (2002) observed burbot in Goat River spawning habitat when water temperatures were 1.5 to 2.0 °C; mean water temperature at the capture site during the sampling period was 0.8 °C.

2.6.6 Water Flow

Most observations of burbot spawning in the literature were reported from lakes (Bjorn 1940, Clemens 1951b, McCrimmon 1959, Bailey 1972, Muth 1973, Johnson 1981, Boag 1989). Because documentation of river spawning has focused on spawning migrations (Robins and Deubler 1955, Chen 1969, Sorokin 1971, Breeser at al. 1988), little is known about the water flow requirements or preferences for burbot spawning in streams and rivers. Burbot have low swimming endurance (Jones et al. 1974), and would logically prefer low water velocities. Burbot spawn during the winter months, which is typically the low flow period for unregulated river systems. Most river spawning observations have occurred in low velocity areas within main river channels. Low water velocity would likely be associated with the aforementioned river spawning substrate composition. Paragamian (2000) found that high flows in the Kootenai River impaired burbot spawning migrations. An additional study (Paragamian et al., in press) found that burbot moved substantial distances (5 km or more in 10 days or less) when flows were < 300 m^3/s. However, the effect of water velocity on burbot spawning success at site locations is poorly understood. Low water velocity habitats may be more hospitable to larval or YOY burbot survival. However, high water velocity is reported as an important factor in the spawning success of communal broadcast spawners such as white sturgeon that have adhesive eggs (unlike burbot) due to the assumed importance of its role in gamete mixing and separation, and downstream embryo dispersal (Parsley et al. 1993, 2002, Perrin et al. 1999, 2003, Coutant 2004).

The Goat River is a documented spawning location for Kootenay River burbot, although little recruitment has not been quantified. Historic flow data from 1914-1995 indicated that mean annual discharges of the lower Goat River during January and February (the presumed spawning time) were 6.05 and 6.24 m^3/s, respectively (Bisset and Cope 2002). However, flow (river discharge) was not directly measured in specific burbot spawning locations within the Goat River, and water velocity rather than flow is a more meaningful measure, relative to predicting burbot spawning habitat requirements.

2.6.7 Fecundity

Individual fecundity of burbot is high. Bailey (1972) reported an average number of eggs per female of about 812,300. Other estimates of egg number ranged from 6,300 (Miller 1970) to 3,477,699 (Roach and Evenson 1993). Average fecundity can vary substantially between fish from different lakes in the same region (Boag 1989). A positive relationship exists between fish length and fecundity; however, the effect of size on fecundity is not as pronounced in burbot as in many other fishes (Boag 1989, Roach and Evenson 1993).

2.7 Early Life History

As with most fish, burbot egg development and mortality rates are functions of temperature. Embryos generally develop faster at higher temperatures, and mortality increases on either side of thermal optima (McPhail and Paragamian 2000). Most researchers agree that the optimum temperature for burbot zygote development is between 0 and 4 °C (Andersson 1942, McCrimmon 1959, Lawler 1963, Meshkov 1967, Sorokin 1971, Ryder and Pesendorfer 1992). Incubation periods have been reported as 41days at 2 °C (Andersson 1942) and from 98 to 128 days at 0 °C (Meshkov 1967). Additional burbot early life history information was reported by Taylor and McPhail 2000)

Larval size at hatching was reported at between 3 and 4 mm (McCrimmon 1959, Ghan and Sprules 1991, Fischer 1999). Larval burbot are capable of exogenous feeding within a few days post-hatch (Ghan and Sprules 1991), but endogenous feeding can last between 11 and 23 days (Fischer 1999). Larval densities are high shortly after hatching but drop within a month (Ghan and Sprules 1991). Larvae are initially positively phototactic (Girsa 1972), and exhibit diurnal activity patterns and schooling behaviors.

At approximately 40 mm, burbot become negatively phototactic (Girsa 1972). In lakes, this reversed reaction to light appears to cause a change to a nocturnal, solitary, benthic existence. Numerous researchers reported observing burbot feeding at night and seeking shelter under rocks or other debris during the day (Lawler 1963, Boag 1989, Ryder and Pesendorfer 1992, Fischer and Eckmann 1997). The only exception appears to be at latitudes above the Arctic Circle where Kroneld (1976) stated that age-0 burbot are night-active during summer and day-active in winter. Age-0 burbot grow rapidly and can reach 110-120 mm in total length by late fall (Chen 1969, Sandlund et al. 1985). Burbot continue to grow throughout the winter (Boag 1989).

3.0 STATUS

3.1 Abundance & Population Trends

Despite their wide circumpolar geographical range, some burbot populations are in decline or have been extirpated in many European countries. McPhail and Lindsey (1970) indicated that burbot were relatively abundant in the other drainages of western Canada. They are described as common throughout the upstream reaches of the Columbia River Basin in the northwestern US and Canada (Paragamian et al. 2001). Local distribution and stock status have been investigated throughout the burbot's range. Specific assessments have occurred in Asia (Nelichik 1978, Nikiforov et al. 1993), Canada (Lindsey 1956, Hatfield et al. 1972, Paragamian et al. 2001), Alaska (Hallberg 1986, Peckham 1986, Parker et al. 1987, Parker et al. 1988, Lafferty et al. 1990), and the northern United States (Robins and Deubler 1955, Muth 1973, Clady 1976, Edsall et al. 1993).

The most reliable burbot population abundance estimates come from a stock assessment program on lacusterine populations in Alaska (Bernard et al. 1991, Lafferty et al. 1990, 1991, 1992, Evenson 1993, Lafferty and Bernard 1993, Parker 1993). Across a variety of lakes, adult burbot (>450mm) density estimates ranged from 0.24 to 21.9/hectare. The highest recorded adult densities encountered in this literature review (139/hectare) existed in southwestern Lake Michigan at Julian's Reef (Edsall et al. 1993).

Extensive burbot sampling occurred throughout the Kootenai River Basin since the early 1990s, and intermittently before that since the late 1950s (Table 1). In the Kootenai River, burbot were sampled by fisheries agencies as early as 1957; a total of 199 burbot were captured during a 1957-1958 winter sampling period. The length-frequency distribution of this sample indicated an abundance of young fish and good representation of older fish (Paragamian et al. 2000), indicative of previously successful natural recruitment. During the 1960s, the combined average annual catch of the sport and commercial fisheries was thought to have exceeded thousands of kilograms. Anecdotal information from historic angler surveys indicated that an excellent winter burbot fishery existed from the 1930s through the early 1950s. These interviews suggested previous abundance declines due to heavy harvest from Dust Bowl immigrants to the Kootenai River Valley (Appendix 2).

During a sampling program from 1979 to 1982, Partridge (1983) captured a total of 108 burbot with three different gear types. Although all catchable age classes were represented in this sampling program, Partridge (1983) believed that burbot abundance was substantially lower than in the 1950s. The annual burbot harvest from 1979-1982 was estimated at less than 250 fish (Partridge 1983). Several burbot were captured while using setlines to sample white sturgeon in the Kootenai Falls area in Montana during 1990, although catch rates were very low (Apperson and Anders 1991). During the early 1990s, catch numbers were low, but numerous age groups were represented, indicating that some burbot recruitment was occurring. Sampling during the winter of 1993-1994 at the mouths of Lower Kootenai River tributaries in Idaho resulted in no burbot. One burbot was caught between Bonners Ferry, Idaho, and the Montana border; there was no evidence of reproduction occurring in Idaho. Burbot were nonexistent in a creel survey that extended from spring 1993 to spring 1994 (Paragamian 1993, 1994). With the exception of two young burbot (age 1), one fingerling length (age 0) and one free swimming age-0 burbot, young burbot have not been observed in the Lower Kootenai River during the last 10 years, despite intensive effort (V. Paragamian, IDFG, personal communication).

Table 1. Summary of burbot sampling in Kootenai River and Kootenay Lake. Specific information is presented only if provided in the original reference; for example, sampling months and CPUE units are not provided in all references.

Year/ Month	Location	Capture Method	No. Burbot Caught	CPUE	Reference
1957-58	Kootenai River	Unknown	199	Unknown	Paragamian et al. 2000
1979-82	Kootenai River	3 gear types	108	Unknown	Partridge 1983
1993, March-June	Kootenai River, rkm 225-273	Hoop traps	17	0.03 fish/net-day	Paragamian 1994
1994	Kootenai River	Hoop traps	8	0.009	Marcuson et al. 1994
1994-1995, November-February	Kootenay River, B.C., rkm 145-170	Hoop traps	33	0.047 fish/net-day	Paragamian 1995
1995, April-June	Kootenai(y) River, rkm 115-245	Larval fish net, Minnow traps, Beach seine, Electrofishing	0 larval burbot, 1 juvenile burbot	Unknown	Fredericks and Fleck 1995
1995-1996, November-March	Kootenai(y) River, rkm 120-178	Hoop traps	28	0.055 fish/net-day	Paragamian and Whitman 1997
1997	Kootenay River delta, Balfour, Pilot Bay, Duncan River outlet	Set lines, Hoop traps	8	28,000 hook hours; 12,981 hours hoop trap	Redfish Consulting Ltd. 1998
1997, July; 1998, June	West Arm Kootenay Lake (inlet to Akokli Creek)	Hoop traps	1 in 1997 1 in 1998	unknown	Spence 1999
1998, June-August	Kootenay Lake, Duncan River, Goat River	Electrofishing, Minnow traps, Beach seine	1 juvenile	0.01 fish* $100s^{-1}$	Spence 1999
1998-1999, January-March	Kootenay Lake, Duncan River	Hoop traps, Cod traps	20	0.051 fish/ 100 h (hoop traps)	Spence 1999
1999-2000, October-April	Kootenai(y) River, rkm 144-244	Hoop traps	36	0.0216 fish/net-day	Kozfkay and Paragamian 2001
2000, April-May; 2001, February-March	Kootenay Lake: Balfour, Sunshine Bay, Queen’s Bay	Cod traps	1	0.004	Baxter et al. 2002a
2001, January-March	Kootenay Lake: Balfour, Sunshine Bay, Nine Mile Narrows, Queen’s Bay	ROV (remote operated vehicle)	0	0	Baxter et al. 2002a
2002, February	Kootenay Lake	TOV (towable operated video camera)	0	0	Baxter et al. 2002b
2002, January-February	Goat River	Fish fence/trap	15	0.03 fish/hour	Bisset and Cope 2002

Improvement in the status of the Kootenai/y River burbot population should be indicated by a combination of adult catch per unit effort (CPUE) records, total annual catch, changes in proportional stock density (PSD), and increasing Seber-Jolly-Cormack population abundance estimates.

Catch per unit effort is based on the catch per 24 hr. hoop net set, thus, one 24-hr. set is equal to one unit. Catch per unit effort generally decreased since 1995 (Table 2, Figure 5 and 6). Some of the variation in CPUE likely resulted from inter-annual and inter-site differences in condition; annual effort ranged from 507 to 2,122 net days (Figure 7). Consistent capture of burbot occurs in only a few distinct areas: Ambush Rock, Idaho and in and near the Goat River, BC, and in the vicinity of Nick's Island, BC. During some years over half of the burbot captures occurred at Ambush Rock or the Goat River during late January and the first two weeks of February 2002. These locations represented inferred spawning locations, and were sampled up to six times more frequently than other areas (Figure 7). Since the winter of 1995-1996, burbot CPUE values ranged from 0.055 to 0.006, and decreased on average about 0.005 each season since 1995 (Table 2).

Declining CPUE values over an 8 year period (Figure 5) and insufficient numbers of captured fish to reliably estimate population abundance over this time indicate that the Kootenai/y River burbot population may be functionally extinct.

Table 2. Idaho Department of Fish and Game burbot captures, PSD, and catch per unit effort in the Kootenai River, Idaho and British Columbia 1995-2003.

Sample Year (Fall-Spring)	No. Burbot Captures	PSD	Total Net Days	CPUE (fish/net day)
1995-1996	28	100	507.0	0.055
1996-1997	23	100	1,048.33	0.022
1997-1998	42	90	1,214.44	0.035
1998-1999	44	91	1,441.63	0.031
1999-2000	36	---	1,669.07	0.022
2000-2001	73	100	2,122.87	0.034
2001-2002	17	91	1,484.44	0.011
2002-2003	11	---	1,775.85	0.006
Total or mean	274		11,263.59	0.024

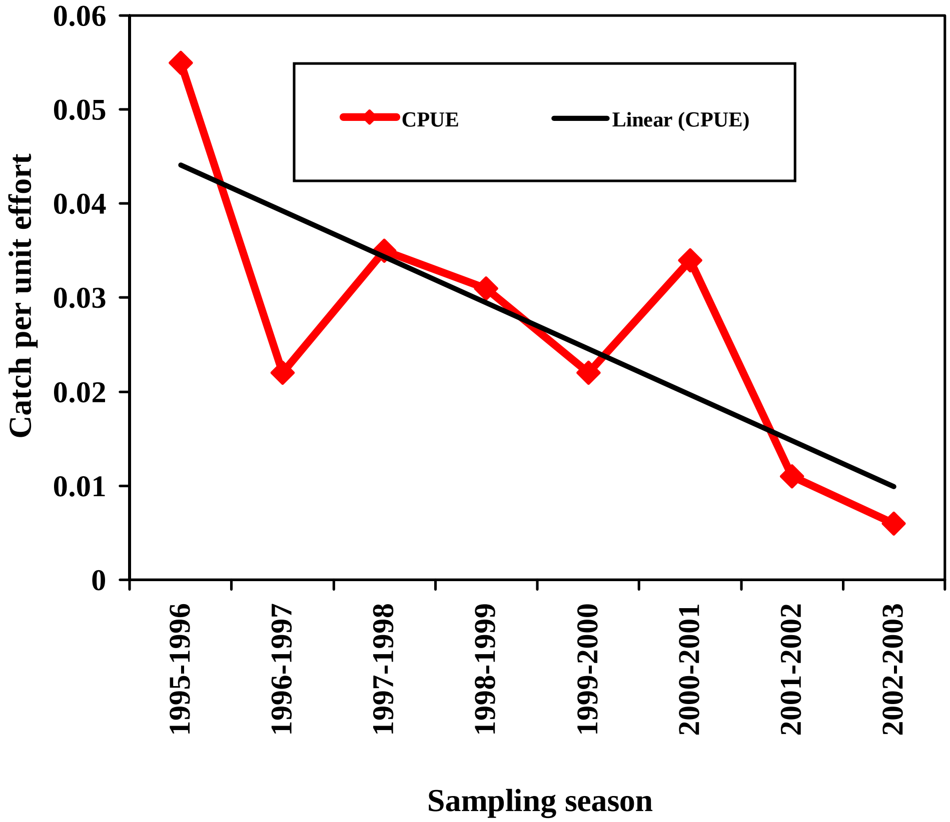

Figure 5. **Catch per unit of effort (CPUE) of burbot in the Kootenai(y) River, Idaho and British Columbia, by sampling season. Sampling extended from October through April each season. The downward trend in CPUE may portray the extirpation of remnant burbot in the Kootenai River.**

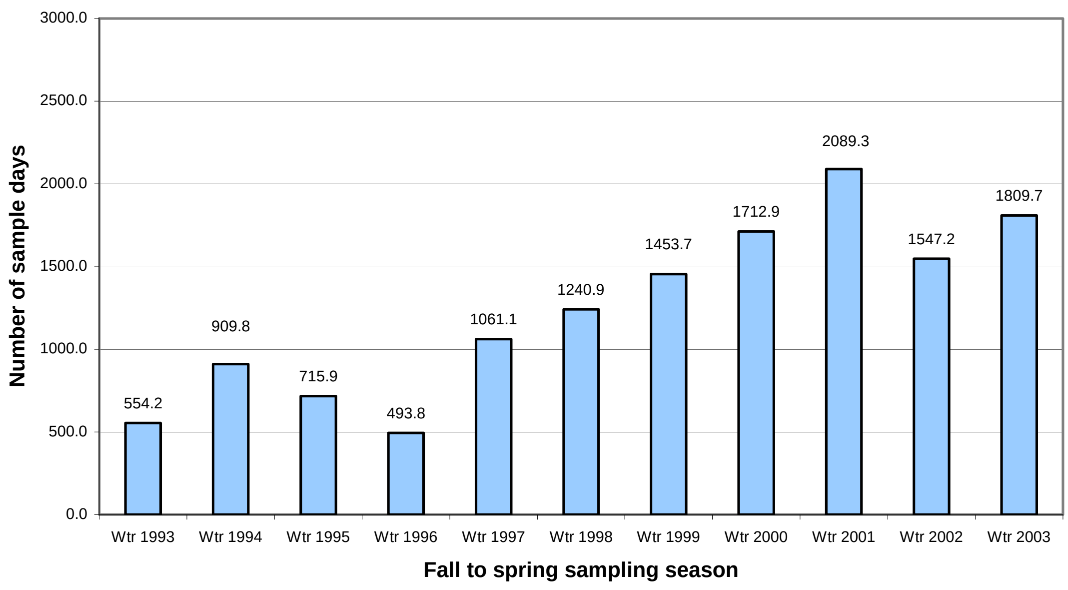

Figure 6. **Annual IDFG burbot sampling in the Kootenai(y) River Idaho, and British Columbia, 1993-2003.**

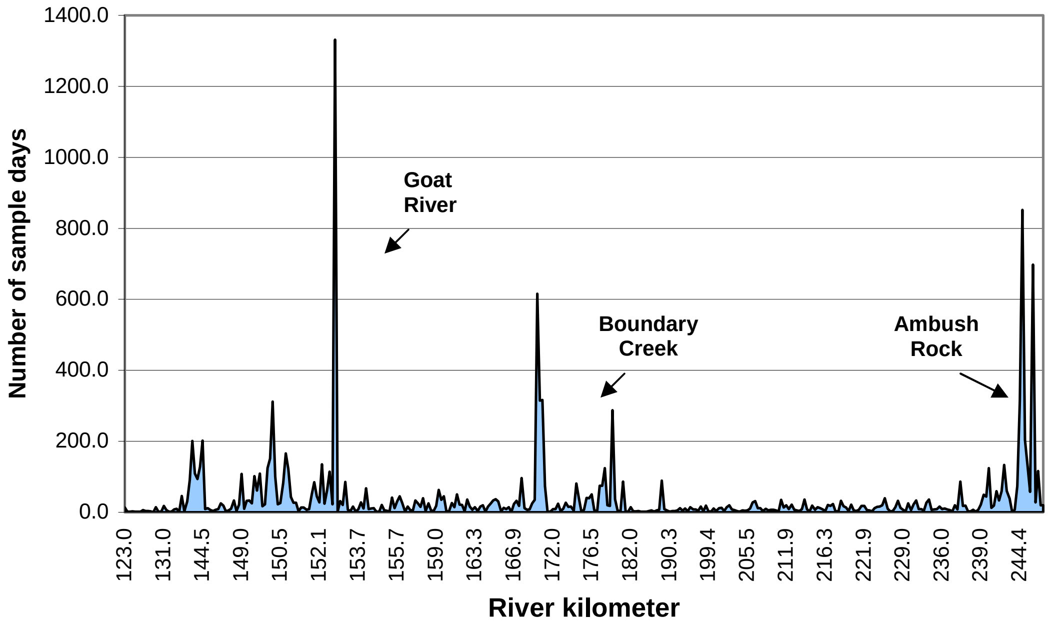

Figure 7. Annual IDFG burbot sampling in the Kootenai(y) River, Idaho and British Columbia, by river kilometer, 1993-2003.

The proportional stock density index (PSD) describes the size-structure of a fish population, can vary annually or seasonally, and ranges from 0 to 100. PSD values can change in unexploited populations due to gear selectivity or recruitment changes. Fisher et al. (1996) provided information on PSD values for burbot, PSD for burbot is the proportion of stock length burbot $\geq$ 200 mm that are quality length or $\geq$380 mm, and suggested that when stock densities were high (e.g.>70), recruitment may be low or inconsistent. Improved recruitment reduces PSD values as the young individuals join the population. Proportional stock densities of the Kootenai River stock burbot ranged from 91 to 100 (Table 2). Improved recruitment of burbot would drive the PSD to lower values, perhaps in the 70 to 80 range for the Kootenai River. However, some caution must be exercised with PSD alone because of a gear bias. One of the smallest burbot caught to date was 352 mm TL. In 2001-2002, two small burbot escaped through the web of a hoop net and were most likely evidence of successful spawning in winter 2000-2001 (Gunderman and Paragamian 2004). Partridge (1983) aged burbot in the Kootenai River using otoliths and found that age-1 and -2 fish were about 200 and 340 mm TL, respectively. Based on studies of Bernard et al. (1991), burbot can be caught in hoop nets at about 350 mm TL but were not fully recruited until 450 mm TL. Thus, many small burbot of age-1 and 2 can escape our standard hoop nets of about 1" bar mesh, however nets can be made with smaller web.

Increases in estimated population size based on the ongoing annual Seber-Jolly-Cormack population abundance estimates are a third measure of population improvements. A recent estimate of burbot population numbers is an estimate of 540 (SE=730) fish based on that of Paragamian and Whitman (2000). However, this estimate did not meet criteria of large sample sizes, which jeopardized the accuracy of the estimate (Robson and Regier 1964). The most recent and most robust estimate suggests a mere 50 fish remain in the remnant Lower Kootenai River burbot population, with 95% confidence intervals around that estimate ranging from 25 to 100 individuals (Pyper et al. 2004).

In Kootenay Lake, burbot were historically concentrated in the Balfour area of the West Arm. The burbot fishery in Kootenay Lake occurred primarily during late spring/early summer. In 1969, over 26,000 burbot were caught in the fishery and in 1971; approximately 20,000 were caught during 1971 (Martin 1976). Harvest declined substantially over subsequent years. A production and harvest study was conducted during the mid 1970s. Optimum sustainable yield was calculated at 11,680 fish and the optimal fishing effort was estimated at 14,560 rod hours (Martin 1976). Harvest of Kootenay Lake burbot continued to decline through the 1970s and 1980s; by 1987, no burbot have been recorded in the fishery at Balfour. Canadian researchers have conducted extensive sampling in Kootenay Lake since the 1990s (Table 1). Although sampling accounted for few burbot in the West Arm of Kootenay Lake, they have been captured in the North Arm (Table 1). There was evidence of adult burbot spawning in the North Arm during 1998-2000 based on the presence of ripe fish; however, no spawning activity was observed in this area during 2001 or 2002.

Elsewhere in the Kootenay Basin, burbot appear moderately abundant (Figure 3). As part of a comparison of burbot trap efficiencies, Spence (2000) captured 13 adult burbot in Duncan Reservoir (Figure 3) during February-March 1999. During a radio telemetry study of burbot in Duncan Reservoir, a total of 29 adult burbot were captured in cod traps between November 3 and December 8, 1999 (Spence and Neufeld 2002). Neufeld and Spence (2001) captured 26 burbot in Duncan Reservoir from October-November 2001 during an investigation of decompression procedures. During a 1995 sturgeon set lining program in Trout Lake (Figure 3), adult and sub-adult burbot were captured, suggesting that the population was fairly abundant (R.L. & L. 1996). During a rainbow trout electrofishing study on the Lardeau River in 2000, several young of the year burbot were captured close to the outlet of Trout Lake (Redfish Consulting 2000). The MWLAP conducted a baseline trapping and radio telemetry study in Trout Lake during the winter 2001-2002; a total of 44 burbot were captured, 43 in cod traps and one on a baited setline (Baxter et al. 2002b). Twenty Kootenai River burbot were captured in the Libby Dam tailrace, and an additional 34 in Lake Koocanusa (Snelson et al. 2000, Dunnigan et al. 2003). Burbot are believed to be relatively abundant in these areas of Montana. Bisset and Cope (2002) indicated that a viable burbot population exists in Moyie River/Lake based on creel survey data.

3.2 History

Although the abundance of the West Arm Kootenay Lake burbot population prior to 1967 was estimated at 200,000 (Ahrens and Korman 2002), historical abundance of Kootenai River and Kootenai Basin burbot populations remains largely unknown. Kootenai River burbot experienced habitat alteration and considerable harvest from private and commercial fishing after the 1920s Anecdotal evidence suggests that burbot fisheries in Idaho was socially very popular (Appendix 2). Most interviewed elderly anglers felt there was a decline in the fishing prior to the middle 1900s due to habitat alteration (drainage districts) and unregulated harvest (Appendix 2). Others interviewed in an independent survey indicated the fishing quality took the most serious turn for the worse after the regulated flow operations of Libby Dam began in the mid 70s (Paragamian 1995a).

Earliest agency records of burbot sampling in Kootenai River, Idaho, by IDFG were dated from the winter of 1957-1958. A winter sample produced 199 burbot with a resulting length frequency that demonstrated presence of young and older fish (Paragamian et al. 2000). In an interview with the late Paul Jeppson, retired from IDFG, indicated that burbot were very abundant in the river in the late 50s and into the 60s (V.L. Paragamian, IDFG, personal communication). Burbot creel limits were set in Kootenay Lake at 15 fish/day into the mid-1960s, 12 fish/day in 1967, 10 fish/day in 1975, and 5 fish/day in 1976. No burbot were recorded in the fishery at Balfour since 1987 and Kootenay Lake was officially closed to burbot fishing in 1997 (Paragamian et al. 2000).

More recent reports, since the 1990s, suggest that burbot fisheries in the Kootenai River and in Kootenay Lake collapsed during the early 1970s (Paragamian 1995a). Burbot harvest was banned in Idaho in 1992 (Paragamian et al. 2000). Burbot were non-existent in Kootenai River creel survey from 1993-1994 (Paragamian 1993, 1994). No larval burbot and one young of the year burbot captured in extensive sampling in Kootenay Lake and Kootenai River in 1995 (Fredericks and Fleck 1995). Cooperative sampling by US and Canada in Kootenai River in BC and Idaho from 1994-1996 indicated burbot density diminished rapidly upstream of Goat River, BC. During the winter of 1994-95, 2 fish were caught upstream of Goat River and 31 were caught in Goat River and downstream (Paragamian et al. 2000).

3.3 Current Stock Status

Demographic analysis of Lower Kootenai River burbot indicated that approximately 50 fish currently remain in this population; the 95% confidence interval on this estimate ranged from 25-100 fish (Pyper et al. 2004). A total of 300 burbot were caught 403 times from 1993 through 2004. Although some small fish were represented in the catch throughout this time period, analysis revealed an aging population that is recruitment limited, increasing numbers of recaptures, increasing annual mean fish lengths, decreasing catch rates, and population abundance estimates (Figures 8 through 11). Without immediate, substantive management actions, native Lower Kootenai River burbot are expected to disappear completely.

Elsewhere in the Kootenai/y Basin, the West Arm Kootenay Lake burbot stock has been extirpated (Ahrens and Korman 2002). Little is known about the distribution of burbot in Lake Koocanusa and the upper Kootenai River upstream from Lake Koocanusa. Recent extensive sampling captured very few adult burbot in Kootenay Lake and Kootenai River, and juvenile burbot were scarce (Figures 12 and 13) (Redfish Consulting 1997, Spence 1999, Paragamian et al. 2001, Baxter et al. 2002a, 2002b).

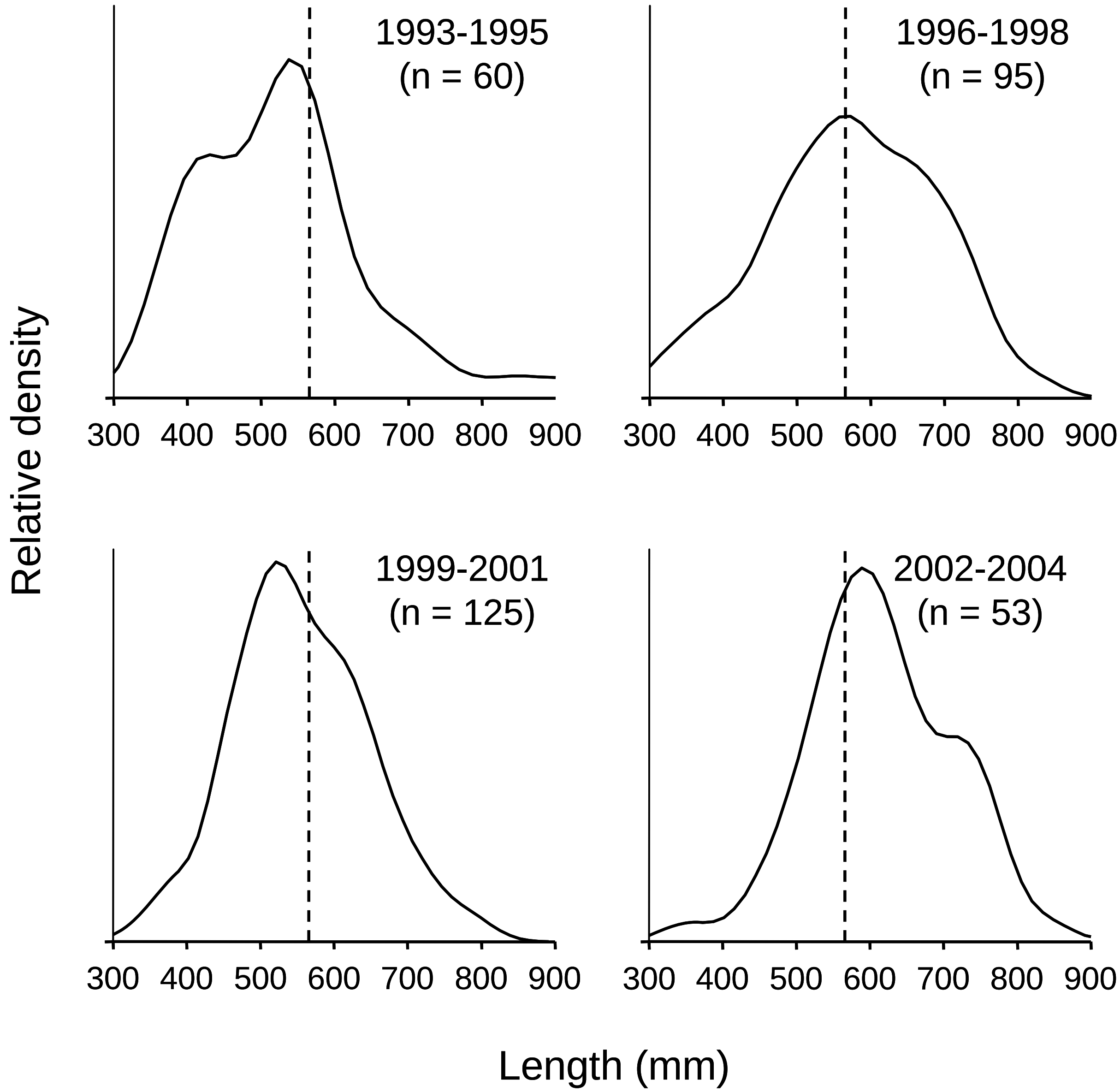

Figure 8. **Length distributions by period for burbot captured in strata 2-5 (dashed line is the grand mean) (Figure 14 from Pyper et al. 2004).**

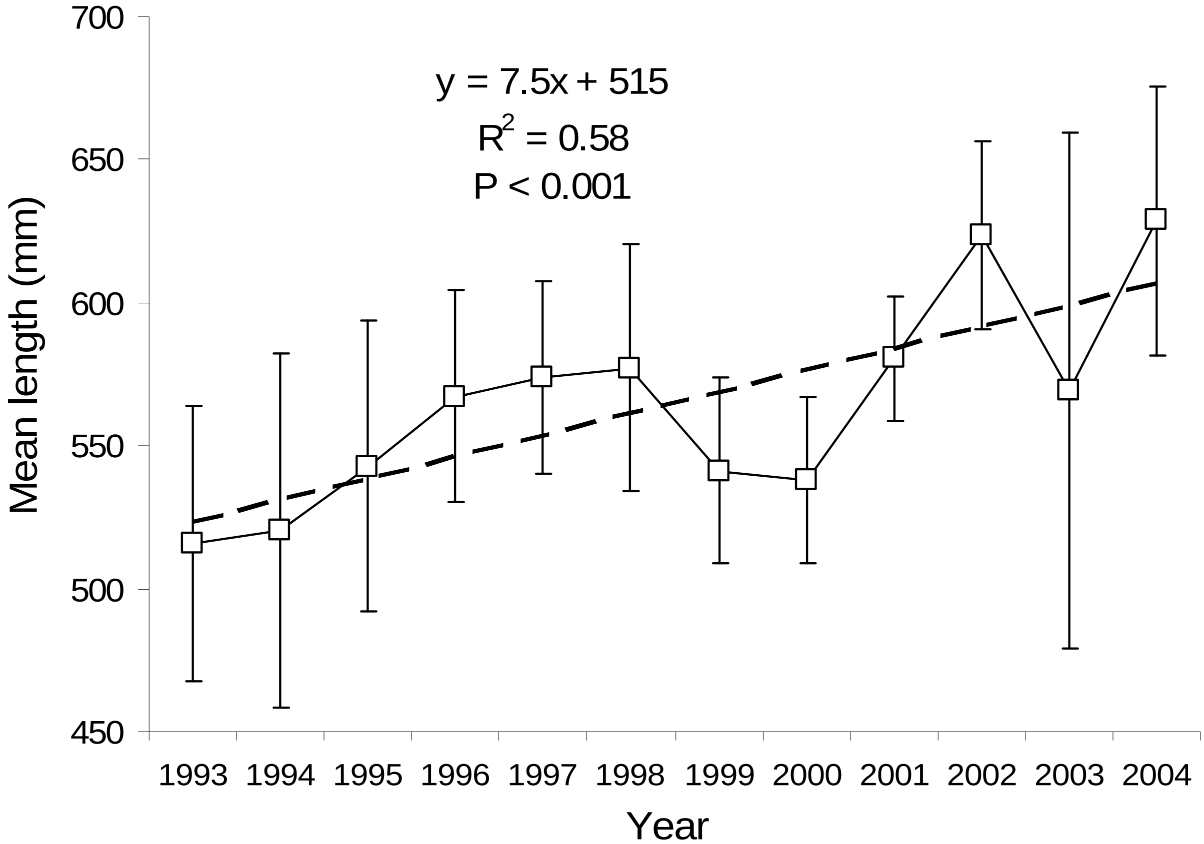

Figure 9. **Annual mean lengths and regression against year for burbot captured in strata 2-5 (Figure 12 from Pyper et al. 2004).**

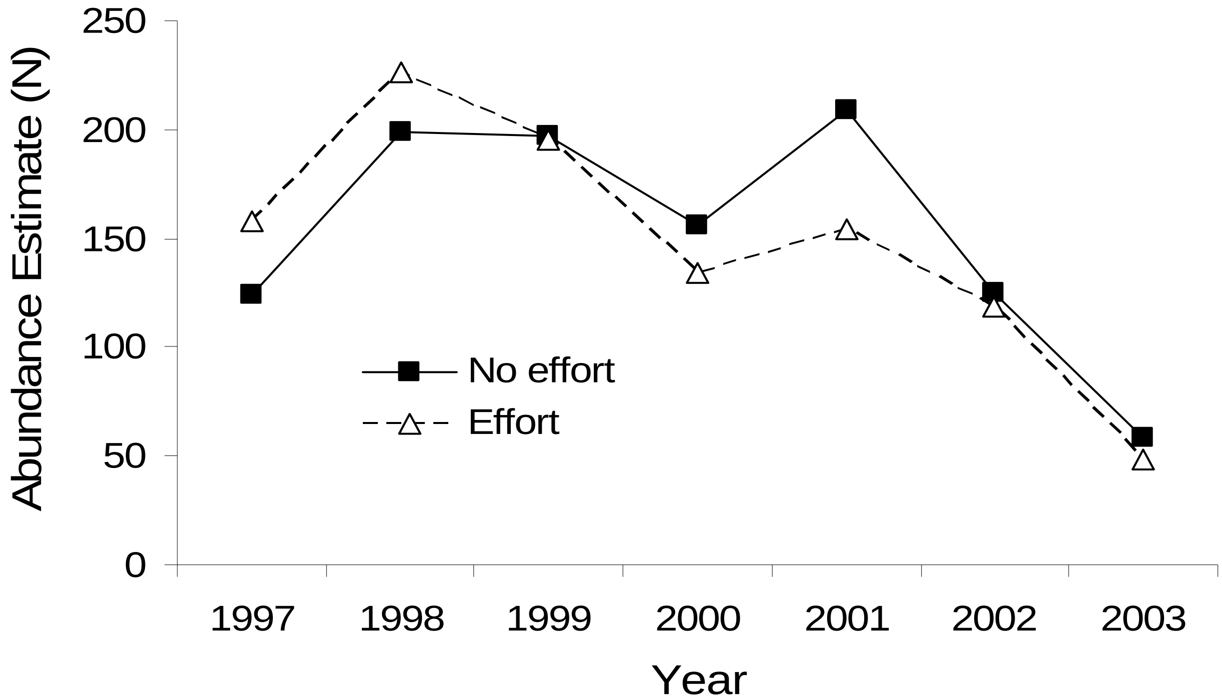

Figure 10. Estimates of Kootenai burbot abundance (N_t) for capture-recapture models (strata 2-5) (Figure 17 from Pyper et al. 2004).

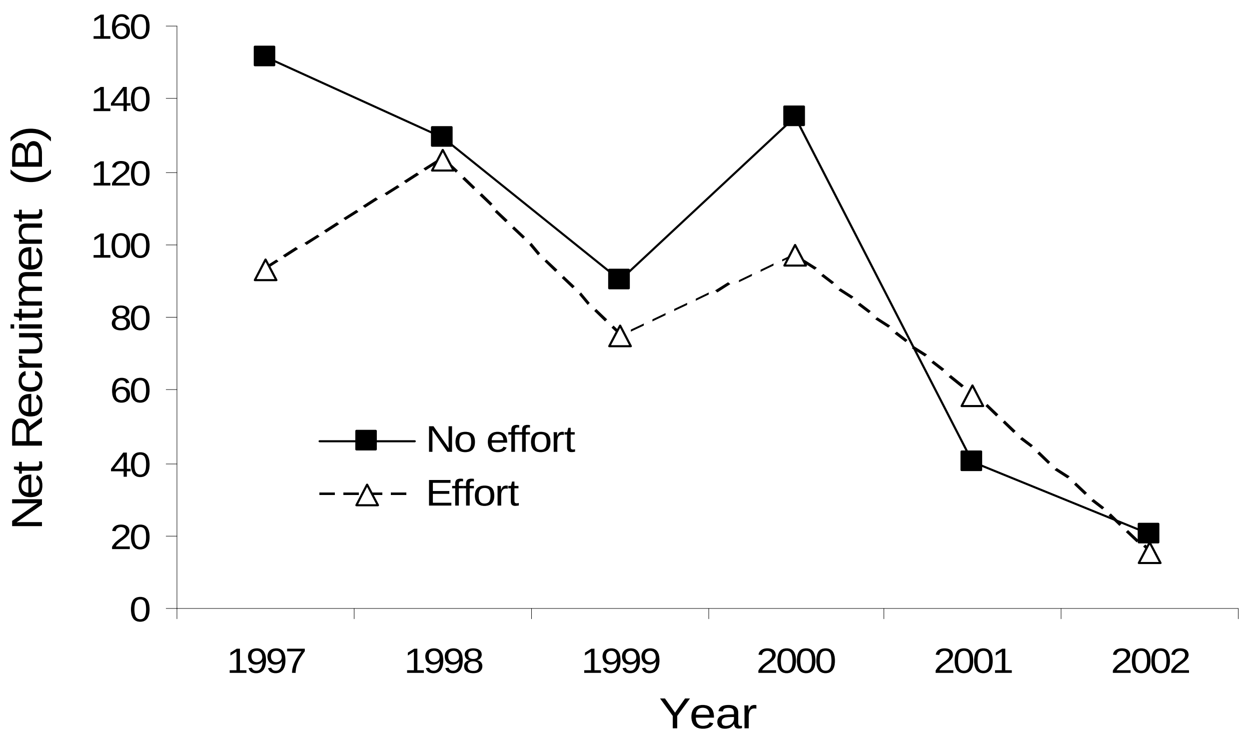

Figure 11. Estimates of Kootenai burbot recruitment (B_t) for capture-recapture models (strata 2-5). Year refers to year of recruitment to adult population – not year of spawning Figure 18 from Pyper et al. 2004).

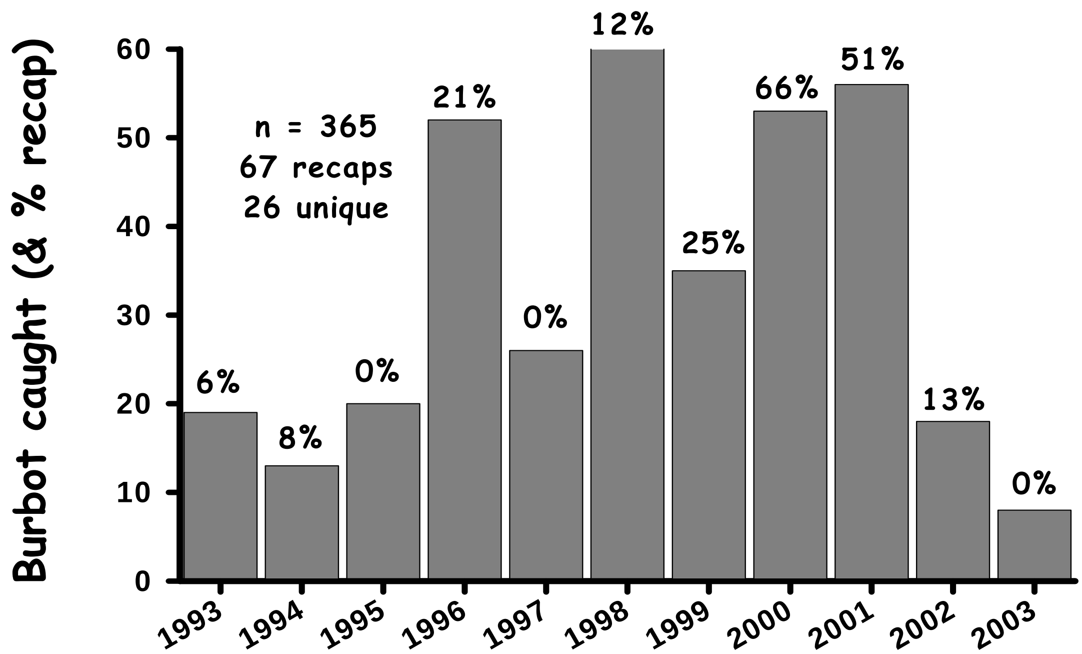

Figure 12. Catch and recapture sample sizes for Kootenai River burbot in IDFG sampling, 1993-2004.

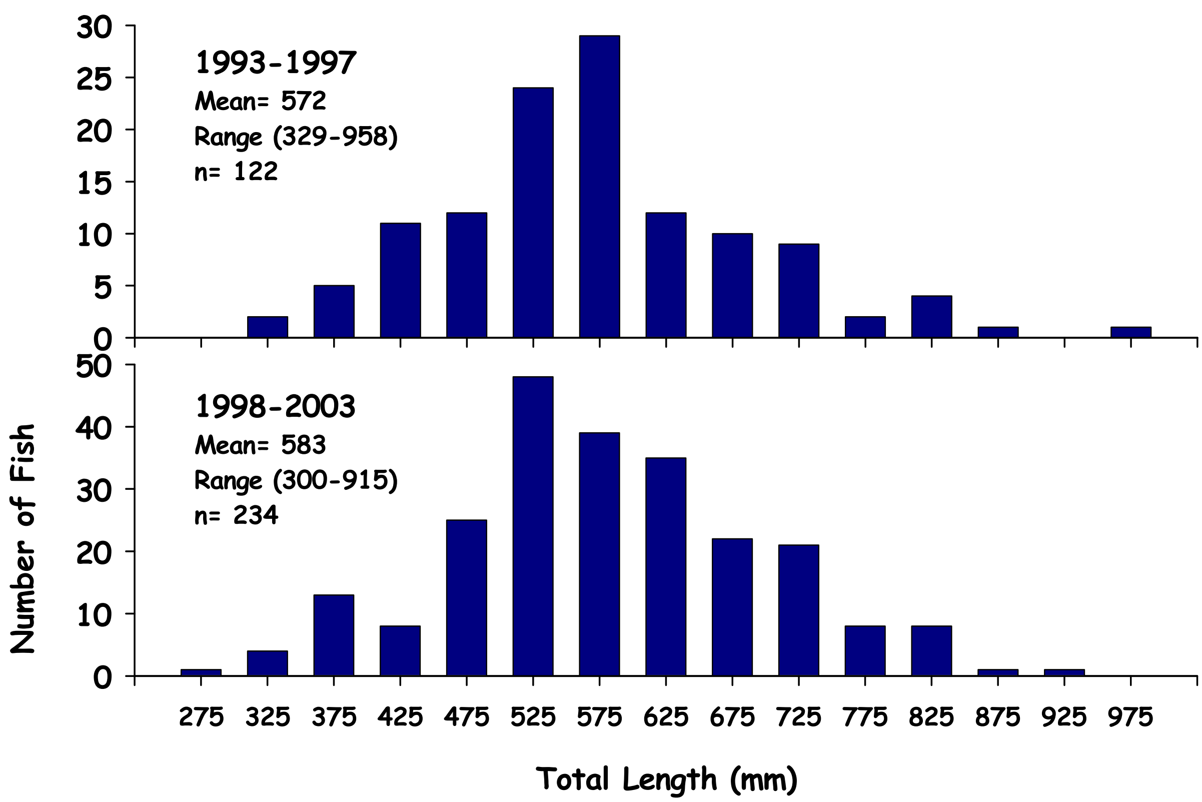

Figure 13. Length frequency distribution of Kootenai River burbot sampled by IDFG, 1993-2003.

4.0 NATURE AND EXTENT OF THREATS

No single factor appears solely responsible for the collapse of burbot populations in the Kootenai/y Basin (Paragamian 2000, Ahrens and Korman 2002, Hammond and Anders 2003). A long term assessment of burbot in the Kootenai River indicated that regulation of winter flows during spawning migration and spawning periods played an important role in the decline (Paragamian 2000, Paragamian et al., in press). However, similar to the Kootenai River white sturgeon population (Anders et al. 2002), collapse of Kootenai River burbot likely resulted from a combination of large and small-scale habitat and system changes, and from subsequent trophic cascading interactions resulting from these changes. Harvest also may have had negative effects on burbot by accelerating their decline, especially in the West Arm Kootenay Lake fishery at Balfour BC (Figure 3 and Figure 15), where annual harvest rates more than doubled stock-specific optimal yield estimates (Martin 1976, Ahrens and Korman 2002), and in Lower Kootenai River tributaries in Idaho from the early to mid-1900s (Appendix 2). Linkages among many of the following hypotheses are also expected regarding the timeline of potential impacts to the Kootenai River/Kootenay Lake burbot population(s).

4.1 Timeline of Potential Impacts

- Logging and mining operations beginning in 1880s
- Attempts to dike lower river to claim land for agricultural use in 1892
- Completion of Cora Linn Dam (former natural Bonnington Falls) in 1930
- Harvest following dust bowl immigrants 1930's-1950s (Appendix 2)
- Fertilizer plant operation (nutrient loading) on St. Mary's river from 1953-1970
- Substantial sport and commercial fishery harvest from 1950s to 1970s
- Completion of Duncan Dam in 1967
- Completion of Libby Dam in 1972
- Pollution abatement activities throughout watershed
- Regulated river, altered hydrograph and thermograph conditions
- Ultraoligotrophication of system due to dams and dikes.

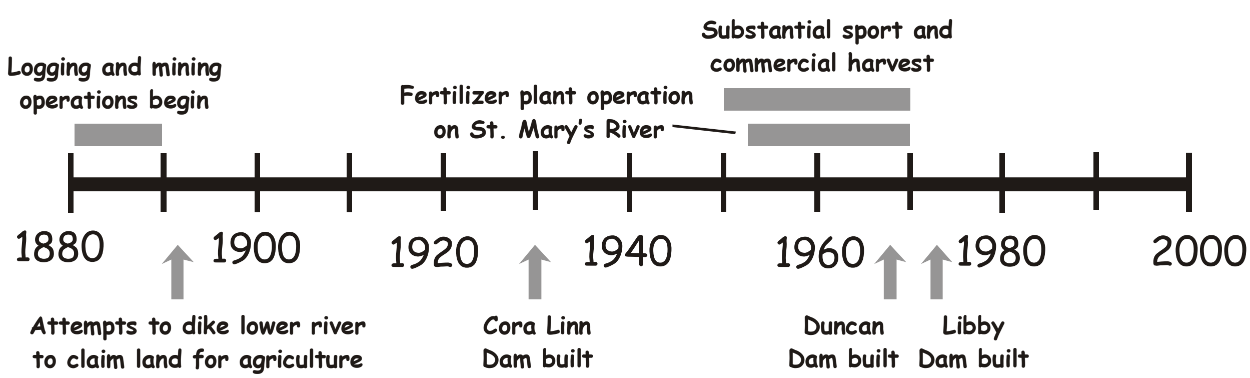

Figure 14. Timeline of potential impacts to Kootenai River burbot and their habitat.

4.2 Fishery Harvest

Lower Kootenai River burbot experienced harvests from private and commercial fishing after the 1920s through the early 70s (Appendix 2, Martin 1976, Paragamian 1995a). By some accounts, burbot fisheries in Idaho collapsed by the 1950s, following several decades of unregulated but substantial harvest, and the degradation and loss of spawning and rearing habitat. Kootenai River burbot experienced harvest from private and commercial fishing after the 1920s (Appendix 2). The Balfour burbot fishery in Kootenay Lake (Figure 17) collapsed during the early 1970s. Likely simultaneous reductions in productivity and food availability and possible unsustainable harvest rates were reported as causal factors in the decline of this burbot stock (Aherns and Korman 2002). Martin (1976) estimated the annual allowable harvest for the Kootenay Lake fishery at 12,000 fish. However, annual burbot harvest estimates at Balfour reached 20,000 to 26,000 fish during the late 1960s and early 1970s (Table 3), nearly double the annual harvest rates recommended for population persistence.

Exploitation (harvest) is an important consideration as burbot stocks in Alaska have been shown to be vulnerable to exploitation (Vincent-Lang 1993, Mills 1994). However, restrictive angling regulations and fishery closures applied to the Alaskan burbot stocks with suitable habitat and recruitment resulted in improved age structures and densities in some lakes (Taube and Bernard 1995). Reduced creel limits in Kootenai/y Basin burbot sport fisheries and the closure of the commercial fisheries failed to restore the burbot fisheries and their supporting stocks. Ahrens and Korman (2002) suggested that these management actions were too little too late, given the timing and magnitude of previous harvest, system alteration, and possible overestimation of burbot population abundance and persistence.

Figure 15. Historical West Arm Kootenay Lake burbot fishery in the Balfour area during the 1960s. During some years anglers harvested burbot at more than double the recommended annually sustainable rate (Photo courtesy of Colin Spence, BC Ministry of Water, Land and Air Protection, Nelson).

Table 3. Balfour burbot fishery statistics 1967-1986. Data from Martin (1976) and Redfish Consulting Ltd. (1998).

Year	Harvest	Effort (hours)	CPUE (fish/hr)
1967	7,567	7,500	1.0
1968	12,690	15,240	0.83
1969	25,920	17,460	1.48
1970	8,880	15,840	0.56
1971	20,647	21,565	0.96
1972	18,930	31,680	0.60
1973	2,305	8,280	0.28
1974	11,012	10,920	1.01
1975	6,802	7,258	0.94
1976	4,139	6,330	0.65
1977	1,820	3,567	0.51
1978	3,227	4,864	0.66
1979	852	1,259	0.68
1980	1,378	1,874	0.74
1981	443	890	0.50
1982	993	1,213	0.82
1983	689	1,238	0.56
1984	223	359	0.62
1985	296	469	0.63
1986	20	295	0.06

4.3 Increased Winter Water Flow

Winter water flow in the Kootenai River is typically 3 to 4 times higher since completion and operation of Libby Dam (Paragamian 2000) due to water releases for power production and flood control requirements. Based on empirical burbot swimming performance test data (Jones et al. 1974), Paragamian (2000) reported that water column velocities associated with post-dam winter flows inhibited or precluded burbot spawning migrations in the Kootenai River.

Burbot are known to move extensive distances to spawn (Robins and Deubler 1955, McCrimmon 1959, Percy 1975, Morrow 1980, Johnson 1981, Breeser et al. 1988, Evenson 2000, Paragamian 2000, Schram 2000). Tagging and telemetry studies indicate that some burbot freely move between Kootenay Lake and Kootenai River during low discharge periods. Paragamian (2000) reported that burbot moved downstream during artificially higher flows during winter**.** Paragamian (2000) speculated that increased post-dam discharges during late fall and winter resulted in increased water column velocities that negatively affected burbot migration and spawning in the Lower Kootenai River. Analysis of burbot telemetry data indicated movements of 5 km or more in 10 days or less, which suggests optimum flows for burbot of about 176 m^3/s but less than 300 m^3/s (Paragamian et al., in press).

4.4 Increased Winter Water Temperature

The Kootenai River has been ice-free every winter since the beginning of Libby Dam operation (1974); the river commonly froze during the winter prior to dam operation. Since 1974, winter water temperatures in the Kootenai River have averaged 3 to 4°C compared to pre-dam river temperatures of 1°C or less (Partridge 1983). Burbot spawn in water temperatures between 1 and 4°C (Morrow 1980, McPhail and Paragamian 2000). Burbot survival from fertilization to hatching was highest at 3°C and all embryos died at water temperature above 6°C Taylor and

McPhail (2000). Thus, it has been suggested that warmer post-dam water temperatures may have negatively affected spawning success of Lower Kootenai River burbot.

4.5 Environmental Degradation

Logging and mining operations were documented in the drainage as early as the 1880s, with effects of these operations on habitat in the Kootenai River well documented (Northcote 1973, Cloern 1976, Daley et al. 1981, Partridge 1983, Anders et al. 2002, 2003, Kootenai River Subbasin Plan 2004). These operations resulted in unnatural, flashy tributary discharge regimes that physically alter streams and increase siltation and sediment transport (Northcote 1973). Partridge (1983) raised concerns about water toxicity from potential releases of heavy metals from flashy discharge regimes.

Attempts to dike the lower river to claim land for agricultural use began as early as the late 1800s (Northcote 1973, Kootenai River Subbasin Plan 2004, Tetra Tech 2004). By 1931 nine drainage/diking districts had already constructed levees, drainage ditches, and pumping stations "for the reclamation and protection of 22,000 acres of land" in the Kootenai Flats area in Idaho (House Document No 157, 1931; cited in Pick 1991). Approximately 94% of historic floodplain habitat was lost during the 1900's (Pick 1991). Thus, Lower Kootenai River levy construction represents substantial alteration, resulting in the loss of functional large river floodplain habitat, habitat complexity, biological interactions and biological productivity.

4.6 Changes in Primary and Secondary Productivity

Nutrient loading was greatly increased due to a fertilizer plant operated on the St. Mary River, an Upper Kootenay River tributary in BC, and pulp mill and municipal effluent from the early 1950s to 1970 (Northcote 1973). When operations ceased at the plant, total phosphorus loading to Kootenay Lake was reduced by one to two orders of magnitude (Figure 16)(Ashley and Thompson 1993, Ashley et al. 1994, 1997, Ahrens and Korman 2002). Subsequent pollution abatement activities in the watershed have also reduced nutrient loading to the river and decreased productivity in Kootenay Lake (Daley et al. 1981, Ashley and Thompson 1993, Ashley et al. 1994, 1997, Ahrens and Korman 2002) (Figure 16). Duncan Dam had the same effect of severely reducing nutrient input to Kootenay Lake (Figure 17).

Lake Koocanusa, the impoundment created by Libby Dam, acts as a nutrient sink, retaining 40-65% of N and P, with 95% sediment trapping efficiency, denitrifying the river downstream (Daley et al. 1981, Woods 1982, Snyder and Minshall 1996). Libby and Duncan dams reduced productivity in Kootenay Lake, which reduced food available to juvenile burbot, reducing their growth and survival rates (Ahrens and Korman 2002).

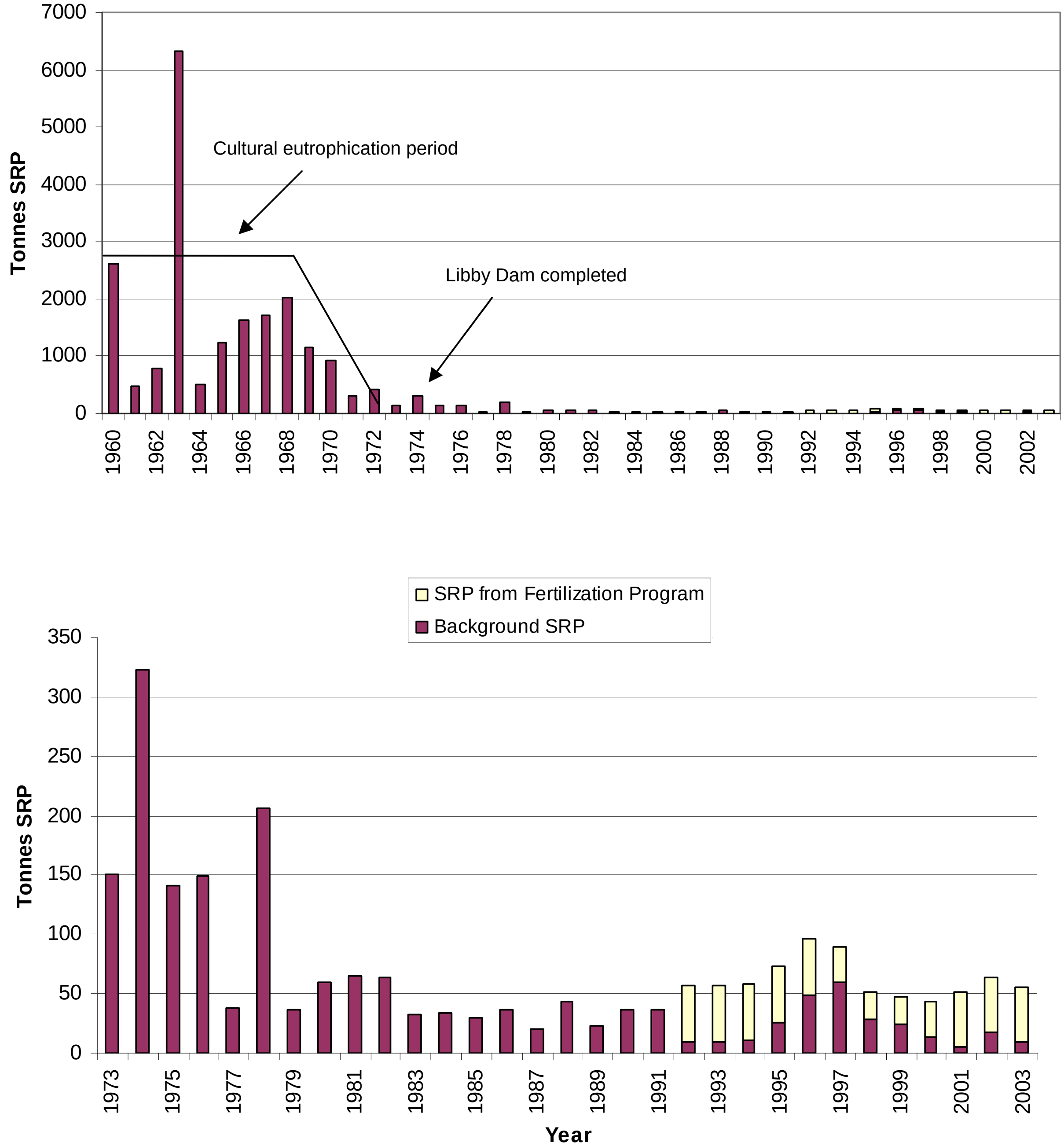

Figure 16. Estimated soluble reactive phosphorous (SRP) loading to Kootenay Lake from the Kootenay River, 1960-2003 (Data from Ken Ashley, BC WLAP).

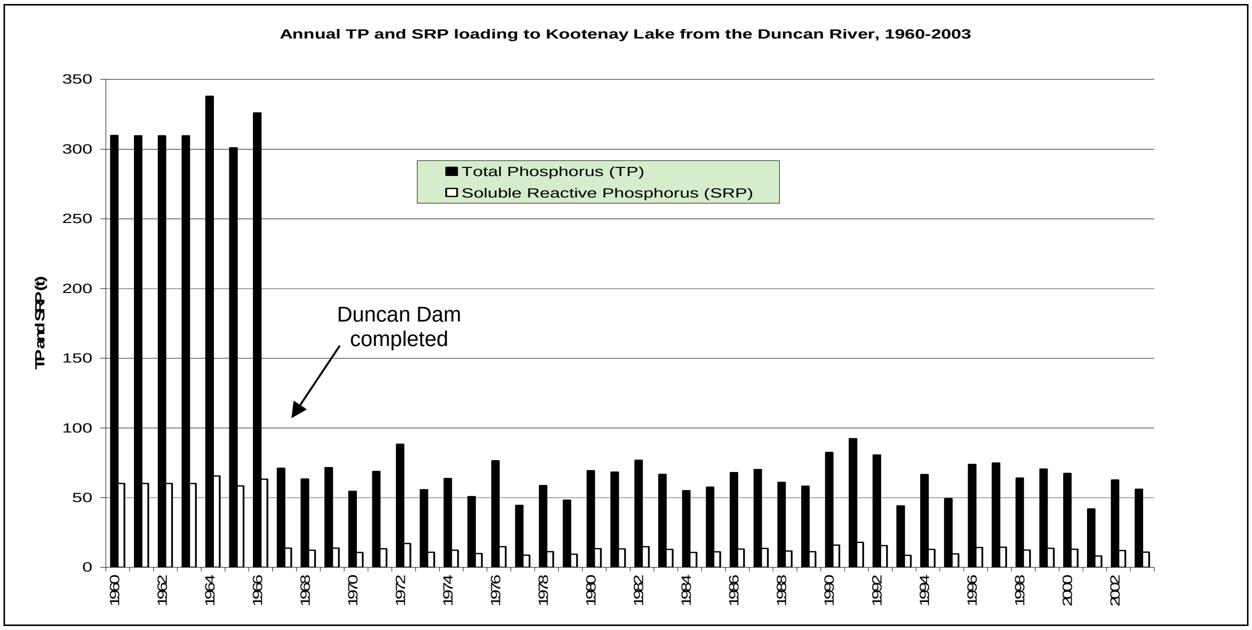

Figure 17. **Estimated total phosphorous (TP) and soluble reactive phosphorous (SRP) loading to Kootenay Lake from the Duncan River, 1960-2003 (Data from Ken Ashley, BC WLAP).**

4.7 Kootenay Lake Flood Control

During spring, generally in March, Kootenay Lake is lowered approximately 2m to dewater adjacent agricultural fields, while providing flood control storage space. Lowering Kootenay Lake lowers upstream portions of the Kootenai River, could increase velocity in lower reaches of upstream tributaries that could wash out rearing larval burbot. However, no appropriate empirical analyses have been performed to support whether biologically meaningful velocity increases from such drafting actually occur, and the naturally low gradient of the entire Kootenai/y River floodplain would suggest this is not an issue of biological concern.

Prior to the construction of the Cora Linn Dam in the 1930s at the outlet of Kootenay Lake, the lake would rise approximately 3m each spring as a result of runoff from snowmelt. Since construction of Cora Linn Dam, the lake continues to rise approximately 3m each spring; however the rise starts from a lower elevation. Raising the lake level would theoretically decrease the velocity in the Kootenai River and tributaries. Again, it is not known whether this has any positive or negative biological effects of aquatic taxa or physical habitat conditions. However, the naturally low gradient of the entire Kootenai/y River floodplain would suggest this is not an issue of biological concern.

4.8 Mysid Transport

Impoundment of the Duncan and Kootenai rivers increased water clarity in Kootenay Lake. Ahrens and Korman (2002) hypothesized that deeper mysid distribution in response to increased water clarity resulted in reduced transport of mysids over the West Arm sill at Balfour. This, they speculated, led to reduced growth and survival rates of juvenile West Arm burbot. These changes, together with harvest, contributed to extinction of the Balfour burbot stock (Ahrens and Korman 2002).

4.9 Fish Community Composition Shift

Burbot were assumed to dominate the demersal fish community in West Arm of Kootenay Lake during the 1960s and 1970s. However, recent reductions in burbot population abundance/density presumably allowed the increase of other fish populations, such as northern pikeminnow, and largescale sucker (Figure 18). These changes may have also contributed to increased predation on and competition with YOY and juvenile burbot, if any burbot remained (Ahrens and Korman 2002).

Upstream in the Kootenai River in Idaho, relative abundance among fish species also changed during the decades following completion and operation of Libby Dam (Paragamian 1994, 2002, Anders et al. 2002). Relative to pre-impoundment values, an 83% reduction in the density of insectivorous fish (from 70 to 12 kg/ha), a reduction in growth rates and a 76% reduction in biomass of mountain whitefish (*Prosopium williamsoni*, from 480 to 117 kg/ha) were reported following impoundment (Paragamian 1994). Catch rates and abundance estimates of rainbow trout (*Oncorhynchus mykiss*) in the Kootenai River were also reported to have declined since the early 1980s (Paragamian 1994). The Lower Kootenai River burbot population has also declined during recent decades, as indicated by low catch rates (Paragamian 1994) low abundance, and lack of recruitment (Pyper et al. 2004).

Figure 18. **Underwater film footage of high density of largescale suckers (*Catostomus macrocheilus*) on the substrate at the historical "ling beds" near the mouth of Kootenay Lake's West Arm. (Photo courtesy of Colin Spence, BC Ministry of Water, Land, and Air Protection, Nelson).**

5.0 EXISTING CONSERVATION MEASURES

5.1 The Kootenai Valley Resource Initiative (KVRI) and the KVRI Burbot Committee

The Kootenai Valley Resource Initiative (KVRI) was formed under a Joint Powers Agreement (JPA) between the Kootenai Tribe of Idaho (KTOI), the City of Bonners Ferry, and Boundary County, dated October 2001. Under the JPA, the KVRI is empowered to restore and enhance the resources of the Kootenai Valley and foster community involvement and development. The mission of KVRI is to act as a locally based effort to improve coordination, integration, and implementation of existing local, state, and federal programs that can effectively maintain, enhance, and restore the social, cultural, and natural resource bases in the community. The KVRI membership and its partners include the KTOI, who initiated the initiative, federal, state, and provincial fisheries and water regulatory agencies, regional city and county governments, private citizens, landowners, environmental advocacy groups, and regional representatives of business and industry. The KVRI Burbot Committee was later formed as a subset of the KVRI to pursue coordinated burbot conservation and management.

Rather than listing burbot as threatened or endangered under the Endangered Species Act (ESA), the KVRI Burbot Committee, along with the US Fish and Wildlife Service and additional committed stakeholders, contributed to this Conservation Strategy. The Committee proposed the Kootenai River drainage as a "pilot project" to develop, implement, and evaluate this Conservation Strategy for Lower Kootenai River Burbot, in lieu of formal ESA listing. It is this multi-faceted international focus and commitment, and consistency with the proposed federal "Policy for Evaluating Conservation Efforts" (PECE Policy; U.S. Vol. 65 No. 114, June 13, 2000) that empowers this Conservation Strategy

5.2 Endangered Species Act

Due to low population abundance and failing natural recruitment, Kootenai River burbot in the Idaho portion of the Kootenai Subbasin were petitioned as threatened under the U.S. Endangered Species Act (http://www.wildlands.org/w_burbot_pet.html). However, the USFWS 12-month finding for the petition reported that: "After reviewing the best available scientific and commercial information, we find that the petitioned action [listing] is not warranted, because the petitioned entity is not a distinct population segment (DPS) and, therefore, is not a listable entity"

> (http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/2003/pdf/03-5737.pdf).

5.3 Kootenai River Burbot Status Determination

The IDFG is conducting ongoing research on Kootenai River burbot (Paragamian et al. 2001). Current project components include: trapping and tagging of adult burbot in Kootenai River, Idaho, tracking of burbot movement throughout the winter, comparison of burbot movements during different flow regimes regulated by discharge from Libby Dam, genetic sample collection from other Kootenai Basin stocks and larval sampling.

5.4 Burbot Status Determination and Inventory in British Columbia

The BCMWLAP is conducting research on burbot in Kootenay Lake and elsewhere in the Kootenay Basin (Baxter et al. 2002b). Current components of the project include: trapping and tagging of adult burbot in Kootenay Lake, investigation of decompression procedures to reduce gas bubble trauma in burbot caught at depths, TOV assessment of habitat and burbot in Kootenay Lake, night surveys for juvenile, adult, and spawning burbot in Kootenay Lake, Kootenay Lake Recovery Planning, inventory of burbot in Duncan Reservoir and Trout Lake, and investigation of possible donor stocks for Kootenay Lake/Kootenai River recovery.

5.5 Experimental Aquaculture

The Kootenai Tribe of Idaho and the University of Idaho are developing burbot aquaculture techniques to provide fish for a conservation stocking program. Brood stock for the development of burbot aquaculture techniques were provided by the BC MWLAP from Duncan Lake Reservoir and the Arrow Lakes Reservoir. Aquaculture development experiments successfully spawned 20 burbot (13F, 7M) using several different spawning treatments, and provided hatch, and larval and juvenile fish from egg groups. This research is ongoing at the Kootenai Hatchery and at the University of Idaho's Aquaculture Research Institute (Cain and Jensen 2004). Thirty-two burbot from the Arrow Lakes Reservoir were captured during November 2004 to facilitate additional burbot aquaculture research and development. These fish were moved to the UI facility on January 4, 2005.

5.6 Libby Dam Operations and Water Management

Requests for Libby Dam operation modifications during winter have occurred since 1997 in an attempt to provide suitable migration and spawning conditions for burbot in the Kootenai River. Currently, requests (System Operational Requests or SORs) are made via the Technical Management Team (TMT) of the National Oceanic and Atmospheric Administration (NOAA) (formerly National Marine Fisheries Service, NMFS) Regional Forum. Invited participants to this forum are state and tribal fish managers and representatives of other federal agencies. Within this forum, current water supply forecasts, biological data, and other information are considered in making recommendations on potential system operations. Various hydro operational changes have occurred during some of these years. However, little recent empirical evidence of successful burbot recruitment with or without modified dam operations is available from the Lower Kootenai River, despite intensive sampling over many years. These operational changes were reported to be inadequate to provide for a sustained migration corridor for burbot to lead to successful spawning and recruitment, with the exception of the drought winter of 2000-2001 when hospitable conditions resulted in documented evidence some burbot had spawned (Kozfkay and Paragamian 2002).

5.7 Adaptive Management

Current and future fish and wildlife projects on the Kootenai River are being coordinated and incorporated into a 15-year Adaptive Management Plan advanced by the International Kootenai Ecosystem Restoration Team (IKERT; Anders et al. 2004). As part of this multi-agency Plan, the IKERT will be developing a year-round ecologically based alternative hydrograph for the Kootenai River, designed not only to improve natural population functions of burbot, but to re-establish more natural ecological functions and their seasonal dynamics. The IKERT forum will incorporate recommendations from the Burbot Committee regarding desirable hydrograph characteristics for burbot, and will incorporate this Conservation Strategy into the Kootenai River Adaptive Management Plan.

5.8 Lake and River Fertilization

North Arm Kootenay Lake fertilization began in 1992 as a mitigation technique to restore the nutrient balance and assist in the recovery of salmonid populations, which had collapsed from a lack of forage. Competition with introduced mysids, and simultaneous ultraoligotrophication of Kootenay Lake caused the food shortage (Daley et al. 1981, Ashley and Thompson 1993, Ashley et al. 1994, 1997, Ahrens and Korman 2002). High fertilization loading occurred from 1992-1996); fertilizer loading was reduced from 1997-2000, and restored to original loading rates after 2000 (Figure 16). Kokanee have exhibited up to seven-fold population responses to North Arm fertilization.

Fertilization (N only) of the South Arm of Kootenay Lake began during the summer of 2004 in accordance with an international rehabilitation plan with US (BPA) support for South Arm Kootenay Lake and the Arrow Lakes Reservoir (Anders et al. 2003). Experimental fertilization of the Kootenai River in Idaho, as part of a river-scale adaptive management experiment, was evaluated and is scheduled to begin during the summer of 2005 (Anders et al. 2004).

5.9 Burbot genetic analysis

Genetic analysis of burbot is ongoing to further refine and delineate burbot population structure in the Kootenai/y Basin. Resulting information will be used to guide brood stock selection choices for conservation aquaculture.

6.0 CONSERVATION GOAL

The goal of this Conservation Strategy is to restore and maintain a viable and harvestable burbot population in the Kootenai River and South Arm of Kootenay Lake. A viable population is one that can be expected to sustain itself over the long term. A harvestable population is one that is sufficiently productive to provide a harvestable surplus while remaining well above minimum viability levels.

7.0 PERFORMANCE OBJECTIVES

Performance measures are benchmarks by which progress toward recovery will be measured. Benchmarks identified are based on population viability guidelines identified in the scientific literature and are similar to those adopted in other recovery plans and conservation strategies.

1. **Minimum adult number of 2,500 adults in the burbot population of the Kootenai River and South Arm of Kootenay Lake.**

   The desired adult population size of 2,500 is based on population viability guidelines applied in U.S. Endangered Species Act assessments, population viability literature, and criteria developed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2001). Population conservation and recovery guidelines generally suggest a minimum effective population size of at least 500 adults and a census population of several times the effective population size to allow for multiple life history strategies, and to maintain genetic diversity believed to be necessary for long-term population viability in the face of future environmental stochasticity.

2. **Consistent natural recruitment in at least three different spawning areas with net recruitment and juvenile population size sufficient to support desired adult population size.**

   Effective conservation can only be achieved by restoration of natural population processes including recruitment of naturally spawned juveniles. Multiple spawning areas provide the spatial diversity necessary to protect the species from local impacts. For burbot, multiple spawning areas might include Kootenai River mainstem and at least two tributaries.

3. **Stable size and age distributions.**

   Stable size and age distributions are required for effective long-term population viability and persistence, and provide the population with demographic and genetic resilience needed to sustain these fish over the long term.

4. **Complete restoration will be achieved when monitoring and evaluation of activities recommended in this Conservation Strategy reveal a sufficient surplus of fish exists to provide a harvest of burbot.**

   Natural reproduction rates sufficient to provide harvest or withstand other fishery impacts recognize a desire to restore historic fishing opportunities that have been lost. Reproduction rates that provide a harvestable surplus also provide an additional safety factor from long-term risks to population (demographic and genetic) viability.

8.0 CONSERVATION & RESTORATION STRATEGIES

Conservation and Restoration Strategies frame the broad vision for burbot conservation and the central elements of this plan. Specific measures that address each of the following strategies are outlined in Section 9. The conservation goal will be addressed using a combination of the following five general strategies:

1. **Implement an aggressive adaptive program of experimental recovery measures.** The Lower Kootenai River burbot population is currently either functionally extinct or near functional extinction (Paragamian 2000, Hammond and Anders 2003, Pyper et al. 2004). Functional extinction occurs when populations are so small that they are unable to recover on their own, even if it suitable conditions exist or are restored. Without immediate and substantive actions, the native burbot population is likely to disappear completely. Even with immediate and substantive actions, it may already be too late and the Conservation Strategy may phase into a burbot reintroduction program. The acutely imperiled status of Lower Kootenai River burbot no longer affords the luxury of an incremental, linear research approach, in which measures are not implemented until after extensive research and evaluation. The risks of doing too little are substantially greater than the risks of trying and failing. In this case, the lack of Federal Endangered Species status for Kootenai River burbot may expedite population conservation and recovery by allowing greater flexibility and expediency in implementing measures of this Conservation Strategy.

2. **Develop a broad-based habitat restoration program to address altered ecosystem problems that have contributed to the burbot collapse.** Burbot declines are the result of an extended period of pervasive, large-scale changes in the Kootenai River and Kootenay Lake ecosystems. Declines, in some cases were exacerbated by past harvest (e.g. West Arm burbot fishery). The changes extend from physical habitat and ecological function loss to primary and secondary system productivity, nutrient availability, and possible contaminant dynamics. Some factors such as harvest, levee construction, and hydro development are obviously implicated; population collapse resulted from the combined impacts of these multiple factors, rather than from the isolated effect of any single factor. The complex interactions of changes and their relative impacts on burbot are difficult to partition. However, effective long-term persistence and viability of a sustainable, naturally producing burbot population depends on significant conservation and restoration across the current ecosystem.

   Measures narrowly focused on increasing numbers of one species are likely to fail if by concentrating on the symptom, they overlook the underlying causes. Ecosystem-based approaches are given wide lip service but rarely translated into specific, scale-appropriate activities. In this Conservation Strategy an ecosystem-based approach includes a combination of mainstem habitat protection, tributary and mainstem habitat restoration, fish population protection and recovery measures, conservation aquaculture, fish community and primary productivity improvements, and pollution control. This Conservation Strategy also exists as part of a larger context of the Kootenai River Adaptive Management Program currently being developed (Anders et al. 2004).

3. **<u>Employ conservation aquaculture methods as a key near-term component for burbot protection and restoration.</u>** Conservation aquaculture can be an effective means to protect remnant stocks, or contribute to reintroduction if the native population is extirpated (Anders 1988). Favorable survival rates of eggs and larvae in the hatchery can boost productivity of appropriate parents. Development and use of a brood stock suitability evaluation template is recommended. Such a template should include genetic/evolutionary, demographic, and geographic/environmental parameters of fish from donating and receiving waters. Implementation of hatchery measures has been hampered by the lack of effective burbot culture techniques. However, progress in successful spawning, incubating, hatching, and rearing have recently occurred at the UI-ARI during 2003 and 2004 (Cain and Jensen 2004). Refinement of effective hatchery methods is ongoing to evaluate use of this tool for burbot conservation or introduction. The critical status of burbot warrants actions with immediate benefits. Conservation aquaculture may provide the best short-term opportunity for boosting remnant burbot populations above critically low threshold numbers, from which they may not be able to recover even if favorable habitat conditions were immediately restored.

   Conservation aquaculture may be employed as a short term tool to achieve natural recruitment and production objectives described in this Conservation Strategy. When consistent natural recruitment on at least three different spawning areas is achieved, conservation aquaculture will no longer be needed or included in this Conservation Strategy.

4. **<u>Employ alternative hydro operations as a key component for burbot protection and restoration.</u>**

   Altered hydro system operations, especially at Libby Dam, provide the most direct opportunity for restoring hydraulic and thermal conditions suitable for burbot migration, spawning, and recruitment. Little is known about favorable hydraulic conditions for natural recruitment of burbot in the Kootenai River. However, providing a hydrograph during winter that more closely resembles pre-dam conditions is expected to be a positive operational change. Such operations may be able to provide immediate benefits to the last remaining burbot as well as long-term ecosystem benefits.

   Paragamian (2000) suggested that post-dam water column velocities in the Lower Kootenai River exceeded empirical burbot swimming performance (Jones et al. 1974), thus, possibly limiting or prohibiting upstream spawning migration of burbot in the Lower Kootenai River. However, burbot populations exist upstream from and adjacent to higher velocity areas in Montana and British Columbia, upstream and downstream from Libby Dam. Burbot may have exploited suitable low-velocity upstream migration paths of through this portion of the Kootenai/y Basin, even when it was unimpounded, when peak Kootenai River discharges historically exceeded 100 kcfs at Bonners Ferry. However, significant difference in haplotype frequencies in burbot upstream and downstream from Kootenai falls may in theory be explained by the high degree of similarity of those burbot above Kootenai Falls to burbot in the Missouri Basin in Montana and differences in post glacial invasions from different glacial refugia in the last 10,000 years (V. L. Paragamian of IDFG and M. Powell of U of Idaho, personal communication).

To gain valuable perspective on potential roles of hydro system alteration in burbot conservation, this Conservation Strategy provides: a) an account of historical conditions, b) desired (normative) conditions, and c) hydro operation schemes for Libby Dam designed to enhance natural burbot production. (e.g. 2003-2004 System Operation Request; See Appendix 1).

a. Historical conditions - Kootenai River hydrographs and thermographs during pre- and post-dam periods illustrate and quantify significant changes in the Kootenai River environment due to construction and operation of Libby Dam (Figures 19 and 20). Average annual Kootenai River water temperature prior to Libby Dam construction and operation were consistently cooler than analogous post-dam thermographs (Figure 19). The average annual post-dam hydrograph generally more than doubled pre-dam river discharge volumes from October through March (Figure 20). Currently, the Corps implemented VARQ (Variable Flow) flood control at Libby Dam on an interim basis. VARQ flood control is expected to reduce outflow from Libby Dam in the January through March period in near average water conditions. The Corps also is implementing a variable end of December flood control draft at Libby Dam. This operation will reduce the outflow from Libby Dam in December in below average water years. These operations may provide flow conditions for burbot in the January to March period to more closely resemble pre-dam conditions.

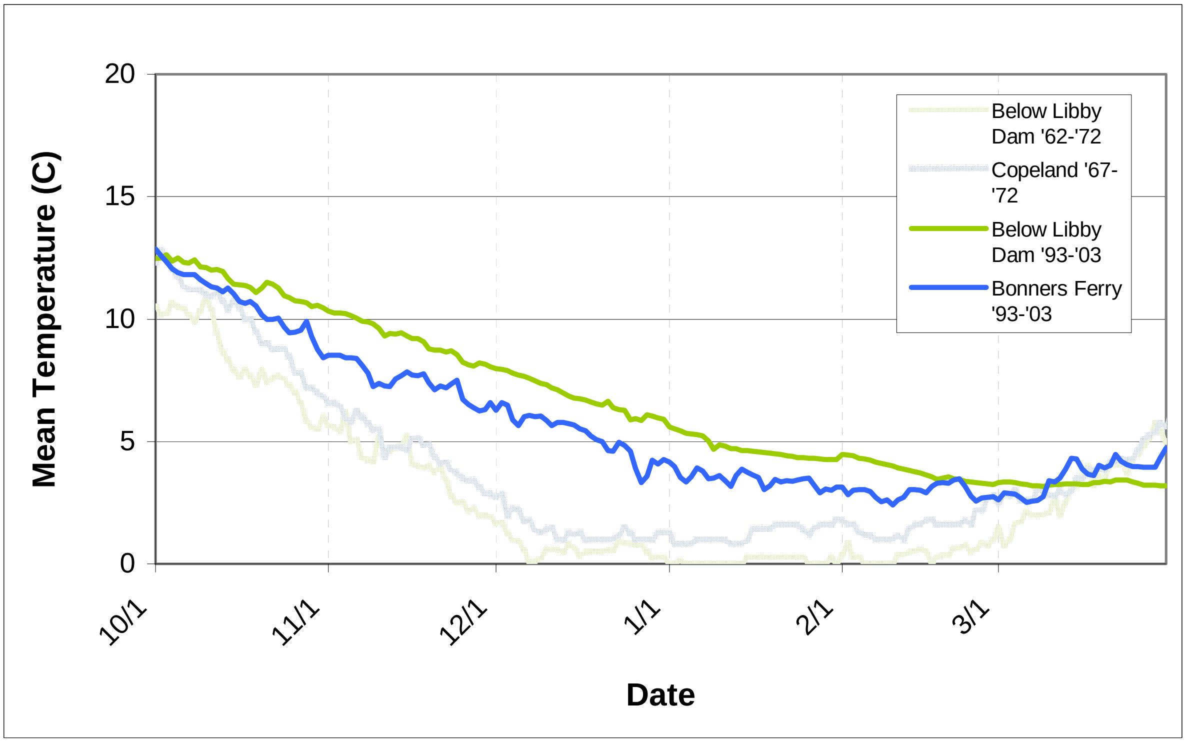

Figure 19. Pre- and post-Libby Dam Kootenai River thermograph. (Data courtesy of the US Army Corps of Engineers).

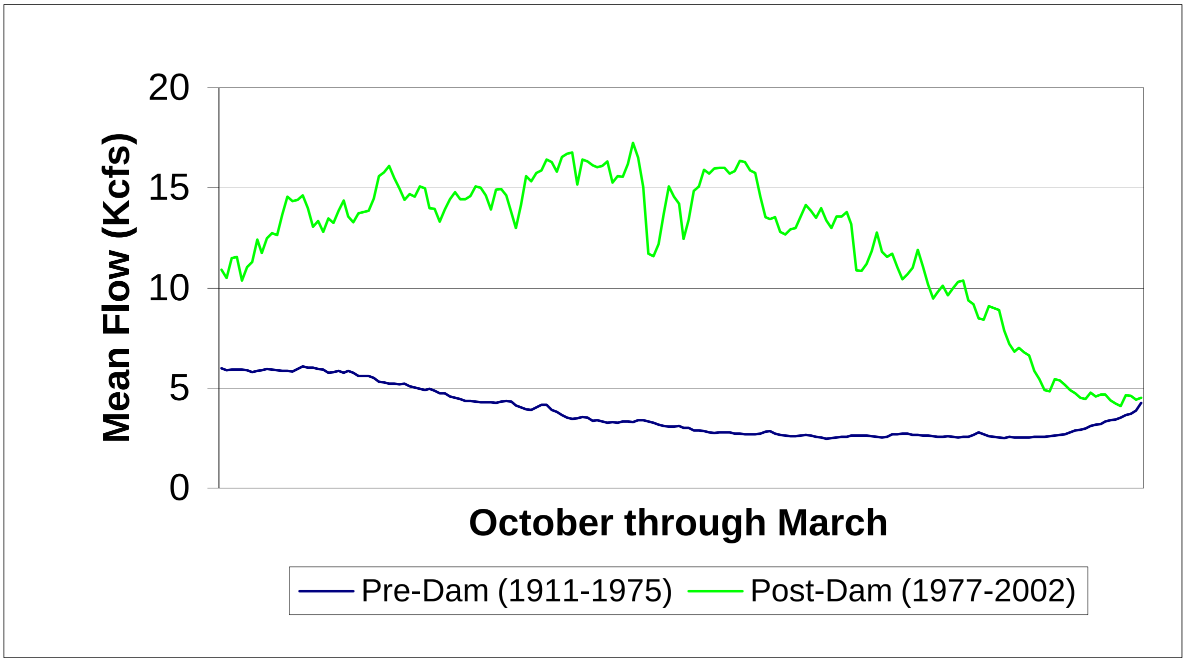

Figure 20. Pre- and Post-Libby Dam Kootenai River hydrograph downstream from Libby Dam (Data courtesy of the US Army Corps of Engineers).

b. Desired (normative) river conditions

Provision of desired future hydraulic conditions in the Kootenai River and appropriate hydro operations at Libby Dam to provide them have been recently discussed at KVRI Burbot Committee meetings. Requests for Libby Dam operation changes during winter have occurred since 1997 to provide what are perceived as suitable migration and spawning conditions for burbot in the Kootenai River. Various experimental hydro operational changes have occurred during some of these years. However, little recent empirical evidence of successful burbot recruitment with or without modified dam operations exists from the Lower Kootenai River (Figure 11), despite the past 10 years of sampling (Figure 6 and Figure 7).

Recent analysis of burbot movement in the Kootenai River and management as a regulated rivers demonstrates it is in need of significant discharge intervention to eliminate the hydro threats, conservation measures that include winter operating daily discharges that average 176 m^3/s and do not exceed 300 m^3/s for 90 d (November 15 – February 15) would be of significant benefit for burbot spawning migration (Paragamian et al., in press). These discharges are similar to pre-Libby Dam conditions during historic fall and winter discharge conditions.

Current and future fish and wildlife projects on the Kootenai River are currently being organized and incorporated into a 15-year Adaptive Management Plan by the International Kootenai Ecosystem Restoration Team (IKERT; Anders et al. 2004). Within this Plan, the IKERT will be developing a year-round ecologically based alternative hydrograph for the Kootenai River, designed not only to improve natural population functions of burbot, but to re-establish more natural ecological functions and their associated seasonal dynamics. The IKERT forum will incorporate recommendations from the KVRI Burbot Committee regarding desirable hydrograph characteristics for burbot, and will incorporate this Conservation Strategy into the 15 year Adaptive Management Plan (Anders et al. 2004).

c. 2003-2004 Libby Dam System Operation Request (SOR) for Kootenai River burbot

As an alternative to the Kootenai River historical and thermographs and hydrographs, the KVRI Burbot Committee recommended reductions in discharge during the winter to test their effects on burbot spawning and migration. These recommendations formed the 2003-2004 System Operation Request for Libby Dam (Appendix 1). The intent of this request was to define the upper flow and temperature thresholds for burbot migration and spawning, and encourage the fish to move into and utilize its historic spawning areas in the Kootenai River.

5. **Maintain a strong adaptive management scientific monitoring and evaluation program to guide implementation of population conservation and recovery activities.**

Prospects for effective burbot conservation and management are limited by incomplete understanding of burbot life history in the Kootenai system and the interactive web of factors responsible for their decline. Adaptive management (Walters 1986, 1997) simply monitoring responses to deliberate research and management treatments, is a key premise of this Conservation Strategy. Results inform decision points built into this plan to select alternative pathways based on what works and what does not. Monitoring and evaluation activities in the Conservation Strategy differs from many conventional research programs, which sequentially test a hierarchy of increasingly specific hypothesizes in order to dissect the mechanisms of factors regulating the subject of interest. In a conventional research approach, implementation of significant measures is often delayed by studies that aim to reduce uncertainties regarding which measures will be most effective and efficient. However, with Lower Kootenai River burbot, this approach would require more time than remnant stock has left.

In response to the dire demographic status of Lower Kootenai burbot, the adaptive management experimental approach in this Conservation Strategy: 1) replaces the incremental approach, and 2) identifies effective and ineffective measures by direct experimentation and evaluation. However, conventional research will continue to play an important role in burbot conservation planning, but not at the expense of rapidly dwindling remnant burbot stocks (Figures 5, 8, 10, and 11).

6. **Burbot recovery measures must strike a fair and reasonable balance between the needs of fish and the needs of people.** For a conservation strategy to be successful, it must work for the fish and for the people of the region. Immediate, substantive actions are needed for Lower Kootenai River burbot to persist. However, actions must carefully consider tradeoffs with other land and water uses. This Conservation Strategy must work within very real and valid societal concerns and constraints. For instance, the hydro system plays a critical role in the livelihood and economy of the people of the region, and hydro system operations can only be modified so far in the interest of burbot. The levee

system similarly protects people and property throughout the lower Kootenai Valley and significant alterations or risks for fish purposes can be unrealistic. In addition, tradeoffs exist in the altered Kootenai River ecosystem between the needs of different fishes including burbot, sturgeon, and other resident or anadromous fish species upstream and downstream. In this difficult management and recovery environment, effective burbot restoration and conservation clearly require an innovative and adaptive conservation strategy, as well as support from reliable, long-term partnerships among diverse groups of stakeholders.

9.0 CONSERVATION MEASURES

9.1 Fishery Management

9.1.1. Continue current restrictions on burbot harvest in the Kootenai River, Kootenay Lake, and their tributaries.

9.1.2. Continue to monitor and limit incidental impacts and prohibit illegal harvest of burbot.

9.1.3. Integrate this Conservation Strategy into the multi-agency Kootenai River Adaptive Management Program, using IKERT as an annual review and input forum.

9.1.4. Consider resumption of subsistence and recreational fisheries after Conservation Strategy targets are met.

9.2 Habitat Restoration

9.2.1. Seek opportunities to reestablish lost natural river functions in the Lower Kootenai River, including hydrograph cycles, habitat diversity, and floodplain connectivity and function.

9.2.2. Continue to implement tributary habitat improvement projects that address instream, riparian, and upland conditions that affect stream discharge, water quality, and habitat diversity and complexity.

9.3 System Productivity & Aquatic Communities

9.3.1. Continue annual nutrient restoration of Kootenay Lake (North Arm fertilization began in 1992, South Arm began during 2004) and expand the program to include the Kootenai River in Idaho, near the Idaho-Montana border (2005) to increase the forage base available to burbot.

9.3.2 Continue efforts to restore and maintain other components of the native fish community, including kokanee and white sturgeon through approved habitat and population enhancement measures.

9.3.3 Endorse potential benefits to the burbot population and food base of ongoing efforts in other forums to assess and remedy sources of environmental contaminants.

9.3.4 Conduct controlled and in-situ laboratory bio-assays to determine the physiological effects of temperature, contaminants, predation, nutrients and other potential environmental stressors on different life stages of burbot.

9.4 Hydro Operations

9.4.1 Develop an experimental Kootenai River flow/water temperature operation to evaluate the effectiveness of restoring natural spawning and recruitment by reducing winter temperatures and velocities. Implement experimental operations when conditions allow to evaluate burbot spawning requirements while preserving flexibility in needed hydropower production and flood control operations. Annual operations will be coordinated through the Regional Forum Technical Management Team (TMT). The KVRI Burbot Committee will coordinate with the U.S. Fish and Wildlife Service to develop System Operations Requests (SOR) to the TMT to request flow conditions or temperature requirements in any given year. When conditions allow, the Regional Forum process will be used to develop recommendations for winter flow measures to provide experimental conditions for burbot spawning migrations (e.g. 45 day low flow period to begin in November). See Appendix 1 for an empirical example: 2003-2004 System Operation Request for Libby Dam Operations before, during, and after the historic burbot spawning period.

9.4.2 Document specific temperature and flow requirements that provide for natural spawning, incubation, rearing, recruitment, and survival of Kootenai River burbot.

9.4.3 Investigate existing hydrological models based on historic temperature, flow, and velocity data, and use to evaluate effects of operational alternatives on conditions required for completing various burbot life stages.

9.4.4 Evaluate use of selective withdrawal during migratory pre-spawning periods to affect thermograph at Bonners and downstream to benefit burbot, and monitor water temperature at Porthill.

9.4.5 Develop a long-term process to recommend annual Libby Dam operations for burbot, while providing for other project uses consistent with Endangered Species Act and other statutory and regulatory responsibilities. The multi-year plan may explore opportunities for experimental operations to evaluate burbot response to the operations.

9.5 Culture, Supplementation & Reintroduction

9.5.1 Develop effective methods to successfully hold, spawn, fertilize, and rear burbot in a hatchery. Develop these techniques using burbot from other regional populations to avoid impacts to remnant Kootenai River, Kootenay Lake, and Duncan Reservoir populations.

9.5.2 Evaluate donor stock suitability using a multidisciplinary broodstock evaluation template that incorporates: genetic/evolutionary, biological, ecological, and management parameters for fish in receiving and donating waters. In the short term, complete burbot microsatellite analysis to identify stock structure and guide decisions regarding stock source for conservation aquaculture.

9.5.3 When effective burbot culture techniques have been identified, and if natural recruitment sufficient to meet recovery goals has not been restored, implement an experimental burbot stocking program to: 1) identify life cycle bottlenecks in burbot survival, 2) determine whether hatchery-produced burbot can effectively survive in the wild, and 3) contribute to demographic and genetic vigor of remnant or re-introduced populations.

9.5.4 Design, evaluate, and implement a fish culture strategy with strict genetic guidelines, fish health protocols, and rigorous M&E components to assess and balance benefits and risks of natural production, while recognizing the need for significant conservation measures.

9.5.5 Identify subsequent hatchery roles in burbot conservation, based on monitoring and evaluation of post-release fish performance and responses of any natural recruitment to other recovery measures, and to the performance of experimental releases of hatchery fish.

9.6 Research, Monitoring, and Evaluation

9.6.1 When adequate numbers of burbot are restored in the wild, periodically conduct standardized assessments of burbot status in the Kootenai River from Montana downstream into Kootenay Lake (contingent on availability of appropriate sample numbers, and on donor source brood stock populations).

9.6.2 Periodically conduct standardized assessments of wild larval and juvenile abundance (contingent on availability of appropriate sample numbers and reliable empirical evidence of natural production).

9.6.3 Identify essential habitats and conditions by monitoring burbot movement and habitat use with radio and sonic telemetry in response to various flows and temperatures (contingent on availability of appropriate sample numbers).

9.6.4 Evaluate current use and suitability of the mainstem Kootenai River and its tributaries for burbot spawning.

9.6.5 Evaluate the contribution of entrainment from Libby Dam to the downstream Kootenai River burbot population.

9.6.6 Identify burbot behavior in Kootenay Lake to determine if special habitat limitations or biological interactions affect effectiveness of the burbot conservation strategy.

9.6.7 Monitor burbot responses to specific conservation measures and modify projects/operations to meet biological performance criteria values.

9.6.8 Design, implement and evaluate natural production experiments with remnant Lower Kootenai River burbot.

9.7 Information/Education

9.7.1. Increase public awareness of the need for Kootenai River burbot conservation by developing and distributing informational and educational materials and by hosting periodic public meetings.

9.7.2. Pursue opportunities to integrate Kootenai River burbot conservation activities with other ongoing fish management, fish and wildlife recovery activities, and habitat and ecosystem restoration efforts, via the multi-agency Kootenai River Adaptive Management Plan.

9.7.3. Prepare and distribute annual monitoring, evaluation and research reports.

9.7.4. Continue to involve a broad coalition of interested stakeholders in burbot conservation through the Kootenai River Resource Initiative Process (See Section 5.0 “Existing Conservation Measures” for more details).

9.8 Planning, Implementation, and Coordination

9.8.1 Maintain a standing technical committee (currently the KVRI Burbot Committee) to evaluate, coordinate, and adapt implementation of this Conservation Strategy. (See Section 5.1 for a description of KVRI Burbot Committee).

9.8.2 Review and update this Conservation Strategy annually; formally update it every five years or less as necessary.

9.8.3 Continue to build regional and international program coordination and participate in timely data sharing.

10.0 PRIORITIES, SCHEDULE, AND RESPONSIBILITIES

Table 4. Conservation Strategy Implementation Matrix.

Recovery Measure	Task	Recovery Measure Description	Time Frame*	Lead Agency	Participating Agencies
9.1		**Fish Management**			
	9.1.1	Continue current restrictions on burbot harvest in the Kootenai River, and Kootenay Lake, and their tributaries.	O-L	IDFG MFWP WLAP	IDFG MFWP WLAP
	9.1.2	Continue to monitor and limit incidental impacts and prohibit illegal harvest of burbot.	S-L	IDFG MFWP WLAP	IDFG MFWP WLAP
	9.13	Integrate aspects of Conservation Strategy into the multi-agency Kootenai River Adaptive Management Program, using IKERT as an annual review and input forum	O-L	All Agencies	All agencies
	9.1.4	Consider resumption of subsistence and recreational fisheries after Conservation Strategy targets are met.	L	IDFG MFWP WLAP	KTOI
9.2		**Habitat Restoration**			
	9.2.1	Seek opportunities to reestablish lost natural river functions in the Lower Kootenai River, including hydrograph cycles, habitat diversity, and floodplain connectivity and function.	M-L	KTOI IDFG MFWP WLAP USFWS NOAA KVRI	KVRI Burbot Committee IDEQ NRCS
	9.2.2	Continue to implement tributary habitat improvement projects that address in-stream, riparian, and upland conditions that affect stream discharge, water quality, and habitat diversity and complexity.	M-L	KTOI IDFG MFWP WLAP USFS	KVRI Burbot Committee IDEQ, IDL USFS, NRCS
9.3		**System Productivity, Aquatic Communities**			
	9.3.1	Continue annual fertilization of Kootenay Lake (North Arm fertilization began in 1992, South Arm began during 2004) and expand the program to include the Kootenai River in Idaho, near the Idaho-Montana border (2005) to increase the forage base available to burbot.	S	WLAP BC Hydro KTOI IDFG	IKERT
	9.3.2	Continue efforts to restore and maintain other components of the native fish community including kokanee and white sturgeon through approved habitat and population enhancement measures.	S-O	USFWS KTOI IDFG MFWP WLAP USACE	IKERT BEF
	9.3.3	Endorse potential benefits to the burbot population and food base of ongoing efforts in other forums to assess and remedy sources of environmental contaminants.	S-L	USFWS KTOI IDFG MFWP WLAP	All agencies
	9.3.4	Conduct controlled and in-situ laboratory bioassays to determine the physiological effects of temperature, contaminants, predation, nutrients and	S-M	USFWS KTOI IDFG	UI-ARI, USGS, and other labs

Recovery Measure	Task	Recovery Measure Description	Time Frame*	Lead Agency	Participating Agencies
		other potential environmental stressors on different life stages of burbot.		MFWP WLAP	
9.4		**Hydro Operations**			
	9.4.1	Develop an experimental Kootenai River flow/water temperature operation to evaluate the effectiveness of restoring natural spawning, and recruitment by reducing winter temperatures and velocities. Implement experimental operations when conditions allow to evaluate burbot spawning requirements while preserving flexibility in needed hydropower production and flood control operations.	S-M	USACE BPA BCHydro	IDFG KTOI WLAP MFWP USFWS KVRI M&E and Hydro Operations Subcommittee
	9.4.2	Document specific temperature and flow requirements that provide for natural spawning, incubation, rearing, recruitment, and survival of Kootenai River burbot.	S-L	IDFG KTOI WLAP MFWP USFWS	USACE BPA BCHydro KVRI M&E and Hydro Operations Subcommittee
	9.4.3	Investigate existing hydrological models based on historic temperature, flow, and velocity data, and modify if necessary to evaluate effects of operational alternatives on conditions required for completing various burbot life stages	S-L	BPA USACE USGS BC Hydro	IDFG KTOI WLAP MFWP USFWS KVRI M&E and Hydro Operations Subcommittee
	9.4.4	Evaluate use of selective withdrawal during migratory pre-spawning periods to affect thermograph at Bonners and downstream to benefit burbot, and monitor water temperature at Porthill.	S	USACE	IDFG KTOI WLAP MFWP USFWS KVRI M&E and Hydro Operations Subcommittee
	9.4.5	Develop a long-term process to recommend annual Libby Dam operations for burbot, while providing for other project uses consistent with Endangered Species Act and other statutory and regulatory responsibilities. The multi-year plan may explore opportunities for experimental operations to evaluate burbot response to the operations.	L	BPA USACE USFWS BC Hydro	IDFG KTOI WLAP MFWP USFWS KVRI M&E and Hydro Operations Subcommittee
9.5		**Culture, Supplementation & Reintroduction**			
	9.5.1	Develop effective methods to successfully hold, spawn, fertilize, and rear burbot in a hatchery. Develop these techniques using burbot from other regional populations to avoid impacts to remnant Kootenai River, Kootenay Lake, and Duncan Reservoir populations.	S	KTOI WLAP UI-ARI	KVRI Burbot Culture Subcommittee

Recovery Measure	Task	Recovery Measure Description	Time Frame*	Lead Agency	Participating Agencies
	9.5.2	Evaluate donor stock suitability using a multidisciplinary broodstock evaluation template that incorporates: genetic, evolutionary, biological, ecological, and management parameters for fish in receiving and donating waters. In the short term, complete burbot microsatellite analysis to identify stock structure and guide decisions regarding stock source for conservation aquaculture.	S	KTOI UI-ARI IDFG MFWP WLAP SPC&A	KVRI Burbot Culture Subcommittee
	9.5.3	When effective burbot culture techniques have been identified, and if natural recruitment sufficient to meet recovery goals has not been restored, implement an experimental burbot stocking program to: 1) identify life cycle bottlenecks in burbot survival, 2) determine whether hatchery-produced burbot can effectively survive in the wild, and 3) contribute to demographic and genetic vigor of remnant or re-introduced populations.	S-L	KTOI UI-ARI IDFG MFWP WLAP	KVRI Burbot Culture Subcommittee SPC&A
	9.5.4	Design, evaluate, and implement a fish culture strategy with strict genetic guidelines, fish health protocols, and rigorous M&E components to assess and balance benefits and risks of natural production, while recognizing the need for significant conservation measures.	S-L	KTOI UI-ARI IDFG WLAP	KVRI Culture Subcommittee SPC&A
	9.5.5	Identify subsequent hatchery roles in burbot conservation, based on monitoring and evaluation of post-release fish performance and responses of any natural recruitment to other recovery measures, and to the performance of experimental releases of hatchery fish.	S-L	IDFG MFWP WLAP KTOI	UI-ARI WSU IDFG
9.6		**Research, Monitoring, and Evaluation**			
	9.6.1	Periodically conduct standardized assessments of burbot status in the Kootenai River from Montana downstream into Kootenay Lake contingent on availability of appropriate sample numbers, and on donor source brood stock populations.	S-L	IDFG WLAP MFWP KTOI (w/ hatchery progeny)	KVRI Burbot Committee
	9.6.2	Periodically conduct standardized assessments of wild larval and juvenile abundance.	S-L	IDFG WLAP MFWP KTOI (w/ hatchery progeny)	KVRI Burbot Committee
	9.6.3	Identify essential habitats and conditions by monitoring burbot movement and habitat use.	S-L	IDFG WLAP MFWP	KVRI Burbot Committee
	9.6.4	Evaluate current use and suitability of the mainstem Kootenai River and its tributaries for burbot spawning.	S-M	IDFG KTOI MFWP WLAP	KVRI Burbot Committee
	9.6.5	Evaluate the contribution of entrainment from Libby Dam to the downstream Kootenai River burbot population.	S-L	MFWP IDFG WLAP	KVRI Burbot Committee
	9.6.6	Identify burbot behavior in Kootenay Lake to determine whether special habitat limitations or	S-M	WLAP	KVRI Burbot Committee

Recovery Measure	Task	Recovery Measure Description	Time Frame*	Lead Agency	Participating Agencies
		biological interactions affect effectiveness of the burbot Conservation Strategy.			
	9.6.7	Monitor burbot responses to specific conservation measures, and modify projects/operations to meet biological performance targets.	S-L	IDFG KTOI MFWP WLAP	Relevant KVRI Sub-Committees
	9.6.8	Design, implement and evaluate natural production experiments.	S-L	IDFG KTOI MFWP WLAP	Relevant KVRI Sub-Committees
9.7		**Information and Education**			
	9.7.1	Increase public awareness of the need for Kootenai River burbot conservation by developing and distributing informational and educational materials and by hosting periodic public meetings.	S-L	KVRI I&E Committee	KVRI Burbot Committee
	9.7.2	Purse opportunities to link Kootenai River burbot conservation activities with other ongoing fish management, fish and wildlife recovery activities, and habitat and ecosystem restoration efforts via the multi-agency Kootenai River Adaptive Management Plan.	S-L	IDFG KTOI WLAP USFWS MFWP	All agencies
	9.7.3	Prepare and distribute annual monitoring, evaluation and research reports.	S-L	IDFG KTOI WLAP USFWS MFWP	All Agencies
	9.7.4	Continue to involve a broad coalition of stakeholders in burbot conservation through the Kootenai Valley Resource Initiative Process.	S-L	KVRI Burbot Committee	All Agencies
9.8		**Planning, Implementation, and Coordination**			All Agencies
	9.8.1	Maintain a standing technical committee to coordinate and adapt implementation of this Conservation Strategy.	S-L	KVRI Burbot Committee	All Agencies
	9.8.2	Review and update this Conservation Strategy annually; formally update it every five years or less as necessary.	S-L	KVRI Burbot Committee	All Agencies
	9.8.3	Continue to build regional and international program coordination and participate in timely data sharing.	S-L	KVRI Burbot Committee	All Agencies

*** S – Short term < 3 yr**
M - Medium 3-10
L – Long-term > 10
O – Ongoing

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APPENDIX 1: 2003-2004 SYSTEM OPERATION REQUEST FOR LIBBY DAM

SYSTEM OPERATIONAL REQUEST #2003-03

TO:	General.Grisoli	USACE-NPD
	William Branch	USACE-Water Management
	Cindy Henricksen	USACE-RCC
	Witt Anderson	USACW-P
	Col. Lewis	USACE-Seattle District
	J. William McDonald	USBR-Boise Regional Director
	Steven Wright	BPA-Administrator
	Greg Delwiche	BPA-PG-5

FROM: Susan Martin, Supervisor, Upper Columbia Fish and Wildlife Office, U. S. Fish and Wildlife Service, on behalf of the following cooperating agencies and tribe: Idaho Office of Species Conservation, the Kootenai Tribe of Idaho, Idaho Department of Fish and Game, the City of Bonners Ferry and Boundary County, Idaho.

DATE:

SUBJECT: Request for releases from Libby Dam for migration, spawning, incubation and larval development of burbot in the Kootenai River.

SPECIFICATIONS: Beginning December 1, 2003 and continuing through December 22, 2003, to the extent feasible, limit releases from Libby Dam to 15,000 cfs, while maintaining established ramping rates. Beginning December 18, 2003 and continuing through January 30, 2004, maintain releases between 4,000 and 10,000 cfs, and preferably less than 7300 cfs to the extent possible. If, subsequent to this request it becomes necessary to release more than 10,000 cfs, it is recommended that the new release rate be the lowest stable flow, which can be sustained through January 30. We acknowledge that unforseen circumstances such as local or system flood control or power emergencies may supersede this recommendation.

Secondly, throughout this operation utilize the selective withdrawal system at Libby Dam to release the coldest water available. The objective is to maintain water temperatures in the Kootenai River between Bonners Ferry and the U. S. - Canada border below 4.0 degrees C, and as near to 1.5 degrees C as possible through operations of Libby Dam.

PURPOSE and JUSTIFICATION:

The intent of this request is to define the upper flow and temperature thresholds for burbot migration and spawning, and encourage the fish to move into and utilize its historic spawning areas in the Kootenai River. Monitoring of this operation will be conducted by the Idaho Department of Fish and Game and Bonneville Power Administration.

The burbot (*Lota lota*) population in the Lower Kootenai River in Idaho and in Kootenay Lake, British Columbia, is very depressed. Harvest has been discontinued, but the burbot population has not responded as expected based on the exceptional fecundity characteristic of this species (Becker 1983; Jakob Kjellman, University of Helsinki, pers. com. in The Kootenai River Burbot Recovery Committee 2001). Available information suggests that the most significant remaining environmental stressor is the altered flow regime during the late fall and winter. Researchers have suggested that these unnaturally high flows, associated changes in water temperature, and rapid fluctuations in flow resulting from hydroelectric load following may be altering normal burbot migration and or spawning behavior (The Kootenai River Burbot Committee 2001).

During the winter 2000, agreement was reached to curtail load following from Libby Dam for conservation of bull trout and sturgeon. In addition, 2001 flows were generally low in response to the drought and the need to retain water high in the system for a possible extended power emergency. With a couple of exceptions, releases from Libby Dam during the fall/winter migration and spawning period remained below 10,000 cfs, with the lowest flows in the 4,000 to 6,000 cfs range. During winter 2001, under these low flow conditions, some burbot did migrate to the Bonners Ferry area, and for the first time in recent years, there was evidence that spawning occurred there. Successful recruitment from that spawning event has yet to be verified (Vaughn Paragamian, IDFG. personal communication, 2001).

Secondly, burbot historically were believed to have spawned when water temperatures were near 1.0 ^{o}C. Prior to operations of Libby Dam, spawning may have occurred some years beneath the ice that commonly covered the Kootenai River in Kootenai Flats during the winter. In 2003, during the third week of January when burbot were believed to have spawned in the Kootenai River, water temperatures at Bonners Ferry ranged from slightly below freezing to 3.3^{o}C. Since Libby Dam operations began, typical winter river water temperatures have been increased from about 1.0 ^{o}C to about 4.0 ^{o}C during the same time periods (Partridge 1983). Burbot would be expected to spawn when water is only about 1.5 ^{o}C (Becker 1983; MacKay 1963). It is not known whether change of this magnitude in river water temperature is affecting burbot migration, spawning behavior, egg development, larval development, the timing of any of these events, or possibly the efficiency of egg or larval predators.

We believe that the river has not frozen over in any major way since Libby Dam became operational. This is a result of unseasonally high flow releases from Libby Dam during the winter months, with associated high energy from increased velocity and friction. In addition the water released is often warmer, as a result of heat retention and delayed release from the reservoir. We believe that these effects on water temperature will be diminished when releases are within the flow range recommended above, because of increased travel time allowing for more cooling of water. The selective withdrawal structure in place at the Libby Project may be used to a limited extent to manage winter water temperature in the Kootenai River with relatively little cost. The intent here is to reduce temperature to the extent possible within constraints of the Libby Project.

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