STATUS OF BURBOT IN MONTANA

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EXECUTIVE SUMMARY

In Montana, burbot *Lota lota* are native to the Kootenai, Missouri, and Saskatchewan drainages. Despite that they are found throughout much of the state, little is known about their status. We were able to obtain and analyze trend data from several populations throughout Montana, but most of these data were from incidental catches while biologists were sampling for target species such as rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, or sauger *Sander canadensis*. Thus, low sample size was a common problem with these data and made any conclusions regarding population trends relatively unreliable. Fisheries biologists throughout the state also agreed that data was limiting to reliably make any recommendations regarding the status of burbot in Montana. Where standardized long-term data sets exist, it appears that burbot abundance can be highly variable and may be related to discharge (e.g., Kootenai River, Montana, Idaho). Further, we found no evidence of a large-scale decline in burbot. Interestingly, we did observe consistently low relative weight (W_r) values for burbot—likely a function of many populations occurring in lotic ecosystems. The current MFISH database (www.map2.nris.state.mt.us) lists burbot throughout a larger area than reported by Brown (1971). However, the distribution expansion since 1970 is a function of the lack of records prior to 1970 not a rapid expansion of burbot throughout Montana. We recommend that standardized sampling be incorporated for burbot and that sampling for burbot be specifically targeted in areas that are identified as potential spawning and rearing habitat. Tracking population trends and status will be more productive in the future if burbot are targeted by fisheries biologists. Finally, research is needed on the population characteristics, habitat use, and early life history of burbot in Montana. Burbot are native to much of Montana, but still little is known about their status, usefulness as an indicator species, and function in fish assemblages.

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INTRODUCTION

Burbot are the only freshwater member of the family Gadidae (cods) (McPhail and Lindsey 1970; McPhail and Paragamian 2000). This species has a circumpolar distribution (McPhail and Lindsey 1970; Scott and Crossman 1973) and are native to the region above the 40^{th} parallel in the continental United States (McPhail and Paragamian 2000). In Montana, burbot are native to the Kootenai, Missouri, and Saskatchewan drainages (Brown 1971).

Fishing pressure for burbot in Montana is generally low relative to other sport fish; however, angler interest in this species has been increasing during the last decade throughout its range (Quinn 2000). In Montana, harvest of burbot has steadily increased in both Clark Canyon and Canyon Ferry reservoirs over the past five years [B. Rich, Montana Fish, Wildlife and Parks (MTFWP), personal communication]. Popular winter fisheries have been established on other reservoirs, such as Newlan Creek Reservoir (T. Horton, Montana Fish, Wildlife and Parks, personal communication) and Fort Peck Reservoir (M. Ruggles, Montana Fish, Wildlife and Parks, personal communication). Burbot are typically not sought by anglers in lotic ecosystems.

Little effort has been made to sample specifically for burbot and assess their population status in Montana waters. Sampling has been impeded by the relative inactivity of burbot during common sampling periods. Thus, basic population characteristic data (e.g., size structure, age structure, mortality, size at maturity) is lacking throughout the state.

Despite the limited amount of information regarding burbot population characteristics in Montana, concern about the status of burbot has been increasing among fisheries biologists. Several biologists have reported sampling fewer burbot within their management area. Additionally, anglers have become concerned over reduced numbers in many fishing areas. The decline in burbot is epitomized by the burbot population in the Kootenai River below Kootenai Falls because it has been petitioned for listing as a federally endangered species. The decline in this population has been attributed to the operation of Libby Dam for hydroelectric power and flood control. Similar declines in burbot populations have been seen in other states following dam construction. Three dams have been created on the Kootenai River between Idaho and Montana from 1931 to 1972 (Paragamian 1994). These dams disrupt winter spawning migrations by increasing flows during the winter (Paragamian 1994; Paragamian 2000). As a result, the burbot fishery in Idaho was closed in 1992. Several populations in Montana could be affected in a similar manner. For example, Clark Canyon and Canyon Ferry are operated by the U.S. Bureau of Reclamation for flood control, power generation, and irrigation. Subsequently, these reservoirs experience highly fluctuating water levels and the operation affects the natural hydrograph.

Presently, burbot management is poorly understood or non-existent (McPhail and Paragamian 2000). To implement any management strategies designed at maintaining or enhancing burbot populations in Montana, we must know more information regarding basic population characteristics (e.g., population sizes, age structure, and condition). Therefore, the objectives of this study are: i) provide information regarding burbot life history, ii) summarize all available burbot population characteristic data and anecdotal information for Montana, iii) synthesize information regarding the status of burbot in surrounding areas, and iv) identify management and research needs. These objectives were met by collecting information through scientific literature; Montana Fish, Wildlife and Parks (MTFWP) reports; a survey of state fisheries biologists; and personal contacts.

REVIEW OF BURBOT LIFE HISTORY

Description

Burbot are easy to discern from other North American freshwater species because they are the only inland cod (McPhail and Paragamian 2000). The body is elongated and eel-like with a rounded caudal fin (see cover image). Two soft dorsal fins are present; the first fin is relatively short while the second is almost as long as the anal fin. The pectoral fins are located just ahead of the pelvic fins and both pairs are placed forward on the body. The smooth skin on the dorsal surface of an adult burbot is colored with olive, black or brown mottling and embedded with tiny cycloid scales that are not useful for aging (McPhail and Paragamian 2000). The ventral side is yellow or white. A solitary barbell is located at the very tip of the chin and two tiny tube-like projections originate from each nostril.

Habitat

Burbot are located in cold-water lotic and lentic ecosystems within Europe, Asia, and North America (Brown 1971; McPhail and Paragamian 2000). In North America, the distribution of burbot includes almost all of Canada and Alaska (McPhail and Lindsey 1970; Scott and Crossman 1973) and extends south to the backwaters of the Mississippi and Missouri rivers (Pfleiger 1997). In Montana, burbot are native to the Missouri (including Yellowstone River), Saskatchewan, and Kootenai (Brown 1971; Penkal 1981; Holton and Johnson 1996) drainages (Figure 1). Burbot are also found in the Lower Clark Fork River, but are not native to this area (L. Katzman, MTFWP, personal communication).

Burbot typically occupy the hypolimnion of oligotrophic and mesotrophic lakes (Ryder and Pesendorf 1992), where they are most associated with bedrock or rubble substrates (Edsall et al. 1993). If soft substrates are present, burbot may construct burrows (Boyer et al. 1989). Burbot may migrate to the littoral zone in the evening or during cooler months (Fischer et al. 2001).

Lotic habitat requirements are less understood, but it is believed burbot in the southwest portion of their range (i.e., Idaho, Montana, and Wyoming) are restricted to backwater areas of cooler high-altitude systems (McPhail and Paragamian 2000). Their long cylindrical shape and poor swimming ability prevents them from inhabiting high current areas (Jones et al. 1974). Jones et al. (1974) found that large fish will exhaust themselves within 10 minutes of swimming in a current velocity greater than 25 cm/s. Thus, impounding rivers may impair the overall fitness of this species as a result of increased flows downstream of the dam (Paragamian 1993; Paragamian 2000; Kozfkay and Paragamian 2002).

Spawning, Rearing, Growth

Arndt and Hutchinson (2000) found that burbot mature after two growing seasons in Columbia Lake, British Columbia. However, they concluded that the majority of burbot likely mature around age 3 to 4, at total lengths of 401 mm to 530 mm, respectively. The spawning period may occur from December to early March (McPhail and Paragamian 2000), but Brown (1971) stated spawning in Montana occurs during February when water temperatures are near 1° to 4°C.

Most spawning is believed to occur in lakes (Scott and Crossman 1973; McPhail and Paragamian 2000); however, reproduction may also occur in rivers and streams (Cahn 1936; Arndt and Hutchinson 2000; Paragamian 2000). Some studies have documented spawning migrations from lakes or large rivers to smaller tributaries (Sorokin 1971; Bresser et al. 1988). Telemetry data provides evidence that burbot are capable of migrating long distances to reach spawning areas. For example, Paragamian (2000) tracked a single burbot traveling approximately 120 km during a low flow period in the Idaho portion of the Kootenai River.

The nocturnal spawning of burbot is highly synchronous (Cahn 1936; Scott and Crossman 1973; Morrow 1980). The spawning period may last from one week (Evenson 2000) to three weeks (Boag 1989). Males arrive at the spawning site prior to females, but no site preparation occurs as the fish begin to congregate (Cahn 1936; Arndt and Hutchinson 2000). Spawning fish assemble into a large "ball" with one or two females in the center of several males, and fish will weave in and out of this mass continuously, releasing eggs and sperm until spent (Cahn 1936; Brown 1971). Burbot do not exhibit any parental care.

Fecundity estimates for burbot in Montana have been estimated to be 50,000 to 2,000,000 eggs per female in a single spawning season (Brown 1971). Fertilized eggs may drift for a short period, but the non-adhesive eggs quickly sink to the bottom in the interstitial spaces of the fine gravel and silt substrate (Fabricus 1954). Taylor and McPhail (2000) found burbot eggs hatch in 28d at 5°C, 32d at 4°C, and 38d at 3°C in Columbia Lake, British Columbia.

Burbot hatch at 3 to 4 mm (Scott and Crossman 1973; McPhail and Paragamian 2000) and are phototactic (McPhail and Paragamian 2000; Taylor and McPhail 2000). Taylor and McPhail (2000) found this behavior to be quite advantageous to larval burbot as it reduces the potential for suffocation within fine substrates and aids in downstream dispersal. The yolk sac is absorbed four (Ghan and Sprules 1993) to 10 days (Taylor and McPhail 2000) after hatching, and the mouth begins to form. The swim bladder develops during the first month of life and fry begin to orient themselves horizontally (Taylor and McPhail 2000).

Burbot grow rapidly during the first three to four years (Scott and Crossman 1973; Katzman and Zale 2000); females eventually become larger than males. The standard weight equation for burbot is: $\log_{10} W_s = -4.868 + 2.898 \log_{10} L$, where W_s is the standard weight in grams and L is the total length in millimeters (Fisher et al. 1996). Growth rates for burbot, as for other species of fish, vary among different geographical locations and whether or not the population is exploited. Stocks in the southern portion of the range may grow at a faster rate than northern populations (Scott and Crossman 1973; McPhail and Paragamian 2000). Katzman and Zale (2000) compared mean back-calculated lengths at age from an unexploited population in Upper Red Rock Lake, Montana, with those from other exploited populations in Montana, the United States, and Canada. Although burbot from Upper Red Rock Lake are not among the largest burbot in North America, they have some of the fastest growth rates.

In Montana, the longest burbot ever recorded measured 1,003 mm TL and was caught in Lake Koocanusa (Chisholm et al. 1989). The heaviest burbot was found in the Missouri River and weighed 7.74 kg (Quinn 2000).

Feeding and Food Habits

Burbot experience an ontogenetic shift in diet, beginning as invertivores and then becoming primarily piscivorous. Larval burbot are pelagic, diurnal feeders and may eat copepods and cladocerans (Ryder and Pesendorf 1992). At approximately 30 mm TL, burbot become solitary, benthic feeders and begin to eat immature insects and sometimes even fathead minnows *Pimephales promelas*. At a length of approximately 500 mm, the diet shifts further toward piscivory (Scott and Crossman 1973; Gardner and Stewart 1987; Pfleiger 1997) and burbot become ambush (Boyer et al. 1989) or stalking (Hackney 1973) predators. This shift has been shown in burbot from Lake Koocanusa, Montana collected from 1988 to 1991 (Figure 2). Dipterans and yellow perch *Perca flavescens* appear to be important to burbot less than 500 mm TL, but fish constitute a greater proportion for burbot greater than 500 mm TL. In the Kootenai drainage, mountain whitefish *Prosopium williamsoni*, largescale sucker *Catostomus macrocheilus*, yellow perch, kokanee *Oncorhynchus nerka*, peamouth *Mylocheilus caurinus*, and northern pikeminnow *Ptychocheilus oregonensis* were found in the diet of burbot (Dalbey et al. 1998); some cannibalism does occur. In the lower Missouri River, Gardner and Stewart (1987) found goldeye *Hiodon alosoides* to be the predominant food item of adult burbot greater than 500 mm. Seasonal diet shifts also occur in adult burbot (Bailey 1972). During January in Lake Superior, burbot fed almost exclusively on fish and a few crayfish of the genus *Orconectes* spp. As temperatures increased during the months of April to June, more crayfish were eaten. During the warmer months, burbot became more concentrated on the bottom and the diet shifted to *Mysis relicta* (Bailey 1972; Scott and Crossman 1973). Burbot may compete with larger fish species such as lake trout *Salvelinus namaycush* and whitefishes *Coregonus* spp. because adult burbot are voracious predators (Bailey 1972; Scott and Crossman 1973).

Economic and Conservation Importance

Opinions over the value of burbot are highly variable. Before the settlement of Europeans, the Kootenay Indians used burbot as a sustainable food source during the winter (Northcote 1973). However, some early settlers did not find burbot palatable and were repelled by their physical appearance (McPhail and Lindsey 1970). Others, especially those of Scandinavian descent, found the liver to be a nutritious delicacy when smoked and canned (Scott and Crossman 1973). Commercial fisheries for burbot are typically ephemeral, but Northcote (1973) found that a few individuals made a profit by marketing burbot from Kootenay Lake, British Columbia to hotels and other local outlets. Commercial interest in this species increased in the Great Lakes region during the 1930s and 1940s because burbot liver oil was used as a substitute for saltwater cod in lamps (Bailey 1972).

Angler interest in burbot has increased throughout its range over the past decade (Quinn 2000). Increased fishing pressure for burbot has also occurred in some places in Montana, such as Canyon Ferry and Clark Canyon reservoirs (B. Rich, MTFWP, personal communication). As a result of increased interest, several natural resource agencies, including MTFWP, have implemented more restrictive harvest regulations to reduce the likelihood of overexploitation (Quinn 2000).

SAMPLING

A variety of sampling gears have been used to sample burbot including: gill nets (Lawler 1963; Bailey 1972); otter trawls (Bailey 1972); fyke nets, set lines and seines (Lawler 1963); hoop nets (McCrimmon and Devitt 1954; Lawler 1963); and electrofishing gear (Wagner 1972). Gill nets are highly effective at sampling burbot, but can be size selective (Bernard et al. 1991). Seines only appear to be effective for sampling adult burbot in the winter in shallow waters under ice during spawning (Scott and Crossman 1979). Fyke nets and otter trawls are less size selective than gill nets; however, they cannot be used in all habitats and are typically difficult to operate (Bernard et al. 1991).

Hoop nets are arguably the most effective gear for sampling burbot in both lentic and lotic habitats (Lawler 1963; Bernard et al. 1991); however, temporal variation in sampling influences efficiency. Bernard et al. (1993) found sampling precision is maximized in small and moderate-sized lakes if sampling is done immediately after the lake becomes ice-free in the spring or just before it freezes over in the late autumn or early winter. During the autumn months, burbot are equally likely to be active during the day and night as water temperatures cool (Kroneld 1975). Baited hoop nets are effective and should be baited with pieces of an odiferous prey species because burbot use odor cues to locate prey; however, bait loses its potency after two days (Bernard et al. 1991).

Determining gear efficiency and selectivity is important especially given that burbot catch rates in some areas have been declining in recent years. Spence (2000) evaluated the capture efficiency of burbot in Duncan River and Kootenay Lake in British Columbia with a sampling gear that was based on the commercial traps used in British Columbia's coastal black cod *Anoplopoma fimbria* fishery. The baited "cod traps" were effective in capturing burbot in lentic environments and easier to transport and store than hoop nets (Spence 2000). Spence (2000) also suggested that cod traps were more effective than hoop nets especially during longer sets (> 7 days). However, cod traps are not recommended for lotic systems because they can become dislodged or filled with sediment.

STATUS OF BURBOT IN MONTANA

Kootenai River

The burbot fishery in the Kootenai River between British Columbia, Canada, and Idaho collapsed in 1994 (see **STATUS OF BURBOT IN SURROUNDING STATES AND PROVINCES**). The decline of burbot has been primarily attributed to the construction of several dams along the river, including Libby Dam at Libby, Montana, in 1972 (Paragamian 1994). A relatively productive burbot fishery existed in the Montana section of the river both upstream and downstream of Lake Koocanusa prior to impoundment (Hammond and Anders 2003). Chisholm and Fraley (1985) noted a stable burbot population in Lake Koocanusa from 1984 to 1985. However, angler catch rates of several species have been reduced over the past several decades, prompting monitoring of the Kootenai River and Lake Koocanusa fisheries. Burbot have been collected using trap nets in the river below Libby Dam during the winter months (i.e., December through April) from 1992 to 2003 and below Kootenai Falls from 1992 to 1999. The population appears to be declining since the 1995-1996 samples even though effort has remained steady or increased (Figure 3). However, biologists have noted that burbot sampling has become increasingly difficult as a result of consistent high flows downstream of the dam (J. Dunnigan, MTFWP, personal communication).

Sonic- and radio-tracking of burbot in the Kootenai River have indicated that some burbot may migrate from the Kootenai River to the St. Mary River (Snelson et al. 1996; Ostrowski et al. 1997). One fish in particular migrated approximately 75 km from its original capture location to the confluence of the Kootenai and St. Mary rivers during the spawning period in mid-February 1997.

Although burbot populations have been shown to increase after reservoir construction (McPhail 1995), entrainment may still be detrimental to the population. Reservoir management appears to impact the number of burbot collected downstream of Libby Dam (Figure 4), possibly due to the entrainment of fish. Catch per unit effort (C/f) for burbot peaked in the winter of 1995-1996. During this period, a temporary shift in reservoir management occurred and burbot were flushed downstream.

Although, reservoirs provide new slow-water habitat for burbot, the entrainment of fish and population fragmentation may have negative effects on the burbot population in the Kootenai River. Similar to Libby Dam, the C/f of burbot below Kootenai Falls has declined during the late 1900s (Figure 5) and may be influenced by discharge (Figure 6).

Movement of burbot in Lake Koocanusa was evaluated from 1995 to 1997 using biotelemetry. In late 1995, 7 mature males, 2 mature females, and 4 burbot of unknown gender were captured and implanted with sonic transmitters in Rexford Bay. In early 1997, one male, one female, and two additional fish were captured in Tobacco River Bay and implanted with sonic transmitters. Approximately one-fourth of the burbot stayed in the Tobacco River Bay area. One fish moved upstream of the U.S.-Canadian border and four made significant migrations, even as far upstream as Wardner, B.C. (approximately 50 km), and one burbot moved to the mouth of the St. Mary River (approximately 75 km). The remaining fish were never relocated again after tagging.

Currently, MTFWP, the Idaho Department of Fish and Game, and the Kootenai Tribe are working on a cooperative agreement to study the genetics of burbot populations within the Kootenai drainage. Results from this study will help identify source populations for recolonization of burbot in the Idaho and British Columbia portions of the Kootenai River where they are declining or are extirpated (J. Dunnigan, MTFWP, personal communication).

Clark Fork River

Burbot are not native to the Clark Fork River, but have been stocked in Cabinet Gorge Reservoir and Triangle Pond possibly as late as the 1980s from the Kootenai River in Region 1 (P. Saffel, MTFWP, personal communication). Few burbot are present in these two waterbodies (L. Katzman, MTFWP, personal communication). Only two burbot were collected during sampling of Gabinet Gorge in 1994; both were greater than 200 mm total length (TL). Triangle Pond has never been monitored by MTFWP, but a young angler snagged a dead adult burbot during a kids' fishing day (ca. 2001).

Elk Lake, Twin Lakes, and Clark Canyon Reservoir

In southwest Montana, several lowland lakes and reservoirs in the Red Rock, Ruby, Beaverhead, and Big Hole River drainages contain burbot (Oswald 2000; Oswald 2002a); these waterbodies include (but are not limited to): Elk Lake, Twin Lakes, and Clark Canyon Reservoir. In Elk Lake, burbot have been sampled using sinking gill nets since 1991. Catch per unit effort of burbot in Elk Lake has varied from 6 in 1991 to 23 in 1998 (Figure 7). In general, C/f of burbot has increased from 1991 to 2001 (C/f = -1855.6 + 0.936 (year); r^2=0.29; P = 0.09). The mode length for the Elk Lake population is 292 mm and varied from 191 to 572 mm (Figure 8). Oswald (2002a) suggested that the small size of burbot in Elk Lake has decreased the popularity of the fishery.

Twin Lakes has been sampled sporadically since 1964. Mean C/f of lake trout (0.6 per sinking gill net) was similar to that of Elk Lake and burbot C/f (2.9 per net) is less than Elk Lake (Oswald 2000).

In general, when lake trout catch rates are high burbot catch rates are low (Figure 9). Total length of burbot varied from 216 mm to 579 mm in 1998, similar to the Elk Lake population (Figure 10). However, the length frequency histogram is skewed toward larger fish in Twin Lakes than Elk Lake (Figures 8 and 10).

Clark Canyon Reservoir supports a relatively popular burbot fishery; however, data on angling are limited and most information on the fishery comes from creel surveys (Oswald 2002b). Clark Canyon Reservoir contains some of the largest burbot in the state. However, the recent drought and subsequent reservoir management appear to have reduced the number of burbot and the average size of burbot harvested (Oswald 2002b).

Big Hole River Subbasin

Several creeks have been sampled using electrofishing in the Big Hole River subbasin by MTFWP and National Forest Service In 2002, burbot were collected at eight sites (Table 1). Proportional stock density and relative stock densities were zero at all sites. These creeks may be important spawning and rearing areas for burbot in the Big Hole River because all of these fish were relatively small (i.e., < 380 mm TL). Based on the number of burbot sampled, Jacobson, Tie, and Wise Creek may be important nursery areas. Additional research is needed to better understand the life history dynamics of burbot in the Big Hole basin.

Gallatin, Madison, and Jefferson Rivers

Burbot are believed to inhabit the confluence of the Gallatin, Madison, and Jefferson rivers (P. Byorth, MTFWP, personal communication); however, they are rarely sampled and do not appear to extend far into the Gallatin or Madison. The distribution of burbot in the Jefferson River is unknown.

Hauser, Helena Valley, and Holter Reservoirs

Data regarding burbot are typically collected during annual gill net and creel surveys at Hauser, Helena Valley, and Holter reservoirs. No fish have been observed in any tributaries connected to these waterbodies (Troy Humphrey, MTFWP, personal communication). Vertical gill nets (used for standardized sampling) are not efficient at sampling burbot in Hauser Reservoir. For example, catch per unit effort is well below values reported for horizontal gill nets (Figures 11 and 12). Relative weight values for burbot sampled in vertical gill nets were variable and never exceeded 100 (Table 2). Catch per unit effort values from autumn gill netting are less variable than spring sampling (Figure 12). Interestingly, there appears to be no difference in W_r values between spring and autumn samples (Table 3). No burbot of preferred to memorable length (530-669 mm) were collected during autumn 1998-2002.

Creel surveys have been conducted during the summer from 1986 to 2002, and during the winter from 1989 to 2002 on Hauser Reservoir (T. Humphrey, MTFWP, personal communication). Angler catch rates for burbot are typically low (< 0.01 fish/hour). Burbot harvested from Hauser Reservoir vary in length from 380 mm to 670 mm.

Catch per unit effort values in Helena Valley Regulating Reservoir were similar to those in Hauser Reservoir (Table 4). Winter creel surveys have been completed every year from 1990 to 2002 on the reservoir. Burbot have only been observed in the creel for three of these years; one in 1998 and two in 1999 and 2000. The smallest burbot in the creel survey was 370 mm and the largest was 670 mm.

Gill net surveys have been conducted on Holter Reservoir during autumn and spring since 1986; however, few burbot have been sampled (Table 5). Three of the five burbot sampled in Holter Reservoir have been aged using otoliths; the youngest burbot was age 3 (TL = 470 mm) and the oldest was age 6 (TL = 680 mm). A burbot has never been observed in the creel. Low C/f values and angler catch rates suggest a low density population in Holter Reservoir.

Mainstem Missouri River Upstream of Great Falls

Four river reaches are electrofished annually on the Missouri River during the spring and autumn to monitor brown trout and rainbow trout populations: Holter, Craig, Hardy, and Cascade (T. Horton, MTFWP, personal communication). Burbot are incidentally captured during these surveys, and subsequently lengths and weights are measured. Burbot have only been sampled during 1983, 1986, 1987, and 1993 at the Holter reach (Table 6). Most fish sampled are less than 530 mm and mean W_r values are less than 85 (Table 6).

The burbot population in the Missouri River at the Cascade and Craig reaches appears to be one of the highest density populations. However, it is difficult to compare to other waterbodies given the variation among sampling gears and lack of standardization. Burbot have been collected almost every spring and autumn from 1983 to 2002 in the Cascade and Craig reaches (Figure 13). Catch per pass has increased over time, most likely due to an increase in effort (time) in sampling rainbow trout and brown trout (T. Horton, MTFWP, personal communication). The number of burbot sampled in the autumn is consistently higher than the spring. Several burbot sampled in this stretch are near trophy length (820 mm), thus possibly providing a unique angling opportunity. Length of burbot sampled in the Cascade and Craig reach is variable (127 to 762 mm), with most fish being 305 to 406 mm TL (Figure 14). Similar to other populations in the state, mean W_r values were below 80.

Burbot catches have been sporadic since the early 1980s at Hardy, and most burbot have been sampled during the autumn (Table 7). Effort has increased from 1981 to 2000 and total length of fish sampled has varied from 150 to 730 mm. Similar to other areas in the state, mean W_r values are relatively low.

North Fork Smith River Reservoir

The North Fork Smith River Reservoir has been sampled during the summer and autumn since 1977 using floating gill nets, sinking gill nets, and trap nets. Burbot have been captured primarily in the autumn in both types of gill nets. Capture efficiencies may differ between the gears (Table 8). Floating gill nets appear to be more consistent in capturing burbot, but sinking gill nets may capture higher numbers of fish. However, the number of burbot sampled in both years is low and makes the comparison unreliable. Fischer et al. (2001) did find that burbot will move up higher in the water column once water temperatures begin to decline in the autumn.

Newlan Creek Reservoir, Sun River, and Wadsworth Pond

Burbot have also been sampled in Newlan Creek Reservoir, Sun River, and Wadsworth Pond using gill nets and trap nets since the early 1990s. Few burbot are sampled in Newlan Creek Reservoir, despite using various gear types (Table 9). In the Sun River, one burbot was sampled with a sinking gill net in 1988 and two were caught in 2000 with a floating gill net. A single burbot was sampled in Wadsworth Pond using a sinking gill net in 1999. The burbot populations in Newlan Creek Reservoir, Sun River, and Wadsworth Pond are likely at low densities.

Smith River

Burbot have been sampled at four locations along the mainstem of the Smith River: Eagle Creek, Deep Creek, Mid-Canyon, and Zieg. Few fish have been captured in the river at the Eagle Creek reach during autumn electrofishing surveys since 1984 (Table 10). The highest numbers of burbot sampled are at the Deep Creek reach (Table 11); few of the fish were greater than preferred length (530 mm), and mean condition values never exceeded 85. The Mid-Canyon section of the Smith River was only sampled from 1984 to 1992 (Table 12); burbot were first sampled in 1986. At Zieg, only one burbot was collected in 1976 and this fish was 500 mm long. It is unknown whether this species still exists in this area of the Smith River.

Lake Frances and Tiber Reservoir

Trap nets have been used to sample burbot in Lake Frances and Tiber Reservoir since the 1970s. Netting was suspended during several periods in both lakes, thus it is difficult to identify any trends in the C/f data (Table 13). Lengths and weights were only recorded during 1994 to 1998. However, the condition of burbot during these years appears to be relatively high. Several fish collected had relative weight values greater than 100, and only a couple had values less than 85.

Two areas of Tiber Reservoir have been sampled with trap nets—Devon and the Willow Creek Arm. Burbot appear to be more abundant in the Willow Creek Arm than Devon (Table 14). Approximately 240 fish were sampled from Tiber Reservoir in 1974 and transferred to Sutherlin Reservoir (D. Yerk, MTFWP, personal communication). Lengths and weights of burbot were only taken during sampling from 1994 to 1996, thus any trend in condition can not be evaluated. However, large burbot (i.e., preferred length) appear to be relatively abundant in Tiber Reservoir (Figure 15).

Middle Missouri Downstream of Great Falls

Burbot are believed to be relatively uncommon in the Missouri River between Great Falls and the Fred Robinson Bridge (B. Gardner, MTFWP, personal communication). Electrofishing data has provided limited information on the abundance of burbot in the Middle Missouri River from 1999 to 2000 (Tables 15 and 16). Many of the burbot captured in this reach appear to be larger than quality length. The size of burbot in the sample may be biased because of the sampling gear. Trawling for age-0 sturgeon *Scaphirhynchus* spp. in the delta area (river kilometer 3,056) occasionally yields a few age-0 burbot, indicating this area may be used for rearing (B. Gardner, MTFWP, personal communication). Several age-0 burbot have also been sampled by MTFWP biologists in a small reservoir in the Willow Creek drainage near Galata, Montana. This reservoir was once breached, causing burbot to be washed into Tiber Reservoir.

Creel surveys in the middle Missouri River indicate little fishing pressure on burbot. In a 2002 creel survey, it was reported that burbot were fished for two angler days (Gilge and Perszyk 2002). During this time, 35 burbot were caught and 28 were kept.

A few burbot have also been collected from the lower Marias River and Judith River. As in the mainstem of the Missouri River, burbot in these rivers are typically large. Length of burbot sampled in the Marias River varied from 300 to 650 mm (Figure 16). Only four burbot were collected from the Judith River in 2002.

Lower Missouri River

The lower mainstem of the Missouri River and its major tributaries were sampled by Gardner and Stewart (1987) in the late 1970s to early 1980s. A total of 533 fish were collected.

Mean back-calculated lengths at age indicated that burbot grow faster between ages 5 and 6, coinciding with a shift from insectivory to piscivory. Additionally, burbot in the lower Missouri River grow more slowly at younger ages but more rapidly at older ages compared to other North American populations. Burbot in this section of river do not appear to migrate great distances. In fact, tagging and recapture information revealed only 9% of recaptured burbot moved greater than 16 km from their original capture site; the longest movement was only 19 km. Little information is available on the spawning habits of burbot in the lower Missouri due to the difficulty in monitoring burbot during the spawning period.

Burbot have been incidentally sampled during pallid sturgeon *Scaphirhynchus albus* sampling in the lower Missouri River from 1994 to 2002. Thus, the number of burbot sampled is low, and length of burbot sampled is highly variable from 100 to 1100 mm (Figure 17). The presence of small burbot in the area suggests the lower Missouri River may provide spawning or rearing habitat.

Little data on the abundance and distribution of burbot exists for the Milk River; however, burbot do not appear to be abundant in the river (K. Gilge, MTFWP, personal communication). Anecdotal observations suggest that the species is associated with the tailwaters and riprap associated with diversion dams.

A relatively popular burbot winter fishery exists at Fort Peck Reservoir, but creel data is lacking. Further, few burbot are sampled in Fort Peck Reservoir because most of the sampling is for walleye during the spring. Anglers have reported catching a variety of sizes suggesting that several year classes are present in the reservoir (M. Ruggles, MTFWP, personal communication). However, there has been some concern that the species abundance is declining in the reservoir.

Upper to Middle Yellowstone

Burbot have been sampled in the Bighorn River, Bighorn Lake, Yellowtail Reservoir, and Yellowstone River at several locations from Big Timber to Huntley Dam. Burbot are not easily sampled and are rarely targeted (M. Vaughn, MTFWP, personal communication).

Sampling generally occurs in the spring and the autumn; however, most burbot are collected in the spring. Larger burbot are more common in the Yellowstone River than Bighorn Lake or Big Horn River (Table 17). The condition of burbot in the Yellowstone River drainage is low with no W_r values exceeding 95 (Table 18).

Middle to Lower Yellowstone

Five areas along the Yellowstone River have been established as standardized sampling areas since 1984: Intake, Fallon Creek, Miles City, Forsyth, and the Rancher Ditch Area. Most burbot are sampled by electrofishing; however, a few are sampled by drifting trammel nets, and one was sampled in a trap net. Effort information is not available, thus, we are unable to calculate C/f. Nevertheless, the highest number of burbot collected was during the spring at Intake in 1999 and the Rancher Ditch Area had the least number of burbot sampled (Table 19).

Burbot captured in the middle to lower Yellowstone River typically do not exceed preferred length (Table 20). Penkal (1981) suggested that rearing likely occurred downstream of Forsyth diversion. However, it may be possible that larger fish move out of the system, experience higher mortality, or are not being sampled. Angling most likely does not have an effect on the size structure of the population because harvest of burbot from the Yellowstone River is minimal. Burbot in the lower Yellowstone River have some of the highest W_r values in the state (Figure 18).

HISTORIC AND CURRENT STATUS OF BURBOT IN MONTANA

Historic and current distributions of burbot in Montana were compared using data from three sources: *Fishes of Montana* (Brown 1971); *A Field Guide to Montana Fishes: Third Edition* (Holton and Johnson 2003); and the MFISH (www.map2.nris.state.mt.us) database. Brown's (1971) distribution map included 52 individual sites and Holton and Johnson (2003) added records in the Poplar, Powder, and Bighorn rivers. The MFISH database included information on the presence of burbot at 98 sites with a potential distribution of approximately 8,193 river kilometers (Figure 19); this represents an 88% increase in distribution from Brown's (1971) data. However, the distribution expansion since 1970 is a function of the lack of records prior to 1970, not a rapid expansion of burbot throughout Montana. No populations appear to have been extirpated since 1971.

Burbot do have a wide distribution throughout the state and is one of the few species that is present in cold, cool, and warm water rivers (Figure 19). However, the status of the species varies among drainages and little is known about the status of many populations throughout the state.

SURVEY RESULTS

Most concern regarding the status of burbot in Montana has been based on anecdotal observation by fisheries biologists, and little quantitative data exists. To get a better understanding of the perceived status of burbot from MTFWP fisheries biologists throughout the state we sent each biologist a survey. Twenty-three surveys were mailed and the response rate was 74%. Questions were related to burbot sampling (e.g., locations where burbot have previously been sampled, potential areas burbot may occupy, gear choice), opinions on the status of burbot in the seven management regions, opinions on burbot management, and information about the recreational fishing for burbot (see **APPENDIX B**).

Questions one and two pertained to the distribution of burbot statewide. Burbot have been sampled in lakes, streams, and rivers throughout the state (as indicated by the green lines in Figure 20); this represents only 77% of the total length of habitat indicated by the records of burbot in the MFISH database. The second question asked what, if any, other streams or lakes could burbot be found, but have not been sampled (as indicated by the red lines in Figure 20); the addition of these areas increased the perceived distribution by approximately 90% of the total potential area occupied by burbot in the MFISH database.

Few areas are sampled to assess the status of burbot. Most biologists (65%) indicated that none of the waters they sample have been monitored for burbot. Those who do collect this species use a combination of sampling gears, with gill nets being the most popular gear, followed by hoop nets, electrofishing, and trap nets, respectively. Other gears employed include: beam trawls, drifting trammel nets, bag seines, and larval nets.

As a result of not targeting burbot, most fisheries biologists believe that there is insufficient data to make sound management decisions (Figure 21). Similarly, most believe the status of burbot in their area is unknown (Figure 22). Of the three who believed burbot were declining in their area, all cited modified temperatures and flow regimes as a result of reservoir management as the main factor contributing to the decline. Water withdrawal for irrigation was ranked as the number two reason, followed by climate changes and loss of suitable habitat (tied). Overharvest was ranked as the lowest, and there was one write-in for poor fish passage.

Seventy-one percent of respondents do not actively manage for burbot; those that do strive primarily to maintain viable populations for recreational fishing (Table 21). However, it is evident that burbot angling has not been promoted in all management areas, as 73% of biologists said the general public has either no opinion of burbot or does not even know that it is a fish. Interest in burbot angling has neither increased nor decreased over the past ten years, according to 63% of respondents. Sixty-four percent of the respondents said burbot are of little to no importance to the local area. Surprisingly, fishing for burbot is highest in the summer months, followed by autumn, spring and winter, respectively.

STATUS OF BURBOT IN SURROUNDING STATES AND PROVINCES

Nebraska

Burbot were collected from Lewis and Clark Lake from 1955 to 1957, the two years immediately following dam construction on the Missouri River (Walburg 1976). However, burbot were not collected in the same area from 1958 to 1974. Walburg (1976) concluded that the decline in burbot was a result of conversion from a lotic to lentic system and subsequent management of the reservoir. Although there is no direct burbot fishery within the state of Nebraska, Hesse (1993) found that burbot became vulnerable to angler harvest during the months of spawning as a result of entrapment in tailwaters created by impoundment of the Missouri River. Evidence suggests that few reproducing adults still remain in the area between Fort Randall Dam and Gavins Point Dam (Hesse 1993). Thus, it has been recommended that burbot in Nebraska be listed as endangered and the fishery closed (Hesse 1993).

South Dakota

Burbot are relatively common in lakes Oahe and Sharpe (Quinn 2000) and burbot inhabit the upper Missouri River. However, burbot are not considered a game species in South Dakota. Few anglers target burbot, and no harvest regulations are in place. The largest burbot caught in South Dakota by hook and line weighed approximately 5,525 g and was caught from Lake Sharpe in April 1974.

North Dakota

Burbot are present in the Missouri River system, and anglers fish for post-spawning adults as they enter the tributaries prior to migrating walleye (Quinn 2000). Throughout the 1970s and 1980s, burbot became smaller in length and weight and less abundant, perhaps providing evidence of a population decline (Quinn 2000). No harvest regulations exist for burbot in North Dakota. The record size burbot was caught from the Knife River in 1984 and weighed approximately 8,272 g.

Wyoming

Burbot are native to the Tongue River and Bighorn-Wind River drainages and are also found in larger lakes within the Lander and Dubois area, including Boysen Reservoir and Ocean Lake (Baxter and Stone 1995). Prior to the 1960s a popular winter fishery existed in Fremont County (Baxter and Stone 1995); Miller (1970) calculated the value of the 1968 to 1969 fishery on Boysen Reservoir, Ring Lake, and Trail Lake at $75,000. Residents of the Wind River Indian Reservation also fish regularly for burbot. However, CPUE and W_r values have declined significantly throughout the state (Krueger and Hubert 1997), most likely due to siltation from dams reducing spawning success (Miller 1970; Krueger and Hubert 1997). Additionally, overexploitation by anglers may be depleting the population (Krueger and Hubert 1997). Current state regulations allow a creel limit of six burbot or channel catfish in any combination.

Idaho and British Columbia, Canada

In Idaho, burbot are only found within the Kootenai River drainage (Quinn 2000). These fish migrate throughout the drainage between Kootenay Lake in British Columbia and the Kootenai River in Idaho; thus, it is difficult to separate the population according to national borders. Due to the interconnectedness of burbot populations in the Kootenai drainage, the burbot of Idaho and British Columbia will be treated together. The Kootenai River drainage supported an excellent winter fishery from the 1950s to the early 1970s (Paragamian 1994). During this period, no harvest limits existed for burbot. After construction of several hydroelectric dams (e.g., Corra Linn in 1931, Duncan in 1967 and Libby in 1972) burbot stocks declined significantly and in 1992 the fishery was closed (Paragamian 1994). Most biologists believe that the construction of the dams had the greatest effect on the decline of burbot in the region. However, other anthropogenic activities (e.g., logging, mining, and urbanization) occurred along the river prior to the construction of the impoundment (Paragamian et al. 2000; Hammond and Anders 2003). No evidence exists to suggest a single cause of this crash throughout the Kootenai River drainage.

Alberta

Burbot are not a popular sport fish in Alberta. However, Nelson and Paetz (1992) believe that angling popularity of this species will probably increase as more anglers discover its qualities as a game fish and as other traditional sport fish species face increasing pressure from recreational fishing and environmental degradation. Current creel limits for burbot in Alberta are 10 fish per day.

MANAGEMENT AND RESEARCH NEEDS

1. Develop standardized methods for sampling and reporting data.

   A. Use hoop nets as a standardized gear in lotic and lentic systems, if comparisons between ecosystem types is necessary. Use cod traps on an experimental basis. If cod traps become the gear of choice in lentic systems, then determine how catch per effort can be compared between cod traps and hoop nets.

   If comparisons among ecosystem type are not necessary, then cod traps should be used in lentic systems.

   Standardize sampling for burbot in the spring immediately after lakes become ice-free.

   B. Use catch per effort (C/f; number of fish per net night) as the standard unit of measure for abundance. (Research idea: Determine if catch per unit effort in hoop nets is an index to density).

   C. Use standardized length categories for burbot to calculated size structure indices. Use published standard-weight equation for burbot to calculate relative weight values.

2. Determine the amount of exploitation on burbot populations during the winter.

3. Determine the amount of harvest burbot populations can endure by waterbody.

4. Compare variation in C/f during spring and autumn samples.

5. Evaluate spawning habitat and early life history of burbot in lotic systems in southwest Montana.

6. Assess the population characteristics (age, growth, mortality, recruitment, density) of burbot in lotic and lentic ecosystems statewide.

7. Determine the effects of water level fluctuations, altered hydrographs, and altered stream temperatures on burbot populations.

8. Evaluate the interactions among westslope cutthroat trout, rainbow trout, brown trout, lake trout, and burbot.

9. Determine the factors causing low condition values for burbot in Montana waters.

10. Determine the distribution of burbot in high-mountain lakes.

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Table 1. Summary of burbot captured within the Big Hole subbasin, 2003.

Creek	N	Number of stock-length fish (> 200 mm)	Minimum length	Maximum length
Jacobson Creek	98	18	200	238
Tie Creek	17	5	243	332
Wise Creek	12	2	210	224
Lacy Creek	8	5	211	275
Sheep Creek	8	2	206	209
Johnson Creek	4	2	240	285
Butler Creek	1	1	230	N/A
Mono Creek	1	0	190	N/A

Table 2. Mean relative weight (W_r) of burbot by length category sampled by vertical gill nets in Hauser Reservoir during the winter from 1992 to 2002. Length categories are: stock to quality (S-Q; 200-379 mm), quality to preferred (Q-P; 380-529 mm), and preferred to memorable (P-M; 530-669 mm).

Year	Mean W_r S-Q	Mean W_r Q-P	Mean W_r P-M
1992	85		
1993			
1994	98	78	76
1995		89	88
1996	72	90	93
1997	84	84	
1998			92
1999	85		
2000			
2001	86		
2002	80	65	

Table 3. Mean relative weight values (W_r) by length category for burbot sampled by horizontal gill nets in Hauser Reservoir during spring (May) and autumn (October). Length categories are: stock to quality (S-Q; 200-379 mm), quality to preferred (Q-P; 380-529 mm), and preferred to memorable (P-M; 530-669 mm).

Year	Mean W_r S-Q (autumn)	Mean W_r S-Q (spring)	Mean W_r Q-P (autumn)	Mean W_r Q-P (spring)	Mean W_r P-M (autumn)	Mean W_r P-M (spring)
1988				78		
1989					82	86
1990						
1991	72		73			
1992	63	81	65			
1993	76	66	78	87	91	75
1994	86			82	82	
1995	76	83	76	77	74	94
1996	81	70	81	87	84	74
1997	72	87	76	86	79	79
1998		73	80	74		91
1999	79	74		77		84
2000	91	105	70	75		65
2001	63	77		77		
2002	84	72	81	80		75

Table 4. Catch per unit effort of burbot sampled in Helena Valley Regulating Reservoir using horizontal gill nets from 1997 to 2002.

Year	N	Number of burbot per net
1997	23	2.09
1998	1	0.33
1999	9	3.00
2000	6	2.00
2001	1	0.33
2002	3	1.00

Table 5. Catch per unit effort (number per net) for burbot sampled in the spring and autumn using sinking gill nets in Holter Reservoir from 1986 to 2002.

Year	Spring	Autumn
1986	0.00	0.00
1987	0.00	0.00
1988	0.00	0.00
1989	0.00	0.00
1990	0.00	0.00
1991	0.00	0.00
1992	0.00	0.00
1993	0.00	0.00
1994	0.00	0.00
1995	0.00	0.17
1996	0.00	0.00
1997	0.00	0.00
1998	0.00	0.00
1999	0.17	0.00
2000	0.17	0.00
2001	0.00	0.17
2002	0.00	0.17

Table 6. Number of burbot per electrofishing pass and mean W_r values for burbot sampled in the Missouri River at Holter from 1983 to 1993.

Year	Season	N	Number per pass	Mean W_r
1983	Autumn	10	0.67	76
1986	Spring	8	0.80	77
1986	Autumn	17	8.50	71
1987	Autumn	16	8.00	76
1993	Autumn	7	3.00	84

Table 7. Number of burbot sampled per electrofishing pass and mean W_r values for burbot sampled in the Missouri River at Hardy from 1981 to 2000.

Year	Season	N	Number per pass	Mean W_r
1981	Autumn	9	0.50	69
1992	Autumn	33	11.00	82
1993	Spring	10	1.33	68
1993	Autumn	39	13.00	79
1994	Spring	34	11.00	71
1999	Autumn	87	21.75	69
2000	Autumn	109	27.25	67

Table 8. Number of burbot sampled in the North Fork Smith River Reservoir using floating and sinking gill nets from 1977 to 2002.

Year	Floating gill net	Sinking gill net
1977	1	1
1978	6	0
1979	0	4
1980	0	1
1981	0	0
1982	1	0
1983	0	0
1984	0	0
1985	0	0
1986	0	0
1987	2	0
1988	0	28
1989	0	1
1990	0	1
1991	1	0
1992	8	0
1993	0	3
1994	7	0
1994	9	0
1996	4	2
1997	0	0
1998	5	0
1999	0	4
2000	0	0
2001	0	0
2002	2	12

Table 9. Number of burbot sampled in Newlan Creek Reservoir using floating gill nets, sinking gill nets, and trap nets from 1992 to 2003.

Year	Floating gill net	Sinking gill net	Trap net
1992	0	2	0
1993	0	2	0
1994	1	2	0
1995	6	1	0
1996	0	1	3
1997	1	0	0
1998	0	0	2
1999	0	3	0
2000	0	0	0
2001	0	0	0
2002	3	1	0
2003	1	0	0

Table 10. Number of burbot sampled per electrofishing pass on the Smith River at Eagle Creek from 1984 to 2002.

Year	N	Number per pass
1984	0	0.00
1985	0	0.00
1986	0	0.00
1987	2	1.00
1988	0	0.00
1989	1	0.25
1990	0	0.00
1991	0	0.00
1992	0	0.00
1993	0	0.00
1994	0	0.00
1995	1	0.25
1996	1	0.25
1997	0	0.00
1998	1	0.25
1999	0	0.00
2000	0	0.00
2001	0	0.00
2002	1	0.25

Table 11. Number of burbot sampled per electrofishing pass on the Smith River at Deep Creek from 1986 to 2002.

Year	N	Number per pass	Mean W_r
1986	3	0.75	74
1987	5	1.25	76
1988	0	0.00	
1989	2	0.67	69
1990	9	0.56	69
1991	16	4.00	76
1992	5	2.00	69
1993	1	0.20	75
1994	3	1.33	70
1995	5	0.75	79
1996	17	4.25	78
1997	0	0.00	
1998	15	3.75	77
1999	41	10.25	81
2000	0	0.00	
2001	0	0.00	
2002	12	3.00	80

Table 12. Number of burbot sampled per electrofishing pass on the Smith River at the Mid-Canyon reach from 1986 to 1992.

Year	N	Number per pass
1986	7	2.33
1987	15	3.75
1988	0	0.00
1989	4	1.00
1990	3	0.75
1991	1	0.25
1992	0	0.00

Table 13. Number sampled, effort, and catch per effort for burbot sampled in Lake Frances from 1972 to 1998.

Year	N	Number of net nights	Number per trap net
1972	3	20	0.15
1973		0	
1974		0	
1975		0	
1976		0	
1977		0	
1978		0	
1979		0	
1980		0	
1981	1	11	0.09
1982	4	10	0.40
1983	0	0	
1984	8	6	1.33
1985	13	11	1.18
1986	79	47	1.68
1987		0	
1988	23	23	1.00
1989	121	60	2.02
1990		0	
1991		0	
1992	3	62	0.05
1993	2	20	0.10
1994	8	52	0.15
1995	4	30	0.13
1996	5	18	0.28
1997	2	35	0.06
1998	6	24	0.25

Table 14. Sample size and number per trap net of burbot sampled in Devon and Willow Creek Arm of Tiber Reservoir from 1973 to 2000.

	Devon		Willow Creek	
Year	N	Number per trap	N	Number per trap
1973	0	0.00	271	13.60
1974	0	0.00	180	7.20
1975	0	0.00	368	6.00
1976	0	0.00	5	0.10
1977	0	0.00	77	1.50
1978	0	0.00	17	1.20
1979	0	0.00	26	0.90
1980	0	0.00	18	0.50
1981	0	0.00	4	0.20
1982	0	0.00	6	0.30
1983	1	0.30	0	0.00
1984	1	0.10	3	0.10
1985	1	0.10	6	0.10
1986	4	0.10	18	0.40
1987	15	0.40	15	0.40
1988	0	0.00	247	2.70
1989	0	0.00	0	0.00
1990	5	0.30	26	0.40
1991	56	0.80	93	1.00
1992	23	0.30	0	0.00
1993	10	0.20	8	0.80
1994	32	0.30	17	0.80
1995	75	1.10	18	0.30
1996	28	1.20	21	0.70
1997	38	0.60	29	1.50
1998	9	0.20	24	0.30
1999	14	0.40	22	0.20
2000	1	0.20	0	0.00

Table 15. Number per hour of boat electrofishing for burbot sampled in the middle Missouri River from 1999 to 2000 (adapted from Gardner 2000).

	Number per hour of electrofishing	
Location	1999	2000
Marias River Confluence	0.00	0.20
Coal Banks	0.60	0.10
Judith Landing	0.30	0.20
Grand Island	0.90	0.30

Table 16. Mean length of burbot sampled in the middle Missouri River from 1999 to 2000 (adapted from Gardner 2000).

	1999		2000	
Location	N	Mean Length (mm)	N	Mean Length (mm)
Loma	3	307	4	424
White Rocks	1	406	2	368
Stafford Ferry	23	447	1	742
Robinson	11	397	5	470
Marias River Confluence	1	493	1	534

Table 17. Size-structure indices of burbot in the upper to middle Yellowstone River drainage. Length categories are: stock to quality (S-Q; 200-379 mm), quality to preferred (Q-P; 380-529 mm), and preferred to memorable (P-M; 530-669 mm).

Location	Year	N	PSD	RSD-P	RSD-M	RSD-T
Bighorn Lake	1997	18	89	22		
	1998	1	0			
	1999	3	33			
	2000	7	43	14		
	2001	4	75			
Bighorn River	1986	1	100	100		
	1989	2	100	100	50	
	1990	1	0			
	1991	5	60	20		
	1996	8	63			
	1999	2	100			
	2000	10	100	40	10	
Yellowstone River	1989	85	100	86	26	1
	1995	38	89	50	16	3
	1999	10	100	60	10	
	2000	96	95	57	10	

Table 18. Relative weight of burbot in the upper to middle Yellowstone River drainage according to size structure categories. Length categories are: stock to quality (S-Q; 200-379 mm), quality to preferred (Q-P; 380-529 mm), and preferred to memorable (P-M; 530-669 mm).

Location	Year	Stock-quality	Quality-preferred	Preferred-memorable	Memorable-trophy	Trophy
Bighorn Lake	1997	75	74	83		
	1998	95				
	1999	62				
	2000	70	60			
	2001	68	90			
Bighorn River	1986			85		
	1989			79	78	
	1990	72				
	1991	71	82	76		
	1996	75	82			
	1999		79			
	2000		84	66	73	
Yellowstone River	1989		75	72	74	63
	1995			86	86	80
	1999		74			
	2000	77	70	71	72	

Table 19. Burbot sampled from the Yellowstone River by location from 1984 to 2002.

	Intake		Fallon		Miles City		Forsyth		Rancher Ditch	
Year	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
1984										
1985		1								
1986								4	2	9
1987							5			
1988							13	3		
1989										
1990						14				
1991	2									
1992				1	1	2		7		
1993				1		1		2		
1994		5		2		7		2		
1995		15		3		2		6		
1996	1	1		2		1	6	4		
1997						1	1	1		
1998		4		1						
1999	50			1				1		
2000		1		1						
2001	1			1						
2002	4					1		1		
Totals	58	27	0	13	1	29	25	31	2	9

Table 20. Size structure indices for burbot in the Yellowstone River from 1985 to 2002. Length categories are: stock to quality (S-Q; 200-379 mm), quality to preferred (Q-P; 380-529 mm), and preferred to memorable (P-M; 530-669 mm).

Year	N	PSD	RSD-P	RSD-M	RSD-T
1985	1	0	0	0	0
1986	5	80	40	0	0
1987	5	20	20	0	0
1988	7	14	14	0	0
1989	0	0	0	0	0
1990	8	50	13	0	0
1991	1	0	0	0	0
1992	11	18	0	0	0
1993	4	25	0	0	0
1994	14	57	21	0	0
1995	20	40	10	5	0
1996	15	20	13	0	0
1997	3	100	67	0	0
1998	3	33	33	33	0
1999	43	30	14	2	0
2000	2	50	0	0	0
2001	2	0	0	0	0
2002	6	17	0	0	0

Table 21. List of where burbot are sampled to obtain population status by region.

Management area	Management goals for burbot
Region 1	Provide quality angling.
	Provide for stable/increasing populations.
	Provide for quality habitat for all life stages.
Region 2	Not applicable
Region 3	Adequate storage in reservoir to provide sufficient habitat for functional life history.
	Maintain sufficient age structure to sustain angler harvest of larger, older fish.
	Functional persistent populations in lakes which are actively managed with stocked salmonids.
Region 4	Catch per effort of 0.5-1.0 per autumn sinking gill net in Hauser Reservoir.
	Maintain a viable population.
	To provide recreational fishing opportunities while maintaining viable and healthy populations.
Region 5	No data
Region 6	No data
Region 7	No data

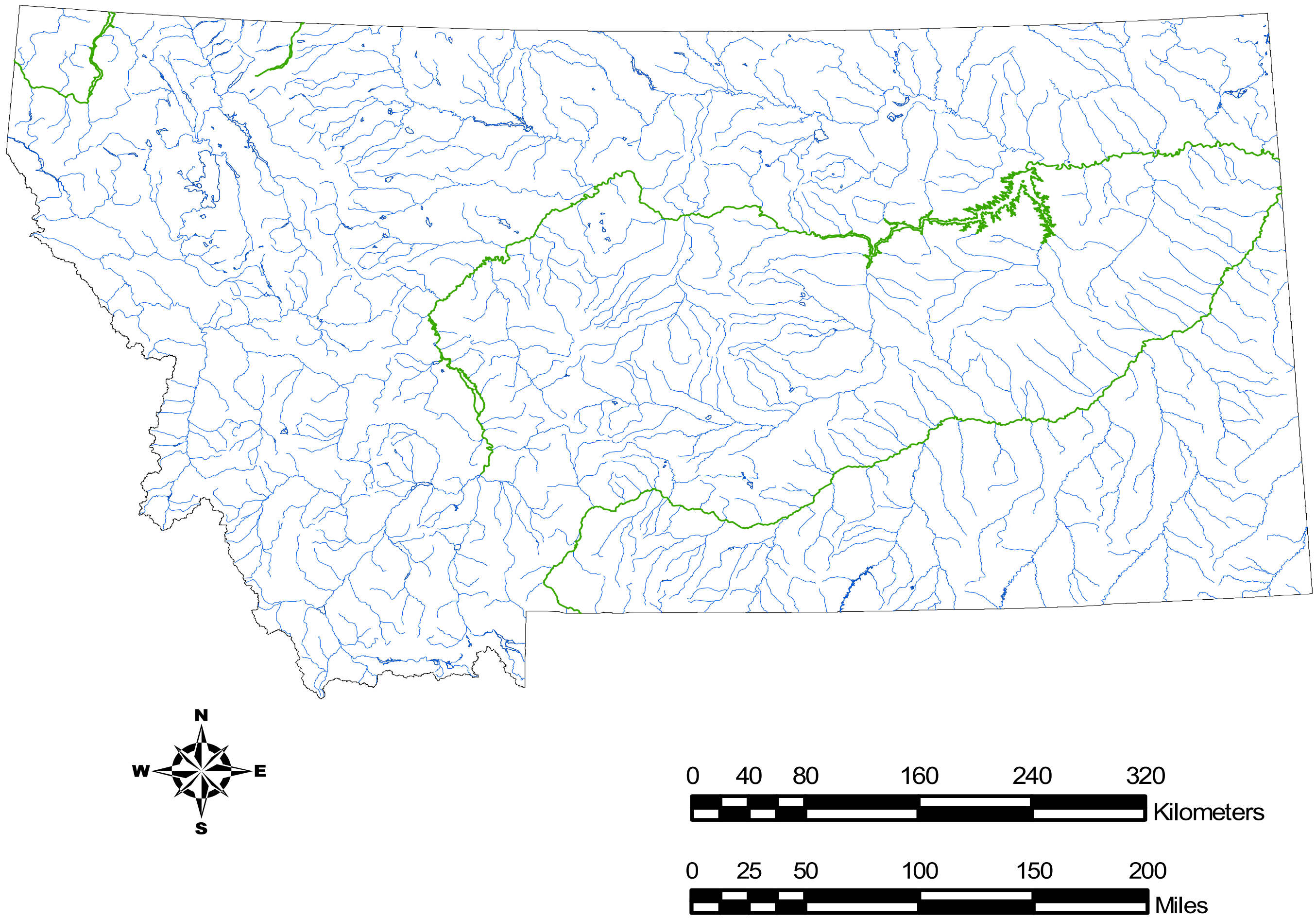

Figure 1. Native distribution of burbot in Montana (only major rivers are highlighted designating the drainages).

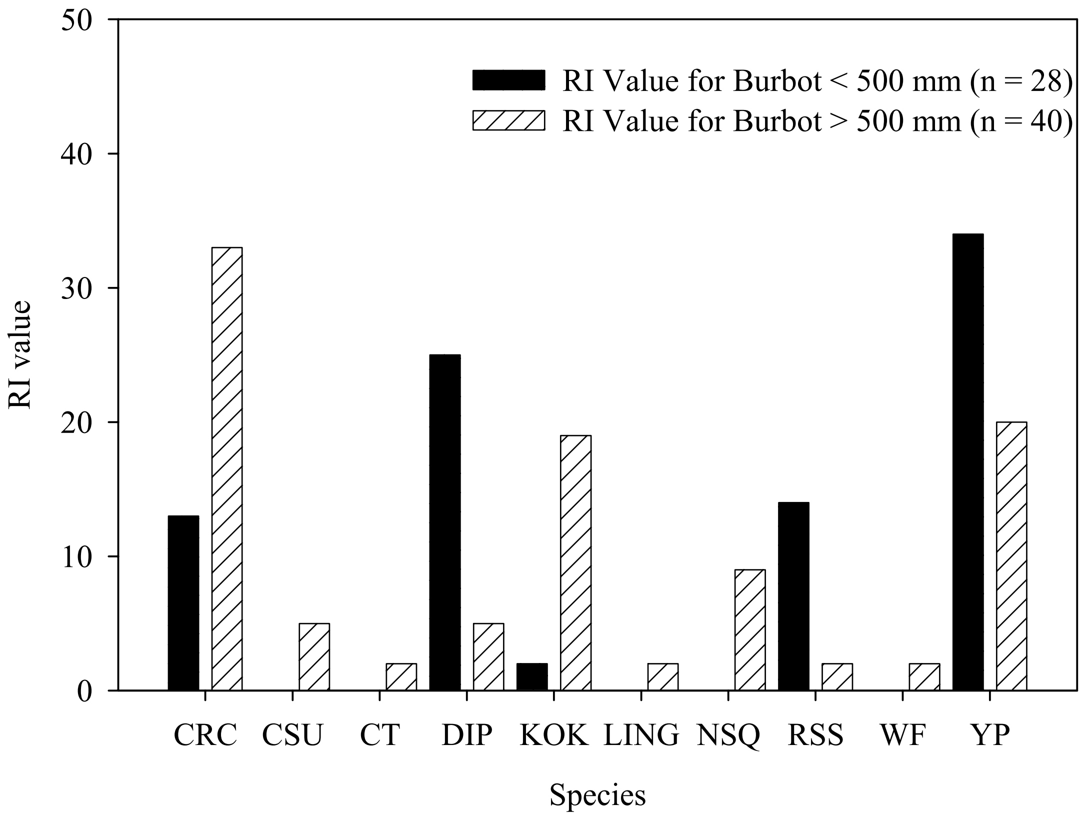

Figure 2. Comparison of burbot RI (relative importance) values for burbot less than or greater than 500 mm TL in Lake Koocanusa, MT from 1988 to 1991. Abbreviations are as follows: CRC = Columbia River chub (*Mylocheilus lateralis*); CSU = largescale sucker (*C. macrocheilus*); CT = cutthroat trout (*Salmo clarki*); DIP = Diptera spp.; KOK = Kokanee (*O. nerka*); LING = burbot (*L. lota*); NSQ = northern pikeminnow (*P. oregonensis*); RSS = redside shiner (*Richardsonius balteatus*); WF = mountain whitefish (*P. williamsoni*); YP = yellow perch (*P. flavescens*) (Data from J. Dunnigan, MTFWP).

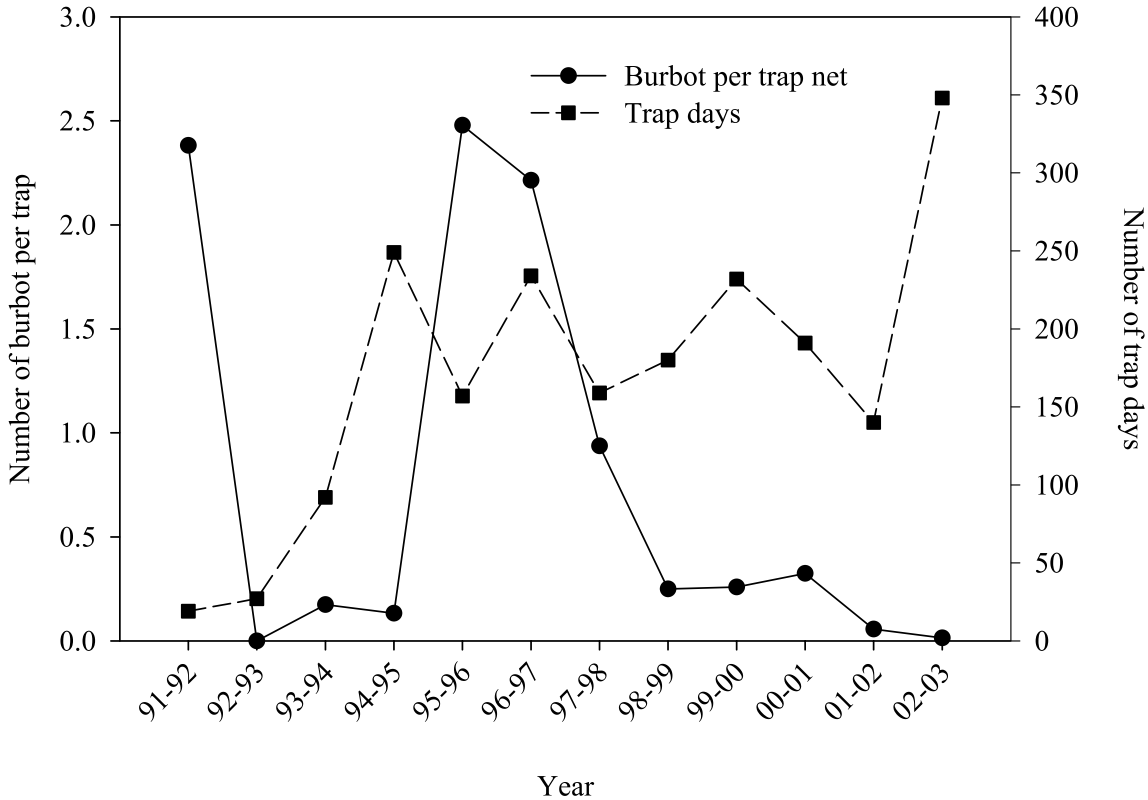

Figure 3. Catch per unit effort (C/f) and sampling effort for burbot during the winter below Libby Dam, Montana from 1991 through 2003.

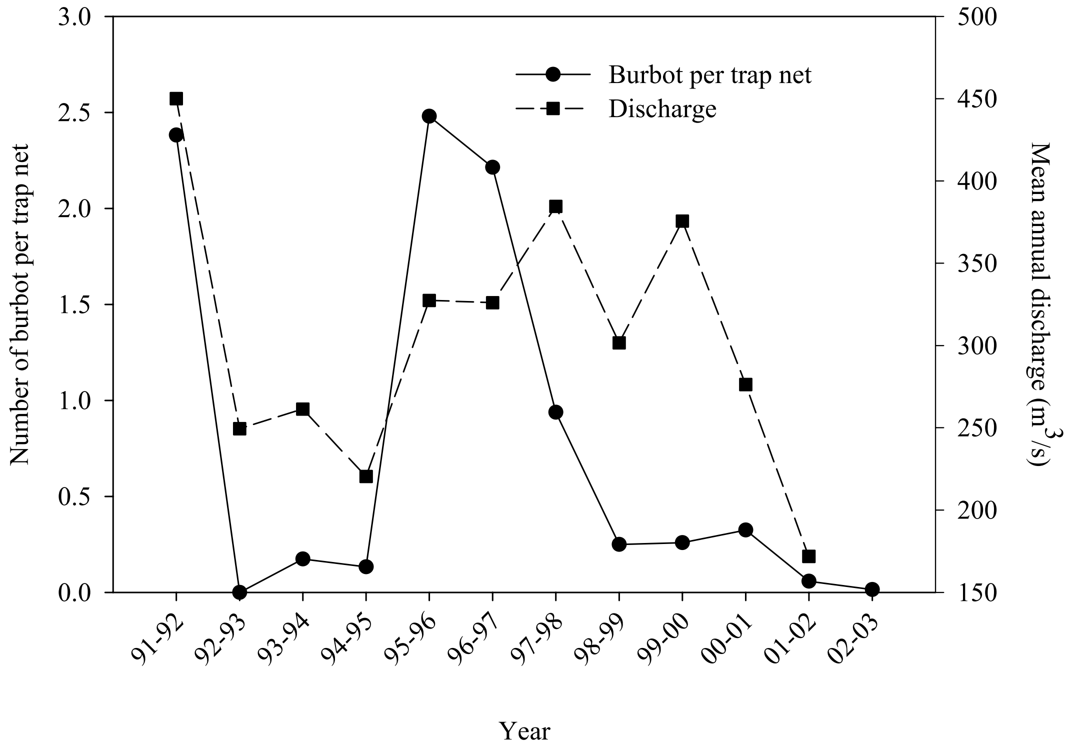

Figure 4. Catch per unit effort (C/f) for burbot and mean discharge during the winter below Libby Dam, Montana from 1991 through 2003.

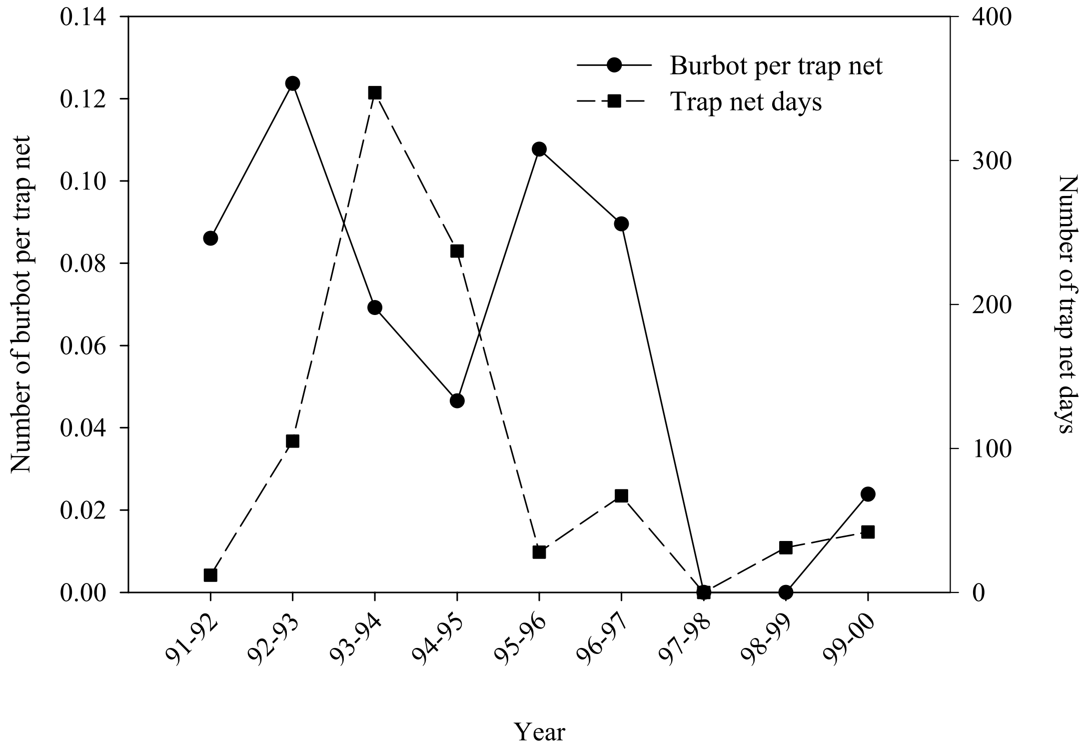

Figure 5. Catch per unit effort (C/f) for burbot and number of trap net days during the winter below Kootenai Falls, Montana from 1991 through 2000.

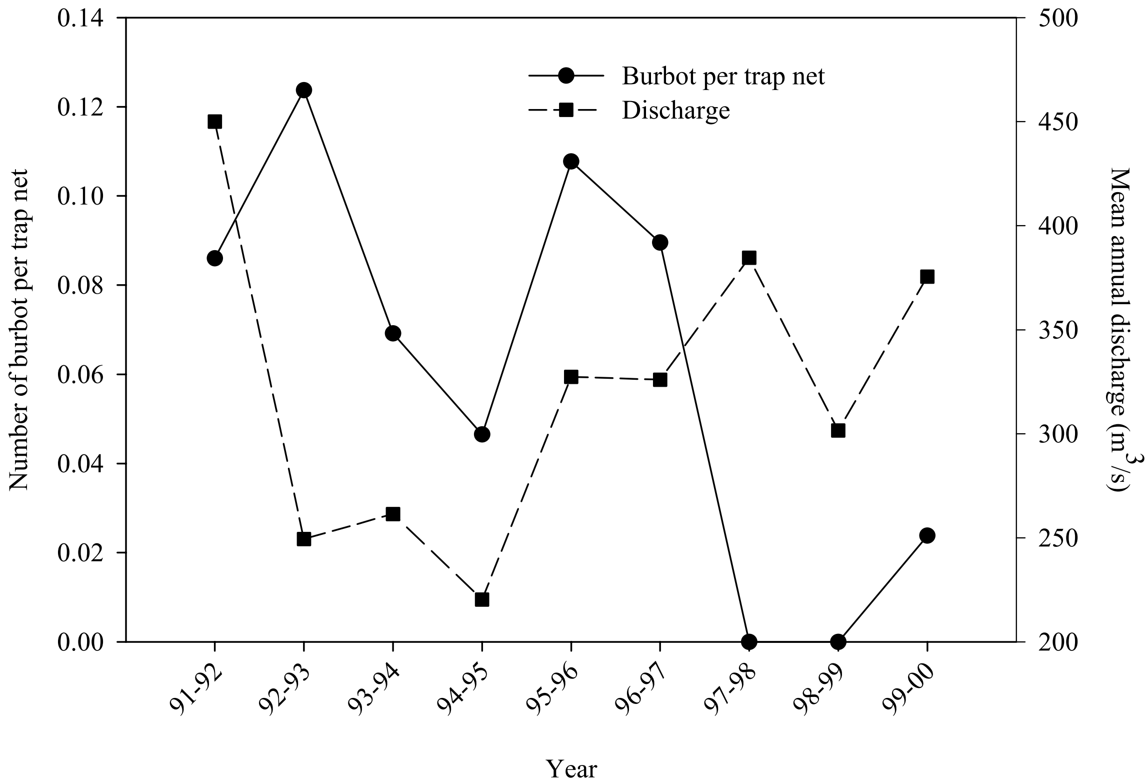

Figure 6. Catch per unit effort (C/f) for burbot and mean discharge during the winter below Kootenai Falls, Montana from 1991 through 2000.

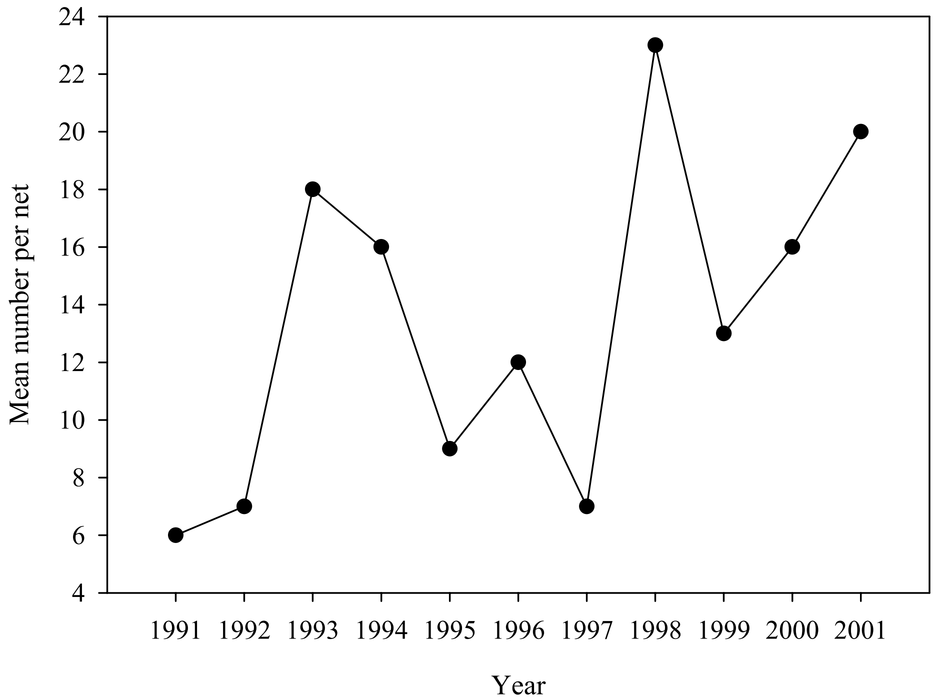

Figure 7. Catch per effort (C/f) of burbot sampled using gill nets in Elk Lake from 1991 to 2001 (adapted from Oswald 2002a).

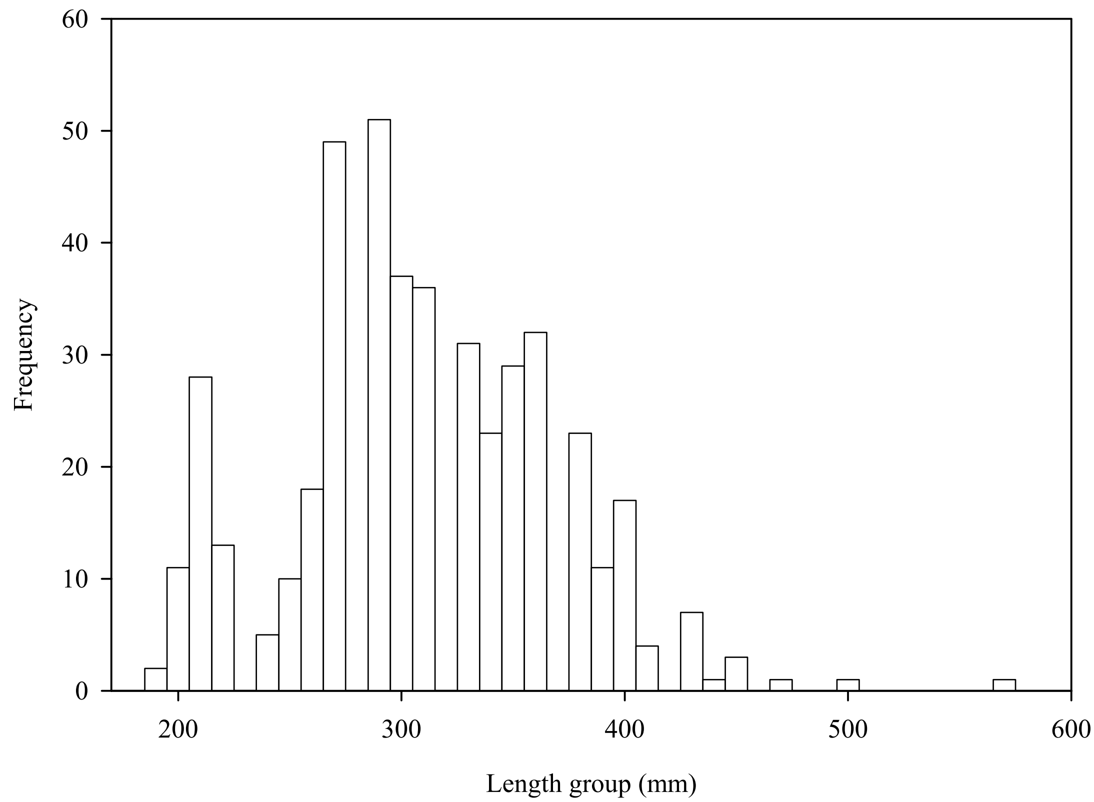

Figure 8. Length-frequency distribution of burbot in Elk Lake from 1991 to 2001 (N = 445) (adapted from Oswald 2002a).

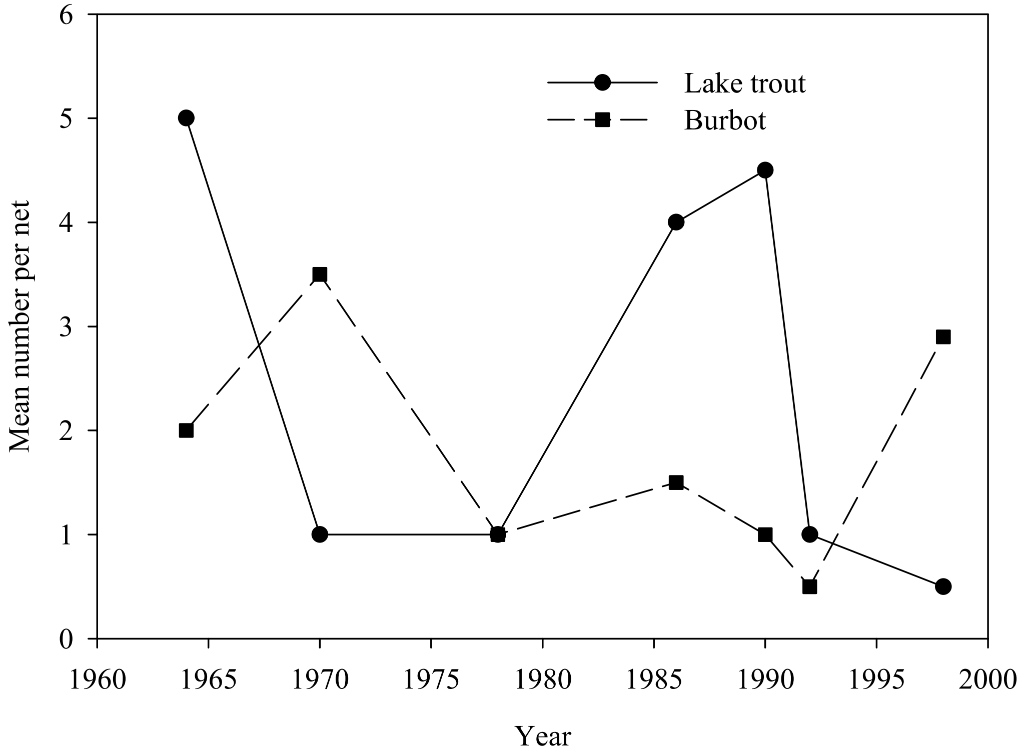

Figure 9. Catch per unit effort of lake trout and burbot in Twin Lakes from 1964 to 1998 (adapted from Oswald 2000a).

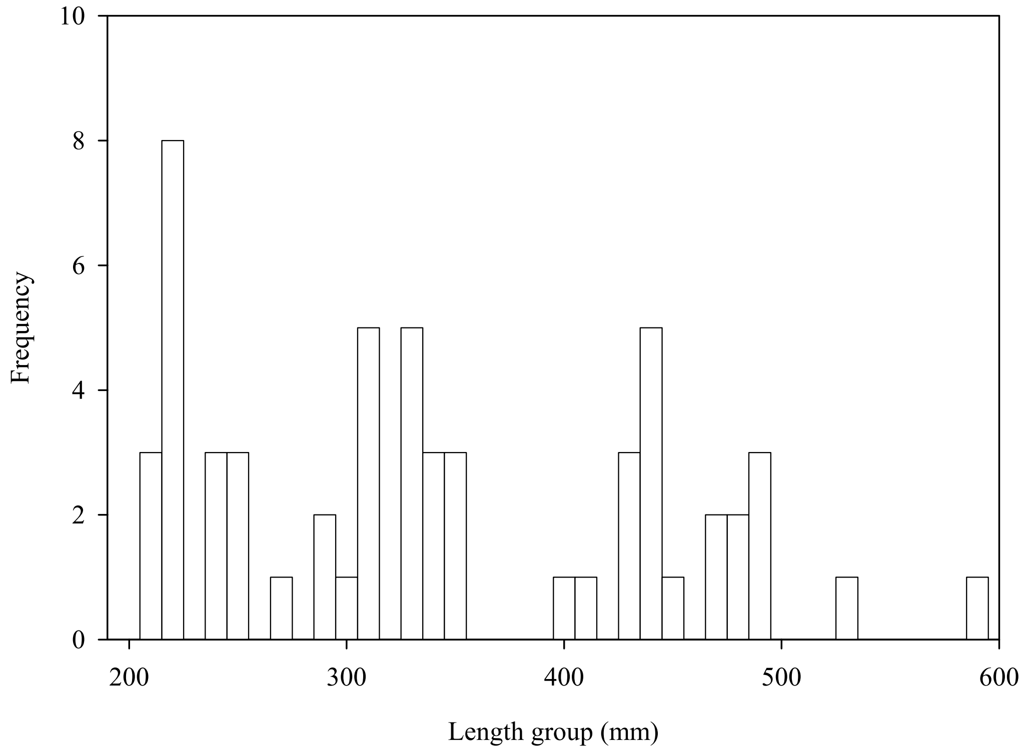

Figure 10. Length-frequency of burbot sampled from Twin Lakes in 1998 (N = 57) (adapted from Oswald 2000a).

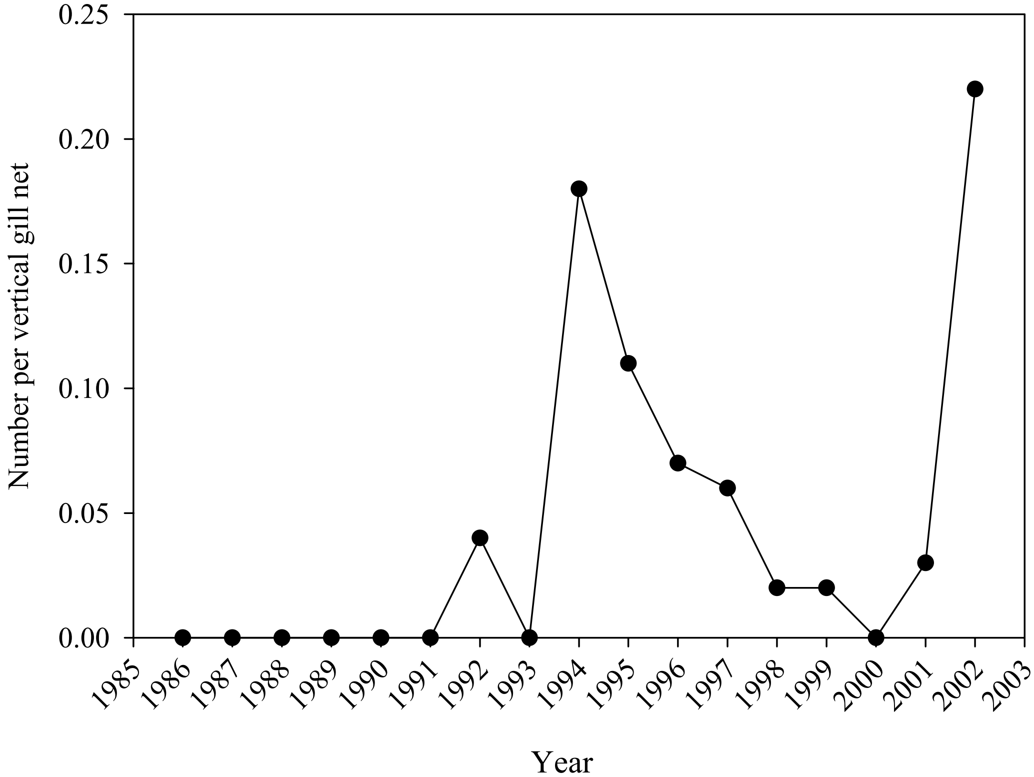

Figure 11. Catch per unit effort (C/f) of burbot in vertical gill nets in Hauser Reservoir during winter from 1986 to 2002.

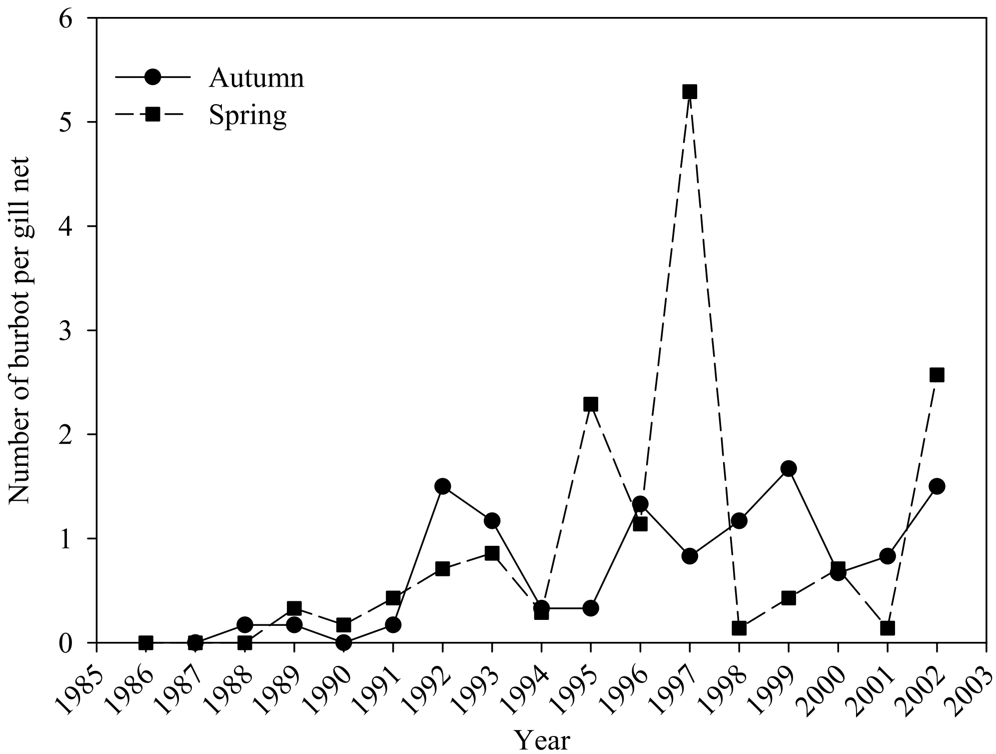

Figure 12. Catch per unit effort (C/f) of burbot sampled using horizontal gill nets in Hauser Reservoir for spring (May) and autumn (October) periods.

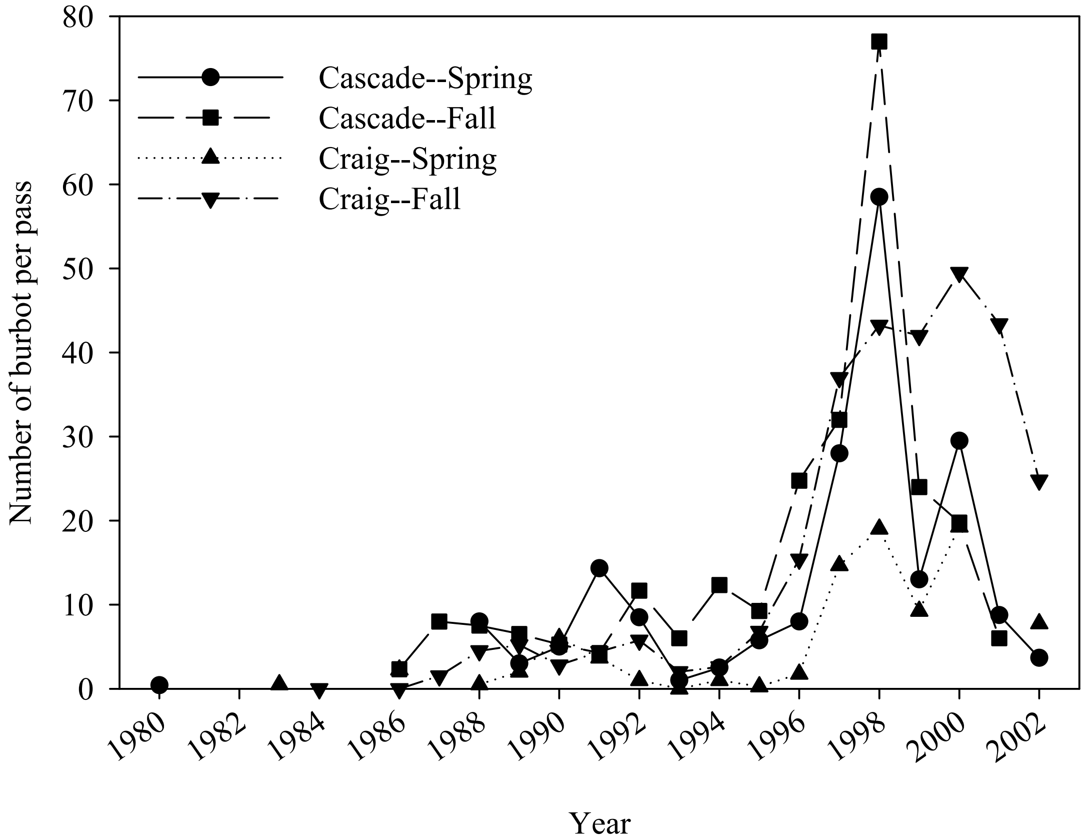

Figure 13. Number of burbot sampled per pass during the spring and autumn from 1986 to 2002 in the Missouri River at the Cascade and Craig reaches.

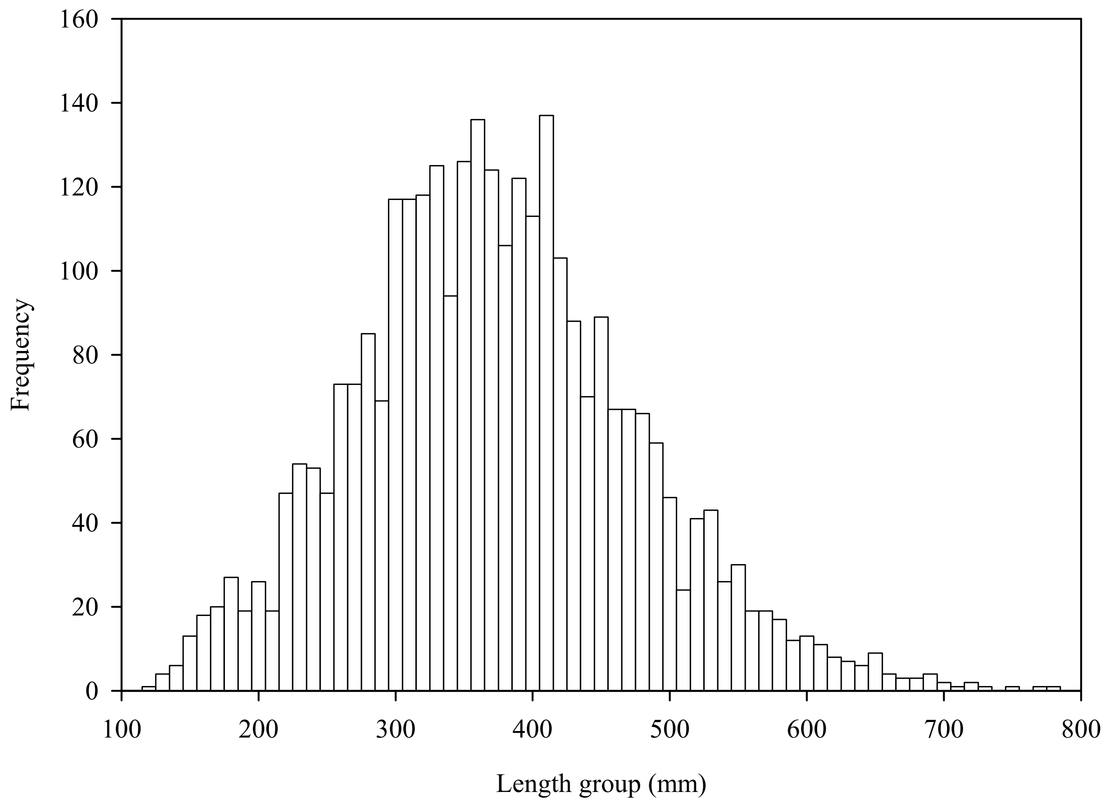

Figure 14. Length-frequency of burbot in the Craig and Cascade sections of the Missouri River from 1983 to 2002 (N = 3,055).

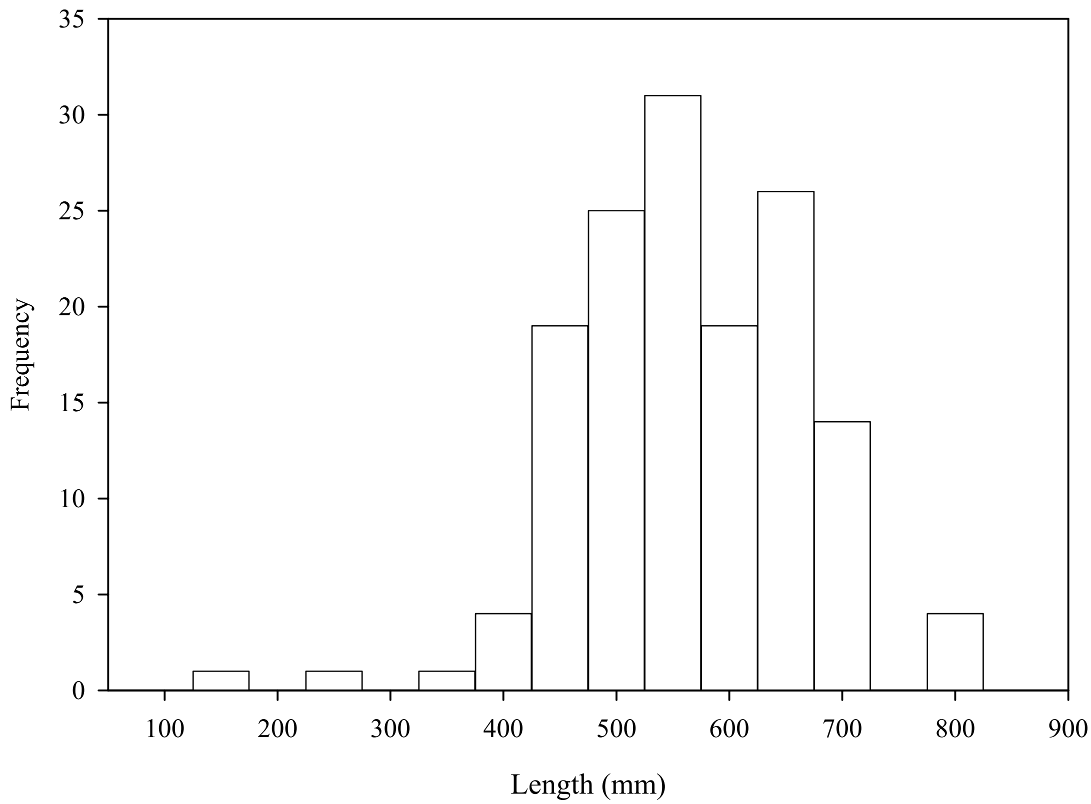

Figure 15. Length-frequency for burbot sampled in Tiber Reservoir from 1994 to 1996.

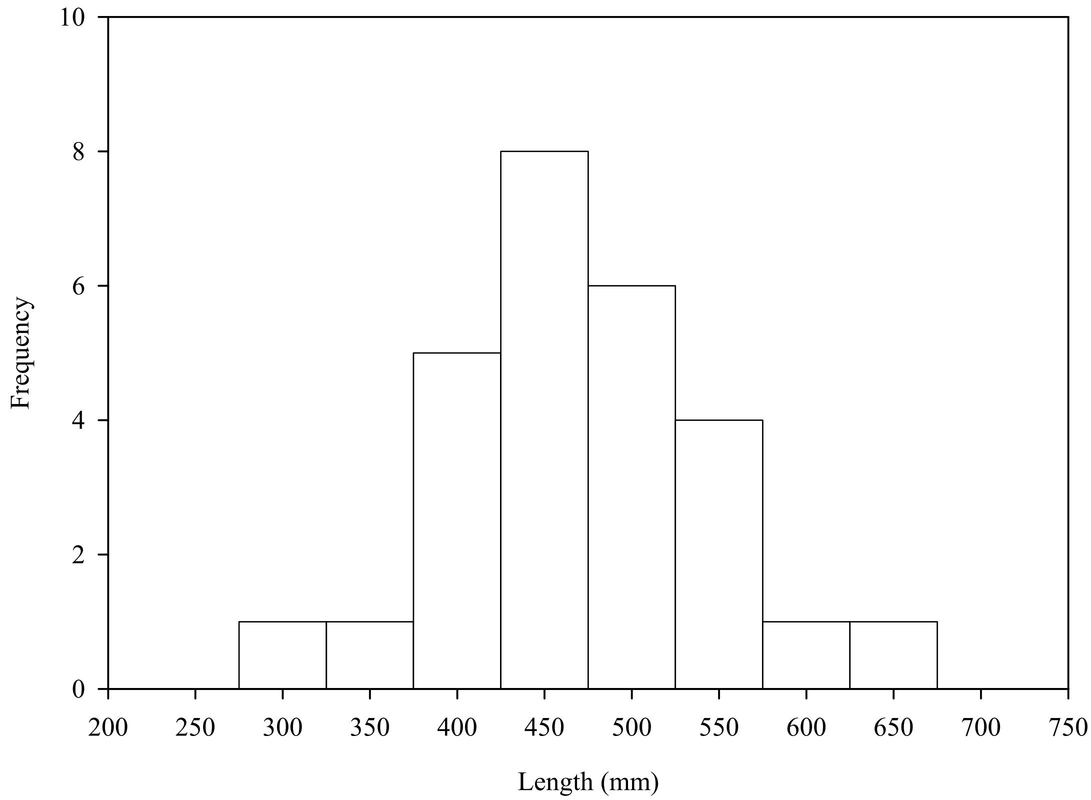

Figure 16. Length-frequency of burbot in the lower Marias River from 2000 and 2002.

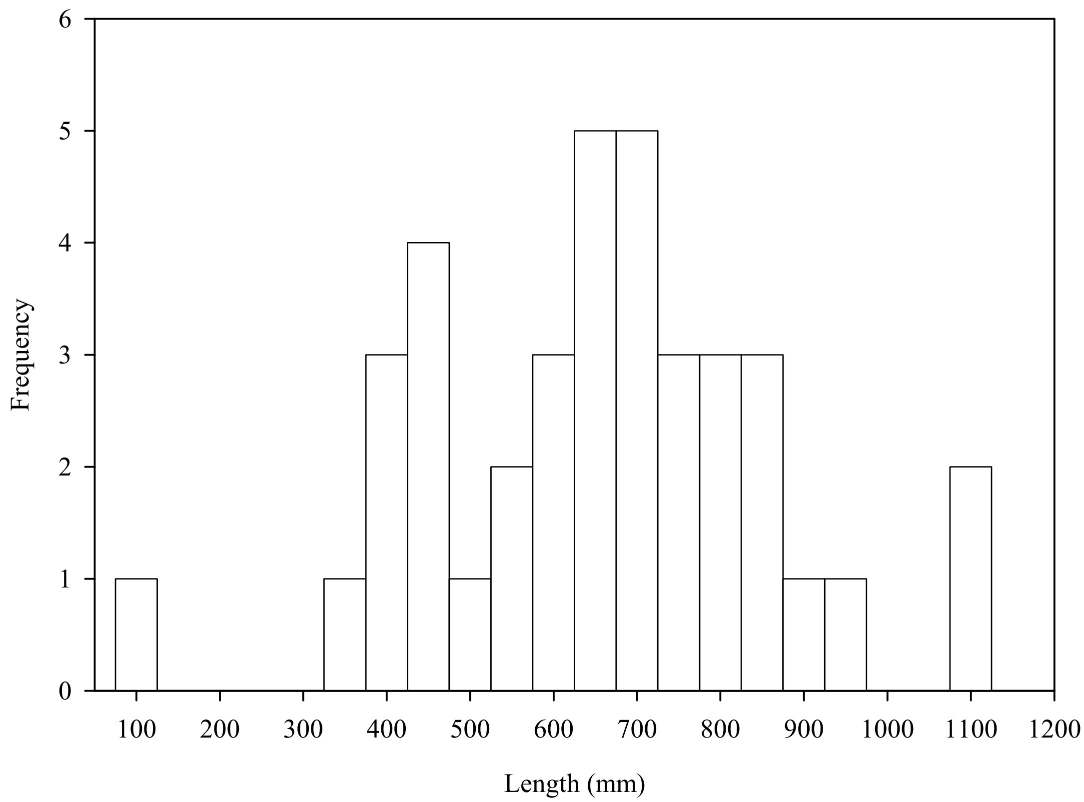

Figure 17. Length-frequency of burbot sampled in the lower Missouri River (Fred Robinson Bridge to headwaters of Ft. Peck Reservoir) from 1994 to 2002.

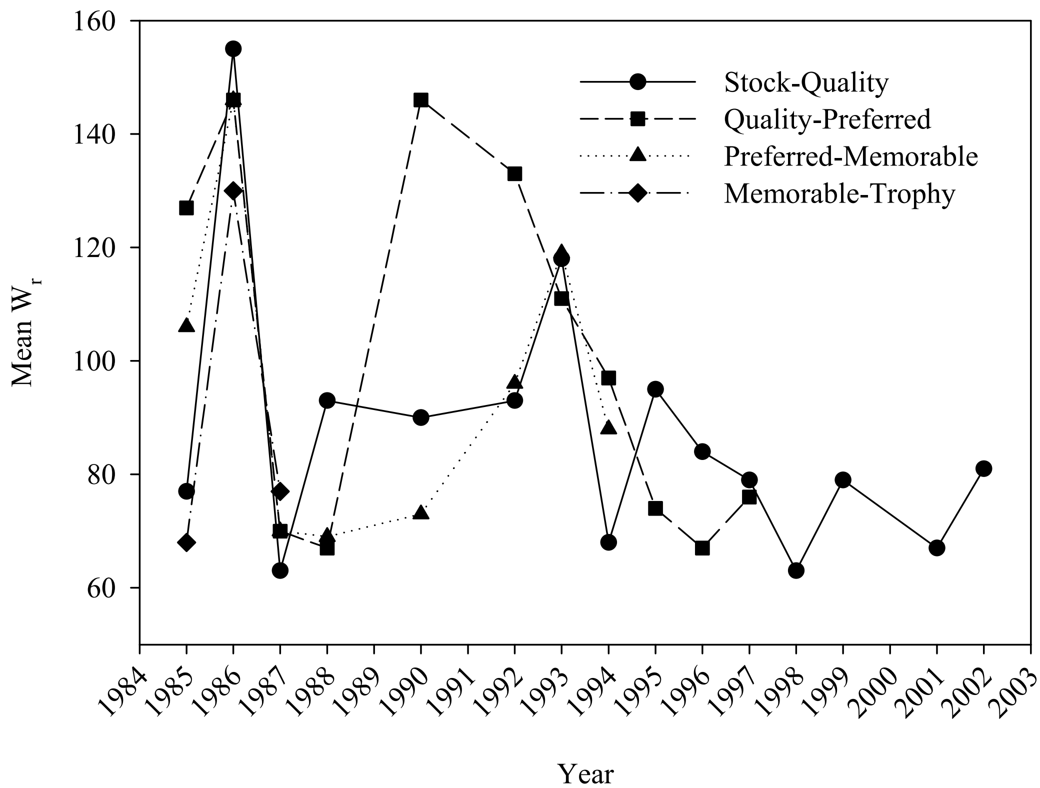

Figure 18. Mean relative weight (W_r) of burbot by length category in the Yellowstone River, 1985–2002.

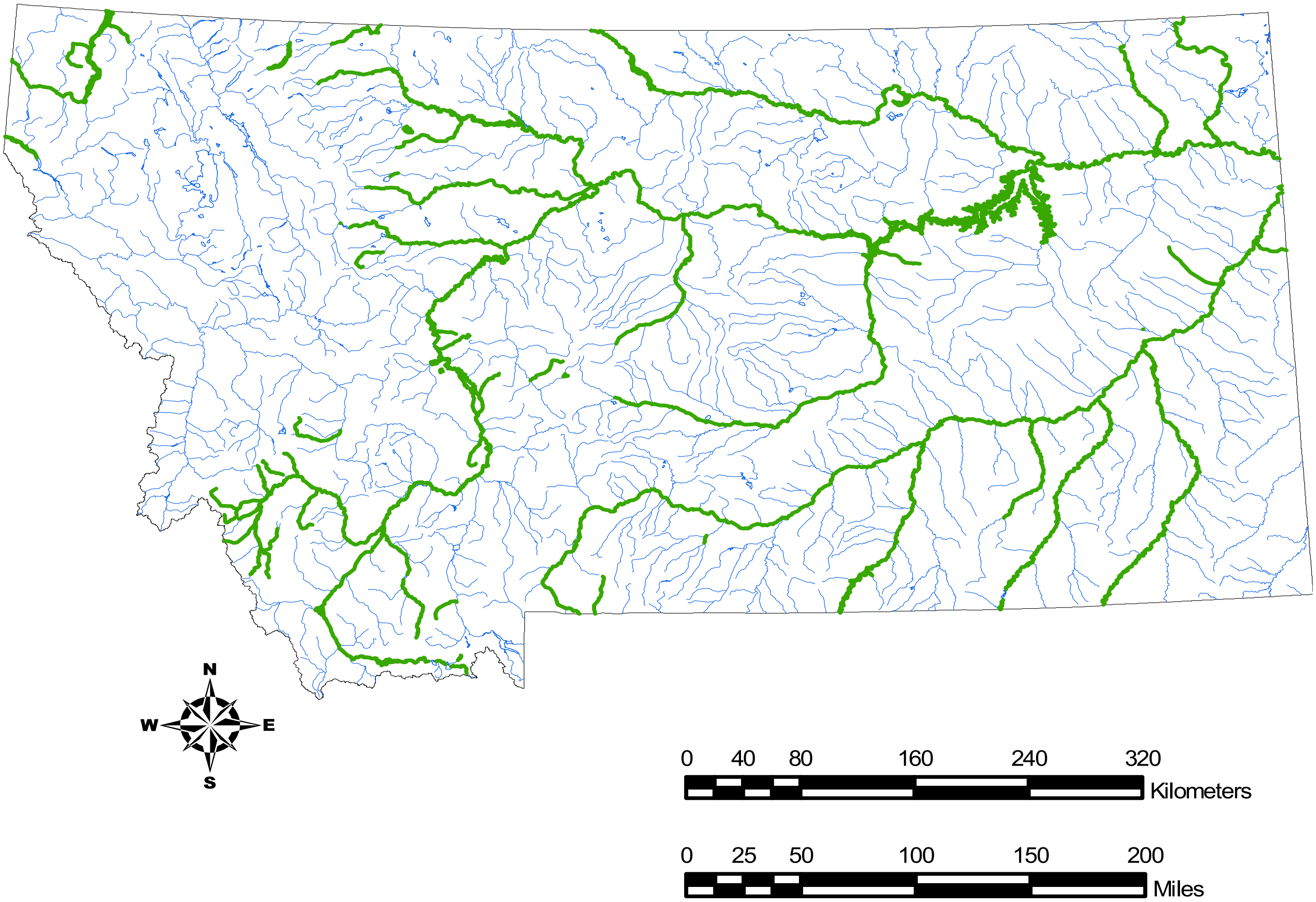

Figure 19. Current distribution of burbot according to the MFISH database (as of March 2004).

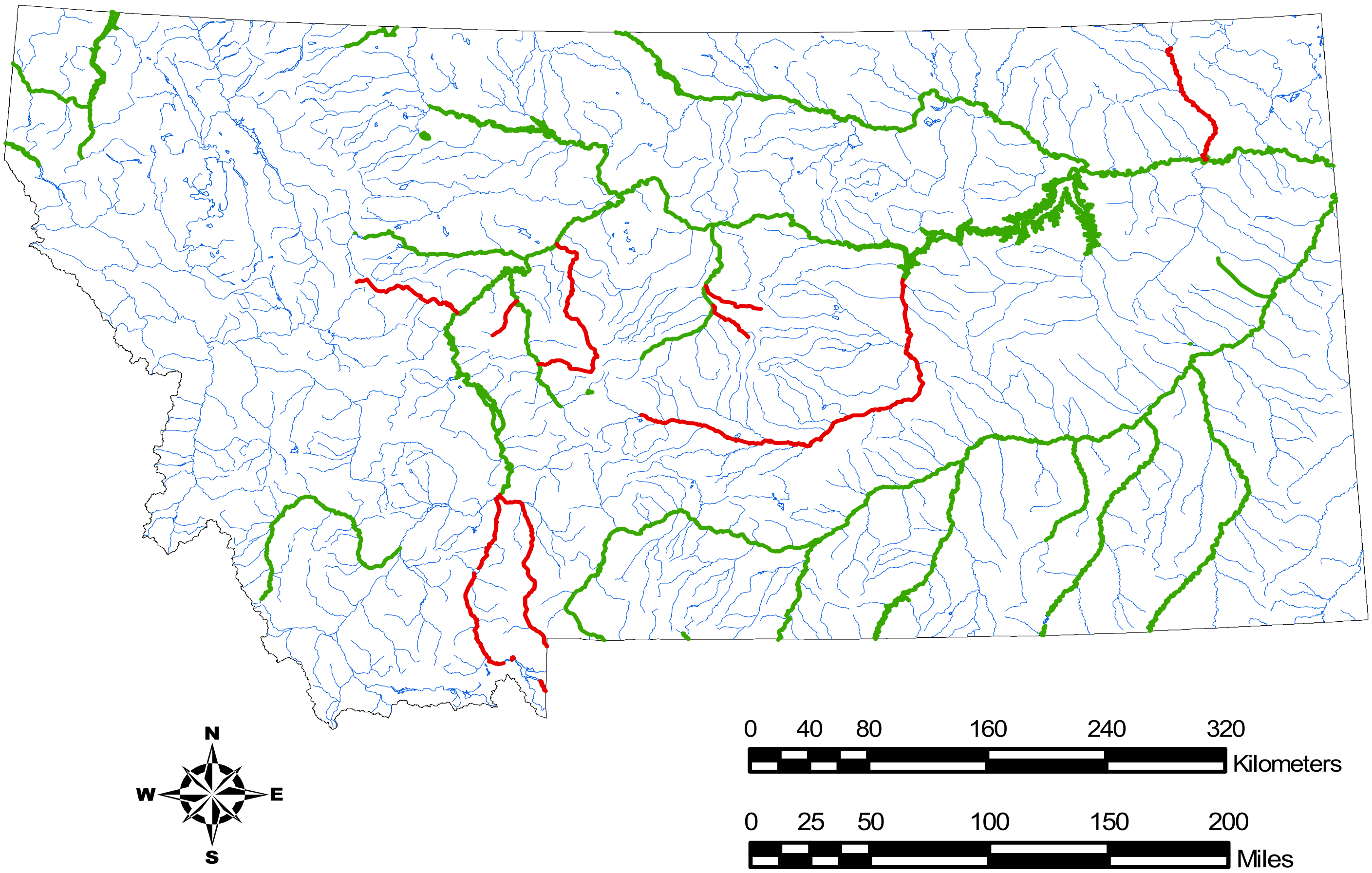

Figure 20. Locations where burbot have been sampled (green lines) and locations where burbot may be found (red lines) according to a survey of state biologists.

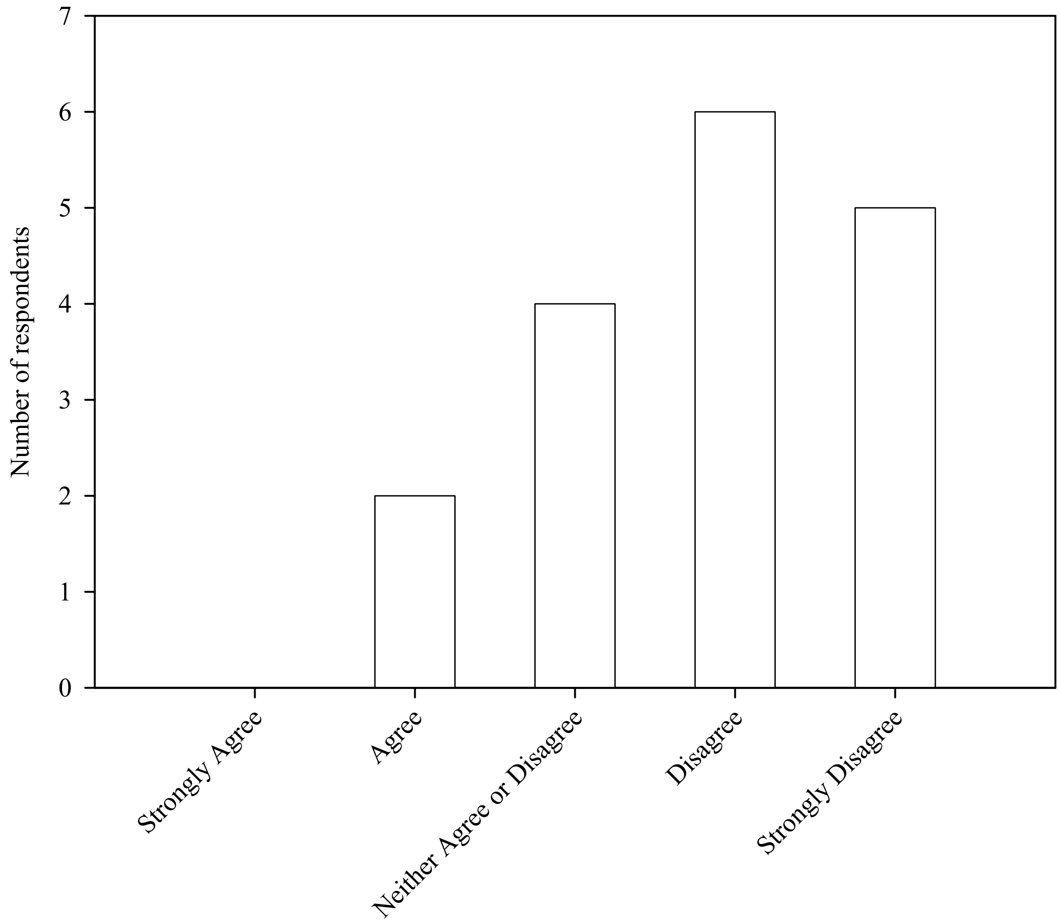

Figure 21. Level of agreement to the statement, “We have adequate data on burbot stocks in my area to make sound management decisions.”

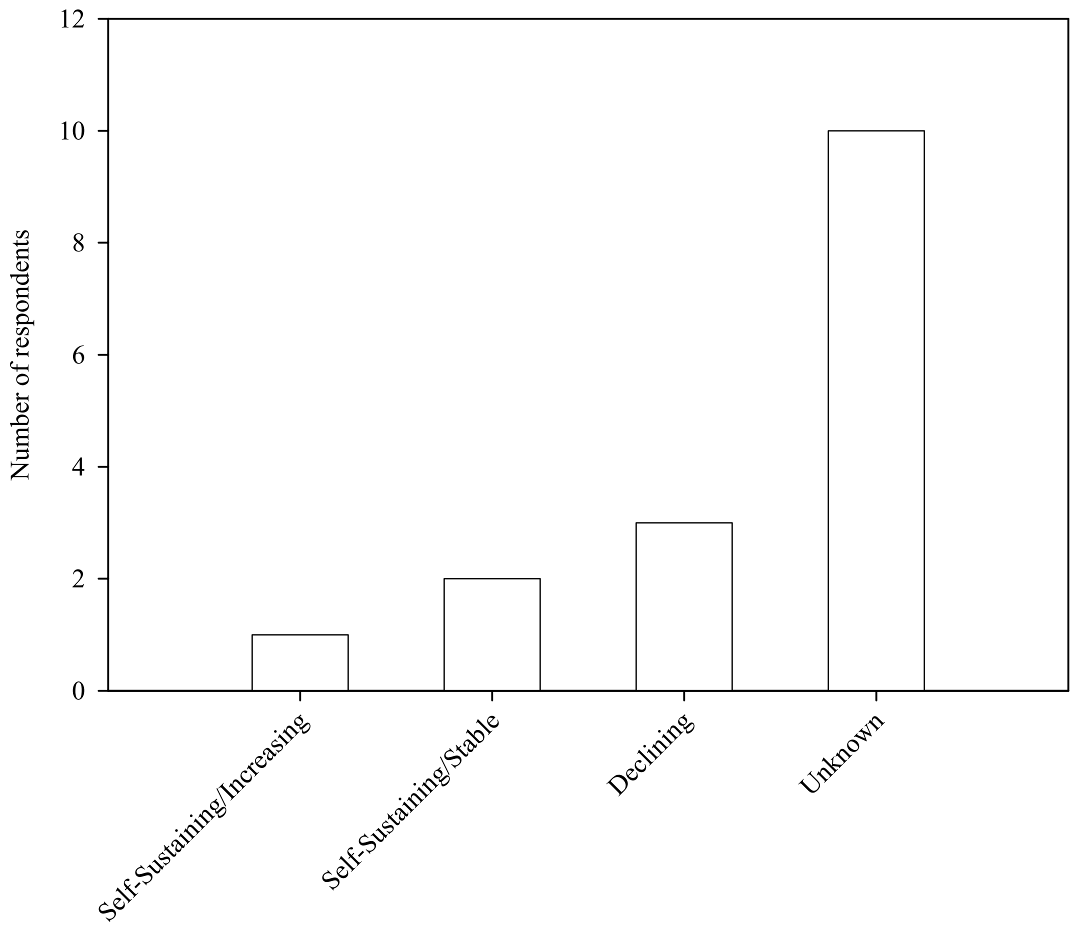

Figure 22. Opinion of state biologists regarding the current status of burbot.

APPENDIX A

Waterbodies that contain burbot according to the MFISH database:

Albers Slough
Anita Reservoir
Beaver Creek (Tributary of Missouri River)
Beaverhead River
Big Creek (Tributary of Kootenai River)
Big Hole River
Big Lake Creek
Big Muddy Creek
Bighorn Lake
Bighorn River
Blue Lake
Bristow Creek
Butler Creek
Cabinet Gorge Reservoir
Canyon Ferry Lake
Clark Canyon Reservoir
Clarks Fork Yellowstone River
Confederate Gulch
Cut Bank Creek
David Creek
Deep Creek
Deer Creek
Dry Fork Marias River
Elk Creek (Tributary of Trail Creek on the North Fork Big Hole River)
Elkhorn Creek
Fishtrap Creek (Tributary of Big Hole River)
Fort Peck Lake
Francis Creek
French Creek
Fresno Reservoir
Governor Creek
Hackett Creek
Hauser Reservoir
Helena Valley Regulating Reservoir
Hell Roaring Creek
Holter Reservoir
Jacobson Creek
Jefferson River
Johnson Creek
Joseph Creek
Judith River
Kootenai River

Lacy Creek
Lake Francis
Lake Helena
Lake Sutherlin
La Marche Creek
Lima Reservoir
Marias River
May Creek
Milk River
Miner Creek
Missouri River
Musselshell River
Mussigbrod Creek
Missigbrod Lake
Nelson Reservoir
North Fork Big Hole River
Old Tim Creek
Pintler Creek
Poplar River
Powder River
Red Rock Creek
Red Rock Lake (Upper and Lower)
Red Rock River
Rock Creek (Tributary of Big Hole River)
Rosebud Creek (Tributary of Yellowstone River)
Ruby Creek
Ruby River
Sandhollow Creek
Seymour Creek
Sheep Creek
Sherburne Lake
Smith River
South Branch Big Swamp Creek
Squaw Creek
St. Mary Lake
Steel Creek
Sun River
Swamp Creek
Teton River
Thompson Falls Reservoir
Tiber Reservoir
Tie Creek
Tobacco River
Tongue River
Trail Creek (Tributary of North Fork Big Hole River)
Twin Lakes

Warm Springs Creek
West Fork Fishtrap Creek
Willow Creek (Tributary of Missouri River)
Wise River
Wyman Creek
Yellowstone River
Young Creek

Waterbodies where burbot have been sampled according to survey of fisheries biologists:

Big Hole River (and tributaries)
Bighorn Lake
Bighorn River
Cabinet Gorge Reservoir
Clark Canyon Reservoir
Clarks Fork Yellowstone River
Deer Creek
Elk Lake
Fisher River
Fort Peck Lake
Fresno Reservoir
Hauser Reservoir
Helena Valley Regulating Reservoir
Holter Reservoir
Judith River
Kootenai River
Lake Francis
Lake Judith
Lake Marias
Lake Koocanusa
Lake Teton
Marias River
Milk River
Miner Lake
Middle Missouri River
Missouri River (below Hauser to 4.6 mi below Holter)
Newlan Creek Reservoir
Powder River
Red Rock Lake (Upper and Lower)
Rosebud Creek (at confluence with Yellowstone River)
Smith River
Sun River
Sutherlin Reservoir
Tiber Reservoir
Tongue River

Triangle Pond
Twin Lakes
Wadsworth Pond
Yellowstone River
Young Creek

Waterbodies that may contain burbot according to survey of fisheries biologists:

Belt Creek
Big Spring Creek (Lower)
Dearborn River
Gallatin River (at Missouri headwaters)
Highwood Creek
Hound Creek
Lower Beaverhead Valley Sloughs
Madison River (at Missouri headwaters)
Milk River
Mill Coulee Creek
Musselshell River (Lower)
Poplar River
Sheep Creek
Tenderfoot Creek (below falls)
Warm Spring Creek

APPENDIX B

Biologist Survey For Status Assessment of Burbot

Questions Regarding Management of Burbot:

1.) Please list the rivers or lakes in your <u>Area</u> (Region 1) where burbot have been sampled (if more than 10 please use the back of the page):

1.	**2.**
3.	**4.**
5.	**6.**
7.	**8.**
9.	**10.**

2.) Please list the rivers or lakes in your <u>Area</u> that might contain burbot but have not been sampled (if more than 10 please use back of the page):

1.	**2.**
3.	**4.**
5.	**6.**
7.	**8.**
9.	**10.**

3.) From the list in question 1, please list the waters where you specifically sample burbot to obtain their population status or check the appropriate box below.

- ❑ **All**
- ❑ **None**

1.	**2.**
3.	**4.**
5.	**6.**
7.	**8.**
9.	**10.**

4.) If you specifically sample for burbot, what gear or gears do you use (check all that apply)? (If you don't sample for burbot skip to question 5).

- ❑ **Electrofishing**
- ❑ **Trap nets**
- ❑ **Gill nets**
- ❑ **Hoop nets**
- ❑ **Other (please list):**

5.) Select your level of agreement with the following statement: We have adequate data on burbot stocks in my Area to make sound management decisions.

- ❑ **Strongly agree**
- ❑ **Agree**
- ❑ **Neither agree or disagree**
- ❑ **Disagree**
- ❑ **Strongly disagree**

6.) What is your opinion regarding the current status of burbot in your Area (check one)?

- ❑ **Stocks are self-sustaining and increasing (If you check here, skip to question 9)**
- ❑ **Stocks are self-sustaining and stable (If you check here, skip to question 9)**
- ❑ **Stocks are declining. (If you check here, go to Question 7).**
- ❑ **Unknown (If you check here, skip to question 9)**

7.) In your opinion, rank the following potential reasons for the decline in burbot stocks in your Area (1 = most important, 5 or 6 = least important).

___ **Overharvest**
___ **Climate changes**
___ **Modified temperature and flow regimes as a result of reservoir management**
___ **Loss of suitable spawning habitat**
___ **Water withdraw for irrigation**
___ **Other (Explain):**

8.) In your opinion, rank the following items that may lead to enhancing burbot stocks in your Area (1 = most important, 5 or 6 = least important).

___ **Reducing overharvest**
___ **Modified temperature and flow regimes as a result of reservoir management**
___ **Increasing suitable spawning habitat**
___ **Reducing water withdraw for irrigation**
___ **Other (Explain):**

9.) Do you actively manage for burbot in your Area (if Yes, go to Question 10, otherwise proceed to Question 11)?

- ❑ **Yes**
- ❑ **No**

10.) Please list three of your management goals for burbot.

1.____

2.____

3.____

Questions Regarding Public and Angler Opinions:

11.) In your opinion, how are burbot viewed in your <u>Area</u> by the general public (check one)?

- ❑ **They are a species that has little value and interferes with the management of other game species**
- ❑ **Burbot are valuable and MTFWP should manage to enhance their populations**
- ❑ **No opinion, most people do not know a burbot is a fish**

12.) How do anglers view burbot in your <u>Area</u> (check one)?

- ❑ **Burbot are a popular game fish**
- ❑ **Burbot are somewhat a popular game fish**
- ❑ **Anglers have a negative opinion of burbot as a game fish**
- ❑ **Anglers appear to have neither a favorable nor a negative opinion of burbot**

13.) What is the trend in recreational burbot fishing in your <u>Area</u> in the past 10 years?

- ❑ **There is no burbot recreational fishing in this area. (If you checked here, please skip Questions 16.)**
- ❑ **Recreational burbot fishing has become more popular.**
- ❑ **Recreational burbot fishing has become less popular.**
- ❑ **Interest in recreational burbot fishing has neither increased nor decreased.**

14.) In which seasons are burbot fished for the most? Rank in order (1 = most popular, 4 = least popular).

___ **Winter**
___ **Spring**
___ **Summer**
___ **Fall**

15.) How important (i.e., to the local economy, angler draw, culture, etc.) are burbot to the local area?

- ❑ **Very important**
- ❑ **Somewhat important**
- ❑ **Not very important or of little importance**
- ❑ **No importance at all**

16.) Is there any other information that you would like to share with us that you believe is important for this status assessment?