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Biology, Distribution and Management of Burbot (*Lota lota*) in Washington State

Abstract

There are recent concerns that burbot stocks have been declining in some Northwestern states and Canadian Provinces. Therefore, we investigated the distribution, status and management history of burbot stocks in Washington, and compared their growth, condition, and life history characteristics with those in other regions. Eleven stocks of burbot occurred in eastern Washington, primarily in large, deep lakes and reservoirs of the upper Columbia and Yakima River watersheds. Status of three stocks was known: the Lake Roosevelt burbot stock has increased; the Palmer Lake stock has declined; and the non-indigenous stock in Banks Lake may be extinct. Average growth rate of age 1-10 burbot from four Washington lakes was slower than that in Midwestern states, but similar to that in Alaska, Northern Canada, and Wyoming. Washington burbot over age 10 grew at slower rates than those in all other regions. Average relative weight of Washington burbot was similar to that in reservoirs in other areas of the country, but less than that of lake populations in those other areas. We reported available harvest rates of Washington burbot, but there was insufficient information to determine what impact angler harvest has on most Washington populations.

Introduction

Burbot (*Lota lota*), also known as freshwater ling, is the only freshwater member of the cod family (Gadidae). Burbot are found in fresh and brackish water in northern temperate regions worldwide (Carlander 1969). In North America, burbot are found across the northern United States and Canadian provinces, from Alaska and Labrador south to Oregon, Wyoming, and Connecticut (Wydoski and Whitney 1979). Washington State is near the southern limit of burbot distribution on the west coast of North America, and the species contributes to important recreational fisheries in a few Washington waters.

Recreational burbot catch declined in some British Columbia, Idaho, and Montana waters during the 1980's (McPhail 1997). Burbot declines have been attributed to commercial and recreational overfishing, (Christie 1972, Christie 1974, Parker et al. 1987), hydropower (Paragamian 1995, McPhail 1997), pollution (Christie 1974) and competition with other species of fish (Christie 1974, Carl 1992). We compiled available information on Washington burbot stocks to determine if similar declines had occurred and to gain a better understanding of their status.

Approach

Data on Washington's current and historical burbot distribution and abundance were obtained from: (1) Washington Department of Fish and Wildlife (WDFW) creel, set-line, and gill net surveys conducted statewide between 1965 and 1996; (2) Eastern Washington University and tribal surveys conducted in Lake Roosevelt from 1988 to 1996; (3) historical records from the Washington State Archives and the Washington State Library; and (4) unpublished data and interviews with State, University and Federal fisheries biologists. Depth, size, elevation, and trophic state of Washington lakes containing burbot was obtained from Wolcott (1973), Dion et al. (1976) and Sumioka and Dion (1985). The management history of Washington's burbot fisheries was obtained from state fish and wildlife regulations between 1922 to 1995. Additionally, Washington State Archives were consulted for transcripts of State Department of Game Commission meetings addressing burbot issues.

We defined burbot stocks as those groups occurring in individual lakes and reservoirs that were reproductively isolated (Bonar et al. 1997). Origins of stocks (i.e. transplanted or native) were determined through interviews with Federal, State, Local and Tribal biologists, and compilations of historical data from the WDFW and state archives. Status of individual burbot stocks was rated using a four category system developed for Washington salmon stocks (Washington Department of Fisheries et al. 1993, Washington Department of Fish and Wildlife 1997, Bonar et al. 1997). These categories were: (1) healthy—those characterized by increasing or stable long- or short-term abundance, stable condition and stable growth over a 5-10 year period; (2) depressed—those exhibiting a declining trend of abundance, average size or any other factors related to fitness, but declines were above the level where permanent damage to the stock was likely; (3) critical—those experiencing production levels that were so low that permanent damage to the stock was likely or had already occurred; and (4) unknown—those where less than 5-10 years of abundance information was available to rate status.

Biological data on selected stocks were obtained from WDFW creel and set line surveys conducted between 1981 and 1996. Growth of Washington burbot in Chelan, Palmer, Kachess, and Cle Elum Lakes was determined using whole or sectioned otoliths following DeVries and Frie (1996). Relative weights (W_r, Wege and Anderson 1978) of burbot in each lake were determined by dividing the weights of burbot captured in the lake by the standard weight (W_s) of burbot for that length as established by Fisher et al. (1996). Analysis of variance was used to compare growth and condition among lakes in Washington and other regions.

Current Distribution and Habitat

Washington burbot populations probably originated from dispersion of fish from the southern unglaciated portion of the Columbia River basin following the last (Fraser) glaciation, approximately 17,000-13,000 years B.P. (McPhail and Lindsey 1986). Only northern lakes and reservoirs in Washington are known to currently contain burbot and expansion of this species to more southerly regions may be limited by high water temperatures (McPhail and Lindsey 1986).

Eleven Washington lakes and reservoirs in the northern Columbia River drainage, the upper Yakima River drainage, and the Pend Oreille region are known to contain burbot (Figure 1). No burbot have been documented in western Washington, although they inhabit the Skeena River and Nass River drainages in western British Columbia (McPhail and Carveth 1992).

Although there have been sporadic reports of burbot in other Washington waters, there was not enough information to designate these as stocks. Diamond Lake in Pend Oreille County may have contained a small burbot stock prior to 1959, but a piscicide (rotenone) was used to eliminate all fish. One burbot was recovered in 1987 following a subsequent treatment. Isolated "sightings" of burbot were made in canals and seep lakes of the Columbia Basin soon after the irrigation systems were constructed in the 1950's (M. Spence, WDFW unpublished data). To our knowledge, there have been no recent reports of burbot in these systems. Four burbot were captured in Wells and Rocky Reach Reservoirs in 1993. These fish may have been migrants from other areas or came from distinct populations within these systems (Burley and Poe 1994).

Lakes and reservoirs currently containing burbot in Washington are large, ranging from 291 to 31,995 ha, and deep (8 of 11 are over 30 m; Table 1). Of the eight lakes and reservoirs containing burbot where trophic status was measured, five were oligotrophic. They are located at a wide range of elevations, from 280 m to 877 m above sea level, but most tend to be at elevations greater than 600 m.

The habitat burbot use within lakes and reservoirs in Washington is similar to that used in other areas. Burbot tend to inhabit deep water in the southern parts of their range (Robins and Deubler 1955), especially in summer. In our study, burbot were captured at depths of 31-52 m in Lakes Cle Elum, Kachess and Keechelus using set lines; at depths of 25-31 m in Sullivan Lake by jig anglers;

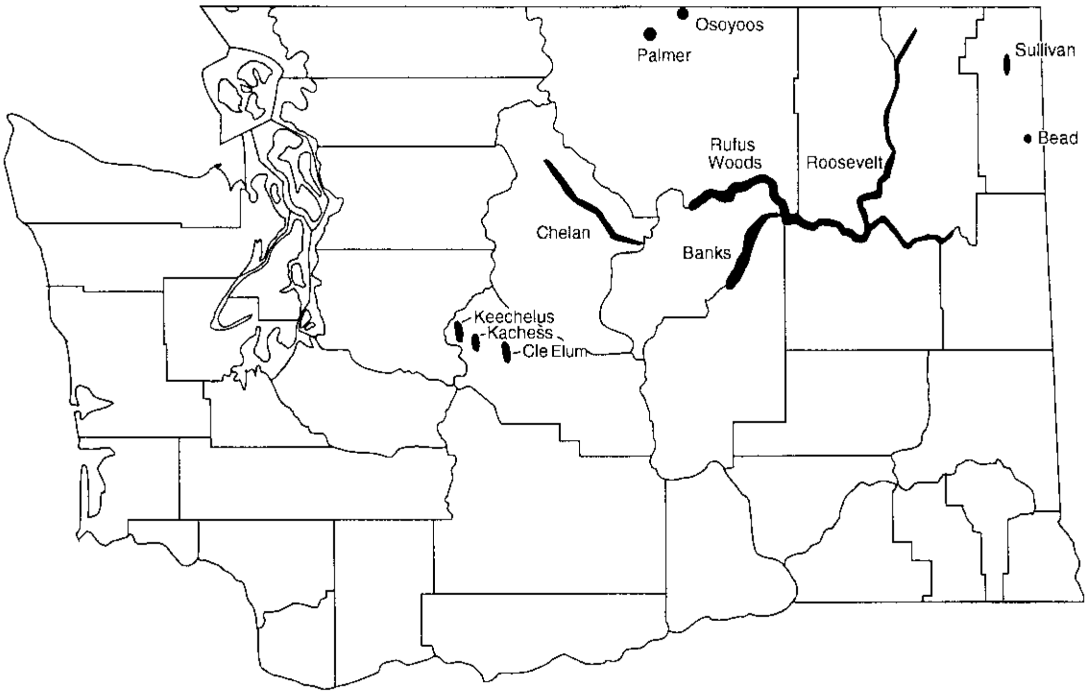

Figure 1. Locations of Washington lakes containing burbot.

TABLE 1. Stock origin, elevation, maximum depth, size and secchi depth trophic state index (TSI) of lakes in Washington where burbot have been captured. Generally, a TSI of >50 is eutrophic, from 40-50 is mesotrophic and <40 is oligotrophic. Trophic state index data was obtained from Sumioka and Dion (1985) and Dion et al. (1976).

Lake	County	Stock Origin	Elevation (m above msl)	Max Depth (m)	Size (ha)	TSI
Banks	Grant	non-indigenous	480	26	10,085	50
Bead	Pend Oreille	indigenous	877	52	291	-
Chelan	Chelan	indigenous	342	494	13,486	28
Cle Elum	Kittitas	indigenous	684	43+	1,948	29
Roosevelt	Stevens, Ferry, Lincoln, Okanogan, & Grant	indigenous	396	115	31,995	-
Kachess	Kittitas	indigenous	694	18+	1839	25
Keechelus	Kittitas	indigenous	774	28+	1037	29
Osoyoos	Okanogan	indigenous	280	63	2,320	45
Palmer	Okanogan	indigenous	352	28	836	47
Rufus Woods	Douglas & Okanogan	unknown	291	58	3,159	-
Sullivan	Pend Oreille	non-indigenous	795	96	559	37

and at depths up to 61 m in Lakes Chelan, Cle Elum, Kachess, Keechelus and Sullivan using gill nets. During winter, burbot often move into shallow water (Bergersen et al. 1993). An intense recreational fishery for burbot occurred in shallow lagoons of Banks Lake during winter in the 1950s and 1960s when burbot were captured through the ice.

Life History

Reproduction

Burbot can either spawn in lakes (Hewson 1955, Robbins and Deubler 1955, Becker 1983, Carl 1992) or rivers (Robins and Deubler 1955, Breeser et al. 1988). In Washington, burbot evidently spawn in lakes and reservoirs except for some Lake

Roosevelt fish that spawn in a flowing section of the Columbia River near the Canadian border (A. Scholtz, Eastern Washington University unpublished data).

Burbot mature at the same rate or more slowly in Washington compared to other regions, depending on the stock. Burbot matured in Lake Cle Elum at 2-4 years (28-43 cm TL). In Palmer Lake, all mature males were six years or older and mature females seven years or older (54 and 64 cm TL, respectively; K. Williams, WDFW unpublished data). Most burbot matured at 3-4 years of age in three Wyoming lakes (Miller 1970), and two years in Lake Winnipeg (Hewson 1955).

Burbot spawn in the winter or early spring in most areas (Cahn 1936, Hewson 1955, Robins and Deubler 1955, Miller 1970, Scott and Crossman 1973), including Washington. Burbot in spawning condition were collected from the Columbia River between mid-February and mid-March (A. Scholtz, Eastern Washington University unpublished data). During the 1950's and the 1960's, the Banks Lake fishery was at its height in late winter in shallow lagoons where burbot were aggregating, reportedly to spawn (M. Spence, WDFW unpublished data). However, two ripe females and one ripe male were captured in WDFW gill net surveys of Lake Chelan during late June, considerably later in the season than usually recorded.

Feeding Habits, Growth, and Condition

Little information is available on growth, condition, and feeding habits of young-of-year burbot of Washington. Burbot fry hatch from early to late spring in other areas (Carl 1992, Ryder and Pesendorfer 1992, Ghan and Sprules 1993). The diet of young-of-year burbot includes amphipods, copepods, and cladocerans (Ryder and Pesendorfer 1992, Ghan and Sprules 1993). Growth during the first five months averaged 16 mm per month in Shebandowan Lake, Ontario (Ryder and Pesendorfer 1992) and burbot grew from 3.2 to 15.0 mm over a 41-day period in Oneida Lake, New York (Ghan and Sprules 1993).

Diet of adult burbot in Washington is similar to that in other areas, where fish can be an important component (Clemens 1951, Hewson 1955, Lawler 1963, Wagner 1972). In Lake Roosevelt, adult burbot preyed on stocked kokanee (*Oncorhynchus nerka,* A. Scholtz, Eastern Washington University unpublished data). Walleye (*Stizostedion vitreum vitreum*), tethered on lines during a hooking mortality study, were also preyed upon heavily by burbot (Bruesewitz et al. 1996). Stomach contents of burbot collected from other Washington lakes have included peamouth (*Mylocheilus caurinus*), smallmouth bass (*Micropterus dolomieui*), kokanee, rainbow trout (*Oncorhynchus mykiss*, K. Williams, WDFW unpublished data) and Mysids (*Mysis relicta,* Brown 1984; P. Mongillo, WDFW unpublished data).

Average growth of burbot has been estimated for only four Washington lakes. Because of this low sample size, statistical tests used to compare growth in Washington with that in other regions were not powerful enough ($1 - \beta < 0.40$ for all ages) to be meaningful. However, average growth rate of Washington burbot less than 10 years old appears slower than that in the Midwestern states and Canadian provinces, but similar to that in Alaska, northern Canada, and Wyoming (Figure 2). Washington burbot over age 10 also grew at slower rates than those in all other regions. Within Washington, Palmer Lake burbot grew most rapidly, followed by those in Cle Elum and Kachess lakes that had similar growth rates ($P < 0.05$ for lengths at ages 3-9). Growth rates of Lake Chelan burbot appeared similar to those in Cle Elum and Kachess, but this could not be tested since only

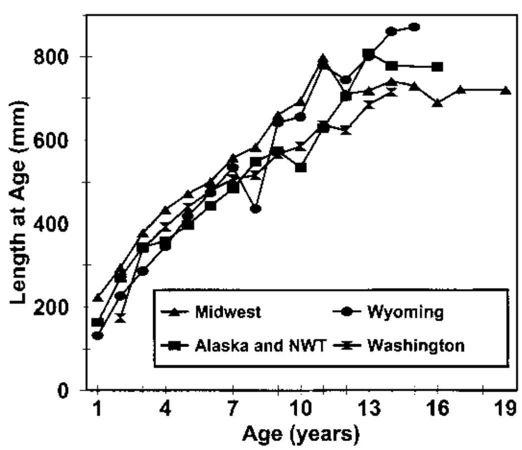

Figure 2. Comparison of mean length at age of lacustrine burbot collected from Midwestern North America (Lawler 1963; Carlander 1969; Bruesewitz 1990) Alaska and the Northwest Territories (Carlander 1969; Parker et al. 1987), Wyoming (Miller 1970), and Washington state.

mean length at age was available for this lake (Figure 3).

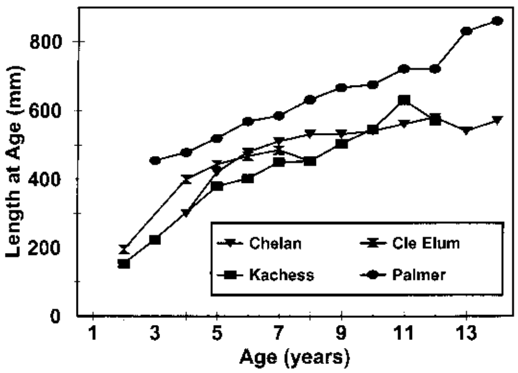

Figure 3. Mean length at age of burbot from four Washington lakes.

Average relative weights for burbot (Fisher et al. 1996) ranged from 43-93 in Washington, with most values in the 80's. These are lower than those usually recorded in large and small North American lakes (approximately 100) but similar to North American riverine and reservoir populations (approximately 80) (Fisher et al. 1996).

The oldest burbot recorded from Washington to date, 19 yr. (741 mm TL), was captured in a gill net in Keechelus Lake. Forty percent of the few fish sampled from this lake were over 10 years old (P. Mongillo, WDFW unpublished data). Burbot over 10 yr. old have been common in catches from other Washington waters. The current state record burbot was caught in January 15, 1993 from Palmer Lake. At a weight of 7.72 kg, its size was impressive, but smaller than some fish reportedly caught from the same lake decades earlier (Meigs 1940).

Status of Individual Stocks

Eight Washington burbot stocks are considered indigenous, two were introduced and the origin of one is unknown (Bonar et al. 1997, Table 1). Of these stocks, we rated one critical (Banks), one depressed (Palmer), one healthy (Roosevelt), and the rest unknown.

Banks Lake, originally known as the "Equalizing Reservoir", appeared to be the only Washington lake where a burbot stock has collapsed. The cause of this collapse was unknown. However this stock was not considered indigenous because the fish likely colonized the lake in the 1950's from Lake Roosevelt. Banks Lake, a 10,085 ha reservoir, was constructed from dams at the north and south ends of Grand Coulee. Water was first pumped into Banks Lake from Lake Roosevelt in the spring of 1951 inundating several small lakes that were already present. Burbot appeared soon after in both the reservoir and adjacent canals (M. Spence, WDFW unpublished data), and fisheries soon followed. In 1965, total burbot catch in Banks Lake was estimated to be 3,250 fish (Spence 1965, cited in Duff 1972). However, the number of burbot in the fishery catch declined 91.6% by 1971-72 to 273 fish (Duff 1972). By the late 1970's, no burbot were reported from the lake. Various explanations have been given for this decline including overfishing; reductions in prey abundance, competition with introduced walleye, and changes in water quality (Bonar et al. 1997). In May, 1988, 192 burbot, averaging 0.6 kg/fish, were transported from Red Rock Reservoir in Montana and stocked into the lake. However, no burbot have been reported in angler catches as of 1999.

The abundance of burbot in Palmer Lake also declined. Angler catch per effort of burbot in the lake was 0.847 fish per angler hour in 1984 and declined to 0.261 fish per angler hour by 1995 (K. Williams, WDFW, unpublished data; F. Bender, unpublished data). High angler harvest and an increase in the abundance of competing smallmouth bass have been cited as possible reasons for the decline.

Burbot were thought to have been introduced into Sullivan lake, a 559 ha natural lake in Pend Oreille county. Burbot appeared in the creel between 1992 and 1994, and a substantial fishery developed. In the winter of 1995, anglers frequently captured 0.9 -1.4 kg burbot with occasional 4.5 kg fish at depths of 25-30 m. No data were available to evaluate population trends in the lake.

Burbot populations in Lake Roosevelt have increased (Underwood and Shields 1996, A. Scholtz, Eastern Washington University unpublished data). Electrofishing catch per effort (CPE) of burbot increased from 0.009 fish/min in 1988 to 0.040 fish/min in 1996. Gill netting CPE of burbot increased from 0.003 fish/hr in 1988 to 0.180 fish/hr in 1996.

Other than these lakes and reservoirs, limited information was available to assess the health of burbot populations. The status of most burbot stocks is still unknown.

Factors Affecting Distribution and Abundance

Harvest History and Management

We found no references to burbot in studies of early Washington tribal fisheries (Ruby and Brown 1970, Horr 1974, Boas and Teit 1985, Chance 1986, Hunn 1990). European settlers first reported burbot from lakes that currently contain the species. Evermann (1899) reported that burbot were occasionally captured in Lake Chelan before the turn of the century and attained lengths of 77 cm and weighed 5.4 kg or more. Mr. C. Robinson of Chelan found a large fish floating in the lake of total length 81 cm, and reported it to the U.S. Fish Commission. Evermann (1899) identified this fish as a burbot based on the description, and reported that it was one of the largest known at that time.

R.C. Meigs (1940) of the Washington Department of Game provided an early description of burbot fishing in Palmer Lake. Meigs reported that "natives" fished the lake heavily each winter with set lines. Each line contained several hooks; each baited with 23-25 cm "chubs" or northern pikeminnow (*Ptychocheilus oregonensis*). Meigs stated that two or three burbot a night, each weighing as much as 16 kg, was a common catch.

Before 1969, burbot fishing was unregulated in Washington. In 1969, burbot were classified as a game fish, but there were no catch or size limits on the species until 1998. From 1971 to 1998, one set line with an unlimited number of hooks was allowed for burbot fishing in Lakes Cle Elum, Kachess, Keechelus, and Palmer. Set lines were also permitted in Lake Chelan, where the number of hooks allowed per line alternated between unlimited and 25. Set line catches in Cle Elum, Kachess Keechelus and Chelan have averaged 4.91 fish per set or 0.240 fish per hook (Table 2).

Fishing for burbot using conventional methods, the most popular of which is jigging, is allowed in all Washington lakes. We found no information to compare catch rates of set lines and jig fishing.

Angler surveys and additional anecdotal evidence from management biologists suggests that burbot harvest on many state lakes is low but increasing. Burbot are the least popular game fish in Washington according to 1986 and 1995 angler surveys (Mongillo and Hahn 1988, Washington Department of Fish and Wildlife 1996). Only 0.2% of Washington anglers preferred fishing for burbot to other species in 1986, while none listed the species as most-preferred in 1996. The percentage of anglers fishing for burbot increased slightly from 1.4% of the total in 1986 to 4.1% in 1995.

Excessive harvest has contributed to decline of burbot abundance outside of Washington State. Commercial overfishing, sea lamprey invasions, and degradation of habitat were identified as major factors contributing to the collapse of burbot populations in the Great Lakes earlier in the last century (Christie 1972, Christie 1974, Jude and Leach 1993). McPhail (1997) reported the collapse of several recreational burbot fisheries in British Columbia, and suggested that a combination of factors, including excessive harvest, may have been responsible. In Alaska, regulations have become increasingly restrictive and monitoring programs have been initiated, as sport exploitation of burbot stocks has grown (Evenson 1988, Bernard et

TABLE 2. Set line catch of burbot in Washington lakes.

Lake	Date	Number of Set line Sets	Average Hooks/ Set Line	Fish/ Set line/Set	Fish/ Hook/Set	Source
Chelan	Spring and Summer 1982 and 1996	22	12.91	6.23	0.483	Brown 1984, Foster et al. 1996
Cle Elum	April, 1989	3	30.67	6.67	0.222	L. Brown, WDFW unpublished data
Kachess	Summer 1989, 1995, 1996	8	36.13	4.75	0.131	S. Bonar, L. Brown, M. Divens, WDFW unpublished data
Keechelus	Summer, 1995	3	16.00	2.00	0.125	M. Divens, WDFW unpublished data
Mean		–	–	4.91	0.240	

al. 1993). To reduce the heavy exploitation occurring on lacustrine Alaskan populations, the number of hooks per set line was reduced from unlimited, to five per day, to two per day, to a total closure of set line fisheries. Since very little jig fishing was directed at burbot, this reduced the overall burbot harvest considerably. Most lakes were closed for 5-6 years, and since then, some populations have rebounded (M. Evenson, Alaska Department of Fish and Game, personal communication). The catch limit of burbot in Montana lakes varies from 5 to 10 depending on the region of the state. However, little is known about most Montana burbot populations. Total catch increased in the popular fishery at Canyon Ferry, but it is not known if this was primarily due to increased burbot numbers or angler pressure (R. Spoon, Montana Department of Fish, Wildlife and Parks, personal communication).

In 1998, the WDFW established a five burbot daily limit statewide, and in those waters where set lines are allowed, the number of hooks was restricted to 10 per angler. These regulations were enacted to help protect populations until monitoring programs could be established to determine which populations, if any, are at risk for overharvest.

Interactions With Other Species

The diet of adult burbot is similar to that of other piscivorus fish such as lake trout (*Salvelinus namaycush*) and walleye; many authors have suggested that these species compete for food. Edsall et al. (1993) saw no lake trout on a Lake Michigan reef containing a high density of burbot, even though large numbers of juvenile lake trout were stocked there annually and temperatures on the reef were in the preferred summer temperature range for lake trout. Day (1983) found that burbot numbers increased and growth declined following a decrease in lake trout numbers in Lake Athapapuskow, Manitoba.

Juvenile burbot may compete with planktivorous or insectivorous fish such as yellow perch (*Perca flavescens*), and juvenile walleye (Clemens 1951). Carl (1992) found no relationship between lake trout and burbot abundance in Lake Openongo, Ontario, but stated that competition and predation from lake herring (*Coregonus artedii*) on larval burbot may have controlled burbot numbers more than competition with lake trout.

Burbot prey on many fish species and serve as food for others. Burbot fingerlings were eaten by nocturnally foraging walleye in an Ontario Lake (Ryder and Pesendorfer 1992). Burbot feed heavily on yellow perch (Clemens 1951, Lawler 1963, Miller 1970, Becker 1983), and Becker (1983) has suggested that burbot may provide a useful biological control for stunted populations of this species. The burbot was the principal coldwater predator of stocked salmonids in Maine lakes (Warner 1972).

Washington burbot usually inhabit lakes containing coldwater species such as trout, kokanee, and whitefish (*Coregonus clupeaformis*). Lake trout were stocked, primarily early this century, in many Washington lakes containing burbot; including Bead, Chelan, Cle Elum, Kachess, and Keechelus. In large Washington reservoirs, such as Banks, Rufus Woods, and Roosevelt, burbot occur with a variety of warmwater and coldwater species including kokanee, whitefish, walleye, smallmouth bass, and yellow perch. While almost nothing is known about the interaction between burbot and other fish species in Washington, interactions which have been documented in other areas probably occur in this state (Clemens 1951, Lawler 1963, Miller 1970, Warner 1972, Day 1983, Carl 1992, Ryder and Pesendorfer 1992). Therefore, stocking lake trout, walleye and other exotics into lakes containing native burbot stocks should be discouraged.

Other Factors Affecting Distribution and Abundance of Burbot

Burbot abundance can increase after rivers are impounded to form reservoirs (McPhail 1997). Increased larval survival and adult foraging opportunities in impoundments relative to flowing waters may be responsible for these increases. Burbot stocks in Lakes Chelan, Cle Elum, Kachess, and Keechelus, where lake levels were raised, and Roosevelt and Rufus Woods, which are reservoirs in the Columbia system, may have increased following impoundment earlier last century. Downstream of dams, burbot abundance can decline. Paragamian (1995) found a significant relationship between winter power production and the spawning migration of burbot in the Kootenai River, Idaho, and suggested peak winter flows may have reduced the ability of this fish to migrate into spawning areas.

Extreme drawdowns during winter and early spring may either reduce the amount of habitat available to burbot for spawning, or expose eggs and embryos in the substrate following spawning. Burbot generally spawn in shallow bays or backwaters over a sand or gravel bottom (Cahn 1936, Miller 1970, Scott and Crossman 1973, Becker, 1983). Sand and gravel habitat was exposed during an extreme winter drawdown in Bull Lake, Wyoming, and the remaining substrate in the reservoir consisted primarily of fine silt, which is unsuitable for spawning (Bergersen et al. 1993). No larval burbot were caught following this drawdown in either trawls or traps. At least half of the lakes and reservoirs containing burbot in Washington have experienced significant drawdowns. Reservoir elevations were low at some of these sites during winter or spring (Griffith and Scholtz 1990, Cichosz et al. 1997, U.S. Bureau of Reclamation, unpublished data), which may have limited habitat available to spawning or rearing burbot.

Climate change may also directly or indirectly affect burbot populations. McPhail (1997) suggests that increasing water temperatures may be responsible for some of the reductions in burbot populations recorded in southern regions.

Since burbot occupy a high trophic level, they can accumulate enough trace elements to be unfit for human consumption in some waters. Trace element accumulation in burbot can be high if populations are in close proximity to forest industry wastes and paper mills and these trace elements increase in many reservoirs following impoundment (McPhail 1997). Elevated trace elements in Lake Roosevelt have been of concern for many years because of the discharge of lead-zinc smelters and mining operations (Munn and Short 1997). Lowe et al. (1985) collected several fish species close to Grand Coulee Dam that contained high levels of trace elements. However, Munn and Short (1997) found that trace element concentration in walleye tissue samples from Lake Roosevelt did not exceed the current Federal standard designed to protect the health of people who eat small quantities of fish. Little is known about trace element accumulation in Washington burbot, so studies specific to burbot would be helpful for identifying any potential health risks associated with consuming this species.

Management Implications

The scarcity of information on Washington burbot stocks demonstrates the need for standardized monitoring programs that compare size structure, abundance, growth, and condition of individual burbot stocks to regional averages and evaluate trends over time. Standardized sampling and monitoring programs have been used successfully to assess a variety of fish populations (Ney 1993, Willis and Murphy 1996). Studies in other regions have used underwater video systems along transects (Edsall et al. 1993) and hoop-trapping techniques (Bernard et al. 1991, Bernard et al. 1993) to sample burbot stocks. Monitoring trends in burbot abundance, growth and condition, and relating trends to changes in habitat conditions, harvest, or water quality would help evaluate the status of Washington stocks, and identify factors limiting any stocks at risk.

Washington burbot have the potential to be overharvested because of: (1) increasing angler interest; (2) their slow growth; (3) their advanced age at sexual maturity in some lakes; (4) the few sites where they are found in this state; and (5) the high trophic level that they occupy. Until standardized monitoring programs can be established, conservative harvest regulations and management strategies would aid in preserving self-sustaining stocks in Washington.

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