4 Focal and Target Species

4.1 Bull Trout (*Salvelinus confluentus*)

4.1.1 Background

Reasons for Selection as Focal Species

Globally, the bull trout has a G3 ranking: very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factor(s). The federal government listed bull trout (*Salvelinus confluentus*) in the coterminous United States as threatened on November 1, 1999 (64 FR 58910) (go to: http://pacific.fws.gov/bulltrout/). Earlier rulemakings had listed distinct population segments of bull trout as threatened in the Columbia River and Klamath River (June 1998; 63 FR 31647, 63 FR 42757), and Jarbidge River basins (November 1999; 64 FR 17110).

The USFWS recovery priority number for bull trout in the contiguous United States is 9C, on a scale of 1 to 18, indicating that (1) taxonomically, these populations are distinct population segments of a species; (2) the populations are subject to a moderate degree of threat(s); (3) the recovery potential is high; and (4) the degree of potential conflict during recovery is high (USFWS 2002).

The U.S. Forest Service lists bull trout as a sensitive species, primarily to emphasize habitat protection. The Idaho Panhandle National Forests have named bull trout as Management Indicator Species (MIS) in their Forest Plan to guide stream and riparian management and to monitor progress toward achieving Forest Plan objectives. Forest Plan standards must be met regarding habitat needs of these species, thereby ensuring a quality environment for other aquatic organisms, such as sculpins, amphibians, and aquatic insects (USFS 1998).

In Montana, bull trout have received a ranking of *S2*, meaning they are considered imperiled because of rarity or because of other factor(s) making them very vulnerable to extinction throughout their range. Montana Department of Fish, Wildlife, and Parks (MFWP) has designated them a species of special concern due to their limited distribution, sensitivity to environmental disturbances, vulnerability to hybridization and/or competition with other fish species, and risk of over-exploitation.

LINKS

For more information on the federal listing, go to the USFWS bull trout website at: http://pacific.fws.gov/bulltrout/

Click Here

The lexicon for describing bull trout population units has evolved. In the USFWS Draft Bull Trout Recovery Plan (USFWS 2002a), the bull trout population units are hierarchically described, from the Columbia River Basin distinct population segment (DPS) at the largest scale, to recovery units, to core areas, each of which are comprised of one to many local populations. The term "subpopulation" although used in places in this document, was considered less useful and the use of this term was officially discontinued by the Bull Trout Recovery Team. For more thorough definitions of these and other terms used in this section, go to Appendix 96.

Click Here

LINKS

State, federal and tribal biologists in Montana have done extensive work on bull trout. Results from these efforts, which have resulted in some of the best and most detailed information available for bull trout in the Montana portion of the Kootenai Subbasin, are entered onto the Montana Fisheries Information System (MFISH) database accessible on the internet at: http://nris.state.mt.us/scripts/esrimap.dll?name=MFISH&Cmd=INST.

Click Here

For various bull trout reports from the B.C. Ministry of Water, Land, and Air Protection, go to Appendix 113.

Click Here

The Kootenai Tribe of Idaho and the Confederated Tribes of the Salish and Kootenai consider bull trout a sensitive species and an important cultural resource.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild Canadian species, subspecies and separate populations suspected of being at risk. In British Columbia, bull trout are listed as an intermediate priority candidate species (COSEWIC 2003). COSEWIC candidate species are those that are suspected of being in some category of risk of extinction or extirpation at the national level, before being examined through the status assessment process. The B.C. Conservation Data Centre has blue-listed bull trout in British Columbia, which means they are a species considered to be vulnerable or of special concern because of characteristics that make them particularly sensitive to human activities or natural events (BC Ministry of Sustainable Resource Management 2003).

The British Columbia *Forest Practices Code* includes an "Identified Wildlife Management Strategy" that lists wildlife, wildlife habitat areas and associated landscape units. "Identified Wildlife" lists species considered to be at risk (e.g. endangered, threatened, vulnerable or sensitive) and that require management of critical habitats in order to maintain populations and/or distributions (BC Ministry of Forest 1997).

Bull trout are good indicators of aquatic ecosystem health. They have relatively strict habitat requirements. They require high quality, cold water; high levels of shade, undercut banks, and woody debris in streams; abundant gravel in riffles with low levels of fine sediments; stable, complex stream channels; and connectivity among and between drainages (USFWS 2002). These requirements make them a good indicator of the health of an aquatic environment. Because bull trout use the entire aquatic system in the subbasin, impacts in any single component can potentially affect bull trout. Because of this and their status, we have selected bull trout as a focal species in this assessment.

Summary of population and current distribution data[1]

In the final ESA listing rule for bull trout, five subpopulations were recognized within the Kootenai River Subbasin (USFWS 1998). These included three portions of the mainstem system: (1) Upper—upstream from Libby Dam, (2) Middle—from Libby Dam downstream to Kootenai Falls, and (3) Lower— downstream

[1] *As mentioned previously, metapopulations are composed of one or more local populations. As in the Bull Trout Recovery Plan, in this assessment bull trout have been grouped into distinct population segments, recovery units, core areas and local populations. Core areas are composed of one or more local populations, recovery units are composed of one or more core areas, and a distinct population segment is composed of one or more recovery units.*

from Kootenai Falls through Idaho to the United States/Canada border. The two disconnected subpopulations (referred to as disjunct by the Montana Bull Trout Scientific Group), in Bull Lake (MBTSG 1996b) and Sophie Lake (MBTSG 1996c), were considered separate subpopulations. At the time of listing, all Kootenai River bull trout subpopulations were considered to have unknown status and population trend, and the Sophie Lake subpopulation was considered to be at risk of stochastic extirpation due to its single spawning stream and small population size.

In its Bull Trout Draft Recovery Plan, the USFWS identified 27 recovery units based on large river basins and generally following existing boundaries of conservation units for other fish species described in state plans, where possible. The Kootenai River Recovery Unit forms part of the range of the Columbia River population segment. The Kootenai River Recovery Unit includes 4 core areas (figure 4.1) and about 10 currently identified local populations.

In recent years, emphasis for the Kootenai River Subbasin has been placed on determining abundance through redd counts[2, 3]. Table 4.1 summarizes the status of redd count information from 1996 to 2000 for the four core areas in the Kootenai River recovery unit. Redd counts represent an unknown but substantial portion of the possible spawning population. Three of the four core areas have an established history of redd count trend information for migratory fish. Eight streams in the United States and three in Canada are now being monitored, with index redd counts conducted on an annual basis. Table 4.2 summarizes this information. In addition, six bull trout redds were counted in Goat Creek (a tributary of Callahan Creek, Montana) in 2003, the first year this stream was surveyed (A. Rief, USFS, unpublished data). Information for the Idaho portion of the subbasin is presented in tables 4.3 and 4.4. Redd counts have traditionally been conducted only for migratory fish. In some drainages, there are likely to be additional resident bull trout spawners whose redds are smaller than those of migratory fish, therefore difficult to identify in streams where brook trout exist. They have not been included in these totals. On the Wigwam River, five permanent monitoring sites were established in 2000 to evaluate juvenile abundance (Cope and Morris 2001). Juvenile abundance has also been monitored at three sites on Skookumchuck Creek for two years (Cope 2003 and Cope 2004 in prep), two sites on the White River, and at

LINKS

For a map showing current bull trout distribution and restoration and core habitat areas within the Montana portion of the Kootenai, go to Appendix 52.

Click Here

USFS bull trout distribution maps for the Kootenai Subbasin portion of the Idaho Panhandle and Kootenai National Forests are included in Appendix 1.

Click Here

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[2] *The Bull Trout Draft Recovery Plan states: Because of the large size of the migratory fish and the geology of the streams (which generally makes the redds easy to recognize), redd counts (Spalding 1997) have been shown to provide a repeatable method of indexing spawner escapement in many streams in this recovery unit (Rieman and McIntyre 1996). However, several authors have cautioned that redd counts should not be relied upon as the sole method of population monitoring (Rieman and Myers 1997, Maxell 1999) and may, in fact, lead to erroneous conclusions about population status and trend.*

[3] *Adapted from the Bull Trout Draft Recovery Plan (2003).*

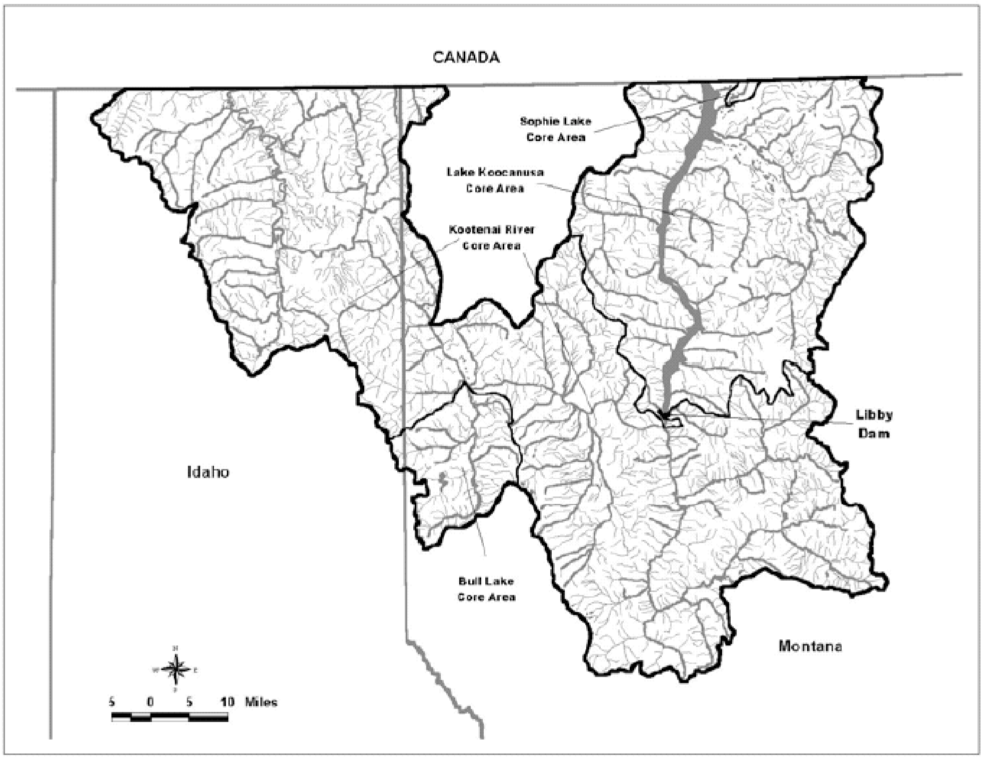

Figure 4.1. The Kootenai River Recovery Unit showing Core Areas Source: Bull Trout Draft Recovery Plan (USFWS 2002b).

LINKS

For bull trout information in the Kootenai Subbasin in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information (including reports pertaining to bull trout) for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

For the B.C. Fisheries Inventory Data Queries site go to: http://srmapps.gov.bc.ca/apps/fidq/

Click Here

For the Conservation Data Centre, which also has bull trout information for B.C., go to http://srmwww.gov.bc.ca/cdc/

Click Here

Table 4.1. Summary of redd count information for migratory adults in the four bull trout core areas in the Kootenai River Recovery Unit.

Core Area Name	Drainage Basin (approx. square kilometers)	# of Local Populations Monitored	Mean Total # of Redds Counted (1996-2000)
Lake Koocanusa (Upper Kootenai)	270 (U.S. Only)	2 (1 in Canada)	848
Kootenay Lake and River (Lower Kootenai)	1230 (U.S. Only)	4	165
Sophie Lake	12	0	----
Bull Lake	130	1	83

Table 4.2. Summary of Montana and Idaho Kootenai River bull trout redd surveys for all index tributaries, 1993-2003. Source: MFWP and IDFG .

	93	94	95	96	97	98	99[b]	2000	2001	2002	2003
Stream						**Number of Redds**					
Grave Creek Includes (Clarence) and (Blue Sky) Creeks			15[g]	35 (5) (6)	49 (6) (1)	66 (13) (1)	134 (39) (10)	97 (9) (1)	173 (29) (13)	199 (38) (5)	245 (52) (20)
Quartz Creek Includes (West Fork)			67 (26)	47 (42)	69 (39)	105 (72)	102 (88)	91 (39)	154 (109)	62[e] (10)	55 (26)
O'Brien Creek			22	12	36	47	37	34	47	45	46
Pipe Creek			5	17	26	34	36	30	6[a]	11	10
Bear			6	10	13	22	36	23	4[e]	17	14
Keeler includes (North Frk) and (South Fork)				74	59 (18) (16)	92 (43) (10)	99 (52) (5)	90 (82) (5)	13[d] (4) (0)	102 (75) (0)	87 (26) (0)
Wigwam (U.S.) Includes Bighorn, Desolation, Lodepole Creeks			247	512 (12)	598 (17)	679 (6)	849 (21)	1195 (9)	1496 (19)	1892 (11)	2053 (10)
Other B.C. Includes (Skookumchuk) (White) (Blackfoot)					66 (66)	105 (105)	161 (161)	189 (189)	298 (132) (166)	404 (143) (153) (108)	373 (134) (143) (96)
West Fisher (USFS)	2	0	3	4	0	8	18	23	1	1	1
Callahan Creek (IDFG) (North) and (South Callahan) not mainstem										(13)f (14)	(32) (10)
Goat Creek (Callahan drainage in MT)											6

a Human-built dam below traditional spawning area.
b Included resident and migratory redds.
c Libby Creek dewatered at highway 2 bridge below spawning sites during spawning run.
d Beavers dammed lower portion during low flows, dam was removed but high water made accurate redd counts impossible.
e Log jam may have been a partial barrier.
f The 2002 survey on N. Callahan Creek was less extensive than in 2003.
g High flows.

• Note that during low-water years, beavers in some streams (Keeler, Pipe, Quartz) have an opportunity to build dams across the entire stream rather than just in side channels. Some bull trout migrate upstream before dam construction is complete, most either try to build redds below dams or appear to leave he streams entirely. This happened in Keeler Creek and Pipe Creek in 2001.

• Construction of dams by human for swimming is a chronic problem in Libby and Pipe Creeks. They usually are not complete barriers except during low water years. Also, in 2001, Libby Creek was dry for more than a mile during the spawning run. This probably accounts for the low numbers of redds counted relative to the previous years.

• In 2001, additional streams in B.C. Were surveyed either by plane or on foot. They include Skookumchuck (143), Middle Fork White River (197), Verdant Creek in Kootenay National Park (31), Blackfoot Creek, tributary to White River (50).

Table 4.3. Idaho Department of Fish and Game documented bull trout distribution in Kootenai River tributaries in Idaho through 2003. Streams where redd surveys were conducted are included even if no bull trout were observed. Source: IDFG.

Date	Stream	Method	# of Bull Trout	Total Length (mm)	Water Temp °C	Sourcea	Comments
10/13/99	Ball Cr.	Redd Survey	0			Walters and Downs 2001	
7/11/00	Boulder Cr.	Drift Net	1	120	11.5	Walters 2002	
8/23/00	Boulder Cr.	Snorkel	1	170	15	Walters 2002	Estimated size
10/4/00	Boulder Cr.	Redd Survey	0			Walters 2002	
10/18/00	Boulder Cr.	Redd Survey	0			Walters 2002	
8/16/01	Boulder Cr.	Snorkel	1	300	15	Walters 2003	Estimated Size
Sept-Oct 2001	Boulder Cr.	Redd Survey	0			Walters 2003	2 bull trout redds
8/14/02	Boulder Cr.	Snorkel	1	150	16.5	IDFG unpubl.	Estimated Size
8/16/02	Boulder Cr.	Snorkel	1	120	14.5	IDFG unpubl.	Estimated Size
8/16/02	Boulder Cr.	Snorkel	1	170	14.5	IDFG unpubl.	Estimated Size
Sept-Oct 2002	Boulder Cr.	Redd Survey	2		6.5	IDFG unpubl.	2 bull trout redds
10/18/99	Boundary Cr.	Redd Survey	0			Walters and Downs 2001	
9/27/00	Boundary Cr.	Redd Survey	0			Walters 2002	
10/2/00	Boundary Cr.	Redd Survey	0			Walters 2002	
10/6/00	Boundary Cr.	Redd Survey	0			Walters 2002	
Jul-Aug 98	Caboose Cr.	e-fish	1		13	Downs 2000	
Summer 1999	Caboose Cr.	e-fish	2		13	Walters and Downs 2001	
10/19/99	Caribou Cr.	Redd Survey	0			Walters and Downs 2001	
10/19/00	Caribou Cr.	Redd Survey	0			Walters 2002	
10/23/01	Caribou Cr.	Redd Survey	0			Walters 2003	
July-Aug 93	Caribou Cr.	e-fish	1			Paragamian 1994	
8/9/00	Curley Cr.	e-fish	1	124	19	Walters 2002	
10/2/02	Curley Cr.	Redd Survey	0			IDFG unpubl.	
1980-82	Curley Cr.	e-fish	1			Partridge 1983	Length not reported
July-Aug 98	Curley Cr.	e-fish	1		22	Downs 2000	
10/4/00	Curley Cr.	Redd Survey	0			Walters 2002	
Summer 1999	Debt Cr.	e-fish	1			Walters and Downs 2001	

Table 4.3 (cont.). Idaho Department of Fish and Game documented bull trout distribution in Kootenai River tributaries in Idaho through 2003. Streams where redd surveys were conducted are included even if no bull trout were observed. Source: IDFG.

Date	Stream	Method	# of Bull Trout	Total Length (mm)	Water Temp °C	Sourcea	Comments
1980-82	Deep Cr.	Observed	?			Partridge 1983	Number seen not reported
10/13/99	Fisher Cr.	Redd Survey	0			Walters and Downs 2001	
10/13/99	Long Canyon Cr.	Redd Survey	0			Walters and Downs 2001	
10/5/00	Long Canyon Cr.	Redd Survey	0			Walters 2002	
10/11/00	Long Canyon Cr.	Redd Survey	0			Walters 2002	
Jul-Aug 94	Long Canyon Cr.	e-fish	1			Paragamian 1995	
10/3/00	Moyie R.	Redd Survey	0			Walters 2002	
10/16/00	Moyie R.	Redd Survey	0			Walters 2002	
Sept-Oct 2001	Moyie R.	Redd Survey	0			Walters 2003	
10/13/99	Myrtle Cr.	Redd Survey	0			Walters and Downs 2001	
8/25/97	Myrtle Cr.	Snorkle	1	125		Downs 1999	
9/20/00	Myrtle Cr.	Redd Survey	0			Walters 2002	
10/7/02	N. Callahan Cr.	Redd Survey	4			IDFG unpubl.	
10/16/02	N. Callahan Cr.	Redd Survey	1		4	IDFG unpubl.	13 bull trout redds in 2002
9/16/03	N. Callahan Cr.	Redd Survey	2		8.5	IDFG unpubl.	
9/24/03	N. Callahan Cr.	Redd Survey	10		8	IDFG unpubl.	
9/30/03	N. Callahan Cr.	Redd Survey	2		7	IDFG unpubl.	32 bull trout redds in 2003
10/13/99	Parker Cr.	Redd Survey	0			Walters and Downs 2001	
10/5/00	Parker Cr.	Redd Survey	0			Walters 2002	
9/24/02	S. Callahan Cr.	Redd Survey	3		8	IDFG unpubl.	
9/25/02	S. Callahan Cr.	Redd Survey	16		7.5	IDFG unpubl.	
10/3/02	S. Callahan Cr.	Redd Survey	1		6.5	IDFG unpubl.	
10/17/02	S. Callahan Cr.	Redd Survey	0			IDFG unpubl.	4 bull trout redds in 2002
9/15/03	S. Callahan Cr.	Redd Survey	2		10	IDFG unpubl.	
9/25/03	S. Callahan Cr.	Redd Survey	3		8.5	IDFG unpubl.	10 bull trout redds in 2003
10/5/99	Snow Cr.		0			Walters and Downs 2001	
10/19/00	Snow Cr.		0			Walters 2002	
10/23/01	Snow Cr.		0			Walters 2003	
Jul-Aug 93	Snow Cr.	e-fish	1			Paragamian 1994	

Table 4.4. Estimated historic and current distribution of bull trout in the Idaho portion of the Kootenai.

Watershed	HUC Code	Bull Trout Distribution Historic (Prior to 1985)	Current (Since 1985)	Area of Sub-Watershed mi²
Kootenai River		**P**	**SAR**	
Callahan Creek		P	SER	
Star Creek		U	U	
Boulder Cr	1701010407	SNF	SER	63.3
EF Boulder Cr	170101040707	U	SNP	15.5
Boulder Cr abv EF	170101040709	U	SNP	31.9
Curly Cr	1.70101E+13	P	SSR	11.4
Moyie River	17010105	U	SAR	204.8
American Cr	170101050208	U	U	12.8
Canuck Cr	170101050205	U	U	15.0
Spruce Cr	17010105020030	U	SNF	7.6
Round Prarie Cr	170101050201	U	SNF	37.5
Meadow Cr	170101050104	U	SNF	24.3
Placer Cr	17010105010209	U	SNF	3.9
Deer Cr	170101050106	P	SSR	30.8
Skin Cr	17010105010209	U	U	10.2
Cow Cr	1.70101E+13	U	U	11.4
Fry Cr	1701010404	U	U	50.8
Deep Cr	1701010408	P	SSR	184.0
Dodge Cr	1701010408070720	U	SNF	11.5
Trail Cr	17010104080705	U	SNF	16.2
Fall Cr	17010104080709	U	SNF	22.2
Ruby Cr	170101040809	U	SNF	14.9
Twentymile Cr	17010104080507	U	SNF	10.0
Brown Cr	170101040805	U	U	25.6
Caribou Cr	170101040810	P	SSR	13.1
Snow Cr	170101040812	P	SSR	17.9
Myrtle Cr	1701010409	P	SSR	42.9
Ball Cr	1701010410	U	SNF	26.8
Fleming Cr	170101040310	U	U	18.6
Rock Cr	170101040301	P	SSR	16.4
Trout Cr	170101040214	P	SSR	19.5
Mission Cr	170101040203	U	SNF	30.9
Parker Cr	170101040110	P	SSR	16.4
Long Canyon Cr	1701010411	P	SSR	30.3
Smith Cr	1701010412	U	SNF	71.6
Smith Cr abv Cow Cr	17010104120111	U	SNP	30.7
Cow Cr	17010104120113	U	SNP	21.9
Boundary Cr	1701010414	SSR	SNF	94.6
Boundary Cr abv Blue Joe	170101041415	SSR	SNF	10.5
Blue Joe Cr	170101041412	SSR	SNF	10.7
Grass Cr	170101041409	SSR	SNF	27.4
Saddle Cr	170101041405	SSR	SNF	10.3
Kootenai Drainage, ID	17010104, 17010105			1081

SER = Spawning/Early Rearing.
SSR = Suspected Spawning/Rearing,
SAR = Sub Adult and Adult Rearing.
SNF = Surveyed, Not Found.
SNP = Suspected Not Present.
P = Historically Present.
U = Unknown.

one site on Blackfoot Creek for one year (Cope 2004 in prep). On the Wigwam River, five permanent monitoring sites were established in 2000 to evaluate juvenile abundance (Cope and Morris 2001). In North and South Callahan Creeks, estimated minimum densities were 5.3 fish/100m^2 and 4.2 fish/100m^2, respectively during August 2003 (Idaho Department of Fish and Game unpublished data). Much of the following narrative summary of population and current distribution data for Kootenai River Core Areas is excerpted from USFWS (2002b).

Koocanusa Reservoir Core Area

The population in the Canadian headwaters of Koocanusa Reservoir is believed to be one of the strongest metapopulation in existence (Marotz, B. MFWP, pers. comm. 2000). Adult bull trout reach large sizes in Koocanusa Reservoir. Researchers noted higher growth in bull trout through age four in Koocanusa Reservoir than for bull trout from Flathead Lake and Hungry Horse Reservoir (MBTSG 1996c). Radio telemetry studies involving 36 adult bull trout surgically implanted with tags at the Wigwam River weir in 1996 to 1998 showed that post-spawning adult fish generally wintered in Koocanusa Reservoir in Montana (Baxter and Westover 2000). Before making the spawning run in the Kootenay River, the fish gathered off the mouth of the Elk River during late May and early June. Between mid-June and mid-July, most were in the lower reaches of the Elk River, and by the end of July they entered the Wigwam River. Spawning peaked the last week of September, and adults were back in the Kootenay River or Koocanusa Reservoir by the end of October (Baxter and Westover 2000).

Bull trout redd counts have 9 and 10 years of consecutive data in Wigwam and Grave Creek, respectively, and both indicate an significantly increasing population trend. Surveys in British Columbia's Wigwam River drainage began in 1978, but were sporadic until recently. Gill netting trend data from Koocanusa Reservoir has been collected since reservoir construction and are significantly correlated to redd counts and indicate that the Koocanusa bull trout population is increasing.

Upstream from Libby Dam, bull trout from Koocanusa Reservoir also utilize the Grave Creek drainage in the United States for spawning and rearing. The Tobacco River provides the migration corridor between the reservoir and Grave Creek. The redd count information presently available for Grave Creek suggests this local population is increasing in concert with other waters supporting adfluvial runs from Lake Koocanusa.

Redd searches have been conducted on other Koocanusa Reservoir tributaries in the United States, including Five Mile, Cripple Horse, Bristol, Warland, Williams, Lewis, Stahl, and Barron creeks. Field crews have not found redds, and bull trout presence in these and other United States tributaries is described as "incidental" (MBTSG 1996c).

LINKS

QHA spreadsheets contain current and historic bull trout distribution by lifestage for HUC-6 watersheds and selected lakes in the U.S. and B.C. portions of the Kootenai. These data are a compilation put together by our Technical Team. Go to Appendix 32 and 33.

Click Here

Appendix 54 also provides narrative information on bull trout status and distribution for much of the Montana portion of the Kootenai.

Click Here

Bull Trout distribution and abundance information for the Upper Kootenai in Montana is summarized in Appendix 55.

Click Here

Appendix 91 presents the results of the Upper Kootenay River Bull Trout Radio Telemetry Project (2000-2003).

Click Here

In 1978, British Columbia Ministry of Water, Land, and Air Protection first monitored spawning bull trout in the upper Wigwam River and Bighorn (Ram) Creek, using migrant traps (Oliver 1979). Between July and October 1978, 515 adult bull trout passed upstream through the traps. During the next survey, in 1995, 247 bull trout redds were identified on the Wigwam River system in British Columbia. Since 1995, a trapping study has indicated that the numbers of bull trout that spawn in the Wigwam River are increasing. Baxter *et al.* (2000) reported the capture of between 616 and 978 adult bull trout annually during 1996 to 1999 at a weir on the Wigwam River. The weir was operated to catch migrating and post-spawning adults in the fall. Due to the location of the weir, these counts represent only a portion of the total numbers of fish using that drainage. Ground surveys conducted from 1994 to 2003 found increasing numbers of bull trout redds in the Wigwam River drainage (figure 4.2). Baxter and Westover (2000) state that the Wigwam River is arguably "the most prolific bull trout population in the species distributional range."

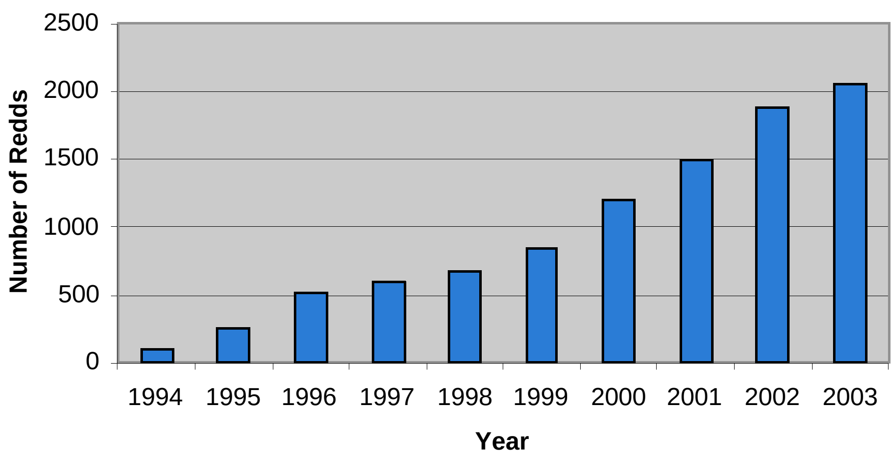

Figure 4.2. Bull trout redd counts, 1994-2003 (Bill Westover, BCWLAP pers. comm. 2003)

Spawning by migratory bull trout is also known to occur in British Columbia in several upper Kootenay River tributaries, including Gold Creek, Bull River, St. Mary River, Skookumchuck Creek, Lussier River, White River, Kikomun Creek, and Findlay Creek (B. Westover, British Columbia Ministry of Water, Land, and Air Protection, pers. comm., 2001). Numbers of fish and location of spawning activity in these drainages are currently being examined. A study using radio telemetry to find other spawning concentrations and track movements of bull trout in the upper Kootenay has recently been completed (Westover 2004 in prep). Redd counts have been established on index reaches of several streams (Westover, pers. Comm. 2003) In Skookumchuck Creek, bull trout redds have steadily increased, from 66 in 1997 to 143 in 2002 and 134 in 2003. In the index reach of the Middle Fork White River, 67 redds were located in 2000, increasing to 166 in 2001, 153 in 2002, and 143 in 2003. In the index reach of Blackfoot Creek 108 redds were located in 2002 and 96 in 2003. Both fluvial and adfluvial (from Koocanusa Reservoir) bull trout were tracked into the same spawning streams (B. Westover pers. Comm. 2004).

Five juvenile bull trout monitoring sites were established in the Wigwam River basin in 2000. Bull trout represented 92.4 percent of the catch, and the mean density of juvenile bull trout was estimated to be 17.2 fish per 100 square meters, indicating a very high population density for this species (Cope and Morris 2001). Mean density of juvenile bull trout on Skookumchuck Creek ranged from 0.8 – 9.7 fish/100m ≤ in 2002 (Cope 2003)and from 1.5 – 36.3 fish/100m ≤ on the White River and Blackfoot Creek in 2003 (Cope 2004 in prep).

Kootenai River / Kootenay Lake Core Area

Bull trout are widely distributed through the lower Kootenai River, from Libby Dam downstream to Kootenay Lake in British Columbia. Spawning and rearing by migratory adults occur in tributaries draining portions of British Columbia, Idaho, and Montana (Figure 4). These migratory fish spend their adult lives in Kootenay Lake or the Kootenai River. Libby Dam is an impassable barrier to upstream migration.

Spawning and rearing of migratory bull trout have been documented in four tributaries of the Kootenai River between Libby Dam and Kootenai Falls (Quartz, Pipe, and Libby creeks and the Fisher River). These migratory fish spend their adult lives in the Kootenai River or Kootenay Lake. Tagging studies had previously confirmed that fish from above the falls sometimes moved downstream over Kootenai Falls (Marotz et al. 1988). Kootenai Falls is not a complete barrier, but rather a substantial barrier to upstream bull trout movement. The most recent and extensive telemetry study (Dunnigan et al. 2003) found that out of 58 radio tagged bull trout captured and subsequently tagged (and released) above Kootenai Falls, 22 (38 percent) migrated over the falls after tagging. Of these 22 fish, only one bull trout ascended the falls.

The most heavily used spawning and rearing stream for bull trout between Kootenai Falls and Libby Dam is in the Quartz Creek drainage (MBTSG 1996a). Between 1994 and 2003, this drainage supported from 47 to 154 redds annually. Most of the redds were observed in the West Fork of Quartz Creek. The remaining redds were observed in Quartz Creek downstream from the confluence with the

West Fork. Personnel from MFWP and the Kootenai National Forest have conducted inventories of bull trout spawning sites on several other tributaries to the Kootenai River between Libby Dam and Kootenai Falls. These include Pipe, Granite, Libby, Midas, and Dunn creeks and the Fisher River drainage. Pipe Creek (5 to 36 redds in 1991 to 2003) and Bear Creek, a tributary to Libby Creek (4 to 36 redds in 1995 to 2003) support annual bull trout spawning. Resident bull trout are also suspected to be present in tributaries to Libby Creek, such as Big Cherry Creek. They also exist in Libby Creek above Libby Falls. During the late 1980s, several tributaries of Libby Creek were sampled, and bull trout were found in Poorman Creek and Ramsey Creek, but not in Little Cherry Creek (MBTSG 1996a).

In the Fisher River, low numbers of adult migratory bull trout have been documented (MBTSG 1996a). In 1993, redd counts were completed on 13 streams in the Fisher River drainage. A total of 13 suspected bull trout redds were observed (4 in the East Fisher River, 8 in Silver Butte Fisher River, and 1 in the Fisher River). In 1999, 18 redds were found in West Fisher Creek, and 23 were counted there in 2000. Between 2001 and 2003, only a single redd was located in West Fisher Creek each year, reflecting a fair amount of instability in the numbers of adult bull trout spawning in this drainage. The majority of streams surveyed contained potential obstacles to fish passage (including beaver dams, log jams, and falls), and few suitable spawning sites exist due to the high gradient, the large streambed substrate, low pool/riffle ratio, and subterranean water flow.

The most important spawning and rearing stream in the Montana portion of the Kootenai River downstream from Kootenai Falls is O'Brien Creek (MBTSG 1996b). From June to September 1992, the Montana Fish, Wildlife and Parks operated an upstream trap in O'Brien Creek. During this period, 20 adult bull trout were captured in the trap. Because of the relatively large size of adults captured (up to 76 centimeters [30 inches]), these fish were probably migrants from the Kootenai River or Kootenay Lake (MBTSG 1996b). Since 1992, spawning site inventories have been completed annually in O'Brien Creek, and 12 to 47 redds have been counted (table 4.2). Resident bull trout are also suspected to occur in O'Brien Creek, but have not been confirmed. Brook trout are present in O'Brien Creek, and 87 probable brook trout redds (species determination was based on size, timing, and observation of fish on redds) were recorded in 1994 (MBTSG 1996b). Brook trout hybridization with bull trout is suspected in O'Brien Creek.

During 1992, Montana Fish, Wildlife and Parks conducted redd searches in several other Montana tributaries to the Kootenai River below Kootenai Falls, including Callahan, Ruby, and Star creeks and the Yaak River. Field crews found no redds in the Yaak River, from its junction with the Kootenai River to Yaak Falls, a barrier falls located approximately 11 kilometers (7 miles) upstream

(MBTSG 1996b). The channel through this area is high gradient and composed of large substrate. The Yaak River is a large system with average discharges around 4.25 to 5.66 cubic meters per second (150 to 200 cubic feet per second) during August through October. Because of the substrate composition and the size of the stream, redds may be hard to detect. Low numbers of small bull trout were present during electrofishing surveys downstream from Yaak Falls. Additional survey work is needed to determine potential bull trout utilization of the Yaak River below the falls. Extensive sampling upstream from Yaak Falls has failed to document the presence of bull trout in the United States section of the Yaak River (MBTSG 1996b).

Redd counts conducted in the headwaters portion of Callahan in 2002 and 2003 by IDFG found 17 and 42 bull trout redds in the Idaho portion of the North and South Forks of Callahan, respectively (Jody Walters, IDFG, pers. comm. 2004). Ruby and Star creeks do not appear to be suitable for spawning, and no redds have been found, but juvenile bull trout occur in low numbers. Bull trout spawning in the mainstem Kootenai River has not been documented at this time and probably does not occur due to lack of suitable habitat and thermal conditions.

Limited information is available regarding abundance and life history attributes of bull trout in the lower Kootenai River in Idaho. The Idaho Department of Fish and Game is currently conducting research on bull trout distribution and movements. Bull trout have been documented in the Idaho portion of the basin in the Kootenai and Moyie Rivers and Callahan, Curley, Deer, Deep, Fall, Caribou, Snow, Myrtle, Rock, Trout, Parker, Long Canyon, and Boundary Creeks (PBTTAT 1998). Additional observations of bull trout were reported in Boulder, Caboose, and Debt creeks in Idaho, just downstream from the Montana border (Table 4.3). Typically, sightings of bull trout in Idaho waters have been limited to individual fish. Adult bull trout appear to be well distributed throughout the Kootenai River in Idaho, but at very low densities, based on electrofishing data. Radio telemetry data indicates that some of those fish overwinter in the deep holes of the lower river (Walters 2002). Five of eight adult bull trout radio-tagged in O'Brien Creek in Montana migrated downstream into Idaho following spawning.

There is evidence that some bull trout sampled in Idaho are migrants from Kootenay Lake, British Columbia. At least two fish tagged by biologists in British Columbia have been located in Idaho as far upstream as the Moyie River (L. Fleck, B. C. Ministry of Water, Land, and Air Protection, pers. comm.; D. O'Brien, U. of B.C., pers. comm.).

While there were previous anectdotal reports of large bull trout spawning in the Callahan drainage, spawning by fluvial or adfluvial bull trout has recently been documented for the first time in Boulder Creek and North and South Callahan Creeks in Idaho (Walters 2003; IDFG unpublished data). Juvenile bull trout less than 200 millimeters (7.9 inches) long have been occasionally documented in the Kootenai River and tributaries in Idaho, but may have originated from upstream sources in Montana (Table 4.3; Walters and Downs 2001).

Bull Lake and Sophie Lake Core Areas

Bull Lake, a natural lake in the headwaters of the Lake Creek drainage near Troy, Montana, is considered in the Draft Bull Trout Recovery Plan to be a bull trout secondary core area (figure 4.1). In 1917, Troy Dam (also called Northern Lights Electric Company Dam) was constructed on Lake Creek, about 24 kilometers (15 miles) downstream from Bull Lake (MBTSG 1996b). It is believed that migration of bull trout over a natural barrier at the dam site was difficult or impossible prior to this dam. The dam is currently an upstream passage barrier. The local population(s) of bull trout in Bull Lake is unusual in that the adult spawners run downstream from Bull Lake, using Lake Creek as a corridor to access spawning areas in Keeler Creek. This pattern of downstream spawning migration has also been observed in the Flathead River drainage (Upper Kintla Lake and Cyclone Lake) and the Pend Oreille drainage (IDFG unpublished data) but is considered rare across the range of bull trout. Trapping of Keeler Creek in 1977 resulted in the collection of migrating adult bull trout during June to October (Marotz *et al.* 1988).

Sophie Lake contains a small and disjunct bull trout secondary core area in a closed basin (Figure 4.1). There is no historical record of bull trout stocking or transplant to this water, but because of the closed nature of this basin, these fish could have been artificially introduced early in the 20th century.

Bull trout reach maturity in Sophie Lake, with a single spawning and rearing area in Phillips Creek (MBTSG 1996c). Phillips Creek headwaters are in British Columbia, and Phillips Creek flows through private timberland that has substantial logging history and road development in its upper reaches. About 3 kilometers (2 miles) north of the United States/Canada border, Phillips Creek drops over a large (120 meters) series of falls and cascades (a complete natural barrier) and then proceeds south across the border. In the United States, Phillips Creek continues south for another 5 kilometers (3.5 miles) across private land before terminating at Sophie Lake. This lake has intermittent drainage to Koocanusa Reservoir, which lies just 1.5 kilometers (1 mile) to the west, but the two lakes are probably not sufficiently connected for fish passage to occur. Water is withdrawn from Phillips Creek upstream from the barrier falls (in British Columbia) for power production, and Phillips Creek is heavily dewatered for irrigation purposes in the United States and Canada. Bull trout juveniles (70 to 182 millimeters) were sampled just north of the border by survey crews of the British Columbia Ministry of Water, Land, and Air Protection (Westover, in litt. 1999). Bull trout are not known to exist in the stream system upstream from the falls. The U.S. Fish and Wildlife Service Partners For Fish and Wildlife program is working to improve habitat in the degraded lower reaches of the stream.

Bull trout are also present in Glen Lake, but they are probably not reproducing in this system. The fish access Glen Lake as juveniles outmigrating from Grave Creek via the Glen Lake ditch (MBTSG 1996c). Bull trout that mature in Glen Lake cannot return to Grave Creek because of a migration barrier in the ditch. These fish are essentially lost from the Koocanusa Reservoir core area. In 2001, a project was completed to screen this ditch and improve fish passage over the dam on Grave Creek.

Historic Distribution[4]

Historically, bull trout were one of six native salmonid species distributed throughout the Kootenai River drainage. The historical importance of Kootenai Falls as a barrier to fish movement is unknown, although recent radio telemetry information indicates that this series of falls is traversed by adult bull trout at certain flows. If this was the case, this bull trout population likely included migratory fish from Kootenay Lake in British Columbia as well as Kootenai River fish, which may have moved freely throughout the drainage. Resident bull trout may have been present. If upstream passage did not occur over Kootenai Falls, the bull trout population in the Kootenai Drainage upstream was isolated at this point, likely resulting in one-way gene flow downstream. Libby Dam is currently a barrier blocking upstream migration as there are no fish ladders at the dam. Therefore, any bull trout that are entrained at Libby dam cannot return upstream to their natal streams to spawn. Little quantitative information exists regarding historic bull trout abundance downstream from Kootenai Falls in Montana or Idaho. The valleys of the lower Kootenai were developed for agriculture during the late 19th and early 20th century, and the habitat for bull trout was negatively impacted prior to the collection of substantive fishery data. We recognize the lack of information as a major gap in our knowledge of the drainage. Suckley (1861) reported collecting a bull trout from the Kootenay River, but the exact location of this collection is unknown.

The ethnographic literature provides some information about historical distribution of bull trout. Schaeffer (1940) said of the Kutenai Indians that char (bull trout), trout, and whitefish were the important fish varieties, taken principally

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QHA spreadsheets contain historic bull trout distribution by lifestage for HUC-6 watersheds in the U.S. and B.C. portions of the Kootenai. These data are a compilation put together by our Technical Team. Go to Appendices 32 and 33.

Click Here

For bull trout information in the Kootenai Subbasin in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information (including reports pertaining to bull trout) for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

[4] *Adapted from MBTSG 1996a, b, and c.*

during the period of spring freshette. He mentions the Upper Kutenai using basket traps for fishing in the tributaries of the Kootenai and Elk rivers, where trout and char were taken when they were moving into the main river in the autumn. Harpoons were used to catch char during their downstream movement in September. Char were caught in this way at the junctions of the Wigwam and Lodgepole Creek, with the Elk River (Schaeffer 1940). Smith (1984) reviewed the ethnographic literature for the Kutenai Indians. He records four sources of information that state that the Kutenais used bull trout as a food source (Boas 1918; Schaeffer 1940; Turney-High 1941; Ray 1942). Appendices 32 and 33, which are our lake and stream Qualitative Habitat Assessment (QHA) spreadsheets contain historic bull trout distribution by lifestage for HUC-6 watersheds and selected lakes in the U.S. and B.C. portions of the Kootenai as estimated by the Technical Team.

Bull trout age and growth data were analyzed in O'Brien Creek in 1950, Grave Creek in 1952 and Flower Creek in 1959 (Peters 1964). Opheim (1960) collected bull trout in Pipe Creek and Flower Creek in 1959. They were collected in Flower Creek in 1960, 1961, and 1962 and were estimated to comprise 5.5 percent of the fish population (by number) (Huston 1961, 1963).

Status of Bull Trout Introductions, Artificial Production, and Captive Breeding Programs

The only captive bull trout propagation program currently ongoing in the United States is conducted ate the Creston National Fish Hatchery near Kalispell, MT. This has been a successful experimental program for over ten years, and progeny from the Creston NFH broodstock have been used for a wide variety of research and educational purposes (Mark Maskill, USFWS, pers. comm. 2004). Fish produced from the current stock are not available for outplanting to the wild, due in part to the legal terms of a settlement agreement.

The USFWS (2002) states that the small, disjunct, bull trout population in Sophie Lake may have been artificially introduced early in the 20th century. Though there is no historical record of bull trout stocking or transplants into Sophie Lake, artificial introduction is a possibility because Sophie Lake is a closed-basin lake.

LINKS

For current and Historic Fish Stocking Records in Montana, go to http://www.fwp.state.mt.us/fishing/stock02.asp

Click Here

Historic and current harvest

The harvest of bull trout has not been legal in the Kootenai River drainage in the United States since 1995. In 2003, Montana Fish, Wildlife & Parks (MFWP) proposed, and the USFWS agreed, to allow limited, experimental angler harvest of bull trout in Koocanusa Reservoir beginning in the spring of 2004. The proposal was prompted by a significant increase in redd counts in Koocanusa Reservoir tributaries, reflecting recovered status for bull trout in this core area.

Currently below Libby Dam there is some risk to bull trout from incidental hooking and handling mortality. A fishery for large rainbow trout is becoming more popular in the Kootenai River, and many of the techniques used by those anglers are also effective on bull trout.

Table 4.5 shows angler days each year from 1997 to 2001 in the Montana portion of the Kootenai Subbasin.

LINKS

Appendix 57 is the Environmental Assessment for the MFWP proposal to allow for a limited recreational bull trout fishery in Koocanusa Reservoir.

Click Here

Table 4.5. Annual angler days in the Montana portion of the Kootenai Subbasin. Source: Montana Fisheries Information System Database Query 2003.

Watershed	1997	1999	2001
17010101 Upper Kootenai	66,191	61,074	61,687
17010102 Fisher	8534	8399	5589
17010103 Yaak	6513	4557	5,650
Totals	81,238	74,030	72,926

The program by MFWP to allow limited angling for bull trout went into affect in the spring of 2004. The agency has modified fishing regulations to reestablish a recreational bull trout fishery in Koocanusa Reservoir with the following limits and restrictions:

- Creel card that allows for the yearly capture of two (2) bull trout, only one daily and in possession, at Koocanusa Reservoir.
- Anglers that acquire cards will be required to provide name, address, and telephone number for a creel survey to identify the success and monitor success of the program.
- There will be a seasonal reservoir-wide bull trout harvest closure (catch and release) from March 1 through May 31 to protect bull trout as they migrate along the shorelines of the reservoir.

In British Columbia, anglers are currently allowed to harvest one bull trout per day from Kootenay Lake and Koocanusa Reservoir (table 4.6), but they may not take bull trout from most of the tributaries to those waters. British Columbia also allows anglers to keep one trophy bull trout over 75 cm (~30 inches) per day in the lower Elk River and one bull trout per day from the Kootenay River between April 1 and October 31. Between June 1 and September 21, 1996, a creel survey estimated only 23 bull trout were taken from the Canadian portion of Koocanusa Reservoir in nearly 27,000 angler days, a harvest rate not believed to present a problem for bull trout recovery (USFWS 2002b).

Table 4.6. Bull trout regulations summary for British Columbia. Source: British Columbia Ministry of Water, Land, and Air Protection.

Area Governed **Regulation**
General
Regional daily catch quota = 1 bull trout
Lake Koocanusa
Daily catch quota = 1 bull trout (any size)
Kootenay River upstream of Lake Koocanusa to the confluence with the White River
Daily catch quota = 1 bull trout (none under 30 cm) from April 1 to October 31
Bull trout release from November 1 to March 31
Single barbless hook all year
Bait ban from June 15 to October 31
Kootenay River upstream of the confluence with the White River
Same regulations as above except it is closed to all fishing from April 1 to June 14.
Lower Elk River
Daily catch quota = 1 bull trout (none under 75 cm) from June 15 to October 31.
Bull trout release from November 1 to March 31
No fishing from April 1 to June 15.
Single barbless hook all year
Bait ban from June 15 to October 31
Wigwam River and tributaries
Bull trout release
No fishing April 1 to June 15
Fly fishing only and bait ban all year
There is also no fishing in Lodgepole Creek, Bighorn Creek and the Wigwam River upstream of km 42 from September 1 to October 31.

Since 1959, increasingly protective regulations have been established to maintain healthy bull trout populations in western Montana (table 4.7). Complete closure of all waters to bull trout fishing, except Swan Lake in 1995, eliminated all legal harvest of bull trout in Montana, including Koocanusa Reservoir.

Table 4.7 Bull trout regulations summary for Montana.

Year	Bull Trout Regulation
Pre-1959	15 fish, not >10 lb. & 1 fish 18 minimum
1959	10 fish, not >10 lb. & 1 fish 18 minimum
1982	Lakes and streams — 1 bull trout 18 minimum
1985	Streams & lakes — 1 bull trout per day, no minimum size
1990	Streams & lakes — 1 bull trout per day, immediate kill or release
1992	Close all waters to taking of bull trout except HHR and Swan Lake
1995	Close all waters except Swan Lake

MFWP estimates that if every angler fished for bull trout, the incidental daily catch rates for bull trout would be between 0.04 and 0.09 fish per day or between 1,900 and 4,200 bull trout from Koocanusa Reservoir, and they assume that the new angling regulations will produce similar catch rates, except that the actual take will be substantially lower than the catch. This is based on Rumsey and Weaver (1997) who report that anglers at Swan Lake released 86 percent of bull trout. The agency expects similar results at Koocanusa Reservoir. Additionally, more than 50 percent of harvested fish in Swan Lake were subadult or nonspawning adult bull trout, and MFWP predicts that the take from Koocanusa Reservoir will be similar. The agency also notes that anglers would be limited to one bull trout daily and in possession and only two bull trout per year, and that would further reduce impacts to the population. Furthermore, the proposed closure from March 1 through May 31 will reduce take of bull trout during a popular Kamloops fishing period and when bull trout are actively moving along the shorelines.

In the Idaho section of the Kootenai River, 24 bull trout were estimated harvested from January to August 14, 1982 (Partridge 1983). Bull trout made up 1 percent of the total salmonid harvest that year. Partridge (1983) documented angling effort of 102 h/km in 1982, with 82 percent (74 h/km) of the effort for salmonids. In comparison, Graham (1979) estimated fishing pressure of 1,662 h/km of river for a 5.6 km section above Kootenai Falls, Montana in 1979. In a 1993 creel survey, Paragamian (1995a) reported that no bull trout were seen during survey days, but there were reports of bull trout being caught that year. Paragamian (1995a) documented angling effort of 144 h/km. In 2001, bull trout made up 1 percent of the total catch (includes all species caught, but not necessarily harvested) for the Kootenai River, Idaho (Walters 2003). Angling effort in 2001 was 384 h/km, but this estimate only included the section of river from Deep Creek to the Idaho-Montana border. Angling effort downstream of Deep Creek is minimal, but this section of river was included in Partridge (1983) and Paragamian's (1995a) effort estimates.

With increasing fishing pressure throughout the entire Kootenai Subbasin, some hooking mortality is inevitable, as are problems with identifying fish that are caught (i.e., mistaking bull trout for lake trout, brook trout, or other species). Illegal harvest of bull trout in northwest Montana has been an ongoing problem for at least 100 years. Bull trout spawners are particularly vulnerable to poaching because they often enter small tributary streams several months prior to spawning and congregate in pools. In some watersheds, extensive road systems provide easy access to prime spawning areas. Poaching activity usually peaks during July, August, and September when large fish are in tributaries and are easily taken (Long 1997).

After Long (1997) interviewed poachers in northwest Montana to learn about their fishing habits and success rate, he estimated that, on average, 22 bull trout were killed per week per poacher during 3 months, July through September. Of the 9 poachers interviewed, 7 felt that poaching could have a major impact on reducing bull trout numbers. The numbers of fish harvested per poacher were much higher than expected, pointing out the danger that illegal harvest posed to local bull trout populations, especially because of the species' declining status (Long 1997). In response to this information, Montana Fish, Wildlife and Parks increased enforcement efforts, and penalties for illegal harvest of bull trout were raised. Enforcement has not seen this kind of poaching in recent years.

4.1.2 Population Delineation and Characterization

Population Units

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Appendix 58 is Chapter 4 of the Bull Trout Draft Recovery Plan, which addresses the Kootenai River Recovery Unit.

Click Here

The Bull Trout Draft Recovery Plan recognizes 10 identified local populations. (In that document, bull trout have been grouped into distinct population segments, recovery units, core areas and local populations. Core areas are composed of one or more local populations, recovery units are composed of one or more core areas.) Table 4.8 lists local populations by core area. Each of these are described in the section titled: *"Summary of population and current distribution data."*

Table 4.8. List of local populations (in bold) by core area, in the Kootenai River Recovery Unit. Streams designated by (mc) are migratory corridors only, and are not considered to host their own local population. Source: USFWS (2002b).

CORE AREA	LOCAL POPULATION
Lake Koocanusa	Kootenai River (mc) **Wigwam River** (BC and MT) Tobacco River (mc) **Grave Creek** BC tributaries - Unspecified1
Sophie Lake	**Phillips Creek** upstream of Sophie Lake
Kootenai River (MT/ID/BC) and Kootenay Lake (BC)	Kootenai River (mc) **Fisher River** **Libby Creek** **Pipe Creek** **Quartz Creek** **O Brien Creek** **Callahan Creek** ID tributaries - Unspecified BC tributaries - Unspecified
Bull Lake	Lake Creek (mc downstream) **Keeler Creek**

Life History[5]

Bull trout populations in the Kootenai may exhibit one of three life history forms: resident, fluvial, or adfluvial. Resident bull trout generally spend their entire life cycle in small headwater streams. Fluvial and adfluvial bull trout spawn in tributary streams where the juveniles rear from one to four years before migrating to either a river system (fluvial) or a lake/reservoir system (adfluvial) where they grow to maturity (Fraley and Shepard 1989). All three life history forms are present in the Kootenai subbasin.

Adfluvial bull trout mature at four to seven years of age (Mallet 1969; Pratt 1985; Shepard et al. 1984; Goetz 1989) and may spawn every year or in alternate years (Block 1955; Pratt 1985; Fraley and Shepard 1989; and Ratliff 1992). Adfluvial fish grow larger in size and have higher average fecundities than fluvial or resident stocks.

Bull trout are fall spawners, typically migrating to spawning areas during August and early September, primarily in third and fourth-order streams. In some systems, bull trout have been observed moving into spawning tributaries during high spring runoff, giving them access to habitat that becomes inaccessible later in the year when flows are lower (Pratt 1985; Pratt and Huston 1993). In the Idaho section of the Kootenai River, bull trout generally began moving upstream toward O'Brien Creek, Montana (a spawning tributary) by June or July and entered O'Brien Creek in June, July, and September (Walters and Downs 2001; Walters 2002, 2003). In North and South Callahan Creeks, bull trout spawning commenced when water temperatures dropped below 9° C. Peak spawning in these two streams occurred from the third week of September to the first week of October (IDFG unpublished data).

Eggs hatch after 100 to 145 days of incubation (Heimer 1965; Allan 1980; Weaver and White 1984). Fry remain in the gravel for another 65 to 90 days until yolk sac absorption is complete; parr marks develop and actual feeding begins while fry are still in the gravel. Fry emerge from gravels in early spring, usually April (Shepard et al. 1984). Bull trout generally reach lengths of about one inch (25 to 28 mm) before filling their air bladders and emerging from the stream bed (Shepard et al. 1984).

Juvenile bull trout live near the stream bottom for the first two years of life using pockets of slow water within swift stream reaches (Pratt 1984b; Shepard et al. 1984). Unembedded cobble and boulders, and dispersed woody debris are commonly used forms of cover. Juvenile bull trout typically rear close to spawning areas, usually in middle to upper stream reaches. Young fish feed primarily on aquatic insects including mayflies (*ephemeroptera*), true flies (*diptera*), stoneflies

LINKS

Appendix 59 contains additional information on life histories of Montana bull trout. See also Shepard et al. 1984.

Click Here

[5] *Adapted and condensed from PBTTAT (1998)*

LINKS

Appendix 60 shows bull trout genetic distribution and status in the Montana portion of the Kootenai Subbasin.

Click Here

Appendix 52 shows bull trout distribution and restoration and core habitat areas in the Montana portion of the Kootenai.

Click Here

Appendix 61 lists the streams in the Montana portion of the Kootenai Subbasin that contain brook trout as of February 2003.

Click Here

Bull Trout genetic purity information for the Upper Kootenai in Montana is summarized in Appendix 55.

Click Here

(*plecoptera*), caddisflies (*trichoptera*), and beetles (*coleoptera*) until they reach about 4 inches (100 to 110 mm) and become piscivorous, sometime during their second growing season (Graham et al. 1980; Shepard et al. 1984; Boag 1987).

Juvenile bull trout may migrate from natal streams during the summer or fall of their second or third growing season (Ringstad 1976; Oliver 1979; Shepard et al. 1984; Pratt 1996). In tributaries to the Clearwater system in north-central Idaho, juvenile bull trout are routinely captured by smolt traps during spring runoff. In Callahan Creek, approximately 2 km from the mouth, 19 juvenile bull trout were caught in a screw trap fished from early April through early July, 2003. These fish were believed to be out-migrants, as some were recaptured the day after being released upstream of the trap (Idaho Department of Fish and Game, unpublished data). Time spent migrating from natal streams to the Kootenai River has not been studied, but Goetz (1991) reported that juvenile out migrants move downstream quickly in other stream systems.

Migratory corridors tie spawning, wintering, summering, and foraging habitat areas together. Movement is also important in the long term for persistence and interaction of local populations within the metapopulation. Gene flow, refounding of locally extinct populations, and support of locally weak populations require open corridors among populations. Disruption of migratory corridors increases stress, reduces growth and survival, and may lead to the loss of migratory life history types. Resident stocks in isolated marginal habitats are at a greater risk for extinction (Rieman and McIntyre 1993).

Bull trout grow rapidly in lake environments. In Lake Pend Oreille, fish six inches to ten inches (150 to 250 mm) in size can grow to adult size (over 20 inches (500 mm)) within three years (Jeppson 1960; 1961). Growth rate and size at maturity are greater for fluvial fish than resident fish, and greater for adfluvial fish than fluvial fish. Compared to current knowledge of tributary habitats, less is known about daily and seasonal habitat needs of bull trout in Kootenay Lake.

Genetic Integrity

Brook trout, numerous in many bull trout spawning and rearing streams in the U.S. portion of the Kootenai, can and do hybridize with bull trout, though the offspring are generally sterile. Brook trout are found throughout the upper Kootenai River drainage in British Columbia. Their numbers, however, are generally low and they do not occur in the Wigwam River system. Most brook trout are found in warmer, more heavily impacted streams (USFWS 2002b). The rate of hybridization of bull trout with brook trout was 25 percent for a sample of 24 fish collected in the river between Kootenai Falls and Libby Dam (USFS KNF 2002). Downstream from Kootenai Falls, brook trout are present in O'Brien Creek, and 87 probable brook trout redds were recorded in 1994 (MBTSG 1996b). Brook trout hybridization with bull trout is suspected in O'Brien Creek. Brook trout are also present in Pipe Creek, Keeler Creek, Lower Grave Creek (although not in spawning areas), and West Fisher Creek. Bull trout sampled from Kootenay Lake were not hybridized and had significant genetic differences from fish sampled upstream from Kootenai Falls (USFS KNF 2002). In the past, there were only a few private fish ponds in the upper Kootenai. Several unlicensed ponds are known to be present in the Grave Creek drainage (MBTSG 1996c). In recent years, the Lincoln County Conservation District has received numerous requests for private pond construction permits, many which requested permission to stock brook trout (USFWS 2002b). The trend is expected to continue. The USFWS (2002b) believes the proliferation of private ponds presents a risk to bull trout recovery efforts. In the upper Kootenai River drainage in British Columbia, private fish farms are permitted to raise only rainbow trout and they must be in self-contained artificial ponds on their own property (USFWS 2002b).

4.1.3 Population Status

Current Status

The status and population trend of all Kootenai River bull trout subpopulations was unknown at the time the species was listed (USFWS 1998) (table 4.9), however the Sophie Lake subpopulation was considered to be at risk of stochastic extirpation due to its single spawning stream and small population size. The section entitled *"Summary of Population Data"* in the Bull Trout Focal species section of this report provides information on the current status of local populations, including data on populations of index streams up to 2003.

Table 4.10 summarizes the Kootenai National Forest's characterization of subpopulations in the Montana portion of the Kootenai as part of their Section

LINKS

Appendix 55 includes Idaho Panhandle and Kootenai National Forest assessments of the status of bull trout (and other salmonid species) in the Idaho and Montana portions of the Kootenai.

Click Here

Table 4.9. Summary of bull trout subpopulation characteristics. Source: Klamath River and Columbia River Bull Trout Population Segments: Status Summary (1998).

Drainage	Subpopulation	Single Spawning Area	Re-founding Unlikely	Life History Forms[1]	Number	Status[2]
Kootenai	Upper Kootenai River	N	Y	M	500	U
	Sophie Lake	Y	Y	M	U	U
	Middle Kootenai River	Y	N	M, R	<75	U
	Lower Kootenai River	N	N	M	<40	U
	Bull Lake	N	Y	M	<75	U

[1] *M= Migratory; R = Resident*
[2] *D= Depressed; S= Strong, U = Unknown*

Table 4.10. Kootenai National Forest characterization of bull trout subpopulations in the Montana portion of the Kootenai Subbasin as part of their Section 7 consultation with the USFWS. FA=Functioning Appropriately; FAR=Functioning at Risk.

Stream	Subpopulation Size	Growth and Survival	Life History Diverstiy & Connectivity	Persistence and Genetic Integrity
UPPER KOOTENAI				
Wigwam	FA	FA	FA	FA
Grave Creek	FAR	FAR	FAR	FAR
Sophie/Phillips Creek	FAR	FAR	FAR	FAR
MIDDLE KOOTENAI				
Fisher River	FAR	FAR	FAR	FAR
Libby Creek	FAR	FAR	FAR	FAR
Quartz Creek	FA	FAR	FA	FAR
Pipe Creek	FAR	FAR	FAR	FAR
LOWER KOOTENAI				
O'Brien Creek	FAR	FAR	FAR	FAR
Lake and Keeler Creeks	FAR	FAR	FA	FAR
Callahan Creek	FAR	FAR	FAR	FAR
Lower Yaak River	FAR	FAR	FAR	FAR

7 consultation with the USFWS. Appendix 55 includes the Idaho Panhandle and Kootenai National Forests' assessments of the status of bull trout local populations (and other salmonid species) in the Montana and Idaho portions of the Kootenai (see the links column).

In the final listing rule, the magnitude of threats to bull trout was rated high for the Middle Kootenai subpopulation (between Libby Dam and Kootenai Falls) and moderate for the other four subpopulations. In all five subpopulations, the threats were considered imminent. In its Draft Bull Trout Recovery Plan, the US Fish and Wildlife Service (2002b) states that the historic distribution of bull trout in the Kootenai Recovery Unit is relatively intact, but abundance of bull trout in portions of the watershed has been reduced, and remaining populations are fragmented.

Historic Status

Quantitative data on historic bull trout abundance and productivity in the Kootenai Subbasin are not available. Evermann (1892) reported bull trout were common in most of the larger tributaries of the Columbia River in Montana. It is known that bull trout were an important food species for the Kutenai Indians (Smith 1984).

Theoretical Reference Condition[6]

The goal of the Draft Bull Trout Recovery Plan is to ensure the long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the species native range, so that the species can be delisted. Specifically, the Kootenai River Recovery Unit Team adopted the goal of a net increase in bull trout abundance in the Kootenai River Recovery Unit, with restored distribution of any extirpated populations that the recovery unit team identifies as necessary to recovery.

In order to assess progress toward the Kootenai River Recovery Unit objective, the recovery unit team adopted the following recovery criteria. The assumption was made that no core area is viable with a population of less than 100 adults because of the inherent stochastic and genetic risks associated with populations smaller than that. The recovery criteria are applied on a core area-by-core-area basis. In this recovery unit, a distinction was made between two types of core areas—primary and secondary—based mostly on the size, connectedness, complexity of the watershed, and the degree of natural population isolation. Koocanusa Reservoir and the Kootenai River/Kootenay Lake complex downstream from Libby Dam are the two primary core areas. Bull Lake and Sophie Lake are the two secondary core areas.

1. Distribution criteria will be met when the total number of identified local populations (currently numbering 10 in United States waters) has been maintained or increased, and local populations remain broadly distributed in all 4 existing core areas.

2. Abundance criteria will be met when the primary Koocanusa Reservoir and Kootenai River/Kootenay Lake core areas are each documented to host at least 5 local populations (including British Columbia tributaries) with 100 adults in each, and each of these primary core areas contains at least 1,000 adult bull trout. The abundance criteria for the Bull Lake and Sophie Lake secondary core areas will be met when each core area supports at least 1 local population of bull trout containing 100 or more adult fish.

3. Trend criteria will be met when the overall bull trout population in the Kootenai River Recovery Unit is accepted, under contemporary

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[6] Northwest Power and Conservation Council direction for this section is that the determination of a theoretical reference condition that ensures the long-term sustainablility for ESA-listed species should be made by the approprate ESA recovery team. This section is excerpted from the Bull Trout Draft Recovery Plan (2002b).

standards of the time, as stable or increasing, based on at least 10 years of monitoring data.

4. Connectivity criteria will be met when dam operational issues are satisfactorily addressed at Libby Dam (as identified through U.S. Fish and Wildlife Service Biological Opinions) and when over half of the existing passage barriers identified as inhibiting bull trout migration on smaller streams within the Kootenai River Recovery Unit have been remedied.

Table 4.11 presents the numeric standards necessary to recover abundance of bull trout in primary and secondary core areas of the Kootenai River Recovery Unit.

Table 4.11. Numeric standards necessary to recover abundance of bull trout in primary and secondary core areas of the Kootenai River Recovery Unit of the Columbia River drainage. Source: USFWS (2002b). The numbers in the second and third columns refer to numbers of adult bull trout spawning annually.

CORE AREAS	Existing Number (Estimated) Local Populations (United States)	Existing Number (Estimated) Local Populations with > 100 (United States)	Recovered Minimum Number Local Populations with > 100 (United States)	Recovered Minimum Number Core Area Total Adult Abundance
Lake Koocanusa	2	2	2	1,000
Kootenai River/Kootenay Lake	6	1 to 4	5	1,000
Bull Lake	1	1	1	100
Sophie Lake	1	0	1	100

4.1.4 Out-of-Subbasin Effects and Assumptions

Mainstem Columbia River operations profoundly influence dam operations as far upstream as headwater reservoirs. Dam operations affect environmental conditions in the reservoirs upstream and rivers downstream from Libby Dam. The abundance, productivity and diversity of fish and wildlife species inhabiting the headwaters of the Columbia River are dependent on their immediate environment that ebbs and flows with river management. Mainstem Columbia River operations affect bull trout in the following ways (Brian Marotz, MFWP, pers. comm. 2003):

- Unnaturally high flows during summer and winter negatively impact resident fish. The effects can be mitigated by releasing flows at a constant rate, producing constant stable, or slowly declining (unidirectional) flows.

- Summer flow augmentation causes reservoirs to be drafted during the biologically productive summer months. This impacts productivity in the reservoirs.

- Drafting the reservoirs too hard prior to receiving the January 1 inflow forecast places the reservoirs at a disadvantage for reservoir refill. This is especially important during less than average water years.

- Flow fluctuations caused by power, flood control or fish flows create a wide varial zone in the river, which becomes biologically unproductive.

- The planned reservoir refill date in the NOAA Fisheries BiOp of June 30 will cause the dam to spill in roughly the highest 30 percent of water years. This is because inflows remain above turbine capacity into July on high years. That means the reservoirs fill and have no remaining capacity to control spill. This causes gas super saturation problems. A sliding refill date allows filling later in high water years.

LINKS

For a more complete discussion of how Mainstem Columbia River operations affect subbasin fisheries, and how those effects might be minimized see Appendix 18.

Click Here

4.1.5 Environment-Population Relationships

Environmental Factors Particularly Important to Bull Trout Survival or Key Ecological Correlates (KECs)[7]

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these

[7] *This section is adapted from USFWS (2002).*

LINKS

For the website containing descriptions of surface waters included in the Montana water quality assessment database go to: http://nris.state.mt.us/wis/environet/2002_305bhome.html.

Click Here

For the website listing 303(d) water-quality impaired streams and lakes for the Idaho portion of the subbasin, go to: http://inside3.uidaho.edu/WebMapping/IDEQ/

Click Here

For more detailed results of the QHA lake and stream assessment, including attribute scores, see Appendices 32 and 33.

Click Here

Appendix 31 summarizes the baseline condition for bull trout in bull trout drainages in the Montana portion of the Kootenai.

Click Here

watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), fish should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997b).

Migratory corridors link seasonal habitats for all bull trout life histories. For example, in Montana, migratory bull trout make extensive migrations in the Flathead River system (Fraley and Shepard 1989), and resident bull trout in tributaries of the Bitterroot River move downstream to overwinter in tributary pools (Jakober 1995). The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993; Gilpin 1997; Rieman et al. 1997). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed, or stray, to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants.

Bull trout are found primarily in cold streams, although individual fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman et al. 1997). Water temperature above 15 degrees Celsius (59 degrees Fahrenheit) is believed to limit bull trout distribution, a limitation that may partially explain the patchy distribution within a watershed (Fraley and Shepard 1989; Rieman and McIntyre 1995). Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993; Rieman et al. 1997; Baxter et al. 1999). Goetz (1989) suggested optimum water temperatures for rearing of about 7 to 8 degrees Celsius (44 to 46 degrees Fahrenheit) and optimum water temperatures for egg incubation of 2 to 4 degrees Celsius (35 to 39 degrees Fahrenheit).

All life-history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich 1996; Sexauer and James 1997; Watson and Hillman 1997). Jakober (1995) observed bull trout overwintering in deep beaver ponds or pools containing large woody debris in the Bitterroot River drainage, Montana, and suggested that suitable winter habitat may be more restricted than summer habitat. Maintaining bull trout habitat requires stability of stream channels and flow (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993).

Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989) and water temperatures of 5 to 9 degrees Celsius (41 to 48 degrees Fahrenheit) in late summer to early fall (Goetz 1989). In the Swan River, Montana, abundance of bull trout redds (spawning areas) was positively correlated with the extent of bounded alluvial valley reaches, which are likely areas of groundwater to surface water exchange (Baxter et al. 1999). Survival of bull trout embryos planted in stream areas of groundwater upwelling used by bull trout for spawning were significantly higher than embryos planted in areas of surface-water recharge not used by bull trout for spawning (Baxter and McPhail 1999). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

LINKS

Appendix 62 presents the results of a GIS-based fisheries vulnerability analysis conducted by the Cohesive Strategy Team of Region 1 of the USFS.

Click Here

Appendix 63 presents the results of an American Wildlands GIS-based, coarse-scale analysis of the current condition of native aquatic integrity across an Upper Columbia basin (called the Aquatic Integrity Areas (AIA) model). Go also to: http://www.y2y.net/science/aquatic_research.asp#aia

Click Here

Environment s Ability to Provide Key Ecological Correlates

As part of our assessment, the Kootenai Subbasin (MT, ID, and B.C.) Technical Teams[8] evaluated all the sixth-code HUCs and selected lakes in Montana, Idaho, and Canada[9] on the basis of eleven stream habitat attributes (Parkin and McConnaha 2003) and thirteen lake habitat attributes considered key to resident salmonids. This watershed analysis was done utilizing a spreadsheet tool developed by Mobrand Biometrics called Qualitative Habitat Assessment (QHA). Mobrand Biometrics and Dr. Paul Anders developed the lacustrine or lake version of QHA, called LQHA. The habitat attributes used in the stream version of QHA are generally thought to be the main habitat drivers of resident salmonid production and sustainability in streams (Parkin and McConnaha 2003) (table 4.12). Those used in LQHA are the ones considered by our Technical Team to be the main habitat drivers in lakes in the subbasin (table 4.13). For each 6th Code HUC, the technical team used quantitative data (when it existed) and professional knowledge and judgement to score each of the attributes for each HUC. We did the same for selected lakes (table 4.14).

Table 4.15 ranks stream habitat-attributes for bull trout averaged across the regulated mainstem HUCs in the U.S. portion of the subbasin. Tables 4.16

[8] *The Kootenai Subbasin Technical Team members participating in the HUC-by-HUC assessment included fisheries biologists and hydrologists from the Kootenai Tribe of Idaho, Montana Fish, Wildlife and Parks, Idaho Fish and Game, Idaho Department of Environmental Quality, US Army Corps of Engineers, US Fish and Wildlife Service, the Idaho Panhandle and Kootenai National Forests, two provincial Canadian ministries, and a private consulting firm.*

[9] *In the U.S. portion of the subbasin, some valley HUCs were lumped. In the Canadian portions of the subbasin, time limitations prevented the use of 6th-code HUCs. Instead, the Canadian members of the team used analogous watersheds developed during a previous watershed restoration planning exercise in B.C.*

Table 4.12. Eleven habitat attributes used in the Kootenai Subbasin QHA analysis of 6th code HUCs with definitions.

Attribute	Brief Definition
Riparian Condition	Condition of the stream-side vegetation, land form and subsurface water flow.
Channel Stability	The condition of the channel in regard to bed scour and artificial confinement. Measures how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types.
Habitat diversity	Diversity and complexity of the channel including amount of large woody debris (LWD) and multiple channels
Fine Sediment	Amount of fine sediment within the stream, especially in spawning riffles
High Flow	Frequency and amount of high flow events.
Low Flow	Frequency and amount of low flow events.
Oxygen	Dissolved oxygen in water column and stream substrate
High Temperature	Duration and amount of high summer water temperature that can be limiting to fish survival
Low Temperature	Duration and amount of low winter temperatures that can be limiting to fish survival
Pollutants	Introduction of toxic (acute and chronic) substances into the stream
Obstructions	Barriers to fish passage

Table 4.13. Habitat attributes used in the Kootenai Subbasin Lacustrine QHA analysis of selected lakes with definitions.

Attribute	Brief Definition
Temperature	Duration and amount of high or low water temperatures that can be limiting to fish survival
Dissolved Oxygen	Dissolved oxygen in water column and stream substrate
Gas Saturation	Percent water is saturated (<100%) or super-saturated (>100%) with Nitrogen gas
Volumetric Turnover Rates	Time required to replace entire reservoir with new water based on rate of its downstream expulsion
Pollutants	Introduction of toxic (acute and chronic) substances into the lake or reservoir
Trophic Status	Level (status) of biological productivity in lake or reservoir
Entrainment	Downstream fish loss through a hydropower dam, other than through a spillway of fish ladder
Migratory Obstacles	Natural and artificial barriers to upstream and/or downstream fish migration
Macrophytes	Emergent and submergent aquatic plant species and community structure in lakes and reservoirs
Hydraulic Regime	Temporal and volumetric characteristics of hydrograph
Shoreline Condition	Physical condition of water-land interface, riparian and varial zones
Habitat Diversity	Relative degree of habitat heterogeneity
Substrate Condition	Physical condition of substrates

Table 4.14. Lakes assessed in the Kootenai Subbasin using the Lacustrine QHA spreadsheet tool.

Lake	Location
Kootenay Lake	Canada
Moyie Lakes	Canada
Duncan Lake	Canada
Trout Lake	Canada
Koocanusa Reservoir	U.S./Canada
Kilbrennan	U.S.
Loon Lake	U.S.
Bull Lake	U.S.
Sophie Lake	U.S.
Boulder Lake	U.S.
Granite Lake	U.S.
Leigh Lake	U.S.
Therriault Lake	U.S.
McArthur Lake	U.S.

and 4.17 rank stream habitat-attributes for bull trout averaged across all tributary 6th-code HUCs in the U.S. and B.C. portions of the subbasin, respectively. Tables 4.18 and 4.19 show the ranking by 4th-code HUC for the U.S. and B.C. portions of the subbasin. Table 4.20 ranks habitat attributes for selected subbasin reservoirs and lakes in both Canada and the U.S. The rankings provide a good indication of the subbasin's ability to provide key ecological correlates required for bull trout viability and persistence and the habitat attributes that may be the most limiting for bull trout in the subbasin.

Based on this analysis, of the eleven stream habitat attributes considered key to resident salmonids, the most degraded for bull trout in the tributary streams of the U.S. portion of the subbasin (when averaged across all the HUCs) are high temperature, riparian condition, channel stability, and fine sediment, in that order. In the regulated mainstem, they are altered flows, riparian condition, fine sediment, and channel stability. In the B.C. portion they are channel stability, fine sediment, riparian condition, and habitat diversity. The rankings vary at the HUC-4 scale.

Of the thirteen lake/reservoir-habitat attributes considered key to resident salmonids, the four most limiting to bull trout in reservoirs are: migratory obstructions, volumetric turnover rates, hydraulic regime, and trophic status. The habitat in lakes is in significantly better condition, and none of the lake habitat attributes scored low enough to be considered limiting.

Table 4.15. Ranking of key habitat attributes for the regulated mainstem in the U.S. portion of the Kootenai Subbasin for bull trout based on a QHA analysis. Those with the highest rank (1 being highest) scored highest in terms of their condition with respect to bull trout (the higher the QHA score the more degraded the attribute).

Habitat Attribute	Score	Rank
Oxygen	0.00	1
Low Temperature	0.03	2
Obstructions	0.16	3
Pollutants	0.17	4
Habitat Diversity	0.23	5
High Temperature	0.33	6
Channel stability	0.34	7
Fine sediment	0.37	8
High Flow	0.44	9
Riparian Condition	0.50	10
Low Flow	0.86	11

Table 4.16. Ranking of key habitat attributes for 6th-code HUC tributary watersheds in the U.S. portion of the Kootenai Subbasin for bull trout based on a QHA analysis.

Habitat Attribute	Score	Rank
Low Temperature	0.00	1
Oxygen	0.03	2
Obstructions	0.06	3
Pollutants	0.07	4
High Flow	0.15	5
Low Flow	0.17	6
Habitat Diversity	0.20	7
Fine sediment	0.26	8
Channel stability	0.26	8
Riparian Condition	0.27	9
High Temperature	0.28	10

Table 4.17. Ranking of key habitat attributes for 6th-code HUC iwatersheds in the B.C. portion of the Kootenai Subbasin for bull trout based on a QHA analysis.

Habitat Attributes	Score	Rank
Low Temperature	0.00	1
Oxygen	0.03	2
Obstructions	0.07	3
Pollutants	0.09	4
High Flow	0.17	5
Habitat Diversity	0.21	6
Low Flow	0.22	7
Fine sediment	0.27	8
Channel stability	0.27	8
High Temperature	0.28	9
Riparian Condition	0.29	10

Table 4.18. Ranking of key stream-habitat attributes for the regulated mainstem and tributaries at the HUC-4 watersheds for bull trout in the U.S. portion of the subbasin based on a QHA analysis of 6th-field HUCs. Those attributes with the highest rank (with 1 being highest) scored highest in terms of their condition with respect to bull trout (the higher the QHA score, the more degraded the attribute). The most limiting attributes are highlighted in yellow. Note that the QHA scores for some HUC-4s (e.g., Lower Kootenai) and the regulated mainstem are significantly higher than for others. Note also that the attribute rankings in the regulated mainstem differ from those of the tributaries.

	Regulated Mainstem		Fisher		Lower Kootenai		Moyie		Upper Kootenai	
Habitat Attribute	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Channel stability	0.34	7	0.28	6	0.41	8	0.30	8	0.21	8
Fine sediment	0.37	8	0.32	8	0.41	8	0.27	7	0.20	7
Habitat Diversity	0.23	5	0.25	5	0.28	6	0.23	5	0.17	5
High Flow	0.44	9	0.13	3	0.22	4	0.10	2	0.14	3
High Temperature	0.33	6	0.31	7	0.50	9	0.33	10	0.19	6
Low Flow	0.86	11	0.24	4	0.22	4	0.17	4	0.15	4
Low Temperature	0.03	2	0.00	1	0.01	1	0.00	1	0.00	1
Obstructions	0.16	3	0.04	2	0.11	2	0.16	3	0.04	2
Oxygen	0.00	1	0.00	1	0.15	3	0.00	1	0.00	1
Pollutants	0.17	4	0.00	1	0.24	5	0.25	6	0.00	1
Riparian Condition	0.50	10	0.38	9	0.29	7	0.31	9	0.25	9

Table 4.19. Ranking of key stream-habitat attributes at the HUC-4 scale for bull trout in the B.C. portion of the subbasin based on a QHA analysis of all 6th-field HUCs.

	Bull River		Duncan Lake		Elk		Kootenay Lake		Slocan		St. Mary	
Habitat Attribute	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Channel stability	0.45	6	0.18	3	0.25	6	0.16	7	0.22	6	0.38	8
Fine sediment	0.51	7	0.13	3	0.27	7	0.14	5	0.27	8	0.31	7
Habitat Diversity	0.38	4	0.11	2	0.20	5	0.13	4	0.17	5	0.23	5
High Flow	0.34	3	0.00	1	0.10	2	0.03	3	0.05	4	0.13	3
High Temperature	0.05	2	0.00	1	0.00	1	0.00	1	0.02	3	0.00	1
Low Flow	0.51	7	0.00	1	0.18	4	0.02	2	0.01	2	0.21	4
Low Temperature	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1
Obstructions	0.00	1	0.00	1	0.00	1	0.00	1	0.01	2	0.02	2
Oxygen	0.00	1	0.00	1	0.00	1	0.00	1	0.01	2	0.00	1
Pollutants	0.00	1	0.00	1	0.14	3	0.00	1	0.01	2	0.00	1
Riparian Condition	0.41	5	0.11	2	0.20	5	0.15	6	0.24	7	0.29	6

Table 4.20. Ranking of key habitat attributes for reservoirs and selected lakes in the Kootenai Subbasin for bull trout based on a LQHA analysis. Those with the highest rank scored highest in terms of their condition with respect to bull trout. It is important to note that the lake scores were much lower than reservoir scores. All of the habitat attributes in lakes are relatively intact when compared to that of reservoirs.

Reservoirs	Score	Rank
Oxygen	0.00	1
Gas saturation	0.00	1
Macrophytes	0.00	1
Habitat diversity	0.03	2
Temperature	0.06	3
Substrate condition	0.07	4
Pollutants	0.08	5
Shoreline condition	0.11	6
Entrainment	0.16	7
Trophic status	0.19	8
Hydraulic regime	0.22	9
Volumetric turnover rates	0.28	10
Migratory obstruction	0.41	11
Lakes		
Oxygen	0.00	1
Gas saturation	0.00	1
Entrainment	0.00	1
Macrophytes	0.00	1
Volumetric turnover rates	0.01	2
Habitat diversity	0.01	2
Substrate condition	0.01	2
Shoreline condition	0.02	3
Pollutants	0.03	4
Temperature	0.03	4
Hydraulic regime	0.03	4
Trophic status	0.04	5
Migratory obstruction	0.06	6

4.1.6 Bull Trout Limiting Factors and Conditions

Guidance from the NWPPC defines limiting factors as those factors or conditions that have led to the decline of each focal species and/or those conditions that currently inhibit populations and ecological processes and functions relative to their potential.

In the HUC-by-HUC assessment of all Kootenai Subbasin 6th-field HUCs, the technical team concluded that of the habitat attributes considered most important to resident salmonids (when averaged across all the HUCs) are high temperature, riparian condition, channel stability, and fine sediment, in that order. In the regulated mainstem, they are altered flows, riparian condition, fine sediment, and channel stability. In streams in the B.C. portion they are channel stability, fine sediment, riparian condition, and habitat diversity. In reservoirs they are migratory obstructions, volumetric turnover rates, hydraulic regime, and trophic status. The rankings vary at the HUC-4 scale. This phase of the HUC assessment considered only habitat factors (factors such as the presence of non-native species were evaluated in a second phase of the HUC assessment and were not ranked against the habitat attributes in terms of which is most limiting).

According to a series of 1996 reports by the Montana Bull Trout Scientific Group (MBTSG 1996a, 1996b, and 1996c) forestry practices rank as the highest risk to bull trout in the subbasin, largely because it was the dominant land use in all core areas. This risk to the bull trout population is elevated due to the number of core areas (Quartz, Pipe and Libby Creek drainages) available due to fragmentation caused by Libby Dam. The threat from dam operations is considered high because of the biological effects associated with unnatural flow fluctuations and gas supersaturation problems that may arise from spilling water. The dam is a fish migration barrier, restricting this migratory population to 29 miles of river, which increases the likelihood of localized effects becoming a higher risk. Dam operations are considered a very high risk to the continued existence of the Kootenai drainage population of bull trout (Montana Bull Trout Scientific Group 1996).

LINKS

Appendix 87 reports on a spill test conducted in June of 2002.

Click Here

The following paragraphs are adapted from the Draft Bull Trout Recovery Plan. They summarize the factors or conditions identified by the USFWS (2002) that have led to the decline of bull trout and/or that currently inhibit bull trout populations in the Kootenai Subbasin.

Dams

In Koocanusa Reservoir, drawdown limits to protect fishery resources have been advocated since at least 1987 (MBTSG 1996c). In the late 1980s and early 1990s, proposed drawdown limits were exceeded during more than 50 percent of these years. Extreme drawdowns have been shown to have negative consequences on benthic insect production, zooplankton production, and terrestrial insect deposition (MFWP 1997). There is concern about the long-term maintenance of fisheries in Koocanusa Reservoir, given the continuing operational fluctuations (MFWP 1997).

Entrainment studies at Libby Dam have documented low numbers of bull trout passing through the dam, primarily in the spring. Skaar et al. (1996) found a total of 6 bull trout in a sample of 13,186 entrained fish captured below the dam. They estimated that the total number of fish entrained was 1.15 to 4.47

million and that the total number of bull trout could be as high as several thousand. However, since the time of that study, operations and discharge schedules have changed, and the total number of bull trout present in the reservoir has also likely increased substantially. Adult bull trout marked with floy tags in the Wigwam River system (upstream from Koocanusa Reservoir) have also been documented to pass through Libby Dam. One fish was subsequently recaptured alive in O'Brien Creek, at least 55 kilometers (34 miles) downstream from Libby Dam (Baxter and Westover 2000). Two others were found dead in the Kootenai River downstream from the dam.

In 1978, a selective withdrawal system was installed at Libby Dam (MBTSG 1996c). Selective withdrawal results in little or no thermocline formation in Koocanusa Reservoir. The absence of a thermocline may contribute to entrainment of fish. Currently, the fisheries sampling program is not designed to identify affects of operations on use of the reservoir by bull trout. The impact of existing dam operations on bull trout represents a major research need.

Impoundment of the Kootenai River by Libby Dam in 1972 also altered the aquatic environment in the river downstream from the dam. The operation of Libby Dam by the U.S. Army Corps of Engineers departs drastically from natural downriver discharge patterns on a seasonal and sometimes daily basis. After the dam was built, temperature patterns, sediment loads, and water quality were altered downstream from Libby Dam. These alterations resulted in changes in periphyton, aquatic insects, and fish populations (Dayley et al. 1981; MFWP 1983). Snyder and Minshall (1996) proposed bottom-up food limitation as the mechanism behind declining fish populations in the Kootenai River. As an example, by the 1990s, the mountain whitefish population in the Idaho reach had decreased by up to 75 percent compared to the early 1980s (Partridge 1983; Paragamian 1995a,b; Downs 2000; Walters and Downs 2001). Mountain whitefish are likely a prey species of bull trout in the Kootenai River and therefore may affect bull trout survival or fitness. Maximum discharge through the existing turbines is about 792.4 cubic meters per second (28,000 cubic feet per second). Daily peaking of flows has been identified as another issue of concern in the river downstream. Gas supersaturation, which can cause gas bubble disease in fish, is a problem when spilling occurs. Except for a spill test in June of 2002 (Appendix 87), spill has not routinely occurred in over a decade. An additional affect of Koocanusa Reservoir was that it became a nutrient sink, reducing available phosphorous and nitrogen to the Kootenai River below and reduced productivity in the river (Woods 1982; Snyder and Minshall 1996). Paragamian (2002) suggested the change in productivity led to a fish community shift, with a greater representation of omnivores and fewer insectivores. Collectively, these changes in river ecology as a result of dam operations have had variable and largely unquantified impacts on downstream habitat for juvenile bull trout and their food supply.

Since dam construction, lack of seasonal peak flows has been allowing delta formation at the mouths of some tributaries in Montana and Idaho. These depositional areas may eventually impede upstream movement of bull trout spawners during low flows. Migrant bull trout may be especially sensitive because their fall spawning run coincides with low tributary flows and reduced water depths. A delta at the mouth of Quartz Creek is of particular concern because of that stream's importance to migratory bull trout reproduction. Studies completed in 1988 concluded that this delta did not represent a barrier, but the delta should be monitored periodically to determine whether the surface elevation is increasing (Marotz et al. 1988).

Troy Dam, constructed in 1917 at the mouth of Lake Creek, is an upstream fish passage barrier. The dam is located at the site of a natural waterfall suspected to have been at least a seasonal barrier to fish passage. The Bull Lake bull trout secondary core area population is isolated upstream from this barrier and is supported by spawning and rearing habitat within the Lake Creek drainage, especially in Keeler Creek.

LINKS

Appendix 98 shows barriers in the Montana portion of the Kootenai Subbasin.

Click Here

Forest Management Practices

Forestry practices rank as a high risk in the Kootenai River Subbasin, largely because forestry is the dominant land use in the basin. The risk to bull trout is elevated due to the fragmentation in the drainage caused by Libby Dam. Virtually all drainages supporting bull trout in the Kootenai River Subbasin are managed timberlands. In the upper Kootenai River Subbasin, upstream from Libby Dam, both the Grave Creek and Wigwam River drainages are largely second-growth forest, and timber harvest continues. Extensive road construction has resulted in increased water and sediment yields (MBTSG 1996c). At the present time, within the United States portion of the basin, only the headwaters of the Grave Creek drainage are protected from future timber management activities.

In the Elk River watershed in British Columbia (a tributary to the upper end of Koocanusa Reservoir), sediment from roads and logging sites was once so severe that water quality investigators felt that settling basins may be needed to protect the stream's water quality. New logging practices in British Columbia, conducted under the current Forest Practices Code, are much more stringent than they were 25 years ago (Westover, in litt. 1999). However, high-water events continue to cause sedimentation. New timber harvest and road building underway in the Wigwam River watershed are of major concern because this watershed currently provides high-quality bull trout habitat. The new activities are being monitored closely, with data to be collected on flows, suspended sediment, temperature, and ground water, both before activities begin and into the future (Westover, in litt. 1999).

There are extensive private timberlands in the upper Kootenai River watershed in the United States, mostly owned by Plum Creek Timber Company (formerly Champion International). Much of this land has been heavily roaded and logged, particularly in the Fisher River drainage and the Lake and O'Brien Creek watersheds (MBTSG 1996c). These lands are now covered under the Native Fish Habitat Conservation Plan, which the U.S. Fish and Wildlife Service agreed to with Plum Creek Timber Company in 2000; condition of native-fish habitat in these watersheds is expected to improve under that agreement.

According to the Environmental Impact Statement for the Kootenai National Forest Plan, almost two-thirds of the Kootenai National Forest in Montana, particularly the west half, has problems with watershed instability. Frequent flooding and concentrated high water yields, sedimentation, and small slumps occur below clear-cuts and roads (MBTSG 1996a). The Montana Department of Environmental Quality (MDEQ 2003) lists 129 stream miles in the Kootenai River drainage as having impaired water quality as a result of silvicultural activities. The channel of Keeler Creek, in Montana, is in a destabilized condition because of extensive timber harvest activities and poorly constructed roads, built primarily between 1941 and 1970 (MBTSG 1996c). During that period, over 100 million board feet were clear cut from 23 square kilometers (5,780 acres). Serious flooding occurred in 1974 and 1980.

A point source of sediment pollution exists on Therriault Creek Road, in the Tobacco River drainage, due to improper road drainage and fill slope construction along the stream channel. Edna Creek, tributary to Fortine Creek, has heavy accumulations of sediment in the stream channel (Marotz et al. 1988).

A review of the National Forest database for portions of the Kootenai River Subbasin in Idaho (PBTTAT 1998) revealed that in watersheds important to bull trout, road density averaged 1.5 kilometers per square kilometer (2.4 miles per square mile), with roads covering 1.7 kilometers per square kilometer (2.8 miles per square mile) of riparian area and with 1.1 road crossings per kilometer of stream. A total of 16 percent of the watersheds had been logged. Zaroban et al. (1997) found that Idaho Forest Practice Act rules were implemented 97 percent of the time, and when applied, they were 99 percent effective at preventing pollutants from reaching a stream (PBTTAT 1998). However, in half the timber sales reviewed, sediment was still being delivered to streams.

Current forestry practices are less damaging than past practices were, but the risk is still high because of the existing road system, mixed land ownership, lingering results of past activities, and inconsistent application of best management practices (MBTSG 1996c).

Livestock Grazing

While there may be site-specific impacts, aquatic habitat degradation due to improper livestock grazing is not considered a widespread problem in the Kootenai River Subbasin, in either the United States or British Columbia. Where localized impacts occur, these should be addressed.

Agricultural Practices

The Montana Department of Environmental Quality lists 73 miles of streams in the upper Kootenai River watershed in Montana as having impaired water quality as a result of agriculture (MDEQ 2003).

There are at least two irrigation diversions in Grave Creek. The North Fork of Grave Creek is actually an irrigation ditch and requires occasional work within the stream channel to maintain suitable flow conditions. The Glen Lake Ditch has lacked any functional fish screening, and bull trout moving downstream were historically lost into this irrigation ditch, some ending up in Glen Lake (MBTSG 1996c). In 2001, a project to stabilize the structure, screen the ditch, and improve fish passage over the dam was completed. The diversion still results in some dewatering of the mainstem of Grave Creek in certain years. Dewatered streams in the upper Kootenai River drainage include Grave, Phillips, Sinclair, and Therriault creeks—a total of 22.5 kilometers (14 miles) of streams (MFWP 1991).

In the Idaho portions of the Kootenai River valley, channel straightening, diking, and creation of drainage ditches have grossly modified and/or eliminated some of the lower tributary and mainstem river habitat (PBTTAT 1998; USFWS 1999). Practices that contribute to decreased water quality and/or temperature increases in the lower river corridor could hinder fish use of this river as a migratory corridor and rearing habitats. A problematic diversion on Boundary Creek in Idaho is being screened to eliminate the entrainment of juvenile and adult bull trout. Additional diversion issues may exist on Long Canyon Creek (USFWS 2002).

Agricultural practices have not had major impacts in the upper Kootenay River watershed in British Columbia, as most of the lands are forested.

Transportation Networks

Railroads are located along the middle portion of the Kootenai River and along the Fisher River. The rerouting of the Great Northern Railroad in the late 1960s shortened the stream channels of the Fisher River, Wolf Creek, and Fortine Creek by over 3 kilometers (0.6 miles) (MBTSG 1996a). Major portions of the lower 16 kilometers (10 miles) of the Fisher River and most of Wolf Creek were channelized.

On portions of Pleasant Valley Fisher River, the main Fisher River, and Swamp Creek east of Libby, there are straightened and riprapped channels along U.S. Highway 2. This highway also parallels the Kootenai River further west. The potential for negative impacts to bull trout to occur as a result of migration barriers, spills, weed suppression, fire suppression, and road maintenance is high (MBTSG 1996a).

Transportation corridors also occur along portions of the drainage in British Columbia, but their overall impact to habitat on the Kootenai River system has not been extensive.

Mining

Annual discharges from the Cominco, Ltd. phosphate plant in Kimberly, British Columbia, exceeded 7,257,472 kilograms (8,000 tons) of phosphorous in the middle to late 1960s (MBTSG 1996c). Pollution abatement measures were installed in 1975, and the plant eventually closed in 1987. Phosphorus levels in Koocanusa Reservoir are now much lower. High fluoride levels also existed in the Kootenai River prior to the early 1970s.

The Sullivan Mine, at Kimberly, British Columbia, has been in operation since 1900. Until 1979, acid mine drainage and heavy metals from the mine and concentrator were discharged untreated into Mark, Kimberly, and James creeks, tributaries of the St. Mary River (MBTSG 1996c). This discharge negatively affected fish and aquatic life in these tributaries, as well as in the Kootenay River itself. Wastewater treatment facilities were installed in 1979, significantly decreasing the quantity of heavy metals reaching the Kootenay River (Kootenai River Network 2000). The Sullivan Mine closed in December 2001 (B. Westover, pers. comm., 2004).

Five open pit coal mines occur in the Elk River drainage in British Columbia. The major water quality problems associated with these coal fields are nitrogen residuals from bulk explosives and increased delivery of suspended sediment to the Elk River and its tributaries. In recent years, better runoff collection systems have been installed, along with settling ponds, and chemical flocculents are selectively used at the mines. Under permit stipulations, suspended sediment concentrations in effluents are not to exceed 50 milligrams per liter (50 parts per million) (MBTSG 1996c). Impacts are likely to continue on a localized scale. In 1995, it was discovered that selenium was being released from the weathering of large accumulations of waste rock at the mines (McDonald and Strosher 1998). To date, studies on trout embryos from sites near the mines have found none of the toxic effects often associated with bioaccumulated selenium (Kennedy et al. 2000). Additional concerns have been expressed over presence of heavy metals. The mines are located over 96.6 kilometers (60 miles) from the Kootenay River, in the Elk River drainage upstream from a passage barrier at Elko. Overall, current mine impacts to bull trout in the upper Kootenai River may not be significant, but the potential for future problems remains. Recently the B.C. government attempted to auction off coalbed methane leases in the Canadian headwaters of North Lodgepole Creek, a tributary of the Wigwam River but no bids were received. The potential remains, however, for development at some future date.

Historically, mining was much more active in the Kootenai River drainage than it is today. Underground mining began in the Kootenai River Subbasin in the late 1800s, and large-scale surface mining flourished beginning in the late 1960s. The Montana Department of Environmental Quality (MDEQ 2003) lists 35 stream miles in the Kootenai River drainage as having impaired water quality as a result of mine tailings. Twenty-nine stream miles are listed as impaired from abandoned mines, and 12 miles from placer mining. Some small private mining operations continue in the Lake Creek drainage and in Canada. Water quality impairment in Lake Creek is the result of a copper and silver mine, mill, and tailings impoundment owned by ASARCO, Inc. (MBTSG 1996b). This facility is not presently in operation.

Acid mine drainage from the Snowshoe Mine in the Libby Creek drainage has affected trout populations in 5 kilometers (3 miles) of Snowshoe Creek and 24 kilometers (15 miles) of Big Cherry Creek for over 70 years (MBTSG 1996a). Efforts are currently underway to reclaim this site, but other abandoned mines need similar attention (MBTSG 1996a). Historic mining operations in the Fisher River drainage have contributed to channel degradation. Big Cherry, Libby, and Snowshoe creeks suffer from impaired water quality as a result of mining activities. Several other drainages in the basin have historical impacts from small mining operations.

In Idaho, Boulder Creek and Blue Joe Creek have a legacy of water quality and habitat degradation problems from mining activity (PBTTAT 1998). Blue Joe and Boundary Creeks experience episodes of toxic runoff from the Continental Mine.

A large copper and silver mine complex has been proposed in the Libby Creek watershed, with potential impacts on Little Cherry Creek, which may contain a local population of genetically pure, native Columbia River redband trout (MBTSG 1996a). This Noranda proposal is not currently active; it will require consultation for potential impacts to bull trout under section 7 of the Endangered Species Act if it is revived. Because of risks from historic mines and proposed future mines, the historic/current and restoration risks of mining are rated as high in the Kootenai River drainage.

Residential Development

Many of the streams in this area, particularly in the lower Kootenai River Subbasin, flow through private land. The human population in areas around Eureka, Libby, and Troy, Montana; around Bonners Ferry, Idaho; and in portions of southern British Columbia is increasing, resulting in increased housing development along streams. Development exacerbates temperature problems, increases nutrient loads, decreases bank stability, alters instream and riparian habitat, and changes hydrologic response of affected watersheds. Because of the proximity of this development to bull trout spawning and rearing habitat, rural residential development is considered to be a risk. The location of the development and not the magnitude is of primary concern at this time for bull trout recovery.

Fisheries Management

Illegal harvest has been well documented in this subbasin and is considered a high risk to bull trout recovery because of the well-known and limited spawning areas (MBTSG 1996a, 1996b, 1996c). Poaching activity peaks during summer months when fish are in the tributaries and can be easily taken (Long 1997). Using interviews with convicted poachers in northwest Montana (and northern Idaho), researchers estimated that an average of 22 bull trout per week were harvested from a portion of the Kootenai River in recent years, with additional fish mortally injured but not retrieved (Long 1997). An angler survey on the Elk and Wigwam Rivers in British Columbia estimated that 28 bull trout were illegally taken from these waters during the summer of 1998 (Westover 1999).

In the late 1960s and early 1970s, just prior to completion of Libby Dam, several tributaries to Koocanusa Reservoir were treated with toxicants to remove rainbow trout and restore westslope cutthroat trout. These tributaries included Young, Big, Five Mile, Sullivan, and Clarence creeks (MBTSG 1996c). At the time of treatment only Clarence Creek was known to support bull trout.

Brook trout are present in many bull trout spawning and rearing streams in the Kootenai River Subbasin. Brook trout are present throughout the upper Kootenay River drainage in British Columbia, although their numbers are generally low and they do not occur in the Wigwam River system. Most brook trout are found in warmer, more heavily impacted streams (Westover, in litt. 1999).

Other non-native fish species found in the Kootenai River drainage include coastal rainbow trout (the Kamloops/redband trout are native in the lower Kootenai), Yellowstone cutthroat, kokanee salmon (in Koocanusa Reservoir), lake trout (in a closed basin lake), northern pike, yellow perch, smallmouth bass, largemouth bass, black bullhead, and pumpkinseed sunfish. *Mysis relicta* (opossum shrimp) have also been introduced into lakes in the drainage. Brown trout were collected in Lake Creek in 1994 and in the Kootenai River downstream from Kootenai Falls in 1998 and 2000. These are the first recorded occurrences of brown trout in the Kootenai River drainage in Montana. Brown trout, collected sporadically in the Idaho portion of the Kootenai since 1998 (Downs 2000; Idaho Dept. of Fish and Game, unpublished data), were also collected in the Idaho portion of the Kootenai River in 2001, 2002, and 2003 in very low numbers during an annual late-summer electrofishing effort by KTOI and IDFG. Most were collected near Crossport, ID.

Predation or competition by largemouth bass, northern pike, or other cool or warm-water species could have negative impacts in localized situations. The presence of kokanee salmon in Koocanusa Reservoir and in the Kootenai River downstream may benefit bull trout by providing a food source for subadult and adult fish (MBTSG 1996c).

Historically, few private fish ponds existed in the upper Kootenai River drainage. Several unlicensed ponds are known to be present in the Grave Creek drainage (MBTSG 1996c). The Lincoln County Conservation District has received numerous requests for private pond construction permits during the past few years. Many applicants for private pond permits request authorization to stock brook trout. Requests for private fish pond permits are likely to continue to increase along with local human population growth (MBTSG 1996c). Proliferation of private ponds presents a risk to bull trout recovery efforts. In the upper Kootenai River drainage in British Columbia, private fish farms are permitted to raise only rainbow trout and they must be in self-contained artificial ponds on their own property.

Extensive gravel mining occurred when Highway 93 was reconstructed near Eureka. The pits created by this mining have now filled with water, potentially creating habitat for non-native fish species such as perch and northern pike (MBTSG 1996c). There is a concern that this newly created habitat may exacerbate the spread of some non-native species.

Most non-native species currently present were intentionally introduced through agency stocking in the last century. Such stocking of brook trout, coastal rainbow trout, and Kamloops rainbow has occurred in the upper Kootenai River drainage (extending the range of the latter, which are native in Kootenay Lake). The kokanee salmon population in Koocanusa Reservoir resulted from an accidental release of fish from a hatchery in British Columbia in the 1970s (MBTSG 1996c). Presently, coastal rainbow trout are planted only in isolated lakes. All other fish plants in the United States, with the exception of Koocanusa Reservoir, are with westslope cutthroat trout, which are native to the Kootenai River.

There have been continuing problems across northwest Montana with illegal fish introductions. Illegal introductions have occurred in at least 28 waters in the Kootenai River drainage (Vashro, in litt. 2000), most of which involved warm- or cool-water species (pike, perch, bass, bluegill, bullhead) and most of which occurred or were only detected in the past 10 years. Two northern pike have been gill netted in Koocanusa Reservoir (Westover, in litt. 1999). Illegal fish stocking is reportedly a problem on both sides of the border (Westover, in litt. 1999). A lake trout was documented for the first time in an angler catch from Kootenay Lake in fall 1999 (Westover, pers. comm., 2001). As with other large lakes, the potential for establishment of a reproducing lake trout population in Kootenay Lake is cause for concern (Donald and Alger 1993; Fredenberg 2000).

Stocking programs on either side of the international border have the potential to negatively impact Kootenai River bull trout if the non-native species emigrate and become established. The Province of British Columbia stocks brook trout only in landlocked lakes in the upper Kootenai River drainage (Westover, in litt. 1999). High-elevation lakes are stocked with westslope cutthroat trout. Some low-elevation lakes in the lower Kootenay River drainage are stocked with rainbow trout. Fisheries management programs in Canada are outside our jurisdiction, but close communication and collaboration has occurred in the past and must be continued.

In recent years, the fisheries management emphasis in the United States portion of Koocanusa Reservoir has switched from westslope cutthroat trout (a failed program because of reservoir constituency and possibly the cutthroat stock) to Kamloops rainbow trout (MBTSG 1996c). Koocanusa Reservoir is being stocked with sterile Kamloops rainbow trout in United States waters in hopes of providing a trophy fishery sustained by the kokanee salmon forage base, circumstances similar to those occurring naturally downstream in Kootenay Lake. The full extent of interactions between Kamloops and bull trout, two large, piscivorous species, are unknown, however, they have been stocked since 1985 (in B.C.) and 1988 (in MT) and bull trout have increased every year since. In addition, anecdotal evidence from Kootenay Lake, British Columbia, and Lake Pend Oreille, Idaho, indicates they are compatible in the presence of an abundant kokanee forage base. Anglers in British Columbia have reported catching hatchery-reared rainbow trout (Westover, in litt. 1999), and the potential impacts of these plants on remaining westslope cutthroat trout need to be further evaluated.

Currently, in British Columbia, anglers are allowed to harvest one bull trout per day from Kootenay Lake and Koocanusa Reservoir (Westover 1999). Bull trout caught in most tributaries to these waters must be released. Between June 15 and October 31, anglers are allowed to keep one trophy bull trout (over 75 centimeters [30 inches]) per day in the lower Elk River and one bull trout per day from the Kootenay River from April 1 to October 31. There is also a summer bait ban and a year-round single barbless hook restriction in these rivers. Parnell (1997) estimated only 23 bull trout were harvested from the Canadian portion of Koocanusa Reservoir in nearly 27,000 angler days between June 1 and September 21, 1996. This low rate of harvest is not believed to present a problem for bull trout recovery.

The North Arm of Kootenay Lake, British Columbia, has been supplemented with commercial fertilizer since 1992, following an intensive investigation that concluded such a program would partially compensate for declining productivity in the fishery due to the loss of nutrients. Declining nutrient loads were correlated with lower in-lake nutrient concentrations, chlorophyll *a* concentrations, and macrozooplankton densities and with a dramatic decline in kokanee salmon stocks (Thompson 1999). Nutrients were applied at the north end of the lake, and the response of the food web was monitored. Models predicted that increased zooplankton production resulting from fertilization might be shunted into increased abundance of *Mysis relicta*. In fact, *Mysis relicta* abundance decreased during the experiment. Kokanee abundance increased fourfold to sevenfold, and populations of Gerrard rainbow trout also increased (Ashley and Thompson 1993; Ashley et al. 1994, 1997, 1999). Thompson (1999) was unable to obtain an estimate of bull trout abundance in Kootenay Lake, but stated that tributary surveys found as many as 200 bull trout (presumably adult spawners) in some tributaries and suggests that the bull trout population may be increasing in a trajectory similar to Gerrard rainbow as a result of improved forage (especially kokanee). Olmsted *et al.* (2001) estimated that over 500 adult bull trout from Kootenay Lake congregated annually in 1995 to 1997 below Duncan Dam, a structure blocking upstream access to spawning areas in the upper Duncan River. British Columbia Hydro successfully passed most of those fish over the dam.

Except for Koocanusa Reservoir, the harvest of bull trout is no longer legal in the Kootenai River drainage in the United States. However, there is still some risk to bull trout in these closed areas from incidental hooking and handling mortality. The Kootenai River in Montana received an estimated 37,491 angler days of fishing pressure in 1999, up from 25,213 angler days in 1991 (MFWP 1992, 2000).

For Bull and Sophie lakes, anglers have expressed strong support for attempts to improve the fishery with non-native fish. Largemouth bass are well established in Bull Lake and northern pike have also been seen there. The interaction of largemouth bass with bull trout is unknown (MBTSG 1996b). Northern pike and bluegill were illegally introduced in Sophie Lake during the past decade and have become well established (Vashro, in litt. 2000). The northern pike population appears to have grown dramatically in recent years.

Lake trout are present in Spar Lake, which is a closed basin lake (MBTSG 1996b) located adjacent to Bull Lake and in the same drainage. Northern pike are present in some other valley lakes and in backwater areas of the Kootenai River. Both lake trout and northern pike are potential predators on, and competitors with, juvenile bull trout. Although their distribution in the drainage is presently limited, lake trout, if they become established in the Kootenai River/ Kootenay Lake system, could pose a major threat to bull trout. Interactions of bull trout with many other non-native species are presently unknown. Future sport fishery management directed at improved recreational fishing for non-native species has the potential to conflict with the goal of restoring bull trout in portions of this drainage (MBTSG 1996c).

Isolation and Habitat Fragmentation

There are two components to the risk from environmental instability. First is the likelihood that a catastrophic event could occur. Second is the risk to bull trout when such events occur. The Kootenai River drainage is at a relatively high risk from environmental instability due to climate, geology, and aspect (MBTSG 1996a, 1996b, 1996c; PBTTAT 1998). This area receives high annual precipitation and frequent rain-on-snow events. Rain-on-snow is a common term used to describe cloudy weather periods when warm winds and rain combine to produce rapid snowmelt. These events generally occur during early to midwinter periods. Much of the bull trout spawning and rearing habitat in the Kootenai River drainage is in watersheds with unstable soils and steep slopes. Extensive bedload aggradation combined with low flow conditions can result in dewatering. Seasonal loss of surface flow is evident within aggraded reaches of the Libby, Callahan, and Keeler Creek watersheds (MBTSG 1996a, 1996b). Several landslides have occurred in the Wigwam River drainage (Westover, in litt. 1999), sometimes extending entirely across the river downstream from Lodgepole Creek in British Columbia. A poorly timed or extremely large slide could potentially block spawning access to this and other critical tributaries.

Rieman and McIntyre (1993) concluded that temperature is a critical habitat variable for bull trout. Temperatures in excess of 15 degrees Celsius (59 degrees Fahrenheit) are thought to limit bull trout distribution in many systems (Fraley and Shepard 1989; Brown 1992). In Libby Creek, summer water temperatures as high as 22 degrees Celsius (72 degrees Fahrenheit) and 27 degrees Celsius (81 degrees Fahrenheit) were recorded during 1992 and 1994, respectively (MBTSG 1996a). The Fisher River is also known to have elevated water temperatures (MBTSG 1996a).

Natural thermal limits to bull trout distribution are suspected at several locations. For example, Fortine Creek joins Grave Creek, forming the Tobacco River. Fortine Creek drains mostly low-elevation lands. Summer maximum water temperatures in Fortine Creek greatly exceed those recorded in Grave Creek, which drains high-elevation lands along the Whitefish Divide. Grave Creek is the only bull trout spawning and rearing habitat for this core area that is situated entirely in the United States, and the Tobacco River provides the migratory corridor linking it to Koocanusa Reservoir. Concerns exist that the migratory corridor of the Tobacco River may be compromised by the thermal input of Fortine Creek (MBTSG 1996c).

Water temperatures are probably limiting to bull trout in many Idaho tributaries (PBTTAT 1998), particularly those in watersheds that have natural barriers that block access to the upper drainage (e.g., Moyie River). All are low-elevation streams, and many may not have been hospitable for bull trout, even historically.

If a local population is small enough, variations in survival can cause a declining population for a period long enough that it can be extirpated (Rieman and McIntyre 1993). The local bull trout population in Bull Lake is estimated at several hundred fish or fewer (MBTSG 1996b). Sophie Lake covers only about 81 hectares (200 acres), and bull trout spawn and rear only in Phillips Creek (MBTSG 1996c). The number of adult bull trout is probably fewer than 100 fish. Both of these secondary core areas are at high risk due to their small size, isolation, and restricted habitat.

LINKS

Appendix 64 lists the waters in Montana Fish, Wildlife & Park's Region One that have tested positive or have questionable results for fish pathogens in the National Fish Health Database. Further queries may be conducted at: http://www.esg.montana.edu/nfhdb/fh1.html

Click Here

Pathogens

One other issue that should be mentioned is that of disease. While not a limiting factor for bull trout in the subbasin, it can be an issue of local concern. Appendix 64 lists the waters in Montana Fish, Wildlife & Park's Region One that have tested positive or have questionable results for fish pathogens.

Table 4.22 rates the potential effects of these various land management activities on important bull trout habitat components in Montana, and table 4.23 rates the degree of risk the various activities pose to the restoration of bull trout populations within identified bull trout restoration/conservation areas in the Kootenai Subbasin.

*Table 4.21. Potential effects of land management activities on important bull trout habitat components (source: MBTSG 1998). * = potentially affected or indirect effect; ** = high magnitude effect or direct effect.*

	Rural and Indus. Develop.	Mining	Grazing	Agri.	Irrig. Diver-sion	Dams	Timber Harv: Upland	Timber Harv: Ripar.	Secon-dary Roads	Recera-tion	Trans-porta-tion System	Fire
Cold water, thermal refuges	*		*	*	**	**	*	**	*	*	*	*
High quality pools	*	**	**	*		**	**	**	**	*	**	*
Habitat complexity	**	**	**	**	*	**	*	**	**	*	**	*
Clean substrate	**	**	**	**	*	**	**	**	**	*	**	*
Stable substrate		**		*	*	**	*	*	*		*	*
Ground-water inflow	**	**		**	**	*	*	*	*		*	*
Connect between systems	*	*		*	**	**			**		**	*
Large woody debris	*	*	*	*		*	*	**	*	*	*	*
Adequate stream-flow	*	*	*	*	**	**			*			
Chemical water quality	**	**	*	**	*					*	*	*
Stable vegetated banks	**	*	**	*	*	**	*	**	*	*	**	*

Table 4.22. Activities posing risk to the restoration of bull trout populations within identified bull trout restoration/conservation areeas in the Kootenai Subbasin (source: MBTSG 1998).

Activity	Lower Kootenai	Middle Kootenai	Upper Kooteani
Rural and Industrial Development			High Risk
Mining	High Risk	High Risk	
Grazing			
Agriculture	Very High Risk		High Risk
Irrigation Diversion			High Risk
Dams	High Risk	Very High Risk	High Risk
Forestry (timber harvest and secondary roads)	Very High Risk		Very High Risk
Recereation			
Transportation System	High Risk	High Risk	
Fire		High Risk	

4.2 Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*)

4.2.1 Background

Reasons for Selection as Focal Species

Globally, westslope cutthroat trout (*Oncorhynchus clarki lewisi*), one of thirteen subspecies of cutthroat trout, have a G4T3 ranking, meaning the subspecies is either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors. A recent status report estimated that the subspecies currently occupies about 59 percent of its historic range, but only about 10 percent of its currently occupied range is populated by westslope cutthroat trout with no evidence of genetic introgression (Shepard et al. 2003).

The USFWS, charged with administering the federal Endangered Species Act (ESA) for resident salmonids, recently determined that westslope cutthroat trout are not threatened or endangered. In 2003, the agency reevaluated their finding and concluded again that the subspecies does not warrant listing.

Region I of the US Forest Service lists westslope cutthroat trout as a sensitive species. The state rank for both Montana and Idaho is S2, which means the species is considered imperiled because of rarity or because of other factor(s), demonstrably making it very vulnerable to extinction throughout its range. Montana Fish, Wildlife & Parks and the Montana Chapter of the American Fisheries Society have listed westslope cutthroat trout as a Class A State Species of Special Concern since 1972. Class A designation indicates limited numbers and/or limited habitats both in Montana and elsewhere in North America; elimination from Montana would be a significant loss to the gene pool of the species or subspecies.

In British Columbia, westslope cutthroat trout are blue-listed, meaning they are a species considered to be vulnerable, or of special concern because of characteristics that make them particularly sensitive to human activities or natural events (BC Ministry of Sustainable Resources 2003).

Like bull trout, westslope cutthroat trout are often considered an indicator of the health of the aquatic ecosystem. Both species require high quality, cold water and clean gravel for spawning, and both species do best in complex habitats, much of which is created by large woody debris.

It appears that many of the areas in western Montana where westslope cutthroat trout have been displaced are also areas with a considerable amount of riparian disturbance and instream effects from upland management (USFS 1998). Because they use the entire aquatic system in the subbasin, impacts in any single

LINKS

State, federal and tribal biologists in Montana have done extensive work on westslope cutthroat trout. Results from these efforts, which have yielded some of the best and most detailed information available for westslope cutthroat trout in the Montana portion of the Kootenai Subbasin, are entered onto the Montana Fisheries Information System (MFISH) database accessible on the internet at: http://nris.state.mt.us/scripts/esrimap.dll?name=MFISH&Cmd=INST.

Click Here

For westslope cutthroat trout information in the Kootenai in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information (including reports pertaining to westslope cutthroat trout) for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

component is potentially reflected by westslope cutthroat trout populations. We selected westslope cutthroat trout as a focal species in this assessment because of this susceptibility and their conservation rankings.

LINKS

The Westslope Cutthroat Trout Conservation website is a reference source for documents relating to the conservation and restoration of the westslope cutthroat. http://www.fwp.state.mt.us/wildthings/westslope/content.asp

Click Here

Data supporting the 2003 Status Review can be downloaded for further analysis at: http://www.streamnet.org/online-data/OutSideDataSets.html

Click Here

For the B.C. Fisheries Inventory Data Queries site go to: http://srmapps.gov.bc.ca/apps/fidq/

Click Here

For the Conservation Data Centre for B.C., go to http://srmwww.gov.bc.ca/cdc/

Click Here

Summary of Population Data[1]

Westslope cutthroat occur in about 1,440 linear miles of stream habitat in the U.S. portion of the Kootenai River Subbasin. Abundance data are available for 1,051 of those stream miles. Approximately 70 percent of those have stocks that are considered abundant (table 4.23). However, those stocks have various degrees of genetic purity or have not yet been tested genetically. Only 170 miles of the 1,051 stream miles for which abundance data are available have westslope cutthroat trout stocks that have genetic purity of greater than 90 percent. And in only 125 of those 170 miles of stream are the fish considered abundant. Hence, westslope cutthroat trout with a genetic purity of greater than 90 percent are consideered abundant in only about 12 percent of the total stream miles surveyed.

Data for the Montana portion of the Kootenai from the Interior Columbia Basin Ecosystem Management Project (ICBEMP) (table 4.27) indicate westslope cutthroat trout stocks are strong or predicted strong in 15 HUCs, depressed or predicted depressed in 159 HUCs, and absent or predicted absent in the remaining 11 HUCs. Correlation analysis performed among watersheds in this part of the drainage revealed a significant, positive relation between the number of stream miles occupied by westslope cutthroat trout (MFWP, in litt. 1998) and the number of HUCs that ICBEMP indicated

Table 4.23. Total number of stream miles and tributaries or stream reaches occupied by westslope cutthroat trout (WCT) in the historic range of the subspecies as of 1998. Source: USFWS (1999a).

Watershed	4th-field HUC No.	No. of 6th Field HUCs	No. of Occupied Miles			Occupied Tribs or Reaches
			Abundant	Rare	Total	
Upper Kootenai River	17010101	89	512	162	674	122
Fisher River	17010102	33	97	76	173	48
Yaak River	17010103	22	125	79	204	53
Lower Kootenai River	17010104	35	no data	no data	324	30
Moyie River	17010105	8	no data	no data	65	7
COMBINED KOOTENAI		187	734	317	1440	260

[1] For the Lower Kootenai River, IDFG included the entire stream length if westslopes were present, however, the species has been shown to be absent in numerous stream reaches below barriers within this drainage.

[1] Condensed and adapted from Status Review for Westslope Cutthroat Trout in the United States, USFWS 1999a.

were known or predicted to have westslope cutthroat trout. Using data generated by ICBEMP, 43 HUCs compose the Kootenai drainage within Idaho (table 4.27). Westslope cutthroat trout were determined present in a HUC if the HUC was known or predicted to have spawning and rearing occurring, or if it was a migratory corridor. A strong or depressed status was only conferred to a HUC if spawning and rearing occurs. Hence, in HUCs that are determined to be utilized by westslope cutthroat trout only as migratory corridors, the status is absent. Therefore, in the Idaho portion of the Kootenai River drainage, westslope cutthroat trout presence is known or predicted in 41 HUCs and absent in two. Westslope cutthroat trout status is known or predicted strong in four HUCs and known or predicted depressed in 37 HUCs.

Upper Kootenai River (including all of the Kootenai in Montana except the Yaak and Fisher)

Among the total 674 stream miles occupied by westslope cutthroat trout stocks in the Upper Kootenai in Montana, 512 have stocks that are considered abundant; stocks in the remaining 162 miles of stream are considered rare. Data from ICBEMP (table 4.27) indicate westslope cutthroat trout stocks are strong or predicted strong in 15 HUCs; depressed or predicted depressed in 159 HUCs; and absent or predicted absent in the remaining 18 HUCs.

Fisher River

Among the total 173 stream miles occupied by westslope cutthroat trout stocks in the Fisher River drainage, 97 have stocks that are considered abundant; stocks in the remaining 76 miles of stream are considered rare. Data from ICBEMP (table 4.27) indicate westslope cutthroat trout stocks are strong or predicted strong in none of the HUCs; depressed or predicted depressed in 29 HUCs; and absent or predicted absent in the remaining four HUCs.

Yaak River

Among the total 204 stream miles occupied by westslope cutthroat trout stocks in the Yaak drainage in Montana, 125 contain abundant stocks; stocks in the remaining 79 miles of stream are considered rare. Data from ICBEMP (table 4.27) indicate westslope cutthroat trout stocks are strong or predicted strong in five HUCs; depressed or predicted depressed in 15 HUCs; and absent or predicted absent in the remaining two HUCs.

Lower Kootenai (including all of the Kootenai in Idaho except the Moyie)

In the Idaho portion of the Lower Kootenai watershed, stocks of westslope cutthroat trout are known to occur in 33 stream reaches. Data from ICBEMP (table 4.27) indicate westslope cutthroat trout stocks are strong or predicted strong in two HUCs and depressed or predicted depressed in the remaining 31 HUCs.

LINKS

A map in Appendix 65 shows westslope cutthroat trout distribution and conservation classes in the Montana portion of the Kootenai Subbasin.

Click Here

Westslope cutthroat trout abundance and distribution data compiled by the USFS for the U.S. portion of the Kootenai are summarized in Appendix 55.

Click Here

For various westslope cutthroat trout reports from the B.C. Ministry of Water, Land, and Air Protection, go to Appendix 113.

Click Here

Moyie River

Data from ICBEMP (table 4.27) indicate westslope cutthroat trout stocks are strong or predicted strong in two HUCs and depressed or predicted depressed in the remaining six HUCs that collectively constitute the Moyie River watershed in Idaho.

In summary, westslope cutthroat trout in the Kootenai River drainage in Montana occur in about 223 tributaries or stream reaches that collectively encompass 1,051 linear miles of stream habitat, distributed among 3 watersheds (table 4.23). Westslope cutthroat trout in the Kootenai River drainage in Idaho occur in about 37 tributaries or stream reaches that collectively encompass 389 linear miles of stream habitat, distributed between 2 watersheds (table 4.23). Appendix 92 gives a brief history and current status of the westslope cutthroat trout fishery in the upper Kootenai, B.C.

LINKS

For a MFWP map showing westslope cutthroat trout genetic distribution and status in the Montana portion of the Kootenai, see Appendix 66.

Click Here

QHA spreadsheets contain current and historic westslope cutthroat trout distribution by lifestage for HUC-6 watersheds and selected lakes in the U.S. and B.C. portions of the Kootenai. These data are a compilation put together by our Technical Team. Go to Appendices 32 and 33.

Click Here

Appendix 92 is a brief history of the westslope cutthroat trout fishery in the Upper Kootenay, B.C

Click Here

Historic Distribution

Behnke (1996) states that the original distribution of westslope cutthroat trout is uncertain. It is believed they inhabited all major drainages west of the Continental Divide (Leary et al. 1990). In the Montana portion, westslope cutthroat trout are believed to have historically occupied all of the streams and lakes to which they had access (USFWS 1999). Shepard et al. (2003) estimates they historically occupied 2,640 miles of stream (table 4.24).

Table 4.24. Miles of habitat historically (circa 1800) occupied by westslope cutthroat trout in the U.S. (Shepard et al. 2003).

4th Code HUC Name	Occupied	Unoccupied	Total
Upper Kootenai	1213	218	1430
Fisher	416	38	454
Yaak	356	14	369
Lower Kootenai	526	6	531
Moyie	130	9	138
Totals	**2640**	**283**	**2923**

Current Distribution

Westslope cutthroat trout in the U.S. portion of the Kootenai River drainage occur in about 260 tributaries or stream reaches. In Montana, however, only 1,615 miles (39.2 percent) of the estimated 4,119 miles of stream habitat have been surveyed for westslope cutthroat trout. Thus, the subspecies could occupy additional unsurveyed stream miles. Among those 1,615 surveyed miles, westslope cutthroat trout of varying degrees of genetic purity were documented in 1,051

(65.1 percent) (USFWS 1999). Only 170 of those miles had stocks with a genetic purity of greater than 90 percent. In the Idaho portion, westslope cutthroat trout of varying degrees of genetic purity are known to occupy another 389 miles. The Idaho Department of Fish and Game has collected westslope cutthroat trout from Ball, Burton, Caboose, Caribou, Cascade, Fall, Grass, Snow, and Trout Creeks (Paragamian 1994, 1995a and b). Most of those collections were made in the lower stream reaches where access to and from the Kootenai River mainstem is possible.

Status of Westslope Cutthroat Trout Introductions, Artificial Production and Captive Breeding Programs

In Montana, westslope cutthroat captive brood stock (M012) are held at Washoe Park State Fish Hatchery in Anaconda, Montana. These fish are not stocked in rivers or streams, but are planted in lakes for recreation. Because they are not stocked in rivers, they currently appear to have no effect on wild riverine stocks, with the possible exception of planted fish escaping downstream and mixing with wild fish. As partial mitigation for Libby Dam, the Army Corps of Engineers constructed a westslope cutthroat trout hatchery, the Murray Springs Hatchery near Eureka, Montana, which was completed in 1980. Cutthroat trout raised there were first released into Koocanusa Reservoir in 1981. The hatchery is owned by the U.S. Army Corps of Engineers and is operated by the Montana Department of Fish, Wildlife & Parks. The Corps pays for the operation and maintenance of the hatchery, and the fish it raises are planted into many Lincoln County lakes and streams. Cutthroat trout have not been stocked directly in Koocanusa for several years and will likely never be again, although remote site incubators (RSIs) are being used on Young Creek, a tributary.

In 1996, MFWP began testing the use of RSIs at Young Creek as a recovery technique to imprint westslope cutthroat to specific Koocanusa Reservoir tributaries. The objectives of the study were to: (1) to determine if recruitment of 0-to-2 year-old westslope cutthroat from reservoir tributaries is limiting the reservoir population; and (2) to determine if artificial imprinting of eyed westslope cutthroat trout eggs can be an effective technique to reestablish spawning runs in tributaries where habitat degradation or local extirpation due to random events has caused an under utilization of adequate quality spawning habitat. Westslope cutthroat trout eggs for the Young Creek RSI studies came from Washoe Park State Fish Hatchery in Anaconda, Montana. The results of this study are expected to quantify the proportion of both juvenile and adult production attributable to wild and hatchery origin. Researchers are optimistic that the program will demonstrate that RSIs can increase the number of juvenile and adult westslope

LINKS

Appendix 54 provides information in narrative form on westslope cutthroat trout distribution for much of the Montana portion of the Kootenai.

Click Here

USFS westslope cutthroat trout distribution maps for Montana and Idaho are included in Appendix 1.

Click Here

LINKS

For current and historic fish stocking records in Montana, go to: http://www.fwp.state.mt.us/fishing/stock02.asp

Click Here

For stocking information for Idaho, go to: http://www2.state.id.us/fishgame/fish/fishstocking/stocking/year.cfm?region=1

Click Here

For westslope cutthroat trout hatchery brood stock histories in Montana, see Appendix 67

Click Here

For more information on the use of Remote Site Incubators in the Kootenai to Appendix 68.

Click Here

cutthroat trout in Young Creek. Efforts to determine if these fish return to their natal areas to spawn as adults are ongoing. Success would offer promise for future tributary restoration. Some of the most productive, low-gradient spawning habitats available in the upper Kootenai drainage were lost due to inundation by Koocanusa Reservoir. Additional information on the use of RSIs in the Kootenai River Subbasin is presented in Appendix 68.

In Idaho, Yellowstone cutthroat trout have been stocked into some of the lakes in the Kootenai River subbasin. However, only westslope cutthroat trout are currently stocked in the Idaho portion of the subbasin (http://www2.state.id.us/fishgame/fish/fishstocking/stocking/year.cfm?region=1). These fish are from Conner Lake, British Columbia broodstock. No streams in the Idaho portion of the subbasin are stocked with trout of any species.

Historic and current harvest[2]

Since the 1950s, fisheries managers in the Montana portion of the Kootenai River Subbasin have attempted to protect bull trout and westslope cutthroat trout (MBTSG 1995c) from overharvest by recreational angling. Even with these efforts, native populations of these species have declined, and MFWP has increased restrictions on anglers in response. However, even under catch-and-release regulations, hooking mortality can be a major souce of mortality in heavily fished waters. Table 4.25 shows angler days in each of the major subbasin watersheds in Montana.

Table 4.25. Angling pressure on waters in the Kootenai Subbasin (source: MFWP 2003)

Watershed	1997	1999	2001
17010101 Upper Kootenai	66,191	61,074	61,687
17010102 Fisher	8534	8399	5589
17010103 Yaak	6513	4557	5,650
Totals	81,238	74,030	72,926

Although angler harvest of westslope cutthroat trout may have caused appreciable declines in some Montana Kootenai westslope stocks during the 1900s, angler harvest is now closely regulated in the state and is not considered a threat to the subspecies (MFWP, in litt. 1999). In many Kootenai River Subbasin waters, fishing for westslope cutthroat trout is restricted to catch and release. Elsewhere in the drainage, harvest is greatly restricted.

[2] *The Montana part of this section is excerpted from USFWS (1999)*

In the Idaho reach of the Kootenai River, westslope cutthroat trout comprise 2 to 7 percent of the salmonid harvest (Partridge 1983; Paragamian 1994; Walters 2003). A total of 45, 156, and 235 westslope cutthroat trout were harvested in 1982, 1993, and 2001, respectively (Partridge 1983; Paragamian 1995a; Walters 2003). On the mainstem Moyie River, Horner and Rieman (1984) reported that rainbow trout and brook trout were caught by 18 anglers checked in the summer of 1984, but no westslope cutthroat trout were reported.

In the Idaho portion of the subbasin, the harvest of westslope cutthroat trout is allowed year around in the Kootenai River, while tributaries have a Memorial Day weekend opener (last weekend in May) and November 30, season closure. The Kootenai River has a 2-trout bag limit and 16 inch (406 mm) minimum size limit. A 6-trout bag limit and no size limit is allowed in tributary streams with the exception of a 2-trout bag limit in the Moyie River. Fishing pressure for westslope cutthroat trout in Moyie and Kootenai River tributaries is believed to be minimal as Boundary County, Idaho has relatively few anglers, especially in comparison to the rest of the Idaho Panhandle (N. Horner, IDFG, pers. comm.). In addition, fishing pressure on the Kootenai River ranges from only 10 to 39 h/ha (Partridge 1983; Paragamian 1995a; Walters 2003).

4.2.2 Population Delineation and Characterization

Population Units

The USFWS has found no morphological, physiological, or ecological data for westslope cutthroat trout that indicate unique adaptations of individual stocks or assemblages of stocks anywhere within the historic range of the subspecies (USFWS 1999). Hence, the agency found that at this time there is no compelling evidence to support the recognition of distinct population segments, and they recognize only a single westslope cutthroat trout population.

Life History[3]

Westslope cutthroat trout usually mature at 4 or 5 years of age and spawn entirely in streams, primarily small tributaries. Spawning occurs between March and July, when water temperatures warm to about 10 °C (50 °F) (Trotter 1987; Behnke 1992; McIntyre and Rieman 1995). Natal homing, the return of adult fish to spawning areas where they themselves were produced, is believed to occur in

[3] *Adapted from USFWS Status Review (1999). For additional information, see also Shepard et al. (1984).*

westslope cutthroat trout. Individual fish may spawn only in alternate years (Shepard et al. 1984; Liknes and Graham 1988). Fertilized eggs are deposited in stream gravels where the developing embryos incubate for several weeks, with the actual time period inversely related to water temperature. Several days after hatching from the egg, westslope cutthroat trout fry about 2.5 cm (1 inch) long emerge from the gravel and disperse into the stream.

Westslope cutthroat trout fry may grow to maturity in the spawning stream or they may migrate downstream and mature in larger rivers or lakes. Consequently, three westslope cutthroat trout life-history types (resident, fluvial, and adfluvial) are recognized (Trotter 1987; Liknes and Graham 1988; Behnke 1992; McIntyre and Rieman 1995): *Resident* fish spend their lives entirely in the natal tributaries; *fluvial* fish spawn in small tributaries but their resulting young migrate downstream to larger rivers where they grow and mature; and *adfluvial* fish spawn in streams but their young migrate downstream to mature in lakes. After spawning in tributaries, adult fluvial and adfluvial westslope cutthroat trout return to the rivers or lakes (Rieman and Apperson 1989; Behnke 1992). All three life-history types occur within the Kootenai River Subbasin (Marotz et al. 1998).

Whether these life-history types represent opportunistic behaviors or genetically distinct forms of westslope cutthroat trout is unknown. However, establishment of numerous, self-sustaining stocks of westslope cutthroat trout in streams and lakes outside the historic range of the subspecies as the result of widespread introductions of hatchery westslope cutthroat trout in Washington state, for example, suggests the life-history types represent opportunistic behaviors.

Westslope cutthroat trout feed primarily on macroinvertebrates, particularly immature and mature forms of aquatic insects, terrestrial insects, and, in lakes, zooplankton (Liknes and Graham 1988). These preferences for macroinvertebrates occur at all ages in both streams and lakes. Westslope cutthroat trout rarely feed on other fishes (Liknes and Graham 1988; Behnke 1992).

Growth of individual westslope cutthroat trout, like that of fish of other species, depends largely upon the interaction of food availability and water temperature. Resident westslope cutthroat trout usually do not grow longer than 30 cm (12 inches), presumably because they spend their entire lives in small, cold-water tributaries. In contrast, fluvial and adfluvial westslope cutthroat trout often grow longer than 30 cm (12 inches) and attain weights of 0.9-1.4 kg (2-3 pounds). Such rapid growth results from the warmer, more-productive environments afforded by large rivers, lakes, and reservoirs (Trotter 1987; Behnke 1992).

Genetic Integrity

The headwaters of Koocanusa Reservoir contain important, genetically pure stocks of fluvial and adfluvial westslope cutthroat trout. However, recent research in the

LINKS

The Montana Trout Genetic Purity Data Set (Data in Excel format) describes the genetic makeup of trout populations from 839 sites in Montana. See Appendix 69.

Click Here

For additional genetic information, see also Appendix 70, the Status Review for Westslope Cutthroat Trout in the United States, September 1999.

Click Here

See also the Status Update (Shepard et al. 2003), which is Appendix 71.

Click Here

For a MFWP map showing westslope cutthroat trout genetic distribution and status in the Montana portion of the Kootenai, see Appendix 66.

Click Here

For a map showing westslope cutthroat trout distribution and conservation classes throughout the Montana portion of the subbasin, see Appendix 65.

Click Here

Kootenai River drainage in British Columbia (Rubidge et al. 2001) reports the rapid spread of rainbow trout introgression into westslope cutthroat trout populations previously reported as free from detectable levels of introgressive hybridization. Shepard and others (2003) reported that among the streams surveyed in the U.S. portion of the Kootenai Subbasin, stocks of unintrogressed cutthroat trout occupied 142.5 miles; stocks that are less than 10 percent introgressed occupied 29.5 miles; stocks between 25 percent and 10 percent introgressed occupied 86.3 miles; and stocks greater than 25 percent introgressed occupied 576.5 miles. Westslope cutthroat trout stocks inhabiting 197.1 miles of stream are suspected to be unintrogressed (with no record of stocking or contaminating species present), and stocks inhabiting 1,498 miles are potentially altered (potentially hybridized with records of contaminating species being stocked or occurring in stream). Table 4.26 presents the break down by watershed. The most likely reason for the apparent increase in hybridization and introgression within the tributaries of the upper Kootenai River is the continued and expanded introductions of rainbow trout into the Koocanusa Reservoir and adjacent tributaries (Rubidge et al. 2002).

LINKS

Westslope cutthroat trout status in Montana and Idaho and data on genetic purity for the Upper Kootenai in Montana are summarized in Appendix 55.

Click Here

Table 4.26. Genetic Status of Westslope Cutthroat Trout in U.S. portion of the Kootenai. Source: Shepard et al. 2003.

Basin	Genetically Tested				Suspected	Potentially	
	Unaltered	< 10%	>10% & <25%	>25%	Unaltered	Unaltered	Total
Kootenai	67.9	21.3	54.7	321.3	65.6	699.8	1230.5
Fisher River	20.2		5.7	156.8	6	227.6	416.4
Yaak	54.4	8.2	25.9	98.4	15.8	155.9	358.6
Kootenai					91.1	313.8	404.9
Moyie River					18.6	92.1	110.6
Totals	**142.5**	**29.5**	**86.3**	**576.5**	**197.1**	**1489.2**	**2521**

In the Idaho portion of the Kootenai River Subbasin there is evidence of introgression from nonnative species such as coastal rainbow trout and Yellowstone cutthroat trout (Sage 1993, 1995; Leary 1997). Columbia River redband trout are also native to the Kootenai River and add to the complexity of determining the distribution and status of westslope cutthroat trout in the drainage. Redband trout X westslope cutthroat trout hybrids are reported from the Boundary and Boulder Creek drainages (Sage 1993, 1995; Leary 1997). Similar visual (i.e., phenotypic) and meristic characteristics of westslope cutthroat trout and Columbia River redband trout make correct identification difficult, which is furthermore complicated when hybridization between the two species occurs (USFWS 1998). Behnke (1992) indicated that the redband trout of the Columbia River drainages share cutthroat trout-like characteristics.

4.2.3 Population Status

LINKS

Appendix 72 shows the "risk scores" for Kootenai and Flathead Subbasin conservation populations.

Click Here

Current Status

Twenty-five years of population estimates reveal a population decline for westslope cutthroat trout in the Kootenai River Subbasin (Hoffman et al. 2002). Severe declines in westslope cutthroat trout abundance in Koocanusa Reservoir tributaries have been measured since the early eighties in population index streams (Marotz et al. 1998).

During the late 1940s, anglers caught primarily westslope cutthroat trout (*Oncorhynchus clarki lewisi)* and burbot (*Lota lota)* in the section of the Kootenai River between Kootenai Falls and the site of the present Libby Dam. Rainbow trout (*Onchorhynchus mykiss)*, bull trout (*Salvelinus confluentus)*, and mountain whitefish (*Prosopium williamsoni)* were seldom captured at that time. Catch of burbot and westslope cutthroat trout declined during the 1950s, while rainbow trout and mountain whitefish catches increased (Bonde and Bush 1982). This trend continued following the completion of Libby Dam in 1972 (May and Huston 1979). Bull trout, rainbow trout, and westslope cutthroat trout were not common in the section of the river from Kootenai Falls to one mile upstream of Bonners Ferry, Idaho prior to impoundment by Libby Dam, and remained uncommon following impoundment. This is likely due to a lack of spawning habitat (May and Huston 1979).

In 1973, 44 percent of trout captured in the Kootenai River were westslope cutthroat trout, with angler catch rates recorded at 0.5 fish/hour, ranking the river among other Montana blue ribbon trout streams. Estimates in a 1994 report documented significant population reductions in the river, less than five percent of the trout captured were westslope cutthroat trout. In the Idaho reach of the Kootenai River, westslope cutthroat trout comprise 2 to 7 percent of the salmonid

Table 4.27. Total number of stream miles and tributaries or stream reaches occupied by westslope cutthroat trout (WCT) in the historic range of the subspecies. Trend is given as unknown (U), declining (D), or stable (S). Also shown are ICBEMP data that give status of WCT in 6th-field HUCs in the Columbia River basin. Data are given as the number of 6th-field HUCs in which WCT stocks are strong (S), depressed (D), absent (A), predicted strong (PS), predicted depressed (PD), or predicted absent (PA).

Watershed	4th-field HUC No.	No. of 6th Field HUCs	No. of Occupied Miles			Trend	ICBEMP Data						
			Abundant	Rare	Total		S	D	A	PS	PD	PA	TOTAL
Upper Kootenai River	17010101	89	512	162	674	U	6	69	5	0	9	0	89
Fisher River	17010102	33	97	76	173	U	0	25	4	0	4	0	33
Yaak River	17010103	22	125	79	204	U	5	12	2	0	3	0	22
Lower Kootenai River	17010104	35	no data	no data	324	U	2	19	0	0	12	0	33
Moyie River	17010105	8	no data	no data	65	U	2	6	0	0	0	0	8
COMBINED KOOTENAI		187	734	317	1440	U	15	131	11	0	28	0	185

harvest (Partridge 1983; Paragamian 1995a; Walters 2003). There is no data to indicate that the westslope cutthroat trout population has decreased in the Idaho reach of the Kootenai River as it has in Montana, but there is no data prior to the work of Partridge (1983). Also, Columbia River redband trout were likely always the dominant trout in the Idaho reach.

Table 4.27 shows the trend and status for cutthroat trout across the U.S. portion of the Kootenai Subbasin as determined in the USFWS 1999 Status Review. Appendix 65 shows westslope cutthroat trout distribution and conservation classes for the Montana portion of the subbasin.

In 2002, Shepard et al. (2003) rated risks to 539 of the 563 designated westslope cutthroat trout conservation populations (across the entire range of the subspecies), segregating the two distinct types of conservation populations, "isolets" and "metapopulations." They found that in general, more isolet populations were at higher risk due to temporal variability, population size, and isolation than metapopulations. However, more isolet populations were at less risk than metapopulations due to genetic introgression, disease, and population demographics. Composite population risk scores ranged from a low of 4 to a high of 16. "Isolets" were at relatively high risk from population-type risks, but at much lower risk from genetic and disease risks than "metapopulations." Appendix 72 presents the risk scores for Kootenai Subbasin conservation populations assessed as part of the Westslope cutthroat trout status review update done in 2002. Figure 4.3 shows a frequency distribution of composite population risk scores for the westslope cutthroat trout populations in the Kootenai Subbasin.

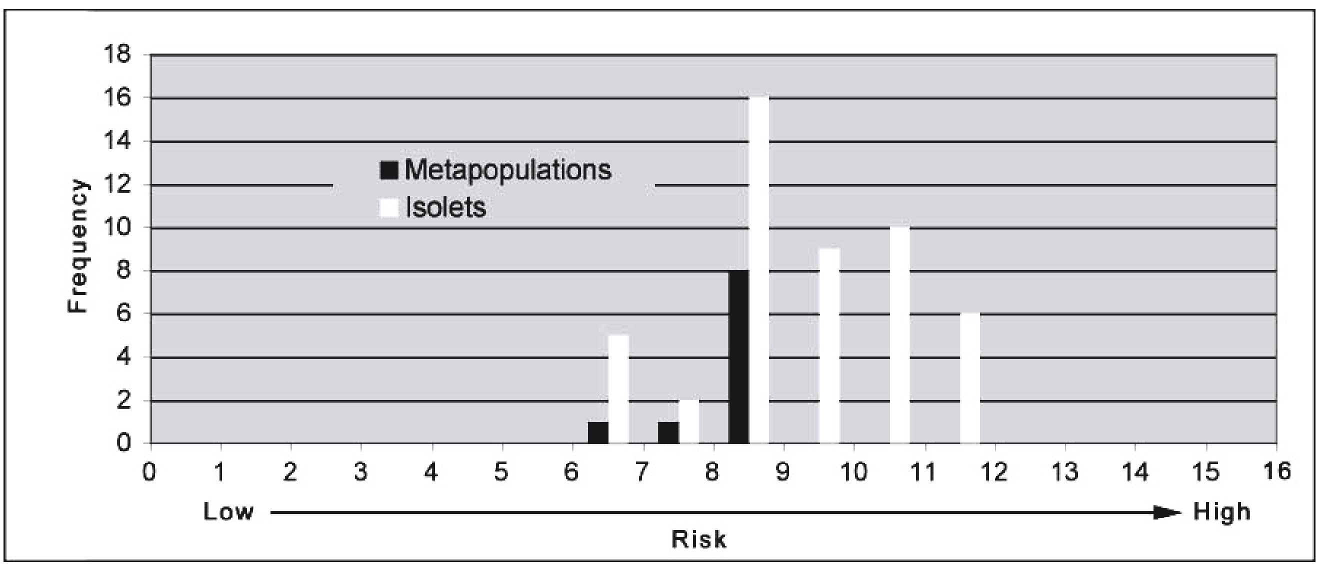

Figure 4.3. Distribution of the number of designated westslope cutthroat trout populations by composite population risk scores and population type for the Kootenai Subbasin (excludes genetic and disease risks).

Historic Status

Quantitative data on historic westslope cutthroat trout abundance and productivity in the Kootenai Subbasin is not available. Shepard et al. (2003) estimated that the subspecies historically occupied 2,640 miles of stream. It is assumed that prior to European settlement most of these streams were generally characterized by optimum habitat conditions and therefore supported abundant and productive native fisheries.

Theoretical Reference Condition[4]

In 1999, MFWP finalized a "Memorandum of Understanding and Conservation Agreement for Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in Montana" (MFWP 1999), which was signed by representatives of the principal state and federal natural resources management agencies concerned with the protection and management of westslope cutthroat trout. The goal of the agreement is: To ensure the long-term, self-sustaining persistence of the subspecies within each of the five major river drainages they historically inhabited in Montana. To meet this goal, it identified the following objectives:

1. Protect all genetically pure westslope cutthroat trout populations. All genetically pure populations are to be provided the protection necessary to ensure their long-term persistence. Protection includes expansion of small, isolated populations where possible and maintaining or developing high quality habitats to prevent extirpation due to small population size or stochastic events. Each tributary that supports westslope cutthroat trout, regardless of its length, constitutes a population.

2. Protect slightly introgressed (less than 10 percent introgressed) populations. Populations where a genetic sample shows greater than a 90 percent westslope cutthroat trout genetic contribution indicate suitable habitat for westslope cutthroat trout and may have genetic value. The protections afforded to pure westslope populations, therefore, will be provided to such populations until land management and fish management agencies make a determination about the role

LINKS

Appendix 73 is the Memorandum of Understanding and Conservation Agreement for westslope cutthroat trout in Montana

Click Here

[4] *Guidance from the NWPCC states that "this [section of the assessment] is a key component of the NMFS and USFWS ESA delisting evaluation, and that for ESA-listed species these determinations will be made by the appropriate recovery team." For westslope cutthroat trout, which are not listed under ESA, we rely instead on "Memorandum of Understanding and Conservation Agreement for Westslope cutthroat trout in Montana."*

of such habitats and populations for westslope cutthroat trout restoration.

3. Ensure the long-term persistence of the westslope cutthroat trout within their native range. The long-term persistence of westslope cutthroat trout within their native range will be ensured by maintaining at least ten population aggregates distributed throughout the five major river drainages in which they occur, each occupying at least 50 miles of connected habitat. The Kootenai River drainage will have at least one interconnected population. To ensure that this population persists, it must be isolated from potentially introgressing species, and at least one local population (tributary population within the connected habitat), must persist for more than 10 years (representing 2-3 generations). The interconnected populations within each major river drainage should be geographically separate to help ensure long-term persistence. Every effort should be made to develop interconnected populations that have open connectivity up and down stream throughout at least 50 continuous miles of stream habitats. However, it might be impossible to have upstream connectivity of all headwater habitats of some tributaries due to natural upstream migration barriers. Where these conditions exist, monitoring of persistence must be done above any natural barriers, as well as somewhere else within the connected habitats, to ensure that these segments of the population persist. If isolated headwater segments become extinct, those population segments must be refounded by moving westslope cutthroat trout from below the natural barrier.

4.2.4 Out-of-Subbasin Effects and Assumptions

Mainstem Columbia River operations profoundly influence dam operations as far upstream as headwater reservoirs. Dam operations affect environmental conditions in the reservoirs upstream and rivers downstream from Libby Dam. The abundance, productivity and diversity of fish and wildlife species inhabiting the headwaters of the Columbia River are dependent on their immediate environment that ebbs and flows with river management. Mainstem Columbia River operations affect westslope cutthroat trout in the following ways (Brian Marotz, MFWP, pers. comm. 2003):

- Unnaturally high flows during summer and winter negatively impact resident fish. The effects can be mitigated by releasing flows at a constant rate, producing constant stable, or slowly declining (unidirectional) flows.

LINKS

For a more complete discussion of how Mainstem Columbia River operations affect subbasin fisheries, and how those effects might be minimized see Appendix 18.

Click Here

- Summer flow augmentation causes reservoirs to be drafted during the biologically productive summer months. This negatively affects productivity in the reservoirs.

- Drafting the reservoirs too hard prior to receiving the January 1 inflow forecast places the reservoirs at a disadvantage for reservoir refill. This is especially important during less than average water years.

- Flow fluctuations caused by power, flood control or fish flows create a wide varial zone in the river, which becomes biologically unproductive.

- The planned reservoir-refill date in the NOAA Fisheries BiOp of June 30, will cause the dam to spill in roughly the highest 30 percent of water years. This is because inflows remain above turbine capacity into July on high years. That means the reservoirs fill and have no remaining capacity to control spill. This causes gas super saturation problems.

4.2.5 Environment-Population Relationships

Environmental Factors Particularly Important to Westslope Cutthroat Trout Survival or Key Ecological Correlates (KECs)[5]

Spawning habitat for westslope cutthroat trout occurs in low-gradient stream reaches that have gravel substrate ranging from 2 mm to 75 mm (0.8 to 3 inches) in diameter, water depths near 0.2 m (0.7 ft), and mean water velocities from 0.3 to 0.4 m/sec (1 to 1.3 ft/sec) (Liknes 1984; Shepard et al. 1984). Proximity to cover (e.g., overhanging stream banks) is an important component of spawning habitat. On the basis of information for other salmonid species, survival of developing westslope cutthroat trout embryos is likely inversely related to the amount of fine sediment in the substrate in which the fertilized eggs were deposited (Alabaster and Lloyd 1982; Waters 1995).

After they emerge from the spawning gravel, fry generally occupy shallow waters near stream banks and other low-velocity areas (e.g., backwaters, side channels) (McIntyre and Rieman 1995) and move into main-channel pools as they grow to fingerling size. Juveniles are most often found in stream pools and runs with summer water temperatures of 7-16 °C (45-61 °F) and a diversity of cover (Fraley and Graham 1981; McIntyre and Rieman 1995). Adult westslope

[5] *This section is condensed from the USFWS (1999).*

cutthroat trout in streams are strongly associated with pools and cover (Shepard *et al.* 1984; Pratt 1984a; Peters 1988; Ireland 1993; McIntyre and Rieman 1995). During winter, adults congregate in pools (Lewynsky 1986; Brown and Mackay 1995; McIntyre and Rieman 1995), while juveniles often use cover provided by boulders and other large instream structures (Wilson et al. 1987; Peters 1988; McIntyre and Rieman 1995). During summer in lakes and reservoirs, the primary habitat for rearing and maturation of adfluvial fish, westslope cutthroat trout are often found at depths where temperatures are less than 16 °C (61 °F) (McIntyre and Rieman 1995).

Data on the distributions of various species of native and nonnative salmonids suggest cutthroat trout are typical in thermal tolerance. Eaton et al. (1995) reported thermal tolerance limits for 4 species of salmonids at the 95th percentile of observed maximum water temperatures inhabited by each species. Maximum thermal tolerance limits for brook, cutthroat, rainbow, and brown trout were reported at 22.3, 23.2, 24.0, and 24.1 °C, respectively.

Historically, habitats of westslope cutthroat trout ranged from cold headwater streams to warmer, mainstem rivers (Shepard et al. 1984; Behnke 1992). Today, remaining stocks of westslope cutthroat trout occur primarily in colder, headwater streams (Liknes and Graham 1988). Westslope cutthroat trout may exist in these streams not because the thermal conditions there are optimal for them, but because nonnative salmonid competitors like brook trout cannot exploit these cold, high-gradient waters (Griffith 1988; Fausch 1989).

In addition to the above variables — channel form and stability, water temperature; cover; discharge; the presence of loose, clean gravels — the geologic makeup of watersheds is likely an important habitat parameter for predicting westslope cutthroat trout productivity in the subbasin. Belt Supergroup rocks are generally deficient in nitrogen and phosphorous (Stanford and Hauer 1992). Hence the subbasin's bedrock geology contributes relatively little in the way of dissolved ions, nutrients, and suspended particulates to streams (Makepeace 2003). Fraley and Graham (1981b), however, found that of five geologic types in the North and Middle Forks of the Flathead (which has a bedrock geology very similar to that of much of the Kootenai), watersheds composed of quartzite and those underlain by a combination of limestone and argillite/siltite have significantly higher trout densities than those composed of limestone alone, argillite/siltite alone, or shales, sandstone, and limestones. They caution however that geology is not independent of other key habitat variables and must be considered in combination with them. The western margin of the Idaho and southern B.C. portions of the subbasin encompass a portion of the Priest River Complex, which exposes Cretaceous granitic rocks of the Kaniksu batholith (Link 2002), and which intrudes Belt Supergroup rocks. Smaller granitic intrusions also occur in other parts of the subbasin. These

LINKS

For the website containing descriptions of surface waters included in the Montana water quality assessment database go to: http://nris.state.mt.us/wis/environet/2002_305bhome.html.

Click Here

For the website listing 303(d) water-quality impaired streams and lakes for the Idaho portion of the subbasin, go to: http://inside3.uidaho.edu/WebMapping/IDEQ/

Click Here

Brook trout are believed to have displaced many westslope cutthroat trout populations. Appendix 61 lists streams in the Montana portion of the Kootenai that contain brook trout as of May 2003.

Click Here

granitic rocks generally contribute higher levels of dissolved ions, nutrients, and suspended particulates to subbasin streams than Belt rocks.

Environment's Ability to Provide Key Ecological Correlates

LINKS

For more detailed results of the QHA assessment, including attribute scores and HUC rankings, see Appendices 32 and 33.

Click Here

Appendix 31 summarizes the baseline condition for bull trout in bull trout drainages in the Montana portion of the Kootenai. (These determinations can also be used for assessing conditions for westslope cutthroat trout.

Click Here

As part of our assessment, the Kootenai Subbasin (MT, ID, and B.C.) Technical Teams[8] evaluated all the sixth code HUCs and selected lakes in the Montana, Idaho, and Canadian[9] portions of the subbasin on the basis of eleven stream habitat attributes (Parkin and McConnaha 2003) and thirteen lake habitat attributes considered key to resident salmonids. This was done utilizing a spreadsheet tool developed by Mobrand Biometrics called Qualitative Habitat Assessment (QHA). Mobrand Biometrics and Dr. Paul Anders developed the lacustrine or lake version of QHA, called LQHA. The habitat attributes used in the stream version of QHA are generally thought to be the main habitat drivers of resident salmonid production and sustainability in streams (Parkin and McConnaha 2003) (table 4.28). Those used in LQHA are the ones considered by our Technical Team to be the main habitat drivers in lakes in the subbasin (table 4.29). For each 6th Code HUC, the technical team used quantitative data (when it existed) and professional knowledge and judgement to score each of the attributes for each HUC. We did the same for selected lakes (table 4.30).

Table 4.31 ranks stream habitat-attributes for westslope cutthroat trout averaged across the regulated mainstem HUCs in the U.S. portion of the subbasin. Tables 4.32 and 4.33 rank stream habitat-attributes for westslope cutthroat trout averaged across all tributary 6th-code HUCs in the U.S. and B.C. portions of the subbasin, respectively. Tables 4.34 and 4.35 show the ranking by 4th-code HUC for the U.S. and B.C. portions of the subbasin. Table 4.36 ranks habitat attributes for selected subbasin reservoirs and lakes in both Canada and the U.S. The rankings provide a good indication of the subbasin's ability to provide key ecological correlates required for westslope cutthroat trout viability and persistence and the habitat attributes that may be the most limiting for westslope cutthroat trout in the subbasin.

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[8] *The Kootenai Subbasin Technical Team members particiapating in the HUC-by-HUC assessment included fisheries biologists and hydrologists from the Kootenai Tribe of Idaho, Montana Fish, Wildlife and Parks, Idaho Fish and Game, Idaho Department of Environmental Quality, US Army Corps of Engineers, US Fish and Wildlife Service, the Idaho Panhandle and Kootenai National Forests, two provincial Canadian ministries, and a private consulting firm.*

[9] *In the U.S. portion of the subbasin, some valley HUCs were lumped. In the Canadian portions of the subbasin, time limitations prevented the use of 6th-code HUCs. Instead, the Canadian members of the team used analogous watersheds developed during a previous watershed restoration planning exercise in B.C.*

Table 4.28. Habitat attributes used in the QHA analysis of 6th code HUCs.

Attribute	Brief Definition
Riparian Condition	Condition of the stream-side vegetation, land form and subsurface water flow.
Channel Stability	The condition of the channel in regard to bed scour and artificial confinement. Measures how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types.
Habitat diversity	Diversity and complexity of the channel including amount of large woody debris (LWD) and multiple channels
Fine Sediment	Amount of fine sediment within the stream, especially in spawning riffles
High Flow	Frequency and amount of high flow events.
Low Flow	Frequency and amount of low flow events.
Oxygen	Dissolved oxygen in water column and stream substrate
High Temperature	Duration and amount of high summer water temperature that can be limiting to fish survival
Low Temperature	Duration and amount of low winter temperatures that can be limiting to fish survival
Pollutants	Introduction of toxic (acute and chronic) substances into the stream
Obstructions	Barriers to fish passage

LINKS

Appendix 62 presents the results of a GIS-based fisheries vulnerability analysis conducted by the Cohesive Strategy Team of Region 1 of the USFS.

Click Here

Table 4.29. Habitat attributes used in the Kootenai Subbasin Lacustrine QHA analysis of selected lakes with definitions.

Attribute	Brief Definition
Temperature	Duration and amount of high or low water temperatures that can be limiting to fish survival
Dissolved Oxygen	Dissolved oxygen in water column and stream substrate
Gas Saturation	Percent water is saturated (<100%) or super-saturated (>100%) with Nitrogen gas
Volumetric Turnover Rates	Time required to replace entire reservoir with new water based on rate of its downstream expulsion
Pollutants	Introduction of toxic (acute and chronic) substances into the lake or reservoir
Trophic Status	Level (status) of biological productivity in lake or reservoir
Entrainment	Downstream fish loss through a hydropower dam, other than through a spillway of fish ladder
Migratory Obstacles	Natural and artificial barriers to upstream and/or downstream fish migration
Macrophytes	Emergent and submergent aquatic plant species and community structure in lakes and reservoirs
Hydraulic Regime	Temporal and volumetric characteristics of hydrograph
Shoreline Condition	Physical condition of water-land interface, riparian and varial zones
Habitat Diversity	Relative degree of habitat heterogeneity
Substrate Condition	Physical condition of substrates

Appendix 63 presents the results of an American Wildlands GIS-based, coarse-scale analysis of the current condition of native aquatic integrity across an Upper Columbia basin (called the Aquatic Integrity Areas (AIA) model). Go also to: http://www.y2y.net/science/aquatic_research.asp#aia

Click Here

Table 4.30. Lakes assessed in the Kootenai Subbasin using LQHA.

Lake	Location
Kootenay Lake	Canada
Moyie Lakes	Canada
Duncan Lake	Canada
Trout Lake	Canada
Koocanusa Reservoir	U.S./Canada
Kilbrennan	U.S.
Loon Lake	U.S.
Bull Lake	U.S.
Sophie Lake	U.S.
Boulder Lake	U.S.
Granite Lake	U.S.
Leigh Lake	U.S.
Therriault Lake	U.S.
McArthur Lake	U.S.

Table 4.31. Ranking of key habitat attributes for the regulated mainstem in the U.S. portion of the Kootenai Subbasin for westslope cutthroat trout based on a QHA analysis.

Habitat Attribute	Score	Rank
Oxygen	0.00	1
Pollutants	0.17	2
Obstructions	0.17	2
High Temperature	0.26	3
Low Temperature	0.33	4
Habitat Diversity	0.34	5
Channel stability	0.38	6
Fine sediment	0.38	6
Low Flow	0.40	7
High Flow	0.54	8
Riparian Condition	0.63	9

Table 4.32. Ranking of key habitat attributes for 6th-code HUC tributary watersheds in the U.S. portion of the Kootenai Subbasin for westslope cutthroat trout based on a QHA analysis.

Habitat Attribute	Score	Rank
Low Temperature	0.01	1
Oxygen	0.02	2
Pollutants	0.05	3
Obstructions	0.07	4
Low Flow	0.08	5
High Flow	0.21	6
High Temperature	0.25	7
Habitat Diversity	0.31	8
Channel stability	0.32	9
Fine sediment	0.44	10
Riparian Condition	0.47	11

Table 4.33. Ranking of key habitat attributes for 6th-code HUC watersheds in the B.C. portion of the Kootenai Subbasin for westslope cutthroat trout.

Habitat Attribute	Score	Rank
Oxygen	0.00	1
Low Temperature	0.00	1
Obstructions	0.00	1
High Temperature	0.00	1
Pollutants	0.02	2
High Flow	0.14	3
Low Flow	0.15	4
Fine sediment	0.36	5
Channel stability	0.38	6
Habitat Diversity	0.38	6
Riparian Condition	0.40	7

Table 4.34. Ranking of key stream-habitat attributes for the regulated mainstem and tributaries at the HUC-4 scale for westslope cutthroat trout in the U.S. portion of the subbasin based on a QHA analysis of all 6th-field HUCs. The most limiting attributes are highlighted in yellow.

	Regulated Mainstem		Fisher		Yaak		Lower Kootenai		Moyie		Upper Kootenai	
Habitat Attribute	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Channel stability	0.38	6	0.36	6	0.23	7	0.42	10	0.22	6	0.29	7
Fine sediment	0.38	6	0.79	8	0.36	8	0.40	9	0.21	5	0.37	9
Habitat Diversity	0.34	5	0.36	6	0.17	4	0.39	8	0.23	7	0.30	8
High Flow	0.54	8	0.23	4	0.18	5	0.21	6	0.06	3	0.23	6
High Temperature	0.26	3	0.34	5	0.19	6	0.32	7	0.21	5	0.21	5
Low Flow	0.40	7	0.11	3	0.06	3	0.06	2	0.03	2	0.09	4
Low Temperature	0.33	4	0.00	1	0.00	1	0.05	1	0.00	1	0.00	1
Obstructions	0.17	2	0.05	2	0.05	2	0.12	4	0.14	4	0.06	3
Oxygen	0.00	1	0.00	1	0.00	1	0.11	3	0.00	1	0.00	1
Pollutants	0.17	2	0.00	1	0.00	1	0.19	5	0.21	5	0.01	2
Riparian Condition	0.63	9	0.52	7	0.60	9	0.40	9	0.33	8	0.47	10

Table 4.35. Ranking of key stream-habitat attributes at the HUC-4 scale for westslope cutthroat trout in the B.C. portion of the subbasin based on a QHA analysis of all 6th-field HUCs.

	Bull River		Elk		Kootenay Lake		Kootenay River		St. Mary	
Habitat Attribute	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Channel stability	0.47	4	0.35	5	0.35	5	0.29	6	0.46	7
Fine sediment	0.53	6	0.36	6	0.33	4	0.23	4	0.35	5
Habitat Diversity	0.53	6	0.37	7	0.37	7	0.27	5	0.38	6
High Flow	0.28	3	0.13	3	0.11	2	0.06	3	0.14	3
High Temperature	0.01	2	0.00	1	0.00	1	0.00	1	0.00	1
Low Flow	0.28	3	0.15	4	0.13	3	0.05	2	0.16	4
Low Temperature	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1
Obstructions	0.00	1	0.00	1	0.00	1	-0.01	1	0.02	2
Oxygen	0.00	1	0.00	1	0.00	1	0.00	1	0.00	1
Pollutants	0.00	1	0.11	2	0.00	1	0.00	1	0.00	1
Riparian Condition	0.52	5	0.35	5	0.36	6	0.31	7	0.47	8

Table 4.36. Ranking of key habitat attributes for reservoirs and selected lakes in the Kootenai Subbasin for westslope cutthroat trout based on a LQHA analysis.Note the lake scores are much lower than reservoir scores. Habitat attributes in lakes are relatively intact when compared to that of reservoirs.

Reservoirs	Score	Rank
Temperature	0.00	1
Oxygen	0.00	1
Gas saturation	0.00	1
Substrate condition	0.12	2
Pollutants	0.14	3
Habitat diversity	0.18	4
Volumetric turnover rates	0.33	5
Trophic status	0.34	6
Entrainment	0.40	7
Migratory obstruction	0.44	8
Macrophytes	0.46	9
Hydraulic regime	0.46	9
Shoreline condition	0.80	10
Lakes		
Oxygen	0.00	1
Gas saturation	0.00	1
Entrainment	0.00	1
Volumetric turnover rates	0.01	2
Macrophytes	0.02	3
Habitat diversity	0.03	4
Pollutants	0.03	4
Substrate condition	0.03	4
Temperature	0.04	5
Migratory obstruction	0.06	6
Hydraulic regime	0.06	6
Trophic status	0.07	7
Shoreline condition	0.09	8

Based on this analysis, of the eleven stream habitat attributes considered key to resident salmonids, the most degraded for westslope cutthroat trout in tributaries in the U.S. portion of the subbasin (when averaged across all the tributary HUCs) are riparian condition, fine sediment, channel stability, and habitat diversity, in that order. In the regulated mainstem they are riparian condition, altered hydrograph, fine sediment, and channel stability. In the B.C. portion of the subbasin they are riparian condition, habitat diversity, channel stability, and fine sediment. The rankings vary at the HUC-4 scale. Of the thirteen lake/reservoir-habitat attributes considered key to resident salmonids, the four most limiting to westslope cutthroat trout in reservoirs are: shoreline condition, hydraulic regime, macrophytes, and migratory obstructions. The habitat in lakes is in significantly better condition, and none of the lake habitat attributes scored low enough to be considered limiting.

Long-term Viability of Westslope Cutthroat Trout Populations Based on Habitat Availability and Condition

In 2000, the USFWS, charged with administration of the Endangered Species Act (ESA), determined that the listing of westslope cutthroat trout as a threatened species under the ESA was not warranted, due to the species wide distribution, available habitat in public lands and conservation and management efforts underway by state and federal agencies. Under the Endangered Species Act, threatened means a species is likely to become endangered within the foreseeable future. In 2003, the agency finished reevaluating that finding and found again listing was not warranted.

Since the initial finding by the USFWS, Shepard et al. (2003), in their report on the status of the subspecies in the United States, found that westslope cutthroat trout "currently occupy significant portions of, and are well distributed across, their historical range." Their assessment also found that "the data suggest genetically unaltered westslope cutthroat trout occupy at least 13 percent and possibly up to 35 percent of currently occupied habitats and 8 to 20 percent of historical habitats." MFWP estimates that westslope cutthroat trout currently occupy only 27 percent of their historic range in Montana, and genetically pure populations occupy only 3 percent of their historic range. In the U.S. portion of the Kootenai Subbasin, Shepard et al. (2003) found that non-introgressed westslope cutthroat trout occupy 5 to 72 percent of their historical habitats (the second percentage includes habitats occupied by genetically unaltered, suspected unaltered, and potentially unaltered westslope cutthroat trout).

In addition, signers of the state of Montana's Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana (MOA), stated that they believed implementation of the agreement and achievement of its goals and objectives "should ensure the long-term viability of westslope cutthroat trout in the state of Montana." Signers included representatives from American Wildlands, Montana Chapter of the American Fisheries Society, Montana Department of Natural Resources and Conservation (DNRC), Montana Farm Bureau, Montana Fish, Wildlife & Parks (MFWP), Montana Stockgrowers Association, Montana Trout Unlimited, Montana Wildlife Federation, Natural Resource Conservation Service (NRCS), private landowners, U.S. Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), and U.S. Forest Service (USFS). At an interagency meeting (December 1999), participants prioritized river drainages in Montana for westslope cutthroat trout conservation and restoration.

LINKS

Appendix 64 lists the waters in Montana Fish, Wildlife & Park's Region One that have tested positive or have questionable results for fish pathogens. Further queries may be conducted at: http://www.esg.montana.edu/nfhdb/fh1.html

Click Here

Based on the conclusion of these analyses, the MOA, and the conservation priority agencies have placed on westslope cutthroat trout, we believe that proper conservation, restoration, and mitigation actions will secure the long-term viability of westslope cutthroat trout in the Kootenai Subbasin.

4.2.6 Westslope Cutthroat Trout Limiting Factors and Conditions

The NPCC defines limiting factors as those factors or conditions that have led to the decline of each focal species and/or that currently inhibit populations and ecological processes and functions relative to their potential.

The Montana Chapter of the American Fisheries Society (MTAFS) identified the following four factors as the primary reasons for the decline of westslope cutthroat trout in Montana: over exploitation, genetic introgression and competition from nonnative fish species, and habitat degradation (MTAFS website). The Kootenai Subbasin Summary (Marotz et al. 2000) describes these four limiting factors (and others) as they relate to native fish in the subbasin.

In our own HUC-by-HUC assessment of all Kootenai Subbasin 6^{th} field HUCs in the U.S., our technical team concluded that of the habitat attributes considered most important to resident salmonids, the most limiting for westslope cutthroat trout when averaged across all the HUCs in the U.S. portion of the subbasin are riparian condition, fine sediment channel stability, and habitat diversity, in that order. In the B.C. portion of the subbasin they are riparian condition, habitat diversity, channel stability, and fine sediment. This phase of the HUC assessment considered only habitat factors (factors such as the presence of nonnative species were evaluated in a second phase of the HUC assessment and were not ranked against the habitat attributes in terms of which is most limiting).

Shepard and others (2003) asked fishery professionals to assess whether various land, water, and/or fish management activities affected each designated westslope cutthroat trout conservation population. Table 4.37 provides results of this survey and lists the known impacts to conservation populations and the miles of stream presently impacted within the Kootenai Subbasin by 4^{th} Code HUC.

As part of their Status Review for Westslope Cutthroat Trout in the United States (USFWS 1999), the USFWS assessed limiting factors and threats to westslope cutthroat trout. The following paragraphs are condensed and adapted from that review and summarize the threat posed by various known and suspected potential limiting factors for westslope cutthroat trout in the Kootenai River Subbasin.

Table 4.37 Known impacts to conservation populations and miles of stream presently impacted within the Kootenai Subbasin.

4th Code HUC	Management Impact	Miles Presently Impacted
Upper Kootenai	Angling	14.4
Upper Kootenai	Dewatering	14.2
Upper Kootenai	Hydroelectric, water storage, and/or flood control	8.9
Upper Kootenai	Mining	17.3
Upper Kootenai	Range (livestock grazing)	28.2
Upper Kootenai	Roads	80.2
Upper Kootenai	Stocking	26.0
Upper Kootenai	Timber Harvest	69.3
Yaak	Range (livestock grazing)	29.9
Yaak	Roads	75.8
Yaak	Stocking	29.9
Yaak	Timber Harvest	75.8

Montana Portion of the Kootenai

Timber management is the dominant land use in the Kootenai River drainage, and an extensive road system to support forestry practices and other forest uses exists throughout the Montana portion of the drainage. Forestry practices have had adverse effects on the habitats of westslope cutthroat trout in some areas of the drainage. The Montana Department of Environmental Quality (MTDEQ) lists 182 miles water in the Kootenai River drainage as being water-quality impaired as the result of silviculture and 125.5 impaired by agricultural practices; additional impairments result from other land-use practices (MTDEQ 303(d) website 2003). Many of these streams are impaired by more than one activity. However, information on the possible occurrence of westslope cutthroat trout in these streams is presently unavailable.

LINKS

For a map showing barriers to fish passage in the Montana portion of the Kootenai go to Appendix 98.

Click Here

Although harvest of westslope cutthroat trout may have caused appreciable declines in some westslope stocks during the 1900s, angler harvest is now closely regulated in Montana and is not considered a threat to the subspecies (USFWS 2002). In many waters in the Kootenai River drainage, fishing for westslope cutthroat trout is restricted to catch-and-release. Elsewhere in the drainage, harvest is greatly restricted.

Whirling disease has not been found in the Kootenai River drainage (Montana Whirling Disease Task Force Website 2003). We are aware of no other diseases or predators that pose threats to westslope cutthroat trout in the drainage.

There are no evident, inherent inadequacies in existing federal, state, or local regulatory mechanisms that affect westslope cutthroat trout in the drainage. However, effective implementation of the various regulatory mechanisms that potentially affect westslope cutthroat trout depends largely on the appropriation of adequate funding and, ultimately, commitment on the part of the management or regulatory agencies to fulfill their respective responsibilities. Where these responsibilities are not being fulfilled, westslope cutthroat trout may be threatened by ongoing or planned, adverse changes in their habitats or by chronic, adverse effects that remain unabated.

As the result of stocking for recreational purposes, nonnative brook trout, brown trout, and rainbow trout became established long ago in many streams and lakes throughout the Kootenai River drainage. Although such stocking has not occurred for more than two decades, the nonnative fishes that became established probably constitute the greatest contemporary threat to the maintenance and restoration of westslope cutthroat trout in Montana (MFWP, in litt. 1999).

Idaho Portion of the Kootenai

Forest management practices, including timber harvest and road construction, both past and current, are major contributors to degraded watershed conditions and aquatic habitats on public lands in Idaho. Baseline data on watershed conditions throughout this drainage are not available to precisely quantify the rates of change.

The development of road systems in the Kootenai River drainage have contributed to extensive sediment input and poor channel conditions throughout the drainage. Road densities have been used to correlate the probability of a stream to support bull trout populations (Lee et al. 1997b in USFS, in litt. 1998e)—the higher the road densities, the lower the probability of finding strong bull trout populations. Baseline environmental conditions for road densities were considered good if densities were less than 0.7 m/m^2, moderate if densities were between 0.7 m/m^2 and 1.7 m/m^2, and poor if densities were greater than 1.7 m/m^2 (Lee et al. 1997b in USFS, in litt. 1998e). While these determinations were made for bull trout, they may also be used for assessing threats to westslope cutthroat and other trout species. Until road densities are reduced significantly in this drainage, threats to westslope cutthroat trout are considerable.

The mainstem Kootenai River habitat has had dramatic changes beginning in the late 1800s. Attempts at diking began as early as 1892 in order to claim land for agricultural purposes (Paragamian 1995). Today, approximately 30 miles of the Kootenai River have been diked. In 1966, construction of Libby Dam in Montana was initiated and impoundment of Koocanusa Reservoir and regulation of downstream flows began in 1972. From 1972 to the fall of 1975, while the turbine installation was being completed, water discharge was through the sluiceways or spillways (Partridge 1983). The main purpose of Libby Dam is flood control; hydropower and recreation are secondary benefits. The flow regime of the Kootenai River has changed dramatically due to the operation of Libby Dam, and mean winter water temperatures have increased, whereas mean summer water temperatures have decreased (Partridge 1983; Paragamian 1995).

Hybridization with coastal rainbow trout and Columbia River redband trout threatens the genetic integrity of westslope cutthroat trout in the Kootenai River drainage of Idaho. Stocking of coastal rainbow trout and Yellowstone cutthroat trout in several streams and lakes in the Kootenai River drainage was common in the past (IDFG stocking records database). As stated earlier, there is evidence of introgression from nonnative species such as coastal rainbow trout and Yellowstone cutthroat trout, as well as hybridization with Columbia River redband trout (Sage 1993, 1995; Leary 1997).

The threat of hybridization to pure westslope cutthroat trout stream populations is great where pure populations of westslope cutthroat trout occupy headwater streams and hybrids or stocked nonnative fish occupy the lower portion of the same stream, and there is no migration barrier to prevent the movement upstream (Perkinson, USFS, pers. comm. 1998). Compounding this threat is the stocking of high-mountain lakes. Even where upstream migration barriers exist to prevent hybridization, if high-mountain lakes are stocked with nonnative trout species, downstream migration and subsequent gene flow from the lake are possible; hybridization and introgression may then occur throughout the stream.

Based on creel surveys, harvest does not appear to be a limiting factor in the mainstem Kootenai River, Idaho (Partridge 1983; Paragamian 1995a; Walters 2003). Although fishing pressure for westslope cutthroat trout in tributaries does not appear to be a limiting factor, no quantitative creel data exists.

Predation on westslope cutthroat trout by numerous native and non-native species is an important source of mortality and can act as a destabilizing force when habitat loss and overexploitation is experienced (Rieman and Apperson 1989). No quantitative data exists on the affects of predation on westslope cutthroat trout in the Kootenai drainage.

Diseases are potential limiting factors of fish populations. The water source for the former Clark Fork Hatchery was inhabited by brook trout that had Infectious Pancreatic Necrosis (IPN). The broodstock fish (including rainbow trout and westslope cutthroat trout) from the Clark Fork Hatchery that were used for stocking lakes, rivers, and streams in the Idaho Panhandle region were known to be infected with IPN (Horner, IDFG, pers. comm. 1999). This is a contagious virus that affects young fish, generally 80-90 mm in length, and may cause large losses (Van Duijn 1967; Horner, IDFG, pers. comm. 1999). The extent of this threat in the Kootenai River drainage is unknown. Since 1999, IDFG no longer stocks rivers and streams in the Kootenai drainage with fish from this hatchery. Available information does not identify any other disease threats in this drainage.

Heavy metals could potentially limit westslope cutthroat trout populations in the Kootenai subbasin. Metals, including copper, accumulated in food chain items in the Clark Fork River have resulted in reduced growth, deformity and death in juvenile cutthroat trout (Woodward 1993). Heavy metals released from past mining activities have been documented in the lower Kootenai River. Of those identified, copper appears to be the greatest concern biologically. Copper was found to have accumulated in oocytes of Kootenai River white sturgeon, water, and sediments from the lower Kootenai River (Apperson and Anders 1991). Although sturgeon appeared to hatch normally, potential impacts to other aquatic biota have not been evaluated. Water-quality monitoring conducted on the Kootenai River and several tributary streams by the Kootenai Tribe of Idaho indicated that mercury, lead, and selenium exceeded EPA aquatic criteria at several sites and that arsenic, copper, and lead were found in the river sediment (Kruse and Scarnecchia 2001a; Kruse and Scarnecchia 2001b).

Rieman and Apperson (1989) summarized that while competition between westslope cutthroat trout and nonnative fish is minimized in streams by habitat segregation, the loss of suitable westslope cutthroat trout habitat has allowed for nonnative fishes to expand into altered habitats. Brook trout tend to replace westslope cutthroat trout where westslope cutthroat trout have declined, whereas rainbow trout (once established and naturally reproducing) can displace westslope cutthroat trout where the two exist sympatrically. These threats occur in the Kootenai River drainage, where rainbow trout and brook trout have been observed in a few of the tributary streams surveyed.

Table 4.38, from USFWS (1999), presents the threats to westslope cutthroat trout by 4th-field HUC for the Kootenai Subbasin.

Table 4.38. Threats to westslope cutthroat trout throughout the historic range of the subspecies. Data are given as the number of water bodies considered water-quality impaired by that particular land-use activity, or as low (L), moderate (M), or extensive (E). Harvest is given as catch and release only (C & R), restricted (R), low (L), moderate (M), or extensive (E). Nonnative fish are given as yellowstone cutthroat trout (YCT), brook trout (BKT) and rainbow trout (RBT). Source: USFWS 1999.

Watershed	Upper Kootenai River	Fisher River	Yaak River	Lower Kootenai River	Moyie River
Dams	1			M/E	L
Forestry	12	3	8	M	M
Agriculture	7	2			
Water Withdrawls	10		8	M	L
Roads	3		1	E	M/E
Channelization	1	2		M	L
Mining	5			L	L
Natural Sources	3				
Water Quality	17	3	7		
Harvest	R	R	R	L/M	L
Non-native Fish	BKT RBT	BKT RBT	BKT RBT	YCT, BKT, RBT	YCT, BKT, RBT

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4.3 Columbia River Redband Trout

4.3.1 Background

Reasons for Selection as Focal Species

Globally, redband trout (*Oncorhynchus mykiss gairdneri*), a subspecies of rainbow, have a G5T4 ranking, meaning that the subspecies is apparently secure, although it may be quite rare in parts of its range, especially at the periphery. A recent status report estimated that in Oregon, Washington, Idaho, western Montana, and northern Nevada, only 4.6 percent of subwatersheds within the subspecies historic range are currently occupied by known strong populations, and 75 percent of subwatershed populations with known status are depressed (Bradley et al. 2002). Columbia River redband trout in the Kootenai River drainage in Montana represent the farthest inland penetration of native rainbow trout in the Columbia River drainage (Hensler and Muhlfeld 1999).

Region I of the US Forest Service lists Columbia River redband trout as a sensitive species. The state rank for Montana is S1, for Idaho S2S3, and the provincial rank for B.C. is S4. The S1 rank means the subspecies is critically imperiled because of extreme rarity or because of some factor(s) of its biology making it especially vulnerable to extinction. The S2 rank means the species is considered imperiled because of rarity or because of other factor(s), demonstrably making it very vulnerable to extinction throughout its range. An S3 rank means it is either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factor(s). The American Fisheries Society has listed Columbia River redband trout as a Class A Species of Special Concern since 1993. A Class A species of special concern is defined as a species or subspecies that has "limited numbers and/or habitats both in Montana and elsewhere in North America and elimination from Montana would be a significant loss to the gene pool of the species or subspecies". The USFWS also classifies Columbia River redband trout as a species of special concern (Muhlfeld 2003).

The Biodiversity Legal Fund of Colorado and Mr. Donald Kern of Kalispell, Montana, formally petitioned the USFWS to consider the Kootenai River population of Columbia River redband trout as an endangered species under the ESA on April 4, 1994. However, the petition was dismissed due to lack of information. Concern has arisen in recent years that Columbia River redband trout in the Kootenai River basin are at a high risk of extinction (Muhlfeld 1999).

Columbia River redband trout were selected as a focal species in this assessment because of their conservation rankings, current concerns over their

LINKS

Columbia River redband trout information generated by state, federal, and tribal biologists working in Montana is available from the Montana Fisheries Information System (MFISH) database accessible on the internet at: http://nris.state.mt.us/scripts/esrimap.dll?name=MFISH&Cmd=INST.

Click Here

For fisheries information in the Kootenai in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information (including reports pertaining to Kamloop trout) for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

For the B.C. Fisheries Inventory Data Queries site go to: http://srmapps.gov.bc.ca/apps/fidq/

Click Here

For the Conservation Data Centre go to: http://srmwww.gov.bc.ca/cdc/

Click Here

status, and their considerable evolutionary and recreational fishery importance in the Kootenai River Subbasin.

Summary of Population Data

In its Analysis of the Management Situation for the Kootenai and Idaho Panhandle National Forests, the USFS reports that current populations range from strong to depressed. In all but five of the 6-field HUCs on the Idaho Panhandle National Forest, Columbia River redband trout status is described as "presence unknown." In three HUCs, redbands are known to be present but their population status is unknown, and in two they are present but depressed. In the Upper Kootenai Subbasin, Muhlfeld (2003) reports that genetically pure stocks of Columbia River redband trout have been identified in Callahan Creek, Basin Creek, the upper north (British Columbia) and east forks of the Yaak River, and upper Big Cherry Creek and Wolf Creek (Allendorf et al. 1980; Leary et al. 1991; Huston 1995; Hensler et al. 1996). Recent results of additional genetic testing conducted by MFWP (Allendorf 2003 unpublished) show the range of genetically pure populations of redband also includes upper Libby Creek and the upper Fisher River (including the Pleasant Valley Fisher, East Fisher River drainages). The status of these Montana Columbia River redband trout populations is presumed to be stable (J. Dunnigan, MFWP, pers. comm. 2004).

LINKS

For information on the relationship between Gerrard rainbow, Kamloops, and Columbia River redband trout, see section 4.3.2.

Click Here

Columbia River redband trout are native to the lower Kootenai River in Idaho, although it is unclear how extensively the subspecies used the river below Kootenai Falls during pre-settlement times (PWI 1999). In the Kootenai River mainstem, introgression from hatchery (coastal) rainbow trout that have been stocked in the drainage is likely.

No specific trend data is available for Columbia River redband trout populations in Idaho, though there is some abundance data. In North Callahan Creek, the minimum estimated Columbia River redband trout density was 8.7 fish/100m^2, while in South Callahan Creek the minimum density was 9.3 fish/100m^2 based on electrofishing in August 2003 (IDFG unpublished data). In Boulder Creek, estimated summer Columbia River redband trout densities ranged from 5.5 fish/100m^2 to 44.7 fish/100m^2 (Fredericks and Hendricks 1997; Walters 2002, 2003). In the Deep Creek drainage, densities ranged from 7.8 fish/100m^2 to 108.5 fish/100m^2 in summer 1996 (Fredericks and Hendricks 1997). In the Kootenai River, Idaho, Columbia River redband trout densities (age-2 and older) ranged from 33 fish/km (0.03 fish/100m^2) to 73 fish/km (0.07 fish/100m^2) (Paragamian 1995a and b; Downs 2000; Walters and Downs 2001).

Historic Distribution

Redband trout of the Columbia River basin (*Oncorhynchus mykiss gairdneri)* are a subspecies of the rainbow trout evolutionary line (*Oncorhynchus mykiss*) native to the Fraser River Basin and Columbia River Basin east of the Cascade Mountains to barrier falls on the Pend Oreille, Spokane, Snake and Kootenai rivers (Allendorf et al. 1980; Behnke 1992). They are also native to Kootenay Lake, B.C. and the Kootenai River in Idaho and Montana.

In its Analysis of the Management Situation (KIPNF 2003), the USFS reported that historically, Columbia River redband trout were the most widely distributed salmonid in the Columbia River Basin, but that they were not naturally widespread in areas within the Kootenai and Idaho Panhandle National Forests. For years, the upper distribution of redband trout in the Columbia River Basin was believed to extend upstream to Kootenai Falls, which was considered a barrier falls (Allendorf et al. 1980; Chapman and May 1986), but it is now thought the barrier was not Kootenai Falls, but one that existed in geologic time near the present day Libby Dam or Fisher River (Hensler et al. 1996). Genetic surveys also indicate that Columbia River redband trout were not just found in headwater reaches as they are now, but were native to low-gradient valley-bottom streams throughout the Kootenai River drainage (Muhlfeld 1999). This range contraction may have occurred in response to past and present land use and fishery management practices.

LINKS

For Columbia River redband trout abundance and distribution information for the U.S. portion of the subbasin go to Appendix 55.

Click Here

Appendices 32 and 33 list streams and selected lakes in the Kootenai Subbasin (B.C., ID, and MT portions) that were thought to support populations of Columbia River redband trout prior to European settlement.

Current Distribution[1]

Based on genetic analyses in Montana, populations of Columbia River redband trout have been identified in Callahan Creek, the East Fork Yaak River and its tributaries, the Yaak River (downstream from Yaak Falls), the North Fork Yaak River, and tributaries to Libby Creek and the upper Fisher River (including the Pleasant Valley Fisher, East Fisher River drainages) (Allendorf et al. 1980; Leary et al. 1991; Huston 1995; Hensler et al. 1996; Knudsen 2002). Currently, unintrogressed Columbia River redband trout populations are restricted to headwater reaches. Columbia River redband trout inhabiting Callahan Creek and the upper Yaak drainage are isolated into two separate regions by Yaak River Falls, a falls-chute barrier located 4 km from the mouth of Callahan Creek and a barrier falls located in the lower East Fork of the Yaak river. Telemetry-based research conducted by MFWP (1999) suggest that Columbia River redband trout

[1] *Excerpted from Muhlfeld 1999.*

in Basin Creek and East Fork Yaak River (upstream from the barrier falls) may represent a metapopulation of Columbia River redband trout that includes both resident and fluvial life history forms.

Columbia River redband trout did not occur in the section of the Kootenai River above the current site of Libby Dam prior to impoundment but are now present, and they continue to be stocked. Five thousand Gerrard rainbow trout were stocked annually into Kikomun Creek, a tributary to Koocanusa Reservoir, between 1986 and 1998 by the B.C. Ministry of the Environment. This practice was discontinued because of concerns with hybridization of stocked rainbow trout with westslope cutthroat trout. (For more information on the relationship between Gerrard rainbow, Kamloops, and Columbia River redband trout, see section 4.3.2: Population Delineation and Characterization.) MFWP continues to stock rainbow trout into the reservoir; MFWP stocks hatchery-reared Duncan strain from the Murray Springs Fish Hatchery (Dalbey et al. 1998; B. Marotz, MFWP, pers. comm. 2003).

In Idaho, genetics studies have documented Columbia River redband trout in the Boulder, Boundary, and Deep creek drainages, and North and South Callahan Creeks (Sage 1993, 1995; Leary 1997; Knudsen et al. 2002; M. Powell, U. of Idaho, pers. comm.). Spawning and rearing habitat in several Idaho tributaries has been lost or is now inaccessible to fluvial Columbia River redband trout due to anthropogenic factors (Partridge 1983). These streams include, but are not limited to, Caboose, Cow, Debt, and Twenty-Mile creeks. In addition, mining activities in Boundary Creek may be detrimental to fish populations due to heavy metal concentrations (Partridge 1983).

LINKS

For a MFWP map showing Columbia River redband trout genetic distribution in the Montana portion of the Kootenai, see Appendix 74.

Click Here

QHA spreadsheets contain current and historic Columbia River redband trout distribution by lifestage for HUC-6 watersheds and selected lakes in the U.S. and B.C. portions of the Kootenai. These data are a compilation put together by our Technical Team. Go to Appendices 32 and 33.

Click Here

Status of Columbia River Redband Trout Introductions, Artificial Production and Captive Breeding Programs

MFWP has developed an isolation facility for the conservation of Columbia River redband trout at the Libby Field Station. Existing ponds were restored and the inlet stream was enhanced for natural outdoor rearing. The agency treated the newly renovated spring creek and pond with antimycin on November 1, 2000, to remove eastern brook trout and non-native rainbow trout. Native Columbia River redband trout from Basin Creek were stocked into the pond and spring creek in early May 2001 to provide a future source of eggs for restoring redband stocks within their historic range in the Kootenai River basin. The isolation facility also provides a source of native redband for use as an alternative to stocking lakes and private ponds with non-native fish.

Koocanusa Reservoir is currently stocked with redband trout from Murray Springs State Trout Hatchery. Those fish are presumed to be Duncan Kamloops redband trout (Knudsen et al. 2002).

Table 4.39. Angling pressure on waters in the Kootenai Subbasin (in angler days per year). Source: MFWP 2003

Watershed	1997	1999	2001
17010101 Upper Kootenai	66,191	61,074	61,687
17010102 Fisher	8534	8399	5589
17010103 Yaak	6513	4557	5,650
Totals	81,238	74,030	72,926

Historic and Current Harvest

Fisheries managers in the Montana portion of the Kootenai River Subbasin have actively protected Columbia River redband trout with increasingly restrictive harvest regulations: i.e., a shortened season (July 1 to Nov. 30 and a combined trout limit of 3 daily). Specific data on the extent of historic and current harvest of Columbia River redband trout in Montana are not available. Table 4.39 presents annual angler-day estimates in the Montana portion of the Kootenai Subbasin.

In the Kootenai River in Idaho, an estimated 1,040 (95% C.I. = ± 905) Columbia River redband trout were harvested in 1993, and 1,882 (95% C.I. = ± 1,209) were harvested in 2001 (Paragamian 1995a; Walters 2003). In the 1993 survey, Columbia River redband trout was the second most abundant species in the harvest following mountain whitefish, and in 2001, Columbia River redband trout was the most common species harvested. On January 1, 2002, new regulations for trout in the Kootenai River in Idaho were initiated. The bag limit is now two trout (redband, westslope cutthroat, or hybrids) with a 16" (406 mm) minimum length limit. There is no closed season for trout in the mainstem Kootenai River, Idaho. Regulations prior to 2002 included a 6-trout bag limit with no minimum length limit. Kootenai River Idaho tributaries have a Memorial Day weekend opener (last weekend in May) and November 30, season closure. A 6-fish bag limit is allowed in the tributaries. However, fishing pressure for Columbia River redband trout in the tributaries appears to be minimal due to limited access or private property (J. Walters, Idaho Department of Fish and Game, pers. comm. 2003).

4.3.2 Population Delineation and Characterization

Population Units

Behnke (1992) separated rainbow trout into the following three separate evolutionary significant groups: 1) the redband trout of the Sacramento, Kern, and McCloud Rivers in California, 2) the Columbia River redband trout of the Columbia and Fraser River basins located east of the Cascade Mountains to barrier falls on the Kootenai, Pend Oreille, Spokane, and Snake rivers and 3) coastal

LINKS

For current and historic fish stocking records in Montana, go to: *http://www.fwp.state.mt.us/fishing/stock02.asp*

Click Here

For stocking information for Idaho, go to: http://www2.state.id.us/fishgame/fish/fishstocking/stocking/year.cfm?region=1

Click Here

rainbow trout. Under this taxonomy, all redband trout of the Columbia and Fraser River basins are classified as *O. mykiss gairdneri* (Muhlfeld 2003).

Based on MFWP genetics and behavioral data, we conclude that there are (at least) two distinct Columbia River redband trout population units in the Montana portion of the Kootenai: the Yaak (above Yaak Falls) and the Kootenai populations, like Callahan Creek (Knudsen et al. 2002; Muhlfeld et al. 2001). These populations are genetically distinct and isolated from genetic exchange. They constitute separate, naturally reproducing populations (Clint Mulfield, MFWP, pers. comm. 2003). The Gerrard strain (Kamloops) native to Kootenay Lake, a large adfluvial form, is likely the parent stock to the Montana resident populations and is genetically distinct from the Yaak population (Clint Mulfield MFWP pers. comm. 2003). The Kamloops redband trout is more similar genetically to the Callahan Creek fish (Knudsen et al. 2002). Gene flow between Kootenay Lake and Callahan Creek redband trout is possible because migratory Kamloops redband trout have been found in the Kootenai River upstream of the mouth of Callahan Creek, and the barriers on Callahan Creek could have been breached by migrating Kamloops redband trout in the past (Knudsen et al. 2002). At present there is not sufficient information to determine if Callahan Creek redband and Kamloops redband constitute distinct population units.

In Idaho, redband trout in the Boundary Creek drainage are also likely similar to the Kamloops strain. Adfluvial fish from Kootenay Lake should have access to this drainage, as Partridge (1983) reported there were no known migration barriers. The Boulder Creek population could be considered a distinct population unit because a waterfall approximately 2 km from the mouth (and downstream of the E. Fork Boulder Creek) is a barrier to upstream migration (Partridge 1983).

Life History[2]

A variety of life history strategies can be found among Columbia River redband trout. Anadromous stocks (which are known commonly as steelhead) historically migrated to the middle and upper Columbia River drainage, but this range probably became more restricted when barriers formed during the last (Tahoe stage) glacial advance (Behnke 1992). So there are presently redband trout populations isolated from anadromous influence, such as in Kootenay Lake and the Kootenai River upstream. An adfluvial form, the Kamloops redband trout of Kootenay Lake, British Columbia, has a piscivorous diet and therefore grows quite large and exhibits an advanced size at sexual maturity. Kamloops redband trout spawn in Kootenai River tributaries in Montana and Idaho but do not migrate upstream from Kootenai Falls (Huston 1995). Fluvial stocks occupy large rivers and spawn in smaller

[2] *The first paragraph of this section is adapted from Mulfeld (2002)*

tributaries. Resident forms complete their entire life cycles in smaller tributaries and headwater areas. The Kootenai River drainage supports all three life histories (Downs 1999, 2000; Muhlfeld et al. 2001b; Walters and Downs 2001; Knudsen 2002). The different redband trout life history forms are indistinguishable using meristic counts, coloration patterns, or allozyme data (Knudsen et al. 2002).

Columbia River redband trout generally spawn between March and June depending on water temperatures. In Basin Creek, Montana, adult Columbia River redband trout commenced spawning (e.g. redd construction) during June as spring flows subsided following peak runoff. (Muhlfeld 2002). In the Deep Creek drainage of Idaho, Columbia River redband trout spawned during April and May (Downs 2000). Emerging from the redd about two months after spawning, the fry occupy the stream anywhere from one year to the rest of their life (depending on their life-history form). Adfluvial and migratory fluvial juveniles typically move downstream to their ancestral lake or river after 1 to 3 years of headwater residence. Most juveniles out-migrate from the Deep Creek drainage at age-1 or 2 (Fredericks and Hendricks 1997; Downs 1999, 2000) Out-migrants from the Boundary Creek drainage were mainly age-2 and age-3 (Walters and Downs 2001). In Idaho tributaries upstream of Deep Creek, a large proportion of Columbia River redband trout may out-migrate at age-0 (Walters 2002, 2003). Sexual maturity typically occurs at 3 to 5 years. Sympatric interior redband and westslope cutthroat trout populations appear to have evolved strategies to limit introgression, as observed in Yaak River tributaries.

Genetic Integrity

Allendorf and others (1980) surmised that "planting of hatchery rainbow trout has created a situation of tremendous genetic divergence among local populations." Muhlfeld (2003) reported that genetically pure stocks of Columbia River redband trout have been identified in Callahan Creek, Basin Creek, the upper north (British Columbia) and east forks of the Yaak River, and upper Big Cherry Creek and Wolf Creek (Allendorf et al. 1980; Leary et al. 1991; Huston 1995; Hensler et al. 1996). Recent genetic testing conducted by MFWP (Allendorf 2003 unpublished) shows the range of genetically pure populations of redband also includes upper Libby Creek and the upper Fisher River (including the Pleasant Valley Fisher and East Fisher River drainages). Those inhabiting Callahan Creek and the upper Yaak River Drainage are isolated into two separate regions by Yaak River Falls, a falls-chute barrier located 4 km from the mouth of Callahan Creek and a barrier falls located in the lower East Fork of the Yaak River.

Rainbow trout in the Boulder Creek drainage of Idaho had alleles of Columbia River redband trout, coastal rainbow trout and westslope cutthroat trout (Sage 1993; Leary 1997). Columbia River redband trout in the Deep Creek

LINKS

The Montana Trout Genetic Purity Data Set (Data in Excel format) describes the genetic makeup of trout populations from 839 sites in Montana. See Appendix 69.

Click Here

For a MFWP map showing Columbia River redband trout genetic distribution in the Montana portion of the Kootenai, see Appendix 74.

Click Here

drainage appear to have coastal rainbow trout genes as well (M. Powell, Univ. of Idaho, personal communication). Sage (1995) identified redband X westslope cutthroat trout hybrids from Boundary Creek, with a larger proportion of interior (redband) rainbow trout genes. Sage (1995) determined that samples from Grass and Saddle creeks (Boundary Creek drainage) were Columbia River redband trout. Fish from North and South Callahan creeks were identified as pure Columbia River redband trout (Sage 1995; Knudsen et al. 2002). Genetic testing of fish from the mainstem Kootenai River in Idaho has not been conducted.

Our QHA analysis for the U.S. portion of the Kootenai River drainage (Montana and Idaho), showed that Columbia River redband trout from thirty-seven of the 6th-code HUCs were estimated to be genetically pure. Eighteen (43 percent) of those had stocks believed to be less than 10% introgressed, and 21 (57 percent) had stocks believed to be greater than 10% introgressed.

It is interesting to note that several tributaries in the Yaak River in Montana currently contain Columbia River redband trout and westslope cutthroat trout that have apparently coexisted with no introgression. Apparently when humans have not tampered with the fish community, the redband and westslope cutthroats segregate temporally and physically in their respective spawning areas (Marotz, MFWP, pers. comm. 2003), and where hatchery fish have been introduced, this segregation breaks down and hybridization occurs. The currently unintrogressed population in Callahan Creek, Montana, is apparently protected by a passage barrier created by two falls/cataracts in the lower reach of this Kootenai River tributary.

4.3.3 Population Status

Current Status

Though redband trout are broadly distributed (they occur in Idaho, Oregon, Washington, Nevada, California and Montana), few strong populations remain. Lee and others (1997) reported that known or predicted secure populations inhabit 17 percent of the historic range and 24 percent of the present range and that only 30 percent of the watersheds currently supporting spawning and rearing populations are considered strong. Populations in Montana, Oregon, and California have been petitioned for listing under the Endangered Species Act (ESA). The California petition is currently under review, the 1994 petition in Montana was dismissed due to lack of information, and the 1999 petition to list the Great Basin redband trout in Oregon was deemed unwarranted at this time.

The status of Montana Columbia River redband trout populations is presumed to be stable (J. Dunnigan, MFWP, pers. comm. 2004). On the Idaho Panhandle National Forest, little is known about the status of Kootenai-drainage

Columbia River redband trout populations. In all but five of the 6-field HUCs in the Idaho portion of the Kootenai, the Columbia River redband trout status is described by the USFS as "presence unknown". In three HUCs, redbands are known to be present but their population status is unknown, and in two they are present but depressed. PWI (1999) reports that the rainbow trout population in the lower Kootenai River itself (downstream of Kootenai Falls) may be the strongest stock of all the salmonids, but that the genetic integrity of the native interior redband has been significantly compromised through stocking of non-native rainbow strains and hybridization with cutthroat trout.

Some abundance data has been collected, but little is known about capacity or productivity from the Idaho portion of the drainage. In North Callahan Creek, the minimum estimated Columbia River redband trout density was 8.7 fish/100m^2, while in South Callahan Creek the minimum density was 9.3 fish/100m^2 based on electrofishing in August 2003 (Idaho Department of Fish and Game unpublished data). In Boulder Creek, estimated summer Columbia River redband trout densities (age-2 and older) ranged from 5.5 fish/100m^2 to 44.7 fish/100m^2 (Fredericks and Hendricks 1997; Walters 2002, 2003). Boulder Creek is the largest source of juvenile redband recruitment to the Kootenai River, Idaho upstream of Deep Creek (Walters 2003). In the Deep Creek drainage, densities (age-2 and older) ranged from 7.8 fish/100m^2 to 108.5 fish/100m^2 in the summer of 1996 (Fredericks and Hendricks 1997). In the Kootenai River, Idaho, Columbia River redband trout densities (age-2 and older) ranged from 33 fish/km (0.03 fish/100m^2) to 73 fish/km (0.07 fish/100m^2) (Paragamian 1995a and b; Downs 2000; Walters and Downs 2001).

The Kootenai River drainage supports adfluvial, fluvial, and resident life history forms of Columbia River redband trout (Downs 1999, 2000; Muhlfeld et al. 2001b; Walters and Downs 2001; Knudsen 2002). Some life history forms have probably been eliminated from some tributaries. For example, culverts on Cow and Twentymile Creeks (Deep Creek drainage) are barriers to upstream migration, leaving little if any accessible spawning habitat in those streams for adfluvial fish.

Rainbow trout in the Boulder Creek drainage of Idaho had alleles of Columbia River redband trout, coastal rainbow trout, and westslope cutthroat trout (Sage 1993; Leary 1997). Columbia River redband trout in the Deep Creek drainage appear to have coastal rainbow trout genes as well (M. Powell, Univ. of Idaho, personal communication). Sage (1995) identified redband X westslope cutthroat trout hybrids from Boundary Creek, with a larger proportion of interior (redband) rainbow trout genes. Sage (1995) determined that samples from Grass and Saddle creeks (Boundary Creek drainage) were Columbia River redband trout. Fish from North and South Callahan creeks were identified as pure

LINKS

Columbia River redband trout genetic purity information for the Upper Kootenai in Montana and status information for redbands in Montana and Idaho are summarized in Appendix 55.

Click Here

LINKS

For a more complete discussion of how Mainstem Columbia River operations affect subbasin fisheries, and how those effects might be minimized see Appendix 18.

Click Here

Columbia River redband trout (Sage 1995; Knudsen et al. 2002). Genetic testing of fish from the mainstem Kootenai River in Idaho has not been conducted. As part of a management plan, a drainage-wide analysis of the genetic status of rainbow trout would reduce the uncertainty of the Columbia River redband trout distribution in Idaho.

Given the lack of pre-1970s data for the Kootenai drainage, it is difficult to document population changes and assign a risk rating to Columbia River redband trout. However, as stated earlier, the USFWS was petitioned to consider the Kootenai River population of Columbia River redband trout as an endangered species under the ESA on April 4, 1994. Recent concern has arisen that the Kootenai River Basin Columbia River redband trout population is at a high risk of extinction due to hybridization with non-native coastal rainbow trout, habitat fragmentation, and stream habitat degradation (Perkinson 1993; Muhlfeld 1999). Libby Dam has caused dramatic changes to the river including an altered hydrograph (including higher winter flows and the elimination of flood events) and lower biological productivity. In addition, anthropogenic effects have caused the loss of, or inaccessibility to, Columbia River redband trout habitat in tributaries (Partridge 1983). At best, the risk rating should probably be “unknown” for at least some populations, and possibly “depressed” or “critical” for some in the drainage.

Historic Status

Quantitative empirical data on historic Columbia River redband trout abundance and productivity in the Kootenai Subbasin are not available. It is known that historically, Columbia River redband trout occupied much of the Kootenai River system downstream from Kootenai Falls, including the Yaak River. Isolated populations exist today in the Fisher River drainage, which is upstream from Kootenai Falls, and it is believed the passage barrier preventing upstream movement in the Kootenai system existed in geologic time near the present day Libby Dam or Fisher River (Hensler et al. 1996). It is also assumed that historically (prior to European settlement) most of these streams were generally characterized by optimum habitat conditions and therefore likely supported abundant and productive native fisheries.

Theoretical Reference Condition[3]

Although a specific theoretical reference condition remains unknown for Columbia River redband trout in the Kootenai River Subbasin, the management goal for Columbia River redband trout in the U.S. portion of the subbasin is to ensure the long-term, self-sustaining persistence of the subspecies within the drainages they historically inhabited and to maintain the genetic diversity and life history strategies represented by the remaining local populations.

LINKS

Appendix 76 includes four scientific papers on Montana Columbia River redband trout habitat use and genetic structure.

Click Here

4.3.4 Out-of-Subbasin Effects and Assumptions

Out-of-subbasin effects and assumptions are similar to those described for westslope cutthroat trout (see the focal species description for westslope cutthroat trout).

4.3.5 Environment-Population Relationships

Environmental Factors Particularly Important to Columbia River redband trout Survival or Key Ecological Correlates (KECs)[4]

Seasonal habitat requirements of Columbia River redband trout in the Kootenai River drainage in Montana were investigated during 1997 and 1998 (Muhlfeld 1999; Hensler and Muhlfeld 1999; Muhlfeld et al. 2001a; Muhlfeld et al. 2001b). Summer results demonstrated that juvenile (36-125 mm) and adult (> 126 mm) Columbia River redband trout preferred deep microhabitats (> 0.4 m) with low to moderate velocities (< 0.5 m/s) adjacent to the thalweg. Conversely, age-0 (< 35mm) Columbia River redband trout selected slow water (< 0.1 m/s) and shallow depths (< 0.2 m) located in lateral areas of the channel. Age-0, juvenile and adult Columbia River redband trout strongly selected pools and avoided riffles; runs were used generally as expected (based on availability) by juveniles and adults and more than expected by age-0 Columbia River redband trout. At the macrohabitat scale, a multiple regression model indicated that low-gradient, mid-elevation reaches with an abundance of complex pools were critical areas for the

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[3] *Guidance from the Power Planning Council states that "this [section of the assessment] is a key component of the NMFS and USFWS ESA delisting evaluation, and that for ESA-listed species, these determinations will be made by the appropriate recovery team." For Columbia River redband trout, which are not listed under ESA, we have modeled our theoretical reference condition after the"Memorandum of Understanding and Conservation Agreement for Westslope cutthroat trout (Oncorhynchus clarki lewisi) in Montana.*

[4] *This section adapted from the Muhlfeld (2003).*

production of Columbia River redband trout. Mean reach densities ranged from 0.01-0.10 fish/m2. During the fall and winter period, adult Columbia River redband trout occupied small home ranges and found suitable overwintering habitat in deep pools with extensive amounts of cover in headwater streams. In Basin Creek, adult Columbia River redband trout began spawning (e.g., redd construction) during June as spring flows subsided following peak runoff. Columbia River redband trout generally selected redd sites in shallow pool tail-out areas (mean depth = 0.27 m; range: 0.20-0.46) with moderate water velocities (mean velocity = 0.50 m/s; range: 0.23-0.69 m/s) dominated by gravel substrate.

LINKS

For more detailed results of the QHA assessment, including attribute scores and HUC rankings, see Appendices 32 and 33.

Click Here

Environment s Ability to Provide Key Ecological Correlates

As part of our assessment, the Kootenai Subbasin (MT, ID, and B.C.) Technical Teams[5] evaluated all the sixth code HUCs and selected lakes in the Montana, Idaho, and Canadian[6] portions of the subbasin on the basis of eleven stream habitat attributes (Parkin and McConnaha 2003) and thirteen lake habitat attributes considered key to resident salmonids. This was done utilizing a spreadsheet tool developed by Mobrand Biometrics called Qualitative Habitat Assessment (QHA). Mobrand Biometrics and Dr. Paul Anders developed the lacustrine or lake version of QHA, called LQHA. The habitat attributes used in the stream version of QHA are generally thought to be the main habitat drivers of resident salmonid production and sustainability in streams (Parkin and McConnaha 2003) (table 4.40). Those used in LQHA are the ones considered by our Technical Team to be the main habitat drivers in lakes in the subbasin (table 4.41). For each 6th Code HUC, the Technical Team used quantitative data (when it existed) and professional knowledge and judgement to score each of the attributes for each HUC. We did the same for selected lakes (table 4.42).

Table 4.43 provides a ranking of stream habitat-attributes for Columbia River redband trout averaged across the regulated mainstem HUCs in the U.S. portion of the subbasin. Tables 4.44 and 4.45 show the rankings for stream habitat-attributes for Columbia River redband trout averaged across all tributary 6th-code HUCs in the U.S. and B.C. portions of the subbasin, respectively. Tables

[5] The Technical Team included fisheries biologists and hydrologists from the KTOI, MFWP, IDFG, IDEQ, USACE, USFWS, the IPNF, KNF, two provincial Canadian ministries, and a consulting firm.

[6] In the U.S. portion of the subbasin, some valley HUCs were lumped. In the Canadian portions of the subbasin, time limitations prevented the use of 6th-code HUCs. Instead, the Canadian members of the team used analogous watersheds developed during a previous watershed restoration planning exercise in B.C.

Table 4.40. Habitat attributes used in the QHA analysis of 6th code HUCs.

Attribute	Brief Definition
Riparian Condition	Condition of the stream-side vegetation, land form and subsurface water flow.
Channel Stability	The condition of the channel in regard to bed scour and artificial confinement. Measures how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types.
Habitat diversity	Diversity and complexity of the channel including amount of large woody debris (LWD) and multiple channels
Fine Sediment	Amount of fine sediment within the stream, especially in spawning riffles
High Flow	Frequency and amount of high flow events.
Low Flow	Frequency and amount of low flow events.
Oxygen	Dissolved oxygen in water column and stream substrate
High Temperature	Duration and amount of high summer water temperature that can be limiting to fish survival
Low Temperature	Duration and amount of low winter temperatures that can be limiting to fish survival
Pollutants	Introduction of toxic (acute and chronic) substances into the stream
Obstructions	Barriers to fish passage

Table 4.41. Habitat attributes used in the Kootenai Subbasin Lacustrine QHA analysis of selected lakes with definitions.

Attribute	Brief Definition
Temperature	Duration and amount of high or low water temperatures that can be limiting to fish survival
Dissolved Oxygen	Dissolved oxygen in water column and stream substrate
Gas Saturation	Percent water is saturated (<100%) or super-saturated (>100%) with Nitrogen gas
Volumetric Turnover Rates	Time required to replace entire reservoir with new water based on rate of its downstream expulsion
Pollutants	Introduction of toxic (acute and chronic) substances into the lake or reservoir
Trophic Status	Level (status) of biological productivity in lake or reservoir
Entrainment	Downstream fish loss through a hydropower dam, other than through a spillway of fish ladder
Migratory Obstacles	Natural and artificial barriers to upstream and/or downstream fish migration
Macrophytes	Emergent and submergent aquatic plant species and community structure in lakes and reservoirs
Hydraulic Regime	Temporal and volumetric characteristics of hydrograph
Shoreline Condition	Physical condition of water-land interface, riparian and varial zones
Habitat Diversity	Relative degree of habitat heterogeneity
Substrate Condition	Physical condition of substrates

Table 4.42. Lakes assessed in the Kootenai Subbasin using the Lacustrine QHA spreadsheet tool.

Lake	Location
Kootenay Lake	Canada
Moyie Lakes	Canada
Duncan Lake	Canada
Trout Lake	Canada
Koocanusa Reservoir	U.S./Canada
Kilbrennan	U.S.
Loon Lake	U.S.
Bull Lake	U.S.
Sophie Lake	U.S.
Boulder Lake	U.S.
Granite Lake	U.S.
Leigh Lake	U.S.
Therriault Lake	U.S.
McArthur Lake	U.S.

Table 4.43. Ranking of key habitat attributes for the regulated mainstem in the U.S. portion of the Kootenai Subbasin for Columbia River redband trout based on a QHA analysis.

Habitat Attribute	Score	Rank
Oxygen	0.00	1
Obstructions	0.16	2
Pollutants	0.17	3
Habitat Diversity	0.26	4
High Temperature	0.33	5
Channel stability	0.38	6
Fine sediment	0.40	7
Low Temperature	0.45	8
High Flow	0.51	9
Riparian Condition	0.64	10
Low Flow	0.86	11

Table 4.44. Ranking of key habitat attributes for 6th-code HUC tributary watersheds in the U.S. portion of the Kootenai Subbasin for Columbia River redband trout based on a QHA analysis.

Habitat Attribute	Score	Rank
Low Temperature	0.03	1
Oxygen	0.03	1
Obstructions	0.07	2
Pollutants	0.08	3
High Flow	0.21	4
Low Flow	0.25	5
Habitat Diversity	0.28	6
Channel stability	0.40	7
High Temperature	0.41	8
Riparian Condition	0.52	9
Fine sediment	0.52	9

Table 4.45. Ranking of key habitat attributes for 6th-code HUC watersheds in the B.C. portion of the Kootenai Subbasin for Columbia River redband trout.

Habitat Attribute	Score	Rank
Low Temperature	0.00	1
Obstructions	0.00	1
Pollutants	0.01	2
Oxygen	0.01	2
High Temperature	0.02	3
Low Flow	0.04	4
High Flow	0.05	5
Habitat Diversity	0.17	6
Fine sediment	0.20	7
Channel stability	0.21	8
Riparian Condition	0.26	9

Table 4.46. Ranking of key stream-habitat attributes for the regulated mainstem and tributaries at the HUC-4 scale for Columbia River redband trout in the U.S. portion of the subbasin based on a QHA analysis of all 6th-field HUCs. The most limiting attributes are highlighted in yellow.

	Regulated Mainstem		Upper Kootenai		Fisher		Yaak		Lower Kootenai		Moyie	
Habitat Attribute	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Channel stability	0.38	6	0.48	9	0.42	6	0.25	6	0.45	8	0.38	7
Fine sediment	0.40	7	0.16	5	0.89	9	0.39	7	0.42	7	0.33	6
Habitat Diversity	0.26	4	0.32	7	0.33	5	0.13	3	0.31	6	0.29	5
High Flow	0.51	9	0.14	4	0.26	3	0.19	4	0.22	5	0.13	2
High Temperature	0.33	5	0.39	8	0.51	7	0.25	6	0.46	9	0.33	6
Low Flow	0.86	11	0.30	6	0.32	4	0.24	5	0.19	4	0.19	4
Low Temperature	0.45	8	0.05	2	0.00	1	0.00	1	0.09	1	0.00	1
Obstructions	0.16	2	0.06	3	0.05	2	0.03	2	0.11	2	0.15	3
Oxygen	0.00	1	0.00	1	0.00	1	0.00	1	0.13	3	0.00	1
Pollutants	0.17	3	0.00	1	0.00	1	0.00	1	0.22	5	0.29	5
Riparian Condition	0.64	10	0.50	10	0.58	8	0.61	8	0.42	7	0.46	8

4.46 and 4.47 show the ranking by 4th-code HUC for the U.S. and B.C. portions of the subbasin. Table 4.48 ranks habitat attributes for selected subbasin reservoirs and lakes in both Canada and the U.S. The rankings provide a good indication of the subbasin's ability to provide key ecological correlates required for Columbia River redband trout viability and persistence and the habitat attributes that may be the most limiting for Columbia River redband trout in the subbasin.

Based on this analysis, of the eleven stream habitat attributes considered key to resident salmonids, the most degraded for Columbia River redband trout in tributaries in the U.S. portion of the subbasin (when averaged across all the

Table 4.47. Ranking of key stream-habitat attributes at the HUC-4 scale for Columbia River redband trout in the B.C. portion of the subbasin based on a QHA analysis of all 6th-field HUCs.

	Duncan Lake		Kootenay Lake		Kootenay River		Slocan	
Habitat Attribute	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**
Channel stability	0.22	6	0.20	7	0.14	3	0.25	8
Fine sediment	0.17	4	0.20	7	0.14	3	0.32	9
Habitat Diversity	0.14	3	0.18	6	0.10	2	0.22	7
High Flow	0.01	2	0.09	5	0.00	1	0.08	6
High Temperature	0.00	1	0.00	1	0.00	1	0.08	6
Low Flow	0.00	1	0.08	4	0.00	1	0.05	5
Low Temperature	0.00	1	0.00	1	0.00	1	0.00	1
Obstructions	0.00	1	0.00	1	0.00	1	0.01	2
Oxygen	0.00	1	0.03	3	0.00	1	0.02	3
Pollutants	0.00	1	0.01	2	0.00	1	0.03	4
Riparian Condition	0.20	5	0.30	8	0.14	3	0.34	10

Table 4.48. Ranking of habitat attributes for selected lakes and reservoirs for Columbia River redband trout based on a LQHA analysis. Note lake scores are much lower than reservoir scores.

Reservoirs	**Score**	**Rank**
Gas saturation	0.00	1
Macrophytes	0.04	2
Habitat diversity	0.07	3
Pollutants	0.08	4
Entrainment	0.17	5
Oxygen	0.19	6
Trophic status	0.21	7
Substrate condition	0.24	8
Volumetric turnover rates	0.26	9
Temperature	0.27	10
Shoreline condition	0.28	11
Migratory obstruction	0.37	12
Hydraulic regime	0.46	13
Lakes	**Score**	**Rank**
Oxygen	0.00	1
Gas saturation	0.00	1
Volumetric turnover rates	0.00	1
Entrainment	0.00	1
Hydraulic regime	0.00	1
Macrophytes	0.00	1
Habitat diversity	0.01	2
Trophic status	0.01	2
Substrate condition	0.01	2
Pollutants	0.02	3
Temperature	0.02	3
Shoreline condition	0.03	4
Migratory obstruction	0.03	4

tributary HUCs) are fine sediment, riparian condition, altered thermal regime, and channel stability, in that order. In the regulated mainstem they are altered hydrograph, riparian condition, altered thermal regime, and fine sediment. In the B.C. portion of the subbasin they are riparian condition, channel stability, fine sediment, and habitat diversity. The rankings vary at the HUC-4 scale. Of the thirteen lake/reservoir-habitat attributes considered key to resident salmonids, the four most limiting to Columbia River redband trout in reservoirs are hydraulic regime, migratory obstructions, shoreline condition, and temperature. The habitat in lakes is in significantly better condition, and none of the lake habitat attributes scored low enough to be considered limiting.

Long-term Viability of Columbia River redband trout Populations Based on Habitat Availability and Condition

Region I of the US Forest Service lists Columbia River redband trout as a sensitive species. The state rank for Montana is S1, for Idaho S2S3, and for B.C. S4. The S1 rank means the subspecies is critically imperiled because of extreme rarity or because of some factor(s) of its biology making it especially vulnerable to extinction. The S2 rank means the species is considered imperiled because of rarity or because of other factor(s), demonstrably making it very vulnerable to extinction throughout its range. An S3 rank means either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factor(s). The American Fisheries Society has listed Columbia River redband trout as a Class A Species of Special Concern since 1993. A Class A species of special concern is defined as a species or subspecies that has "limited numbers and/or habitats both in Montana and elsewhere in North America and elimination from Montana would be a significant loss to the gene pool of the species or subspecies." Monitoring of at least some populations will be crucial in determining long-term viability.

4.3.6 Columbia River Redband Trout Limiting Factors and Conditions

The NWPCC defines limiting factors as those factors or conditions that have led to the decline of each focal species and/or that currently inhibit populations and ecological processes and functions relative to their potential.

In our assessment of Kootenai Subbasin 6th field HUCs, we concluded the most limiting habitat attributes for Columbia River redband trout in U.S. tributaries are riparian condition, fine sediment, high temperature, and channel stability, in that order. In the mainstem, the most limiting were altered hydrograph

LINKS

Appendix 62 presents the results of a GIS-based fisheries vulnerability analysis conducted by the Cohesive Strategy Team of Region 1 of the USFS.

Click Here

Appendix 63 presents the results of an American Wildlands GIS-based, coarse-scale analysis of the current condition of native aquatic integrity across an Upper Columbia basin (called the Aquatic Integrity Areas (AIA) model). Go also to: http://www.y2y.net/science/aquatic_research.asp#aia

Click Here

Appendix 64 lists the waters in Montana Fish, Wildlife & Park's Region One that have tested positive or have questionable results for fish pathogens. Further queries may be conducted at: http://www.esg.montana.edu/nfhdb/fh1.html.

Click Here

due to Libby Dam, riparian condition, low temperature, and fine sediment. In the B.C. portion of the subbasin the most limiting habitat attributes include riparian condition, channel stability, fine sediment, and habitat diversity. The rankings vary at the HUC-4 scale. Biological limiting factors in U. S. tributaries include non-native species, system productivity, and connectivity between the mainstem and tributaries. Biological limiting factors in the U. S. mainstem include non-native species and system productivity. In lakes the most limiting attributes are hydraulic regime, migratory obstructions, shoreline condition, and temperature. This phase of the HUC assessment considered only habitat factors (factors such as the presence of nonnative species were evaluated in a second phase of the HUC assessment and were not ranked against the habitat attributes in terms of which is most limiting).

Land and water use practices[7], habitat loss, over harvest, hybridization and a geographical restricted range are leading factors contributing to the decline of Columbia River redband trout abundance, distribution and genetic diversity in the Columbia River basin (Williams et al. 1989; Behnke 1992). Habitat degradation has been primarily attributed to poor land management practices, construction of dams and diversions, and floodplain development. Land development activities such as road construction, logging and grazing can alter substrate composition and reduce the frequency and area of pools, which may have very deleterious effects to the abundance and distribution of Columbia River redband trout. Recent concern has arisen that Kootenai River Basin Columbia River redband trout populations are at a high risk of extinction due to hybridization with non-native coastal rainbow trout, habitat fragmentation, and stream habitat degradation (Perkinson 1993; Muhlfeld 1999). Genetic introgression with coastal rainbow trout has been documented in both Idaho and Montana (Sage 1993; Leary 1997; Knudsen et al. 2002; M. Powell, Univ. of Idaho, personal communication). Habitat fragmentation examples include aggraded alluvial fans preventing migration from tributary streams, and culvert barriers preventing upstream migration of adults to spawning habitat (Partridge 1983; Downs 2000; Walters 2002, 2003). Introductions of non-native trout including coastal rainbow trout, brown trout (*Salmo trutta*), and eastern brook trout (*Salvelinus fontinalis*), could lead to competition and species replacement. Stocking non-native fish upstream from geologic barriers and in adjacent drainages poses a threat to the genetic purity and population persistence of isolated populations of Columbia River redband trout.

Libby Dam is responsible for several physical (habitat) and biological changes that together are probable limiting factors for Columbia River redband

[7] *Portions of this paragraph are excerpted from Muhlfeld (2003). See also the section titled Westslope Cutthroat Trout Limiting Factors.*

trout. For example, Koocanusa Reservoir is a nutrient sink, limiting biological productivity downstream of the dam (Woods 1982; Snyder and Minshall 1996). Abundance and diversity of important aquatic invertebrates has declined since construction of Libby Dam (Hauser and Stanford 1997), reducing food abundance for trout. Limited food resources could affect survival of Columbia River redband trout, especially juveniles. The altered hydrograph (e.g., high winter flows, fluctuating daily flows, no flood events) may also have affected Columbia River redband trout through loss of mainstem juvenile habitat and possibly mainstem spawning habitat. Direct affects of other changes due to Libby Dam including the hydrograph and lack of flood events to flush and sort substrates are difficult to measure due to the lack of pre-Libby Dam data, but aquatic ecosystems are not resistant to changes of this magnitude.

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4.4 Kokanee *(Onchorynchus nerka)*

4.4.1 Background

Reasons for Selection as Focal Species

We selected kokanee salmon (*Onchorynchus nerka*) as a focal species in the Kootenai River Subbasin because they represent the biological engines for most large lake and river systems in the Pacific Northwest, including those in the Kootenai Subbasin. In these systems, piscivores such as rainbow trout, bull trout, burbot, lake trout, sturgeon and lesser-known species are highly dependent on kokanee as forage; hence the reference to kokanee as biological engines. Kokanee also nourish small freshwater streams with their carcasses after spawning, providing an adfluvial nutrient pump effect, analogous to the important marine nutrient pump in functional anadromous salmon ecosystems.

Native kokanee in the Kootenai Basin are found downstream from Kootenai Falls in Montana. All populations upstream from Libby Dam, in Lake Koocanusa and elsewhere were introduced, and are not considered native. Much of the former lower Kootenai River fish assemblage was historically oriented toward kokanee as forage. This would certainly be the case for adfluvial rainbow trout, bull trout, sturgeon and burbot that occupied Kootenay Lake. It is most likely that Kootenai burbot and sturgeon also targeted on spawning kokanee when they migrated into tributary streams in the Kootenai Basin. Fraser River sturgeon are known to follow and forage on sockeye salmon runs that migrate upriver during August and September (M. Rosenau, U.B.C. Research Biologist, Vancouver, B.C., pers. comm.). In an analogous fashion, white sturgeon in Kootenay Lake appear to move to the mouth of the Lardeau River to prey on staging kokanee prior to their upriver spawning migration. Loss of these spawning migrations as a potential food source could unquestionably impact these two species. Furthermore, kokanee were an important component of the diet of Native Americans and First Nations peoples in the U.S. and Canada. This traditional food source remains culturally important to the Kootenai Tribe of Idaho and the Lower Kootenay First Nation Bands in southeastern British Columbia.

Summary of Population Data

From a Subbasin perspective, most kokanee populations appear relatively stable and abundant, bearing in mind that the impacts of the Duncan and Libby dams were never fully assessed. Therefore pre-dam population levels are unknown. Abundance is a relative term, with today's observations of abundance most likely

LINKS

For kokanee information in the Kootenai in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information (including reports pertaining to kokanee) for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

For the B.C. Fisheries Inventory Data Queries site, go to: http://srmapps.gov.bc.ca/apps/fidq/

Click Here

For the Conservation Data Centre for B.C., go to: http://srmwww.gov.bc.ca/cdc/

Click Here

considered sparse by previous generations of Native Americans and early Europeans. There are currently six populations of kokanee in the Kootenai River Subbasin in Idaho, Montana, and British Columbia:

1) Trout Lake
2) Duncan Reservoir
3) Kootenay Lake main lake,
4) West Arm of Kootenay Lake
5) Moyie Lake
6) Koocanusa Reservoir

LINKS

For various kokanee reports from the B.C. Ministry of Water, Land, and Air Protection, go to Appendix 113.

Click Here

In addition to the above water bodies, Bull, Crystal, Glen, Dikey, and Spar Lakes, among others hold kokanee. All these lakes, the Kootenai River, and their tributaries support kokanee populations, although the Koocanusa population and most likely the Moyie Lake population are naturalized as a result of earlier introductions (Appendix 88). In addition to the above six kokanee populations, a native South Arm (Kootenay Lake) kokanee stock historically reared in the lake's South Arm, and ascended upstream Kootenai River tributaries to spawn in B.C. and Idaho. However, this stock is thought to have been extirpated (Ashley and Thompson 1994).

Trout Lake even today remains relatively pristine, although impacts of turn of the century mining and logging were never assessed. Regardless, there are no historical data and very little current data on kokanee numbers. This lake is oligotrophic and the primary spawning stream (Wilkie Creek) usually supports from 5 to 12,000 spawners. Based on a biostandard (5.6 kg•ha•yr) used to calculate theoretical kokanee yield (Anon 1987) in large lakes of B.C. suggests this lake could produce about 16,000 spawners per year.

Duncan (alias Howser) Lake was known to support a natural population of kokanee prior to development of the Duncan Dam (Peterson and Withler 1965). The dam now isolates the reservoir population from those in Kootenay Lake. No comprehensive assessment has ever been conducted on the impacts of Duncan Dam on the fish populations that inhabited the former Duncan Lake. Therefore, historic kokanee numbers are unknown, and very little is known about present day numbers in Duncan Reservoir. Based on a theoretical yield estimate Duncan Reservoir kokanee spawner numbers unlikely exceed 30,000 with the theoretical yield approximating 40,000 fish.

The North Arm of Kootenay Lake kokanee population has been monitored for over forty years (Andrusak 2002). This population has been estimated as high as 4.1 million (Bull 1964) and as low as 200,000 (Andrusak 2003). Currently the population is rebuilding after nutrient enhancement started in the early 1990s. A reduction in fertilizer loading from 1997-2000 resulted in a decline of kokanee from over one million to less than 500,000 (figures 4.4 and 4.5). It is expected that this population will recover during the next four-year cycle to escapement levels of between 1-1.5 million.

Kokanee populations in the West Arm of Kootenay Lake have been well documented in numerous publications. Redfish Consulting, Ltd. (2002) analyzed the upper West Arm kokanee population data available from 1972-2002. Escapement estimates during that time ranged from about 2,000 to nearly 40,000. This population supported the largest kokanee sport fishery in the province in the 1970s but the decline in lake productivity commencing in the early 1980s has reduced this population to less than 10,000 today, compared to over 50,000 in the 1970s (Andrusak 1987). This decline is almost certainly due to nutrient changes in the lake since two spawning channels are now required simply to sustain this population. There has been no measurable positive impact to this population as a result of fertilization of the North Arm. The population size today varies from 10,000 to 30,000 adults, depending on whether or not a fishery is permitted.

Smaller numbers of kokanee spawn in several West Arm tributaries, based on size appear to be distinct from the upper West Arm population. Upper West Arm kokanee are much larger. Escapements to local streams in the lower West Arm have been periodically monitored with only a few hundred to one thousand spawners observed annually.

The South Arm population is virtually nonexistent in the 2000s. Ashley and Thompson (1994) reported that the South Arm kokanee stock as likely functionally extinct by the early 1990s. Andrusak et al. (2004) summarized the limited historic escapement data available. They believe the total numbers even prior to hydro-development impacts likely did not exceed 200,000. In 2003 the total escapement to all streams was < 1,000 spawners.

The virtual absence of South Arm kokanee in Kootenai River tributaries and the South Arm of Kootenay Lake is troublesome considering the positive response of North Arm spawners to lake fertilization (Andrusak 2003). It is suspected that the South Arm kokanee have been driven to near extinction due to comparatively lower stream egg-to-fry survival rates (hence small numbers of fry) combined with competition for food with massive numbers of fry being produced by North Arm kokanee. Further, suspected large numbers of displaced kokanee from the Koocanusa Reservoir rearing in Kootenay Lake could also serve as competitors for the weaker South Arm stock. The total number of kokanee rearing in Kootenay Lake is likely near capacity (40 million in 2003), therefore the South Arm stock as reflected in escapements is unlikely to respond unless some management intervention is undertaken.

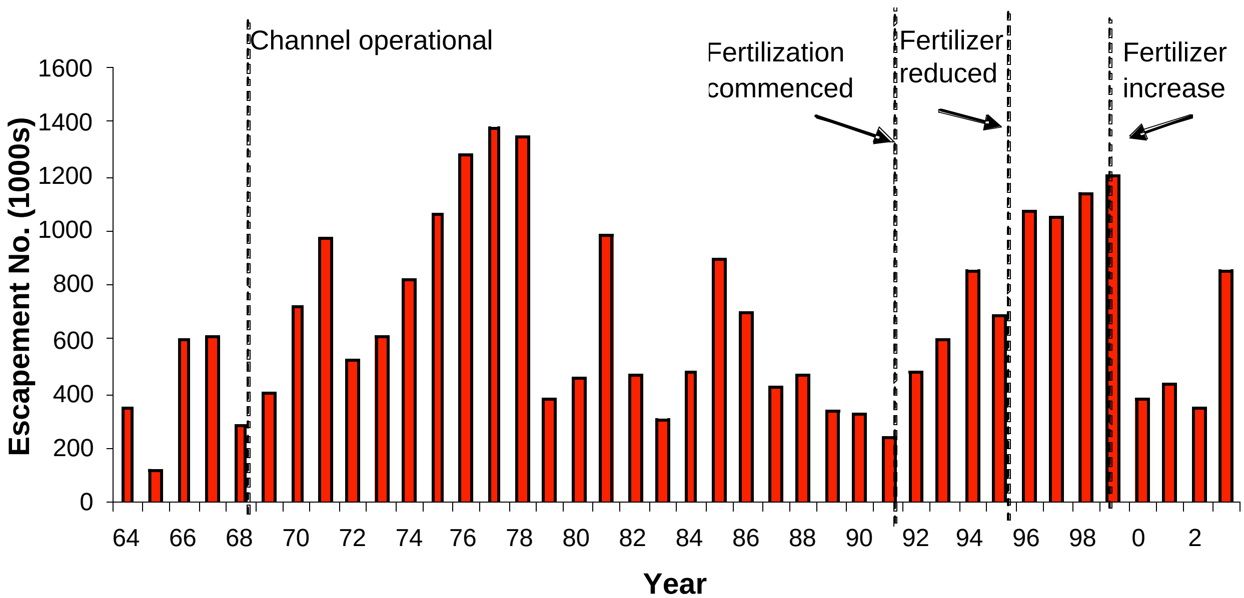

Figure 4.4. Kokanee escapement to Meadow Creek 1964-2003. Vertical dotted lines indicate commencement of Meadow creek spawning channel (1967), commencement of fertilization (1992), reduction in fertilizer (1997-2000) and full fertilizer loading (2001).

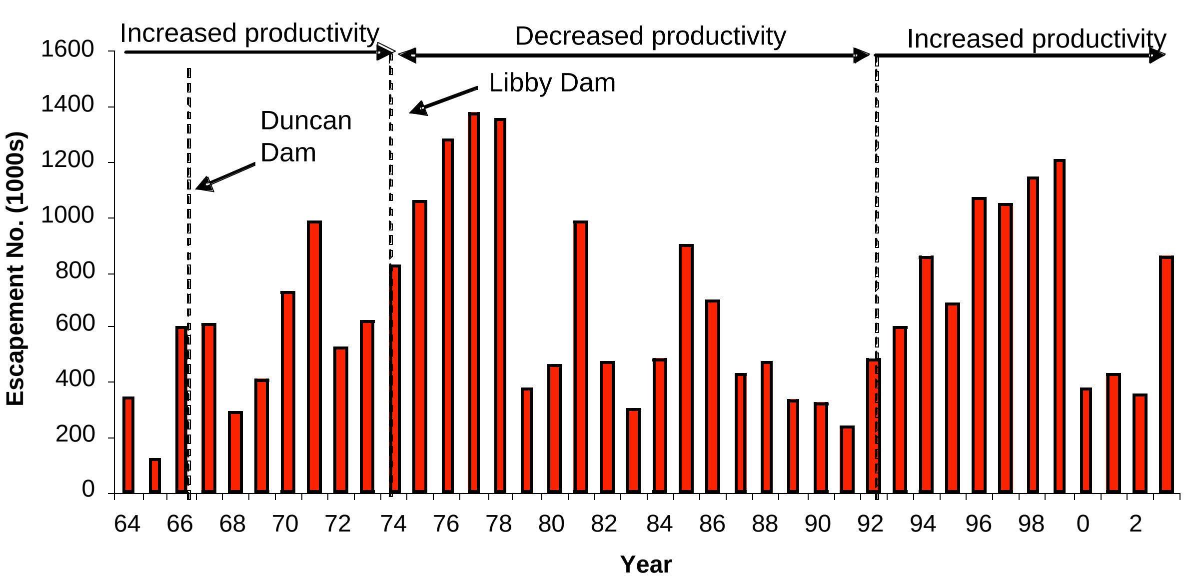

Figure 4.5. Kokanee escapement to Meadow Creek 1964-2003. Vertical dotted lines indicate major changes in lake productivity due to: a) fertilizer plant in operation in 1950s and 1960s; b) reduction in lake productivity due to elimination of fertilizerfrom upstream plant and c) Increased lake productivity due to lake fertilization. Note: decrease in escapements 2000-2002 believed due to reduction in fertilizer loading.

Little is known of the origin of Moyie Lake kokanee, although historical stocking (Appendix 88) dates back to the 1940s, possibly suggesting that none were present prior to this time. A major fish barrier exists on the lower Moyie River in Idaho preventing any Kootenay Lake kokanee from migrating up the river to Moyie Lake. Moyie Lake is ultra oligotrophic so it is not surprising that some informal assessments (periodic counts) of spawner numbers places escapement estimates at < 5,000, most of which can be found in Lamb and Cotton Creeks. Moyie Lakes have been stocked since 2000 with approximately 90,000 kokanee fry annually. Mysids are also present in Moyie Lake.

Koocanusa Reservoir was fully formed by 1974. Due to accidental introduction from British Columbia's Wardner Hatchery via discharge into Norbury Creek, and Kootenay River, kokanee initially entered the reservoir as early as 1973 (file note, B.C. Fisheries Nelson, B.C.). Additional releases probably occurred until 1979 when kokanee no longer were reared in this hatchery. The reservoir population rapidly expanded and kokanee spawners were initially observed in Norbury Creek in the early 1980s. This population continues to expand and by 2002 a cumulative peak count of 450,000 spawners was made for eleven index streams tributary to the upper Kootenay River (Westover 2003).

Quantitative population abundance and escapement data are lacking for kokanee in Montana waters of the Kootenai Subbasin. However, kokanee exist in Koocanusa reservoir, which largely reproduce upstream in Canadian waters of the Subbasin. Alternatively, entrainment studies at Libby Dam revealed that approximately 98 percent of all entrained fish sampled in the draft tubes were kokanee, primarily age-0 fish, with a few age-1 fish. The dynamics of water temperatures and shallow water withdrawals (25-50 from surface) from Libby Dam exacerbates kokanee entrainment. As surface waters in the reservoir warm in the spring, they attract kokanee. Along with freshet plumes of turbid water, which pushs fish downstream to the dam ahead of the turbid water avoided by the fish, these two elements increase probability and magnitude of kokanee entrainment at Libby Dam (B. Marotz, FWP, personal communication).

Marotz (FWP, personal communication) also suggested that survival of these entrained fish may be as high as 70 percent. After entraining, some fish appear to stay in the tail waters areas, where zooplankton are suitable, available forage. Following entrainment, kokanee can either stay in Montana waters from Kootenai Falls to the dam, below the falls, or they can migrate downstream to rear in Kootenay Lake. Quantification of these habitat use patterns has not occurred with much accuracy due to limited empirical data, and high associated variability of existing data. Kokanee that mature following entrainment upstream from Kootenai Falls converge in the Libby Dam tailrace, which blocks their upstream migration tendencies; fish that have reared downstream from Kootenai Falls converge on the falls following upstream spawning migrations. During some years, snag fisheries produced kokanee harvests ranging from thousands to tens of thousands of fish, depending on production and entrainment rates of previous years.

It is unclear how many entrained kokanee from Koocanusa Reservoir migrate downstream to Kootenay Lake. However, it is thought that considerable numbers may be showing up in hydroacoustic surveys in the lake's South Arm (Ken Ashley, B.C. MWLAP, pers. comm.). Genetic analysis is planned to separate origins of fish from catches in the South Arm during nonreproductive seasons to help address this uncertainty.

Native kokanee salmon runs in lower Kootenai River tributaries in Idaho have experienced dramatic population declines during the past several decades (Ashley and Thompson 1993; Partridge 1983). The kokanee that historically spawned in these tributaries inhabited the South Arm of Kootenay Lake in British Columbia. Native kokanee are considered an important prey item for white sturgeon and also provided an important fishery in the tributaries of the lower Kootenai River (Partridge 1983; Hammond, J., B.C. MELP, per. comm. 2000). Kokanee runs into North Idaho tributaries of the Kootenai River that numbered into the thousands of fish as recently as the early 1980s have now become "functionally extinct" (Anders 1993; KTOI, unpublished data). Since 1996, visual observations and redd counts in five tributaries found no spawners returning to Trout, Smith, and Parker Creeks, while Long Canyon and Boundary Creeks had very few kokanee returns.

Historic Distribution

Region-wide

Kokanee are the non-anadromous or land locked form of sockeye salmon that are found in the large lake systems throughout the entire Columbia River Basin (McPhail and Carveth 1992). In British Columbia they are indigenous in all drainages except the Peace River drainage. They overlap the distribution of sockeye salmon in British Columbia, but are also found in lakes that are now cut off to sockeye as a result of human interventions, the best example being the upper Columbia River system. Morphologically, kokanee and sockeye are identical and are considered to be the same species (*Onchorynchus nerka*).

Kokanee are found in the North Pacific region generally distributed between 40 °N and 61 °N from Japan northward on the Asian Coast through the Bering Sea westward along Alaska and southward to just below the Columbia River (Smith et al. 1987). They commonly overlap the distribution of sockeye salmon but twentieth century transplants now have them found as normalized viable populations outside their natural range in the Columbia and Fraser River basins, e.g., the Peace and Colorado River basins. Stock status has been investigated in most states and provinces with some of the best assessments conducted on Pend Oreille Lake (Reiman and Bowler 1980; Reiman and Meyers 1992), Okanagan Lake (Andrusak et al. 2003) and Kootenay Lake (Thompson 1999; Andrusak 2003). Indigenous kokanee populations tend to be found exclusively in the large lake systems of the Columbia and Fraser River systems. However, numerous populations exist in smaller lake systems in Alaska that are accessible to the Pacific Ocean.

Kootenai River Basin

Historically kokanee in the Kootenay Subbasin have been isolated for at least 10,000 years due to a natural barrier located on the lower Kootenay River at Bonnington Falls approximately 20 km upstream from the confluence with the Columbia River (Northcote 1973). Discrete natural populations are currently found in Trout, and Kootenay lakes, and Duncan reservoir, whereas the Moyie and Koocanusa reservoir kokanee populations are naturalized from hatchery introductions.

The Duncan Dam, completed in 1967, isolated Kootenay Lake kokanee from those inhabiting the Duncan Reservoir. A major waterfall on the lower Moyie River in Northern Idaho prevents fish movement to Moyie Lake. Kootenai Falls in Montana serves as a barrier to all upstream movement of kokanee. However, kokanee introductions into the Koocanusa (Libby) Reservoir in the 1970s have resulted in an extension of their distribution to the very upper reaches of the Upper Kootenay River and tributaries.

Some of the earliest kokanee research in British Columbia was actually conducted by the federal government while assessing sockeye salmon stocks in several Fraser River nursery systems. Ironically kokanee data were collected on some lakes such as Quesnel, Shuswap and Adams in the 1940s and 1950s, due to concern by salmon biologists who considered kokanee to be a competitor with sockeye. Several investigations were conducted by the International Pacific Salmon Commission (IPSC) to determine the extent of the "kokanee problem." One report written on Quesnel Lake entitled "An Outline of the Kokanee Problem" (Idyll 1944) discussed the possible origin of kokanee with mention of how kokanee may impact sockeye numbers through interspecific competition. Several other IPSC reports in the 1940s and 1950s expressed interest and concern about kokanee and their impact on sockeye. Goodman (1958) summarized the 1950s work on Quesnel, Shuswap, and other important interior sockeye nursery lakes and concluded that kokanee and sockeye seldom compete for spawning sites and that there was no correlation between kokanee abundance and sockeye cyclical dominance at least in Quesnel Lake (a theory pursued by the IPSC for a number of years during the 1950s).

Following this early work of the Federal sockeye biologists, the province began to show some interest in kokanee. The first major study was conducted on Kootenay Lake by Vernon (1954, 1957), who provided an excellent account of the biology of kokanee in Kootenay Lake. His work demonstrated that there were three stocks of kokanee within the lake that were morphologically distinct. Size, growth and age at maturity were distinguishing features between the three stocks. Bull (1964) conducted the initial estimates of kokanee spawner abundance in the Lardeau-Duncan River system in 1964, in an effort to determine impacts of the Duncan Dam. His estimate through mark (tagging) and recapture was placed at just over 4.1 million (Lardeau River 1.4 million, Duncan River 2.7 million) with an additional 0.35 million in Meadow Creek. Acara (1970 Unpublished MS) estimated that the Lardeau-Duncan River system escapements ranged from 0.6 to 1.3 million between 1965-1968. It should be noted that at that time Kootenay Lake was undergoing cultural eutrophication due to huge discharges of phosphorous from an unregulated fertilizer plant located upstream on the St. Mary's River, a tributary to the upper Kootenay River (Northcote 1973; Daley et al. 1981). In other words, the lake was at historically and artificially high levels of productivity.

Current Distribution

Within the Kootenai Subbasin kokanee populations are generally abundant and flourishing, although much of this is due to significant management intervention in the form of spawning channels and lake fertilization. The one exception to this generally healthy status is the kokanee population that inhabits the south end of Kootenay Lake and spawns in South Arm tributary streams, including a number of streams in Northern Idaho. These kokanee are in serious decline, on the edge of extinction, or functionally extinct.

Current escapement estimates to Trout and Moyie Lake streams, and Duncan Reservoir are unavailable. Escapement levels to these three systems are unlikely to exceed 40,000 (Duncan Reservoir), 16,000 (Trout Lake) or 5,000 (Moyie Lake).

Kokanee populations can vary considerably within one or two cycles, and they can be highly variable from one year to the next. Hydroacoustic estimates on Kootenay, Arrow and Okanagan lakes show that numbers as low as 50 fish/hectare and as high as 1500/ha (all age groups) are possible. By way of comparison, values up to 7000/ha have been recorded in Quesnel Lake (Sebastian et al. 2004, draft report) but most of these (≈ 90 percent) were sockeye fry. Kootenay Lake usually ranges from 250-750 fish/ha and of this total about 5-7 percent are usually adult size fish. Good population estimates have been made for Kootenay, Okanagan, Shuswap, and Quesnel Lakes and Arrow Lakes Reservoir (Wright et al. 2003; Andrusak et al. 2003; Sebastian et al. 2000; Redfish Consulting Ltd. 2003; Sebastian et al. 2004, draft report). Total lake population numbers (all age groups) vary from Quesnel Lake (3-4 million), Okanagan (5-10 million), Arrow lakes Reservoir (12-20 million) and Kootenay Lake (25-40 million). However, in Kootenay Lake and Arrow Lakes Reservoir, these numbers are currently being supported by ongoing fertilization operations.

Annual escapements for these lakes range between 0.5 million and 1.5 million. The current estimates for Kootenay Lake (main lake) range from 0.5 - 1.2 million spawners with over 99 percent of these found in the North Arm tributaries and very few in the South Arm streams. The North Arm population is rapidly expanding as a result of increased lake fertilization loading commencing in 2001. Further discussion on this work is described below. Currently the total escapements to South Arm tributary streams including those in Northern Idaho are < 1000 fish.

The most studied kokanee populations in British Columbia are those that inhabit Kootenay Lake. For nearly a century Meadow Creek has been the primary kokanee egg collection site for the province of B.C. (Northcote 1973). The Meadow Creek stock has been planted in many systems throughout B.C. including egg and fry plants in streams tributary to the South Arm of Kootenay Lake (Andrusak and Slaney 2004).

During the mid-1960s Meadow Creek was selected as the site for construction of the largest kokanee spawning channel found anywhere in the Pacific Northwest (Redfish Consulting, Ltd. 1999). This channel became operational in 1967 and its production history is discussed in more detail below.

Escapements of kokanee to Meadow Creek have been monitored for nearly a half a century and these estimates provide an excellent graphic of the dramatic changes that have taken place in Kootenay Lake (figures 4.4 and 4.5). During the 1950s and 1960s the lake was at a very high level of productivity and the North Arm escapement levels were high as documented by Bull (1964) and Acara (1970). Meadow Creek numbers were < 350,000 in 1964-1965 but increased thereafter due to Duncan River kokanee displacement. Spawning channel operation began in 1967 and the escapement levels gradually increased over two cycles until the late 1970s when escapements exceeded 1 million. During this same period the fertilizer loading to the lake began to decline with closure of the St. Mary's fertilizer plant, and concurrent pollution abatement activities. Coincidentally, Libby dam also became operational, and while there were concerns

LINKS

QHA spreadsheets contain current and historic kokanee distribution by lifestage for HUC-6 watersheds and selected lakes in the U.S. and B.C. portions of the Kootenai. These data are a compilation put together by the Kootenai Subbasin Aquatic Technical Team. Go to Appendices 32 and 33.

Click Here

about the impact of this dam on Kootenay Lake, the combined impact of reduction in P loadings and nutrient retention in Koocanusa Reservoir were largely unforeseen. Daley et al. (1981) documented the changes that resulted in a significant decline in lake productivity by 1980. Nutrient input to the lake declined below pre-dam conditions and the lake underwent a gradual decline in productivity through the early 1990s and Meadow Creek escapements reflected this decline. Lake fertilization commenced in 1992 and an immediate response was observed in kokanee escapements with numbers again exceeding 1 million by the late 1990s. Reduction in fertilizer loading rates began during 1997 were reflected in a dramatic decline in escapements from 2000-2002. The increased numbers in 2003 reflect increased productivity when fertilization rates were increased to the 1992 level.

Hydroacoustic and trawl surveys have been carried out on the main body of Kootenay Lake since the mid 1980s, providing some excellent data on whole lake kokanee numbers and population trends. (The following data were provided by D. Sebastian B.C. Fisheries population biologist Victoria B.C.). The lake supported less than 10 million kokanee through most of the 1980s and early 1990s (figures 4.6 and 4.7). Such low abundance was the reason lake fertilization was initiated in 1992. An initial response to fertilization was evident by 1994 when total numbers shot up over 35 million and ranged between 25-35 million until the amount of fertilizer was reduced in 1997 (figure 4.8). A decreasing trend was evident through 2000 when the estimate was only 11.6 million. The fertilizer loading rate was increased in 2000 and by 2002 and 2003 the numbers were again in excess of 35 million.

Distribution of kokanee within the main lake basin is of particular interest. Despite fertilization only taking place in the upper North Arm, the kokanee are

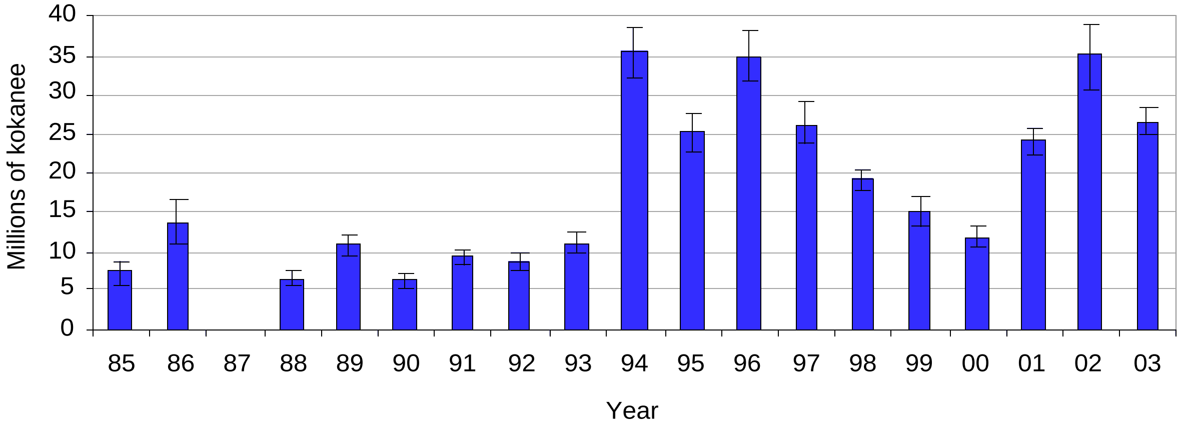

Figure 4.6. Hydroacoustic estimates of total numbers of kokanee in Kootenay Lake.

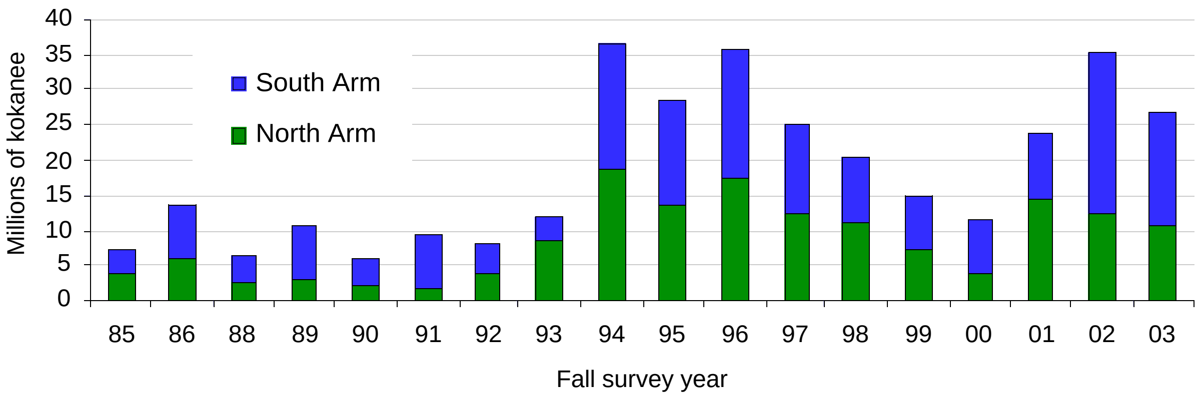

Figure 4.7. Hydroacoustic estimates of total kokanee numbers in the North vs. South Arms.

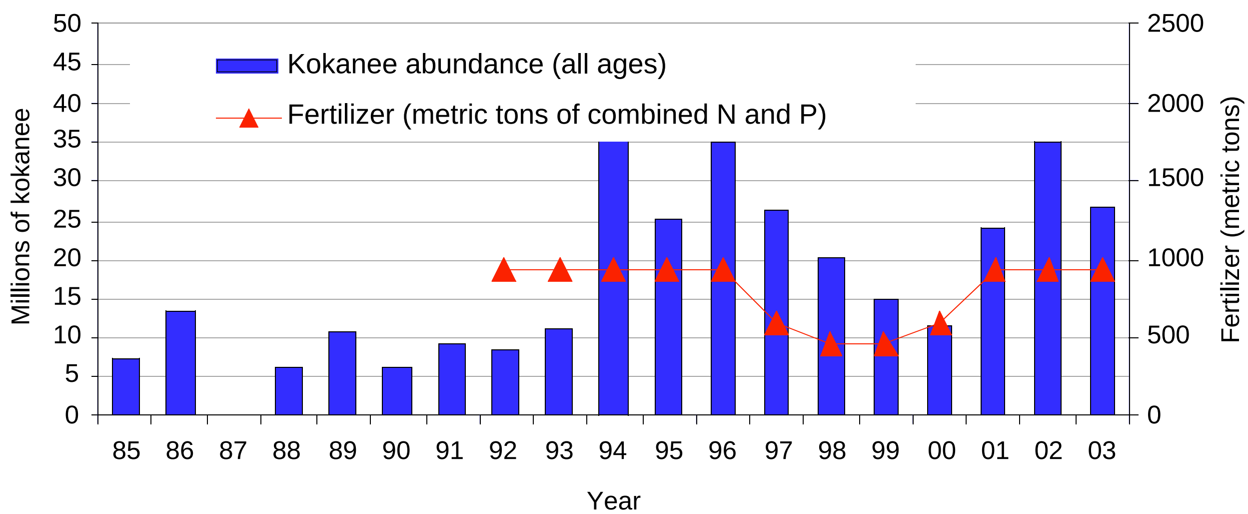

Figure 4.8. Hydroacosutic estimates of kokanee abundance in Kootenay Lake and amount of fertilizer added since 1992.

fairly evenly distributed throughout the lake (figure 4.7) In fact, the 2002 data indicated that more kokanee were in the South Arm. There is some speculation that in some years a good proportion of the kokanee in the South Arm may be displaced Koocanusa Reservoir kokanee. At the time of this writing, the 2003 data had not been completely analyzed but there is some thought that the 40 million estimate may reflect lake carrying capacity. Genetic analysis (microsatellites) is planned to further assess kokanee stock (origin) composition in Kootenay Lake.

West Arm kokanee were larger than North or South Arm kokanee prior to mysid introduction or lake fertilization as evidenced in Vernon's data (Vernon 1957). Mysids were introduced into the lake in 1949 but were not discovered until 1961 (Sparrow et al. 1961), whereas the fertilizer plant began operation in 1953 (Northcote 1973). It is unlikely that the lake was fully populated with mysids by 1952 when Vernon collected his spawner samples. Northcote (1973) also shows some kokanee data from 1949-1950 where the size of West Arm kokanee is greater than those sampled in other parts of the lake. What is clear is that West Arm kokanee were the primary beneficiary of the mysid introduction (Northcote 1973) largely due to the unique flow features of the West Arm. Mysids in the vicinity of the outlet move to the surface at night where they are caught up in the current and displaced over the sill where they are highly vulnerable to kokanee predation (Thurber Consultants 1981). North and South Arm kokanee did not respond with much increased growth as a result of the mysid introduction (Northcote 1973). Martin and Northcote (1991) attributed the significant increase in size of West Arm kokanee during the 1970s and 1980s to the availability of mysids at the lakes' outlet.

The escapement pattern for upper West Arm kokanee (figure 4.9) is similar but does not completely match that of North Arm kokanee, primarily because the West Arm stock has been greatly influenced by harvest levels. Certainly in the 1960s and early 1970s the West Arm stock was quite abundant as was the North Arm stock, but this is not reflected in escapements due to the intensive sport fishery that annually harvested between 30,000-100,000 fish from 1968-1978 (Andrusak 1987). The decline during the 1980s is similar for both stocks but the West Arm stock did recover in the late 1980s and early 1990s as a result of the fishery being closed and enormous fry production from two spawning channels built in the mid 1980s. Trend in escapements to Meadow Creek show increases during the period of fertilization, whereas there has been no increase by West Arm kokanee (figure 4.10). Fry-to-adult survival rates for North Arm kokanee initially increased substantially to an average of 6 percent at the onset of fertilization but have declined to just over 2 percent with the lake at capacity (Andrusak 2002). On the other hand West Arm fry-to-adult survival rates have remained low (average 1.7 percent), just sufficient for any allowable harvest (Andrusak 2002).

As mentioned, the Upper West Arm kokanee population at one time supported British Columbia's most productive, inland sport fishery with an annual catch exceeding 100,000 and sizes up to 4 kg (Andrusak 1981; Andrusak and Brown 1987). The resort industry at Balfour rapidly expanded in response to this fishery and overcrowding at the resorts and on the West Arm was a common sight. This fishery was very intensive but not sustainable, with overfishing evident

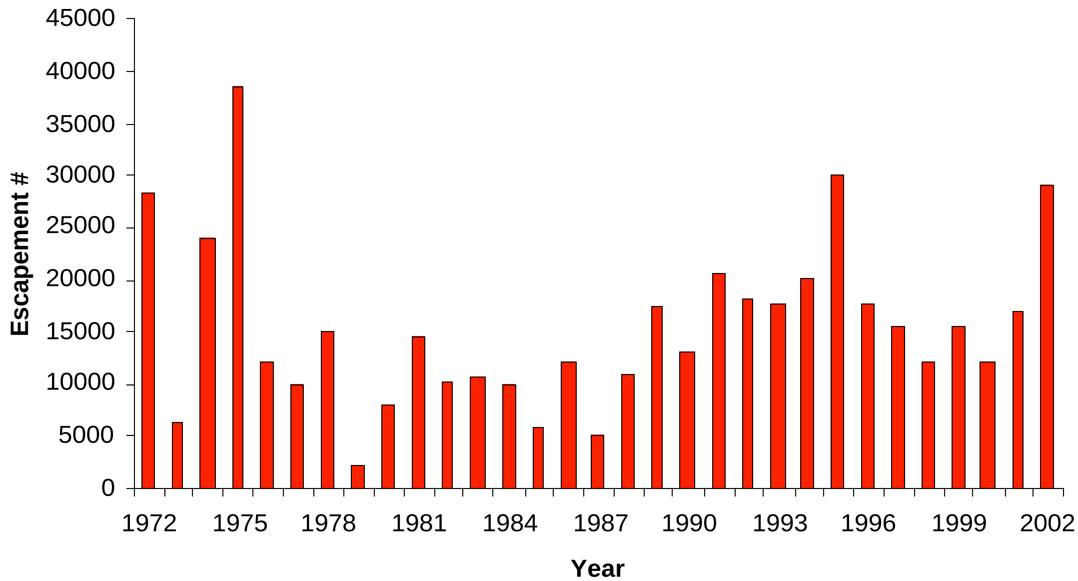

Figure 4.9. Total escapement numbers for the three major kokanee spawning streams in the Upper West Arm of Kootenay Lake, 1972-2002.

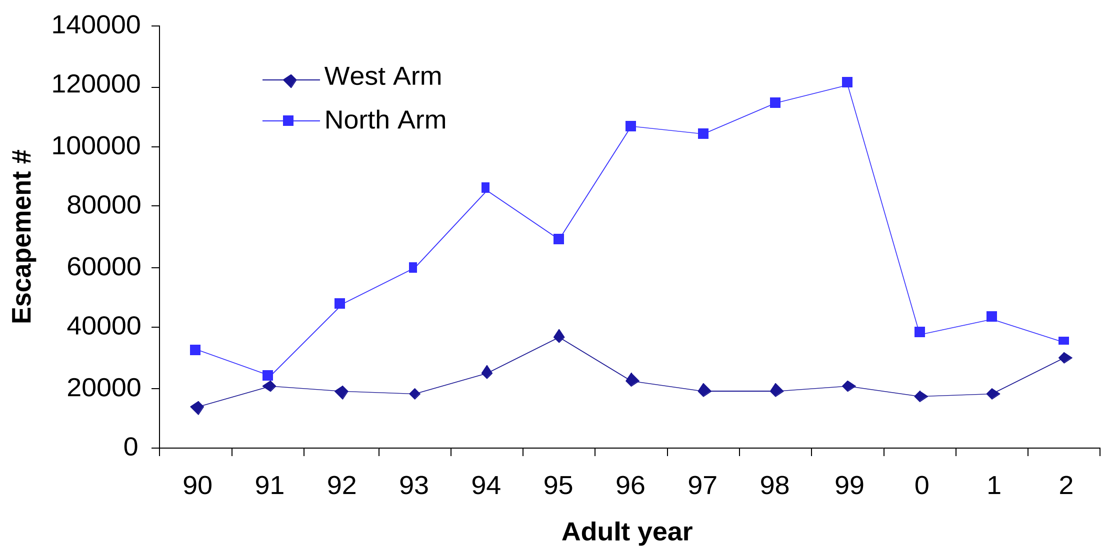

Figure 4.10. North Arm kokanee escapements compared to the West Arm escapements for the last four cycles that have grown in the lake during lake fertilization. Note: for purposes of comparison North Arm numbers were scaled down to 10% and the West Arm numbers include harvest estimates.

by the end of the 1970s (Andrusak 1981). In the 1980s, this fishery collapsed and the tourist industry underwent a dramatic change, resulting in most resorts closing. Today the fishery is largely enjoyed by local residents who comprise 95 percent of all anglers compared to only 50 percent in the 1970s (Redfish Consulting, Ltd. 2002). The obvious decline of nonresident anglers is an economic impact often overlooked.

Decline of West Arm kokanee numbers was initially addressed in the early 1980s by closing the fishery and constructing small spawning channels on the two key spawning streams—Kokanee and Redfish Creeks. The feasibility of rearing West Arm kokanee using net pens was also examined by Perrin and Levy (1990) and a small-scale experimental fertilization of the upper West Arm was also attempted (Perrin 1989). The upper West Arm fertilization experiment and the net pen rearing strategies did not appear to work and they were abandoned (J. Hammond, Fisheries Biologist, Nelson, B.C., pers. comm.).

Low fry-to-adult survival rates in the primary spawning streams combined with high harvest rates in the West Arm kokanee fishery forced a prolonged closure of the fishery from 1980 until 1994 with the exception of short seasonal fisheries in 1983 and 1985. Stock recovery over nearly five cycles was very slow despite excellent fry production from two spawning channels built in the 1980s and virtually no sport catch in nearly 15 years. With stock recovery evident, B.C. Fisheries was confident enough to open a short-term annual fishery commencing in 1994. In April 1994, the West Arm was reopened to kokanee fishing with a harvest quota set at 5,000. The quota for 1995 and 1996 was 8,000 and from 1997 – 2003 it has been 5,000. West Arm kokanee are highly vulnerable to sport fishing and with such a small margin of error it is essential that angler effort and harvest be closely monitored each year.

Presently, the size of the upper West Arm kokanee fishery is only a fraction of what existed in the 1970s. However, the size and high catch rate of these fish in a somewhat unique, riverine habitat make them exceptionally attractive to anglers. The fishery in April 2000 was so popular that the entire quota (~5,000 fish) was reached in 11 days and the fishery had to be closed. Poor fry production from the Kokanee Creek spawning channel in 2000 and poor test fishery results in the spring of 2002 led to the decision by fisheries managers not to open the fishery in 2002, but it was reopened in 2003 with an estimated harvest of nearly 8,000. Regardless of how well the spawning channels perform, this population is driven by in-lake survival rates that are extremely low, declining from rates > 3 percent in the late 1970s to < 1.5 percent in the 1990s and early 2000s (Redfish Consulting, Ltd. 2002).

In retrospect, it is now quite apparent that West Arm in-lake survival limits its kokanee population and there is no evidence to-date that the North

Arm fertilization experiment has had any beneficial effect on the West Arm stock (Redfish Consulting, Ltd. 2002).

South Arm kokanee have not fared as well as North Arm or West Arm kokanee. Andrusak and Slaney (2004) summarized all available kokanee escapement data for South Arm tributaries including five Northern Idaho streams. While the data is sparse, there is an unmistakable trend in what they found. Kokanee numbers were evidently never that large in South Arm streams. However, empirical data indicated that all spawning runs have declined from numbers in the tens of thousands in the 1970s to less than 1,000 in all streams today. Despite North Arm fertilization for over ten years there has been no measurable response by South Arm kokanee. It is arguable that no response could be expected since the runs have virtually disappeared. However, there were enough kokanee counted and spawned in 1996 and 1997 that some increase in recruits should have occurred in 2000 and 2001.

Current kokanee escapement levels to tributaries of the upper Kootenay River from Koocanusa Reservoir are in the order of 150,000-450,000 (figure 4.11). This population is expanding with more and more spawners found in the very upper reaches of the Upper Kootenay River (B. Westover, B.C. Fisheries Biologist, Cranbrook B.C., pers. comm.). The Tobacco and Grave creeks provide the only kokanee spawning habitat in Koocanusa Reservoir tributaries in Montana (Jay DeShazer, MFWP, personal communication), and fish that have entrained through Libby Dam have not colonized tributaries to spawn in Idaho or Montana downstream from Libby Dam.

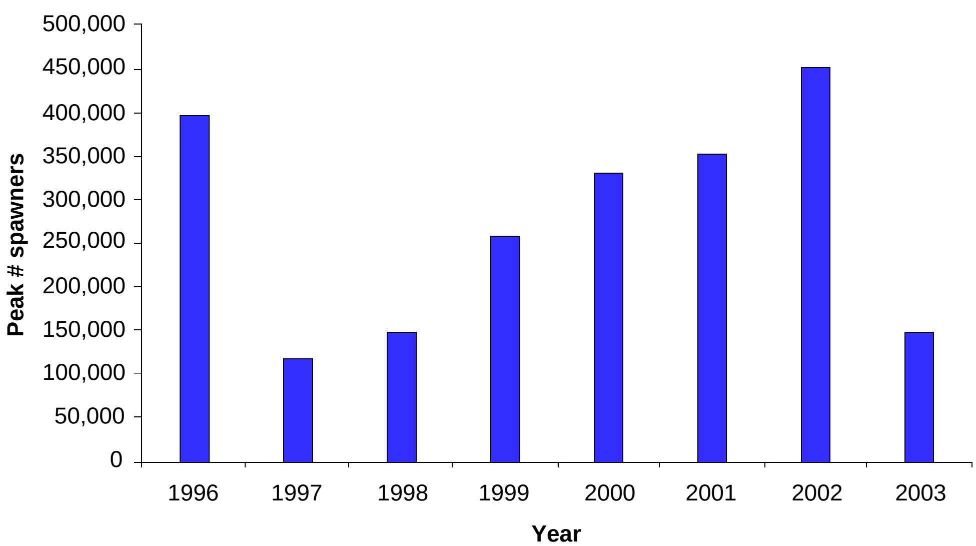

Figure 4.11. Peak number of kokanee spawners in 11 selected tributaries of the upper Kootenay River 1996-2003.

LINKS

For current and historic fish stocking records in Montana, go to: http://www.fwp.state.mt.us/fishing/stock02.asp

Click Here

For Idaho stocking information, go to: http://www2.state.id.us/fishgame/fish/fishstocking/stocking/year.cfm?region=1

Click Here

For the Moyie Lake, B.C. Kokanee stocking history, go to Appendix 88.

Click Here

In summary, kokanee populations within the Kootenai Subbasin are generally abundant and flourishing, although much of this is due to significant management intervention in the form of spawning channels and lake fertilization. The one exception to this generally healthy status is the southern kokanee population that inhabits Kootenay Lake and spawns in South Arm tributary streams, including a number of streams in Northern Idaho. These kokanee are in serious decline and on the edge of extinction.

Status of Kokanee Introductions, Artificial Production and Captive Breeding Programs

Kootenay Lake

Kokanee eggs from Meadow Creek have been the primary source of kokanee transplants throughout the province as well as many systems in Idaho. Slaney and Andrusak (2004) show that kokanee eggs were planted in some North and South Arm tributaries as early as 1929 and particularly during the 1940s. The most recent egg plants into B.C. tributary streams were in 1988 and 1989 (Goat River and Summit Creek). Most recently, the Kootenai Tribe of Idaho obtained Meadow Creek eggs and planted them in Long Canyon, Parker, Myrtle and Trout creeks (table 4.49). Some 15,000 fed fry were released into Parker Creek in 1998. Otherwise, all introductions have been eyed eggs. Unfortunately, eggs were not available from 2000-2002, but 1.5 million were made available during 2003.

Table 4.49. Meadow Creek kokanee egg and fry plants into four Northern Idaho streams 1997-2003 (data provided by the Kootenai Tribe of Idaho).

Year	Long Canyon	Parker	Trout	Myrtle
1997	100,000 EE			
1998	100,000 EE	15,000 Fry 100,000 EE	100,000 EE	
1999	200,000 EE	150,000 EE	150,000 EE	
2003	400,000 EE	400,000 EE	400,000 EE	400,000 EE

EE = Eyed eggs

Koocanusa

Kokanee were accidentally introduced into the Upper Kootenay River via Norbury creek, the receiving waters of Wardner Hatchery flows. It is believed that fry or egg "leakage" from the rearing ponds resulted in viable fish entering the hatchery discharge system as early as 1972 (table 4.50). Returning fish to Norbury Creek were initially evident in the early 1980s.

Table 4.50. Year, egg source and estimated number of mortalities that may have contributed to origin of Koocanusa Reservoir kokanee. (data from P. Brown B.C. Fisheries, Fish Culturist, Wardner Hatchery, Wardner, B.C. pers. comm.).

Brood year	Release year	Source	Mortalities
1971	1972	No kokanee reared	
1972	1973	Okanagan River	302,000
1973	1974	Okanagan River	488,000
1974	1975	No kokanee reared	
1975	1976	No kokanee reared	
1976	1977	Meadow Creek	112,000
1977	1978	Meadow Creek	34,000
1978	1979	Meadow Creek	101,000
1979	1980	Kokanee rearing ceased @ Wardner hatchery	

It is suspected that kokanee in Moyie Lake were also the result of hatchery introductions during the 1940s (Appendix 88).

Historic and current harvest

British Columbia

Kokanee harvest data are unavailable for Trout Lake, Moyie Lake and Duncan Reservoir. Recreational fishing is very light with rainbow trout and bull trout the target species for those who do fish there, i.e., kokanee are infrequently targeted and harvested incidentally. An informed "guesstimate" of harvest would be < 1000 for Trout Lake, < 2000 for Moyie Lake and <2,000 for Duncan Reservoir (H. Andrusak, Redfish Consulting, Ltd., Nelson, B.C., pers. comm.).

The sport fishery on Kootenay Lake was monitored by an extensive creel census program from 1967-1986 but budget constraints resulted in cessation of this program in 1987. Prior to the 1960s Kootenay Lake was well known for its excellent fishing, particularly for the large-size Gerrard rainbow trout. It wasn't until the mid 1960s that angler effort rapidly grew (figure 4.5), largely because of the discovery of large kokanee at the outlet area (Balfour, B.C.). During the 1970s this freshwater sport fishery was the most intensive in all of British Columbia, attracting anglers from throughout North America. The peak of angling activity was from 1972-1977 with a gradual decline in kokanee catch commencing in 1978, resulting in angler effort decreasing to less than 50 percent of the mid-1970s level by 1986. Most of the decline in effort and catch was due to the collapse of the West Arm kokanee fishery.

Main lake (north and south arm) kokanee fishery

The main lake kokanee fishery is quite different from that described for the West Arm. Virtually all the fishing takes place in the summer months (July-August) largely by family fishing using small trolling gear. The kokanee are small (20-25 cm), abundant and high success rates are common, but angler interest wanes if the size is < 22 cm. The annual census on the lake from 1968-1986 separated angler effort by species and therefore catch (almost entirely harvest). Low levels of angler effort were recorded during the late 1960s and 1970s, primarily because most anglers preferred the much larger-sized West Arm kokanee, and so most fished the West Arm. With the West Arm kokanee fishery collapsing in the late 1970s, a shift in effort to the main lake occurred (figure 4.12). This much higher level of fishing on the main lake only occurred for a few years and was not sustainable, not because of over fishing, but largely because of the dramatic decline (figures 4.4 and 4.5) in the main lake stock(s) due to nutrient impoverishment as a result of upstream reservoir formation (Duncan and Libby dams). Although no catch data is available for the main lake today, it probably is in the order of 30-40,000.

North and South Arm kokanee stocks decreased in the 1980s with virtually no South Arm fish evident, while North Arm escapements declined from a range of 0.5-3.5M in the 1960s and 1970s to 0.3 - 0.5 M in the late 1980s and early 1990s (Ashley et al. 1999). This decline led researchers to consider a method for

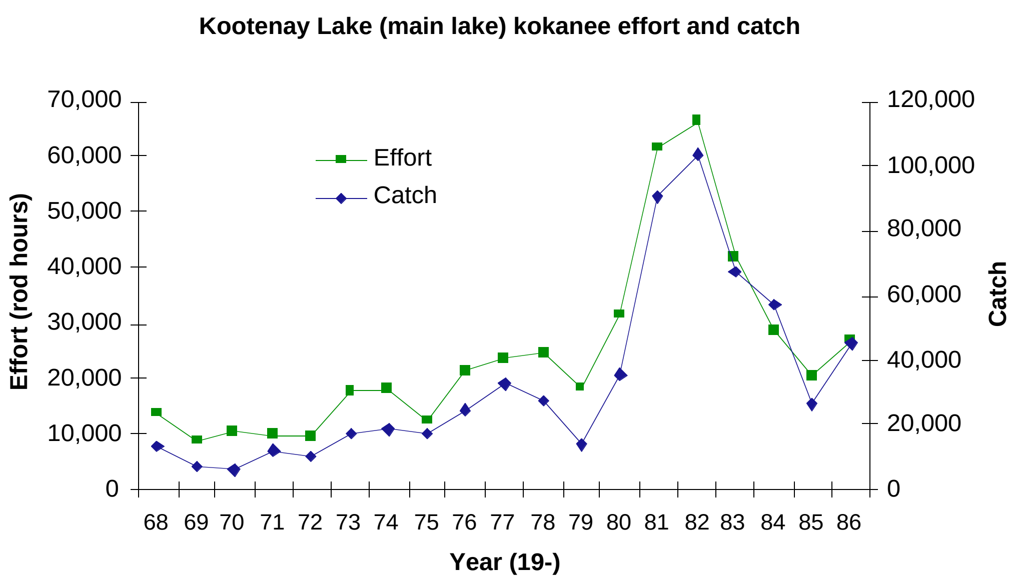

Figure 4.12. Kootenay Lake (main lake) kokanee effort and catch 1968-1986.

reversing this trend, especially since the world famous Gerrard rainbow trout were so dependent upon kokanee as their food source (Andrusak and Parkinson 1984). Initial results of experimental fertilization have been reported by Ashley (in Murphy and Munawar 1999) and the response by North Arm kokanee has been very positive. Kokanee escapements to the North Arm's Lardeau River and Meadow Creek systems are once again over one million, and these escapements are very comparable to those of the 1960s and 1970s (Ashley et al. in Murphy and Munawar 1999; Andrusak 2002). The introduction of fertilizers to the North Arm of Kootenay Lake that has resulted in increased numbers of kokanee brings into question how large of a role mysids had in the 1980s kokanee decline.

West Arm kokanee fishery

The West Arm serves as an outlet river for Kootenay Lake with water chemistry very similar to that of the epilimnion of the main lake (Daley et al. 1981). Elimination of spring peak flows, higher winter flows, and lower spring water levels reducing important littoral areas were identified as major changes to the West Arm as a result of the upstream dams (Daley et al. 1981). The main beneficiaries of the 1949 mysid introduction have been West Arm kokanee, which feed heavily on them as they are displaced downstream of the main lake. Over the last three decades, their size has been much larger (Redfish Consulting, Ltd. 2000), although size in 2001 (Redfish Consulting, Ltd. 2002) was similar to those originally reported by Vernon (1957). Martin and Northcote (1991) attributed the significant increase in size of West Arm kokanee during the 1970s and 1980s to the availability of mysids.

One obvious result of the change in the hydrological regime of the West Arm since the dams became operational in the mid 1970s has been a reduction in *Mysis relicta* displacement (Thurber Consultants 1981; Martin and Northcote 1991). During peak discharge, mysids were easily observed at the surface but this is usually no longer the case. It is unclear if reduction in mysid transport into the West Arm has adversely affected West Arm kokanee numbers but analysis of food habit in 2001 indicates less consumption of mysids compared to the 1960s (Redfish Consulting, Ltd. 2002).

It was the unusually large size of kokanee that began to attract the attention of anglers in the mid 1960s. Prior to then, few anglers had been interested in kokanee. They preferred to target the big Gerrard rainbow trout. By the end of the 1960s, word of big kokanee at Balfour had spread and a classic boom and bust fishery occurred within a ten-year period. At its peak, this fishery annually harvested 80-100,000 kokanee (figure 4.13), many of which were 1-2 kg in size with a few individuals exceeding 4 kg. The fishery was concentrated in the upper

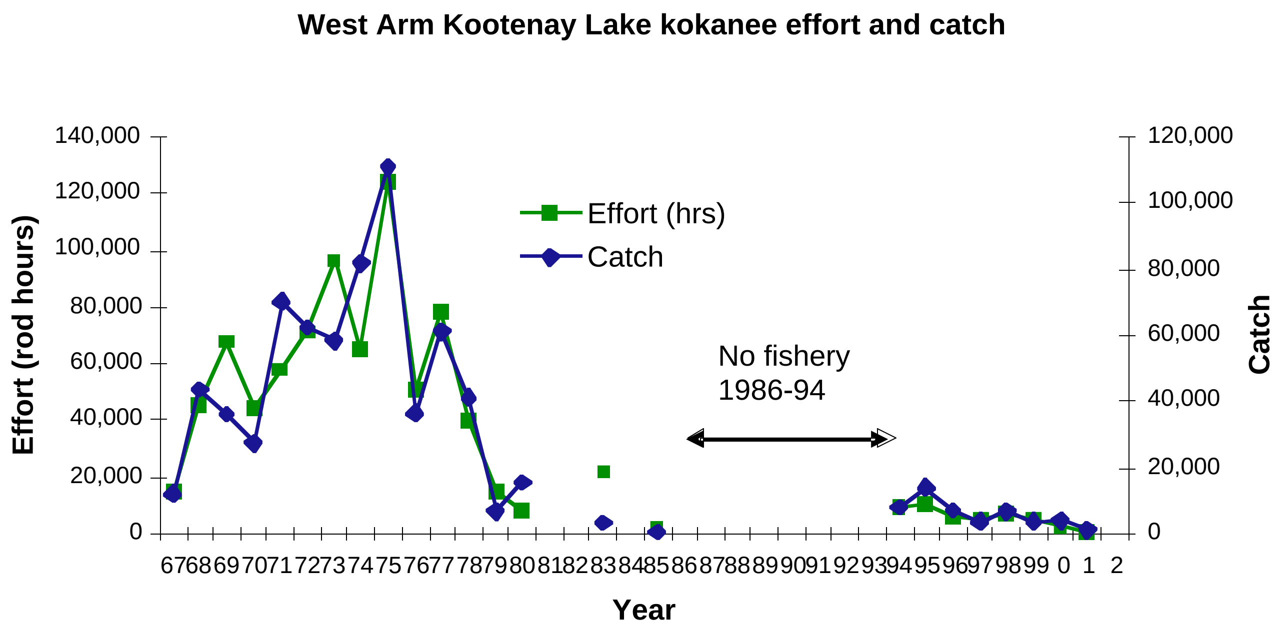

Figure 4.13. West Arm of Kootenay Lake kokanee effort and catch 1967-2002. No fishery from 1986-1994 and 2002.

5 km of the West Arm and it was not unusual to see 400-500 boats at one time fishing during the summer in this small area. These much larger kokanee offered some excellent spin cast fishing in the winter-spring months, changing to trolling as the summer advanced. The resort industry at Balfour rapidly expanded in response to this fishery and overcrowding at the resorts and on the West Arm was a common sight. This fishery was very intensive but not sustainable, with overfishing evident by the end of the 1970s (Andrusak 1981). A major reason the West Arm stock was over fished was due to large numbers of main lake kokanee entering the West Arm during the summer months (Martin 1984) creating a mixed stock fishery. The more abundant main lake stock mixed with the weaker stock (West Arm) and masked the impact of fishing on the weaker stock. In the 1980s this fishery collapsed and the tourist industry underwent a dramatic change, resulting in most resorts closing. Today, the fishery is limited to a few weeks largely enjoyed by local residents who comprise 95 percent of all anglers compared to only 50 percent in the 1970s (Redfish Consulting, Ltd. 2002). The obvious decline of nonresident anglers is an economic impact often overlooked.

Decline of West Arm kokanee numbers was initially addressed in the early 1980s by closing the fishery and constructing small spawning channels on the two key spawning streams - Kokanee and Redfish creeks. The feasibility of rearing West Arm kokanee using net pens was also examined by Perrin and Levy

(1990) and a small-scale experimental fertilization of the upper West Arm was also attempted (Perrin 1989). The upper West Arm fertilization experiment and the net-pen-rearing strategies did not work, and they were abandoned (former Regional Fisheries Biologist, J. Hammond, Vancouver, B.C., pers. comm.).

Fry-to-adult survival rates (figures 4.14 and 4.15) have been determined from fry production estimates and adult returns to the primary spawning channel streams (Kokanee and Redfish creeks). Very low survival rates combined with high harvest rates in the West Arm kokanee fishery forced a prolonged closure of the fishery from 1980 until 1994 with the exception of short seasonal fisheries in 1983 and 1985. Stock recovery over nearly five cycles was very slow despite excellent fry production from two spawning channels built in the 1980s and virtually no sport catch for nearly 15 years. With stock recovery evident, B.C. Fisheries[1] was confident enough to open a short-term annual fishery commencing in 1994. In April 1994, the West Arm was reopened to kokanee fishing with a harvest quota set at 5,000. The quota for 1995 and 1996 was 8,000 and from 1997 – 2003 it has been 5,000. West Arm kokanee are highly vulnerable to sport fishing and with such a small margin of error it is essential that angler effort and harvest be closely monitored each year.

Presently, the size of the upper West Arm kokanee fishery is only a fraction of what existed in the 1970s. However, the size and high catch rate of these fish in a somewhat unique, riverine habitat make them exceptionally attractive to anglers. The fishery in April 2000 was so popular that the entire quota (~5,000 fish) was reached in 11 days and the fishery had to be closed. Poor fry production from the Kokanee Creek spawning channel in 2000 and poor test fishery results in the spring, 2002 led to the decision by fisheries managers not to open the fishery in 2002 (B. Lindsay, Ministry of Water, Land and Air Protection, Fisheries Biologist, Nelson, B.C., pers. comm.). The 2003 fishery was quite successful with approximately 7800 fish harvested in a three week period.

In retrospect, it is now quite apparent that in-lake survival limits this kokanee population and there is no evidence to-date that the North Arm fertilization experiment has had any beneficial effect on the West Arm stock (Redfish Consulting, Ltd. 2000, 2002).

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[1] *In recent years, numerous provincial government organizational changes have occurred resulting in several name changes. Throughout this report, reference is made to B.C. Fisheries, the former provincial Fish and Wildlife Branch presently located in the Ministry of Water, Land and Air Protection.*

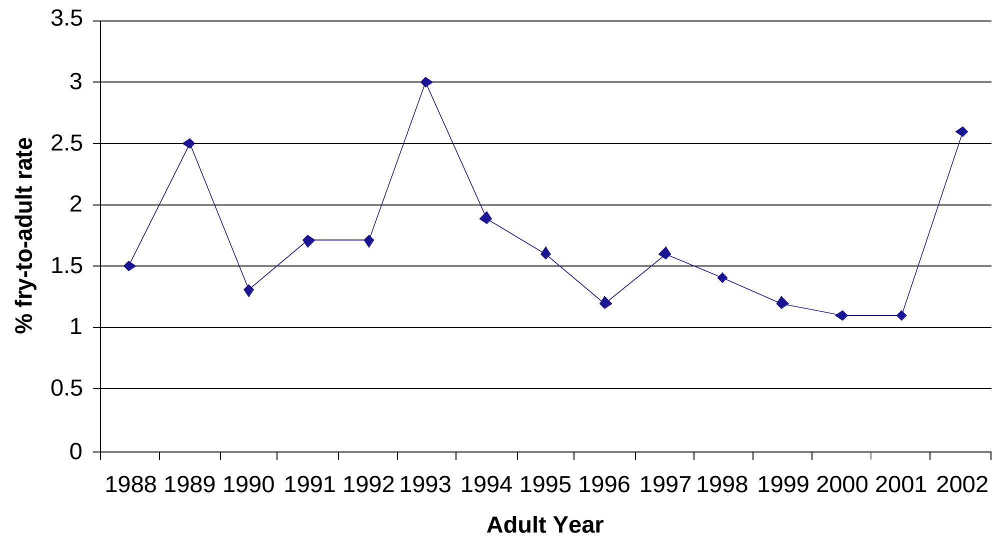

Figure 4.14. Percent survival rate fry-to-adult from Kokanee and Redfish Creek spawning channels.

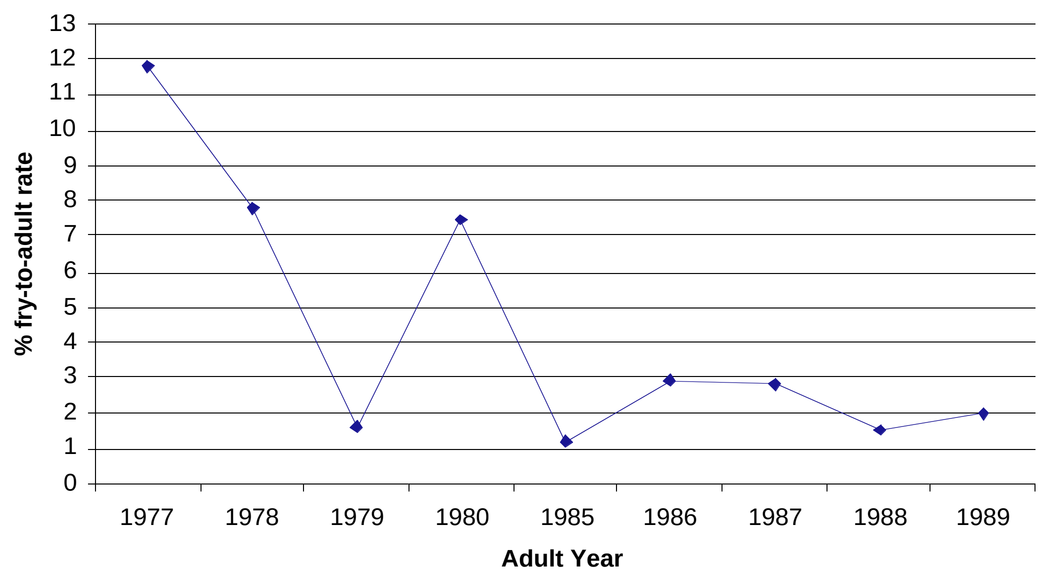

Figure 4.15. Percent survival rate fry-to-adult from Redfish Creek 1975-1989.

Koocanusa Reservoir

Kokanee in Koocanusa Reservoir often grow to 30 cm, thus providing excellent fishing. The most recent survey of the kokanee fishery on the Canadian portion of the Koocanusa Reservoir was in 1996 for the months of June-September. Angler effort was ≈ 27,000 angler days (≈ 80,000 hours) with an estimated catch of ≈ 114,000 and harvest of ≈ 103,000 (B. Westover, B.C. Fisheries Biologist, Cranbrook B.C., pers. comm.).

MFWP conducts an angler mail survey in odd-numbered years. The Montana portion of Koocanusa Reservoir was estimated by MWP to have supported 35,588 angler days of use in 1995, 48,750 in 1997, 57,493 in 1999, and 38,217 in 2001. Thus, Koocanusa Reservoir was either the first or second (only to Flathead Lake) most heavily fished lake in northwest Montana during those years.

As previously mentioned, this fishery resulted from accidental releases of Okanagan and Meadow Creek stocks from Wardner Hatchery in B.C. Entrainment affects natural production upstream from Koocanusa Reservoir, mainly in B.C., and downstream from the dam in Montana and Idaho. The non-native kokanee population in Koocanusa Reservoir appears to be stable and persistent.

4.4.2 Population Delineation and Characterization

Population Units

Genetic analysis of the kokanee populations within the Subbasin is incomplete. Morphometric differences were evident for the three subpopulations within Kootenay Lake as demonstrated by Vernon (1957). Genetic analysis conducted in 1994 by the University of Montana indicated a difference between West Arm kokanee and those from the North and South Arms, but no difference was detected between North and South Arm kokanee. No analyses have been conducted between Kootenay, Duncan, Moyie and Trout Lake stocks, although there are some obvious spatial as well as temporal differences in run timing.

Five new microsatellite loci have been identified and tested for *O. nerka*. The University of Idaho's Aquaculture research Institute is currently arranging microsatellite analyses on kokanee from numerous spawning populations throughout the Kootenai River Basin (M. Powell, UI, ARI, pers. comm.).

Life History

Spawning

Many aspects of kokanee life history, the non-anadromous form of Pacific sockeye salmon, have been well documented (Vernon 1957; Northcote and Lorz 1966; Northcote 1973; Thompson 1999; Sebastian et al 2000; Andrusak and Sebastian in Andrusak et al. 2000). Most kokanee populations found in the large lakes of British Columbia migrate up tributary streams to spawn, usually in September. Information and documentation of shore spawning kokanee in British Columbia has been quite limited, but recent investigations have identified several shore spawning populations that were previously unknown. The best documented examples of kokanee shore spawning are those in Okanagan, Kalamalka and Quesnel lakes but recently studies have shown that kokanee are also capable of spawning in reservoirs with sizeable drawdowns (e.g., Alouette, Seton and Anderson reservoirs). It is now known that the majority of kokanee in Okanagan Lake, Seton, Anderson and Alouette Reservoirs are in fact shore spawners (Andrusak and Sebastian in Andrusak et al. 2000; G. Wilson Fisheries Biologist U.B.C. Vancouver, B.C. pers. comm.). Surveys in Seton and Anderson lakes in late November 2003 have confirmed kokanee were spawning on shore at water depths of 30-50 m.

Kokanee prefer low gradient streams for spawning, and while some will utilize streams that have gradients of 1 to 5 percent, they generally will select the lower gradient sites. Most often kokanee that ascend larger rivers will utilize the side channels for spawning with the exception being in a regulated stream system where spawning coincides with lower flows, e.g., Mabel Lake kokanee in the middle Shuswap River (A. Caverly, MWLAP Biologist, Kamloops, B.C., pers. comm.). For example, in most years the Lardeau River that flows into Kootenay Lake supports 0.5-1.0 million kokanee. The river gradient averages 1.0 percent but despite this low gradient spawning kokanee will select side channels where the grade is <0.5 percent, gravel size is < 5 cm and the flow is much less than the mainstem river. The six kokanee spawning channels in British Columbia were all designed with reach gradients <0.25 percent and gravel size of 1-5 cm (Redfish Consulting, Ltd 1999).

Run timing

Most kokanee in the southern interior large lakes such as Arrow, Okanagan, Slocan and Kootenay spawn from late August to early October with the peak of spawning around the third week of September. Most Quesnel Lake stream spawning kokanee spawn slightly later (early October). Kokanee in the West

Arm of Kootenay Lake spawn quite early, commencing in mid-August and completed by mid-September. The peak of Okanagan Lake shore spawning kokanee usually occurs in the third week of October, a month later than their stream spawning counterparts (Andrusak and Sebastian in Andrusak et al. 2000). Some very late shore spawning (mid-December) has been observed in Adams Lake that is similar in timing to those in Anderson Reservoir (A. Caverly, MWLAP Biologist, Kamloops, B.C., pers. comm.)

The South Arm of Kootenay Lake kokanee spawn earlier than their northern counterparts, usually from mid-August to mid-September whereas Lardeau River kokanee spawn in the latter part of September until late October.

Size at maturity

Okanagan Lake supports two populations of kokanee, with the stream spawning component slightly larger (Mission Creek mean 28.9 cm) than the shore spawners (mean 25 cm). The length of spawning kokanee sampled in Quesnel Lake are similar in size to those of Okanagan Lake, ranging from about 22-30 cm with the means ranging from 24.6-27.7 cm. Lorz and Northcote (1965) reported a variation in the size of spawning kokanee in Nicola Lake ranging from 22-29 cm with an average of 27 cm during most years. Spawning kokanee in Arrow and Kootenay lakes are typically 20-23 cm in size, slightly smaller than Okanagan, Quesnel and Nicola lake kokanee. Vernon (1957) reported that South Arm kokanee were slightly smaller than North Arm fish and much smaller than the West Arm kokanee.

There are a few kokanee populations that grow larger than the usual 23-27 cm size found in most B.C. lakes. West Arm of Kootenay Lake kokanee have ranged in mean size from 22-38 cm but in most years the mean exceeds 30 cm (Redfish Consulting, Ltd. 2000). Mission Creek (Okanagan Lake) kokanee in the last two decades have ranged in size from 25-37 cm with an average of 28.7 cm (Andrusak et al. 2003). In addition, there are some unproductive lakes such as Slocan, Moyie and Whatshan lakes in the Kootenay area of B.C. that have very small kokanee with size at maturity of < 22 cm. Coastal lakes are generally unproductive, oligotrophic lakes that support small kokanee populations with spawner size typically around 20 -22 cm e.g., Alouette Reservoir prior to fertilization (G. Wilson, Fisheries Biologist, U.B.C. Vancouver, B.C., per. comm.).

Age at maturity

Okanagan, Quesnel, Arrow and Kootenay Lake kokanee usually spawn at age 3+ (Vernon 1957, Martin 1984, Andrusak and Sebastian in Andrusak et al 2000, Redfish Consulting, Ltd. 2003, Pieters et al. 2003). Mission Creek kokanee are primarily age 3+ but a few larger fish appear annually in the spawning population and these have been aged as 4+ and 5+ (Andrusak and Sebastian in Andrusak et al. 2000). Alouette Reservoir kokanee appear to be primarily 3+ at maturity but this may have changed as a result of fertilization that began in 1999 (Wilson 2000). West Arm of Kootenay Lake kokanee spawn as age 2+ with a few (<10 percent) spawning at age 3+ (Redfish Consulting, Ltd. 2000). Recent investigations on Adams, Shuswap and Bonaparte lakes in the upper Thompson River drainage indicate the majority of kokanee spawn as age 3+ (Redfish Consulting, Ltd. 2003).

Vernon (1957) determined that South Arm kokanee matured mostly at age 2+ whereas North Arm kokanee were primarily age 3+. Hydroacoustic and trawl surveys have been conducted on the main lake annually since 1985. Ageing of juveniles has been carried out for most years through length frequency analysis and scale reading. Three age groups are typically found in the trawl samples (ages 0-2+) while age 3+ fish make up the majority of spawners. Thompson (1999) reported that Meadow Creek spawners in 1994-96 were primarily age 2+ most likely in response to lake fertilization. More recent data (Andrusak 2003) indicates that age of maturity is once again age 3+.

Fecundity

The number of eggs found in a gravid female is size dependent and there are a number of data sources that provide detail on kokanee fecundity including good estimates on Arrow Reservoir (Sebastian et al. 2000), Kootenay Lake (Andrusak 2001) and Okanagan Lake (Sebastian and Andrusak in Andrusak et al. 2000). Arrow Reservoir kokanee usually are about 22 cm and the twenty year average fecundity is 277 (Sebastian et al. 2000). Twenty two years of data on Meadow Creek kokanee (Kootenay Lake) indicate that the mean length is 22.2 cm and that mean fecundity determined from 35 years of data is 260 (Andrusak 2003). Okanagan Lake kokanee (Mission Creek) are somewhat larger (mean size 28.8 cm) with a mean fecundity of 774 but over the fourteen years that data has been collected fecundity has ranged from 425 to 1586 (Andrusak in Andrusak et al. 2003).

West Arm kokanee are far more fecund than their main lake counterparts. Mean fecundity over the last fifteen years has been 739 compared to 260 for Meadow Creek. No fecundity data are available for South Arm kokanee.

Food Habits

It is generally understood that kokanee fry move immediately to open waters after emergence from spawning areas, whether from tributaries or beach spawning sites. This rapid dispersion of fry to the open water is consistent with many anadromous sockeye populations. There are well documented examples of sockeye fry undergoing rapid and intricate dispersion patterns into nursery lakes upon emergence (McCart 1967; McDonald and Hume 1984). Babine Lake populations have been studied extensively and McDonald and Hume (1984) demonstrated that fry migrating from tributary streams might either remain on the lakeshore for weeks or move directly into open water. There are also examples of sockeye stocks in which the juveniles initially reside on-shore in the littoral area for a period of months (see Burgner 1991). Kokanee fry in the West Arm of Kootenay Lake remain on-shore for two months before moving to the limnetic area (Redfish Consulting, Ltd. 1999) but most kokanee fry do seem to move directly to open water, usually coinciding with increased production of zooplankton (Reiman and Bowler 1980; Thompson 1999).

Once in the limnetic area, both kokanee and sockeye feed primarily on zooplankton, especially copepods and cladocerans. In lakes that are cohabited with sockeye, it appears that kokanee potentially experience intraspecific competition with underyearling sockeye since they prey upon the same macrozooplanktors such as *Daphnia* and *Diaptomus* (Stockner and Shortreed 1989; Hume et al. 1996). Northcote and Lorz (1966) found that Nicola Lake kokanee utilized copepods and cladocerans during the spring and fall months, but chironomid pupae were the dominant food source during June and July. Thompson (1999) found that Kootenay Lake kokanee fry preferred *Daphnia sp.* and *Diaphanasoma* spp., but *Mysis relicta* were also consumed. In Quesnel Lake, under yearling sockeye are found at dusk in the same layers of the lake as juvenile kokanee (D. Sebastian, Ministry of Water, Air and Lands Protection, Fisheries Victoria, B.C., pers. comm.). In Okanagan Lake it is generally believed that kokanee compete with *Mysis relicta* for preferred zooplanktors (*Diaphanasoma* and *Daphnia* spp.) (Whall and Lasenby in Ashley et al. 1999).

The West Arm of Kootenay Lake kokanee behave differently than most studied kokanee populations. The fry move from the natal streams and associate themselves with the shoreline for the first two months before moving to open water within the West Arm (Redfish Consulting, Ltd 1999). Benthic organisms, aquatic insects and littoral zooplankton are consumed in addition to pelagic zooplankton. As the summer advances, the fry move off shore and utilize macrozooplanktors and mysids.

Genetic Integrity

Within the Subbasin, only Kootenay Lake kokanee have been investigated for genetic composition, although the origin of non-native Koocanusa Reservoir kokanee is also known. Prior to the Duncan Dam, kokanee could readily intermingle and move to and from Kootenay Lake to Duncan Lake and or Trout Lake. However, it is clear from Vernon's work (Vernon 1957) that reproductive segregation due to strong homing tendencies had resulted in some genotypic divergence and strong phenotypic variability between the three spawning populations in Kootenay Lake. Electrophoretic analysis by the University of Montana (G.K. Sage letter on file) in 1994 of kokanee samples captured in the North, Central, West and South areas of the lake determined some significant differences amongst the samples. West Arm kokanee had significant allele frequency differences compared to the other samples and were considered separate from the others. No difference was detected between North and South Arm samples, perhaps not surprising since North Arm stock had been used for egg plants and the fact that very little South Arm spawning had occurred for two decades. Further genetic analysis is required of spawners from each of the three arms of the lake to determine with certainty if a South Arm stock persists as it did when Vernon (1957) did his work.

Koocanusa Reservoir kokanee originated from accidental releases from the Kootenay Trout hatchery located on the upper Kootenay River near Cranbrook, B.C. Two strains of kokanee likely contributed to the eventual population that now resides in the reservoir. Kokanee eggs from Okanagan River adults were in the hatchery in 1972 and 1973 and could have entered the newly forming reservoir in 1973 and 1974 through accidental releases when disposing of mortalities (P. Brown Fish Culturist Wardner Hatchery pers. comm.). Meadow Creek stock is the more likely contributor to the Koocanusa population since these eggs were reared in the hatchery from 1976-1979, the period of time when the reservoir was fully formed and most likely quite productive.

4.4.3 Population Status

Native kokanee salmon runs in lower Kootenai River tributaries in Idaho have experienced dramatic population declines during the past several decades (Ashley and Thompson 1993; Partridge 1983). The kokanee that historically spawned in these tributaries inhabited the South Arm of Kootenay Lake in British Columbia. Native kokanee are considered an important prey item for white sturgeon and also provided an important fishery in the tributaries of the lower Kootenai River (Partridge 1983; Hammond, J., B.C. MELP, per. comm. 2000). Kokanee runs into North Idaho tributaries of the Kootenai River, numbering into the thousands of fish as recently as the early 1980s, have now become "functionally extinct" (Anders 1993; KTOI, unpublished data; Ashley and Thompson 1994) (figure 4.16, table 4.51). Since 1996, visual observations and redd counts in five tributaries found no spawners returning to Trout, Smith, and Parker Creeks, while Long Canyon and Boundary Creeks had very few kokanee returns (figure 4.16, table 4.51).

Table 4.51. Estimated peak number of kokanee spawners for stream reaches in six tributaries to the Kootenai River in Idaho (N/S = not surveyed)

Year	Boundary Creek (610 m)	Smith Creek (380 m)	Long Canyon Creek (700 m)	Parker Parker Creek (790 m)	Trout Creek
1981	1,100	600	1,600	350	N/S
1993	0	N/S	12	64	0
1996	0	0	0	0	0
1997	0	0	3	0	0
1998	8	0	0	0	0
1999	38	0	0	0	0
2000	15	N/S	30	7	0
2001	31	N/S	25	0	0
2002	N/S	N/S	0*	30+	0*
2003	N/S	N/S	40+	55+	0*

** Survey time and effort minimal.*
+ Conservative estimate, based on production from introduced Meadow Cr. stock.

However, a series of kokanee stream restoration activities lead by the Kootenai Tribe of Idaho appears to be contributing to recent increases in spawner counts in Long Canyon and Parker creeks (table 4.51). These activities included:

- 1997 – In cooperation with the B.C. Ministry of Environment, Land, and Parks, Idaho Fish and Game, and the US Fish and Wildlife Service, the Kootenai Tribe began a reintroduction program for kokanee in the westside tributaries to the Kootenai River in Idaho.

- Fall 1997 – Obtained 100,000 disease-free eyed kokanee eggs from Canada (Meadow Creek stock from Kootenay Lake). Planted eggs in Long Canyon Creek using instream incubation techniques demonstrated by employees from the B.C. Ministry of Environment Fisheries.

- Spring 1998 – Released approximately 15,000 kokanee fry in Parker Creek (incubated at tribal Sturgeon hatchery in Bonners Ferry).

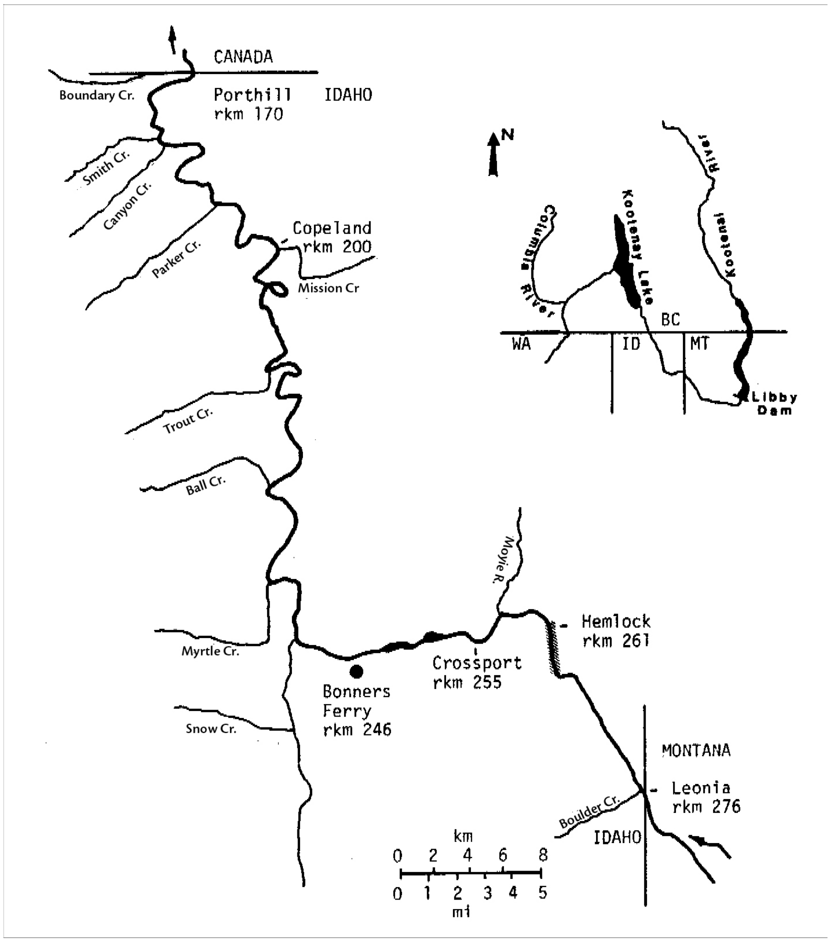

Figure 4.16. Location of Idaho Kootenai River tributaries where visual

LINKS

For a more complete discussion of how Mainstem Columbia River operations affect subbasin fisheries, and how those effects might be minimized see Appendix 18.

Click Here

- Fall 1998 – Planted 300,000 eyed kokanee eggs in Long Canyon, Parker, and Trout Creeks in October using instream incubation techniques (100,000 eggs per creek). Kokanee originated from the North Arm Kootenay Lake stock (Meadow Creek) in British Columbia. Placed thermographs in each creek.

- Fall 1999 – In October, reintroduction (instream incubation) of kokanee occurred in three tributaries (200,000 – Long Canyon; 150,000 – Parker Creek; and 150,000 – Trout Creek) using eyed eggs from the North Arm of Kootenay Lake stock (Meadow Creek)with assistance from staff from the B.C. Ministry of Fisheries.

- Fall 2000, 2001, and 2002 – no kokanee eggs were available for reintroduction.

- Fall 2003 – In October, reintroduction of eyed kokanee eggs occurred in four tributaries (1.5 million eyed eggs from Meadow Creek stock, B.C.) with assistance from staff from the B.C. Ministry of Water, Land and Air Protection (Freshwater Fisheries Society). Eggs were planted in Long Canyon, Parker, Trout (north and south forks), and Myrtle Creeks.

Human impacts

The Kootenay Lake watershed has been the subject of a great deal of attention from the scientific community for well over fifty years due to a series of human influences that have resulted in dramatic changes to lake productivity. These changes have had profound impacts on several fish species, most notably kokanee (*Onchorynchus nerka*). Kootenay Lake has also been well studied by fisheries scientists because it supports what is arguably the largest rainbow trout found in the world. These trout, known as Gerrard rainbow trout (*Onchorynchus mykiss*) are exceptional predators that can grow up to 15 kg. They are reliant almost entirely on kokanee for food and therefore any significant decline in kokanee has been a major cause for public concern and fisheries managers. Gerrard rainbow trout and kokanee are also sought by anglers in what has been one of the most popular and intensive inland sport fisheries in British Columbia.

LINKS

For information on the relationship between Columbia River redband trout and Gerrard (kamloops) rainbow, see the section on population delineation in the redband focal species description.

Click Here

Northcote (1973) summarized the historical impacts endured by Kootenay Lake as a result of early European settlement and subsequent “development" through agriculture, mining, forestry, cultural eutrophication, fishing and hydro-development. By far, hydro-development has had the most significant impacts. Kootenay Lake was initially affected by hydro-development in 1932 with completion of the Corra Linn dam that had the ability to store up to 2.5 m of water on the lake (Daley et al. 1981). The Columbia River Treaty signed between the United Sates and Canada in 1961 put into motion development of the Duncan Dam completed in 1967. The Libby Dam on the Kootenai River in Montana was completed in 1974, although the reservoir began forming in 1972.

One of the earliest changes to the ecology of Kootenay Lake noted by various researchers was the introduction of *Mysis relicta* in 1949 by P.A. Larkin (Northcote 1991). Successful introduction of these macrozooplanktors was not confirmed until 1964 when they were observed drifting through the outlet of the lake (Sparrow et al. 1964). Northcote (1991) concluded that this introduction was only partially successful since the targeted species—Gerrard rainbow trout—have not benefited to any measurable degree. West Arm kokanee have benefited from the mysid introduction (Northcote 1973; Martin and Northcote 1991) but main lake kokanee have not (Martin and Northcote 1991). Many researchers including Ashley et al. (1997) and Walters et al. (1991) suggested that mysids may have been at least partially responsible for the dramatic decline in main lake kokanee stocks in the 1980s.

Northcote (1973) described the cultural eutrophication of the lake in the 1960s and 1970s due to phosphorous introduction from a fertilizer plant into a tributary of the Kootenay River some 400 km upstream from the lake. Daley et al. (1981) described in considerable detail the reversal of eutrophication during the late 1970s and early 1980s. Cessation of phosphorous discharge and nutrient retention due to formation of reservoirs on the two major inflow rivers (Kootenay and Duncan) were the primary reasons for the reversal process and the lake once again became oligotrophic (Daley et al., 1981; Ashley et al. 1999).

By the mid-1980s it had become apparent that lake productivity had declined to such an extent that the main lake kokanee population was on the verge of collapse. The potential for a decline in the economically important rainbow trout sport fishery (Andrusak and Brown 1987, MS; Korman et al. 1990) and fear of a kokanee collapse were impetus for increased research. Also, the opportunity to measure trophic level responses to short term productivity changes on such a large system was of considerable scientific interest.

Main lake kokanee stocks actually began to decline in the mid 1980s (Andrusak 1987, MS; Ashley et al. 1997). North and South Arm kokanee stocks decreased with virtually no South Arm fish evident while North Arm stock escapements dropped from a range of 0.5 - 4.1 million in the 1960s and 1970s to 0.3-0.5 million in the late 1980s and early 1990s (Ashley et al. 1999). This decline led researchers to consider means of reversing this trend, especially since the world-renowned Gerrard rainbow trout are so dependent upon kokanee as their food source (Andrusak and Parkinson 1984).

In 1990, a series of meetings were held amongst fisheries researchers and managers to consider what, if anything, could be done to reverse the downward trend in main lake kokanee numbers. Korman et al. (1990) describes the various alternatives that were contemplated. The Kootenay Lake Fertilization Response Model (Walters et al. 1991) was developed to understand what would happen if the lake was fertilized to pre-impoundment and pre-cultural enrichment levels. The model predicted that fertilization would not likely be successful, but fisheries management, faced with no other option, proceeded to initiate a five-year fertilization experiment commencing in 1992. Results of this experiment have been reported in a series of technical reports (Ashley et al. 1999; Wright et al.

2003), and the response by North Arm kokanee has been very positive. Kokanee escapements to the North Arm's Lardeau River and Meadow Creek systems are once again over 1 million and comparable to escapements of the 1960s and 1970s (Ashley et al. 1999). A reduction in fertilizer loading from 1997-2000 resulted in a decline in the kokanee population, prompting fisheries managers to increase the loading rate in 2000 and 2001 (Andrusak 2002).

LINKS

For the website containing descriptions of surface waters included in the Montana water quality assessment database go to: http://nris.state.mt.us/wis/environet/2002_305bhome.html.

Click Here

For the website listing 303(d) water-quality impaired streams and lakes for the Idaho portion of the subbasin, go to: http://inside3.uidaho.edu/WebMapping/IDEQ/

Click Here

Environment s Ability to Provide Key Ecological Correlates

In most of the Subbasin there are adequate numbers of kokanee in each of the described subpopulations with the notable exception of the South Arm of Kootenay Lake. Despite North Arm fertilization, the South Arm stock has not responded, most likely due to a much smaller initial population size, lower stream egg-to-fry survival rates and interspecific competition for preferred food items. Timing of fry out-migration from the southern tributary streams is unknown, but if Koocanusa Reservoir kokanee fry move into Kootenay Lake prior to South Arm stream-kokanee fry, South Arm kokanee may be at a disadvantage. South Arm kokanee are unlikely to recover without improvement to the productivity of the South Arm combined with egg transplants and restoration of some key spawning habitat. At the same time, it is possible that fertilization of the South Arm may provide some benefits to upper West Arm kokanee. Increased zooplankton production may result in greater outwash of zooplankters to the West Arm.

Habitat availability and condition

Slaney and Andrusak (2004) evaluated a number of South Arm tributaries during September 2003. Several streams, completely void of kokanee spawners, were deemed to have suitable kokanee spawning habitat. Good kokanee habitat was documented in Boulder, Boundary, and Summit Creeks. Habitat restoration measures have been recommended to improve the quality of kokanee spawning habitat as well as improve rainbow trout rearing habitat.

The Kootenai Tribe of Idaho is conducting habitat restoration work on lower Kootenai River tributaries through the Lower Kootenai River Model Watershed Restoration Project. The tribe is working on restoring riparian and instream habitat on Trout, Long Canyon and Parker Creek and will be working with USFWS on Myrtle Creek and Anheiser-Busch on Fisher Creek.

QHA Results for Kokanee

As part of this assessment, the Kootenai Subbasin (MT, ID, and B.C.) Technical Teams[2] evaluated all the 6th-code HUCs and selected lakes in the Montana, Idaho, and Canadian[3] portions of the subbasin on the basis of eleven stream habitat attributes (Parkin and McConnaha 2003) and thirteen lake habitat attributes considered key to resident salmonids. This was done utilizing the QHA and LQHA spreadsheet tools. The habitat attributes used in the stream version of QHA are generally thought to be the main habitat drivers of resident salmonid production and sustainability in streams (Parkin and McConnaha 2003) (table 4.52). Those used in LQHA are the ones considered by our Technical Team to be the main

Table 4.52. Eleven habitat attributes used in the Kootenai Subbasin QHA analysis of 6th-code HUCs with definitions.

Attribute	Brief Definition
Riparian Condition	Condition of the stream-side vegetation, land form and subsurface water flow.
Channel Stability	The condition of the channel in regard to bed scour and artificial confinement. Measures how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types.
Habitat diversity	Diversity and complexity of the channel including amount of large woody debris (LWD) and multiple channels
Fine Sediment	Amount of fine sediment within the stream, especially in spawning riffles
High Flow	Frequency and amount of high flow events.
Low Flow	Frequency and amount of low flow events.
Oxygen	Dissolved oxygen in water column and stream substrate
High Temperature	Duration and amount of high summer water temperature that can be limiting to fish survival
Low Temperature	Duration and amount of low winter temperatures that can be limiting to fish survival
Pollutants	Introduction of toxic (acute and chronic) substances into the stream
Obstructions	Barriers to fish passage

LINKS

For more detailed results of the QHA assessment, including attribute scores and HUC rankings, see Appendices 32 and 33.

Click Here

[2] The Kootenai Subbasin Technical Team members particiapating in the HUC-by-HUC assessment included fisheries biologists and hydrologists from the Kootenai Tribe of Idaho, Montana Fish, Wildlife and Parks, Idaho Fish and Game, Idaho Department of Environmental Quality, US Army Corps of Engineers, US Fish and Wildlife Service, the Idaho Panhandle and Kootenai National Forests, the B.C. Ministry of Sustainable Resource Management, the B.C. Ministry of Land, Water, and Air Protection, and a private consulting firm.

[3] In the U.S. portion of the subbasin, some valley HUCs were lumped. In the Canadian portions of the subbasin, time limitations prevented the use of 6th-code HUCs. Instead, the Canadian members of the team used analogous watersheds developed during a previous watershed restoration planning exercise in B.C.

habitat drivers in lakes within the subbasin (table 4.53). For each 6th-code HUC, the technical team used quantitative data (when it existed) and professional knowledge and judgement to score each of the attributes for each HUC. We did the same for selected lakes (table 4.54).

Table 4.55 ranks stream habitat attributes for kokanee averaged across the regulated mainstem HUCs in the U.S. portion of the subbasin. Tables 4.56 and 4.57 rank stream habitat-attributes for kokanee averaged across all tributary 6th-code HUCs in the U.S. and B.C. portions of the subbasin, respectively. Tables 4.58 and 4.59 show the ranking by 4th-code HUC for the U.S. and B.C. portions of the subbasin. Table 4.60 ranks habitat attributes for subbasin reservoirs in both Canada and the U.S. The rankings provide a good indication of the subbasin's ability to provide key ecological correlates required for kokanee viability and persistence and the habitat attributes that may be the most limiting for kokanee in the subbasin.

Based on this analysis, of the eleven stream habitat attributes considered key to resident salmonids, the most degraded for kokanee trout in tributaries in the U.S.

LINKS

Appendix 62 presents the results of a GIS-based fisheries vulnerability analysis conducted by the Cohesive Strategy Team of Region 1 of the USFS.

Click Here

Table 4.53. Habitat attributes used in the Kootenai Subbasin Lacustrine QHA analysis of selected lakes with definitions.

Attribute	Brief Definition
Temperature	Duration and amount of high or low water temperatures that can be limiting to fish survival
Dissolved Oxygen	Dissolved oxygen in water column and stream substrate
Gas Saturation	Percent water is saturated (<100%) or super-saturated (>100%) with Nitrogen gas
Volumetric Turnover Rates	Time required to replace entire reservoir with new water based on rate of its downstream expulsion
Pollutants	Introduction of toxic (acute and chronic) substances into the lake or reservoir
Trophic Status	Level (status) of biological productivity in lake or reservoir
Entrainment	Downstream fish loss through a hydropower dam, other than through a spillway of fish ladder
Migratory Obstacles	Natural and artificial barriers to upstream and/or downstream fish migration
Macrophytes	Emergent and submergent aquatic plant species and community structure in lakes and reservoirs
Hydraulic Regime	Temporal and volumetric characteristics of hydrograph
Shoreline Condition	Physical condition of water-land interface, riparian and varial zones
Habitat Diversity	Relative degree of habitat heterogeneity
Substrate Condition	Physical condition of substrates

Appendix 63 presents the results of an American Wildlands GIS-based, coarse-scale analysis of the current condition of native aquatic integrity across an Upper Columbia basin (called the Aquatic Integrity Areas (AIA) model). Go also to: http://www.y2y.net/science/aquatic_research.asp#aia

Click Here

Table 4.54. Lakes assessed in the Kootenai Subbasin using the Lacustrine QHA spreadsheet tool.

Lake	Location
Kootenay Lake	Canada
Moyie Lakes	Canada
Duncan Lake	Canada
Trout Lake	Canada
Koocanusa Reservoir	U.S./Canada
Kilbrennan	U.S.
Loon Lake	U.S.
Bull Lake	U.S.
Sophie Lake	U.S.
Boulder Lake	U.S.
Granite Lake	U.S.
Leigh Lake	U.S.
Therriault Lake	U.S.
McArthur Lake	U.S.

Table 4.55. Ranking of key habitat attributes for the regulated mainstem in the U.S. portion of the Kootenai Subbasin for kokanee based on a QHA analysis.

Habitat Attributes	Score	Rank
Oxygen	0.00	1
High Temperature	0.13	2
Obstructions	0.27	3
Habitat Diversity	0.50	4
Pollutants	0.50	4
Riparian Condition	0.67	5
Channel stability	0.80	6
Fine sediment	0.80	6
Low Temperature	0.80	6
High Flow	1.07	7
Low Flow	1.33	8

Table 4.56. Ranking of key habitat attributes for 6th-code HUC tributary watersheds in the U.S. portion of the Kootenai Subbasin for kokanee based on a QHA analysis.

Habitat Attributes	Score	Rank
Low Temperature	0.05	1
Oxygen	0.07	2
Obstructions	0.08	3
Habitat Diversity	0.23	4
High Flow	0.27	5
Low Flow	0.27	5
Riparian Condition	0.30	6
Fine sediment	0.37	7
Channel stability	0.43	8
High Temperature	0.43	8
Pollutants	0.47	9

Table 4.57. Ranking of key habitat attributes for 6th-code HUC watersheds in the B.C. portion of the Kootenai Subbasin for kokanee.

Habitat Attribute	Score	Rank
Low Flow	0.00	1
Oxygen	0.00	1
Low Temperature	0.00	1
High Temperature	0.00	1
Pollutants	0.00	1
Obstructions	0.00	1
High Flow	0.04	2
Habitat Diversity	0.14	3
Riparian Condition	0.17	4
Fine sediment	0.21	5
Channel stability	0.22	6

Table 4.58. Ranking of key stream-habitat attributes for the regulated mainstem and tributaries at the HUC-4 scale for kokanee in the U.S. portion of the subbasin based on a QHA analysis of all 6th-field HUCs. The most limiting attributes are highlighted in yellow.

	Regulated Mainstem		Lower Kootenai		Moyie	
Habitat Attribute	Score	Rank	Score	Rank	Score	Rank
Channel stability	0.80	6	0.47	9	0.27	3
Fine sediment	0.80	6	0.40	7	0.27	3
Habitat Diversity	0.50	4	0.25	4	0.17	2
High Flow	1.07	7	0.27	5	0.27	3
High Temperature	0.13	2	0.47	9	0.27	3
Low Flow	1.33	8	0.25	4	0.33	4
Low Temperature	0.80	6	0.07	1	0.00	1
Obstructions	0.27	3	0.10	3	0.00	1
Oxygen	0.00	1	0.08	2	0.00	1
Pollutants	0.50	4	0.42	8	0.67	5
Riparian Condition	0.67	5	0.29	6	0.33	4

Table 4.59. Ranking of key stream-habitat attributes at the HUC-4 scale for kokanee in the B.C. portion of the subbasin based on a QHA analysis of all 6th-field HUCs.

	Duncan Lake		Kootenay Lake		Slocan	
Habitat Attribute	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**
Channel stability	0.29	5	0.14	4	0.30	6
Fine sediment	0.22	4	0.14	4	0.40	7
Habitat Diversity	0.13	2	0.13	3	0.19	4
High Flow	0.00	1	0.06	2	0.13	3
High Temperature	0.00	1	0.00	1	0.00	1
Low Flow	0.00	1	0.00	1	0.00	1
Low Temperature	0.00	1	0.00	1	0.00	1
Obstructions	0.00	1	0.00	1	0.02	2
Oxygen	0.00	1	0.00	1	0.00	1
Pollutants	0.00	1	0.00	1	0.00	1
Riparian Condition	0.15	3	0.17	5	0.25	5

Table 4.60. Ranking of key habitat attributes for reservoirs in the Kootenai Subbasin for kokanee based on an LQHA analysis.

Reservoirs	Score	Rank
Oxygen	0.00	1
Gas saturation	0.00	1
Macrophytes	0.00	1
Habitat diversity	0.01	2
Pollutants	0.03	3
Shoreline condition	0.05	4
Substrate condition	0.05	4
Temperature	0.06	5
Entrainment	0.08	6
Trophic status	0.12	7
Migratory obstruction	0.12	7
Volumetric turnover rates	0.31	8
Hydraulic regime	0.40	9

portion of the subbasin (when averaged across all the tributary HUCs) are pollutants, altered thermal regime, channel stability, and fine sediment, in that order. In the regulated mainstem they are altered hydrograph, altered thermal regime, fine sediment, and channel stability. In the B.C. portion of the subbasin they are channel stability, fine sediment, riparian condition, and habitat diversity. The rankings vary at the HUC-4 scale. Of the thirteen lake-habitat attributes considered key to resident salmonids, the four most limiting to kokanee in reservoirs are hydraulic regime, volumetric turnover rates, migratory obstructions, and trophic status.

4.4.4 Kokanee Limiting Factors and Conditions

Dams

As previously mentioned, hydro-developments have by far had the greatest impact on kokanee populations in the Subbasin. Three types of impacts are evident:

1. Physical displacement: The loss of the lower Duncan River due to construction of the dam just below the outlet of the former Duncan Lake resulted in theloss of approximately 10 km of spawning habitat that supported an estimated 2.8 million kokanee in 1964 and approximately 1 million kokanee annually from 1965-1967. There are no known shore spawners in the main portion of Kootenay Lake, therefore annual drawdown regulation does not impact kokanee. Some shore spawning in the West Arm is affected by the drawdown.

2. Nutrient uptake in upstream reservoirs: Koocanusa reservoir is relatively productive and ties up much of the nutrients that would otherwise flow into Kootenay Lake. The Arrow Lakes Reservoir has experienced a similar fate due to nutrient uptake in upstream Mica and Revelstoke Reservoirs (Pieters et al. 2003). The response of kokanee to lake fertilization in Kootenay and Arrow Lakes Reservoir has been well documented (Ashley et al. 1997; Andrusak 2003; Andrusak 2002).

3. Lake level drawdown: Most noticeable in the West Arm of Kootenay Lake. Dewatering of extensive littoral zones impacts rearing kokanee fry that inhabit and feed in the shallow areas of the West Arm after out-migrating from the streams (Andrusak 2000). Reduction in the peak of the hydrograph has resulted in fewer mysids being swept over the sill at Balfour, B.C. thus adversely affecting growth and survival rates.

LINKS

Appendix 64 lists the waters in Montana Fish, Wildlife & Park's Region One that have tested positive or have questionable results for fish pathogens. Further queries may be conducted at: http://www.esg.montana.edu/nfhdb/fh1.html

Click Here

Grazing and agricultural practices

Lower floodplain reaches of several streams in northern Idaho have been adversely impacted by the grazing of domestic animals in the riparian zone (EcoAnalysts, Inc. 1998; KTOI and Kruse 2002; KTOI and Kruse 2004a; and KTOI and Kruse 2004b). Due to the use of spring to fall seasonal grazing practices, riparian use by animals probably affects rearing salmonids more so than spawning kokanee. However, animals do affect the quality of spawning habitat during the spring and summer by grazing down the riparian vegetation, increasing erosion and bedload movement, and disrupting stream substrates.

The Results of QHA

In our HUC-by-HUC assessment of all Kootenai Subbasin 6th-code HUCs in the U.S., the technical team concluded that of the habitat attributes considered most important to resident salmonids, the most limiting for kokanee, when averaged across all the HUCs in the U.S. portion of the subbasin, were low flow, channel stability, high flow, and fine sediment, in that order. In the B.C. portion of the subbasin they were channel stability, fine sediment, riparian condition, and habitat diversity. In the lakes assessed, the limiting factors were hydraulic regime, volumetric turnover rates, migratory obstructions, and trophic status. This phase of the HUC assessment considered only habitat factors.

4.5 Burbot (*Lota lota*)

4.5.1 Background

Burbot are common throughout their Holarctic distribution, but in some regions of their natural range they have either been extirpated or are at risk. They are also described as common throughout the upstream reaches of the Columbia River Basin in the northwestern U.S., and in much of Canada (Scott and Crossman 1973; McPhail and Paragamian 2000). McPhail and Lindsey (1970) indicated that burbot were relatively abundant in the other drainages of western Canada. Local distribution and stock status have been investigated throughout the burbot's range. Specific assessments have occurred in Asia (Nelichik 1979; Nikiforov 1992), Canada (Lindsey 1956; Hatfield et al. 1972; Paragamian et al. 2001), Alaska (Hallberg 1986; Peckham 1986; Parker et al. 1987; Parker et al. 1988; Lafferty et al. 1990), and the northern United States (Robins and Deubler 1955; Muth 1973; Clady 1976; Edsall et al. 1993).

The most reliable burbot population estimates come from a stock assessment program on lacustrine populations in Alaska (Bernard et al. 1991; Lafferty et al. 1990, 1991, 1992; Evenson 1993b; Lafferty and Bernard 1993; Parker 1993). Across a variety of lakes, adult burbot (>450mm) density estimates ranged from 0.24-21.9 per ha^{-1}. The highest recorded adult densities (139 per ha^{-1}) were from southwestern Lake Michigan at Julian's Reef (Edsall et al. 1993). Based on most recent (2003) stock assessment modeling of burbot in the Kootenay Lake/lower Kootenai River portion of the Subbasin, abundance estimates ranged between 50 and 500 fish in the Bonners Ferry to Kootenay Lake reach, likely closer to 50 than 500 (Ray Beamesderfer, S.P. Cramer and Associates, pers. comm. Sept. 2003). No other more current population abundance estimates exist for Kootenai Subbasin burbot.

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

In Kootenay Lake the species has been red-listed by the B.C. Conservation Data Centre, and anglers can no longer harvest burbot from this system.

LINKS

The petition for the listing of burbot under the ESA can be viewed at: http://www.wildlands.org/w_burbot_pet.html

Click Here

The Federal Register 12-month Finding for the Petition to list the Lower Kootenai River Burbot (Lota lota) can be downloaded at: http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/2003/pdf03-5737.pdf

Click Here

LINKS

Burbot information generated by State, federal, and tribal biologists working in Montana is available from the Montana Fisheries Information System (MFISH) database accessible on the internet at: http://nris.state.mt.us/scripts/esrimap.dll?name=MFISH&Cmd=INST.

Click Here

For fisheries information for the Kootenai in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

Reasons for Selection as Focal Species

Throughout their geographic range, burbot (*Lota lota*) historically exhibited fluvial, adfluvial, and lacustrine life history strategies (Paragamian and Willis 2000, and references therein). Successful expression of these life history strategies required suitable tributary, mainstem river, and/or lake (reservoir) habitat conditions. Burbot populations specifically require functional, cold water, ecosystems to successfully reproduce, recruit, and persist. Kootenai River Subbasin burbot persisted because these conditions existed within the Subbasin following postglacial recolonization by burbot and other native fishes, some 10,000-12,000 years ago, after the retreat of the most recent glaciation (Wisconsin period, Alden 1953). Because of their ecological sensitivity, Kootenai Subbasin burbot serve as a valuable focal species for Subbasin Planning purposes. The imperiled status of some Subbasin burbot stocks indicates compromised aquatic ecosystem health and function within the Subbasin (figure 4.17). The global rank for the Lower Kootenai population is G5T1 because burbot are "likely isolated in the lower Kootenai River in British Columbia, Idaho, and Montana; declining in abundance and in number of spawning sites, likely due to flow, temperature, and nutrient impacts of Libby Dam; current regulations and conservation efforts have not reversed the decline." Also, the burbot is a culturally significant species to the Kootenai Tribe of Idaho and provided vital subsistence use in the winter months. For all of these reasons we have selected burbot as a focal species in this assessment.

Summary of Population Data

Overall, there are very few burbot left in the Kootenai River between Kootenay Lake and Kootenai Falls. The greatest concentration occurs seasonally (spawning migration) near and in the Goat River in B.C., and even there the numbers are quite small. However, burbot currently exist in and upstream from Koocanusa Reservoir, in adjacent downstream areas, and were reported as seasonal inhabitants of Idaho waters of the Kootenai Subbasin (Partridge 1983). Recently, most of the burbot have been collected in the general vicinity of the Goat River confluence, near the town of Creston, B.C. The majority of empirical telemetry data, as they relate to burbot movements in the fall and winter (spawning) period, have been collected in this part of the Kootenay River. With few exceptions, documented upstream migrations were relatively short. Very few burbot have been recently collected in Idaho (table 4.61), and almost all were captured in the Ambush Rock area (figure 4.17). Modeling results suggested that the West Arm (Kootenay Lake) burbot population size prior to 1967 numbered approximately 200,000 individuals (Ahrens and Korman 2002). The estimated trend in age-1 recruitment indicated a substantial increase of recruits in the early 1960s, peaking in 1964

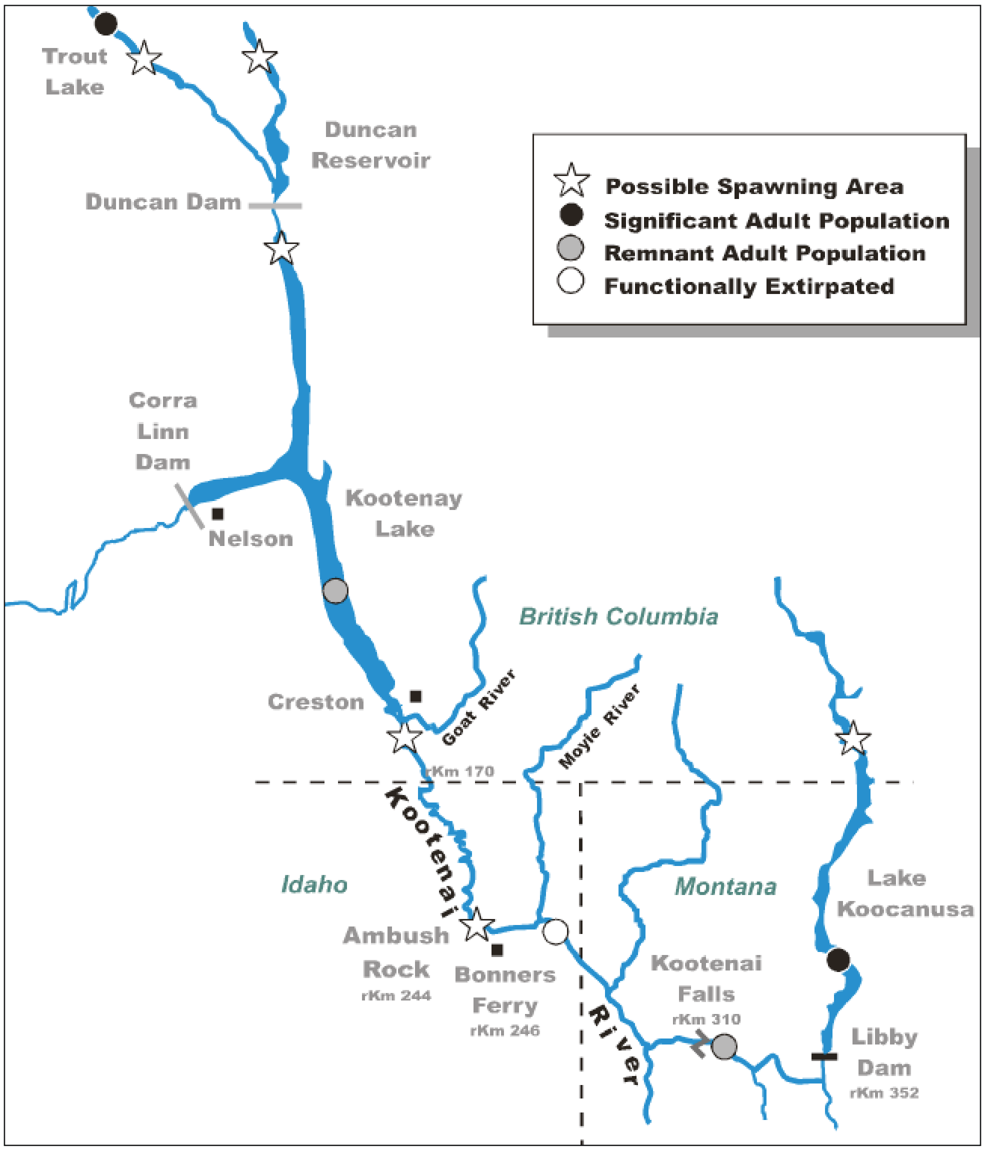

Figure 4.17. Distribution of burbot (Lota lota) within the Kootenai River Subbasin. Symbols indicate general location and status of existing burbot populations. (From KVRI Burbot Committee 2004).

and failing by the late 1960s. It seems reasonable to assume the burbot fishery collapsed as a result of the recruitment failure, but the collapse may have been accelerated substantially by unsustainable harvest rates.

Historic and Current Distribution[1]

Burbot is the single freshwater species of the cod family (Gadidae), and has a wide, circumpolar distribution (McPhail 1997; Scott and Crossman 1973). In North America, burbot are found throughout most of Canada and in the northern third of the U.S. (Scott and Crossman 1973). Owing to its widespread distribution, especially in the remote northern regions of its range, the species as a whole is healthy and thriving. Toward the southern edge of the species range however, some burbot populations are in jeopardy for a variety of reasons. The B.C. and Idaho portion of the Kootenai River Subbasin is one such area where the continued existence of local burbot populations is in question. In Montana, their existence is also questionable in the Kootenai River below Libby Dam, but there is not enough information to whether the species is in peril above Libby Dam.

Historic Distribution

Historically, burbot were distributed throughout the Kootenai River Subbasin, however, their natural distribution does not appear to have been contiguous. Although burbot existed in numerous adjacent watersheds in British Columbia (e.g., Arrow Lakes, Columbia River, Slocan Lake), burbot in the Kootenai system were historically isolated from those watersheds by the impassable Bonnington Falls, located downstream from Nelson, B.C. and now inundated between dams. This geographic isolation is reported to occur post-glacially from 10,000-12,000 years ago (Alden 1953; Northcote 1973). Kootenai Falls in Montana was reported to be a natural upstream barrier to burbot passage. However, burbot and burbot fisheries historically existed upstream from both falls, and burbot can successfully move downstream through this upstream migration barrier. Numerous dams (e.g. Cora Linn, 1931; Duncan, 1967; and Libby, 1972) have further restricted the distribution and movements of Kootenai Subbasin burbot.

The largest burbot concentrations were believed to have inhabited the Balfour area near the inlet to Kootenay Lake's West Arm, and to a lesser extent seasonally inhabited the Kootenai River from Kootenay Lake to Kootenai Falls (figure 4.17). Based on empirical reproductive data collected from fisheries, at least two distinct burbot stocks likely existed in Idaho and British Columbia. One was a lacustrine population in Kootenay Lake, the other a fluvial or adfluvial population in the Kootenai River. Temporal and geographic reproductive isolation appears sufficient to infer reproductive isolation (Martin 1976; Hammond and Anders 2003). However, burbot stock status throughout the entire Subbasin

[1] *The information presented here on historic and current burbot distribution in the Kootenai Subbasin was largely excerpted from Hammond and Anders (2003).*

remains uncertain. Stock separation at Kootenai Falls in Montana has also been suggested based on mtDNA analysis (Paragamian et al. 1999).

Current distribution

Currently, most burbot in the Kootenai River Subbasin exist in three separate lake systems: Koocanusa Reservoir in Montana, Duncan Reservoir in B.C., and Trout Lake in B.C. (figure 4.17). Little is known about the distribution of burbot in Koocanusa Reservoir and the upper Kootenai River upstream from the lake. Distribution of burbot in Duncan Reservoir and Trout Lake was addressed in Spence (2000), Neufeld and Spence (2001), Spence and Neufeld (2002), and Baxter et al. (2002a, 2002b). In addition, Bisset and Cope (2002) indicated that a viable burbot population exists in Moyie Lake based on a 2002 creel survey. There is a modest burbot fishery at Moyie Lakes from mid-January to the end of February, however, over the last 15 years the daily possession limit for burbot in the Kootenay Region has been reduced from 15 to 2 fish. Burbot have been observed during the last few years in the North Arm of Kootenay Lake (Spence 1999), at the confluence of the Goat River and the Kootenai River (Paragamian 1995; Bisset and Cope 2002), and in the mainstem Kootenai River, primarily at Ambush Rock, just downstream from Bonners Ferry, Idaho (rkm 244; Paragamian et al. 2001). However, current burbot abundance in these locations is believed to be a fraction of historic levels. Only two burbot have been captured in the Balfour area of the West Arm of Kootenay Lake in recent years: one in 1997 and one in 1998 (Spence 1999). Recent underwater photography on the historical Balfour "ling beds" revealed that substrates in these areas are now covered (literally) with suckers (Catastomidae), which may have opportunistically filled the demersal niche vacated by lost (overharvested) burbot stocks.

Very few burbot remain in the Kootenai River between Kootenay Lake and Kootenai Falls. The largest concentration, which is actually quite small, occurs seasonally (spawning migration) near and in the Goat River in B.C. However, burbot currently exist in and upstream from Koocanusa Reservoir, in adjacent downstream areas, and were reported as seasonal inhabitants of Idaho waters of the Kootenai Subbasin (Partridge 1983). Recently, most burbot in this section of the Subbasin have been collected in the general vicinity of the Goat River confluence, near the town of Creston, B.C. The majority of empirical telemetry data (as they relate to burbot movements in the fall and winter (spawning) period) have been collected in this part of the Kootenay River. With few exceptions, documented upstream migrations were relatively short. Very few burbot have been collected recently in Idaho (table 4.61), and almost all were captured in the Ambush Rock area (figure 4.17).

Table 4.61. Summary of burbot sampling efforts in Kootenai River and Kootenay Lake.

Year/ Month	Location	Capture Method	Number of Burbot Caught	CPUE	Reference
1957-58	Kootenai River	Unknown	199	Unknown	Paragamian et al. 2000
1979-82	Kootenai River	3 gear types	108	Unknown	Partridge 1983
1993, March-June	Kootenai River, rkm 225-273	Hoop traps	17	0.03 fish/net- day	Paragamian 1994
1994	Kootenai River	Hoop traps	8	0.009	Marcuson et al. 1994
1994-1995, November-February	Kootenay River, B.C., rkm 145-170	Hoop traps	33	0.047 fish/net- day	Paragamian 1995
1995, April-June	Kootenai(y) River, rkm 115-245	Larval fish net, Minnow traps, Beach seine, Electrofishing	0 larval burbot, 1 juvenile burbot	Unknown	Fredericks and Fleck 1995
1995-1996, November-March	Kootenai(y) River, rkm 120-178	Hoop traps	28	0.055 fish/net-day	Paragamian and Whitman 1997
1997	Kootenay River delta, Balfour, Pilot Bay, Duncan River outlet	Set lines, Hoop traps	8	28,000 hook hours; 12,981 hours hoop trap	Redfish Consulting Ltd. 1998
1997, July; 1998, June	West Arm Kootenay Lake (inlet to Akokli Creek)	Hoop traps	1 in 1997 1 in 1998	unknown	Spence 1999
1998, June-August	Kootenay Lake, Duncan River, Goat River	Electrofishing, Minnow traps, Beach seine	1 juvenile	0.01 fish* 100s-1	Spence 1999
1998-1999, January-March	Kootenay Lake, Duncan River	Hoop traps, Cod traps	20	0.051 fish/ 100 h (hoop traps)	Spence 1999
1999-2000, October-April	Kootenai(y) River, rkm 144-244	Hoop traps	36	0.0216 fish/net-day	Paragamian, Kozfkay, and Whitman 2001
2000, April-May; 2001, February-March	Kootenay Lake: Balfour, Sunshine Bay, Queen s Bay	Cod traps	1	0.004	Baxter et al. 2002a
2001, January-March	Kootenay Lake: Balfour, Sunshine Bay, Nine Mile Narrows, Queen s Bay	ROV (remote operated vehicle)	0	0	Baxter et al. 2002a
2002, February	Kootenay Lake	TOV (towable operated video camera)	0	0	Baxter et al. 2002b
2002, January-February	Goat River	Fish fence/trap	15	0.03 fish/hour	Bisset and Cope 2002

Note: Specific information is presented only if provided in the original reference; for example, sampling months and CPUE units are not provided in all references.

In Montana, practically all the burbot information came from the Koocanusa Reservoir area. Telemetry data indicated upstream movements during the winter (spawning) period, some as far as the St. Mary River in B.C. (~ 75 km) (Ostrowski et al. 1997).

Status of Burbot Introductions, Artificial Production and Captive Breeding Programs

No burbot have been introduced into Idaho, Montana, or British Columbia waters of the Kootenai River Subbasin. No within-basin introductions or translocations of native burbot have occurred into these waters, with the following exception, reported in the paragraph that follows. Currently (2003), all burbot inhabiting the Kootenai River Subbasin are wild fish, with no effects from non-native burbot stock introductions, artificial production, or captive breeding programs.

During 2002, twenty burbot from Duncan Reservoir in B.C. were transported to the Kootenai Hatchery near Bonners Ferry, Idaho, to serve as experimental brood stock to help develop burbot conservation aquaculture techniques. An additional twenty fish were transferred during 2003. However, these twenty fish are expected to be subsequently transferred to the University of Idaho's Aquaculture Research Institute for the development of burbot culture techniques and systems based on an international agreement of conditional fish use between the British Columbia Ministry of Water, Land, and Air Protection; the Kootenai Tribe of Idaho; the Idaho Department of Fish and Game; and the University of Idaho (Sue Ireland, KTOI, pers. comm. 2003).

LINKS

See the 2004 annual report on preliminary investigations into the feasibility of developing conservation aquaculture techniques for burbot.

Click Here

To date (2003), three experimental burbot spawning operations have occurred within the Subbasin: one at Montana Fish, Wildlife & Parks' Libby Field Station during the early 1990s, and two in the Kootenai Hatchery, in Bonners Ferry, Idaho, during the late winters of 2002 and 2003. The spawning attempt at the Libby Field Station produced several larvae that survived only a few days post-hatch. Currently (2003), no artificial burbot production in Idaho, Montana, or B.C. waters of the Kootenai Subbasin has ever resulted in surviving progeny. Thus, all burbot within the Subbasin remain wild, with no effects from artificial production.

No captive breeding programs using reared, captive brood stock have occurred, exist, or are currently (2003) proposed within the Kootenai Subbasin. However, the Kootenai Tribe of Idaho is currently embarking on an experimental culture program to: (1) assess conservation aquaculture as a potential recovery tool for Kootenai River burbot, and (2) possibly help prevent extinction of local burbot stocks (Cain et al. 2003). This experimental program represents the only current burbot culture activities in the Subbasin, but does not rear and spawn captive brood stock.

The first year of an experimental burbot aquaculture feasibility study was completed during the summer of 2004 at the University of Idaho's Aquaculture Research Institute (Cain and Jensen 2004). System design, brood stock holding and spawning, fertilization, incubation, and larval and juvenile rearing and feeding were addressed. All 20 burbot brood stock were successfully spawned, using three distinct spawning treatments: (1) natural spawning (no hormone treatment), (2) hormone injection, and (3) hormone implant. Fertilization rates generally exceeded 90 percent across all fertilization trials. Four types of incubators were used for burbot embryos, yielding mixed results. McDonald jars appeared to work best, based on observed hatching success among the different incubator designs. Handling stress contributed to larval mortality until the larvae were clearly eating enriched rotifers, at which time they began to exhibit a slight tolerance to handling stress. This feature made grading fish by size problematic. Cannibalism among larvae and juveniles is an additional challenge to overcome in burbot aquaculture, based on the literature and as was observed in this study. Handling stress and mortality-associated with grading will be evaluated relative to stress and mortality associated with cannibalism to further develop conservation aquaculture techniques that maximize larval and juvenile survival.

Juveniles approximately 20 mm in length exhibited a notable behavioral shift, including consistent attempts to hide and use any available cover, such as air stones, corners, screening, and tank-wall junctions. Primary (exogenous) feeding proved to be a delicate process that included algal cells and rotifers. Larvae fed exclusively artificial feed resulted in high mortality, whereas larvae and juveniles survived better on natural feed.

The first year of conservation aquaculture feasibility assessment provided a wealth of valuable information about culture systems and techniques required to successfully culture burbot. Further testing of methods and apparatus based on the first year of this study (2003-2004) is planned. Based on the first year's results, and the magnitude of challenges already overcome, it appears likely that burbot culture techniques will be successful and suitable for conservation aquaculture purposes

Historic Harvest[2]

Historically, Kootenai River Subbasin burbot supported numerous and varied fisheries between Bonnington Falls and Kootenai Falls. Traditionally, Native Americans targeted burbot during the winter spawning period as a source of

[2] *Parts of the historical harvest section were excerpted from Hammond and Anders (2003), KVRI Burbot Committee (2004), Anders et al. (2002) and Paragamian et al. (2002).*

fresh meat. Recreational burbot fisheries subsequently occurred throughout much of the Subbasin, although most were often highly localized and appear to have been associated with burbot reproductive aggregations.

Numerous credible, independent, written accounts of significant burbot harvest suggest that Dustbowl immigrants to the Idaho portion of the Subbasin were responsible for significant and unregulated burbot harvest during the 1930s (KVRI Burbot Committee 2003). Following harvest during the 1930s and 1940s, a winter commercial burbot fishery persisted into the 1950s and 1960s in the Idaho portion of the Subbasin. Partridge (1983) reported that local residents harvested and canned burbot during the winter months to supply their personal needs through the summer or for sale in local stores. Burbot were still reported to be abundant during the 1950s, with one angler selling 380 kg (838 lbs) in 1951, and a Bonners Ferry market handling 1,800 kg (3,940 lbs) of burbot during 1957. (However, "abundant" in this context is subjective. Without quantified time series burbot abundance data, perspectives can change across human generations. In other words, abundant burbot to one generation of human residents may have constituted a significantly reduced population to the previous generation). Three additional fishermen harvested over 2,000 kg (4,409 lbs) of burbot from the Kootenai River during 1958 (IDFG unpublished data). Anglers reported catching as many as 40 burbot per night during winter setline fishing trips in the Kootenai River, where past annual burbot harvest was estimated at approximately 22,700 kg (50,053 lbs) (Paragamian and Whitman 1996). This annual harvest weight represents just over 10,000 5-lb fish, or 16,684 3-lb fish, which does not appear to be sustainable.

Furthermore, the harvesting of burbot targeted fish in spawning aggregations in or near Kootenai River tributaries in Idaho, further reducing the probability of subsequent population persistence. Because no historical population abundance estimates existed for burbot in Idaho Subbasin waters, burbot catch rates were substituted to infer historical population status in this part of the Subbasin. Repeated annual harvest of the magnitudes reported above, in conjunction with unreported harvest, likely had considerable negative effects on demographic and genetic integrity of burbot stocks that historically reproduced in Idaho waters of the Kootenai Subbasin. This in turn may have negatively affected natural recruitment for subsequent decades during the early to mid 1900s.

In Kootenay Lake in B.C., there was a heavily utilized burbot fishery during the late winter-spring period at the upper end of the West Arm. Although the seasonal timing of these fisheries varied, all of them collapsed and remain so today. This population supported popular sport and commercial fisheries throughout the basin (table 4.62).

Table 4.62. Balfour burbot fishery statistics 1967-1986

Year	Harvest	Effort (hours)	CPUE (fish/hr)
1967	7,567	7,500	1
1968	12,690	15,240	0.83
1969	25,920	17,460	1.48
1970	8,880	15,840	0.56
1971	20,647	21,565	0.96
1972	18,930	31,680	0.6
1973	2,305	8,280	0.28
1974	11,012	10,920	1.01
1975	6,802	7,258	0.94
1976	4,139	6,330	0.65
1977	1,820	3,567	0.51
1978	3,227	4,864	0.66
1979	852	1,259	0.68
1980	1,378	1,874	0.74
1981	443	890	0.5
1982	993	1,213	0.82
1983	689	1,238	0.56
1984	223	359	0.62
1985	296	469	0.63
1986	20	295	0.06

Current harvest

It is illegal to kill a burbot in Kootenay Lake, B.C., however, fishing is allowed for burbot in Lake Koocanusa (although the Montana portion of Koocanusa is closed to burbot retention from January 15 to February 28), the upper Kootenay River in B.C., Duncan Lake, the Kootenai River from Libby Dam downstream to the Montana-Idaho border, and Moyie Lake. Over the last 15 years the daily possession limit for burbot in the Kootenay Region of B.C. has been reduced from 15 to 2 fish. In Montana, the limit is five daily and in possession.

4.5.2 Population Delineation and Characterization

Population Units

Initial mtDNA analysis of burbot population structure in the Subbasin (Paragamian et al. 1999) suggested that fish downstream from Kootenai Falls form a separate genetic group from burbot upstream from the falls. Fisheries managers in Idaho and Montana currently use these findings to manage burbot in these two areas as genetically divergent (different) stocks. This genetic study also reported that burbot from the Idaho portion of the Kootenai River were insignificantly different from those in Kootenay Lake. Hammond and Anders (2003) reviewed the mtDNA analysis of Kootenai Subbasin burbot (Paragamian et al. 1999), and provided additional interpretation of the published findings. Fisheries agencies within the Subbasin are currently (2003) pursuing microsatellite DNA analysis to further refine the current understanding of burbot population structure in the Subbasin.

Life history[3]

Burbot normally complete their life cycle in freshwater and rarely enter marine environments. However, they have been documented in estuaries and brackish lagoons (Preble 1908; Percy 1975; Pulliainen et al. 1992). Burbot residence in saltwater appears transitory, and a high proportion of adult burbot are either sterile or fail to mature under brackish conditions (Pulliainen and Korhonen 1990). Burbot are cold water spawners during highly synchronized communal spawning periods, with reported optimal spawning and incubation temperatures from 0 to 4 °C (Bjorn 1940; Andersson 1942; Clemens 1951b; McCrimmon and Devitt 1954; Lawler 1963; Meshkov 1967; Chen 1969; Johnson 1981; Kouril et al. 1985; Sandlund et al. 1985; Breeser et al. 1988 Boag 1989; Arndt and Hutchison 2000; Evenson 2000). Eggs are thought to drift in the water column and lodge in interstitial spaces in the substrate.

LINKS

For more life history information on burbot, go to the Kootenai River/Kootenay Lake Burbot Conservation Strategy. See Appendix 99.

Click Here

The Kootenai River Burbot Conservation Committee's Conservation Strategy provides a more comprehensive review of burbot life history and habitat requirements and behaviors of all burbot life stages.

Burbot life span varies geographically, and northern populations generally contain older fish than southern populations (McPhail and Paragamian 2000). Maximum ages recorded in northern populations ranged from 20 to 22 years (Hatfield et al. 1972; Nelichik 1979; Guinn and Hallberg 1990). Maximum age of burbot in Canada is likely in the range of 10 to 15 years (Scott and Crossman 1973). In Quebec, Magnin and Fradette (1977) noted that burbot older than 7 years are uncommon at latitude 45 °N, but adults ranged from 8 to 12 years at latitude 55 °N.

Fecundity

Individual female burbot fecundity falls within the upper range for freshwater fishes. Bailey (1972) reported an average of 812,300 eggs per female. Additional estimates ranged from 6,300 to 3,477,699 eggs per female (Miller 1970; Roach and Evenson 1993). However, average fecundity can vary substantially between lakes in the same region (Boag 1989), and a positive relation exits between length

[3] *The life history model (figure 4.18) and some of the text describing burbot life history was excerpted from the Kootenai River/Kootenay Lake Burbot Conservation Strategy (KVRI Burbot Committee 2004).*

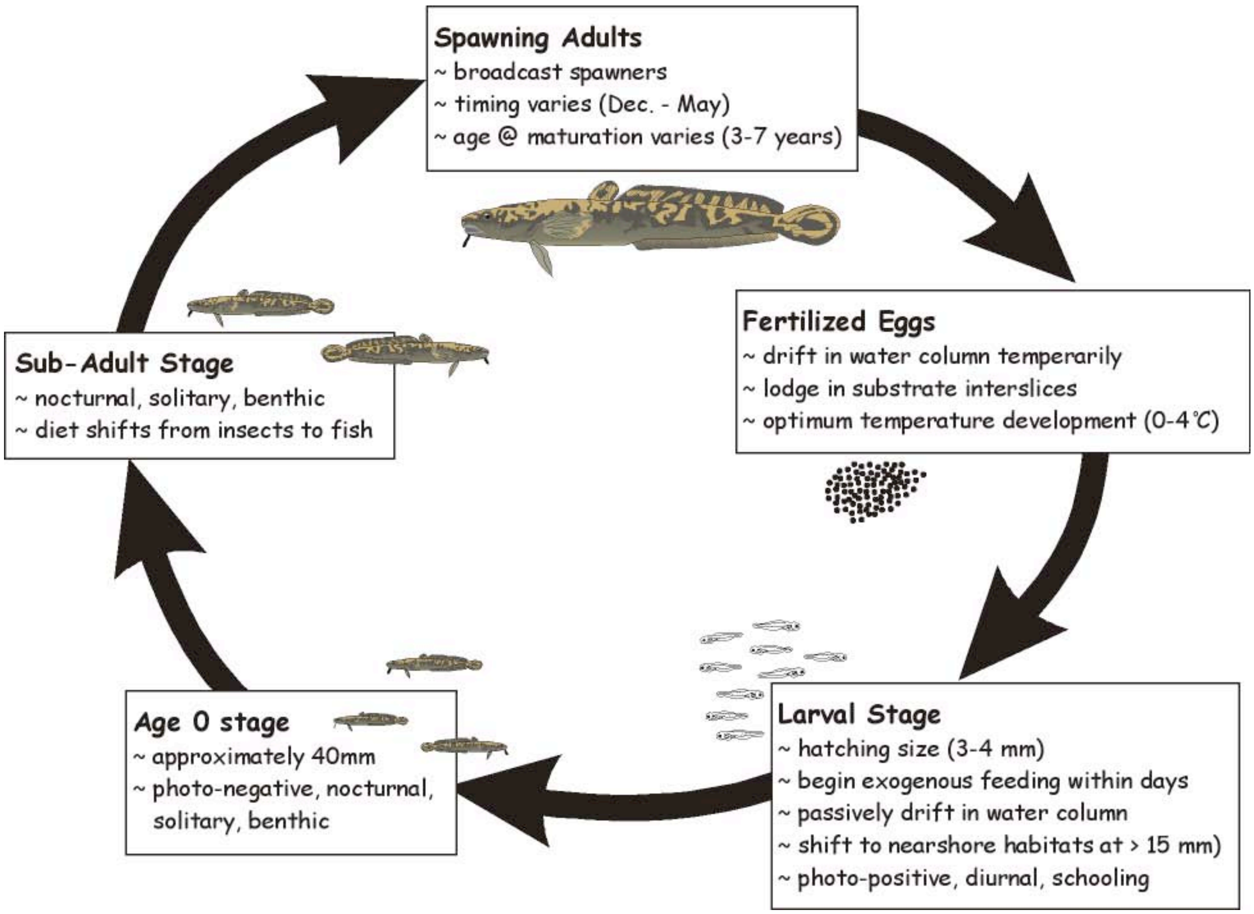

Figure 4.18. A general burbot life history model (From KVRI Burbot Committee 2004).

and fecundity, although the effect of size on fecundity is not as pronounced as in many other fish species (Boag 1989; Roach and Evenson 1993).

Embryo development

As with most fish (poikilotherms), embryo development and mortality rates are temperature dependent, such that development is faster at higher temperatures and mortality increases on either side of an optimal incubation temperature (McPhail and Paragamian 2000). Most researchers agree that the optimum temperature for burbot zygote development is between 0 and 4 °C (Andersson 1942; McCrimmon 1959; Lawler 1963; Meshkov 1967; Sorokin 1971; Ryder and Pesendorfer 1992). Incubation periods have been reported as 41 days at 2 °C (Andersson 1942) and 98-128 days at 0 °C (Meshkov 1967).

Larval Stage

Newly hatched larval burbot were reported to be between 3 and 4 mm long (McCrimmon 1959; Ghan and Sprules 1991; Fischer 1999). Burbot larvae are capable of exogenous feeding within a few days post-hatch (Ghan and Sprules 1991), but endogenous feeding can last between 11 and 23 days post-hatch (Fischer 1999). Larval densities can be high shortly after hatching but reportedly drop within a month (Ghan and Sprules 1991). Larvae are positively phototaxic, and exhibited diurnal and schooling behaviors (Girsa 1972).

In lakes, larval burbot are limnetic and planktonic, drifting passively in the water column (Clady 1976; Ghan and Sprules 1991; Ryder and Pesendorfer 1992; Wang and Appenzeller 1998; Fischer 1999). As they grow, improved swimming performance allows larvae to become more mobile. Larval depth appears to decrease as mobility increases and they are more commonly found feeding near the top of the water column. During early summer, larval burbot (>15 mm TL) seem to undergo a habitat shift to near-shore areas (Clady 1976; Ghan and Sprules 1991; Ghan and Sprules 1993).

Little is known of the fate of larval burbot in rivers, however, they likely drift downstream. This downstream drift may decrease in backwater areas or at physical obstructions that reduce river flow. As swimming performance improves, burbot conceivably are able to maintain position in low velocity areas of the river.

Age-0 Stage

At approximately 40 mm, burbot become negatively phototaxic (Girsa 1972). In lakes, this reversed reaction to light causes larval burbot to exhibit nocturnal, solitary, and benthic habitat use behaviors. Numerous researchers reported observing burbot feeding at night, and seeking shelter under rocks or other debris during the day (Lawler 1963; Boag 1989; Ryder and Pesendorfer 1992; Fischer and Eckmann 1997). The only exception to this appeared to be at latitudes above the Arctic Circle where Kroneld (1976) reported that age-0 burbot were night-active during summer and day-active during winter. Age-0 burbot grow rapidly and can reach 110-120 mm in total length by late fall (Chen 1969; Sandlund et al. 1985). Burbot continue to grow throughout winter (Boag 1989). In lakes, age-0 burbot are found in near-shore areas with adequate cover. Lawler (1963) and Boag (1989) observed age-0 burbot sheltered under stones and debris in shallow bays and along rocky shorelines.

Juveniles

Fischer and Eckmann (1997) documented a strong correlation between juvenile burbot distribution in the littoral zone and the presence of gravel substrate and large stones. Ryder and Pesendorfer (1992) noted that burbot fingerlings sheltered under rocks and debris where they excavated small burrows. In rivers, similar ontogenic habitat use shifts occurred, and age-0 burbot sought shelter in weed beds and under rocks, debris, and cut banks (Robins and Deubler 1955, Hanson and Qadri 1980).

Little is known about larval or juvenile burbot habitat use in the Kootenai River Subbasin because very few larval and juvenile burbot have been captured. Although most sampling focused on capturing adults, extensive juvenile sampling resulted in very low catch (Fredericks and Fleck 1995; Spence 1999; Paragamian et al. 2001). A juvenile burbot of about 350 mm TL was reported captured by backpack electrofishing in the Goat River in 1994 (Paragamian 1995). One YOY burbot (40 mm) was caught in the lower Kootenai River at the mouth of Trout Creek along the bottom at about 4 m depth; no habitat description was provided other than the benthic association (Fredericks and Fleck 1995). Paragamian and Whitman (2000) reported the capture of a larval burbot in the Kootenai River downstream of the confluence of the Goat River. Spence (1999) captured one YOY burbot at the north end of the north arm of Kootenay Lake; this fish was found among a cobble and boulder substrate in 30 cm of water.

Subadults

Subadult burbot were reported to occupy similar habitats as age-0 burbot (Clemens 1951a; Beeton 1956; Bishop 1975; Nagy 1985; Sandlund et al. 1985; Guthruf et al. 1990). Subadult burbot in the Kootenai Subbasin (i.e. <250 mm) were observed during the night at the north end of Kootenay Lake's North Arm. Although detailed habitat descriptions were not possible, substrate in areas used by subadult burbot appeared to consist primarily of fines, with woody cover occasionally in close proximity (Spence 1999; Baxter et al. 2002b). Such habitat may also have been used during nocturnal foraging forays.

Genetic Integrity

Although not affected by introductions, artificial production or captive breeding programs, the genetic integrity of burbot in the lower Kootenai River and Kootenay Lake has likely been compromised by severe demographic bottlenecks (reductions in abundance and natural recruitment) that occurred during the 1900s (See previous "Historical Status" section of this report for more details). Genetic integrity is directly linked to population size and success of reproductive strategies, both of which were largely compromised during the mid to late 1900s. Currently, riverine burbot populations within the Kootenai Subbasin, regardless of geographic population definition or genetic population structure, are in a state of demographic collapse (figure 4.17; KVRI Burbot Committee 2004). Thus, analysis of future or recent samples collected to delineate genetic and geographic population structure of Kootenai Subbasin burbot may not accurately or fully describe historical population structure and the historical range of genetic variability. This failure is proportional to the degree that populations and population components have been reduced or extirpated. Thus, accurate historical characterization of Kootenai Subbasin burbot genetic integrity is currently unavailable, and may be difficult if not impossible to reconstruct.

Because burbot in the Kootenai River Subbasin recolonized after the most recent Pleistocene glacial retreat, one would expect burbot in the Subbasin to be relatively closely related (compared to species that have not undergone recent post-glacial recolonization). However, no phylogenetic studies of Kootenai Subbasin burbot have been conducted, so the number of contributing evolutionary lineages and colonizing events for burbot in the Subbasin is currently unknown. Possible physical isolation mechanisms for burbot in the Subbasin include(d) Bonnington Falls (downstream from Kootenay Lake), Cora Linn Dam (completed in 1930s; formerly the natural Bonnington Falls), Duncan Dam (completed in 1967), Kootenai Falls, and Libby Dam (completed in 1972). Furthermore, temporal and geographic reproductive isolation mechanisms likely existed among burbot in the West Arm of Kootenay Lake that spawned from April to June (Martin 1976), and burbot in the Idaho tributaries of the Kootenai River that historically spawned under the ice during January or February several hundred km upstream. Thus, given adequate geographic isolation and divergence time, a unique genetic signal could have evolved separately in both areas. Maintenance of such differences could maintain genetic integrity. However, West Arm (Kootenay Lake) burbot are functionally extinct (Ashley et al 1992; Ahrens and Korman 2002), and burbot that historically spawned in Idaho reaches of the Kootenai River and their tributaries are currently so rare that it is difficult to estimate their population abundance.

Current genetic integrity of Kootenai River Subbasin burbot is best described by the only genetic study of these fish (Paragamian et al. 1999). In this work, several authors at the University of Idaho performed mitochondrial DNA analysis of burbot captured in four different areas within the Kootenai River Basin: Kootenay Lake, B.C.; Kootenai River in B.C. and Idaho; Kootenai River at the base of Libby Dam, Montana; and Koocanusa Reservoir, Montana. Results indicated that sequence divergence among haplotypes, and significant geographic heterogeneity among haplotype frequency distributions supported the conclusion of two genetically dissimilar burbot populations upstream and downstream from Kootenai Falls.

Various fisheries management entities within and outside of the Kootenai River Subbasin are currently developing higher resolution genetic analysis techniques (microsatellite analysis) for burbot from the Subbasin. Such studies are expected to further reveal population structure if it exists, from which inferences can be derived concerning genetic integrity and stock structure of Kootenai Subbasin burbot.

4.5.3 Population Status

Current Status

Significant adult burbot populations in the Kootenai Subbasin currently exist in Koocanusa Reservoir and Trout Lake, with remnant populations between Libby Dam and Kootenai Falls and in the South Arm of Kootenay Lake (figure 4.17). Populations thought to have been functionally extirpated existed in the riverine portion of the Kootenai Subbasin and in the West Arm of Kootenay Lake. Very few burbot remain in the Kootenai River Subbasin between Kootenay Lake and Kootenai Falls. In this reach of the Subbasin, the greatest concentration occurs near and in the Goat River in B.C., and even there the numbers are quite small.

Imperiled status formed the basis for the petition to list Lower Kootenai River burbot as endangered under the Endangered Species Act (Prepared February 2, 2000, received by the USFWS February 7, 2000) (http://www.wildlands.org/w_burbot_pet.html). Based on most recent (2003) stock assessment modeling of burbot in this portion of the Subbasin, abundance estimates ranged between 50 and 500 fish, likely closer to 50 than 500 (Ray Beamesderfer, S.P. Cramer and Associates, personal communication, September 2003). No other current population abundance estimates exist for Kootenai Subbasin burbot, but extensive demographic analysis is expected within 2004.

Current status of Kootenai Subbasin burbot ranges from common in significant adult populations, to functionally extirpated (figure 4.17). Recent extensive sampling efforts have resulted in very few adult burbot in Kootenay Lake or Kootenai River; juvenile burbot are even more scarce (Redfish Consulting, Ltd. 1997; Spence 1999; Paragamian et al. 2001; Baxter et al. 2002). Burbot spawning activity was observed on the west shore at the north end of Kootenay Lake from 1998 (Spence 1999) to 2000; no spawning burbot were observed at this location in 2001; spawning area potentially becomes dewatered with low lake levels (Baxter et al. 2002). Eight burbot in different stages of sexual maturity were captured at Ambush Rock (rkm 244.5) on March 10, 2000 (Paragamian et al. 2001), and evidence of spawning was documented in the Goat River, B.C. (Paragamian 1995; Paragamian and Whitman 1996, 1997; Bisset and Cope 2002).

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

Burbot in the Koocanusa Reservoir area of Montana are referred to as common (Hoffman et al. 2001), and make up a substantial adult population in this area (KVRI Burbot Committee 2004).

Historical Status

British Columbia[4]

Modeling suggested that the West Arm (Kootenay Lake) burbot population size prior to 1967 numbered approximately 200,000 individuals. The estimated trend in age-1 recruitment indicated a substantial increase of recruits in the early 1960s, peaking in 1964 and failing by the late 1960s. It seems reasonable to assume the burbot fishery collapsed as a result of the recruitment failure but, the collapse was accelerated, substantially, by unsustainable harvest rates. Recruitment anomalies did not correlate well with environmental indices that changed as a result of dam operations. Recruitment failure occurred before 1970 and changes in the lake environment due to dam operations did not occur until after 1974.

[4] *The section on historical population status in British Columbia was largely excerpted from Ahrens and Korman (2002).*

Changes in nutrient loading to the lake were also a poor correlate with recruitment because nutrient loads peaked in 1967, three years after the predicted recruitment peak. The best correlation resulted when cladoceran densities were compared to burbot recruitment. It is likely that changes in the West Arm community structure, most noticeably the increases in mysid densities, resulting from increased productivity (via nutrient loading) caused a substantial reduction in the cladoceran community through competition and predation. The previous increase and subsequent collapse of the cladoceran community in 1964 likely resulted in a catastrophic reduction in juvenile burbot food resources contributing to or resulting in recruitment failure. The exact mechanism, which resulted in recruitment failure, can only be speculated.

In Kootenay Lake, burbot were concentrated in the Balfour area of the West Arm. The fishery at Balfour occurred primarily during late spring/early summer. In 1969, over 26,000 burbot were caught in the fishery and in 1971, approximately 20,000 were caught. Harvest declined substantially over the subsequent years (table 4.62, figure 4.19). A production and harvest study was conducted during the mid 1970s; the optimum sustainable yield was calculated at 11,680 fish and the optimal fishing effort was estimated at 14,560 rod hours (Martin 1976). Thus, estimated annual harvest (20,000-26,000 fish) more than doubled annual estimates of maximum sustainable yield (Martin 1976). Harvest of burbot continued to decline through the 1970s and 1980s; as of 1987, no burbot have been recorded in the fishery at Balfour. Canadian researchers have conducted extensive sampling in Kootenay Lake since the 1990s (table 4.61). Although recent sampling efforts indicated the complete lack of burbot in the West Arm at Balfour, burbot have been captured in the North Arm. There was evidence of burbot spawning in the North Arm during 1998-2000; however, no potential spawning activity was observed in this area during 2001 or 2002.

Cooperative sampling by US and Canada in Kootenai River in B.C. and Idaho from 1994-1996 indicated burbot density diminishes rapidly upstream of Goat River, BC; during the winter of 1994-95, 2 fish were caught upstream of Goat River and 31 fish were caught in the Goat River and downstream (Paragamian et al. 2000). One larval burbot and one young of the year burbot were captured in extensive sampling in Kootenay Lake and Kootenai River in 1995 and 1999 (Fredericks and Fleck 1995; Paragamian and Whitman 2000).

Idaho

The following historical account describes historical burbot harvest in Idaho, during the 1920s and 1930s, after which local residents considered the Kootenai River burbot gone. The KVRI Burbot Committee is assembling local testimony

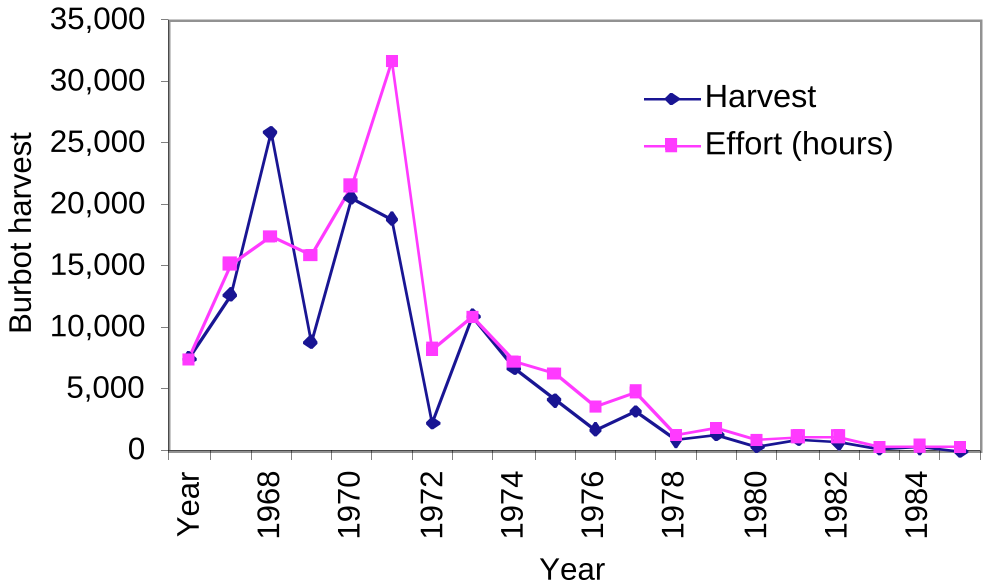

Figure 4.19. Balfour (West Arm Kootenay Lake) burbot fishery trends 1967-1986. Data from Martin (1976) and Redfish Consulting, Ltd. (1988).

and a temporally relevant chronology of the demise of Kootenai River burbot. Important events leading to this collapse likely occurred during the early 1900s, as corroborated by numerous independent historical accounts. One such account is presented below, taken from a letter by Hartley King, lifelong Boundary County resident, written during May, 2003:

> "We lived on the [Kootenai] river bank during the 1920s at Riley Bend, which later became the Ray Sims place. We only knew them as ling. I never heard the name burbot until I grew up years later. The river was full of fish of all kinds in them days. I slept upstairs and in the summertime the fish jumping would wake me up about four in the morning. It was just a paradise for fish.
>
> The ling went up the creeks to spawn, and of course, that's where people could get at them. They used spears and pitchforks to throw them out. They would be piled in there. Some people would take a sack-full and go home, but others would take a wagonload. What they did with that many fish I don't know. I heard of some that fed them to their pigs. They were the finest eating fish I know of. I'd rather have them than halibut or salmon or trout. They had a big head and were shaped something like an eel, with sort of a beard.
>
> They ran up the creeks about in February sometime. The creeks were frozen then, so they had to cut holes in the ice and spear them through the holes. I never heard of any ling going up the creeks south of the Canadian boarder since then. In Canada those creeks have never been disturbed, they still spawn up them.
>
> We lived across the river from Lucas Creek. When they diked District 6, they dammed the creek about 150 feet from the river and put a big drain pipe in about 5 or 6

> feet above the river. We were going to school near there, so we had to go across the river every day.
>
> One day we came by there and there were bass by the thousands trying to get up the creek to spawn, but they couldn't get up there. They were in there 4 to 5 feet deep. I can't imagine how many fish were there. I never saw a bass in the river after that. That's a sample of what happened to the fish, also the ling. We just overfished and muddled with their spawning grounds until we just didn't have any fish left.
>
> We never did go to the creeks to spear them. We cut holes in the river ice and put setlines out overnight. We got bigger ones that way. Some were almost 4 feet long. I can't remember of ever weighing any of them, but we weren't interested in beating somebody else to see who got the bigger fish. We just wanted them to eat.
>
> When they diked the country, I know that knocked the ling and the bass for a loop. The creeks came from the mountains to the river. Some of them, like Smith Creek, ran for 2 or 3 miles. They had been there for thousands of years, and the bed of the creeks was gravel and sand all the way to the river. When they diked, they just ran a ditch from the mountains straight to the river.
>
> I think over fishing hurt them real bad. There weren't too many people who fished them through the 1920s, but during the 1930s, when the dust-bowlers came in, they were hungry for anything. There didn't seem to be any laws for fishing them. We didn't ever hear of licenses. They might have had such a thing, I never knew of anybody who had a fishing license.
>
> The dam is another thing that finished them off. They raise the water and lower it, which is not natural, and the fish can't live that way. We will never get the fish back now. The once bountiful Kootenai River is dead".

LINKS

Appendix 64 lists the waters in Montana Fish, Wildlife & Park's Region One that have tested positive or have questionable results for fish pathogens.

Click Here

Extensive burbot sampling has occurred throughout the Kootenai River basin; a summary of catch statistics is found in table 4.61. In the Kootenai River, burbot were sampled as early as 1957; a total of 199 burbot were captured during a 1957-1958 winter sampling period. The length-frequency distribution of this sample indicated an abundance of young fish and good representation of older fish (Paragamian et al. 2000). In the 1960s, the combined average annual catch of the sport and commercial fisheries was thought to have exceeded thousands of kg. Anecdotal information from historic angler surveys indicated an excellent winter fishery existed from the 1950s through the early 1970s. During a sampling program from 1979 to 1982, Partridge (1983) captured a total of 108 burbot with three different gear types. Although all catchable age classes were represented in this sampling program, Partridge (1983) believed that burbot abundance was substantially lower than in the 1950s. The annual burbot harvest from 1979-1982 was estimated at less than 250 fish (Partridge 1983). A 2-fish daily bag limit adopted in 1983, with a ban on all burbot harvest in 1992 (Paragamian et al. 2000). However, this restriction in the fishery did not result in population recovery (Paragamian et al. 2000).

Catch numbers were low during the early 1990s but numerous age groups were represented, indicating that some burbot recruitment was likely occurring.

Sampling during the winter of 1993-1994 at the mouths of Idaho tributaries resulted in no burbot (table 4.61). One burbot was caught between Bonners Ferry, Idaho, and the Montana border; there was no evidence of reproduction occurring in Idaho. Burbot were nonexistent in a creel survey that extended from spring 1993 to spring 1994 (Paragamian 1993, 1994).

Theoretical Reference Condition

Other than the following conservation goals and issues concerning restoration of Kootenai River subbasin burbot populations, no formal theoretical reference conditions have been proposed or identified.

Kootenai River (ID/BC)

The burbot conservation goal is to maintain and restore multiple life-history strategies and maintain genetic diversity necessary to sustain a viable burbot population in the Kootenai River. Complete restoration of this burbot population will be achieved when monitoring and evaluation of recovery indicates a sufficient surplus of fish to provide a sport harvest (KVRI Burbot Committee 2004). The KVRI Burbot Committee defined a target restoration goal for Kootenai River burbot at 2,500 fish, with natural recruitment in at least 3 areas or populations, and a stable size and age class distribution (KVRI Burbot Committee 2004).

West Arm, Kootenay Lake (BC)

Although estimated at approximately 200,000 fish prior to 1967, no theoretical reference conditions have been proposed for the West Arm. Because of its current status in the West Arm—functionally extirpated—all participants at recent burbot population workshops acknowledged that establishing a West Arm burbot population will require, in the short term, an experimental stocking or transplant program. However, the workshops generated a reasonable amount of skepticism about whether stocking or transplanting burbot would result in a viable, self-sustaining West Arm stock. In particular, there was uncertainty as to whether juvenile burbot could survive given the currently large biomass of northern pikeminnow and largescale sucker occupying former burbot habitat and ecological niches.

LINKS

For a more complete discussion of how Mainstem Columbia River operations affect subbasin fisheries, and how those effects might be minimized see Appendix 18.

Click Here

Kootenai River, Koocanusa Reservoir (MT)

No theoretical reference conditions have been developed for burbot in Montana Subbasin waters.

4.5.4 Out-of-Subbasin Effects and Assumptions

Mainstem Columbia River hydro and flood control operations profoundly influence ecological, biological, and physical habitat conditions in upriver and headwater areas, including the Kootenai River Subbasin. The abundance, productivity, and diversity of fish and wildlife species inhabiting the Kootenai River Subbasin and other headwater areas of the Columbia River Basin depend on the dynamic conditions of their immediate environments. These conditions are profoundly affected by out-of-basin effects (e.g., operation of the Mainstem Columbia River hydropower system). Mainstem and out-of basin operations affect Kootenai Subbasin burbot in the following ways:

- Unnatural water discharge and temperature regimes at any time of the year can negatively affect resident fish and taxa in supporting lower trophic levels. For example, unnaturally high discharge during winter in the Kootenai River is thought to negatively affect or prohibit burbot spawning migrations (Paragamian 2000). However, unnatural, detrimental effects of hydro operations to burbot and other native taxa can be mitigated to varying degrees by releasing flows at more constant rates, and providing smoother shaped water blocks required to meet power production and flood control requirements.

- Summer flow augmentation causes reservoirs in the Kootenai Subbasin to be drafted during the most biologically productive summer months. This loss of productivity reduces forage availability and in-reservoir biomass production of all taxa in the reservoir.

- Drafting reservoirs too deep prior to the January 1 and the potential of subsequent inflow under-forecasts may decrease the probability of reservoir refill.

- Flow fluctuations caused by variable power production needs, flood control, or fish flows create wide varial zones in near-shore river and reservoir habitats. Varial zones are characterized by biological instability, due to frequent inundation and dewatering, and by losses of ecological and biological productivity and function. Burbot use areas of Koocanusa Reservoir that regularly dewater for power production. Although not significantly different statistically, the catch distribution indicated that smaller burbot more frequently occupied the Tobacco-Sophie Bay area of the reservoir (which gets dewatered) compared to the main body of the reservoir (Ostrowski et al. 1997). These authors reported that the lack of a statistically significant difference in burbot habitat use may have been due to unrepresentative (small) sample size (figure 4.20).

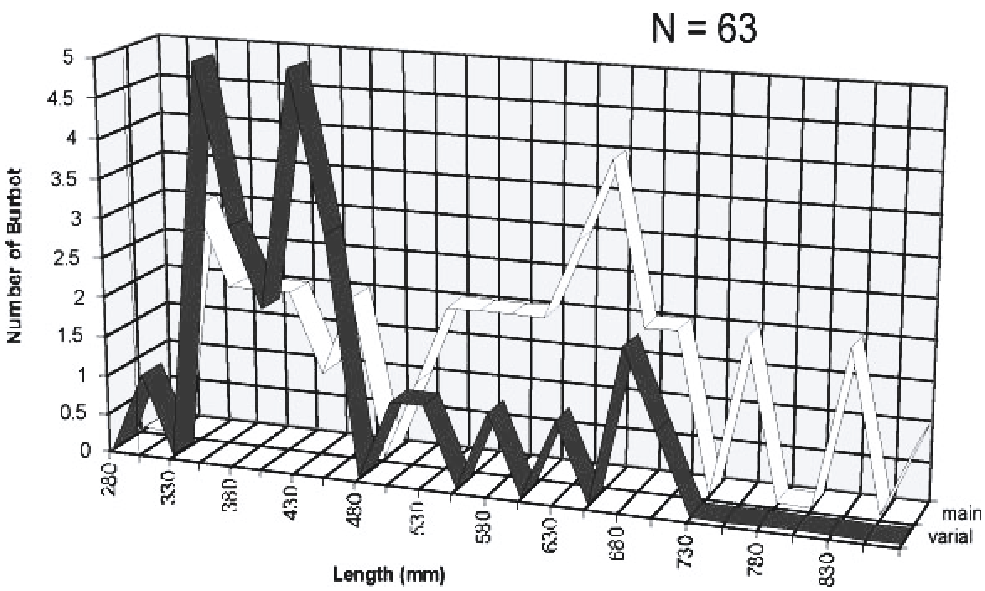

Figure 4.20. Comparison of burbot length frequency distributions between the varial zone and the main areas of Koocanusa Reservoir.

4.5.5 Environment-Population Relationships

Prior to discussing environmental factors of importance to burbot survival (Key Ecological Attributes, KECs) it is important to understand the role of population size in environment-population relationships. Small population size, characteristic of most imperiled populations, may eclipse environmental and ecological concerns otherwise relevant to environmental-population relationships. Specifically, if genetically effective population size (the functional size of a population based on its instantaneous ability to successfully produce a subsequent generation) is too small to provide population viability and persistence, given a reasonable amount of ecological uncertainty, population trajectories may be determined more by stock-limitation than by inferred effects of environment-population relationships (habitat limitation). Furthermore, a positive relation exists between population size and measures of genetic diversity or genetic integrity—a decline in one produces a decline in the other. Finally, even in small, imperiled populations, ecological limitation may further contribute to population decline along with small population size.

Thus, various external and internal drivers contribute to population declines, sometimes independently, sometime collectively, depending on which part of the decline trajectory a particular population represents. Therefore, it is also important to document and understand environmental factors that are important to burbot survival.

Environment s Ability to Provide Key Ecological Correlates

In most waters of the Kootenai River Subbasin, with the possible exception of Duncan and Trout lakes in B.C., and Montana waters, extremely low numbers of remaining burbot appear to currently pose a greater risk to their continued existence than does any combination of key ecological correlates or non-demographic limiting factors. Thus, in these regions of the subbasin, it appears that the current post-development environmental conditions can provide little restorative value to these remnant stocks or populations. Furthermore, it appears that restoration of these native burbot populations to include natural recruitment and stable size and age class structures is unlikely to occur without improvement of current ecological conditions and restoration of ecological functions.

Subbasin burbot managers and researchers recently began experimental alterations of Libby Dam discharge operations in order to restore natural production. However, monitoring of recent experimental discharge reductions during the historical burbot spawning season (December-March) failed to provide evidence of any natural spawning or recruitment in the Idaho portion of the Subbasin (Kootenai Basin Burbot Conservation Committee, pers. comm. 2003). This may be due to extreme stock limitation (i.e., too few burbot may be left to measure a response to experimentally reduced discharge regimes, or to provide observable experimental treatment effects), or to other effects. However, Kozfkay and Paragamian (2002) found drought conditions of the winter of 2000-2001 provided ideal conditions for burbot movement and documented spawning of burbot through weight changes in recaptured fish and a limited number of post-spawn biopsies.

Long-term Viability of Populations Based on Habitat Availability and Condition

Based on natural production and habitat availability and condition, burbot (other than the Duncan Lake, Trout Lake, and Montana populations) long-term viability does not currently appear favorable. To date, no formal population viability or persistence modeling has been undertaken with Kootenai Subbasin burbot. However, extremely low remnant burbot numbers in the riverine portions of the Subbasin in Idaho and B.C. suggest low probabilities of long-term viability for burbot in these areas. Long-term viability of lacustrine populations in BC and in the Kootenai River and Koocanusa Reservoir in Montana appears more favorable, however, no analyses have occurred to support or refute this claim.

LINKS

For the website containing descriptions of surface waters included in the Montana state water quality assessment database go to: http://nris.state.mt.us/wis/environet/2002_305bhome.html.

Click Here

For the website listing 303(d) water-quality impaired streams and lakes for the Idaho portion of the subbasin, go to: http://inside3.uidaho.edu/WebMapping/IDEQ/

Click Here

Holderman and Hardy (2004) discuss potential limiting factors in the Lower Kootenai. Go to Appendix 120.

Click Here

4.5.6 Burbot Limiting factors and Conditions[5]

No single factor appears responsible for the collapse of burbot in the Kootenai River Subbasin. Rather, a combination of overharvest, habitat alteration, and ecosystem degradation appears to be the cause (KVRI Burbot Committee 2004). Possible linkages may exist (or have existed) among many of the following interrelated hypotheses of burbot collapse:

- Increased winter water flow
- Increased winter water temperature
- Environmental degradation
- Changes in primary and secondary productivity
- Kootenay lake flood control
- Altered ecological community composition

These factors are outlined and briefly described below, and are based on information from the Kootenai River/Kootenay Lake Burbot Conservation Strategy (KVRI Burbot Committee 2004), Hammond and Anders (2003), Ahrens and Korman (2002), Paragamian (2002), and Anders et al. (2002):

Increased Winter Water Flow

Burbot are known to move extensive distances to spawn (Robins and Deubler 1955; McCrimmon 1959; Percy 1975; Morrow 1980; Johnson 1981; Breeser et al. 1988; Evenson 2000; Paragamian 2000; Schram 2000), and spawn during winter over a relatively confined time period (Arndt and Hutchinson 2000, Evenson 2000, McPhail and Paragamian 2000). Tagging, telemetry, and genetic studies indicated that burbot freely move between Kootenay Lake and Kootenai River during low flow periods (Paragamian et al. 1999). However, Hammond and Anders (2003) could not subsequently substantiate major burbot spawning

[5] *The following section on limiting factors was largely excerpted from the Kootenai River/Kootenay Lake Burbot Conservation Committee's Conservation Strategy (KVRI Burbot Committee 2004).*

migrations from Kootenay Lake and the lower Kootenay River in British Columbia to upstream historical spawning tributaries in Idaho after reviewing available data. Based on empirical burbot swimming performance data (Jones et al. 1974), Paragamian (2000) suggested that burbot spawning migrations in the Kootenai River may be limited or prohibited by increased post-dam water column velocities in the Kootenai River associated with higher post-dam discharge regimes. Post-Libby Dam Kootenai River winter regimes discharge average 3 to 4 times higher than natural due to power production and flood control operations (Partridge 1983; Paragamian 2000).

Increased Winter Water Temperature

Burbot spawning has been reported in water temperatures between 1 and 4 °C (Morrow 1980; McPhail and Paragamian 2000). Taylor and McPhail (2000) demonstrated that survival from fertilization to hatching was highest at 3 °C, and that all embryos died at water temperature above 6 °C. Since 1974 (post-Libby Dam), winter river temperatures have averaged 3 to 4 °C, compared to pre-dam river temperatures of 1 °C or less (Partridge 1983). The Kootenai River in Idaho commonly froze during winter prior to dam operation, but has remained ice-free every winter since initial dam operation. Thus, if burbot are spawning in the Idaho portion of the Kootenai Subbasin, artificially elevated post-dam water temperatures may be having a negative effect on spawning and incubation success and natural recruitment. Warmer post-dam water temperatures in the Kootenai River and the resulting lack of ice cover may also have negative effects on burbot spawning, especially in the historical spawning tributaries in the Idaho portion of the Subbasin.

Environmental Degradation

Logging and mining operations occurred in the Kootenai River Subbasin as early as the 1880s. Affects of these operations on habitat in the Kootenai River are documented in Northcote (1973), Cloern (1976), Daley et al. (1981), and Partridge (1983). These operations have caused flashy tributary discharge patterns, which have physically altered the streams and caused siltation (Northcote 1973). There is concern with water toxicity because of the release of heavy metals (Partridge 1983). Attempts were made as early as 1892 to dike the lower river to claim land for agricultural use (Northcote 1973). A fertilizer plant operated on the St. Mary River from 1953-1970 which greatly increased nutrient loading (Northcote 1973).

Changes in Primary and Secondary Productivity

During the mid-1960s the Cominco fertilizer plant on the St. Mary River in BC caused eutrophication in the Kootenai River and increased productivity in the river and Kootenay Lake (Northcote 1973). When operations ceased at the plant during the late 1960s, total phosphorus loading to Kootenay Lake was greatly reduced, contributing to current ultraoligotrophic system status (Ahrens and Korman 2002).

Simultaneous pollution abatement practices further reduced nutrient (and contaminant) loading to the system (Daley et al. 1981). Koocanusa Reservoir, the impoundment created by Libby Dam, acted as a nutrient sink, and has reduced productivity of the river and Kootenay Lake downstream (figure 4.21), with sediment trapping efficiencies of over 95 percent (Woods and Falter (1982) report 75 percent phosphorous trapped) (Snyder and Minshall 1996). Resulting reductions in Kootenay Lake productivity are thought to have reduced food available to juvenile burbot (Paragamian 1994) and reduced growth and survival rates (Ahrens and Korman 2002).

Fishery Harvest

The West Arm of Kootenay Lake once supported a significant burbot fishery with an annual harvest of up to 26,000 fish from the late 1960s to the early

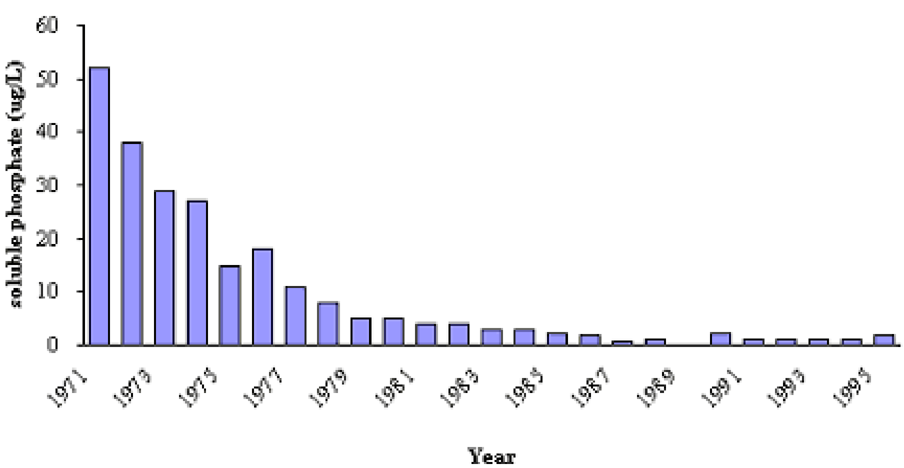

Figure 4.21. Phosphorous loading to Kootenay Lake from the Kootenai River before and after Libby Dam (1974). Data are integrated water-column averages for soluble reactive phosphorous collected at depths of 0-30 m during spring (March 1-July 15) from a mid-lake station. Data collection was changed in 1992. Station 5 was used in place of historic mid-lake station. Source: B.C. MELP 1998).

1970s. Catches declined precipitously beginning in the mid 1970s. and by the mid-1980s annual burbot catches were typically less than 400 fish. This reduction in catch resulted in the fishery being closed to angling in 1997. Martin (1976) estimated the annual allowable harvest for the Kootenay Lake fishery at 12,000 fish, however, estimated annual catch (~26,000) more than doubled the estimated annual allowable harvest. Simultaneous reduction in food availability following decreased productivity from pollution abatement efforts, loss of the Kootenai River floodplain, and impoundment (Duncan (1967) and Libby (1972) dams) likely contributed to the extirpated status of burbot in the West Arm of Kootenay Lake.

In Idaho Subbasin waters, early harvest accounts (1930s-1940s) suggested that the combination of overharvest and habitat alterations decimated Idaho burbot runs before 1950. However, unregulated harvests for another 20 years, with annual estimates exceeding 50,000 lbs (Paragamian and Whitman 1996) likely further contributed to the demise of burbot stocks that spawned in Idaho portions of the Subbasin (KVRI Burbot Committee 2004). Harvest restrictions during the 1970s and the fishery closure during the early 1980s failed to restore Idaho burbot populations, possibly due to the severity of harvest and concurrent habitat loss and degradation (Anders et al. 2002).

It has been subsequently argued that failed recruitment, not harvest, caused the collapse of Idaho burbot stocks in the Kootenai River. Paragamian et al. (2000) suggested that burbot populations, which possess considerable resilience, often respond favorably after harvest is eliminated and cited several published accounts of recovery in Alaska, Wisconsin, and Finland. These authors also reported that because the Idaho burbot population(s) did not rebound after fishery closures, recruitment limitation, not overharvest, caused their demise. However, harvest can exceed a population's level of resiliency (Longhurst 1998). Due partly to their patchy distributions, the Gadid species, Atlantic cod and Kootenai Subbasin burbot, often exhibit catch rate hyperstability, making them prone to unexpected and undetected overharvest, including overharvest beyond a stock's ability to recover. In the case of Kootenai Subbasin burbot, a series of temporally correlated habitat alterations (e.g., diking, impoundments and their subsequent system denutrification) contribute to the difficulty of partitioning or prioritizing causal factors of decline. As was stated for the collapse of the burbot fishery at Balfour, (West Arm Kootenay Lake; Ahrens and Korman 2002), the exact mechanism(s) of collapse of burbot stocks in Idaho can only be speculated.

Kootenay Lake Flood Control

During spring, generally during March, Kootenay Lake is lowered approximately 2m (6 feet) to provide water storage space for flood control. In contrast, prior to the construction of the Cora Linn Dam in the 1930s at the outlet of Kootenay Lake, the lake would rise approximately 3m (9 ft) each spring as a result of runoff from snowmelt. Raising the lake level could potentially decrease current velocity in the Kootenai River and its tributaries, and is thought to "move the upstream edge of flat water upstream".

Due to the lack of gradient in the historic lower river floodplain, lower Kootenay Lake elevation also lowers Kootenai River elevation, causing a potential drafting effect in tributary streams and potentially increasing current velocity in the low gradient reaches of Idaho tributaries. Some have speculated that potential velocity increases could wash rearing larval burbot from their natal streams (KVRI Burbot Committee 2004). However, no empirical observation, measurement, or simulation modeling has occurred to quantify or validate this idea.

Altered Ecological Community Composition

British Columbia

West Arm Kootenay Lake – Based on abundance estimates and catch records, burbot likely dominated the demersal fish community in West Arm of Kootenay Lake during 1960s-70s (Martin 1976; Ahrens and Korman 2002). However, extirpation of West Arm burbot population was followed by increased abundance of other native fishes (northern pikeminnow, largescale sucker) likely due to compensatory population growth from relaxation of interspecific competition. Recent benthic surveys on the historic "ling beds" near the mouth the lake's West Arm recently revealed extremely high densities of largescale suckers in areas historically dominated by burbot. This community composition shift may have also resulted in increased predation on and competition with any remaining YOY and juvenile burbot (Ahrens and Korman 2002).

In addition to documented and hypothesized changes in fish community composition in the West Arm, changes also occurred in the invertebrate community. Reduced transport of non-native *Mysis* shrimp over the shallow sill from the main lake into the West Arm may have occurred due to increased water clarity following impoundment (sediment trapping) by Duncan and Libby dams (Ahrens and Korman 2002). These authors suggested that significant increases in water clarity following impoundment and cultural denutrification (figure 4.21) resulted in deeper distribution of photophobic mysids in the main lake. Thus, reduced transport of mysids over the shallow West Arm sill could have led to reduced growth and survival rate for juvenile burbot (Ahrens and Korman 2002).

Idaho

Paragamian (2002) assessed the changes in the species composition of the fish community in a reach of the Kootenai River known as the Hemlock Bar. Paragamian found a post-dam change in the fish community from one in which insectivores and omnivores were equally represented to one that was dominated by omnivores. Paragamian (2002) also documented changes in the growth rate of mountain whitefish and lower densities.

Timeline of Impacts

- Logging and mining operations beginning in the 1880s,
- Attempts to dike the lower river to claim land for agricultural use in 1892,
- Completion of Cora Linn Dam (former natural Bonnington Falls) in 1930.
- Unregulated harvest beginning with “dust bowlers" during the 1930s.
- Local recognition of burbot collapse by the early 1900s.
- Fertilizer plant operation (nutrient loading) on St. Mary’s River from 1953-1970.
- Substantial sport and commercial fishery harvest from 1950s to 1970s.
- Completion of Duncan Dam in 1967.
- Completion of Libby Dam in 1972.
- Alteration of Kootenai River hydrograph and thermograph beginning in 1974 downstream from Libby Dam.
- Pollution abatement activities throughout watershed.
- Kootenay Lake fertilization beginning in 1992.

Human Impacts

The Kootenai River system has been subjected to many human influences over the course of the past 100 years or more (Northcote 1973). A comprehensive account of anthropogenic changes and resulting ecological responses in the Kootenai Basin is provided by Anders et al. (2002), Paragamian (2002), and other authors. By the mid-1960s, phosphorus concentrations increased 15-fold, and nitrogen doubled from baseline conditions in the Kootenai River due to municipal and industrial development. Pollution abatement beginning in the late 1960s, and subsequent impoundment of the Kootenai River (Libby Dam, 1972) reversed this culturally eutrophic condition. By the mid-1990s the Kootenai River was classified as ultraoligotrophic, as it remains today. Reverberating trophic responses to cultural denutrification were temporally correlated with the collapse of the functional Kootenai River Subbasin downstream from Libby Dam, and its native burbot populations.

The pre-impoundment Kootenai River hydrograph was characterized by annual average discharge peaks of approximately 60,000 cfs during the natural high-runoff period in spring and early summer, with highest discharge during the period of record reaching 160,000 cfs (Scott Bettin, Bonneville Power Administration, personal communication). Post-impoundment river discharge (1973-1989) rarely exceeded 20,000 m^3/sec. Post-impoundment river discharge during the spring and early summer has been reduced by as much as 67 percent, and has increased during the winter by as much as 300 percent relative to pre-impoundment conditions (Partridge 1983). The pre-development Kootenai River ecosystem included a naturally functional floodplain over 5 km wide along the 128 km of the river immediately upstream from Kootenay Lake. Diking of this section of the river eliminated thousands of hectares of natural floodplain, and the associated productivity, diversity of habitats, and ecosystem functions (Duke et al. 1999; Anders et al. 2002).

Post-impoundment winter water temperatures in the Kootenai River downstream from Libby Dam averaged 3 °C warmer than pre-impoundment values (Partridge 1983). Summer water temperatures in the same river reaches during the same years were consistently lower than pre-impoundment values, due to hypolimnetic withdrawal from Libby Dam (Partridge 1983; Snyder and Minshall 1994). Libby Dam and the impounded Koocanusa Reservoir reduced downstream transport of phosphorous and nitrogen by as much as 63 percent and 25 percent respectively (Woods 1982), with sediment trapping efficiencies exceeding 95 percent (Snyder and Minshall 1996).

Diking and channelization altered channel bed conditions by trapping sediments previously deposited over the historic floodplain during periods of high river discharge. Like other large river-floodplain ecosystems, the Kootenai River was historically characterized by seasonal flooding that promoted the exchange of nutrients and organisms among a mosaic of habitats, reported to enhance biological productivity and habitat diversity (Junk et al. 1989; Bayley 1995).

Agricultural activities (farming, channelization, and diking) have restricted the Kootenai River's natural floodplain from Kootenay Lake upstream to Bonners Ferry, Idaho. Forest developments have affected a significant area of the drainage. A fertilizer plant in B.C. (on the St. Mary River near Kimberley) polluted the river and lake. The Cora Linn Dam on the Kootenay River downstream from Nelson, the Duncan Dam at the north end of Kootenay Lake, and the Libby Dam upstream from Kootenai Falls have all dramatically affected movement of water through the system. In addition to these major perturbations, numerous but smaller impacts have also shaped the present integrity of the Kootenai River ecosystem (e.g., road construction, urbanization, introduction of non-native fish and invertebrates).

Impoundment of rivers represents a cataclysmic event for large river-floodplain ecosystems (Ligon 1985). By altering water, sediment, and nutrient flow dynamics, dams interrupt and alter a river's important ecological processes in aquatic, riparian, and surrounding terrestrial environments. These environments, their life-supporting ecological functions, and the persistence of their floral and faunal communities are inexorably linked. Alteration of any component of such highly integrated natural systems generally results in cascading trophic effects throughout the ecosystem. Thus, major system perturbations, such as impounding large rivers, create a myriad of ecological dysfunction, reflected at all trophic levels on an ecosystem scale. The importance of nutrient and energy dynamics during natural pulses of water discharge in rivers has been extensively described in terms of river ecology (e.g., flood pulse, river continuum, nutrient spiraling, and serial discontinuity concepts).

Depressed biological productivity, alteration of spawning and rearing habitats, fish species abundance changes, altered predator-prey dynamics, and consistent white sturgeon recruitment failure constituted biological and ecological responses to Kootenai River Basin development (Ashley et al. 1999; Marcuson 1994; Paragamian 1994; Snyder and Minshall 1994, 1995, 1996; Anders and Richards 1996; Duke et al. 1999; USFWS 1999). Closures of the recreational kokanee (*Oncorhynchus nerka*), burbot (*Lota lota*), and white sturgeon harvest fisheries in Idaho and BC since the mid-1980s were fisheries management responses to ecological perturbations and possible past overharvest (Anders et al. 2002).

4.6 White Sturgeon (*Acipenser transmontanus*)

4.6.1 Background

Worldwide, diversity of sturgeon and paddlefish is currently imperiled, as evident by the extirpation of many North American, European, and Asian forms (Rochard et al. 1999; Birstein 1993; Birstein et al. 1997a, 1997b; 1997c; Findeis 1997; Khodorevskyaya et al. 1997; Kryhtin and Svirskii 1997; Ruban 1997; Wei et al. 1997). With few exceptions (Bruch et al. 2001a), the population abundance of most *Acipenser* species is currently at historically low levels. This includes many North American taxa, such as white sturgeon (*Acipenser transmontanus*) (Rieman and Beamesderfer 1990; Birstein 1993; Waldman 1995; Boreman 1997; Beamesderfer and Farr 1997; Wirgin et al. 1997; Campton et al. 2000; Mayden 2001).

Although sturgeons express many different life histories, all spawn exclusively in freshwater (Kynard 1997). Many require large, river systems with intact functional processes to complete various early life stages. Proceedings from recent international meetings on sturgeon management, research, and conservation share consistent findings that the sturgeon's imperiled status reflects the degree of degradation of large river habitats and ecological functioning of large river-floodplain systems. Four causal factors were cited repeatedly for the demise of sturgeons across geography: harvest, habitat fragmentation, hydropower development, and pollution (4th International Sturgeon Symposium 2001; Van Winkle et al. 2002; 1994 New York). Humans have harnessed the energy of most large river systems, and have modified their hydrographs to prevent flooding and the associated losses of human life and property. These changes have occurred at the expense of native species, such as white sturgeon.

White sturgeon are endemic to the Pacific coast of North America and its tributaries west of the Rocky Mountain continental divide, from central California to the Gulf of Alaska and the Aleutian Islands (Scott and Crossman 1973). White sturgeon are typically an anadromous species. However, the Kootenai River of British Columbia, Montana, and Idaho contains a unique headwater population that has been isolated from the ocean and other downstream Columbia River populations for over 10,000 years (Alden 1953; Northcote 1973). Kootenai River white sturgeon are genetically and behaviorally distinct from other white sturgeon stocks. The Kootenai population is characterized by significantly lower genetic diversity than found in other populations in the downstream Columbia Basin waters (Setter and Brannon 1992; Anders et al 2002; Anders and Powell 2002). Kootenai River sturgeon are also more active at 6 °C, several degrees cooler than the activity threshold for Columbia and Snake River sturgeon (Paragamian and Kruse 2001).

LINKS

White sturgeon information generated by State, federal, and tribal biologists working in Montana is available from the Montana Fisheries Information System (MFISH) database accessible on the internet at: http://nris.state.mt.us/scripts/esrimap.dll?name=MFISH&Cmd=INST.

Click Here

For fisheries information for the Kootenai in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

LINKS

For summaries of and access to four scientific papers on Kootenai River white sturgeon, including papers on spawning locations, success of hatchery-reared fish, assessment of bioaccumulated metal and organochlorine compounds, and temporal distribution of spawning events, go to Appendix 107.

Click Here

Reasons for Selection as a Focal Species

Due to their dependence on functioning large river-floodplain ecosystems, and their sensitivity to largescale alterations of such systems, white sturgeon serve as a valuable and informative focal species. Furthermore, due to their unusual longevity (> 100 yrs.) temporal correlation of population status with particular ecological perturbations or environmental conditions serves as a valuable indicator, further supporting their role as an important focal species for Subbasin Planning activities.

On September 6, 1994, the U.S. Fish and Wildlife Service listed the Kootenai River population of white sturgeon as an endangered species *(59* FR 45989) under the authority of the Endangered Species Act of 1973, as amended. The global heritage status rank for the Kootenai River white sturgeon is T1 (critically imperiled) because of the fish's limited range in the Kootenai River of British Columbia, Idaho, and Montana; the population is isolated and small; there has been very limited reproduction since 1977 (figures 4.22 and 4.23); and the population has been negatively impacted by river regulation and probably other habitat alterations. The state/province heritage rank for Idaho, Montana, and B.C. is S1 (critically imperiled). The white sturgeon is a culturally significant species to the Kootenai Tribe of Idaho. For these reasons, we have selected the Kootenai River white sturgeon as a focal species.

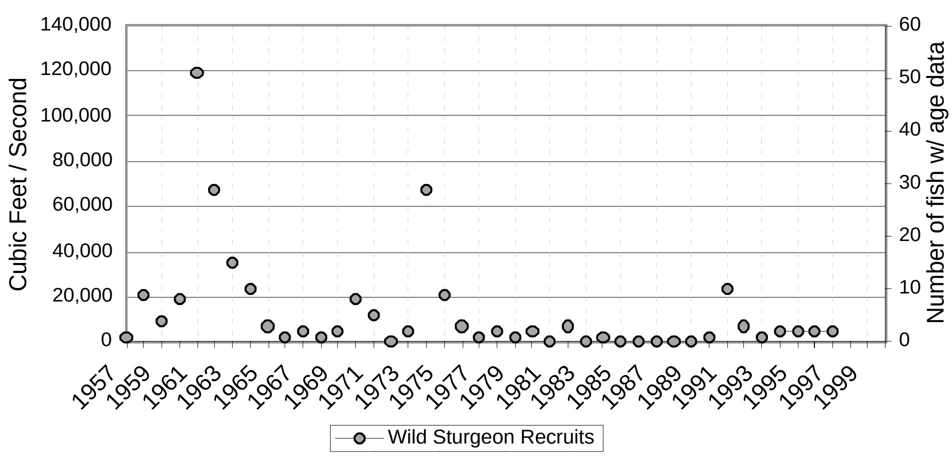

Figure 4.22. Numbers of white sturgeon recruits 1957 to 1999.

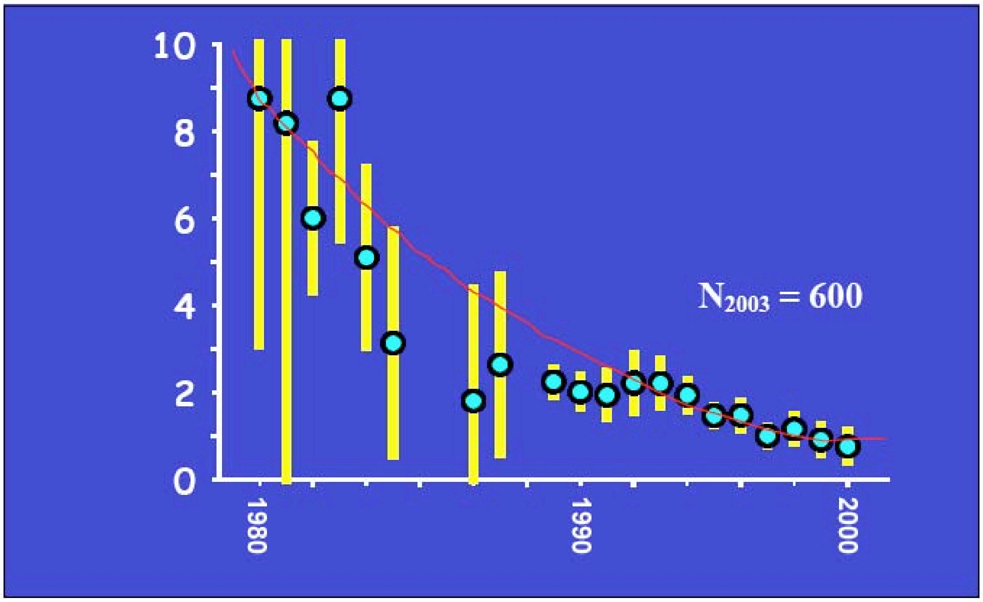

Figure 4.23. Summary of Kootenai River white sturgeon population abundance estimates. Source: Paragamian et al. In Press.

Summary of population data

The abundance of the Kootenai River white sturgeon population was estimated to be 6,800 fish during the early 1980s, before a precipitous population crash resulted in the current (2003) estimate of approximately 600 fish remaining in the population (figure 4.23). However, the accuracy of these early abundance estimates is questionable, as indicated by the large amount of variability associated with them. Empirical demographic modeling during 2002 revealed the increasingly imperiled demographic status of the population. Modeling suggested 90 percent, 75 percent, and 72 percent reductions in population abundance, biomass, and annually available spawners, respectively, over the past 22 years (1980-2002), and a current population "halving time" of 7.4 years (Paragamian et al. In Press).

Because of the near-complete failure of natural recruitment, the modeled sturgeon population declined by nearly 90 percent from 6,800 fish in 1980 to 630 in 2002 (figure 4.23). It is estimated that fewer than 500 adults from the existing wild population will remain by 2005, and fewer than 50 adult fish will be left by 2030 (figure 4.24). Total biomass declined by about 75 percent, from 80 to 20 metric tons between 1980 and 2002. Annual numbers of female spawners declined from 270 per year in 1980 to about 77 in 2002. It is estimated that fewer than 30 females will be spawning during any year after 2015.

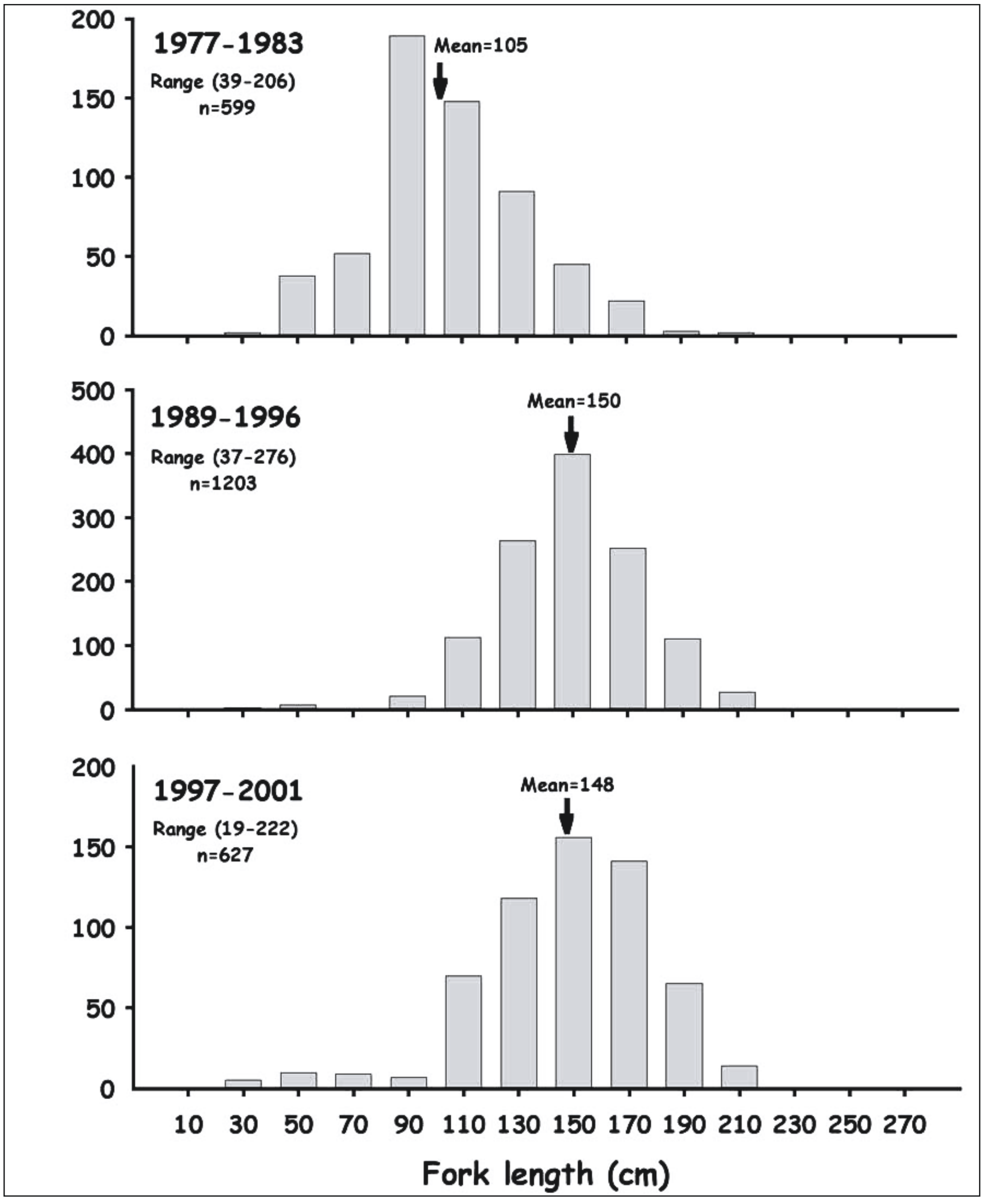

Figure 4.24 Changes in size composition of the Kootenai River white sturgeon population from 1977 to 2001 (Paragamian et al. In Press).

In the absence of natural recruitment, the Kootenai white sturgeon population is threatened by demographic and genetic bottlenecks, as indicated by the right-shifting size composition of the population (figure 4.24).

Historic and Current Distribution

Within the Kootenai River Subbasin, white sturgeon historically occupied an approximately 300 km (186.5 mile) reach, from Kootenai Falls (km 380.5) downstream to the north end of Kootenay Lake (km 17), and upstream into what is now Duncan Reservoir, as well all of the lake's West Arm (approx. 50 km or 31 miles) (figure 4.25). This population was thought to have been post-glacially recolonized and subsequently trapped in this area between upstream (Kootenai Falls) and downstream (Bonnington Falls) migration barriers. The population's current range is similar to its historic range, although population abundance is now greatly diminished, and very few fish appear to inhabit waters upstream from Bonners Ferry.

Status of White Sturgeon Introductions, Artificial Production and Captive Breeding Programs

No introductions of white sturgeon from outside the Kootenai River Subbasin have ever occurred. To date (2004), no captive breeding (captively rearing juveniles in a hatchery to broodstock age for future spawning in captivity) has occurred within the Subbasin. However, conservation aquaculture techniques using exclusively wild, native broodstock were first applied to wild white sturgeon populations in 1990 on the Kootenai River in northern Idaho following concerns that missing year classes, failed recruitment, and skewed age-class structure were threatening this population. Subsequent concerns regarding duration, breadth, and magnitude of ecosystem degradation in Montana, Idaho, and B.C. portions of the Kootenai River suggested that a conservation hatchery program may be warranted to preclude extinction. The Kootenai River white sturgeon population was listed as endangered under the Endangered Species Act (ESA) in 1994 (USFWS 1994). A Recovery Plan was completed in 1999, which incorporated the conservation aquaculture program (Duke et al. 1999; USFWS 1999; Kincaid 1993). The Hatchery Genetics and Management Plan prepared for the Northwest Power and Conservation Council (Ireland 2000) and the Adaptive Multidisciplinary Conservation Aquaculture Plan prepared for the USFWS White Sturgeon Recovery Team (KTOI 2004) provide the guidance for the conservation aquaculture program.

The Kootenai River Conservation Aquaculture Program has greatly expanded since 1990, and has: (1) provided frequent year classes of captively reared progeny from wild, native brood stock; (2) preserved within-population genetic diversity; (3) minimized disease introduction and transmission; and (4) substantially

LINKS

For the Kootenai River White Sturgeon Conservation Aquaculture HGMP, go to Appendix 77.

Click Here

For the Recovery Plan for the Kootenai River Population of the White Sturgeon, go to Appendix 78.

Click Here

For An Adaptive Multidisciplinary Conservation Aquaculture Plan for Endangered Kootenai River White Sturgeon, go to Appendix 103

Click Here

For the NPCC's Artificial Production Review Evaluation of the Kootenai Tribe of Idaho's white sturgeon hatchery, go to: http://www.apre.info/APRE/apre_report/ShowAPREReport?Section=Landing

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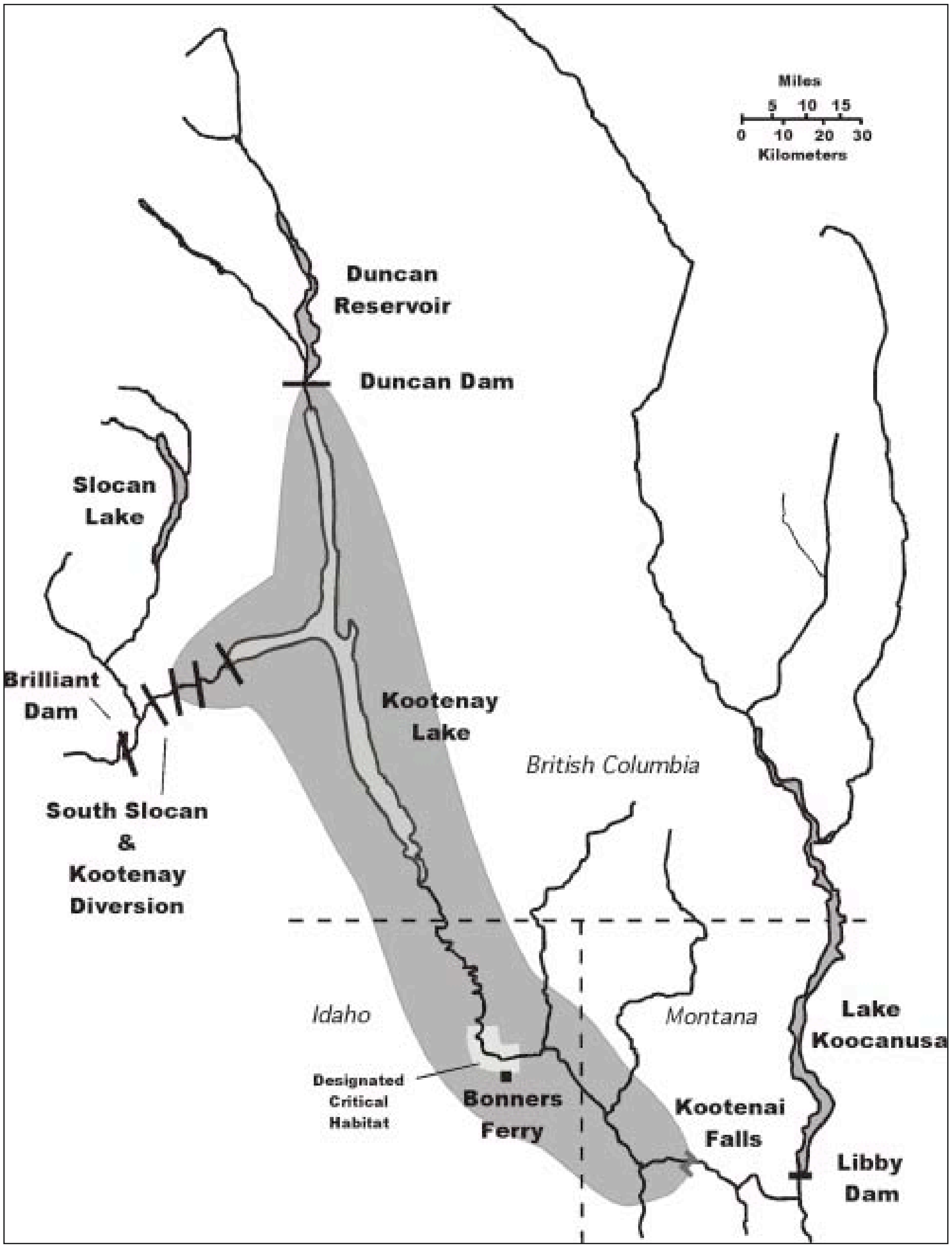

Figure 4.25. Historic distribution of Kootenai River white sturgeon (shaded area). Currently, the population generally inhabits the meandering reach from Bonners Ferry downstream into and including Kootenay Lake. Adult fish are rarely captured between Bonners Ferry and Kootenai Falls. White sturgeon have been recently isolated in Duncan Reservoir (1967), upstream from Duncan Dam. Critical habitat designated by the USFWS following the listing of the population as endangered under the ESA in 1994 is indicated just downstream from Bonners Ferry, Idaho (Figure from Paragamian et al. In Press)

contributed to the developing field of white sturgeon conservation aquaculture (Ireland et al. 2002a, 2002b; LaPatra et al. 1999). This program is also developing, implementing, and evaluating relatively rigorous fish health, population biology, and population genetic research components. In 1999, the Program expanded to include the use of a "fail-safe" facility in British Columbia (expansion of the existing Kootenay Trout Hatchery near Fort Steele, B.C. to hatch and rear white sturgeon; spelled "Kootenay" in Canada) to guard against catastrophic loss due to facility failure or a possible disease outbreak at one location. Program arrangements with the Province of B.C. facilitate annual hatching and rearing of various progeny groups at one or both locations, and provide an efficient mechanism for demographic restoration stocking in Canadian waters of the Kootenay system.

During the first 12 years of the Program (1990-2002), with the exception of 1994, mature wild fish were captured annually and bred to produce 4 to 12 separate families, and 4 to 10 adults per family at breeding age (~20 yrs) (figure 4.26). Annual egg-to-larval survival rates ranged from 1.8 to 86 percent from 1990 though 2002, and up to 12 families (including half-sib families with a shared female parent) were produced (figure 4.27). A total of slightly over 40,000 fish have been released since the early 1990s, with the majority of those releases occurring since the late 1990s.

Inter-annual variation in survival and production rates was affected by differential gamete viability among brood stock and improved by facility upgrades. Facility improvements were temporally correlated with increased survival and

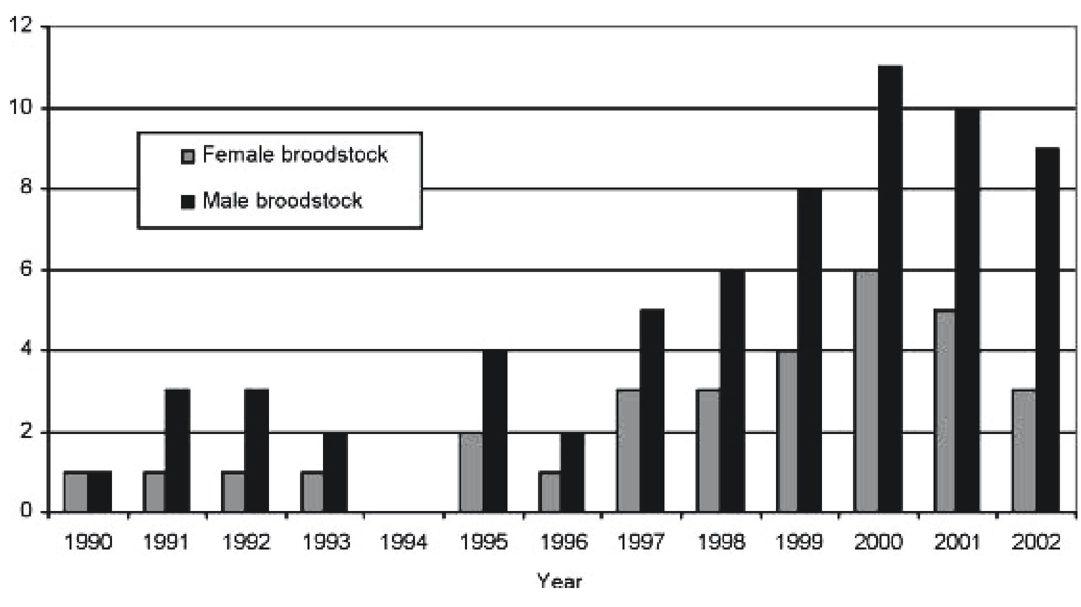

Figure 4.26. Male and female white sturgeon brood stock spawned in the Kootenai River Hatchery from 1990 through 2002. No fish were spawned during 1994.

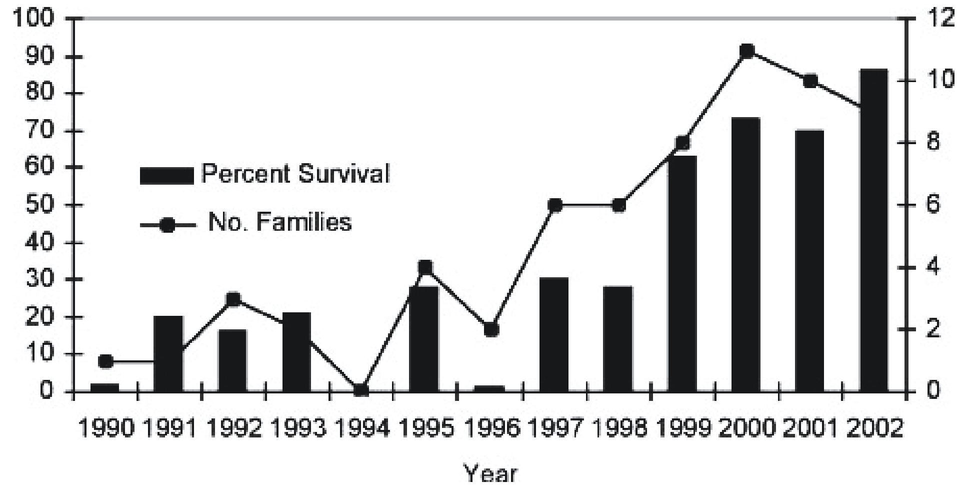

Figure 4.27. Mean annual white sturgeon egg to larval survival rates and numbers of families produced in the Kootenai Hatchery from 1990 through 2002. No fish were spawned during 1994; poor brood stock egg quality during 1996 resulted in extremely low egg to larval survival rates. Facility upgrades at the Kootenai Hatchery were completed in 1999.

production rates and performance measures. Most performance measures have increased substantially during the first 10 years of the program (figures 4.26 and 4.27).

Recapture and survival rates of juvenile white sturgeon produced in the Conservation Aquaculture Program exceeded initial expectations. Average annual post-release juvenile survival rates also exceeded initial expectations at approximately 60 percent within the release year, and 90 percent during all subsequent years (Ireland et al. 2002b). These estimates are currently being updated to include recapture and survival rates during 2003 (Ray Beamesderfer, S.P. Cramer and Associates, pers. comm. 2003).

Genetic brood stock management

Length variation arises in the D-loop of white sturgeon as a consequence of a gain or loss of 1-5 repeated tandem 78-82 base-pair nucleotide sequences (Brown et al. 1992, 1996; Buroker et al. 1990). Length variation or length polymorphism in the D-loop has been previously examined in a phylogenetic context in white sturgeon of the Columbia Basin (Brown et al. 1992, 1993). This marker system was applied to Kootenai River white sturgeon by Anders et al. (2002). Five different mtDNA length variants were observed among the 54 brood stock samples (Anders et al. 2000). The same five length variants were also observed among the 112 samples from the wild population (figure 4.28). Based on results of Chi-square (X^2) analysis, haplotype (length variant) frequency distributions of the wild population and brood stock sample groups were not significantly different (P ≤ .05; df=4, X^2 matrix value = 0.87; X^2 critical = 11.41, Appendix A; Anders et al. 2000). Therefore, brood stock selection to date appeared sufficiently representative such that statistical differences in haplotype frequencies of wild population and brood stock sample groups were nonsignificant (i.e., the brood stock sample group provided a robust, random sample of the wild population, based on our analysis).

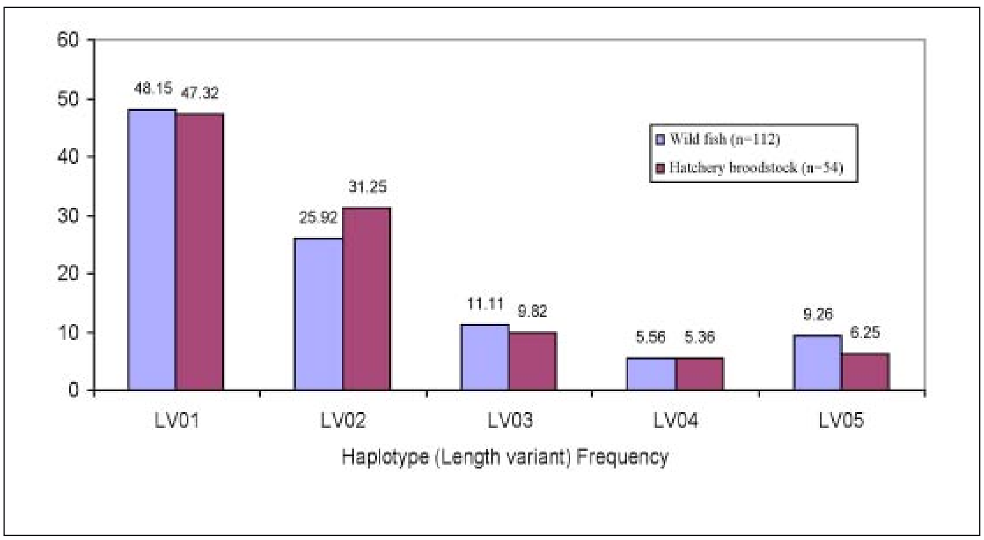

Figure 4.28. Comparison of haplotype (length variant, LV) frequencies between the wild population and the subset of Kootenai Hatchery brood stock, (1997 through 2000).

Future population trajectories with hatchery intervention

Hatchery-reared fish released since 1990 can be expected to begin recruiting to the adult population after year 2020 (figures 4.29 and 4.30). The adult population will rapidly increase from 2020 to 2030, after which it is projected to stabilize to about 3,000 sturgeon, which is 5 times the current adult population size and just under half the total number estimated in 1980. Population projections describe a significant near-term bottleneck in spawner numbers as the wild population fades but hatchery fish have not yet matured. A total of 113 to 203 females are projected to contribute to hatchery brood stock over the expected life span of the current wild population depending in catachability in out-years when abundance

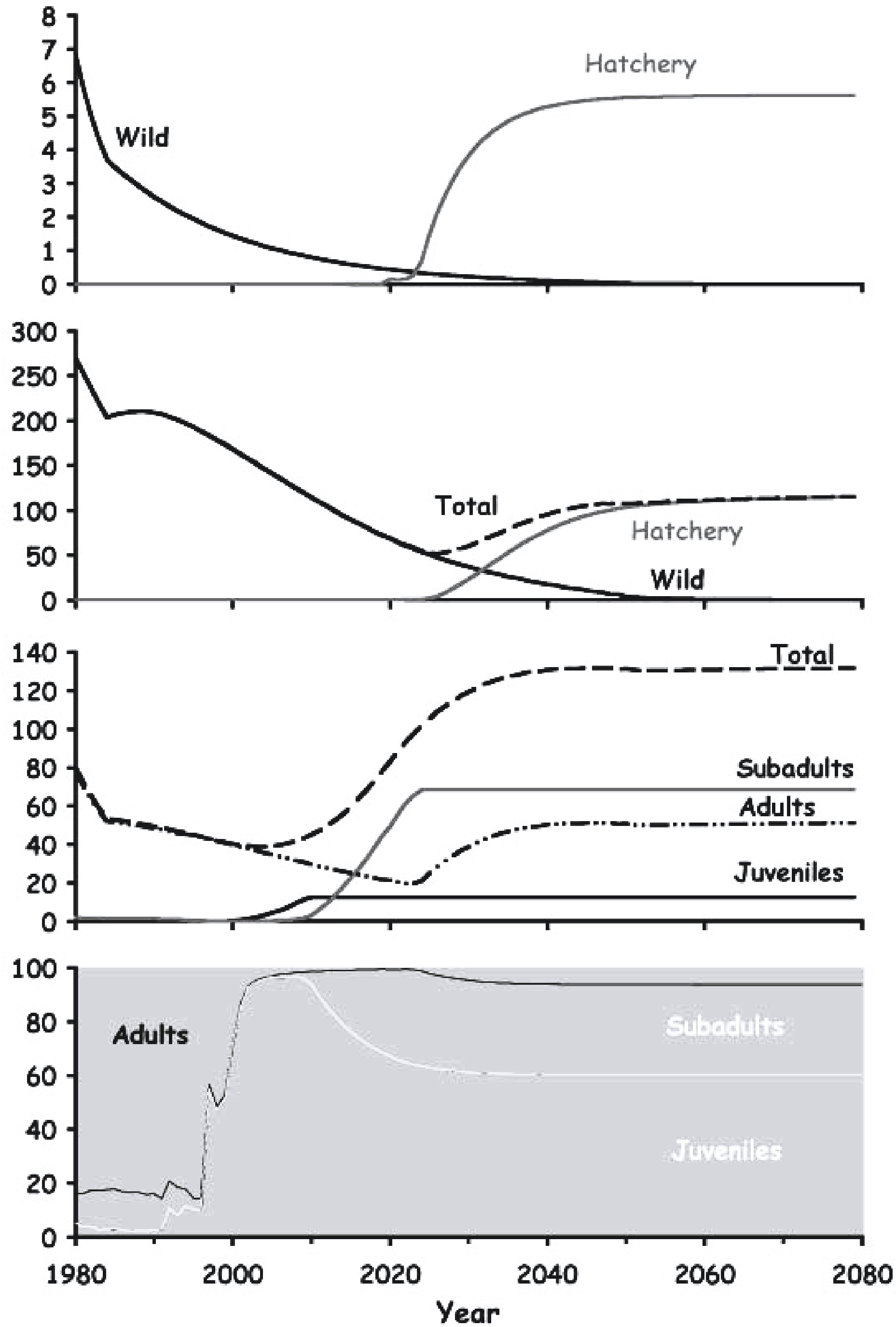

Figure 4.29. Simulated population size, female spawner number, biomass, and size composition (From Paragamian et al. In Press).

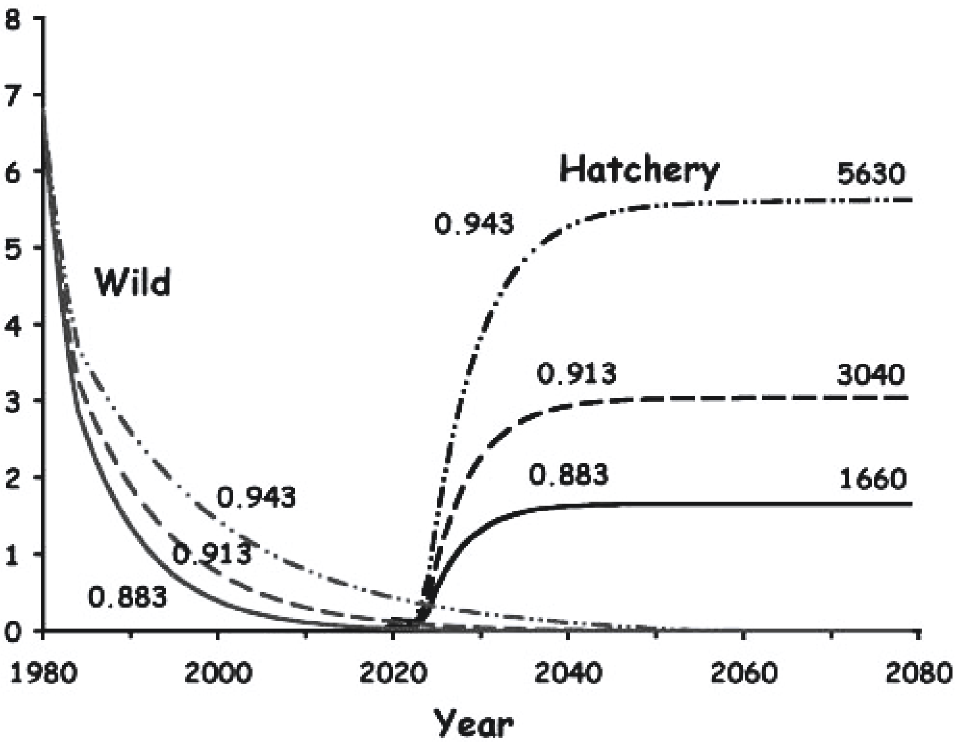

Figure 4.30. Sensitivity to annual mortality rate in model projections of hatchery-origin adult number (From Paragamian et al. In Press).

is low. Projections also indicate that equilibrium populations established over the long term (if hatchery production can be sustained through this bottleneck) will be dominated by juveniles (by numbers) and subadults (by biomass) (figure 4.29). Numbers predicted by these simple population simulations are extremely sensitive to estimates of annual survival rate but predicted patterns do not change. Figure 4.30 illustrates the profound effect of a +/- 3 percent change in survival rate on resulting population demographics.

Historic and Current Harvest

Historic harvest of white sturgeon in the Kootenai River Subbasin was typically undocumented. Although past quantitative records of white sturgeon harvest from the Kootenai River were unavailable, commercially harvested white sturgeon were locally marketed in the earlier part of this century (Partridge 1983). Up until 1984 there was a limited sport fishery for white sturgeon in the Idaho reach of the Kootenai River. From 1984 through 1994 fishing was catch and release only (Apperson and Wakkinen 1993). Currently, fishing for white sturgeon is not allowed in the Kootenai River. For a description of past fishing regulations for white sturgeon in Idaho, Montana, and British Columbia, see the USFWS White Sturgeon Recovery Plan (1999) (Appendix 78).

4.6.2 Population Delineation and Characterization

Population Units

With the exception of the artificial separation of white sturgeon in Duncan Reservoir from the rest of the Kootenai River Subbasin, which was caused by completion of Duncan Dam in 1967, all empirical demographic, telemetry, and genetic analyses (Anders 1991; Apperson and Anders 1991; Duke et al. 1999; USFWS 1999; Paragamian and Kruse 2001) indicate the presence of a single white sturgeon population in the Kootenai River Subbasin. The only known reproduction areas for this population exist in the Idaho section of the Kootenai River, and have been designated as critical habitat by the USFWS after the agency listed the species as endangered. In the Kootenai River, in a river reach several hundred kilometers in length, upstream spawning and subsequent downstream migrations of white sturgeon have been consistently observed during the past 10 years (Anders 1991; Apperson and Anders 1991; Marcuson 1994; USFWS 1999; Duke et al 1999; Paragamian et al. 1999, 2001). Thus, white sturgeon in the Kootenai River Subbasin appear to possess no geographic population structure or population units.

Life History[1]

Sturgeons exhibit several life history forms including diadromy (migrating between fresh and saltwater), anadromy (spawn in fresh water, spend nonreproductive periods in marine environment), amphidromy (bidirectional, nonreproductive migration between fresh and saltwater), and potadromy (all feeding and reproductive migrations within a freshwater river system). Poorly understood, but accounting for most white sturgeon in impounded reaches of the Columbia River system in the U.S. and Canada, is facultative potadromy, which occurs when dams prohibit expression of historically anadromous or amphidromous life history strategies (Kynard 1997). Based on expressed life histories, white sturgeon appear to be best described as facultatively anadromous, where not dam-locked. Regardless of life history strategies expressed, all sturgeons spawn

[1] *This section on white sturgeon life history characteristics was largely excerpted from Anders (2002). General life history characteristics of Acipenserids were recently summarized by Bemis and Kynard (1997) and Kynard (1997).*

exclusively in large freshwater river systems, often following upstream migrations of considerable distance (Bemis and Kynard 1997).

White sturgeon are characterized by delayed onset of first reproduction. First maturation generally occurs from 10 to 20 years of age for males, and from 15 to 30 for females (Scott and Crossman 1973; Semakula and Larkin 1968; Conte et al. 1988; Paragamian et al. In Press). This trait, coupled with empirically confirmed migratory and dispersal ability, are theorized to contribute to gene flow in white sturgeon (Brown et al. 1992, 1993). Furthermore, individual longevity ($\leq$ 82 years of age, Simpson and Wallace 1982), infrequently exceeding 100 years of age (Smith et al. 2001) may also contribute to observed migration, dispersal, and gene flow (Brown et al. 1993, 1996).

White sturgeon are iteroparous spawners that broadcast gametes into the water column. Fertilization occurs before the demersal, adhesive embryos settle to the substrate (Wang et al. 1985; Conte et al. 1998; Paragamian et al. 2001, and references therein). In demographically viable white sturgeon populations, iteroparity provides the opportunity for within-year reproduction by numerous generations of fish. Reproductive periodicities vary between sexes; males may reproduce every 2 to 4 years, while females may reproduce at no less than 5-year intervals (Conte et al. 1988; Chapman et al. 1996; Paragamian et al. In Press). Simpson and Wallace (1982) reported 4 to 11 year spawning periodicity for white sturgeon, but made no mention of gender. Little is known regarding reproductive senescence in *A. transmontanus*, although a recent review of the literature and datasets for sturgeon suggested that the Kootenai River white sturgeon population will remain reproductive throughout their lifespan (Webb 2003). One perspective suggests that natural selection would not favor the persistence of this life history trait because longevity beyond reproductive age would serve no advantageous purpose to the population (E. Brannon, University of Idaho, pers. comm.). Mature adults are thought to spawn numerous times over a 30-40 year period, and possibly longer (S. Doroshov, University of California, Davis, pers. comm.). If an individual female initially reproduced at age 25 and successfully spawned in subsequent 5-year intervals until age 65, it theoretically could contribute gametes to subsequent generations up to nine times. Finally, communal spawning, along with the above reproductive mechanisms, likely contributes to increased gene flow and maintenance of genetic diversity in white sturgeon relative to that of paired, semelparous fishes (e.g., Salmonidae), especially in the absence of confirmed homing fidelity.

Genetic Integrity

Geographic isolation, potential postglacial population founding effects, subsequent demographic bottlenecks, and past harvest may have all contributed to the relatively low genetic diversity currently observed for the Kootenai River white sturgeon population (Setter and Brannon 1990; Anders et al. 2002). Genetic studies of white sturgeon involving allozyme analysis began during the mid 1980s (Bartley et al 1985; Setter 1988; Setter and Brannon 1992). Two subsequent studies (Anders and Powell 2002; Anders et al. 2002) evaluated population genetics of Kootenai River white sturgeon using two mitochondrial DNA (mtDNA) marker systems: control region length polymorphism, and sequencing of a non-repetitive, hypervariable 453 bp. segment of mitochondrial control region. Both these studies involved white sturgeon from over approximately 18 locations in the Columbia, Snake, Kootenai, Fraser, and Sacramento River Basins (Anders and Powell 2002; Anders et al. 2002).

Results of the two independent genetic analyses (protein electrophoresis) (Bartley et al. 1985; Setter and Brannon 1992) suggested that white sturgeon from the Kootenai River population had lower heterozygosities (H= 0.014) than conspecifics from the Columbia, Fraser, and Sacramento river systems (H= 0.049-0.069). The mean percentage of 29 polymorphic loci surveyed was lowest in the Kootenai River population (27.6 percent) compared with white sturgeon from the Snake (31.0 percent) and the mid-Columbia (44.8 percent) rivers, and Lake Roosevelt (55.2 percent, Setter and Brannon 1992). Kootenai River white sturgeon are believed to be a post-glacially isolated population of ancestral Columbia River stock; no unique alleles were found in Kootenai River fish relative to downstream populations (Setter and Brannon 1992). Setter and Brannon (1992) suggested that due to lower diversity and genetic distance estimates separating white sturgeon in Kootenai system from other areas, the Kootenai River population constituted a stock within a species.

In the third genetic study involving Kootenai Subbasin sturgeon (mtDNA), length variants revealed reduced haplotype diversity in Kootenai Subbasin sturgeon compared to those in downriver areas in the Columbia Basin, and in the Fraser and Sacramento basins (Anders and Powell 2002). Samples from the Kootenai River Basin locations each shared five haplotypes (figure 4.28). Frequencies of each haplotype were similar between populations in Kootenay Lake (KL) and the Kootenai River (KR). However, the frequency of LV-01 in Kootenay Lake (53.4 percent) was slightly higher than in the Kootenai River (43.9 percent).

In the final genetic analysis involving Kootenai Subbasin white sturgeon to date, sequence analysis of a 453 base-pair non-repetitive section of the mtDNA control region from 40 fish from the Kootenai system (20 from Kootenai River, 20 from Kootenay Lake) revealed that 37 fish (92.5 percent) shared one haplotype (Anders and Powell 2002). (This haplotype was also the most common among 20 samples at each of the 11 other sites in WA, OR, ID, CA, and BC). Three haplotypes existed in both the Kootenai River and Kootenay Lake, compared to 4 to 11 (mean = 7) from a sample of 20 fish in 11 other areas of western North America (Anders et al. 2001). These and earlier genetic research findings (Bartley et al. 1985; Setter and Brannon 1992) support the postglacial isolation hypothesis, and consideration of Kootenai River white sturgeon as a separate population.

Genetic relationships of white sturgeon throughout their geographic range remain unclear. Contemporary gene flow between and among populations or locations has not been well characterized (Brown et al. 1993). However, Anders and Powell (2002) provided empirical evidence of population structure at large geographic scales on the west coast of North America.

In addition, appropriate biological and ecological data needed to accurately define white sturgeon populations and putative population structure remain inadequate. Previous examinations of genetic variation among white sturgeon from several locations using protein electrophoresis reported a reduced level of genetic variation in the Kootenai River population relative to downstream Columbia River Basin locations (Bartley et al. 1985; Setter and Brannon 1992). However, the level of genetic variation or the degree to which conspecifics in the Columbia, Snake, and other rivers form genetically distinct populations, distinct population segments (DPS; Federal Register, 1973, Endangered Species Act, Section 15.3, No. 3-16; Waples 1991), or evolutionary significant units (ESU; Ryder 1986; Moritz et al. 1987; Waples 1991; Moritz 1994) remains unknown.

The Kootenai Tribe of Idaho and the Genomic Variation Lab at the University of California, Davis have partnered to begin a more rigorous genetic evaluation of the wild population and the hatchery program using a suite of nine polymorphic microsatellite loci (Rodzen and May 2002; Rodzen et al. 2004).

4.6.3 Population Status

Current Status[2]

Empirical demographic modeling during 2002 revealed increasingly imperiled demographic status for the endangered Kootenai River white sturgeon population. Modeling suggested 90, 75, and 72 percent reductions in population abundance, biomass, and annually available spawners, respectively, during the past 22 years (1980-2002), and a current population “halving time” of 7.4 years. Recruitment failures continue to drive the decline of the Kootenai sturgeon population. No significant recruitment of juvenile sturgeon has occurred since at least 1974 and

[2] *This section on the current status of Kootenai River Subbasin white sturgeon was taken largely from Paragamian et al. (In review).*

consistent recruitment has not occurred since at least 1965. A few wild juveniles are periodically captured (0-11 annually). Of 659 recently captured juveniles, 620 were hatchery-reared and 39 (~6 percent) were wild, confirming very low natural recruitment. Managed (augmented) flows have not stimulated recruitment to date as hoped. Thus, prospects for restoring natural production remain uncertain. Furthermore, this population may be currently or intermittently stock-limited (Anders et al. 2002).

Current population abundance and dynamics confirm that time has not yet run out for the Kootenai sturgeon, but opportunities for effective intervention are rapidly dwindling. The long life span of sturgeon provides an extended period in which to identify and implement effective but contentious recovery measures. However, 35 and possibly 50 years of this window of opportunity have now passed for Kootenai white sturgeon. Consistent recruitment collapsed 15 to 30 years prior to the first systematic population surveys around 1980. Another 20 years have passed, during which the species was listed under the U.S. Endangered Species Act, a recovery plan was completed (Duke et al. 1999; USFWS 1999), a conservation hatchery program was developed (Ireland et al. 2002a; Ireland et al. 2002b), and spring spawning flow measures have been implemented (Paragamian et al. 2001a, 2001b).

The next 5 to 20 years will be a critical period in the preservation of Kootenai River white sturgeon. A bottleneck in spawner numbers will occur as the wild population dwindles and hatchery-reared fish released beginning in 1992 are not yet recruited to the spawning population. Critically low fish numbers cannot be avoided by any action that has not yet been implemented (Paragamian et al. In Press).

Historic Status

Little is known of the historical status of white sturgeon in the Kootenai River Subbasin. Kootenai Falls, Montana, and Bonnington Falls, B.C. were reported to be migration barriers that isolated white sturgeon in a ~300 km reach of the Kootenai River in Montana, Idaho, and B.C. after recolonization following the most recent Pleistocene glacial period (Wisconsin), approximately 12,000 years BP (Alden 1953; Northcote 1973; Partridge 1983). During this glacial period, the outlet of the West Arm of Kootenay Lake was blocked by ice. This blockage formed glacial Lake Kootenai, which extended south into the area currently occupied by the Lake Pend Oreille system. It is believed that this connection with the large glacial lakes to the south permitted recolonization of the Kootenai region by fish species whose subsequent migration was blocked by Kootenai and Bonnington Falls (Alden 1953).

Historically, the Lower Kootenai River produced approximately ten different species of fish utilized as food by the Kootenai Indians (Scholz 1985). Some of these species included the Kootenai River white sturgeon (*Acipenser transmontanus*), bull trout (*Salvelinus confluentus*), whitefish (*Prosopium williamsoni*) and burbot (*Lota lota*). For the Kootenai Tribe of Idaho, the Kootenai white sturgeon held a cultural and religious significance. Even their canoes took the shape and name (sturgeon-nosed canoes) of this large native fish (figure 4.31).

Historically, natural production of white sturgeon in the Kootenai River supported commercial and recreational fisheries (Partridge 1983), as well as a subsistence fishery for the native Kootenai Indians (Schaeffer 1940; Johnson 1969; Turney-High 1969; Scholz et al. 1985). Currently, white sturgeon occupy the meandering reach, from Bonners Ferry, Idaho, downstream to the river delta at the south end of Kootenay Lake. White sturgeon are also found throughout Kootenay Lake (Duke et al. 1999; USFWS 1999). Accurate estimates of historical population size are unknown. The first calculated estimate of Kootenai River white sturgeon population size was 1,194 individuals (95 percent CI: 907-1,503; Partridge 1983). At that time, natural recruitment appeared to be lacking (Partridge 1983). Population size was subsequently estimated in 1990, (880 individuals, 95 percent CI: 639-1,211; Apperson and Anders 1991), and 1996 (1,469 individuals, 95 percent CI: 720-2,197; Paragamian et al. 1996). During the mid-1990s, approximately 90 percent of the individuals in this population were estimated to be ≥ 21 years of age (Paragamian et al. 1995; BPA 1997). During the late 1990s, natural recruits since 1974 comprised approximately 1 percent of the current population (Bonneville Power Administration 1997). For comparison, immature fish accounted for over 95 percent of the white sturgeon population downstream from Bonneville Dam, the furthest downstream impoundment on the Columbia River (DeVore et al. 1999). This unimpounded lower Columbia River population is considered the most productive of any white sturgeon population in the Columbia River Basin (DeVore et al. 1999), and also has access to food resources in estuarine and marine habitats unavailable to upstream impounded populations.

Figure 4.31. Photograph of a Kutenai sturgeon-nosed canoe.

Theoretical Reference Condition[3]

The short-term recovery objectives of the Kootenai River White Sturgeon Recovery Plan are to reestablish successful natural recruitment and prevent extinction through the use of conservation aquaculture. The long-term objective is to downlist and then delist the fish when the population becomes self-sustaining and can provide at least a catch and release fishery.

Criteria for reclassification or downlisting to threatened status for Kootenai River white sturgeon include:

1. Natural production of white sturgeon occurs in at least 3 different years of a 10-year period. A naturally produced year class is demonstrated through detection by standard recapture methods of at least 20 juveniles from that class reaching more than 1 year of age, and;

2. The estimated white sturgeon population is stable or increasing and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year for a 10-year period. For this purpose, a year class will be represented by the equivalent of 1,000 one year old fish from each of 6 to 12 families, i.e., 3 to 6 female parents. Each of these year classes must be large enough to produce 24 to 120 white sturgeon surviving to sexual maturity. Over the next 10 years, the number of hatchery reared juvenile

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[3] *Guidance from the Power Planning Council states that "this [section of the assessment] is a key component of the NMFS and USFWS ESA delisting evaluation, and that for ESA-listed species, these determinations will be made by the appropriate recovery team."*

fish released annually will be adjusted depending upon the mortality rate of previously released fish and the level of natural production detected. Additionally, if measures to restore natural recruitment are successful, the conservation aquaculture program may be modified. Conversely, the U.S. Fish and Wildlife Service may recommend that the conservation aquaculture program be extended beyond 10 years if adequate natural recruitment to support full protection of the existing Kootenai River white sturgeon gene pool is not clearly demonstrated, and;

3. A long-term Kootenai River Flow Strategy is developed in consultation of interested State, Federal, and Canadian agencies and the Kootenai Tribe at the end of the 10-year period based on results of ongoing conservation actions, habitat research, and fish productivity studies. This strategy should describe the environmental conditions that resulted in natural production, i.e., recruitment (as described in criterion No. 1) with emphasis on those conditions necessary to repeatedly produce recruits in future years.

Recovery or delisting will be based on providing suitable habitat conditions and restoring an effective population size and age structure capable of establishing a self-sustaining Kootenai River population of white sturgeon.

4.6.4 Out-of-Subbasin Effects and Assumptions

Mainstem Columbia River hydro and flood control operations influence ecological, biological, and physical habitat conditions in upriver and headwater areas, including the Kootenai River Subbasin. The abundance, productivity, and diversity of fish and wildlife species inhabiting the Kootenai River Subbasin, and other headwater areas of the Columbia River Basin, depend on the dynamic conditions of their immediate environments. These conditions are profoundly affected by out-of-basin effects (e.g., operation of the Mainstem Columbia River hydropower system). Mainstem and out-of-basin operations affect Kootenai Subbasin white sturgeon in the following ways:

- Unnatural water discharge and temperature regimes at any time of the year can negatively affect resident fish and supporting lower trophic level taxa. However, unnatural, detrimental effects of hydro operations to white sturgeon and other native taxa can be mitigated to varying degrees by releasing flows at more constant rates and providing smoother shaped water blocks required to address power production and flood control requirements.

- Summer flow augmentation causes reservoirs in the Kootenai Subbasin to be drafted artificially during the most biologically productive summer months. This loss of productivity reduces forage availability and in-reservoir biomass production of all taxa in the reservoir.

- Drafting reservoirs too hard (deep) prior to the January 1 and subsequent inflow forecasts decreases the probability of reservoir refill.

- Flow fluctuations caused by variable power production needs, flood control, or fish flows create wide varial zones in near-shore river and reservoir habitats. Varial zones are characterized by biological instability, due to frequent inundation and dewatering, and by losses of ecological and biological productivity and function.

4.6.5 Environment-Population Relationships

In addition to demographic and genetic requirements, suitable physical habitat (abiotic) and ecological (biotic) conditions are required for viability and persistence of fish populations (table 4.63). In particular, key ecological correlates for Kootenai River white sturgeon include, but are not limited to: suitable water quality, hydraulic and thermal conditions, and predation and competition within ranges that collectively allow life cycle completion. Abiotic and biotic factors must be collectively suitable for completion of each specific life stage in the life cycle continuum, including: spawning, incubation, recruitment, juvenile and subadult rearing, sexual maturation and reproduction.

LINKS

For the USGS report summarizing lower Kootenai River channel conditions and changes in suspended-sediment transport and geometry in white sturgeon habitat, go to: http://id.water.usgs.gov/PDF/wri034324/index.html

Click Here

For the USGS surveys of lower Kootenai River cross sections, go to: http://id.water.usgs.gov/PDF/ofr041045/index.html

Click Here

Long-term Viability of Populations Based on Habitat Availability and Condition

Based on empirical research during the past 20 years, and on current habitat availability and condition, the Kootenai River white sturgeon population appears to possess no long-term viability without intervention (figure 4.32). Without intervention, continued recruitment failure and population extinction are certain during the next 20-40 years (Paragamian et al. In Press). To compensate for: (1) limited or failed natural recruitment since at least the 1960s, (2) the need to preclude extinction, and (3) the failure to reestablish natural recruitment during the 1990s with limited altered hydrograph experiments, a more rigorous

Table 4.63. Description of environment/population relationships by life stage for Kootenai River white sturgeon. Key environmental correlates are presented as a series of abiotic and biotic factors.

Life Stage:	Spawning
Life stage status	Limiting
	Population appears to be stock limited (too few spawners to compensate for collective early life mortality due to biotic and abiotic factors; Anders et al. 2002)
Abiotic factors	
Hydrograph	Post-impoundment thermograph reversed Higher discharge during winter, much lower during summer; absence of natural spring freshet. Absence of historical hydrograph may be responsible for lack of upstream migration to suitable spawning habitat (in canyon reach)(Partridge 1983; Anders 1991; Duke et al 1999; USFWS 1994, 1999; Bob Hallock, USFWS pers, comm.)
Thermograph	Post-impoundment thermograph cooler in spring, summer, warmer in winter, unnatural thermal changes may negatively affect spawning migrations, success (Duke et al. 1999; USFWS 1994, 1999; Paragamian and Kruse 2001).
Water Quality	Although contamination may be a chronic and possibly sub-lethal stressor in the Kootenai River (Kruse and Scarnecchia 2002) observations of embryo mortality rates does not indicate water quality *per se* is limiting spawning. However, bioaccumlated toxins could negatively affect gamete viability, and therefore spawning success.
Physical habitat	Habitat conditions where spawning is occurring appear to limit or preclude successful embryo incubation (post-dam depositional areas lacking interstitial space) (Duke et al. 1999; USFWS 1994, 1999; Paragamian and Kruse 2001; Anders et al 2002).
Biotic factors	
Food Availability	Food availability is not directly applicable to spawning success. Nutrient limitation in wild sturgeon diets could negatively affect spawning success through reduced gamete viability or fecundity. However, empirical relative weight estimates provided an index of condition factor and has declined from a robust average of 150% in 1977-1983 to 90% in 1989-2001. (Ray Beamesderfer, S.P. Cramer and Associates, personal communication; Paragamian et al. In Press).
Predation	Confirmed predation on white sturgeon eggs and embryos by native omnivorous fishes in the Kootenai River (Anders 1994, 1996), and confirmed ingestion rates of white sturgeon eggs and embryos by native omnivorous fishes in Columbia River impoundments (Miler and Beckman 1996) suggest that white sturgeon recruitment in the Kootenai River may be negatively affected by predation. This potentially limiting effect to recruitment may be exacerbated by additional post-dam habitat and ecological community changes downstream from Libby Dam (Korman and Walters 1999; Anders et al. 2002; Paragamian 2002). During 1994 and 1995, 632 stomach content samples from predatory fishes collected from the Kootenai River (northern pikeminnow (*Ptychocheilus oregonensis*), peamouth chub (*Mylocheilus caurinus*), and suckers (*Catotomus spp*.) were analyzed (Anders, 1994, 1996). Of 428 naturally spawned white sturgeon eggs collected from the Kootenai River during 1994 and 1995, 12.2% (n=52) were recovered from stomach content samples of these predatory fishes; 662 stomach samples were processed (Anders 1994, 1996).
Competition	Interspecific competition is irrelevant to spawning success (with the exception of predation on eggs and embryos). Due to reduced effective population size of Kootenai River white sturgeon population (numbers of breeders each year) interspecific competition does not appear to limit spawning.
Growth	NA
Survival	NA
Recruitment	Over generations, recruitment failure has negatively affected spawning by reducing the number of breeders spawning in the Kootenai River.

Table 4.63. (cont.). Description of environment/population relationships by life stage for Kootenai River white sturgeon. Key environmental correlates are presented as a series of abiotic and biotic factors.

Life Stage:	**Embryo**
Life stage status	**Limiting**
Abiotic factors	
Hydrograph	May have indirect negative effects on embryo incubation if altered hydrograph contributes to spawning over unsuitable incubation habitat.
Thermograph	No apparent negative effects on incubation. However, if unnaturally cold hypolimnetic water from Libby Reservoir results in spawning reduction or limitation, that limitation to spawning would be reflected in an equal or greater limitation at the embryo life stage.
Water Quality	In terms of contaminants, no empirically confirmed direct negative effects of Kootenai River water quality on embryo incubation in the wild. However, Kruse and Scarnecchia (2002) reported that copper and Aloclor 120 in experimental rearing medium may have decreased survival of experimentally incubating embryos in situ. Furthermore, tens of thousands of progeny from over 100 brood stock have hatched and reared on river water, and have survived well after release from the Kootenai Hatchery. However, these early life stages were incubated and reared with no contact to river sediments.
Physical habitat	Habitat conditions where spawning is occurring appear to limit or preclude successful embryo incubation (post-dam depositional areas lacking interstitial space) (Duke et al. 1999; USFWS 1994, 1999; Paragamian and Kruse 2001; Anders et al. 2002).
Biotic factors	
Food Availability	NA-Embryos are endogenously supplied with nutrients.
Predation	Current incubation habitat appears to be limiting or prohibiting completion of embryo incubation in the Kootenai River. This is based on empirical observation, lab tests of effects of fine material deposition (embryo suffocation), and theory (Korman and Walters 1999; Anders et al. 2002; Koch 2003), and on predation. Empirical evidence of predation on sturgeon embryos (Anders 1994,1996), and ingestion rates of omnivorous fish consuming sturgeon embryos (Miler and Beckman 1996) suggest spawning may be overwhelmed by post-development predation pressure, facilitated by additional post-dam habitat and community changes (Korman and Walters 1999; Anders et al. 2002).
Competition	NA
Growth	NA
Survival	Embryo survival appears compromised or negated by predation and suffocation in current incubation habitat (USFWS 1999; Duke et al 1999; Korman and Walters 1999; Anders et al. 2002).
Recruitment	Significant embryo mortality can result in partial or total recruitment failure, depending on the magnitude of the mortality.

Table 4.63. (cont.). Description of environment/population relationships by life stage for Kootenai River white sturgeon. Key environmental correlates are presented as a series of abiotic and biotic factors.

Life Stage:	Larvae
Life stage status	**Limiting**
Abiotic factors	
Hydrograph	May have indirect negative effects on embryo incubation if altered hydrograph contributes to spawning over unsuitable incubation habitat.
Thermograph	No apparent negative effects on incubation. However, if unnaturally cold hypolimnetic water from Libby Reservoir results in spawning reduction or limitation, that limitation to spawning would be reflected in an equal or greater limitation at the larval life stage.
Water Quality	No larvae have been captured from the Kootenai River to determine whether water quality parameters are limiting larval production and survival.
Physical habitat	Habitat conditions where larval rearing is occurring appear to limit or preclude successful embryo incubation (post-dam depositional areas lacking interstitial space) (Duke et al. 1999; USFWS 1994, 1999; Paragamian and Kruse 2001; Anders et al 2002).
Biotic factors	
Food Availability	It is currently unknown whether food availability limits larval production. Anders et al. (2002) speculated that food limitation could have negative effects on larvae, given the current ultraoligotrophic status of the Kootenai River (Snyder and Minshall 1996; Hoyle 2003; Anders et al. 2002, 2003).
Predation	Current larval rearing habitat appears to be limiting or prohibiting completion of this life stage in the Kootenai River. Alternatively, the absence of larvae could result from near total embryo mortality due to mechanisms explained above. Larval suffocation and predation may also be limiting completion in the larval life stage for Kootenai River white sturgeon (Brannon et al. 1985; Korman and Walters 1999; Anders et al. 2002).
Competition	NA
Growth	NA
Survival	No known surviving larvae from natural production have been collected from the Kootenai River. Therefore, no estimates of survival rate are available.
Recruitment	Significant larval mortality could result in partial or total recruitment failure, depending on the magnitude of the mortality.

Table 4.63. (cont.). Description of environment/population relationships by life stage for Kootenai River white sturgeon. Key environmental correlates are presented as a series of abiotic and biotic factors.

Life Stage:	**Juvenile Rearing**
Life stage status:	**Non-limiting**
Abiotic factors	
Hydrograph Thermograph Water Quality Physical habitat	The post-development thermograph, hydrograph, water quality, and physical habitat features do not appear to be limiting juvenile rearing. Most juvenile rearing in the Kootenai River currently involves hatchery-produced fish, which survived and grew better than expected after release. Annual survival rates averages 60% for the year of release, and 91% during all subsequent post-release years (Paragamian et al. In Review).
Biotic factors	
Food Availability Predation Competition Growth Survival Recruitment	Based on empirical survival and growth estimates, biotic factors of food availability, predation, competition, growth and survival do not appear to be limiting or prohibiting completion of the juvenile life stage. However, as with all post-development systems, large-scale system perturbations have effects on the aquatic communities that may not be detected due to the lack of a previous reference pre-dam condition. The importance of nutrient and energy dynamics during natural pulses of water discharge in rivers has been extensively described in terms of river ecology (e.g., flood pulse, river continuum, nutrient spiraling, and serial discontinuity concepts. (Vannote et al. 1980; Daley et al. 1981; Woods et al 1982; Ward et al. 1983; Junk et al. 1989. Bayley 1995; Ligon 1995; Snyder and Minshall 1996, and others). Post-development environmental and ecological conditions may have non-lethal negative effects on this life stage.
Life Stage:	**Sub-Adult Rearing to Sexual Maturity**
Life stage status	**Non-limiting**
Abiotic factors	
Hydrograph Thermograph Water Quality Physical habitat	The hydrograph, thermograph, water quality, and physical habitat do not appear to be limiting or prohibiting the completion of the sub-adult life stage for Kootenai River white sturgeon. However, as with all post-development systems, large-scale system perturbations have effects on the aquatic communities that may not be detected due to the lack of a previous reference pre-dam condition.
Biotic factors	
Food Availability Predation Competition Growth Survival Recruitment	Based on current food availability, predation, competition, growth and survival do not appear to be limiting the Kootenai River white surgeon population, or the completion of the sub-adult life stage. However, recruitment failures on decadal scales are seriously limiting the population, with a projected persistence estimate of less than 30 years without intervention (Ray Beamesderfer, S. P Cramer and Associates, pers. comm.; Paragamian et al. In Review). However, as with all post-development systems, large-scale system perturbations have effects on the aquatic communities that may not be detected due to the lack of a previous reference pre-dam condition. The importance of nutrient and energy dynamics during natural pulses of water discharge in rivers has been extensively described in terms of river ecology (e.g., flood pulse, river continuum, nutrient spiraling, and serial discontinuity concepts) (Vannote et al. 1980; Daley et al. 1981; Woods et al. 1982; Ward et al. 1983; Junk et al. 1989. Bayley 1995; Ligon 1995; Snyder and Minshall 1996, and others). Post-development environmental and ecological conditions may have non-lethal negative effects on this life stage.

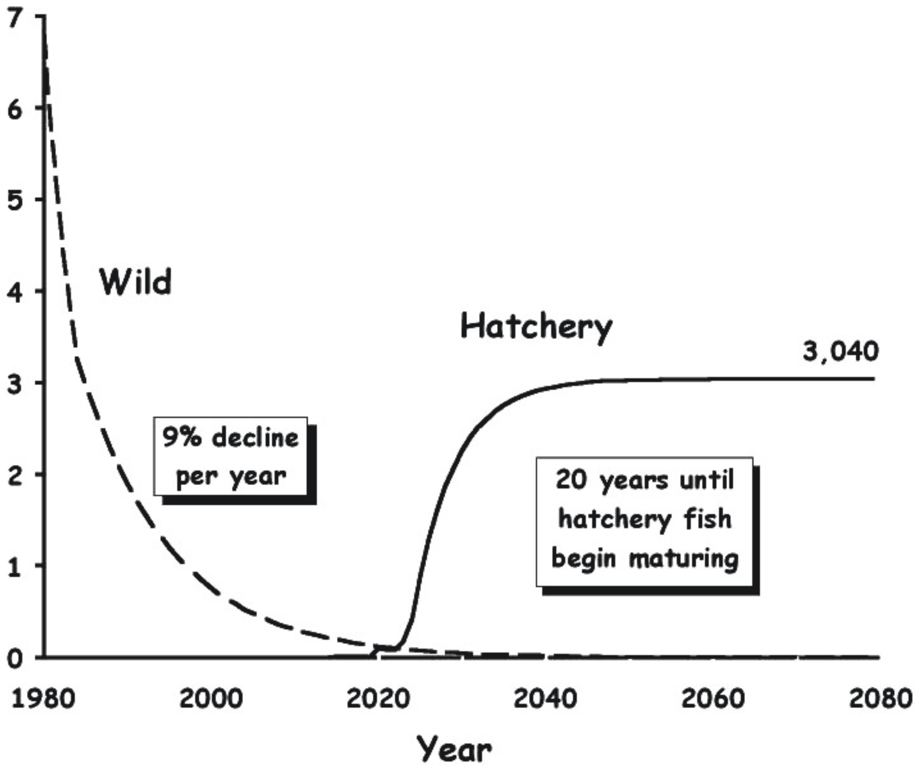

Figure 4.32. Empirically modeled trajectory of Kootenai River white sturgeon with and without hatchery intervention (Paragamian et al. In Press).

conservation program has been implemented to preclude extinction while factors limiting or prohibiting natural recruitment are being addressed and resolved (KTOI 2004).

4.6.6 White Sturgeon Limiting Factors and Conditions[4]

A series of factors appear to be limiting natural recruitment in the Kootenai River white sturgeon population (figure 4.33). These factors fall into two general categories: demographic stock limitation and post-spawning early life mortality factors.

[4] *This section on limiting factors and conditions of Kootenai River white sturgeon were largely excerpted from Anders et al. 2002.*

Demographic stock limitation

An important initial question regarding natural recruitment failure in the Kootenai River white sturgeon population was whether this population is stock limited. Because males in this system are believed to spawn every 2 to 3 years, and females at least every 5 years (USFWS 1999), natural production in this population should be initially limited by reduced annual numbers of female spawners. Severe limitation of female spawners in a given year could render post-spawning early life mortality factors obsolete during that year.

Early-life mortality factors

During years lacking female stock limitation, given natural spawning and failed natural recruitment, post-spawning early-life mortality factors (figure 4.33, shaded boxes) could explain failed recruitment. These potential early-life mortality factors may have affected egg, larval, fingerling, and young-of-the-year (YOY) stages of white sturgeon. Spawning location may be the most significant issue to post-ESA listing of white sturgeon (Paragamian et al. 2001, 2002). While spawning has been documented each year since listing in 1994 (as evidenced by the capture of over 1,000 eggs (Paragamian et al. 2001, 2002)) only one larval fish was captured, while the capture of hatchery fish (released at about 15 to 20 cm) totals 200 to 400 each year. Survival of hatchery fish stocked at age 1+ to 2 is about 65 percent for the first year and 90 percent thereafter (Ireland et al. 2002b). These data suggest a survival bottleneck at the egg-to-hatch-out stage, and habitat appears to be the most limiting factor.

A major contribution to the debates about white sturgeon recruitment failure and habitat requirements associated with successful natural recruitment was provided in a recent paper that presented a riparian habitat hypothesis to explain successful white sturgeon recruitment (Coutant 2004). Based on an extensive review of available literature and studies, this paper proposed that submerged riparian habitat during seasonal high water is needed for early development. Where recruitment is successful, channels are complex and floodable riparian vegetation or rocky substrate is abundant. There—spawning occurs in turbulent zones upstream (1–5 km) of seasonally submerged riparian habitat—eggs can disperse into inundated habitat and adhere to newly wetted surfaces for incubation; yolk-sac larvae can move to riparian crevices for pre-feeding development; feeding larvae have food-rich flooded habitat for early growth; and larvae can transition to juveniles as water recedes to permanent channels. Such habitat is lacking where recruitment is low and present only in high-flow years where recruitment is sporadic. These observations suggest that management should

LINKS

For a riparian habitat hypothesis for successful reproduction of white sturgeon (Coutant 2004), go to Appendix 118.

Click Here

Holderman and Hardy (2004) discuss potential limiting factors in the Lower Kootenai.

Click Here

In her MS Thesis, Hoyle (2003) discusses the responses of periphyton, benthic macroinvertebrates, and juvenile white sturgeon to experimental additions of nitrogen and phosphorous in the Kootenai River, Idaho.

Click Here

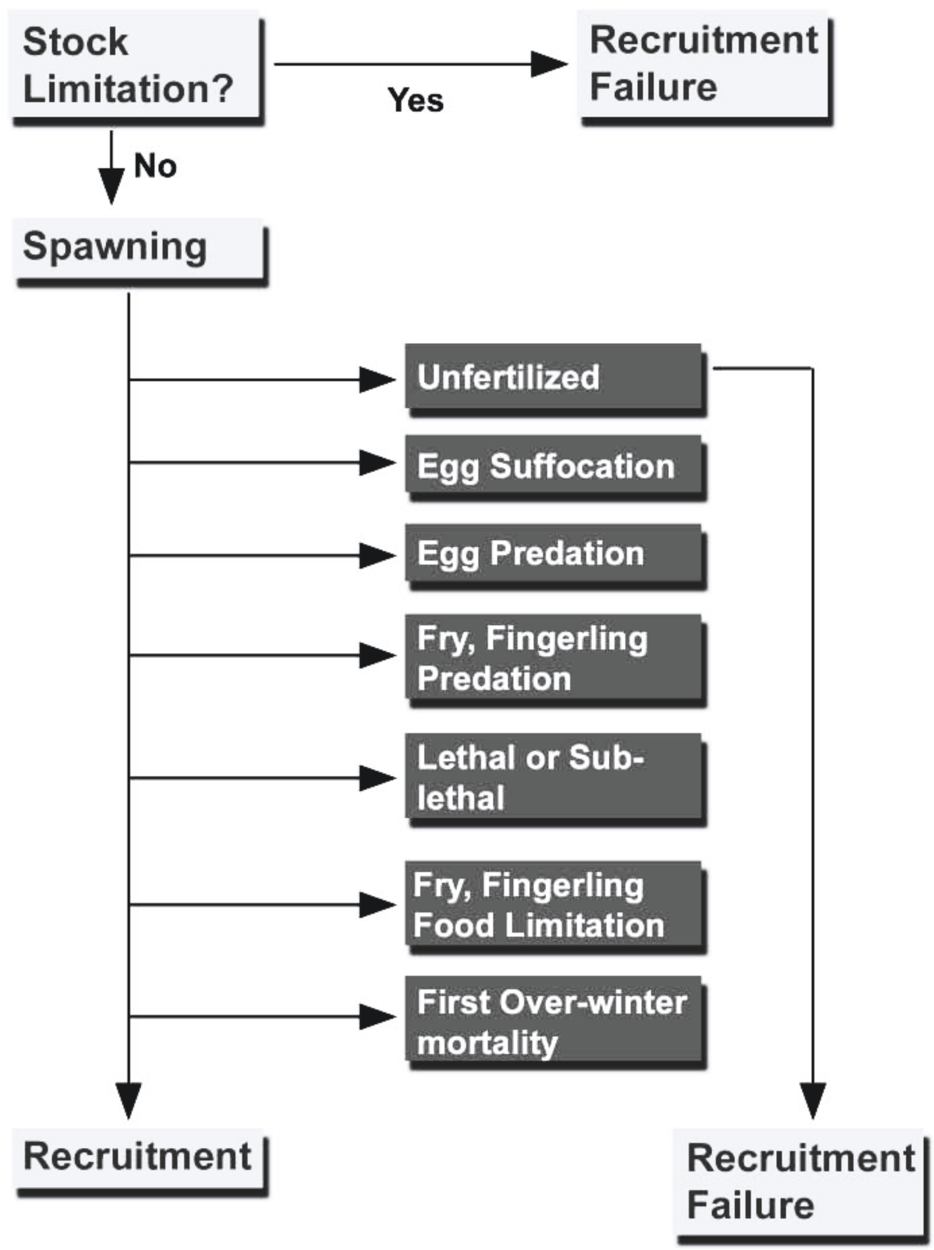

Figure 4.33. Hypothesized causes of natural recruitment failure in the Kootenai River white sturgeon population. Although post-spawning mortality factors (shaded boxes) operate in natural, unaltered ecosystems, post-development alterations in the Kootenai River may have increased their relative contributions to recruitment failure in this population. (See text for discussion of mortality mechanisms). Figure from Anders et al. 2002.

LINKS

The declining population of Kootenai River white sturgeon has prompted an assessment of the feasibility of various habitat enhancement scenarios to reestablish white sturgeon populations. For the first phase in this assessment, go to Appendix 95.

Click Here

rehabilitate riparian zones and provide high river flows during spawning to stimulate natural recruitment.

Additional empirical evidence for the use of riparian and side channel habitat for successful completion of early life stages was also recently reported from the lower Fraser River in British Columbia (Perrin et al. 2003). Six spawning sites were reported by the authors, five of which were in side channels. Multiple lines of evidence, including radio tracking of pre-spawning adults and visual observations, substantiated the use of side channels by white sturgeon for spawning. These observations are consistent with observations supporting the riparian habitat hypothesis (Coutant 2004).

LINKS

For T.J. Kock's MS thesis entitled: Effects of Sedimentation nnd WaterVelocity on White Sturgeon Embryo Survival, go to Appendix 119:

Click Here

Eggs

Based on empirical evidence, egg suffocation and predation were suspected egg mortality factors for Kootenai River white sturgeon (Paragamian et al. 2001, 2002). Paragamian and Kruse (1999) experimented with egg sampling mats by placing drift nets on seven experimental mats. Of 484 eggs collected in 1998, 91 were collected by the experimental mats, of which 81 were on the mat and 10 were mixed with sand in the drift nets. Over 96 percent (428 of 444) of the naturally produced white sturgeon eggs collected from the Kootenai River between 1991 and 1995 were collected from habitat that appeared to be suboptimal for incubation (Paragamian et al. 2001, 2002). River velocity and substrate characteristics of documented white sturgeon egg collection areas (near assumed spawning habitat) in the Kootenai River were atypical of white sturgeon spawning habitat in other parts of the Columbia River Basin (Parsley et al. 1993; Hildebrand and McKenzie 1994; Paragamian et al. 2001, 2002). In the three farthest downstream Columbia River reservoirs, the free-flowing reach downstream from Columbia River dams in the U.S., and the Columbia River in B.C., white sturgeon spawned in higher water-velocity areas with substrate particle size larger than those observed in the Kootenai River (table 4.64). These differences in spawning habitat use by Kootenai River and Columbia River white sturgeon may have contributed to recruitment failure. White sturgeon also spawned in considerably colder water in the Kootenai River than in all lower and upper Columbia River locations (table 4.64). Spawning in colder water would subject white sturgeon eggs in the Kootenai River to a longer incubation period. Longer incubation periods could result in increased egg mortality by increasing the duration of exposure to predation and suffocation.

Additionally, white sturgeon spawning and incubation microhabitat characteristics may have limited or prohibited successful incubation and hatching of white sturgeon eggs in the Kootenai River. Egg incubation and collection areas in the Kootenai River lacked interstitial space (Paragamian et al. 2001,

Table 4.64. Physical habitat conditions at sites where white sturgeon (Acipenser transmontanus) eggs were collected in the Columbia River in the United States and Canada, and from the Kootenai River in the United States. (From Anders et al. 2002 b).

Location	Years	Water Temp (°C)	Mean water column velocity (m/s)	Velocity near substrate	Substrate type	References
Lower Columbia River	1987-1991	18-Oct	1.0-2.8	0.06-2.4	Boulder	Parsley et al. 1993
Columbia River Impoundments	1987-1991	18-Dec	0.81-2.10	0.52-1.62	Cobble	Parsley et al. 1993
Kootenai River	1994	7.8-11.2	0.03-0.27	-	Fine sediment and sand	Anders 1994
	1995	8.4-12.9	0.68	0.93	Fine sediment and sand	Anders and Westerhof 1996
	1991-1998	8.5-12.0	0.19-0.83	-	Fine sediment and sand	Paragamian et al. 2001
Columbia River, BC.	1993	15.5-17.0	-	-	Clean small boulder, large cobble	Hildebrand and McKenzie 1994
	1995	15.5-21.6	0.5-1.8	-	Bedrock, boulder, cobble	RL&L 1996
Fraser River, BC	1998	15.1	-	-	Bedrock	RL &L 1998; Perrin et al. 1999
Sacramento River, CA.	1970	14-22	-	-	Gravel	Stevens and Miller 1970
	1973	-	-	-	Mud and sand	Kohlhorst 1976

2002; USFWS 1999). These habitats occurred predominantly in the historical alluvial floodplain, currently characterized by low gradient, low water velocity, and the deposition of fine sands, silts, and sediments (Anders and Richards 1996).

Spawning location of Kootenai River white sturgeon appears to be a contradiction to white sturgeon life history (Paragamian et al. 2001, 2002). The depositional characteristics of white sturgeon egg incubation habitats are relevant to egg survival in the Kootenai River due to the eggs' demersal and adhesive qualities. An adhesive jelly layer surrounds white sturgeon eggs throughout early development. The adhesiveness of the jelly layer is important for anchoring eggs to the substrate at the vegetal pole during natural spawning (Conte et al. 1988). Attachment to the substrate in this fashion orients the micropyle upward prior to fertilization. Contact with freshwater causes the jelly layer to hydrate and the egg becomes adhesive within 5 minutes (Conte et al. 1988). The observation that no confirmed viable white sturgeon eggs collected from the Kootenai River from 1991 through 1995 had developed beyond approximately 60 hours after estimated spawning and fertilization suggested that egg suffocation might have been a substantial early life mortality factor for this population. However, during 1996, many of the naturally spawned eggs collected were within a day of hatching (V. Paragamian, IDFG, pers. comm.).

During 1994 and 1995, 632 stomach content samples from predatory fishes collected from the Kootenai River (northern pikeminnow (formerly northern squawfish), (*Ptychocheilus oregonensis*), peamouth chub, (*Mylocheilus caurinus*), and suckers (*Catotomus* spp.) were analyzed (Anders 1994, 1996). Of 428 naturally spawned white sturgeon eggs collected from the Kootenai River during 1994 and 1995, 12.2 percent (52) were recovered from stomach content samples of these predatory fishes (Anders 1994, 1996). Although observed predation accounted for only 12 percent of all eggs collected during these 2 years, identification of ingested eggs in stomach content samples was likely for a presumably short period of time. Thus, documented consumption of white sturgeon eggs likely represented an extremely conservative estimate of predation.

Miller and Beckman (1996) reported the occurrence of 1 to 70 white sturgeon eggs in guts of four omnivorous fish species in the Columbia River (northern pikeminnow, largescale sucker *(Catostomus macrocheilus)*, prickly sculpin *(Cottus asper)*, and common carp, *(Cyprinus carpio*)). Empirical confirmation of one largescale sucker in the Columbia River consuming 70 white sturgeon eggs (Miller and Beckman 1996) suggested that predation may account for considerable egg mortality in the Columbia River. Given the inefficiency of collecting consumed white sturgeon eggs from stomach content samples, and the presence of these predatory species, predation may have been an important, underestimated mortality factor for white sturgeon eggs in the Kootenai River. Furthermore, this predation scenario may have been exacerbated by reduced predator search times and volumes due to reduced river discharge (volume) during white sturgeon spawning and incubation seasons in the post-impoundment Kootenai River, relative to pre-impoundment water volumes (Risk-Ratio hypothesis; Korman and Walters 1999). In addition, reduced turbidity in the post-impoundment system may have also increased efficiency of visual predation (Korman and Walters 1999). However, predation is a natural phenomenon and there is very little empirical data for the Kootenai River to substantiate predation as the leading mortality factor.

Larvae

If naturally spawned and fertilized eggs hatched in the post-development Kootenai River, mortality of larval white sturgeon may have occurred due to post-impoundment rearing habitat losses or degradation, suffocation, predation, sublethal exposure to contaminants, or larval starvation (figure 4.33, shaded boxes). Over a 5-year period (1991-1995), no larval white sturgeon were collected from the Kootenai River (USFWS 1999; Paragamian et al. 2001, 2002) despite extensive sampling with gear and techniques proven to efficiently capture larval white sturgeon in other river systems (Palmer et al. 1988; Parsley et al. 1993; Anders and Beckman 1993; McCabe and Tracy 1993). No white sturgeon larvae were subsequently collected from the Kootenai River from 1995 through 1998 (USFWS 1999). Only one larval white sturgeon has been caught to date. However, the same gear has been used to successfully recapture hatchery reared larval white sturgeon shortly after their release (Paragamian et al. 2003).

Brannon et al. (1985) conducted laboratory studies to characterize distribution behaviors of Columbia River white sturgeon larvae and fry. These authors concluded that "substrate composition in a river may influence both the emergence and settling response of white sturgeon larvae and could affect whether they remain in an area once they become bottom oriented. Upon hatching, larvae enter the water column and are subject to the influences of current. Larvae then seek the substrate for places that provide cover. Larvae remained in the substrate until the yolk is absorbed and feeding initiated. Larvae were noted to enter just about every conceivable space where they could hide their head. Beneath rocks, gravel interstices, amongst plants, and under detrital material were the places harboring the larvae during the "hiding" phase".

Larval white sturgeon were observed in aquaria to burrow into fine sediments, resulting in mortality by suffocation in some observed cases (E. Brannon, University of Idaho, pers. comm.). Based on habitat sampling and underwater observation, larval rearing habitat in the post-impoundment Kootenai River was characterized by deposition of fine sediments and appeared devoid of interstitial space. If undetected white sturgeon larvae were produced in the Kootenai River, and if laboratory results (Brannon et al. 1985) represent behaviors of larval white sturgeon in the wild, altered larval habitat, predation, or suffocation may have contributed to larval mortality factor in the post-development Kootenai River.

Effects of water- or sediment-borne contaminants have been reported as potential limiting factors for various life stages of Kootenai River white sturgeon

(Apperson and Anders 1991; Kruse and Scarnecchia 2002). However, despite the fact that increased sensitivity to contamination may occur with the earliest life stages, little conclusive empirical evidence suggests this to be a significant factor in the Kootenai River. Kruse and Scarnecchia (2002) reported significant effects of copper and Aroclor exposure on Kootenai River egg mortality in laboratory experiments, however, extrapolation of these findings to the Kootenai River ecosystem remains tenuous. These authors also reported from laboratory studies that contact with Kootenai River sediments can potentially increase exposure of embryos to metals. Unfortunately, no definitive laboratory studies to date have established any threshold levels of contamination relative to empirical damage to any life stages of white sturgeon caused by exposure to contaminants.

Young-of-the-year

If young-of-the-year (YOY) white sturgeon were naturally produced in the Kootenai River, food limitation and subsequent first overwintering mortality may have contributed to recruitment failure at this life stage (figure 4.33). Scott and Crossman (1973) reported that age-0 white sturgeon diets consisted primarily of Chironomid larvae. Amphipods (*Corophium* spp.) accounted for 98 percent of diet items from 149 age-0 white sturgeon (20-267 mm TL) collected from Bonneville and The Dalles pools in the Columbia River from 1988 through 1991 (Sprague et al. 1993). Wydowski and Whitney (1979) reported that the stomachs of small white sturgeon in California contained primarily *Mysis* shrimp (M. relicta) and amphipods. Age-0 lake sturgeon (*Acipenser fulvescens*) in the Lake Winnebago system in Wisconsin were observed in close contact with the substrate, oriented upstream, apparently feeding on drifting benthic organisms (Kempinger 1996). Kempinger (1996) also reported that species of Baetidae nymphs and dipteran larvae were the two principal organisms consumed by lake sturgeon during their first summer of life. No YOY white sturgeon have been collected from the Kootenai River to infer food limitation from gut content analyses. However, low zooplankton (mean < 0.1/L, Paragamian 1994) and low invertebrate densities (Hopkins and Lester 1995) could suggest the possibility of YOY food limitation.

No diet analyses have been reported for YOY white sturgeon in the Kootenai River. The Kootenai River supported low to moderate macroinvertebrate densities (overall mean density of benthic macroinvertebrates was 344.4/m^2, Hopkins and Lester 1995), consistent with reported low nutrient levels (Snyder and Minshall 1996). Hopkins and Lester (1995) also reported that invertebrate densities in Lower Granite Reservoir of the Snake River, Idaho, which has a naturally spawning and recruiting white sturgeon population, averaged 940.5/m^2, nearly threefold greater than in the Kootenai River. Because individual female white sturgeon may be very fecund (at Columbia basin latitudes hundreds of thousands of eggs per fish), consistently failing recruitment during the past few decades suggests considerable system alteration to explain this natural recruitment failure.

Energy requirements and food availability requirements for first overwinter survival of YOY white sturgeon in the Kootenai River are currently unknown. However, cultural denutrification, low density and diversity of invertebrate food items, and possible deficits in first overwintering energy budgets for YOY white sturgeon could contribute to natural recruitment failure or limitation in the Kootenai River.

Human Impacts

The Kootenai River system has been subjected to many human influences over the course of the past 100 years or more (Northcote 1973). A comprehensive account of anthropogenic changes and resulting ecological responses in the Kootenai Basin is provided by Anders et al. (2002), Paragamian (2002), and other authors. By the mid-1960s, phosphorus concentrations increased 15-fold, and nitrogen doubled from baseline conditions in the Kootenai River due to municipal and industrial development. Pollution abatement beginning in the late 1960s, and subsequent impoundment of the Kootenai River (Libby Dam, 1972) reversed this culturally eutrophic condition. By the mid-1990s the Kootenai River was classified as ultraoligotrophic, as it remains today. Reverberating trophic responses to cultural denutrification were temporally correlated with the collapse of the functional Kootenai River Subbasin downstream from Libby Dam.

The pre-impoundment Kootenai River hydrograph was characterized by annual average discharge peaks of approximately 60,000 cfs, during the natural high-runoff period in spring and early summer, with highest discharge during the period of record reaching 160,000 cfs (Scott Bettin, Bonneville Power Administration, pers. comm.). Post-impoundment river discharge (1973-1989) rarely exceeded 20,000 m^3/sec. Post-impoundment river discharge during the spring and early summer has been reduced by as much as 67 percent, and has increased during the winter by as much as 300 percent relative to pre-impoundment conditions (Partridge 1983). The pre-development Kootenai River ecosystem included a naturally functional floodplain over 5 km wide along the 128 km of the river immediately upstream from Kootenay Lake. Diking of this section of the river eliminated thousands of hectares of natural floodplain, and the associated productivity, diversity of habitats, and ecosystem functions (Duke et al. 1999; Anders et al. 2002).

LINKS

For an assessment of Kootenai River dike vegetation, go to Appendix 102.

Click Here

Post-impoundment winter water temperatures in the Kootenai River downstream from Libby Dam averaged 3 °C warmer than pre-impoundment values (Partridge 1983). Summer water temperatures in the same river reaches during the same years were consistently lower than pre-impoundment values, due to hypolimnetic withdrawal from Libby Dam (Partridge 1983; Snyder and Minshall 1994). Libby Dam and the impounded Koocanusa Reservoir reduced downstream transport of phosphorous and nitrogen by as much as 63 percent and 25 percent respectively (Woods 1982), with sediment trapping efficiencies exceeding 95 percent (Snyder and Minshall 1996).

Diking and channelization altered channel bed conditions by trapping sediments previously deposited over the historic floodplain during periods of high river discharge. Like other large river-floodplain ecosystems, the Kootenai River was historically characterized by seasonal flooding that promoted the exchange of nutrients and organisms among a mosaic of habitats, reported to enhance biological productivity and habitat diversity (Junk et al. 1989; Bayley 1995).

LINKS

A brief summary of white sturgeon contaminant studies can be found in Appendix 101.

Click Here

Agricultural activities (farming, channelization, and diking) have restricted the Kootenai River's natural floodplain from Kootenay Lake upstream to Bonners Ferry, Idaho. Forest developments have affected a significant area of the drainage. A fertilizer plant on the St. Mary River near Kimberley, B.C. polluted the river and lake. The Cora Linn Dam on the Kootenay River downstream from Nelson, the Duncan Dam at the north end of Kootenay Lake, and the Libby Dam upstream from Kootenai Falls have all dramatically affected movement of water through the system. In addition to these major perturbations, numerous but smaller impacts have also shaped the present integrity of the Kootenai River ecosystem (e.g., road construction, urbanization, and introduction of non-native fish and invertebrates).

Impoundment of rivers represents a cataclysmic event for large river-floodplain ecosystems (Ligon 1985). By altering water, sediment, and nutrient flow dynamics, dams interrupt and alter a river's important ecological processes in aquatic, riparian, and surrounding terrestrial environments. These environments, their life-supporting ecological functions, and the persistence of their floral and faunal communities are inexorably linked. Alteration of any component of such highly integrated natural systems generally results in cascading trophic effects throughout the ecosystem. Thus, major system perturbations, such as impounding large rivers, create a myriad of ecological dysfunction, reflected at all trophic levels on an ecosystem scale. The importance of nutrient and energy dynamics during natural pulses of water discharge in rivers has been extensively described in terms of river ecology (e.g., flood pulse, river continuum, nutrient spiraling, and serial discontinuity concepts).

The Kootenai River also has indications of contamination by PCBs, organochlorine pesticides, dioxins, and certain metals. Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food chain, could possibly be reducing the successful reproduction and early-age recruitment to the Kootenai River white sturgeon population. Contaminants that are bioaccumulated and passed to progeny through ova or sperm can impact viability, survival, and development of naturally spawned sturgeon eggs (Adams 1990; Heath 1995). Recent research indicates that Kootenai River water concentrations of total iron, zinc, manganese, and the PCB Arochlor 1260 exceeded suggested environmental background levels (Kruse and Scarnecchia 2001a; Kruse and Scarnecchia 2001b). Zinc and PCB levels exceeded EPA freshwater quality criteria. Several metals, organochlorinepesticides, and the PCB Arochlor 1260 were found above laboratory detection limits in ova from adult female white sturgeon in the Kootenai River. Plasma steroid levels in adult female sturgeon showed a significant positive correlation with ovarian tissue concentrations of the PCB Arochlor 1260, zinc, DDT, and all organochlorine compounds combined, suggesting potential disruption of reproductive processes. In an experiment designed to assess the effects of aquatic contaminants on sturgeon embryos, results suggest that contact with river-bottom sediment increases the exposure of incubating embryos to metal and organochlorine compounds. Increased exposure to copper and Arochlor 1260 significantly decreased survival and incubation time of white sturgeon embryos and could be a potentially significant additional stressor to the white sturgeon population.

Although pollution abatement has taken place at several sources throughout the basin, the effects on sturgeon may be long term. Pollution effects are usually compounded generationally and often require generations before they dissipate.

Depressed biological productivity, alteration of spawning and rearing habitats, fish species abundance changes, altered predator-prey dynamics, and consistent white sturgeon recruitment failure constituted biological and ecological responses to Kootenai River Basin development (Ashley et al. 1999; Marcuson 1994; Paragamian 1994; Snyder and Minshall 1994, 1995, 1996; Anders and Richards 1996; Duke et al. 1999; USFWS 1999). Closures of the recreational kokanee (*Oncorhynchus nerka*), burbot (*Lota lota*), and white sturgeon harvest fisheries in Idaho and B.C. since the mid-1980s were fisheries management responses to ecological perturbations and possible past overharvest (Anders et al. 2002).

LINKS

For the USGS report summarizing lower Kootenai River channel conditions and changes in suspended-sediment transport and geometery in white sturgeon habitat, go to: http://id.water.usgs.gov/PDF/wri034324/index.html

Click Here

For the USGS surveys of lower Kootenai River cross sections, go to: http://id.water.usgs.gov/PDF/ofr041045/index.html

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4.7 Target Species

The Kootenai Subbasin encompasses an enormous diversity of habitats, which in turn, are home to a large array of birds, mammals, amphibians, and reptiles. In all an estimated 364 terrestrial vertebrate species[1] occur in the subbasin (IBIS 2003). (Appendix 79 gives the predicted distributions of terrestrial vertebrate species in Montana and Idaho in acres and by percent distribution by land stewardship.)

While the concept of using one or two focal species to characterize habitats subbasin-wide may be appropriate for an aquatic system (which involves just a single biome), it does not work for the terrestrial system of a subbasin as large as the Kootenai, which is composed of multiple and diverse biomes.

To help us answer the questions set forth in the Technical Guide for Subbasin Planners (NWPCC 2001), our technical team has taken a multi species approach. We have selected a group of species that we are calling target species (table 4.65). These target species were selected because they:

1. Have been designated as a Federal endangered or threatened species or have been otherwise designated a priority species for conservation action,

2. Play an important ecological role in the subbasin such as a functional specialist or a critical functional link species,

3. Possess economic or cultural significance to the people of the Kootenai Subbasin, and/or

4. Collectively they represent a cross-section of the wildlife community.

Because of the number of wildlife species that we are targeting, we have chosen, in the interest of saving space and generating a more user-friendly document, to provide the bulk of the information about each of these species, including information on biological needs and limiting factors, in the form of electronic links in Appendix 94. Most of the links summarize what is known about the species across its entire range or at least its range in Idaho and Montana. For most target species detailed, subbasin-scale information simply does not exist.

LINKS

The IBIS-USA website has done further analysis that are generally descriptive in nature. These can be viewed at the following URLs:

http://www.nwhi.org/ibis/subbasin/ecos2.asp

Click Here

http://www.nwhi.org/ibis/subbasin/uscan2.asp

Click Here

http://www.nwhi.org/ibis/subbasin/subs2.asp

Click Here

Appendix 79 gives the predicted distributions of terrestrial vertebrate species in Montana and Idaho in acres and by percent distribution by land stewardship.

Click Here

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[1] *This does not include extirpated or accidental species. This number is for the U.S. portion of the subbasin. A similar analysis for the Canadian portion yielded an estimate of 363 species.*

Table 4.65. Terrestrial target species.

MAMMALS	IBIS STATUS	BIRDS (CONT.)	IBIS STATUS	BIRDS (CONT.)	IBIS STATUS
American Beaver	*CFLS*	Barrow s Goldeneye		Long-billed Curlew	
American Pika	*CFLS*	Black Swift	*FS*	Merlin	*FS*
Big Brown Bat	*CFLS*	Black Tern	*CFLS*	Northern Goshawk	
Black Bear	*CFLS*	Black-backed Woodpecker		Northern Pygmy-owl	*FS*
Bushy-tailed Woodrat	*CFLS*	Black-chinned Hummingbird	*CFLS*	Olive-sided Flycatcher	
Deer Mouse	*CFLS*	Boreal Owl	*FS*	Peregrine Falcon	*FS*
Fisher	*CFLS*	Brewer s Sparrow		Pileated Woodpecker	
Golden-mantled Grnd Squirrel	*CFLS*	Brown Creeper		Red-eyed Vireo	
Grizzly Bear	*CFLS*	Brown-headed Cowbird	*CFLS*	Red-naped Sapsucker	
Lynx	*FS*	Calliope Hummingbird		Ruffed Grouse	
Mink	*CFLS*	Canada Goose	*CFLS*	Rufous Hummingbird	*CFLS*
Montane Vole	*CFLS*	Columbian Sharp-tailed Grouse		Snowy Owl	*FS*
Moose	*CFLS*	Common Loon		Three-toed Woodpecker	
Mule Deer	*CFLS*	Common Nighthawk	*FS*	Trumpeter Swan	
Northern Bog Lemming	*FS*	Cordilleran Flycatcher		Tundra Swan	*CFLS*
Northern Pocket Gopher	*CFLS*	Flammulated Owl		Turkey Vulture	*FS*
Nuttall's Cottontail	*CFLS*	Grasshopper Sparrow		Vaux s swift	
Raccoon	*CFLS*	Great Blue Heron	*CFLS*	Veery	
Red Squirrel	*CFLS*	Great Horned Owl	*CFLS*	Williamson's Sapsucker	*CFLS*
River Otter		Gyrfalcon	*FS*	Willow Flycatcher	
Rocky Mountain Elk	*CFLS*	Hammond s Flycatcher		Winter Wren	
Snowshoe Hare	*CFLS*	Harlequin Duck	*FS*	**AMPHIBIANS**	
Wolverine	*FS*	Hooded Merganser		Boreal Toad	
Mountain Caribou		Horned Grebe		Long-toed Salamander	*CFLS*
BIRDS		House Finch	*CFLS*	Northern Leopard Frog	
American Crow	*CFLS*	Lazuli Bunting		Spotted Frog	
Bald Eagle		Lewis s woodpecker			

[1]FS = Functional specialist, species that have only one or a very few number of key ecological functions. Functional specialist species could be highly vulnerable to changes in their environment (such as loss of carrion causing declines or loss of carrion-feeder functional specialists) and thus might be good candidates for focal species.

[2]CFLS = Critical functional link species, species that are the only ones that perform a specific ecological function in a community. Their removal would signal loss of that function in that community. Thus, critical functional link species are critical to maintaining the full functionality of a system. See Appendix 65 (see links column) for the critical functions associated with each of these species.

LINKS

See Appendix 49 for a list of key ecological functions.

Click Here

While Appendix 94 provides a generalized overview of wildlife species, the heart of our terrestrial assessment is focused on the condition of habitats, specifically the target biomes within each 4th-field HUC. We developed and employed a spreadsheet tool called Terrestrial Biome Assessment (TBA) that, like QHA, the aquatic assessment tool, utilizes existing data and the knowledge of professional biologists who have worked in the subbasin for many years to assess the current condition of subbasin terrestrial habitats. The results are presented in Appendix 80. We have supplemented this biome analysis with data from IBIS to assess subbasin-wide conditions (for example, the change in acres—

historic vs current—of wildlife habitats and habitat guilds across the subbasin). Results of the IBIS analysis are presented in the *Fish and Wildlife Communities* section of this document and at the IBIS website (see Links column). Finally, in our assessment of the terrestrial ecosystem, our Technical Team reviewed results of the Nature Conservancy's SITES model and used that information to complement the results of our own biome assessment.

4.7.1 Terrestrial Limiting Factors and Conditions

Guidance from the NWPCC defines limiting factors as those factors or conditions that have led to the decline of target species and/or that currently inhibit populations and ecological processes and functions relative to their potential. Because the term *limiting factor* has another meaning to most biologists (i.e., the abiotic condition that most controls the growth of a species) and because this analysis involves multiple species, our terrestrial technical team chose to use term *impact* when describing the factors or conditions that have led to the general decline of target species.

As part of our Terrestrial Biome Assessment (TBA), the terrestrial technical team identified the primary, secondary, and tertiary impacts on the target species associated with each subunit analyzed. Table 4.66 lists the impacts in each of those categories that biologists identified most often in the regulated mainstem and across the rest of the subunits. Because of the nature of the assessment, certain impacts—chiefly impoundments and reductions in nutrients/productivity—are under-represented in the riparian and wetland biomes with respect to the degree that they are currently inhibiting populations of target species and ecological processes and functions. These "under-represented impacts" are shown in column 5 of Table 4.66.

LINKS

Appendix 94 provides more information and links for each of target species.

Click Here

For the results of the Terrestrial Biome Assessment (TBA), go to Appendix 80.

Click Here

Table 4.66. Primary, secondary, and tertiary impacts on the target species associated with each subunit analyzed.

	Primary Impacts (number of subunits)	Secondary Impacts (number of subunits)	Tertiary Impacts (number of subunits)	Major Impacts Under-Represented in this Analysis
Regulated Mainstem				
Riparian	Altered Hydrograph (6)	Diking (2)		
Wetland	Altered Hydrograph (5)	Diking (2)		
Rest of the Subbasin				
Mesic Forest	Forest Management (23) Fire Exclusion and Forest Management (4)	Non-native Species (7) Insects and Disease (4)	Fire Exclusion (6) Roads (4)	
Grassland	Forest Encroachment (27) Fire Exclusion (4) Land Conversion (4)	Overgrazing (10) Human Development (7)	Non-native Species (8)	
Riparian	Forest Management (9) Land Conversion (8)	Forest Management (7) Non-native Species (5)	Human/wildlife Conflicts (6) Land Conversion (3)	Impoundment Reductions in Nutrients/Productivity
Wetland	Roads (9) Land Conversion (5) Overgrazing (4)	Land Conversion (10)	Forest Management (8)	Impoundment Reductions in Nutrients/Productivity
Xeric Forest	Fire Exclusion (9) Forest Management (5)	Non-native Species (8)	Fire Exclusion (4) Forest Management (4)	

[1] *Roads and associated logging practices in watersheds can affect the hydrography and ecology of wetlands even though those impacts do not occur directly in wetlands (Jones and Hendricks 2000). See Appendix 37.*

Forest management impacts in the context of TBA are defined as negative impacts on target wildlife species stemming from forest management practices that cause changes in thermal cover, hiding cover, large snage density, down woody debris, early seral forage habitat, the level of habitat fragmentation, and hydrologic processes. Changes to any one of these parameters may have negative or postive affects, depending on the wildlife species at issue.