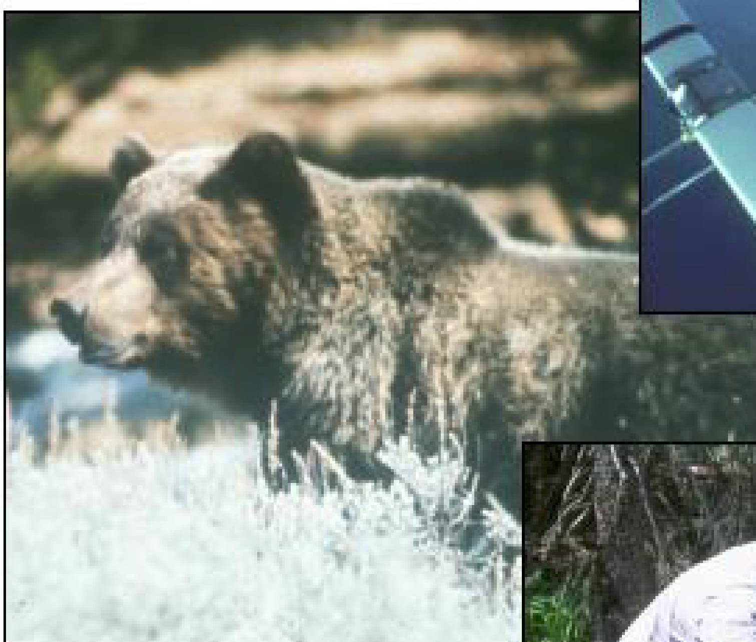
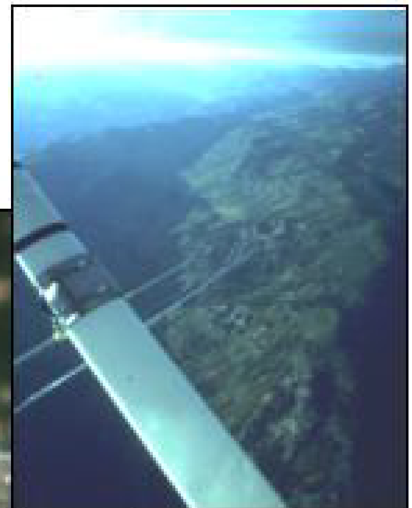
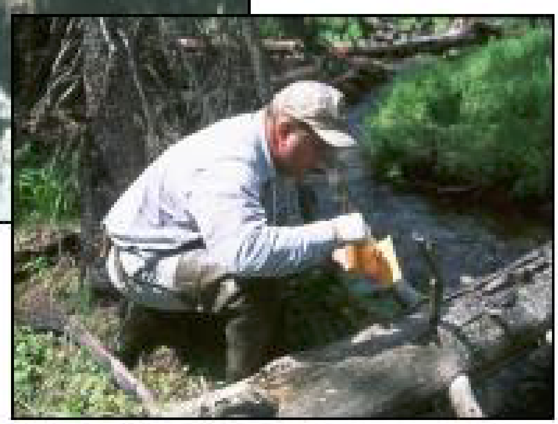
Yellowstone Grizzly Bear Investigations

1997







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Annual Report of the Interagency Grizzly Bear Study Team

YELLOWSTONE GRIZZLY BEAR INVESTIGATIONS

Report of the Interagency Grizzly Bear Study Team

1997

U.S. Geological Survey, Biological Resources Division
National Park Service
Wyoming Game and Fish Department
U.S. Fish and Wildlife Service
Montana Department of Fish, Wildlife and Parks
U.S. Forest Service
Idaho Fish and Game Department

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Both Bonnie and Dick left the study during 1997.

Yellowstone Grizzly Bear Investigations for 1995-1997 are now available at
http://www.nrmsc.usgs.gov/research/igbst-home.htm

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INTRODUCTION

Early research on grizzly bears (*Ursus arctos horribilis*) in Yellowstone National Park provided data for the period 1959-67 (Craighead et al. 1974). However, changes in management philosophy and operations by the National Park Service in 1967, mainly the closing of open pit garbage dumps, markedly changed food habits (Mattson et al. 1991), population parameters (Knight and Eberhardt 1985), and growth patterns (Blanchard 1987) for grizzly bears in the Yellowstone area. Concern and uncertainty over the grizzly bear population status in the Yellowstone ecosystem lead to its listing as "threatened" under the Endangered Species Act in 1975.

A centralized research group promotes data collection and analysis on an ecosystem scale, prevents overlap of effort, and pools limited economic and personnel resources. The need for a centralized research group, responsible for collecting, managing, analyzing, and distributing grizzly bear data in the Yellowstone area was recognized early on as a critical component of a successful recovery effort. To fill this need, the Department of Interior initiated the Interagency Grizzly Bear Study Team (IGBST) in 1973. Initial members were the National Park Service, Forest Service, U.S. Fish and Wildlife Service, and since 1974 the States of Idaho, Montana, and Wyoming. The U.S. Geological Survey, Biological Resources Division, Midcontinent Ecological Science Center, currently administers the IGBST.

Quantitative data on grizzly bear abundance, distribution, survival, mortality, nuisance activity, and bear food availability is critical to formulating management strategies and decisions. Moreover, they are also critical for evaluating the recovery process. The goal of the IGBST is to conduct research that provides the cooperating agencies with data needed for the immediate and long-term management of grizzly bears in the Yellowstone area. Primary objectives include determining status and trend of the Yellowstone grizzly bear population, habitat use, diet, and the effects of land management practices. Appendix A provides a list of reports, publications, and theses produced by IGBST and its cooperators since 1973.

This report contains the results of the research and monitoring conducted during 1997. In 1997, count of unduplicated females with cubs-of-the-year (COY) was used to estimate minimum population size as in past years. However, the IGBST also reviewed its aerial observation protocol to determine if a mark-resight-based estimator could be derived starting in 1998. Research involving DNA analysis from hair samples was also intensified by establishing more collection sites along established food (spawning cutthroat) survey routes (stream sides).

Data analyses and summaries presented in this report supersede all previously published data. Study methods are reported by Blanchard (1985) and Mattson et al. (1991). The study area has been described in detail by Blanchard and Knight (1991) and Mattson et al. (1991).

RESULTS AND DISCUSSION

Monitoring/Population Trend

Marked Animals

Twenty-four individual grizzly bears were captured on 28 occasions during 1997 (Table 1), including 9 females (6 adult) and 15 males (11 adult). Fifteen bears had not been previously marked. Twenty captures were a result of research efforts and the bears were released on-site. Eight captures resulted from management actions involving conflicts on private land (#291 and #301), campground-trailhead conflict (#293), livestock depredation (#292 and #212), roadside habituation involving an injured cub (#264 and G62), and conflict in a development (#300). The capture of bear #294 was considered a research trapping as she was not the target bear. However, bear #294 was moved 2 km away from her capture site, which was near a sheep allotment, and released. Five of the 8 management bears were transported to release sites within the Yellowstone ecosystem, 1 was released on-site (#264) after the uninjured second cub could not be captured in a timely manner.

A total of 70 grizzly bears were monitored for varying intervals during 1997, including 21 adult females (Table 2). Twenty-two females (17 adult) were wearing active transmitters at denning. Since 1975, 298 grizzly bears have been radio-marked (Table 3).

Unduplicated Females

One method of assessing population status, and over time estimating trend, is recording the number of unduplicated females with cubs-of-the-year (COY) annually. A summary of procedures used to determine whether or not observations are duplicates was reported by Knight et al. (1995). A technique that will use the number of unduplicated females and the re-sight frequency for each female to estimate total population size is also being investigated (Boyce et al. 1997)

Thirty-one unduplicated females with 62 COY were observed in 12 Bear Management Units (BMUs) within the Recovery Zone during 1997 (Fig. 1). One instrumented female (#249) with COY was observed initially outside the Recovery Zone but within the 10 mile buffer zone.

The current running 6-year average (1992-97) for unduplicated females with COY is 24 per year with an average litter size of 2.17 cubs (Table 4). This 6-year average has steadily increased from 12 females per year with 1.85 cubs per litter during the period of 1973-78 (Table 4).

Table 1. Grizzly bears captured during 1997.

Bear	Sex	Age	Date	Location[a]	Release site[a]	Trapper/Handler
288	Male	Adult	5/7/97	Wood River, WY (res)	on site	WYGF
264	Female	7	6/18/97	Norris Geyser Basin, YNP (mgt)	on site	YNP / IGBST
G62	Male	COY	6/18/97	Norris Geyser Basin, YNP (mgt)	Euthanized	YNP / IGBST
				Injured cub of 264, euthanized		
289	Female	Subadult	6/18/97	Eldridge Crk, GNF (res)	on site	IGBST
			6/23/97	Deadhorse Crk, GNF (res)	on site	IGBST
239	Male	Adult	7/1/97	Eldridge Crk, GNF (res)	on site	IGBST
290	Male	Subadult	7/14/97	Hayden Valley, YNP (res)	on site	IGBST
205	Female	13	7/17/97	Hayden Valley, YNP (res)	on site	IGBST
291	Male	Adult	7/23/97	Hunter Peak Ranch, Clark's Fork (mgt)	Ramshorn Basin, SNF	WYGF
292	Male	Adult	7/31/97	Tepee Crk, Sublette Co, WY, (mgt)	Otter Crk, YNP	WYGF
293	Male	Subadult	8/8/97	The Bend, BTNF WY (res)	on site	WYGF
			8/26/97	Green River, BTNF, WY (mgt)	Management Removal	WYGF
212	Male	6	8/12/97	TE Ranch, S Fk Shos, WY-pr (mgt)	Frog Rock, YNP	WYGF
294	Female	Adult	8/14/97	S. Badger Crk, TNF (res)	Indian Lake, TNF	ADC/WYGF
295	Female	Subadult	8/14/97	Mesa Pit, YNP (res)	on site	IGBST
296	Female	Adult	8/16/97	Norris, YNP (res)	on site	IGBST
297	Male	Adult	8/23/97	Wapiti Crk, GNF (res)	on site	IGBST
298	Female	Adult	9/4/97	Buffalo Plateau (res)	on site	IGBST
299	Male	Adult	9/7/97	Buffalo Plateau (res)	on site	IGBST
300	Female	Subadult	9/8/97	West Yellowstone, MT-pr (mgt)	Trident, BTNF	MTFWP/IGBST
282	Male	7	10/4/97	Pelican Valley, YNP (res)	on site	IGBST
206	Male	23	10/15/97	Mesa Pit, YNP (res)	on site	IGBST
			10/16/97	Mesa Pit, YNP (res)	on site	IGBST
			10/19/97	Mesa Pit, YNP (res)	on site	IGBST
211	Male	7	10/17/97	Grebe Lake, YNP (res)	on site	IGBST
214	Female	5	10/23/97	Stephens Crk, YNP (res)	on site	IGBST
219	Male	7	10/23/97	Antelope Crk, YNP (res)	on site	IGBST
301	Male	Subadult	10/28/97	N of Gardiner, MT-pr (mgt)	Norris Junction, YNP	MTFWP

		Females	Males
New bears = 15			
Individual bears = 24	Adult	6	11
Total captures = 28	Subadult	3	4

	Females		Males	
	Ad	SAd	Ad	SAd
Research	4	3	10	2
Management	4	1	3	3

[a] BTNF = Bridger-Teton National Forest, GNF = Gallatin National Forest, TNF = Targhee National Forest, YNP = Yellowstone National Park, (res) = research, (mgt) = management, -pr = private.

Table 2. Grizzly bears monitored, captured, and transported 1980-1997.

Year	Number Monitored	Individuals Trapped	Total Captures		
			Management	Research	Transported
1997	70	24	8	20	5
1996	76	36	15	25	10
1995	71	39	28	26	22
1994	60	43	31	23	28
1993	43	21	8	13	6
1992	41	16	1	15	0
1991	42	27	3	28	4
1990	35	15	13	4	9
1989	40	15	3	14	3
1988	46	36	21	23	15
1987	30	21	10	15	8
1986	29	36	31	19	19
1985	21	4	5	0	2
1984	35	33	22	20	16
1983	26	14	18	0	13
1982	46	30	25	27	17
1981	43	36	35	30	31
1980	34	28	0	32	0

Table 3. Status of all radio-marked grizzly bears as of December 1997. Age at time of death or age during 1997 is shown in parentheses.

Known dead				Suspected dead	
Human-caused		Natural	Unknown	Human-caused	Natural or Unknown
3 (7)	95 (11)	1 (28 [a])	77 (9)	7 (5)	2 (25 [a])
4 (5)	97 (16)	12 (25 [a])	108 (4)	11 (7)	13 (25 [a])
5 (14)	105 (Ad)	56 (1)	238 (3)	24 (2)	16 (27 [a])
6 (8)	110 (5)	65 (3)		32 (4)	19 (25 [a])
8 (17)	113 (2)	145 (2)		75 (1)	36 (25 [a])
9 (17)	120 (3)	161 (20)		102 (2)	42 (25 [a])
10 (12)	121 (6)	180 (5)		147 (10)	51 (26 [a])
14 (12)	122 (3)	187 (5)			54 (1)
15 (12)	127 (1)	200 (11)			55 (1)
17 (2)	134 (8)	241 (2)			57 (25 [a])
18 (3)	150 (5)				68 (25 [a])
20 (14)	154 (4)				84 (31 [a])
22 (9)	158 (7)				86 (25 [a])
25 (5)	160 (5)				109 (7)
26 (22)	163 (11)				
27 (2)	176 (5)				
28 (16)	177 (12)				
29 (1)	183 (4)				
30 (2)	186 (4)				
31 (cub)	191 (18)				
34 (22)	198 (Ad)				
38 (13)	202 (4)				
39 (3)	209 (9)				
45 (6)	216 (10)				
46 (5)	223 (2)				
47 (2)	226 (12)				
49 (3)	230 (SAd)				
58 (2)	231 (2)				
59 (8)	233 (3)				
60 (6)	235 (4)				
62 (3)	236 (14)				
63 (4)	240 (SAd)				
67 (4)	244 (9)				
69 (3)	250 (5)				
76 (6)	254 (8)				
79 (22)	255 (cub)				
81 (4)	256 (cub)				
83 (19)	257 (SAd)				
87 (15)	259 (SAd)				
88 (7)	285 (1)				
90 (2)	293 (SAd)				
93 (2)	297 (Ad)				
94 (1)					
85 Total		10 Total	3 Total	7 Total	14 Total

Table 3. Continued.

Off air before 1997			Bears monitored during 1997 until			
			Collar cast	Denning	Lost	Killed
21 (23)	124[g] (17)	181[b] (8)	103 (Ad)	179 (7)	199 (8)	293 (SAd)
23 (20)	126 (24)	182[g] (8)	106 (21)	189 (16)	203 (Ad)	297 (Ad)
33 (21)	128[f] (11)	184[d] (15)	125 (14)	205 (13)	212 (7)	
35 (21)	129 (15)	185[c] (10)	168 (Ad)	206 (23)	219 (7)	
37 (18)	130 (14)	190 (11)	188 (9)	211 (7)	229 (14)	
40 (21)	131 (15)	192 (9)	215 (Ad)	214 (5)	278 (5)	
41 (18)	132 (13)	193 (10)	224 (9)	227 (5)	281 (5)	
43 (19)	133 (15)	194 (20)	225 (4)	237 (14)	286 (4)	
44 (unk)	135 (15)	195[c] (9)	243 (6)	239 (Ad)		
48 (18)	136[g] (14)	196[e] (11)	249 (9)	242 (16)		
50 (22)	137 (16)	197[d] (12)	254 (8)	246 (9)		
61 (20)	138 (18)	201[g] (7)	262 (4)	258 (10)		
64 (18)	139 (17)	204[e] (6)	265 (9)	264 (6)		
70 (18)	140[f] (17)	207[g] (16)	266 (5)	267 (Ad)		
71 (18)	141[b] (10)	208[f] (9)	269 (Ad)	271 (5)		
72 (19)	142[c] (15)	210[g] (14)	272 (16)	276 (7)		
73 (17)	143 (17)	213[e] (4)	274 (Ad)	279 (4)		
74 (15)	144 (10)	217[f] (12)	275 (7)	282 (7)		
78 (17)	146 (16)	218[f] (7)	277 (5)	284 (6)		
80 (16)	148[f] (13)	220[f] (13)	280 (10)	289 (SAd)		
82 (20)	149 (Ad)	221[g] (5)	283 (6)	290 (SAd)		
85 (20)	151[g] (17)	222[g] (5)	288 (7)	291 (Ad)		
89 (15)	152[d] (23)	228[e] (6)		292 (Ad)		
91 (15)	153 (16)	232[g] (4)		294 (Ad)		
92 (17)	155[d] (10)	234[f] (11)		295 (SAd)		
96 (unk)	156 (14)	245[f] (5)		296 (Ad)		
98 (unk)	157 (Ad)	247[g] (8)		298 (Ad)		
99 (15)	159 (Ad)	248[g] (3)		299 (Ad)		
100 (13)	162 (22)	251[g] (8)		300 (SAd)		
101[f] (14)	164[b] (12)	252[g] (8)		301 (SAd)		
104[f] (14)	165[b] (18)	253[g] (5)				
107 (17)	166[g] (14)	260[g] (6)				
111 (13)	167 (21)	261[g] (7)				
112[f] (23)	169[c] (10)	263[g] (9)				
114 (14)	170 (15)	268[g] (Ad)				
115 (20)	171 (15)	270[g] (Ad)				
116 (22)	172 (9)	273[g] (Ad)				
117[b] (13)	173[b] (Ad)	287[g] (7)				
118 (13)	174[g] (11)					
119 (15)	175[b] (Ad)					
123 (12)	178[b] (10)					
120 Total			22 Total	30 Total	8 Total	2 Total

[a] Suspected to have died of old age.
[b] Known to be alive during 1991.
[c] Known to be alive during 1992.
[d] Known to be alive during 1993.
[e] Known to be alive during 1994.
[f] Known to be alive during 1995.
[g] Known to be alive during 1996.

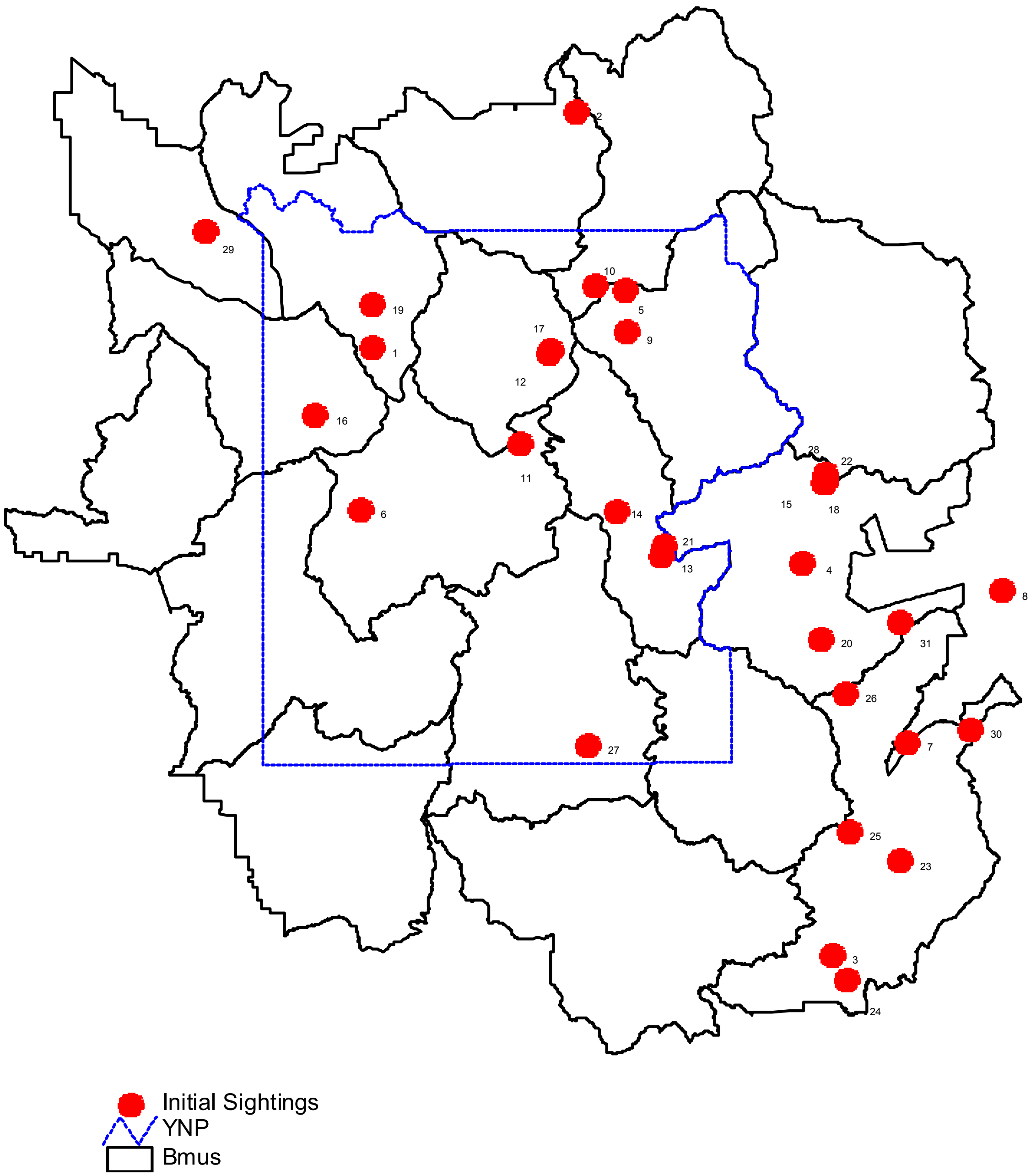

Fig. 1. Distribution of initial observations of unduplicated female grizzly bears with cubs-of-the-year within Bear Management Units inside the Recovery Zone during 1997.

Table 4. Number of unduplicated females with COY, number of COY, average litter size, and six-year running averages for the years 1978-1997.

		Total #	Mean Litter	6 Year Running Averages		
Year	F/COY	Cubs	Size	F w/COY	Cubs	Litter Size
1973	14	26	1.9			
1974	15	26	1.7			
1975	4	6	1.5			
1976	17	32	1.9			
1977	13	25	1.9			
1978	9	19	2.1	12.0	22.3	1.8
1979	13	29	2.2	11.8	22.8	1.9
1980	12	23	1.9	11.3	22.3	1.9
1981	13	24	1.8	12.8	25.3	2.0
1982	11	20	1.8	11.8	23.3	2.0
1983	13	22	1.7	11.8	22.8	1.9
1984	17	31	1.8	13.2	24.8	1.9
1985	9	16	1.8	12.5	22.7	1.8
1986	25	48	1.9	14.7	26.8	1.8
1987	13	29	2.2	14.7	27.7	1.9
1988	19	41	2.2	16.0	31.2	1.9
1989	16	29	1.8	16.5	32.3	2.0
1990	25	58	2.3	17.8	36.8	2.0
1991[a]	24	43	1.9	20.3	41.3	2.1
1992	25	60	2.4	20.3	43.3	2.1
1993	20	41	2.1	21.5	45.3	2.1
1994	20	47	2.4	21.7	45.8	2.1
1995	17	37	2.2	21.8	47.2	2.2
1996	33	72	2.2	23.2	49.5	2.1
1997	31	62	2.0	24.3	52.7	2.2

[a] = One female with unknown number of cubs. Average litter size was calculated using 23 females.

Occupancy of BMUs by Females with Young

Sixteen of 18 BMUs had verified observation of female grizzly bears with young (COY, yearlings, 2-year-olds, and/or young of unknown age) during 1997 (Table 5). Eighteen of 18 BMUs contain verified observation of females with young at least 1 year out of the last 6 year period (Table 5).

Table 5. Bear management units occupied by verified female grizzly bears with young (cubs of the year, yearlings, 2-year-olds or young of unknown age) for the years 1992-1997.

Bear Management Unit	1992	1993	1994	1995	1996	1997	Years occupied
1) Hilgard	X	X	X	X	X	X	6
2) Gallatin	X	X	X	X	X	X	6
3) Hellroaring/Bear		X				X	2
4) Boulder/Slough					X	X	2
5) Lamar	X	X	X	X	X	X	6
6) Crandall/Sunlight	X	X		X	X	X	5
7) Shoshone	X	X	X	X	X	X	6
8) Pelican/Clear	X	X	X	X	X	X	6
9) Washburn	X	X	X		X	X	5
10) Firehole/Hayden	X	X	X	X	X	X	6
11) Madison			X			X	2
12) Henry's Lake				X			1
13) Plateau			X				1
14) Two Ocean/Lake	X	X		X	X	X	5
15) Thorofare	X	X	X	X	X	X	6
16) South Absaroka	X	X	X	X	X	X	6
17) Buffalo/Spread Creek	X	X	X	X	X	X	6
18) Bechler/Teton	X	X			X	X	4
Totals	13	14	13	12	14	16	

Mortalities

Nineteen known and probable grizzly bear mortalities were documented during 1997 (Table 6), which was the highest number observed since 1973 and 4 higher than last year (Table 7). Documented mortalities included cases where a carcass was inspected (classified as known, $n = 13$), and cases where enough evidence was collected to strongly suggest a mortality but no carcass was found (classified as probable, $n = 6$). One additional mortality was classified as possible (evidence suggested that a mortality likely occurred, but was not sufficient to be considered probable).

Of the 19 known and probable mortalities, 10 were human-caused, including 8 shootings by hunters or outfitters during bear-hunter encounters, 1 illegal shooting, and 1 management removal due to human habituation (Table 6). Age and sex composition of man-caused mortalities was 6 male (2 adult, 4 subadult) and 4 female (3 adult, 1 subadult). The remaining 9 mortalities included 8 cubs, 4 that disappeared from their mothers, 3 that died from attacks by other bears, and 1 that was classified as unknown (Table 6). One adult was also observed traveling with severe injuries from an unknown cause. The single mortality classified as possible involved an adult female that was shot at by a hunter during a mauling.

Table 6. Grizzly bear mortalities recorded during 1997.

Bear	Sex	Age	Date	Type	Location[a]	Cause
unm	Unk	Cub	10/15	Known	Wapiti Cr., GNF	Unk: scavenged carcass found
unm	M	Ad	10/26	Known	Tom Miner, GNF	Human: self defense by hunter
297	M	Ad	10/4	Known	Little Wapiti Cr., GNF	Human: self defense by hunter
unm	M	Cub	5/21	Known	Diamond G Rch, WY	Nat: suspected bear predation
unm	M	SAd	5/8	Known	W. of Red Lodge, MT	Human: illegal[b]
G62	M	Cub	6/18	Known	Norris Geyser, YNP	Nat: suspected bear predation[c]
unm	M	Cub	6/7	Known	Diamond G Rch, WY	Nat: suspected bear predation
293	M	SAd	8/26	Known	Upper Green R., BTNF	Human: mgt removal[b]
254	F	Ad	9/15	Known	Cabin Cr., GNF	Human: self defense by hunter
unm	F	Ad	9/15	Known	Silvertip Cr., BTNF	Human: self defense by hunter[d]
unm	F	Yrl	9/15	Known	Silvertip Cr., BTNF	Human: self defense by hunter[d]
unm	M	Yrl	9/15	Known	Silvertip Cr., BTNF	Human: self defense by hunter[d]
unm	M	Yrl	9/15	Known	Silvertip Cr., BTNF	Human: self defense by hunter[d]
unm	Unk	Ad	10/5	Probable	Thorofare, BTNF	Nat: unk., injured bear obs. by hunter
unm	Unk	Cub	5/6-7/22	Probable	Hellroaring R., CNF	Nat: unknown, cub disappeared
unm	Unk	Cub	5/6-7/22	Probable	Hellroaring R., CNF	Nat: unknown, cub disappeared
unm	F	Ad	9/2	Probable	Coyote Cr., BTNF	Human: self defense by hunter (2 COY)
unm	Unk	Cub	9/20-26	Probable	Swan Flats, YNP	Nat: unknown, cub disappeared
unm	Unk	Cub	9/3-9	Probable	Dunoir R., SNF	Nat: unknown, cub disappeared
unm	F	Ad	10/5	Possible	Copper Cr., GNF	Human: huntershot at bear during/after mauling

[a] BTNF = Bridger-Teton National Forest, CNF = Custer National Forest, GNF=Gallatin National Forest, SNF = Shoshone National Forest, YNP=Yellowstone National Park.
[b] Greater than 10 miles outside the Recovery Area
[c] Injured cub was captured, examined, and euthanized
[d] All shot by same hunting party in 1 encounter

Table 7. Known and probable grizzly bear deaths, 1973-97.

	All bears				All adult females			
	Human-caused		Other[a]		Human-caused		Other	
Year	In[b]	Out[b]	In[b]	Out[b]	In[b]	Out[b]	In[b]	Out[b]
1973	14	0	3	0	4	0	0	0
1974	15	0	1	0	4	0	0	0
1975	3	0	0	0	1	0	0	0
1976	6	0	1	0	1	0	0	0
1977	16	0	1	0	6	0	0	0
1978	7	0	0	0	1	0	0	0
1979	8	0	0	0	1	0	0	0
1980	6	0	4	0	1	0	0	0
1981	10	0	3	0	3	0	2	0
1982	14	0	3	0	4	0	0	0
1983	6	0	1	0	2	0	0	0
1984	9	0	2	0	2	0	0	0
1985	6	0	7	0	2	0	0	0
1986	9	0	2	0	2	0	0	0
1987	3	0	0	0	2	0	0	0
1988	5	0	8	0	0	0	2	0
1989	2	0	1	0	0	0	0	0
1990	9	0	0	0	6	0	0	0
1991	0	0	0	0	0	0	0	0
1992	4	0	4	0	0	0	0	0
1993	3	0	2	0	2	0	1	0
1994	11	0	1	0	4	0	0	0
1995	17	0	1	0	3	0	0	0
1996	9	0	6	0	3	0	0	0
1997	8	2	9	0	3	0	0	0

[a] Includes deaths from natural and unknown causes.
[b] In refers to inside the Recovery Zone or within a 10 mile buffer around the Recovery Zone. Out refers to outside the 10 mile buffer.

Two of the 19 documented mortalities occurred outside the Recovery Zone. These include the 1 management removal and the 1 illegal shooting. As a result, all human-caused mortalities that occurred within the Recover Zone, and therefore all mortalities that counted towards annual recovery quotas, were the outcome of hunter-bear encounters. Calculations to determine yearly mortality limits for grizzly bears within the recovery zone are presented in the USFWS Grizzly Bear Recovery Plan (1993). We present a summary of these calculations for mortality in the Yellowstone ecosystem in Table 8.

Table 8. Annual known grizzly bear mortality and Grizzly Bear Recovery Plan (1993) mortality thresholds.

								FWS Grizzly Bear Recovery Plan Mortality Thresholds				
					Man Caused Mortality			Min	Total Man Caused Mortality		Total Female Mortality	
	Unduplicated	Man Caused Mortality			6 -Year Running Averages			Pop		Year	30% of	Year
Year	F w/COY	Total	Total Female	Ad Female	Total	Female	Ad Female	Estimate	4% of Min Pop	Result	Total Mortality	Result
1973	14	14	6	4								
1974	15	15	7	4								
1975	4	3	1	1								
1976	17	6	2	1								
1977	13	16	7	6								
1978	9	7	1	1	10.17	4.00	2.83	113	4.53		1.36	
1979	13	8	1	1	9.17	3.17	2.33	99	3.94		1.18	
1980	12	6	3	1	7.67	2.50	1.83	113	4.53		1.36	
1981	13	10	5	3	8.83	3.17	2.17	120	4.82		1.45	
1982	11	14	5	4	10.17	3.67	2.67	102	4.09		1.23	
1983	13	6	3	2	8.50	3.00	2.00	102	4.09		1.23	
1984	17	9	5	2	8.83	3.67	2.17	120	4.82		1.45	
1985	9	6	4	2	8.50	4.17	2.33	120	4.82		1.45	
1986	25	9	5	2	9.00	4.50	2.50	164	6.57		1.97	
1987	13	3	2	2	7.83	4.00	2.33	150	5.99		1.80	
1988	19	5	3	0	6.33	3.67	1.67	193	7.74		2.32	
1989	16	2	0	0	5.67	3.17	1.33	168	6.72		2.01	
1990	25	9	6	4	5.67	3.33	1.67	204	8.18		2.45	
1991	24	0	0	0	4.67	2.67	1.33	223	8.91		2.67	
1992	25	4	1	0	3.83	2.00	1.00	255	10.22		3.07	
1993	20	3	2	2	3.83	2.00	1.00	245	9.78	Under	2.93	Under
1994	20	11	4	4	4.83	2.17	1.67	215	8.61	Under	2.58	Under
1995	17	17	7	3	7.33	3.33	2.17	175	7.01	Exceded	2.10	Exceded
1996	33	9	4	3	7.33	3.00	2.00	219	8.76	Under	2.63	Exceded
1997	31	8	4	3	8.67	3.67	2.50	263	10.51	Under	3.15	Exceded

Observation Flights

Two rounds of observations flights were conducted during 1997, 1 during 24 July-17 August and 1 during 25 August-13 September. All 18 BMUs were surveyed at least once during each session. Round 1 consisted of 26 flights (55.5 hrs of observation); round 2 consisted of 24 flights (59.3 hrs of observation), and the average duration of flights was 2.3 hrs (Table 9).

One-hundred fourteen bear sightings were recorded during observation flights, excluding dependent young. This included 5 radio-marked bears, 70 solitary unmarked bears, and 39 unmarked females with young (Table 9). Observation rates were 0.99/hr for all bears or 0.34/hr for females with young.

Eighty young (36 cubs, 31 yearlings, and 13 unknown age) were observed. The most commonly sighted family group was an adult female with 2 COY (23%, 9 of 39 sightings), followed by an adult female with 2 yearlings (18%, 7 of 39, Table 10). Observation rates were 0.17/hr for females with COY and 0.12/hr for females with yearlings.

Of the 31 female with COY sightings classified as unduplicated in 1997 (Figure 1), 9 (29%) were initially recorded during observation flights (Table 11). This was slightly lower than the 1986-96 average of 40%, whereas the number of initial sightings recorded during telemetry relocation flights increased (42% in 1997 vs. 16% in 1996).

Telemetry Relocation Flights

One-hundred one telemetry relocation flights were conducted during 1997, resulting in 440.6 hours of search time (ferry time to and from airports excluded; Table 12). The average duration of flights was 4.4 hrs. Flights were conducted at least once during all months except February and March, but 87% (88 of 101 flights) occurred during May-October.

During telemetry flights, 613 locations of bears equipped with radio-transmitters (i.e., marked) were collected, 71 of which included a visual sighting (observation rate of 12% or 0.16 marked bear/hr). Forty-five sightings of unmarked bears were also obtained during telemetry flights, including 25 solitary bears, 14 females with COY, 4 females with yearlings, and 2 females with unknown age young. Rate of observation for all unmarked bears during telemetry flights was 0.10/hr. Rate of observing females with COY was 0.03/hr, which was considerably less than during observation flights (0.17/hr).

Movements

Seventeen bears (13 females, 4 males) were located at least once during each season (spring, summer, and fall) and ≥12 times throughout the entire year during 1997. Minimum convex polygon home ranges for these bears ranged from 59-5861 km^2 (Table 13). Females traveling with young displayed the smallest home ranges (mean = 191 km^2, SD = 167.39, *n* = 10, bear #237 excluded), while adult males averaged 1,147.5 km^2 (SD = 865.37, *n* = 4).

Table 9. Annual summary statistics for observation flights conducted during 1987-97.

Date	Observation period	Total hours	Number of flights	Average hours/ flight	Bears seen: Marked Lone	Bears seen: Marked w/young	Bears seen: Unmarked Lone	Bears seen: Unmarked w/young	Bears seen: Total	Observation rate (bears/hr): All bears	Observation rate (bears/hr): w/yng	Observation rate (bears/hr): w/COY
1987	Total	47.2	20	2.4					35[a]	0.74		
1988	Total	33.9	17	2.0					62[a]	0.66		
1989	Total	88.7	37	2.4					87[a]	0.98		
1990	Total	86.0	39	2.2					81[a]	0.94		
1991	Total	99.2	46	2.2					257[a]	2.59		
1992	Total	68.7	31	2.2					204[a]	2.97		
1993	Total	58.4	29	2.0					43[a]	0.74		
1994	Total	64.5	32	2.0					112[a]	1.75		
1995	Total	65.2	30	2.2					70[a]	1.07		
1996	Total	77.1	35	2.2					105[a]	1.36		
1997	Round 1[b]	55.5	26	2.1	3	0	39	21	63	1.14		
	Round 2[c]	59.3	24	2.5	2	0	31	18	51	0.86		
	Total	114.8	50	2.3	5	0	70	39	114	0.99	0.34	0.17

[a]Only includes unmarked bears. Checking for radio-marks on observed bears was added to the protocol starting in 1997.
[b]Flights conducted during 24 July - 17 August, 1997.
[c]Flights conducted during 25 August - 13 September, 1997.

Table 10. Size and age composition of family groups seen during observation flights, 1997.

Date	Females with COY				Females with Yrls				Females w/ unk young		
	w/1	w/2	w/3	w/4	w/1	w/2	w/3	w/4	w/1	w/2	w/3
Round 1[a]	4	5	2	0	2	4	3	0	0	1	0
Round 2[b]	2	4	2	0	0	3	2	0	1	2	2
Total	6	9	4	0	2	7	5	0	1	3	2

[a]Flights conducted during 24 July - 17 August, 1997.
[b]Flights conducted during 25 August - 13 September, 1997.

Table 11. Sightings of unduplicated female grizzly bears with cubs-of-the-year by method of observation, 1986-97.

Year	Observation flights		Ground sightings	Radio flights/trap	Total
	IGBST & WY	Other			
1986	9	2	10	4	25
1987	5	1	4	3	13
1988	7	1	7	4	19
1989	7	2	5	2	16
1990	8	0	12	4	24
1991	17	2	2	3	24
1992	10	4	6	3	23
1993	3	4	10	3	20
1994	12	4	2	2	20
1995	2	2	12	1	17
1996	13	1	10	9	33
1997	9	0	9	13	31

Table 12. Summary statistics for radio-telemetry relocation flights conducted during 1997.

Month	Hours	No. flts	Ave. hrs/ flight	Radioed bears		Unmarked bears observed				Observation rate (bears/hr)		
				No. loc.s	No. seen	Lone bears	Female w/COY	Female w/yrls	Female w/yng	Marked	Unmarked	Females w/COY
January	9.60	1	9.60	9	0	0	0	0	0	0.00	0.00	0.00
February	0.00	0	---	0	0	0	0	0	0	---	---	---
March	0.00	0	---	0	0	0	0	0	0	---	---	---
Apr	11.55	2	5.78	23	2	0	0	0	0	0.17	0.00	0.00
May	87.10	15	5.81	120	18	5	0	0	1	0.21	0.07	0.00
June	55.37	11	5.03	48	7	2	0	0	0	0.13	0.04	0.00
July	79.64	19	4.19	101	19	10	7	1	0	0.24	0.23	0.09
August	66.61	16	4.16	83	8	5	7	3	1	0.12	0.24	0.11
September	53.36	15	3.56	106	5	2	0	0	0	0.09	0.04	0.00
October	44.64	12	3.72	90	11	1	0	0	0	0.25	0.02	0.00
November	30.42	9	3.38	58	1	0	0	0	0	0.03	0.00	0.00
December	2.30	1	2.30	4	0	0	0	0	0	0.00	0.00	0.00
Total	440.59	101	4.36	612.72	71	25	14	4	2	0.16	0.10	0.03

Table 13. Annual range sizes (km^2) of grizzly bears located ≥12 times and during all 3 seasons of 1997.

Cohort	Bear #	Number of locations	MCP[a]	Cohort mean (1975-87) MCP	(SD)
Females					
With cubs	125	17	102	231	(136)
	249	29	72		
	258	19	313		
	264	20	181		
	267	30	82		
	271	16	113		
With yearlings	179	32	590	338	(244)
	189	24	98		
	237	28	5861		
	242	12	59		
	246	14	300		
Lone adult	284	21	3817	236	(114)
Subadult	279	26	379	365	(191)
Males					
Adults	199	18	338	674	(630)
	227	15	1873		
	281	18	461		
	282	12	1918		

[a] Minimum Convex Polygon.

Two adult females displayed home ranges that were dramatically larger than all other females. Bear #237 had an annual home range of 5,861 km^2. Her large home range was primarily due to a long distance movement made during July-September, in which she traveled from near Moran Junction north of Jackson, WY, to northwest of Henry's Lake in Idaho, and back. Notably, this movement was made while accompanied by yearlings and appeared unrelated to food availability. The other female with an unusually large home range (3,817 km^2) was bear #284. Her large home range was likely influenced by the absence of dependent young, although she was the only adult female without young included in the 1997 home range calculations. Nevertheless, her annual home range was 3,581 km^2 larger than the average observed for similar bears during 1975-87.

Food Habits

Spring Ungulate Availability and Use by Grizzly Bears in Yellowstone National Park

Introduction

Grizzly bear use of ungulates as carrion (Mealey 1980, Henry and Mattson 1988, Green 1994, Blanchard and Knight 1996, Mattson 1997) and as prey (Cole 1972, Houston 1978, Schleyer 1983, Harting 1985, Gunther and Renkin 1989, Mattson 1997) in Yellowstone National Park (YNP) has been well documented. When available, ungulates as carrion are the major source of protein for bears coming out of hibernation in early spring (Green 1994, Mattson 1997). However, several researchers have suggested that the importance of ungulate resources to grizzly bears is underestimated in YNP (Cole 1972, Schleyer 1983, Harting 1985, Mattson 1997).

Mattson (1997) hypothesized that ungulates may provide as much as half of the energy required by Yellowstone's grizzly bears during the non-denning season. Much of this use is scavenged during spring when ungulate mortality peaks. Availability of carrion fluctuates among years, and is largely dependant upon winter severity (Green 1994). Yellowstone's grizzlies rely on ungulate carcasses as a primary food source (Knight et al. 1984, Mattson et al. 1991, Green 1994). This importance of carrion to bears lead Mealy (1975) and Picton (1978) to postulate a dependant relationship between reproductive success of female grizzlies and the availability of carrion on spring ranges.

The availability and competition for carrion has changed with the reintroduction of wolves (*Canis lupus*) to YNP. The wolf is a keystone predator/scavenger and has modified the ecological processes associated with spring use of carcasses. However, the impact wolves have on the grizzly bear population and bear use of carcasses in the greater Yellowstone area is speculative. Servheen and Knight (1993) stated, in the short term, wolf-grizzly bear interactions in YNP will likely be individualistic in nature and occur at large ungulate carcass sites. At present, grizzly bears are usurping wolves of predated ungulates within 1 day in many instances (D. Smith, Yellowstone National Park, personal communication). Servheen and Knight (1993) further stated that the most severe competition between bears and wolves would likely be in the spring after bears come out of the den and would be for available carrion and winter-weakened animals.

Green et al. (1997) found that bison (*Bison bison*) carcasses were more available, and thus, more important to grizzly bears due to carcass depletion rates and total biomass available. Elk carcass depletion rates were <1-2 days in all areas of YNP, whereas it took 2-10 days for the same depletion of bison carcasses (Green et al. 1997). Variations in the number of elk and especially bison carcasses will likely have a greater effect on bears compared to other scavengers (Green et al. 1997). Concerns with bison and brucellosis (*Brucella aborta*) management in YNP and the surrounding states has the potential to severely limit the future number of bison carcasses available to bears and other scavengers. The effects of bison herd reduction and disease management on bears is speculative, however, the impacts of reduced numbers of bison carcasses to bears in the Yellowstone ecosystem can only be negative.

Competition for carrion and changes in ungulate management in the Yellowstone ecosystem has potential ecological ramifications to the threatened grizzly bear. A reassessment of spring use of ungulates through carcass surveys and direct observations should illuminate potential relationships between these keystone predator/scavengers, and provide continued monitoring of a major food source for bears, wolves, and other scavengers in YNP.

Objectives

1) Document ungulate carcass availability and associated grizzly bear and wolf use on historical carcass survey routes in Yellowstone National Park.

2) Evaluate the availability and use of carcasses by bears and wolves and discern the impact, if any, wolves have on bear use of carcasses on ungulate winter ranges.

3) Document the interspecific relationships and behavior between bears (especially females with cubs) and wolves in YNP.

Study Areas

Ungulate species in the study areas include bison, pronghorn (*Antilocapra americana*), elk (*Cervus elaphus*), moose (*Alces alces*), mule deer (*Odocoileus hemionus*), and bighorn sheep (*Ovis canadensis*). Secondary consumers common in the area include the grizzly bear, black bear (*Ursus americanus*), mountain lion (*Felis concolor*), coyote (*Canis latrans*), and wolf. The avifauna which are major scavengers include the golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaeetus leucocephalus*), raven (*Corvus corax*), and magpie (*Pica pica*).

Northern Range.--The northern range lies between 1,585 m and 2,475 m elevation and is wholly within the northern winter range for elk described by Houston (1979) in the Yellowstone and Lamar River drainages (Green 1994). The vegetation in the area is a mix of grassland, shrub, and forest types with the nonforest habitats dominating the majority of the land base (Despain 1990).

Norris and Firehole Geyser Basins.--This study area lies between 2,164 m and 2,316 m in elevation and is fully described by Mattson and Knight (1992). The area is composed mostly of nonforest meadow and marsh habitats associated with geothermal activity lying along the Gibbon and Firehole Rivers. Thermal influenced vegetation communities are arranged along temperature gradients from barren ground and scattered moss on warmer areas to grass and herb communities as the thermal influence subsides (Sheppard 1971). Timbered habitat types are dominated by subalpine fir (*Abies lasiocarpa*) with lodgepole pine (*Pinus contorta*) occupying a minor portion.

Heart Lake Thermal Basin.--This study area lies between 2,249 m and 2,493 m in elevation and is mostly on the north and west sides of Heart Lake. This area consists of the geothermal-influenced portions of the Witch Creek drainage, the lower eastern portions of Mount Sheridan adjacent to Heart Lake to the west, and the open marsh-meadow network near the mouth of Beaver Creek on the north shore of Heart Lake (Green 1994). This area is an intermix of forest, nonforest, and geothermal habitats, with the geothermal types limited to the Witch Creek drainage.

Methods

This study duplicated survey routes established by Green (1994) and the IGBST. These routes were initially chosen because of known concentrations of spring carcasses (Houston 1978), and spring locations of grizzly bears obtained from IGBST data files (Green 1994). Routes were surveyed for carcasses once from the beginning of April through mid-May, which provides a relative index to carcass abundance and utilization. Flexibility in following survey routes was necessary to investigate concentrations of ravens and/or coyotes, or any behavior by scavengers that may have indicated the presence of a carcass.

Data collected at carcass sites replicated data collected by Green (1994) and Green et al. (1997). These included: UTM, aspect, slope, elevation, distance to road, scats present, distance to forest/non-forest edge, species of carcass, age, sex, approximate date of death, cause of death (i.e. predation, malnutrition, etc.) if cause could be determined, percent consumed by each scavenger or predator, site specific descriptions, and observations of predators at carcass sites. Available observed edible biomass was calculated for each carcass following calculations of Houston (1978) for elk, and bison biomass was calculated for calves (72 kg), cows (207 kg), yearlings (117 kg), and bulls (360 kg) (Turner Ranches, Gallatin Gateway, Montana, personal communication). Biomass used by bears, wolves, or unknown large scavengers could not be calculated due to survey methodology.

Weather, winter severity, and forage availability are the limiting factors to ungulate survival during winter (Cole 1971, Houston 1982). Long-term changes in weather and winter severity monitoring are useful in predicting potential carcass availability. Winter Severity Index (WSI), developed for elk (Farnes 1991), tracks winter severity monthly within a winter and is useful to compare winter severity among years. WSI uses a weight of 40% of minimum daily winter temperature below 0°F, 40% of current winters snowpack measured as snow water equivalent, and 20% of June and July precipitation as surrogate for forage production (Farnes 1991).

Results

Northern Range.--We surveyed 13 routes on the northern range totaling 203.5 km traveled. One route was partially surveyed and 2 routes were not surveyed due to closures in effect to protect wolf denning sites. We counted 108 carcasses consisting of 105 elk, 2 bighorn sheep, and 1 bison, which equated to 0.53 carcasses/km. The total observed biomass available to scavengers on these transacts totaled 11,385 kg excluding the bighorn sheep. Observed elk biomass equated to 11,178 kg and the observed bison biomass equaled 207 kg (Table 14).

We observed bear sign at 31 carcass sites located on 8 of the 11 survey routes. Grizzly bear sign was observed at 26 sites on 6 of the 11 routes. We documented black bear sign on 2 of the 11 routes, and sign from unknown bear species on 3 routes. Wolf sign was observed at 18 carcass sites on 6 of the 11 routes. Percentages of ungulate carcasses visited by bears, wolves, and unknown large scavengers is presented in Table 14.

Table 14. 1997 results, calculated biomass available, and percent of carcasses by bears, wolves, and unknown large scavengers for survey area.

	Elk				Bison				Totals[b]	
	# Carcasses	% Visitation by species			# Carcasses	% Visitation by Species			Biomass	
Survey area (# routes)	(Biomass, kg)	Bear	Wolf	Unk	(Biomass)[a]	Bear	Wolf	Unk	observed (kg)	Carcass/km
Firehole (8)	21 (1,904)	33	21	25	56 (9,360)	14	6	13	11,264	0.97
Norris (4)	8 (704)	13	0	87	13 (1,827)	8	8	70	2,531	1.24
Heart Lake (3)	5 (510)	0	100	0					510	0.16
Northern Range (13)	105 (11,178)	25	14	44	1 (207)	0	0	100	11,385	0.53

Norris/Firehole Geyser Basins.--We surveyed 4 routes in the Norris Basin and 8 routes in the Firehole Basin, with a total of 99.5 km traveled (17 km and 82.5 km in the Norris/Firehole areas, respectively). We counted 101 carcasses in the 2 areas (21 and 80 in the Norris/Firehole areas, respectively) which equated to 1.02 carcasses/km traveled (1.24 and 0.97 carcasses/km for the Norris and Firehole area, respectively)(Table 14). In the Norris and Firehole areas there were 8 and 24 elk carcasses which equated to available biomass of 704 kg and 1,904 kg, respectively. Additionally, there were 56 and 13 bison carcasses observed in the Norris and Firehole areas, with biomass estimated at 1,827 kg and 9,360 kg, respectively. The total observed biomass available to scavengers from elk and bison from routes was 13,795 kg (Table 14).

We observed bear sign at 17 carcass sites on 9 of the 12 routes. Grizzly, black, and unknown bears accounted for sign at 5, 0, and 9 of the 12 routes, respectively. Wolf sign was documented at 12 carcass sites on 6 of the 12 routes. We heard wolf calls while walking one transect in the Firehole Geyser area. Percent use of observed carcasses in the Norris/Firehole areas by bears, wolves, and unknown large scavengers is presented in Table 14.

Heart Lake.--We surveyed 3 routes in the Heart Lake thermal basin covering 32 km. We counted 5 elk carcasses equating to 0.16 carcass/km, with a total biomass of 510 kg. Grizzly, black bear, and wolf sign was observed on all routes. Percent use of observed carcasses in the Heart Lake area for bears, wolves, and unknown large scavengers is presented in Table 14.

Discussion

According to the WSI, the winter of 1996-97 was the worst recorded since 1988-89, and the 7th worst since 1948-49 (Fig. 2). Carcass numbers for the northern range and the Norris/Firehole areas plotted against the WSI shows that carcass numbers were nearly as abundant during the winter of 1997-98 as observed in 1988-89 in all survey areas of the park (Fig. 3).

Green (1994) observed that elk carcass numbers exceed bison in all years, except during winters of lightest die-off. In 1996-97, however, bison carcasses were observed at nearly twice the rate of elk carcasses observed on routes in both the Norris and Firehole Geyser Basins. This was contrary to observations of Green (1994) since this was the second worst winter since the carcass transects began.

Evidence (e.g. sign, bone marrow) at carcass sites suggested that all elk carcasses had been preyed upon or scavenged by wolves before they could be utilized by bears emerging from hibernation. The Heart Lake geyser basin is a wintering area where elk are isolated by deep snow. Historically, winter-killed elk were available to grizzlies in spring. With the advent of wolf reintroduction, this pattern appears to be changing. The utilization of weakened animals and carcasses by wolves likely will exclude grizzly bears from this nutritional food source. These effects of carrion availability to bears, especially females with cubs, need further investigation. These results also amplify the need to continue carcass surveys in this area. Continued study and monitoring of bear and wolf use of spring carcasses and the interspecific relationships between these 2 species are warranted, especially in winters of light die-off.

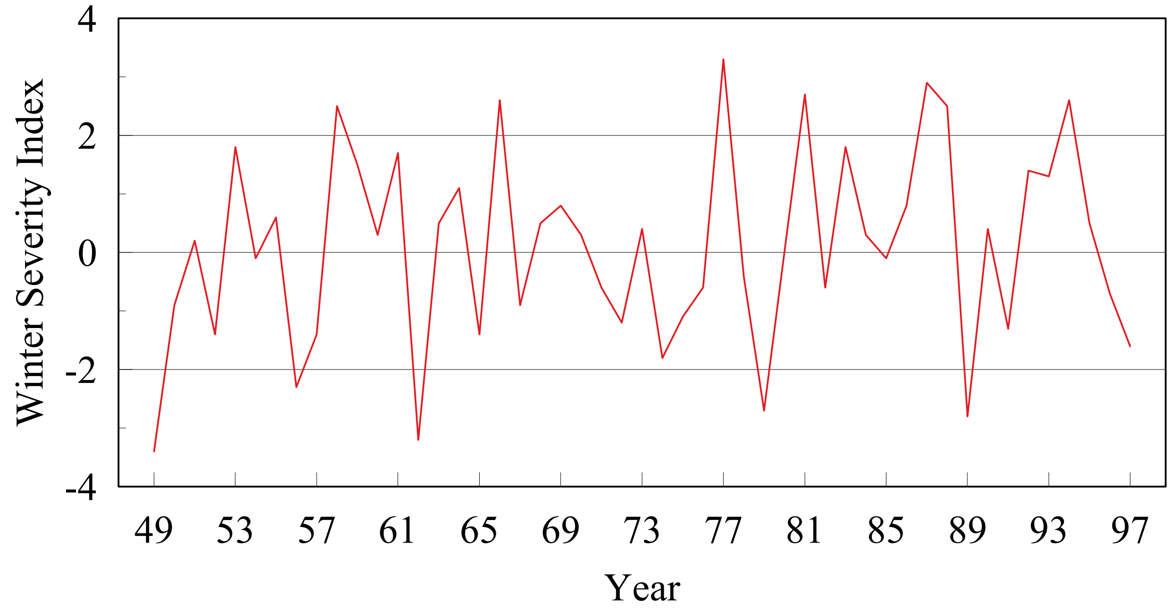

Fig. 2. Yellowstone National Park northern range Winter Severity Index for the years 1948-97. Rating scale: 3 to 4 very mild; 0 average; -3 to -4 very severe.

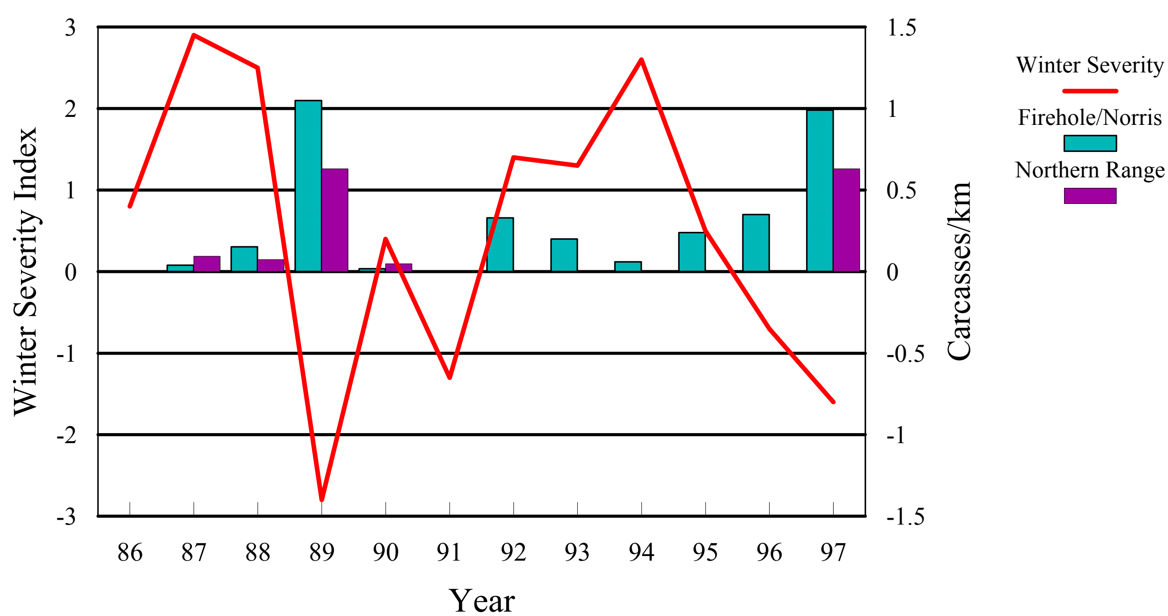

Fig. 3. Ungulate carcasses observed per kilometer for 2 survey areas plotted against a Winter Severity Index derived for elk on the northern range of Yellowstone.

Effects of Cutthroat Trout Abundance on Grizzly Bear Use of Spawning Streams in Yellowstone National Park

Introduction

Yellowstone Lake is one of the last remaining undisturbed natural habitats for native Yellowstone cutthroat trout (*Oncorhynchus clarki*) (Varley and Gresswell 1988). This population is in jeopardy due to the discovery, in 1994, of non-native lake trout (*Salvelinus namaycush*). Declines in native lake populations of cutthroat trout have been known to occur where lake trout have been introduced (Kaeding et al. 1996). Fisheries experts contend that if the lake trout population in Yellowstone Lake continues to expand, the native cutthroat trout population could decline as much as 80-90% (McIntyre 1996). A decline in cutthroat trout numbers of this magnitude would have dramatic negative impacts on the food supply for an estimated 42 wildlife species including the threatened grizzly bear (*Ursus arctos*) (Schullery and Varley 1996). Grizzly bears fish for spawning cutthroat trout in small tributary streams of Yellowstone Lake. In comparison, lake trout spawn in deep water of the lake making them unavailable to grizzly bears and other terrestrial predators.

The importance of spawning cutthroat trout to black (*Ursus americanus*) and grizzly bears in YNP has been well documented (Hoskins 1975, Mealey 1980, Reinhart 1990, Mattson and Reinhart 1995). Each spring and early summer, cutthroat trout provide a food resource high in protein and lipid content when bears are recouping nutritional losses incurred during hibernation (Pritchard and Robbins 1990, Mattson et al. 1991). Bear use of spawning cutthroat trout in YNP was studied in the mid 1970s (Hoskins 1975, Mealey 1980) and in the 1980s (Reinhart 1990). Since 1975, changes in management of the cutthroat trout fishery have resulted in an increased proportion of older and larger fish in Yellowstone Lake (Varley and Gresswell 1988), providing increased numbers of cutthroat trout available and used by bears (Reinhart 1990). The lake trout discovery in Yellowstone Lake has the potential to cause a precipitous decline in the cutthroat trout population (Schullery and Varley 1996) and bear use of cutthroat trout.

Spawner abundance and bear use of front country spawning streams in YNP has declined since 1990 (Reinhart et al. in press). Reinhart et al. (in press) found that peak spawner counts on front country streams declined significantly, whereas bear use of these streams apparently declined, but not statistically. The downward trends in trout numbers and bear use on front country streams have led park managers to question the special rules and regulations governing recreation and access on all spawning streams associated with Yellowstone Lake (Reinhart et al. in press). It is unknown whether the apparent decline of cutthroat trout and bear use on front country streams is an anomaly associated with increased use by people or has occurred throughout all Yellowstone Lake tributaries.

This assessment of front country and select backcountry streams that have a history of spawning activity and bear use will determine whether similar trends are evident throughout the Yellowstone Lake tributary system. The results obtained from this study will be compared to results obtained by Hoskins (1975) and Reinhart (1990) to determine if estimated trout numbers in these streams have declined and also if bear use of cutthroat trout has declined.

Objectives

1) Determine if changes in spawner abundance has occurred since the 1980s for backcountry and front country streams.

2) Estimate the number of grizzly bears using spawners as a food source and determine changes in levels of bear use since the 1980s.

3) Evaluate 2 techniques, track surveys and DNA methodology, for estimating bear population use of cutthroat trout spawning streams.

Study Area

Yellowstone Lake has approximately 176 km of shoreline. There are 124 known tributaries to the lake identified by SONYEW numbers (System of Numbering Yellowstone Waters) (Varley et al. 1976, Jones et al. 1986) and about 59 streams have exhibited evidence of bear fishing activity during cutthroat spawning season (Reinhart 1990). Streams that have shown no spawning activity have either insufficient flow, too steep of gradient, incompatible substrate, natural or artificial blocks, or thermal influence with incompatible chemical composition (D. Reinhart, personal communication). Spawning of the cutthroat trout occurs from ice-off (average onset ranges from 7 May through 6 June) and lasts until late July (Reinhart 1990, Reinhart et al. in press).

Methods

Since 1989, YNP staff at Lake and Grant Village have monitored spawning streams near YNP roads and developments commonly called front country streams (Reinhart et al. in press). Survey methods were similar to those used in Reinhart's study during the 1980s (Reinhart 1990). These surveys estimated relative spawner abundance and associated bear use of these front country streams. By monitoring bear use, managers are able to vary opening dates of park facilities, allowing bears to fish relatively undisturbed by humans, and avoid bear-human conflicts.

This study includes the front country tributaries of Yellowstone Lake that have been surveyed by park staff in addition to select backcountry spawning streams (Fig. 4). Determination of backcountry streams to survey was based upon the significance of spawner abundance and associated bear use as determined by previous studies (Hoskins 1975, Reinhart 1990) and placement around the lake. Eleven front country streams and nine backcountry streams were surveyed during the first year of this project. Front country streams surveyed included 8 in the Lake area and 4 in the West Thumb area. Backcountry streams surveyed included 3 from the East shore, 5 from the West shore in South and Flat Mountain Arms, and Arnica Creek in the West Thumb.

Cutthroat trout abundance.--Data collected from spawning streams approximated data collected by Reinhart (1990) and Reinhart et al. (in press) and included fish numbers and upstream extent of the spawning run (Frame 1974, Reinhart 1990, Reinhart et al. in press).

Spawning streams were surveyed weekly from ice off through mid-August. A visual estimate of cutthroat trout spawners provided a comparative estimate of trout abundance as well as a method to determine the beginning, peak, and end dates of the spawning run.

Bear activity.--Grizzly bear activity was determined by recording bear tracks, levels of use on bear trails, scats and fish carcasses (Reinhart 1990). Bear tracks that are recorded give an approximate number of grizzly and black bears that visited spawning streams on each survey date and are called bear visits. Bear tracks were measured to establish the number and species of bears on each stream for each survey visit. Tracks that varied by greater than 2 cm in width, by species, or by association (e.g., adult with young) were considered to be different bears. Total number of visits by bears found from track surveys did not necessarily reflect the total number of autonomous bears that fished spawning streams on Yellowstone Lake since some bears travel among streams. A subjective classification on intensity of bear trails (light, moderate, heavy) was also made during each visit. Bear scats found along streams were counted and collected for diet content analysis. Fish carcasses associated with bear activity were counted along streams.

Finally, the sex and number of individual bears utilizing spawning streams was determined using DNA from hair collected using hair collection corrals (HCC). Each stream had at least 1 and sometimes 2 HCCs at least 1.5 km apart, depending on the length of the spawning run and streamside topography. All HCCs were placed in bear fishing areas prior to onset of spawn. Blood was used as an attractant (Haroldson and Anderson 1997) on all HCCs. All hairs caught on a single barb of the perimeter fence were treated as a single sample for DNA analysis (Proctor 1995). The number of individual bears identified through this procedure provided a quantitative assessment of the number of bears using spawning streams and was compared to the track methodology techniques.

Results

Twelve front country and 9 backcountry streams were surveyed during 1997 (Fig. 4), the first year of study. Earliest spawning activity observed was 7 June and the last on 18 August. Dates of average peak spawn in the Lake and West Thumb areas were 7 and 12 June, respectively. Average peak spawn dates for West and East shore spawning areas were 15 June and 10 July, respectively (Table 15).

Bear tracks, to approximate grizzly and black bear visits, varied by spawning streams and survey date (Table 16). Track surveys on the east shore streams revealed that there were 38 grizzly, 5 black bear, and 1 wolf visit recorded for the 3 streams combined. Cub Creek had 14 grizzly visits, Clear Creek had 11 grizzly and 1 black bear visits, and Columbine Creek had 13 grizzly, 4 black bear, and the wolf visit. The West shore streams had a total of 33 grizzly and 3 black bear visits. Stream #1138 (South Arm) had 12 grizzly and 1 black bear visits, Stream #1150 (Grizzly Bay) had 4 grizzly and 2 black bear visits, Flat Mountain Creek had 16 grizzly visits, and Stream #1158 (Delusion Lake outlet) had 1 grizzly bear visit.

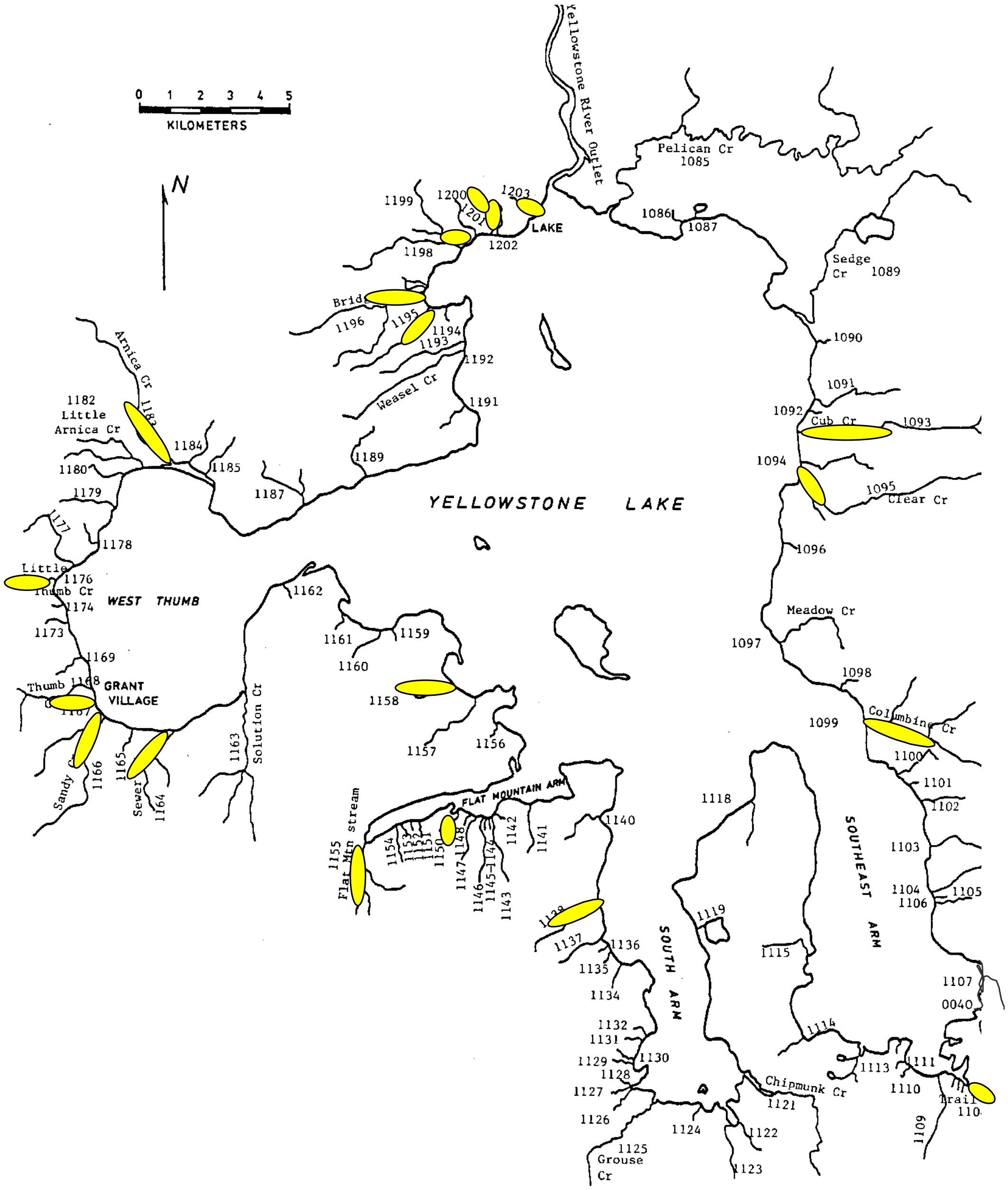

Fig. 4. Yellowstone Lake and location of cutthroat trout spawning streams surveyed (highlighted) for spawner numbers and grizzly bear use.

Table 15. Beginning, peak, and ending dates and peak number of spawning activity by stream.

Stream name (SONYEW number)	Beginning date	Peak date	Peak number	End date
Front country streams				
Lake Area streams				
Lodge Creek (1203)	5/15	6/4	115	6/24
Hotel Creek (1202)	No spawn	No spawn	0	No spawn
Hatchery Creek (1201)	5/15	6/4	89	7/1
Incinerator Creek (1199)	5/28	6/9	4	7/1
Bridge Creek (1197)	5/15	6/9	149	7/1
Wells Creek (1198)	6/4	6/9	15	7/1
West Thumb Area streams				
Stream 1167 (1167)	5/28	6/4	1	6/9
Sandy Creek (1166)	5/28	6/9	33	6/24
Sewer Creek (1164)	5/28	6/4	18	6/24
Little Thumb Creek (1176)	6/9	6/24	155	7/6
Arnica Creek (1183)	5/28	6/4	14	7/1
Backcountry streams				
East shore				
Cub Creek (1093)	6/26	7/10	754	8/13
Clear Creek (1095)	6/26	7/10	261	8/18
Columbine Creek (1099)	6/26	7/10	461	8/7
West shore				
Stream 1138 (1138)	5/30	6/12	984	7/24
Flat Mountain Creek (1155)	5/30	6/19	456	8/6
Stream 1150 (1150)	5/28	6/4	23	7/24
Delusion Lake Outlet (1158)	5/26	6/4	5	6/25
Trail Creek (1108)	7/3	7/13	14	7/22

Table 16. Estimated number of bears[a] by species as indicated by detailed track analysis, and number of hair samples by stream in 1997.

Stream	Number of grizzly bears	Number of black bears	Hair samples collected
Backcountry			
East shore streams			
Cub Creek	3-5	0	25
Clear Creek	4-5	1	39
Columbine Creek	4-5	1-2	70
West shore streams			
Stream #1138	5	0	95
Flat Mountain Creek	4-7	0	79
Stream #1150	2	1-2	2
Trail Creek	1	1	25
Front country			
Lake Area streams			
Lodge Creek[b]	4	0	
Hotel Creek[b]	0	0	
Hatchery Creek[b]	1	0	
Incinerator Creek[b]	0	1	
Bridge Creek	2	0	11
Wells Creek[b]	0	0	
West Thumb Area			
Stream #1167[b]	0	0	
Sandy Creek[b]	1	1	
Sewer Creek[b]	0	1	
Little Thumb Creek	1	2	14
Arnica Creek[b]	1	0	

[a] Numbers of bears on each stream does not equate to the definitive number of bears using the spawning streams due to movements of bears between streams.
[b] Streams without Hair Collection Corrals.

A more detailed track analysis to determine the number of bears on these streams from beginning to end of spawn was conducted looking at size groupings of individual tracks. On Cub Creek, it was determined that 3-5 individual bears fished this stream. Clear Creek had 4-5 grizzlies and 1 black bear, whereas Columbine Creek had 4-5 grizzly and 1-2 black bears utilizing the spawning trout or the streamside habitats. The spawning stream #1138 on the South Arm had 5 grizzly bears, Flat Mountain Creek had 4-7 grizzly bears, and Stream #1150 had 2 grizzlies and 1 black bears fishing for cutthroat trout (Table 16).

Results from the DNA analysis of the hair samples are pending. There were 360 samples collected from 15 HCCs on 10 different spawning streams (Table 16). Results are expected by summer of 1998.

Discussion

This cooperative study was undertaken by the IGBST, YNP-Bear Management Office, and the YNP-Lake Area resource management. The objectives were to obtain some preliminary results and to work out the "bugs" of the study. Despite a year that consisted of cold temperatures, high water, and logistical problems, preliminary data are interesting.

Except for Clear Creek, spawner numbers on the backcountry streams were similar to numbers observed during the 1980s. The front country streams in the Lake Development area also had similar numbers when compared to previous studies. However, streams in the West Thumb area continued to show significant declines in numbers of fish and bear use (Fig. 5).

Although reasons for declines in spawner numbers in the West Thumb area are speculative, these streams are in the area of known lake trout spawning (Yellowstone Science, vol. 5, num. 4, 1997), suggesting lake trout might be a possible cause. If lake trout are the cause of the observed declines in the West Thumb area, it portends similar declines throughout Yellowstone Lake. The decline in spawner numbers on Clear Creek, however, seemed to be caused by high water. With record or near record snow pack, water conditions were very high and turbid which made counting fish very difficult and variable.

Bears fed in close proximity to people or campsites near East shore streams and the Lake area front country streams. In the Lake area development, there were at least 5 individual bears utilizing either the spawning streams or the stream-side habitat after the development opened to people. There were also instances of bear-human interactions along the backcountry streams. In 1 instance, a bear walked through a campsite near the mouth of Columbine Creek. Near Columbine Creek, an unwary black bear was encountered on the trail by hikers. Both instances support the need to continue special management regulations governing areas around Yellowstone Lake (Gunther 1996).

Although first year results are preliminary, they demonstrate a need for continuation of the project to establish trends of bear use, cutthroat trout spawning, and bear-human interactions. Trend data are useful in comparing current measures with previous data. Data will also provide information on yearly variation of spawning fish, stream use, and bear feeding activity. The continued collection and analysis of hair samples will also help determine the number and types

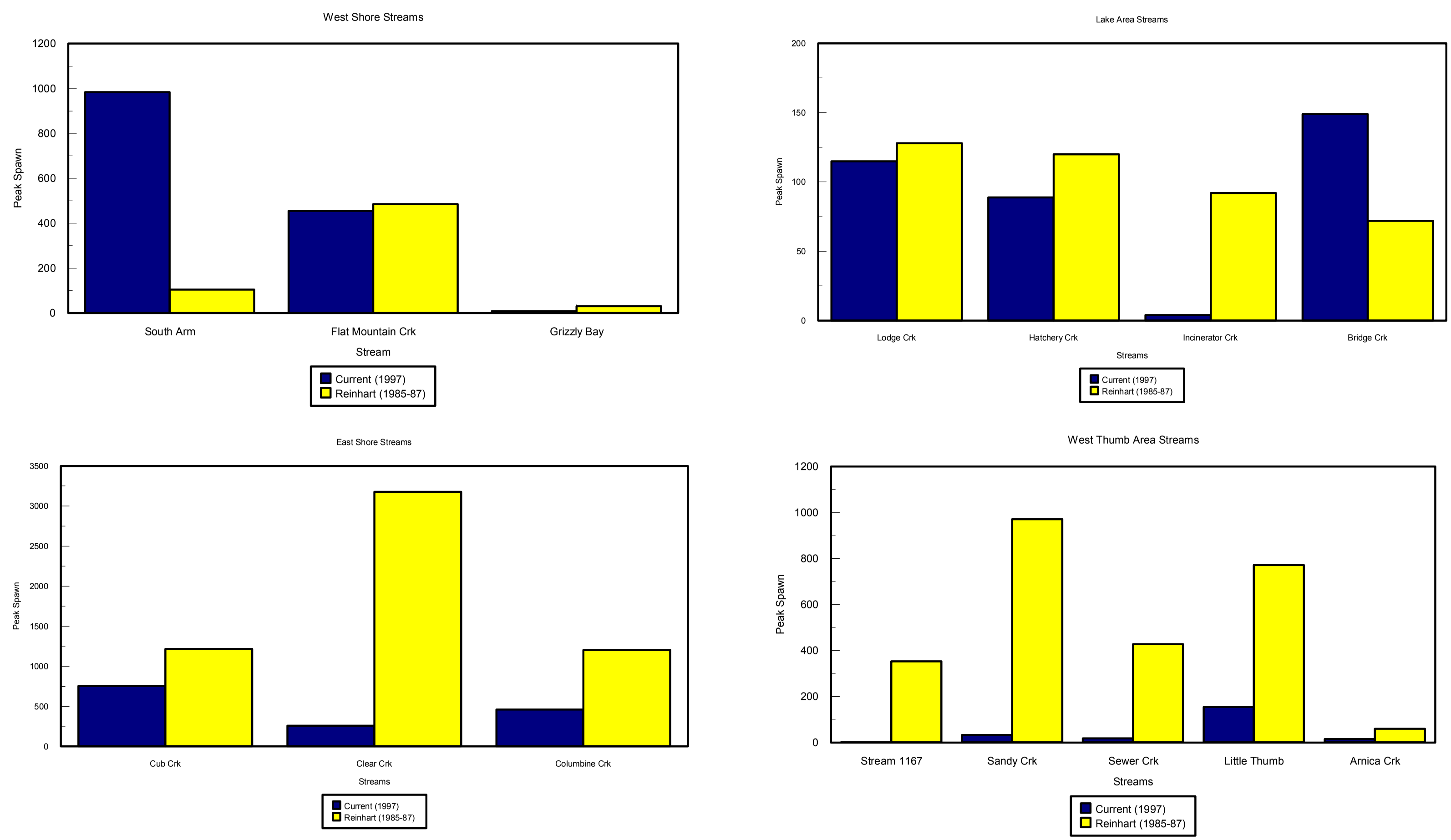

Fig. 5. Comparisons of peak spawner numbers between study periods for different areas of the lake.

of bears using spawning streams and the movement of bears among streams. It will also provide an estimate of the number of bears that may be impacted by lake trout effects on cutthroat trout.

Whitebark Pine Cone Production

Grizzly bears generally consume the seeds of whitebark pine (*Pinus albicaulis*) to the near exclusion of other food items when available in sufficient quantities. These seeds are largely unavailable to bears until cone production approaches 20 cones per tree (Blanchard 1990). Widespread use by bears generally occurs when production exceeds 22 cones per tree (Mattson et al. 1992).

Cone production during 1997 averaged 4.5 cones per tree (Table 17) for the 19 transects surveyed in the Yellowstone ecosystem (Fig. 6). Cone productivity was poor throughout most of the study area. The exception occurred in the southeastern portion of the ecosystem where good cone productivity was observed (transects H, T, and U, Fig. 7). Field observation by Pat Hnilicka (WYGF) in the Wiggins Fork, Emerald Creek, and Sheep Creek drainages north of Dubois, Wyoming, also indicated good cone productivity in the southeastern portion of the ecosystem.

Table 17. Summary statistics for the 1997 whitebark pine transects.

Year	Total cones	Total trees	Total transects	Mean cones per tree	Mean cones per transect	Cones per transect		
						SD	Min.	Max.
1997	855	188	19	4.55	45.00	91.46	0	292

During years of low whitebark pine seed availability, grizzly bears often seek alternate foods at lower elevations which also brings them in closer association with human activities. During falls of poor whitebark productivity, the number of management actions resulting in capture and transport of bears usually increases. Similarly, the number of human-caused bear mortalities also usually increases during poor cone producing years. However, during late July to November of 1997 only 5 management captures resulting in transport of the bears away from conflict situations occurred. One additional conflict resulted in a management removal. When virtually no whitebark pine seeds were available in 1995, 38 grizzly bears captures resulting in 17 transports and 6 removals took place during the same time period. Factors probably contributing to the low number of management actions during the fall of 1997 were the abundance of spring carrion, the spring and summer use of 1996 over-wintered whitebark pine cones, and the extensive use of army cutworm moths by bears in the eastern portion of the ecosystem. Numerous bears used insect feeding sites from late July through September during 1997.

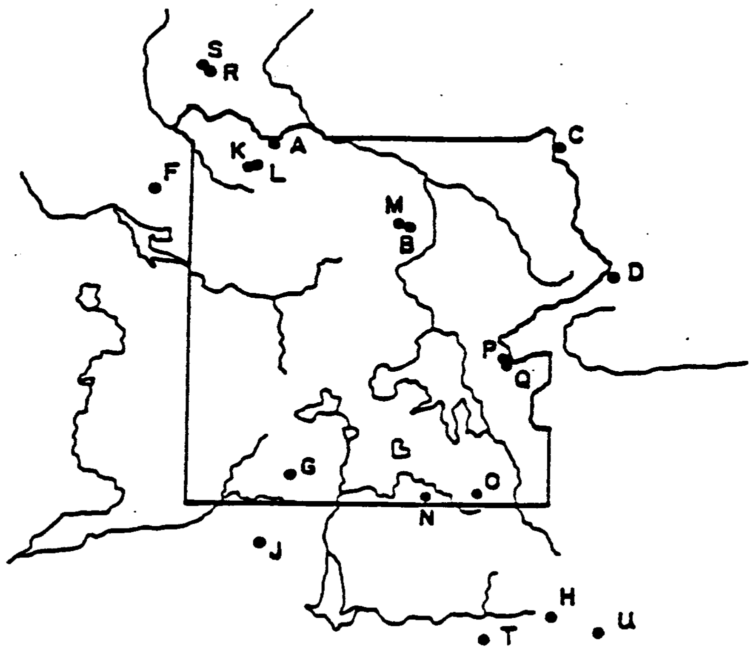

Fig. 6. Location of whitebark pine cones transects in the Yellowstone ecosystem.

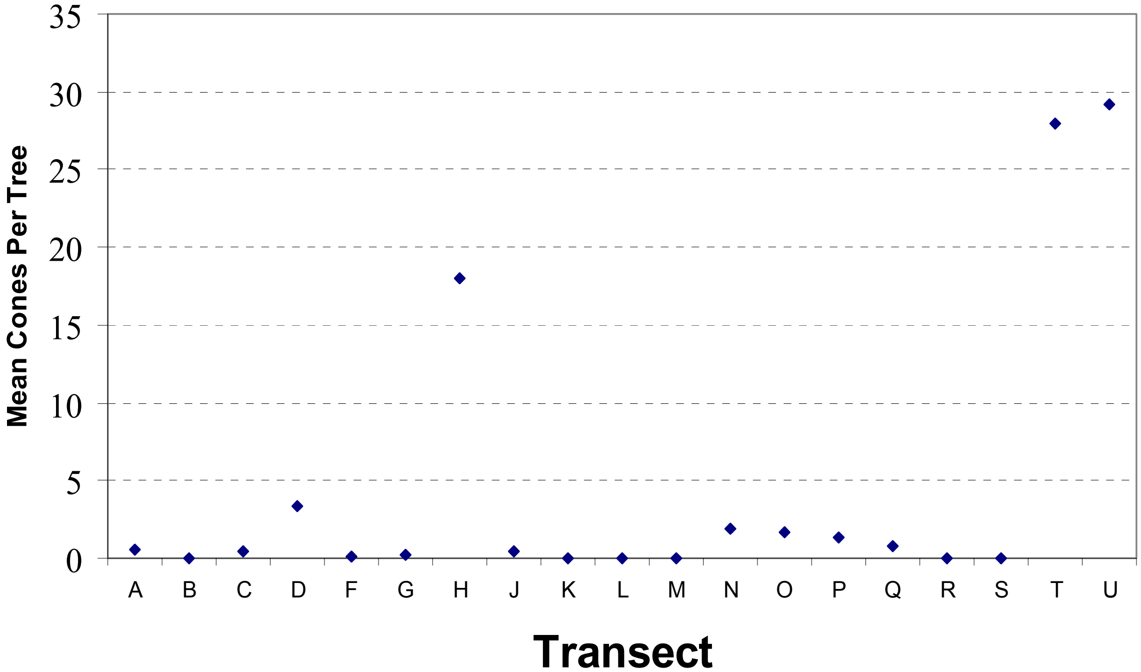

Fig. 7. Average whitebark pine cone production by transect for 1997.

Feed Sites

Ground crews investigated 51 aerial locations of radio-marked grizzly bears from May through October. We found evidence of feeding activity at 16 sites. Evidence of activity other than feeding was recorded at an additional 6 sites, and no sign of bear activity was evident at the remaining 29 sites. Grizzly bear activity was recorded at an additional 17 sites not associated with an aerial location of a telemetered bear. Of those sites, 13 had feeding activity and 4 had other sign recorded (e.g. daybeds, rub trees, etc). Activities for all 32 sites with evidence of feeding are summarized in Table 18.

Table 18. Seasonal frequencies of 32 activities at 29 feeding sites during 1997.

Feeding activity	Spring [a] (n = 10)	Summer [b] (n = 15)	Fall [c] (n = 7)	Total (n = 32)
Whitebark pine seeds	0.00	0.07	0.00	0.03
Grazing	0.10	0.00	0.00	0.06
Digging roots	0.10	0.47	0.00	0.25
Digging rodents/caches	0.30	0.00	0.00	0.09
Digging for other items	0.10	0.00	0.00	0.03
Large mammals	0.30	0.07	0.00	0.13
Searching for insects	0.00	0.20	0.14	0.13
Mushrooms	0.00	0.20	0.71	0.25
Berries	0.10	0.00	0.14	0.03

[a] Spring = May-June
[b] Summer = July-August
[c] Fall = September-October

Use of ungulates and digging for pocket gophers (*Thymomys talpoides*) and their root caches were the most frequently recorded spring feeding activities. Bears used over-wintered whitebark pine caches well into mid-summer. During the summer, digging roots of biscuit root (*Lomatium coos*) and yampa (*Perideridia gairdneri*) were the most frequently observed activities. Feeding on mushrooms was the predominant activity observed in the fall.

Scat Analysis

Food habits represented by fecal analysis often do not accurately reflect relative proportions of ingested items because different diet items are digested at varying rates and to different degrees. More easily digested items such as meat and berries are under-represented in fecal analysis while vegetal items are over-represented.

A brief summary of fecal analysis for scats collected by IGBST during 1997 (Table 19) indicates graminoids, forbs, and meat, primarily from bison, dominated food items found in spring scats. This finding was expected as the winter of 1996-97 was severe and carrion from winter-killed ungulates was abundant. Whitebark pine seeds were also a fairly common food item. This pattern of spring use of over-wintered whitebark pine seeds is typical following abundant cone crops. The fall of 1996 produced an abundant cone crop.

Table 19. Contents of 170 scats collected during 1997. Analysis included both known grizzly bear scats and scats for which species was unknown. Known black bear scats were excluded.

	Spring [a] (n = 31)		Summer [b] (n = 50)		Fall [c] (n = 31)		Total (n = 170)	
	% freq.	% vol.	% freq.	% vol.	% freq.	% vol.	% freq.	% vol.
Pial Seeds	6	6	2	2	6	6	5	4
Berries								
Vaccinium	6	6			6	5	2	1
Sporophytes								
Equisetum	3	1	8	2	3	1	6	3
Mushrooms	19	16			19	16	4	3
Foligae								
Graminoids	39	23	76	56	39	23	64	38
Melica (roots)			2	1			1	T [d]
Forbs	32	18	38	19	32	18	48	29
Claytonia (roots)							1	T
Cirsium	6	5	2	2	6	5	5	3
Delphinium							1	1
Epilobium							1	1
Synthyris							1	T
Taraxacum	6	5	18	8	10	8	20	13
Trifolium	16	6	20	6	16	6	21	7
Osmorhiza			2	1			2	1
Lomatium (roots)	3	T	2	2			4	3
Mammals								
Ungulates	35	17	20	10	35	18	19	9
Bison	23	10			23	11	5	2
Elk	6	4	16	8	6	4	7	3
Moose	3	3			3	3	1	T
Cervidae (spp unk)	3	1	4	2	3	1	7	3
Bear (Grizzly)			2	T			1	T
Rodent	3	T	4	2	3	T	3	T
Fish								
Cutthroat trout			6	4			2	1
Insects								
Ants	6	T	2	T	6	T	13	1
Bee			2	1			1	T
Debris	26	12	16	4	26	12	32	11

[a] Spring = March, April, May, and June
[b] Summer = July and August
[c] Fall = September and October
[d] Trace (less than 0.5)

Graminoids and forbs dominated the summer food items found in scats, but use of meat from ungulates and cutthroat trout was also common. A grizzly bear feeding activity that was frequently observed during telemetry follow-up, but was not indicated by scat analysis, was the summer use of roots from biscuitroot and yampa.

Graminoids, forbs, mushrooms, and meat from ungulates were the most prevalent fall food items found in our scat sample (Fig. 8). This pattern of increased reliance on mushrooms and meat from ungulates during falls when whitebark pine cone crops fail is typical for grizzly bears in the Yellowstone ecosystem.

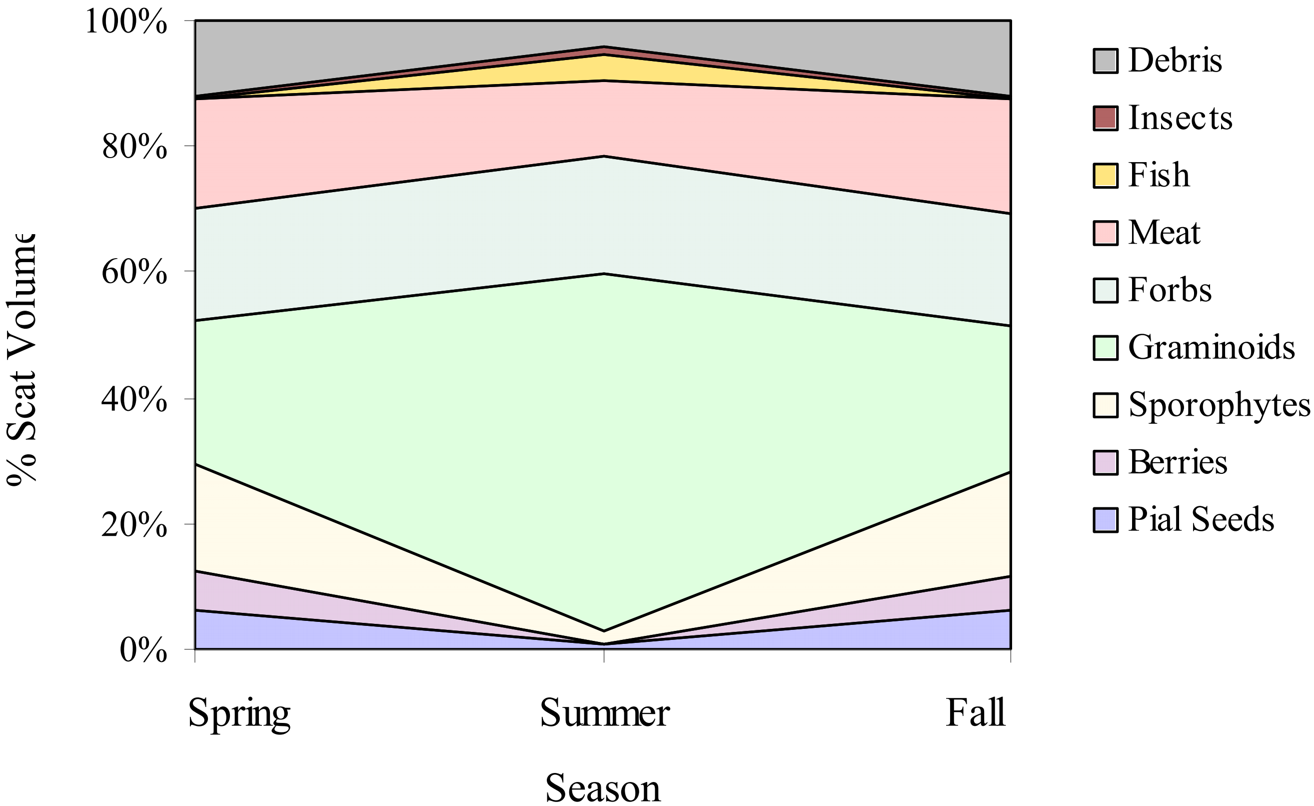

Fig. 8. Percent volume of food items by season for scats collected during 1997. Spring includes March through June, summer, July and August, and fall, September and October.

Movements and Feeding Strategies

The foraging year for grizzly bears in the Yellowstone ecosystem began with an abundance of carrion from winter-killed ungulates. The numbers of winter killed ungulates of 1997-98 were comparable to that of 1989-90. Bears also found an abundance of over-wintered whitebark pine cones during the spring and early summer. Poor production of whitebark pine cones was typical throughout most of the ecosystem during the late summer and fall 1997. The exception was the southeast corner of the ecosystem, in the south Absaroka Mountains. Grizzly bears in the southeast had abundance of late summer and fall foods from army cutworm moths and whitebark pine. Bears in the north dug root foods and used mushrooms and ungulates during in the late summer and fall. Low numbers of management actions throughout the ecosystem indicated that grizzly bears found adequate natural foods and were not forced to move widely which often brings them into closer association with humans.

LITERATURE CITED

Blanchard, B. 1985. Field techniques used in the study of grizzly bears. National Park Service, Interagency Grizzly Bear Study Team report. 24pp.

Blanchard, B. 1987. Size and growth patterns of the Yellowstone grizzly bear. International Conference on Bear Research and Management 7:99-108.

Blanchard, B. 1990. Relationships between whitebark pine cone production and fall grizzly bear movements. Pages 362 *in* W.C. Schmidt and K.J. McDonald, compilers. Proceedings - symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource. U.S. Forest Service General Technical Report INT-270.

Blanchard, B., and R. Knight. 1991. Movements of Yellowstone grizzly bears. Biological Conservation 58:41-67.

Blanchard, B.M. and R. R.Knight. 1996. Effects of wildfire on grizzly bear movements and foraging strategies. Procceedings of the Second Biennial Scientific Conference (in press).

Boyce, M.S., B.F.J. Manly, S. Cherry, R.R. Knight, and C. Servheen. 1997. Cumulative counts of unique individuals for estimating population size. Journal of Wildlife Management (December 1997).

Craighead, J.J., J. Varney, and F. Craighead. 1974. A population analysis of the Yellowstone grizzly bears. Montana Forest and Conservation Experiment Station Bulletin 40. University of Montana, Missoula. Montana. 20pp.

Cole, G.F. 1971. An ecological rationale for the natural or artificial regulation of native ungulates in parks. Transactions of the North American Wildlife and Natural Resources Conference 36:417-425.

Cole, G.F. 1972. Grizzly bear-elk relationships in Yellowstone National Park. Journal of Wildlife Management, Volume 36, Numer. 2, April 1972, pp. 556-561.

Despain, D.G. 1990. Yellowstone vegetation: consequences of environment and history in a natural setting. Roberts Rinehart, Inc., Boulder, Colorado. 239 pp.

Farnes, P.E. 1991. A scaled index of winter severity. Proceedings of the Western Snow Conference, April 12-15, 1991, Juneau, Alaska.

Frame, G.W. 1974. Black bear predation on salmon at Olsen Creek, Alaska. Zeitschrift fur Tierpsychologie 35:23-28.

Green, G.I. 1994. Use of spring carrion by bears in Yellowstone National Park. M.S. Thesis, University of Idaho, Moscow, Idaho. 161 pp.

Green, G.I., D.J. Mattson, and J.M. Peek. 1997. Spring feeding on ungulate carcasses by grizzly bears in Yellowstone National Park. Journal of Wildlife Management 61:1040-1055.

Gunther, K.A. 1996. Bear management areas program in Yellowstone National Park. YNP Information Paper #BMO-5, National Park Service Report. Yellowstone National Park, Wyoming. 4pp.

Gunther, K.A. and R.A. Renkin. 1989. Grizzly bear predation on elk calves and other fauna of Yellowstone National Park. International Conference on Bear Research and Management 8:329-334.

Haroldson, M., and C. Anderson. 1997. Effectiveness of attractants to lure grizzly bears into hair collection sites for future DNA fingerprinting. Pages 37-45 *in* R.R. Knight, B.M. Blanchard, and M.A. Haroldson. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 1996. U.S. Geological Survey, Bozeman, Montana.

Harting, A.L. 1985. Relationships between activity patterns and foraging strategies of Yellowstone grizzly bears. M.S. Thesis, Montana State University, Bozeman, Montana. 103pp.

Henry, J. and D.J. Mattson. 1988. Spring grizzly bear use of ungulate carcasses in the Firehole River drainage: third year progress report. Pages 51-59 *in* R.R. Knight, B.M. Blanchard, and D.J. Mattson. Yellowstone grizzly bear investigations: annual report of the Interagency Study Team, 1987. National Park Service, Bozeman, Montana.

Hoskins, W.P. 1975. Yellowstone Lake tributary study. Interagency Grizzly Bear Study Team. Bozeman, Montana. Unpublished report. 31pp.

Houston, D.B. 1978. Elk as winter-spring food for carnivores in northern Yellowstone Park. Journal of Applied Ecology 15:653-661.

Houston, D.B. 1979. The northern Yellowstone elk - winter distribution and management. Pages 263-272 *in* M.S. Boyce and L.D. Hayden-Wing, editors. North American Elk: Ecology and Management. University of Wyoming, Laramie, Wyoming.

Houston, D. B. 1982. The northern Yellowstone Elk. Macmillan Publishing Company, New York, New York. 474pp.

Jones, R.D., D.G. Carty, R.E. Gresswell, C.J. Hudson, L.D. Lentsch, and D.L. Mahony. 1986. Annual project report, fishery and aquatic management program, Yellowstone National Park, Calendar year 1985. U.S. Fish and Wildlife Service unpublished mimeo. 204pp.

Kaeding, L.R., G.D. Boltz, and D.G. Carty. 1996. Lake trout discovered in Yellowstone Lake threaten native cutthroat trout. Fisheries 21(3):16-20.

Knight, R.R., B.M. Blanchard, and L.L. Eberhardt. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245-248.

Knight, R.R., and L.L. Eberhardt. 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66:323-334.

Knight, R.R., D.J. Mattson, and B.M. Blanchard. 1984. Movements and habitat use of the Yellowstone grizzly bear. National Park Service, Interagency Grizzly Bear Study Team report 177pp.

Mattson, D.J. 1997. Use of ungulates by Yellowstone grizzly bears (*Ursus arctos*). Biological Conservation 81: 161-177.

Mattson, D.J., B.M. Blanchard, and R.R. Knight. 1991. Food habits of Yellowstone grizzly bears. Canadian Journal of Zoology 69:1619-1629.

Mattson, D.J., B.M. Blanchard, and R.R. Knight. 1992. Yellowstone grizzly bear mortality, human-habituation, and whitebark pine seed crops. Journal of Wildlife Management 56:432-442.

Mattson, D.J. and R.R. Knight. 1992. Spring bear use of the Firehole River drainage of Yellowstone National Park. Section 5, pages 93-120 *in* Wolves for Yellowstone? A report to the United States Congress. Volume IV Research and Analysis.

Mattson, D.J., and D.P. Reinhart. 1995. Influences of cutthroat trout (*Oncorhynchus clarki*) on behavior and reproduction of Yellowstone grizzly bears (*Ursus arctos*), 1975-1989. Canadian Journal of Zoology 73:2072-2079.

McIntyre, J.D. 1996. Review and assessment of possibilities for protecting the cutthroat trout of Yellowstone Lake from introduced lake trout. Pages 28-33 *in* J.D. Varley and P. Schullery, editors. The Yellowstone Lake crisis: confronting a lake trout invasion. National Park Service report Yellowstone National Park, Wyoming.

Mealy, S.P. 1975. The natural food habits of free-ranging grizzly bear in Yellowstone National Park, 1973-74. M.S. Thesis, Univiversity of Idaho, Moscow, Idaho. 409pp.

Mealy, S.P. 1980. The natural food habits of grizzly bears in Yellowstone National Park, 1973-74. International Conference on Bear Research and Management 3: 281-292.

Picton, H.D. 1978. Climate and reproduction of grizzly bears in Yellowstone National Park. Nature 274:888-889.

Pritchard, G.T., and C.T. Robbins. 1990. Digestive and metabolic efficiencies of grizzly and black bears. Canadian Journal of Zoology 69:1645-1651.

Proctor, M. 1995. DNA fingerprint from black bear hair as a basis for a mark recapture population estimate. Okanagan University College, British Columbia, Canada. 36pp.

Reinhart, D.P. 1990. Grizzly bear use of cutthroat trout spawning streams in tributaries of Yellowstone Lake. M.S. Thesis, Montana State University, Bozeman, Montana. 128pp.

Reinhart, D.P., S.T. Olliff, and K.A. Gunther. In press. Managing bears and developments on cutthroat spawning streams in Yellowstone Park. Greater Yellowstone Predators: proceedings of the Third Biennial Scientific Conference on the greater Yellowstone ecosystem.

Schleyer, B.O. 1983. Activity patterns of grizzly bears in the Yellowstone ecosystem and their reproductive behavior, predation, and the use of carrion. M.S. Thesis, Montana State University, Bozeman, Montana. 130pp.

Schullery, P., and J.D. Varley. 1996. Cutthroat trout and the Yellowstone ecosystem. Pages 12-21 *in* J.D. Varley and P. Schullery, editors. The Yellowstone Lake crisis: confronting a lake trout invasion. National Park Service report. Yellowstone National Park, Wyoming.

Servheen, C. and R.R. Knight. 1993. Possible effects of a restored wolf population on grizzly bears in the Yellowstone area. Pages 28-37 *in* R.S. Cook, editor. Ecological issues on reintroducing wolves into Yellowstone National Park. Scientific Monograph NPS/NRYELL/NRSM-93/22. U.S. Department of the Interior, National Park Service.

Sheppard, J.S. 1971. The influence of geothermal temperature gradients upon vegetation patterns in Yellowstone National Park. Ph.D. dissertation, Colorado State University, Fort Collins, Colorado. 159 pp.

USFWS (U.S. Fish and Wildlife Service). 1993. Grizzly bear recovery plan. Missoula, Montana. 181pp.

Varley, J.D., and R.E. Gresswell. 1988. Ecology, status, and management of Yellowstone cutthroat trout. American Fisheries Society Symposium 4:13-24.

Varley, J.D., R.E. Gresswell, S.M. Hoskins, R.B. Mathias, D.E. Jennings, M.D. Carpenter, and J. Doland. 1976. Fishery and aquatic management program, Yellowstone National Park. U.S. Fish and Wildlife Service Annual Project Report 55:1-62.

Yellowstone Science. 1997. [New lake trout spawning areas discovered.] S. Consolo-Murphy, editor. 5(4): 21.