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2008 Warner Valley Fish Investigations- Warner Suckers

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INTRODUCTION

The Warner sucker (*Catostomus warnerensis*) is endemic to the Warner Valley, an endorheic subbasin of the Great Basin in southeastern Oregon and northwestern Nevada. This species was historically abundant and its historical range includes three permanent lakes (Hart, Crump, and Pelican), several ephemeral lakes, a network of sloughs and diversion canals, and three major tributary drainages (Honey, Deep, and Twentymile Creeks). Warner sucker abundance and distribution has declined over the past century and it was federally listed as threatened in 1985 due to habitat fragmentation and threats posed by the proliferation of piscivorous non-native game fishes (U.S. Fish and Wildlife Service 1985).

The Warner Valley is a northeast-southwest trending endorheic basin which extends approximately 90 km (Figure 1). The elevation of the valley floor is approximately 1,370 m and the basin is bound by fault block escarpments, the Warner Rim on the west and Hart Mountain and Poker Jim Ridge on the east. The Warner basin was formed during the middle Tertiary and late Quaternary geologic periods as a result of volcanic and tectonic activity (Baldwin 1976). Abundant precipitation during the Pleistocene Epoch resulted in the formation of Pluvial Lake Warner (Hubbs and Miller 1948). At its maximum extent approximately 11,000 years ago, the lake reached approximately 100 m in depth and 1,300 km^2 in area (Snyder et al. 1964, Weide 1975). In 2008, precipitation and snow pack were near average and Hart and Crump Lakes never filled completely. In 2007, Crump Lake water levels were very low with less than a quarter of the surface area wetted during the winter. Both lakes have been watered continuously since 1993.

The Warner sucker inhabits the lakes and low gradient stream reaches of the Warner Valley. Two life history forms are present that comprise the metapopulation of Warner suckers: lake and stream morphs. The lake suckers are lacustrine adfluvial or potamodromous fish which normally spawn in the streams. However, upstream migration may be blocked by low stream flows during dry water years or by irrigation diversion dams and spawning may occur in nearshore areas of the lakes (White et al. 1990). The stream suckers inhabit and spawn in the three major tributary drainages (Honey, Deep, and Twentymile Creeks). Large lake-dwelling populations of introduced fishes in the lakes likely reduce sucker recruitment by predation on young suckers (U.S. Fish and Wildlife Service 1998).

The Recovery Plan for the Threatened and Rare Native Fishes of the Warner Basin and Alkali Subbasin (U.S. Fish and Wildlife Service 1998) sets recovery criteria for delisting the species. These criteria require that (1) a self-sustaining metapopulation is distributed throughout the Twentymile, Honey, and Deep Creek (below the falls) drainages, and in Pelican, Crump, and Hart Lakes, (2) passage is restored within and among the Twentymile, Honey, and Deep Creek (below the falls) drainages so that the individual populations of Warner suckers can function as a metapopulation, and (3) no threats exist that would likely threaten the survival of the species over a significant portion of its range.

In 2008, we conducted investigations in Hart and Crump Lakes to quantify the abundance and distribution of Warner suckers, to search for evidence of recent recruitment, and to estimate sucker abundance relative to nonnative fish abundance. In addition we investigated growth and movement patterns. We used Passive Integrated Transponder (PIT) tagged suckers to determine growth rates and movements, tracked radio-tagged suckers to document seasonal spawning migrations, fished a screw trap in Twelvemile Creek to monitor downstream movements, and operated a trap at the Dyke diversion dam on Twentymile Creek to monitor upstream movements.

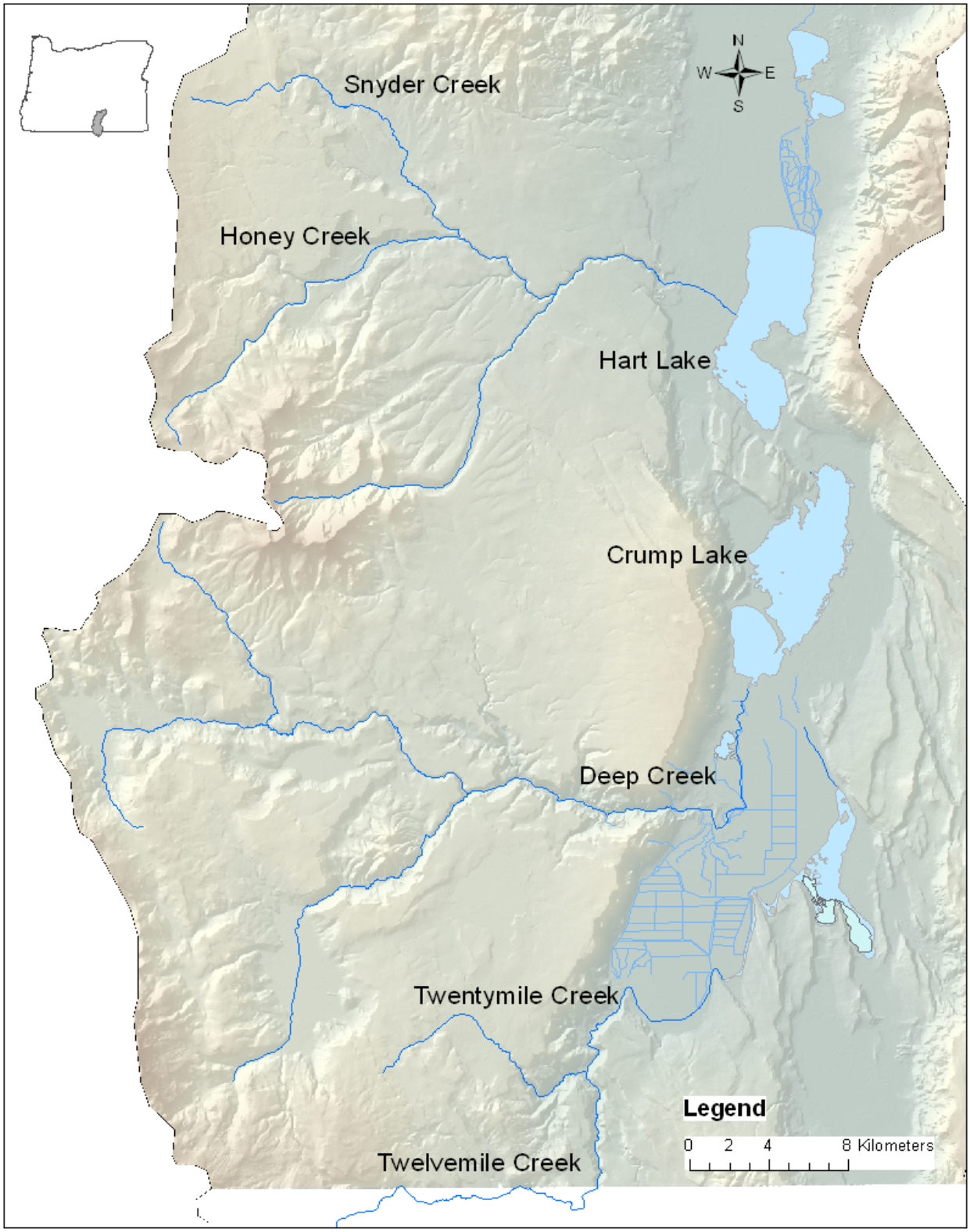

Figure 1. Map of the study area in the Warner Basin.

METHODS

We used trap nets to sample in Hart and Crump Lakes from 1 April to 17 June 2008. The trap nets we used to capture fish in Hart and Crump Lakes had wide rectangular openings that measured 3 ft (0.9 m) tall by 6 ft (1.8 m) wide and narrowed to vertical baffle slots that were 3 ft (0.9 m) tall by 0.75 ft (0.22 m) wide, followed by four funneling hoops that measured 2.5 ft (0.76 m) in diameter with 0.5 ft (0.15 m) diameter fyke openings. Nets were a total of 12 ft (3.7 m) long with a lead net measuring 50 ft (15 m) long by 3 ft (0.9 m) tall. Twelve of the nets had ¾ inch (19 mm) mesh, five had ½ inch (13 mm) mesh, and one had ¼ inch (6 mm) mesh. Because the lakes did not fill in 2008 and mud flats extended out from the shoreline approximately 100 m, we commonly set the nets off-shore in pairs, with their lead nets tied together. We attached an additional lead net, measuring 50 ft (15 m) long by 3 ft (0.9 m) tall with ¾ inch (19 mm) mesh, between the lead nets when we fished paired nets. At locations where the shoreline was steep (east side of Hart Lake) and when water levels rose later in the spring in Crump Lake, we set individual nets perpendicular to the shoreline, connected the lead nets to a metal "T" fence post driven into the substrate at the lake shore or the shoreline of small islands, stretched the nets tight with a boat with the trap pots in an offshore direction. In all cases, we pulled the purse ropes tight and weighed them down with 8-10 lb (3.6-4.5 kg) navy anchors. We accessed the nets using a 20 ft sled boat powered by a 150 hp jet outboard motor or two 14 ft boats powered by 25 and 50 hp motors, respectively (These were used when the sled boat's motor was malfunctioning). We typically set nets on Mondays, checked and reset them approximately every 24 hrs during the week, and removed them from the water after checking them on Fridays (four overnight net sets per week). We did not fish the nets over the weekends. At each trap location, we recorded the time the net was set, the time the net was checked, water depth, water temperature, air temperature, weather, and trap location. We obtained the trap location using a hand-held global positioning system (GPS).

We identified all of the fish that we captured to species and counted them. We measured the fork length (FL) of each Warner sucker and redband trout *Oncorhynchus mykiss* to the nearest 5 mm and weighed each fish on a spring balance to the nearest 10 g. We also measured the fork length to the nearest 5 mm of a subsample of the other species collected (we measured all fish from one net per lake per week). We determined the sex of each sucker, using a combination of the following characteristics: presence of breeding tubercles, presence of eggs or milt, anal fin morphology, and spawning coloration (Coombs et al. 1979). We checked all captured Warner suckers and redband trout for the presence of PIT tags with a hand held reader. If a tag was present, we recorded the tag code. If none was present, we anesthetized the fish with MS-222, made a small ~0.5 cm incision in the ventral cavity, and inserted a half-duplex PIT tag (23 mm x 3 mm) into the ventral cavity. We did not tag fish smaller than 100 mm FL. We sterilized all equipment prior to surgery and applied an antibiotic (antimycin) to the incision and the tag. We also tagged all suckers and trout with colored FLOY® t-bar anchor tags immediately below the dorsal fin. Following processing, we allowed the fish to recover, and then we released them into the lake offshore from the location where they were captured.

We inserted radio transmitter tags (Lotek®) via surgery into 32 Warner suckers, 25 from Hart Lake and 7 from Crump Lake. These radio tags were coded (2000 code set) with a frequency of 150.380 MHz, weighed 8 g, measured 11 mm in diameter and 53 mm in length, and had a calculated life of 641 days at a 5.0 second burst rate. The minimum size of fish that we tagged was ~265 mm (223 g), so the tag weight would be less than 4% of the fish weight. We used surgical procedures that were similar to those used for inserting the PIT tags, except that we made the incision larger ~1 cm, used a canula to thread the trailing antenna, and used

sutures to close the incision. We held most radio-tagged fish in a live box for 24 hours prior to release. We released tagged fish near the point of initial capture, except for five of the radio tagged suckers captured in Hart Lake which were released into Honey Creek to assess stream movement patterns. These fish were released above the diversion dam near the road crossing in Plush. We tracked the movements of radio tagged fish using a mobile radio tracking receiver either from the boat, truck, on foot, or from an Oregon State Police airplane. Each time a fish was located, we recorded the date, the power reading and tag code (when possible), and the geographic coordinates determined using a hand held GPS receiver.

We fished a five foot diameter rotary screw trap in Twelvemile Creek (stream km 2.5) from 8 April through 17 June, 2008 (43 trap nights). We checked the trap daily (approximately every 24 hr), counted all fish, and released them back into the creek. Before release, we measured and weighed all Warner suckers and tagged all redband trout and suckers $\geq$100 mm FL with PIT tags, using the same procedure we used for suckers captured in trap nets. We recorded the time the trap was lowered, the time the trap was checked, water depth, trap speed (RPM), water temperature, air temperature, and weather.

We installed a fish trap in the upstream end of the fish ladder at the Dyke diversion and fished the trap from 18 April through 17 June, 2006 (35 trap nights). We checked the trap daily (approximately every 24 hr). We recorded the time the trap was checked, water temperature, air temperature, and weather.

RESULTS

Catch and Distribution

We captured a total of 103 Warner suckers and 2 redband trout in Hart and Crump Lakes in 2008 (Table 1). We captured the majority of the suckers from locations on the north end of Hart Lake and the south end of Crump Lake (Figures 2 and 3; **APPENDIX A**). Because of limited access due to low lake levels, sampling was restricted to the northern half of Hart Lake and the southern third of Crump Lake. A total of 29,871 fish of all species were captured from 731 overnight trap net sets. Total trap catches of suckers were higher in Hart Lake, 47.5 fish per trap night, compared to 28.6 fish per trap night in Crump Lake. Trap net catch was dominated by nonnative white crappie *Pomoxis annularis* and brown bullhead *Ameiurus nebulosus*. Other abundant species we captured included nonnative black crappie *Pomoxis nigromaculatus* and native tui chub *Gila bicolor*. We also captured a small number of nonnative largemouth bass *Micropterus salmoides*.

Warner Sucker Abundance

We were unable to obtain a mark-recapture estimate for Warner suckers marked in 2008, because only one of these fish was recaptured. However, we were able to obtain a population estimate in Hart Lake using the 2008 catch (n=76) and recaptures (n=4) of fish marked in 2006. By assuming a conservative estimate of 33% mortality of the fish marked in Hart Lake in 2006 (0.67 X 54 marked fish = 36), we calculated an estimate of 565 suckers larger than 155 mm FL (95% CL: 250-1,114; 56-97%). In the past 14 years when lake studies were conducted, dating back to 1990, 1996 was the only other year when a mark-recapture population estimate was obtained (estimate: 493; 95% CL: 439-563; 89-114%) (Allen et al. 1996).

Table 1. Trap net catch and catch per unit of effort (CPUE) of fish by species in the Warner Lakes in 2008. Trapping effort totaled 258 and 473 trap nights in Crump and Hart Lakes, respectively.

	Crump Lake		Hart Lake		Lakes total	
Species	Number	CPUE	Number	CPUE	Number	CPUE
Warner sucker	27	0.1	76	0.2	103	0.1
Redband trout	2	0.0	0	0.0	2	0.0
Tui chub	904	3.5	4,639	9.8	5,543	7.6
White crappie	3,002	11.6	6,152	13.0	9,154	12.5
Black crappie	975	3.8	4,925	10.4	5,900	8.1
Juvenile crappie	18	0.1	54	0.1	72	0.1
Brown bullhead	2,437	9.4	6,596	13.9	9,033	12.4
Largemouth bass	18	0.1	46	0.1	64	0.1
Total	7,383	28.6	22,488	47.5	29,871	40.9

The 2008 trap net catch per unit of effort (CPUE) for Hart Lake was similar to the CPUE from 2006 and substantially lower than the CPUE's from 2001, 1999, 1997, 1996, 1994, and 1990 (Table 2). Note that 1994 and 1995 followed several years of drought (1987 through 1992) and the lakes completely desiccated in 1992. The sampling effort in 2008 (731 trap nights) was substantially greater than past efforts. The CPUE values for 2006 and 2008 were among the lowest on record for Hart and Crump Lakes. When comparing CPUE over time, one must consider the different time periods when sampling occurred each year and the relatively low sampling effort in Crump Lake in past years (Table 2). We found that our catch rate varied substantially across our sampling period. Also, the timing of our peak catches in 2006 varied substantially from peak catches in 2008 and peak catches occurred at different times in Hart and Crump Lakes during the same year (Figure 4). Note that comparing the 2006 and 2008 CPUE estimates with past estimates may be misleading, if past sampling effort was concentrated over a short time period or did not occur during the spring months. Also note that winter weather (colder temperatures) extended later in the spring of 2008, compared to 2006.

We captured 28 Warner suckers, 38 redband trout, and hundreds of speckled dace in the screw trap that was fished in Twelvemile Creek (Figures 5 and 6). We captured over 75% of the suckers and nearly half of the redband trout after mid-May, a time period that corresponds with consistently higher stream flows. During the sampling period, we captured higher numbers of fish during periods of increased stream flows. Rising flows, resulting from snow melt, were frequently concurrent with declining stream temperatures. Temperatures recorded at the trap site ranged from 1.5 ^{o}C to 15^{o}C during the period of operation.

No fish were captured in the trap that was fished in the fish ladder at the Dyke diversion between 18 April and 17 June (Figures 7 and 8). Stream temperatures ranged from 3.5^{o}C to 14^{o}C.

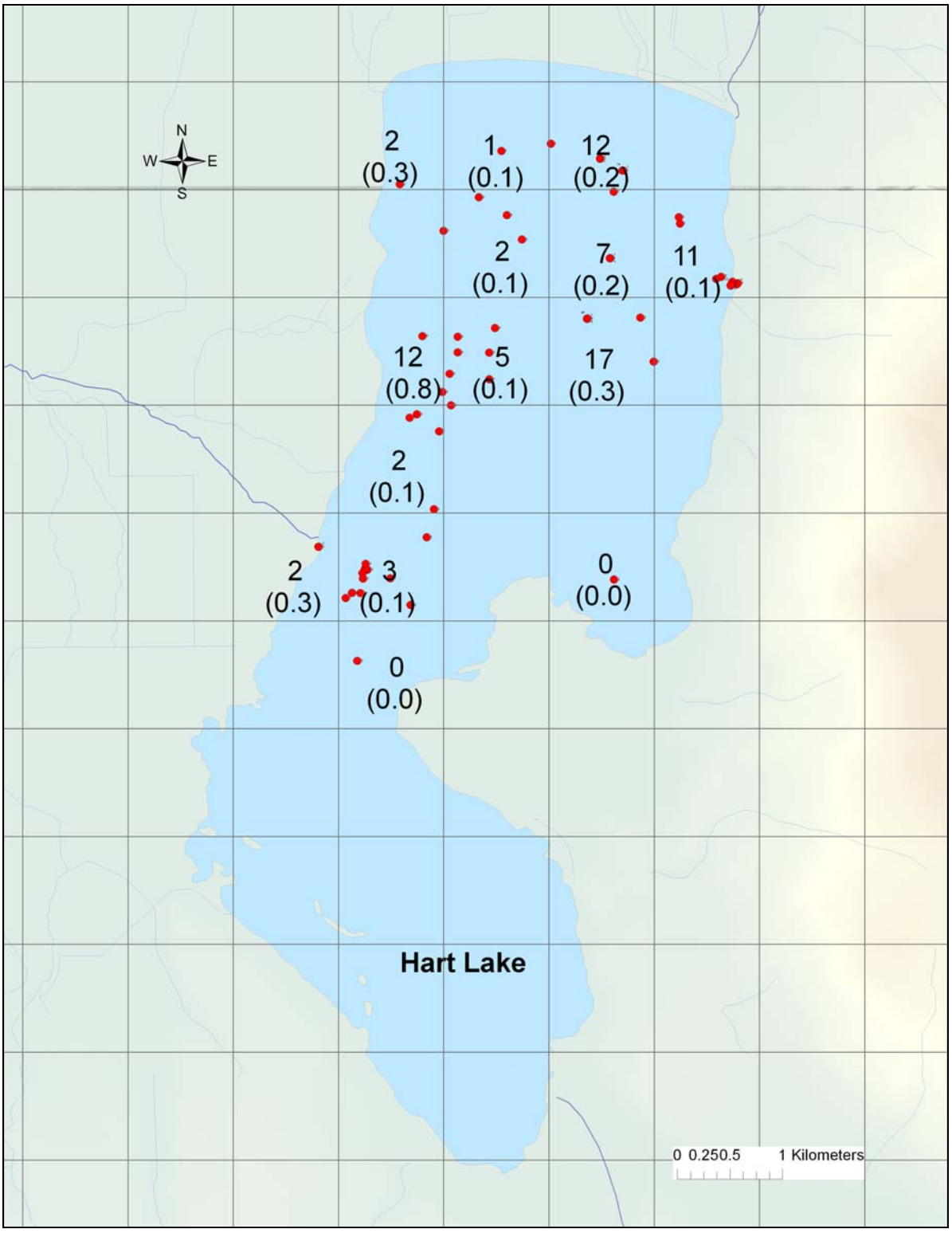

Figure 2. Locations of trap nets fished in the Hart Lake in 2008. Red circles represent trap net locations. Numbers represent the total numbers of suckers captured in each 1 km^2 quadrant. Numbers in parentheses represent the average catch per trap night (CPUE) for nets fished in each quadrant from April through June, 2008.

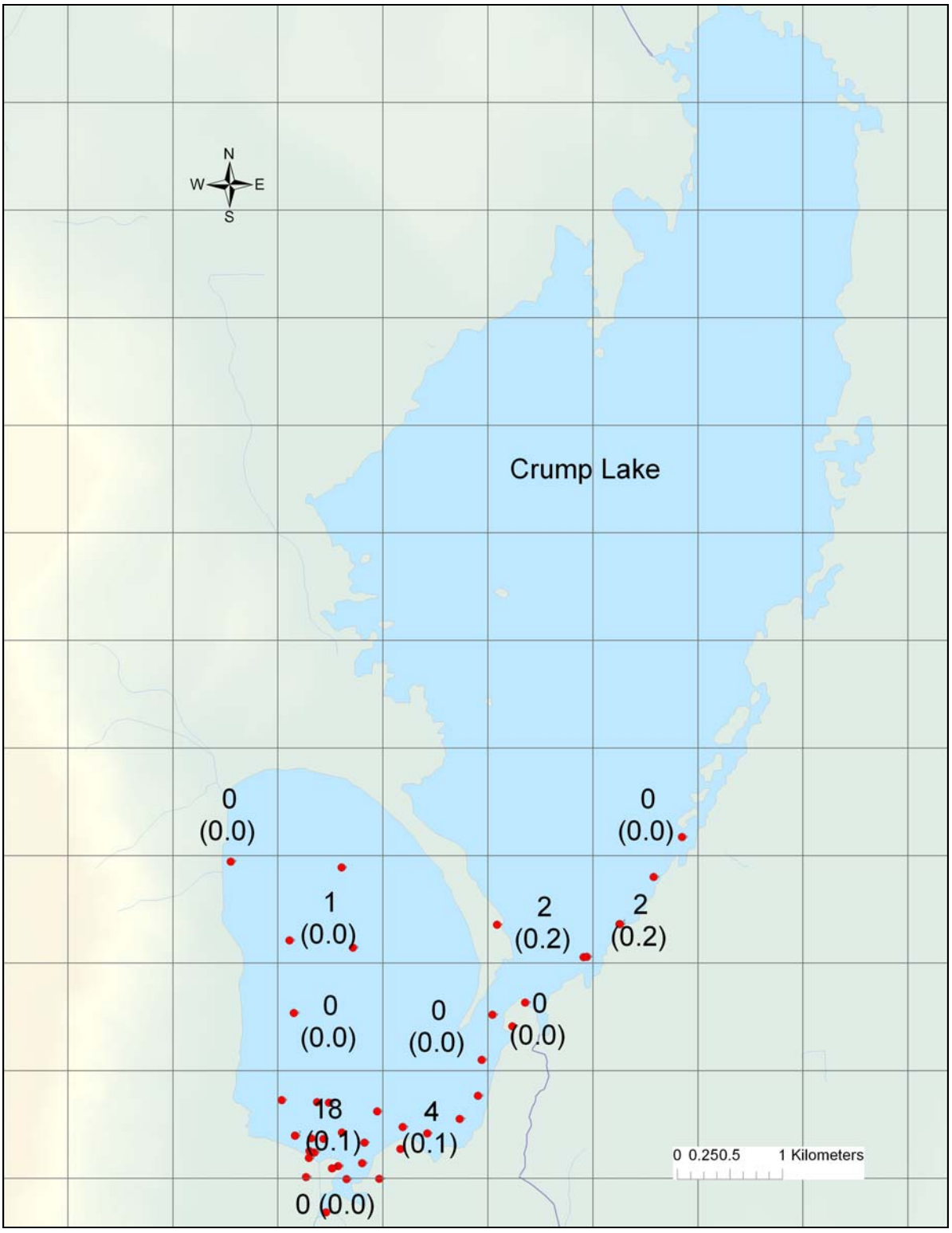

Figure 3. Locations of trap nets fished in the Crump Lake in 2008. Red circles represent trap net locations. Numbers represent the total numbers of suckers captured in each 1 km^2 quadrant. Numbers in parentheses represent the average catch per trap night (CPUE) for nets fished in each quadrant from April through June, 2008.

Table 2. Catch per unit of effort and sampling dates for Warner suckers from 1990 to 2008.

	Number of Suckers		Number of trap nights		Suckers per trap night		Sampling dates	
Year	Hart	Crump	Hart	Crump	Hart	Crump	Hart	Crump
1990	190	16	122	9	1.6	1.8	4/4 - 7/27	4/1 - 5/15
1991	103	0 [a]	175	0	0.6	-	3/19 - 7/31	3/19 - 7/31
1993	0	0	70	0	0.0	-	6/11 - 8/15	6/11-8/15
1994	93	3	40	15	2.3	0.2	7/12 - 8/14	7/12 - 8/14
1995	19	1	104	40	0.2	0.0	6/12 - 7/20	6/12 - 7/20
1996	835	11	252	36	3.3	0.3	4/24 - 6/6	4/24 - 6/6
1997	193	2	137	60	1.4	0.0	4/29- 6/12	4/29 - 6/12
1998	0	0	2	2	0.0	0.0	8/25	8/25
1999	201	2	9	8	22.3	0.3	5/18, 5/19, 11/16	5/18, 5/19, 11/16
2001	176	5	63	24	2.8	0.2	4/14 - 5/22	4/14 - 5/22
2004	0	1	0	6	-	0.2	-	5/25
2005	0	0	9	14	0.0	0.0	7/28	5/25; 7/21
2006	41	60	214	238	0.2	0.3	4/3 - 6/21	4/3 - 6/21
2008	76	27	473	258	0.2	0.1	4/2 - 6/17	4/2 - 6/17

[a] *In 1991, 69 suckers were collected from the Crump Lake shoreline that died from winterkill.*

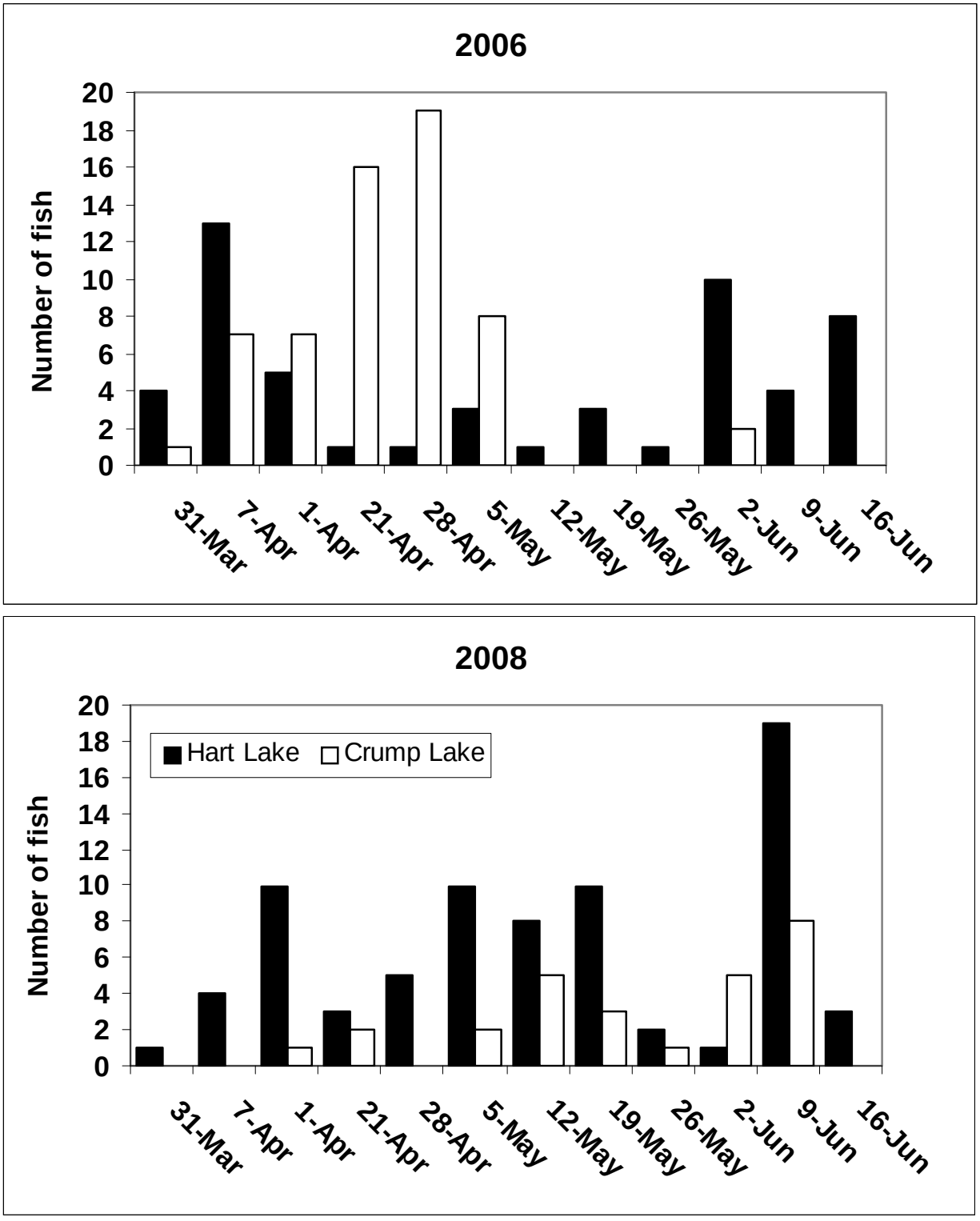

Figure 4. Weekly trap net catch of Warner suckers in Hart and Crump Lakes in 2006 and 2008. Weekly trapping effort was the same for both years.

Figure 5. Downstream migrant screw trap fished in Twelvemile Creek, 2008. The trap was located 2.5 km upstream of the confluence with Twentymile Creek at the site of the former O'Keefe diversion.

Warner Sucker Length Frequency Distributions

The length frequency distribution for Warner Suckers captured in 2008 is shown in Figure 9. Suckers ranged in length from 155-455 mm (mean=319 mm; S.D.=71.5 mm). The proportion of the population ≤250 mm (<5 years old; Coombs et al. 1979) increased from 9% in 2006 to 19% in 2008. This shift possibly resulted from the recruitment of smaller fish into the population and the apparent mortality of larger fish in Crump Lake (Figure 9). Suckers collected in 2008 from Crump Lake were significantly smaller than those collected in 2006 ($p<0.05$) (Table 3). No significant difference was found between suckers collected in 2006 and 2008 in Hart Lake, or from both lakes when data was combined (Table 3). The average length of Warner suckers in the lakes in 2008 was nearly identical for females (mean=318 mm; SD=84 mm; range 155-455 mm; N=60) and males (mean=319 mm; SD=48 mm; range 190-405 mm; N=43), however the smaller size classes were dominated by females. The average length of suckers has increased substantially since 1994 (Figure 10). The mean size of the stream dwelling suckers captured in the screw trap in Twelvemile Creek in the Twentymile Creek subbasin was significantly smaller than that for suckers from Hart and Crump Lakes (Table 3; Figure 9).

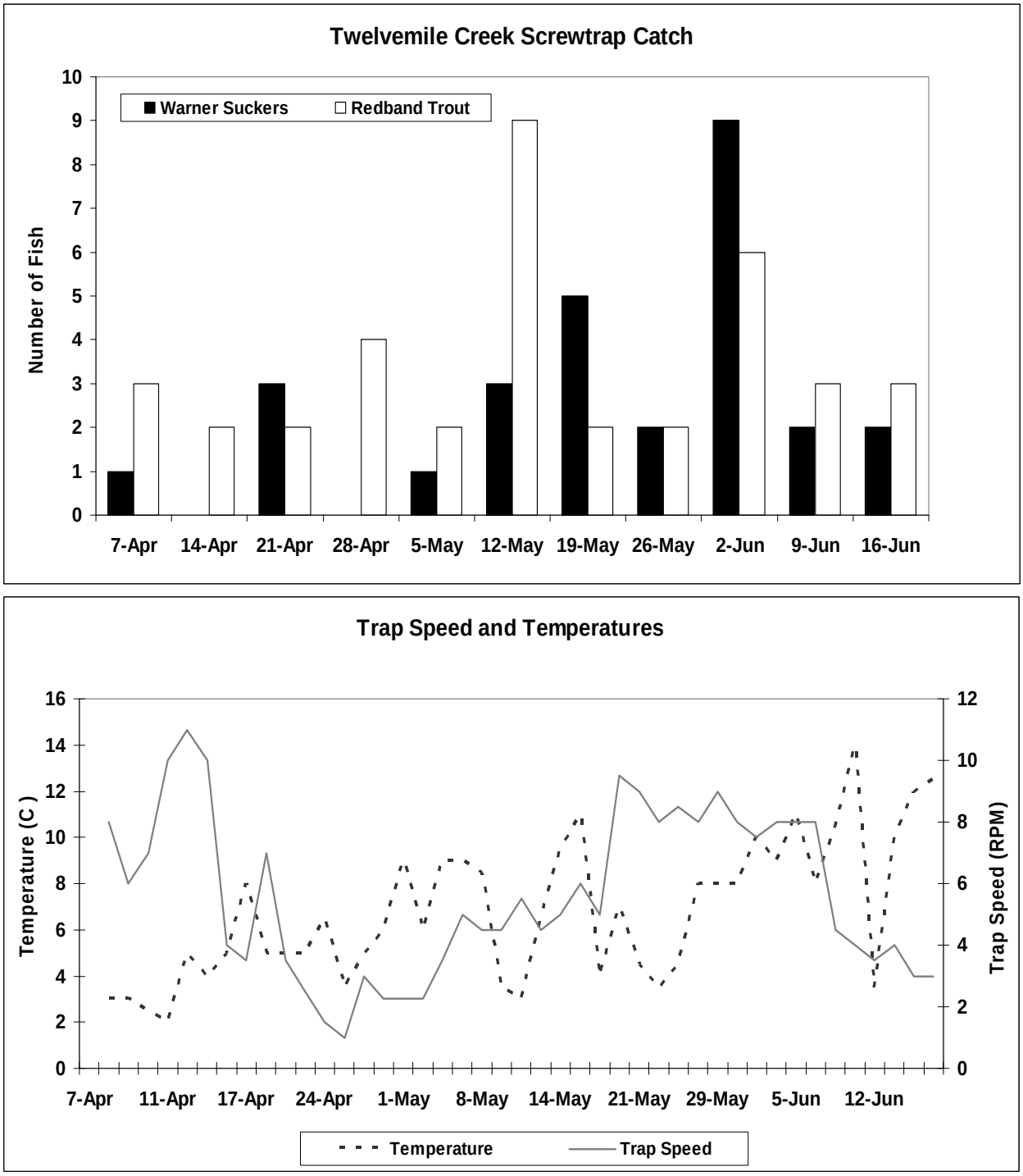

Figure 6. Weekly catch of Warner suckers and redband trout in the downstream migrant screw trap fished in Twentymile Creek in 2008 (top). Water temperatures and trap speeds recorded at the trap site in Twentymile Creek in 2008 (bottom).

Figure 7. Upstream migrant trap fished in 2008 in the fish ladder at the Dyke diversion in Twentymile Creek, Warner basin.

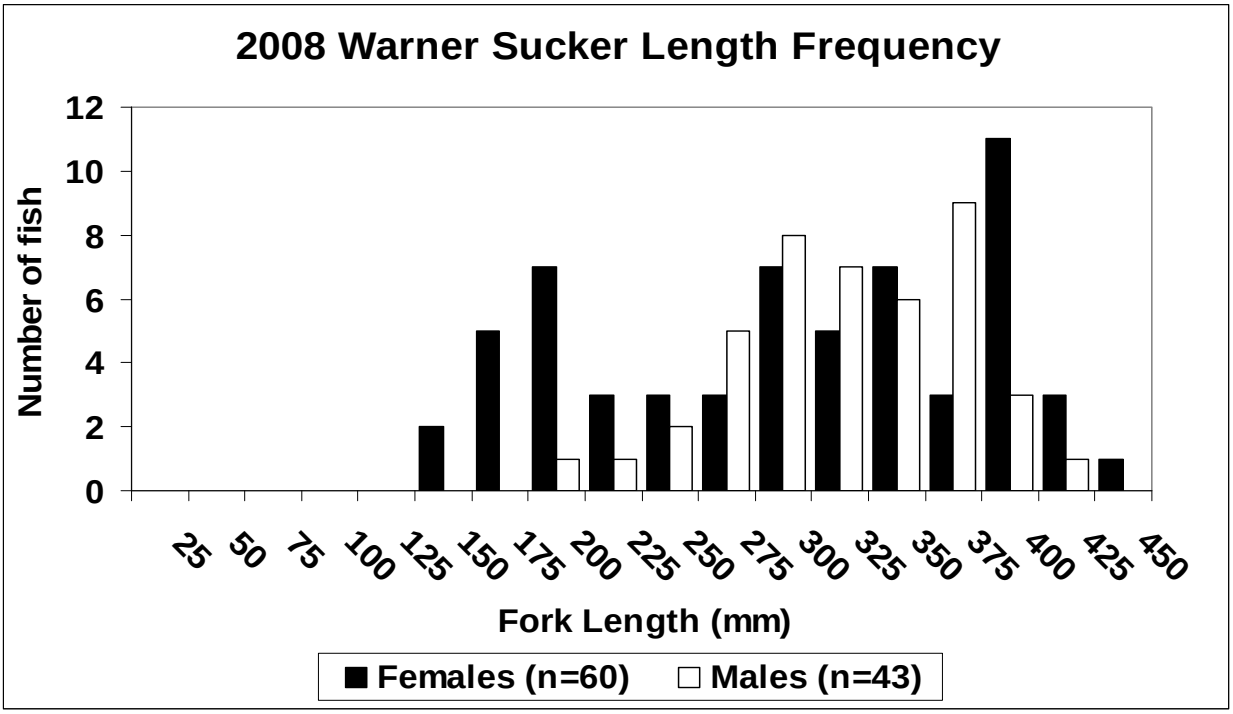

Figure 8. Length frequency histogram for male (white bars) and female (black bars) Warner suckers captured in the Warner Lakes in 2008.

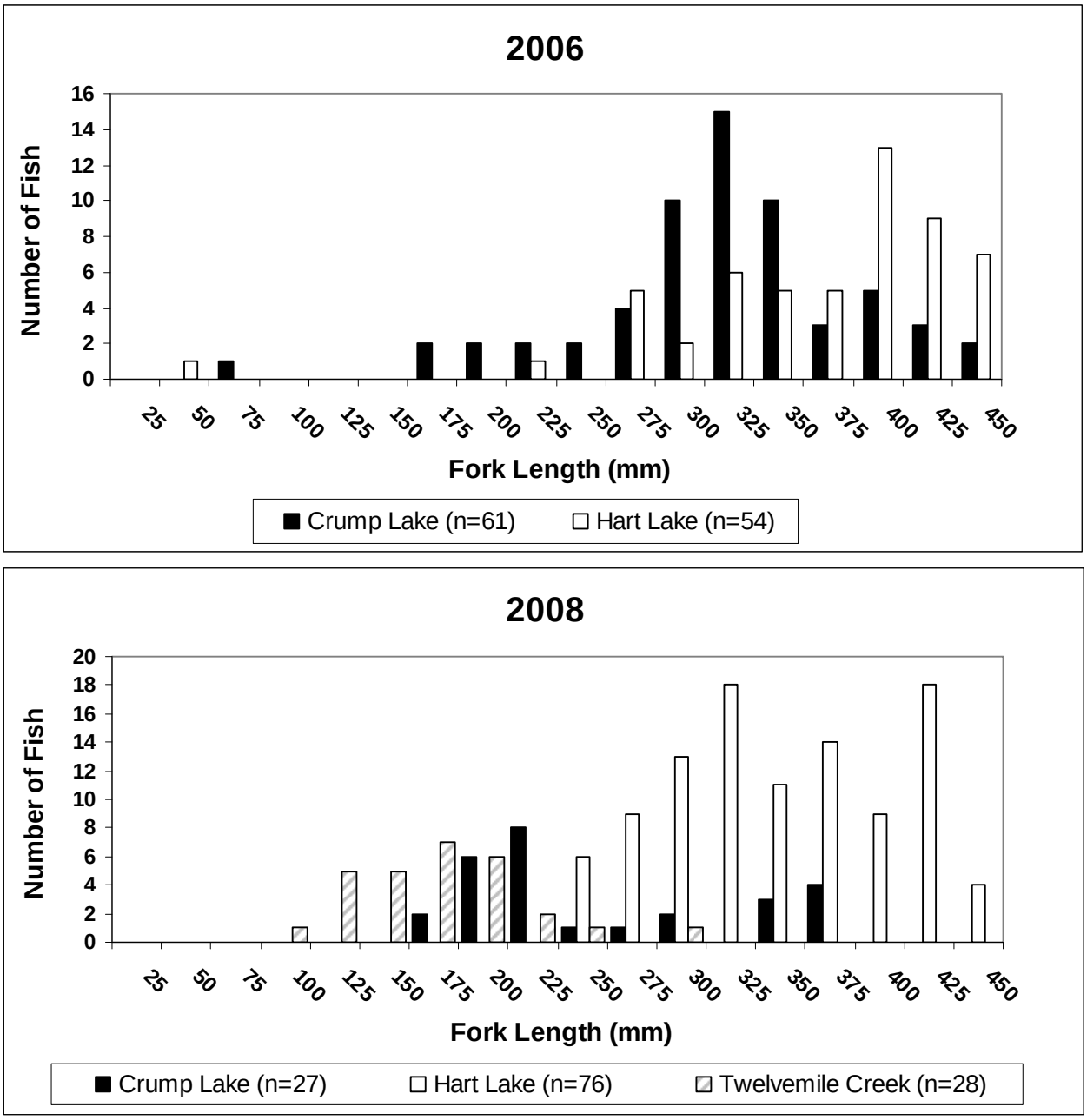

Figure 9. Length frequencies of Warner Suckers captured in trap nets in Hart and Crump Lakes in 2006 and 2008 and in the downstream migrant screw trap in Twelvemile Creek (Twentymile Creek subbasin) in 2008.

Table 3. Mean length (FL) of Warner suckers captured in 2006 and 2008 from Hart and Crump Lakes and from Twelvemile Creek, 2008. Significant differences between years are noted.

		Mean	Confidence limits (95%)		
Lake	Year	length (mm)	Lower	Upper	Significance
Crump	2006	310	292	328	<0.05
	2008	250	238	263	
Hart	2006	361	341	380	NS
	2008	342	314	370	
Both	2006	334	320	348	NS
	2008	319	305	333	
Twelvemile Ck	2008	163	145	180	

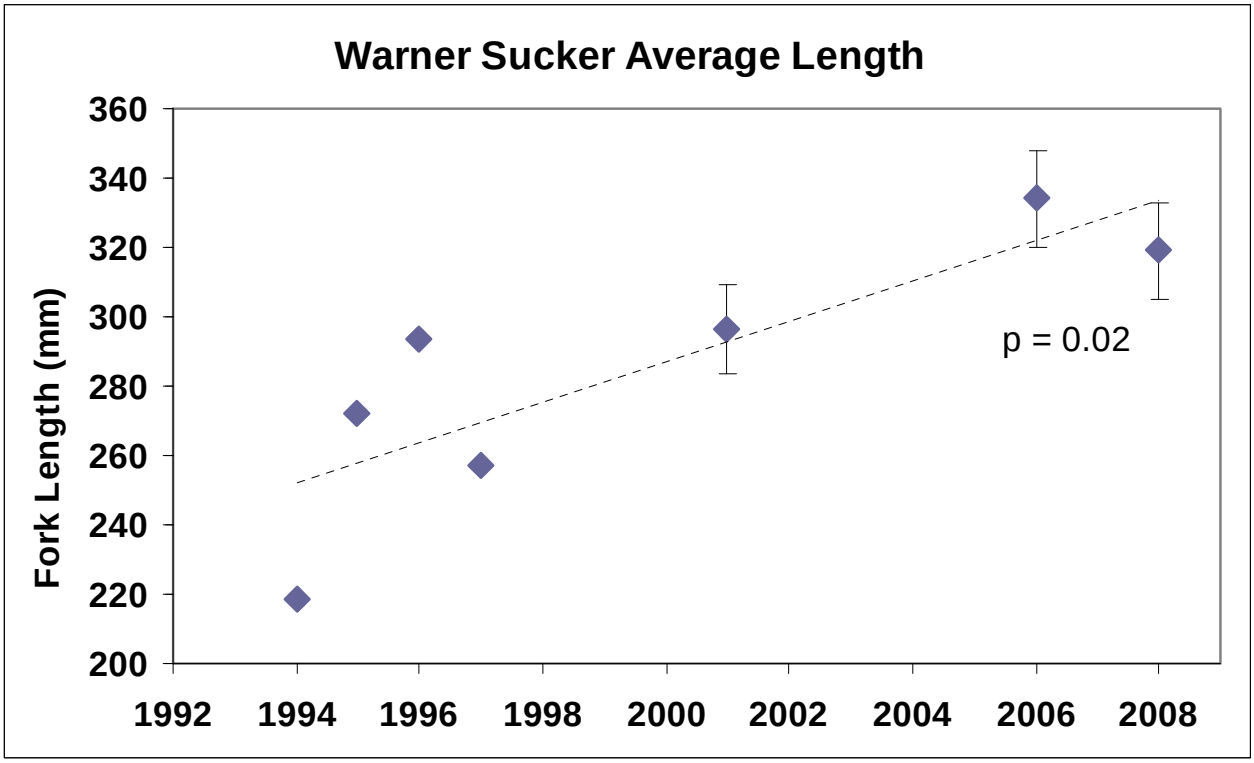

Figure 10. Relationship between the average fork length of Warner suckers in the Warner Lakes and year. Vertical lines represent 95% confidence limits. The dotted line is a fitted regression line (p = 0.02).

PIT-Tagging and Tag Recoveries

A total of 99 Warner suckers and two redband trout were PIT-tagged in Hart and Crump Lakes. Five PIT-tagged suckers were recaptured, all in Hart Lake. Four of these recaptures were tagged in Hart Lake in 2006 and one was tagged in Hart Lake in 2008. Growth of recaptured PIT-tagged fish, ranging in length from 305-400 mm at the time of tagging, was minimal (Table 4). In addition, one PIT tag from a 215 mm female sucker (75 g) was recovered from Tern Island in Crump Lake. This fish was tagged in Crump Lake on 6 June 2008. Twenty-six Warner suckers captured in the downstream trap in Twelvemile Creek were PIT-tagged; no tagged fish were recaptured. The 2008 PIT-tagging details are shown in **APPENDIX B**.

Table 4. Growth of Warner suckers PIT-tagged in Hart Lake and recaptured in 2008.

		Tagged		Recaptured		Extant	Growth	Growth (mm)
Tag number	Sex	Date	Length	Date	Length	(days)	(mm)	per year
132628545	F	11-Apr-06	405	11-Jun-08	420	792	15	7
132628540	M	12-Apr-06	340	9-May-08	335	758	-5	-2
132628634	F	9-Jun-06	380	20-May-08	380	711	0	0
132628673	F	21-Jun-06	385	18-Apr-08	394	667	9	5
152365859	M	8-May-08	300	20-May-08	300	12	0	0

Movement of Radio Tagged Warner Suckers

We radio tagged 32 Warner suckers in the spring of 2008 (Table 5). Twenty suckers were captured in Hart Lake, tagged, and released back into Hart Lake. Five suckers were captured in Hart Lake, tagged, and released into Honey Creek above the diversion dam at the bridge in Plush. Seven fish were captured in Crump Lake, tagged, and released back into Crump Lake. Originally we had intended to tag more fish in Crump Lake, however most suckers captured in Crump lake were too small for tagging (<225 g).

Table 5. Numbers and tag codes for Warner suckers radio tagged by week in the Warner basin in 2008.

	Number of	Radio tag codes		
Week of	fish tagged	Hart Lake	Crump Lake	Honey Creek
3-Apr	2	11,12		
10-Apr	5	10,13,14,15,16		
17-Apr	9	17,18,19,20,21,22,24	23,25	
24-Apr	3	27,28,29		
1-May	6	29,30,35		31,33,34
8-May	4		26,38	36,37
15-May	1		39	
22-May	0			
29-May	0			
5-Jun	1		40	
12-Jun	1		41	

We experienced some initial equipment problems with our hand held radio receiver antennas and cables, but resolved these by early-May. Consequently, tag detections in April were sparse. In addition, we were unable to obtain codes for individual fish from the air during tracking flights.

Fish tagged in Hart Lake were detected an average of 8.2 times and moved an average of 12.0 km among all locations where they were detected during the period of tracking (range 4.1-19.4 km; Table 6). Because these estimates of cumulative movement assume that fish traveled the shortest possible distance between detection locations, they likely underestimate the actual extent of movement. In Hart Lake, we detected the apparent movement of tagged fish towards Honey Creek in early-May. In late-May and in June, we detected tagged fish primarily in the northern and eastern portions of Hart Lake, which had deeper water than southern portion of the lake. Overall, we did not follow any noticeable directed movement patterns of radio-tagged fish in Hart Lake (Figure 11). Movements of a typical Hart Lake fish (tag code 29) are shown in Figure 12. This fish was tagged 30 April in the northern end of Hart Lake, moved toward and entered Honey Creek on 10 June, and then returned to the northern end of Hart Lake on 16 June. We did not detect any movement of fish between Crump and Hart Lakes. We detected suckers radio-tagged in Hart Lake that moved into lower Honey Creek in early-June and detected unidentified suckers (no codes detected) during aerial flights in late-May and June in Honey Creek, some of which were fish captured in Hart Lake and released into Honey Creek (Figure 13). During aerial flights, we did not detect any tagged fish that moved north of Hart Lake. We did, however, detect tagged fish (no codes) during aerial flights that appeared to be in irrigation canals that pull water out of lower Honey Creek (Figure 13).

Suckers radio-tagged in Crump Lake were detected an average of 3.8 times and moved an average of 6.3 km (range 2.7-12.4 km; Table 6). The lower number of tag detections and shorter distances traveled by suckers radio-tagged in Crump Lake is due, in part, to the later tagging dates of these fish compared to fish tagged in Hart Lake (fewer opportunities to track). Most detections of suckers in Crump Lake were from the southern portion of the lake (south of peninsula) with two detections of tagged fish that moved south into Deep Creek (Figure 14). Movements of a typical Crump Lake fish (tag code 23) are shown in Figure 15. This fish was tagged 22 April in the south end of Crump Lake and was detected primarily south of the peninsula.

Table 6. Numbers of Warner suckers radio-tagged, mean length of tagged suckers, mean number of observations (detections) of tagged fish, mean cumulative distance traveled by tagged fish, and ranges of distances traveled by tagged fish in April-June 2008. One sucker tagged late in June in Crump Lake was not detected.

	Number	Mean	Mean Number	Distance traveled (km)	
Release Site	of fish	length (mm)	of Observations	mean	range
Crump Lake	6	330.8	3.8	6.3	2.7 - 12.4
Hart Lake	20	360.7	8.2	12.0	4.1 - 19.4
Honey Creek	5	348.6	5.8	--	--

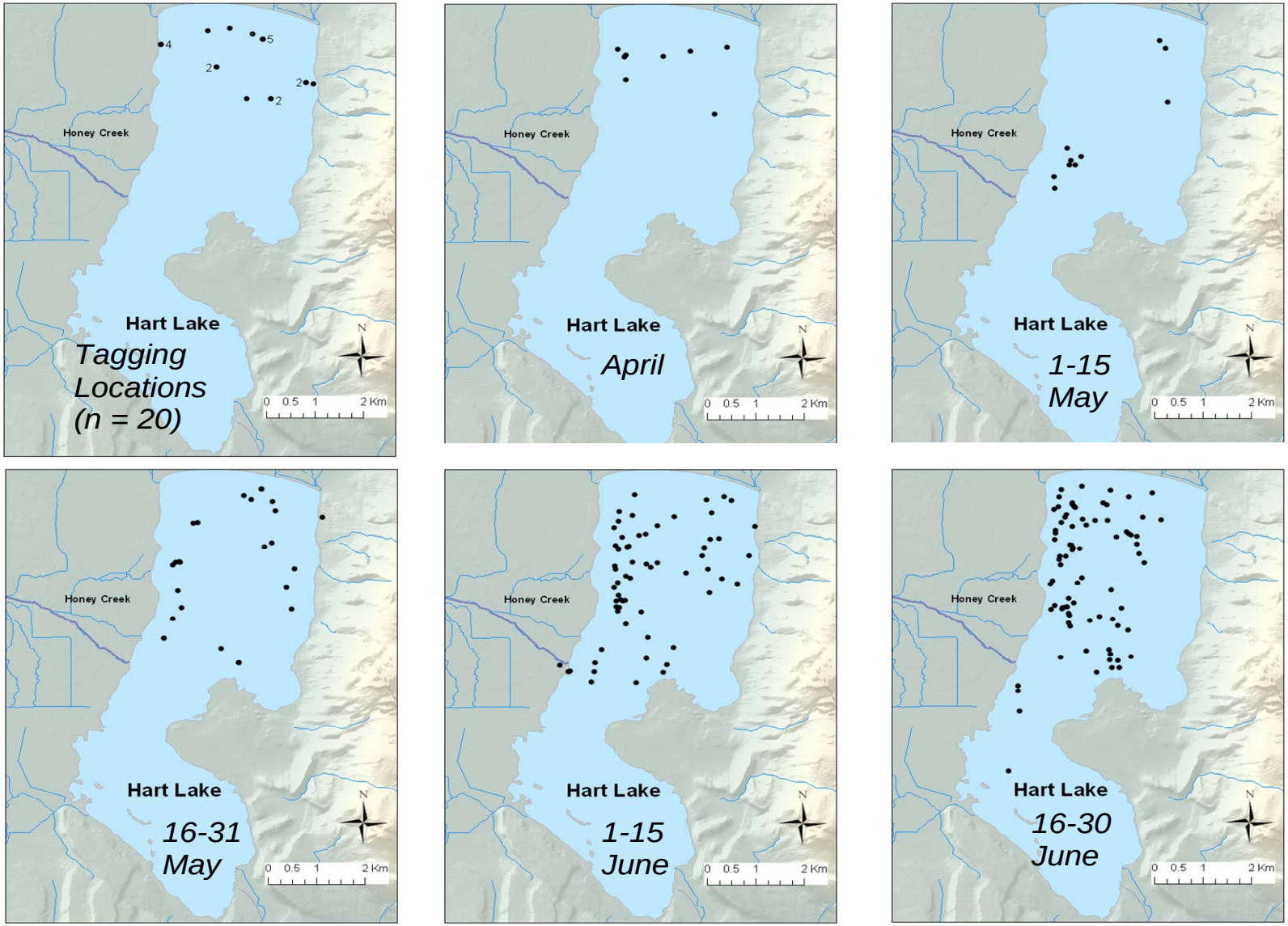

Figure 11. Tagging and tracking locations for Warner suckers tagged in Hart Lake, 2008. Numbers are shown next to tagging locations where more than one fish was tagged.

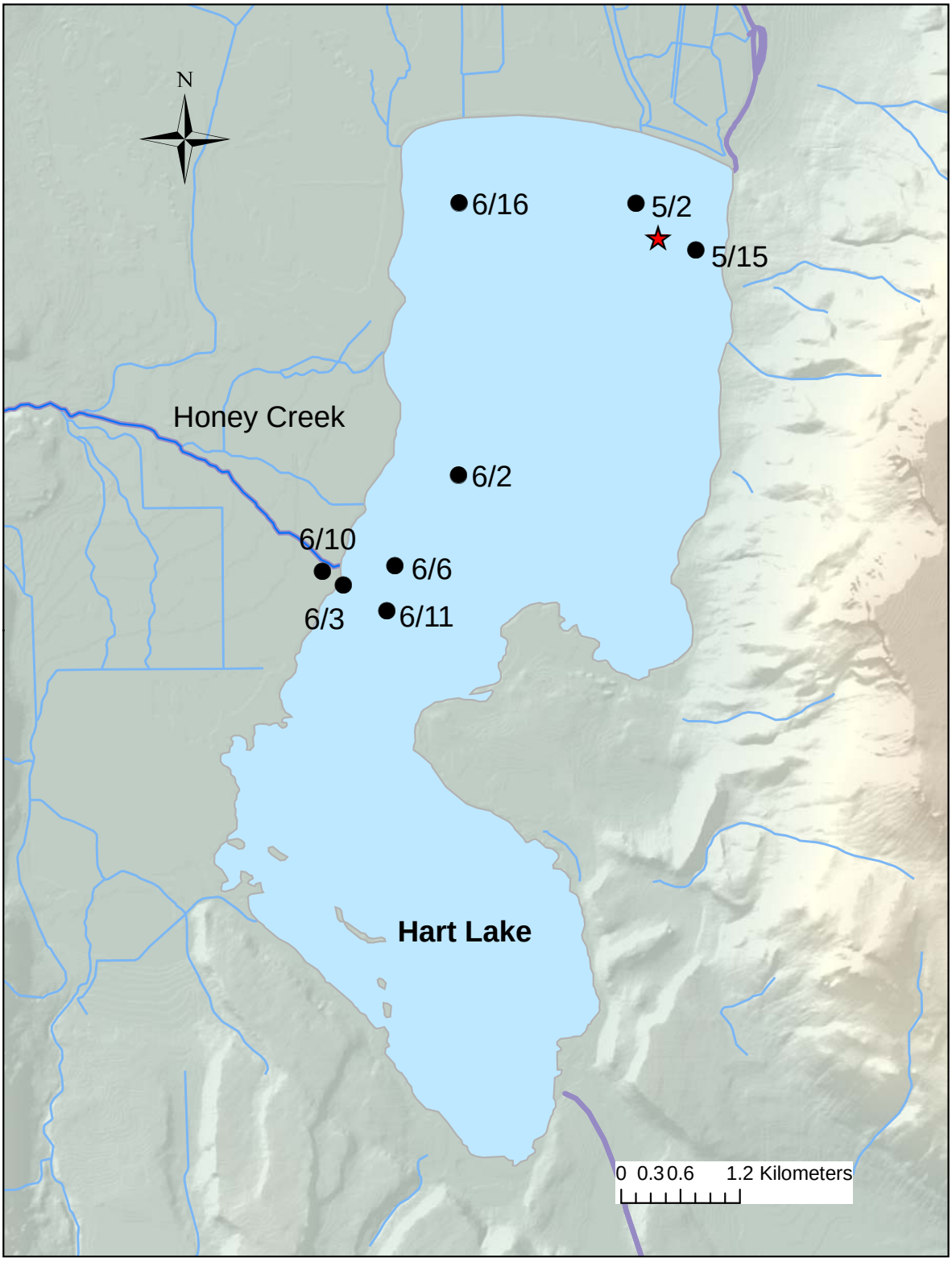

Figure 12. Detections of a radio-tagged Warner sucker (tag code 29) tagged 30 April 2008 in Hart Lake. Dates of tag detections are listed next to each black circle. The tagging location is noted with a red star. The light blue lines exiting lower Honey Creek are irrigation canals.

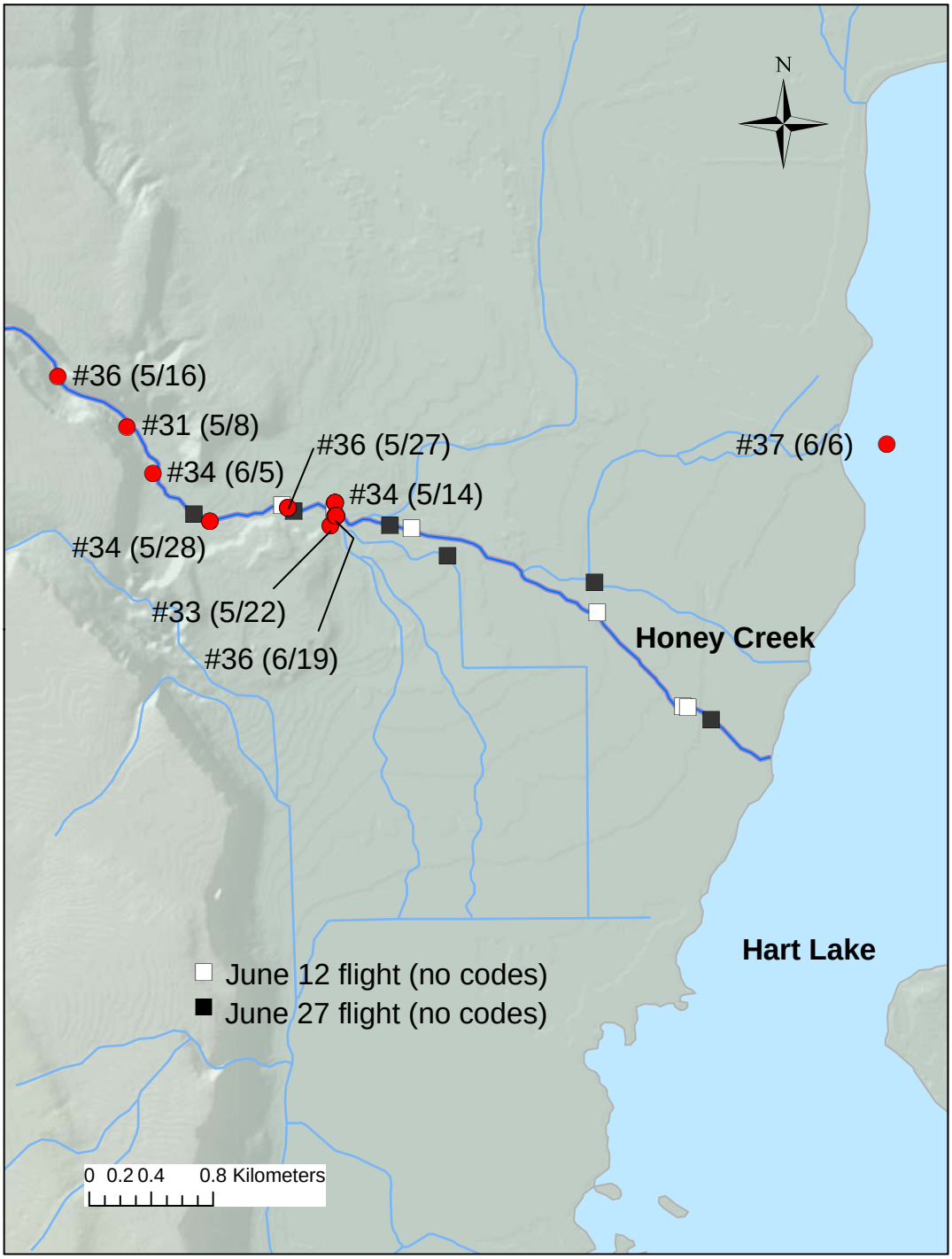

Figure 13. Detections of Warner suckers captured in Hart lake, radio-tagged, and released into Honey Creek (red circles) and detections of other radio-tagged suckers (no codes obtained) from aerial tracking flights (black and white squares). The dark purple line is Honey Creek and the light blue lines are irrigation canals. Dates of tag detections are listed in parentheses next to each symbol. Tag codes, when obtained, are listed next to each red circle. Note: the sucker with tag #37 was preyed upon by a pelican, as this tag moved several times when the pelican moved on 6 June. See Table 5 for tagging dates.

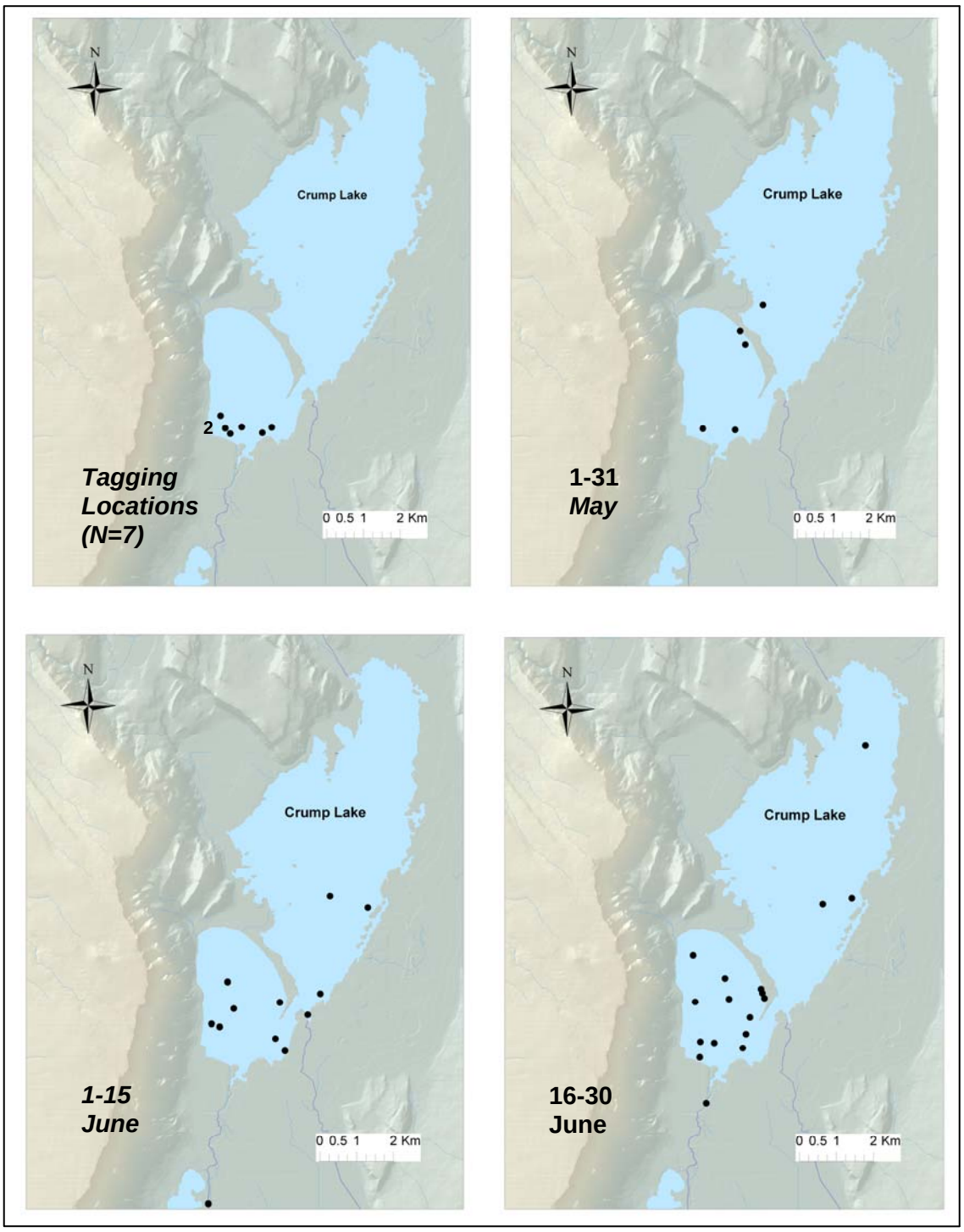

Figure 14. Tagging and tracking locations for Warner suckers tagged in Crump Lake, 2008. Note: two fish were tagged at one of the locations.

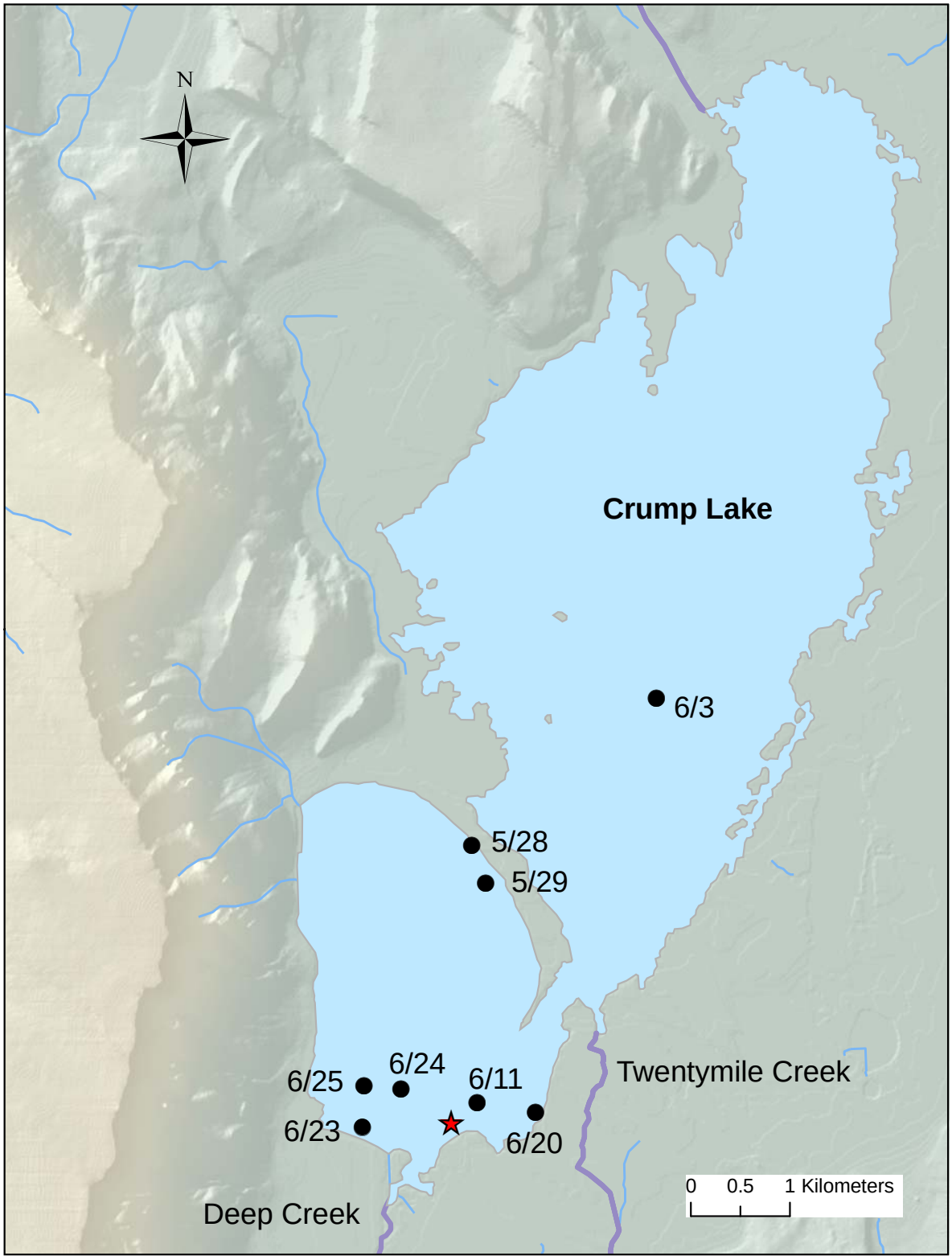

Figure 15. Detections of a radio-tagged Warner sucker (tag code 23) captured in Crump Lake and released on April 22 (red star). The date of each tag detection is listed next to each symbol.

Warner Sucker Sex Ratios and Sexual Maturation

We were able to determine the sex of 103 Warner suckers from the Warner Lakes. Sixty of these fish were females (58%) and 43 were males (42%) resulting in a female to male ratio of 1.4 to 1. This ratio is identical to results from 2006 (Scheerer et al. 2006) and 2001 (Hartzell et al. 2001). The female to male ratio for suckers collected from Hart Lake was 1 to 1.1, whereas the female to male ratio for suckers collected from Crump Lake was 5.8 to 1, skewed heavily towards females. We were able to determine the sex of 25 Warner suckers from Twelvemile Creek. Fifteen of these fish were females (60%) and ten were males (40%) resulting in a female to male ratio of 1.5 to 1. We noted suckers in spawning condition (females with swollen bellies and/or extended vents and males with spawning tubercles on their anal and lower caudal fins and protruding vents) from 4 May through 7 June in the lakes and from 3 June through 6 June in Twelvemile Creek. We captured spawned-out females in the lakes from 24 May through 20 June and captured a single spawned-out female from Twelvemile Creek on 6 June. The smallest mature male and female suckers that we captured in the lakes measured 215 mm and 210 mm, respectively. The smallest mature male and female suckers that we captured in Twelvemile Creek measured 155 mm and 130 mm, respectively. Note: there is some uncertainty when attempting to determine the sex of immature fish based soley on anal fin morphology (Coombs 1979).

Fish Assemblages

Nonnative fishes dominated our catch (Table 1). Crappies (black and white) totaled 51% of the catch and brown bullheads made up another 30%. Changes in species composition have occurred since sampling began in 1990 (Figure 16, **APPENDIX C**). Prior to the lakes drying in 1992, the catch was dominated by nonnative fishes, with white crappie being the most abundant nonnative fish captured. For several years following the drought, native fishes dominated the catch, with tui chub being the most abundant native fish captured. Since 1997, nonnative fish have become reestablished and have dominated the catch. Bullheads were the most abundant nonnative fish the 2001 catch and white crappies were the most abundant nonnative fish in the 2006 and 2008 catch. Total CPUE for all fish species collected from Hart and Crump Lakes was 40.9 fish per trap night, an 11 percent reduction from the 2006 CPUE of 46.1 fish per trap night. This was likely due to the cooler spring water temperatures in 2008, which may have caused fish to be less active. Length frequency histograms for tui chub and for nonnative fishes collected in the lakes are shown in **APPENDIX D**.

Crappie Stomach Analyses

The diets of crappies (N=44 fish) collected from Hart Lake near the mouth of Honey Creek on 16 June 2008 are shown in Figure 17. We found the crappie diets varied with fish size. Smaller crappies (100-199 mm) were eating primarily invertebrates. Fish, mostly other crappies, made up a larger proportion of the diet of crappies larger than 200 mm (**APPENDIX E**). No suckers were found in the diet. Due to the cold spring temperatures and the later spawning of suckers in 2008, it is possible that no larval or juvenile suckers were present when the crappies were sacrificed for stomach analysis. Also, because the fish were frozen and not preserved immediately after capture, it is also possible that juvenile suckers were digested and not identifiable.

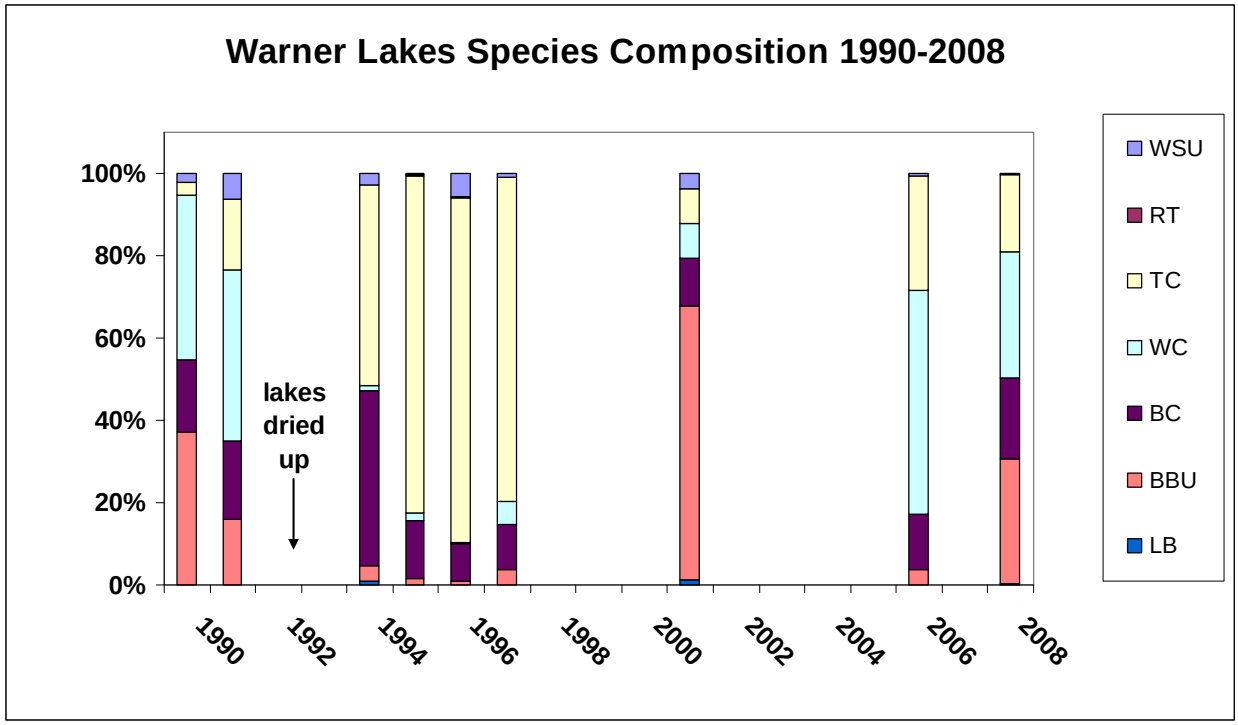

Figure 16. Fish species compositions from trapping in Hart and Crump Lakes, 1990-2008. Fish species codes are: WSU- Warner sucker, RT- redband trout, TC- tui chub, WC- white crappie, BC- black crappie, BBU- brown bullhead, and LB- largemouth bass. Note that drought caused the lakes to dry completely in 1992.

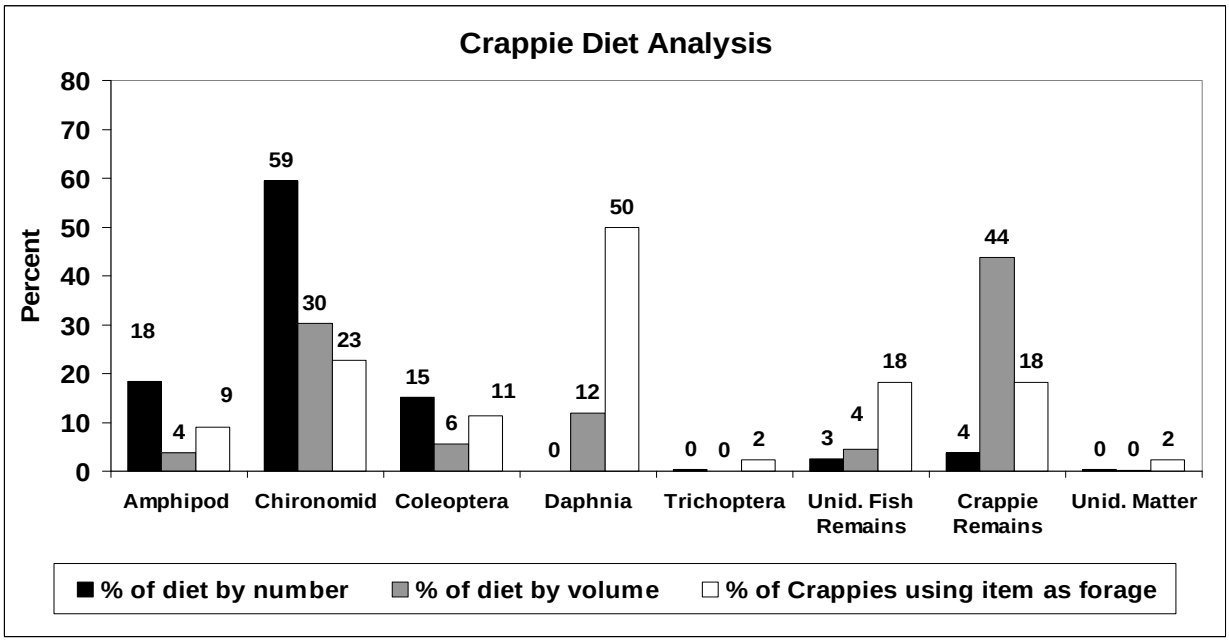

Figure 17. Diet analysis for nonnative crappies (N=44) collected from Hart Lake on 16 June 2008. Numbers above each bar represent the percentage of each food item in the diet. Crappies ranged in size from 100-379 mm FL.

Condition of Crump Lake Suckers

A large proportion of the Warner suckers collected from Crump Lake in 2008 had noticeable lesions on their bodies (Figure 18). In many cases these sores were infected with fungus. In addition, a large proportion of the suckers and tui chubs had external parasites (*Lernaea* sp.). The near desiccation of Crump Lake in 2007 may have resulted in crowding of fish, which could have resulted in heavy parasite loads.

Figure 18. Examples of Warner suckers collected in Crump Lake with external lesions and fungus.

DISCUSSION

The Warner sucker was federally listed as threatened in 1985. Reasons for the listing included watershed degradation, irrigation diversion practices, and predation and competition from introduced fishes (U.S. Fish and Wildlife Service 1998). In most years Hart and Crump Lakes hold water year round, however during droughts the suckers inhabiting the lakes are lost when the lakes desiccate (White et al. 1991; Allen et al. 1994). Stream suckers recolonize the lakes following desiccation (Allen et al. 1994). Irrigation dams and diversions limit movements and genetic exchange between lake and stream suckers (and redband trout) by blocking both the upstream spawning migrations from the lakes into the streams and the downstream migration of young fish into the lakes. To make matters worse, when young fish are able to enter the lakes, they face a gauntlet of introduced fishes which both prey upon and compete with them. These conditions have gone relatively unchanged in the 23 years since listing.

The results of our investigations indicate that the Warner sucker and redband trout populations in Crump and Hart Lakes are severely depressed. In 2008, we obtained an estimate of 565 suckers in Hart Lake, although the precision was low. In most years, only indexes of abundance through CPUE have been obtained. CPUE's for suckers in Hart Lake in 2006 and 2008 were some of the lowest on record. Compared to peak sucker CPUE's in the 1990s, the 2006 and 2008 CPUE's have declined more than 90 percent.

We found little evidence of substantial recruitment of suckers in Hart Lake. The 2006 and 2008 sucker size distributions were dominated by large, older aged fish. We have seen an increasing trend in the average sucker length since the lakes were recolonized in 1993. The proportion of suckers smaller than 250 mm increased in Crump Lake from 2006 to 2008, suggesting recent recruitment events and/or mortality of older aged fish. In 2006, Hart and Crump Lakes were full and overflowing to the north during the spawning period. When Crump Lake is full, there is a large flooded marsh at the south end where Deep Creek enters the lake. This flooded marsh may provide cover for larval and juvenile suckers allowing them to escape predation by the abundant nonnative fish populations in the lake. In 2009, we plan to evaluate the use of fin rays as a non-lethal means to assess the age structure of Warner suckers. Development of a non-lethal aging technique will allow us to track year-class strength and those environmental factors that favor, or those factors that limit, successful sucker recruitment.

We noted minimal growth of the seven PIT-tagged suckers recaptured in the lakes in 2006 and 2008. One of our PIT tags was found on the Tern Island in Crump Lake, suggesting some level of avian predation on lake suckers (tern biologists also noted suckers captured by birds nesting on the island). In the past three years, we PIT-tagged a total of 214 suckers in the lakes and 55 suckers in the tributaries. Future tagging efforts and recaptures of these tagged fish should allow us to obtain additional information on the growth and movements of the suckers in the Warner basin. In 2009, we plan to test the feasibility of using a flat-plate PIT tag antenna near the mouth of Honey Creek to detect spawning movements of PIT-tagged adult suckers.

We documented the substantial movement of radio-tagged suckers in the lakes, including movements into Honey and Deep Creeks. We also documented radio-tagged fish that entered irrigation canals that divert water from lower Honey Creek. One radio-tagged sucker was consumed by a pelican. In 2009, we plan to continue to track movements of adult suckers radio tagged in 2008 in Hart and Crump Lakes, determine whether suckers are able to enter Honey and Deep Creeks to spawn, and may be able to determine which diversion(s) hinder or block migration.

We found the sex ratio of suckers collected in 2008 in the lakes to be similar to past ratios (female to male ratio of 1.4 to 1); however most suckers collected from Crump Lake were females. Our data suggests that lake suckers mature at a larger size (~210-215 mm FL) than stream suckers (~130-155 mm FL).

Nonnative fish continue to dominate the catch in Hart and Crump Lakes. The proportion of nonnative fish in the catch has increased substantially since the mid-1990's. Native fish dominated the catch for several years after the lakes desiccated in 1992 and were recolonized during the mid-1990's. However, by 2001 the nonnative fishes once again dominated the catch, as they did prior to the desiccation of the lakes in the early 1990's (Hartzell et al. 2001).

We collected adult crappies from Hart Lake in June for stomach analysis. Although fish comprised a large proportion of the diet of crappies larger than 200 mm, no suckers were found in the diet. The colder temperatures that persisted in the Warner Lakes in 2008 appeared to delay spawning and larval suckers may not have been present in the lake at the time when the crappies were sacrificed for diet analysis. Because nonnative fishes have been implicated in limiting the survival of larval suckers (Minckley 1983; Markle and Dunsmoor 2007; Carpenter and Mueller 2008), we plan to collect adult crappies and bullheads for stomach analysis in 2009 when larval suckers are present at the mouth of Honey Creek.

The suckers collected from Crump Lake in 2008 were in poor condition. Many had obvious lesions and parasites. The near desiccation of Crump Lake in the winter of 2007 may have resulted in the mortality of larger suckers (as evidenced by length-frequency analysis) and the poor health of the surviving or recently recruited suckers. We plan to work with ODFW fish pathology to assess the health of Warner suckers in the future.

Because impassable diversion dams and unscreened canals act to fragment the habitat of Warner suckers and redband trout in the basin, we recommend future studies to identify which irrigation diversions impede upstream migration of lake suckers and redband trout. This information will allow managers to prioritize restoration funding that can be used to assist local landowners in restoring passage both upstream and downstream of irrigation diversions. Since 2006, we have PIT-tagged fish over 200 suckers in the lakes and over 50 suckers in the streams and plan to continue these tagging efforts. We recommend the installation of fixed PIT tag antennas which would allow us to assess the upstream passage of suckers past selected irrigation diversion structures.

Little is know about the timing of downstream movements of suckers into Hart and Crump Lakes (Kennedy and Vinyard 1997). In 2009, we plan to assess the feasibility of using driftnets and fry traps near the mouth of Honey Creek to determine if and when larval suckers move into Hart Lake.

In 2007, we conducted a population survey of stream-resident Warner suckers in tributaries to the Warner basin. We found stream sucker distribution to be very patchy and densities to be typically low (Scheerer et al. 2008). We found the highest sucker densities in Twelvemile Creek, near the location of the downstream migrant trap we fished in 2008. In 2009, we plan to obtain a mark-recapture population estimate for suckers in Twelvemile Creek. This estimate will allow us to monitor trends in stream sucker distribution and abundance over time. Ultimately, the persistence of Warner suckers in the basin relies on the healthy stream populations, the status of which is currently uncertain.

ACKNOWLEDGEMENTS

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APPENDIX A. Locations of trap nets, the screw trap, and the upstream trap used to sample in the Warner Basin in 2008, dates of operation, number of overnight trap sets, and numbers of Warner suckers and redband trout captured. All UTM coordinates were from zone 11T. A single net number represents one net set individually, whereas two net numbers separated by a slash, represent two nets set together. Gear locations are shown in Figures 2 and 3.

	Net	UTM coordinates				Trap	Net	Numbers captured	
Gear type	number	Easting	Northing	Date start	Date end	nights	nights	Suckers	Redband
				Hart Lake					
Trap net	1	267819	4700916	2-Apr-08	4-Apr-08	3	3	0	0
Trap net	2/3	264175	4698359	2-Apr-08	4-Apr-08	3	6	1	0
Trap net	4/5	264045	4698137	2-Apr-08	4-Apr-08	3	6	0	0
Trap net	6/7	264067	4697491	2-Apr-08	4-Apr-08	3	6	0	0
Trap net	8	267831	4700926	8-Apr-08	11-Apr-08	4	4	1	0
Trap net	1/7	264660	4699778	8-Apr-08	11-Apr-08	4	8	0	0
Trap net	5/6	264152	4698320	8-Apr-08	11-Apr-08	4	8	0	0
Trap net	9/10	267305	4701516	8-Apr-08	11-Apr-08	4	8	1	0
Trap net	11/12	264660	4702000	8-Apr-08	11-Apr-08	4	8	2	0
Trap net	2/3a	264125	4698131	8-Apr-08	11-Apr-08	4	8	0	0
Trap net	1/6	265638	4702276	15-Apr-08	18-Apr-08	4	8	1	0
Trap net	2/4	267626	4700977	15-Apr-08	18-Apr-08	4	8	2	0
Trap net	3/5	265799	4701426	15-Apr-08	18-Apr-08	4	8	2	0
Trap net	7/11	266110	4702326	15-Apr-08	18-Apr-08	4	8	1	0
Trap net	8/10	267296	4701577	15-Apr-08	18-Apr-08	4	8	0	0
Trap net	9/12	266782	4702041	15-Apr-08	18-Apr-08	4	8	4	0
Trap net	9/12	266782	4702041	22-Apr-08	25-Apr-08	4	8	1	0
Trap net	1/6a	266537	4698162	22-Apr-08	25-Apr-08	4	8	0	0
Trap net	2/4b	264155	4698267	22-Apr-08	25-Apr-08	4	8	0	0
Trap net	3/5a	264595	4698000	22-Apr-08	25-Apr-08	4	8	0	0
Trap net	7/11a	267779	4700941	22-Apr-08	25-Apr-08	4	8	1	0
Trap net	8/10a	266572	4702161	22-Apr-08	25-Apr-08	4	8	1	0
Trap net	9/12	266782	4702041	29-Apr-08	2-May-08	4	8	1	0
Trap net	1/6b	264415	4698261	29-Apr-08	2-May-08	4	8	0	0
Trap net	2/4c	267674	4700994	29-Apr-08	2-May-08	4	8	0	0
Trap net	3/5b	266892	4700638	29-Apr-08	2-May-08	4	8	2	0
Trap net	7/11b	264730	4699807	29-Apr-08	2-May-08	4	8	0	0
Trap net	8/10a	266572	4702161	29-Apr-08	2-May-08	4	8	2	0
Trap net	9/12	266782	4702041	6-May-08	9-May-08	4	8	2	0
Trap net	1/6c	264856	4698900	6-May-08	9-May-08	4	8	0	0
Trap net	3/5c	266384	4700649	6-May-08	9-May-08	4	8	6	0
Trap net	7/11c	267760	4700908	6-May-08	9-May-08	4	8	2	0
Trap net	8/10a	266572	4702161	6-May-08	9-May-08	4	8	0	0
Trap net	9/12	266782	4702041	13-May-08	16-May-08	4	8	0	0
Trap net	1/6d	264776	4698637	13-May-08	16-May-08	4	8	1	0
Trap net	3/5c	266384	4700649	13-May-08	16-May-08	4	8	4	0
Trap net	7/11c	267760	4700908	13-May-08	16-May-08	4	8	2	0
Trap net	8/10b	266627	4701214	13-May-08	16-May-08	4	8	1	0
Trap net	1/6e	265404	4701844	20-May-08	23-May-08	4	8	0	0
Trap net	3/5c	266384	4700649	20-May-08	23-May-08	4	8	4	0
Trap net	7/11c	267760	4700908	20-May-08	23-May-08	4	8	2	0
Trap net	8/10b	266627	4701214	20-May-08	23-May-08	4	8	3	0
Trap net	9/12a	266688	4701844	20-May-08	23-May-08	4	8	1	0
Trap net	1/6f	266999	4700215	28-May-08	30-May-08	3	6	0	0
Trap net	3/5c	266384	4700649	28-May-08	30-May-08	3	6	1	0
Trap net	7/11c	267760	4700908	28-May-08	30-May-08	3	6	0	0
Trap net	8/10b	266627	4701214	28-May-08	30-May-08	3	6	1	0
Trap net	9/12b	265664	4701664	28-May-08	30-May-08	3	6	0	0
Trap net	1/6g	265142	4700380	3-Jun-08	6-Jun-08	4	8	0	0
Trap net	3/5c	266389	4700649	3-Jun-08	6-Jun-08	4	8	0	0
Trap net	7/11c	267761	4700909	3-Jun-08	6-Jun-08	4	8	0	0
Trap net	8/10b	266627	4701214	3-Jun-08	6-Jun-08	4	8	1	0
Trap net	9/12c	265056	4701541	3-Jun-08	6-Jun-08	4	8	0	0
Trap net	1/6h	264186	4698408	10-Jun-08	13-Jun-08	4	8	0	0
Trap net	3/5d	264981	4700010	10-Jun-08	13-Jun-08	4	8	3	0
Trap net	7/11d	265506	4700595	10-Jun-08	13-Jun-08	4	8	4	0
Trap net	8/10c	264814	4700549	10-Jun-08	13-Jun-08	4	8	9	0

APPENDIX A. (continued).

Gear type	Net number	UTM coordinates Easting	Northing	Date start	Date end	Trap nights	Net nights	Numbers captured Suckers	Redband
				Hart Lake					
Trap net	9/12d	263982	4698092	10-Jun-08	13-Jun-08	4	8	1	0
Trap net	1/6i	265149	4700527	16-Jun-08	17-Jun-08	2	4	0	0
Trap net	13/15f	265432	4700113	16-Jun-08	17-Jun-08	2	4	1	0
Trap net	14/17g	265443	4700364	16-Jun-08	17-Jun-08	2	4	0	0
Trap net	16/18g	264199	4698351	16-Jun-08	17-Jun-08	2	4	0	0
Trap net	7/11e	265058	4699880	16-Jun-08	17-Jun-08	2	4	0	0
Trap net	8/10d	265059	4700179	16-Jun-08	17-Jun-08	2	4	0	0
Trap net	9/12e	264937	4699637	16-Jun-08	17-Jun-08	2	4	2	0
				Crump Lake					
Trap net	8/9	263558	4680475	2-Apr-08	4-Apr-08	3	6	0	0
Trap net	10/11	263670	4680464	2-Apr-08	4-Apr-08	3	6	0	0
Trap net	12	262830	4682798	2-Apr-08	4-Apr-08	3	3	0	1
Trap net	13/15	263885	4682697	15-Apr-08	18-Apr-08	4	8	1	0
Trap net	14/17	263959	4681930	15-Apr-08	18-Apr-08	4	8	0	0
Trap net	16/18	263359	4682024	15-Apr-08	18-Apr-08	4	8	0	0
Trap net	13/15a	264127	4680362	22-Apr-08	25-Apr-08	4	8	0	0
Trap net	14/17a	263783	4680176	22-Apr-08	25-Apr-08	4	8	1	0
Trap net	16/18a	263221	4680507	22-Apr-08	25-Apr-08	4	8	1	0
Trap net	13/15b	263371	4681332	29-Apr-08	2-May-08	4	8	0	0
Trap net	14/17b	263487	4680133	29-Apr-08	2-May-08	4	8	0	0
Trap net	16/18b	264362	4680203	29-Apr-08	2-May-08	4	8	0	0
Trap net	13/15c	264595	4680134	6-May-08	9-May-08	4	8	1	0
Trap net	14/17c	263963	4679874	6-May-08	9-May-08	4	8	0	0
Trap net	16/18c	263602	4680121	6-May-08	9-May-08	4	8	1	0
Trap net	2/4c	265140	4680811	6-May-08	9-May-08	4	8	0	0
Trap net	13/15d	264333	4679996	13-May-08	16-May-08	4	8	3	0
Trap net	14/17d	263733	4679856	13-May-08	16-May-08	4	8	0	1
Trap net	16/18d	263458	4679946	13-May-08	16-May-08	4	8	2	0
Trap net	2/4d	265577	4681338	13-May-08	16-May-08	4	8	0	0
Trap net	2	265260	4681237	21-May-08	23-May-08	4	4	0	0
Trap net	4	265445	4681119	21-May-08	22-May-08	2	2	0	0
Trap net	13/15e	265091	4680471	21-May-08	23-May-08	4	8	0	0
Trap net	14/17e	264909	4680258	21-May-08	23-May-08	4	8	0	0
Trap net	16/18e	263465	4680011	21-May-08	23-May-08	4	8	3	0
Trap net	13	263424	4679765	28-May-08	30-May-08	3	3	0	0
Trap net	15	263809	4679729	28-May-08	30-May-08	3	3	0	0
Trap net	14/17f	263993	4680070	28-May-08	30-May-08	3	6	1	0
Trap net	16/18f	263512	4679997	28-May-08	30-May-08	3	6	0	0
Trap net	2a	263674	4679837	28-May-08	30-May-08	3	3	0	0
Trap net	14	263598	4679421	3-Jun-08	6-Jun-08	4	4	0	0
Trap net	17	264118	4679720	3-Jun-08	6-Jun-08	4	4	0	0
Trap net	13a	266506	4682048	3-Jun-08	6-Jun-08	4	4	2	0
Trap net	15a	266152	4681749	3-Jun-08	6-Jun-08	4	4	0	0
Trap net	16/18g	263335	4680164	3-Jun-08	6-Jun-08	4	8	3	0
Trap net	2a	263674	4679837	3-Jun-08	6-Jun-08	4	4	0	0
Trap net	13a	266507	4682049	10-Jun-08	13-Jun-08	4	4	0	0
Trap net	14a	267135	4682853	10-Jun-08	13-Jun-08	4	4	0	0
Trap net	15a	266182	4681749	10-Jun-08	13-Jun-08	4	4	1	0
Trap net	16/18g	263335	4680164	10-Jun-08	13-Jun-08	4	8	6	0
Trap net	17a	266849	4682484	10-Jun-08	13-Jun-08	4	4	0	0
Trap net	2b	265339	4682090	10-Jun-08	13-Jun-08	4	4	1	0
				Honey Creek					
Hoop Net		263745	4698588	10-Jun-08	13-Jun-08	4	4	2	0
				Twelvemile Creek					
Screw Trap		254987	4657563	10-Apr-08	17-Jun-08	37	37	28	38
				Twentymile Creek					
Upstream Trap		255129	4661824	18-Apr-08	17-Jun-08	33	33	0	0

APPENDIX B. Details of 2008 PIT tagging of Warner Suckers in Hart and Crump Lakes.

Date	PIT tag number	Radio tag number	Genetics vial number	Gear type or trapnet number	Recap	Length	Weight	Sex	Turbercles	Comments
				Twelvemile Creek						
11-Apr-08	1-52365284	N/A	1153-002	Twelvemile Ck Screw Trap	N	205	-	F	No	Held for weekend for PIT tag
10-Jun-08	1-52365342	N/A	1153-025	Twelvemile Ck Screw Trap	N	188	81	F	No	Released same day, PIT Tagged
23-Apr-08	1-52365289	N/A	1153-003	Twelvemile Ck Screw Trap	N	121	-	?	No	PIT Tag released same day
23-Apr-08	1-52365290	N/A	1153-004	Twelvemile Ck Screw Trap	N	110	-	?	No	PIT Tag released same day
24-Apr-08	1-52365294	N/A	1153-005	Twelvemile Ck Screw Trap	N	165	-	?	No	PIT Tag released same day
6-May-08	1-52365363	N/A	1153-006	Twelvemile Ck Screw Trap	N	194	89	F	No	Released same day
12-May-08	1-52365361	N/A	1153-007	Twelvemile Ck Screw Trap	N	110	15	?	No	PIT Tag released same day
16-May-08	1-52365359	N/A	1153-008	Twelvemile Ck Screw Trap	N	177	67	?	No	Released same day, PIT and FLOY tagged
16-May-08	1-52365357	N/A	1153-009	Twelvemile Ck Screw Trap	N	109	15	?	No	Released same day, PIT tagged
20-May-08	1-52365368	N/A	1153-010	Twelvemile Ck Screw Trap	N	150	41	M	No	Released same day, PIT tagged
20-May-08	N/A	N/A	1153-011	Twelvemile Ck Screw Trap	N	78	3	?	No	
22-May-08	1-52365299	N/A	1153-013	Twelvemile Ck Screw Trap	N	295	-	F	No	Released same day, PIT and FLOY tagged
22-May-08	1-52365297	N/A	1153-012	Twelvemile Ck Screw Trap	N	187	70	?	No	Released same day, PIT tagged
23-May-08	1-52365293	N/A	1153-014	Twelvemile Ck Screw Trap	N	140	24	?	No	Released same day, PIT tagged
28-May-08	1-52365355	N/A	1153-366	Twelvemile Ck Screw Trap	N	132	25	?	No	Released same day, PIT tagged
30-May-08	1-52365354	N/A	1153-016	Twelvemile Ck Screw Trap	N	120	18	?	No	Released same day, PIT tagged
3-Jun-08	1-52365353	N/A	1153-017	Twelvemile Ck Screw Trap	N	127	23	?	No	Released same day, PIT tagged
3-Jun-08	1-52365348	N/A	1153-018	Twelvemile Ck Screw Trap	N	170	58	M	Yes	Tubercles; Sperm milked, PIT Tagged and released same day
3-Jun-08	1-52365347	N/A	1153-019	Twelvemile Ck Screw Trap	N	160	50	M	Yes	Tubercles; Sperm milked, PIT Tagged and released same day
4-Jun-08	1-52365301	N/A	1153-020	Twelvemile Ck Screw Trap	N	175	62	M	Yes	Released samday, PIT and FLOY tagged, sperm present
4-Jun-08	1-52365346	N/A	1153-021	Twelvemile Ck Screw Trap	N	207	105	F	No	Released samday, PIT and FLOY tagged, eggs present
5-Jun-08	1-52365356	N/A	N/A	Twelvemile Ck Screw Trap	N	190	95	F	No	Released samday, PIT and FLOY tagged, full of eggs
6-Jun-08	Mortality	N/A	N/A	Twelvemile Ck Screw Trap	N	165	62	M	Yes	Mortality; Sperm present
6-Jun-08	1-52365345	N/A	1153-022	Twelvemile Ck Screw Trap	N	180	74	F	No	Released same day, PIT Tagged,Eggs Present
6-Jun-08	1-52365343	N/A	1153-024	Twelvemile Ck Screw Trap	N	155	49	F	No	Released same day, PIT Tagged, Spawned-Out!!!
11-Jun-08	1-52365303	N/A	1153-026	Twelvemile Ck Screw Trap	N	130	21	F	No	Released same day, PIT tagged
16-Jun-08	1-52365306	N/A	1153-028	Twelvemile Ck Screw Trap	N	245	172	F	No	Released same day, PIT tagged
16-Jun-08	1-52365310	N/A	1153-027	Twelvemile Ck Screw Trap	N	170	56	F	No	Released same day, PIT tagged

APPENDIX B (continued).

Date	PIT tag number	Radio tag number	Genetics vial number	Gear type or trapnet number	Recap	Length	Weight	Sex	Turbercles	Comments
				Crump Lake						
4-Jun-08	1-52365827	N/A	1152-068	Crump 13	N	190	25	F	No	Released samday, PIT and FLOY tagged
4-Jun-08	1-52365826	N/A	1152-069	Crump 13	N	215	60	F	No	Released samday, PIT and FLOY tagged
17-Apr-08	1-52365883	N/A	1152-012	Crump 13/15	N	195	90	F	No	FLOY tag, PIT tag, released
9-May-08	1-52365854	26	1152-037	Crump 13/15	N	300	300	F	No	Radio tagged and released the same day
14-May-08	1-52365848	N/A	1152-045	Crump 13/15d	N	193	90	F	No	Released same day, PIT and FLOY tagged
14-May-08	1-52365847	38	1152-046	Crump 13/15d	N	290	300	F	No	Released same day, PIT and FLOY tagged
16-May-08	1-52365845	N/A	1152-049	Crump 13/15d	N	210	100	M	Yes	Released same day, PIT and FLOY tagged
22-Apr-08	1-52365878	23	1152-017	Crump 14/17a	N	355	500	F	No	Held overnight. Lots of parasites and ragged caudle fin
28-May-08	N/A	N/A	1152-066	Crump 14/17a	N	365	425	F	No	Released same day- poor condition, possiblly spawned out
12-Jun-08	1-52365800	N/A	1152-095	Crump 15	N	205	75	F	No	Released same day, PIT and FLOY tagged
23-Apr-08	1-52365875	25	1152-018	Crump 16/18a	N	350	460	M	Yes	Held overnight. Lots of parasites and ragged caudle fin
7-May-08	1-52365863	N/A	1152-029	Crump 16/18c	N	200	100	F	No	Released same day, PIT and FLOY tagged
5-Jun-08	1-52365823	N/A	1152-071	Crump 16/18c	N	155	22	F	No	Released samday, PIT tagged
6-Jun-08	1-52365824	N/A	1152-072	Crump 16/18c	N	215	75	F	No	Released same day, Mortality- tag fround on Tern Island.
10-Jun-08	1-52365819	N/A	1152-075	Crump 16/18c	N	205	90	F	No	Released same day, PIT tagged
10-Jun-08	1-52365820	N/A	1152-076	Crump 16/18c	N	220	125	F	No	Released same day, PIT tagged
13-May-08	N/A	N/A	1152-041	Crump 16/18d	N	360	400	M	Yes	Lots of fungus, Lesions, Essentialy dead in net. Mortality
15-May-08	1-52365844	N/A	1152-048	Crump 16/18d	N	255	180	F	No	Released same day, PIT and FLOY tagged
21-May-08	1-52365826	39	1152-056	Crump 16/18e	N	350	450	F	No	Held overnight for observation, PIT and Radio tagged
21-May-08	1-52365835	N/A	1152-057	Crump 16/18e	N	250	120	F	No	Released same day, PIT and FLOY tagged
21-May-08	1-52365834	N/A	1152-058	Crump 16/18e	N	199	90	F	No	Released same day, PIT and FLOY tagged
4-Jun-08	1-52365825	40	1152-070	Crump 16/18e	N	340	325	F	No	Held overnight. PIT and Radio tagged, spawned out
12-Jun-08	1-523653801	N/A	1152-096	Crump 16/18f	N	190	60	M	No	Released same day, PIT and FLOY tagged
12-Jun-08	1-52365798	41	1152-097	Crump 16/18f	N	370	495	F	No	Held overnight for observaion. Radio tagged and PIT tagged.
13-Jun-08	1-52365795	N/A	1152-098	Crump 16/18f	N	212	120	F	No	Released same day, PIT tagged
13-Jun-08	1-52365797	N/A	1152-099	Crump 16/18f	N	170	70	F	No	Released same day, PIT tagged
12-Jun-08	1-52365799	N/A	1152-094	Crump 2b	N	205	85	F	No	Released same day, PIT and FLOY tagged

APPENDIX B (continued).

Date	PIT tag number	Radio tag number	Genetics vial number	Gear type or trapnet number	Recap	Length	Weight	Sex	Turbercles	Comments
					Hart Lake					
15-Apr-08	1-52365291	14	1152-006	Hart 1/6	N	405	925	F	No	Held over night for observation
15-May-08	1-52365846	N/A	1152-047	Hart 1/6d	N	385	740	F	No	Released same day, PIT and FLOY tagged
10-Apr-08	1-52365898	10	1152-003	Hart 11/12	N	320	400	M	Yes	Sperm present. Held overnight; released on 4/11/08
11-Apr-08	1-52365283	13	1153-001	Hart 11/12	N	350	520	M	Yes	Held over night for observation released on 4/12/08
16-Jun-08	1-52365796	N/A	1153-029	Hart 13/15f	N	310	320	F	No	Released same day, PIT and FLOY tagged
17-Apr-08	1-52365888	17	1152-009	Hart 2/4	N	427	990	F	No	Held over night for observation
18-Apr-08	1-52365879	22	1152-015	Hart 2/4	N	353	590	M	Yes	Released same day
17-Apr-08	1-52365884	18	1152-010	Hart 3/5	N	361	650	M	Yes	Held over night for observation
18-Apr-08	1-52365880	20	1152-013	Hart 3/5	N	360	575	M	Yes	Released same day
1-May-08	1-52365867	30	1152-023	Hart 3/5b	N	455	1150	F	No	Held overnight for observation
1-May-08	1-52365869	32	1152-025	Hart 3/5b	N	405	750	M	Yes	Held overnight for observation
7-May-08	1-52365865	35	1152-027	Hart 3/5c	N	300	270	M	Yes	Released same day
7-May-08	1-52365864	34	1152-028	Hart 3/5c	N	305	275	F	No	Held overnight and released in Honey Ck.. On 5/8/08
8-May-08	1-52365861	N/A	1152-031	Hart 3/5c	N	343	550	M	Yes	Released same day, PIT and FLOY tagged
8-May-08	1-52365856	N/A	1152-032	Hart 3/5c	N	320	425	M	Yes	Released same day, PIT and FLOY tagged
8-May-08	1-52365857	N/A	1152-033	Hart 3/5c	N	275	250	M	Yes	Released same day, PIT and FLOY tagged
8-May-08	1-52365862	N/A	1152-034	Hart 3/5c	N	395	780	M	Yes	Released same day, PIT and FLOY tagged
13-May-08	1-52365853	36	1152-040	Hart 3/5c	N	430	1090	F	No	Held overnight and released in Honey Ck.
13-May-08	1-52365855	N/A	1152-039	Hart 3/5c	N	327	445	M	Yes	Released same day, PIT and FLOY tagged
14-May-08	1-52365849	N/A	1152-043	Hart 3/5c	N	265	225	F	No	Released same day, PIT and FLOY tagged
14-May-08	1-52365852	N/A	1152-042	Hart 3/5c	N	265	220	M	Yes	Released same day, PIT and FLOY tagged
20-May-08	1-32628634	N/A	1152-053	Hart 3/5c	**Y**	380	725	F	No	Recapture from 2006:had PIT and Floy tag from 2006
20-May-08	1-52365838	N/A	1152-054	Hart 3/5c	N	300	390	M	Yes	Released same day, PIT and FLOY tagged
20-May-08	1-52365837	N/A	1152-055	Hart 3/5c	N	245	160	F	No	Released same day, PIT and FLOY tagged
23-May-08	1-52365830	N/A	1152-062	Hart 3/5c	N	285	275	F	No	Released same day, PIT and FLOY tagged
28-May-08	1-52365845	N/A	1152-064	Hart 3/5c	N	420	950	F	No	Released samday, PIT and FLOY tagged
12-Jun-08	1-52365814	N/A	1152-091	Hart 3/5d	N	355	625	M	Yes	Released same day, PIT and FLOY tagged
12-Jun-08	1-52365803	N/A	1152-092	Hart 3/5d	N	375	395	M	Yes	Released same day, PIT and FLOY tagged
12-Jun-08	1-52365802	N/A	1152-093	Hart 3/5d	N	360	650	F	No	Released same day, PIT and FLOY tagged
4-Apr-08	1-52365900	N/A	1152-001	Hart 4/5	N	370	N/A	M	Yes	Held over weekend for radio tag but tags were not available
16-Apr-08	1-52365290	15	1152-007	Hart 7/11	N	315	400	F	No	Held over night for observation
25-Apr-08	1-52365873	27	1152-020	Hart 7/11a	N	350	605	M	Yes	Held overnight for observation
8-May-08	1-52365859	N/A	1152-030	Hart 7/11c	N	300	320	M	Yes	Released same day, PIT and FLOY tagged
9-May-08	1-32628540	N/A	1152-038	Hart 7/11c	**Y**	335	550	M	Yes	FLOY and PIT tag present from 2006. Released
16-May-08	1-52365842	N/A	1152-050	Hart 7/11c	N	411	990	F	No	Released same day, PIT and FLOY tagged
16-May-08	1-52365839	N/A	1152-051	Hart 7/11c	N	315	400	F	No	Released same day, PIT and FLOY tagged
20-May-08	1-52365840	N/A	1152-052	Hart 7/11c	N	260	200	F	No	Released same day, PIT and FLOY tagged
21-May-08	1-52365833	N/A	1152-059	Hart 7/11c	N	323	440	M	Yes	Released same day, PIT and FLOY tagged
11-Jun-08	1-52365815	N/A	1152-081	Hart 7/11d	N	271	225	M	Yes	Released same day, PIT and FLOY tagged; Sperm present
12-Jun-08	1-52365805	N/A	1152-089	Hart 7/11d	N	250	225	M	Yes	Released same day, PIT and FLOY tagged; sperm present

APPENDIX B (continued).

Date	PIT tag number	Radio tag number	Genetics vial number	Gear type or trapnet number	Recap	Length	Weight	Sex	Turbercles	Comments
					Hart Lake					
12-Jun-08	1-52365804	N/A	1152-090	Hart 7/11d	N	305	400	M	Yes	Released same day, PIT and FLOY tagged
12-Jun-08	1-52365808	N/A	1152-087	Hart 7/11d	N	368	675	F	No	Released same day, PIT and FLOY tagged
8-Apr-08	1-52365896	12	1152-005	Hart 8	N	415	920	F	No	Held overnight for observation released on 4/11/08
25-Apr-08	1-52365872	N/A	1152- 019	Hart 8/10a	N	323	460	F	No	Mortality
30-Apr-08	1-52365870	29	1152-022	Hart 8/10a	N	301	350	M	Yes	Held overnight for observation
1-May-08	1-52365868	31	1152-024	Hart 8/10a	N	368	675	M	Yes	Held overnight; released into Honey Ck. Above bridge
14-May-08	1-52365850	37	1152-044	Hart 8/10b	N	365	670	F	No	Held overnight; released in Honey Ck. Pelican consumed fish.
20-May-08	1-52365859	N/A		Hart 8/10b	**Y**	300	320	M	Yes	Released same day, Recapture from this year (May 8)
22-May-08	1-52365831	N/A	1152-061	Hart 8/10b	N	405	915	F	No	Released same day, PIT and FLOY tagged
23-May-08	1-52365829	N/A	1152-063	Hart 8/10b	N	250	200	F	No	Released same day, PIT and FLOY tagged
28-May-08	1-52365828	N/A	1152-065	Hart 8/10b	N	324	430	M	Yes	Released samday, PIT and FLOY tagged
6-Jun-08	1-52365822	N/A	1152-073	Hart 8/10b	N	365	560	F	No	Released same day, PIT and FLOY tagged
10-Jun-08	1-52365821	N/A	1152-074	Hart 8/10c	N	405	800	F	No	Released same day, PIT and FLOY tagged
11-Jun-08	1-52365816	N/A	1152-080	Hart 8/10c	N	415	900	F	No	Released same day, PIT and FLOY tagged; Eggs expelled
12-Jun-08	1-52365806	N/A	1152-088	Hart 8/10c	N	380	720	M	Yes	Released same day, PIT and FLOY tagged, spawned out
12-Jun-08	1-52365809	N/A	1152-086	Hart 8/10c	N	300	300	M	Yes	Released same day, PIT and FLOY tagged
12-Jun-08	1-52365813	N/A	1152-082	Hart 8/10c	N	440	1025	F	Yes	Released same day, PIT and FLOY tagged
12-Jun-08	1-52365812	N/A	1152-083	Hart 8/10c	N	335	400	F	No	Released same day, PIT and FLOY tagged, spawned out
12-Jun-08	1-52365811	N/A	1152-084	Hart 8/10c	N	345	450	F	No	Released same day, PIT and FLOY tagged, spawned out
12-Jun-08	1-52365810	N/A	1152-085	Hart 8/10c	N	290	250	M	Yes	Released same day, PIT and FLOY tagged, spawned out
13-Jun-08	1-52365894	N/A	1152-100	Hart 8/10c	N	344	485	F	No	Released same day, PIT and FLOY tagged
9-Apr-08	1-52365897	11	1152-004	Hart 9	N	353	620	M	Yes	Sperm present, held overnight, released on 4/11/07
16-Apr-08	1-52365289	16	1152-008	Hart 9/12	N	320	450	F	No	Held over night for observation
17-Apr-08	1-52365882	19	1152-011	Hart 9/12	N	290	340	M	Yes	Held over night for observation
18-Apr-08	1-32628673	21	1152-014	Hart 9/12	**Y**	394	820	F	No	Recapture from 2006: had PIT tag and FLOY tag from 2006
18-Apr-08	1-52365881	24	1152-016	Hart 9/12	N	385	725	M	Yes	Released same day
25-Apr-08	1-52365874	28	1152-021	Hart 9/12	N	268	230	M	Yes	Held overnight for observation
2-May-08	152365866	33	1152-026	Hart 9/12	N	275	240	M	Yes	Released same day into Honey Ck. above bridge
8-May-08	1-52365860	N/A	1152-035	Hart 9/12	N	292	300	M	Yes	Released same day, PIT and FLOY tagged
8-May-08	1-52365858	N/A	1152-036	Hart 9/12	N	241	150	M	Yes	Released same day, PIT and FLOY tagged
21-May-08	1-52365832	N/A	1152-060	Hart 9/12a	N	410	760	F	No	Released same day, PIT and FLOY tagged
11-Jun-08	1-32628545	N/A	1152-079	Hart 9/12d	**Y**	420	950	F	No	Released same day, 2006 Recapture, swollen vent
17-Jun-08	1-52365794	N/A	1153-030	Hart 9/12e	N	405	860	F	No	Released same day, white bumps on bottom of caudal fin
17-Jun-08	1-52365793	N/A	1153-031	Hart 9/12e	N	325	440	F	No	Released same day, PIT and FLOY tagged
					Honey Creek					
11-Jun-08	1-52365817	N/A	1152-077	HoneyCk Hoop	N	410	820	F	No	Released same day, PIT and FLOY tagged
11-Jun-08	1-52365818	N/A	1152-078	HoneyCk Hoop	N	320	350	M	Yes	Released same day, PIT and FLOY tagged; sperm present

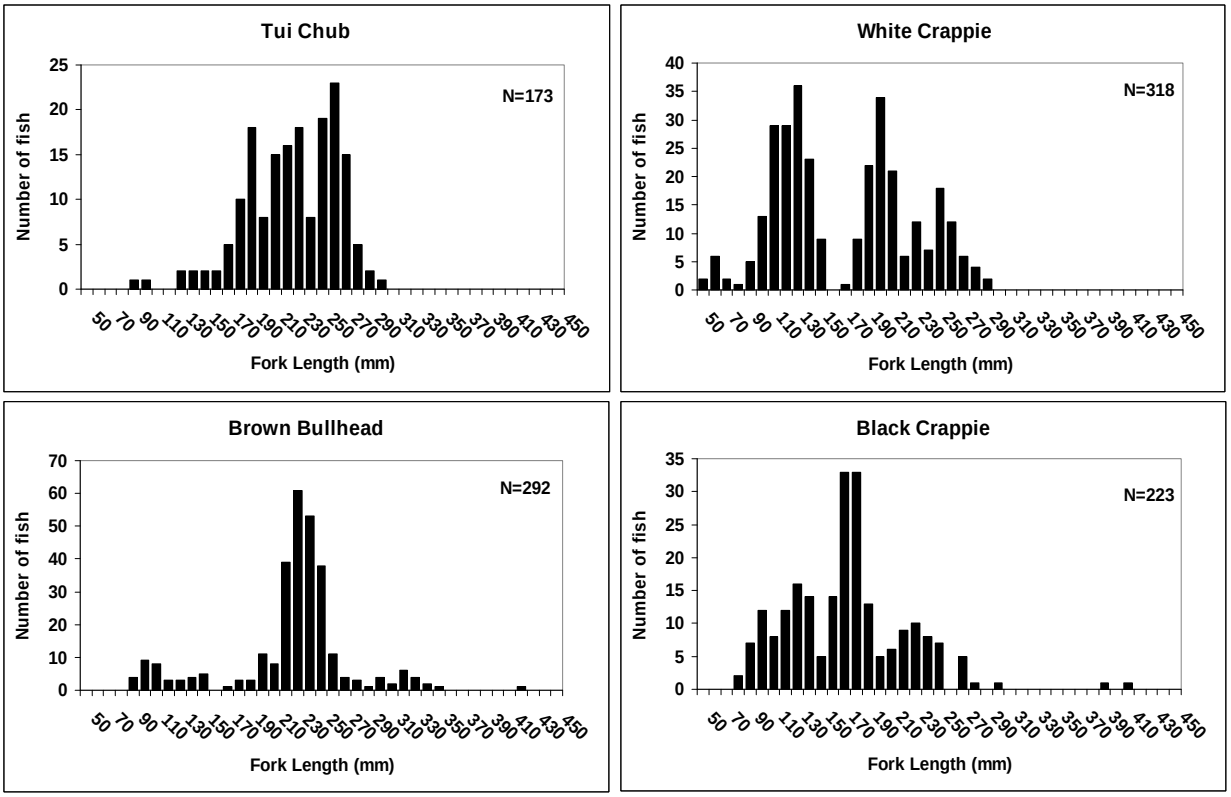
APPENDIX C. Catch per trap night for all fish species collected in Hart and Crump Lakes for all years when sampling occurred from 1990 through 2008. Fish codes are: WSU- Warner sucker, RT- redband trout, TC- tui chub, WC- white crappie, BC- black crappie, BBU- brown bullhead, and LB- largemouth bass.

	Catch per trap night						
Trap nights	WSU	RT	TC	WC	BC	BBU	LB
122	1.6	0.0	2.0	30.0	12.5	27.7	0.0
175	0.6	0.0	1.7	4.0	1.8	1.5	0.0
70	0.0	0.0	0.2	0.0	0.0	0.0	0.0
54	2.3	0.0	11.9	0.5	20.8	3.2	0.0
104	0.2	0.0	24.2	0.7	5.7	1.0	0.0
252	3.3	0.2	50.1	0.1	4.8	0.6	0.0
137	1.4	0.1	135.1	8.7	9.2	6.5	0.0
63	2.8	0.0	4.9	3.7	4.8	41.1	0.1
214	0.2	0.0	15.9	34.3	8.7	2.1	0.0
473	0.2	0.0	9.8	13.0	10.4	14.0	0.1

	Catch per trap night						
Trap nights	WSU	RT	TC	WC	BC	BBU	LB
9	1.8	0.0	6.3	18.0	19.1	18.0	0.4
0	-	0.0	-	-	-	-	-
25	0.0	0.0	0.8	0.0	0.6	0.1	0.0
35	0.2	0.0	85.4	1.3	46.5	0.8	1.7
40	0.0	0.0	71.0	1.2	8.0	0.3	0.0
36	0.3	0.2	4.5	0.1	4.7	0.2	0.0
60	0.0	0.1	19.7	2.5	25.1	0.8	0.0
24	0.2	0.0	4.2	7.6	11.2	27.6	2.2
238	0.3	0.0	9.3	15.4	3.4	1.3	0.0
258	0.1	0.0	3.5	11.6	3.8	9.5	0.1

	Catch per trap night						
Trap nights	WSU	RT	TC	WC	BC	BBU	LB
131	1.6	0.0	2.3	29.1	12.9	27.0	0.1
175	0.6	0.0	1.7	4.0	1.8	1.5	0.0
95	0.0	0.0	0.4	0.0	0.2	0.0	0.0
89	1.7	0.0	31.9	0.7	27.8	2.6	0.5
144	0.1	0.1	37.2	0.8	6.3	0.8	0.0
288	2.9	0.2	44.4	0.1	4.8	0.5	0.0
197	1.0	0.0	100.0	6.8	14.0	4.7	0.0
87	2.1	0.0	4.7	4.8	6.6	37.4	0.7
452	0.2	0.0	12.4	24.4	5.9	1.7	0.0
731	0.1	0.0	7.6	12.5	8.1	12.4	0.1

APPENDIX D. Length frequency histograms for tui chub, brown bullhead, white crappie, and black crappie collected from the Warner Lakes, 2008.



APPENDIX E. Details of diet analysis of crappies collected on 16 June 2008 from the west side of Hart Lake near Honey Creek.

100-300+mm	Sample size = 44		Number empty stomachs = 5		
Diet Item	Volume (ml)	Number	% Volume	Number %	Frequency %
Amphipod	1.2	58	4	18	9
Chironomid	9.8	188	30	59	23
Coleoptera	1.8	48	6	15	11
Daphnia	3.8		12	0	50
Trichoptera	0.0	1	0	0	2
Unid. Fish Remains	1.5	8	4	3	18
Crappie Remains	14.2	12	44	4	18
Unid. Matter	0.1	1	0	0	2
Total	32.3	316	100	100	

100-199 mm	Sample size = 18		Number empty stomachs = 3		
Diet Item	Volume (ml)	Number	% Volume	Number %	Frequency %
Amphipod	0.7	32	15	26	11
Chironomid	0.8	77	17	62	22
Coleoptera	0.5	10	11	8	11
Daphnia	1.5		33		72
Trichoptera	0.0	0	0	0	0
Unid. Fish Remains	0.2	1	5	1	6
Crappie Remains	0.8	4	18	3	22
Unid. Matter	0.0	0	0	0	0
Total	4.4	124	100	100	

200-299 mm	Sample size = 20		Number empty stomachs = 2		
Diet Item	Volume (ml)	Number	% Volume	Number %	Frequency %
Amphipod	0.6	26	8	15	10
Chironomid	1.0	103	14	58	20
Coleoptera	1.3	38	18	21	15
Daphnia	2.3		31		40
Trichoptera	0.0	0	0	0	0
Unid. Fish Remains	1.3	7	17	4	35
Crappie Remains	0.9	3	12	2	15
Unid. Matter	0.1	1	1	1	5
Total	7.3	178	100	100	

>300 mm	Sample size = 6		Number empty stomachs = 0		
Diet Item	Volume (ml)	Number	% Volume	Number %	Frequency %
Amphipod	0.0	0	0	0	0
Chironomid	8.0	8	39	80	33
Coleoptera	0.0	0	0	0	0
Daphnia	0.1		0		17
Trichoptera	0.0	1	0	10	17
Unid. Fish Remains	0.0	0	0	0	0
Crappie Remains	12.5	5	61	36	17
Unid. Matter	0.0	0	0	0	0
Total	20.6	14	100	100	

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