2007 FISHERY ASSESSMENT SURVEYS CONDUCTED ON THE VALENTINE NATIONAL WILDLIFE REFUGE

Prepared by

Greg A. Wanner

U.S. Fish and Wildlife Service
Great Plains Fish and Wildlife Management Assistance Office
Pierre, South Dakota

December 2007

TABLE OF CONTENTS

INTRODUCTION

The Valentine National Wildlife Refuge (NWR) was established in 1935 to provide feeding and resting areas for migrating waterfowl. Public recreation that is compatible with the purposes of the refuge, including hunting and fishing, is promoted. Management of the fisheries is defined in a 1978 Cooperative Agreement between the U.S. Fish and Wildlife Service (Service) and Nebraska Game and Parks Commission (NGPC).

The Valentine NWR contains 39 lakes. The majority of the lakes are small, shallow, potholes that are subject to frequent winter-kills. Nine Lakes are open to fishing: Pelican, Hackberry, Dewey, Clear, Willow, Watts, Duck, Rice, and West Long (Figure 1). These lakes have varying degrees of potential for fisheries management. All of the designated fishing lakes, except Rice Lake, are accessible by vehicles.

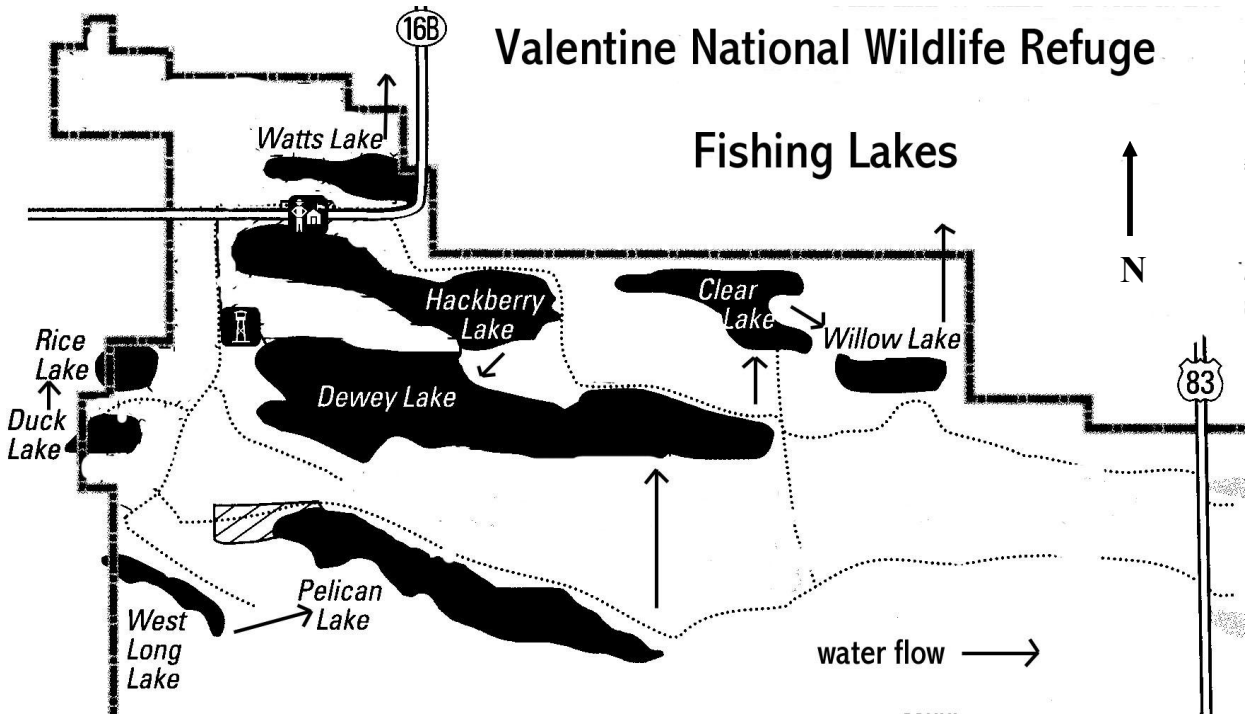

Figure 1. Map of the lakes that are open to fishing on the Valentine NWR. Direction of water flow is depicted by arrows and refuge trails are depicted dotted lines.

Common carp (*Cyprinus carpio*) gained access to the Valentine NWR lake system through Gordon Ditch, which was dug during the 1930's. Carp reproduce well in the shallow, highly-vegetated refuge lakes and generally dominate the fishery within 10 years after introduction. Degradation of aquatic habitats by carp is well documented and high numbers of carp are detrimental to waterfowl and game fish habitat. These refuge lakes have a long history of chemical renovation to remove carp. Historically, for about five years after a renovation and re-stocking game fish (Appendix A), angling is excellent, duck use is high, and then both decline due to carp-induced habitat degradation. Fisheries biologists from the Service and NGPC have experimented with the use of northern pike (*Esox lucius*) as a biological carp-control. Early

attempts were unsuccessful because northern pike were introduced after carp were well established and subsequently too large to be controlled by predation.

In 1988, northern pike and largemouth bass (*Micropterus salmoides*) length limits were changed for Valentine NWR lakes in an attempt to increase abundance and size structure of predators (Appendix B). The size restrictions appeared to be successful as carp numbers stabilized in lakes where the restrictions were enacted. However, strong year classes of carp during years where northern pike populations were down have led to recruitment and higher abundance of carp populations in some lakes. Success has not been without perceived drawbacks. Predation by northern pike has likely reduced the abundance and altered the size structure of largemouth bass, yellow perch (*Perca flavescens)*, and bluegills (*Lepomis macrochirus*). Environmental conditions have likely had greater affects on recreational fisheries such as a 1987-88 winter-kill, low reproduction and recruitment due to drought conditions during the summers of 1989 – 1990 and 2002-2007, and an extremely cool spring/summer (< 21^{o}C) during 1992 and 1993. The springs of 1994-97 were exceptionally wet, and these conditions provided good habitat and conditions for strong year classes for most fish species. However, high water levels also connected lakes that are usually isolated, which allowed fish movement.

Northern pike have been identified as a possible tool for controlling common carp, and evaluating their potential is a high priority for the refuge's fisheries. Many of the results from fishery assessments identified in this report are directed at: 1) evaluating northern pike as biological control agent for carp, 2) evaluating northern pike recruitment and condition in response to the special regulation allowing harvest of northern pike less than 28 inches, and 3) evaluating the impacts of the special northern pike regulations on other game fish populations.

Glossary of fishery terms are summarized in Appendix C and data collation and analysis techniques are summarized in Appendix D.

METHODS

Electrofishing and trap netting surveys were conducted during the spring from 21-24 May 2007 and gill netting surveys were conducted from 4-6 September 2007.

Nighttime electrofishing was conducted with a Smith and Root 5.0 GPP electrofishing system using 200 volts pulsed DC, at 7-9 amps, and a pulse frequency of 120 cycles per second (cps). Electrofishing was conducted in 15 minute transects along the shoreline.

Trap nets consisted of a lead set at the shoreline (15.2 m [50 ft.] length by 1 m [3 ft.] height), two 1.2 m [4 ft] wide and 1 m [3 ft] high rectangular steel frames, and two 1 m [3 ft.] diameter circular hoops with 13 mm (0.5 in.) nylon mesh. A green protective coat was applied to the nylon mesh. Trap nets were set overnight for a maximum of 24 h with leads set perpendicular to the shore.

Gill nets were experimental monofilament nets that were 38.1 m (125 ft.) in length, 1.8 m (6 ft.) in depth, with five 8-m (25 ft.) long panels with bar mesh sizes, in order, of 19 mm (0.75 in.), 25 mm (1 in.), 38 mm (1.5 in.), 51 mm (2.0 in.), and 76 mm (3 in.). Float lines were 1.3 cm poly-foamcoare and lead lines were 22.7 kg leadcore. Gill nets were always set with the small mesh closest to the shore.

Effort for each gear in each lake is presented in Table 1.

Table 1. Effort for each gear in each lake sampled on the Valentine NWR during 2007.

Lake	Electrofishing (h)	Trap nets (n)	Gill nets (n)
Clear[a]	0	0	5
Dewey	1.5	10	5
Hackberry	2.0	0	0
Pelican	2.0	12	7
Duck	1.0	5	3
Watts	1.25	7	3

[a] Could not sample properly with all gears due to low water levels in May.

CLEAR LAKE

Lake Description

Clear Lake is accessed by gravel roads from County Highway 16B or U.S. Highway 83. Ice fishing is popular during winter with good ice, although heavy snow sometimes causes road closures and limits access to this lake. During the spring and again during fall, northern pike fishing is popular.

Clear lake is in the middle of a series of four lakes on the refuge connected by natural drainage and man-made ditches. A ditch dug from Dewey Lake (upstream from Clear Lake) feeds into Clear Lake. The interconnection of these lakes has created problems with controlling inter-lake fish movement in past years. The spring of 1995 and 1997 were years of high run-off resulting in extremely high lake levels. Water flowed from Clear to Willow Lake for much of the spring and summer and inter-lake fish movement was observed. Beginning in 2002 and continuing to date, the refuge lakes have experienced lowered water levels due to below average annual precipitation.

Clear Lake is 172 surface ha (424 acres) with a maximum depth of 3.5 m (10.2 ft.) and mean depth of 1.7 m (6 ft.) during full pool. A dike on the east end can hold the lake about 1.2 m higher than the natural pool level. The added area is primarily flooded sand dunes and provides little fisheries habitat. The bottom is relatively flat with few drop-offs or depressions. Most of the bottom is sandy, but a small bay on the east end of the lake contains an expanse of highly organic bottom. The surrounding shoreline is predominately grass with a few willows (*Salix spp.*) and cottonwoods (*Populus spp.*). High water levels are required to flood shoreline vegetation for spring spawning sites. The limited littoral area reduces spawning and subsequent survival for most of the lake's game fish species. Aquatic vegetation is sparse around the edges. Less than 2% of the lake contains emergent vegetation (primarily cattails [*Typha spp.*]), and submergent vegetation is absent. The lack of vegetation is related to the infertile sandy bottom and turbidity. Surface water quality parameters measured in Clear Lake during each survey (Table 1) are specific conductivity, which averages 578 µS/cm, total alkalinity averages 284 mg/L, phenolphthalein alkalinity averages 9 mg/L, the lake's pH averages 8.5 through most of the year, and Secchi disk averages about 0.3 m. The lake is too shallow to develop a thermocline.

The lake was chemically renovated with rotenone in 1983 and restocked with game fish, such as northern pike and largemouth bass (Appendix A). During the 1986 survey, sub-adult carp were collected for the first time since that renovation. A major winterkill occurred during 1987-1988 and poor recruitment of yellow perch and bluegill were seen in subsequent years. Northern pike size restrictions changed multiple times from 1987 to 1993 (Appendix B). Northern pike greater than 28 in have been protected since 1993. Since enactment of these regulations, fall surveys generally indicated strong northern pike year-classes, improved size structure, and increased condition during high water years of the mid-90's. However, a trend has developed as overall relative abundance has declined since then. Mean W_r has been stable across the years. Since the 28 in. size limit in 1993, the most notable difference has been the increase of memorable to

trophy length northern pike. Fish in this length category have been collected every year since 1996 with incremental RSD-M values ranging from 5 to 27.

Primary fish species in Clear Lake include: northern pike, carp, largemouth bass, bluegill, yellow perch, black bullhead (*Ameiurus melas*), and black crappie (*Pomoxis nigromaculatus*). The lake has been described as having a boom or bust fishery.

Table 1. Clear Lake surface water quality parameters from 1999 to 2007.

Date	Water temp. (°C)	D.O. (mg/L)	Secchi depth (cm)	pH	Salinity (ppt)	Phenolphthalein alkalinity (mg/L)	Total alkalinity (mg/L)	Specific conductivity (µS/cm)
05/2007	19	8.7	91	7.0	0.30	17	308	666
08/2006	21	8.1		7.1	0.30	0	257	649
08/2005	22			7.2		0	290	
09/2003		9.2						
09/2002	21	6.0		8.1		0	513	500
09/2001	18		60	7.2		0	205	486
07/2001 dusk	26	13.0		7.7		60	196	
07/2001 dawn	23	7.4		9.5		0	196	
09/2000	17		30	8.4		0	308	590
09/1999	16			8.2				

Results and Discussion

Low water levels did not allow for effective sampling with electrofishing or trap nets. Therefore, no further data analyses were conducted for bluegill, black crappie, or largemouth bass.

Bluegill

Bluegill relative abundance did increase from 2005 to 2006. However, proportional stock density (PSD) declined (Figure 1). There is evidence of bluegill reproduction every year in Clear Lake with strong year classes in 1995, 1996, 1999, and 2001. However, bluegills have rarely recruited to preferred length since 2001. Relative weights have consistently been similar to other Sandhill lakes (Table 2) (Paukert et al. 2002).

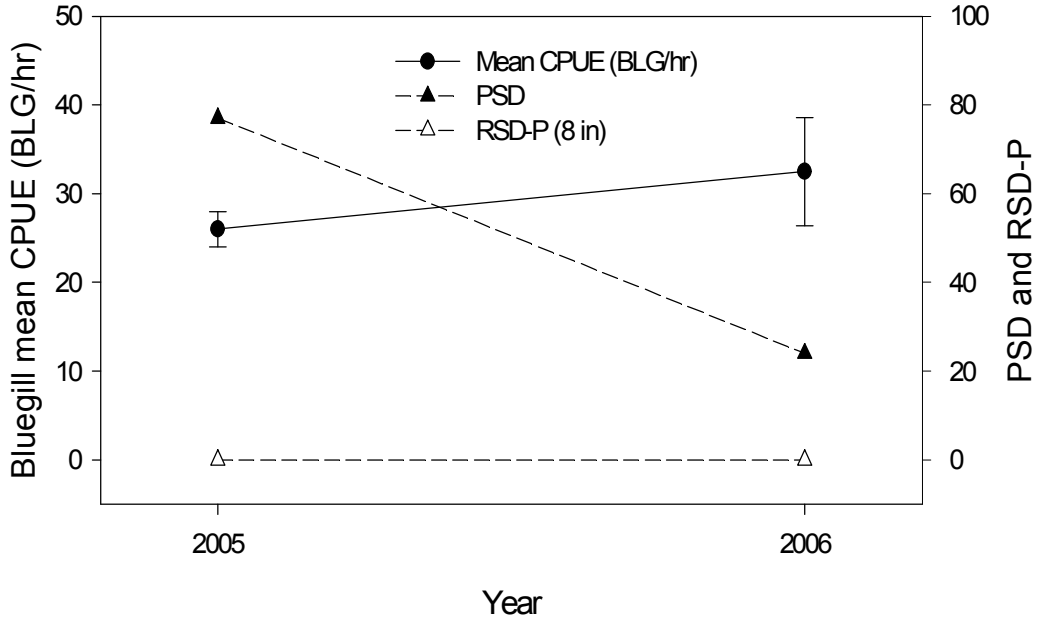

Figure 1. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of bluegills captured by electrofishing in Clear Lake from 2005 to 2006. Mean catch per unit effort (CPUE) calculated for bluegill ≥ stock length (80 mm) only.

Table 2. Bluegill mean relative weight (W_r) with standard error in parenthesis by length category captured by electrofishing and trap nets in Clear Lake from 1992 to 2007. Sampling for bluegill occurred during fall from 1992 to 2004 and during the spring from 2005 to 2007.

Year	Overall W_r	Stock - Quality (80-150 mm) (3-6 in)	Quality - Preferred (150-200 mm) (6-8 in)	Preferred - Memorable (200-250 mm) (8-10 in)	Memorable - Trophy (250-300 mm) (10-12 in)
2007	a	a	a	a	a
2006	115 (2.0)	116 (2.4)	114 (4.0)	b	b
2005	121 (3.2)	124 (5.4)	118 (2.8)	b	b
2004	b	b	b	b	b
2003	113 (22.8)	113 (22.8)	b	b	b
2002	99 (3.2)	100 (2.4)	86 (1.4)	b	b
2001	110 (2.1)	108 (2.0)	113 (6.5)	120 (9.7)	b
2000	113 (2.0)	112 (2.4)	113 (3.9)	124 (2.4)	b
1999	116 (1.5)	117 (2.2)	118 (1.9)	113 (3.9)	b
1998	107 (3.0)	99 (3.7)	120 (4.0)	115 (5.2)	b
1997	110 (4.2)	108 (2.6)	122 (16.0)	b	b
1996	118 (2.0)	116 (2.7)	122 (3.1)	123 (2.6)	b
1995	111 (1.8)	110 (2.1)	115 (3.3)	123 (2.5)	b
1994	133 (4.6)	115 (4.2)	142 (5.2)	152 (4.9)	b
1993	107 (6.7)	107 (6.7)	b	b	b
1992	a	a	a	a	a

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Common carp

The relative abundance of carp has decreased since 2005 and PSD remains near 100 (Figure 2). The length frequency distribution indicates an aging population with some recent reproduction and recruitment (Figure 3). In 2002 and 2004, a large number of sub-stock carp were captured in gill nets. It appears that those carp have recruited to the population as mean CPUE substantially increased in 2005 and 2006 (Figure 3). Sub-stock length carp were found in the stomachs of northern pike in the fall of 2006 and 2007.

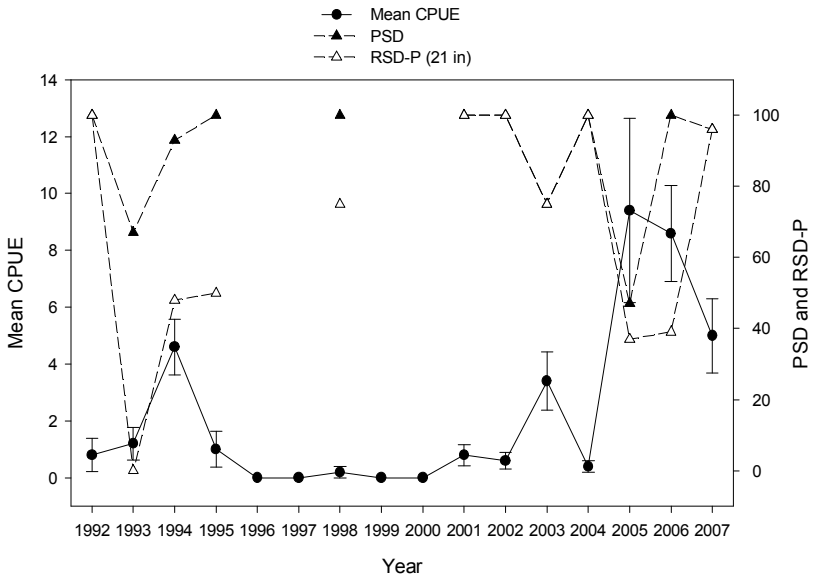

Figure 2. Annual relative abundance (carp/gill net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of common carp captured by gill net in Clear Lake from 1992 to 2007. Mean catch per unit effort (CPUE) calculated for carp ≥ stock length (280 mm) only.

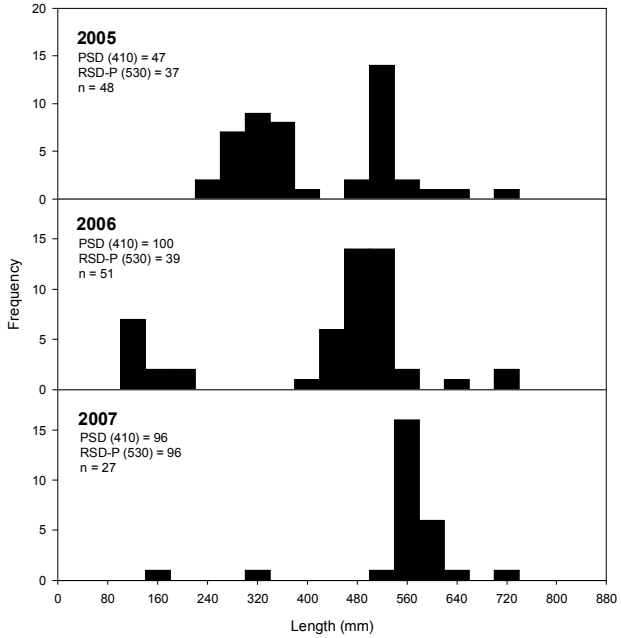

Figure 3. Length frequency distribution (40-mm length groups) of common carp captured in gill nets in Clear Lake, Valentine NWR, from 2005 to 2007.

Largemouth bass

Due to low water levels and lake morphology, it has been difficult to properly electrofish Clear Lake since 2001. The largemouth bass population in Clear Lake has generally been dominated by sub-stock length fish with few preferred length fish. Largemouth bass mean W_r has been similar to other Sandhill lakes (Table 3) (Paukert and Willis 2004)

Table 3. Largemouth bass mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing in Clear Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (200-300 mm) (8-12 in)	Quality - Preferred (300-380 mm) (12-15 in)	Preferred - Memorable (380-510 mm) (15-20 in)	Memorable - Trophy (510-630 mm) (20-25 in)
2007	a	a	a	a	a
2006	105 (7.1)	102 (7.3)	b	b	b
2005	116 (13.9)	94 (11.3)	b	137 (10.2)	b
2004	b	b	b	b	b
2003	b	b	b	b	b
2002	b	b	b	b	b
2001	b	b	b	b	b
2000	119 (9.6)	b	94 (2.1)	119 (9.6)	b
1999	134 (1.8)	136 (1.6)	b	122 (5.9)	b
1998	b	b	b	b	b
1997	b	b	b	b	b
1996	175 (27.8)	223 (4.8)	127 (2.3)	b	b
1995	120 (5.3)	b	113 (7.8)	b	b
1994	152 (2.7)	153 (2.1)	b	134 (1.2)	b
1993	b	b	b	b	b
1992	142 (4.6)	b	138 (4.3)	145 (9.1)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Northern Pike

In 2007, the northern pike population was dominated by quality to preferred and preferred to memorable length fish with no evidence of reproduction or recruitment in the last few years (Figure 4). Relative abundance is not significantly ($P \geq 0.20$) different since 1998 (Figure 5). However, a trend has developed as overall relative abundance has declined since 1992 (Figure 6). Northern pike relative abundance in Clear Lake appears to go in cycles with 2 year declines then a 2 -3 year increase (Figure 6). Changes in relative abundance may be due to fishing mortality. Ice fishing occurred almost exclusively in the month of December during the unusually warm winter of 2005-2006, while fishing pressure was high during December through February during the winter of 2006-2007. Mean W_r is stable (Table 4) and were similar to other Sandhill lakes (Paukert and Willis 2003). The relative abundance of preferred length ($\geq$ 28 in) fish has declined since 2006, but was similar compared to 1999 – 2005 (Figure 6). Since the 28 in. size limit in 1993, the most notable differences in RSD values have occurred for memorable to trophy length fish. Fish in this length category have been collected every year since 1996 with incremental RSD-M values ranging from 5 to 27 (Table 4).

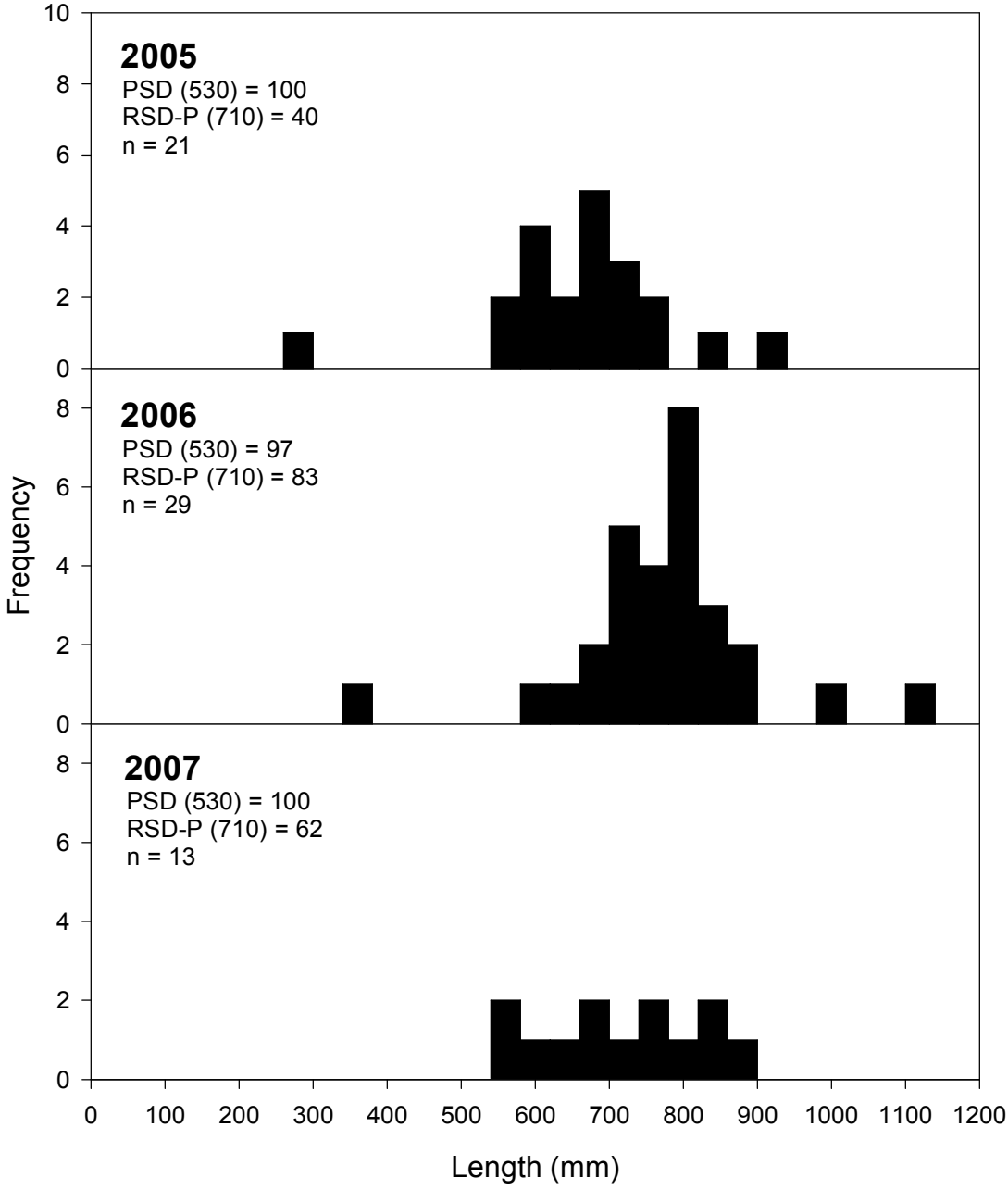

Figure 4. Length frequency distribution (40-mm length groups) of northern pike captured by gill nets during the fall in Clear Lake from 2005 to 2007.

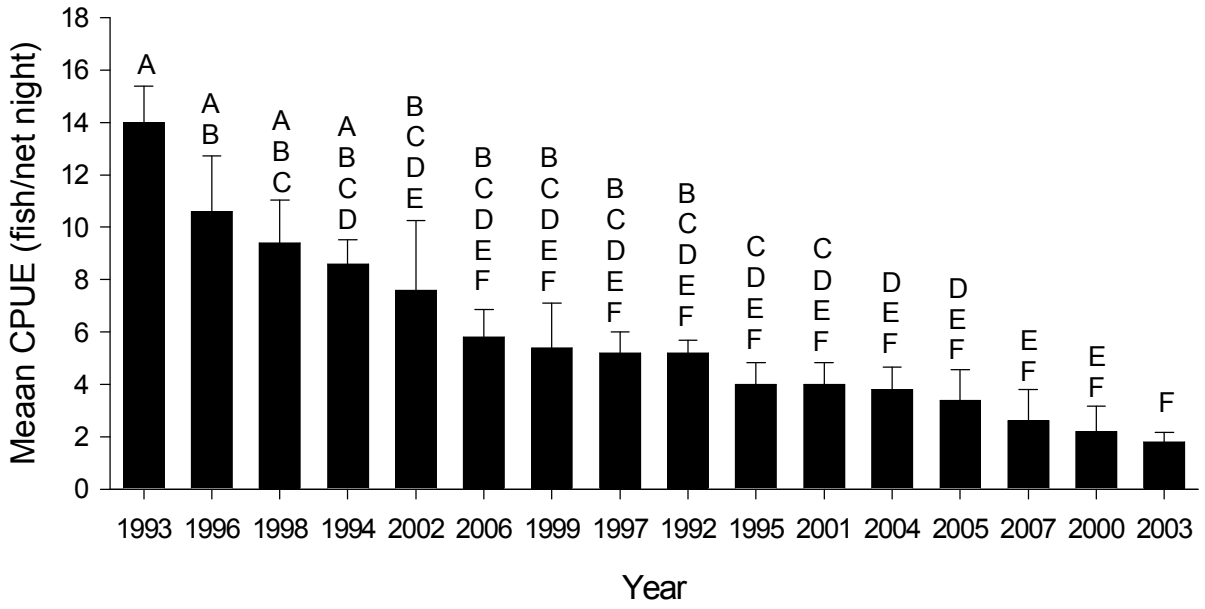

Figure 5. Northern pike gill net mean catch per unit effort (CPUE) in Clear Lake from 1992 to 2007. Years with the same letter are not significantly different (P > 0.20) using ANOVA with Tukey-Kramer multiple comparison test.

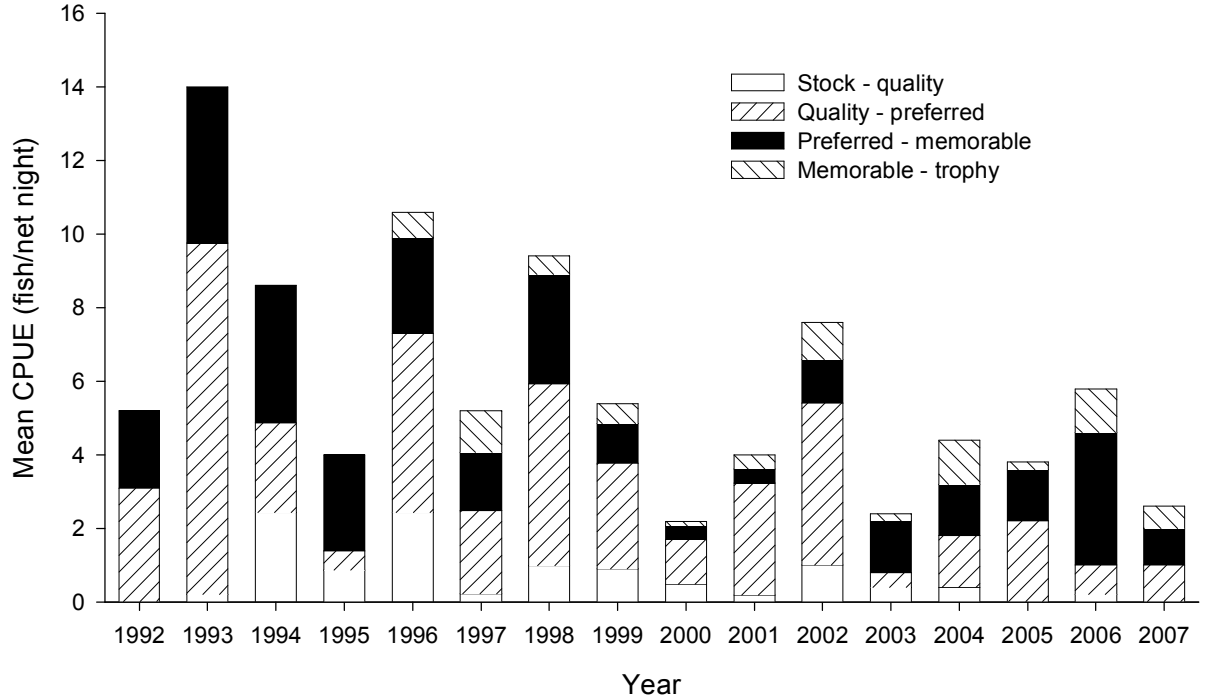

Figure 6. Gill net mean catch per unit effort (CPUE) for northern pike by length category in Clear Lake from 1992 to 2007.

Table 4. Population size structure, traditional proportional stock density (PSD) and incremental relative stock density (RSD) with relative weights (W_r) of northern pike in Clear Lake during the fall. 2006 – 2007 data for gill netting only. Data are pooled for trap and gill nets from 1988 to 2005. Data are summarized by length categories with 80% confidence intervals (+/-) and "a" denotes small sample size, confidence intervals could not be calculated.

Year	% ≥ Quality		S-Q (350-530mm) (14-21 in)			Q-P (530-710mm) (21-28 in)			P-M (710-860mm) (28-34 in)			M-T (860-1120mm) (34-44 in)		
	PSD	W_r	RSD	+/-	W_r	RSD	+/-	W_r	RSD	+/-	W_r	RSD	+/-	W_r
2007	100	96	0	a		38	a	98	38	a	97	23	a	87
2006	97	93	3	a	123	14	a	98	62	22	94	17	a	83
2005	100	93	0	a		60	a	92	35	a	95	5	a	86
2004	91	106	9	a	102	32	a	113	32	a	104	27	a	101
2003	83	89	17	a	89	17	a	100	58	a	88	8	a	79
2002	87	86	13	a	86	58	16	88	16	a	85	13	a	83
2001	95	87	5	a	100	76	16	87	10	a	74	10	a	98
2000	77	79	23	a	87	59	5	76	18	a	74	6	a	76
1999	80	84	20	a	83	53	14	82	20	12	87	10	a	94
1998	89	90	10	6	95	53	10	91	32	9	89	5	a	82
1997	96	94	4	a	100	46	7	105	29	6	93.0	21	6	97
1996	76	101	24	14	101	48	13	102	25	14	101	6	a	88
1995	78	95	22	14	99	13	13	98	63	15	92	0	a	
1994	71	105	28	9	115	28	9	98	43	11	95	0	a	
1993	98	97	1	a	97	68	11	101	30	9	98	0	a	
1992	100	96	0	a		60	9	96	40	9	97	0	a	
1991	100	92	0	a		87	a	94	13	a	90	0	a	
1990														
1989	93	90	7	a	95	68	a	90	23	a	80	2	a	87
1988	55	110	45	a	115	30	a	110	15	a	95	0	a	

Yellow perch

Relative abundance of stock length perch (≥ 130 mm) has remained constant since 2003, while PSD and RSD have substantially increased from 2005 to 2007 (Figure 7). There is no evidence of reproduction in the last few years and it appears that one or two year classes is recruiting to the preferred length group (Figure 8). Almost identical trends are occurring concurrently in the Dewey Lake yellow perch population. There appears to be low recruitment of yellow perch in Clear Lake, either due to environmental conditions or an abundance of predators, including bluegill, crappie, and yellow perch preying on yellow perch fry. Mean W_r declined in 2007 (Table 5), but is similar to other Sandhill lakes (Paukert and Willis 2001).

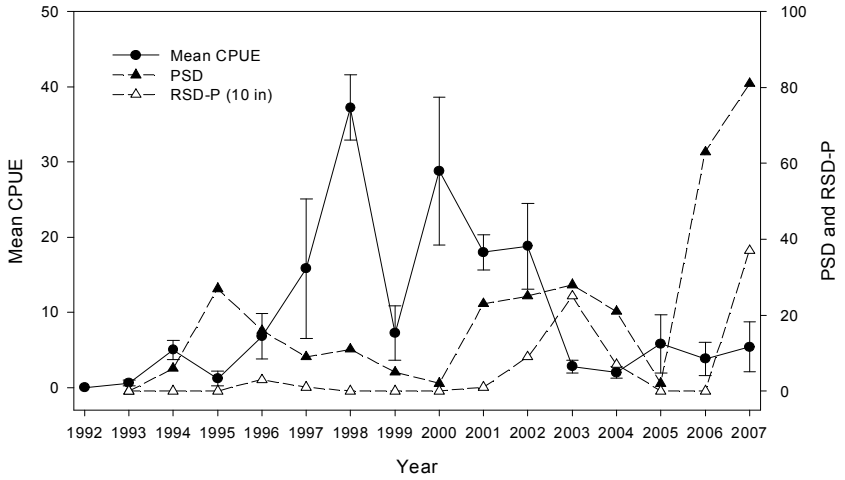

Figure 7. Annual relative abundance (perch/net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of yellow perch caught by gill nets in Clear Lake from 1992 to 2007. Mean catch per unit effort (CPUE) calculated for perch ≥ stock length (130 mm) only.

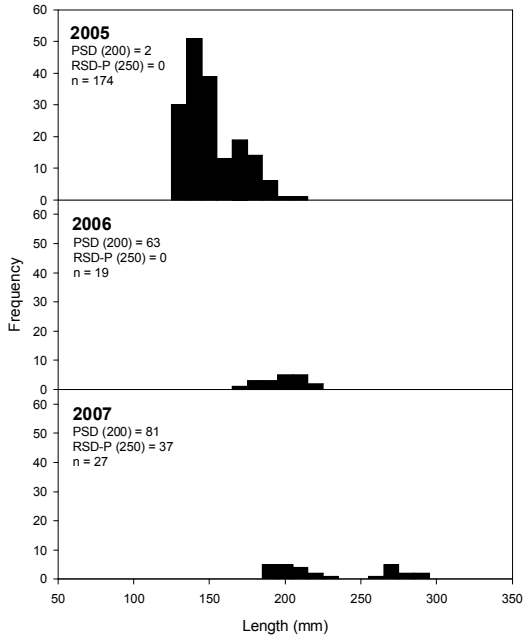

Figure 8. Length frequency distribution (10-mm length groups) for yellow perch captured in gill nets during the fall in Clear Lake from 2005 to 2007.

Table 5. Yellow perch mean relative weight (W_r) with standard errors (SE) in parenthesis by length category captured by gill nets in Clear Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (130-200 mm) (5-8 in)	Quality - Preferred (200-250 mm) (8-10 in)	Preferred - Memorable (250-300 mm) (10-12 in)	Memorable - Trophy (300-380 mm) (12-15 in)
2007	93 (1.6)	86 (2.9)	93 (2.7)	97 (1.5)	b
2006	100 (2.4)	108 (2.2)	96 (2.9)	b	b
2005	98 (2.0)	98 (2.0)	93 (2.7)	b	b
2004	105 (7.6)	110 (9.0)	82 (8.0)	b	b
2003	101 (2.2)	101 (3.4)	b	102 (1.6)	b
2002	91 (1.2)	87 (1.1)	93 (2.4)	100 (2.1)	106 (4.8)
2001	88 (1.3)	92 (1.8)	83 (1.4)	80 (1.2)	b
2000	94 (1.0)	94 (1.1)	94 (2.1)	b	b
1999	93 (1.6)	94 (1.8)	88 (1.3)	b	b
1998	103 (1.6)	99 (1.9)	111 (2.4)	99 (2.9)	b
1997	92 (1.7)	93 (1.9)	87 (4.2)	91 (0.0)	b
1996	96 (2.1)	99 (2.9)	93 (3.1)	88 (7.1)	b
1995	103 (7.4)	107 (9.9)	92 (1.9)	b	b
1994	94 (2.3)	91 (1.7)	115 (4.2)	b	b
1993	89 (4.2)	89 (4.2)	b	b	b
1992	b	b	b	b	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Summary

Common carp – There appears to be some carp reproduction in recent years. Even with the low abundance of northern pike, carp abundance has stabilized. In previous years it appeared that northern pike predation did not allow common carp to recruit to adult sizes in Clear Lake. Prior to 2005, the population of common carp was dominated by only a small number of preferred length and sub-stock fish. However, there was an increase in stock length carp in 2005 and 2006 after the large increase in sub-stock length fish in 2004. The low relative abundance of northern pike from 2003 to 2005 may have allowed carp recruitment.

Northern pike – Relative abundance of pike has remained similar to previous years. However, the overall trend has been a decline in abundance since 1993, the same year the 28 in. maximum length limit began. The northern pike population in Clear Lake was dominated by large individuals with minimal evidence of reproduction, recruitment, and/or increased harvest of pike (< 28 in.). Northern pike mean W_r was average compared to other sandhill lakes.

Largemouth bass – Low water levels did not allow largemouth bass sampling in 2007.

Yellow perch – There is no evidence of reproduction since 2004. One or two year classes have recruited to the preferred length in 2007 providing good angling opportunities for the first time in many years.

Bluegill – Low water levels did not allow bluegill sampling in 2007.

Management Recommendations

1. Continue the 28 in. maximum size limit for northern pike. Encourage catch and release for northern pike to maintain and increase the adult population.

2. Continue moving northern pike from West Long Lake to Clear Lake to supplement the adult population.

3. Continue annual surveys.

4. Extend boat ramp out to deeper water to improve access.

5. Build a handicap accessible fishing dock off the point just east of the boat ramp.

6. Add woody debris in Clear Lake during tree removal projects across the refuge to add fish and macroinvertebrate habitat and structure.

DEWEY LAKE

Lake Description

Dewey Lake is accessible by gravel roads from County Highway 16B or U.S. Highway 83. The lake is heavily utilized during the ice fishing season when accessible, but this can be difficult during rare winters with heavy snow. Angling pressure can also be heavy during spring and fall, but fishing pressure declines during summer when dense submergent vegetation covers much of the lake.

Dewey Lake is in the middle of a series of four lakes on the refuge connected by natural drainage or man-made ditches. A ditch was dug to connect Hackberry (the first in the series) to Dewey. A ditch was also dug from Dewey to Clear (downstream from Dewey), and Dewey now feeds into Clear. The interconnection of these lakes has created problems with controlling inter-lake fish movement in past years.

Dewey Lake is 223 surface ha (560 acres) with a maximum depth of 2.7 m (8 ft) and a mean depth of 1.4 m (4 ft). A dike on the east end of Dewey Lake allows the water to be held about 1.3 m above natural pool. The surrounding shoreline is predominately grassland with few willows and cottonwoods. The west end of the lake has an organic bottom comprised of a broad area of littoral vegetation with small areas of open water. The lake bottom on the north-east edge is sandy and sparsely vegetated; the south-east edge has an organic bottom and is heavily vegetated with emergent vegetation such as cattails and bulrushes (*Scirpus spp.*). During summer, submergent and emergent vegetation is abundant in a band around the lake's edge and is often referred to as "weed choked". The bottom of Dewey Lake is relatively flat with few drop-offs or depressions. The lake is too shallow to develop a summer thermocline. Summer surface water temperatures often exceed 30 °C (80 °F) and dense algae blooms are reported.

Dewey Lake was chemically renovated with rotenone in 1981 and restocked with game fish the following year (Appendix A). However, the renovation was either not 100% successful or carp migrated into Dewey from other lakes. Since the renovation, a fisherman reported catching a carp in 1984. In the spring of 1993, large numbers of carp were noted in the ditch between Dewey and White Water lakes, likely making an upstream spawning migration. These carp were removed with an estimated biomass of several tons. Northern pike size restrictions changed four times from 1987 to 1993 (Appendix B) to improve the abundance and size structure of northern pike in an effort to biologically control the carp population. Northern pike greater than 28 in. have been protected since 1993. The long-term trend for the northern pike population appears to be stable when considering relative abundance, size structure, and condition since enactment of these regulations.

Primary fish species include: yellow perch, northern pike, largemouth bass, bluegill, black bullhead, and carp. In 1987 and 1988, adult flathead catfish (*Pylodictis olivaris*) were stocked to control an expanding slow growing population of black bullhead.

Water quality parameters collected were water temperature, dissolved oxygen, pH, salinity, alkalinity, and conductivity (Table 1).

Table 1. Dewey Lake surface water quality parameters from 1999 to 2007.

Date	Water temp. (°C)	D.O. (mg/L)	Secchi depth (cm)	pH	Salinity (ppt)	Phenolphthalein alkalinity (mg/L)	Total alkalinity (mg/L)	Specific conductivity (µS/cm)
05/2007	20	7.4		7.4	0.2	0	205	304
08/2006	21	11.7		8.1	0.2	0	188	395
08/2005	23			8.5		0	240	320
09/2004	20		42	8.7		0	139	
09/2003	21	9.2						
09/2002	21	9.5		9.8		0	410	320
09/2001	18		66	7.0		0	145	346
07/2001 dusk	27	11.2		7.3		0	171	
07/2001 dawn	23	7.2		8.2		0	154	
09/2000	18		60	9.5		0	308	344
09/1999	15			11.5				

Results and Discussion

Bluegill

In 2007, relative abundance of stock length bluegill remained high (133 bluegill/hr [SE = 40.9]), and PSD and RSD values were also similar to 2006 levels (Figure 1). The bluegill population in Dewey Lake continues to be dominated by stock to quality length fish (Figure 2). Bluegill mean W_r is similar to other Sandhill lakes and also continues to have low variation among years and length categories (Table 2).

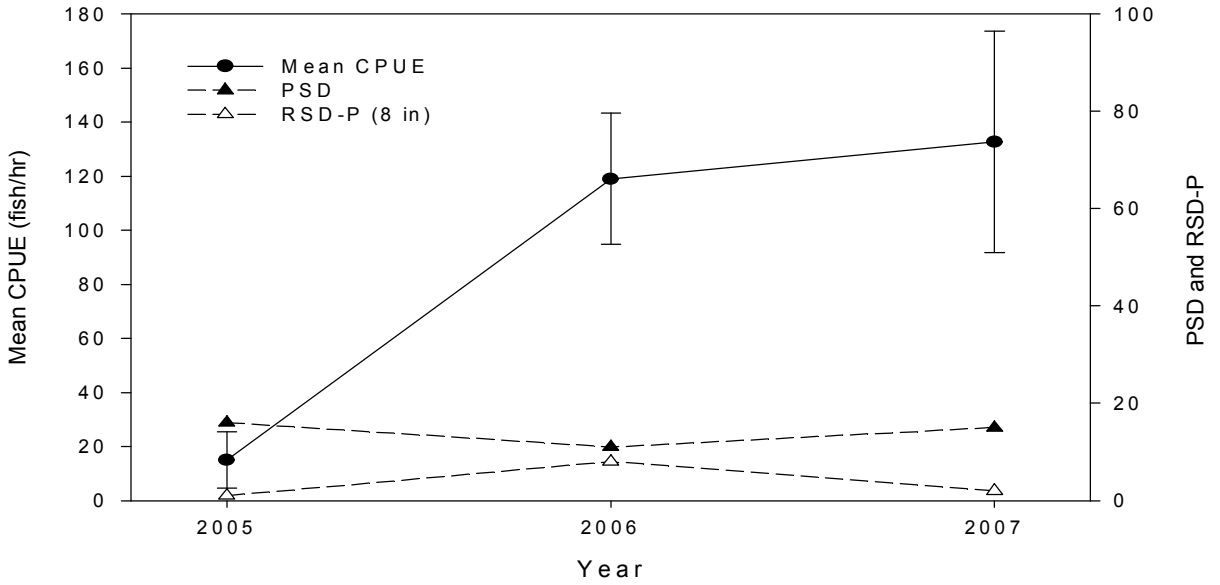

Figure 1. Annual relative abundance (fishl/hr), proportional stock density (PSD), and relative stock density (RSD-P) of bluegills captured by electrofishing during the spring in Dewey Lake from 2005 to 2007. Mean catch per unit effort (CPUE) calculated for bluegill ≥ stock length (80 mm) only.

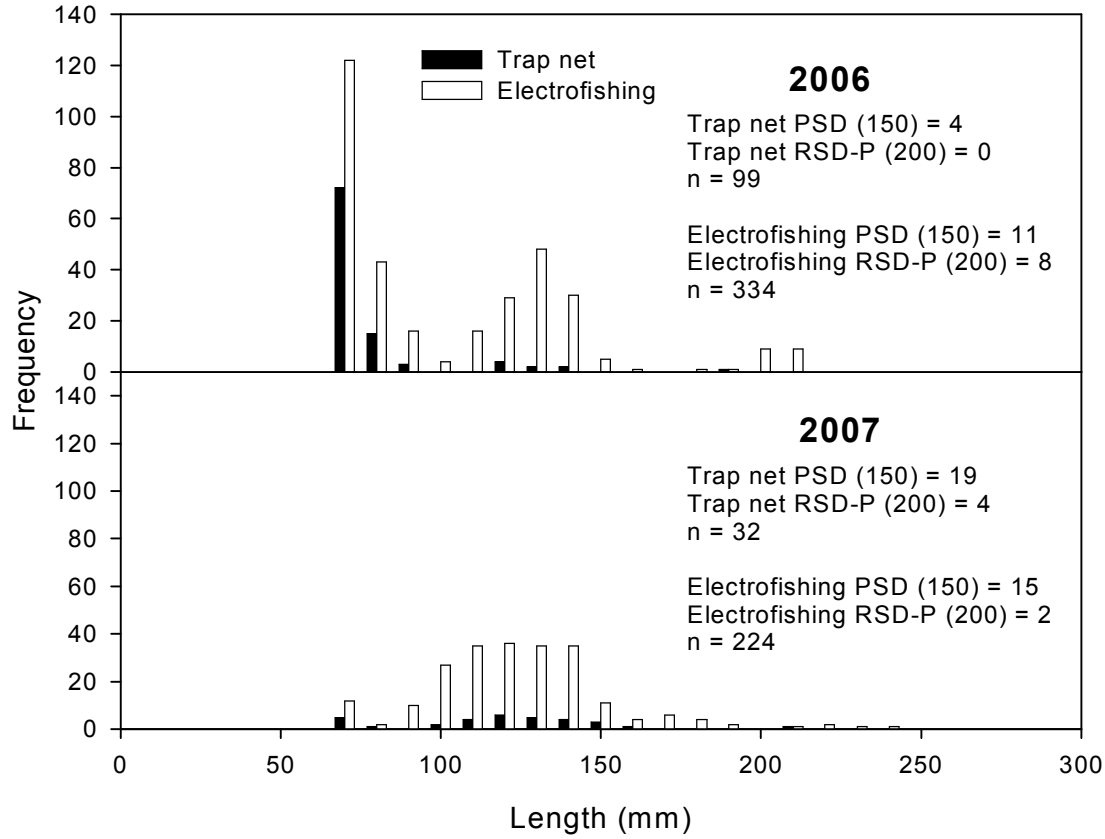

Figure 2. Length frequency distribution (10-mm length groups) for bluegill captured in trap nets and electrofishing during the spring in Dewey Lake from 2006 and 2007.

Table 2. Bluegill mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing and trap nets in Dewey Lake from 1992 to 2007. Sampling occurred during fall from 1992 to 2004 and during the spring from 2005 to 2007.

Year	Overall W_r	Stock - Quality (80-150 mm) (3-6 in)	Quality - Preferred (150-200 mm) (6-8 in)	Preferred - Memorable (200-250 mm) (8-10 in)	Memorable - Trophy (250-300 mm) (10-12 in)
2007	122 (2.1)	125 (2.7)	118 (3.7)	116 (5.2)	b
2006	120 (1.5)	119 (1.7)	126 (3.1)	119 (4.9)	b
2005	114 (1.5)	115 (1.8)	113 (2.6)	b	b
2004	117 (1.4)	114 (1.7)	119 (2.2)	128 (2.1)	b
2003	115 (2.1)	116 (2.6)	115 (3.8)	b	b
2002	115 (1.4)	115 (1.9)	117 (2.1)	b	b
2001	118 (2.9)	118 (3.1)	b	111 (4.5)	b
2000	114 (2.2)	111 (4.0)	118 (2.2)	114 (3.5)	b
1999	124 (1.7)	123 (2.0)	124 (6.4)	123 (1.7)	b
1998	119 (2.1)	118 (3.4)	123 (3.2)	109 (3.6)	b
1997	115 (1.5)	116 (2.7)	114 (1.9)	119 (4.8)	b
1996	121 (1.9)	123 (3.1)	119 (1.9)	117 (2.1)	b
1995	120 (2.2)	116 (1.6)	138 (9.5)	129 (6.0)	b
1994	125 (2.7)	115 (3.0)	140 (2.3)	147 (0.5)	b
1993	114 (2.5)	119 (3.2)	106 (3.3)	b	b
1992	108 (1.3)	107 (1.6)	112 (2.9)	115 (1.4)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Common carp

In 2007, there was a substantial increase in the relative abundance of stock length carp in Dewey Lake with a corresponding decline in PSD and RSD (Figure 3). Mean CPUE was low from 1992 to 2006 and PSD and RSD-P has remained high during the same time period indicating low or no recruitment until this year. The carp population is dominated by stock to quality length fish as the sub-stock length (< 280 mm) carp in 2006 did recruit to the population (Figure 3).

During the spring of 1993, refuge personnel trapped and killed large numbers of carp in the ditch between Dewey and White Water lakes, which may have contributed, to the decline noted in the fall 1993 surveys.

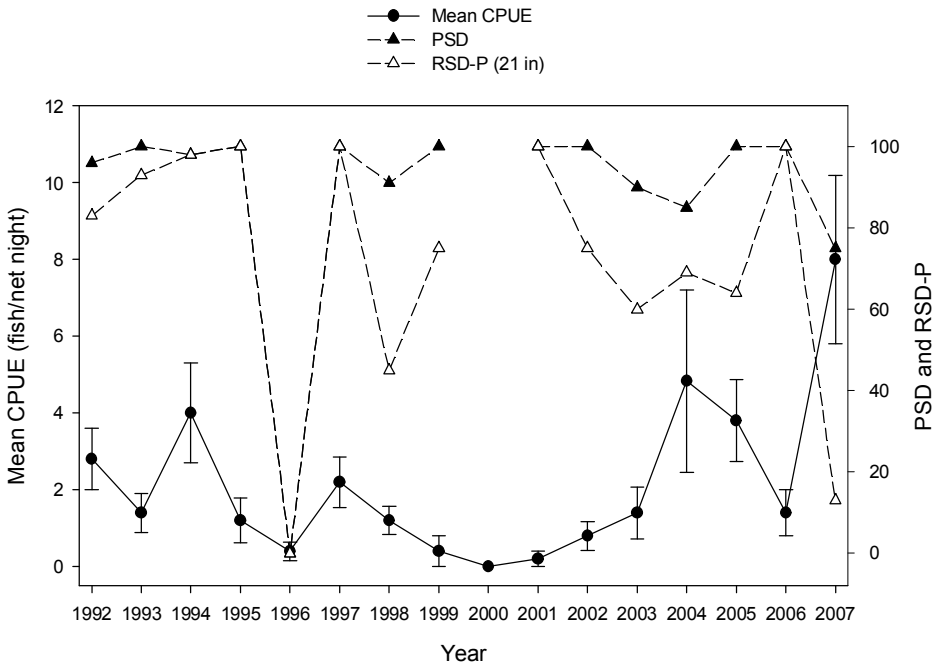

Figure 3. Annual relative abundance (fish/net night with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of common carp caught by gill nets during the fall in Dewey Lake from 1992 to 2007. Mean catch per unit effort (CPUE) calculated for carp ≥ stock length (280 mm) only.

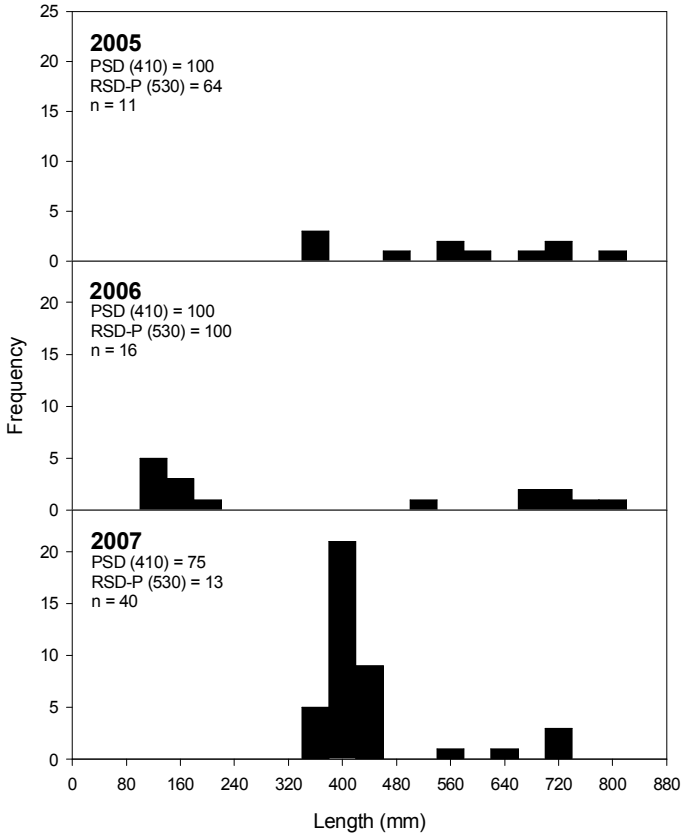

Figure 4. Length frequency distribution (40-mm length groups) of common carp captured in gill nets during the fall in Dewey Lake from 2005 to 2007.

Largemouth bass

Relative abundance continued to decline from a high of 22 fish/hr (SE = 8.2) in 2005 to 5 fish/hr (SE = 1.2) in 2007 (Figure 5). The population in Dewey Lake went from a somewhat "balanced" population in 2005, to a population dominated by sub-stock length fish and few preferred length fish (Figure 6). Mean W_r did increase in 2007 and is above average compared to other Sandhill lakes (Table 3). Largemouth bass fall electrofishing mean CPUE for stock size and larger fish was less than 10 fish/hour from 1989 to 2004. Prior to 2005, length frequency data indicated strong year classes but few of these fish recruited to larger sizes in subsequent years.

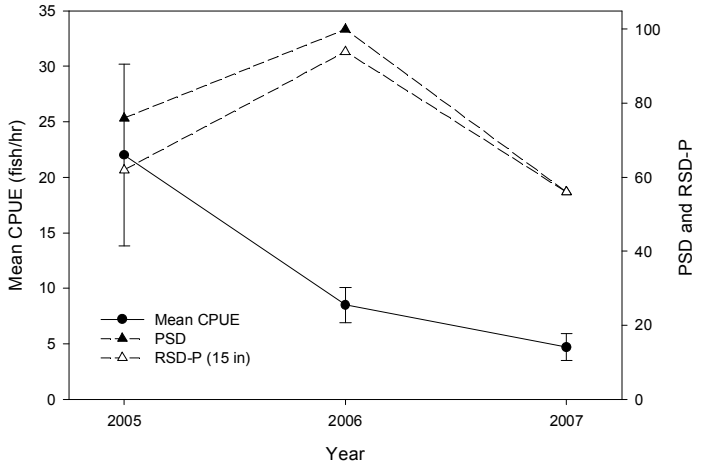

Figure 5. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of largemouth bass captured by electrofishing during the spring in Dewey Lake from 2005 to 2007. Mean catch per unit effort (CPUE) calculated for largemouth bass ≥ stock length (200 mm) only.

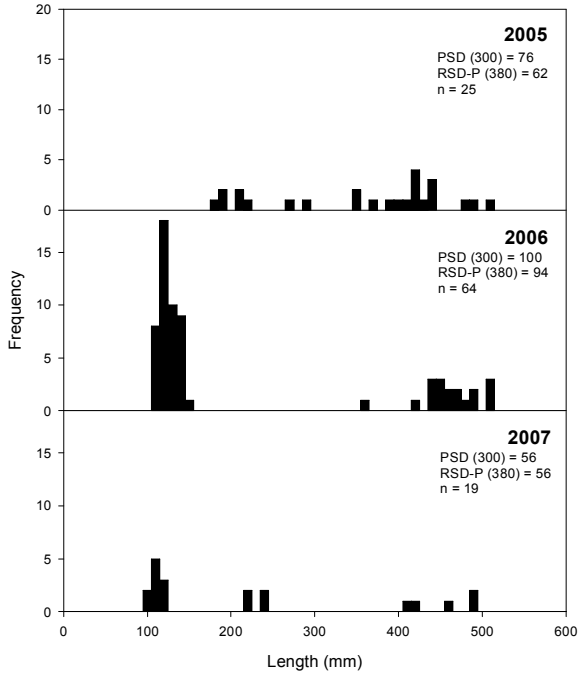

Figure 6. Length frequency distribution (10-mm length groups) for largemouth bass captured by electrofishing during the spring in Dewey Lake from 2005 to 2007.

Table 3. Largemouth bass mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing in Dewey Lake from 1992 to 2007. Sampling occurred during fall from 1992 to 2004 and during the spring from 2005 to 2007.

Year	Overall W_r	Stock - Quality (200-300 mm) (8-12 in)	Quality - Preferred (300-380 mm) (12-15 in)	Preferred - Memorable (380-510 mm) (15-20 in)	Memorable - Trophy (510-630 mm) (20-25 in)
2007	129 (4.0)	115 (2.2)	b	135 (5.8)	b
2006	108 (3.3)	b	b	108 (4.2)	119 (1.7)
2005	135 (2.2)	128 (4.0)	142 (2.7)	135 (3.0)	b
2004	130 (2.1)	130 (3.3)	122 (4.1)	132 (2.9)	b
2003	117 (13.7)	b	b	b	b
2002	127 (2.5)	129 (4.1)	b	125 (3.3)	b
2001	b	b	b	b	b
2000	118 (4.0)	123 (3.7)	100 (7.1)	122 (5.7)	b
1999	131 (1.6)	131 (2.0)	128 (2.5)	b	b
1998	b	b	b	b	b
1997	93 (1.1)	130 (2.6)	b	131 (10.7)	b
1996	135 (2.3)	138 (2.6)	133 (3.4)	117 (5.6)	b
1995	137 (3.4)	137 (3.6)	b	b	b
1994	154 (6.4)	110 (1.9)	163 (9.2)	146 (3.8)	b
1993	131 (8.4)	122 (3.3)	141 (15.2)	b	b
1992	106 (12.5)	106 (12.5)	b	b	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Northern pike

The size structure of northern pike in Dewey Lake has remained nearly constant from 2005 to 2007 (Figure 7). The relative abundance of pike in 2007 (gill net mean CPUE = 8.2; SE = 1.5) was not significantly different ($P > 0.20$) from all years since standardized sampling began in 1992, except for 2004 (Figure 8). There has been a gradual increase in relative abundance since an all time low in 2005 (gill net mean CPUE = 3.6; SE = 1.5), especially in quality to preferred and memorable to trophy length categories (Figure 9). Overall mean W_r increased in 2007 (mean W_r = 100) compared to the mean W_r's from 1998 to 2006 (Table 4) and remained above average compared to other Sandhill lakes.

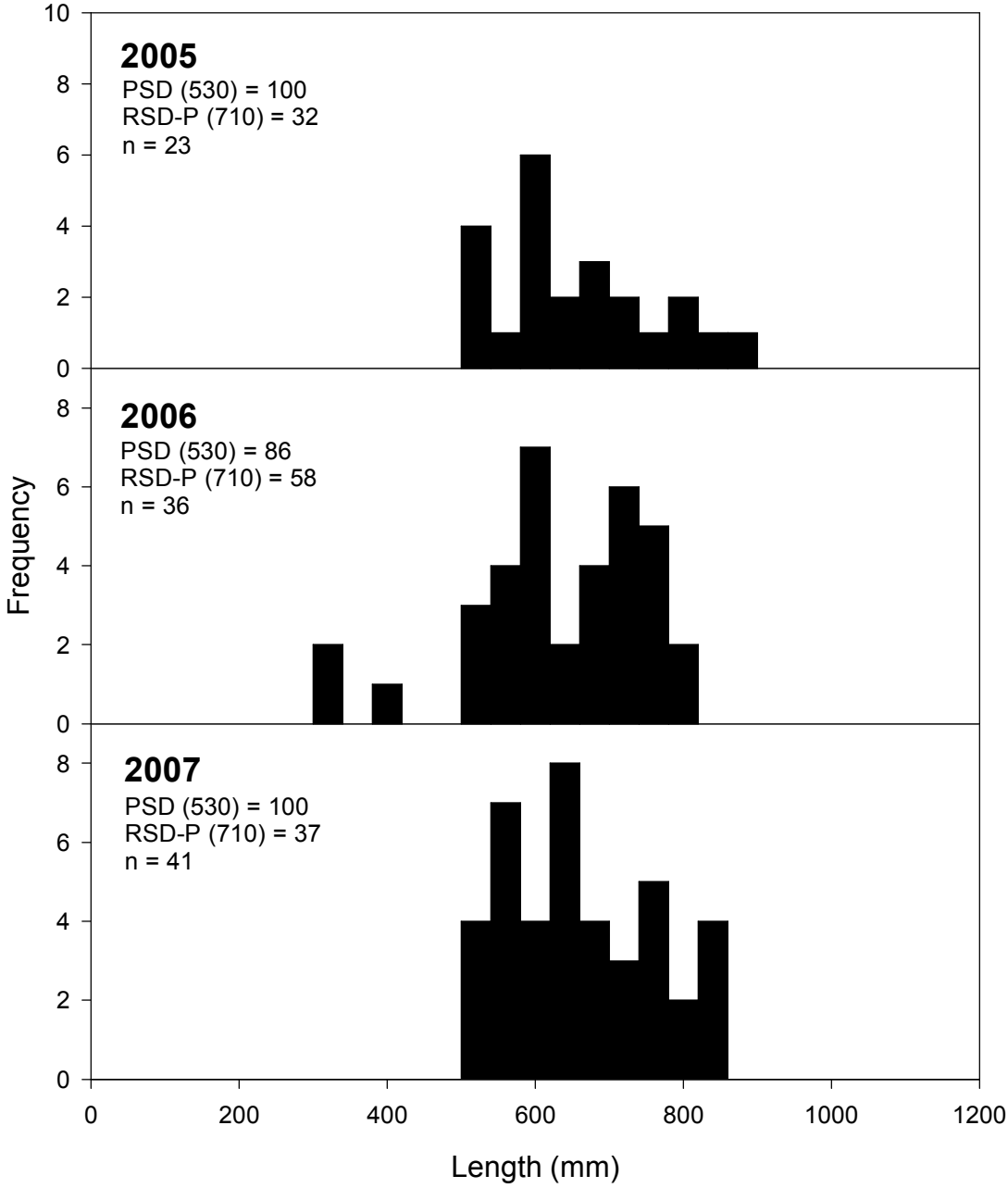

Figure 7. Length frequency distribution (40-mm length groups) for northern pike captured in gill nets during the fall in Dewey Lake from 2005 to 2007.

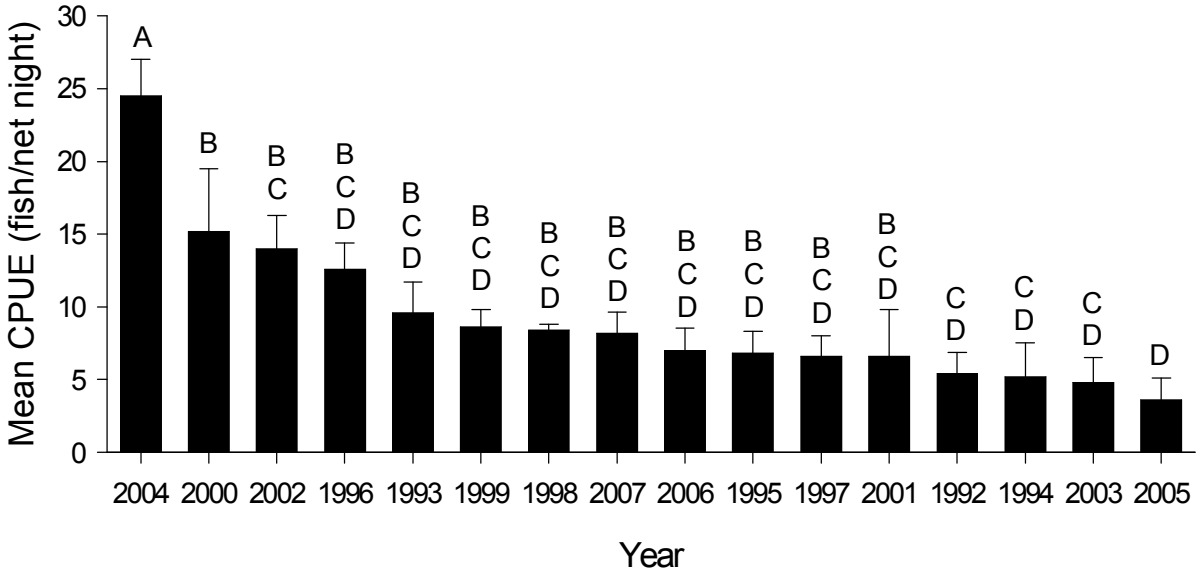

Figure 8. Northern pike gill net mean catch per unit effort (CPUE) with SE bars for Dewey Lake from 1992 to 2007. Years with the same letter are not significantly different (P > 0.20) using ANOVA with Tukey-Kramer multiple comparison test.

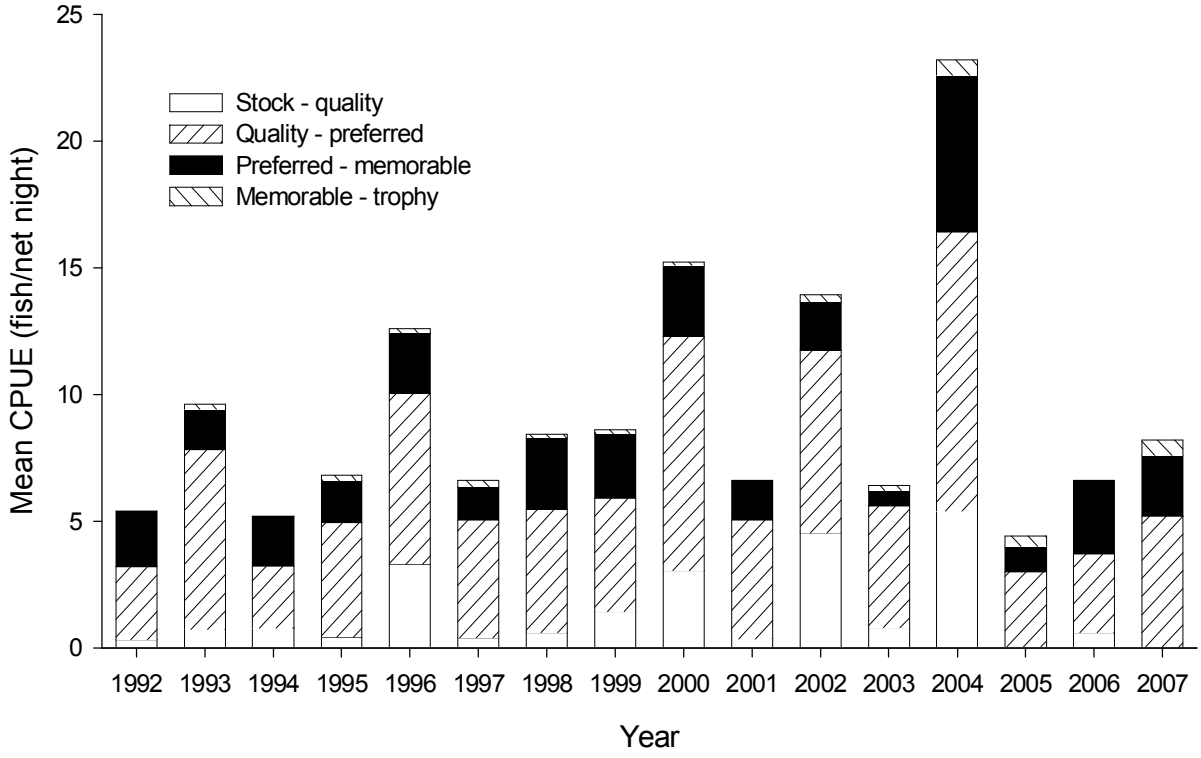

Figure 9. Gill net mean catch per unit effort (CPUE) for northern pike by length category in Dewey Lake from 1992 to 2007.

Table 4. Population size structure, traditional proportional stock density (PSD) and incremental relative stock density (RSD) with relative weights (W_r) of northern pike in Dewey Lake, Valentine NWR during the fall. 2006 and 2007 data for fall gill netting only. Data are pooled for trap and gill nets from 1987 to 2005. Data are summarized by length categories with 80 % confidence intervals (+/-) and "a" denotes small sample size, confidence intervals could not be calculated.

Year	% ≥ Quality		S-Q (350-530mm) (14-21 in)			Q-P (530-710mm) (21-28 in)			P-M (710-860mm) (28-34 in)			M-T (860-1120mm) (34-44 in)		
	PSD	W_r	RSD	+/-	W_r	RSD	+/-	W_r	RSD	+/-	W_r	RSD	+/-	W_r
2007	100	100	0	a		63	16	104	29	a	95	7	a	81
2006	91	98	9	a	133	47	a	111	44	22	76	0	a	
2005	100	89	0	a	a	100	a	93	32	a	81	9	a	78
2004	79	97	21	11	98	47	9	103	27	11	92	3	a	88
2003	88	94	12	a	104	75	12	94	9	a	89	3	a	86
2002	62	84	38	13	80	40	12	87	19	a	88	3	a	89
2001	95	95	5	a	109	71	99	90	24	10	85	0	a	
2000	80	90	20	9	87	62	7	71	17	6	79	1	a	84
1999	78	91	22	7	88	52	10	91	30	9	94	2	a	91
1998	89	92	11	7	90	54	10	92	33	9	92	2	a	80
1997	87	100	13	8	105	63	10	102	25	9	96	5	a	99
1996	69	103	31	9	101	48	11	105	19	9	104	1	a	96
1995	93	107	7	9	122	61	12	107	28	11	106	4	9	103
1994	86	103	14	9	115	47	12	103	38	12	97	0	a	
1993	92	98	8	9	111	71	8	99	21	a	98	0	a	
1992	94	85	6	8	100	51	9	85	43	8	83	0	a	
1991	95	88	5	a	94	59	a	91	36	a	86	0	a	
1990	96	90	4	a	84	72	a	87	24	a	93	0	a	
1989	88	103	12	a	95	65	a	97	19	a	102	4	a	109
1988	85	110	15	a	110	75	a	105	10	a	105	0	a	
1987	17	110	83	a	95	12	a	90	5	a	96	0	a	

Yellow perch

Relative abundance of yellow perch slightly increased in 2007 (gill net mean CPUE = 15; SE = 5.9), but remains low compared to the mid-90's (Figure 10). The PSD/RSD values declined during the years with strong year classes but this is usually a reflection of the increased abundance of smaller fish. The yellow perch population is dominated by stock to quality length fish with few preferred length fish (Figure 11). Overall mean W_r did improve in 2007, is above average for Sandhill lakes, but remained below the highs seen in the mid-90's (Table 5).

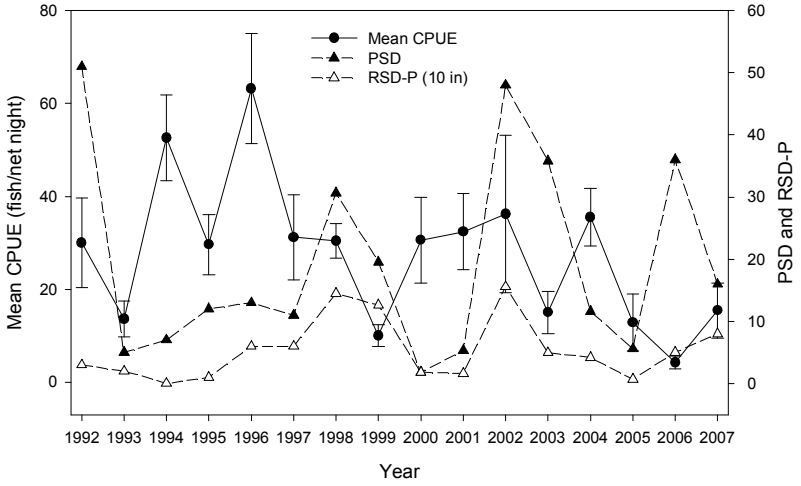

Figure 10. Annual relative abundance (perch/net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of yellow perch captured by gill nets during the fall in Dewey Lake from 1992 to 2007. Mean catch per unit effort (CPUE) calculated for perch ≥ stock length (130 mm) only.

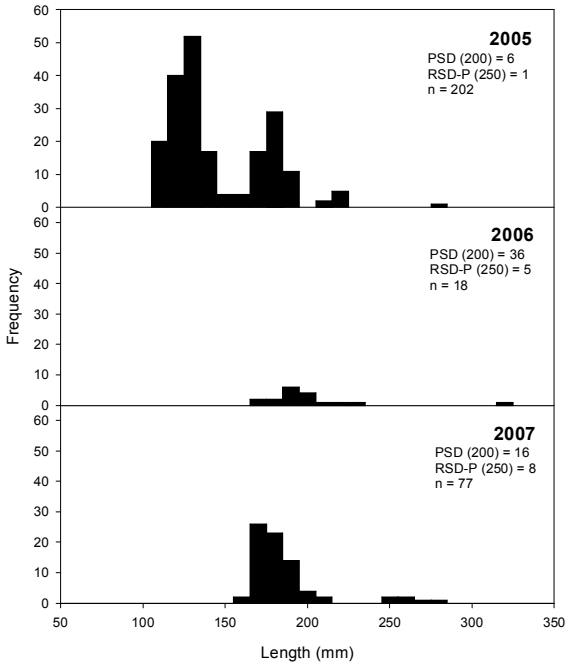

Figure 11. Length frequency distribution (10-mm length groups) of yellow perch captured in gill nets during the fall in Dewey Lake from 2005 to 2007.

Table 5. Yellow perch mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by gill nets during the fall in Dewey Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (130-200 mm) (5-8 in)	Quality - Preferred (200-250 mm) (8-10 in)	Preferred - Memorable (250-300 mm) (10-12 in)	Memorable - Trophy (300-380 mm) (12-15 in)
2007	98 (1.9)	102 (2.0)	92 (3.8)	87 (4.2)	b
2006	94 (2.5)	116 (5.2)	95 (3.8)	b	b
2005	96 (0.9)	97 (1.0)	93 (1.2)	b	b
2004	97 (2.1)	88 (2.1)	106 (5.0)	100 (2.6)	b
2003	101 (2.0)	97 (1.6)	104 (5.3)	110 (3.6)	b
2002	98 (1.2)	97 (2.1)	102 (1.5)	103 (2.3)	b
2001	115 (1.4)	95 (2.1)	82 (3.4)	b	101 (3.7)
2000	92 (1.3)	93 (1.30	b	86 (4.6)	84 (0.1)
1999	99 (1.2)	96 (1.4)	105 (2.3)	102 (2.8)	108 (3.8)
1998	99 (1.0)	95 (1.1)	103 (2.0)	103 (2.3)	101 (2.1)
1997	106 (2.0)	102 (1.5)	112 (7.0)	111 (2.7)	109 (1.2)
1996	102 (1.4)	99 (1.4)	107 (2.6)	103 (3.8)	100 (1.5)
1995	106 (0.9)	103 (1.2)	109 (1.2)	106 (2.9)	b
1994	109 (1.5)	108 (2.1)	110 (1.9)	b	b
1993	108 (2.8)	111 (2.7)	85 (8.7)	98 (8.5)	b
1992	98 (1.3)	100 (2.3)	96 (1.8)	94 (2.3)	102 (6.3)

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Summary

Common carp – The relative abundance of carp substantially increased in 2007. Mean CPUE was low from 1992 to 2006 and PSD and RSD-P remained high during the same time period indicating low or no recruitment until this year. The carp population is dominated by stock to quality length fish as the sub-stock length (< 280 mm) carp in 2006 did recruit to the population

Northern pike – The long-term trends for the northern pike population appears to be stable when considering relative abundance, size structure, and condition. However, it does appear that a strong year class of carp did recruit to the population during the same time of lower than normal northern pike abundances from 2005 to 2007. Northern pike are also likely controlling abundance and size structure of other important game species in Dewey Lake.

Bluegill - In 2007, the bluegill population in Dewey Lake was dominated by sub-stock and stock to quality length fish and maintained a high relative abundance.

Yellow perch – In 2007, the relative abundance and mean W_r of yellow perch in Dewey Lake did improve compared to recent years, but remains below the highs of the mid-90's.

Largemouth bass – Relative abundance of largemouth bass continues to decline in Dewey Lake from a high of 22 LMB/hr (SE = 8.2) in 2005. The population is out of balance as it is dominated by sub-stock length fish and few preferred length fish. Mean W_r is above average compared to other Sandhill lakes.

Management Recommendations

1. Maintain the current size regulations and monitor abundance and size structure of northern pike and the fish community.

2. Continue annual surveys.

3. Improve handicap fishing access. Include a large concrete pad for parking and wheel chair access near the dock. Mow overgrown vegetation around the dock throughout the summer. Extend handicap accessible ramp to deeper waters. Construct a new, roomier dock for handicap access.

HACKBERRY LAKE

Lake Description

Hackberry Lake is adjacent to the Refuge's headquarters and is easily accessible from State Highway 16B. This lake receives heavy fishing pressure during winters when other refuge trails and fishing lakes are inaccessible. Angling is greatest during the ice fishing season through late spring/early summer and then declines as the lake becomes heavily vegetated.

Hackberry Lake is the first in a series of four lakes on the refuge that are connected by natural drainage or man-made ditches. In high water years, a water control structure between Hackberry and Dewey Lake (the next lake downstream) controls water levels in Hackberry. During the spring and summer of 1995-1997, lake levels were near record highs and many lakes and creeks were connected. These connections allowed carp migration.

Hackberry Lake is 275 surface ha (680 ac). Maximum and mean depths are 1.8 m (5 ft.) and 1.0 m (3 ft.), respectively. The lake bottom is relatively flat and highly organic. The lake is too shallow to thermally stratify. Abundant decaying organic matter has reduced dissolved oxygen levels to less than 1 ppm during winters with extended ice cover resulting in periodic winter-kills. Summer-kills have also been noted but are usually less severe. Emergent vegetation (cattail and bulrush) dominates the entire lake edge. Because the lake is shallow, heavily vegetated, and relatively alkaline, dense algae blooms are common and likely contribute to the periodic summer fish kills. During summer, the entire lake is essentially a large littoral area with dense submergent vegetation. Specific conductivity averages 407 µS/cm, total alkalinity averages 204 mg/L, phenolphthalein alkalinity averages 38 mg/L, pH ranges from 8.5 during winter/spring to 10 during summer. Secchi disk averages 0.3 m during summer. The surrounding watershed consists of mixed grass sandhills, which are lightly grazed by cattle.

Hackberry Lake has a history of high carp abundance. In 2004, the Refuge and NGPC cooperated in a joint effort to lower Hackberry Lake and chemically renovate the fishery. Draw down began in August of 2004 and the lake was chemically renovated using rotenone. By October 2004, Hackberry Lake was declared carp free and fish stockings were initiated during the fall of 2004 with additional stockings since (Appendix A). The last chemical renovation prior to 2004 was conducted in 1975. Hackberry Lake was presumed to be carp free until carp were captured during the 1988 surveys. From 1988 to 1992, Hackberry Lake was identified as the "control lake" for evaluating northern pike as a biological agent for controlling carp recruitment and followed state size and bag limits. During January 1992, the 36" northern pike minimum size limit was extended to include Hackberry Lake. During the 1992 northern pike spawning operation, approximately 1,000 northern pike collected from Pelican Lake were transferred to Hackberry Lake to increase the northern pike population in the lake. Beginning January 1993, regulations were implemented to allow the harvest of northern pike 28 in. or less (Appendix B).

The primary fish species in Hackberry Lake are largemouth bass, yellow perch, and bluegill.

Historical surface water quality parameters are reported in Table 1.

Table 1. Hackberry Lake surface water quality parameters.

Date	Water temp. (°C)	D.O. (mg/L)	Secchi depth (cm)	pH	Salinity (ppt)	Phenolphthalein alkalinity (mg/L)	Total alkalinity (mg/L)	Specific conductivity (µS/cm)
08/2002	20	11.0		9.7		137	393	430
09/2001	18		75	7.2		8	154	368
07/2001 dusk	28	12.0		7.1		17	137	
07/2001 dawn	23	4.0		8.0		17	137	
09/2000	18		30	8.5		10	200	425
09/1999	16			7.1				

Results and Discussion

Bluegill

Only 3 stock to quality length and 7 sub-stock bluegills were captured during 2 h of electrofishing in May 2007. Large numbers of dead bluegill were observed during the spring of 2007 after ice out indicating a winter-kill.

Common carp

No carp were observed in 2.0 h of electrofishing in 2007.

Largemouth bass

Only three stock to quality length fish were captured in 2007. Relative abundance decreased from 17.5 LMB/hr in 2006 to 1.5 LMB/hr (SE = 1.1) in 2007. Large numbers of dead largemouth bass were observed during the spring of 2007 indicating a winter-kill.

Northern pike

No northern pike were observed in 2.0 h of electrofishing.

Yellow perch

Although electrofishing is not typically used in standard surveys for yellow perch, we attempted to capture all fish we encountered in our post-renovation survey of Hackberry Lake.

The relative abundance of stock length perch in Hackberry substantially increased from 2006 to 2007 (Figure 1). The size structure is improving with a large number of quality to preferred length fish (Figure 2). However, mean W_r substantially decreased from 2006 to 2007 (Table 1). Mean W_r of yellow perch in Hackberry Lake is still above average for Sandhill lakes.

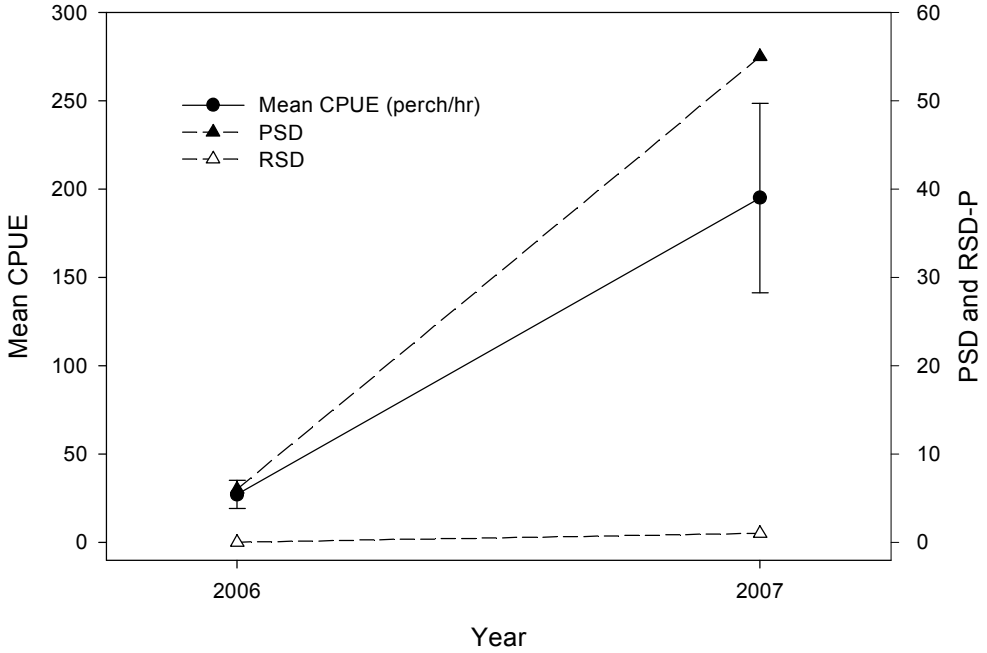

Figure 1. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of yellow perch captured by electrofishing during spring in Hackberry Lake from 2006 to 2007. Mean catch per unit effort (CPUE) calculated for yellow perch ≥ stock length (130 mm) only.

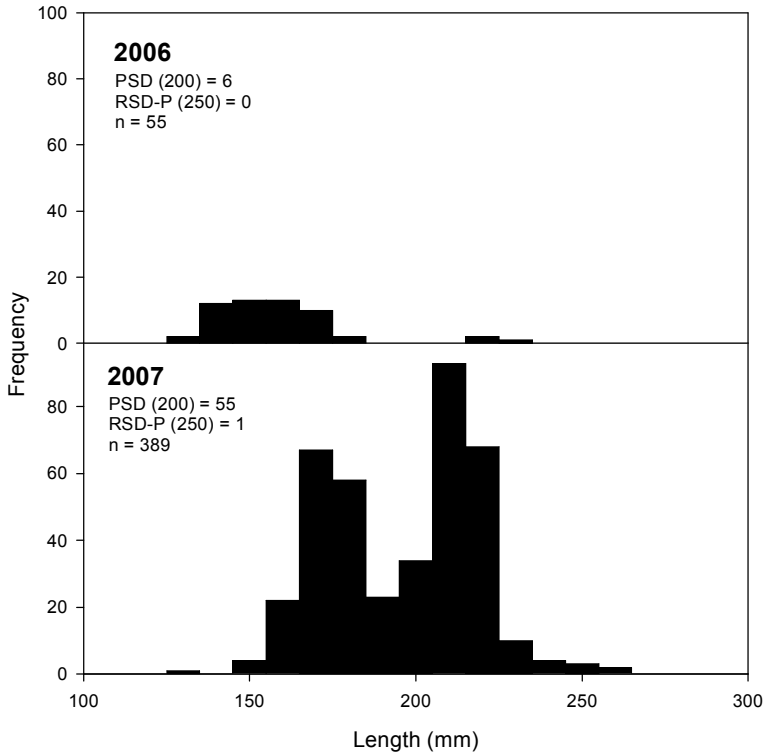

Figure 2. Length frequency distribution (10-mm length groups) of yellow perch captured by electrofishing during spring in Hackberry Lake from 2006 to 2007.

Table 1. Yellow perch mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing during spring in Hackberry Lake from 2006 to 2007.

Year	Overall W_r	Stock - Quality (130-200 mm) (5-8 in)	Quality - Preferred (200-250 mm) (8-10 in)	Preferred - Memorable (250-300 mm) (10-12 in)	Memorable - Trophy (300-380 mm) (12-15 in)
2007	95 (1.0)	93 (1.2)	97 (1.7)	95 (1.7)	b
2006	108 (3.4)	107 (3.7)	115 (8.1)	b	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Summary

Common carp – No carp were observed since the renovation in 2004.

Northern pike – No northern pike were observed since the renovation in 2004.

Largemouth bass – A significant winter-kill during the winter of 2006-2007 reduced the largemouth bass population in Hackberry Lake.

Yellow perch – Mean W_r was exceptional for yellow perch indicating an abundance of prey.

Bluegill – Winter-kills likely influenced the low numbers of bluegill observed.

Management Recommendations

1. Continue electrofishing in the spring to evaluate the fish stockings.

2. Re-evaluate bluegill and largemouth bass stocking. Consider managing Hackberry Lake as a yellow perch only or a yellow perch/bass fishery.

3. Improve boat ramps. The west end of Hackberry Lake was not accessible due to high organic matter throughout the water column. The east boat ramp was choked off by bulrush and cattails during the spring and not accessible during the fall. A raised, gravel ramp leading out to deeper depths at the east boat ramp would improve access to Hackberry Lake.

PELICAN LAKE

Lake Description

Pelican Lake is located three miles south of Highway 16B just west of Valentine NWR headquarters then two miles east along the Pelican Lake sub-headquarters road. The roads are black topped most of the way to the lake, and the west boat ramp is usually accessible. The lake receives heavy angling pressure during the spring and again during the winter ice-fishing season. Pelican Lake has been known as the best fishery on the refuge and is noted for producing trophy bluegill. The excellent fishery is related to the lake depth, the ratio of open water to submergent vegetation during summer, and the abundance of emergent vegetation.

Pelican Lake has had a similar history of carp infestation as the other refuge lakes but to a lesser degree. Pelican Lake was chemically renovated during 1979, but a complete kill did not occur as carp were captured in 1980 surveys. A limited winter-kill was noted during 1987-88. The spring and summer of 1995-1997 were years with excessive run-off and high water. Many of the refuge lakes, including Pelican, were full and flowing over. The high water resulted in many of the lakes becoming inter-connected, and fish movement was observed.

Pelican Lake is 331 surface ha (817 acres). Maximum depth is 3.3 m (10 ft), and mean depth is 1.3 m (4 ft). Specific conductivity averages 328 μS/cm, total alkalinity averages 160 mg/L, phenolphthalein alkalinity averages 10 mg/L, pH ranges from 8 during winter through spring to 9 during summer and secchi disc reading averages 0.3 m. The lake does not develop a thermocline and is a closed system except during periods of excessive rainfall when sheet flow occurs. The lake is situated in the lowlands of the surrounding sandhills, and these conditions create many springs within the lake. The springs provide summer thermal refuge for cool-water species (e.g., northern pike) and are important because surface water temperatures can exceed 30 ^{0}C. The bottom is relatively flat and highly organic. These conditions coupled with the shallow depth make the lake susceptible to winter kills when the ice remains snow covered for extended periods. However, the presence of springs likely reduces the occurrence and severity of winter-kills. Emergent vegetation is primarily cattail, bulrush and *Phragmites*, but scattered stands of wild rice (*Zizania spp.*) occur. Submergent vegetation includes milfoil (*Myriophyllum spp.)*, curly-leaf pondweed (*Potamogeton spp.)*, and scattered areas of coontail (*Ceratophyllum spp.*). The surrounding watershed is rolling sandhills with mixed grasses with a few cottonwoods and willows along the shoreline.

Northern pike size restrictions changed four times from 1987 to 1993 (Appendix B) to improve the size structure and abundance of this species to biologically control carp populations. Northern pike greater than 28 in have been protected since 1993. The carp population in Pelican Lake appears to have stabilized since an increase was observed in 2003. It does appear that carp are successful at spawning nearly every year with some recruitment. Northern pike are likely having an affect on the carp population; however, current low pike numbers may allow a strong carp year class to recruit to the population.

The fishery includes yellow perch, northern pike, largemouth bass, bluegill, black bullhead, and common carp.

Water quality parameters collected were water temperature, dissolved oxygen, pH, salinity, alkalinity, and conductivity (Table 1).

Table 1. Pelican Lake surface water quality parameters from 1999 to 2007.

Date	Water temp. (°C)	D.O. (mg/L)	Secchi depth (cm)	pH	Salinity (ppt)	Phenolphthalein alkalinity (mg/L)	Total alkalinity (mg/L)	Specific conductivity (µS/cm)
05/2007	20	7.4		6.8	0.2	17	137	351
06/2006	24	8.1	129	6.9	0.20	0	137	378
08/2005	21			8.5			240	320
09/2004	23		30			0	205	375
09/2003	23							
09/2001	18		36	7.5		8	120	318
07/2001 dusk	28	11.7		7.7		25	110	
07/2001 dawn	24	7.0		8.7		17	127	
09/2000	18		30	8.0		0	205	
09/1999	14			10.0				

Results and Discussion

Bluegill

Bluegill mean CPUE declined over 50% (28 fish/hr; SE = 3.5) in 2007 from a high of 69 fish/hr (SE = 14.5) in 2006 since electrofishing began in the spring in 2005 (Figure 1). A corresponding increase in PSD was observed in 2007 as stock to quality length fish in 2006 recruited to the quality to preferred length group in 2007 (Figure 2). It also appears that spawning was successful in 2006 as large number of sub-stock bluegill (< 80 mm) were captured in 2007 (Figure 2). Bluegill mean W_r was average compared to other Sandhill lakes and remained stable when comparing among length categories and years (Table 2).

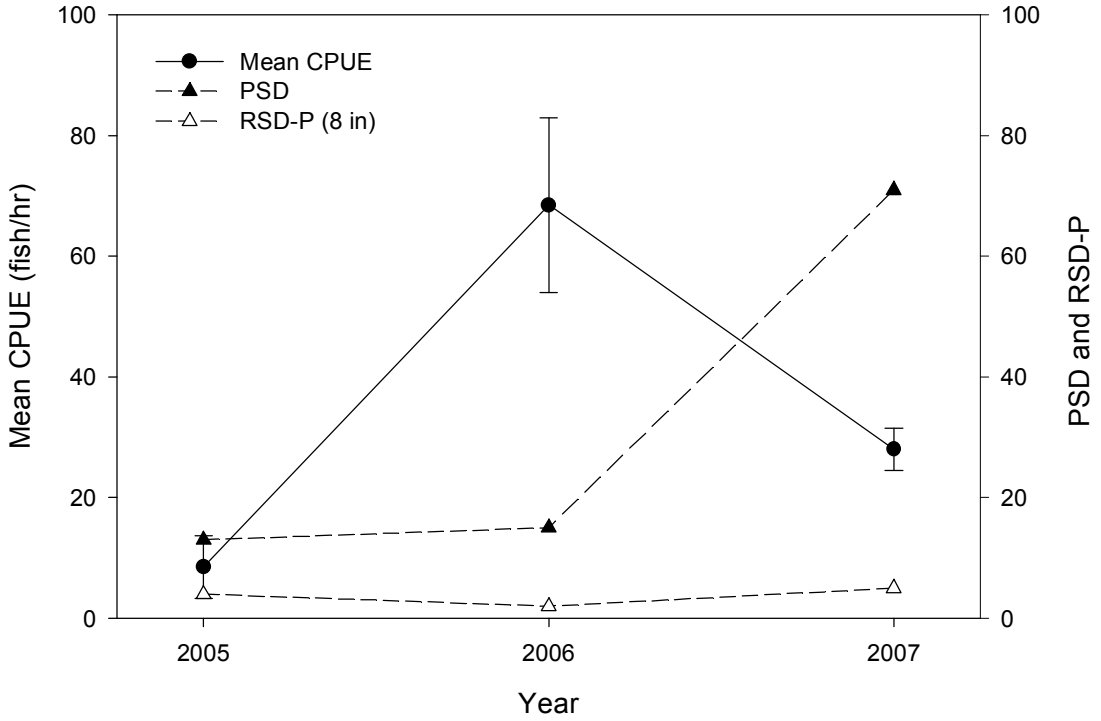

Figure 1. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of bluegills captured by electrofishing in Pelican Lake from 2005 to 2007. Mean catch per unit effort (CPUE) calculated for bluegill ≥ stock length (80 mm) only.

Table 2. Bluegill mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing and trap nets in Pelican Lake from 1992 to 2007. Sampling occurred during fall from 1992 to 2004 and during the spring from 2005 to 2007.

Year	Overall W_r	Stock - Quality (80-150 mm) (3-6 in)	Quality - Preferred (150-200 mm) (6-8 in)	Preferred - Memorable (200-250 mm) (8-10 in)	Memorable - Trophy (250-300 mm) (10-12 in)
2007	115 (1.5)	113 (2.0)	115 (2.0)	116 (4.6)	b
2006	111 (1.3)	111 (2.0)	113 (1.4)	113 (5.5)	113 (3.8)
2005	115 (1.4)	114 (1.7)	113 (3.5)	126 (2.3)	b
2004	114 (2.3)	109 (2.7)	125 (2.8)	121 (0.1)	b
2003	111 (1.6)	112 (2.4)	111 (3.0)	108 (3.4)	b
2002	a	a	a	a	a
2001	114 (1.9)	105 (2.2)	120 (4.0)	124 (2.4)	b
2000	113 (1.8)	108 (2.9)	115 (2.2)	123 (2.6)	105 (15.6)
1999	121 (1.4)	115 (3.3)	124 (1.2)	123 (3.7)	b
1998	105 (1.4)	100 (2.1)	108 (2.0)	116 (2.7)	109 (2.6)
1997	109 (1.3)	102 (1.6)	109 (2.0)	120 (2.2)	120 (2.4)
1996	118 (1.5)	114 (1.6)	121 (3.4)	126 (4.0)	125 (3.7)
1995	124 (2.0)	113 (1.6)	121 (1.7)	136 (1.6)	142 (3.8)
1994	b	b	b	b	b
1993	119 (3.2)	100 (6.6)	116 (3.9)	132 (3.9)	135 (9.7)
1992	122 (1.8)	113 (2.3)	129 (3.4)	125 (2.3)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

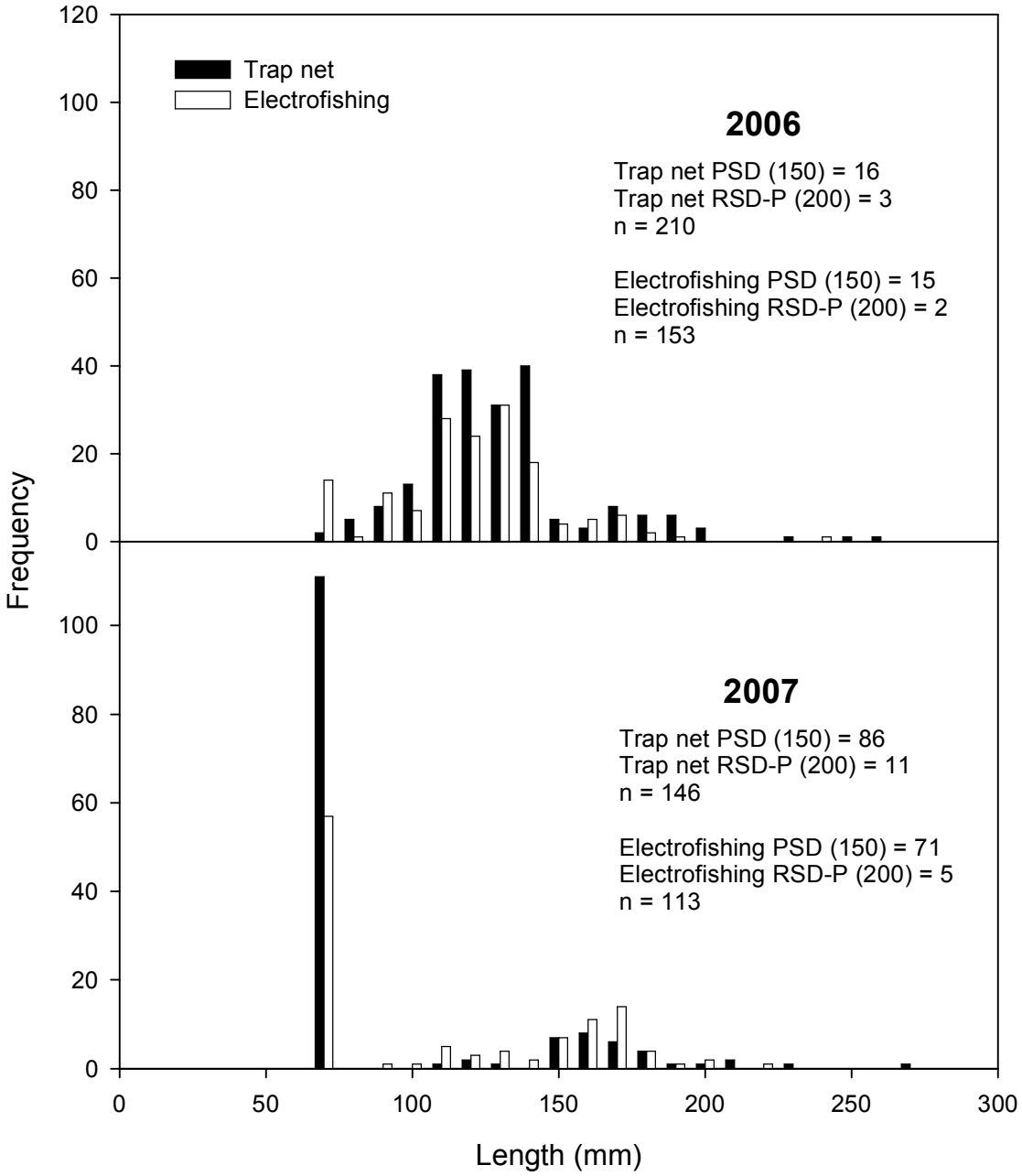

Figure 2. Length frequency distribution (10-mm length groups) for bluegill captured by trap nets and electrofishing during the spring in Pelican Lake from 2006 to 2007.

Common carp

Annual relative abundance of stock length carp appears to be stable since an initial increase between 2001 and 2003 (Figure 3). Since 2001, mean CPUE has ranged from 4.1 carp/gill net (SE = 1.4) in 2004 to 12 carp/gill (SE = 3.5) in 2003. It does appear that spawning is successful for carp in Pelican Lake with a few sub-stock fish (< 280 mm) captured in 2005 and 2007 (Figure 4). Although we were unable to gill net due to low water levels in 2006, the number of stock to quality length (280 – 410 mm) carp captured in 2007 suggests that there were high number of sub-stock length carp in the population during 2006 (Figure 4).

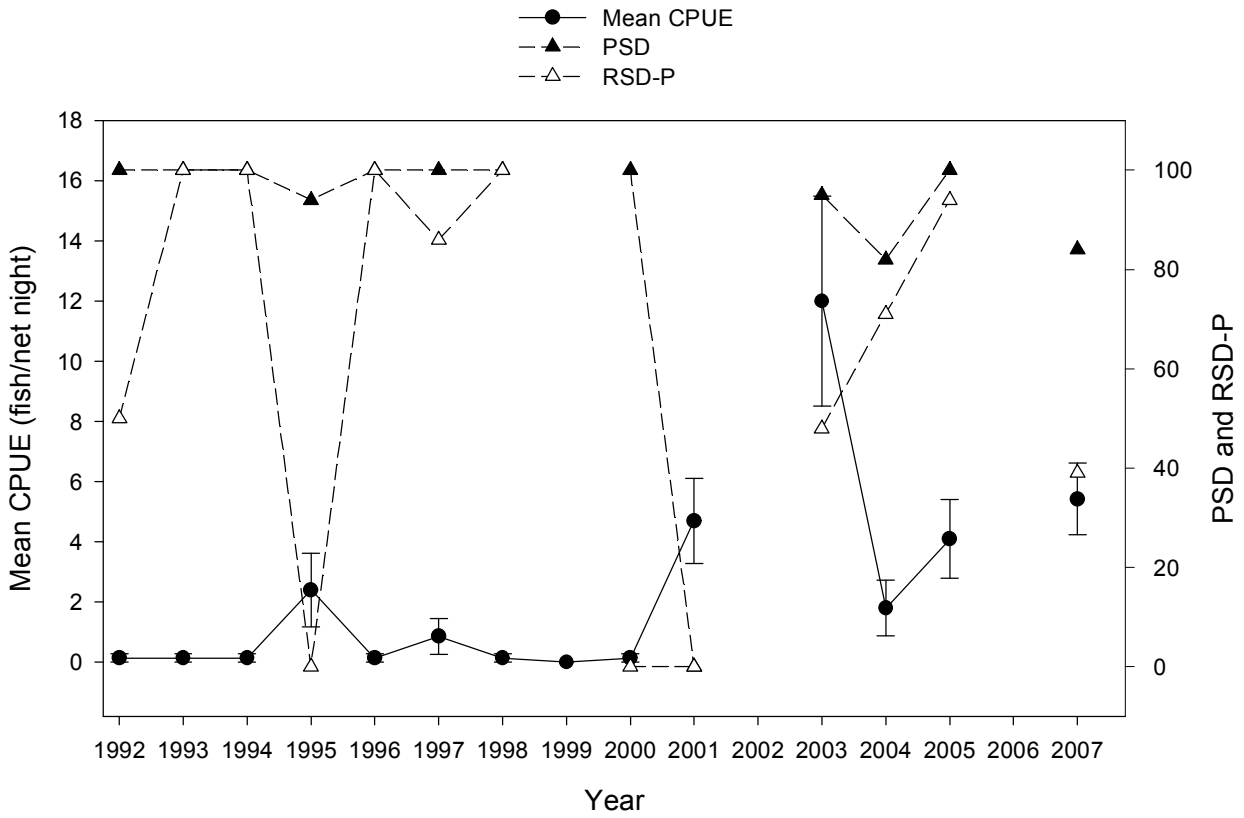

Figure 3. Annual relative abundance (carp/net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of common carp captured gill nets during the fall in Pelican Lake from 1992 to 2007. Mean catch per unit effort (CPUE) calculated for carp ≥ stock length (280 mm) only.

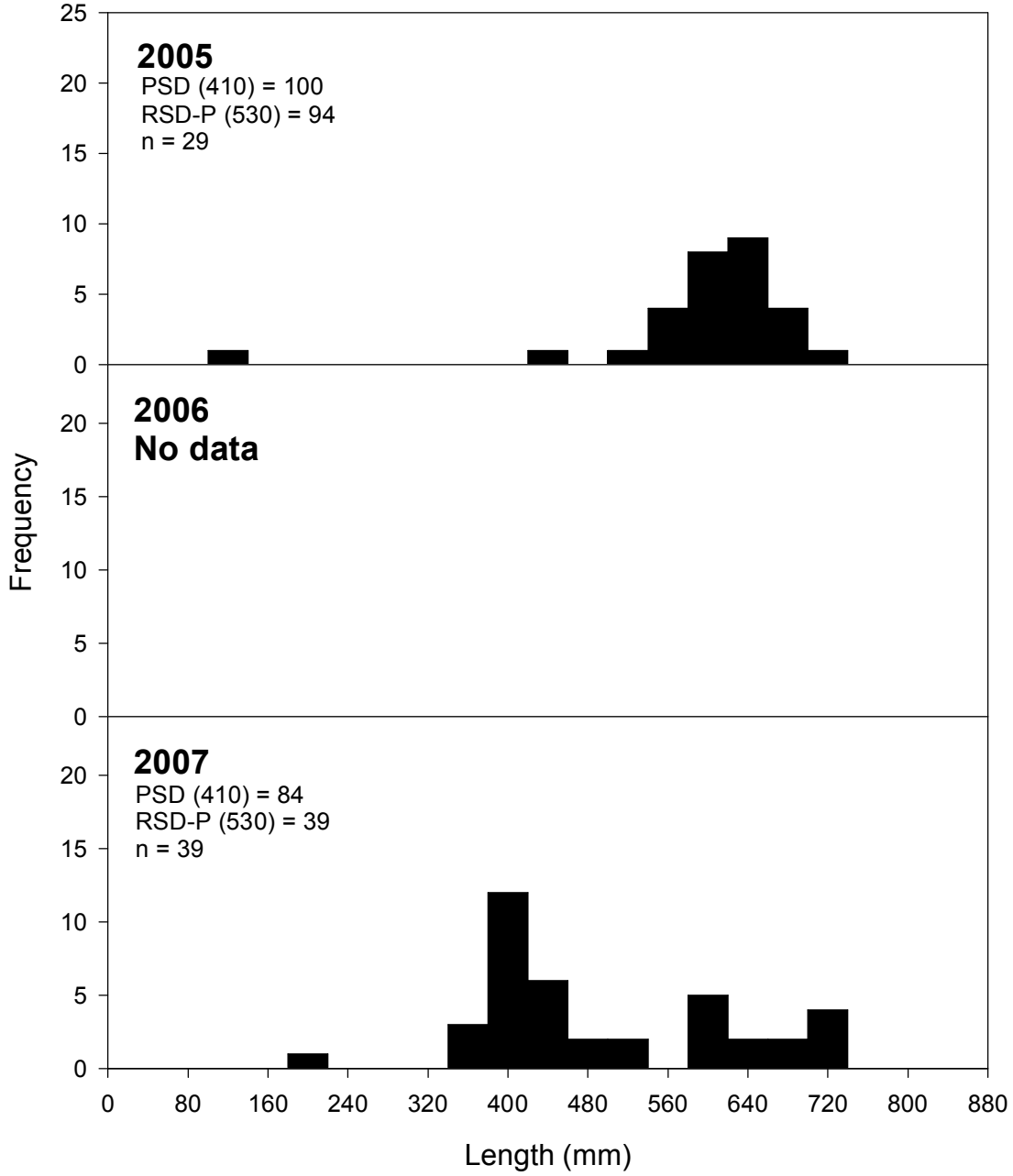

Figure 4. Length frequency distribution of carp captured in gill nets during the fall in Pelican Lake from 2005 to 2007. Gill nets were not deployed in 2006 due to inaccessibility during low water.

Largemouth bass

Relative abundance of stock length largemouth bass (≥ 200 mm) in Pelican Lake in 2007 remained similar to the previous year; however, PSD and RSD-P both substantially declined (Figure 5). Based on length frequency distributions, it appears that a strong 2005 year class is recruiting to the population and is averaging approximately 200 mm (Figure 6). The largemouth bass population does have a healthy number of preferred length fish providing excellent angling opportunities. Mean W_r has steadily improved over the last three year (Table 3) and remains average when compared to other Sandhill Lakes.

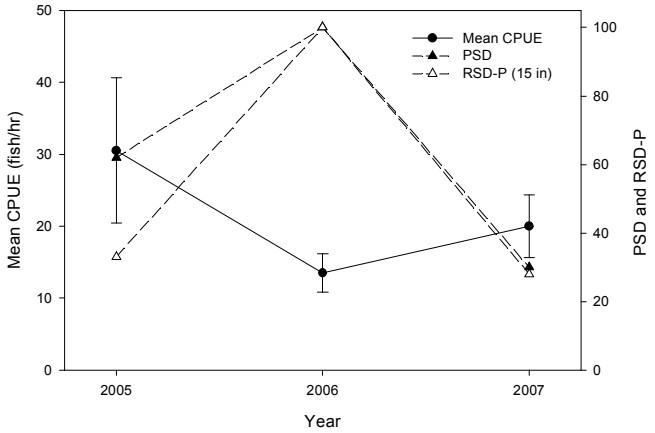

Figure 5. Annual relative abundance (largemouth bass/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of largemouth bass captured by spring time electrofishing in Pelican Lake, Valentine NWR from 2005 to 2007. Mean catch per unit effort (CPUE) calculated for largemouth bass ≥ stock length (200 mm) only.

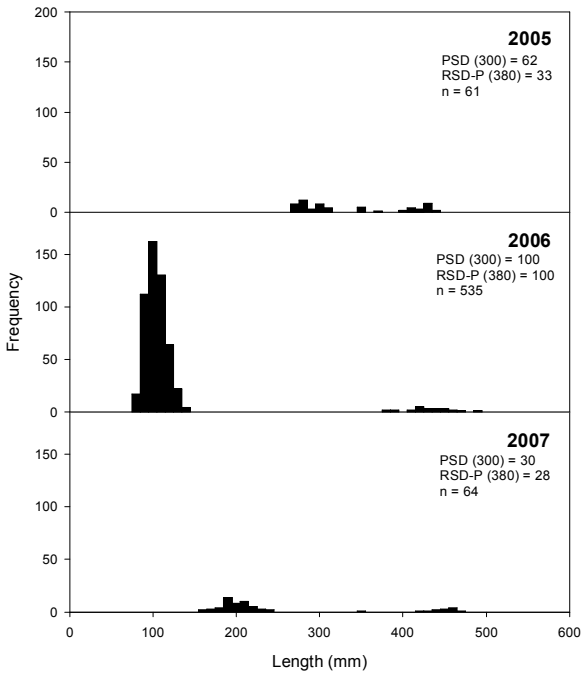

Figure 6. Largemouth bass length frequency distribution (10-mm length groups) captured by electrofishing during the spring in Pelican Lake from 2005 to 2007.

Table 3. Largemouth bass mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing in Pelican Lake from 1992 to 2007.

Year	Overall *Wr*	Stock - Quality (200-300 mm) (8-12 in)	Quality - Preferred (300-380 mm) (12-15 in)	Preferred - Memorable (380-510 mm) (15-20 in)	Memorable - Trophy (510-630 mm) (20-25 in)
2007	117 (2.1)	111 (2.0)	130 (5.0)	123 (4.0)	b
2006	108 (3.0)	b	b	108 (3.0)	b
2005	103 (2.2)	103 (3.3)	92 (4.8)	113 (1.8)	b
2004	120 (4.0)	136 (6.6)	b	114 (4.1)	b
2003	124 (2.4)	b	b	125 (2.5)	b
2002	a	a	a	a	a
2001	123 (5.2)	138 (0.4)	b	120 (3.3)	b
2000	118 (1.2)	131 (6.1)	115 (1.3)	120 (1.7)	b
1999	124 (1.4)	125 (2.2)	125 (2.1)	122 (3.6)	b
1998	128 (1.4)	126 (1.9)	126 (2.1)	133 (3.2)	b
1997	125 (2.4)	124 (2.7)	119 (7.2)	131 (5.7)	b
1996	133 (2.0)	135 (1.8)	b	125 (8.7)	b
1995	128 (5.2)	139 (16.6)	125 (3.1)	122 (5.2)	b
1994	135 (1.9)	128 (6.1)	141 (2.3)	131 (2.9)	126 (0.8)
1993	125 (6.2)	128 (6.4)	b	123 (11.1)	b
1992	129 (2.0)	131 (1.9)	b	122 (0.1)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Northern Pike

The size structure of northern pike in Pelican Lake has remained consistent from 2005 to 2007 (Figure 7). Relative abundance has not significantly changed since a decrease occurred after 2003 (16 fish/gill net night; SE = 1.7) (Figure 8). Gill net mean CPUE for northern pike by length category has remained constant since 2004 (Figure 9). Overall mean W_r and mean W_r by length category was the highest in 2007 since standardized surveys began in 1992 indicating an abundance of prey (Table 4). Mean W_r was well above average compared to other Sandhill lakes.

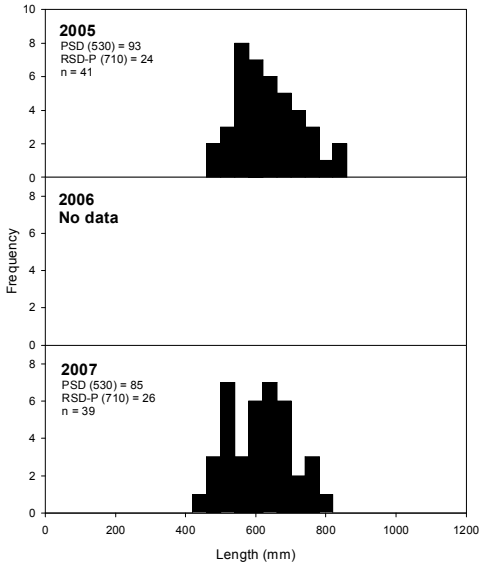

Figure 7. Length frequency distribution (40-mm length groups) for northern pike captured with gill nets during the fall in Pelican Lake from 2005 to 2007. Gill nets were not deployed in 2006 due to inaccessibility during low water.

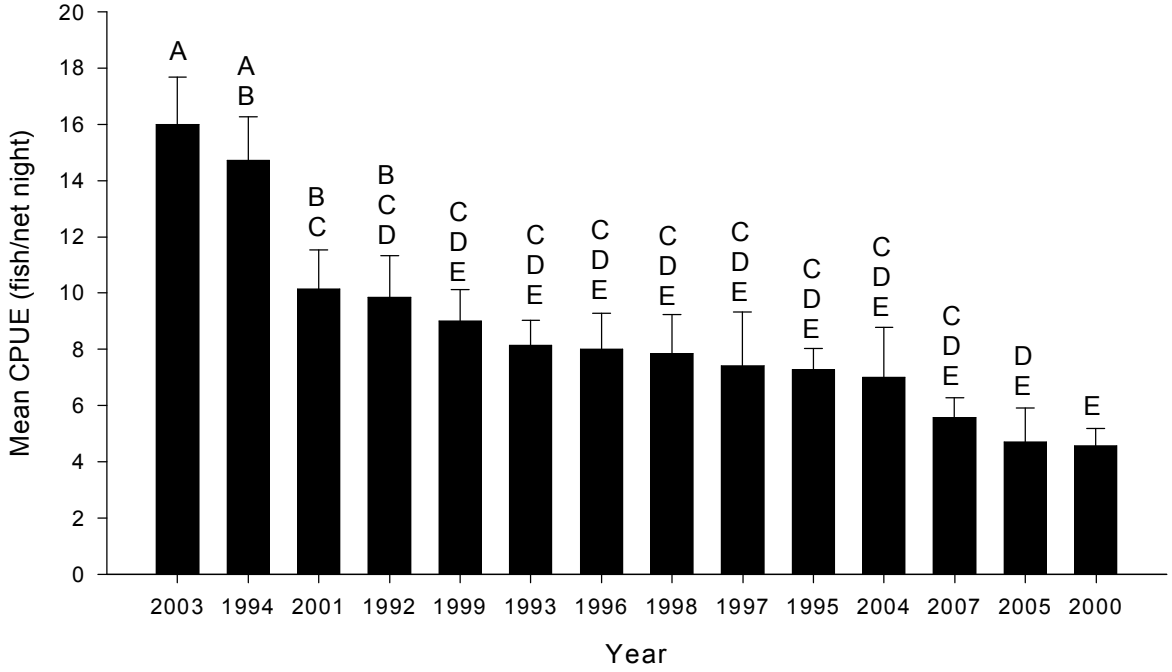

Figure 8. Northern pike gill net mean catch per unit effort (CPUE) in Pelican Lake from 1992 to 2007. Years with the same letter are not significantly different (P > 0.20) using ANOVA with Tukey-Kramer multiple comparison test.

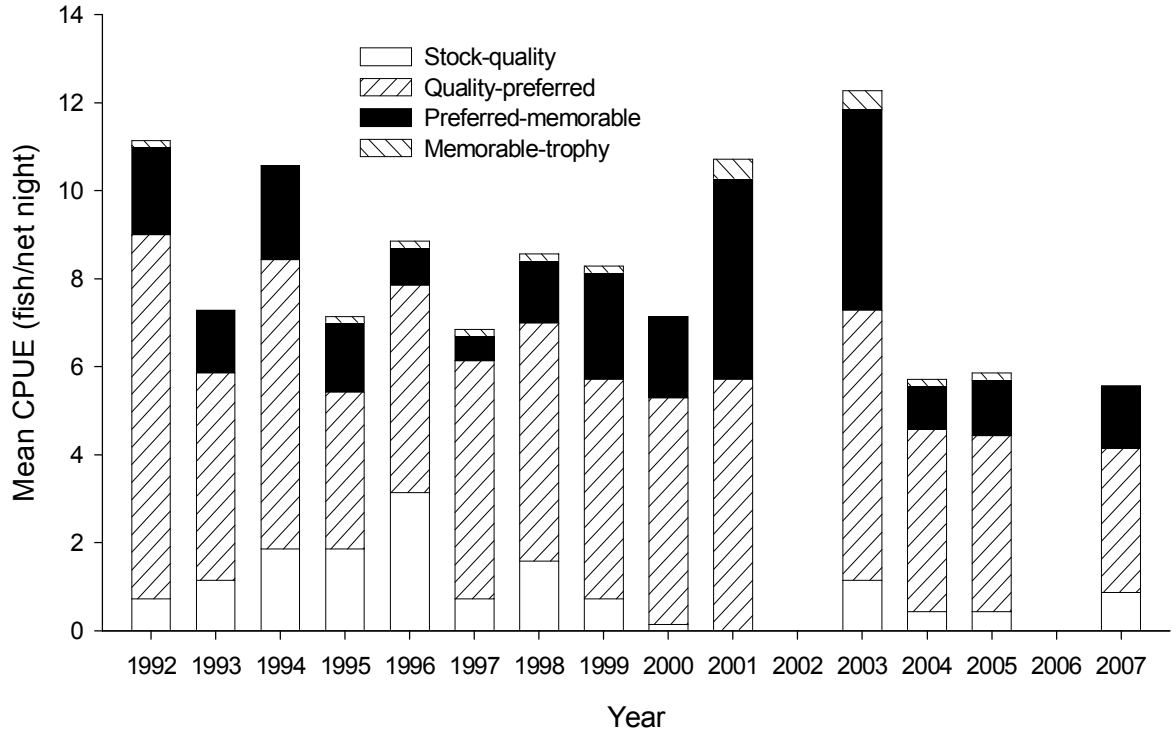

Figure 9. Gill net mean catch per unit effort (CPUE) for northern pike by length category in Pelican Lake from 1992 to 2007.

Table 4. Northern pike population size structure, traditional proportional stock density (PSD), and incremental relative stock density (RSD) with mean relative weights (W_r) in Pelican Lake during the fall from 1989 to 2007. Data are pooled for trap and gill nets from 1989 to 2005. Data from 2006 to 2007 are for fall gill nets only. Data are summarized by length categories with 80% confidence intervals (+/-) and "a" denotes small sample size, confidence intervals could not be calculated.

Year	% ≥ Quality		S–Q (350 – 529mm) (14-21 in)			Q-P (530-709mm) (21-28 in)			P-M (710-859mm) (28-34 in)			M-T (860-1120mm) (34-44 in)		
	PSD	W_r	RSD	±	W_r	RSD	±	W_r	RSD	±	W_r	RSD	±	W_r
2007	85	109	15	a	113	59	18	113	26	a	98	0	a	
2006	No fall gill net sampling in 2006 due to low water levels													
2005	93	90	7	a	108	69	15	94	25	a	74	2	a	75
2004	93	105	2	a	110	73	11	94	18	a	72	3	a	88
2003	91	89	9	14	97	52	10	93	36	12	81	3	a	84
2002	No fall trap or gill netting conducted in 2002 due to low water levels													
2001	100	93	0	a	0	56	9	95	41	9	87	3	a	94
2000	94	88	6	a	82	69	2	89	27	3	86			
1999	91	88	9	6	94	66	9	87	25	8	88	2	a	86
1998	83	89	17	7	90	65	9	89	16	7	87	2	a	91
1997	94	98	6	5	106	87	7	99	7	6	88			
1996	62	93	38	8	96	50	12	92	10	7	88	2	8	96
1995	74	90	26	9	92	51	12	88	20	11	90	2	9	109
1994	84	106	16	5	110	71	6	110	14	5	100	0		
1993	85	90	15	6	90	65	9	97	19	6	93	0		
1992	89	68	11		45	71		72	19		58	0		
1991	94	86	6	5	100	81	7	84	13	6	89	0		
1990	96	91	4	6	95	83	9	92	11	6	91	2		89
1989	86	98	14		101	72		93	8		101	6		102

Yellow perch

Relative abundance of stock length yellow perch (≥ 130 mm) continued to oscillate up and down from one year to the next, but there was a substantial increase in PSD and RSD-P in 2007 (Figure 10). Based on length frequency distributions it appears that strong years classes from 2001 to 2004 have recruited to preferred length in 2007 (Figure 11). Mean W_r were above average at all length categories compared to other Sandhill lakes (Table 5).

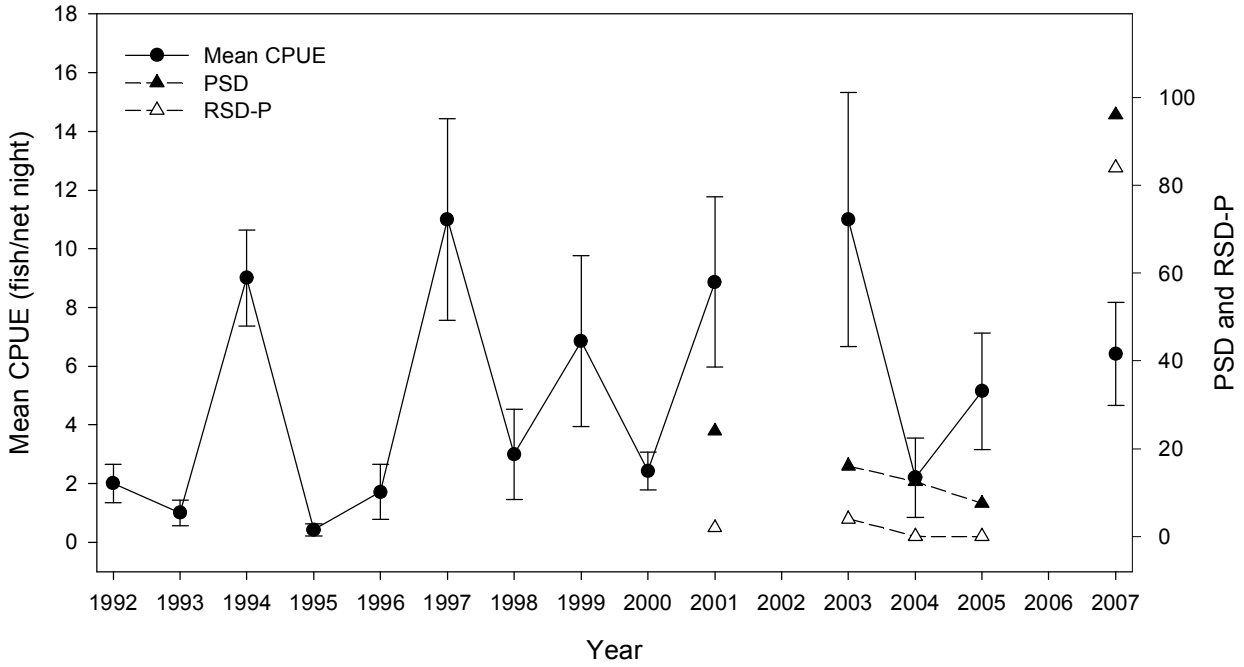

Figure 10. Annual relative abundance (perch/net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of yellow perch captured by gill nets during the fall in Pelican Lake from 1992 to 2006. Mean catch per unit effort (CPUE) calculated for perch ≥ stock length (130 mm) only.

Table 5. Yellow perch mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by gill nets during the fall in Clear Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (130-200 mm) (5-8 in)	Quality - Preferred (200-250 mm) (8-10 in)	Preferred - Memorable (250-300 mm) (10-12 in)	Memorable - Trophy (300-380 mm) (12-15 in)
2007	97 (1.3)	92 (2.5)	102 (4.9)	97 (0.9)	b
2006	a	a	a	a	a
2005	98 (0.9)	99 (1.0)	97 (2.3)	b	b
2004	100 (5.7)	92 (1.7)	109 (11.6)	b	b
2003	102 (1.9)	103 (2.6)	97 (2.4)	109 (8.7)	b
2002	a	a	a	a	a
2001	97 (1.6)	99 (2.0)	92 (2.3)	b	b
2000	100 (4.5)	98 (2.8)	118 (32.4)	b	96 (5.5)
1999	94 (1.2)	94 (1.3)	b	90 (3.6)	b
1998	98 (2.3)	97 (3.4)	b	99 (4.0)	97 (2.8)
1997	96 (1.0)	96 (1.3)	95 (1.7)	99 (3.3)	99 (7.0)
1996	95 (2.8)	91 (1.6)	b	112 (8.7)	b
1995	87 (3.9)	91 (2.8)	b	b	b
1994	100 (2.3)	95 (2.3)	112 (3.7)	b	121 (0.4)
1993	97 (6.0)	96 (9.5)	97 (3.2)	b	b
1992	93 (1.4)	92 (1.4)	b	b	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

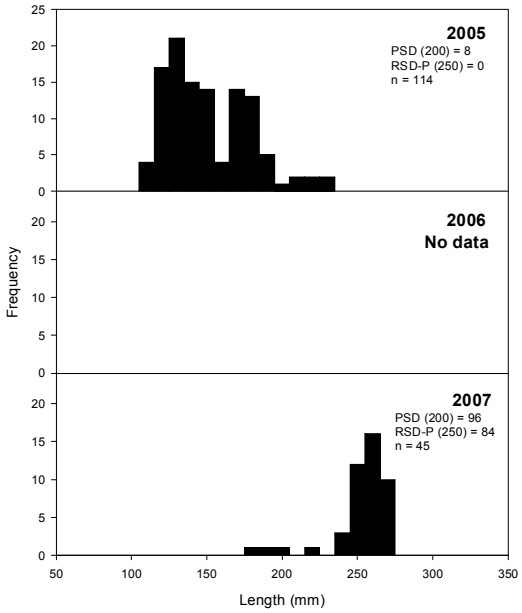

Figure 11. Length frequency distribution of yellow perch captured by gill nets during the fall in Pelican Lake from 2005 to 2007. Gill nets were not deployed in 2006 due to inaccessibility during low water.

Summary

Bluegill – Relative abundance decreased while preferred length bluegills increased in 2007.

Largemouth bass – The relative abundance in 2007 remained similar to 2006. Mean W_r levels indicate an abundance of prey for largemouth bass in Pelican Lake.

Common carp – The carp population in Pelican Lake appears to have stabilized since 2003. Carp are successful at spawning nearly every year with some recruitment. Northern pike are likely having some affect on the carp population; however, current low pike numbers may allow a strong carp year class to recruit to the population.

Northern pike – The northern pike population has remained stable in Pelican Lake since 2004. Environmental conditions have probably reduced spawning success of northern pike. The condition of northern pike shows evidence of abundant prey in Pelican Lake.

Management Recommendations

1. Continue to evaluate northern pike regulations.

2. Improve boat ramps. All boat ramps were choked off by bulrush and cattails during the fall of 2006 making them inaccessible. A raised, gravel ramp leading out to deeper depths at the middle boat ramp would improve access to Pelican Lake.

3. Continue annual surveys

DUCK LAKE

Lake Description

Duck Lake is 1.5 miles south of Highway 16B on an unnamed County Highway. The lake receives moderate fishing during spring and fall, but heavy submergent vegetation during summer precludes fishing during this period. Winter ice-fishing is popular when access to the bigger lakes is restricted by inaccessible roads.

Carp have never been identified in Duck Lake; therefore, chemical renovations have not been necessary. A ditch connects Duck and Rice Lakes, but otherwise the lake is a closed system with no water control structures or draw down capabilities.

The fishery includes yellow perch, largemouth bass, bluegill, pumpkinseed (*Lepomis gibbosus*), orangespotted sunfish (*Lepomis humilis*), and bullheads. The lake is 27 surface hectares (66 ac); maximum depth is 3.3m (8 ft) and the average depth is 1.3m (4 ft). The shoreline is surrounded by cottonwoods and willows with a dense understory of brush and short grasses.

The bottom is relatively flat and highly organic around the edge. About 90% of the bottom is sand and 10% organic silt. Rocky areas are located on the south side and north east corner and during the spring largemouth bass generally congregate in these areas to spawn. The lake's shallow depth makes it susceptible to winter-kills, but underground springs appear to moderate the kill occurrences. Emergent vegetation, predominately cattail, bulrush, and scattered areas of phragmites form a ring around most of the lake. During summer, submergent vegetation, narrow & curly leaf pond weed, coontail, and duck weed cover about 99% of the lake.

Specific conductivity averages 292 μS/cm, total alkalinity averages 174 mg/L, phenolphthalein alkalinity averages 31 mg/L, pH ranges from 8.5 during winter/spring to 10 during summer, and secchi disc readings average 2.0 m. The lake is too shallow to develop a thermocline and summer surface water temperatures reach 30^0C.

Water quality parameters collected were water temperature, dissolved oxygen, pH, salinity, alkalinity, and conductivity (Table 1).

Table 1. Duck Lake surface water quality parameters from 2001 to 2007.

Date	Water temp. (°C)	D.O. (mg/L)	Secchi depth (cm)	pH	Salinity (ppt)	Phenolphthalein alkalinity (mg/L)	Total alkalinity (mg/L)	Specific conductivity (µS/cm)
05/2007	22	10.8	154	6.7	0.1	51	154	333
06/2005	19			7.1		0	290	260
09/2001	16		> 90	10.1		0	120	284
07/2001 dawn	25	10.8		9.6		51	154	
07/2001 dusk	28	12.5		8.1		51	154	

Results and Discussion

Bluegill

Relative abundance of bluegills in Duck Lake has not substantially differed among surveys conducted in 2001, 2005, and 2007 (Figure 1). It appears that spawning and subsequent recruitment is sporadic as PSD and RSD-P is either extremely low or high (Figure 1). It does appear spawning was successful in 2006 with high numbers of sub-stock length fish captured by electrofishing in 2007 (Figure 2). Mean W_r is above average compared to other Sandhill lakes especially for preferred length fish (Table 2).

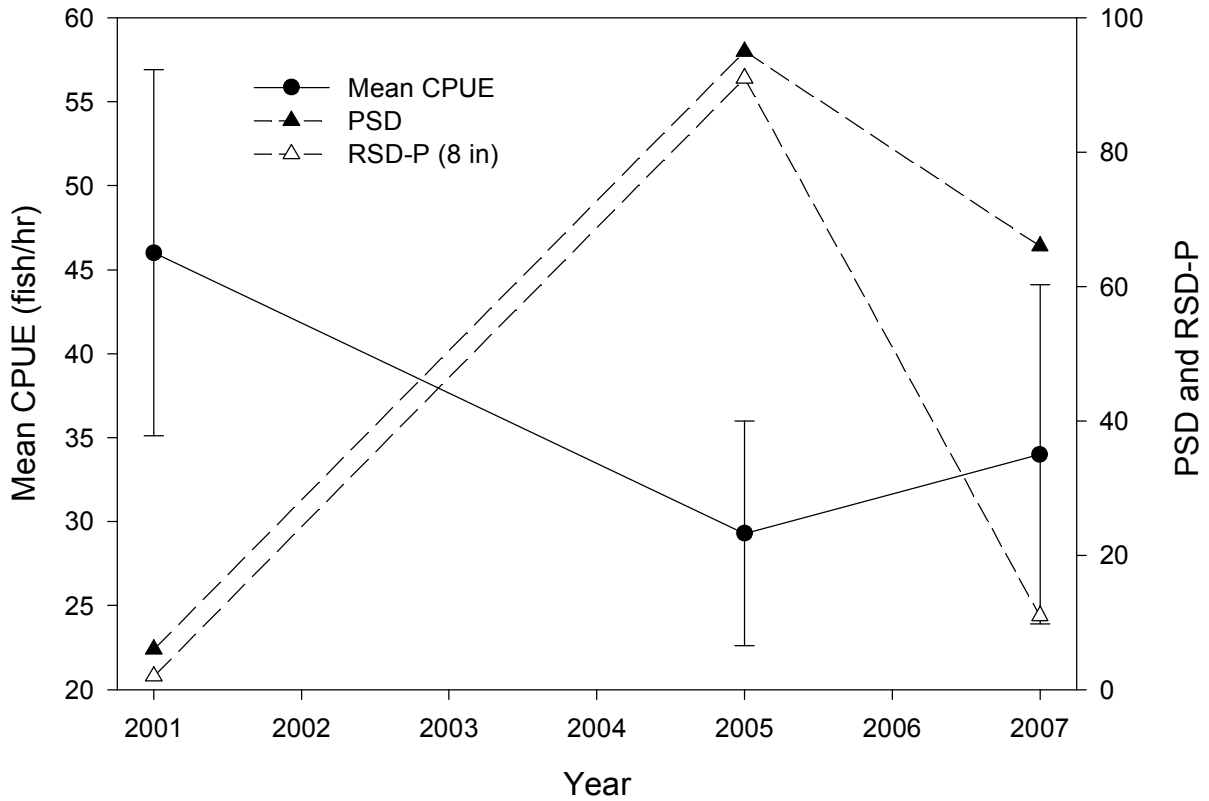

Figure 1. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of bluegills sampled by electrofishing during the spring in Duck Lake in 2001, 2005, and 2007. Mean catch per unit effort (CPUE) calculated for bluegill ≥ stock length (80 mm) only.

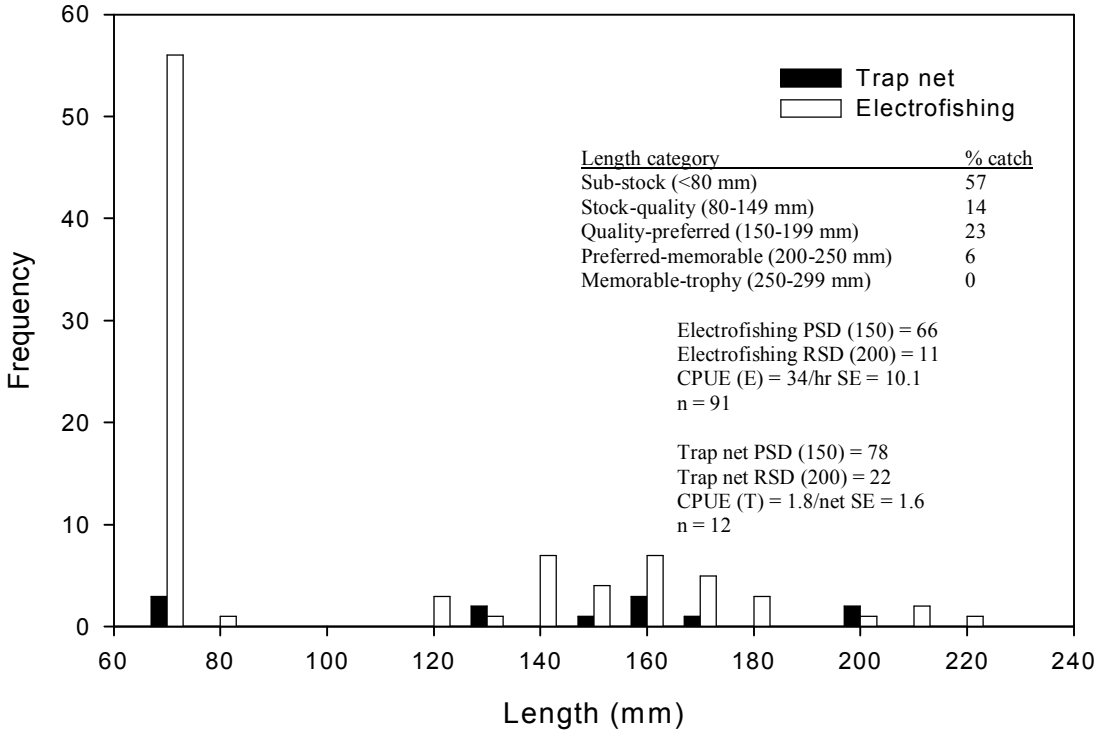

Figure 2. Bluegill length frequency distribution (10-mm length groups) for Duck Lake during May 2007. Mean catch per unit effort (CPUE) for bluegill ≥ stock length (80 mm).

Table 2. Bluegill mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by trap nets and electrofishing during the spring in Duck Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (80-150 mm) (3-6 in)	Quality - Preferred (150-200 mm) (6-8 in)	Preferred - Memorable (200-250 mm) (8-10 in)	Memorable - Trophy (250-300 mm) (10-12 in)
2007	129 (2.7)	119 (2.8)	129 (3.8)	142 (114)	b
2006	a	a	a	a	a
2005	113 (2.1)	112 (1.6)	b	b	b
2004	a	a	a	a	a
2003	a	a	a	a	a
2002	a	a	a	a	a
2001	85 (2.1)	111 (2.9)	111 (3.7)	b	b
2000	a	a	a	a	a
1999	a	a	a	a	a
1998	a	a	a	a	a
1997	a	a	a	a	a
1996	a	a	a	a	a
1995	106 (1.4)	110 (2.2)	129 (1.7)	134 (2.2)	b
1994	a	a	a	a	a
1993	117 (1.8)	114 (3.3)	119 (2.4)	118 (4.1)	b
1992	122 (3.7)	118 (6.2)	128 (5.0)	120 (9.4)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Largemouth bass

Both relative abundance and the size structure indices have remained relatively constant in the three surveys conducted in 2001, 2005, and 2007 (Figure 3). It appears that a strong year class will likely recruit to stock length group next year (Figure 4). The abundant population of small largemouth bass (< 300 mm) will likely have a strong affect on the panfish population in Duck Lake in the next few years and angling opportunities should improve. Mean W_r was below average compared to other Sandhill lakes and was the lowest compared to the other Refuge lakes (Table 3). Historically, largemouth bass relative weights have been low in Duck Lake compared to the other Refuge lakes.

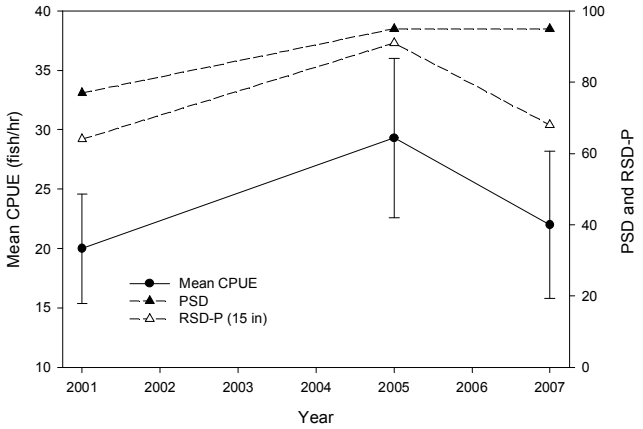

Figure 3. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of largemouth bass captured by electrofishing during the spring in Duck Lake in 2001, 2005, and 2007. Mean catch per unit effort (CPUE) calculated for largemouth bass ≥ stock length (200 mm) only.

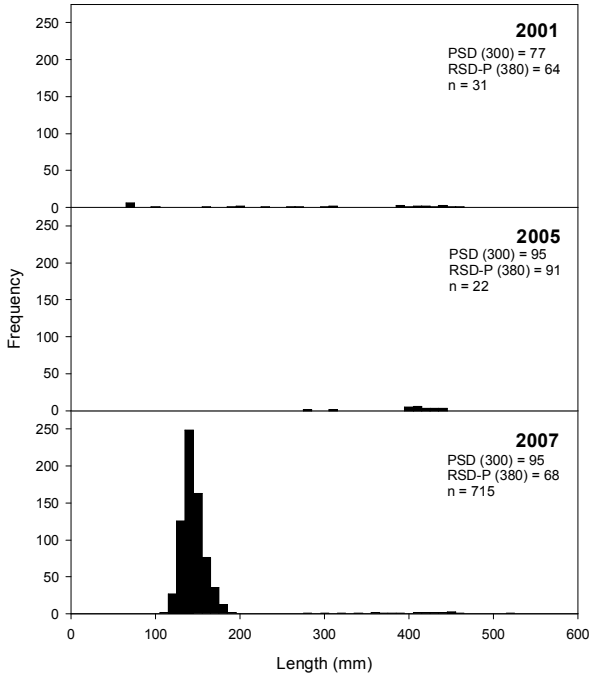

Figure 4. Largemouth bass length frequency distribution (10-mm length groups) captured by electrofishing in Duck Lake during the spring in 2001, 2005, and 2007.

Table 3. Largemouth bass mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing during the spring in Duck Lake, Valentine NWR from 1992 to 2007.

Year	Overall W_r	Stock - Quality (200-300 mm) (8-12 in)	Quality - Preferred (300-380 mm) (12-15 in)	Preferred - Memorable (380-510 mm) (15-20 in)	Memorable - Trophy (510-630 mm) (20-25 in)
2007	97 (4.3)	109 (12.4)	98 (2.6)	91 (5.1)	b
2006	a	a	a	a	a
2005	113 (2.1)	118 (7.3)	113 (8.9)	111 (2.1)	b
2004	a	a	a	a	a
2003	a	a	a	a	a
2002	a	a	a	a	a
2001	111 (4.8)	122 (19.7)	113 (1.8)	106 (3.3)	b
2000	a	a	a	a	a
1999	a	a	a	a	a
1998	a	a	a	a	a
1997	a	a	a	a	a
1996	a	a	a	a	a
1995	106 (1.4)	104 (2.5)	106 (1.5)	108 (5.4)	b
1994	a	a	a	a	a
1993	104 (2.4)	102 (2.5)	118 (1.2)	103 (8.3)	b
1992	102 (1.3)	102 (1.0)	b	101 (1.9)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Yellow perch

Yellow perch relative abundance has consistently been low in Duck Lake in 2001, 2005, and 2007 (Figure 5). There are opportunities for anglers to catch a few preferred length fish (Figure 6). Mean W_r for yellow perch in Duck are average compared to other Sandhill Lakes (Table 4).

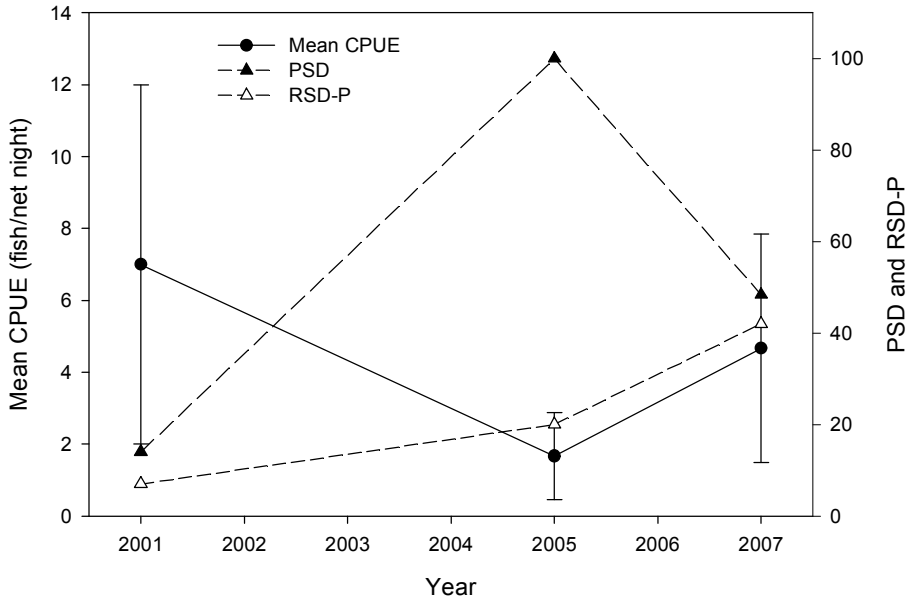

Figure 5. Annual relative abundance (fish/net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of yellow perch captured by gill nets during the fall in Duck Lake in 2001, 2005, and 2007. Mean catch per unit effort (CPUE) calculated for perch ≥ stock length (130 mm) only.

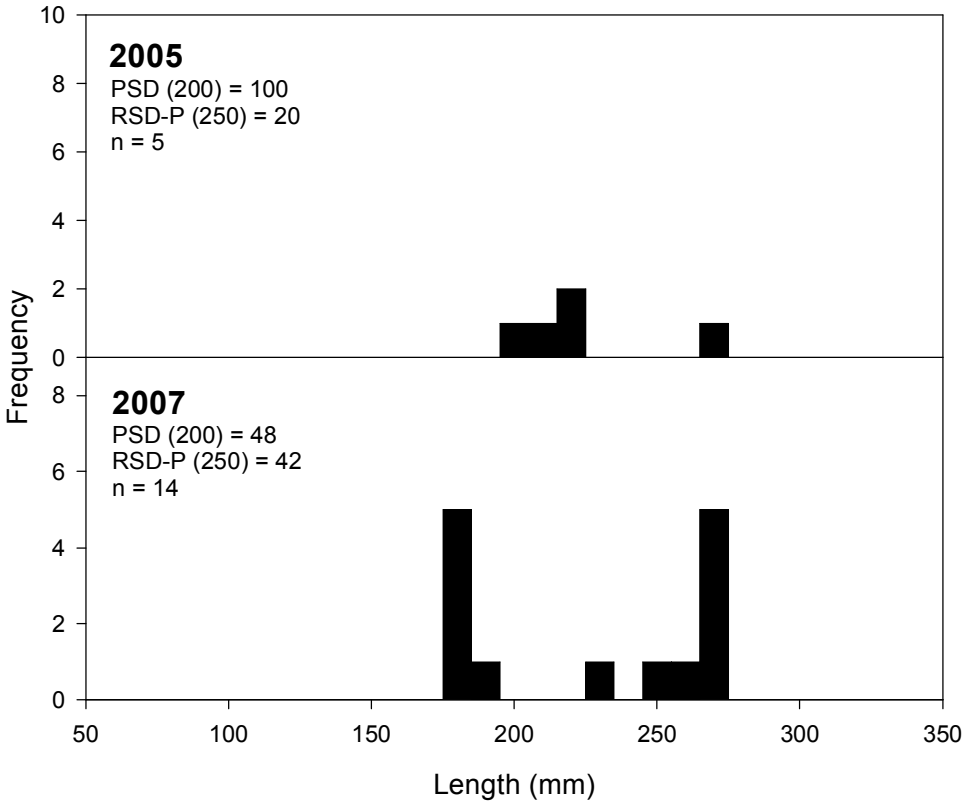

Figure 6. Length frequency distribution of yellow perch captured in gill nets during the fall in Duck Lake in 2005 and 2007.

Table 4. Yellow perch mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by trap and gill nets during the spring in Duck Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (130-200 mm) (5-8 in)	Quality - Preferred (200-250 mm) (8-10 in)	Preferred - Memorable (250-300 mm) (10-12 in)	Memorable - Trophy (300-380 mm) (12-15 in)
2007	92 (2.0)	98 (2.0)	b	89 (1.4)	b
2006	a	a	a	a	a
2005	98 (3.3)	88 (3.1)	103 (2.2)	b	b
2004	a	a	a	a	a
2003	a	a	a	a	a
2002	a	a	a	a	a
2001	85 (2.1)	86 (2.1)	b	b	b
2000	a	a	a	a	a
1999	a	a	a	a	a
1998	a	a	a	a	a
1997	a	a	a	a	a
1996	a	a	a	a	a
1995	104 (2.0)	102 (1.4)	107 (3.7)	b	b
1994	a	a	a	a	a
1993	93 (1.2)	93 (2.2)	93 (2.2)	91 (3.7)	b
1992	90 (1.8)	89 (2.4)	90 (2.6)	b	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Summary

Bluegill – Relative abundance has not substantially changed since 2001. Size structure indices vary from one survey to the next; however, in 2007, the size structure is in balance.

Largemouth bass – The relative abundance and size structure of largemouth bass has remained constant since 2001. A strong year class will likely recruit to stock length group in 2008 and will likely have a strong influence all fish populations in Duck Lake.

Yellow perch – Relatively low abundance with few preferred length fish.

Management Recommendations

1. Continue fishery surveys every odd year (i.e., 2009).

WATTS LAKE

Lake Description

Watts Lake is adjacent to Highway 16B and about 0.3 miles east of the Hackberry Lake headquarters. The lake is easily accessible from the highway and receives considerable fishing pressure, especially during the times that the other refuge lakes are inaccessible. The lake develops dense submergent vegetation during late spring through fall and this curtails fishing during this time. Watts Lake has no inlet and the lake is held artificially high by a water control structure on the east end.

Watts Lake was last renovated during 1976 and re-stocked the following year (Appendix A). No carp were detected since the renovation until one was captured in 2005. During 1987, the lake was opened to musky and largemouth bass harvest. Musky were more susceptible to harvest than predicted and many were harvested. Watts Lake was then designated as a brood stock lake for musky and largemouth bass and managed as a catch-and-release fishery until 2007 (Appendix B). An over abundance of slow growing yellow perch were noted during 1989 surveys and 80 male northern pike were transplanted in an attempt to control yellow perch recruitment for improved growth rates and size class distribution. The 1992 surveys did not indicate that the northern pike had controlled yellow perch recruitment, therefore saugeye (i.e., sauger *Sander canadense* X walleye *S. vitreum* hybrids) were stocked during 1994, 1995, and 1996 (Appendix A) to add additional predators.

Watts Lake is 93 surface ha (230 ac); maximum depth is 2 m (6 ft.) with an average depth of 1.3 m (4 ft.) (Figure 1). The lake is subject to winter-kills during winters that heavy snow occurs early and remain for extended periods. Winter-kills would occur more often if not for the many springs that occur in the lake. The bottom is relatively flat and about 60% silt and 40% sand. Much of the bottom is flocculent and nest builders such as bluegill and largemouth bass have limited spawning habitat. Emergent vegetation (e.g. cattail, bulrush, phragmites) dominate much of the shoreline making access is difficult. The lake is essentially a large littoral area and submergent vegetation is dense during summer. Submergent vegetation includes sago pondweed, curly-leaf pondweed, coontail, and water milfoil. The surrounding watershed is sandy rolling grasslands and the primary land use is livestock grazing. The uplands adjacent to the lake are dominated by short grasses with a few cottonwoods and willows.

Specific conductivity averages 241 µS/cm, total alkalinity averages 149 mg/L, phenolphthalein alkalinity averages 12 mg/L, pH ranges from 8.5 during spring to 10.5 during late summer, and secchi disk reading average 1 m with water clarity limited more by phytoplankton blooms than turbidity. The lake is too shallow to develop a summer thermocline.

The fishery now includes yellow perch, largemouth bass, bluegill, orangespotted sunfish, green sunfish (*Lepomis cyanellus*), grass pickerel (*Esox americanus*), northern pike, saugeye, black bullhead, and common carp.

Water quality parameters collected were water temperature, dissolved oxygen, pH, salinity, alkalinity, and conductivity (Table 1).

Table 1. Watts Lake surface water quality parameters from 2001 to 2007.

Date	Water temp. (°C)	D.O. (mg/L)	Secchi depth (cm)	pH	Salinity (ppt)	Phenolphthalein alkalinity (mg/L)	Total alkalinity (mg/L)	Specific conductivity (µS/cm)
05/2007	17	9.2	110	7.7	0.1	17	103	229
06/2005	20			7.1		0	290	260
09/2001	17		40	7.2		42	111	235
07/2001 dawn	23	5.8		8.8		0	120	
07/2001 dusk	26	12.9		8.0		0	120	

Results and Discussion

Bluegill

The relative abundance of stock length bluegill (≥ 80 mm) substantially increased in 2007 (mean CPUE = 110; SE = 42.7) since the last survey in 2005 (mean CPUE = 5 BLG/hr; SE = 1.9) (Figure 1). However, the population is dominated by sub-stock and stock to quality length fish (Figure 2). Bluegill mean W_r in Watts Lake is above average when compared to other Sandhill lakes (Table 2).

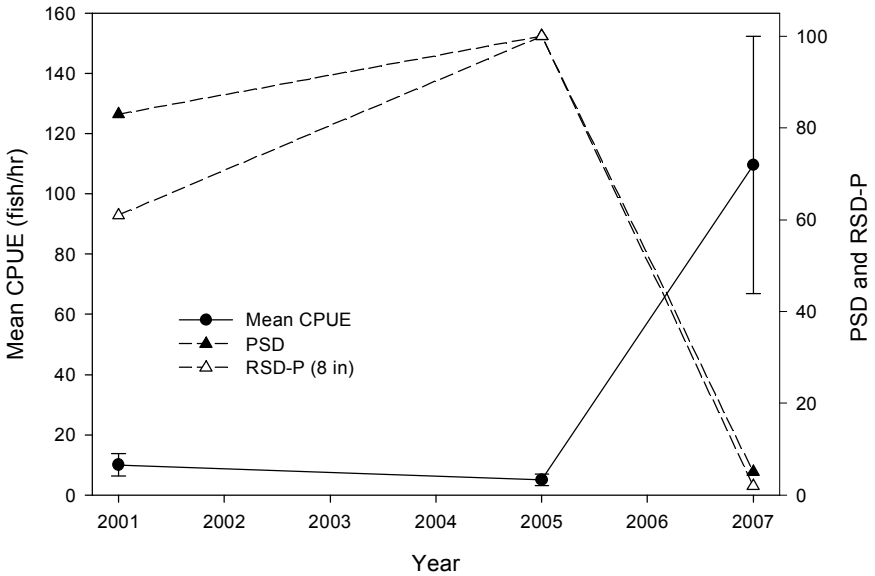

Figure 1. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of bluegills sampled by electrofishing during the spring in Watts Lake in 2001, 2005, and 2007. Mean catch per unit effort (CPUE) calculated for bluegill ≥ stock length (80 mm) only.

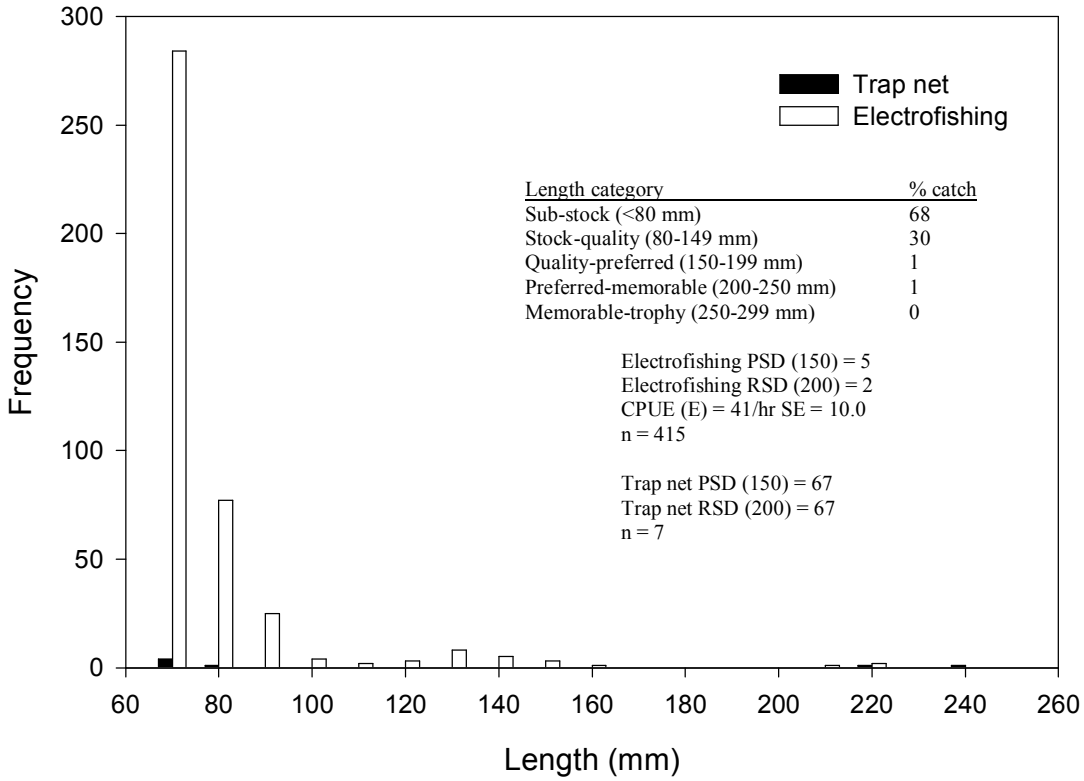

Figure 2. Bluegill length frequency distribution (10-mm length groups) for Watts Lake in May 2007. Mean catch per unit effort (CPUE) for bluegill ≥ stock length (80 mm).

Table 2. Bluegill mean relative weight (W_r) with standard error (SE) in parenthesis by length category that were captured by trap nets and electrofishing during the spring in Watts Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (80-150 mm) (3-6 in)	Quality - Preferred (150-200 mm) (6-8 in)	Preferred - Memorable (200-250 mm) (8-10 in)	Memorable - Trophy (250-300 mm) (10-12 in)
2007	127 (1.9)	127 (2.2)	123 (2.8)	137 (6.7)	b
2006	a	a	a	a	a
2005	b	b	b	b	b
2004	a	a	a	a	a
2003	a	a	a	a	a
2002	a	a	a	a	a
2001	116 (3.4)	113 (4.6)	104 (9.6)	121 (3.4)	b
2000	a	a	a	a	a
1999	a	a	a	a	a
1998	119 (3.9)	136 (3.3)	106 (4.9)	104 (7.1)	b
1997	a	a	a	a	a
1996	130 (3.1)	118 (6.4)	133 (4.8)	136 (2.6)	b
1995	a	a	a	a	a
1994	a	a	a	a	a
1993	a	a	a	a	a
1992	113 (3.7)	111 (4.7)	123 (2.6)	111 (11.5)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Common carp

No carp were observed in 1992, 1996, 1998, or 2001 in Watts Lake during standardized surveys. The first observation was one sub-stock length carp that was captured in a gill net in 2005. In 2007, mean CPUE was 7 carp/gill net (SE = 2.5) and the size structure of the population was of adult fish that were all preferred length (Figure 3).

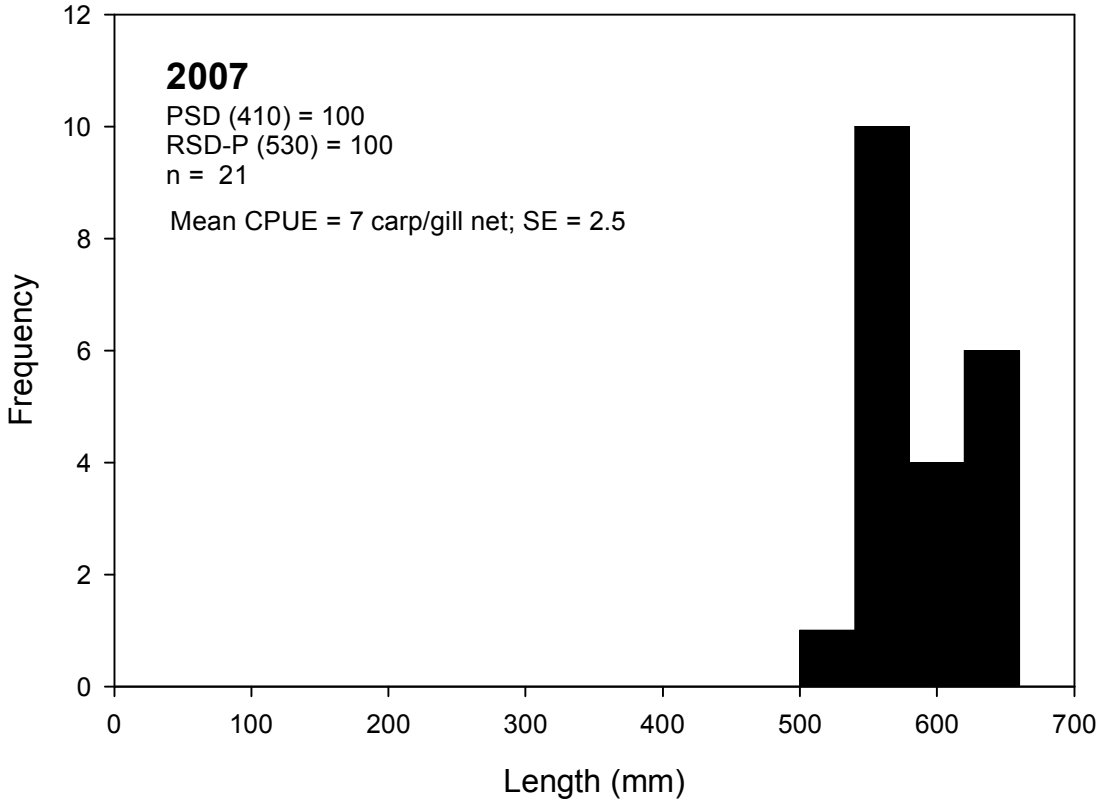

Figure 3. Length frequency distribution (40-mm length groups) of common carp captured in gill nets in Watts Lake in September 2007. Mean catch per unit effort (CPUE) calculated as number carp/overnight gill net for fish ≥ stock length (280 mm) only.

Largemouth bass

Relative abundance of largemouth bass in Watts Lake improved in 2007 (mean CPUE = 38 LMB/hr; SE = 9.1) to levels before the fish kill during the 2004-2005 winter (Figure 4). The size structure has improved with multiple year classes present (Figure 5). Mean W_r declined across all length groups since 2005 (Table 3), but is still above average for Sandhill Lakes.

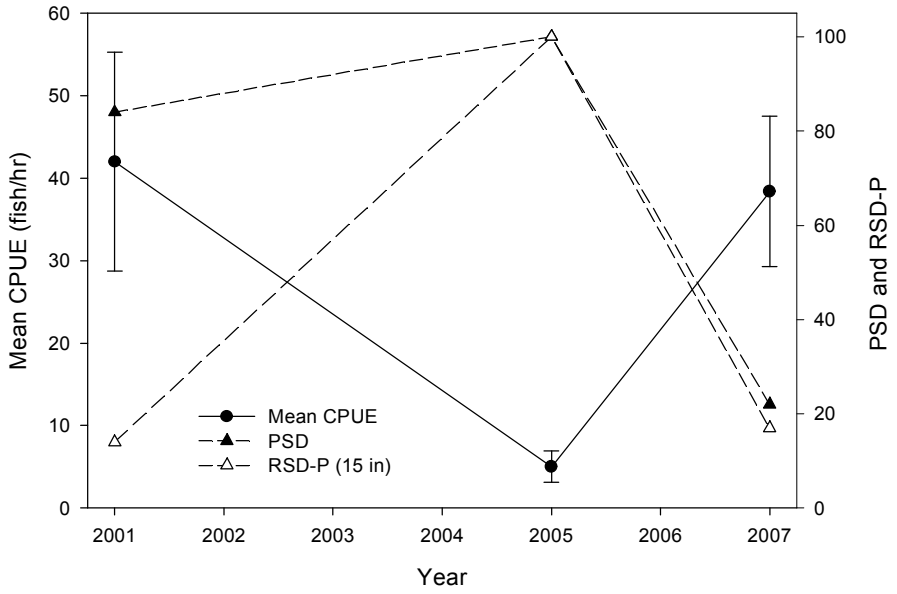

Figure 4. Annual relative abundance (fish/hr with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of largemouth bass captured by electrofishing in Watts Lake in 2001, 2005, and 2007. Mean catch per unit effort (CPUE) calculated for largemouth bass ≥ stock length (200 mm) only.

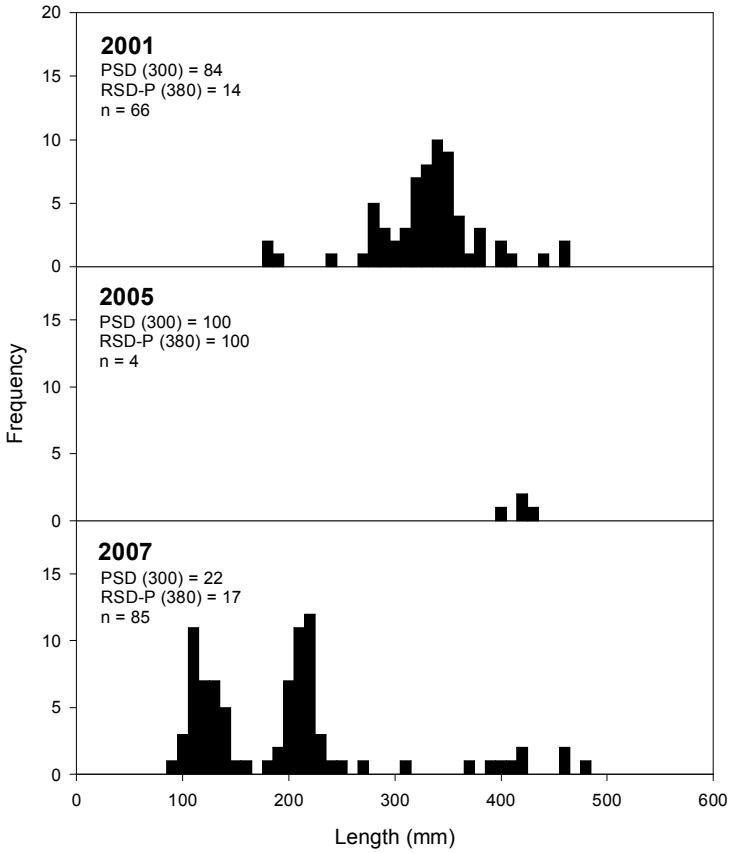

Figure 5. Largemouth bass length frequency distribution (10-mm length groups) captured by electrofishing during the spring in Watts Lake in 2001, 2005, and 2007.

Table 3. Largemouth bass mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by electrofishing during the spring in Watts Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (200-300 mm) (8-12 in)	Quality - Preferred (300-380 mm) (12-15 in)	Preferred - Memorable (380-510 mm) (15-20 in)	Memorable - Trophy (510-630 mm) (20-25 in)
2007	119 (1.4)	116 (1.6)	120 (2.5)	122 (3.2)	b
2006	b	b	b	b	b
2005	129 (3.2)	b	136 (12.3)	128 (3.4)	b
2004	a	a	a	a	a
2003	a	a	a	a	a
2002	a	a	a	a	a
2001	101 (1.6)	103 (1.8)	101 (2.4)	100 (2.4)	b
2000	a	a	a	a	a
1999	a	a	a	a	a
1998	a	a	a	a	a
1997	a	a	a	a	a
1996	113 (2.6)	112 (2.8)	107 (2.8)	127 (4.3)	b
1995	a	a	a	a	a
1994	a	a	a	a	a
1993	a	a	a	a	a
1992	108 (2.0)	120 (3.2)	112 (6.8)	105 (2.1)	b

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Northern pike

In 2007, six northern pike were captured in gill and trap nets ranging from 331 to 702 mm indicating successful spawning and recruitment of multiple year classes in Watts Lake. Only one 655 mm pike was captured in a gill net in 2005.

Saugeye

One 642 mm saugeye was captured in a gill net. This fish was likely 11 to 13 years of age based on stocking records. The population is dominated by a few large, old fish since stocking has not taken place since 1996 (Figure 6).

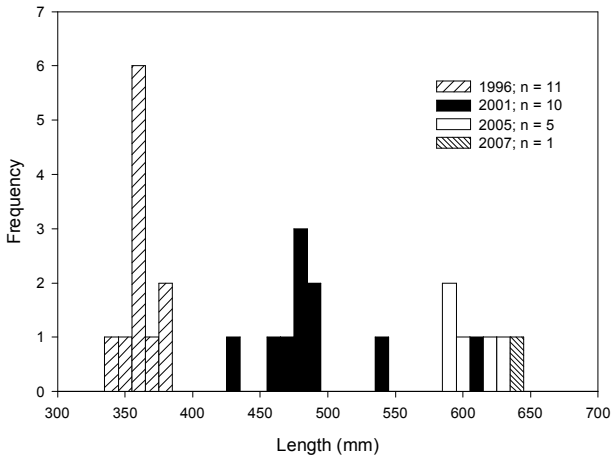

Figure 6. Length frequency distribution of saugeye captured in gill nets in Watts Lake from 1996, 2001, 2005, and 2007.

Yellow perch

Yellow perch relative abundance and size structure continues to improve since 2001, when no perch were collected (Figure 7 and 8). Mean W_r has remained constant over the years with a slight incremental decline among length categories as perch attains great lengths (Table 4).

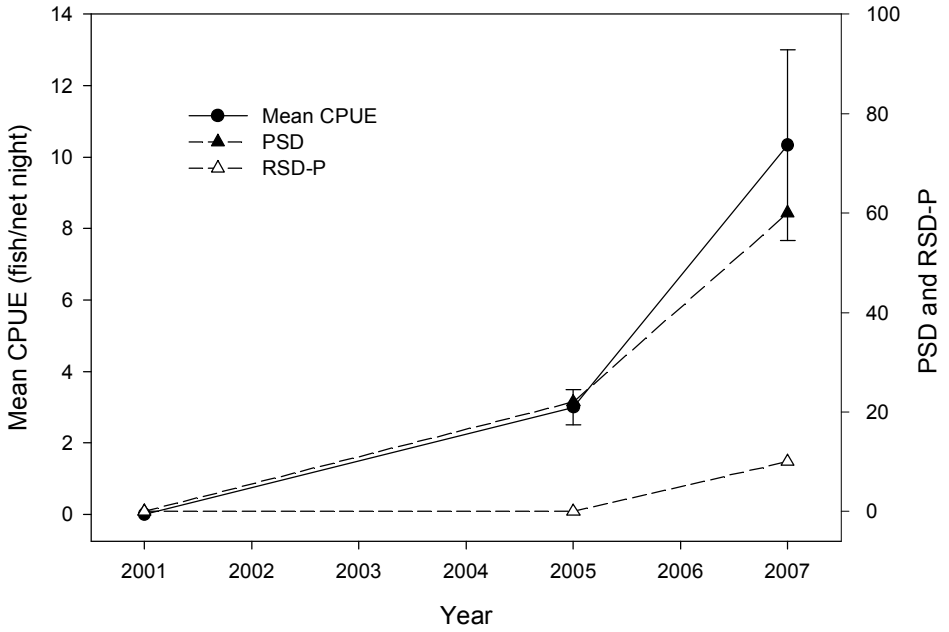

Figure 7. Annual relative abundance (fish/net with SE bars), proportional stock density (PSD), and relative stock density (RSD-P) of yellow perch captured by gill nets in Watts Lake in 2001, 2005, and 2007. Mean catch per unit effort (CPUE) calculated for perch ≥ stock length (130 mm) only.

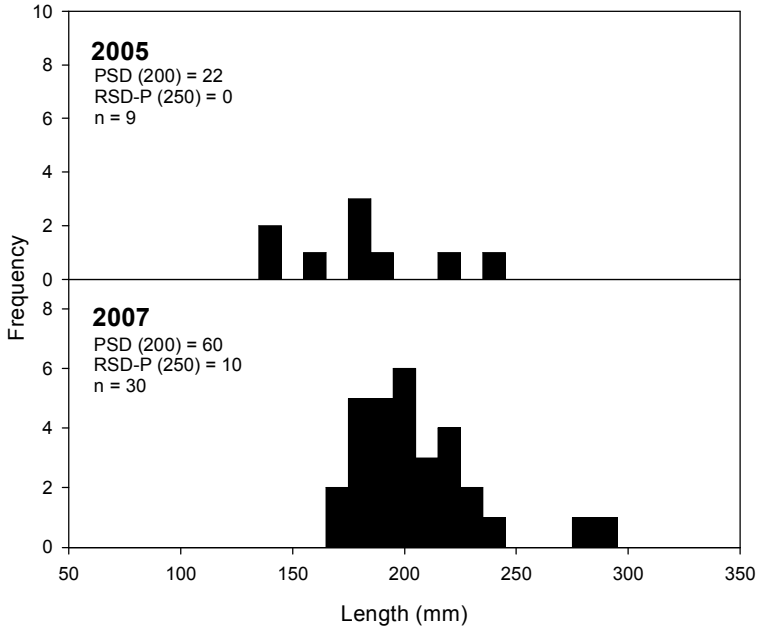

Figure 8. Length frequency distribution (10-mm length group) for perch captured in gill nets during the fall in Watts Lake in 2005 and 2007.

Table 4. Yellow perch mean relative weight (W_r) with standard error (SE) in parenthesis by length category captured by gill nets during the fall in Watts Lake from 1992 to 2007.

Year	Overall W_r	Stock - Quality (130-200 mm) (5-8 in)	Quality - Preferred (200-250 mm) (8-10 in)	Preferred - Memorable (250-300 mm) (10-12 in)	Memorable - Trophy (300-380 mm) (12-15 in)
2007	92 (1.2)	95 (1.6)	90 (1.7)	88 (6.5)	b
2006	a	a	a	a	a
2005	95 (2.0)	97 (2.1)	90 (0.1)	b	b
2004	a	a	a	a	a
2003	a	a	a	a	a
2002	a	a	a	a	a
2001	b	b	b	b	b
2000	a	a	a	a	a
1999	a	a	a	a	a
1998	91 (1.4)	93 (2.0)	90 (1.8)	85 (5.1)	b
1997	a	a	a	a	a
1996	103 (2.7)	104 (3.9)	104 (3.7)	84 (2.2)	b
1995	a	a	a	a	a
1994	a	a	a	a	a
1993	a	a	a	a	a
1992	86 (1.6)	89 (2.7)	84 (1.3)	80 (1.9)	69 (0.7)

a = Sampling did not occur during that year.
b = Category had less than two samples for mean and SE calculations, but may have been calculated in overall W_r.

Summary

Common carp – An adult population of carp is now well established in Watts Lake.

Bluegill – Relative abundance has substantially increased since 2005, but the population is dominated by small fish (<100 mm).

Largemouth bass – Relative abundance of largemouth bass in Watts Lake has dramatically improved since the 2004-2005 winter-kill. The size structure has also improved with evidence of multiple year classes.

Saugeye – There is likely only a few large, 13-14 year old fish remaining in Watts Lake.

Yellow perch – Yellow perch relative abundance and size structure continued to improve since 2001, when no perch were collected.

Management Recommendations

1. Consider supplemental stocking of saugeye as an additional game fish species. Especially after a lake renovation.

2. Due to an abundant population of adult carp, consider renovating Watts Lake during this time of low water levels.

3. Translocated game fish, especially the grass pickerel population to another Refuge lake during renovation.

4. Continue fishery surveys every odd year (i.e., 2009).

5. Improve handicap fishing access. Include a large concrete pad for parking and wheel chair access. Mow overgrown vegetation around the dock throughout the summer. Extend handicap accessible ramp to deep waters. Construct a new, roomier dock for handicap access.

Acknowledgements

I thank Robert Klumb and Dane Shuman (USFWS) for providing field assistance and reviews of earlier drafts of this report. I thank Jeff Jolley and his technicians (South Dakota State University [SDSU]) for providing field assistance. We thank the staff at USFWS, Valentine NWR for providing housing accommodations, field assistance, and angler information. Valentine NWR also provided funding for the fisheries assessments. I also thank Joel Klammer (NGPC) for angler information.

References

Anderson, R. O. 1978. New approaches to recreational fishery management. Pages 73-78 in G. D. Novinger and J. G. Dillard, editors. New approaches to the management of small impoundments. North Central Division, American Fisheries Society, Special Publication 5, Bethesda, Maryland.

Anderson, R. O., and S. J. Weithman. 1978. The concept of balance for coolwater fish populations. American Fisheries Society, Special Publication 11:371-381.

Bister, T. J., D. W. Willis, M. L. Brown, S. M. Jordan, R. M. Neumann, M. C. Quist, and C. S. Guy. 2000. Proposed standard weight (Ws) Equations and standard length categories for 18 warmwater nongame and riverine fish species. North American Journal of Fisheries Management 20:570-574.

Blackwell, B. G., M. L. Brown, D. W. Willis. 2000. Relative weight (W_r) status and current use in fisheries assessment and management. Reviews in Fisheries Science 8(1):1-44.

Flammang, M. K., D. W. Willis, and B. R. Murphy. 1993. Development of condition and length-categorization standards for saugeye. Journal of Freshwater Ecology 8:199-208.

Gabelhouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Henson, J. C. 1991. Quantitative description and development of a species-specific growth from for largemouth bass, with application to the relative weight index. Master's Thesis. Texas A&M University, College Station.

Hillman, W. P. 1982. Structure and dynamics of unique bluegill populations. Master's thesis. Universtiy of Missouri, Columbia.

Neumann, R. M., and B. R. Murphy. 1991. Evaluation of the relative weight (W_r) index for assessment of white crappie and black crappie populations. North American Journal of Fisheries Management 23:243-251.

Paukert, C. P., and D. W. Willis. 2001. Comparison of exploited and unexploited yellow perch *Perca flavescens* (Mitchill) populations in Nebraska Sandhill lakes. Fisheries Management and Ecology 8:533-542.

Paukert, C. P., D. W. Willis, and J. A. Klammer. 2002. Effects of predation and environment on quality of yellow perch and bluegill populations in Nebraska Sandhill lakes. North American Journal of Fisheries Management 22:86-95.

Paukert, C. P. and D. W. Willis. 2003. Population characteristics and ecological role of northern pike in shallow natural lakes in Nebraska. North American Journal of Fisheries Management 23:313-322.

Paukert, C. P., W. Stancill, T. J. DeBates, and D. W. Willis. 2003. Predatory effects of northern pike and largemouth bass: bioenergetics modeling and ten years of fish community sampling. Journal of Freshwater Ecology 18:13-24.

Paukert, C. P., and D. W. Willis. 2004. Environmental influences on largemouth bass *Micropterus salmoides* populations in shallow Nebraska lakes. Fisheries Management and Ecology 11:345-352.

Wege G. J., and R. O. Anderson. 1978. Relative weight (W_r): a new index of condition for largemouth bass. Pages 79-91 in G. D. Novinger and J. G. Dillard, editors. New approaches to the management of small impoundments. North Central Division, American Fisheries Society, Special Publication 5, Bethesda, Maryland.

Willis, D. W. 1989. Proposed standard length-weight equation for northern pike. North American Journal of Fisheries Management 9:203-208.

Willis, D. W., C. S. Guy, and B. R. Murphy. 1991. Development and evaluation of a standard weight (Ws) equation for yellow perch. North American Journal of Fisheries Management 11:374-380.

Appendix A. Fish stocking history for Valentine National Wildlife Refuge lakes. FY: Fry (Hatch to 1.49 in.); FG: Fingerlings (1.5 to 5.49 in.); AD: Adult (Sexually mature, regardless of size); MX: Mixed (transplanted from natural sources).

		Largemouth bass			Bluegill			Northern pike			Yellow perch			Black crappie			Sauger X walleye			Muskellunge		
Lake	Year	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size
Clear	2007							Mar	48	AD												
	2006													Jun	211,385	FY						
	2005							Mar	50	AD				Jul	140,727	FY						
														Mar	514	FG						
	2004													Aug & Sep	12,698	FG						
														Oct	48	AD						
	1996				Oct	45,000	FG															
	1991	Jul	6,000	FG	Aug	50,000	FY															
	1990	Jul	17,000	FG																		
	1989	Jul	15,000	FG							Sep	3,000	FG	Sep	2,448	FG						
	1988													Sep	5,750	FG						
	1987													Sep	4,086	FG						
	1985	Jul	35,541	FG																		
	1983[b]																					
Dad's	1987							Apr	150,000	FY												
Dewey	2004	Aug	43	AD				Aug	195	AD	Aug	150	AD									
	1992[a]																					
	1991	Jul	28,000	FG	Aug	50,000	FY															
	1989							Mar	1,010	AD												
	1987							Mar & Apr	1,256	AD												
	1985				Sep	50,000	FY															
	1981[b]																					
Duck	1995																Jun	4,000	FY			
	1994																Apr	4,000	FG			
	1991	Jul	10,000	FY	Aug	30,000	FY				Jun	20,000	FY									
	1986				Aug	25,000	FY															
	1985				Sep	38,000	FY															

[a] 1,100 channel catfish (6 – 9 in. in TL) stocked on 25 August 1992.

[b] Lake renovation occurred during that year.

Appendix A continued. Fish stocking history for Valentine National Wildlife Refuge lakes. FY: Fry (Hatch to 1.49 in.); FG: Fingerlings (1.5 to 5.49 in.); AD: Adult (Sexually mature, regardless of size); MX: Mixed (transplanted from natural sources).

		Largemouth bass			Bluegill			Northern pike			Yellow perch			Black crappie			Sauger X walleye			Muskellunge		
Lake	Year	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size
Hackberry	2007	Jun	40,865	FG	Mar & Sep	179,194	FG															
	2006				Oct	364,315	FG															
	2005	Aug	31	AD	Oct	148,070	FG				Jun	136,000	FY									
		May& Aug	68,200	FG	Feb & Mar	128,000	FG				Apr	1,400,000	Egg									
											Feb	19,068	FG									
	2004[b]				Oct	86,250	FG															
	1996				Oct	75,000	FG															
	1992							Apr	1,200	MX												
	1991	Aug	35,000	FG																		
	1990	Jul	35,000	FG																		
	1989	Aug	37,000	SA																		
	1986	Jul	30,000	FG	Aug	25,000	FY	Mar	203	AD												
		May	107	AD																		
	1985				Sep	50,000	FY															
Pelican	1996				Oct	102,800	FG															
	1995										Apr	2,000	AD									
	1994							Mar	651	AD	Apr	59,981	MX									
	1993										Apr	5,651	MX									
	1992	Jun	136,000	FY							Apr	1,100	AD									
	1991	Jul	40,000	FG																		
	1990	Jul	40,000	FG																		
	1989	Jul	32,000	FG																		
	1986							Mar	207	AD												
	1985				Sep	50,000	FY				Apr	7,660	AD									
Rice	2004				Mar	26,048	FY				Mar	3,326	FG									

[b] Lake renovation occurred during that year.

Appendix A continued. Fish stocking history for Valentine National Wildlife Refuge lakes. FY: Fry (Hatch to 1.49 in.); FG: Fingerlings (1.5 to 5.49 in.); AD: Adult (Sexually mature, regardless of size); MX: Mixed (transplanted from natural sources).

		Largemouth bass			Bluegill			Northern pike			Yellow perch			Black crappie			Sauger X walleye			Muskellunge		
Lake	Year	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size	Month	N	Size
Watts	2005	Sep	15,525	FG	Oct	148,070	FG				Aug	19,261	FG									
	1997																			Sep	100	SA
	1996				Oct	30,000	FG										Jun	10,000	FG	Sep	50	SA
	1995																Jun	5,000	FG			
	1994																Apr	5,000	FG			
	1992	Jun	50,000	FY																		
	1991	Jul	5,000	FG																		
	1990	Jul	5,000	FG				May	77	AD												
	1989	Jul	5,000	FG																		
	1988																			Jun & Sep	47	AD
	1987																			Aug	347	AD
																				May	6,500	FY
	1986				Aug	25,000	FY													Jun	75	FG
	1985																			Aug	1,152	SA
West Long	1998	Apr	124	AD																		
	1996	Sep	70	AD																		
	1994										Apr	2,241	AD									
	1992										Apr	1,100	AD									
	1991	Jul	10,000	FG	Aug	20,000	FG				Jun	30,000	FG									
	1986	Jul	15,000	FG	Aug	25,000	FY															
Willow	1988				Aug & Sep	116,000	FG	Apr	180,000	FY	Apr	4,000	AD									

Appendix B. Summary of fishing regulations on the Valentine National Wildlife Refuge. *Panfish species include bluegill, yellow perch, black crappie, green sunfish, orangespotted sunfish, pumpkinseed, and all sunfish hybrids. **Panfish bag limit is in aggregate.

Lake	Species	Year	Size limit	Bag limit**
Clear	Northern pike	1993 – present	28 in. max.	3
		1991 – 1992	36 in. min.	3
		1990	30 in. min.	6
		1988 – 1989	36 in. min.	6
		1987	24 in. min	6
	Largemouth bass	2007 – present	15 in. min. and 1 > 21 in.	4
		1988 – 2006	15 in. min. and 1 > 24 in.	4
		1987	12 in. min	8
	Panfish*	1988 – present		30
		1987		No limit
Dewey and Pelican	Northern Pike	1993 – present	28 in. max.	3
		1990 – 1992	36 in. min.	3
		1988 – 1989	36 in. min.	6
		1987	24 in. min.	6
	Largemouth bass	2007 – present	15 in. min. and 1 > 21 in.	4
		1988 – 2006	15 in. min. and 1 > 24 in.	4
		1987	12 in. min	8
	Panfish*	1988 – present		30
		1987		No limit
Hackberry	Northern pike	1993 – present	28 in. max.	3
		1992	36 in. min.	3
		1990 – 1991	24 in min.	3
		1987 – 1989	24 in. min.	6
	Largemouth bass	2007 – present	15 in. min. and 1 > 21 in.	4
		1988 – 2006	15 in. min. and 1 > 24 in.	4
		1987	12 in. min	8
	Panfish*	1988 – present		30
		1987		No limit
Watts	Muskellunge	2007 – present	40 in. min.	1
		1988 – 2006	Catch and release	
		1987	36 in. min.	3
	Largemouth bass	2007 – present	15 in. min. and 1 > 21 in.	4
		1988 – 2006	Catch and release	
		1987	12 in. min.	8
	Panfish*	1988 – present		30
		1987		No limit
	Saugeye	2007 – present	15 in. min. and 1 > 22 in.	4
All refuge lakes not previously identified	Northern pike	1993 – present	28 in. max.	3
		1990 – 1992	24 in. min.	3
		1987 – 1989	24 in. min.	6
	Largemouth bass	2007 – present	15 in. min. and 1 > 21 in.	4
		1988 – 2006	15 in. min. and 1 > 24 in.	4
		1987	12 in. min	8
	Panfish*	1988 – present		30
		1987		No limit

Appendix C. Glossary of fishery terms.

Alkalinity: Alkalinity is a measure of a waters ability to resist a change in pH expressed in mg/l or ppm. Because alkalinity is dependent on minerals such as calcium (Ca), and this relates to aquatic vegetation production, alkalinity is a good indicator of a water bodies potential to produce fish. Less than 40 mg/l is considered soft water; greater than 40 mg/l is hard water.

Catch per Unit Effort (CPUE): CPUE is the catch per unit of sampling effort that is used as an index of abundance or to document population changes over time. This is also known as relative abundance. The formula is:

$$\text{CPUE} = \frac{\text{number of fish in a length class, length category, or sample}}{\text{Hour for electrofishing or net night}}$$

Conductivity: Conductivity is a measure of a water bodies ability to conduct electricity, which is dependent on the amount of ions in the water. Total dissolved solids (TDS) is equal to 0.5 X Conductivity. Conductivity is a good measure of a water bodies productivity because of the relation between minerals and productivity.

Effort: The effort is the total amount of time expended in collecting a sample. The time may be in hours, minutes, or net days. The effort is used to calculate CPUE.

Habitat Suitability Index (HSI): a numerical index (0 = poor, 1 = excellent) which is used to identify how well a fish species should perform in a lake or pond. The HSI value is computed using water quality and habitat conditions and evaluated how well a species can spawn, survive, and grow in a body of water.

Morphoedaphic Index (MEI): This index is used as a fish yield estimator based on average depth (X) and total dissolved solids (TDS). The formula is: MEI = X/TDS.

Memorable length: The memorable length is a standard category unique for each species. The memorable length is the length that most anglers remember catching and is 59 to 64% of the world record length.

Net days: A unit of time used to describe the effort required to collect a sample using Gill nets or Trap nets. For example, if 5 Gill nets were left for a 24 hour period, then 5 Gill net days worth of effort were expended.

pH: a measure of how basic or acidic a body of water is. Pure water is considered neutral with a ph = 7. pH is on a Log10 scale, therefore a change of 1 pH unit equates to a 10 fold increase in H^+ (hydrogen ions). This information is important as many species of game fish have narrow pH tolerances.

Preferred length: The preferred length is a standard category unique for each species. The preferred length is the length that most anglers prefer to catch and is usually within a range of 45 to 55% of the world record length.

Proportional Stock Density (PSD): PSD is the number of fish greater than or equal to a minimum quality length in a sample divided by the number of fish greater than or equal to a minimum stock length. The formula is:

$$PSD = \frac{\text{number of fish} \geq \text{"quality" length}}{\text{number of fish} \geq \text{"stock" length}}$$

Quality length: The quality length is a standard length category unique for each species of fish. The Quality length is usually within a range of 36 to 41% of the world record length and generally the minimum size that most anglers will keep.

Relative Stock Density (RSD): The RSD is the number of fish greater than a minimum preferred length in a stock divided by the number of fish greater than or equal to a minimum stock size. The formula is:

$$RSD = \frac{\text{number of fish} \geq \text{"preferred" length}}{\text{number of fish} \geq \text{"stock" length}}$$

Relative weight (W_r): The relative weight of a fish or group of fish is referred to as a " W_r " value. The relative weight is a comparison of the condition of the fish in a sample and the condition of a theoretical optimum sample. The formula is:

$$W_r = (W/Ws) \times 100$$

where "W" is the weight of an individual and "Ws" is a length specific standard weight.

Stock length: The stock length is the smallest of the standard length category unique for each species of fish. The stock length is usually within a range of 20 to 26% of the world record length and at or near which a species reaches sexual maturity.

Trophy length: Trophy length is a standard length category unique for each species of fish. The Trophy length is size worthy of acknowledgment and is greater than 74% of the world record length.

Appendix D. Data collection and analysis protocol.

For each species, five fish per 10 mm (0.4 inch) for fish > 80 mm (3.2 inches) TL were weighed to the nearest gram (g) and measured to the nearest millimeter (mm). Fish smaller than 80 mm were tallied for length frequency analysis only. Once five fish were recorded for a 10 mm group, additional fish in that group were tallied for length frequency analysis only. Panfish, bass, and walleye should use the 10-mm data sheet. Northern pike and common carp should use the 20-mm data sheet (Figures in this Appendix).

Catch per unit effort (CPUE) was recorded separately for each net and each electrofishing transect to enable calculating CPUE confidence intervals (CI) at the 80% CI level. CPUE and confidence intervals were analyzed using the one or two gears that are appropriate for each species of fish.

Analysis of Data Collected

1) Trends in relative abundance were assessed as catch-per-unit-effort (CPUE) as fish/trap net night, fish/gill net night, and for electrofishing fish/hr.

2) Size structure will be assessed with PSD and RSD. Length categories have been proposed for various fish species (Table D-1).

3) Calculating relative weight (W_r) assessed condition of fish by size groups (Table D-2).

Table D-1. Length Categories that have been proposed for various fish species.

Species	Stock		Quality		Preferred		Memorable		Trophy		Reference
	E	M	E	M	E	M	E	M	E	M	
Saugeye	9	23	14	35	18	46	22	56	56	69	Flammang et al. 1993
Yellow perch	5	130	8	20	10	25	12	30	15	38	Gabelhouse 1984
Largemouth bass	8	20	12	30	15	38	20	51	25	63	Gabelhouse 1984
White and black crappie	5	13	8	20	10	25	12	30	15	38	Gabelhouse 1984
Bluegill, green sunfish, pumpkinseed	3	8	6	15	8	20	10	25	12	30	Gabelhouse 1984
Black bullhead	6	15	9	23	12	30	15	38	18	46	Gabelhouse 1984
Common carp	11	28	16	41	21	53	26	66	33	84	Gabelhouse 1984
Northern pike	14	35	21	53	28	71	34	86	44	112	Gabelhouse 1984

Note: All measurements are total length. E = English units (inches). M = Metric units (cm).

Table D-2. Intercept (a) and slope (b) parameters for standard weight (Ws) equations that have been proposed and the minimum total lengths (mm) recommended for application.

Species	Intercept (a)		Slope (b)	Minimum total length	Source
	M	E			
Black bullhead	-4.974	-3.297	3.085	130	Bister et al. 2000
Black crappie	-5.618	-3.576	3.345	100	Neumann and Murphy 1991
Bluegill	-5.374	-3.371	3.316	80	Hillman 1982
Common carp	-4.639	-3.194	2.920	200	Bister et al.
Green sunfish	-4.915	-3.216	3.101	100	Bister et al.
Largemouth bass	-5.528	-3.587	3.273	150	Henson 1991
Northern pike	-5.437	-3.745	3.096	100	Willis 1989
Yellow perch	-5.386	-3.506	3.230	100	Willis et al. 1991

Note: The standard equation format is Log10(Ws) = a + b(Log10 total length). Metric (M) equations are in millimeters and grams; English (E) equations are in inches and pounds.

Appendix E. Northern pike food habits summary for Valentine NWR in 2006 and 2007.

Introduction

In an attempt to increase abundance and size structure of northern pike, size and bag restrictions were initiated in selected lakes in 1988 and enforced across all Refuge lakes since 1993. It does appear that the restrictions have been somewhat successful as carp numbers stabilized with the increase in large predators across the Refuge lakes. Success has not been without perceived drawbacks. Predation by northern pike likely reduces the abundance and alters the size structure of largemouth bass, yellow perch, and bluegills (Paukert et al. 2002; DeBates et al. 2003; Paukert and Willis 2003; Paukert et al. 2003). Although, bluegill are less likely affected by northern pike predation (Paukert and Willis 2003).

Gill nets have been known to "take" a portion of the fish captured during fisheries surveys. Our objectives were to collect diet data on northern pike that were deceased as a result of being captured in gill nets. This allowed us attain a snapshot of the food habits of northern pike in Refuge lakes during September.

Methods

The stomach contents of northern pike were examined in Clear and Dewey lakes during fall gill netting in 2006 and 2007 and in Pelican Lake in 2007. Only northern pike that were deceased were cut open to remove prey items from the stomach. All northern pike and prey items were measured to total length (TL; mm). A regression of prey length on pike length was performed by combining data from all years, lakes, and prey to increase sample size. Northern pike diet data was summarized by lake, year, and length group for all three lakes that included: number of stomachs examined (N), percent of empty stomachs (% E), identified prey items, mean length of prey, frequency of occurrence (% O), and percent of total number (% N).

Results and Discussion

Northern pike length did not account for the size of prey consumed. The value of R-Squared, the proportion of the variation in prey length that can be accounted for by variation in pike length, was 0.0113. The correlation between prey length and pike length was -0.1065 (Figure E-1) and was statistically insignificant at $\alpha = 0.20$.

Clear Lake
Seventy-five percent of the 20 northern pike examined in 2006 were empty (Table E-1). Only two carp, one northern pike, one largemouth bass, and one crayfish were found in the stomachs. Only 10 northern pike were examined in 2007 with 40% of the fish being empty. However, seven carp were found, with five carp found in one 884-mm northern pike. The unidentified fish were likely carp, perch, or largemouth bass. Our findings were similar to Paukert et al. (2003), where they found pike ($\geq$ 710 mm) consumed primarily carp in September.

Dewey Lake

Twenty-four northern pike were examined for food habits in Dewey Lake in 2006 and 71% of those were empty (Table E-1). Three carp, two perch, and one bluegill were the only identifiable fish found in the stomachs. Interestingly, it was only the quality to preferred length pike (i.e. length not protected by 28 in. maximum limit) that had carp in their stomachs. In 2007, 28 northern pike were examined for food habits. Only 50% were empty. Eleven yellow perch were found in the pike stomachs and only one largemouth bass was found. No carp were found in the stomachs of pike in September 2007, which contradicted our findings in Clear Lake and Paukert et al. (2003). This was likely due to the fact that no carp < 320 mm were available as prey during September 2007 in Dewey Lake based on our gill net findings in this report.

Pelican Lake

Seventeen northern pike were examined for food habits in Pelican Lake in September 2007 (Table E-1). 53% of those fish were empty, 11 yellow perch were found in the stomachs, and the unidentified fish were also likely to be perch. Only one sub-stock carp (205 mm) was captured in gill nets in 2007. Northern pike in Pelican Lake may have been targeting smaller fish since the mean perch preyed upon was 102 (SE = 3.4). Interestingly, the smallest perch captured by our gill nets was 186 mm and the largest perch in a stomach was 127 mm. Either pike are targeting the few small perch in the lake or more likely is that our experimental gill nets are biased to capturing larger perch than representing the true size structure of the perch population in Pelican Lake.

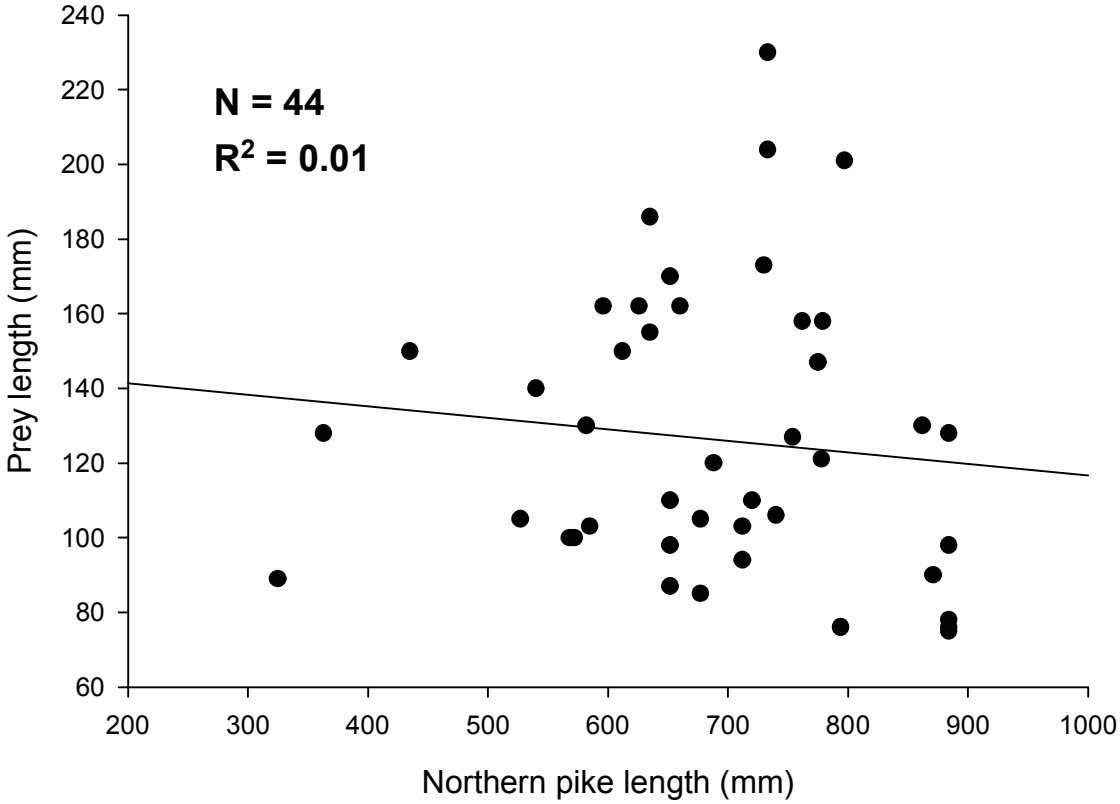

Figure E-1. Regression of northern pike length versus prey length for diet data from 2006 and 2007 in Clear, Dewey and Pelican lakes. All prey types and lakes were combined due to limited sample size.

Table E-1. Northern pike diet summary by lake, year, and length group for Valentine NWR. Number of stomachs examined (N), percent of empty stomachs (% E), prey item, mean length of prey with SE in parenthesis, frequency of occurrence (% O), and percent of total number (% N).

Length group	N	% E	Prey item	Prey mean length	% O	% N
			Clear Lake, 2006			
Stock – quality (350 – 530 mm)	1	0	Common carp	128	100	100
Quality – preferred (530 – 710 mm)	3	100				
Preferred – memorable (710 – 860 mm)	13	69	Unidentified fish		50	33
			Common carp	173	25	17
			Largemouth bass	204	25	17
			Northern pike	239	25	17
			Crayfish		25	17
Memorable – trophy (860 – 1120 mm)	3	100				
			Clear Lake, 2007			
Stock – quality (350 – 530 mm)	0					
Quality – preferred (530 – 710 mm)	3	67	Common carp	120	100	100
Preferred – memorable (710 – 860 mm)	4	25	Unidentified fish	76 (0)	25	50
			Common carp	106	25	25
			Yellow perch	201	25	25
Memorable – trophy (860 – 1120 mm)	3	33	Unidentified fish	90	33	17
			Common carp	91 (10.2)	33	83

Table E-1 continued.

Length group	N	% E	Prey item	Prey mean length	% O	% N
			Dewey Lake, 2006			
Stock – quality (350 – 530 mm)	4	75	Yellow perch	89	100	100
Quality – preferred (530 – 710 mm)	11	64	Unidentified fish		50	40
			Common carp	168 (9.4)	50	60
Preferred – memorable (710 – 860 mm)	9	78	Yellow perch	147	50	50
			Bluegill	121	50	50
Memorable – trophy (860 – 1120 mm)	0					
			Dewey, Lake 2007			
Stock – quality (350 – 530 mm)	1	0	Yellow perch	150	100	100
Quality – preferred (530 – 710 mm)	15	47	Unidentified fish		13	13
			Yellow perch	149 (9.1)	75	75
			Largemouth bass	162	13	13
Preferred – memorable (710 – 860 mm)	10	70	Yellow perch	142 (16.0)	100	100
Memorable – trophy (860 – 1120 mm)	2	0	Unidentified fish		50	50
			Yellow perch	130	50	50
			Pelican Lake, 2007			
Stock – quality (350 – 530 mm)	1	0	Yellow perch	105	100	100
Quality – preferred (530 – 710 mm)	12	58	Unidentified fish		40	22
			Yellow perch	98 (3.5)	80	78
Preferred – memorable (710 – 860 mm)	4	50	Yellow perch	108 (9.8)	100	100
Memorable – trophy (860 – 1120 mm)	0					