

Bitter Lake Site Description

Location

Water designation number (WDN)	22-0016-00
Legal description	T121N-R54W-Sec. 8-10, 15-17, 20-23, 27-29, 33, 34
County (ies)	Day
Location from nearest town	0.5 miles south of Waubay, SD

Survey Dates and Netting Information

Survey dates	August 24-26, 2010 (FN, GN) September 14, 2010 (EF-WAE)
Gill net sets (n)	8
Electrofishing-WAE (min)	40

Morphometry

Watershed area (acres)	71,248
Surface area (acres)	>15,000
Maximum depth (ft)	≈28
Mean depth (ft)	---

Ownership and Public Access

Bitter Lake (Figure 1) is a meandered lake owned by the State of South Dakota and managed by the SDGFP. Prior to 1990's, most of Bitter Lake was located on a 2,353 acre Game Production Area (GPA) managed by the South Dakota Game, Fish and Parks. Currently, much of the Bitter Lake GPA is under water and most of the lakeshore is privately owned. A public access site is located on the east shore off Day Co. Highway 1 and is maintained by the SDGFP (Figure 2). Private (fee) access is available on the northeast shore just outside the city limits of Waubay.

Watershed and Land Use

Land use within the Bitter Lake watershed is primarily agricultural with a mix of pasture or grassland, cropland, and woodland.

Water Level Observations

The elevation of Bitter Lake on September 30, 2009 was 1797.2 fmsl and by May 5, 2010 the elevation had increased to 1799.9 fmsl. On October 6, 2010 the elevation remained at 1799.9 fmsl.

Aquatic Nuisance Species Monitoring

Plant Survey

Submersed vegetation is prevalent in most shallow areas of Bitter Lake. In 2010, no aquatic nuisance plant species were encountered.

Macro-Invertebrate/Mussel Survey

No aquatic nuisance macro-invertebrate or mussel species were sampled in 2010.

Fish Community Survey

Common carp was the only aquatic nuisance fish species captured during the 2010 survey (Table 1).

Fish Management Information

Primary species	walleye, yellow perch
Other species	black crappie, common carp, northern pike, spottail shiner, white bass, white sucker
Lake-Specific regulations	NE Panfish Management Area: 10 daily; 50 possession Walleye: minimum length 15"
Management classification	warm-water permanent
Fish Consumption Advisories	Mercury: walleye (all sizes); northern pike (> 30"). See the South Dakota fishing handbook for more details on meal and portion size recommendations.

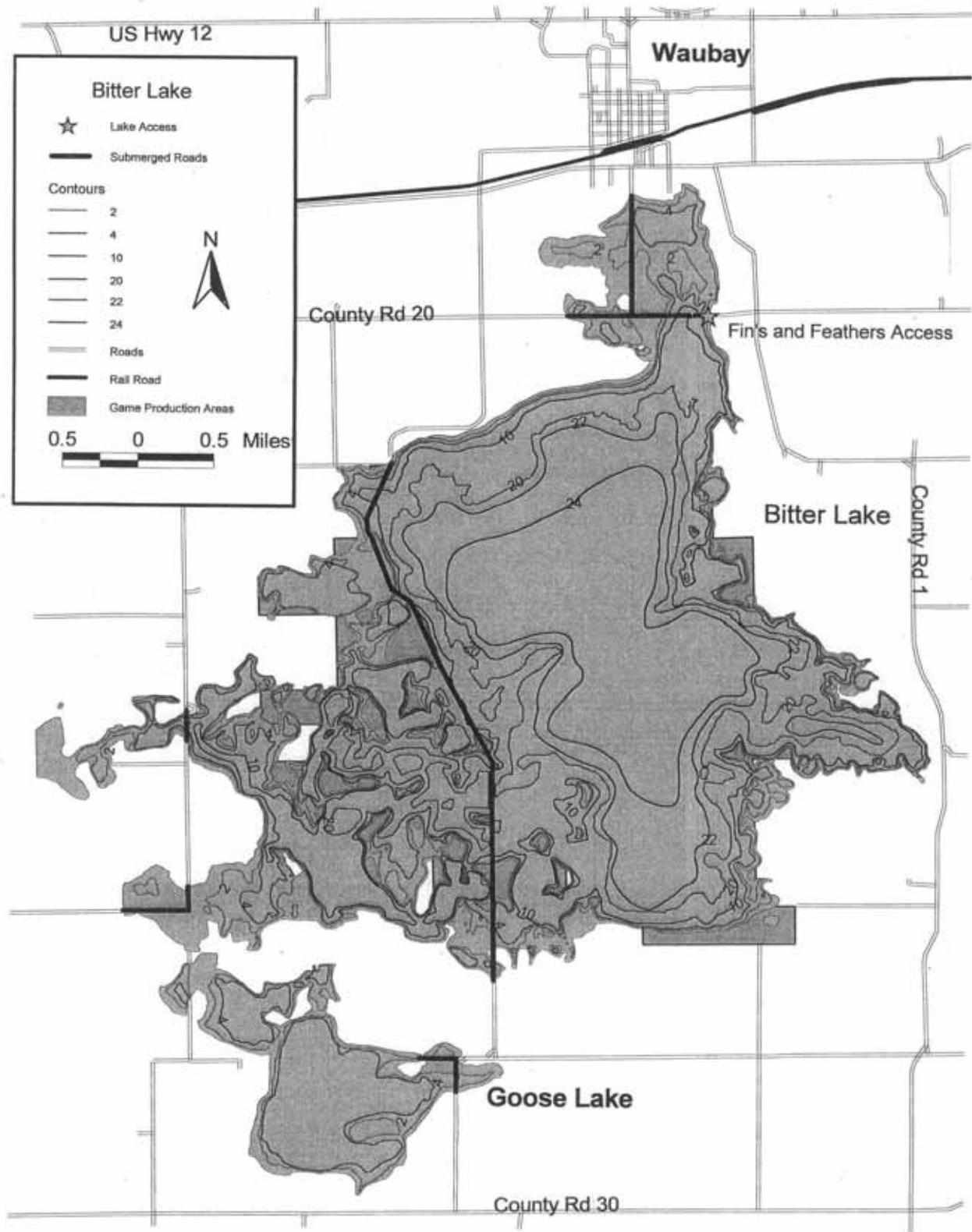


Figure 1. Bitter Lake, Day County, South Dakota contour map.

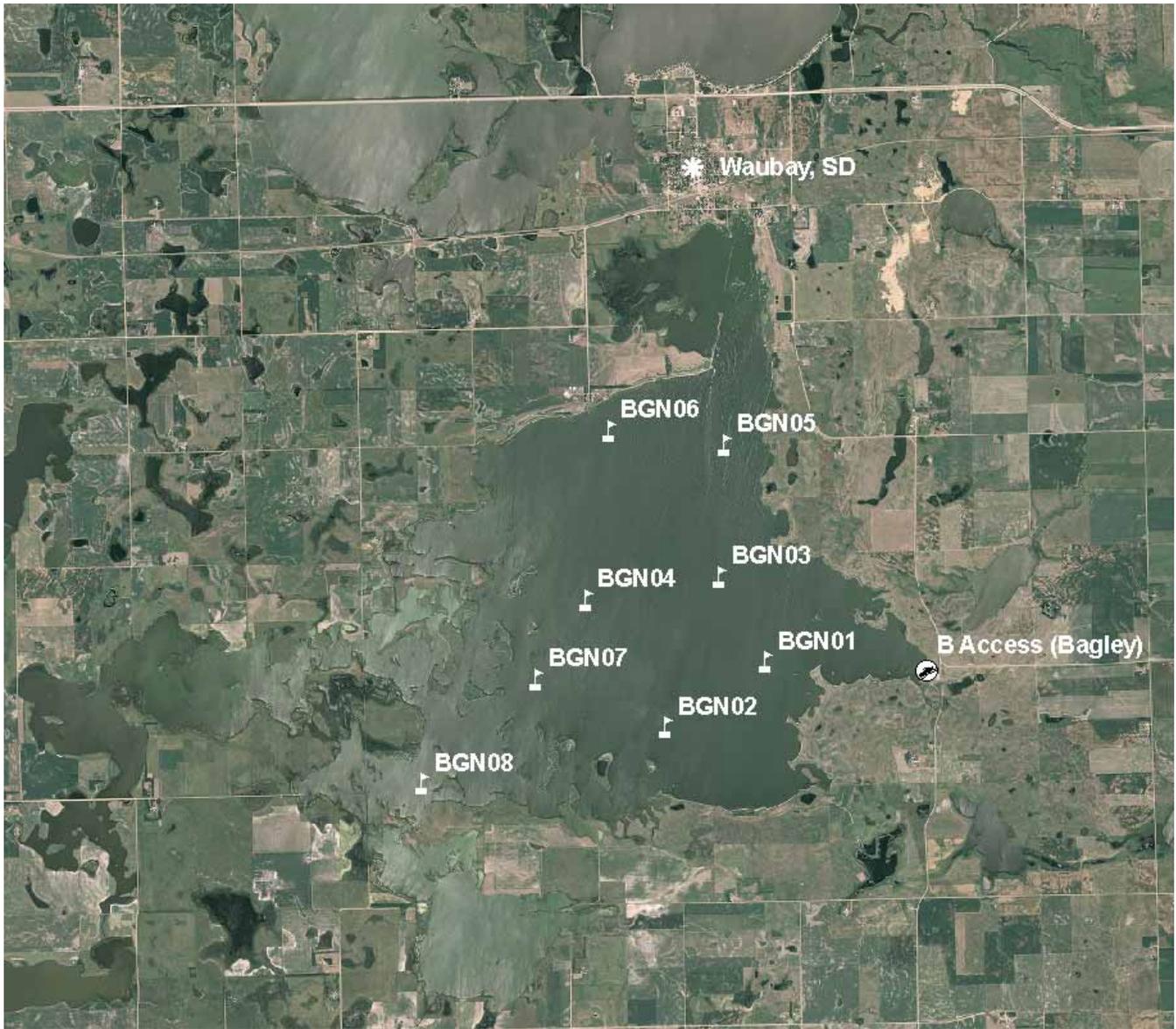


Figure 2. Map depicting public access location and standardized net locations for Bitter Lake, Day County, South Dakota. BGN=gill nets

Management Objectives

- 1) Maintain a mean gill net CPUE of stock-length walleye ≥ 10 , a PSD of 30-60, and a PSD-P of 5-10.
- 2) Maintain a mean gill net CPUE of stock-length yellow perch ≥ 30 , a PSD of 30-60, and a PSD-P of 5-10

Results and Discussion

Bitter Lake is a natural lake located south of Waubay, South Dakota in NE South Dakota. Prior to the 1990's Bitter Lake was a 3,000 acre alkaline slough with an approximate depth of 3 ft. High water conditions since the mid to late 1990's have increased the water depth and surface area of Bitter Lake. Currently, Bitter Lake covers in excess of 15,000 acres and is managed as a walleye and yellow perch fishery.

Primary Species

Walleye: The mean gill net CPUE of stock-length walleye during 2010 was 50.6 (Table 1) and well above the minimum objective (≥ 10 stock-length walleye/net night; Table 3). Since 2003, the mean gill net CPUE has ranged from a low of 9.1 (2008) to a high of 50.6 (2010), with the 2003-2010 average being 22.9 (Table 2). The 2010 gill net CPUE represented a substantial increase from the 11.0 observed in 2009 (Table 2) and indicated high relative abundance.

Walleye captured in the 2010 gill net catch ranged in total length from 17 to 63 cm (6.7 to 24.8 inches), had a PSD of 19 and a PSD-P of 3 (Figure 3). The 2010 PSD and PSD-P were below the objective ranges of 30-60 and 5-10 (Table 3) indicating a population comprised of smaller walleye (Figure 3). Walleye from the strong 2009 year class dominated the 2010 gill net sample and were in the stock-quality category resulting in the low size structure (Table 4; Figure 3). In 2010, approximately 18% of stock-length walleye captured in the gill net catch were above the 381-mm (15-inch) minimum length restriction enforced on Bitter Lake (Figure 3).

Otoliths were collected from a sub-sample of gill net captured walleye in 2010. Ten walleye year classes were present (1998-1999, 2001-2003, 2005, and 2007-2010) with the 2009 cohort being the most represented (Table 4). The 2009 year class was naturally produced and comprised 79% of stock-length walleye in the 2010 gill net catch (Table 4). Five age-0 walleye were captured in the 2010 gill net catch (Table 4), but none were captured during fall night electrofishing (Table 1) potentially indicating limited recruitment in 2010.

Walleye in Bitter Lake generally exceed quality-length (38 cm; 15 in) by age-3 (Table 5). Since 2005, the weighted mean length at capture for age-3 walleye has ranged from 410 to 461 mm (16.1 to 18.1 in) with the 2010 weighted mean length at capture for age-3 walleye being 443 mm (17.4 in; Table 5). Condition of stock-length walleye captured in the 2010 gill net catch was good with a mean Wr of 102 (Table 1). Stock-length walleye had mean Wr values that ranged from 92 to 102 for all length

categories sampled and a slight decreasing trend in condition was observed as total length increased in 2010.

Yellow Perch: The 2010 mean gill net CPUE of stock-length yellow perch was 25.9 (Table 1) and below the minimum objective (≥ 30 stock-length perch/net night). Since 2003, the gill net CPUE of stock-length yellow perch has fluctuated from a low of 2.2 (2003) to a high of 25.9 (2010) with the 2003-2010 average being 9.1 (Table 2). The 2010 gill net CPUE was the highest observed since 2003 and indicated moderate relative abundance.

Yellow perch captured in the 2010 gill net catch ranged in total length from 13 to 31 cm (5.1 to 12.2 in), had a PSD of 29 and a PSD-P of 22. The 2010 PSD was below the objective range of 30-60; while the PSD-P was above the objective range of 5-10 indicating a relatively-high proportion of yellow perch larger than 25 cm (10 in) in the population (Table 3; Figure 4).

Otoliths were collected from a sub-sample of gill net captured yellow perch in 2010. Age structure information indicated that year classes produced in 2007-2009 comprised the entire sample, with the 2009 year class being the most represented (Table 7). The increased relative abundance in 2010 (Table 2) can be attributed to the abundant 2009 year class attaining stock-length (Table 7; Figure 4).

The weighted mean total length at capture for age-1 and age-2 male yellow perch was 161 and 238 mm (6.3 and 9.4 in), respectively (Table 8). The weighted mean total length at capture for age-1 and age-2 female yellow perch was 175 and 258 mm (6.9 and 10.2 in; Table 8). Stock-length yellow perch in the 2010 gill net catch had mean W_r values that ranged from 104 to 106 for all length categories sampled and no length-related trends in condition were apparent as total length increased. The mean W_r of stock-length yellow perch was 106 (Table 1).

Other Species

Northern Pike: Northern pike typically are not sampled effectively using standard lake survey methods; therefore, reported values may not accurately represent the at-large population. Neumann and Willis (1995) reported the most reliable time to sample northern pike with gill nets was late spring following the spawn.

Eight northern pike ranging in total length from 47 to 73 cm (18.5 to 28.7 in) were captured by gill nets in Bitter Lake during 2010, resulting in a CPUE of 1.0 (Table 1). Northern pike relative abundance, as indexed by mean gill net CPUE has varied from a low of 0.3 (2007) to a high of 1.5 (2003) with the 2003-2010 average being 0.8 (Table 2). Recent high water levels in Bitter Lake should benefit the northern pike population. Northern pike depend heavily on flooded vegetation for spawning and recruitment and tend to have improved recruitment during springs that have rising water levels in northeastern South Dakota lakes.

Other: Black crappie, common carp, and white sucker were other fish species captured in low numbers during the 2010 fish community survey on Bitter Lake (Table 1).

Management Recommendations

- 1) Conduct fish population assessment surveys on an annual basis (next survey scheduled in summer 2011) to monitor fish relative abundance, fish population size structures, fish growth, and stocking success.
- 2) Conduct fall night electrofishing on an annual basis to monitor age-0 walleye relative abundance.
- 3) Collect otoliths from walleye and yellow perch to assess age structure and growth rates of each population.
- 4) Stock walleye fry (≈ 500 fry/acre; 50% OTC marked) to establish additional year-classes if gill netting and/or fall night electrofishing CPUE of age-0 walleye results warrant (i.e., low gill net CPUE of < 25 cm (10 in) walleye and/or fall night electrofishing CPUE of age-0 walleye < 75 fish/hour).
- 5) Maintain the 381-mm (15 in) minimum length limit on walleye to benefit the population and comply with tool box options (Lucchesi and Blackwell 2009).
- 6) Maintain a useable public boat ramp and parking area on Bitter Lake as water levels rise.

Table 1. Mean catch rate (CPUE; gill nets = catch/net night, electrofishing = catch/hour) of stock-length fish, proportional size distribution of quality- (PSD) and preferred-length (PSD-P) fish, and mean relative weight (Wr) of stock-length fish for various fish species captured in experimental gill nets and electrofishing in Bitter Lake, 2010. Confidence intervals include 80 percent (\pm CI-80) or 90 percent (\pm CI-90). BLC= black crappie; COC= common carp; NOP= northern pike; WAE= walleye; WHS=white sucker; YEP= yellow perch

Species	Abundance		Stock Density Indices				Condition	
	CPUE	CI-80	PSD	CI-90	PSD-P	CI-90	Wr	CI-90
<i>Gill nets</i>								
BLC	0.1	0.2	0	---	0	---	136	---
COC	0.3	0.2	50	50	0	---	126	49
NOP	1.0	0.5	63	34	13	23	93	5
WAE	50.6	8.6	19	3	3	2	102	<1
WHS	0.3	0.2	50	50	50	50	98	---
YEP	25.9	3.1	29	5	22	5	106	<1
<i>Electrofishing</i>								
WAE ²	0.0	---	---	---	---	---	---	---

Table 2. Historic mean catch rate (CPUE; gill nets = catch/net night, electrofishing = catch/hour) of stock-length fish for various fish species captured using experimental gill nets and electrofishing in Bitter Lake, 2003-2010. BLC= black crappie; COC= common carp; NOP= northern pike; SPS=spottail shiner; WAE= walleye; WHB= white bass; WHS=white sucker; YEP= yellow perch

Species	CPUE								
	2003	2004	2005	2006 ³	2007 ³	2008	2009	2010	Mean
<i>Gill nets</i>									
BLC	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
COC	0.2	0.0	0.1	0.0	0.3	0.1	0.0	0.3	0.1
NOP	1.5	1.3	0.4	0.8	0.3	0.4	0.5	1.0	0.8
SPS ¹	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.1
WAE	25.8	17.9	20.0	31.8	16.9	9.1	11.0	50.6	22.9
WHB	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0
WHS	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.3	0.1
YEP	2.2	2.9	2.6	11.8	2.6	4.1	20.8	25.9	9.1
<i>Electrofishing</i>									
WAE ²	1.4	0.0	90.1	0.0	440.0	136.9	294.0	0.0	120.3

¹ All fish sizes.

² Fall night electrofishing-WAE; catch rate (CPUE) represents age-0 walleye/hour

³ Monofilament gill net mesh size change (0.75", 1.00", 1.25", 1.50", 2.00" and 2.50")

Table 3. Mean catch rate (CPUE; gill nets = catch/net night) of stock-length fish, proportional size distribution of quality- (PSD) and preferred-length (PSD-P) fish, and mean relative weight (Wr) of stock-length fish for selected species captured in experimental gill nets from Bitter Lake, 2003-2010. NOP= northern pike; WAE= walleye; YEP= yellow perch

Species	2003	2004	2005	2006 ¹	2007 ¹	2008	2009	2010	Average	Objective
<i>Gill nets</i>										
NOP										
CPUE	2	1	< 1	1	<1	<1	1	1	1	---
PSD	100	100	100	100	100	100	100	63	95	---
PSD-P	33	10	100	17	100	100	25	13	50	---
Wr	80	84	74	102	84	75	88	93	85	---
WAE										
CPUE	26	18	20	32	17	9	11	51	23	≥ 10
PSD	51	76	96	50	91	81	24	19	61	30-60
PSD-P	2	1	1	8	10	8	2	3	4	5-10
Wr	90	94	89	96	90	92	94	102	93	---
YEP										
CPUE	2	3	3	12	3	4	21	26	9	≥ 30
PSD	77	96	76	64	86	42	34	29	63	30-60
PSD-P	23	61	43	49	29	24	13	22	33	5-10
Wr	114	112	113	97	114	114	116	106	111	---

¹ Monofilament gill net mesh size change (0.75", 1.00", 1.25", 1.50", 2.00" and 2.50")

Table 4. Year class distribution based on the expanded age/length summary for walleye sampled in gill nets and associated stocking history (Number stocked x 1,000) from Bitter Lake, 2006-2010.

Survey Year	Year Class												
	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
2010	5	326	42	16		15		1	3	1		1	1
2009 ¹	---	123	53	15	3	13			1		1	1	
2008 ¹	---	---	28	19	1	50			4	2	1	1	
2007 ^{1,2}	---	---	---	1		97		3	14	6	4	1	3
2006 ^{1,2}	---	---	---	---	1	131	5	9	66		31	5	3
# stocked													
fry				10000		9050					8015	5322	9228
sm. fingerling												404	
lg. fingerling													

¹ Older walleye were sampled, but are not reported in this table.

² Monofilament gill net mesh size change (0.75", 1.00", 1.25", 1.50", 2.00" and 2.50")

Table 5. Weighted mean total length (mm) at capture for walleye age-0 through age-10 sampled in experimental gill nets (expanded sample size) from Bitter Lake, 2005-2010. Note: sampling was conducted at approximately the same time during each year allowing comparisons among years to monitor growth trends.

Year	Age										
	0	1	2	3	4	5	6	7	8	9	10
2010 ¹	185(5)	307(326)	406(42)	443(16)	---	513(15)	---	561(1)	543(3)	635(1)	---
2009 ¹	133(123)	287(53)	358(15)	458(3)	474(13)	---	---	484(1)	---	496(1)	652(1)
2008 ¹	130(28)	271(19)	357(1)	431(50)	---	---	509(4)	510(2)	495(1)	598(1)	---
2007	170(1)	---	402(97)	---	466(3)	497(14)	484(6)	504(4)	455(1)	599(3)	544(6)
2006	191(1)	326(131)	413(5)	461(9)	468(66)	---	490(31)	509(5)	584(3)	442(4)	---
2005	165(64)	295(2)	383(7)	410(52)	429(47)	440(15)	455(14)	438(16)	478(2)	---	---

¹ Older walleye were sampled, but are not reported in this table.

Table 6. Stocking history including size and number for fishes stocked into Bitter Lake, 1998-2010. WAE= walleye; YEP= yellow perch

Year	Species	Size	Number
1998	WAE	fry	9,228,000
	YEP	juvenile	1,875
	YEP	adult	5,340
1999	WAE	fry	5,322,000
	WAE	fingerling	404,100
2000	WAE	fry	8,015,200
2005	WAE	fry	9,050,000
2007	WAE	fry	10,000,000

Table 7. Year class distribution based on the age/length summary for yellow perch sampled in gill nets from Bitter Lake, 2009-2010.

Survey Year	Year Class					
	2010	2009	2008	2007	2006	2005
2010	---	152	48	8	---	---
2009	---	36	108	55	2	2

Table 8. Weighted mean total length (mm) at capture by gender for yellow perch captured in experimental gill nets (expanded sample size) from Bitter Lake, 2009-2010.

Year	Age				
	0	1	2	3	4
2010					
Male	---	161(31)	238(1)	231(1)	---
Female	---	175(117)	258(47)	294(7)	---
Combined	---	172(152)	257(48)	286(8)	---
2009					
Male	92 (26)	165 (7)	223 (2)	---	266 (1)
Female	92 (10)	173 (101)	239 (53)	264 (2)	---
Combined	92 (36)	172 (108)	238 (55)	264 (2)	266 (2)

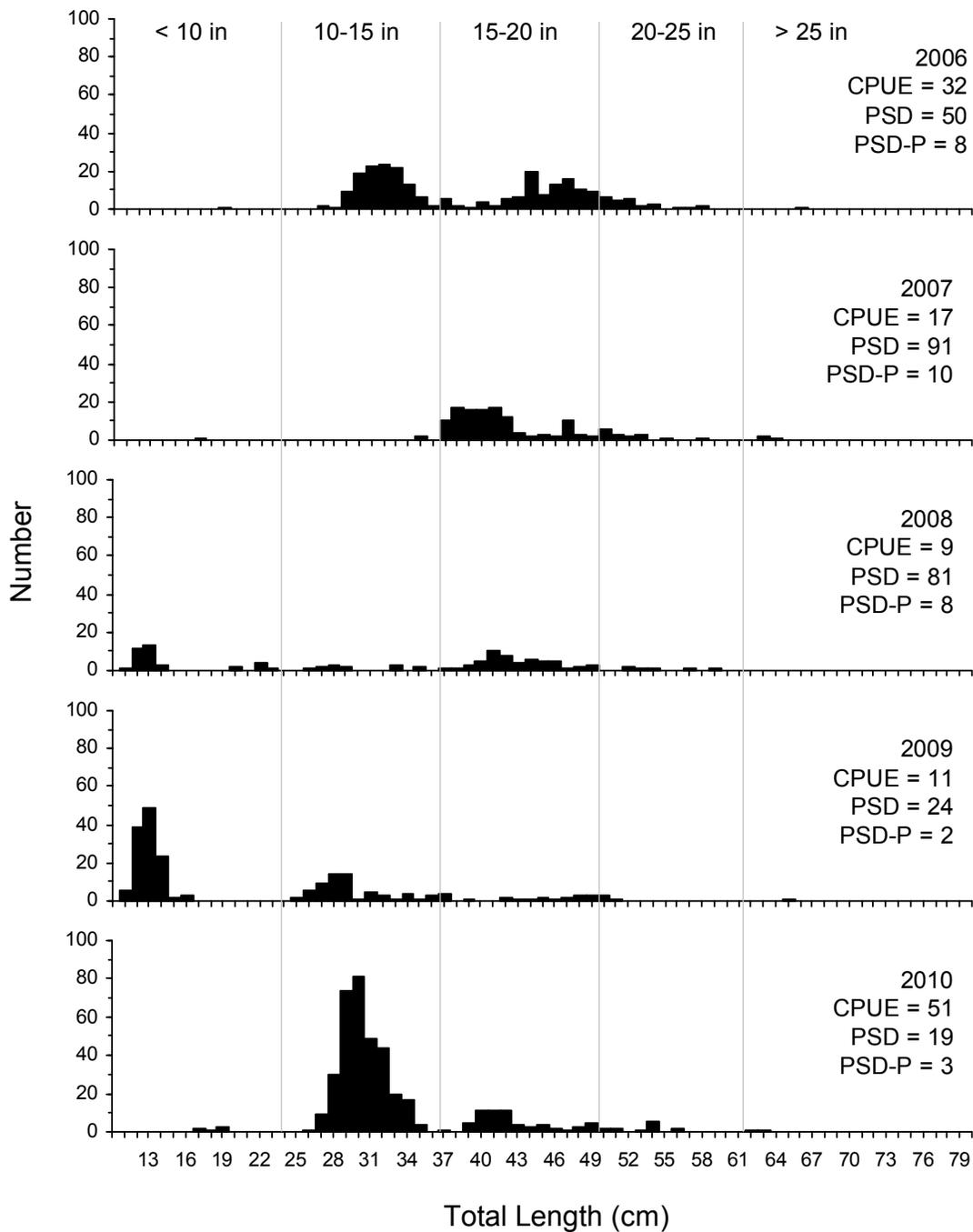


Figure 3. Length-frequency histogram, catch rate of stock-length fish (CPUE), proportional size distribution of quality- (PSD) and preferred-length (PSD-P) fish for walleye captured using experimental gill nets in Bitter Lake, 2006-2010.

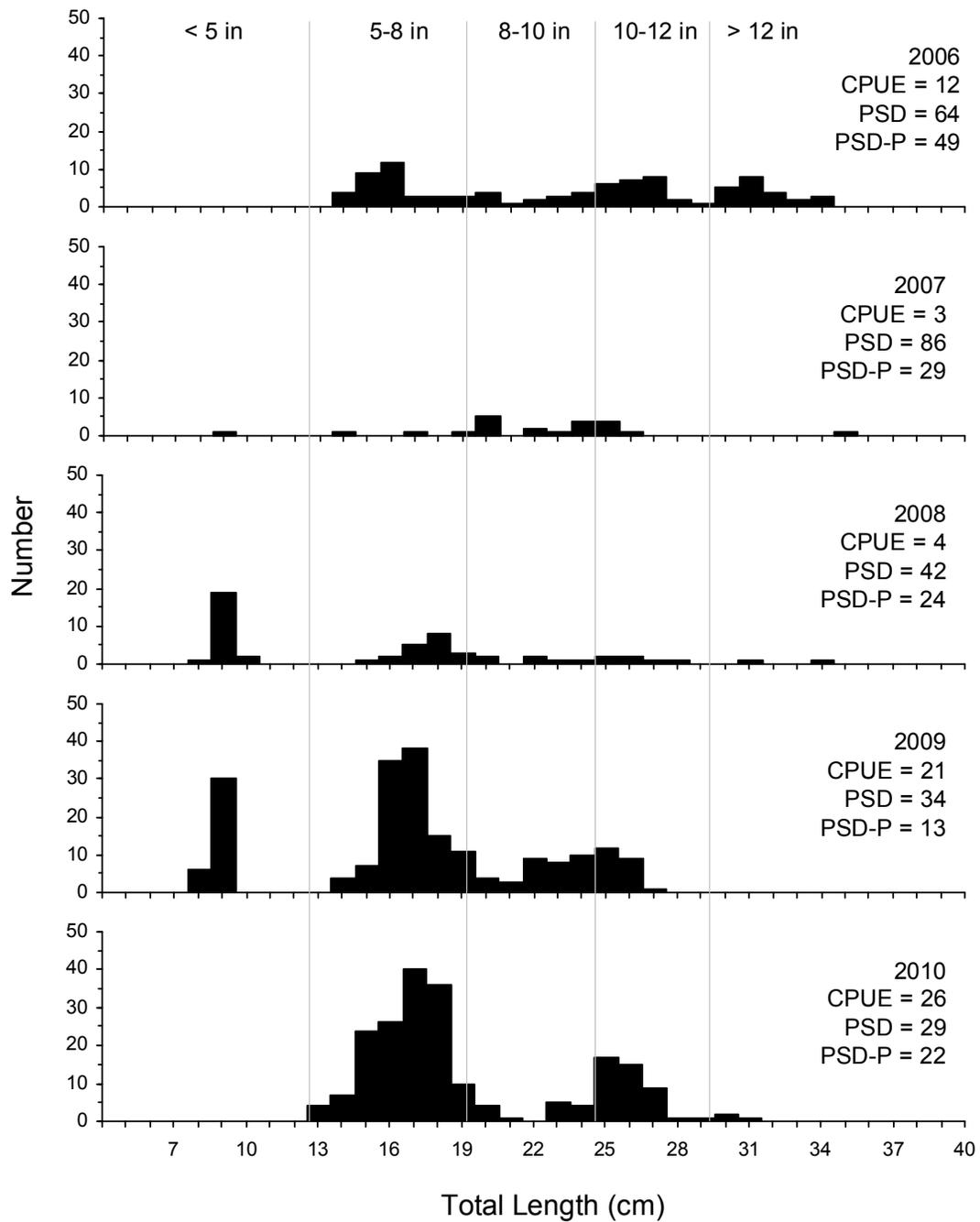


Figure 4. Length-frequency histogram, catch rate of stock-length fish (CPUE), proportional size distribution of quality- (PSD) and preferred-length (PSD-P) fish for yellow perch captured using experimental gill nets in Bitter Lake, 2006-2010.