2006 Annual Report

Missouri River Habitat Assessment Monitoring Program:
Segment 8 and Segment 9

Prepared for the U.S. Army Corps of Engineers – Northwest Division
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June 2007

Executive Summary

The pallid sturgeon (*Scaphirhynchus albus*) is a riverine species that evolved and adapted to large, turbid and free-flowing rivers (USFWS 1993). Sturgeon are known to utilize a diverse range of habitats such as mid-channel sandbars and areas around emergent islands (Bramblett and White 2001; Snook et al. 2002). Historically, the Missouri River was wide, free-flowing, turbid and transported a large amount of sediment. The Missouri River's ecosystem consisted of the main channel, backwaters, sloughs, chutes, sandbars, islands, side channels and the floodplain. Each of these habitats and the transitions between them provided an important element in the life history of the pallid sturgeon. Because of anthropogenic changes today's Missouri River bears little resemblance to the river in which pallid sturgeon evolved.

The pallid sturgeon was listed as an endangered species under the Endanger Species Act in 1990 (USFWS 1990) with habitat degradation being identified as a main factor. In response to the Biological Opinion, the Habitat Assessment Monitoring Program (HAMP) was formed to characterize biological responses to main channel habitat creation activities conducted on the Missouri River. The goals of HAMP are to characterize habitat use of pallid sturgeon and other target fish species and evaluate their response to U.S. Army Corp of Engineers (USACE) habitat creation efforts in an adaptive management framework. The objectives include 1) assess and monitor the physical changes between control bends and modified bends and 2) assess and monitor pallid sturgeon response and other biological changes between control bends and modified bends.

Sampling by the Nebraska Game and Parks Commission (NGPC) for 2006 was conducted on 47 bends of the Missouri River between Ponca, Nebraska and Rulo, Nebraska. Twenty of these bends were established as study bends for the program in May 2006. All gear types selected as the standard gears for the project (i.e., gill nets, trammel nets, otter trawls, and mini-fyke nets) were used during 2006. The effort applied during 2006 consisted of 1,224 trammel net, 454 otter trawl and 320 mini-fyke net deployments.

Twenty-six pallid sturgeon and 2,335 shovelnose sturgeon were collected during the 2006 season. Gill netting collected 16 pallid sturgeon, 61.5 % of all pallid sturgeon captures. The trammel net and otter trawl were less effective in collecting pallid sturgeon (seven and three, respectively). Gill nets collected 48.4 % of all shovelnose and otter trawls collected 40.3 %. The majority of shovelnose sturgeon collected were adults. A total of 1,039 blue suckers, a native large bodied fish and a species thought to be an important indicator of pallid sturgeon ecology, were also collected. Trammel nets accounted for 65.4% of all blue suckers collected. A total of 281 speckled chubs, 58 sicklefin chubs and 12 sturgeon chubs were collected during 2006. The otter trawl collected the majority of chub species (73.8 %) when compared to mini-fyke nets (26.2 %) and was the only gear to collect sicklefin chub.

Catch-rates were variable and no distinct patterns or trends were present in the data with regards to bend treatment type. However, there does appear to be some differences in catch-rates and temperature between Segments 8 and 9. Water temperatures were slightly warmer and turbidity is higher in Segment 9. Catch-rates of chubs also appear to be higher in segment 9. No other fish species showed any preferences by segment.

During 2006, most our effort went into sampling the study bends and refining HAMP standard operating procedures. Currently, HAMP is working to increase data collection efforts for all study bends. HAMP is introducing a new standard gear (push trawl) to target shallow water habitat that is difficult to sample with the stern trawl and not accessible with mini-fyke nets. It is our desire to gain more information on habitat use by juvenile sturgeon and other small bodied target fish species. This information will help to understand if we are missing those fish in our sample because on sampling strategy or that they are not present in the Missouri River. In addition to new gear, we also have plans to implement a telemetry component investigating juvenile sturgeon movements and habitat use. Nebraska Game and Parks Commission's HAMP program accomplished all of its sampling goals and exceeded its own expectations for gear deployments. It is our goal in 2007 to expand our sampling efforts again. We are trying to increase our statistical power by increasing the number of sub-samples and replication of study bends sampled.

This document may be cited as:

Cox O.N. and S.J. Sampson. 2007. 2006 Annual Report, Missouri River Habitat Assessment and Monitoring Program: Segments 8 and 9. Nebraska Game and Parks Commission. Lincoln, NE.

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Introduction

The pallid sturgeon (*Scaphirhynchus albus*), native to the Missouri River Basin, was listed as an endangered species under the Endanger Species Act 1990 (USFWS 1990). The pallid sturgeon is a riverine species that has evolved and adapted to large, turbid and free-flowing rivers (USFWS 1993). Sturgeon are known to utilize a diverse range of habitats such as mid-channel sandbars and areas around emergent islands (Bramblett and White 2001; Snook et al. 2002). Historically, the Missouri River was wide, free-flowing, turbid and transported a large amount of sediment. The Missouri River's ecosystem consisted of the main channel, side channels, backwaters, sloughs, chutes, sandbars, islands and the floodplain. Each of these habitats and the transitions between them provided an important element in the life history of the pallid sturgeon. Inundation of the floodplain was an important source of organic matter and large woody debris. Organic matter and large woody debris would have served as habitat for pallid sturgeon and other aquatic life. Areas of shallow water and slow velocities would have benefited juvenile pallid sturgeon and many cyprinids both directly and indirectly.

During the 1800's and 1900's the Missouri River was altered for the purposes of navigation, flood control, irrigation, municipal water supply and power generation (USFWS 1993; USFWS 2000; USFWS 2003). The modifications included dams, channelization, bank stabilization and removal of large woody debris. As a result, these modifications altered the natural hydrology, decreased turbidity, altered temperature regimes and reduced habitat complexity. Consequently, spawning and rearing habitat was modified or eliminated, spawning cues altered, fish migration impeded and food resources reduced (USFWS 1993; USFWS 2000; USFWS 2003). The U.S. Fish and

Wildlife Service (USFWS) have implicated the loss and degradation of habitat as one of the contributing factors for the decline in pallid sturgeon populations of the Missouri River (USFWS 1993; USFWS 2000; USFWS 2003).

In response to the pallid sturgeon being listed as an endangered species and the U.S. Fish and Wildlife Service's Biological Opinion (USFWS 2000; USFWS 2003) the U.S. Army Corp of Engineers (USACE) has implemented a habitat restoration program to create approximately 5,870 acres of shallow water habitat by 2010 and a comprehensive monitoring program for these efforts. The goal of Habitat Assessment and Monitoring Program (HAMP) is to characterize the response of pallid sturgeon and other target fish species to the USACE habitat creation efforts in an adaptive management framework. The objectives of HAMP are 1) assess and monitor the physical changes between control bends and modified bends and 2) assess and monitor pallid sturgeon response and other biological changes between control bends and modified bends.

Study Area

The study area for the HAMP conducted by Nebraska Game and Parks Commission (NGPC) includes the Missouri River from Ponca State Park, NE (River Mile (rm) 753.6), to the confluence of the Kansas River, Kansas City, KS (rm 367.5). This reach of the Missouri River has been divided into two hydrological reaches (Segments 8 and 9) based on differences in physical attributes, (i.e., degrading or aggrading stream bed, flow fluctuation, natural hydrograph, stream gradient, geology, water temperature, turbidity, and substrate), discrete habitat changes (i.e., influence of the Platte River) and modifications (i.e., presence of restoration projects) (Drobish 2005). Segment 8 includes the reach of the Missouri River from Ponca, NE (rm 753) to the confluence of the Platte River (rm 595.0) and consists of 51 bends (Appendix I). Segment 9 includes the reach of the Missouri River from the confluence of the Platte River (rm 595.0) to the confluence of the Kansas River, Kansas City, KS (R.M. 367.5). However, our study area is only a portion of each Segment (Figure 1). In Segment 8 the study area is from river mile 714.3 to river mile 634.1. In Segment 9 the study area is from the river mile 589.0 to river mile 549.5. The Missouri River within these reaches is highly engineered and is relatively uniform in depth and width. The outside bank has been revetted to control erosion. Wing dikes have been constructed along the inside bank to maintain main channel velocities and minimize sediment deposition to maintain the navigation channel.

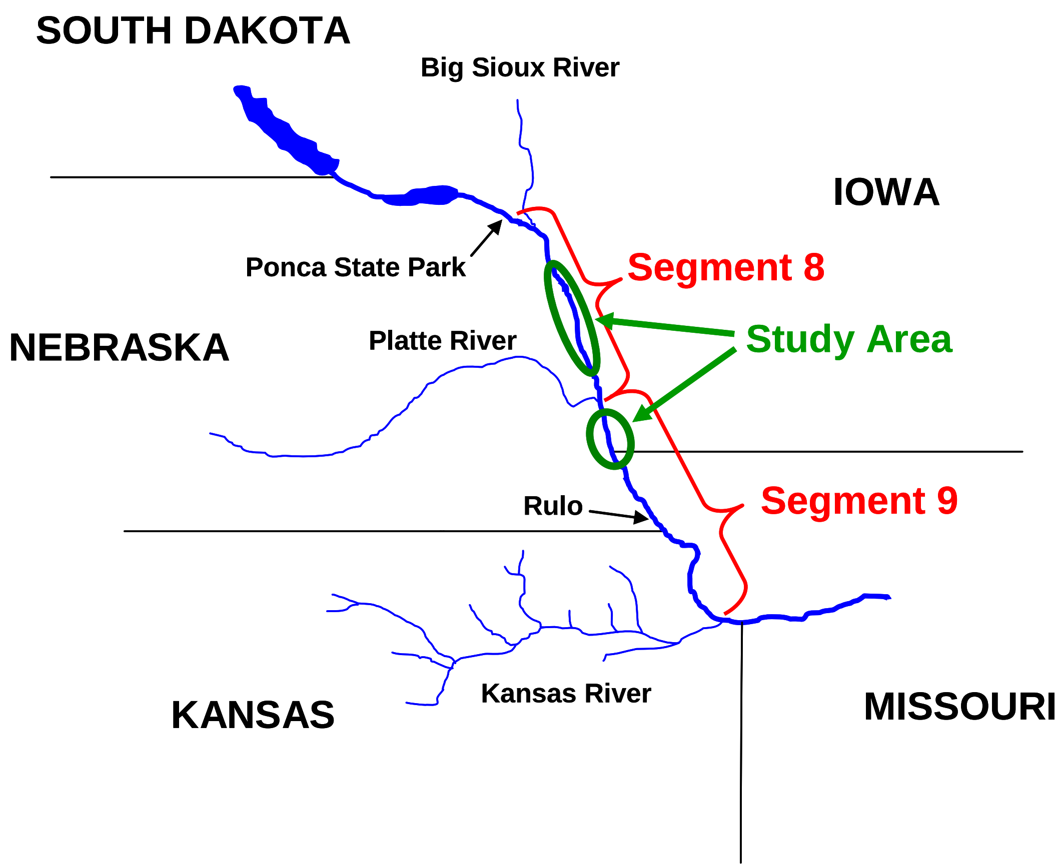

Figure 1. Study area for Nebraska Game and Parks Commission Habitat Assessment and Monitoring Program. Segment 8, study area is from river mile 714.3 to river mile 634.1. Segment 9, study area is from the river mile 589.0 to river mile 549.5.

Methods

Experimental design

The experimental design for HAMP was based on a before-after/control-impact (BACI) design. By implementing a BACI design, differences in response variables with respect to treatment type can be evaluated pre and post-impact to see if there were any changes due to the treatment. For this study, bends were classified based on the presence or absence or on the anticipation of dike modifications. Bends within river segments were also blocked by radius and length. Bend radius (25^{th} and 75^{th} percentile) and length were thought to be significant factors affecting habitat creation; therefore bend radius was included as a blocking structure of the design.

Initially NGPC HAMP sampled 46 different bends, representing all treatments, but as of May 2006 the HAMP bend list was finalized to include 10 bends in each segment representing 4 treatment categories (Table 1). At both the 25^{th} and 75^{th} percentile of bend radius there was one control bend (control-25 and control-75), two before/after bends (before-25 and before-75) and a two previously modified bends (modified-25 and modified-75). Control bends were bends that have not been and will not be modified, and can be thought of as reference bends. Before/after bends are bends scheduled to be modified in the future by either creating notched dikes or chevrons. Modified bends were bends modified prior to the start of the HAMP program, and are being monitored to understand the potential of the modifications. Modifications were done at the bend level and included notching existing wing dike structures at the bank line (notched dike) or lowering some of the existing wing dike structures and creating new chevron dikes (major-modification).

Table 1. List of HAMP study bends in Segment 8 and Segment 9 of the Missouri River sampled during 2006. Bend number represents the number associated with the bend. Upper river mile represents the upper river mile associated with the beginning of the bend and lower river mile represents the lower river mile associated with the end of the bend. Treatment type indicates the treatment type (Control, Before/After = B/A, bank notch = Notched, and chevron = Major Mod) associated with the bend. Percent bend radius represents the 25^{th} or 75^{th} percentile of the bend radius.

Segment	Bend #	Bend Name	Upper River Mile	Lower River Mile	Treatment Type	% Bend Radius
8	14	Glovers Point Upper	714.3	712.0	B/A	75
	25	Decatur Lower	687.4	686.0	B/A	25
	26	Louisville Upper	686.0	683.4	B/A	25
	31	Little Sioux Reach Upper	676.3	674.8	B/A	75
	33	Little Sioux Reach Lower	672.8	670.5	Notched	25
	37	Peterson Cut-off Lower	659.2	657.8	Control	75
	39	Tysons	655.0	651.6	Notched	75
	42	DeSoto Cut-off	644.8	641.8	Major Mod	75
	45	Calhoun Lower	638.5	637.3	Control	25
	46	Boyer Lower	636.0	634.1	Major Mod	25
9	3	Tobacco	589.4	586.3	Major Mod	75
	6	Pin Hook	579.2	576.8	Notched	25
	7	Van Horns	576.8	574.8	Control	75
	8	Civil Upper	574.8	572.8	B/A	75
	9	Civil Lower A	572.8	571.5	Notched	25
	11	Copeland Lower	565.1	562.9	B/A	75
	12	Nebraska	562.9	560.4	Notched	75
	14	Otoe	556.7	555.5	B/A	25
	15	Hamburg Upper	555.5	552.9	Major Mod	25
	17	Barney Upper	550.9	549.5	Control	25

Field sampling

Habitat collection

Water temperature at the surface (ºC) and water depth (m) were collected with each sub-sample using a Garmin GPSMAP 178 depth-finder. Physical habitat characteristics; velocity (m/s), substrate and turbidity (NTU) were collected at a minimum of 25% of the sub-samples collected and for each sub-sample when pallid sturgeon were collected. Velocity was measured at three depths when the depth was > 1.2 m, bottom, 80% and 20% of water depth and two depths when the depth was ≤ 1.2 m, bottom and 60% of water depth, using a Marsh-McBarney flow-mate model 2000. Turbidity was measured using a HACH 2100P turbidimeter.

Fish collection

Fish collection was divided into two seasons, sturgeon and fish community, based on water temperature and time of year. Sturgeon season commenced when surface water temperatures drop below 55 °F (12.8 °C) in the fall and continues until June 30th. Fish community season started on July 1 and finished when water temperatures were below 55 °F (12.8 °C) in the fall. Each gear type was deployed following the standard protocols of the Pallid Sturgeon Population Assessment Program's (Drobish 2005). A minimum of eight sub-samples of each gear type were randomly deployed within each bend based on available macro- and meso-habitaits. Macro-habitat was described as either main channel outside bend, main channel inside bend or main channel crossover. Meso-habitat was described either as channel border, thalwag, pool or bars. Total length (TL) mm was measured on most fish collected with the exceptions of sturgeon (fork length (FL) mm) and paddle fish (eye to fork, mm). Weight (g) of target species (pallid sturgeon, shovelnose sturgeon, blue sucker, speckled chub, sturgeon chub, sicklefin chub, sand shiner, plains minnow, and sauger) was also recorded. These species were selected as target species because they are native big river fishes of the Missouri River and are important for pallid sturgeon ecology and life history. Given that pallid sturgeon are long-lived fishes (60+ years), and can take up to 20 years to become reproductively mature and might reproduce every one to three years, it is necessary to have surrogate indicators of habitat change that will respond in a more timely fashion.

All pallid sturgeon collected were measured (FL and morphometrics), weighed and checked for previously implanted tags (PIT, elastomere, and coded wire tags). Standard morphometric measurements included head length, distance from snout to mouth, interrostral length, mouth-width, and barbel lengths. If the pallid sturgeon was not a known hatchery recapture, anal and dorsal ray counts were taken. Tissue samples were taken for genetic analysis of all pallid sturgeon following the PA protocol (Drobish 2005). If a PIT tag was not present, a one was inserted into the fish according to the PA protocol (Drobish 2005).

Sampling gear

Sampling gears used by HAMP during the 2006 sampling season included trammel nets, otter trawls, mini-fyke nets, experimental gillnets, and small hoop nets. These gears are also being used by other pallid sturgeon recovery projects within the Missouri River Basin (Drobish 2005).

Gill net

The gill net consisted of eight multifilament panels each 7.6 m (25 ft) long and 2.4 m (8 ft) high and a total length of 61 m (200 ft). The gill net had two series of four panels; panels 1 and 5 with 38.1 mm (1.5 in) mesh, panels 2 and 6 with 50.8 mm (2.0 in) mesh, panels 3 and 7 with 76.2 mm (3.0 in) mesh, and panels 4 and 8 with 101.6 mm (4.0 in). Twine size for panels 1, 2, 5 and 6 was #104 and for panels 3, 4, 7 and 8 was #139. The float line was a braided poly-foam core of 13 mm (0.5 in) diameter and the lead line was 7.1 mm (9/32") (22.7 kg/600 ft). Gill nets were deployed in the afternoon and fished overnight with a maximum set time of 24 hours. Gill nets were fished in channel crossover and inside bend macro-habitats and in pool and channel border meso-habitats. Catch-per-unit-effort was calculated as net night per 100 ft. When deployed the first panel set upstream was selected randomly and recorded (Panel 1 or 8).

Otter trawl

The otter trawl had a width of 4.9 m (16 ft), height of 0.9 m (3 ft), and length of 7.6 m (25 ft). The otter trawl had a 6.35 mm (0.25 in) bar inner mesh and a 38.1 mm (1.5 in) bar outer mesh of #9 sapphire twine, with a cod-end opening of 406.4 mm (16 in). Trawl doors, made from 19.1 mm (0.75 in) marine plywood, measuring 762 mm (30 in) by 381 mm (15 in), were used to keep the trawl deployed on the river bottom. A 7.9 m (26 ft) long tickler chain (3.2 mm (0.125 in) galvanized) was attached to the back corner of the trawl doors and ran approximately three feet in front of the footrope. The tickler chain aided in dragging the river bed to ensure a then trawl was effectively sampling benthic habitat sample and provided some additional protection for the lower mouth of the otter trawl. Otter trawls were fished downstream with the length of the trawl dependent upon the size of the macro-habitat and meso-habitat being sampled. Otter trawl samples covered a minimum of 75 m (246 ft) and a maximum of 300 m (984 ft). Otter trawls were fished in channel crossover and inside bend macro-habitats and in channel border meso-habitats.

Trammel net

The trammel net had a length of 38.1m (125 ft), with an inner wall 2.4 m (8 ft) deep and two outer walls 1.8 m (6 ft) deep. The inner wall was composed of #139 multifilament twine with a bar mesh size of 25.4 mm (1.0 in). The outer walls were #9 multifilament twine with a bar mesh size of 203.2 mm (8.0 in). The trammel net had a 12.7 mm 7 (0.5 in) foam core float line and 22.7 kg (50 lb.) lead line. Trammel nets were drifted a minimum of 75 m (246 ft) and a maximum of 300 m (984 ft) with the length of the drift dependent upon the size of the meso-habitat being sampled. Trammel nets were fished in channel crossover and inside bend macro-habitats and in channel border meso-habitats.

Mini-fyke net

The mini-fyke net (small Wisconsin-type fyke net) had two rectangular frames, each 1.2 m (4.0 ft) by 0.6 m (2.0 ft) and two hoops, each 0.6 m (2.0 ft) made of oil tempered spring steel. The second rectangular frame had a 4.5 m (15 ft) long by 0.6 m deep (2.0 ft) lead was connected to it. The mini-fyke net had 3 mm (0.13 in) ace mesh with a 29.5 kg (65 lb) lead core line. Mini-fyke nets were set in the afternoon for and deployed overnight with a maximum set time of 24 hours shallow bank line and bar meso-habitats within the channel crossover and inside bend macro habitat.

Hoop net

The small hoop net is cylindrical in shape, 0.61m (2 ft) and dived by 7 hoops. It has an internal, funnel-shaped throat with tapered end pointing inward. The nets had black coated 38 mm (1.5 in) mesh made of #15 twine. Nets were set in the afternoon and deployed overnight for not more than 24 hours. Macro-habitats sampled included channel crossover, inside bend and outside bend. Meso-habitats sampled included channel borders and pools.

Data analysis

Data was entered into the central pallid sturgeon database by Yan Hong, Missouri Department of Conservation and their staff. This is the same database used by the Pallid Sturgeon Population Assessment and Missouri River Bank Stabilization and Navigation Mitigation Programs. Quality assurance/quality control of the data followed standard procedures developed for all Missouri River projects and was conducted by Yan Hong. Data analyses were conducted using SAS 8.1.

Length frequency histograms were created for target species to illustrate year class strength and gear efficiency. Mean annual catch per unit effort (CPUE) and standard error (±1 SE) was calculated by treatment type (control, before and modified) and gear for comparison between treatment means. Habitat variables (surface water temperature, turbidity, average depth, and velocity) were compared by segment, seasons and gear using analysis of variance (ANOVA). Where significance was determined by the overall model, post-hoc comparisons of segments within a season were made to evaluating differences. Significant differences were based on an alpha level = 0.05.

Multivariate Analysis of Variance (MANOVA) was used to detect differences in mean CPUE of adult and juvenile large bodied fishes (i.e., shovelnose sturgeon, blue suckers and sauger) and small bodied fishes (i.e., sturgeon chub, sicklefin chub, speckled chub and sand shiner) among treatment types (i.e., control, before, impact bends) by gear type (e.g., gillnet trammel net, mini-fyke net and otter trawl). Shovelnose sturgeon and blue suckers were characterized as adults when lengths were greater than 350 mm and sauger were characterized as adults when lengths were greater than 200 mm.

Fish species that were not collected by a particular gear type were left out of the MANOVA model. Relative abundance of each response variable was log transformed to meet the assumptions of ANOVA. When MANOVA's indicated differences between treatment types, the univariate model of each response variable used in the multivariate analysis was used to detect differences in CPUE by bend type blocked by segment (e.g., Segment 8 and Segment 9) and bend radius (e.g., 25th percentile and 75th percentile). Differences within all MANOVA and ANOVA models were considered significant at alpha level = 0.10.

Results

Effort

The 2006 sampling began on November 02, 2005 when surface water temperature dropped below 12.8 ºC initializing sturgeon season and the beginning of our gill net sampling. Gill netting continued until November 14, 2006 and then resumed on March, 1, 2006 until April 05, 2006. Otter trawls and trammel nets were fished for the remainder of sturgeon season once water temperatures had risen above 12.8 ºC. One wild gear, hoop net, was also fished during sturgeon season within two study bends. During fish community season (July, 01, 2006 through October 03, 2006), otter trawls, trammel nets and mini-fyke nets were used.

HAMP deployed 1,736 standard gears on designated study bends (Table 2), an additional 464 gear deployments were completed on non-HAMP study bends and 23 wild gears were deployed on two study bends (Table 3), for a total of 2,223 gear deployments. Non-HAMP study bends were sampled because a set list of study bends was not completed until May 2006 and construction activities were planned in the near future on these bends. Therefore, NGPC HAMP wanted to collect baseline data on these bends before construction activities were completed. Gill netting was incomplete on HAMP study bends because the bend list was not finalized until after gill netting efforts had been completed.

Sampling effort between segments 8 and 9 was comparable for most gears with the exception of an additional round of OT16 sampling in Segment 9. Within Segment 8, a total of 100 gill net sets were deployed, totaling 200 net-nights; 162 otter trawl tows resulting in 17,782 m of effort; 617 trammel net drifts resulting in 63,381 m of effort; and

160 mini-fyke net-nights were accomplished. In Segment 9, a total of 102 gill net sets, resulted in 204 net-nights; 292 otter trawl tows resulting in 34,641 m of effort; 607 trammel net drifts resulting in 59,480 m of effort; and 160 mini-fyke net nights were accomplish.

A total of 56,102 fish were collected (excluding small hoop nets), representing 58 species during the 2006 sampling year (Table 4). The catch was dominated by 9 species (red shiner, emerald shiner, river shiner, sand shiner, silver chub, shovelnose sturgeon, spotfin shiner, channel catfish and blue sucker). Twenty-four species were collected with gill nets, 37 with otter trawls, 26 with trammel nets and 41 with mini-fyke nets. Pallid sturgeon and shovelnose sturgeon were collected using gill nets, trammel nets and otter trawls. Most large bodied fishes were captured with trammel and gill nets; however, shortnose gar and flathead catfish were collected in mini-fyke nets. Mini-fyke nets accounted for 83.0 % of the all fish caught and 73.8 % of all chubs and shiners captured. The remaining chubs and shiners were collected with the otter trawl.

Table 2. Gear deployments and effort, in parenthesis, for HAMP study bends sampled within Segment 8 and Segment 9 of the Missouri River during 2006 sampling year. Treatment type indicates the treatment type (Control, Before/After = B/A, bank notch = Notched, and chevron = Major Mod) associated with the bend.

Segment	Bend #	Treatment Type	Gill Net	Otter Trawl	Trammel Net	Mini-fyke
8	14	B/A	--	16 (1,667)	61 (5,561)	16 (16)
	25	B/A	10 (20)	16 (1,678)	32 (3,141)	16 (16)
	26	B/A	--	16 (1,636)	32 (3,319)	16 (16)
	31	B/A	--	16 (1,874)	45 (5,026)	16 (16)
	33	Notched	10 (20)	18 (1,820)	48 (4,887)	16 (16)
	37	Control	10 (20)	16 (1,810)	40 (3,922)	16 (16)
	39	Notched	10 (20)	16 (1,924)	42 (4,173)	16 (16)
	42	Major Mod	10 (20)	16 (1,993)	50 (5,879)	16 (16)
	45	Control	--	16 (1,769)	32 (3,212)	16 (16)
	46	Major Mod	10 (20)	16 (1,611)	43 (4,132)	16 (16)
Segment 8 Subtotal			**60 (120)**	**162 (17,782)**	**425 (43,252)**	**160 (160)**
9	3	Major Mod	10 (20)	32 (3,997)	56 (5,960)	16 (16)
	6	Notched	--	25 (3,040)	32 (3,485)	16 (16)
	7	Control	10 (20)	24 (3,239)	48 (5,289)	16 (16)
	8	B/A	10 (20)	32 (3,489)	56 (5,491)	16 (16)
	9	Notched	--	32 (3,794)	40 (3,508)	16 (16)
	11	B/A	--	26 (2,906)	48 (4,721)	16 (16)
	12	Notched	--	24 (2,620)	47 (4,372)	16 (16)
	14	B/A	10 (20)	24 (2,762)	48 (4,605)	16 (16)
	15	Major Mod	--	32 (3,799)	32 (3,245)	16 (16)
	17	Control	10 (20)	24 (3,022)	37 (3,218)	16 (16)
Segment 9 Subtotal			**50 (100)**	**275 (32,668)**	**444 (43,894)**	**160 (160)**
Total			**110 (120)**	**437 (50,450)**	**869 (87,146)**	**320 (320)**

-- indicates bends were not sampled with the associated gear

Table 3. Gear deployments and effort, in parenthesis, for Non-HAMP study bends and wild gears deployed within Segment 8 and Segment 9 and of the Missouri River during 2006 sampling year.

Segment	Bend #	Gill Net	Otter Trawl	Trammel Net	Small Hoop Net*
8	10	10 (20)	--	16 (1,278)	--
	13	--	--	10 (746)	--
	15	10 (20)	--	16 (2,282)	--
	17	--	--	8 (1,265)	--
	21	--	--	16 (2,078)	--
	23	--	--	8 (623)	--
	24	--	--	8 (629)	--
	27	--	--	16 (1,975)	--
	29	10 (20)	--	8 (1,040)	--
	30	--	--	8 (799)	--
	34	--	--	16 (1,661)	--
	35	--	--	8 (616)	--
	38	10 (20)	--	8 (636)	--
	43	--	--	16 (1,440)	--
	55	--	--	30 (3,061)	--
Segment 8 Subtotal		**40 (80)**	**0**	**192 (20,129)**	**0**
9	1	10 (20)	--	--	--
	3	--	--	--	14 (14)
	4	--	9 (1,031)	33 (3,526)	--
	6	--	--	--	9 (9)
	16	8 (16)	8 (942)	32 (3,399)	--
	19	--	--	16 (1,747)	--
	20	--	--	14 (1,209)	--
	21	--	--	7 (477)	--
	22	--	--	8 (593)	--
	27	10 (20)	--	8 (696)	--
	31	--	--	8 (625)	--
	32	10 (20)	--	16 (1,292)	--
	33	5 (10)	--	13 (1,289)	--
	34	9 (18)	--	8 (733)	--
Segment 9 Subtotal		**52 (104)**	**17(1,973)**	**163 (15,586)**	**23 (23)**
Total		**92 (184)**	**17 (1,973)**	**355 (35,715)**	**23 (23)**

-- indicates bends were not sampled with the associated gear
* indicates wild gear

Table 4. Total catch and percent of catch by gear of fish species collected from Segment 8 and Segment 9 of the Missouri River during 2006 sampling year. Target species are highlighted in bold.

Species Name	Gill Net	Otter Trawl	Trammel Net	Mini-fyke	Total
Pallid sturgeon	**16 (61.5)**	**3 (11.5)**	**7 (26.9)**	**--**	**26**
Shovelnose X pallid hybrid	--	--	1 (100)	--	1
Shovelnose sturgeon	**1,131 (48.4)**	**262 (11.2)**	**942 (40.3)**	**--**	**2,335**
Paddlefish	5 (100)	--	--	--	5
Gar family	--	1 (100)	--	--	1
Longnose gar	24 (42.9)	1 (1.8)	31 (55.4)	--	56
Shortnose gar	106 (39.7)	7 (2.6)	25 (9.4)	129 (48.3)	267
Goldeye	3285 (48.3)	2 (0.3)	410 (51.4)	--	797
Skipjack herring	3 (27.3)	2 (18.2)	3 (27.3)	3 (27.3)	11
Gizzard shad	37 (20.1)	4 (2.2)	8 (4.3)	135 (73.4)	184
Cyprinid family	--	3 (6.2)	--	45 (93.8)	48
Speckled chub	**--**	**223 (79.4)**	**--**	**58 (20.6)**	**281**
Sturgeon chub	**--**	**53 (91.4)**	**--**	**5 (8.6)**	**58**
Sicklefin chub	**--**	**12 (100)**	**--**	**--**	**12**
Silver chub	--	2,461 (73.9)		868 (26.1)	3,329
Creek chub	--	--	--	3 (100)	3
Red shiner	--	82 (0.4)	--	21,562 (99.6)	21,644
Spotfin shiner	--	15 (1.0)	--	1,451 (99.0)	1,466
Common shiner	--	--	--	2 (100)	2
Emerald shiner	--	127 (1.1)	--	11,576 (98.9)	11,703
River shiner	--	127 (2.6)	--	4,793 (97.4)	4,920
Bigmouth shiner	--	--	--	2 (100)	2
Sand shiner	**--**	**25 (0.6)**	**--**	**3,981 (99.4)**	**4,006**
Plains minnow	**--**	**--**	**--**	**24 (100)**	**24**
Bluntnose minnow	--	--	--	1 (100)	1
Fathead minnow	--	--	--	166 (100)	166
Blacknose dace	--	--	--	1 (100)	1
Grass carp	3 (10.3)	1 (3.4)	25 (86.2)	--	29
Common carp	9 (21.4)	2 (4.8)	9 (21.4)	22 (52.4)	42
Silver carp	1 (33.3)	--	2 (66.7)	--	3
Bighead carp	--	2 (40.0)	3 (60.0)	--	5
River carpsucker	18 (6.2)	48 (16.6)	15 (5.2)	208 (72.0)	289
Quillback	--	--	1 (100)		1
White sucker	1 (100)	--	--	--	1
Blue sucker	**255 (24.5)**	**104 (10.0)**	**680 (65.4)**	**--**	**1,039**
Smallmouth buffalo	12 (13.2)	4 (4.4)	47 (51.6)	28 (30.8)	91
Bigmouth buffalo	4 (30.8)	2 (15.4)	7 (53.8)	--	13
Redhorse	--	--	1 (100)	--	1
Shorthead redhorse	19 (67.9)	1 (3.6)	2 (7.1)	6 (21.4)	28
Bullhead catfish family	--	1 (100)	--	--	1
Black bullhead	--	--	1 (100)	--	1
Blue catfish	5 (4.9)	95 (93.1)	1 (1.0)	1 (1.0)	102
Channel catfish	80 (6.3)	782 (61.3)	84 (6.6)	329 (25.8)	1,275
Flathead catfish	4 (12.1)	12 (36.4)	4 (12.1)	13 (39.4)	33

-- indicates fish were not sampled with the associated gear

Table 4 (continued). Total catch and percent of catch by gear of fish species collected from Segment 8 and Segment 9 of the Missouri River during 2006 sampling year. Target species are highlighted in bold.

Species Name	Gill Net	Otter Trawl	Trammel Net	Mini-fyke	Total
Stonecat	--	3 (100)	--	--	3
Rainbow smelt	--	--	--	20 (100)	20
Western mosquitofish	--	--	--	213 (100)	213
Brook silverside	--	--	--	10 (100)	10
White perch	--	2 (33.3)	--	4 (66.7)	6
White bass	2 (2.0)	12 (11.9)	1 (1.0)	86 (85.1)	101
Yellow bass	--	5 (71.4)	--	2 (28.6)	7
Sunfish family	--	--	--	3 (100)	3
Green sunfish	--	--	--	67 (100)	67
Pumpkinseed	--	--	--	1 (100)	1
Orangespotted sunfish	--	1 (0.9)	--	114 (99.1)	115
O.spot X Gr. Sunfish hybrid	--	--	--	3 (100)	3
Bluegill	--	2 (0.5)	--	407 (99.5)	409
Smallmouth bass	--	--	1 (20.0)	4 (80.0)	5
Largemouth bass	--	--	--	5 (100)	5
White crappie	--	3 (5.6)	--	51 (94.4)	54
Black crappie	--	--	--	4 (100)	4
Sauger	**99 (70.7)**	**18 (12.9)**	**17 (12.1)**	**6 (4.3)**	**140**
Saugeye	2 (22.2)	4 (44.4)	2 (22.2)	1 (11.1)	9
Walleye	16 (69.6)	7 (30.4)	--	--	23
Freshwater drum	2 (0.3)	444 (73.9)	3 (0.5)	152 (25.3)	601
Total	**2,240 (4.0)**	**4,965 (8.8)**	**2,333 (4.2)**	**46,565 (83.0)**	**56,102**

-- indicates fish were not sampled with the associated gear

Habitat

A comparison of measured habitat variables by segment, season and gear showed that there were differences between segments and seasons (Table 5). ANOVA results illustrated differences in surface water temperature, turbidity, average depth and bottom velocity by segment and season. Temperature differed by segment for gill nets, otter trawls and mini-fyke nets. Temperature for trammel nets was different by Segment for FC season, but not ST season. The direction of the difference was not consistent by season or gear. Turbidity differed by segment for otter trawls, trammels and mini-fyke nets. Turbidity was consistently greater in Segment 9. Average depth and bottom velocity differed by segment for mini-fyke nets.

Comparison of habitat variables measured in association with target species during gill net efforts (Table 6) to all habitat variables measured during gill netting (Table 5) revealed only subtle differences. Pallid sturgeon, in Segment 8, during gill netting efforts were caught on average in water that was warmer (11.0 versus 8.0 °C), less turbid (23 versus 53 NTU) and faster (0.60 versus 0.45 m/s) then what was typically sampled (Tables 5 and 6). In Segment 9 during gill netting efforts, pallid sturgeon were caught in water that was the same as what was typically sampled (Tables 5 and 6). Blue suckers were typically caught in deeper, less turbid water than what was usually sampled (Tables 5 and 6). Sauger were captured on average in water that was less turbid (Tables 5 and 6). No other target species deviated from the typical habitat that was sampled.

Comparison of habitat variables measured in association with target species during otter trawl efforts (Table 7) to all habitat variables measured during otter trawling

(Table 5) revealed differences for three species. Speckled chubs were caught in shallower water than what was typically sampled in Segment 9 during ST season (2.0 m versus 3.0 m). Sand shiners in Segment 9 during FC season were captured at slower bottom velocities than what was typically sampled (0.30 versus 0.50 m/s). Sauger in Segment 9, during FC season were also captured at an average depth that was shallower (2.4 versus 3.2 m) and a bottom velocity that was slower (0.34 versus 0.50 m/s) than what was typically sample.

Comparison of habitat variables measured in association with target species during trammel netting efforts (Table 8) to all habitat variables measured during otter trawling (Table 5) revealed differences for three species. Shovelnose captured in Segment 9 during FC season were caught when the water was warmer (26.5 versus 24.1 °C) and at a shallower depth (2.9 versus 3.5 m). Blue suckers were collected during ST season in both Segment 8 and 9 in warm water temperatures, when turbidity was lower and at shallower depths than typical sampling conditions. Sauger were usually collected when trammel nets were fished in shallower water than typically sampled.

Comparison of habitat variables measured in association with target species during mini-fyke nets in FC season (Table 9) to all habitat variables measured during mini-fyke netting (Table 5) revealed differences for three species. Speckled chub in Segment 8 were captured more often when water temperatures were cooler (17.6 versus 20.9 °C). Plains minnows collected in Segment 8 were sampled when water conditions were warmer (24.9 versus 20.9 °C) and bottom velocity was slower (0.12 versus 0.25 m/s). Plains minnows collected in Segment 9 were usually sampled when in deeper water c (0.8 versus 0.5 m). Sauger were collected in Segment 8 when sampling slower than typical bottom velocities (0.16 versus 0.25 m/s).

Table 5. Habitat variables measured when sampling by gear type (GN = gill net, OT = 16 ft otter trawl, TN = 1 in trammel net, MF = mini-fyke), segment (8 or 9) and season (FC = fish community; ST = sturgeon). Values are means ± 1 standard error followed by n in parentheses. Letter codes represent significant differences (ANOVA, α < 0.05) within a gear type.

Gear	Segment	Season	Temperature (°C)	Turbidity (NTU)	Average Depth (m)	Bottom Velocity (m/s)
GN	8	ST	**8.0 ± 0.3 (99) A**	53 ± 15 (41)	2.7 ± 0.1 (99)	0.45 ± 0.05 (24)
	9	ST	**6.8 ± 0.2 (101) B**	87 ± 14 (41)	2.5 ± 0.1 (101)	0.40 ± 0.03 (21)
OT	8	FC	**26.1 ± 0.1 (162) A**	**29 ± 1 (58) A**	3.3 ± 0.1 (161)	0.58 ± 0.04 (50)
	9	FC	**24.9 ± 0.2 (243) B**	**72 ± 7 (88) B**	3.2 ± 0.1 (242)	0.50 ± 0.02 (73)
	9	ST	**25.1 ± 0.1 (49) B**	**57 ± 6 (10) B**	3.0 ± 0.1 (49)	0.45 ± 0.09 (6)
TN	8	FC	**22.4 ± 0.3 (250) A**	**38 ± 3 (96) A**	**3.5 ± 0.1 (250) A**	**0.58 ± 0.02 (84) A**
	8	ST	**16.6 ± 0.2 (366) B**	**79 ± 6 (119) B**	**3.2 ± 0.1 (366) B**	**0.51 ± 0.02 (99) B**
	9	FC	**24.1 ± 0.2 (256) C**	**69 ± 7 (92) B**	**3.5 ± 0.1 (256) A**	**0.60 ± 0.02 (77) A**
	9	ST	**17.1 ± 0.2 (351) B**	**119 ± 10 (107) C**	**3.2 ± 0.1 (351) B**	**0.47 ± 0.03 (81) B**
MF	8	FC	**20.9 ± 0.3 (148) A**	**30 ± 1 (56) A**	0.4 ± 0.1 (148)	**0.25 ± 0.01 (49) A**
	9	FC	**22.5 ± 0.3 (155) B**	**74 ± 8 (60) B**	0.5 ± 0.0 (155)	**0.16 ± 0.02 (52) B**

Table 6. Mean habitat variables for gill netting by segment (8 or 9) and season (FC = fish community; ST = sturgeon). Values are means ± 1 standard error followed by n in parentheses.

Species	**Segment**	**Season**	**Temperature (°C)**	**Turbidity (NTU)**	**Average Depth (m)**	**Bottom Velocity (m/s)**
Pallid sturgeon	8	ST	11.0 ± 0.5 (4)	23 ± 1 (4)	4.3 ± 1.2 (4)	0.60 ± 0.04 (3)
	9	ST	6.8 ± 0.6 (11)	68 ± 22 (11)	2.7 ± 0.3 (11)	0.42 ± 0.03 (7)
Shovelnose sturgeon	8	ST	8.2 ± 0.3 (77)	58 ± 19 (33)	3.0 ± 0.2 (77)	0.45 ± 0.05 (19)
	9	ST	6.9 ± 0.2 (83)	86 ± 15 (36)	2.6 ± 0.1 (83)	0.39 ± 0.04 (20)
Blue sucker	8	ST	8.5 ± 0.4 (54)	24 ± 1 (20)	2.8 ± 0.2 (54)	0.50 ± 0.09 (10)
	9	ST	6.3 ± 0.2 (27)	49 ± 3 (8)	3.1 ± 0.2 (27)	0.37 ± 0.04 (5)
Sauger	8	ST	8.2 ± 0.5 (23)	56 ± 34 (11)	2.9 ± 0.3 (23)	0.42 ± 0.09 (6)
	9	ST	6.4 ± 0.2 (32)	51 ± 2 (11)	2.6 ± 0.1 (32)	0.39 ± 0.06 (5)

Table 7. Mean habitat variables for otter trawling by segment (8 or 9) and season (FC = fish community; ST = sturgeon). Values are means ± 1 standard error followed by n in parentheses.

Species	**Segment**	**Season**	**Temperature (°C)**	**Turbidity (NTU)**	**Average Depth (m)**	**Bottom Velocity (m/s)**
Pallid sturgeon	8	FC	27.3 (1)	32 (1)	2.6 (1)	0.42 (1)
	9	FC	25.2 ± 3.2 (2)	41 ± 5 (2)	2.7 ± 1.1 (2)	0.61 ± 0.09 (2)
Shovelnose sturgeon	8	FC	25.9 ± 0.3 (31)	27 ± 1 (13)	3.5 ± 0.1 (31)	0.67 ± 0.08 (13)
	9	FC	24.3 ± 0.4 (71)	83 ± 15 (27)	3.2 ± 0.1 (71)	0.43 ± 0.03 (25)
	9	ST	25.1 ± 0.2 (18)	55 ± 5 (6)	2.8 ± 0.1 (18)	0.36 ± 0.10 (4)
Speckled chub	8	FC	26.4 ± 0.7 (7)	47 ± (1)	2.3 ± 0.4 (7)	0.63 (1)
	9	FC	23.4 ± 0.4 (50)	97 ± 21 (21)	3.0 ± 0.1 (50)	0.43 ± 0.05 (19)
	9	ST	25.0 ± 0.3 (11)	69 ± (1)	2.0 ± 0.2 (11)	0.69 (1)
Sturgeon chub	8	FC	26.0 ± 0.3 (3)	34 ± 3 (2)	3.6 ± 1.0 (3)	0.11 (1)
	9	FC	24.2 ± 0.5 (28)	104 ± 35 (9)	3.3 ± 0.2 (28)	0.52 ± 0.08 (10)
	9	ST	27.0 (1)	21 ± (1)	3.1 (1)	--
Sicklefin chub	8	FC	25.4 ± 0.6 (7)	30 ± 5 (3)	3.3 ± 0.5(7)	1.02 (1)
	9	FC	28.3 (1)	--	3.2 (1)	--
	9	ST	25.2 ± 0.2 (2)	--	3.7 ± 0.9 (2)	--
Sand shiner	9	FC	26.0 ± 1.2 (8)	68 ± 24 (4)	2.6 ± 0.4 (8)	0.30 ± 0.01 (4)
Blue sucker	8	FC	26.2 ± 0.3 (19)	28 ± 1 (11)	3.4 ± 0.2 (19)	0.58 ± 0.08 (10)
	9	FC	25.2 ± 0.5 (41)	73 ± 22 (15)	3.0 ± 0.2 (41)	0.50 ± 0.05 (14)
	9	ST	25.0 ± 0.3 (12)	53 ± 8 (3)	2.7 ± 0.2 (12)	0.44 (1)
Sauger	8	FC	26.4 ± 1.2 (2)	--	2.4 ± 0.7 (2)	--
	9	FC	25.7 ± 1.2 (8)	44 ± 9 (2)	2.4 ± 0.2 (8)	0.34 ± 0.02 (2)
	9	ST	26.0 ± 0.5 (3)	45 ± 24 (2)	2.4 ± 0.5 (3)	0.40 ± 0.30 (2)

-- indicates the habitat variable was not measured

Table 8. Mean habitat variables for trammel netting by segment (8 or 9) and season (FC = fish community; ST = sturgeon). Values are means ± 1 standard error followed by n in parentheses.

Species	Segment	Season	Temperature (°C)	Turbidity (NTU)	Average Depth (m)	Bottom Velocity (m/s)
Pallid sturgeon	8	FC	26.5 (1)	--	4 (1)	--
	8	ST	14.7 ± 1.0 (4)	192 ± 45 (2)	2.5 ± 0.1 (4)	0.44 ± 0.04 (2)
Shovelnose sturgeon	8	FC	24.1 ± 0.5(37)	43 ± 8 (21)	3.3 ± 0.1 (37)	0.49 ± 0.04 (21)
	8	ST	16.2 ± 0.4 (93)	93 ± 16 (32)	2.9 ± 0.1 (93)	0.50 ± 0.03 (28)
	9	FC	26.5 ± 0.3 (45)	52 ± 4 (19)	2.9 ± 0.1 (45)	0.60 ± 0.03 (19)
	9	ST	17.3 ± 0.4 (116)	125 ± 15 (45)	2.8 ± 0.1 (116)	0.40 ± 0.03 (33)
Blue sucker	8	FC	22.9 ± 0.7 (34)	36 ± 1 (12)	3.1 ± 0.1 (34)	0.49 ± 0.04 (13)
	8	ST	18.3 ± 0.5 (79)	55 ± 4 (26)	2.7 ± 0.1 (79)	0.52 ± 0.04 (22)
	9	FC	24.7 ± 0.5 (61)	65 ± 19 (21)	2.9 ± 0.1 (61)	0.54 ± 0.03 (22)
	9	ST	19.0 ± 0.5 (85)	78 ± 6 (22)	2.6 ± 0.1 (85)	0.45 ± 0.03 (22)
Sauger	8	FC	20.6 ± 4.8 (2)	39 (1)	3.6 ± 0.9 (2)	0.60 (1)
	8	ST	17.1 ± 2.1 (5)	--	1.7 ± 0.2 (5)	--
	9	FC	25.0 ± 2.2 (4)	43 ± 6 (3)	2.5 ± 0.2 (4)	0.47 ± 0.10 (3)
	9	ST	21.4 ± 1.7 (6)	61 (1)	2.2 ± 0.3 (6)	0.18 (1)

-- indicates the habitat variable was not measured

Table 9. Mean habitat variables for mini-fyke netting by segment (8 or 9) and season (FC = fish community; ST = sturgeon). Values are means ± 1 standard error followed by n in parentheses.

Species	Segment	Season	Temperature (°C)	Turbidity (NTU)	Average Depth (m)	Bottom Velocity (m/s)
Speckled chub	8	FC	17.6 ± 0.7 (14)	29 ± 4 (5)	0.4 ± 0.0 (14)	0.29 ± 0.02 (4)
	9	FC	22.6 ± 0.8 (17)	134 ± 35 (8)	0.5 ± 0.0 (17)	0.14 ± 0.07 (6)
Sturgeon chub	9	FC	21.2 ± 1.2 (4)	182 ± 24 (2)	0.4 ± 0.0 (4)	0.43 ± 0.08 (2)
Sand shiner	8	FC	21.1 ± 0.4 (110)	30 ± 1 (46)	0.4 ± 0.0 (110)	0.21 ± 0.02 (39)
	9	FC	22.7 ± 0.4 (96)	61 ± 7 (39)	0.5 ± 0.0 (96)	0.13 ± 0.02 (32)
Plains minnow	8	FC	24.9 ± 1.1 (3)	33 ± 4 (2)	0.5 ± 0.1 (3)	0.12 ± 0.01 (2)
	9	FC	23.6 ± 1.2 (13)	86 ± 22 (5)	0.8 ± 0.0 (13)	0.09 ± 0.03 (5)
Sauger	8	FC	24.1 ± 1.7 (5)	26 ± 2 (5)	0.4 ± 0.1 (5)	0.16 ± 0.03 (5)
	9	FC	19.1 (1)	--	0.3 (1)	--

-- indicates the habitat variable was not measured

Relative abundance

There were no differences among control, before and modified bends in relative abundance of adult and juvenile target species (i.e., shovelnose sturgeon, blue sucker and sauger) and small bodied fishes (i.e., speckled chub, sicklefin chub, sturgeon chub, and sand shiners) collected with otter trawls (F = 0.48, P = 0.9294), mini-fykes (F = 0.47, P = 0.87) and gill nets (F = 2.61, P = 0.141). However, MANOVA indicated differences of relative abundance of adult and juvenile shovelnose sturgeon, blue suckers and sauger among treatment types (F = 2.26, P = 0.053). Relative abundance of juvenile blue sucker was the only univariate response variable that indicated differences among treatment types from ANOVA (F = 8.37, P = 0.0036). Pair-wise comparisons of mean relative abundance of blue suckers < 350 mm indicated there were no differences between control and before modified bends. However, there were differences between control and modified bends and before and modified mends, where CPUE of juvenile blue sucker was greatest in the modified treatment bends (0.117 fish/net-night) when compared to the other two treatments (0.100 fish/net-night).

Pallid sturgeon

Twenty-six pallid sturgeon were collected during the 2006 sampling year, 22 (11 in each Segment) were collected during sturgeon season and 4 (2 in each Segment) were collected during fish community season and ranged from 318 - 905 mm (Figure 2). No young-of-year (YOY, < 100 mm) pallid sturgeon were collected and 11 large (> 480 mm) adult pallid sturgeon were collected. Pallid sturgeon habitat information is summarized by gear, segment and season in tables 6 - 8.

Mean CPUE of pallid sturgeon in Segment 8 gill nets ranged from 0.000 - 0.108 fish/net-night (Figure 3) was highest for modified-75 bends (0.108 fish/net-night), followed by modified-25 bends (0.025). CPUE in Segment 8 for trammel netting (Figure 4) was highest on modified-75 bends (0.025 fish/100 m) followed by modified-25 bends (0.016 fish/100 m). Otter trawl CPUE for Segment 8 (Figure 5) was highest in modified-25 bends (0.015 fish/100 m).

Mean CPUE of pallid sturgeon for Segment 9 ranged from 0.000 - 0.014. For gill nets, CPUE (Figure 6) was highest on control-25 bends and before-75 (0.10 fish/net-night, each) followed by before-25 bends (0.05 fish/net-night). No pallid sturgeon were captured in trammel nets on Segment 9. CPUE for otter trawls in Segment 9 (Figure 7) was highest for modified bends-25 (0.014 fish/100 m) followed by before-75 bends (0.013 fish/100 m). No pallid sturgeon were collected on other bend types in Segment 9 with the otter trawl.

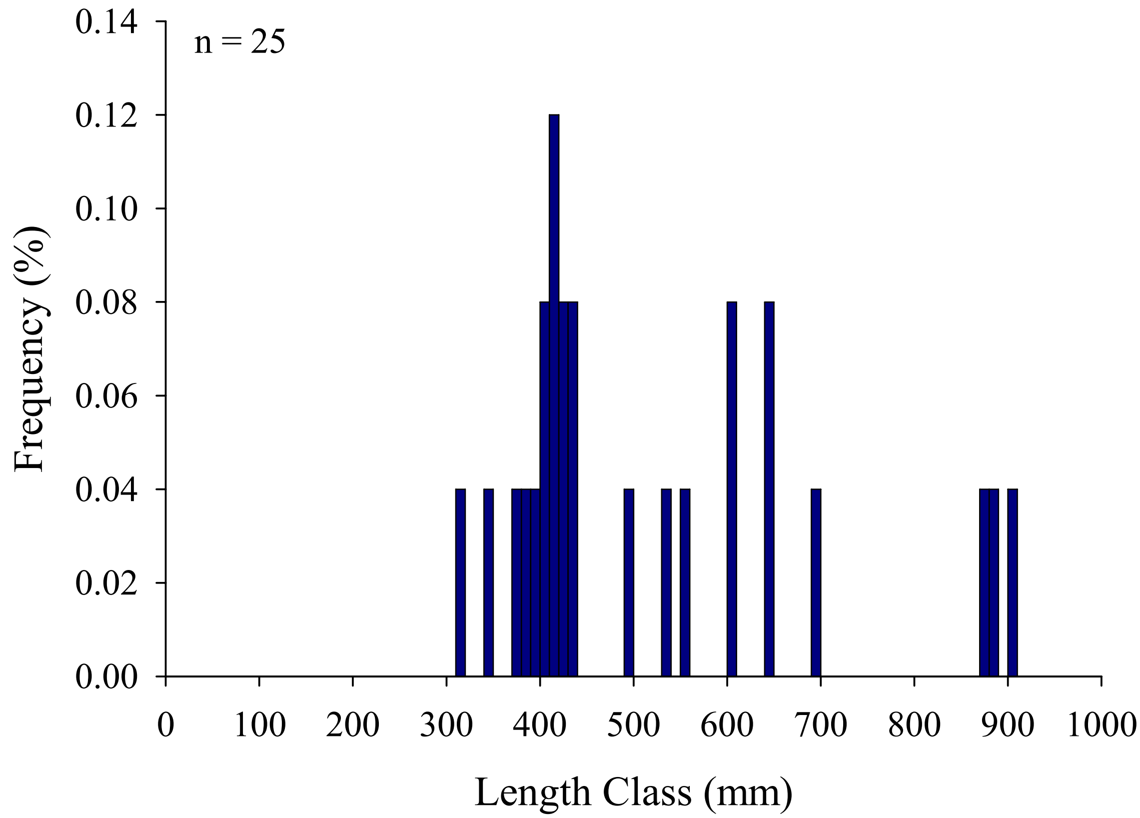

Figure 2. Length frequency (10 mm length class groups) of pallid sturgeon collected from Segment 8 and Segment 9 during sturgeon (ST) and fish community (FC) sampling seasons in 2006.

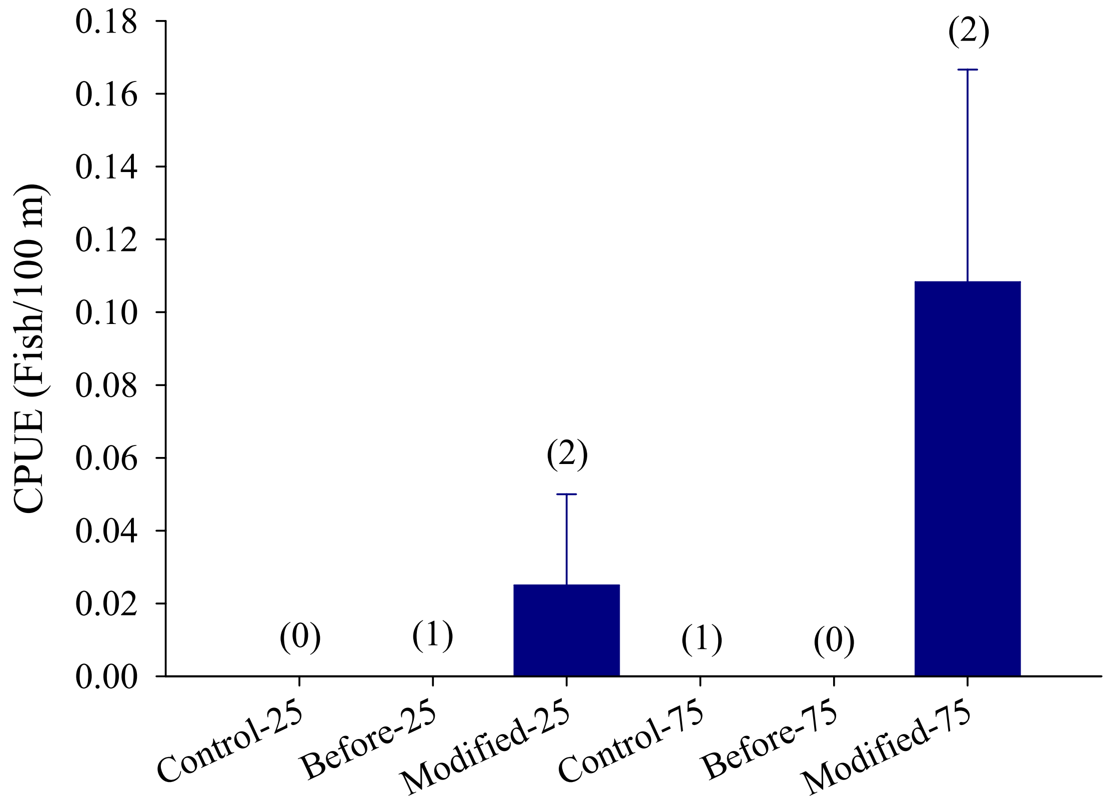

Figure 3. Mean catch-per-unit-effort (CPUE) of pallid sturgeon collected using gill nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

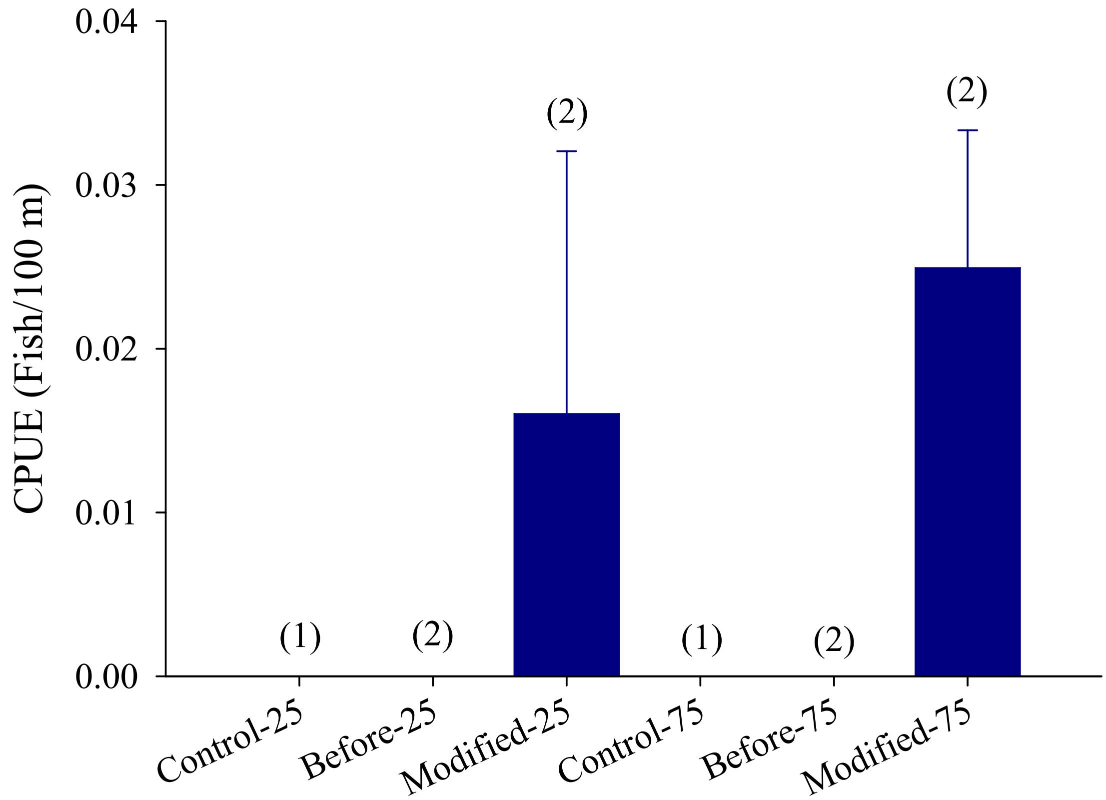

Figure 4. Mean catch-per-unit-effort (CPUE) of pallid sturgeon collected using 1 in trammel nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

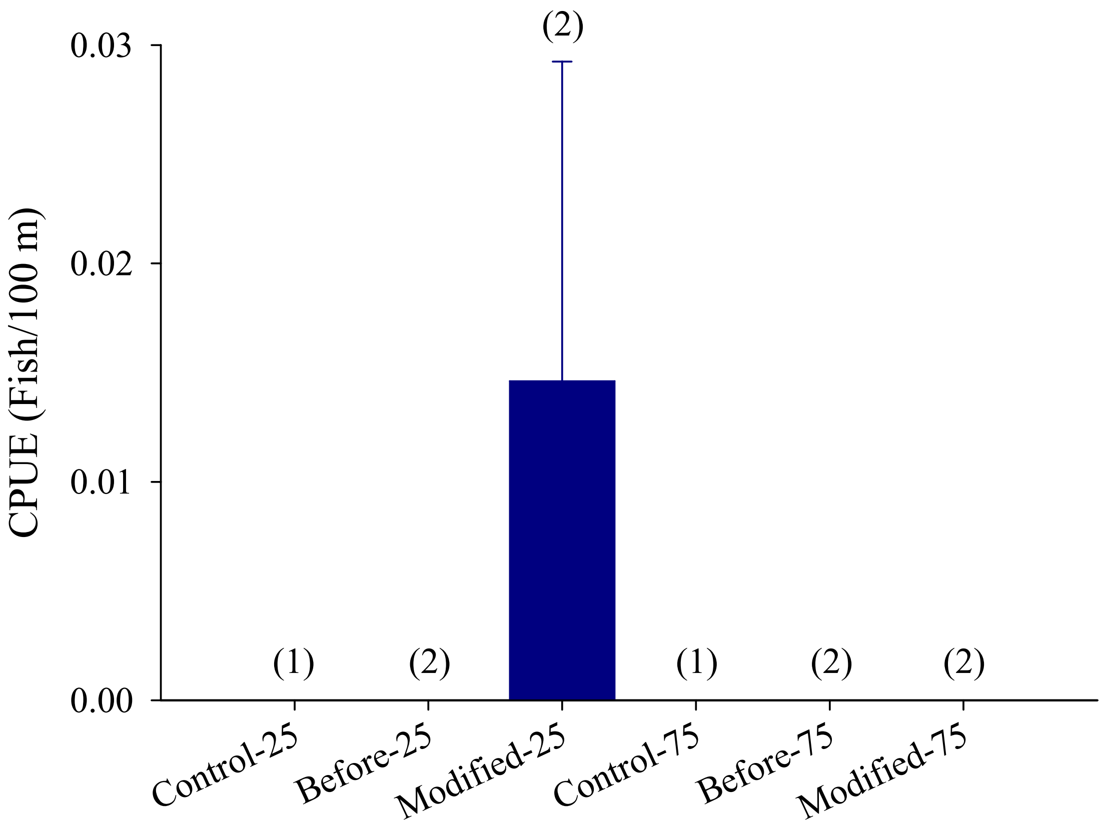

Figure 5. Mean catch-per-unit-effort (CPUE) of pallid sturgeon collected using 16 ft otter trawl from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25^{th} percentile of bend radius and 75 represents bends in the 75^{th} percentile of bend radius.

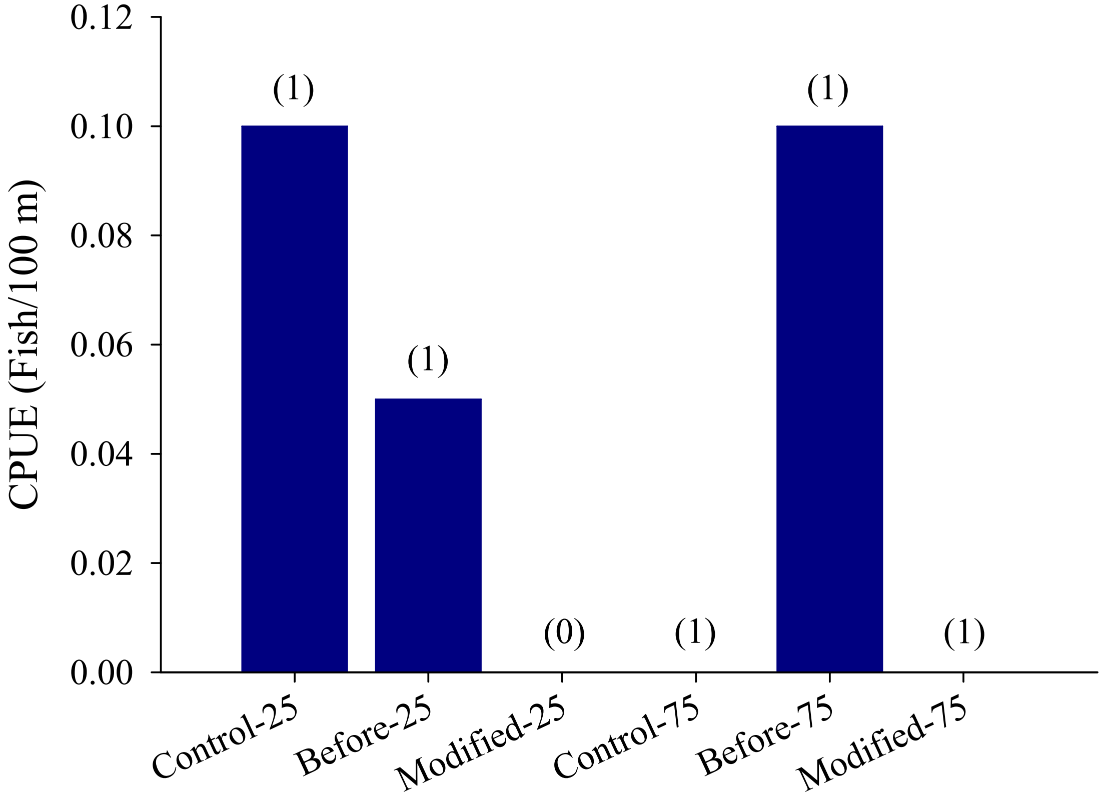

Figure 6. Mean catch-per-unit-effort (CPUE) of pallid sturgeon collected using gill nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

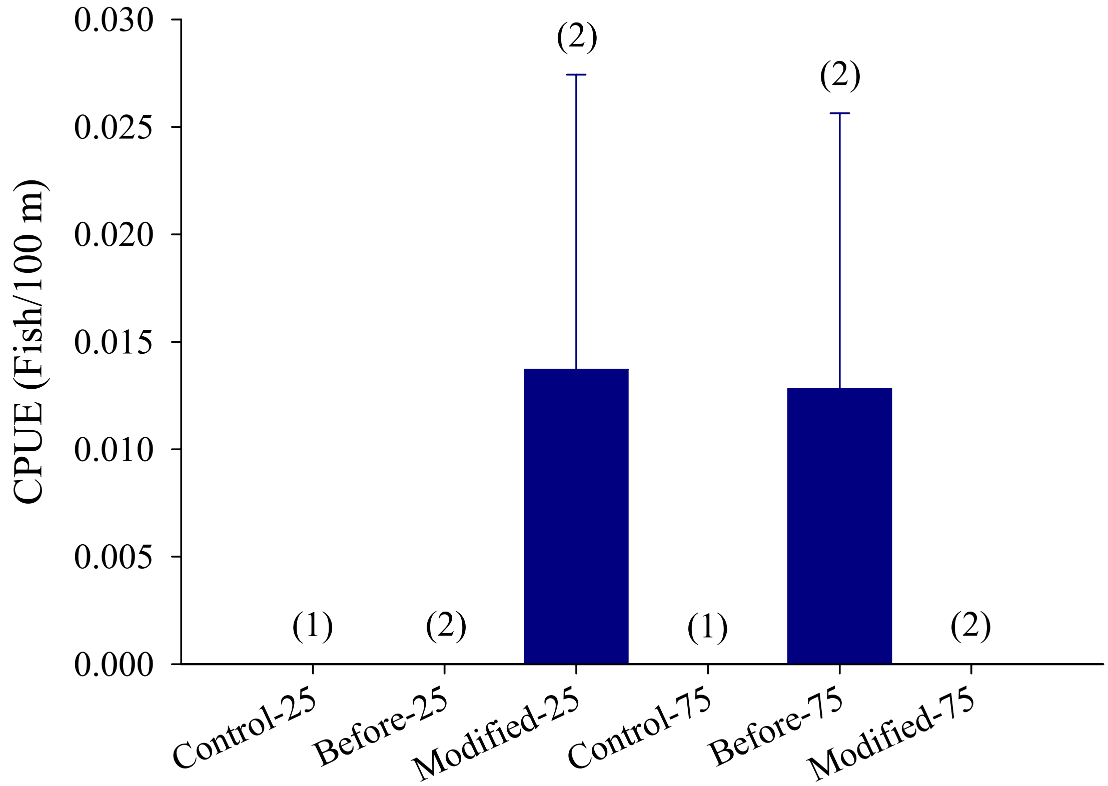

Figure 7. Mean catch-per-unit-effort (CPUE) of pallid sturgeon collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

Shovelnose sturgeon

A total of 2,335 shovelnose sturgeon were collected during the 2006 sampling year (Figure 8). Length of shovelnose sturgeon ranged from 54 - 743 mm FL. The majority of fish collected represent the adult population, ranging between 450 - 650 mm FL. Only 133 shovelnose sturgeon were collected with a FL < 400 mm. In Segment 8, during the ST season, 827 shovelnose sturgeon were collected and during FC season 1,071 were caught. In Segment 9 during ST season 124 shovelnose sturgeon were caught and during FC season 313 were captured. Shovelnose sturgeon habitat information is summarized by gear, segment and season in tables 6 - 8.

Mean CPUE of shovelnose sturgeon collected from Segment 8 using gill nets was variable between bend treatment types, ranging from 0.50 - 4.13 fish/100 m (Figure 9). Mean relative abundance of shovelnose sturgeon was highest in the modified-25 bends (4.13 fish/100 m) and the modified-75 bends (2.86 fish/100 m), followed by control-75 bend (0.80 fish/100 m) and before-25 bend (0.50 fish/100 m).

Mean CPUE of shovelnose sturgeon collected from Segment 8 using trammel nets ranging from 0.25 - 0.97 fish/100 m (Figure 10). Mean relative abundance of shovelnose sturgeon was highest in the modified-75 bends (0.97 fish/100 m) and the modified-25 bends (0.78 fish/100 m). Control-25 and before-25 bends types had low relative abundance (0.24 and 0.25 fish/100 m, respectively).

Mean CPUE of shovelnose sturgeon collected with otter trawls from Segment 8 ranged from 0.16 - 0.33 fish/100 m (Figure 11). Mean relative abundance of shovelnose sturgeon was highest in the before-75 treatment bend (0.33 fish/100 m). Control-25, modified-25 and modified-75 bends all had mean CPUE of 0.25 fish/100 m. Before-25 bends had the lowest CPUE (0.16 fish/100 m), followed by control-75 bends (0.19 fish/100 m).

Mean CPUE of shovelnose sturgeon collected from Segment 9 using gill nets ranged from 1.80 - 4.65 fish/net-night (Figure 12). Mean relative abundance of shovelnose sturgeon was highest in the before-25 bends (4.65 fish/net-night) and the control-75 bends (3.60 fish/ net-night). Mean CPUE for modified-75 bends was 2.85 fish/ net-night and for control-25 bends was 2.15 fish/ net-night. The lowest CPUE was for before-75 bends (1.8 fish/net-night).

Mean CPUE of shovelnose sturgeon collected using trammel nets in Segment 9 ranged from 0.36 - 1.89 fish/100 m (Figure 13). Mean relative abundance of shovelnose sturgeon was highest in the modified-25 bends (1.88 fish/100 m), followed by modified-75 bends (0.99 fish/100 m). The lowest CPUE was for control-75 bends (0.36 fish/100 m) and before-25 bends (0.39 fish/100 m).

Mean CPUE of shovelnose sturgeon collected with otter trawls from Segment 8 ranged from 0.24 - 0.84 fish/100 m (Figure 14). Mean relative abundance of shovelnose sturgeon was highest in the modified-75 bends (0.84 fish/100 m), followed by control-75 bends (0.77 fish/100 m). Control-25 bends had the lowest CPUE (0.24 fish/100 m). Before-25 bends, treatment-25 bends and before-75 bends had comparable CPUE (0.58, 0.68 and 0.62 fish/100 m, respectively).

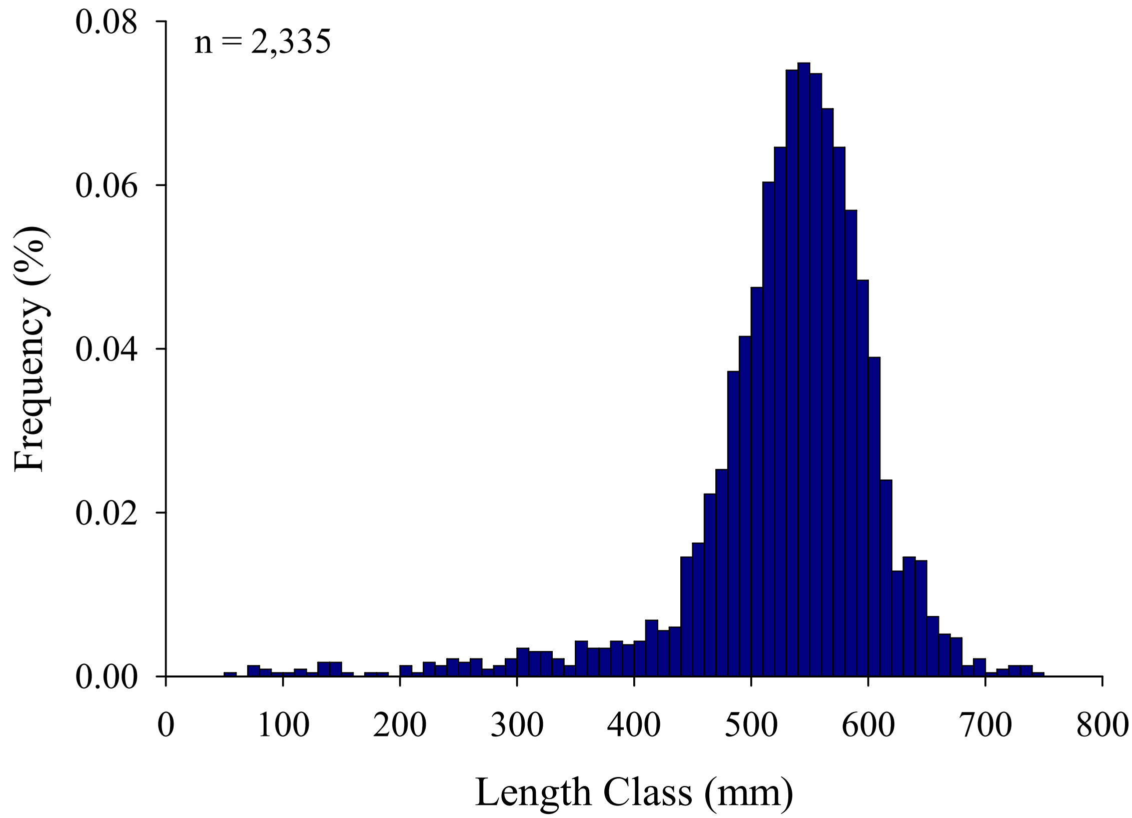

Figure 8. Length frequency (10 mm length class groups) of shovelnose sturgeon collected from Segment 8 and Segment 9 during sturgeon (ST) and fish community (FC) sampling seasons in 2006.

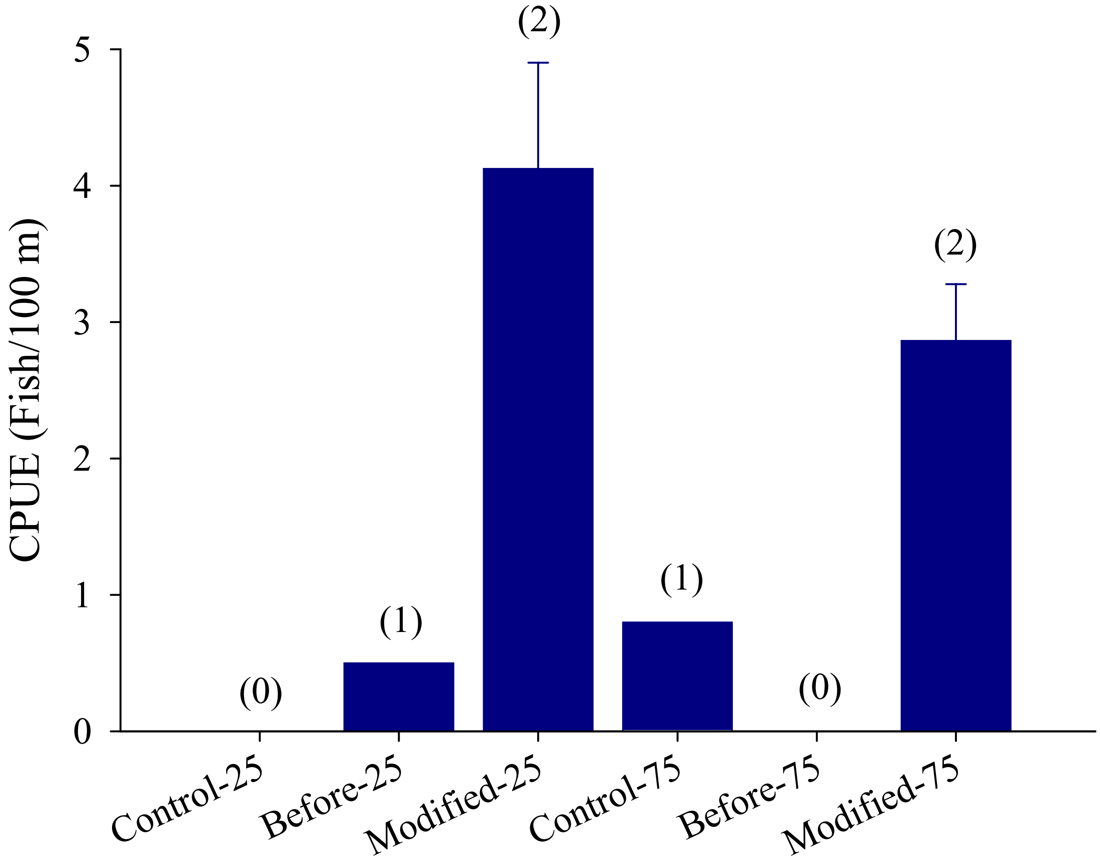

Figure 9. Mean catch-per-unit-effort (CPUE) of shovelnose sturgeon collected using gill nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25^{th} percentile of bend radius and 75 represents bends in the 75^{th} percentile of bend radius.

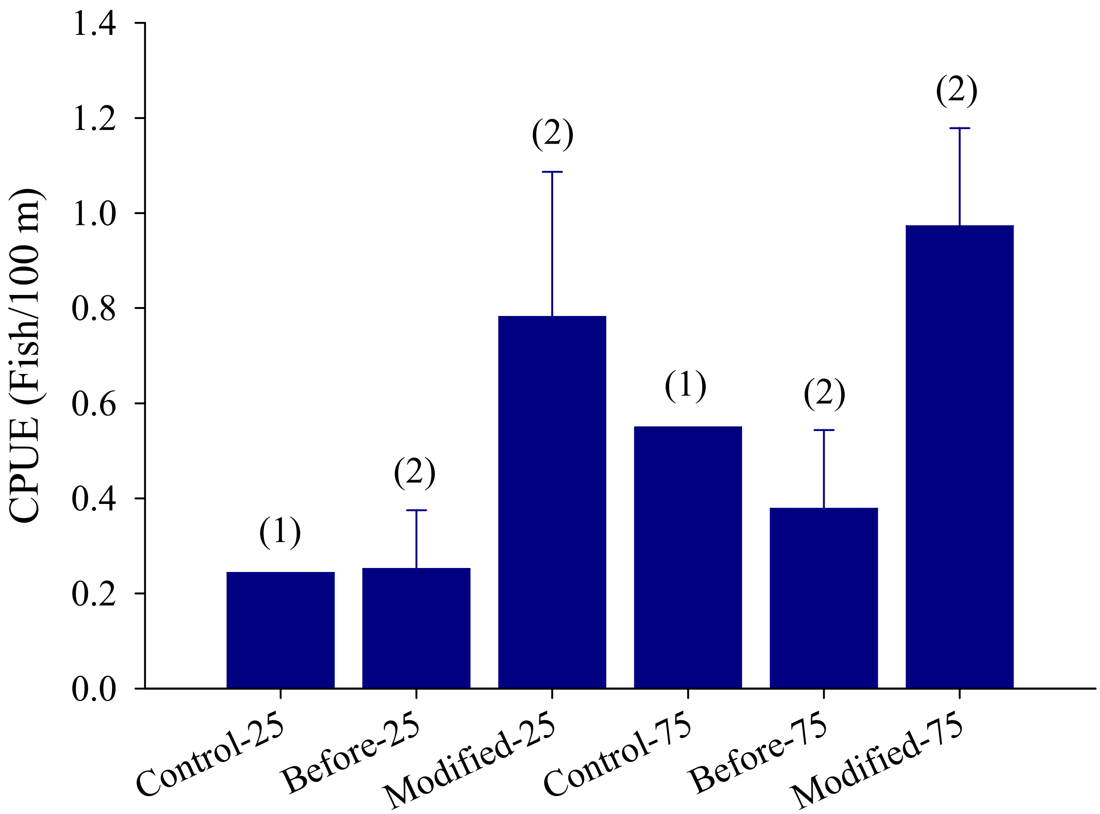

Figure 10. Mean catch-per-unit-effort (CPUE) of shovelnose sturgeon collected using 1 in trammel nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

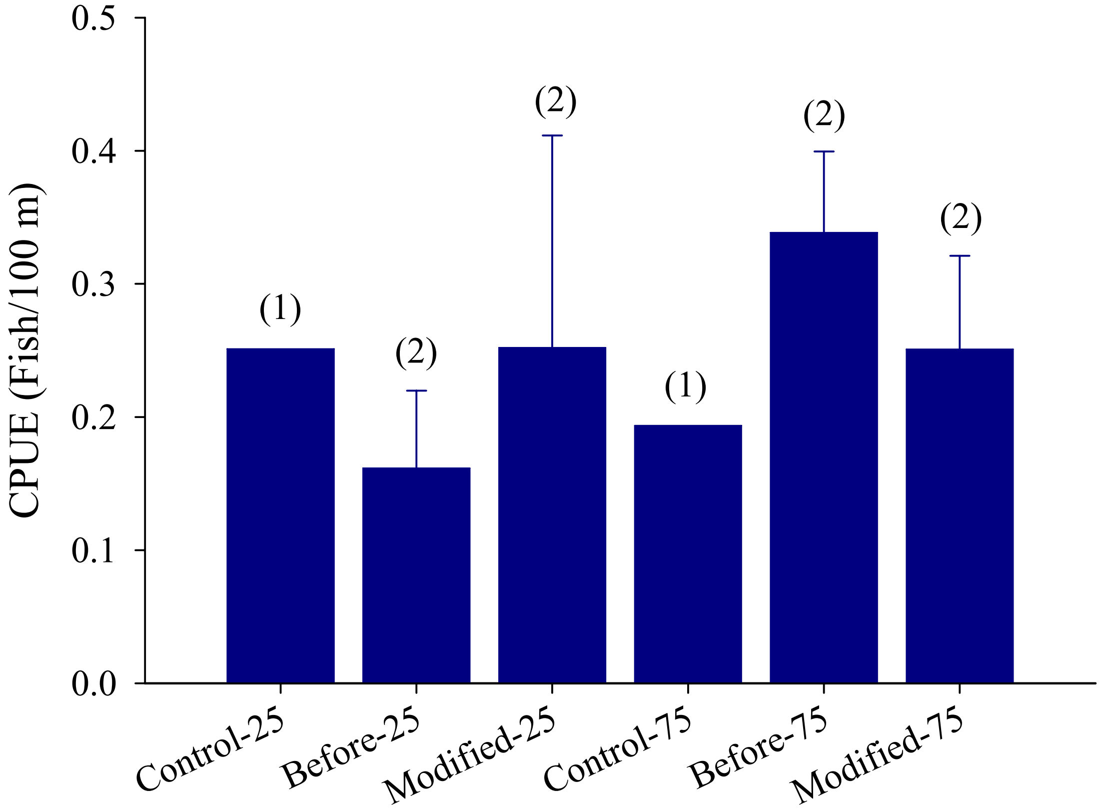

Figure 11. Mean catch-per-unit-effort (CPUE) of shovelnose sturgeon collected using 16 ft otter trawl from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

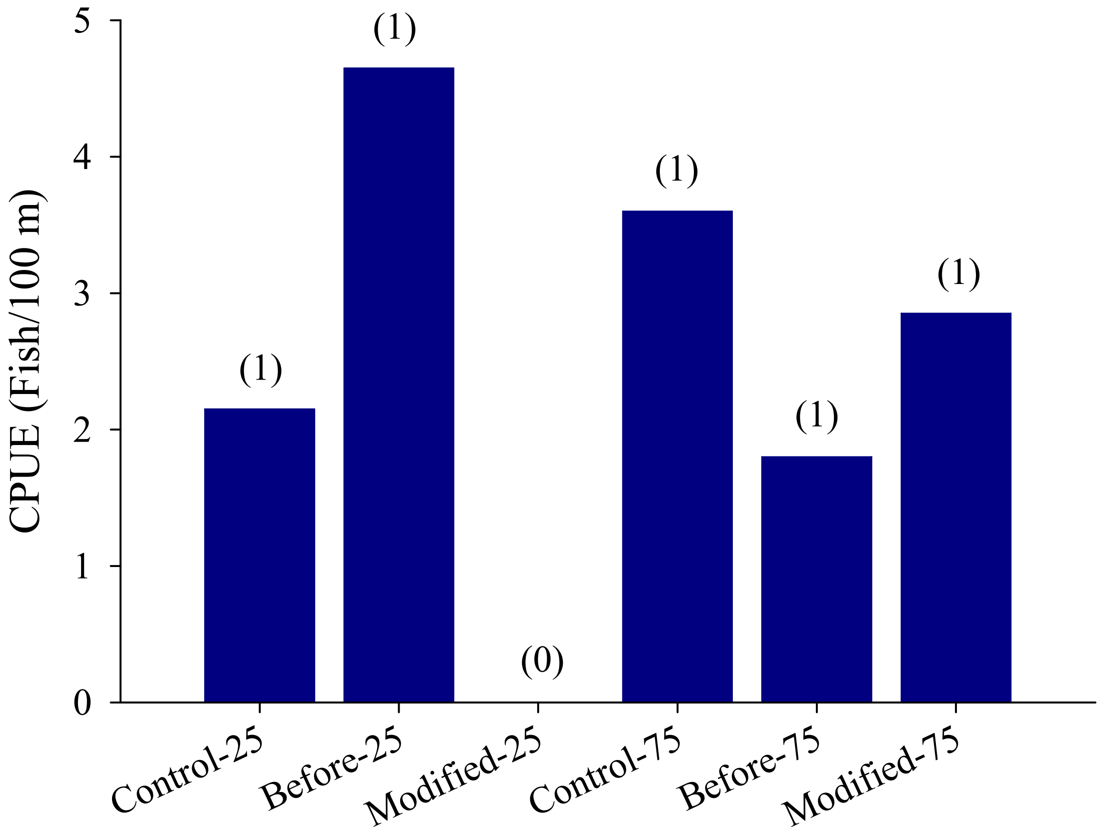

Figure 12. Mean catch-per-unit-effort (CPUE) of shovelnose sturgeon collected using gill nets from Segment 9 during 2006. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

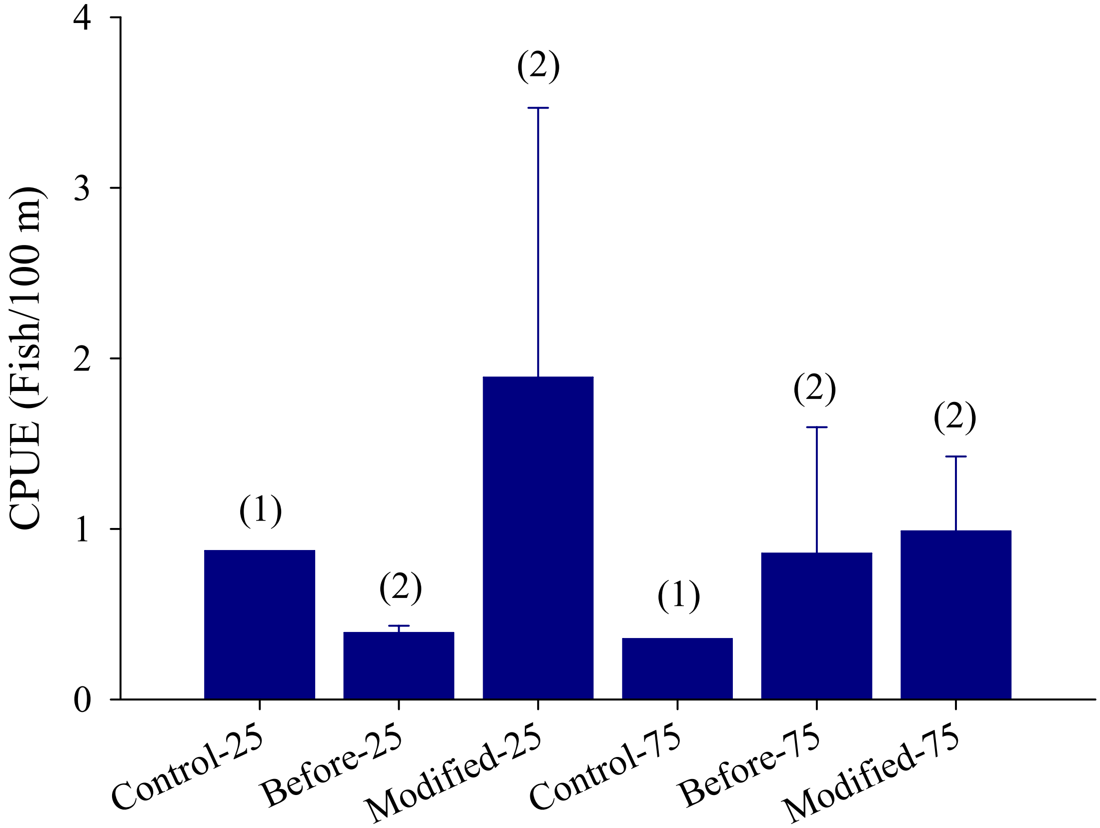

Figure 13. Mean catch-per-unit-effort (CPUE) of shovelnose sturgeon collected using 1 in trammel nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

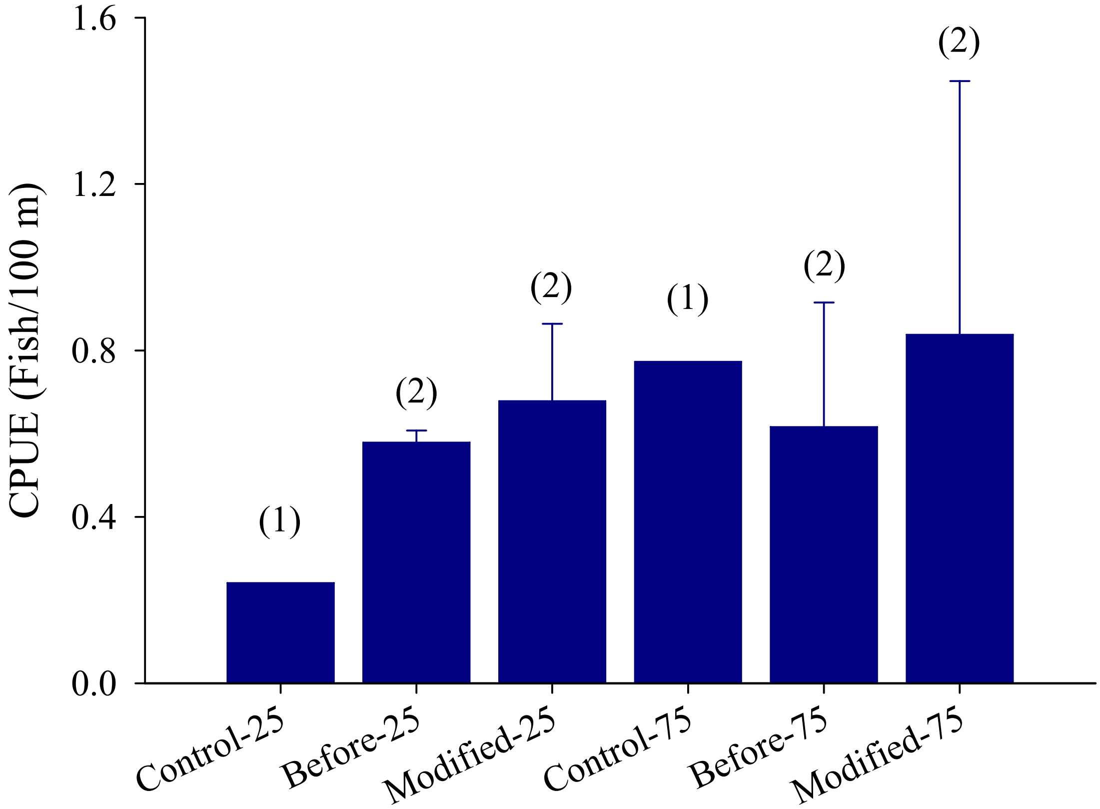

Figure 14. Mean catch-per-unit-effort (CPUE) of shovelnose sturgeon collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

Blue sucker

A total of 1,039 blue suckers were collected during the 2006 season (Figure 15). The length of blue suckers ranged from 125 - 858 mm TL. The majority of blue suckers collected were adults; only 24 were < 400 mm. In Segment 8, during the ST season, 374 blue suckers were collected. During FC season 670 blue sucker were caught. In Segment 9 during ST season 77 blue sucker were catch and during FC season 219 were captured. Blue sucker habitat information is summarized by gear, segment and season in tables 6 - 8.

Mean CPUE of blue suckers collected from Segment 8 using gill nets ranged from 0.85 - 2.06 fish/100 m (Figure 16). Mean CPUE of blue sucker was highest in the modified-25 bends (2.06 fish/100 m). The remaining bend types (control-75, modified-75 and before-25 bends) all had comparable CPUE (0.85, 1.0 and 1.12, respectively).

Mean CPUE of blue suckers collected from Segment 8 using trammel nets ranged from 0.26 - 0.50 fish/100 m (Figure 17). Mean CPUE of blue sucker was highest in the modified-25 bends (0.50 fish/100 m). Control-25, modified -75 and control-75 bends had similar CPUE (0.44, 0.42 and 0.38 fish/100 m, respectively). The lowest CPUE was recorded for before-25 bends (0.25 fish/100 m).

Mean CPUE of blue suckers collected from Segment 8 using otter trawls ranged from 0.08 - 0.24 fish/100 m (Figure 18). Mean CPUE of blue sucker was greatest in the control t-75 bends (0.24 fish/100 m), followed by the before-75 and modified-75 bends (0.21 and 0.18 fish/100 m, respectively). Modified-25, before-25 and control-25 bends all had lower CPUE (0.11, 0.08 and 0.08 fish/100 m, respectively).

Mean CPUE of blue suckers collected from Segment 9 using gill nets ranged from 0.15 - 0.45 fish/100 m (Figure 19). Mean CPUE was highest in the control-25 bends (0.45 fish/100 m), followed by the before-25 bends and the control-75 bends (0.40 fish/100 m, each). Before-25 and modified-25 bends had the lowest CPUE (0.15 and 0.25 fish/100 m, respectively).

Mean CPUE of blue suckers collected from Segment 9 using trammel nets ranged from 0.43 - 1.18 fish/100 m (Figure 20). Mean CPUE of blue sucker was highest in the before bends-25 bends (1.18 fish/100 m), followed by control-75 and modified-75 bends (1.10 fish/100 m, each). Before bend-75 bends had a CPUE of 0.84 fish/100 m and the lowest CPUE were for control-25 and modified-25 bends (0.43 and 0.67 fish/100 m, respectively).

Mean CPUE of blue suckers collected from Segment 9 using otter trawls ranged from 0.09 - 0.33 fish/100 m (Figure 21). Mean CPUE of blue sucker was greatest in the before-75 bends (0.33 fish/100 m), followed by the modified-25 bends (0.30 fish/100 m). The lowest CPUE was recorded for control-25 bends (0.08 fish/100 m). The remaining bend types (control-75, modified-75 and before-25) had comparable CPUE (0.18, 0.24 and 0.25, respectively).

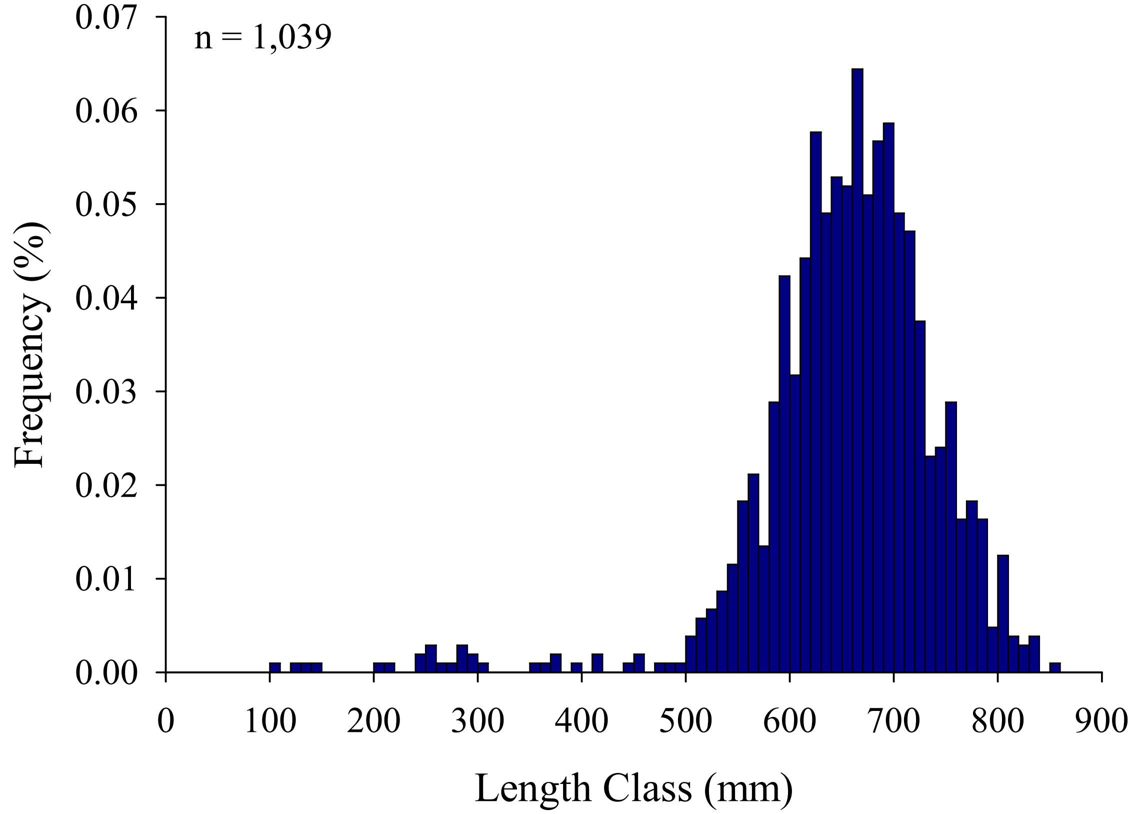

Figure 15. Length frequency (10 mm length class groups) of blue sucker collected from Segment 8 and Segment 9 during sturgeon (ST) and fish community (FC) sampling seasons in 2006.

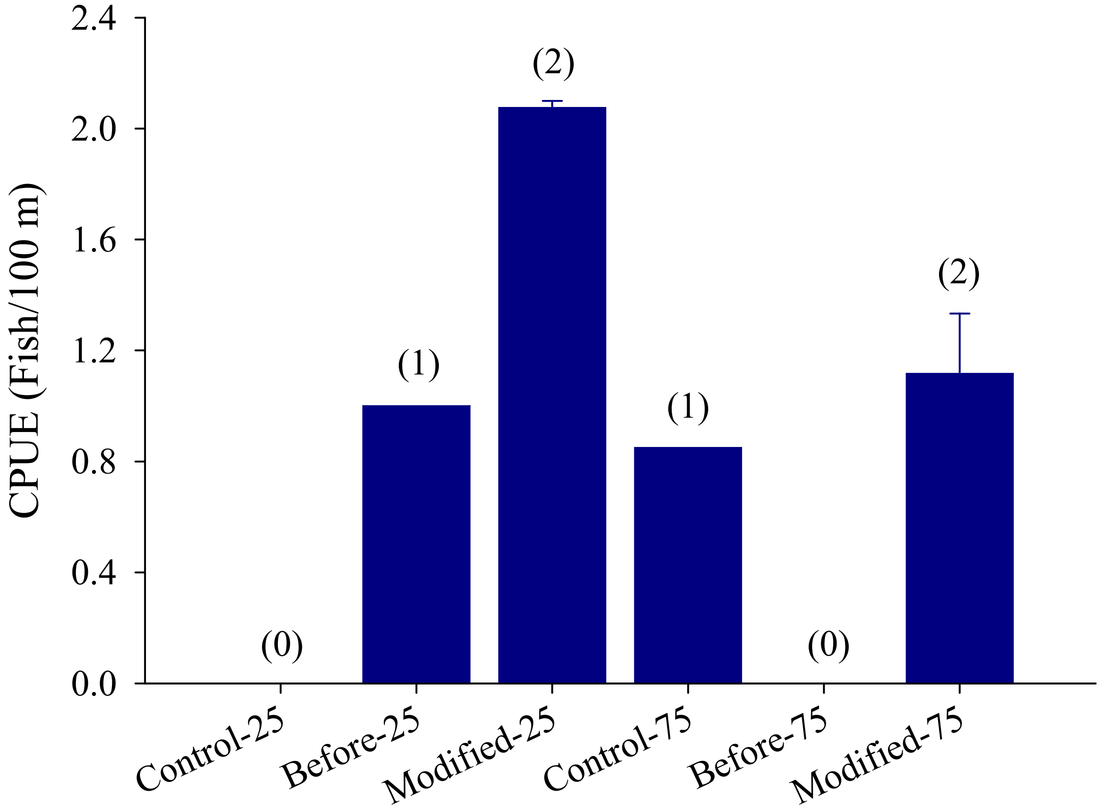

Figure 16. Mean catch-per-unit-effort (CPUE) of blue sucker collected using gill nets from Segment 8 during 2006. Error bar represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

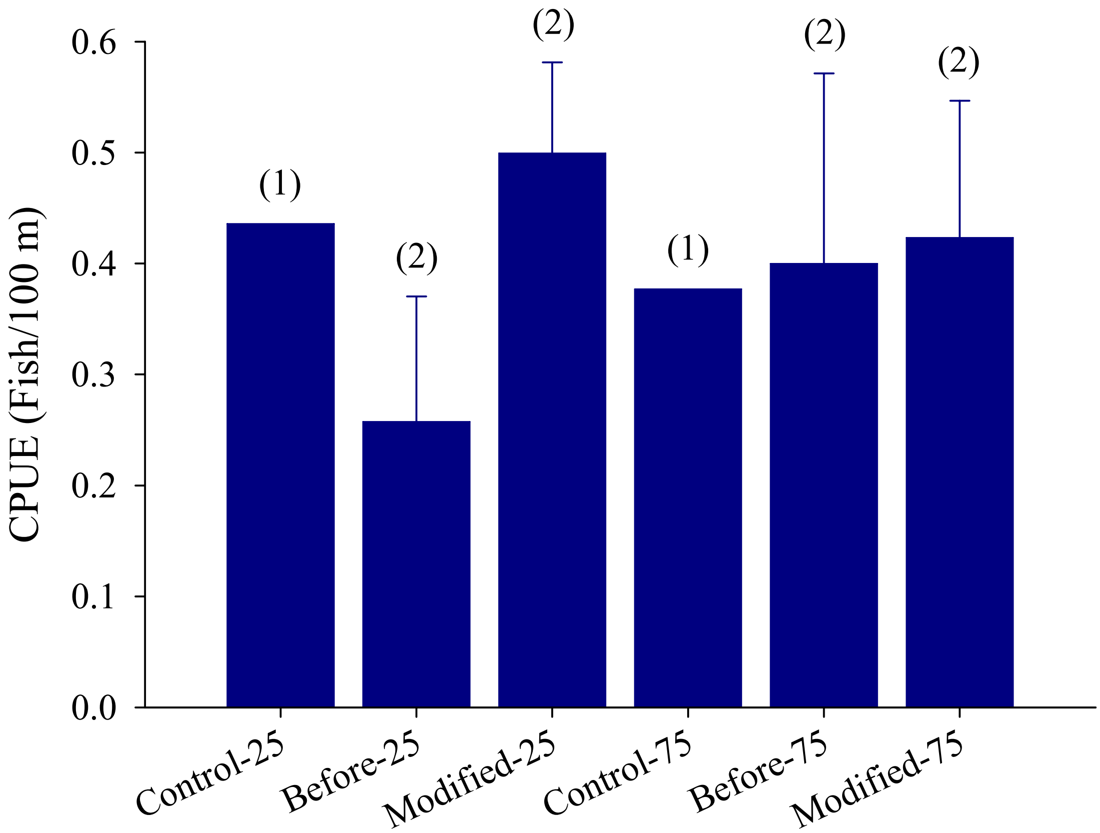

Figure 17. Mean catch-per-unit-effort (CPUE) of blue sucker collected using 1 in trammel nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

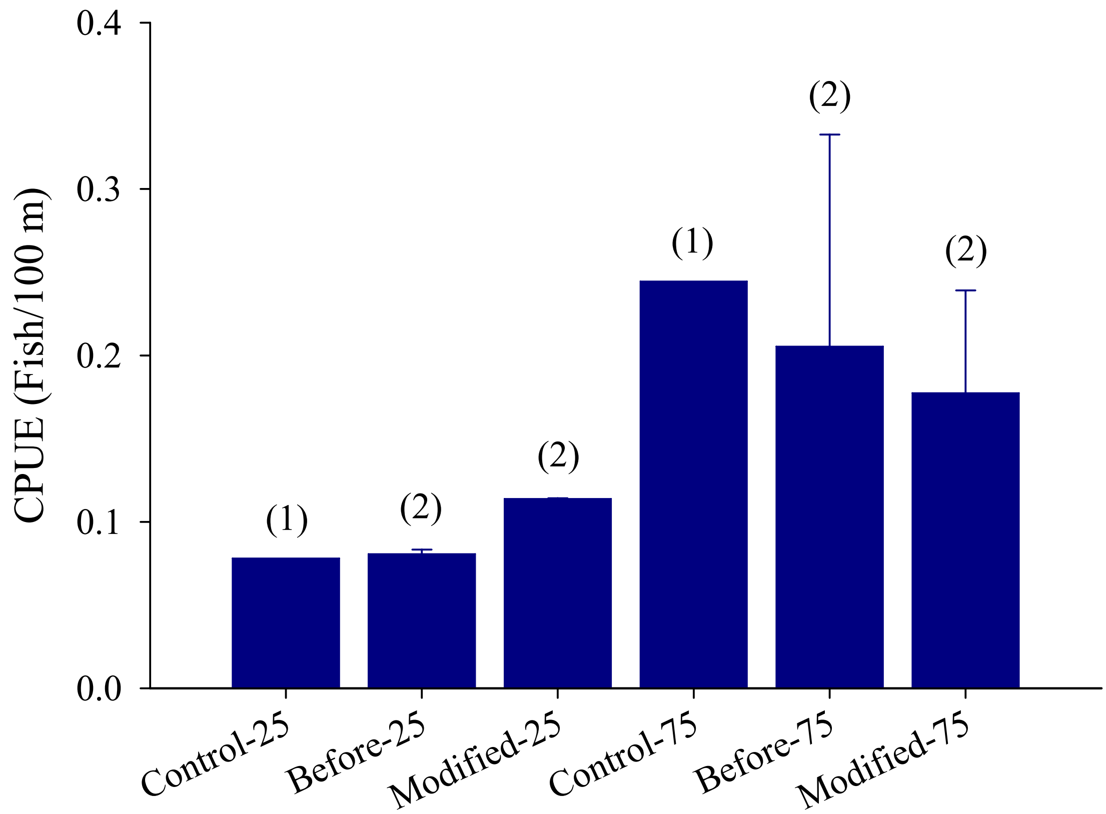

Figure 18. Mean catch-per-unit-effort (CPUE) of blue sucker collected using 16 ft otter trawl from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

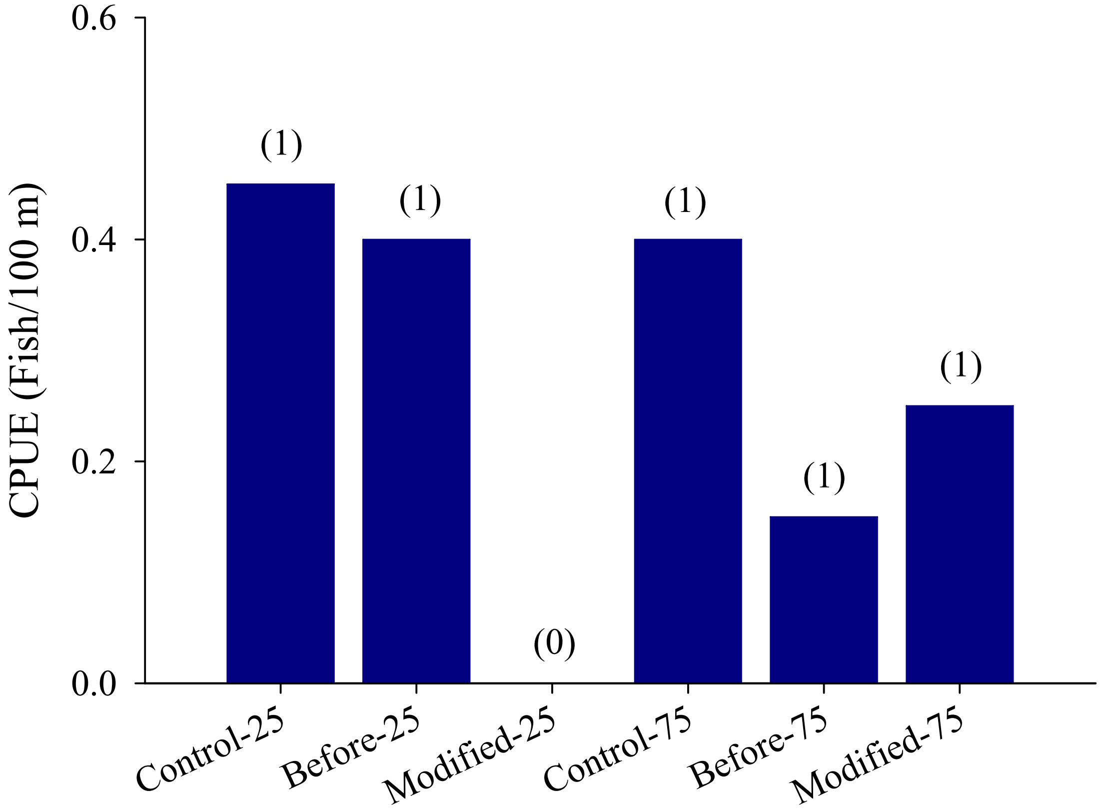

Figure 19. Mean catch-per-unit-effort (CPUE) of blue sucker collected using gill nets from Segment 9 during 2006. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

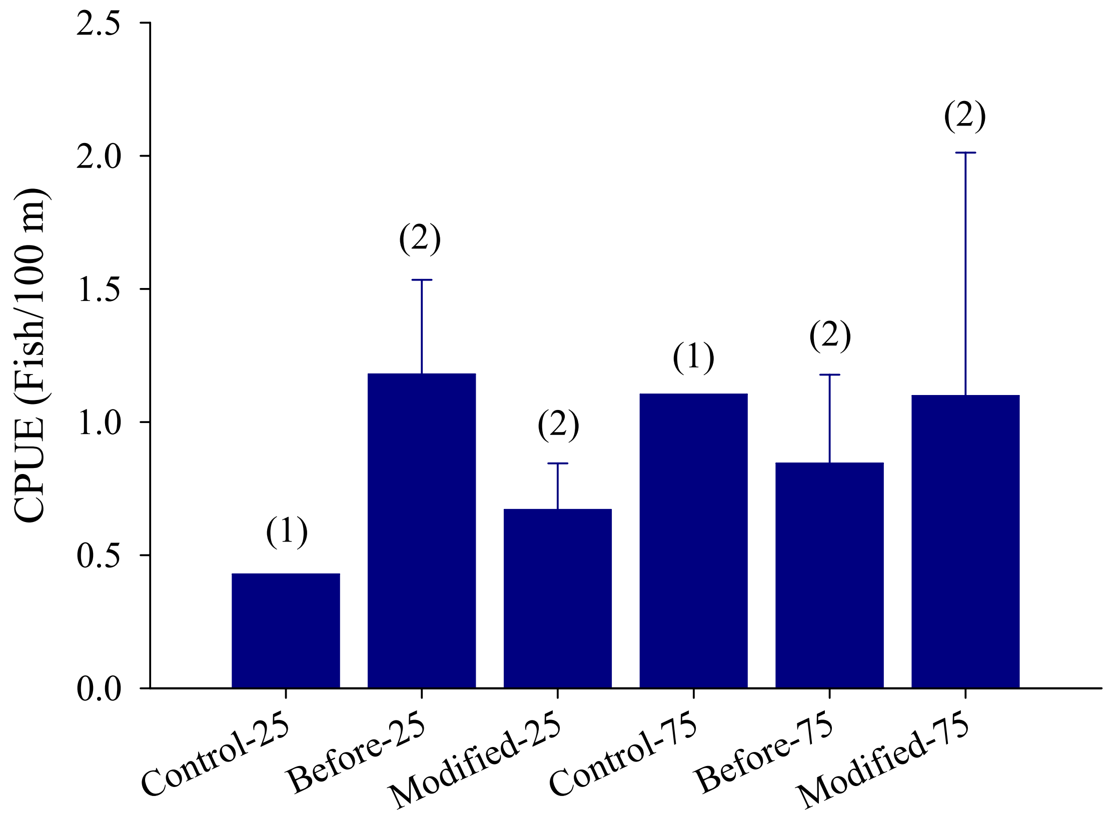

Figure 20. Mean catch-per-unit-effort (CPUE) of blue sucker collected using 1 in trammel nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

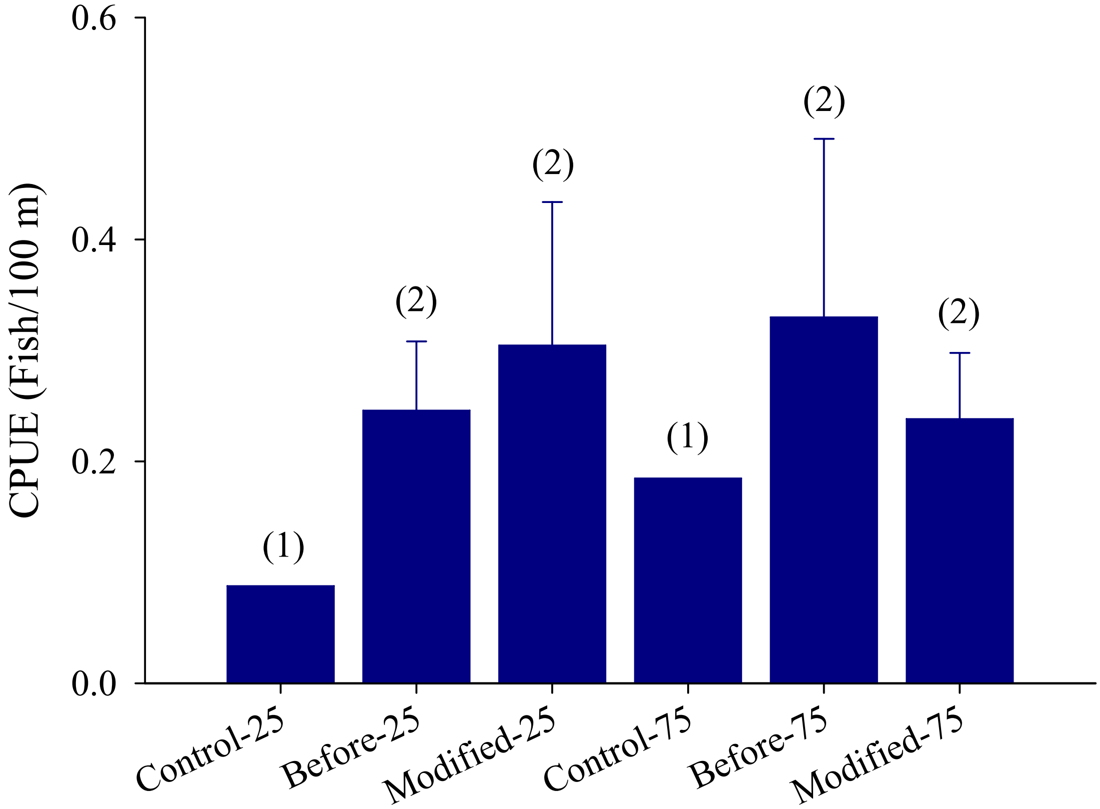

Figure 21. Mean catch-per-unit-effort (CPUE) of blue sucker collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

Speckled chub

A total of 281 speckled chubs were collected from Segments 8 and 9 and ranged from 13 - 66 mm TL (Figure 22). In Segment 8, during FC season 24 speckled chub were caught. In Segment 9 during ST season 31 speckled chub were caught and during FC season 226 were captured. Speckled chub habitat information is summarized by gear, segment and season in tables 7 and 9.

Mean CPUE of speckled chubs collected from Segment 8 using mini-fyke nets ranged from 0.00 - 0.22 fish/net-night (Figure 23). Speckled chub relative abundance was highest in the modified-75 bends (0.22 fish/net-night), followed by before-25 bends (0.16 fish/net-night), modified-25 bends (0.09 fish/net-night) and the before-75 bends (0.06 fish/net-night). Speckled chub was not collected at any of the control bends in mini-fyke nets.

Mean relative abundance of speckled chubs collected in Segment 8 using otter trawl ranged from 0.00 - 0.08 fish/100 m (Figure 24). Mean CPUE of speckled chubs was highest for before-25, modified-25 and modified-75 bends (0.08 fish/100 m, each), followed by control-25 bends (0.07 fish/100 m). Speckled chub were not collected in otter trawl nets on control-75 or before-75 bends.

Speckled chub were collected from all bend types in Segment 9 using mini-fyke nets. CPUE ranged from 0.03 - 0.75 fish/net-night (Figure 25). Speckled chub relative abundance was highest in the before-25 bends (0.75 fish/net-night), followed by before-75 and control-75 bends (0.25 fish/net-night, each). Modified-75 bends had the lowest CPUE (0.03 fish/net-night), followed by control-25 and modified-25 bends (0.07 and 0.09 fish/net-night, respectively).

Mean relative abundance of speckled chub collected from Segment 9 using otter trawl ranged from 0.32 - 1.23 fish/100 m (Figure 26). Mean CPUE of speckled chubs was highest in modified-25 bends (0.1.23 fish/100 m), followed by control-75 bends (0.86 fish/100 m). Before treatment bends of the 75th and 25th percentile of bend radius had CPUE of 0.63 and 0.58 fish/100 m, respectively. Mean CPUE was lowest in the modified-75 and control-75 bends (0.32 and 0.38 fish/100 m, respectively).

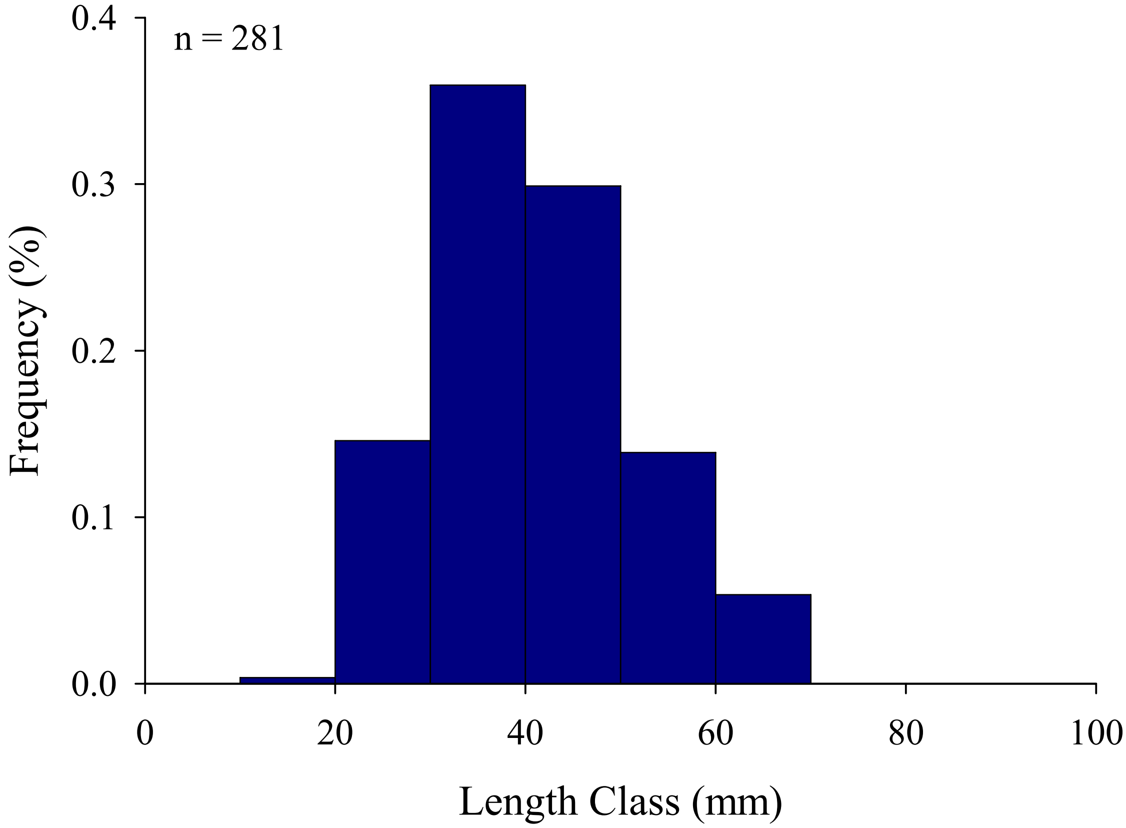

Figure 22. Length frequency (10 mm length class groups) of speckled chubs collected from Segment 8 and Segment 9 during 2006 sampling year.

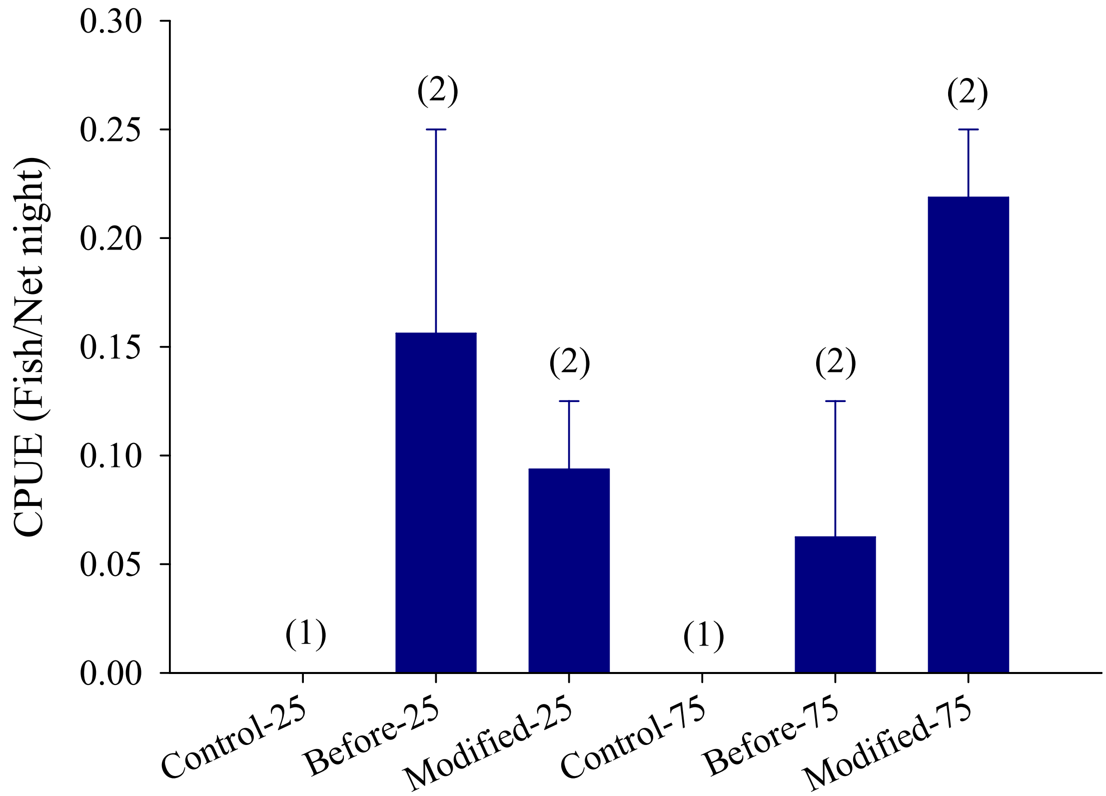

Figure 23. Mean catch-per-unit-effort (CPUE) of speckled chubs collected using mini-fyke nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

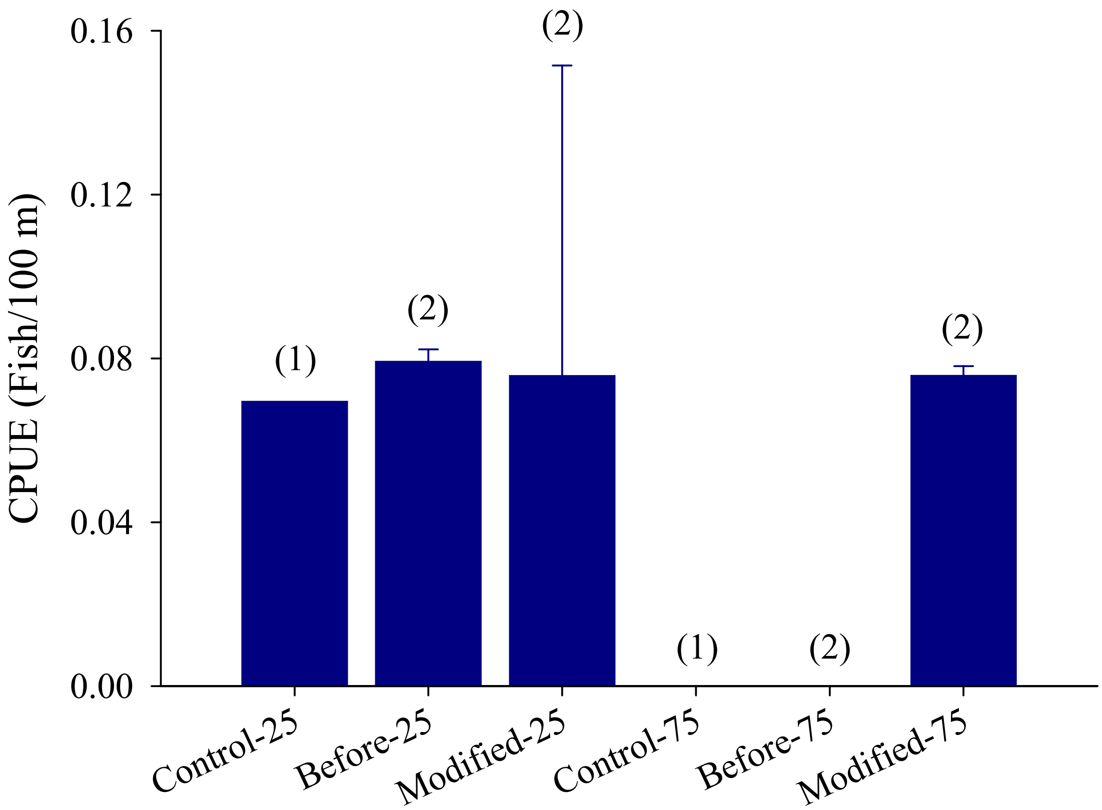

Figure 24. Mean catch-per-unit-effort (CPUE) of speckled chubs collected using 16 ft otter trawl from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius percentile of bend radius and 75 represents treatment bends in the 75th percentile of bend radius.

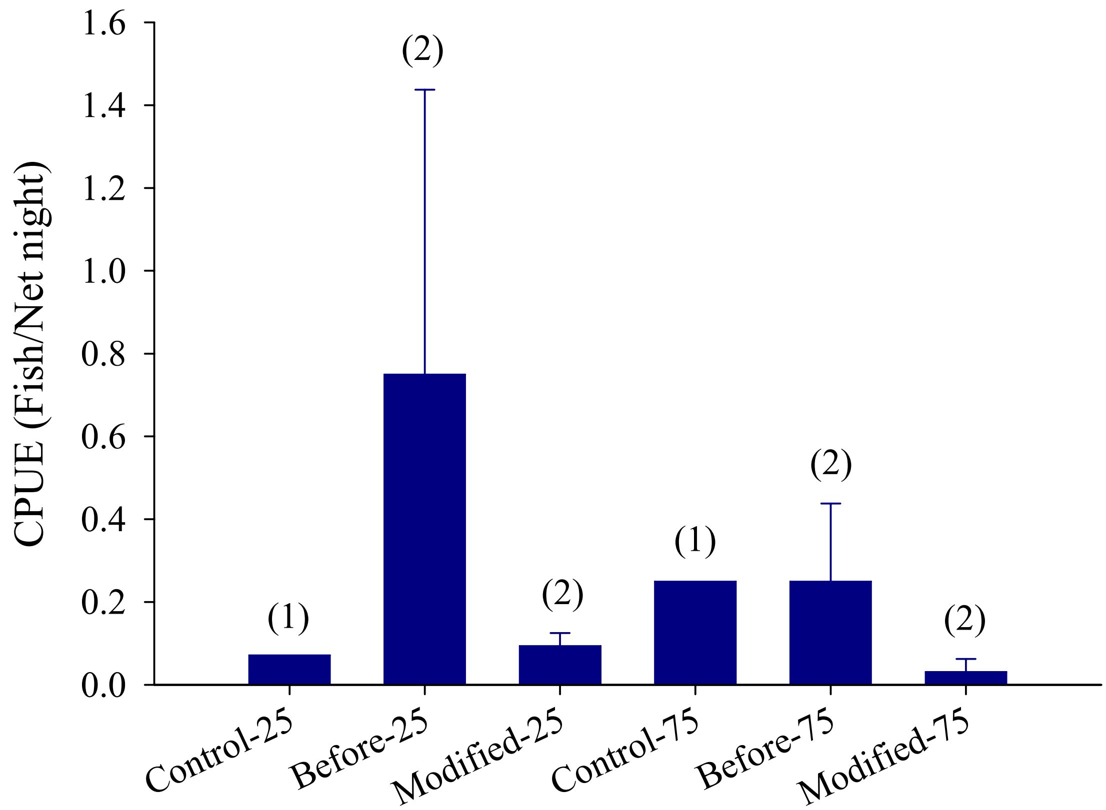

Figure 25. Mean catch-per-unit-effort (CPUE) of speckled chub collected using mini-fyke nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25^{th} percentile of bend radius and 75 represents bends in the 75^{th} percentile of bend radius.

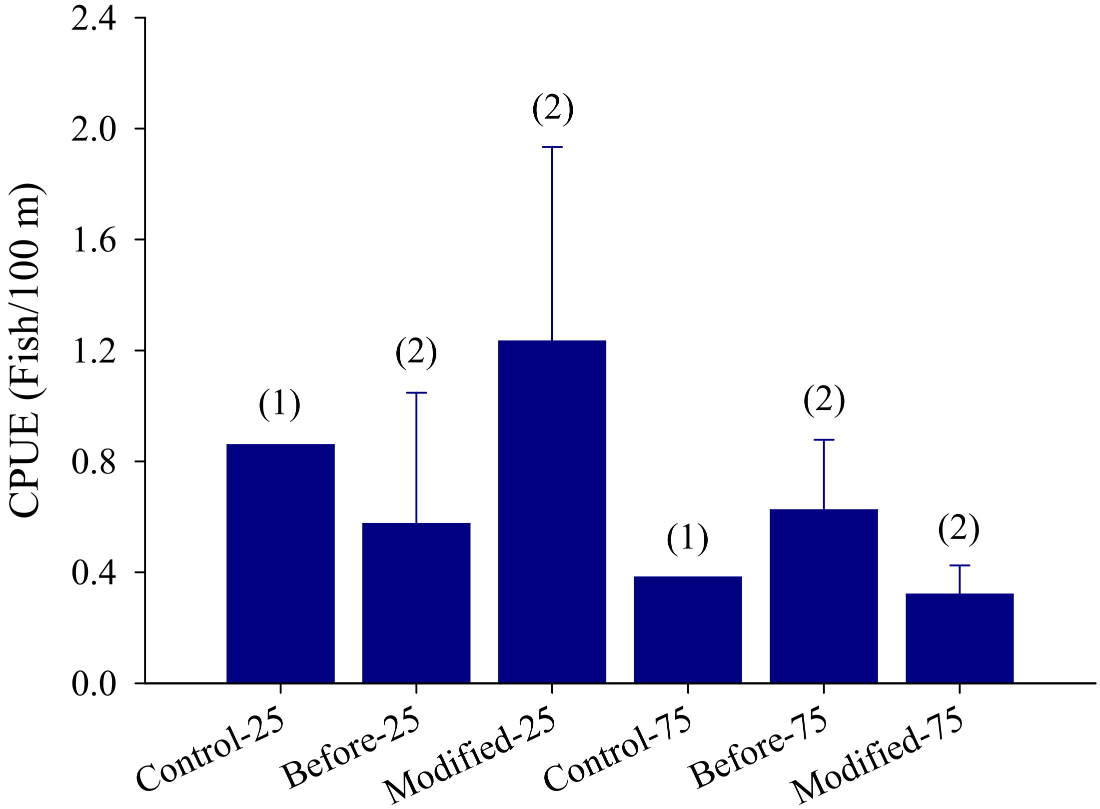

Figure 26. Mean catch-per-unit-effort (CPUE) of speckled chubs collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius percentile of bend radius and 75 represents treatment bends in the 75th percentile of bend radius.

Sturgeon chub

A total of 58 sturgeon chub were collected during the 2006 sampling season, ranging from 14 - 91 mm TL (Figure 27). In Segment 8, during FC season three sturgeon chub were caught. In Segment 9 during ST season one sturgeon chub was caught and during FC season 54 were captured. Sturgeon chub habitat information is summarized by gear, segment and season in tables 7 and 9.

Mean CPUE for sturgeon chub using the otter trawl in Segment 8 ranged from 0.00 - 0.07 fish/100 m. Sturgeon chub were collected with the otter trawl (Figure 28) on control-25 bends (0.07 fish/100 m). Sturgeon chub were not collected on any other bend types by otter trawling. No sturgeon chub were collected using mini-fyke nets in Segment 8.

Mean CPUE of sturgeon chubs ranged from 0.00 - 0.09 fish/net-night using mini-fyke nets in Segment 9 (Figure 29). Mean sturgeon chub CPUE was highest in the modified-25 bends (0.09 fish/net-night), followed by the control-25 bends (0.07 fish/net-night) and before-25 bends (0.03 fish/ net-night). Sturgeon chub were not collected on any treatments bends of the 75th percentile of bend radius.

Mean CPUE of sturgeon chubs collected using otter trawl in Segment 9 ranged from 0.11 - 0.36 fish/100 m (Figure 30). Mean CPUE was highest in the control-25 bends (0.36 fish/100 m). The remaining bend types had CPUE ranging from 0.11 - 0.16.

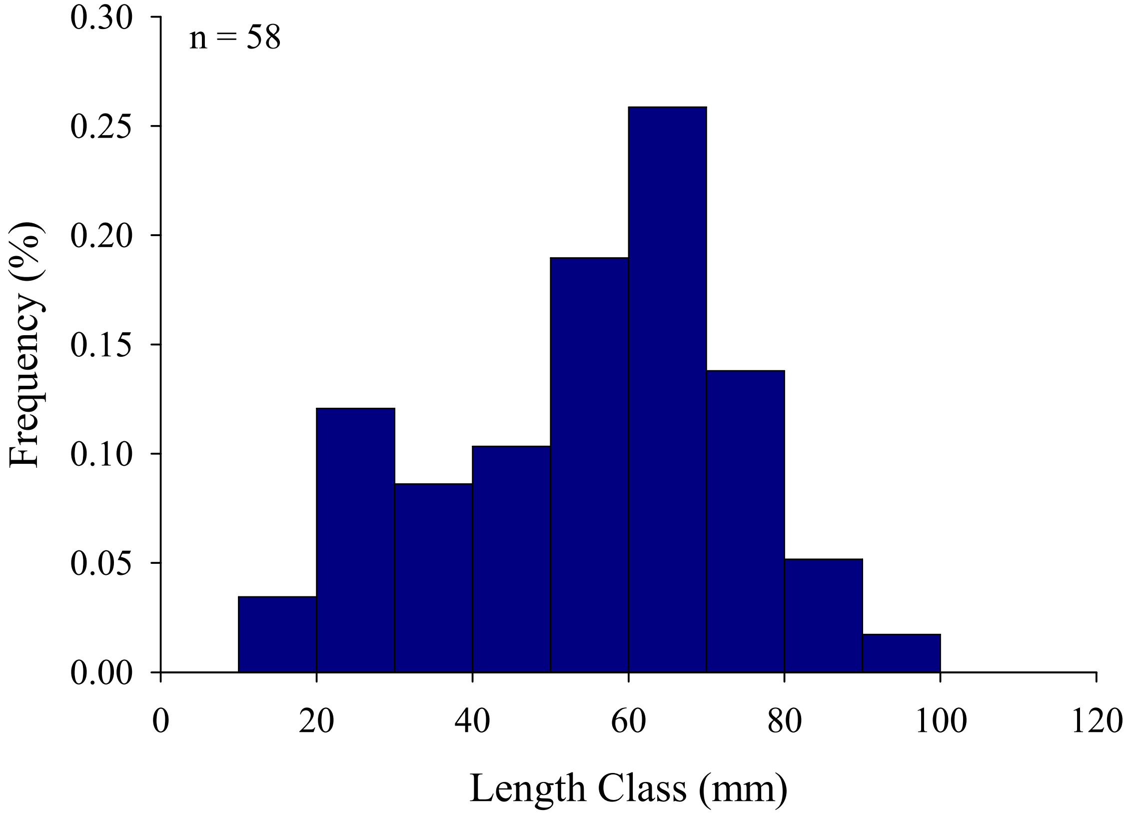

Figure 27. Length frequency (10 mm length class groups) of sturgeon chub collected from Segment 8 and Segment 9 during 2006 sampling year.

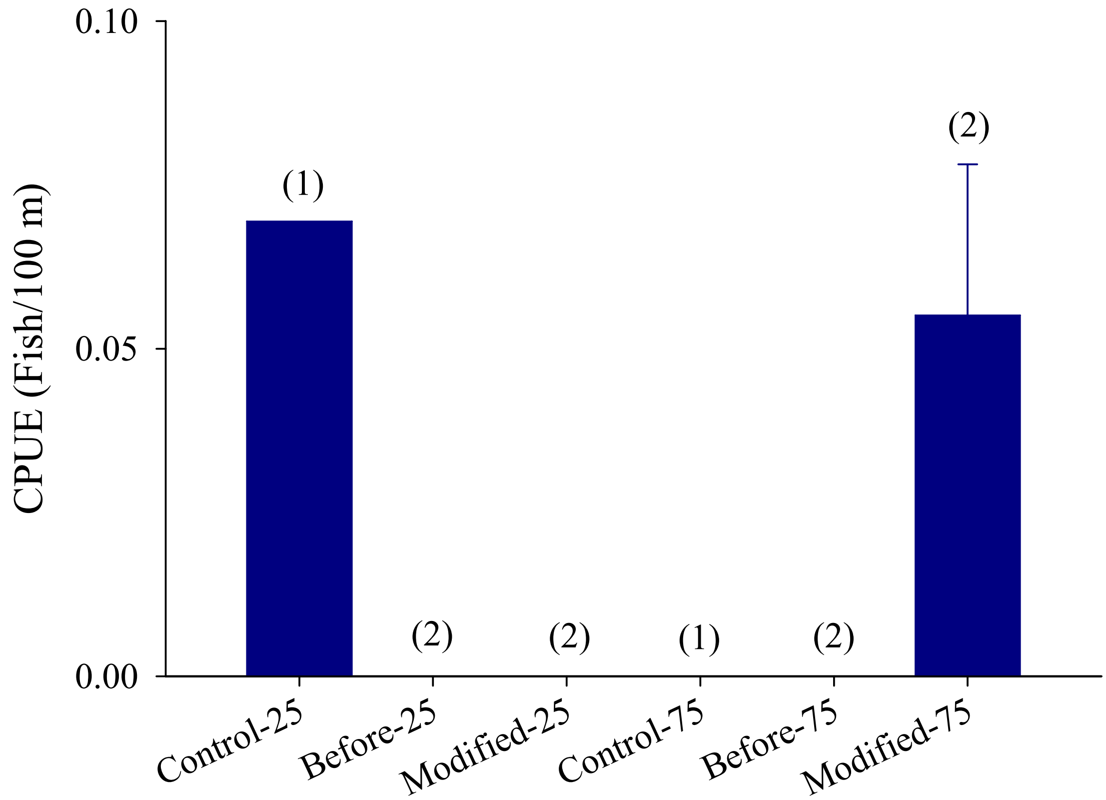

Figure 28. Mean catch-per-unit-effort (CPUE) of sturgeon chub collected using 16 ft otter trawl from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

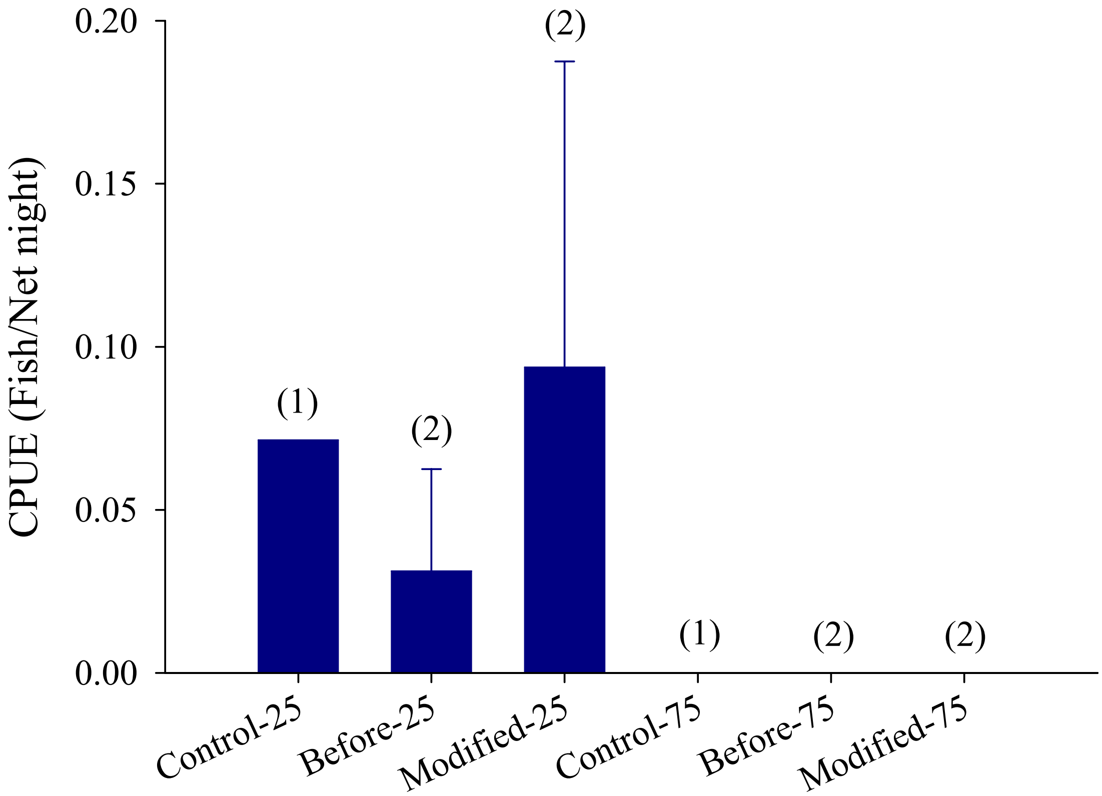

Figure 29. Mean catch-per-unit-effort (CPUE) of sturgeon chub collected using mini-fyke nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

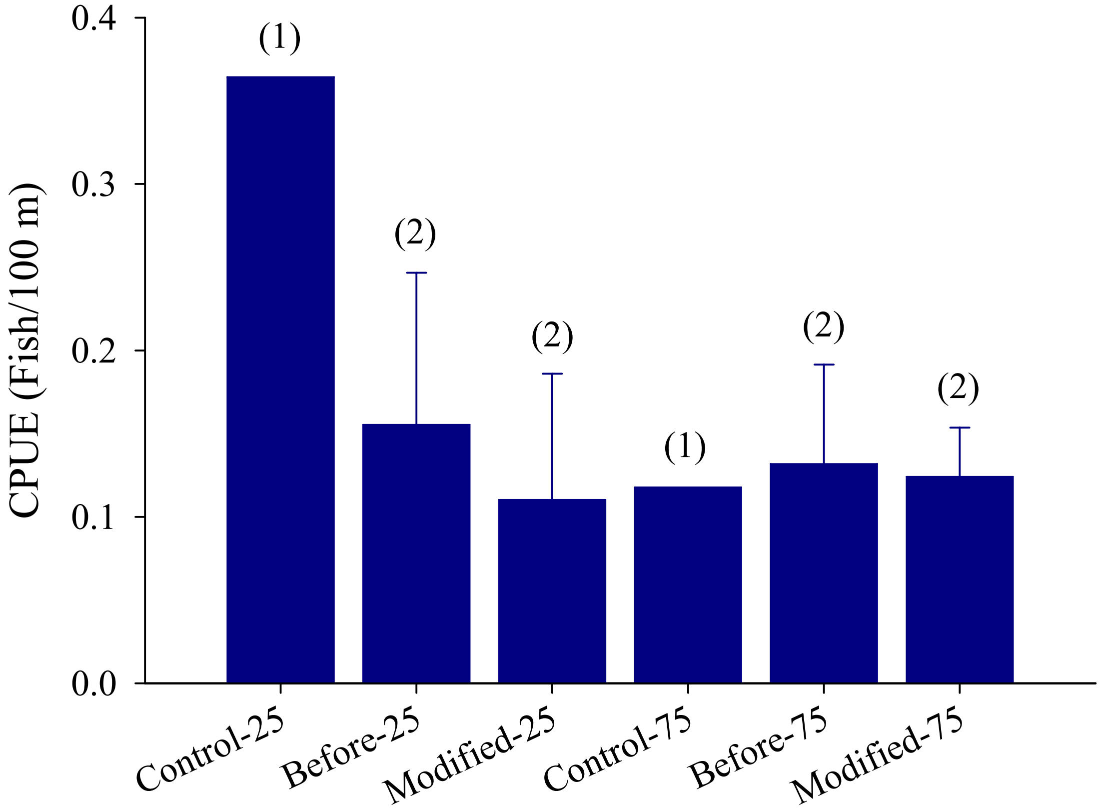

Figure 30. Mean catch-per-unit-effort (CPUE) of sturgeon chub collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

Sicklefin chub

A total of 12 sicklefin chub were collected during 2006 sampling season and ranged from 32 - 110 mm (Figure 31). In Segment 8, during FC season seven sicklefin chub were caught. In Segment 9 during ST season four sicklefin chub were caught and during FC season one was captured. Sicklefin chub habitat information is summarized for otter trawling by segment and season in table 7.

Mean CPUE of sicklefin chub collected using otter trawl in Segment 8 ranged from 0.00 - 0.07 fish/100 m (Figure 32). Mean CPUE of sicklefin chub was highest in control-25 and before-25 bends (0.07 fish/100 m, each), followed by the before -27 bends (0.06 fish/100 m), followed by modified-75 and modified-25 bends (0.02 and 0.06 fish/100 m, respectively). Sicklefin chubs were not collected in control -75 bends.

Mean CPUE of sicklefin chub collected using otter trawl in Segment 9 ranged from 0.00 - 0.02 fish/100 m (Figure 33). Mean CPUE of sicklefin chub was highest in before-25 bends (0.02 fish/100 m, each), followed by modified-25 bends (0.01 fish/100 m). Sicklefin chubs were not collected in any other bend types.

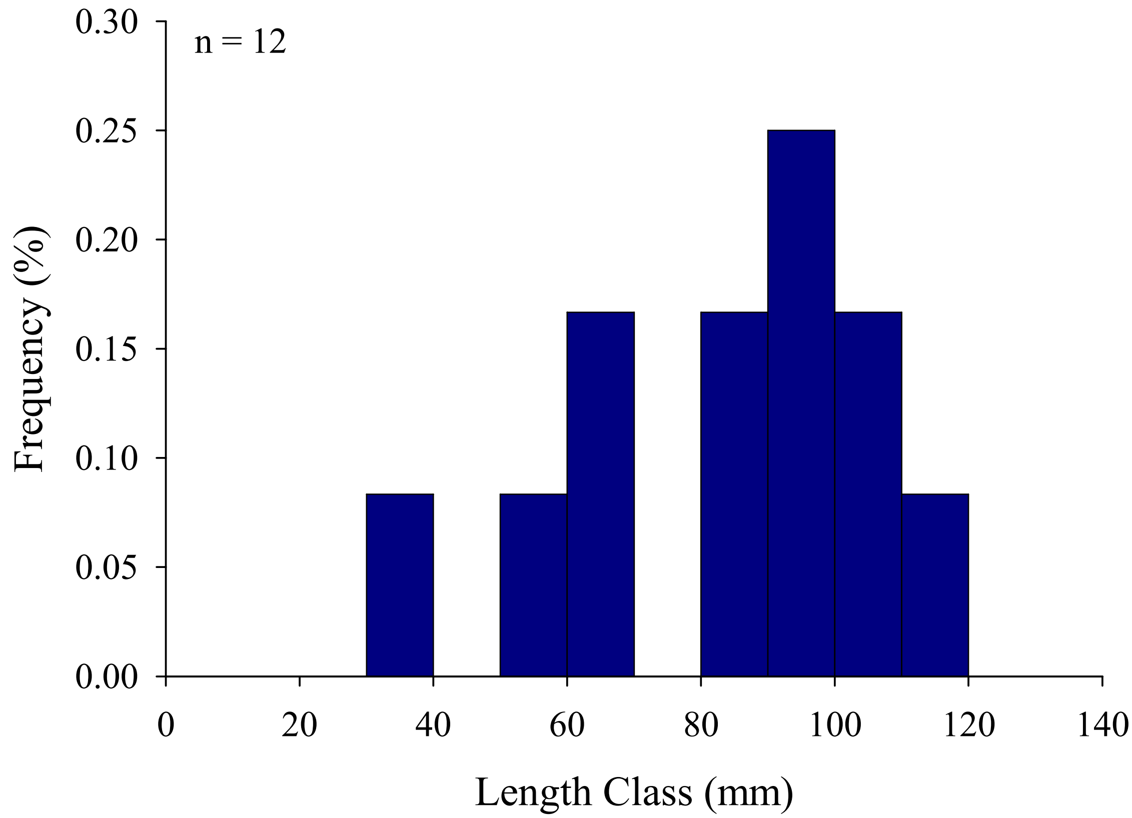

Figure 31. Length frequency (10 mm length class groups) of sicklefin chub collected from Segment 8 and Segment 9 during 2006 sampling year.

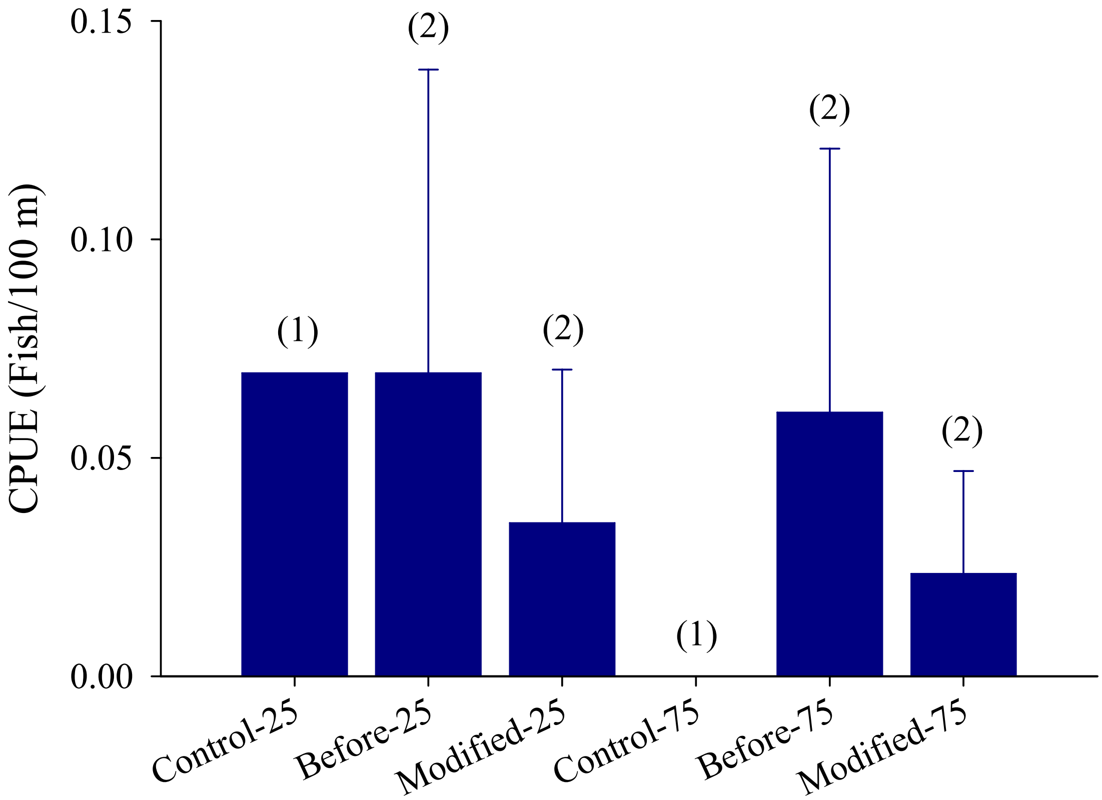

Figure 32. Mean catch-per-unit-effort (CPUE) of sicklefin chub collected using 16 ft otter trawl from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of treatment bends sampled. Twenty-five represents treatment bends in the 25th percentile of bend radius and 75 represents treatment bends in the 75th percentile of bend radius.

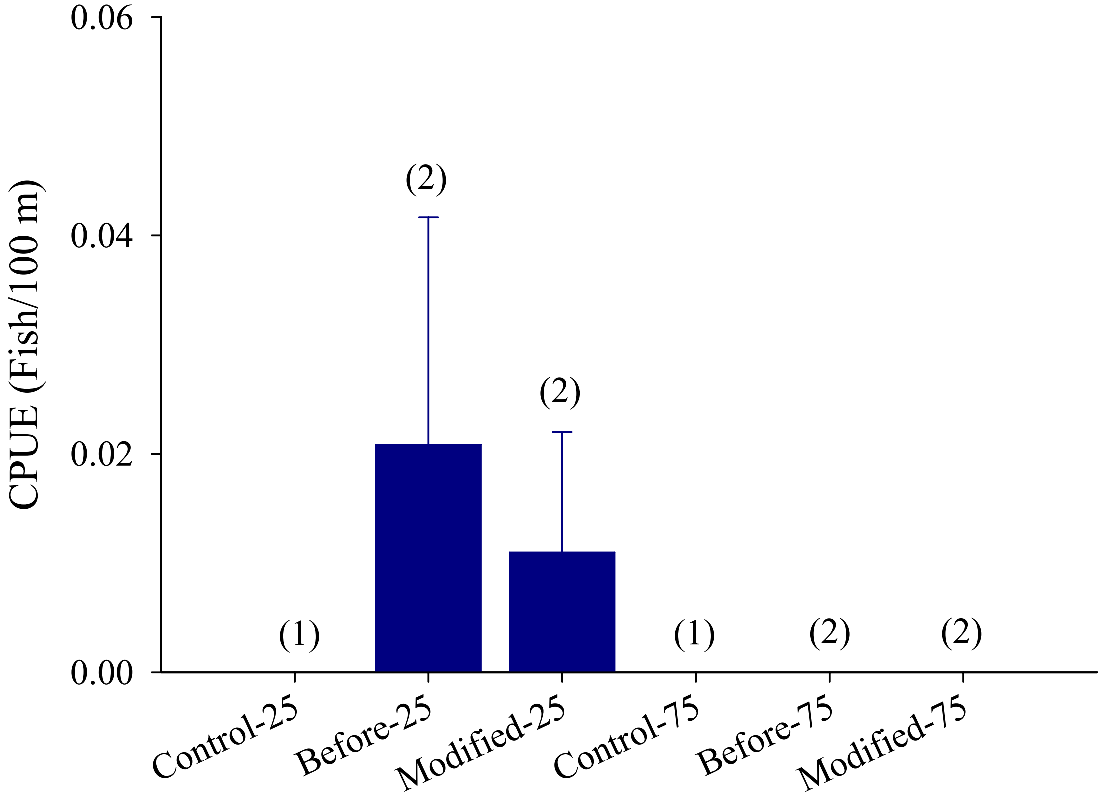

Figure 33. Mean catch-per-unit-effort (CPUE) of sicklefin chub collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of treatment bends sampled. Twenty-five represents treatment bends in the 25th percentile of bend radius and 75 represents treatment bends in the 75th percentile of bend radius.

Sand shiner

A total of 4,006 sand shiners were collected during the 2006 sampling season and ranged from 20 - 75 mm TL (Figure 34). In Segment 8, during FC season 2,668 sand shiner were caught. In Segment 9 during FC season 1,338 were collected. Sand shiner habitat information is summarized by gear, segment and season in tables 7 and 9.

Mean relative abundance of sand shiner in mini-fyke nets from Segment 8 ranged from 6.59 - 34.75 fish/100 m (Figure 35). Mean CPUE was highest in the before-25 and control-25 bends (34.75 and 18.25 fish/100 m, respectively), followed by the modified-25 bends (17.19 fish/100 m). Mean CPUE was lower in all bends of the 75th percentile of bend radius (6.59 - 12.06 fish/net-night). No sand shiners were collected from Segment 8 using the otter trawl.

Sand shiners were collected in each treatment type with mini-fyke nets from Segment 9 (Figure 36). Mean CPUE ranged from 2.91 - 13.81 fish/net-night. Mean CPUE was highest in modified-75 bends (13.81 fish/net-night). Before -75 bends had the lowest CPUE (2.91 fish/net-night). Mean CPUE for all remaining bend types were similar (7.56 - 9.06 fish/net-night).

Mean CPUE of sand shiner collected by otter trawl from Segment 9 ranged from 0.00 - 0.44 fish/net-night (Figure 37). Mean CPUE was highest in before-75 bends 0.44 fish/net-night). Sand shiner were not colleted in control-25 bends. The remaining bend treatment types had low CPUE (0.01 - 0.03 fish/net-night).

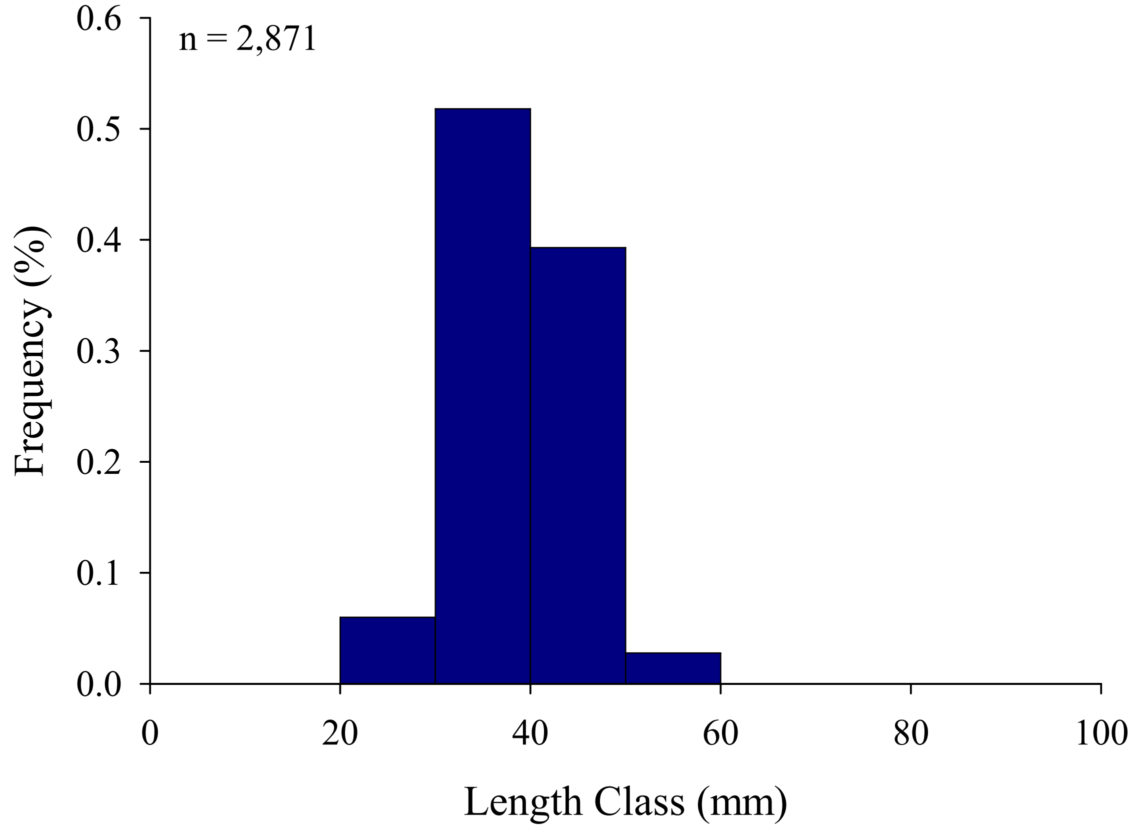

Figure 34. Length frequency (10 mm length class groups) of sand shiners collected from Segment 8 and Segment 9 during 2006 sampling year.

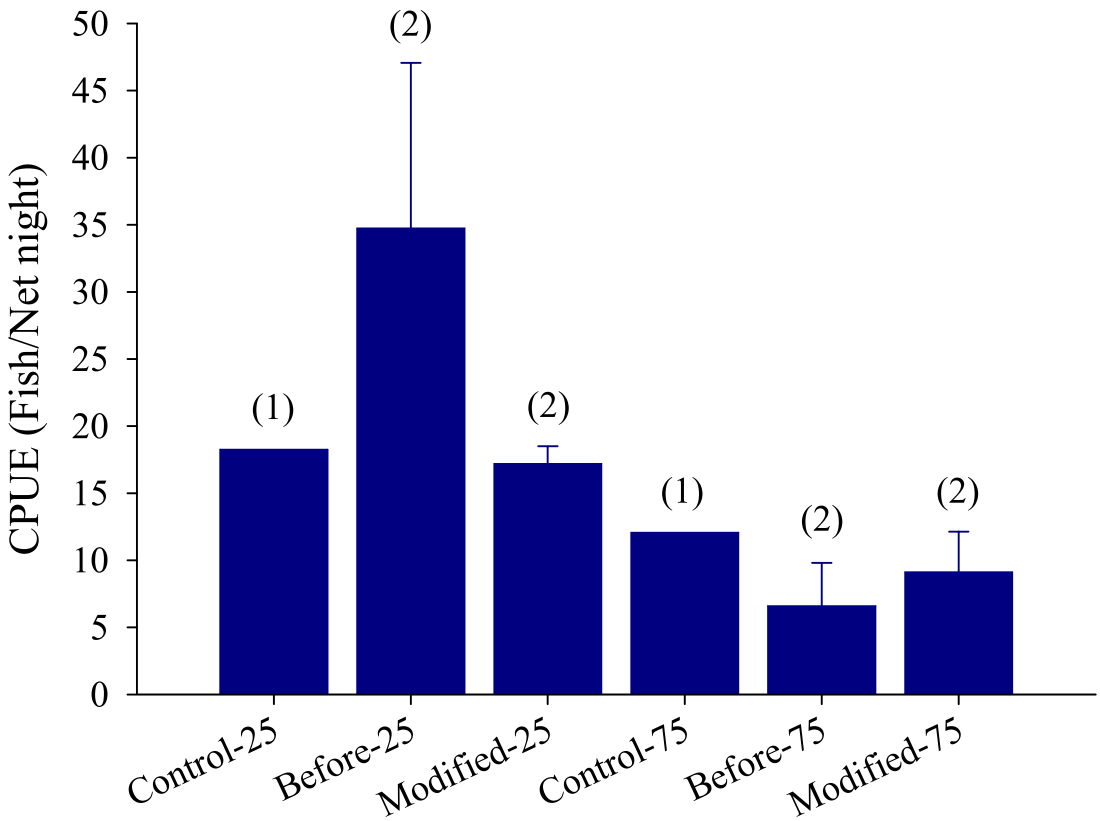

Figure 35. Mean catch-per-unit-effort (CPUE) of sand shiner collected using mini-fyke nets from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

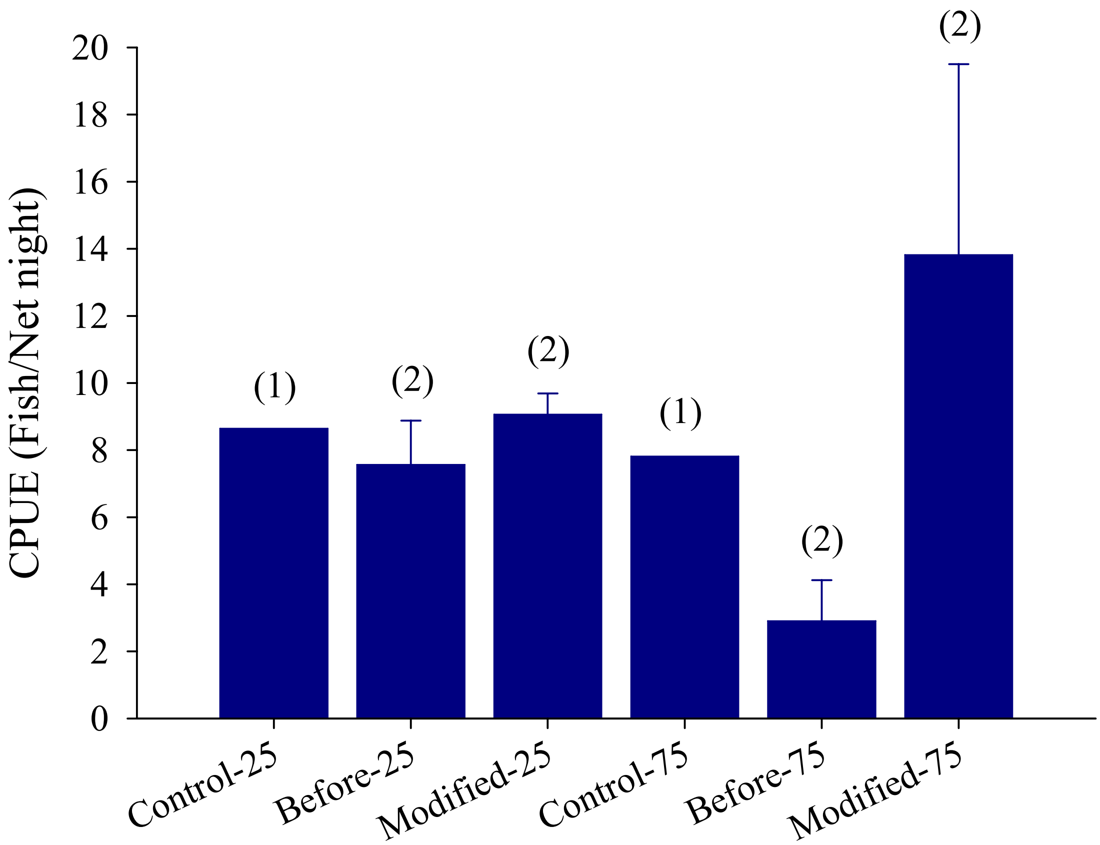

Figure 36. Mean catch-per-unit-effort (CPUE) of sand shiner collected using mini-fyke nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

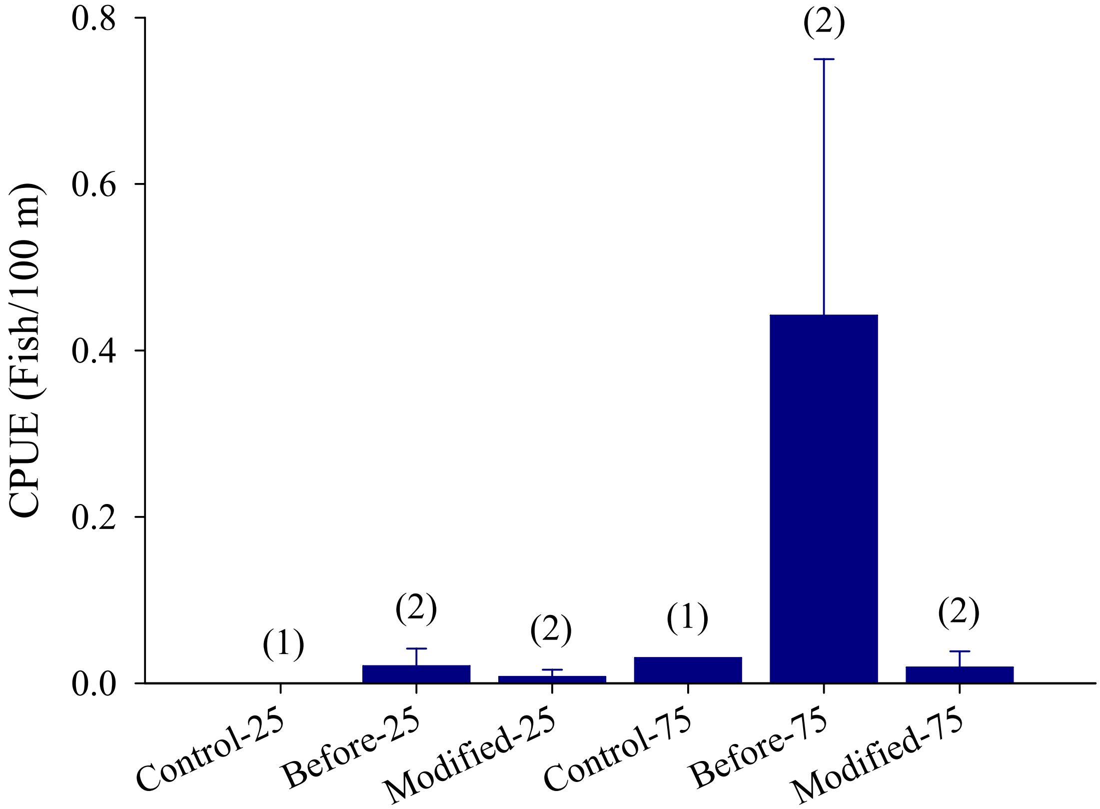

Figure 37. Mean catch-per-unit-effort (CPUE) of sand shiner collected using 16 ft otter trawl from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

Plains minnow

A total of 24 plains minnow were collected from Segments 8 and 9 during the 2006 sampling season and ranged from 34 - 70 mm (Figure 38). In Segment 8, during FC season three plains minnow were caught. In Segment 9 during FC season 21 were collected. Plains minnow habitat information is summarized for mini-fyke nets by segment and season in table 9.

Mean CPUE of plains minnow collected using min-fyke nets in Segment 8 ranged from 0.00 - 0.06 fish/100 m (Figure 39) and was highest in the control-25 bends. Before-25 and modified-25 bends had the same CPUE (0.03 fish/net-night, each). Plains minnow were not collected from any bends in the 75th percentile of bend radius in Segment 8.

Mean CPUE of plains minnow collected from Segment 9 using mini-fyke nets ranged from 0.00 - 0.22 fish/100 m (Figure 40). Mean CPUE of plains minnow was highest in before-25 bends, followed by modified-25 bends (0.22 and 0.19 fish/100 m, respectively). The control-75 and before-75 bends had the same CPUE (0.25 fish/net-night) and modified-75 bends had a CPUE of 0.06.

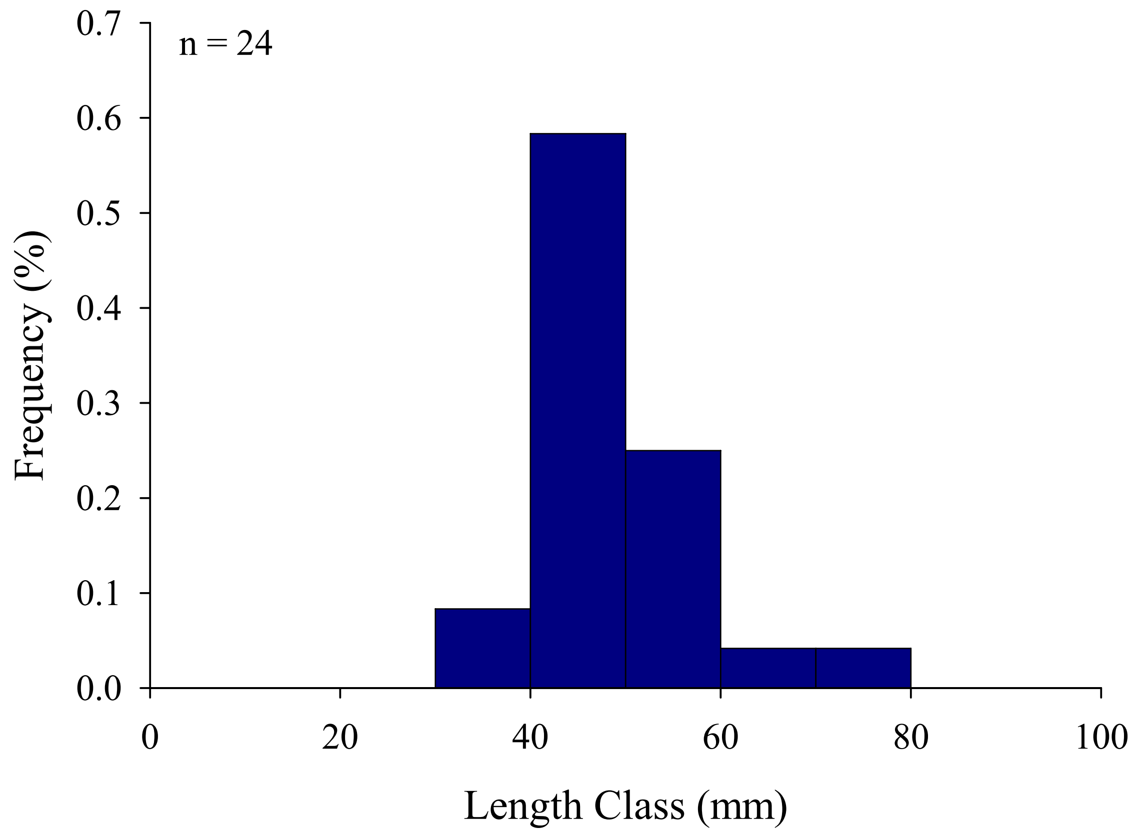

Figure 38. Length frequency (10 mm length class groups) of plains minnow collected from Segment 8 and Segment 9 during the 2006 sampling seasons.

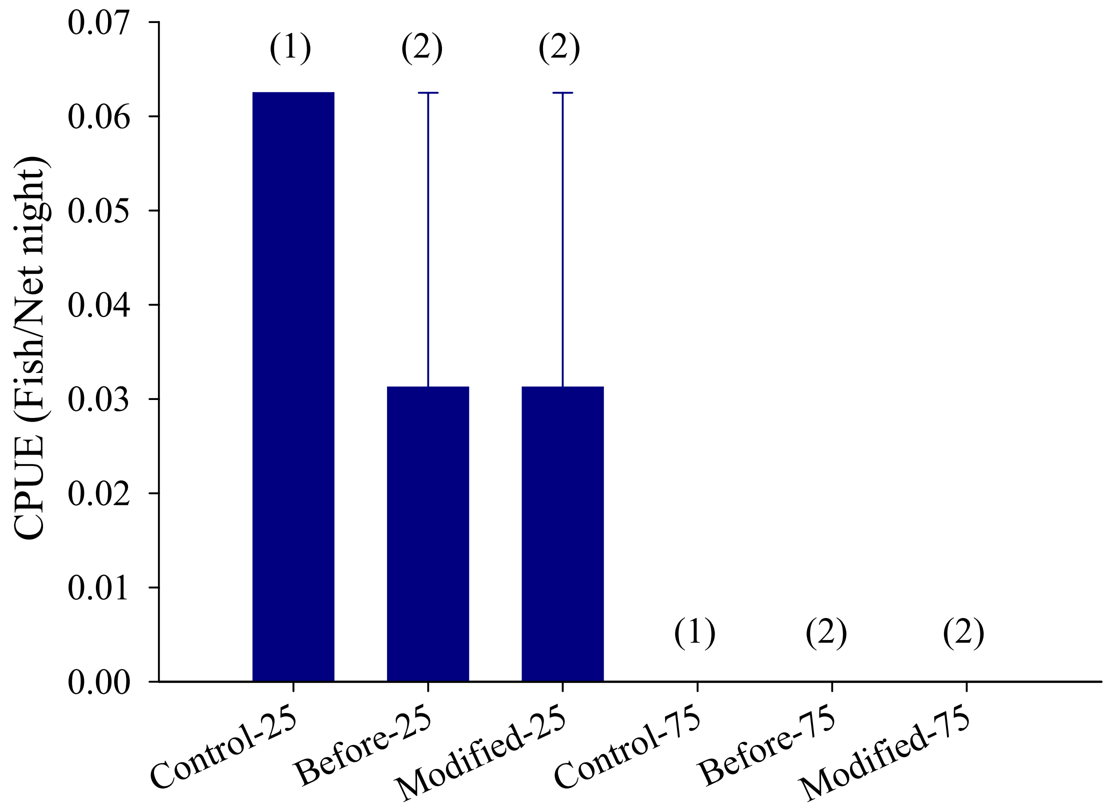

Figure 39 Mean catch-per-unit-effort (CPUE) of plains minnow collected using mini-fyke net from Segment 8 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

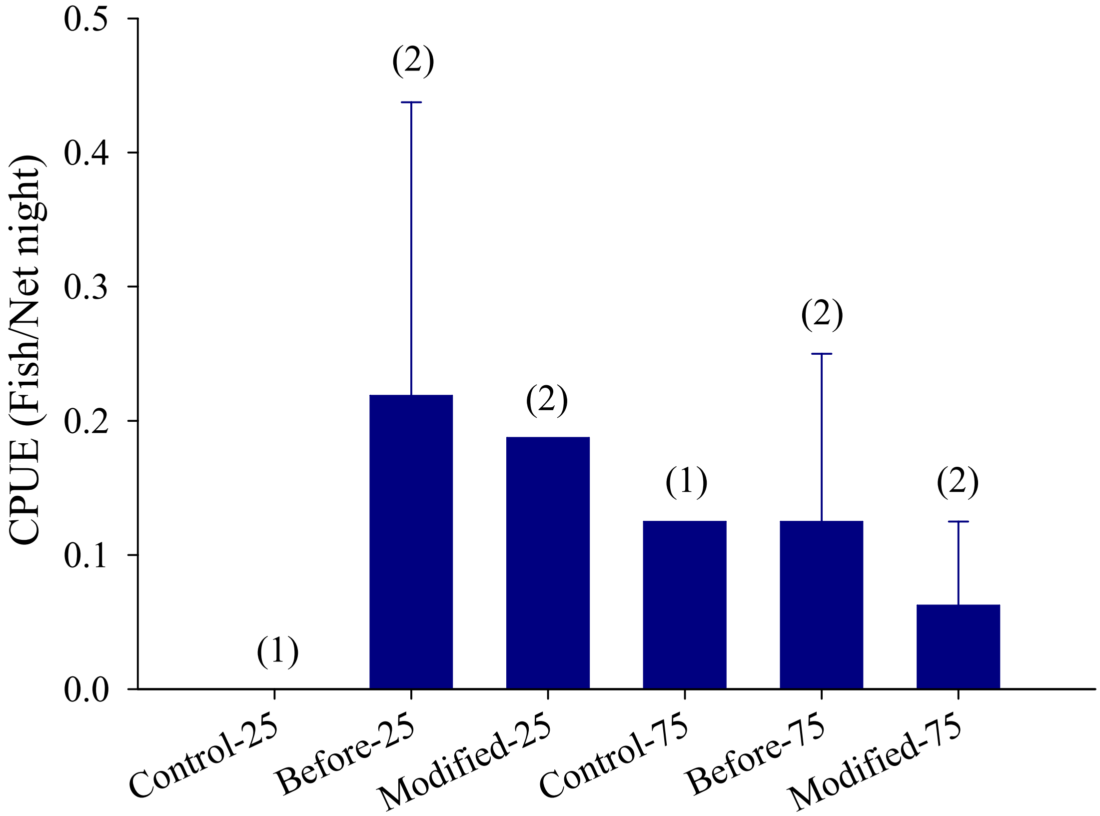

Figure 40 Mean catch-per-unit-effort (CPUE) of plains minnow collected using mini-fyke nets from Segment 9 during 2006. Error bars represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percentile of bend radius and 75 represents bends in the 75th percentile of bend radius.

Sauger

A total of 140 sauger were collected during the 2006 sampling season and ranged from 24 - 757 mm with the majority being >300mm (Figure 41). In Segment 8, during FC season 10 sauger were caught and during ST season 42 were collected. In Segment 9 during FC season 13 sauger were collected and during ST season 75 were caught. Sauger habitat information is summarized by gear, segment and season in tables 6, 7 and 9.

Mean CPUE of sauger collected using gill nets within Segment 8 ranged from 0.18 - 0.40 fish/100 m (Figure 42). Mean catch-rates of sauger was highest before-25 bends (0.40 fish/100 m), followed by control-75 bends (0.30 fish/100 m). Both modified-25 and modified-75 had the same CPUE (0.18 fish/100 m).

Mean sauger relative abundance collected using gill nets in Segment 9 ranged from 0.10 - 0.50 fish/100 m (Figure 43). Mean catch rates of sauger was highest control-25 bends (0.50 fish/100 m), followed by control-75 bends (0.40 fish/100 m). Before-25 and a CPUE of 0.25 fish/net-night. Before-75 and Modified-75 had similar CPUE (0.10 and 0.15 fish/100 m, respectively).

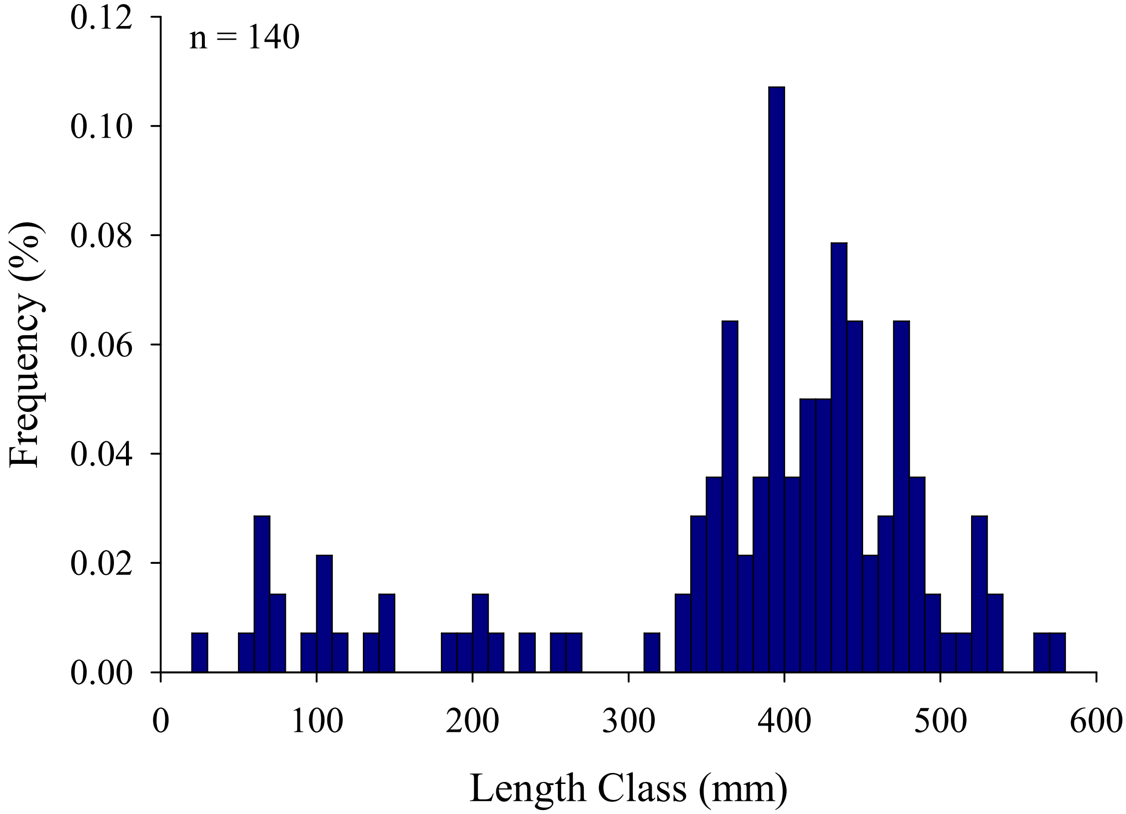

Figure 41. Length frequency (10 mm length class groups) of sauger collected from Segment 8 and Segment 9 during fish community (FC) sampling seasons in 2006.

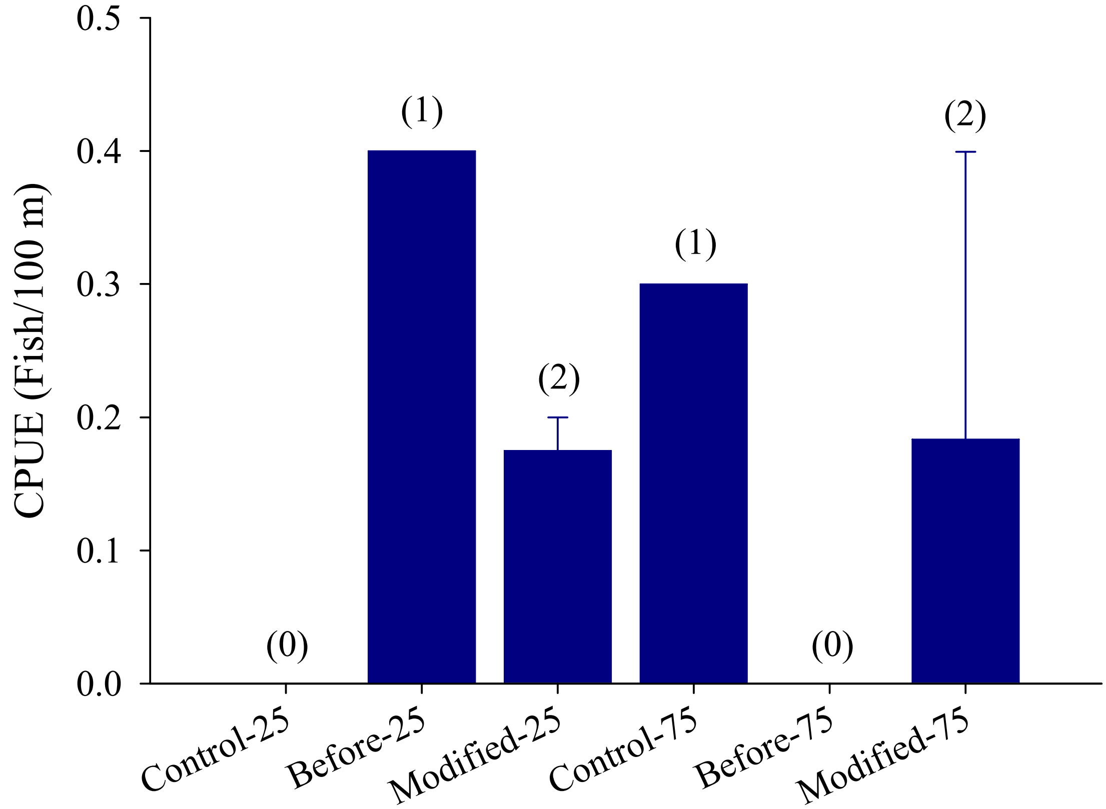

Figure 42. Mean catch-per-unit-effort (CPUE) of sauger collected using gill nets from Segment 8 during 2006. Error bar represent ±1 S.E. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percent bend radius and 75 represents bends in the 75th percent bend radius.

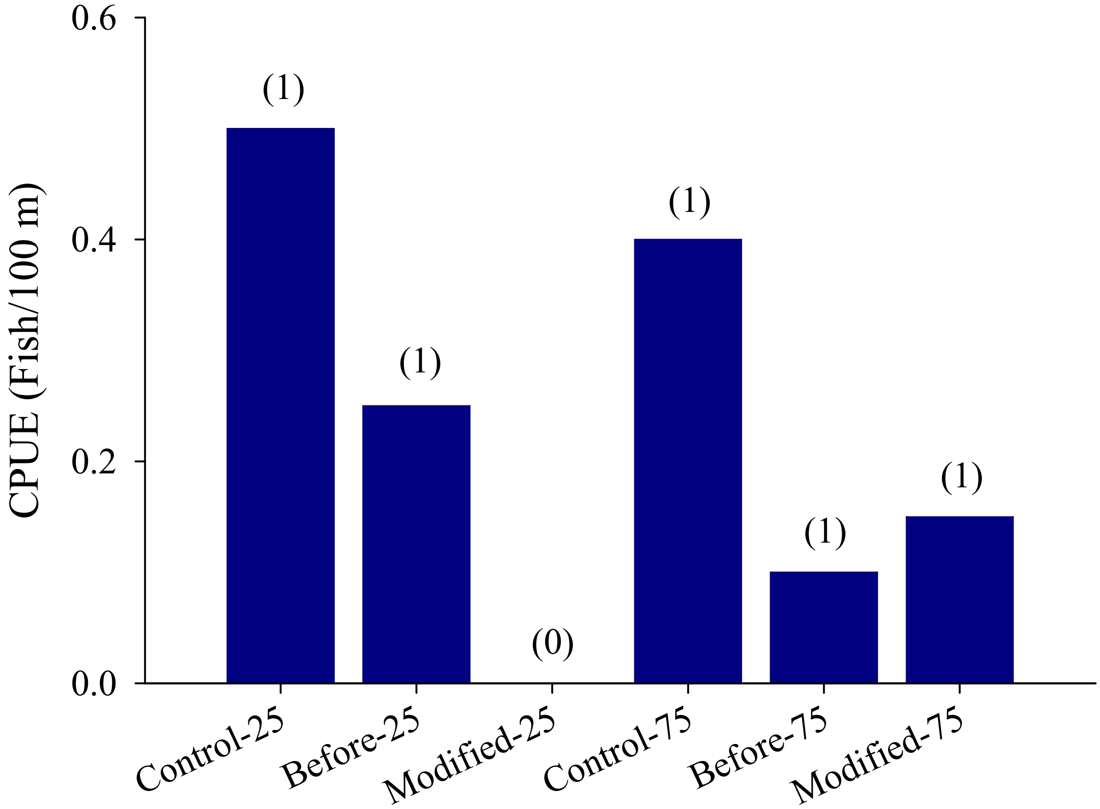

Figure 43. Mean catch-per-unit-effort (CPUE) of sauger collected using gill nets from Segment 9 during 2006. Numbers in parentheses represent number of bends sampled per treatment type. Twenty-five represents bends in the 25th percent bend radius and 75 represents bends in the 75th percent bend radius.

Discussion

Nebraska Game and Parks Commission's HAMP sampled 47 different bends during 2006 including all 20 bends that were finally selected as study bends in May 2006 (Table 1). The additional bends (Table 3) were sampled because field work began before the bend selection process was completed. The sampling goal for NGPC HAMP after the 20 study bends were selected was to sample each bend two times during FC season with trammel nets, otter trawls and mini-fyke nets. For 2006 FC season we completed three visits per bend with trammel nets and otter trawls in Segment 9 and trammel nets in Segment 8. Two visits were completed for mini-fyke nets in Segments 8 and 9 and otter trawls in Segment 8. During the 2006 sampling season a total of 2,223 gear deployments (Table 2 and Table 3) resulted in the collection of over 56,102 fish (Table 4). Of the 58 fish species collected 13 were captured in all four standard gears and 16 species were only captured in a single gear type. It is important to evaluate responses to habitat creation with multiple species and gears, since a short-term pallid sturgeon response is not expected.

These data collected during 2006 represent control data and pre-treatment data for those bends scheduled to be modified. When all of the pre-treatment data is combined, spatial and temporal differences between control and treatment bends will be evaluated. Characterizing differences between control bends and treatment bends prior to modification will establish a baseline for evaluation of bend modifications in the future. Without this pre-treatment data it would be impossible to make inferences regarding the effects of bend modifications. With two years of sampling complete, conclusions regarding the biological response to existing bend modifications are limited to observations between modified and unmodified bends. As more years of data are compiled, more robust statistical analysis will be conducted.

Evaluating trends in the 2006 CPUE data with respect to bend type did not reveal any consistent patterns among different species; furthermore, high variability in catch-rates among bend types limits our ability to distinguish patterns. However, the highest gill netting catch-rates for pallid sturgeon, shovelnose sturgeon and blue sucker in Segment 8, were from modified bends. In contrast, the highest gill netting CPUE in Segment 9 was from before and control bends. Catch-rate for pallid sturgeon, shovelnose sturgeon and blue sucker using trammel nets in Segment 8 were also highest for modified bends. In Segment 9, trammel netting catch-rates for shovelnose sturgeon was highest on modified bends and for blue sucker was highest on before and control bends. With the otter trawl in Segment 8 only one of seven target species (i.e., blue sucker) had a higher CPUE on modified bends. In Segment 9, three of seven target species had greater CPUE on modified bends. Catch-rates for mini-fyke nets of target species in Segments 8 and 9 each had one species with the highest CPUE on modified bends. No species had CPUE that were continuously greater on the same bend type for multiple gears.

Length frequency histograms illustrate sampling across both seasons with multiple gears is needed to accurately represent the fish community. Multiple gears were also needed to represent a broad size-class structure for some species. For example, 140 sauger were collected, 99 with gill nets, 18 in otter trawls, 17 in trammel nets and 6 in mini-fyke nets. If only gill net data was collected then the length-frequency histogram would not have include sauger < 214 mm TL (Figure 41). In contrast, mini-fyke nets only collected sauger between 118 - 194 mm TL. Otter trawls collected a range of sizes (24 - 468 mm TL) and accounted for 14 sauger < 210 mm TL.

It is critical to be able to collect juvenile length classes because it provides valuable information about recruitment. We are concerned with the low number of juveniles collected as you see in the length-frequency histograms for pallid sturgeon, shovelnose and blue suckers (Figures 2, 8 and 15, respectively). There are several possible factors which might be contributing to the limited number of juveniles collected. The first scenario would be that they just don't exist. There is very limited annual reproduction or survival to a vulnerable size in these segments of these species. A second possibility is that the gear being used for HAMP might not be effective in collecting these particular year classes of fishes. However, as indicated in the length-frequency histograms for shovelnose and blue suckers (Figure 8 and Figure 15, respectively), some juvenile fish are being collected. Because the HAMP goal is to create habitats beneficial to these younger fishes, it is important to be able to detect these smaller year classes when present, documenting successful spawning and recruitment and the use of these created habitats for these small fishes and younger life history stages.

It is apparent the Platte River has an influence on the temperature and turbidity of the Missouri River. Over 2,000 temperature and depth measurements were collected in conjunction with our sampling efforts and revealed some differences between segments. Below the Platte River in Segment 9 temperatures were 1 °C warmer on average and turbidity was about 40 NTU higher on average. It is plausible the Platte River influences fish communities. In Segment 9, otter trawl tows had greater CPUE for shovelnose sturgeon, blue sucker, speckled chub, sturgeon chub and sand shiner; however, sicklefin chub CPUE was lower. The same pattern was observed for speckled chub and sturgeon chub collected in mini-fyke nets.

Comparisons of pallid sturgeon and shovelnose sturgeon catches showed that during ST season, with gill nets pallid sturgeon were captured on average in deeper water with greater bottom velocity (Table 6). However, these patterns were not consistent across all gears that captured pallid sturgeon. All three target chub species (speckled chub, sturgeon chub, and sicklefin chub) were collected in otter trawls (Table 6); however, only a few sturgeon chub and no sicklefin chub were collected in mini-fyke nets (Table 7). That suggests sicklefin chub utilized higher water velocity since they were only captured in otter trawls that are sampling higher velocity water then min-fyke nets (Table 5).

The goal of the biological component of HAMP is to determine if there have been biological responses to the habitat creation efforts. In order to address this goal we will need to relate the biological data to the known changes in the physical habitat that may or may not be related to dike modifications. This data was not available to us to include that critical analysis in this report. Thus, the bends were classified only on the treatment types assigned with no assumption that the dike modifications have changed the amount of shallow water habitat. It is clear from our results that differences among bends are not consistent with the assumption that modified bends have created shallow water habitat and/or the fish community has not responded to increase in shallow water habitat.

Currently, HAMP is working to increase data collection efforts for all study bends. We are also trying to collect data in a manner to minimize temporal variation since it is impossible to conduct simultaneous sampling across our study bends. HAMP is introducing a new standard gear (push trawl) to target shallow water habitat that is difficult to sample with the stern trawl and not accessible with min-fyke nets. We are also developing a telemetry component to characterize juvenile sturgeon movements and habitat use. Information from telemetry studies on habitat use by juvenile sturgeon will enable us to determine if we are missing those fish in our samples because on sampling strategy, gear limitations or because they are not present in the River.

Another missing piece of information critical to evaluating pallid sturgeon habitat use includes the detection probability of our sampling gears. That is, if you know a pallid sturgeon is present, what is the probability of capturing it? Knowing the detection probability will allow us to characterize habitat selection of sturgeon species. Nebraska Game and Parks Commission's HAMP program accomplished all of its sampling goals and exceeded its own expectations for gear deployments. It is our goal in 2007 to expand our sampling efforts by increasing replication and the number of sub-samples collected in an effort to increase our statistical power.

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Appendices

Appendix I. List of bends for the Missouri River from Ponca State Park, NE to Rulo, NE. Habitat Assessment and Monitoring Program bends are highlighted in green and blue. List courtesy of U.S. Army Corps of Engineers, Omaha District.

Bend Name	Owner / Area Name	Bend Location	Upstream River Mile (1960)	Downstream River Mile (1960)	Bend Length (miles)	Avg. River Width (ft)	Construction Type	Bend Radius (%)
	Ponca SP (NGPC)			753.6			Backwater (04)	
Big Sioux			737.5	735.0	2.5	900		
Sioux City		Upper	735.0	732.8	2.2	700		
Sioux City		Lower	732.8	731.9	0.9	700		
Floyd		Upper	731.9	730.6	1.3	700		
Floyd		Lower	730.6	726.4	4.2	650		
Dakota		Upper	726.4	723.6	2.8	650		
Dakota	Stone SP (IDNR)	Lower	723.6	722.3	1.3	650	5 Type B (04)	
Omadi		Upper	722.3	720.5	1.8	650		
Omadi		Lower	720.5	719.0	1.5	650		
Browers			719.0	716.4	2.6	650		
Snyder	Snyder Bend (COE)		716.4	714.3	2.1	650	5 Major Mods (04)	
Glovers Point	**Snyder Bend (COE)**	**Upper**	**714.3**	**712.0**	**2.3**	**650**		**75%**
Glovers Point	Snyder / Winnebago (COE)	Lower	712.0	710.4	1.6	650		
Winnebago	Winnebago (COE)		710.4	708.0	2.4	650	12 Major Mods (04), restore side channel (01)	
Omaha Mission		Upper	708.0	706.4	1.6	650		
Omaha Mission		Middle	706.4	704.0	2.4	650		
Omaha Mission		Lower	704.0	702.8	1.2	650		
Monona		Upper	702.8	701.1	1.7	650		
Monona	Lewis and Clark SP (IDNR)	Lower A	701.1	700.0	1.1	650	5 Type B (04)	
Monona	Lewis and Clark SP (IDNR)	Lower B	700.0	697.7	2.3	650	5 Type B (04)	Monona
Black Bird		Upper	697.7	695.0	2.7	650	Black Bird	

Appendix I (continued). List of bends for the Missouri River from Ponca State Park, NE to Rulo, NE. Habitat Assessment and Monitoring Program bends are highlighted in green and blue. List courtesy of U.S. Army Corps of Engineers, Omaha District.

Bend Name	Owner / Area Name	Bend Location	Upstream River Mile (1960)	Downstream River Mile (1960)	Bend Length (miles)	Avg. River Width (ft)	Construction Type	Bend Radius (%)
Black Bird		Lower	695.0	693.8	1.2	600	Black Bird	
Tieville	Tieville-Decatur (COE)		693.8	691.2	2.6	600	Backwater (03)	
Decatur	Tieville-Decatur (COE)	Upper	691.2	689.1	2.1	600	Backwater (03)	
Decatur	Tieville-Decatur (COE)	Middle	689.1	687.4	1.7	600	Backwater (03)	
Decatur		**Lower**	**687.4**	**686.0**	**1.4**	**600**		**25%**
Louisville	**Louisville Bend (IDNR)**	**Upper**	**686.0**	**683.4**	**2.6**	**600**	**Backwater Chute (95)**	**25%**
Louisville	Louisville Bend (IDNR)	Lower	683.4	681.6	1.8	600	Backwater Chute (95)	
Blencoe		Upper	681.6	679.7	1.9	600		
Blencoe	??	Middle	679.7	678.0	1.7	600	6 Type B (04)	
Blencoe		Lower A	678.0	677.0	1.0	600		
Blencoe		Lower B	677.0	676.3	0.7	600		
Little Sioux Reach		**Upper**	**676.3**	**674.8**	**1.5**	**600**		**75%**
Little Sioux Reach		Middle	674.8	672.8	2.0	650		
Little Sioux Reach	Pelican Point SRA (NGPC)	Lower	672.8	670.5	2.3	650	14 Type B (04)	25%
Little Sioux			670.5	666.8	3.7	650		
Bullard			666.8	663.2	3.6	650		
Soldier			663.2	660.8	2.4	650		
Peterson Cut-off	??	Upper	660.8	659.2	1.6	650	Backwater (04)	
Peterson Cut-off		**Lower**	**659.2**	**657.8**	**1.4**	**650**		**75%**

Appendix I (continued). List of bends for the Missouri River from Ponca State Park, NE to Rulo, NE. Habitat Assessment and Monitoring Program bends are highlighted in green and blue. List courtesy of U.S. Army Corps of Engineers, Omaha District.

Bend Name	**Owner / Area Name**	**Bend Location**	**Upstream River Mile (1960)**	**Downstream River Mile (1960)**	**Bend Length (miles)**	**Avg. River Width (ft)**	**Construction Type**	**Bend Radius (%)**
Sandy Point	??		657.8	655.0	2.8	650	7 Type B (04)	
Tysons	??		655.0	651.6	3.4	650	7 Type B (04), Backwater (04)	75%
California Cut-off	California Bend (IDNR)		651.6	649.3	2.3	650	IA Chute (99), Backwater (04), NE chute (03)	
DeSoto			649.3	644.8	4.5	650		
DeSoto Cut-off	DeSoto NWR (FWS)		644.8	641.8	3.0	650	12 Major Mods (04)	75%
Calhoun		Upper	641.8	639.7	2.1	650		
Calhoun		Middle	639.7	638.5	1.2	650		
Calhoun		**Lower**	**638.5**	**637.3**	**1.2**	**650**		**25%**
Boyer	Boyer Chute NWR (FWS)	Upper	637.3	636.0	1.3	650	10 Major Mods (04)	
Boyer	Boyer Chute NWR (FWS)	Lower	636.0	634.1	1.9	650	10 Major Mods (04), Chute (94, 1135 program)	**25%**
Rockport		Upper	634.1	632.7	1.4	650		
Rockport		Lower	632.7	631.3	1.4	650		
Pigeon Creek		Upper A	631.3	629.9	1.4	650		
Pigeon Creek		Upper B	629.9	629.5	0.4	650		
Pigeon Creek		Lower	629.5	627.5	2.0	650		
Florence		Upper	627.5	626.0	1.5	650		
Florence		Lower	626.0	623.1	2.9	650		
Narrows			623.1	617.4	5.7	650		
Council		Upper	617.4	616.4	1.0	650		
Council		Lower	616.4	615.0	1.4	650		
Omaha			615.0	612.9	2.1	650		
Gibson		Upper	612.9	610.5	2.4	650		

Appendix I (continued). List of bends for the Missouri River from Ponca State Park, NE to Rulo, NE. Habitat Assessment and Monitoring Program bends are highlighted in green and blue. List courtesy of U.S. Army Corps of Engineers, Omaha District.

Bend Name	**Owner / Area Name**	**Bend Location**	**Upstream River Mile (1960)**	**Downstream River Mile (1960)**	**Bend Length (miles)**	**Avg. River Width (ft)**	**Construction Type**	**Bend Radius (%)**
Gibson		Lower A	610.5	609.8	0.7	650		
Gibson		Lower B	609.8	608.6	1.2	650		
Manawa		Upper	608.6	606.6	2.0	700		
Manawa		Lower	606.6	604.3	2.3	700		
Bellevue		Upper	604.3	603.1	1.2	650		
Bellevue		Lower	603.1	601.0	2.1	650		
Bellevue Reach		Upper	601.0	599.4	1.6	650		
Bellevue Reach		Lower	599.4	598.3	1.1	650		
St Mary's Cut-off			598.3	596.3	2.0	600		
Papillion			596.3	594.1	2.2	650		
Platte River								
Plattsmouth		Upper	594.1	591.9	2.2	650		
Plattsmouth		Lower A	591.9	590.9	1.0	650		
Plattsmouth		Lower B	590.9	589.4	1.5	650		
Tobacco	Tobacco Island (COE)		589.4	586.3	3.1	650	16 Major Mods (04), NE 3 mi Chute (02)	75%
Rock Bluff	Noddleman Island (COE)		586.3	582.7	3.6	650	15 Type B (04)	
Calmet-Bartlett			582.7	579.2	3.5	650		
Pin Hook	Auldon Bar Bend (COE)		579.2	576.8	2.4	650	13 Type B (04)	25%
Van Horns			**576.8**	**574.8**	**2.0**	**650**		**75%**
Civil		**Upper**	**574.8**	**572.8**	**2.0**	**600**		**75%**
Civil		**Lower A**	**572.8**	**571.5**	**1.3**	**650**		**25%**

Appendix I (continued). List of bends for the Missouri River from Ponca State Park, NE to Rulo, NE. Habitat Assessment and Monitoring Program bends are highlighted in green and blue. List courtesy of U.S. Army Corps of Engineers, Omaha District.

Bend Name	**Owner / Area Name**	**Bend Location**	**Upstream River Mile (1960)**	**Downstream River Mile (1960)**	**Bend Length (miles)**	**Avg. River Width (ft)**	**Construction Type**	**Bend Radius (%)**
Civil		Lower B	571.5	569.8	1.7	650		
Copeland	Copeland (COE)	Upper A	569.8	567.0	2.8	650	10 Type B (04)	EV
Copeland	Copeland (COE)	Upper B	567.0	565.1	1.9	650	11 Type B (04)	
Copeland		**Lower**	**565.1**	**562.9**	**2.2**	**650**		**75%**
Nebraska City	??		562.9	560.4	2.5	650	8 Type B (04)	75%
Frazers			560.4	556.7	3.7	650		
Otoe	**Hamburg (COE)**		**556.7**	**555.5**	**1.2**	**650**		**25%**
Hamburg	Hamburg (COE)	Upper	555.5	552.9	2.6	650	Major Mods (03), NE Chute (96), Backwaters	25%
Hamburg	Lower Hamburg (COE)	Lower	552.9	550.9	2.0	650	Major Mods (03), MO Chute (04)	
Barney	**Lower Hamburg (COE)**	**Upper**	**550.9**	**549.5**	**1.4**	**650**		**25%**
Barney	Lower Hamburg (COE)	Lower A	549.5	548.1	1.4	650		
Barney	Lower Hamburg (COE)	Lower B	548.1	546.3	1.8	650		
Kansas	Kansas Bend (COE)	Upper	546.3	544.7	1.6	650	NE upper Chute (05)	
Kansas	Kansas Bend (COE)	Lower	544.7	543.7	1.0	650	NE lower Chute (05)	
Nishnabotna	Nishnatoba / Kansas (COE)		543.7	542.3	1.4	650		
Peru			542.3	540.1	2.2	650		
Sonora	Nishnatoba (COE)	Upper	540.1	537.1	3.0	650		
Sonora		Lower A	537.1	535.9	1.2	650		
Sonora		Lower B	535.9	534.9	1.0	650		

Appendix I (continued). List of bends for the Missouri River from Ponca State Park, NE to Rulo, NE. Habitat Assessment and Monitoring Program bends are highlighted in green and blue. List courtesy of U.S. Army Corps of Engineers, Omaha District.

Bend Name	Owner / Area Name	Bend Location	Upstream River Mile (1960)	Downstream River Mile (1960)	Bend Length (miles)	Avg. River Width (ft)	Construction Type	Bend Radius (%)
Brownville		Upper	534.9	533.4	1.5	650		
Brownville		Lower	533.4	532.0	1.4	650		
Langdon	Langdon Bend (COE)		532.0	529.2	2.8	650	20 Major Mods (04), Backwater Chute (00)	
Aspinwall		Upper	529.2	527.4	1.8	650		
Aspinwall		Lower	527.4	526.1	1.3	650		
Morgan		Upper	526.1	523.7	2.4	650		
Morgan		Lower	523.7	522.6	1.1	650		
Lincoln			522.6	520.1	2.5	650		
Deroin	Deroin Bend (MDC)	Upper	520.1	518.4	1.7	650	8 Type B (04)	
Deroin	Deroin Bend (MDC)	Lower	518.4	517.7	0.7	650	4 Type B, MO 3.3 mi chute (02)	
Indian Cave	Deroin Bend (MDC)		517.7	516.4	1.3	650	5 Type B (04)	
Hemmies	Corning (COE)		516.4	512.1	4.3	650		
Cottier	Thurnau (COE)	Upper	512.1	508.2	3.9	650	1 Type B (04)	
Cottier		Lower	508.2	506.6	1.6	650		
Arago		Upper	506.6	504.7	1.9	650		
Arago		Lower	504.7	501.7	3.0	650		
Rush Bottom	Rush Bottom (COE)	Upper	501.7	500.3	1.4	650		
Rush Bottom		Lower	500.3	499.2	1.1	650		
Rulo			499.2	498.0	1.2	650		

- (red) = a break in hydrologic reach (occurs at the Platte, Kansas, Grand, and Osage Rivers)
- (light blue) = Aquatic Habitat Assessment treatment sample reach
- **BOLD** (light green) = Aquatic Habitat Assessment control reach
- (orange) = Mitigation chute monitoring (Mit)
- (magenta) = Engineering evaluation (EV)