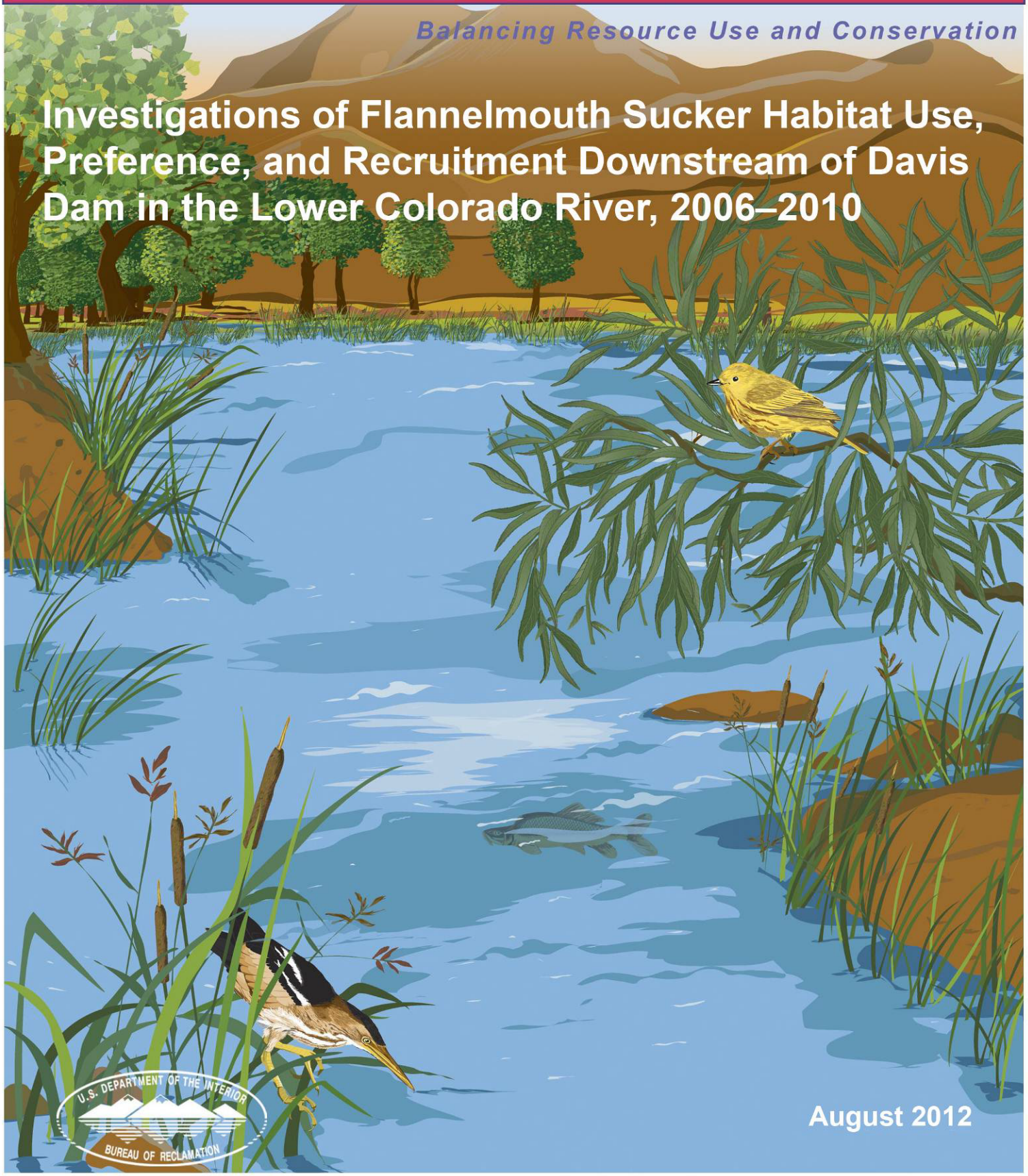
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Investigations of Flannelmouth Sucker Habitat Use, Preference, and Recruitment Downstream of Davis Dam in the Lower Colorado River, 2006–2010



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August 2012

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Lower Colorado River
Multi-Species Conservation Program

Investigations of Flannelmouth Sucker Habitat Use, Preference, and Recruitment Downstream of Davis Dam in the Lower Colorado River, 2006–2010

Prepared by: Eric Best, Technical Service Center, and Jeff Lantow, Fisheries Group

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

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EXECUTIVE SUMMARY

This report summarizes a five-year study funded by the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The study is focusing on describing the habitat use, preference, and recruitment of flannelmouth sucker (*Catostomus latipinnis*) below Davis Dam. Ultimately, this information will be used to develop a management needs and strategies plan for this species. Work accomplished from 2006 to 2010 is representative of conservation measures FLSU-2 and FLSU-3 of the LCR MSCP Habitat Conservation Plan.

Larval and young of year (10–62 mm) life stages of flannelmouth suckers were captured and observed along shore in slackwater, eddy, and backwater habitats from April to June, 2007 to 2010. Relative abundance surveys for larvae and young of year located over 50 different areas of use from river mile (RM) 272 (near Harrah's casino Laughlin, NV) to RM 232 (Mohave Wash Cove, below the I40 bridge near Needles). Shoreline slackwater habitats that preserved their integrity throughout the highly variable flows of the Lower Colorado River consistently maintained the highest densities of young of the year flannelmouth suckers.

Sampling for early life stages of flannelmouth sucker consisted of small-mesh (1.2 and 2.5 cm) trammel nets, seines and electrofishing gear in an attempt to contact juvenile life stages. Age-one to sub-adult (70–350 mm) juveniles have proven difficult to contact. Eleven juveniles have been captured over five years of setting trammel nets in backwaters. Thus far, seining and electrofishing of available habitats throughout our study reach have provided us with only a single contact of a 200-mm juvenile captured in the mainstem with electrofishing gear.

In 2008, 19 adult flannelmouth suckers were aged using non-lethal methods; techniques were refined and an additional 121 were collected and aged in 2009. Individuals ranged in age from 2 years to 24 years with an average age of 14 years. There is evidence that our population is stable as we occasionally document strong year classes of fish every few years.

Sonic transmitters were surgically implanted into 35 flannelmouth suckers. Fifteen males were implanted in 2006, and 10 males and 10 females were implanted in 2007. Fish movements were tracked in the Colorado River from Davis Dam (RM 276) to RM 251. Movements varied according to individual and by sex. Movements show little seasonal or annual patterns. The majority of detections were documented in discrete areas where flannelmouth suckers were consistently located; sonic-tagged fish were observed moving between these areas of high use. Detections of telemetered fish in backwaters were limited to a few detections on submersible ultrasonic receivers and hinted at a diel pattern of crepuscular or night use of backwater habitats.

Habitat data was collected when transmitter fish were located and when other flannelmouth suckers were observed during surveys. During the non-reproductive season, the majority of adult observations from 2006 thru 2009 were between the Laughlin (RM 274.5) and Avi bridges (RM 258.5), in areas of the river with cobble substrates, at depths between 2.0 and 3.0 meters, and with velocities between 0.5 and 1.0 meters per second. Observed habitat use varied little when compared to the spawning season (March–May), as habitats consisted of cobble substrates, depths from 1.0 to 2.0 meters, and velocities between 0.5 and 1.0 meters per second.

INTRODUCTION

Habitat degradation and the proliferation of nonnative fish species have resulted in the federal listing of seven of the nine Colorado River native species as endangered under the Endangered Species Act. Flannelmouth sucker (*Catostomus latipinnis)* is one of two native species not currently federally protected; however, it is a species of special concern to the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) and to the states of Nevada, California, and Arizona. Flannelmouth suckers were not historically common in the lower Colorado River below Davis Dam (Minckley 1973). In 1976, Arizona Game and Fish Department successfully captured 611 flannelmouth suckers at the confluence of the Colorado and Paria rivers at Lee's Ferry, Arizona. These fish were transferred to the Colorado River below Davis Dam, which led to their successful reintroduction (Mueller and Wydoski 2004). Mueller and Wydoski (2004) reported that flannelmouth suckers had established an impressive expanding community of more than 2,000 fish based on mark-recapture estimates. This is remarkable in view of the limited success of 25 years of stocking more than 2.1 million bonytail (*Gila elegans*) and 12 million razorback suckers (*Xyrauchen texanus*) into areas where these species were historically common (Minckley and Deacon 1991). Thus far, this population represents the most successful introduction of a native, mainstem fish species in the Lower Colorado River Basin.

The purpose of these investigations is to gather data and evaluate flannelmouth sucker habitat use, preference, and recruitment downstream of Davis Dam (Reach 3) as per conservation measures FLSU-2 and FLSU-3 of the LCAR MSCP, 2004. Our goals are to: 1) describe community structure, relative abundance, and distribution of flannelmouth sucker, 2) examine flannelmouth sucker seasonal movements and preferred habitats with the aid of sonic telemetry, and 3) examine physical and biological factors contributing to their success.

METHODS

The study reach extends from Davis Dam (River Mile [RM] 276; Lujan, 1990) to the California, Arizona, and Nevada state line (RM 257.5; Figure 1). Flannelmouth suckers have unobstructed access to the Colorado River and Lake Havasu located between Davis and Parker dams; however, previous and ongoing studies show that flannelmouth sucker distribution is highly selective toward the upper river portion of that reach. Field activities have been focused on the reach between the state boundaries to Davis Dam in order to best utilize resources. Additional sampling on the lower reach of river has been conducted on a limited basis (fall and winter surveys) and is supplemented, in part, by the Lake Havasu Native Fish Round-Up and other on-going studies.

All life stages of flannelmouth suckers were sampled or observed using a variety of methods which included: trammel netting, seining, electrofishing and dip-netting. For the purpose of this study: adults are described as individuals >350 mm, juveniles and sub-adults range from 70 mm to 350 mm, and life stages <70 mm were considered larvae and young of year. All contacted flannelmouth suckers were subject to a routing processing at the time of capture. This includes

being measured for total length (TL) (mm) and weight (g); fish >150 mm were injected with a passive integrated transponder (PIT) (134 kHz) before being returned to the water.

Larval and young of year sampling (<70 mm)

Larval fishes were detected and attracted using underwater lights at night and were collected by two people using small meshed aquarium dip nets (Burke 1995). The number of larvae collected during a 15-minute period as well as GPS location and site characteristics were also recorded. As larvae grew, they became less attracted to lights and swimming performance greatly increased making them difficult to dip-net. It was then that seines and visual surveys were used to determine presence. Larval light traps were set during the spawning season. Quadra foil larval traps were constructed out of clear PVC pipe. Larvae were attracted into the trap by a waterproof light constructed inside a clear PVC tube with three flashlight bulbs and powered by two D-cell batteries. A conical shaped net was attached to the trap to capture larvae as water drained out of the trap during retrieval. Traps were set at dusk and retrieved the following morning. A representative sample (10%) was preserved in 70% isopropyl to later confirm species identification under magnification.

Water clarity allowed for visual surface surveys as a method to determine presence and relative abundance. Visual surveys were conducted during the day as biologists walked the shoreline of the river and associated backwaters looking for schools of young of year and estimating their numbers. Sites were randomly selected and initially encompassed several shoreline habitats including rip rap and those with a sweeping laminar flow. If fish were not readily observed in a suspect habitat, then a seine was employed to confirm presence or absence. Fish were measured (TL) and species recorded. In addition, general habitat characteristics were recorded, such as depth and substrate.

Juvenile sampling (70-350 mm)

Small mesh (2 m × 22 m × 1.2 cm or 2.5-cm center panel) trammel nets were set to target juvenile and sub-adult (70–350 mm) flannelmouth suckers. These nets were set in backwaters, along shore, and in slackwaters found downstream of jetties in the main stem. Nets were set in the evening and retrieved the following morning. We utilized these nets in all years with an increased emphasis on effort to collect juveniles from 2007 to 2010. Nets were generally set in backwaters with little to no flow to reduce net fouling.

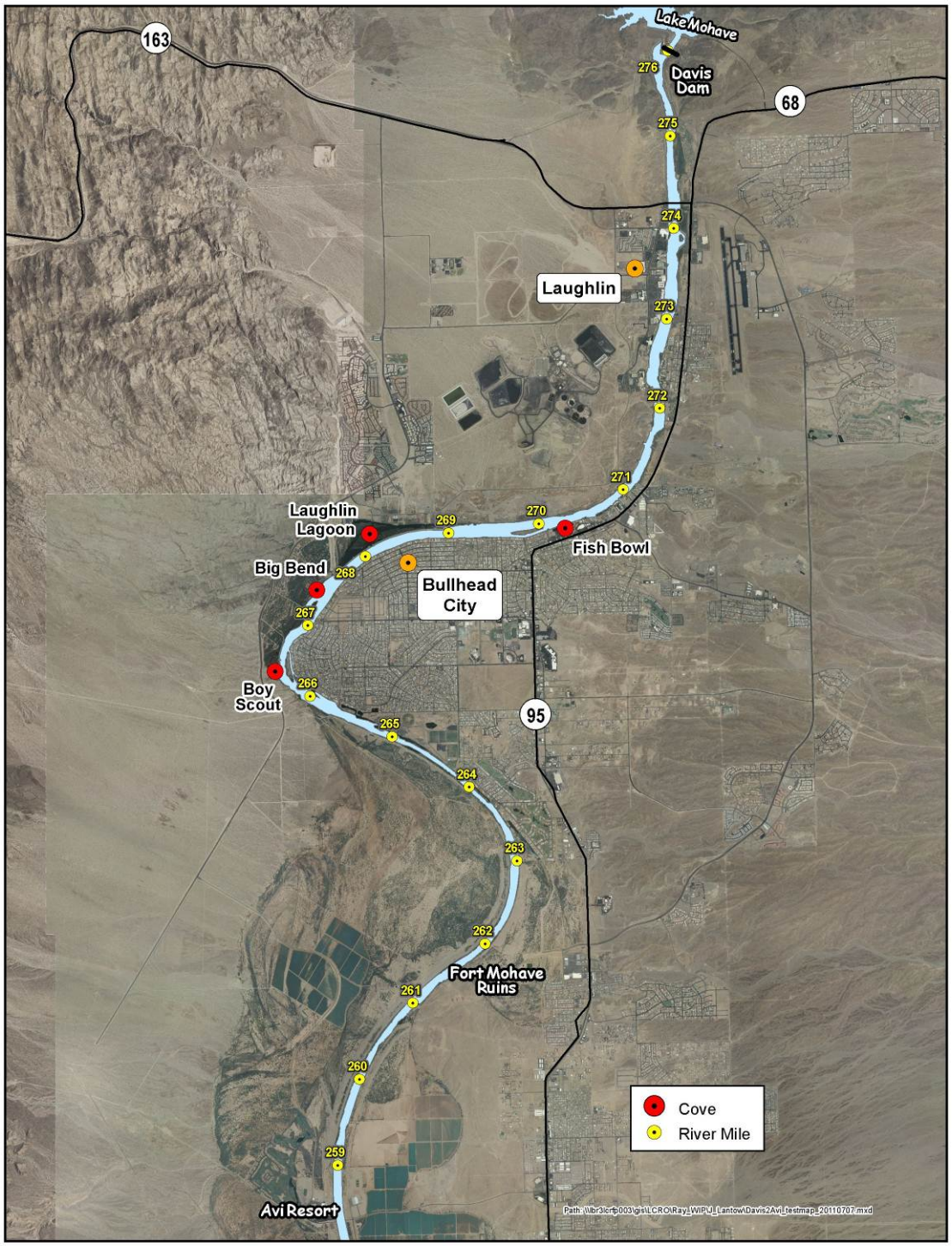

Figure 1. Aerial image of the study area showing the lower Colorado River between Davis Dam and the state line (AZ-CA-NV).

Attempts to capture juveniles were also made using a boat-mounted Smith-Root GPP-7.5 electrofisher during the early (~0400 hours) morning hours. This provided an opportunity to take advantage of low channel flows, and allowed better access to habitats that were unnaccesible during higher flows. Informal snorkel surveys were conducted along shore and in riffle habitats in an attempt to locate young of the year flannelmouth sucker that had presumably dispersed to swifter, deeper shoreline habitats.

Adult sampling (>350 mm)

Boat electrofishing was conducted with a minimum crew of two netters and a boat operator. This was performed after dark to take advantage of flannelmouth suckers congregating near shore in the evenings. The majority of fish were sampled along the river channel shore, while the boat was facing downstream, drifting with the flow. Netters typically only targeted native species due to limited space in the holding tank. Three different electrofishing boats were used: 1) Coffelt RF-10 voltage regulator (Bureau of Reclamation), 2) Smith-Root GPP-5.0 Electrofisher (California Fish and Game Department), and 3) Smith-Root GPP-7.5 Electrofisher (Bureau of Reclamation). In addition, large mesh trammel nets (2 m × 50 m × 3.7 cm) were deployed to target adult (>350 mm) flannelmouth suckers in backwater habitats.

Aging

In addition to the routine processing associated with captures, a section of the second pectoral fin ray from flannelmouth suckers was collected for age analysis in 2008 and 2009. Flannelmouth suckers were anesthetized in a tricane methane sulfonate (MS-222) solution until docile and a pair of clipping pliers, designed by BIO-WEST, Inc., was used to remove a small section (1/4 inch) of the left secondary pectoral fin ray. The wound was disinfected and the fish was placed in fresh river water to recover. Individual fin ray samples were placed in a small envelope and labeled with all relevant information (length, weight, sex, and PIT-tag number). Envelopes were then sent to BIO-WEST, Inc. for age analysis. A more detailed description of the fin sampling and aging techniques used can be found in Albrecht et al. (2008).

Sonic telemetry

Telemetry equipment consisted of Sonotronics brand ultrasonic transmitters and receivers. Utilizing the “two percent” rule (P. Marsh, ASU, personal communication, and Winter, 1996) to determine the appropriate transmitter size, a 20 gram (weight in air), 53 mm × 16 mm sonic transmitter (Sonotronics model CT-82-2-I, life span 14 months) was deemed appropriate for fish larger than 1000 grams. This tag was implanted into all of the flannelmouth suckers in 2006. With the success of the 14-month tag in 2006, we then moved to the CT-05-36-I, a slightly larger (62 mm × 16 mm, 22 grams in air) and longer lasting tag (36 months) for the 2007 tagging.

Fourteen frequencies were used (69 to 83 kHz); each tag had a unique pulse code (e.g. Code 234 would sound two pulses-pause, three pulses-pause, four pulses-pause-pause, repeat). Transmitter detection range varied depending on conditions (river flow, presence of watercraft, etc.), but had a maximum range of about 200 meters under good conditions.

Tracking was accomplished using two Sonotronics USR-5W wide-band receivers with DH-4 directional hydrophone (manual), or a DH-3 omni-directional hydrophone (manual) and several

SUR-1-2D submersible ultrasonic receivers (SUR) that allowed for fixed deployment and manual on-site download via laptop (Figure 2).

Sonic transmitters were surgically implanted into 35 flannelmouth suckers following techniques described by Hart and Summerfelt (1975), Mueller et al. (1998), and Tyus (1987). Transmitters and surgical instruments were sterilized in 70% isopropyl alcohol. Prior to surgery, fish were placed in an anesthetic bath (0.1 g/L mixture of MS-222) and monitored until they lost equilibrium (about 4-6 minutes). Fish were then placed upside down in a specially designed cradle that was lined with a wet towel. The area of incision was sterilized with 10% betadine. A 3 to 4 cm abdominal incision was made about 3 to 4 cm from the mid-ventral line, anterior to the pelvic fin. The sonic transmitter was then inserted and positioned laterally in the abdominal cavity. Four sutures closed the incision (4-0 Ethicon absorbable monofilament with FS-1 cutting needle). During the first half of the procedure, anesthetic bath was passed over the gills and body, while fresh water was used during the second half to speed recovery from anesthesia (Figure 3). Surgery time ranged from 4 to 10 minutes, averaging 6 minutes. Fish were then placed in a holding tank until they recovered (about 3 minutes), after which they were released.

Fifteen males were implanted in 2006, with an additional 10 males and 10 females implanted in 2007. Females were included in the 2007 tagging to determine differences in movements or habitat use associated with sex. Fish implanted in 2006 were released at different locations within the study area in hopes that they would congregate with the first school of flannelmouth suckers encountered, thus increasing our chances of finding new schools. This initially did not appear to work as most fish moved downstream immediately after release, possibly as a result of surgery stressors. In 2007, flannelmouth suckers were released at the location of their surgery to minimize stress experienced from transport to other locations.

The tracking design was comprised of manual (boat) and stationary (submersible ultrasonic receivers) detections. Manual tracking was conducted biweekly from January through April and monthly surveys thereafter. When available, two boats were used and navigators floated opposite sides of the river and associated backwaters with hydrophones in the water listening for transmitter signals. When a signal was detected, it was triangulated until an accurate (+/−50 m) global positioning system (GPS) waypoint could be acquired. In addition to recording the waypoint, landmarks and relative location (shoreline, mid-channel, etc.) in the river channel were noted.

We had near-continuous deployment of submersible ultrasonic receivers (SUR) at several main channel locations. A receiver was located at RM 233 (~1 km upstream of the Bureau of Reclamation gauging station), another at RM 255 (near Willow Valley Estates), a third was located at RM 259 (~2.5 km upstream of the Avi Casino) and a fourth was tethered to a dock across the river from Boyscout Backwater at RM 266. More sporadic deployments were located in backwaters as attempts were made to document backwater use. Backwater deployments ranged from February 9, 2007 to March 20, 2010 in Laughlin Lagoon at RM 268, October 26, 2006 to December 21, 2006 for the backwater at RM 265 and February 16, 2007 to March 29, 2007 for the backwater at RM 263. The SURs recorded the passage of transmittered fish, which aided tracking efforts.

Habitat data were collected wherever flannelmouth suckers were observed (either with the aid of telemetry or chance observation). Habitat data forms included date, time, waypoint, numbers of fish, depth, velocity, and substrate. Substrates were categorized as boulder (>10 inches), cobble (3-10 inches), gravel (0.5-3 inches), and silt/sand (<0.5 inches). Physical measurement was not always an option due to circumstances, and estimated data were later categorized for analysis.

Portions of our study reach contained deep habitats where fish could not be effectively observed or sampled. The Bureau of Reclamation Dive Team was used to investigate whether flannelmouth suckers were using these deeper habitats. Work focused on selected deep water stretches of the Colorado River between Davis Dam and the Arizona, California, and Nevada state line. At these sites, three dive team members floated through channel habitats adjacent to suspected flannelmouth sucker congregation areas. Divers were spaced evenly (5 meters) apart. The dive team was given a detailed briefing on data to be collected. General information on substrate, estimated velocity, and fish densities were recorded throughout each transect.

Figure 2. Stand-alone submersible ultrasonic receiver (Photo courtesy of Sonotronics Inc.).

Figure 3. Surgical cradle and anesthetic bath over gills.

RESULTS

More than 2,400 fish representing 16 species were collected between river miles 278 and 257.5 during the 5-year effort utilizing trammel nets and electro-fishing. Over 900 of these fish were flannelmouth suckers. Table 1 shows sample composition of trammel netting effort in backwaters. Electrofishing produced over 750 flannelmouth suckers, most of which were collected from the river channel.

Larvae and young of year

In 2006 and 2007, larval sampling was limited to the use of light traps to assist with determining larval emergence timing from March to May. Sixteen trap nights (128 hours) in 2006 produced six larvae, all of which were flannelmouth sucker. Five larvae were collected in an eddy pool near the Fort Mojave Ruins (RM 262) on April 20 and a single larva was collected in an eddy pool downstream of a known spawning group at RM 263 on April 19. Fifteen trap nights (120 hours) in 2007 produced 22 larvae. Twenty-one of these were carp and a single flannelmouth sucker was collected March 28 in a shoreline slackwater at RM 266.

In 2008, we employed the use of larval lights with dip nets to collect larvae and confirm presence of larvae in backwater and slackwater habitats. This proved to be a much more efficient technique to sample larvae. Catch per unit effort (CPUE; flannelmouth suckers netted/15 minutes) averaged 6.5 fish/15 minutes in 2008 and 2009 for the months of April and May.

Table 1. Sample composition (%) of fish captured using trammel nets between Davis Dam and AZ, CA, and NV State Line from 2006 through 2010.

Species	2006	2007	2008	2009	2010	Average
Green sunfish	0.7	18.6	45.1	20.3	17.7	20.5
Carp	21.0	31.1	14.3	23.0	10.5	20.0
Largemouth bass	14.9	13.6	11.0	12.1	26.8	15.7
Bluegill	5.7	8.6	13.2	26.6	7.7	12.4
Redear sunfish	8.5	8.6	6.6	5.9	19.5	9.8
Flannelmouth sucker	21.4	6.1	1.1	3.9	8.6	8.2
Rainbow trout	12.7	1.4	0.0	0.0	2.3	3.3
Striped bass	3.1	5.0	2.2	1.6	0.5	2.5
Channel catfish	6.6	0.0	2.2	1.2	1.4	2.3
Razorback sucker	0.0	3.6	0.0	1.6	1.8	1.4
Smallmouth bass	2.2	0.4	1.1	1.2	1.6	1.3
Bonytail chub	0.0	3.2	1.1	0.0	0.0	0.9
Goldfish	0.0	0.0	2.2	1.6	0.9	0.9
Threadfin shad	3.1	0.0	0.0	0.0	0.0	0.6
Bullhead catfish	0.0	0.0	0.0	1.2	0.7	0.4
Tilapia	0.2	0.0	0.0	0.0	0.0	0.0

Larval and YOY presence/absence surveys utilizing dip-netting, seining and visual observation were initiated in 2008. The survey area progressed from Davis Dam (RM 276) to the AVI Casino (RM 258.5). Larvae were first located at RM 272 and were present throughout the survey area down to the boat ramp at the AVI Casino. In 2009, surveys extended an additional 8.5 river miles to RM 250 and in 2010 surveys extended an additional 18 miles to Mohave Wash Cove (RM 232), below the I40 bridge in Needles, California. Over 50 backwater and slackwater habitats were documented as rearing areas in this reach of river. Relative abundance decreased as we surveyed further downstream and later into the year, but rearing areas were located throughout the entire reach of river surveyed. In 2009, larvae and young juvenile lengths averaged 15.9 mm (range 10-20 mm) in April, 22.8 mm (range 16-33 mm) in May, and 46.1 mm (range 25-62 mm) in June. Habitats of larval and young juvenile flannelmouth suckers were characteristic of backwaters and near-shore slackwaters with little or no flow at depths generally less than 0.5 meters. Substrates varied and ranged from cobble to silt and were often a function of water level at the time of sampling.

In 2008, comparisons were made between 12 shoreline slackwater sites that had similar traits (substrate, depth, and flow). These sites were selected and observed/sampled at high and low water elevations (flow range ~ 10,000 cubic feet per second [cfs] – 19,000 cfs). Sites that harbored the greatest number of young maintained their slackwater habitat characteristics, and those that lost their slackwater habitat characteristics at either high or low elevation had few or no larvae or young of the year present (Table 2).

Table 2. Sample sites evaluated at high and low flows for presence of flannelmouth sucker larvae and young of the year.

Site #	High flow presence of young?	Low flow presence of young?	Estimated # flannelmouth observed	Site maintained habitat characteristics?
RM 261.5	No	No	0	No
RM 263	No	No	0	No
RM 264-A	Yes	No	1	No
RM 264-B	Yes	No	1	No
RM 264-C	Yes	Yes	7	Yes
RM 264-D	Yes	Yes	20	Yes
RM 265.5	Yes	Yes	10	Yes
RM 267-A	No	No	0	No
RM 267-B	Yes	Yes	20	Yes
RM 267-C	No	No	0	No
RM 267-D	No	Yes	2	No
RM 267-E	Yes	Yes	50	Yes

Juveniles

Juvenile flannelmouth suckers proved to be rare in collections from 2006 to 2010. In 2006, we fished 669 m² of small mesh and 7,692 m² of large mesh. In 2007, it was discovered that adults were easily sampled from the channel with electrofishing gear and emphasis was put on fishing smaller mesh trammel nets to attempt to increase juvenile captures. Larger mesh nets were not fished from 2007 to 2008. In 2007, we fished 2,216 m², in 2008, we fished 641 m², and in 2009, we fished 1,631 m² small mesh nets. In 2010, 5,309 m² of small mesh were fished and 669 m² of large mesh were fished to increase adult contacts for population estimates. All juveniles were collected in trammel nets except for a single fish collected with electro-fishing gear in the main river channel (Table 3). Four juveniles were captured during the 2006 sampling period, three were captured in 2007, a single fish was captured in 2008, 2009 produced two juveniles, and two fish were captured during the 2010 sampling season. The 2009 field season represented the first year of our study where a juvenile life stage was captured in the maintstem river. Previous seining and electrofishing of channel habitats have failed to locate any juveniles to sub-adult life stages.

Table 3. Juvenile flannelmouth sucker captures from 2006 to 2010 field seasons.

Date	Method	Location	River Mile	Length (mm)
12/21/2005	Trammel net	Laughlin Lagoon	268	135
12/21/2005	Trammel net	Big Bend State Park Backwater	267	341
1/26/2006	Trammel net	Laughlin Lagoon	268	340
3/7/2006	Trammel net	VFW Cove	265.5	226
3/29/2007	Trammel net	Eddy/pool below island	263.5	341
5/1/2007	Trammel net	Boy Scout Backwater	266.5	193
5/2/2007	Trammel net	Arizona Estates Cove	270	160
2/12/2008	Trammel net	Pulpit Rock	229	321
1/28/2009	electrofishing	Upstream Avi Casino	260.5	200
4/22/2009	Trammel net	Big Bend State Park Backwater	267	148
2/3/2010	Trammel net	Big Bend State Park Backwater	267	285
3/10/2010	Trammel net	Big Bend State Park Backwater	267	166

Adults

In general, trammel netting backwaters with 3.7-cm mesh was very productive for adult FMS. Trammel net catch rates provided us with estimates of relative abundance for both native and non-native species. In comparing select backwaters, CPUE (fish/1000 m^2 of net) of flannelmouth sucker ranged from 10/1000 m^2 of trammel nets in Arizona Estates Cove (RM 270) to 26/1000 m^2 of trammel nets in VFW Cove (RM 265.5) (Figure 5). The backwater at Big Bend State Park had the lowest CPUE for nonnatives, and flannelmouth suckers outnumbered other species in most backwaters. Small mesh nets were not as effective at catching adults as CPUEs were generally around half of what was observed with the larger mesh nets.

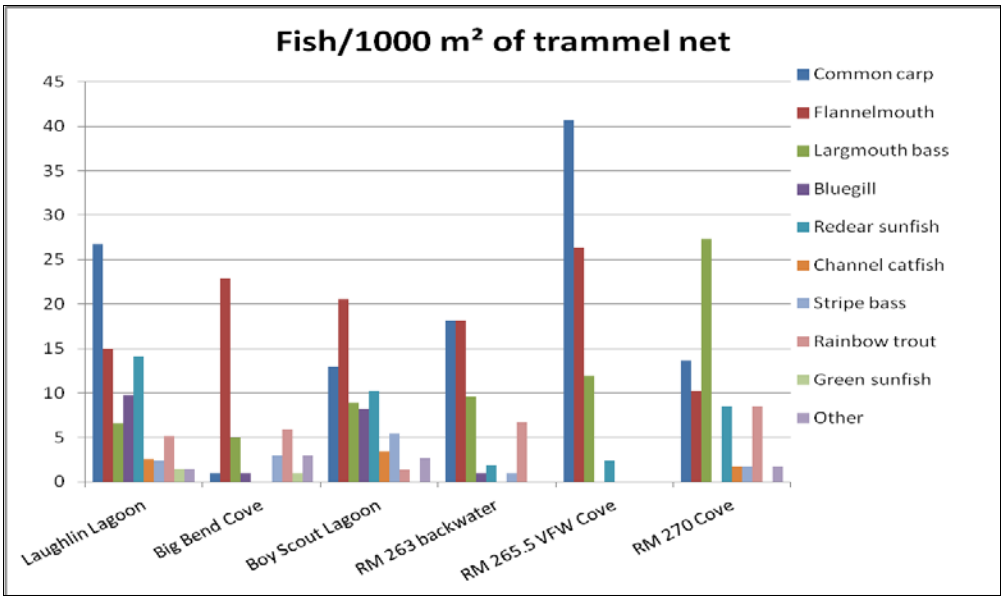

Figure 5. Trammel net catch per unit effort (1.5-inch mesh) for select backwaters downstream from Davis Dam, Colorado River, Arizona.

It was discovered early in the field season of 2006 that adult flannelmouth suckers were highly susceptible to capture while electrofishing at night in channel habitats as adults moved nearer to shore in shallower areas. Over 80 percent of our adult captures were from electrofishing channel habitats. Population estimates derived from electrofishing and trammel netting recapture data (Peterson single-census method, Ricker 1975) in aggregate are shown in Table 4.

Table 4. Yearly adult flannelmouth sucker population estimates derived from Peterson's single-census method from 2006-2010.

Year	Captures*	Recaptures*	Population estimate	95% Confidence limit**
2006	336	12	2,437	1,440-4,399
2007	104	14	2,471	1,577-4,814
2008	28	1	1,523	461-2,768
2009	154	3	1,044	409-4,176
2010	206	8	1,536	992-2,494

*Mortalities, replicate recaptures and juveniles omitted from total.
**Computed using Poisson frequency distribution table (Ricker 1975).

During the 2009 field season, one-hundred and twenty one flannelmouth suckers were fin clipped for aging analysis by BIO-WEST. Figure 6 shows age frequency of flannelmouth suckers clipped in 2009. Overall fish averaged 15 years of age with a range of 2-24 years. Female flannelmouth sucker adults (n=91) averaged 15 years and ranged from five to 24 years of age and adult males (n=27) averaged 13 years and ranged from six to 23 years of age. A table of clipped flannelmouth sucker information can be viewed in Appendix A.

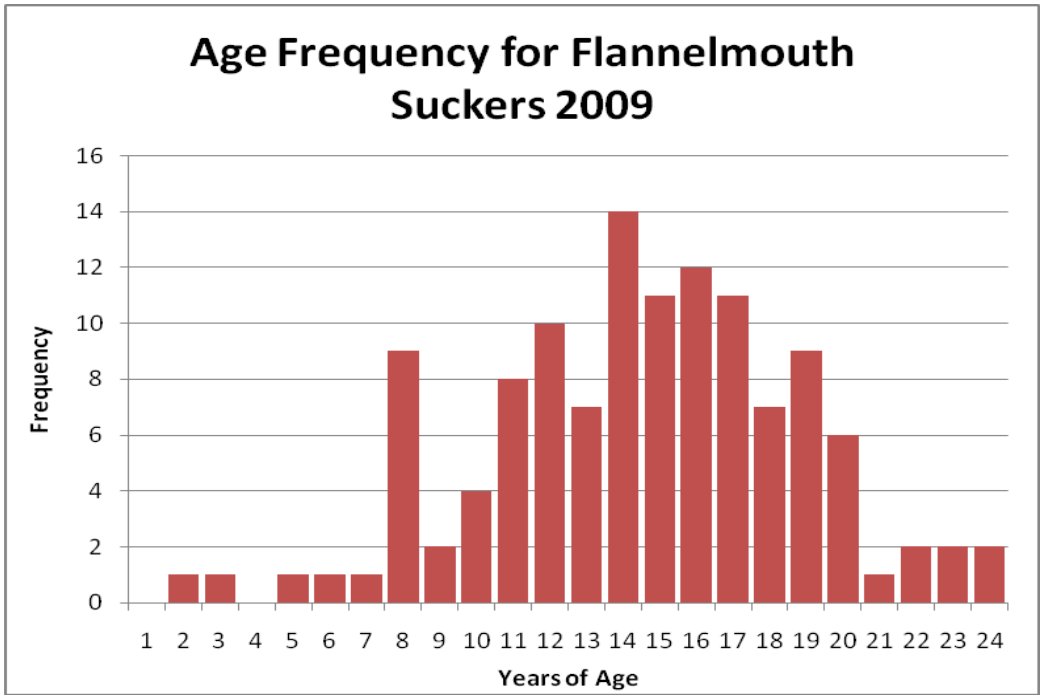

Figure 6. 2009 age frequency of flannelmouth suckers below Davis Dam, Colorado River, Arizona.

Telemetry

In 2006, 15 adult male flannelmouth suckers were surgically implanted with 14-month sonic transmitters and released between January 25 and March 9. Fish averaged 536 mm in total length (390 to 573 mm) and 1,924 grams (640 to 2,333 g). Fish were released at various backwaters: two at Boy Scout Cove (RM 266.3), seven at Big Bend boat ramp (RM 265.3), four at the Riverside Casino boat ramp (RM 275.3), and two in Laughlin Lagoon (RM 267.2).

All flannelmouth suckers tagged initially moved downstream after release. Three fish were mortalities or shed their tags and the fourth fish was never contacted again. Of the 11 remaining fish, 7 began a holding pattern or made upstream movements within four weeks and an additional three within six weeks of release. Flannelmouth suckers that had appeared to recover from surgery stressors soon became associated with other flannelmouth sucker aggregations. Fish locations from manual tracking were representative of channel, near-shore, and eddy pool habitats. No tagged fish were encountered in backwaters or side channel habitats. Of the 11 active tags in 2006, 10 were detected again in 2007, of which three showed preference to a particular spawning location in consecutive years.

Following the successful implanting of the 2006 telemetry fish, an additional 20 adults (10 males and 10 females) were surgically implanted in the 2007 field season with 36-month sonic transmitters; all fish were implanted between December 21, 2006 and March 2, 2007. Males averaged 546 mm in total length (517-575) and 2,061 grams (1,705-2,505); females averaged 578 mm (532-609) and 2,465 grams (1,862-3,008). Fish were captured from numerous

flannelmouth aggregations: near Davis Dam (RM 276), Big Bend State Park (RM 267), and the Arizona, Nevada and California State line (RM 258). Transmitter fish were released at the surgery site (Big Bend State Park and one from the AVI Casino [RM 258]).

We were able to relocate 15 of the 2007 sonic-tagged fish (8 males, 7 females) for portions of the remaining field season. The remaining five were lost due either to mortality, tag failure, or removal from the system. Females ranged an average of 10 miles (2-23) in 2007 and males averaged 5 miles (0-15); in 2008, five females averaged 9 miles (1.5-16) and two males averaged 4 miles (1-11.5). Three tagged females in 2009 ranged between 0.5 and 8 miles while two males ranged 7 and 9.5 miles. Graphs of individual flannelmouth sucker movements with multiple years of tracking data are in Appendix B.

Flannelmouth sucker detections were almost entirely confined to the 20 miles of river below Davis Dam. Over 96% of detections from manual tracking surveys were above RM 255 (Willow Valley Estates). The bulk of detections in our study area (60%) were between RM 270 and RM 263. Within our study area, we found that the majority of detections are located at known areas of aggregation that double as spawning grounds. Seasonal movements show little pattern and are varied and unique for each fish. Many of the fish appear to convalesce at a particular aggregation in the river for months before deviating to another.

Habitat data were collected on 161 observed fish (134 telemetered fish, and 27 chance observations) during the course of the study. Observations were representative of channel (74%), near shore (21%), side channel (3%), and eddy pool habitats (2%). Habitat data collected from 2006-2010 are within the range reported by Beyers et al. (2001) in the Colorado River near Grand Junction, Colorado; however, they found the majority of their fish at depths of 1.5 m, which supports our observed spawning depths, but our non-spawning depths averaged roughly a meter more. Frequency curves of habitat utilization are presented in Appendix C and are separated into non-spawning contacts (June-February) and contacts during the spawning season (March-May). Our habitat data show that a majority of our flannelmouth suckers utilize cobble substrate (57%, n = 62), depths between 2.0 and 3.0 meters (41%, n = 42) and velocities between 0.5 and 1.0 m/s (35%, n = 24). Observed habitat use varied little when compared to the spawning season (March–May) with cobble substrates (72%, n = 34), depths between 1.0 and 2.0 meters (34%, n = 16) and velocities between 0.5 and 1.0 meters per second (66%, n = 23).

Although we never detected flannelmouth suckers in backwaters while manual tracking their use of backwaters was evident as they were detected on SURs and by trammel netting. Backwater deployments of SURs ranged from February 9, 2007 to March 20, 2010 in Laughlin Lagoon at RM 268, October 26, 2006 to December 21, 2006 for the backwater at RM 265, and February 16, 2007 to March 29, 2007 for the backwater at RM 263. No detections were logged at RM 265 during its 55 days of deployment. A single detection of a female flannelmouth sucker was documented in March at RM 263 during its 50 days of deployment. Nine of our telemetered fish were detected on 96 of the 1,114 days that the Laughlin Lagoon SUR was deployed. Several of these detections showed patterns of crepuscular and night time use (Figure 7).

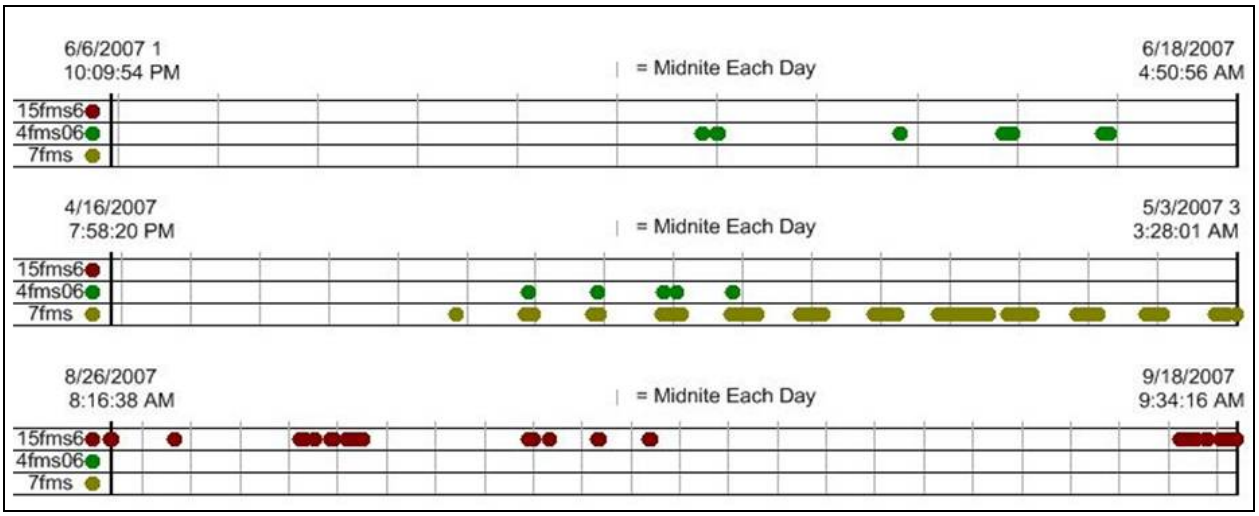

Figure 7. Detections of flannelmouth suckers on a submersible ultrasonic receiver located in Laughlin Lagoon.

In late March of 2007, the Bureau of Reclamation Dive Team surveyed numerous habitat types that were suspected to be occupied by flannelmouth suckers. The three survey areas were deep channel habitats that could not be effectively sampled with traditional gear. The Davis Dam spillway pool (RM 276), and the near-shore habitat adjacent to the tailrace had abundant numbers of carp and several striped bass, but flannelmouth sucker were not observed. A single carp was observed in the deep-water stretch directly adjacent to Harrah's casino (RM 273) where limited numbers of flannelmouth have been electrofished in adjacent near-shore habitats. Another area of interest was the channel across from Boy Scout backwater (RM 266.5). The deep eddy (>20 meters) formed by a jetty at the mouth of the backwater has historically been productive for trammel netting flannelmouth suckers, but fish were not present at the time of the survey.

DISCUSSION

This population of flannnelmouth sucker has certainly expanded since its reintroduction in 1976. The size distribution of this population has shown a similar trend for the duration of our study that is characterized by a relatively large adult population and few juveniles and sub-adults (Appendix D). A relatively strong cohort is evident in the recent aging data (Figure 6), and is represented by the fish estimated at 8 years of age in 2009. It appears that the life span of this species allows for intermittent strong year classes to rejuvinate an aging population and therefore persists. However, the fact that this population of flannelmouth has only been under observation for approximately a decade, which is only a fraction of the life span for this species, greatly inhibits our understanding of population dynamics. Coupled with limitations in aging techniques (Mueller and Wydoski 2004) and insufficient environmental data, it is difficult to identify the conditions of past years that promoted a strong year class.

Our population of flannelmouth suckers averages 15 years of age. Length at age data shows how our fish grow quickly until age 5 when lengths begin to plateau (Mueller and Wydoski 2004). This similar trend is seen in other systems where aging studies have been conducted. Our population deviates from the others, as our average length of adults is much larger than those at similar ages in different systems. Appendix E illustrates additional length at age data collected from other systems in the Colorado River basin (Carlson et al. 1979, McAda 1977, McDonald and Dotson 1960, Sweet et al. 2009). The greater average length of flannelmouth suckers below Davis Dam may be attributed to several factors, incuding but not limited to the temperate climate experienced at this southernmost extent of this populations range and/or the productivity that is often associated with tailwater systems.

Initial sampling efforts were limited to the taking of adults, generally during the spawning season. Efforts intensified toward finding younger age classes as this study progressed. Those efforts were successful in finding schools of larvae and young of year (~10 to 62 mm); however, we were unable to track these fish as they matured. They were either lost to predators or dispersed to locations that were outside our study area or inaccessible with our sampling gear. This phenomenon is similar to that described for the Paria River by Thieme et al. (2001), who reported a dramatic decrease in CPUE from mid-June to mid-July. Presence of young of year was recorded downstream to the beginning of Topock Gorge, the extent of our surveys. It is expected that young of the year would continue to be found throughout Topock Gorge since juveniles have been contacted by previous researchers (Mueller 2003, Mueller and Wydoski 2004) and annual native fish surveys.

As we sampled for young of year at varying water levels it became apparent that we were consistently locating fish in areas that appeared to have a jetty or natural formation that allowed a habitat to maintain its integrity as a slackwater regardless of river elevation. Photos taken throughout the day of a shoreline slackwater habitat that consistently harbored young juvenile flannelmouth suckers can be viewed in Appendix F.

There is a lot of uncertainty as to how much flannelmouth sucker rearing habitat impacts the overall population. Our current thinking is that shoreline slackwater and pool habitats adjacent the main channel that keep their integrity throughout a wide range of daily flows (5,000-20,000 cfs) during the flannelmouth sucker spawning season are limited. These habitats are thought to be important for the rearing of early life stages (0-4 months) of flannelmouth suckers due to their lack of predators, which is in contrast to backwaters. The majority of juvenile (age 1-4 years) flannelmouth sucker captures came from backwaters, but in very low numbers (1-3/year). With such low numbers being collected, we fear that either the backwater habitats are of poor suitability for this age class or that there is a lack of age-0 flannelmouth suckers entering these habitats on a yearly basis. If, in fact, our juvenile capture rate is representative of actual juvenile populations, then this would certainly be described as a threat to the population, and would make this species more prone to a population crash. The creation of shoreline slackwater and pool habitats, either through physical construction or possible flow augmentation (steady flows thus stabilizing shoreline slackwaters), may affect an increase in juvenile catch rates for backwaters and further preserve this population.

Age one to sub-adult (70–350 mm) juveniles have proven difficult to contact. We captured 11 fish over 5 years of setting trammel nets in backwaters. However, as we continue to sample available habitats with different techniques, there is growing evidence that they may simply not be in numbers sufficient to provide meaningful information. For the duration of our study, we expected juveniles to be more abundant, especially with such a healthy population of flannelmouth sucker adults. Mueller and Wydoski (2004) reported that an annual recruitment of 15% of the spawning cohort (age 3-4) is adequate to maintain a population experiencing low adult mortality. This 15% would equate to 375 fish/year in a population of 2500 adults, and these 375 fish would be distributed over 80 km of potential habitat, or fewer than 5 fish/km.

Our sonic tracking data provided us with some interesting information on flannelmouth sucker habits. Adult flannelmouth suckers in our study reach have notable schools or aggregations. Many of these aggregations are found year-round. These preferred habitats are characteristic of channel habitats with current velocities >0.5 m/s, depths from 2 to 3 m, and substrates composed primarily of cobble. Appendix G shows a map of fish detections from 2006 to 2009. The majority of our detections were found in these common areas and adults appear to migrate between schools where they spend most of their time.

Movements of individual fish are difficult to pattern. Appendix B depicts graphs of individual fish movements over a two or three year period. Flannelmouth sucker movements are highly individual. Some fish appear to show a strong fidelity to seasonal locations while others do not, regardless of sex. The data hint at seasonal trends in upstream and downstream movement at varying degrees, most notably, the larger movements observed in the spring.

The low number of adult sucker detections below RM 255 illustrates the flannelmouth sucker's preference for the 20 miles of river below Davis Dam. Rarely were flannelmouth suckers detected outside of our study area, and all detections were above RM 251 (one mile below Willow Valley Estates). This is likely due to changes in river morphology as we observe our study area transitioning from higher gradients, lower temperatures, and rockier substrates to the slower velocieties, warmer water, and sandier substrates that characterize the downstream reaches from Needles, California to the Lake Havasu delta (Mueller 2003).

Habitat use of flannelmouth sucker below Davis Dam is within the range reported by Beyers et al. (2001) in the Colorado River near Grand Junction, Colorado, although they found the majority of their fish at depths of 1.5 m. Our habitat data show that a majority of our flannelmouth suckers utilize depths of 2.5–3.0 meters (Appendix C). This may be a function of several factors including: deeper habitats being available in our study reach; water clarity in our study reach that allows biologists to observe and locate fish utilizing deeper habitats; and clarity of the water, which may not provide the cover requirements that flannelmouth suckers may prefer.

We have observed flannelmouth suckers resting along shorelines in slackwater habitats adjacent to the main channel during the spawning season. Furthermore, trammel net catch per unit effort for backwaters increases as the spawning season progresses. This may indicate that there is an increasing rest requirement as spawning events take a physical toll. It appears that this requirement can be met through backwaters or slackwater habitats. As for the timing of their use,

we noted that adult fish in backwaters were most often captured near the entrance of backwaters with trammel nets. This was evident in all the backwaters sampled. This is probably a product of us capturing the fish before they moved further into the backwater and supports the SUR data that the fish show a diel shift in habitat use. The fish were clearly not in the backwater at the time the net was set (day) or they would have been captured in nets placed in the interior of the backwater.

This portion of river is highly regulated and daily deviations in flow commonly range more than 15,000 cfs, which corresponds to changes in elevations greater than one meter. We speculate that the highest densities of benthic invertebrates would be found in the portion of the river that remains inundated (main channel) and flannelmouth suckers in this reach may have become accustomed to utilizing deeper, more productive habitat. However, this may simply be an artifact of when telemetry surveys were conducted rather than a true indication of fish habitat use. Telemetry surveys never took place during crepuscular periods or at night. The movement into shallower habitats near shore as dusk approaches was quite apparent based on our electrofishing efforts becoming more effective towards dusk. The darkness is thought to provide an element of cover, which allows adults to frequent shallower slower moving habitat to rest, feed, or spawn. It looks as if there is a pattern of habitat use, even though it is not obvious when solely analyzing the telemetry habitat data.

By employing an echo sounder and using Arc GIS, we were able to plot out estimated wetted perimeter of shorelines to show approximately how much shoreline becomes exposed during low flows on a daily basis. Surface area of the river during a common daily peak discharge (roughly 20,000 cfs) for April were used and showed a surface area of 1,246 acres between river miles 257 and 276. This is in contrast to a surface area of 1,078 acres when calculating a common daily base discharge (roughly 10,000 cfs) for April. This represents a difference in surface area of 168 acres (roughly 9 acres/mile) dewatered on a daily basis. When looking at maps depicting high and low flows (Figures 1-7 in Appendix G), we see large amounts of shoreline that are dewatered. These dewatered shoreline areas lack the productivity of permanently inundated habitats since aquatic plants, algae, and benthic invertebrate communities lack the ability to become established. In addition, we have observed flannelmouth suckers spawning in near-shore habitats only to be displaced as water levels drop, allowing spawning bars with eggs to desiccate.

Monitoring and future studies

This population has appeared to remain relatively stable over the past decade, and intense physical monitoring of this population is not necessary. It is recommended that this population of flannelmouth suckers be monitored with less invasive techniques such as annual boat counts (Mueller et. al., 2008), and periodic (spring) sampling to mark adults with PIT tags (137 khz) and supplemented by remote PIT scanning antennas to provide a population estimate through mark-recapture techniques. Several schools of adults should be contacted with electrofishing gear and trammel nets monthly from March to May on an annual basis. While not as intensive as past monitoring, it is believed that a monitoring effort as described above would assist with detecting changes in population structure.

The presence of larvae and young of year should be confirmed from March to June before they seasonally become absent from collections. Use of larval lights in April and seines in June would

be utilized to confirm both larval emergence (April) and the development of larvae into young of the year (June). Backwater and shoreline slackwater habitats should be targeted for these early life stages. A replicated monitoring regime has become more important in recent years as we try to determine whether the invasion of quagga mussels and other introduced organisms into the Lower Colorado River will pose a burden on flannelmouth sucker populations.

It is suggested that any data collected for seasonal monitoring be robust enough to function as baseline data prior to the development of habitat improvements. Upon successful design of constructed habitats we would attempt to ascertain if we are actually increasing the abundance of the various flannelmouth lifestages, or if we are simply dispersing the existing population across available habitats.

Due to the difficulty in contacting flannelmouth suckers between the sizes of 70 mm and 350 mm, initiation of a telemetry study to better research habitat use of this life stage is warranted. It is recommended that an effort be made to contact these life stages with the use of small mesh (1.2-2.5 cm) trammel nets and long (50-100 foot) seines in backwaters during winter months. Flannelmouth suckers that are contacted and of are of appropriate size would then be sonic-tagged and closely monitored following their release. There would probably be few fish captured using these techniques, so it would be recommended that hatchery reared flannelmouth suckers be used to supplement the availability of wild captured juvenile suckers.

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Appendix – A

Summary of Flannelmouth Suckers Clipped for Aging Analysis in 2009

Appendix A. Summary of Flannelmouth Suckers Clipped for Aging Analysis in 2009.

Date Collected	PIT Tag Number	Total Length (mm)	Weight (g)	Sex	Approximate River Mile Collected	B-W Age
28-Jan-09	1c2d05b8e3	581	2245	f	266	8
28-Jan-09	1c2d059ec5	620	2760	f	266	14
28-Jan-09	1c2d060f3c	570	2215	f	266	19
28-Jan-09	1c2c7f479d	567	2200	m	266	13
28-Jan-09	257c60cfa2	546	1785	f	266	14
29-Jan-09	1c2c83ca58	600	2875	f	259	19
28-Jan-09	1c2c83c669	615	2530	f	259	22
28-Jan-09	424e0c497e	644	3025	f	259	13
28-Jan-09	1c2c7f4cd6	624	2720	f	259	12
29-Jan-09	1c2c83c998	560	2205	m	274	14
29-Jan-09	257c6255fa	570	2265	f	274	18
29-Jan-09	1c2c8473a8	602	2530	f	274	20
29-Jan-09	424e2bgf3b	671	3270	f	274	19
29-Jan-09	422e33585a	611	2540	f	274	17
27-Jan-09	1c2c857529	672	3475	f	274	16
29-Jan-09	257c633b41	635	2760	f	274	15
29-Jan-09	425d1c4f09	590	2300	f	274	16
29-Jan-09	1c2c7f4cc0	541	2130	m	274	15
29-Jan-09	1c2c83c4ec	637	3045	f	274	17
29-Jan-09	5019415f14	614	3130	f	274	15
29-Jan-09	424e14517d	572	2530	f	274	18
28-Jan-09	1c2c840615	647	2735	f	259	17
28-Jan-09	1c2c857331	606	3115	f	259	15
28-Jan-09	1c2c7eebae	514	2345	f	259	13
28-Jan-09	1c2c841d38	560	2075	f	259	16
28-Jan-09	1c2c7ef23e	629	3335	f	259	14
28-Jan-09	1c2c843cda	552	1940	f	259	19
28-Jan-09	1c2c8446a7	200	1500	?	259	3
28-Jan-09	1c2c84453f	545	2230	m	259	14
28-Jan-09	1c2c856a0e	553	2920	f	259	14
28-Jan-09	1c2c83c1e4	640	2930	f	259	20
28-Jan-09	257c6112ff	637	3225	f	259	24
28-Jan-09	1c2c83bd18	658	2965	f	259	23
28-Jan-09	1c2c84082e	634	3125	f	259	20
28-Jan-09	1c2c83c472	560	2110	f	259	12
28-Jan-09	1c2c841549	577	2446	f	259	14

Date Collected	PIT Tag Number	Total Length (mm)	Weight (g)	Sex	Approximate River Mile Collected	B-W Age
28-Jan-09	4255607911	529	1800	f	259	12
28-Jan-09	52207b0215	588	2220	f	266	15
28-Jan-09	1c2d05b240	548	1835	f	266	19
28-Jan-09	1c2c3207ff	549	2200	f	266	12
28-Jan-09	257c611aa2	575	2185	f	266	15
28-Jan-09	1c2c844645	600	3138	f	266	16
28-Jan-09	42530f3078	581	2752	f	266	15
28-Jan-09	1c2d061cdc	544	2260	m	266	16
28-Jan-09	1c2d05c77d	551	2320	f	266	16
28-Jan-09	1c2d0660e0	506	1964	m	266	18
28-Jan-09	1c2d05ab74	615	2486	f	266	14
28-Jan-09	50194a6d79	650	2902	f	266	17
28-Jan-09	5019402742	639	3170	f	266	20
28-Jan-09	257c60f55e	525	1580	f	266	13
28-Jan-09	425c6f1b19	570	2460	f	266	14
28-Jan-09	1c2d05c778	570	2230	f	266	16
28-Jan-09	1c2d061d3d	555	2018	m	266	22
28-Jan-09	42551d3f13	550	2058	f	266	17
28-Jan-09	1c2c840c60	585	2450	f	266	16
28-Jan-09	1c2d05aaeb	579	2330	f	266	17
28-Jan-09	1c2d05a186	605	2874	f	266	19
28-Jan-09	257c60ab07	523	1840	m	266	23
28-Jan-09	202833463f	614	3140	f	266	19
28-Jan-09	1c2d061f4c	561	2014	f	266	14
28-Jan-09	502e213667	612	3040	f	266	20
28-Jan-09	42555b4933	591	2700	f	266	12
28-Jan-09	425c617848	559	1912	f	266	14
28-Jan-09	257c60a2dc	587	2690	f	266	15
28-Jan-09	502e2a7014	600	2810	f	266	18
28-Jan-09	1c2d05c952	504	1836	m	266	16
27-Jan-09	424d5e5632	595	2405	f	255	14
28-Jan-09	1c2d05a2bb	558	1628	f	255	18
29-Jan-09	257c60c35f	604	3195	f	255	20
30-Jan-09	257c611730	595	2770	f	255	16
31-Jan-09	1c2c37a6dc	584	2110	f	255	19
28-Jan-09	No Tag 1	625	2745	f	259	18
28-Jan-09	No Tag 2	590	2715	f	259	17
28-Jan-09	Mort 2	598	2800	f	266	19

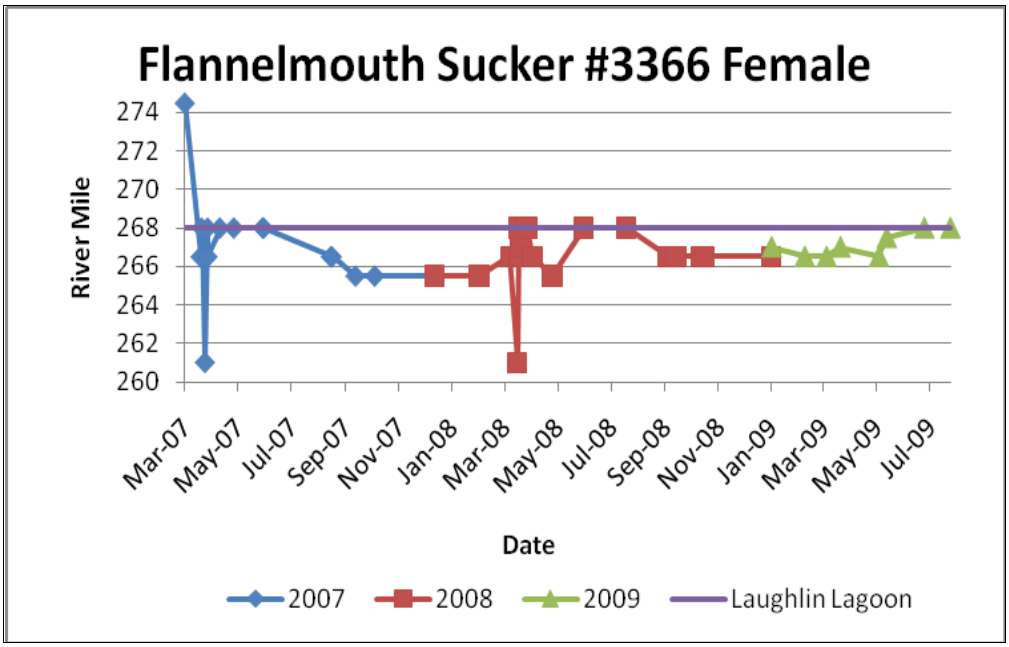
Date Collected	PIT Tag Number	Total Length (mm)	Weight (g)	Sex	Approximate River Mile Collected	B-W Age
4/22/2009	1c2d05c64a	371	NA	f	266	5
4/22/2009	1c2c844045	580	NA	f	266	9
4/22/2009	257c60cc20	554	NA	m	266	8
4/22/2009	1c2c7f4b0e	486	NA	m	266	8
4/22/2009	1c2c7f485e	673	NA	f	266	15
4/22/2009	1c2c7f382c	620	NA	f	266	11
4/22/2009	451f3d4c01	503	NA	m	266	11
4/22/2009	1c2c8417e9	595	NA	f	266	8
4/22/2009	425523322b	527	NA	m	266	6
4/22/2009	257c611395	513	NA	m	266	18
4/22/2009	No Tag Number	148	NA	?	266	2
4/22/2009	1c2c840fea	559	NA	m	266	10
4/22/2009	1c2c83bee4	595	NA	f	266	8
4/22/2009	422e4c3f1f	537	1970	m	266	8
4/22/2009	1c2c856f05	568	NA	m	266	11
4/22/2009	424e0e7d7e	549	NA	m	266	7
4/22/2009	257c6122f0	563	1859	m	266	9
4/22/2009	1c2c7fe05d	555	NA	f	266	10
4/22/2009	1c2c7ff191	604	NA	?	266	17
4/22/2009	1c2c7fe596	?	NA	m	266	8
4/22/2009	5019531b7c	560	NA	f	266	12
4/22/2009	1c2c89812e	578	NA	f	266	10
4/22/2009	424e2c2243	620	NA	f	266	14
4/22/2009	424d1c1b32	590	NA	f	266	12
6/24/2009	1c2d059c93	550	2259	f	266	8
6/24/2009	1c2c840615	645	2472	f	266	12
6/24/2009	424e3a6008	555	2105	f	266	11
6/24/2009	257c60f91c	550	2354	f	266	11
6/24/2009	1c2d05acb6	600	2414	f	266	13
6/24/2009	1c2d05a7df	615	2376	f	266	13
6/24/2009	1c2d060f34	535	1835	f	266	8
6/25/2009	1c2d06b9a1	635	2490	f	266	21
6/25/2009	1c2d06edb7	565	1695	m	266	14
6/25/2009	1c2d061a7a	580	2015	m	266	16
4/22/2009	1c2c85189b	644	NA	f	266	11
4/22/2009	422e676559	600	NA	f	266	15
4/22/2009	1c2c852c7c	570	NA	f	266	17
4/22/2009	423c054a51	514	NA	m	266	11

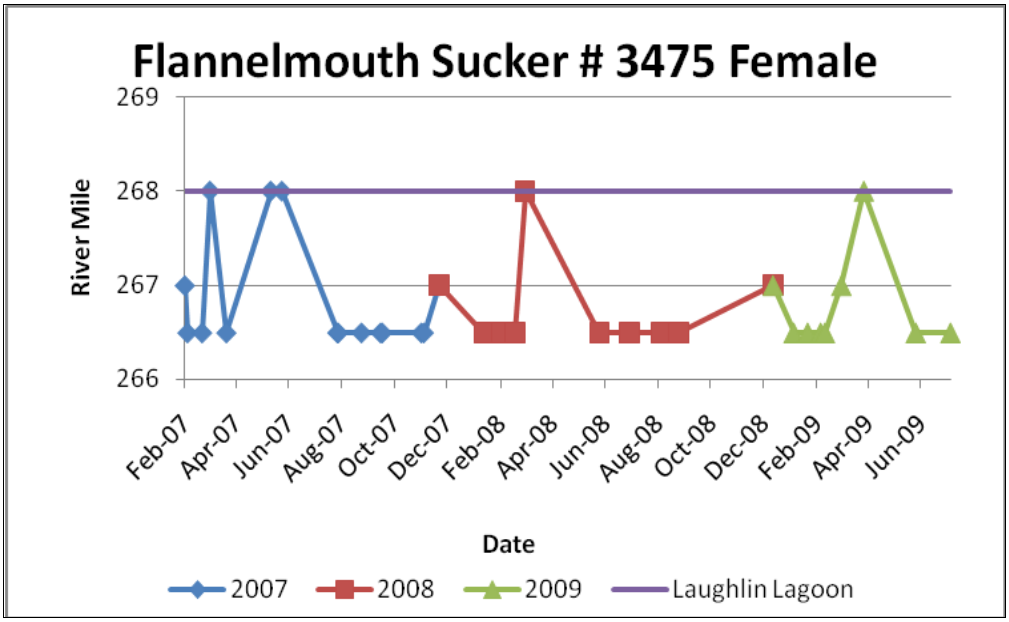
Date Collected	PIT Tag Number	Total Length (mm)	Weight (g)	Sex	Approximate River Mile Collected	B-W Age
4/22/2009	1c2c8577a7	535	NA	m	266	10
4/22/2009	424e572e20	632	NA	m	266	17
4/22/2009	1c2c8520ef	540	NA	f	266	12
4/22/2009	1c2c856de1	546	NA	m	266	16
4/22/2009	1c2c856cb2	510	NA	f	266	11
4/22/2009	1c2c83c0c6	629	NA	f	266	24
4/22/2009	1c2c85073c	541	NA	m	266	12
6/24/2009	5031496238	575	2321	f	266	13
6/25/2009	424e142a28	660	3350	f	268	17

Appendix – B

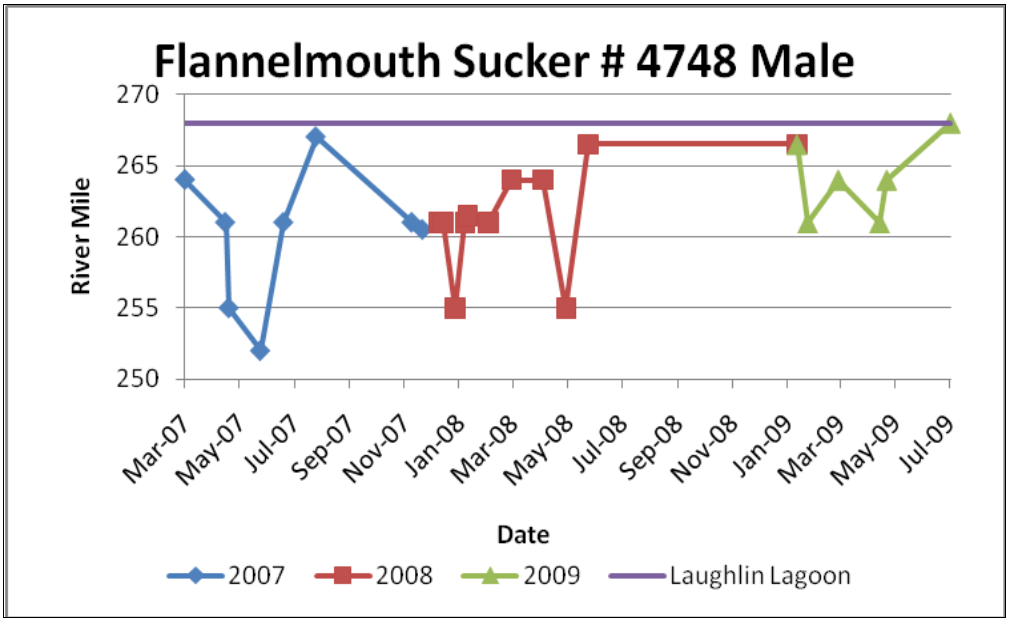
Seasonal Movements of Flannelmouth Suckers with Multiple Years of Detections

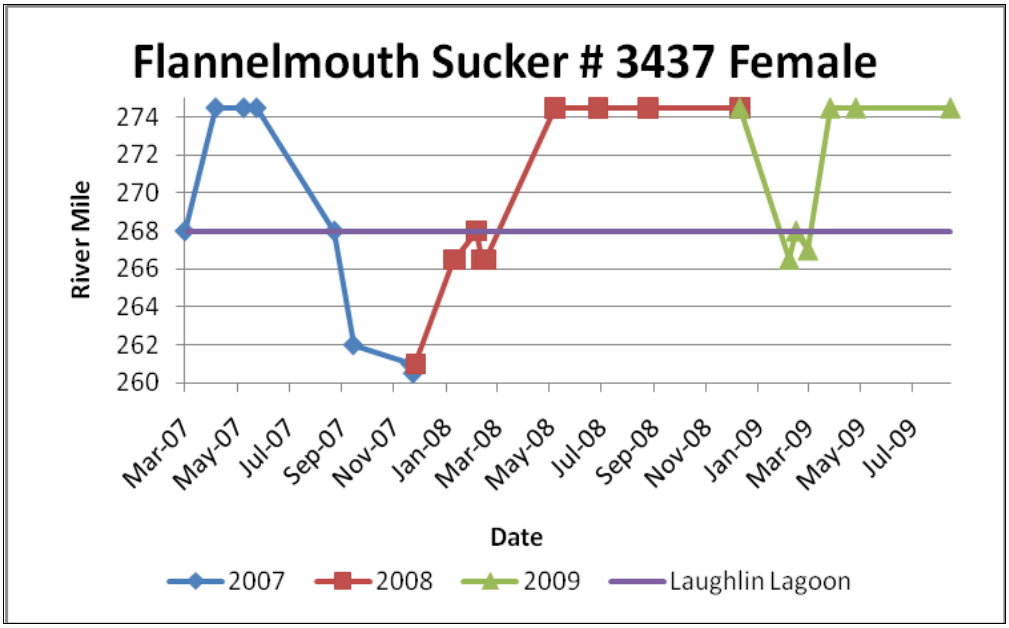
Appendix B. Seasonal movements of flannelmouth suckers implanted with 14-month (2006) and 36-month (2007) transmitters. Sex is indicated next to fish number.



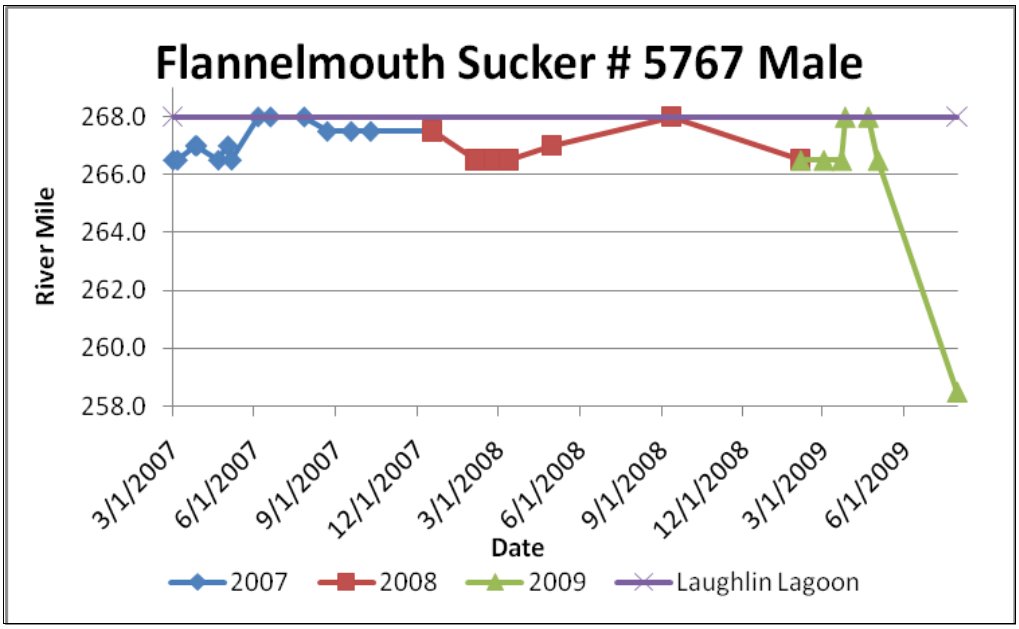


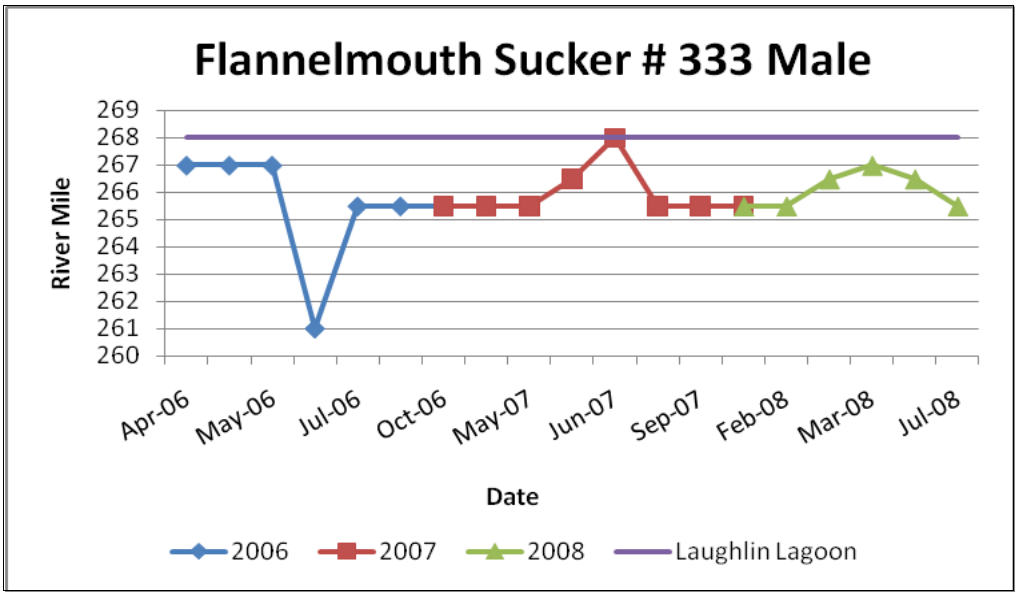
Appendix B. Continued.



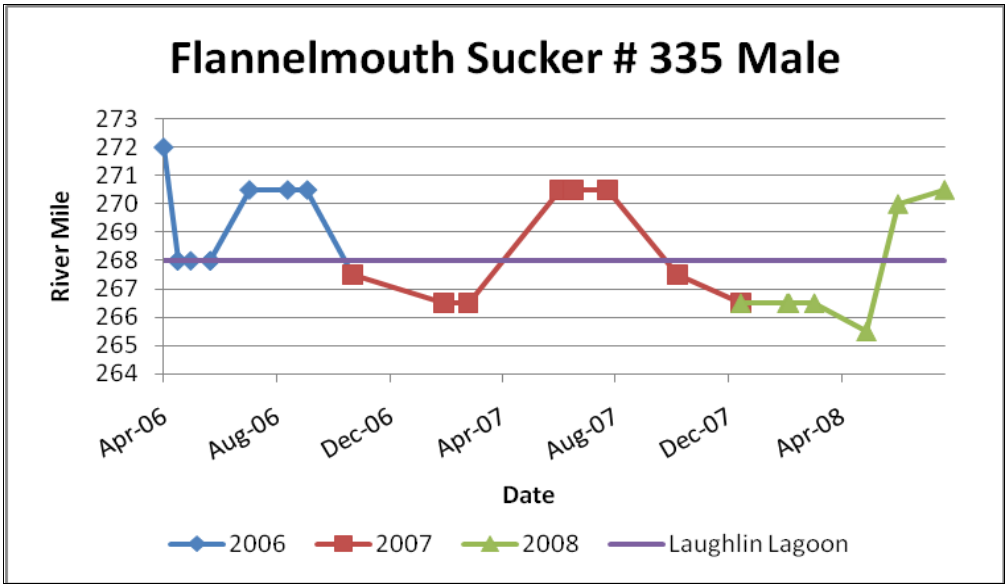


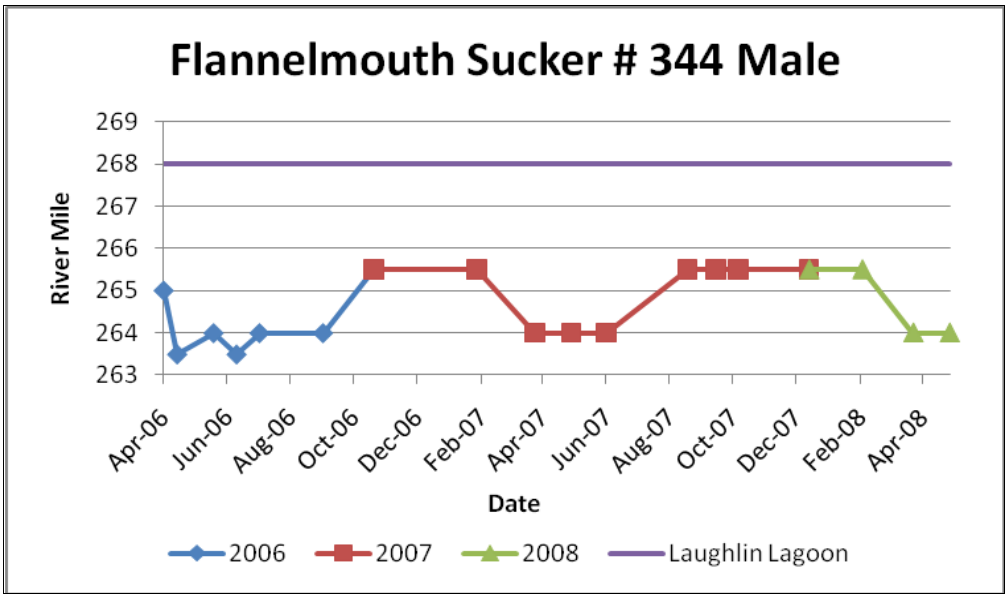
Appendix B. Continued.



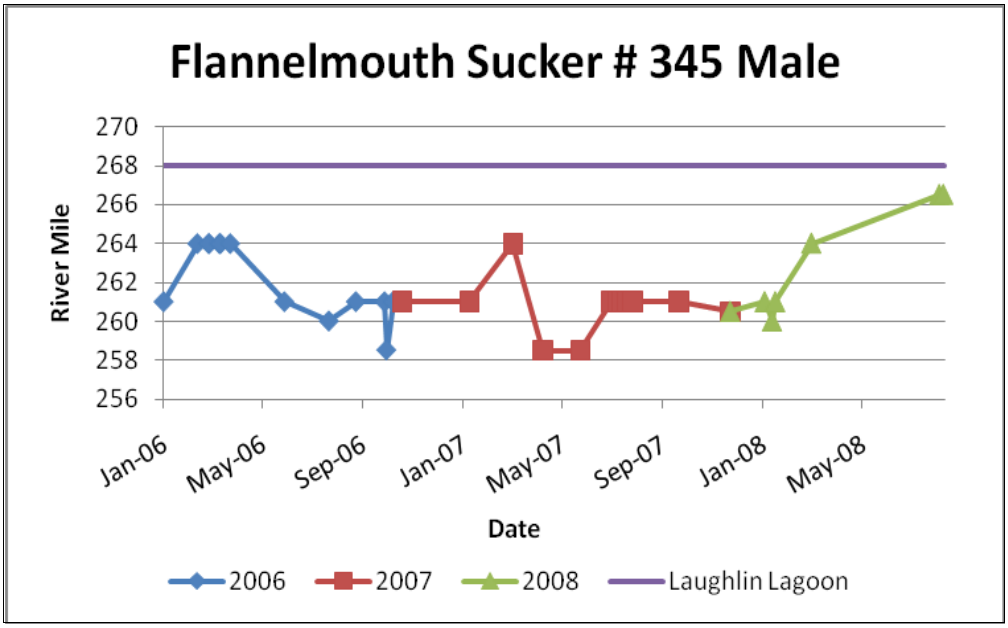


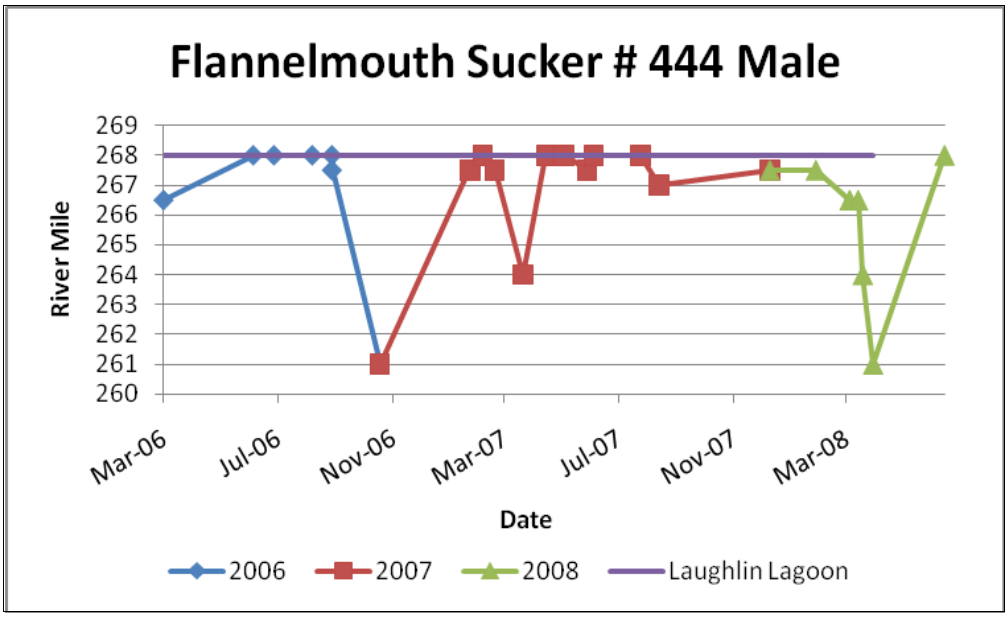
Appendix B. Continued.



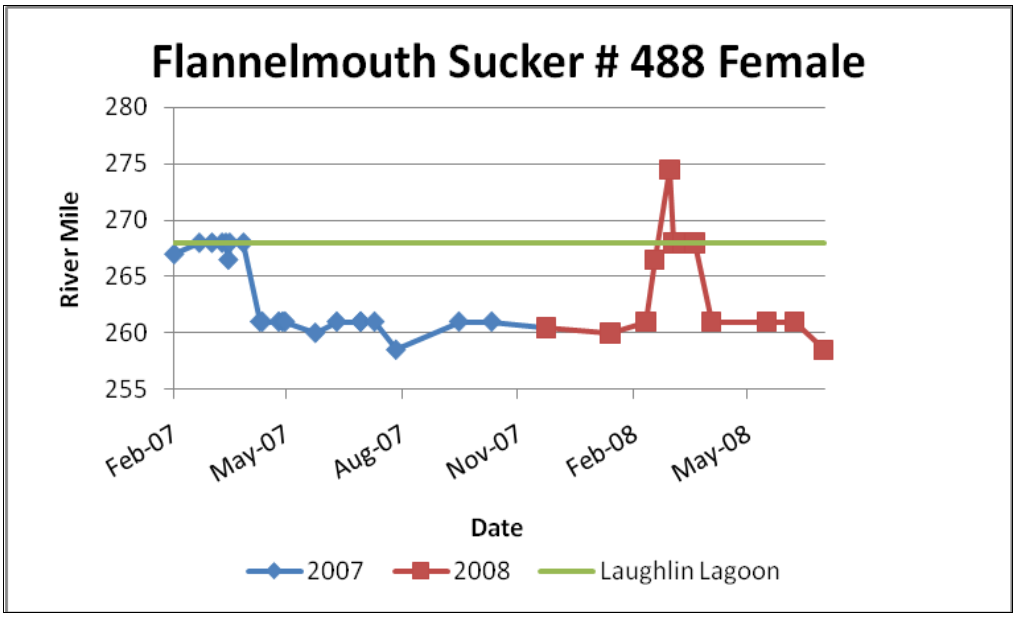


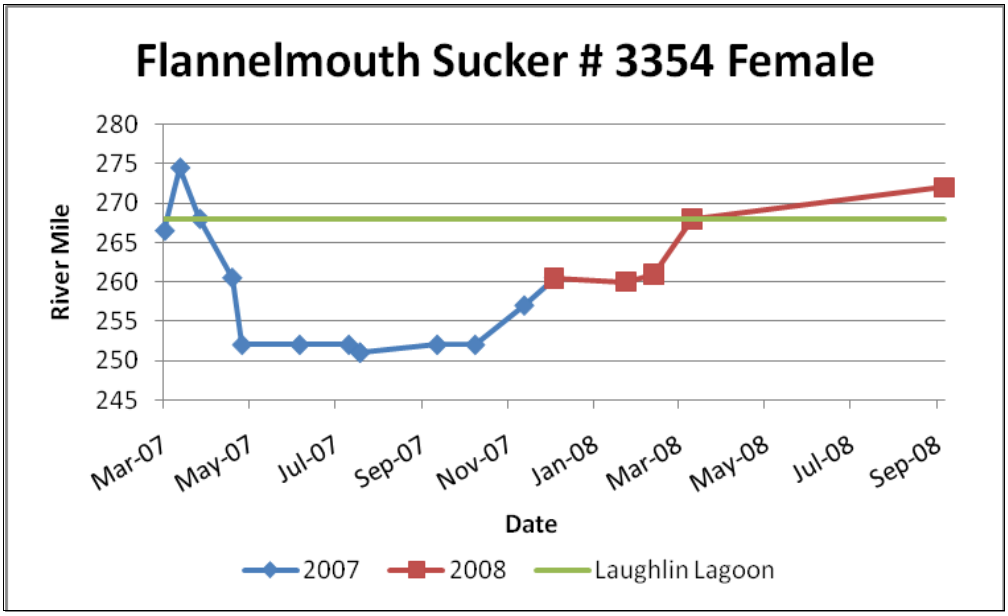
Appendix B. Continued.





Appendix B. Continued.

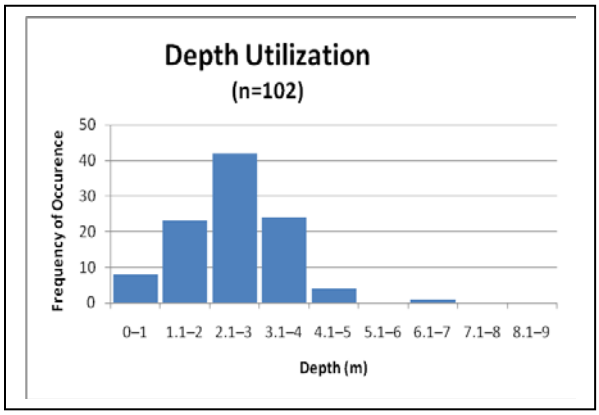


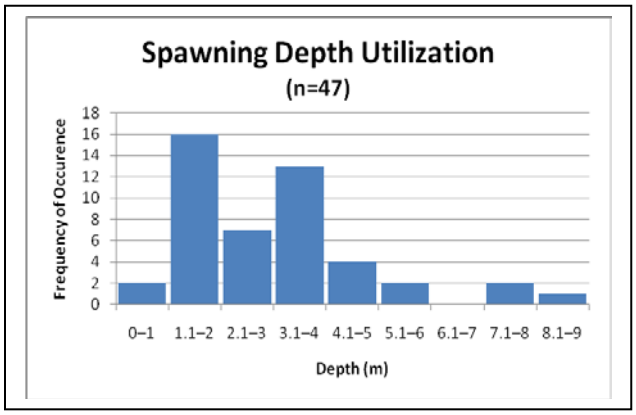


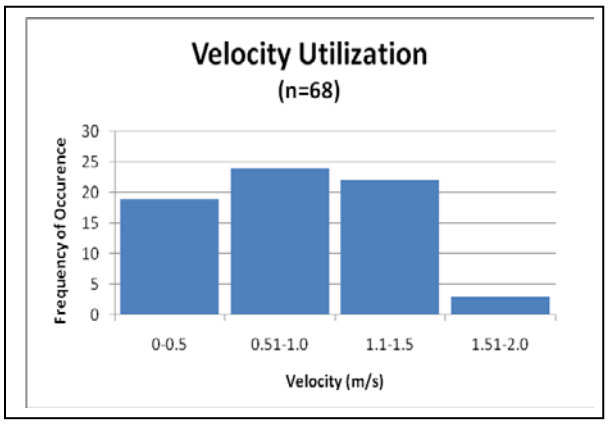
Appendix – C

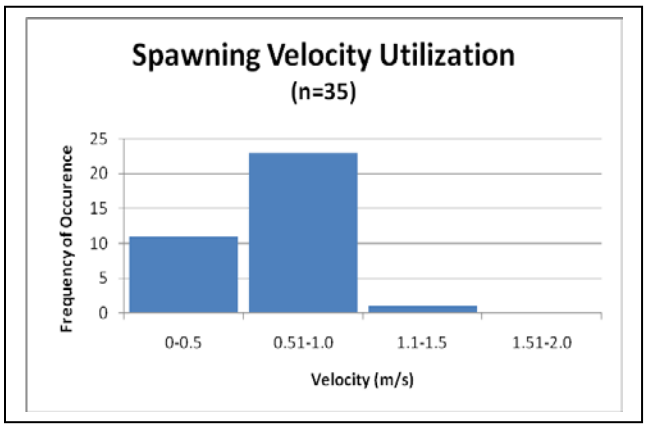
Habitat Utilization Frequency Curves for Flannelmouth Sucker

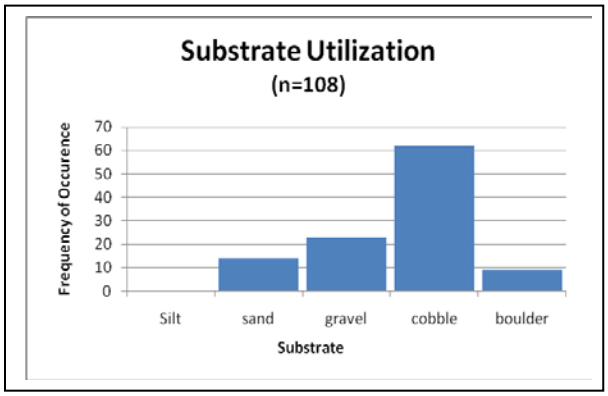
Appendix C. Habitat utilization curves for flannelmouth sucker. Spawning utilization curves encompass March–May and non-spawning utilization curves encompass June–February.

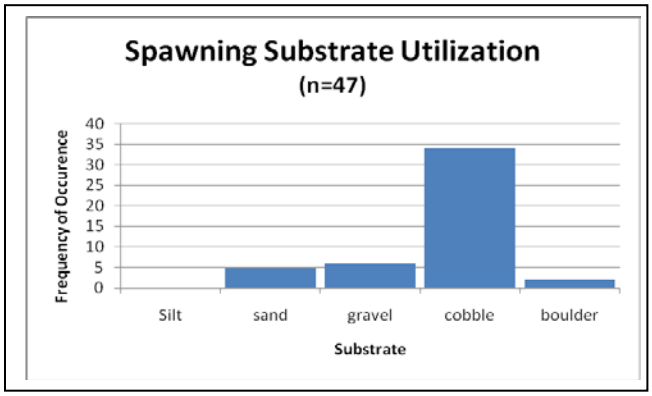








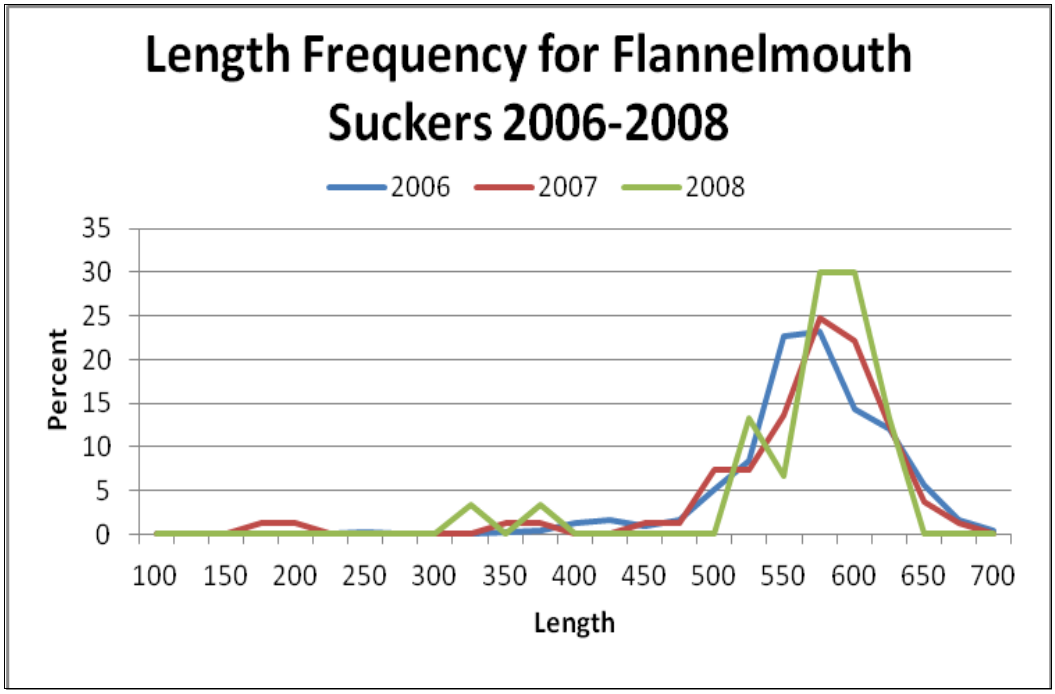


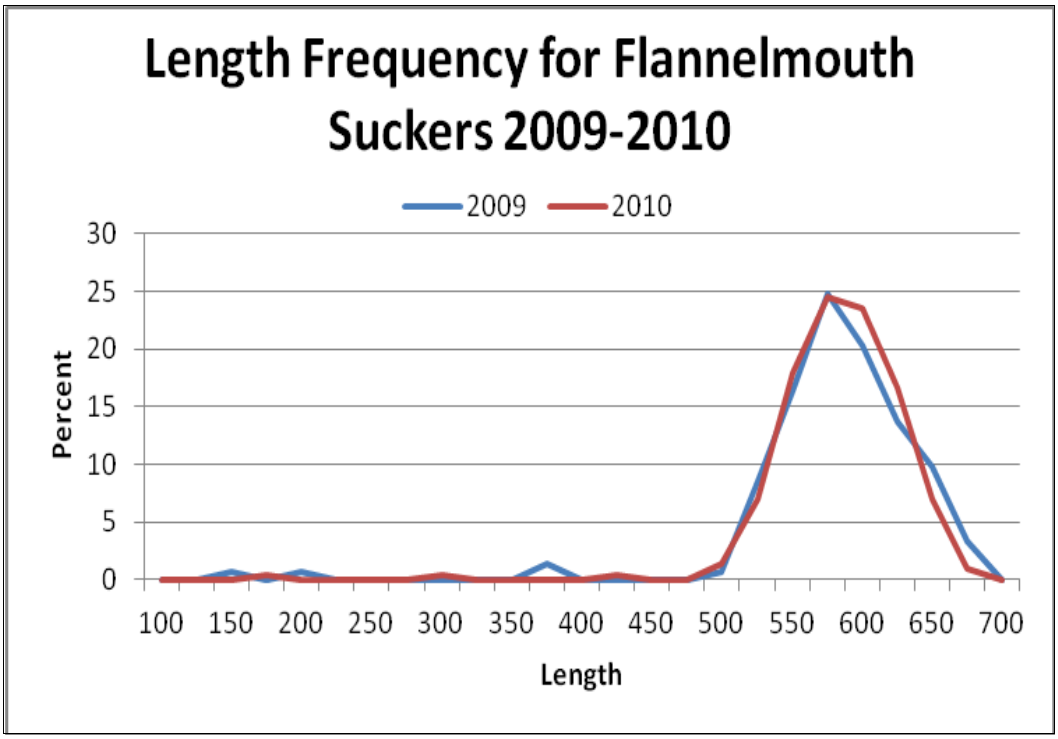


Appendix – D

Length Frequency of Flannelmouth Suckers from 2006 to 2010. Data from electrofishing and trammel netting captures.

Appendix D. Length frequencies of flannelmouth suckers from 2006 to 2010.

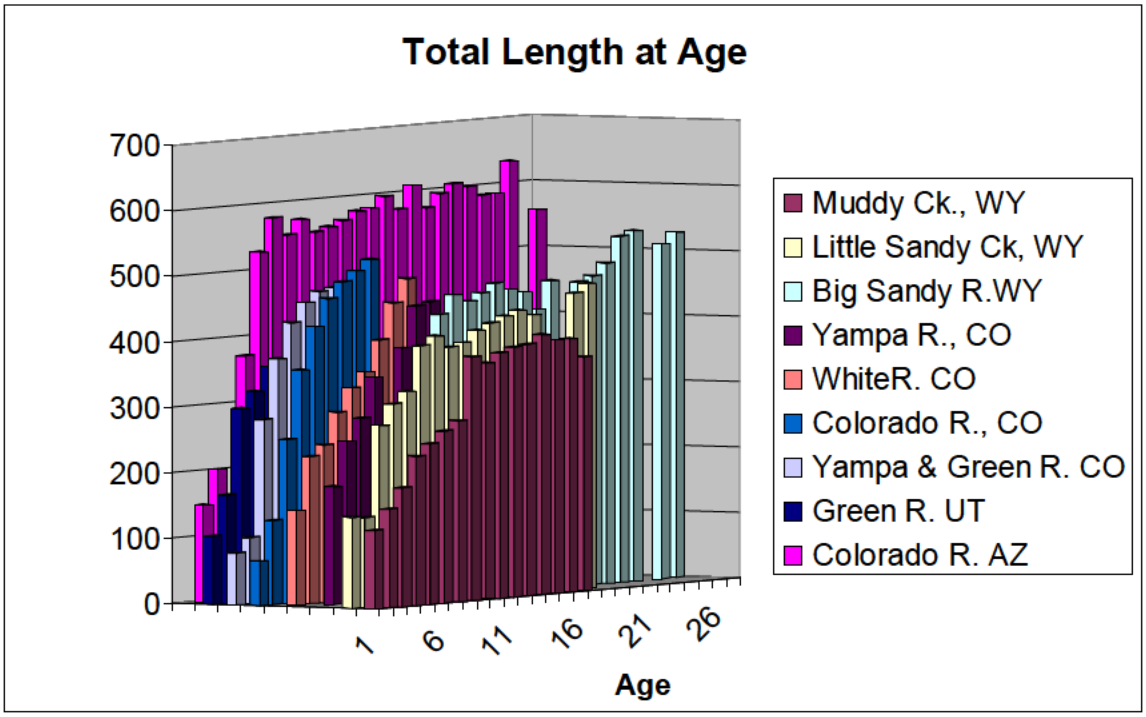




Appendix – E

Length at Age Comparison of Flannelmouth Suckers from other Rivers Systems.
Flannelmouth suckers from the Colorado River, Arizona were collected between Davis Dam and Lake Havasu.

Appendix E. Length at age comparison of flannelmouth suckers from other river systems.



Appendix – F

Photos of Young Juvenile Flannelmouth Sucker Habitat at Varying Flows

Appendix F. Photo sequence of a slackwater habitat at RM 266.5 as flows increase on June 24, 2009. Arrow indicates the location of a slackwater inhabited by a school of young juvenile flannelmouth suckers.

Photo # 1 - June 24 2009, 11:39 am, gauge height – 13.00, CFS – 14,400

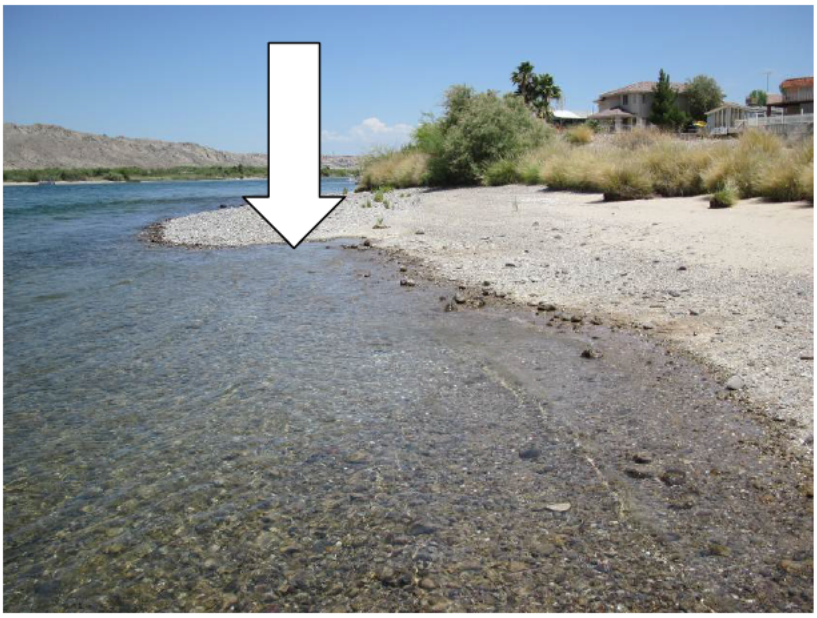


Photo # 2 - June 24 2009, 12:59 pm, gauge height – 14.13, CFS – 18,600

Appendix F. Continued.

Photo # 3 - June 24 2009, 2:27 pm, gauge height – 14.32, CFS – 19,400

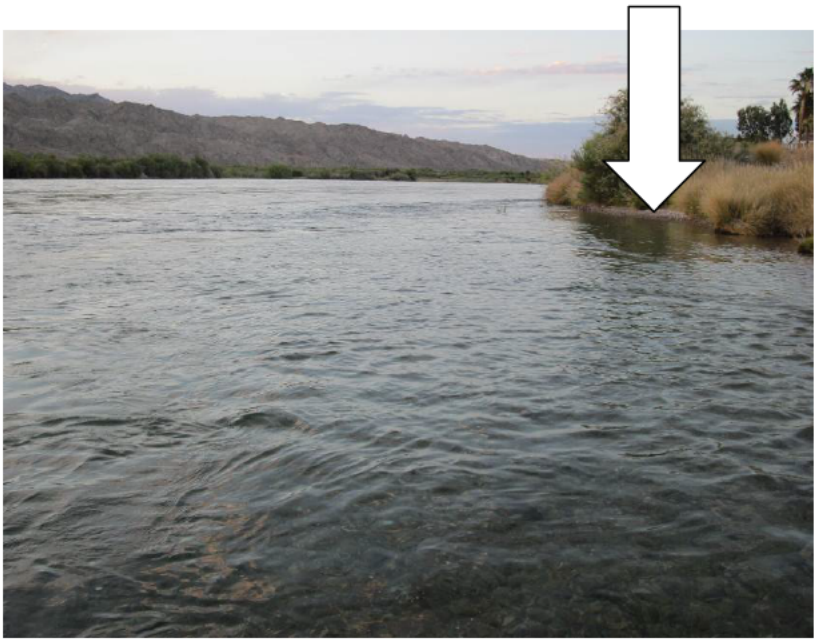
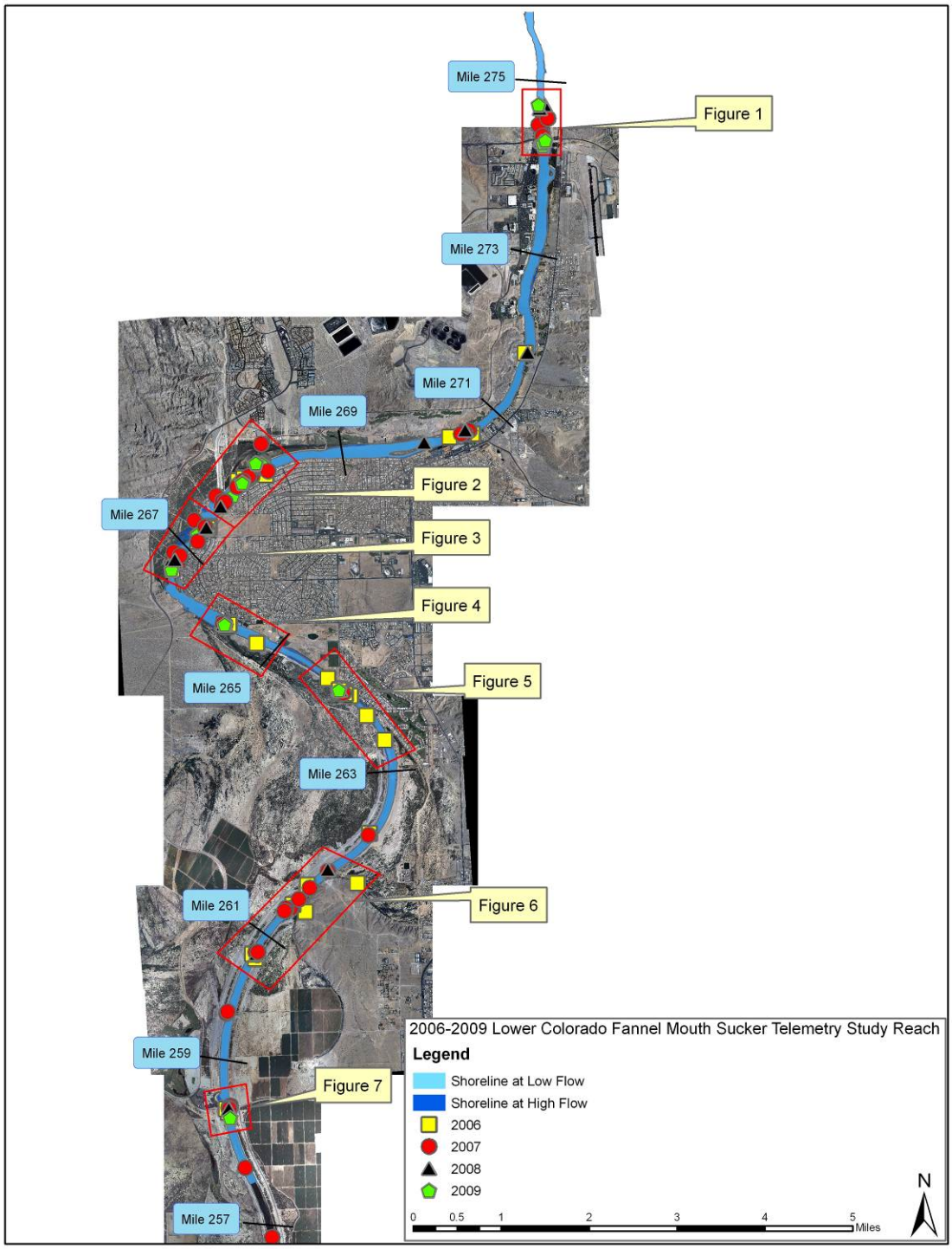


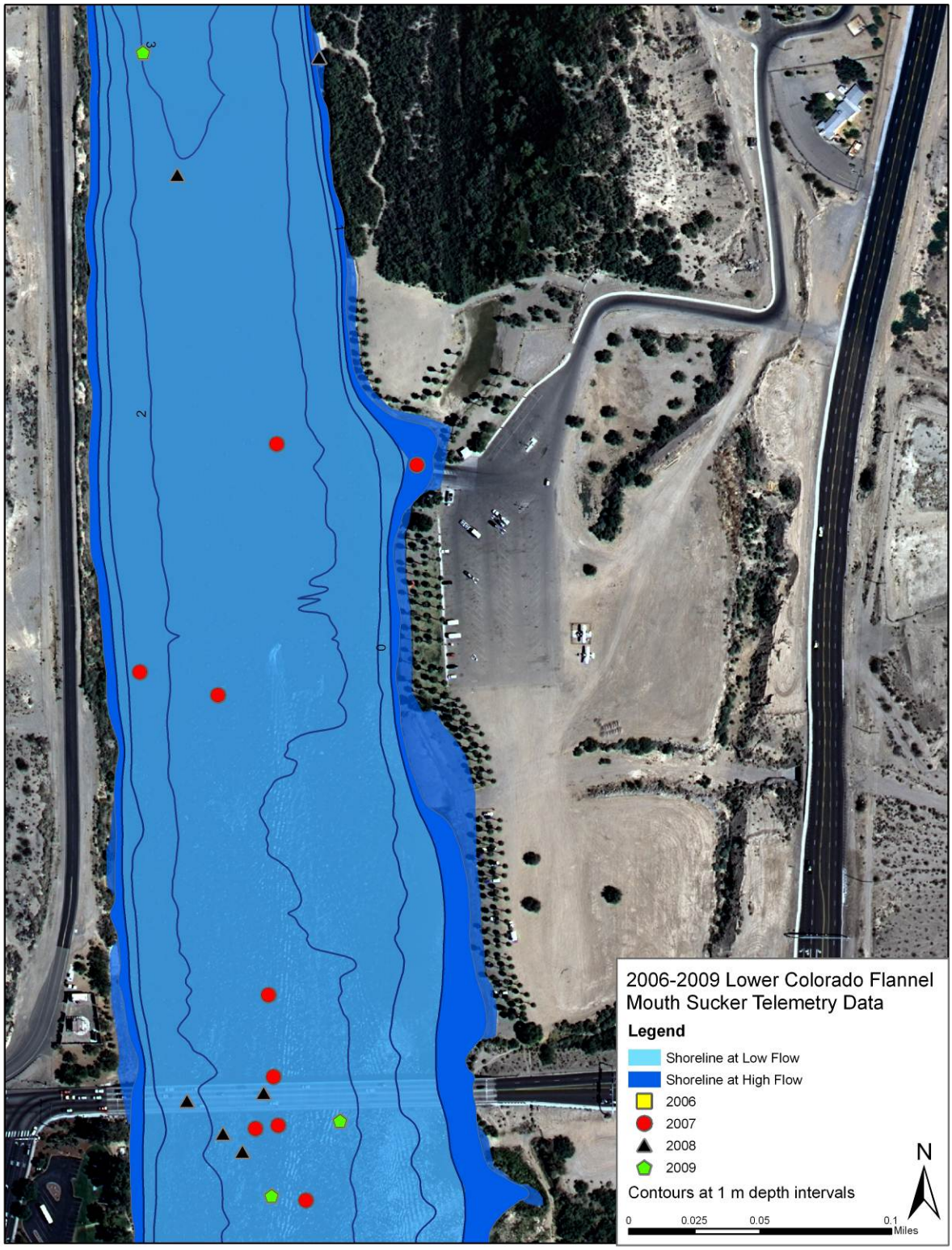
Photo # 4 - June 24 2009, 8:45 pm gauge height – 15.93, CFS – 26,900

Appendix – G

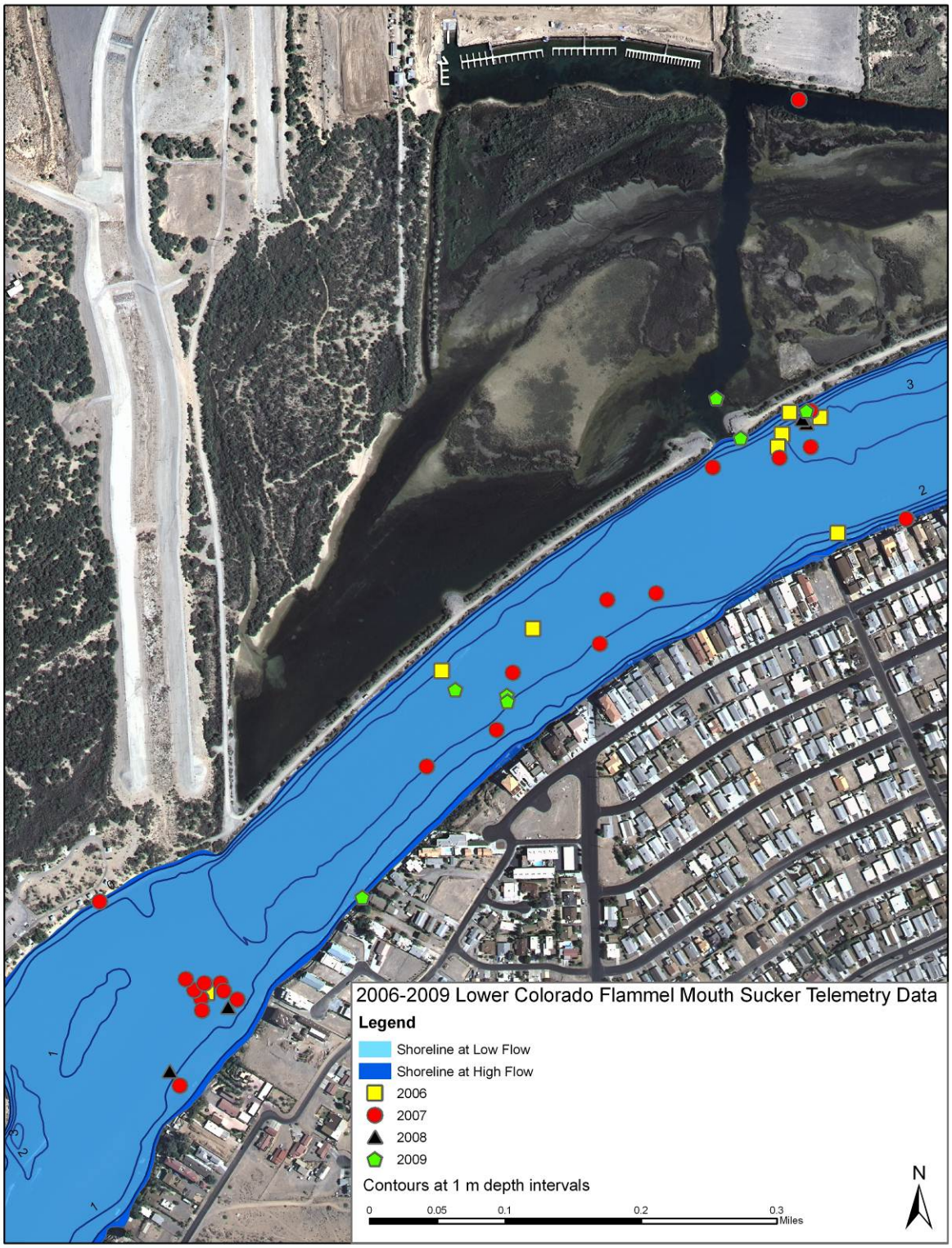
Map of flannelmouth sucker congregations and GIS overlay depicting high (20,000 cfs) and low (10,000 cfs) flows

Appendix G. Overview map (River mile 275-257) showing flannelmouth sucker congregations. More detailed maps can be viewed below by referencing the figure on this map.

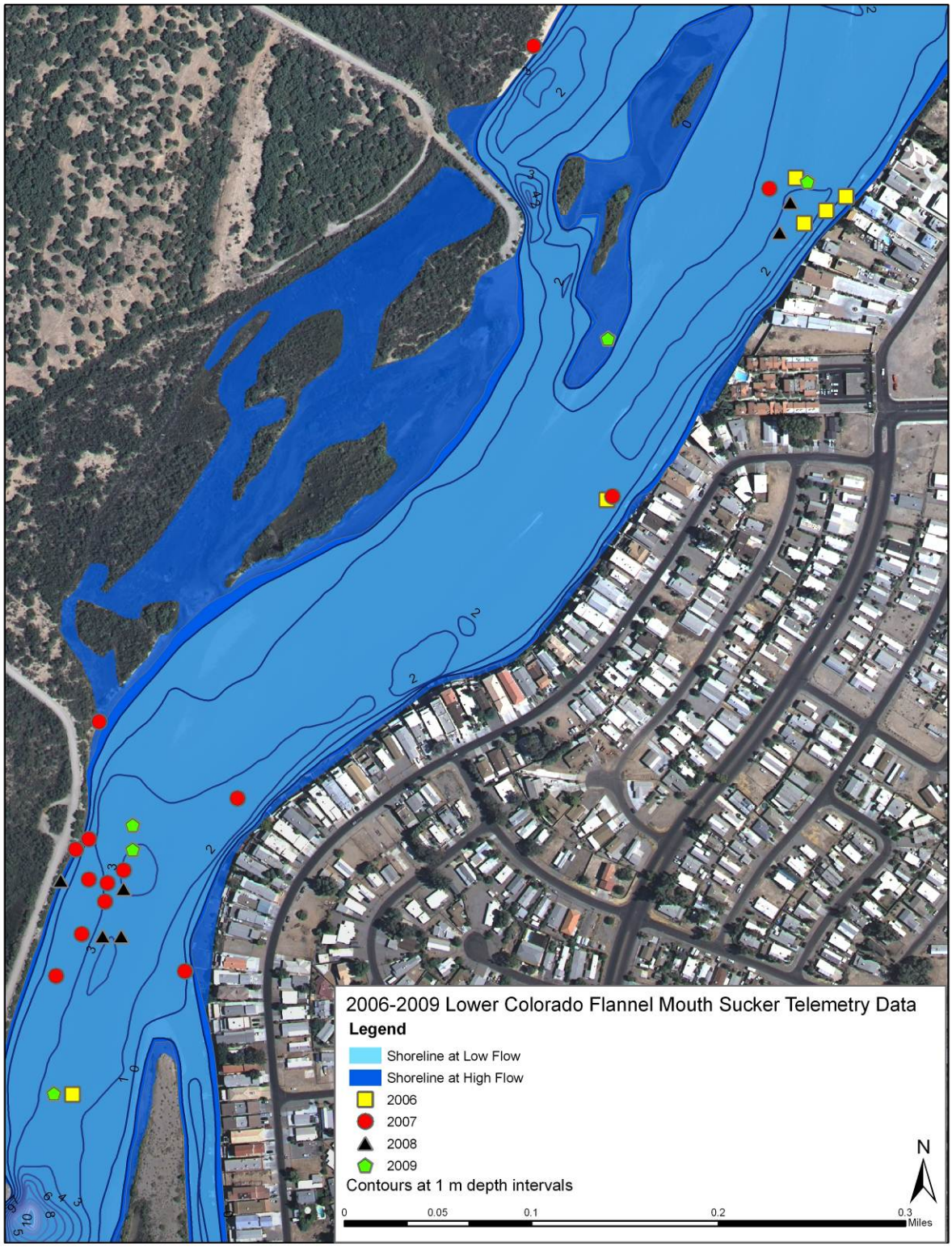




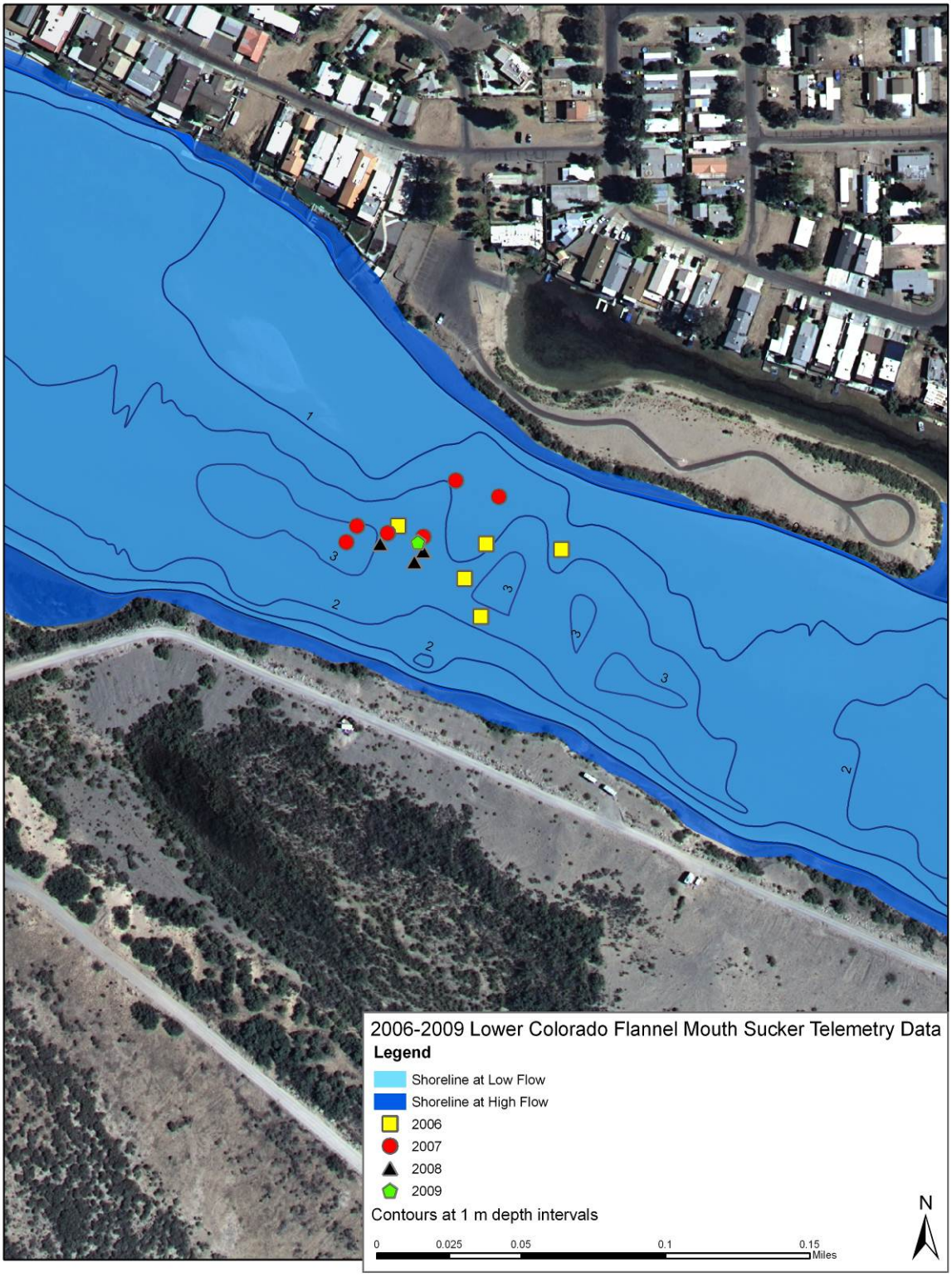
Appendix G. Figure 1 (River mile 274-275).



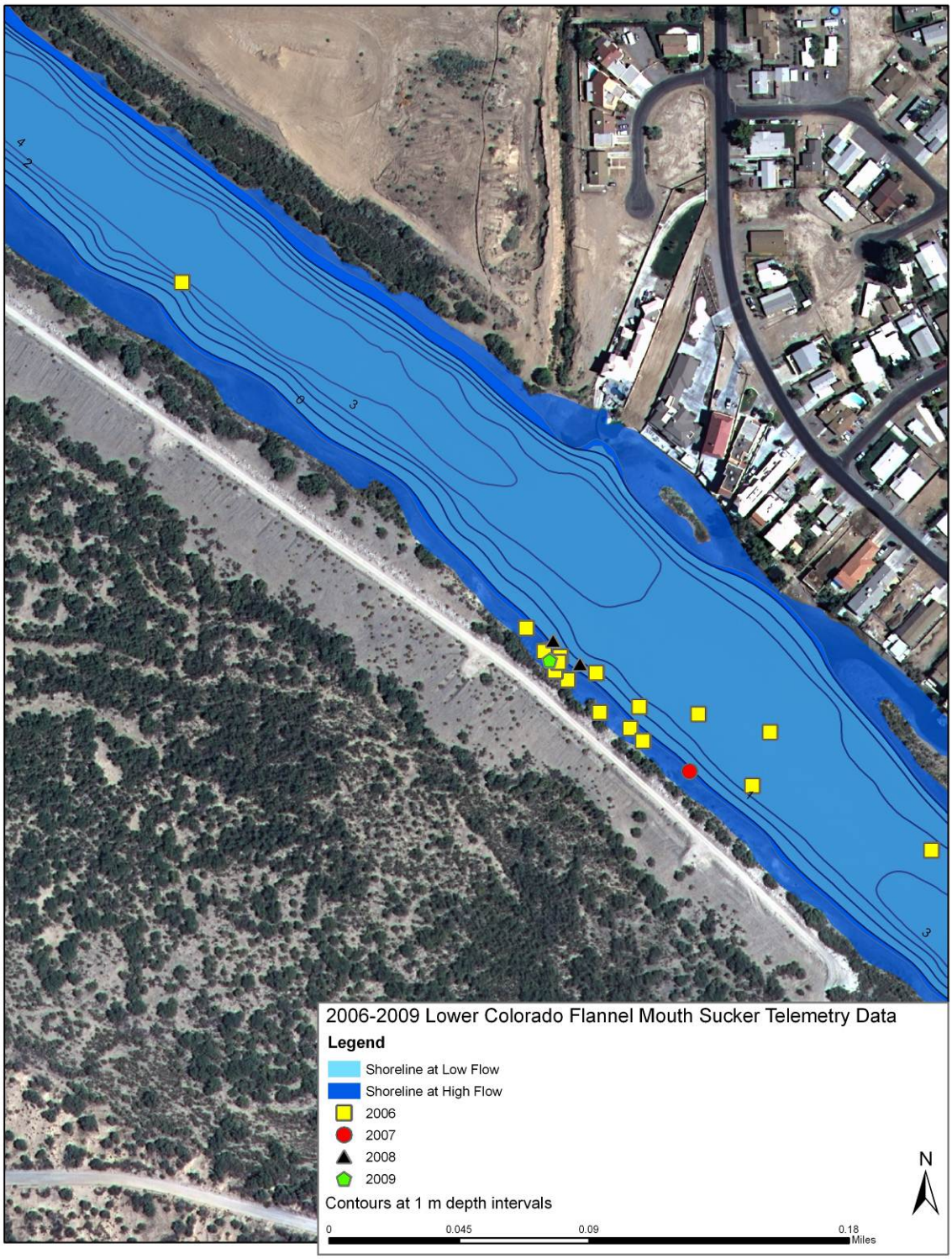
Appendix G. Figure 2 (River mile 268-269).



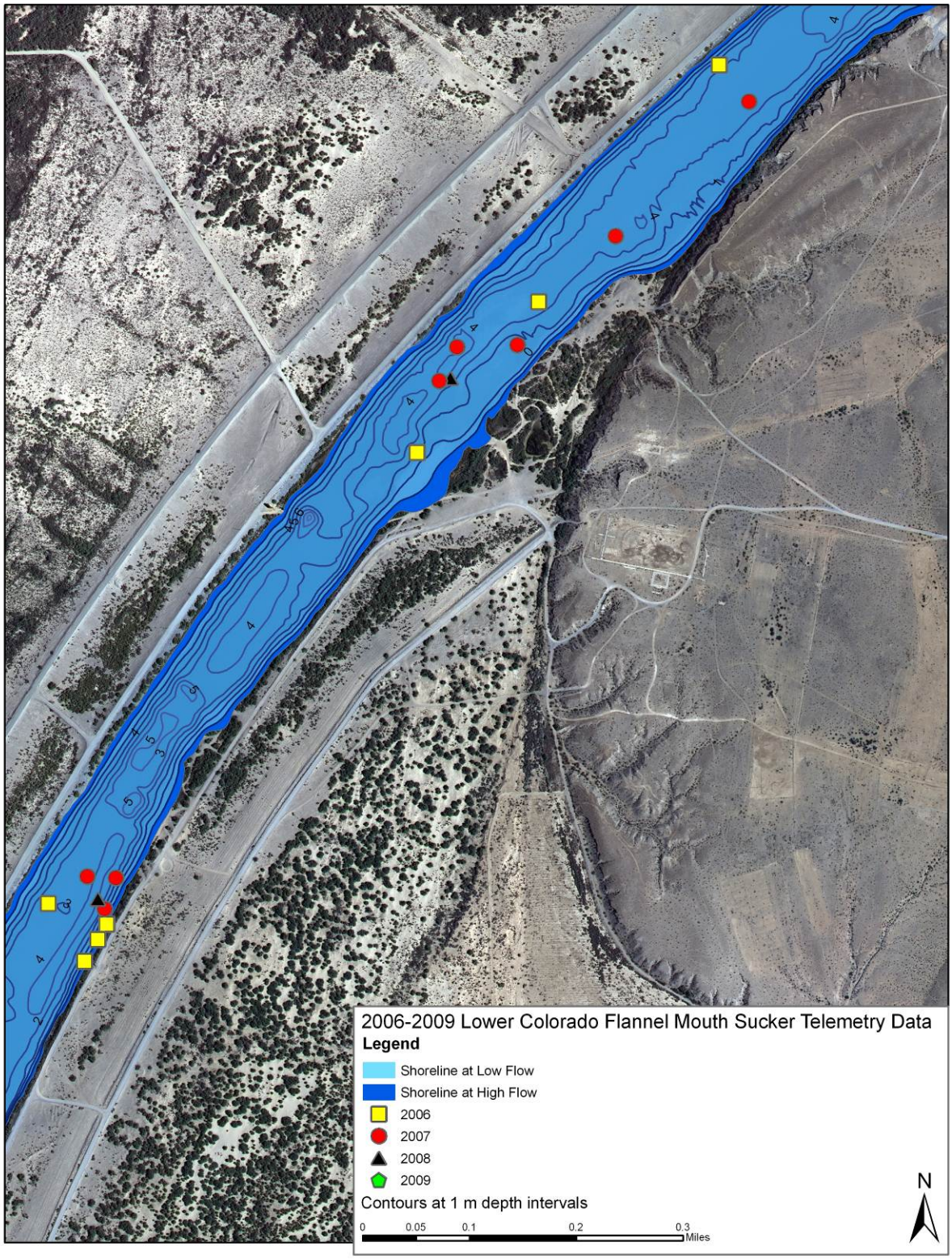
Appendix G. Figure 3 (River mile 267-268).



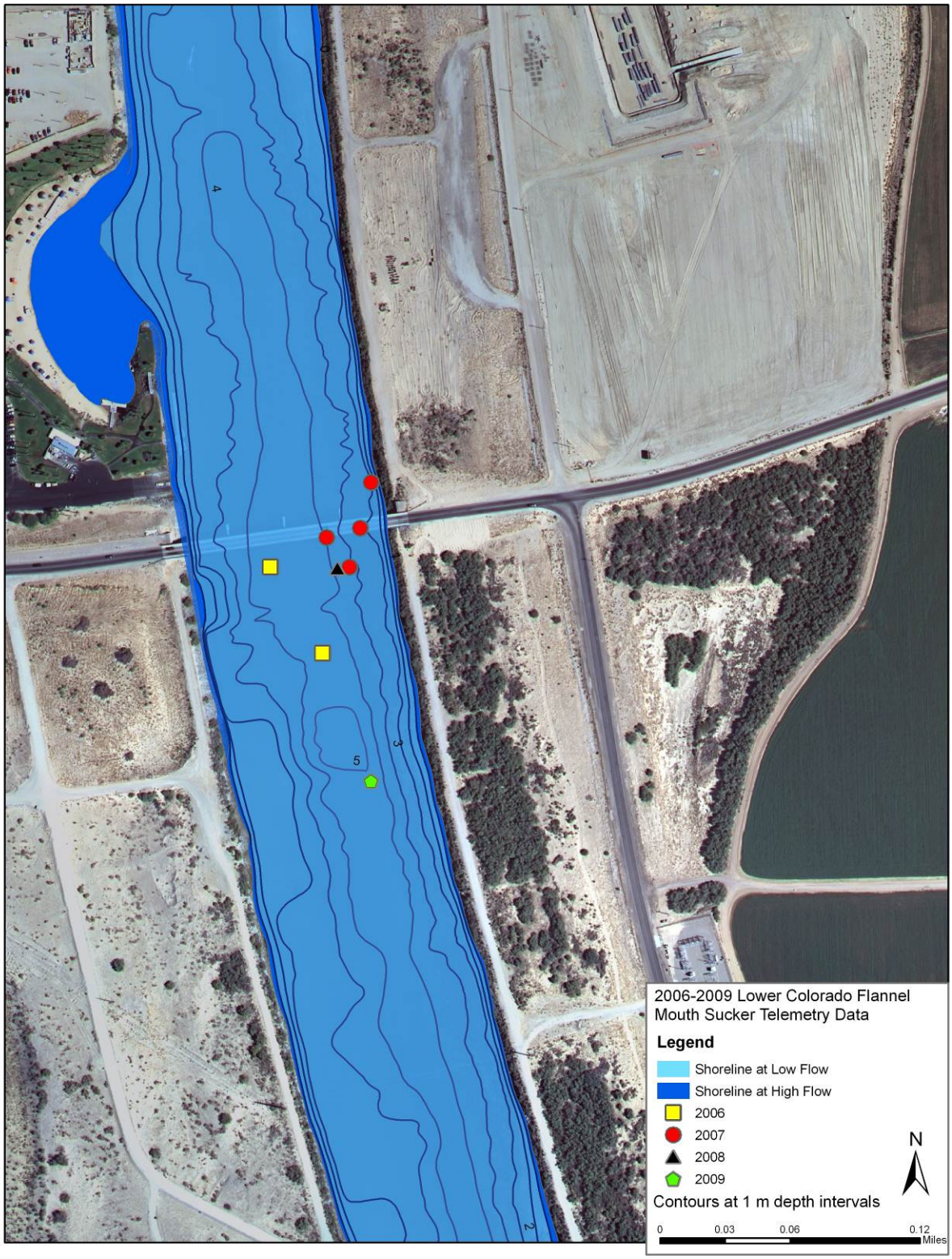
Appendix G. Figure 4 (River mile 265-266).



Appendix G. Figure 5 (River mile 263-264).



Appendix G. Figure 6 (River mile 261-262).



Appendix G. Figure 7 (River mile 258-259).