

FISHERIES SURVEY

of the Virgin River from Halfway Wash to Lake Mead



The Virgin River Bowl, July 2004.



Common carp (Cyprinus carpio) in a seine above the Virgin River-Lake Mead confluence.

FINAL REPORT PR 988

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Blue tilapia (Oreochromis aurea) collected above the Virgin River-Lake Mead confluence.



Virgin River dries below Halfway Wash, July 2004.

EXECUTIVE SUMMARY

Halfway Wash (RM 41.25) is the lower boundary of critical habitat for two endangered fish species of the Virgin River, the woundfin (*Plagopterus argentissimus*) and the Virgin River chub (*Gila seminuda*). The area around Halfway Wash has often been considered one of the best places for a water diversion or fish barrier in the lower Virgin River. However, a barrier would isolate fishes in the area below it from the community above. If native fishes do not occupy the area below Halfway Wash, then installing a barrier in this area may effectively keep nonnative fishes from migrating upstream without negatively impacting native fish populations. The Southern Nevada Water Authority (SNWA) is considering several options to develop its water rights on the Virgin River at Halfway Wash. This water development will probably result in reduced flows below Halfway Wash. Additionally, water development may involve the placement of a diversion somewhere near Halfway Wash. In order to assist in evaluating the various alternatives for water development in the lower Virgin River, SNWA contracted BIO-WEST, Inc. (BIO-WEST) to survey the fish community from the Halfway Wash area to Lake Mead in 2004.

BIO-WEST surveyed a 14.5-mile (23.3-km) section of the Virgin River from Halfway Wash to the current confluence of the Virgin River with Lake Mead in April 2004. Only one native fish, a young-of-the-year flannelmouth sucker (*Catostomus latipinnis*) was collected. Additional surveys in July, August, and September 2004 found no native fish. Red shiner (*Cyprinella lutrensis*), western mosquitofish (*Gambusia affinis*), and common carp (*Cyprinus carpio*) dominated the catch throughout the study area. Blue tilapia (*Oreochromis aurea*) were collected in a 2-mile (3.22-km) section of the Virgin River immediately above Lake Mead in July, August, and September 2004. An area of extremely dense vegetation in the channel upstream from this area appeared to prevent blue tilapia migration upstream.

A large flood event in January 2005 radically changed habitat in the Virgin River and helped to end a 5-year drought in the basin. The SNWA contracted BIO-WEST to perform two follow-up surveys from Halfway Wash to Lake Mead in August 2005 and September 2005. The 2005 surveys were conducted to determine the extent to which the floods and high spring runoff altered habitat and changed the fish community below Halfway Wash.

Surveys of the Halfway Wash to Lake Mead study area in August and September 2005 showed that habitat had been altered dramatically by flooding and spring runoff earlier that year. However, red shiner and western mosquitofish continued to dominate the catch rate, and two speckled dace (*Rhinichthys osculus*) were the only native fishes collected. We collected blue tilapia as far upstream as RM 40.5, and we collected striped bass (*Morone saxatilis*) for the first time in the Virgin River.

The fish fauna of the Virgin River below Halfway Wash is probably depauperate and dominated by nonnative fishes because of low flows from 1999-2004. Nearly 10 miles (16.1 km) of the Virgin River were completely dry in July 2004. Similar drying events have occurred annually (in the

summer) since 2001. Historical sampling indicates that native fishes, including Virgin River chub and woundfin, have been found sporadically near and below Halfway Wash. However, the occurrence of native fishes coincides with average to above average flow years. Therefore, higher numbers of native fishes are transported into the area near and below Halfway Wash during higher flow years, or these species can only persist in the river near and below Halfway Wash when higher water conditions are prevalent. A combination of these two factors is probably responsible for the transient native fish community observed near and below Halfway Wash since the 1970s. The impact of the extended drought and subsequent flooding has lowered native fish abundance in upstream areas, which may explain why so few native fishes were found during 2005 surveys, despite higher flows and improved habitat.

Manipulating existing water rights to maintain or increase flows near and below Halfway Wash may allow for a more permanent native fish population in this area. However, developing a fish barrier near Halfway Wash would help prevent nonnative fishes from migrating further up river from Lake Mead. Continued sampling in this area may show whether native fishes utilize the improved habitat below Halfway Wash and assist in pinpointing the timing and speed of blue tilapia and striped bass migrations.

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BACKGROUND AND INTRODUCTION

Halfway Wash (River Mile [RM] 41.25) is the lower boundary of critical habitat for the two endangered fish species of the Virgin River, the woundfin (*Plagopterus argentissimus*) and the Virgin River chub (*Gila seminuda*) (USFWS 2000). Surveys in the 1990s by BIO-WEST, Inc. (BIO-WEST) and the Virgin River Fishes Recovery Team (Recovery Team) found that both Virgin River chub and woundfin were distributed as far downstream as Halfway Wash (Virgin River Fishes Database, Holden and Abate 1999). Woundfin were collected as far downstream as RM 39.5 and Virgin River chub as far downstream as RM 41.0. Virgin River chub numbers below the Bunkerville Diversion were extremely low and sporadic, indicating that they may have been transient members of the community that drifted downstream from other areas. Conversely, woundfin were collected consistently in an area beginning at the Riverside Bridge and extending several miles downstream (RM49.0-45.25). Other native fishes have been found even further downstream, and flannemouth sucker (*Catostomus latipinnis*) and speckled dace (*Rhinichthys osculus*) appeared to have permanent populations in the Riverside area.

A long-term drought that began in 1999 has substantially changed the fish community in the lower Virgin River. Fisheries sampling from 1999-2003 showed that Virgin River chub appear to be extirpated below the Bunkerville Diversion (RM 59.25) (Holden and Golden 2000, Golden and Holden 2004, Jim Heinrich, Nevada Division of Wildlife, personal communication). Additionally, no woundfin have been collected in the Riverside area (RM 49.0 to 45.25) since June 2001. Numbers of other native fishes have also precipitously declined in the areas below the Bunkerville Diversion. The drought, in concert with human water use, is probably the major cause for these declines (Golden and Holden 2004).

BIO-WEST has sampled near Halfway Wash multiple times from 2001-2003 looking for blue tilapia (*Oreochromis aurea*) migrating upstream from Lake Mead. In 2003 several areas below Halfway Wash were also sampled in an attempt to determine the source of blue tilapia colonizing the Virgin River. No native fishes were collected during those efforts. While native fishes may have once utilized the Riverside and Halfway Wash portions of the Virgin River, their use of the river below Halfway Wash was minimal. Data collected from 2001-2003 indicated that native fishes may no longer be present anywhere below Halfway Wash.

Additionally, Lake Mead provides a continual threat of nonnative species migrating upstream to areas where native fish still survive. Blue tilapia migrated as far upstream as RM 59.5 (above the Bunkerville Diversion) in 2001 and as far as the Bunkerville Diversion in 2002. Plans to minimize the threat of nonnative fishes to the native and endangered fishes of the Virgin River have centered on chemical treatment of the river in a downstream step-wise fashion starting in Utah (USFWS 1995). Treatment efforts to date have shown that a series of barriers will be needed to isolate segments of river for treatments to be effective. The Lower Virgin River Recovery Implementation Team (LVRRIT) has adopted the same philosophy for stopping the advance of blue tilapia in the Virgin River.

The area around Halfway Wash has often been considered one of the best places for a water diversion or fish barrier in the lower Virgin River. However, a barrier would isolate fishes in the area below it from the community above. If native fishes do not occupy the area below Halfway Wash, then a barrier in this area may be effective at keeping nonnative fishes from migrating upstream without negatively impacting native fish populations. The Southern Nevada Water Authority (SNWA) is considering several options to develop its water rights on the Virgin River below Halfway Wash. This water development may result in reduced flows below Halfway Wash. Additionally, water development may involve the placement of a diversion somewhere near Halfway Wash. In order to assist in evaluating the various alternatives for water development in the lower Virgin River, SNWA contracted BIO-WEST to survey the fish community from the Halfway Wash area to Lake Mead in 2004. Additional surveys were completed in 2005 after severe flooding and high spring runoff significantly altered habitat in the Lower Virgin River. The following report presents the results of that survey and compares those results to historical information on the fish community below Halfway Wash.

STUDY AREA DESCRIPTION

The study area for this project was the Virgin River from Halfway Wash to Lake Mead (RM 41.25-26.75, see map inset). Within the study area we found several distinct areas that could be sampled in 2004 (Table 1). In between those distinct areas were several places that were too overgrown with vegetation to be effectively sampled (see map inset). After the April 2004 sampling trip, we designated three smaller monitoring reaches within the study area for continued sampling in July and September 2004 (Table 2, map inset).

Table 1. Distinct sampling areas found within the Halfway Wash to Lake Mead study area on the Virgin River in April 2004.

Area	River Miles	UTM coordinates
Halfway Wash	41.5 - 38.75	4060341N, 740326E, 11S - 4056608N, 740040E, 11S
Overton Wildlife Management Area	37.0 - 33.25	4053694N, 739911E, 11S - 4047379N, 738361E, 11S
Virgin River Bowl	31.5 - 30.25	4044560N, 738540E, 11S - 4042221N, 738553E, 11S
Above Lake Mead	28.5 - 26.75	4040596N, 738452E, 11S - 4038143N, 738144E, 11S

Table 2. Smaller monitoring stations sampled within the study area after the April 2004 sampling trip.

Station	River Miles	UTM coordinates
Halfway Wash	41.5 - 40.0	4060341N, 740326E, 11S - 4058356N, 740202E, 11S
Overton Wildlife Management Area	36.0 - 34.0	4051766N, 739430E, 11S - 4048507N, 7378260E, 11S
Above Lake Mead	28.5 - 26.75	4040596N, 738452E, 11S - 4038143N, 738144E, 11S

In August 2005, we found that the vegetation and woody debris that had prevented sampling several areas in 2004 had been removed or circumvented by the flood. The new channel flowed continuously and unimpeded from Halfway Wash to Lake Mead (RM 41.25-27.0). Therefore, we designated new distinct sampling areas (Table 3) during our August 2005 sampling trip, and we sampled adjusted versions of the smaller sampling sites from July and September 2004 during our September 2005 sampling trip. In September 2005 we sampled the Halfway Wash sampling site from 2004 (RM 41.5-38.5), an adjusted Overton WMA sampling site (RM 37.0-35.0), and an expanded Above Lake Mead site (RM 29.5-27.0).

Table 3. Distinct sampling areas found within the Halfway Wash to Lake Mead study area on the Virgin River in August 2005.

Area	River Miles	UTM coordinates
Halfway Wash	41.5 - 37.5	4060551N, 740317E, 11S - 4054548N, 739441E, 11S
Overton Wildlife Management Area	37.5 - 33.5	4054548N, 739441E, 11S - 4047476N, 738986E, 11S
Virgin River Bowl	33.5 - 29.5	4047576N, 738986E, 11S - 4041495N, 739387E, 11S
Above Lake Mead	29.5 - 27.0	4041495N, 739387E, 11S - 4038436N, 737878E, 11S

METHODS

We performed three sampling trips in 2004 to characterize the current fish community in the study area. We conducted the first trip before spring runoff from April 26-29, 2004. During this trip we sampled the study area, except for several places that were too overgrown with vegetation to be effectively sampled (map inset).

Based on the results of the first sampling trip, we selected three stations to be sampled during the remaining summer and fall sampling trips (Table 2, map inset). We sampled the Halfway Wash, Overton Wildlife Management Area (WMA), and Above Lake Mead stations after spring runoff in July 2004 (July 8-9, 2004) and again in September 2004 (September 22-23, 2004).

Additionally, we conducted two sampling trips in 2005. In August 2005 (August 22-25, 2005) we sampled the entire river between Halfway Wash (RM 41.5) and Lake Mead (RM 27.0). In September 2005 (September 12-13, 2005) we sampled three stations similar to those sampled in 2004 and outlined in the description of the study area above.

Sampling methods were the same as those used in previous survey efforts in the lower Virgin River (Holden and Abate 1999, Holden and Golden 2000, Golden and Holden 2004). We used 1.2 m x 4.5 m x 3 mm seines to sample for fishes in a variety of habitats during all three sampling trips. During each trip we walked downstream and selected habitats based on availability and probable sampling efficiency for seines. Spatially, sampling was randomly applied within 0.25-mile (0.4-km) sections. Some sampling was conducted in adjacent habitats, whereas in long, consistent sections of stream, samples were separated by as much as 90 m.

We recorded the following information for each sample: sample number, river mile (in 0.25-mile [0.4-km] increments), reach, date and time of collection, habitat type, gear type, approximate length and width of the habitat sampled, average and maximum depths, the two dominant substrate types (silt, sand, fine gravel [< 25 mm diameter], coarse gravel [25-75 mm diameter], small cobble [75-150 mm diameter], large cobble [150-255 mm diameter], and boulder [> 255 mm diameter]), and cover availability. The total number of each fish species captured in each seine haul was recorded. When more than 50 red shiner were captured in a single seine haul, their numbers were estimated. We measured all native fish species for total length (mm) until 100 lengths for each species were obtained from each station. During each trip, we also measured the total length of a representative sample of nonnative fishes that we collected other than red shiner (*Cyprinella lutrensis*) and western mosquitofish (*Gambusia affinis*). Red shiner and western mosquitofish were not measured.

RESULTS

Discharge

Flows at the U.S. Geological Survey (USGS) gage on the Virgin River near Overton, NV (gage # 09415240), ranged between 50 and 75 cubic feet per second (cfs) during the April 2004 sampling trip (Figure 1). From April 2004 flows continually declined at the Overton gage, until the river went dry in early June 2004. Except for a few small storm events, the river remained dry at the Overton gage until mid August 2004, when a larger storm event elevated flows for approximately 2 weeks. After this storm event, flows remained near zero for the early part of September 2004. However, another storm event increased flow in mid September 2004. During our final sampling trip

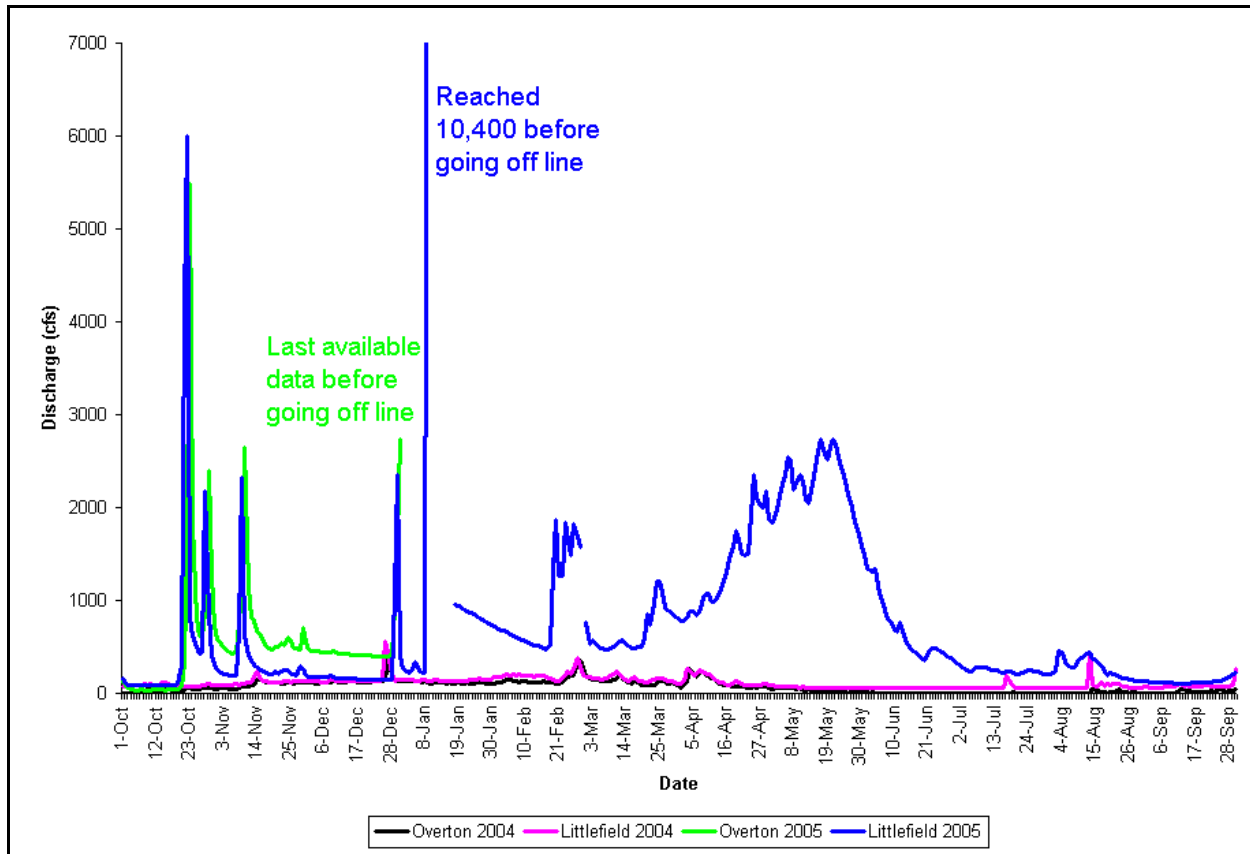


Figure 1. Average daily discharge^a recorded at the USGS gaging stations on the Virgin River near Overton, NV (09415240), and Littlefield, AZ (09415000), for water years 2004 and 2005 (October 1-September 30). ^aData are provisional.

(September 22-23, 2004) average daily discharge varied between 14 and 22 cfs. Continued storm events and increased base flows upstream resulted in higher flows at the Overton, NV, gage for the remainder of 2004. Flows at the Overton gage mirrored flows at the Littlefield, AZ, gage upstream during high flow events. During lower flows the Overton gage showed flows 40-50 cfs lower than the Littlefield gage, reflecting the irrigation withdrawals for Mesquite, Bunkerville, and Riverside, NV.

A large flood event in January 2005 damaged the Littlefield gage and completely destroyed the Overton gage. Peak flow estimates for the flood event were between 35,000-40,000 cfs. Flows at the Littlefield gage stayed over 200 cfs into August 2005. Flows at the Littlefield gage during our August 2005 sampling trip were between 125 cfs and 150 cfs, compared with about 65cfs when we sampled in August 2004. Flows at Littlefield during our September 2005 sampling trip ranged between 100 cfs and 110 cfs, compared with about 125 cfs when we sampled in September 2004. Visual observations suggested that flows in the study area during our August 2005 sampling trip were higher than any flows we saw in the study area between July and September 2004. Flows in September 2005 appeared similar to those in September 2004.

April 2004 Fisheries Survey

Habitat

We sampled the Virgin River from Monday April 26, 2004, through Thursday April 29, 2004. We attempted to sample all of the river from Halfway Wash to Lake Mead. Using the historic river miles from the USGS 1:24,000 quads, nearly 14.5 miles (23.34 km) of river were present below Halfway Wash, from just below RM 41.5 to just above RM 26.75. We found several areas where the river could not be sampled, because of extensive vegetation growth in the channel. Below we outline the general habitat features we observed during the April 2004 sampling trip.

From RM 41.5 to 39.5, the river channel was fairly wide and predominated by riffles and runs. A few areas within this 2-mile (3.22-km) section had an incised narrow channel with dense stands of salt cedar (*Tamarix* sp.) lining the banks. However, the majority of this section had a variety of depths and even some island complexes within the active channel.

Below RM 39.0 the river channel started to become braided with multiple small channels splitting off to run through stands of vegetation. The braided sections alternated between smaller channels with lots of inundated woody debris (dead tamarisk) and broad shallow areas with clear water for less than 0.2 mile (0.32 km) before branching into multiple channels that spread out and inundated a field of dense live and dead tamarisk. By RM 38.75 no major channel was distinguishable, and sampling became impossible because of heavy vegetation (mainly salt cedar) growth in the channel. Below the field of inundated tamarisk, the river was choked with woody debris in deep run areas that were separated by pools > 1 m deep until approximately RM 37.0.

From RM 37.0 to RM 36.25, the river had deep pools separated by longer runs with some woody debris in the channel, but we were able to sample this area. At RM 36.25 the channel began to widen and develop some riffle/run complex areas. However, at RM 35.25 the channel narrowed and was entrenched approximately 5 meters (m) below the floodplain. Here the habitat alternated between deep runs and pools. From RM 35.0 to RM 33.5 the channel widened again and showed a complexity of riffle, run, and pool habitats. Between RM 33.5 and RM 33.25, the floodplain became level with the active river channel.

When Lake Mead was close to full pool in the 1990s, the confluence of the Virgin River with Lake Mead was probably near RM 33.5. Therefore, much of the area referred to as “floodplain” in the description of the remaining habitat was actually lake bed at full pool elevation. Small channels began to braid off until the entire remaining channel flowed into a forest of salt cedar near RM 33.25. We followed the remains of the channel through the salt cedar until the channel completely dissipated in a field of cattails (*Typha* spp.) and dead salt cedar. The cattails were inundated for at least 0.25 mile (0.4 km) or more across the floodplain, with no distinct active river channel. Live and dead salt cedar was interspersed among the cattails. The active channel slowly began to congeal near RM 32.0, and an active channel that could be sampled resurfaced near RM 31.75.

Below RM 31.75 the river bottom was comprised of uneven, hard clay, which appeared to be the result of repeated drying. Cattails and salt cedar lined the banks and frequently encroached on the active channel. Habitat consisted mainly of long, homogenous runs that were interrupted by encroaching vegetation. Near RM 30.5 cattails became a common feature in the active channel, and by RM 30.25 the river had braided into another inundated field of cattails.

The river remained a wide plain of cattails until somewhere near RM 28.75. Below RM 28.75 the active channel was narrow and entrenched up to 5 m. The active channel consisted of a series of shallow runs and pools. Occasionally cattails encroached into the active channel in this section of river. The vegetation along the active channel was dominated by cattails, but the raised floodplain was dominated by salt cedar. Moving downstream the active channel remained entrenched, but the height of the raised floodplain decreased progressively until the active channel finally began to spread out a bit near RM 27.25. The habitat within the active channel here was still dominated by shallow runs and pools. Immediately above Lake Mead, the active channel fanned out and became very shallow. Cattails were common in the active channel in this area.

Fishes

We found one native fish, a young-of-the-year (YOY) (46 mm) flannemouth sucker during April 2004 sampling (Table 4). We collected the flannemouth sucker near RM 35.5.

Table 4. Number of seine hauls pulled and fish collected by species from each area during April 2004 sampling.

Area	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	TL ⁱ
Above Lake Mead	53	767	0	1	27	0	0	28	711	0
Virgin River Bowl	30	1,219	0	0	238	0	0	396	585	0
Overton Wildlife Management Area	119	2,199	0	0	1	1	0	162	2,035	0
Halfway Wash	56	716	0	0	0	0	0	0	716	0
TOTAL NUMBER	258	4,901	0	1	266	1	0	586	4,047	0

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e FM = flannemouth sucker

^f LB = largemouth bass

^g MF = western mosquitofish

^h RS = red shiner

ⁱ TL = blue tilapia

Red shiner dominated the catch in all the areas we sampled in April 2004 (Figure 2). Red shiner was the only species collected in the Halfway Wash area. As we moved downstream, we collected a wider diversity of fishes including western mosquitofish, common carp (*Cyprinus carpio*), and channel catfish (*Ictalurus punctatus*). Western mosquitofish made up a substantial portion of the catch in the Overton WMA and Virgin River Bowl stations. The YOY common carp were a large part of the catch in the Virgin River Bowl station, too (Figure 3). Over 95% of the common carp collected in April 2004 were smaller than 100 mm.

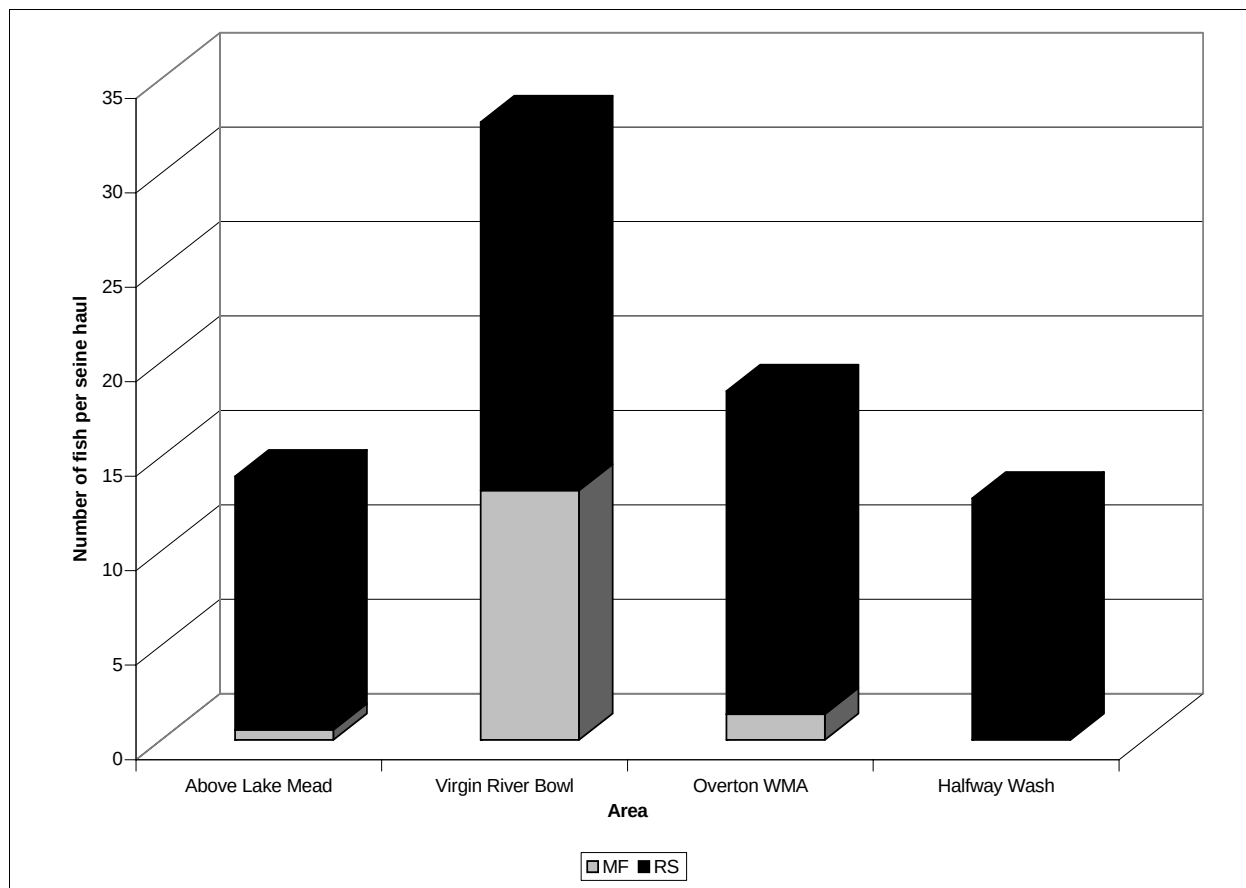


Figure 2. Number of red shiner and western mosquitofish collected per seine haul in each area sampled during April 2004. MF = western mosquitofish, RS = red shiner.

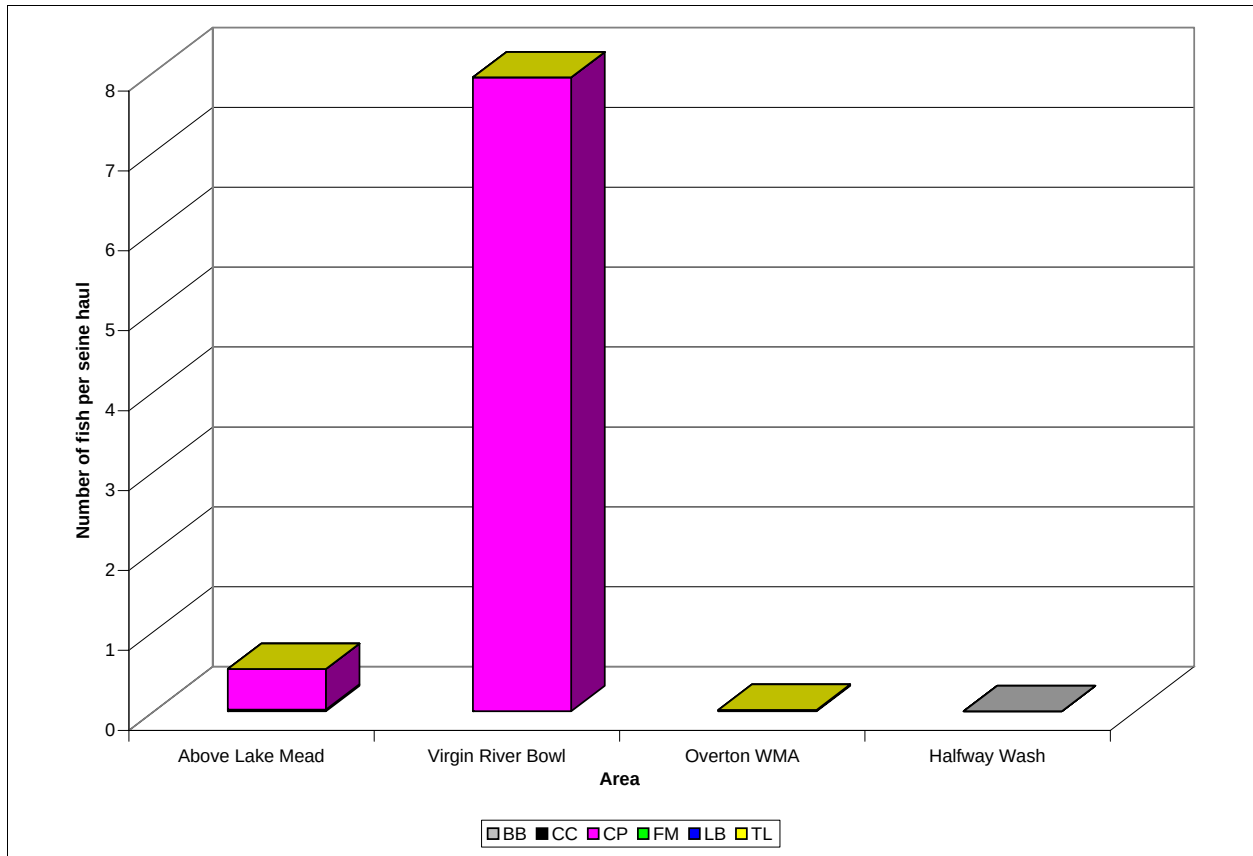


Figure 3. Number of species other than red shiner and western mosquitofish collected per seine haul in each area sampled during April 2004. BB = black bullhead, CC = channel catfish, CP = common carp, FM = flannemouth sucker, LB = largemouth bass, TL = blue tilapia.

July 2004 Fisheries Survey

Habitat

Based on our April 2004 trip, we set up three 1-2 mile (1.6-3.22 km) stations for continued fisheries investigations in July 2004 and September 2004 (Table 2, map inset). However, when we went to sample those stations in July 2004, we found that the river channel had dried near the bottom of our Halfway Wash station (RM 40.5, map inset). We walked the length of the Overton WMA station, investigated the Virgin River Bowl area, and found that the river channel was dry from RM 40.5 to RM 30.25. The entire Above Lake Mead station had water in the channel. Somewhere in the field of cattails between RM 30.25 and RM 28.5, the river resurfaced. During the July 2004 sampling trip, habitat in the Halfway Wash station was reduced over the April 2004 sampling trip. Water depths were shallow, and water clarity was high. Habitat was similarly reduced in the Above Lake Mead station during the July 2004 sampling trip.

Fishes

We did not collect any native fishes during the July 2004 sampling trip (Table 5). Red shiner dominated the catch at the Halfway Wash station, and western mosquitofish dominated the catch at the Above Lake Mead station (Figure 4). We collected one common carp at the Halfway Wash station, but the remaining fish were all red shiner and western mosquitofish. The Above Lake Mead Station had a wider diversity of fish contributing to the catch (Figure 5). We collected a substantial number of common carp in the Above Lake Mead station, as well as 12 YOY blue tilapia. A larger portion of the common carp collected in the July 2004 trip were large adult fish. We had several seine hauls where we collected four or more common carp larger than 400 mm in the Above Lake Mead station. The mean size of blue tilapia collected during the July 2004 sampling trip was 28.5 mm (range 20-36 mm).

Table 5. Number of seine hauls pulled and the number of fish collected by species in each station during the July 2004 sampling trip.

Station	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	TL ⁱ
Above Lake Mead	24	1,181	0	12	80	0	1	656	420	12
Virgin River Bowl	DRY	0	0	0	0	0	0	0	0	0
Overton Wildlife Management Area	DRY	0	0	0	0	0	0	0	0	0
Halfway Wash	20	2,808	0	0	1	0	0	341	2,466	0
TOTAL NUMBER	44	3,989	0	12	81	0	1	997	2,886	12

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e FM = flannelmouth sucker

^f LB = largemouth bass

^g MF = western mosquitofish

^h RS = red shiner

ⁱ TL = blue tilapia

September 2004 Fisheries Survey

Habitat

In September 2004 water was present at all three of the stations we proposed to sample. However, flows were lower than during the April 2004 sampling trip. We saw little difference in habitat at the Halfway Wash station from that seen during July 2004 sampling, except that the river did not dry up within the station. The habitat in the Overton WMA station was similar to the habitat found there during the April 2004 sampling trip, except that water depths were considerably lower and water clarity was higher. The Above Lake Mead station appeared to have similar habitat, too, except that thick green algae was present throughout the station, which made sampling difficult.

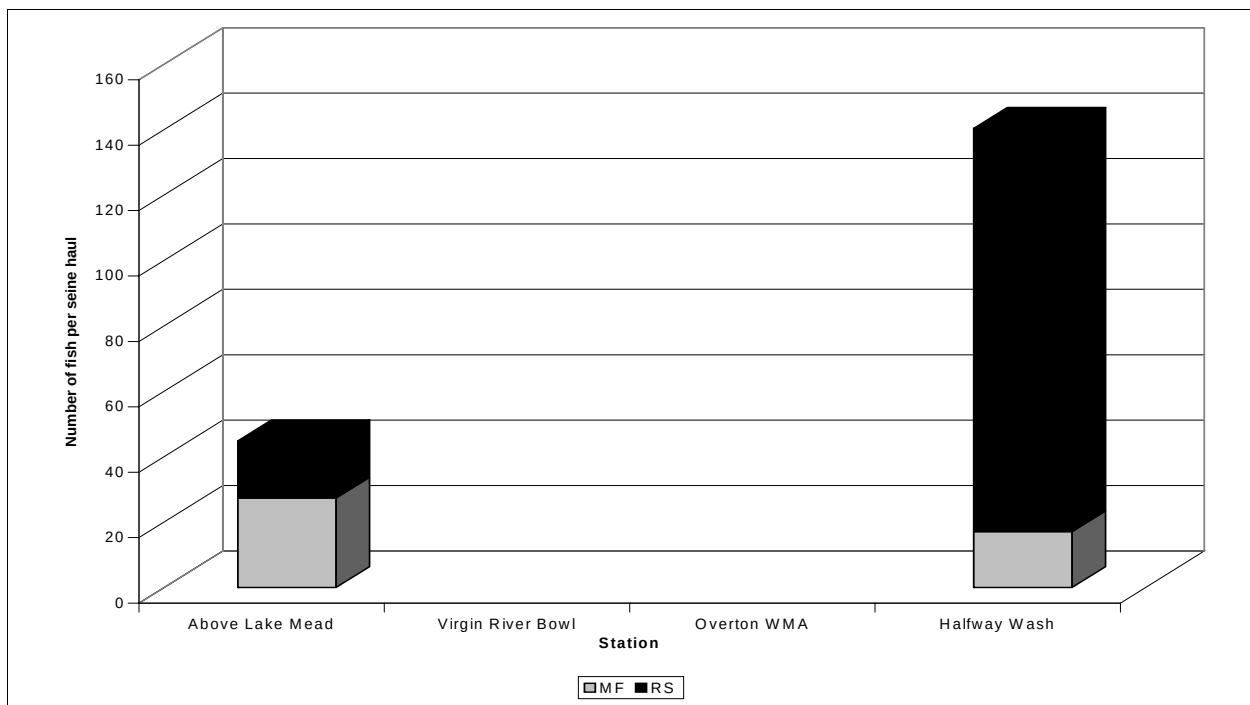


Figure 4. Number of red shiner and western mosquitofish collected per seine haul in each station sampled during July 2004. MF = western mosquitofish, RS = red shiner.

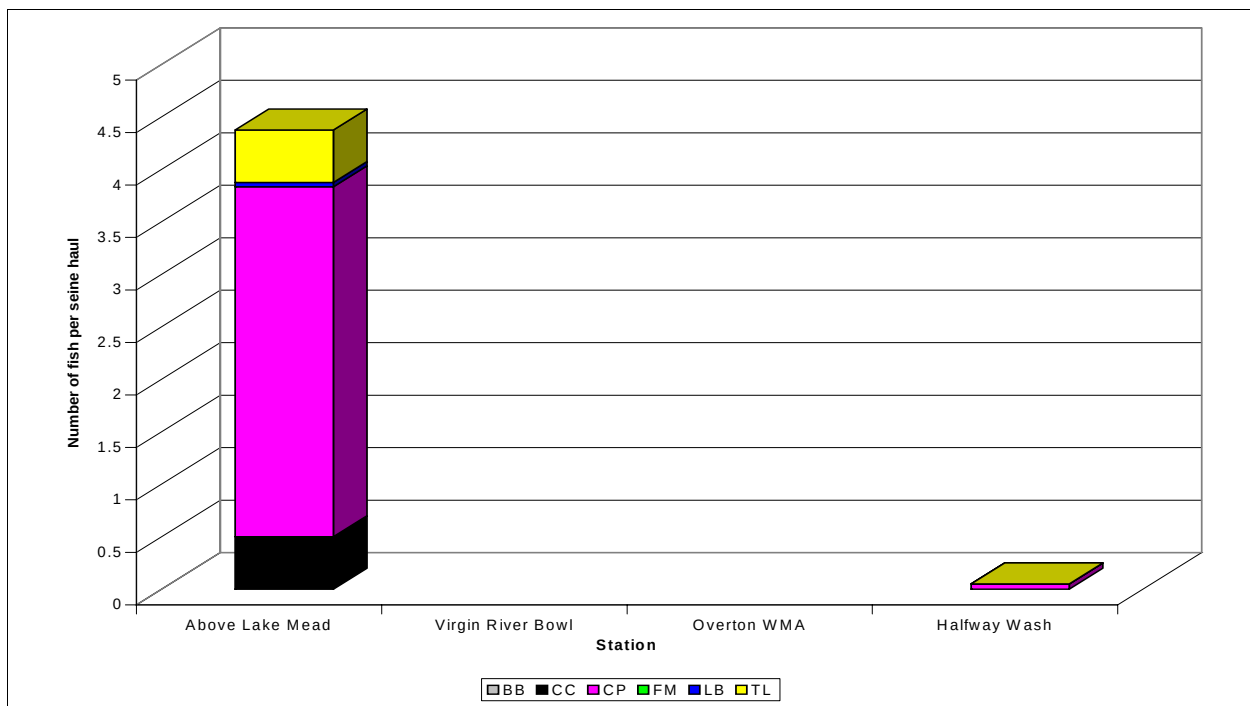


Figure 5. Number of species other than red shiner and western mosquitofish collected per seine haul in each station sampled during July 2004. BB = black bullhead, CC = channel catfish, CP = common carp, FM = flannemouth sucker, LB = largemouth bass, TL = blue tilapia.

Fishes

Again, we collected no native fishes at any of the stations during the September 2004 monitoring trip (Table 6). Collections at the Halfway Wash and Overton WMA stations were dominated by red shiner, while the Above Lake Mead station collection was dominated by western mosquitofish (Figure 6). Few fishes representing other species were collected at the Overton WMA or Halfway Wash stations (Figure 7). However, common carp were numerous at the Above Lake Mead station. We collected nine blue tilapia in the Above Lake Mead station in September 2004, too. Blue tilapia averaged 97.5 mm (range 27-126 mm).

Table 6. Number of seine hauls pulled and fish collected by species in each station during the September 2004 sampling trip.

Station	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	TL ⁱ
Above Lake Mead	19	6,991	0	0	23	0	0	6,576	383	9
Overton Wildlife Management Area	66	1,499	1	0	3	0	0	214	1,281	0
Halfway Wash	24	2,753	0	3	3	0	0	621	2,126	0
TOTAL NUMBER	109	11,243	1	3	29	0	0	7,411	3,790	9

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e FM = flannelmouth sucker

^f LB = largemouth bass

^g MF = western mosquitofish

^h RS = red shiner

ⁱ TL = blue tilapia

August 2004 Blue Tilapia Monitoring

In addition to the three sampling trips conducted to describe the current fish community below Halfway Wash in 2004, BIO-WEST also sampled the Above Lake Mead station and a portion of the Virgin River Bowl area (RM 31.5 - 30.25) on August 19, 2004. The purpose of this trip was to determine whether blue tilapia found at the Above Lake Mead station during the July 2004 sampling trip were moving upstream. Sampling methods were similar to those mentioned earlier, except that we targeted low-velocity habitats, where we thought blue tilapia would reside. Since the results of this sampling trip provided additional information on the fish community in the study area, those results follow.

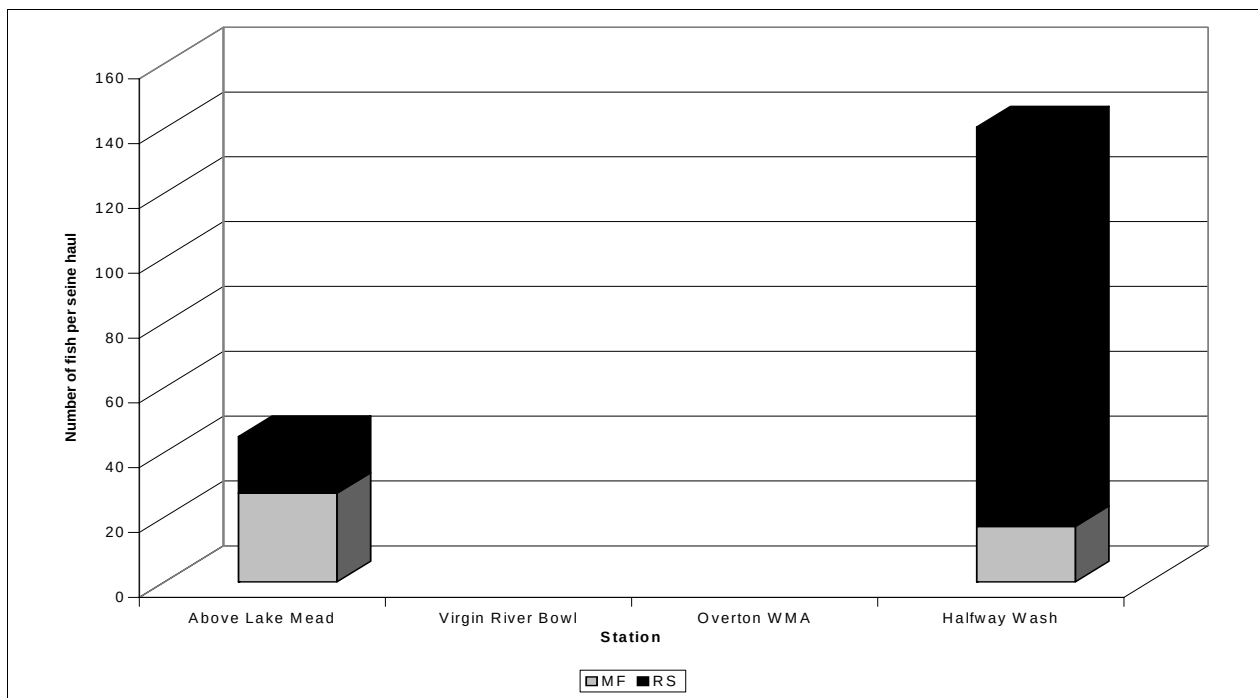


Figure 6. Number of red shiner and western mosquitofish collected per seine haul in each station sampled during September 2004. MF = western mosquitofish, RS = red shiner.

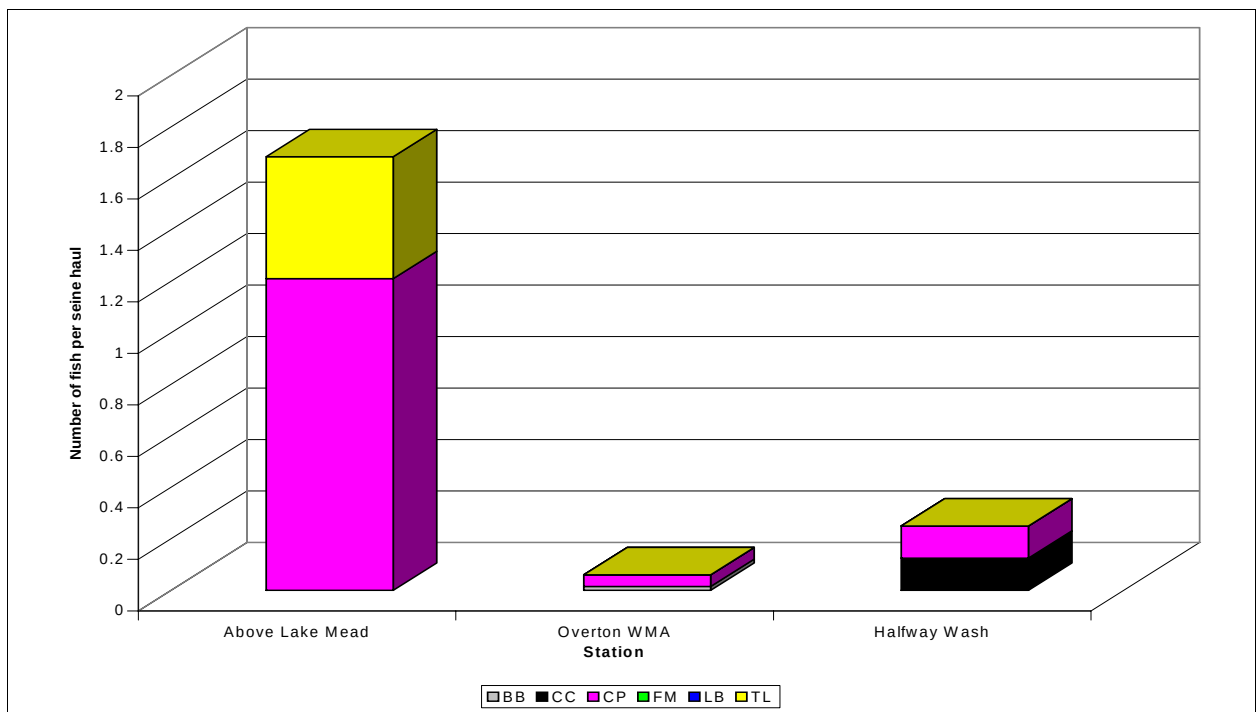


Figure 7. Number of species other than red shiner and western mosquitofish collected per seine haul in each station sampled during September 2004. BB = black bullhead, CC = channel catfish, CP = common carp, FM = flannemouth sucker, LB = largemouth bass, TL = blue tilapia.

Habitat

A spate event on August 13, 2004, contributed to the first flow past the USGS gage near Overton, NV, since mid July 2004. During the August 19, 2004, sampling trip, a small amount of water was still flowing in the Virgin River Bowl. However, the flows were extremely low and clear. Habitat was poor because of the shallow, clear water. Habitat at the Above Lake Mead station appeared unchanged from the July 2004 sampling trip. While the amount of algae had increased dramatically since that trip, it was not yet as dense as the algae we saw in September 2004.

Fishes

No native fishes were collected in the Above Lake Mead station or the portion of the Virgin River Bowl that we sampled (Table 7). We collected very few fish in the Virgin River Bowl, the majority of which were western mosquitofish. Western mosquitofish dominated the catch at the Above Lake Mead station, too (Figure 8). Red shiner were the second most abundant fish in the catch at the Above Lake Mead station in August 2004. Blue tilapia, common carp, and channel catfish comprised a smaller portion of the catch (Figure 9). We collected higher numbers (75) of blue tilapia in August 2004 than we did in July 2004 or September 2004. Average total length of blue tilapia collected in August 2004 was 61 mm (range 19-98 mm, Figure 10).

Table 7. Number of seine hauls pulled and fish collected by species in the Above Lake Mead station and a portion of the Virgin River Bowl (RM 31.5-30.25) during blue tilapia monitoring in August 2004.

Station	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	TL ⁱ
Above Lake Mead	31	6,087	0	11	47	0	0	5,557	397	75
Virgin River Bowl	18	20	0	0	1	0	0	16	3	0
TOTAL NUMBER	49	6,107	0	11	48	0	0	5,573	400	75

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e FM = flannemouth sucker

^f LB = largemouth bass

^g MF = western mosquitofish

^h RS = red shiner

ⁱ TL = blue tilapia

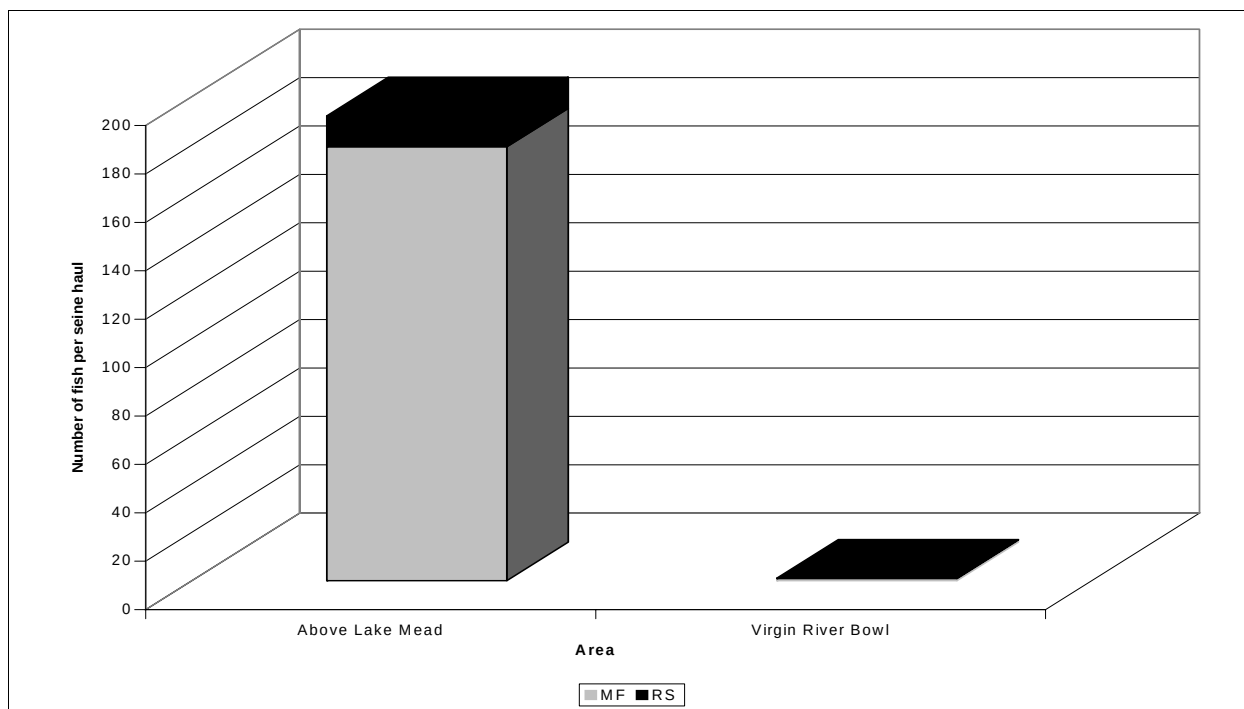


Figure 8. Number of red shiner and western mosquitofish collected per seine haul in the Above Lake Mead station and a portion of the Virgin River Bowl (RM 31.5-30.25) during blue tilapia monitoring in August 2004.

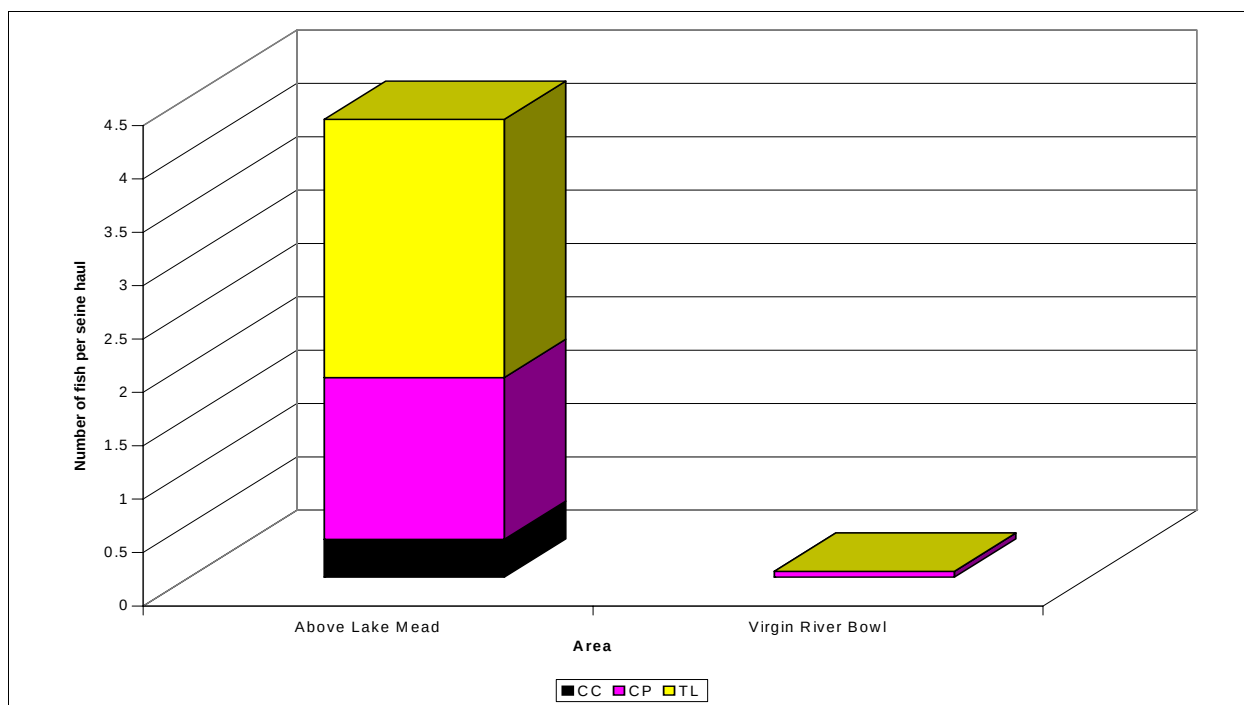


Figure 9. Number of species other than red shiner and western mosquitofish collected per seine haul in the Above Lake Mead station and a portion of the Virgin River Bowl (RM 31.5-30.25) during blue tilapia monitoring in August 2004.

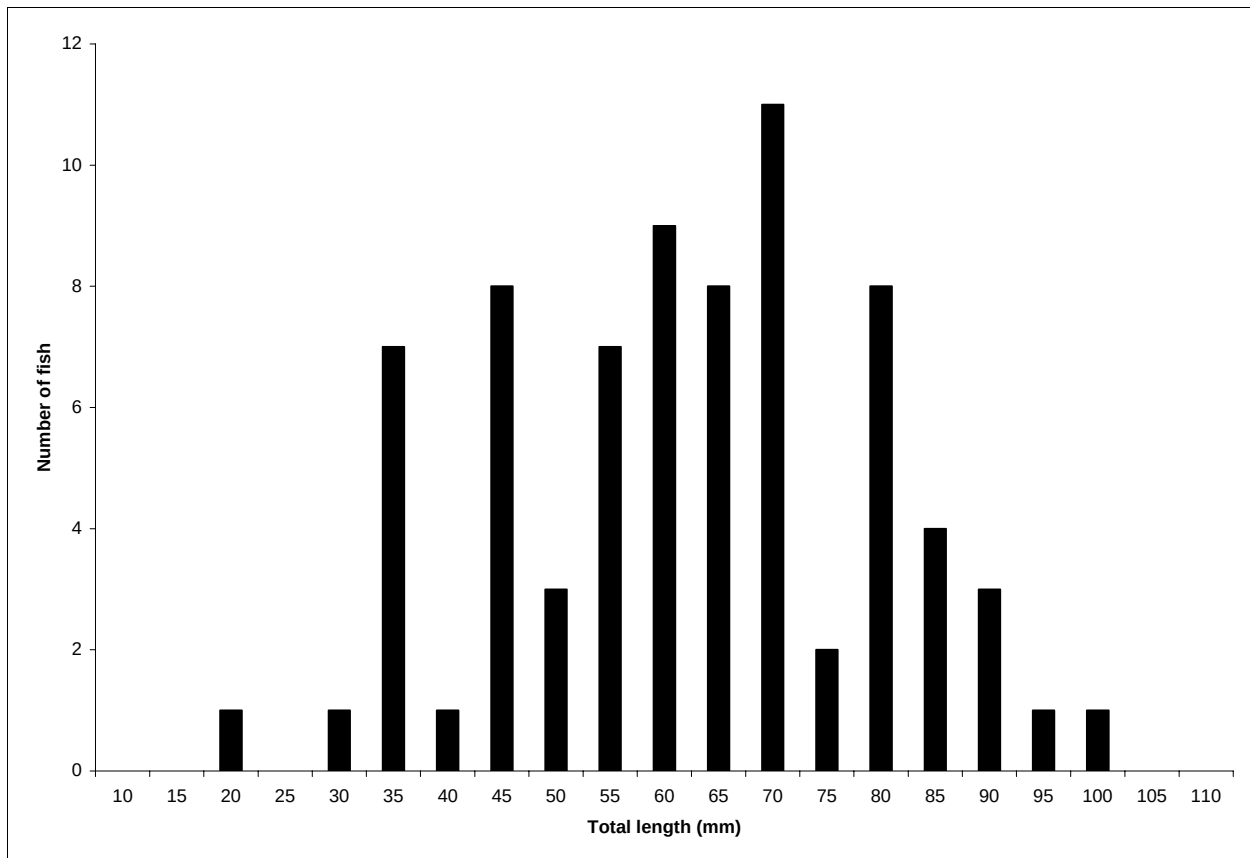


Figure 10. Length frequency distribution of blue tilapia collected in the Above Lake Mead station during blue tilapia monitoring in August 2004.

August 2005 Fisheries Survey

Habitat

When we sampled the study area in August 2005, we found that the high flows of late 2004 and early 2005 had changed the habitat throughout the study area dramatically. Most notably, the river flowed uninterrupted from Halfway Wash to Lake Mead. The areas of dense vegetation between Halfway Wash and the Overton WMA, Overton WMA and the Virgin River Bowl, and the Virgin River Bowl and Fisherman's Cove were no longer an impediment to sampling. In fact, they had either been blown out or the channel had down cut below those areas of vegetation. The high flows also increased the complexity of the channel throughout the majority of the study area. The width of the active channel was increased to several hundred feet in many places, giving rise to multiple wetted channels.

From Halfway Wash to RM 37.5, the active channel was much wider than it had been in 2004. In many spots the wetted channel was split into multiple channels, all of which were fairly shallow. While coarse gravel and small cobble were more abundant than in 2004, sand was still the dominant substrate. In 2004 the active channel migrated from the northwestern side of the floodplain to the southeastern side of the floodplain between RM 39.0 and RM 38.5. The location of the active channel in August 2005 was very similar to the historic channel (map inset). The river stayed on the northwestern side of the floodplain after RM 39.0 and did not migrate to the opposite side until RM 38.0. The new channel was free from both live and dead vegetation between RM 39.0 and RM 37.5.

From RM 37.5 to RM 35.5, the active channel remained wide and shallow, with little to no live or dead vegetation in the channel. However, between RM 35.5 and RM 33.5 the channel remained very entrenched (up to 5 m), similar to 2004. In this area of the river we began to find more woody debris and dead tamarisk in the active channel. Between RM 34.0 and RM 33.5 there were several 100-m-long areas that had dense, dead tamarisk in the active channel.

From RM 33.5 to RM 33.0, the river remained fairly entrenched (5-8 m) with a narrow channel. The river was entrenched well below the dense cattails and dead tamarisk that clogged the channel in 2004. While the river remained entrenched below this level down to RM 32.0, the active channel widened and the wetted channel began to split into multiple channels again.

From RM 32.0 to RM 29.5, the active channel remained entrenched, but it was wide enough to have multiple wetted channels within it. The dense cattails seen below RM 30.25 in 2004 were blown out or left stranded on higher ground during flooding in 2005.

Similarly, the area from RM 29.5 to RM 28.5, which had been impassable because of dense vegetation in 2004, had also been cleared by the flooding. From RM 29.5 to the confluence with Lake Mead the river had a fairly wide channel with a wide, flat floodplain that was only a few feet above the active channel.

Fishes

We only collected two native fishes during our full pass from Halfway Wash to Lake Mead. (Table 8). Both the fish were speckled dace (46 mm and 52 mm) and were found between RM 35.0 and RM 34.5. Red shiner and western mosquitofish dominated the catch rate throughout the study area, and their catch rate did not appear to be appreciably reduced over what we saw in September 2004 (Figure 11). We found a wider variety of other nonnative fishes in August 2005 than we had in September 2004. Most notably, we collected two striped bass (*Morone saxatilis*) during the August 2005 survey. Striped bass are abundant in Lake Mead, but to our knowledge they have not been collected in the Virgin River prior to this survey. One of the striped bass measured 99 mm, and the second was not measured. They were collected at RM 28.0 and RM 36.25.

Table 8. Number of seine hauls pulled and fish collected by species in the full pass from Halfway Wash to Lake Mead in August 2005.

Area	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	SB ⁱ	SD ^j	TL ^k
Above Lake Mead	38	4,068	12	35	37	0	3	456	3,521	1	0	4
Virgin River Bowl	89	4,091	7	33	30	0	6	75	3,931	0	0	9
Overton Wildlife Management Area	103	6,070	11	32	20	0	1	851	5,151	1	2	1
Halfway Wash	135	10,581	38	19	13	0	1	649	9,860	0	0	1
TOTAL NUMBER	365	24,810	68	119	100	0	11	2,031	22,463	2	2	15

^aTotal = all species

^bBB = black bullhead

^cCC = channel catfish

^dCP = common carp

^eFM = flannemouth sucker

^fLB = largemouth bass

^gMF = western mosquitofish

^hRS = red shiner

ⁱSB = striped bass

^jSD = speckled dace

^kTL = blue tilapia

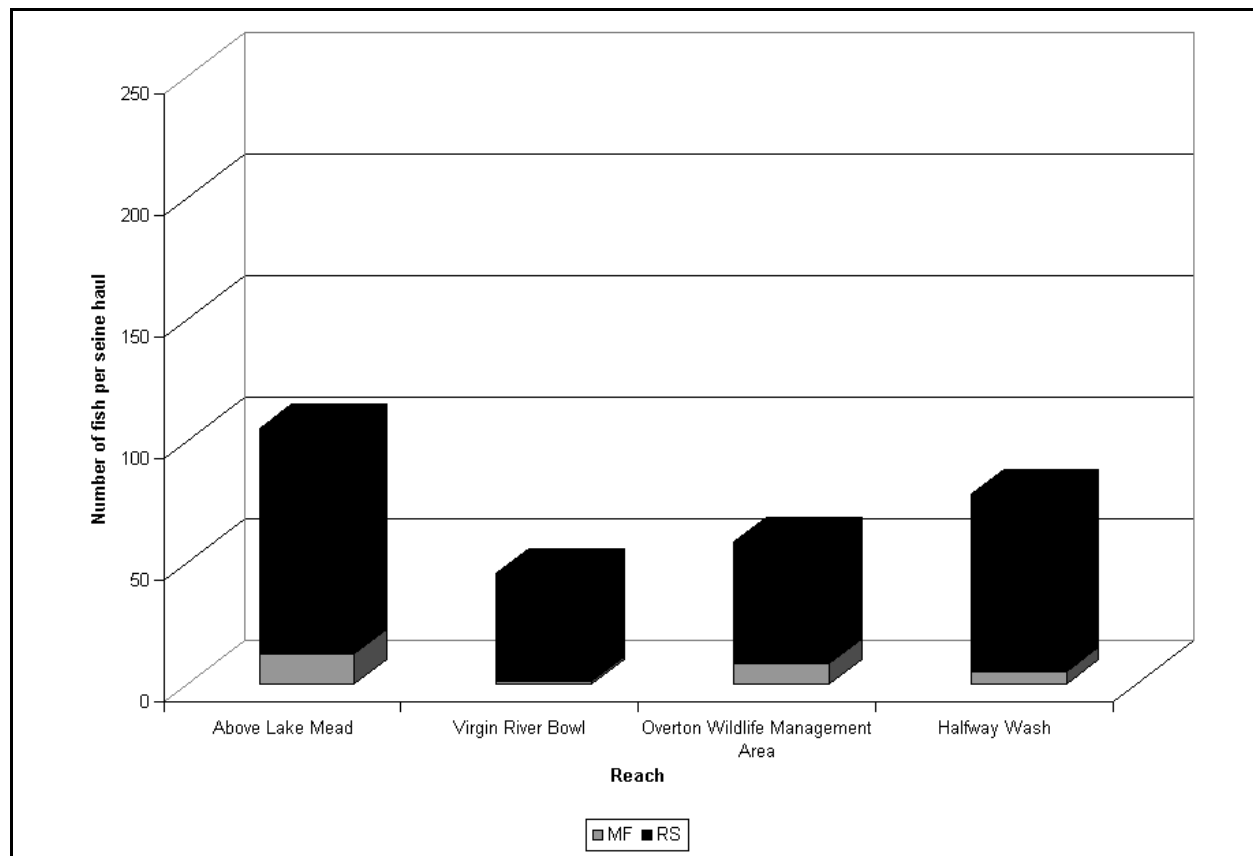


Figure 11. Number of red shiner and western mosquitofish collected per sample during the August 2005 full pass from Halfway Wash to Lake Mead. RS = red shiner and MF = western mosquitofish.

In addition to striped bass we also collected 15 blue tilapia throughout the study area in August 2005. We found blue tilapia from RM 27.25 to RM 40.5 in August 2005, whereas they seemed to be restricted to the area immediately below RM 29.0 during the 2004 surveys. The blue tilapia averaged 92 mm in length (range 58 mm-142 mm).

Channel catfish, common carp, and black bullhead (*Ameiurus melas*) were the next three most abundant species in the catch after red shiner and western mosquitofish (Figure 12). Catch rates of black bullhead and channel catfish were higher in August 2005 than they had been in 2004 surveys. While most of the black bullhead, channel catfish, and common carp we collected were YOY, we did collect several adults of each species, including a 460 mm channel catfish and a 439 mm common carp. We also collected a few largemouth bass (*Micropterus salmoides*).

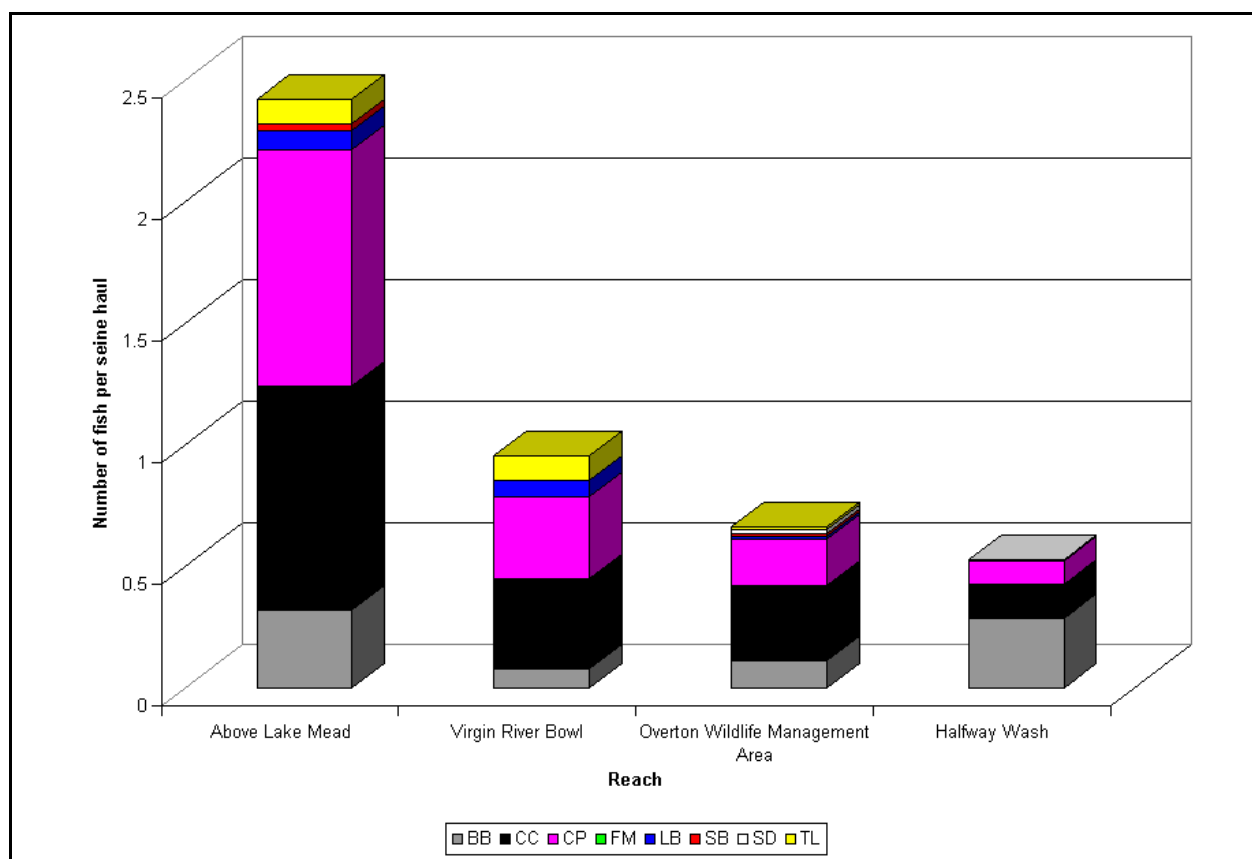


Figure 12. Number of fishes other than red shiner and western mosquitofish collected per sample during the August 2005 full pass from Halfway Wash to Lake Mead. BB = black bullhead, CC = channel catfish, CP = common carp, GS = green sunfish, LB = largemouth bass, TL = blue tilapia.

September 2005 Fisheries Survey

Habitat

In September 2005, we found that habitat was similar to what we had seen in August 2005. Flows were slightly lower, so depths at all of the sampling sites were lower than we saw in August 2005. The only major habitat difference we observed between August 2005 and September 2005 was that a portion of the river channel was dry between RM 37.5 and RM 36.5 in September. We had observed that a portion of the flow left the channel and entered dense stands of tamarisk on river left near RM 37.5 in August 2005. This flow then re-emerged against a cliff on river left near RM 36.5. Apparently, all the flow either left the main channel or went subsurface near RM 37.5 in August 2005. As in August 2005 flow re-emerged against a cliff on river left near RM 36.5.

Fishes

We did not collect any native fishes during our September 2005 surveys below Halfway Wash, in Overton WMA, or above Lake Mead (Table 9). As in August 2005, red shiner and western mosquitofish dominated the catch (Figure 13). Common carp and channel catfish were the next most abundant fishes in the catch (Figure 14), but catch rates of these two species, along with black bullhead, were considerably lower than we saw in August 2005. Once again we collected striped bass and blue tilapia in September 2005. During the September 2005 survey both of these species were restricted to the area immediately above Lake Mead (below RM 29.5). We collected nine striped bass, at an average size of 91 mm (range 76 mm-118 mm). We only collected one blue tilapia (total length 75 mm).

Table 9. Number of seine hauls pulled and fish collected by species in each station during the September 2005 sampling trip.

Station	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	SB ⁱ	SD ^j	TL ^k
Above Lake Mead	50	3,065	0	21	23	0	1	136	2,874	9	0	1
Overton Wildlife Management Area	43	8,736	0	0	2	0	0	683	8,051	0	0	0
Halfway Wash	40	4,824	1	1	1	0	0	267	4,554	0	0	0
TOTAL	133	16,625	1	22	26	0	1	1,086	15,479	9	0	1

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e FM = flannelmouth sucker

^f LB = largemouth bass

^g MF = western mosquitofish

^h RS = red shiner

ⁱ SB = striped bass

^j SD = speckled dace

^k TL = blue tilapia

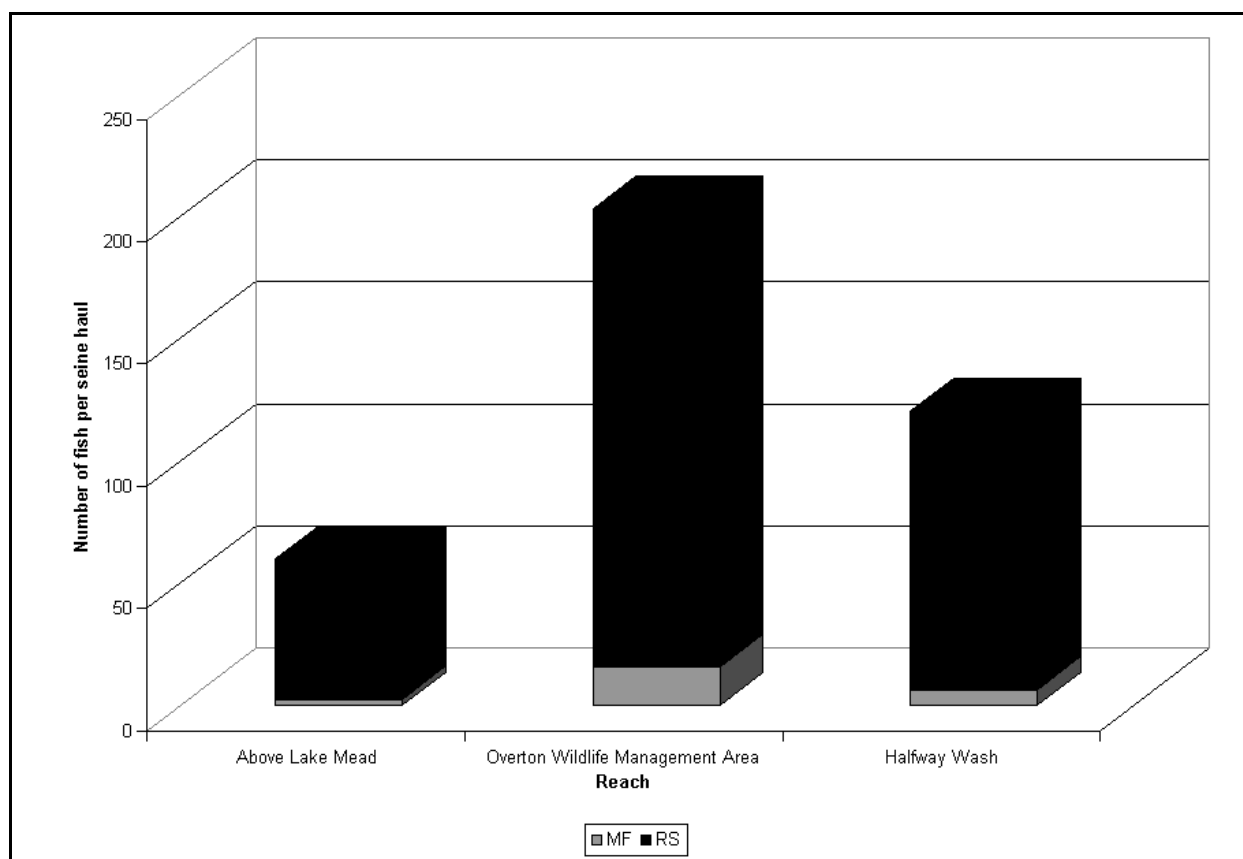


Figure 13. Number of red shiner and western mosquitofish collected per sample during the September 2005 fisheries survey. RS = red shiner and MF = western mosquitofish.

COMPARISONS TO HISTORIC INFORMATION

BIO-WEST Sampling

BIO-WEST has collected a variety of fish community information on the Virgin River for the SNWA since 1993. From 1993-1996 BIO-WEST characterized the fish community of the Virgin River from Halfway Wash to Lake Mead (Holden and Abate 1999). During those studies BIO-WEST surveyed as far downstream as RM 34.5. The influence of Lake Mead made it impracticable to sample any further downstream than this. Therefore, 1993-1996 sampling trips provide fish community information about the Halfway Wash and Overton WMA stations 8 to 12 years prior to the information we collected in 2004 and 2005. Since 2001 BIO-WEST has sampled portions of the Halfway Wash station as part of an effort to monitor blue tilapia distribution and abundance in the lower Virgin River (Holden and Golden 2004). In 2003 portions of the Virgin Bowl area and the Overton WMA stations were sampled as part the same effort to monitor blue tilapia distribution and abundance.

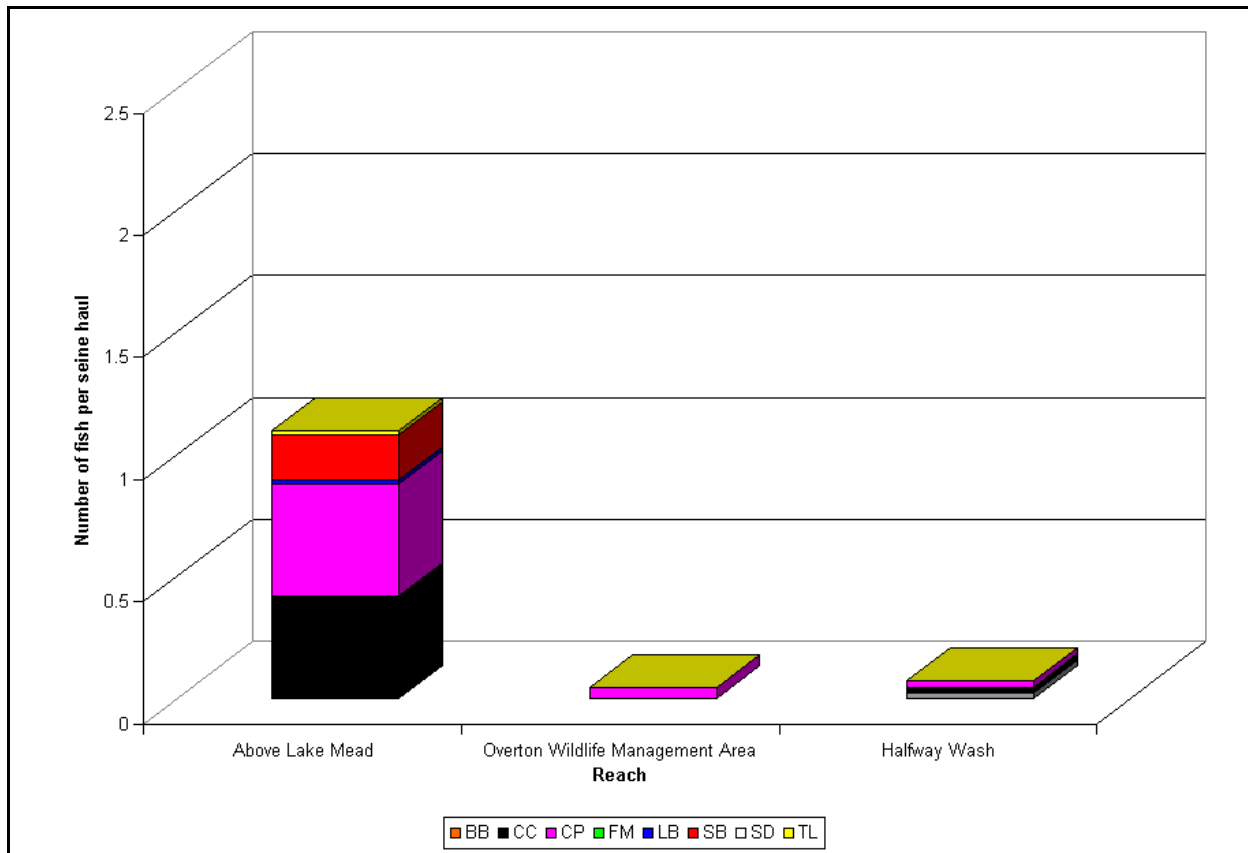


Figure 14. Number of fishes other than red shiner and western mosquitofish collected per sample during the September 2005 fisheries survey. BB = black bullhead, CC = channel catfish, CP = common carp, GS = green sunfish, LB = largemouth bass, TL = blue tilapia.

Sampling in the Virgin River Bowl in 2003, 2004, and 2005 did not find any native fishes (Table 10), and only three species of nonnative fish were found in this area in 2003 and 2004. In 2005 we collected four additional species of nonnative fish in the Virgin River Bowl including blue tilapia. The higher species richness found in the Virgin River Bowl in 2005 is probably attributable to the fact that this section did not go dry during summer 2005, as it did in 2004 and presumably did in 2003. The lower numbers seen in 2003 are probably the result of our sampling in January when cold water temperatures reduce capture efficiency.

Similarly, we saw very low numbers of fish in collections within our Overton WMA station in 2003, which may also be a result of cold temperatures reducing our capture efficiency (Table 8). Sampling in 1993 found that flannelmouth sucker and speckled dace were present in low numbers in this area. Both of these species were also collected in this area during the 2004 and 2005 sampling (Table 11). All three native fishes collected in 1993 were found between RM 36.0-RM 35.75. Similar to the single flannelmouth sucker collected in this area during the 2004 surveys, all of the native fishes collected in 1993 were YOY.

Table 10. Number of seine hauls pulled and fish collected by species in a portion of the Virgin River Bowl (RM 31.5 - 30.25) in 2003, 2004, and 2005.

Year	Seine hauls	Total ^a	BB ^b	CC ^c	CP ^d	LB ^e	MF ^f	RS ^g	TL ^h
2003	39	99	0	0	0	0	60	39	0
2004	48	1,239	0	0	239	0	412	588	0
2005	89	4,091	7	33	30	6	75	3,931	9

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e LB = largemouth bass

^f MF = western mosquitofish

^g RS = red shiner

^h TL = blue tilapia

Table 11. Number of seine hauls pulled and fish collected by species in the Overton Wildlife Management station in 1993, 2003, 2004, and 2005.

Year	Seine hauls	Total ^a	BB ^b	CC ^c	CP ^d	FM ^e	LB ^f	MF ^g	RS ^h	SB ⁱ	SD ^j	TL ^k
1993	13	1,969	0	27	140	2	4	6	1,789	0	1	0
2003	14	13	0	0	0	0	0	4	9	0	0	0
2004	185	3,698	1	0	4	1	0	376	3,316	0	0	0
2005	146	14,806	11	32	22	0	1	1,534	13,202	1	2	1

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e FM = flannemouth sucker

^f LB = largemouth bass

^g MF = western mosquitofish

^h RS = red shiner

ⁱ SB = striped bass

^j SD = speckled dace

^k TL = blue tilapia

BIO-WEST has sampled the Halfway Wash station substantially more often than any areas downstream from it since 1993 (Table 12). Sampling efforts in 1993 found woundfin and Virgin River chub present in low numbers around Halfway Wash. Similarly, sampling efforts in 1995 found Virgin River chub present around Halfway Wash. In both those years other native species were also present around Halfway Wash. In all years except 1993, red shiner and western mosquitofish dominated the catch at the Halfway Wash station (Figure 15, Figure 16, and Figure 17). In 1993 red shiner and common carp dominated the catch. Native fishes comprised only a small proportion of the catch in all years. No native fish species have been collected during surveys between 2001 and 2005.

Table 12. Number of seine hauls pulled and fish collected by species during BIO-WEST sampling at the Halfway Wash station from 1993-2005.

Year	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	DS ^e	FM ^f	GS ^g	LB ^h	MF ⁱ	RC ^j	RS ^k	SD ^l	TL ^m	WF ⁿ
1993	51	6,182	5	0	112	1	9	3	8	52	1	5,984	5	0	2
1994	76	3,879	1	0	10	0	0	0	0	660	0	3,208	0	0	0
1995	75	3,733	0	0	33	2	4	1	2	103	1	3,587	0	0	0
1996	8	63	0	0	0	0	0	0	0	12	0	51	0	0	0
2001	39	2,002	0	0	7	0	0	0	0	348	0	1,643	0	4	0
2002	59	2,636	0	0	3	0	0	1	0	404	0	2,228	0	0	0
2003	36	242	0	0	0	0	0	0	0	43	0	199	0	0	0
2004	100	6,277	0	3	4	0	0	0	0	962	0	5,308	0	0	0
2005	175	15,405	39	20	14	0	0	0	1	916	0	14,414	0	1	0

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e DS = desert sucker

^f FM = flannemouth sucker

^g GS = green sunfish

^h LB = largemouth bass

ⁱ MF = western mosquitofish

^j RC = Virgin River chub

^k RS = red shiner

^l SD = speckled dace

^m TL = blue tilapia

ⁿ WF = woundfin

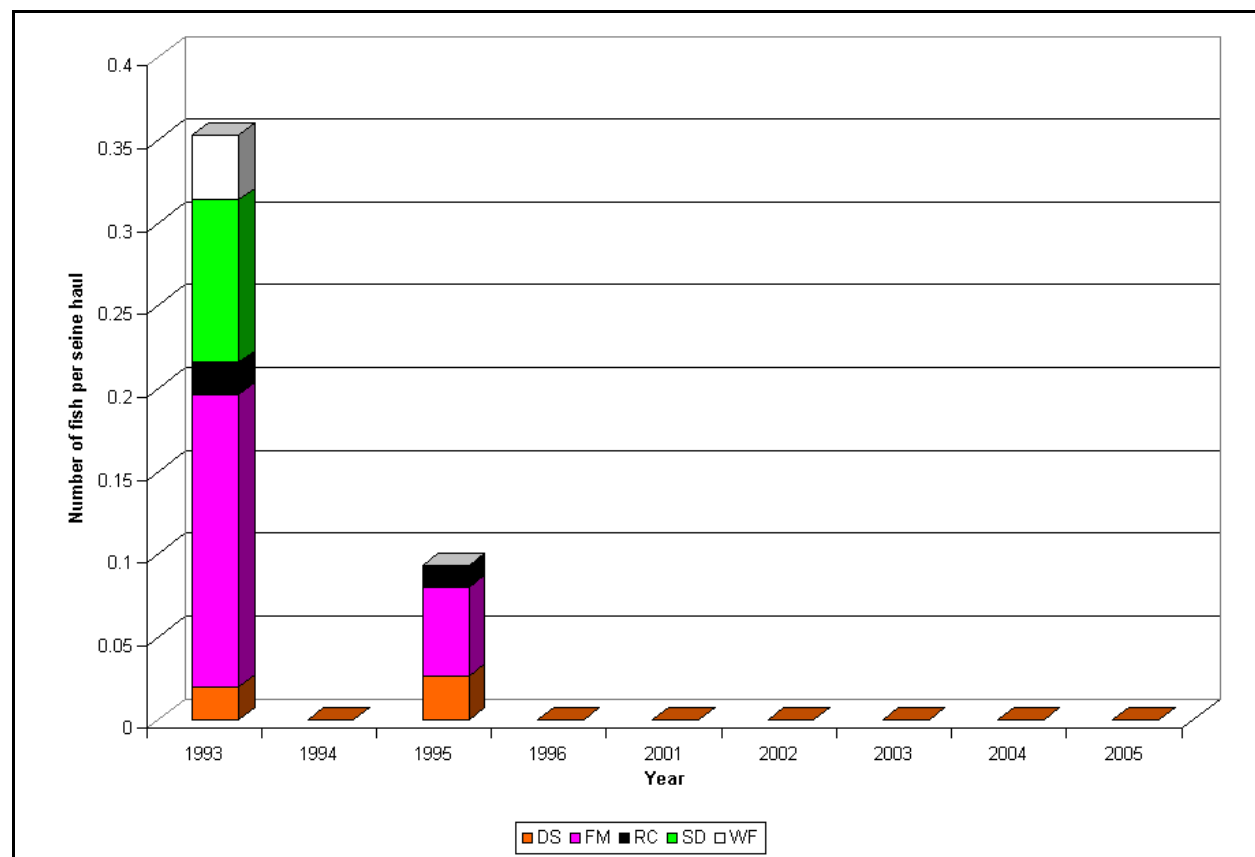


Figure 15. Number of native fishes collected per sample during BIO-WEST sampling at the Halfway Wash station from 1993-2005. DS = desert sucker, FM = flannemouth, RC = Virgin River chub, SD = speckled dace, WF = woundfin.

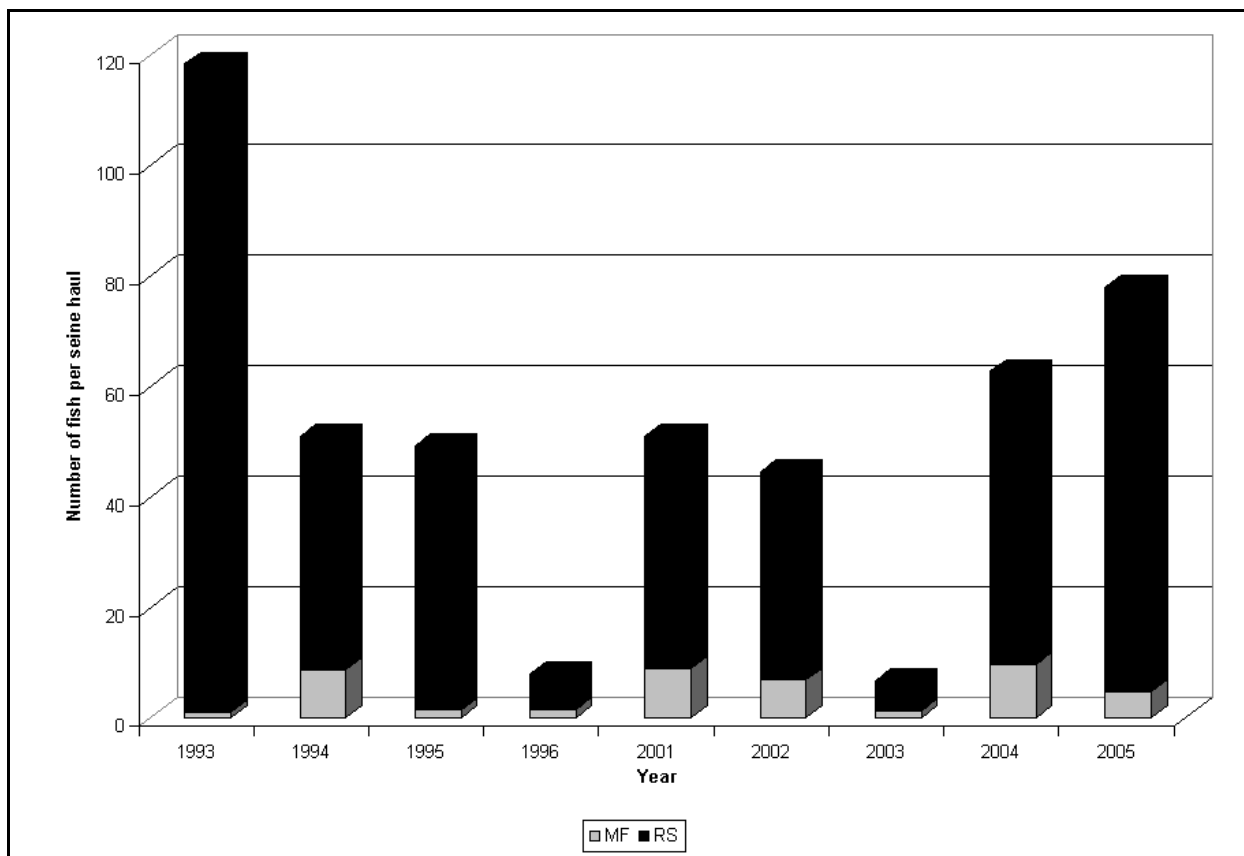


Figure 16. Number of red shiner and western mosquitofish collected per sample during BIO-WEST sampling at the Halfway Wash station from 1993-2005. RS = red shiner and MF = western mosquitofish.

Halfway Wash Recovery Team Sampling

In addition to sampling by BIO-WEST over the last 10 years, the Halfway Wash station was sampled by the Recovery Team in the late 1970s and early 1980s, as well as from 1993 to the present (Table 13, data from Virgin River Fishes database). Sampling in the 1970s showed that woundfin comprised a large portion of the catch around Halfway Wash (Figure 18, Figure 19, and Figure 20). However, by the early 1980s red shiner dominated the catch and woundfin were no longer found at the Halfway Wash station. When sampling resumed in the early 1990s, woundfin were present at the Halfway Wash station, but red shiner still dominated the catch. Woundfin disappeared from the catch between 1994 and 1997, but were found again in 1998 and 1999. Woundfin have not been collected around Halfway Wash in Recovery Team sampling since 1999.

No Virgin River chub have been collected by Recovery Team sampling efforts at Halfway Wash, and other native fishes only appear sporadically throughout the period of record. Red shiner dominated the catch in every year Halfway Wash was sampled, except for 1978 when woundfin

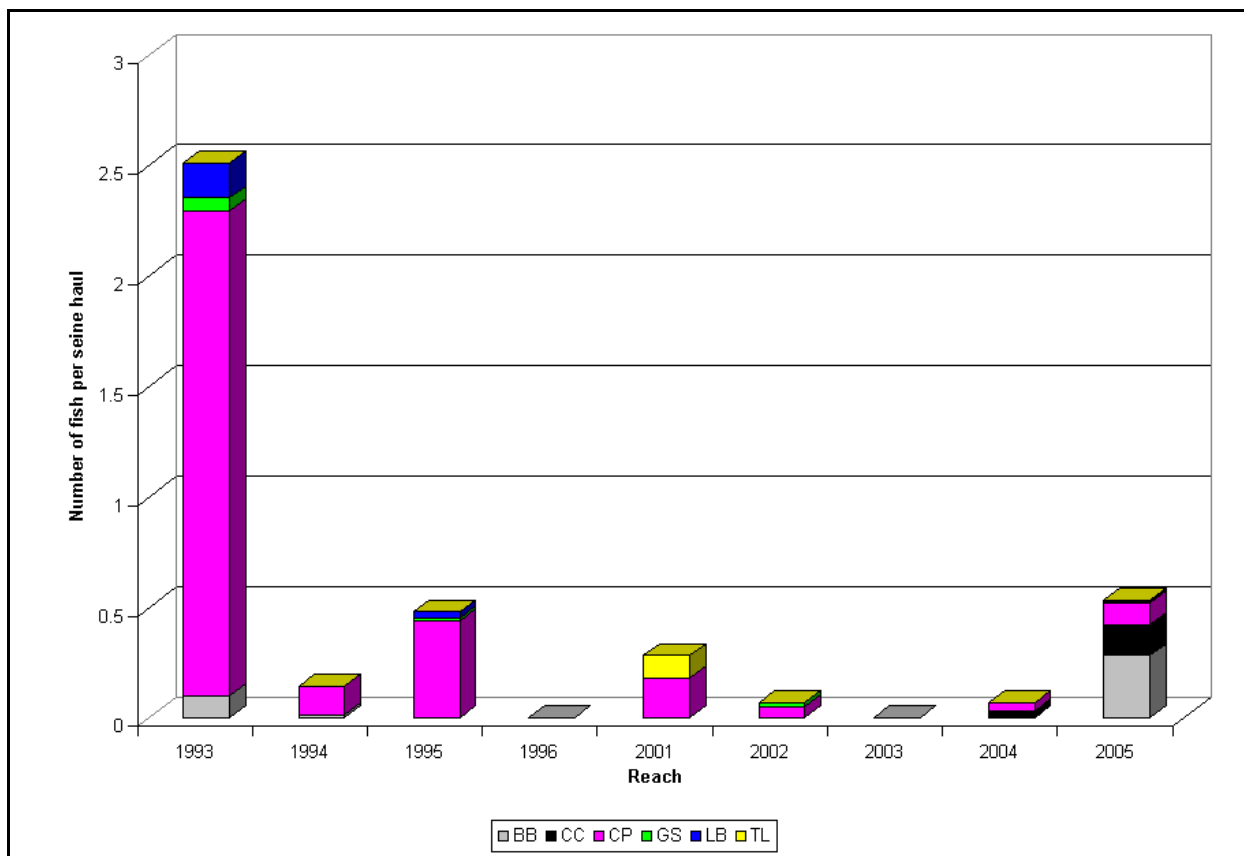


Figure 17. Number of nonnative fishes other than red shiner and western mosquitofish collected per sample during BIO-WEST sampling at the Halfway Wash station from 1993-2005. BB = black bullhead, CC = channel catfish, CP = common carp, GS = green sunfish, LB = largemouth bass, TL = blue tilapia.

dominated the catch. In 1998 flannemouth sucker were the second most abundant species in the catch, but native species comprised a small portion of the catch in all other years except for 1978. No native fishes have been collected by Recovery Team sampling efforts since 2001.

Historic Flow Data

Holden et al. (2001) found that native fish abundance in the Virgin River was lower in drought years, and Hardy et al. (1995) suggested that woundfin abundance varied with the strength of the water year. Native fish abundance below Halfway Wash may be related to the strength of the water year. For each water year (October 1 through September 30) since 1970, we calculated the discharge level that was exceeded on 50% of the days within that year (50% exceedence level). Essentially, this value represents the median discharge. We also calculated the 25% and 75% exceedence levels for each year (Figure 21).

Table 13. Number of seine hauls pulled and fish collected by species during Recovery Team sampling at the Halfway Wash station from 1976-2003.

Year	Seine Hauls	Total ^a	BB ^b	CC ^c	CP ^d	DS ^e	FM ^f	GS ^g	LB ^h	MF ⁱ	RS ^j	SD ^k	SMB ^l	TL ^m	WF ⁿ
1976	2	30	0	0	0	0	0	1	0	2	26	0	0	0	1
1978	3	169	0	0	1	0	1	0	0	0	33	0	0	0	134
1979	7	178	0	0	0	0	0	0	0	2	165	0	0	0	11
1980	8	177	0	0	0	0	0	0	0	0	177	0	0	0	0
1981	2	493	0	0	1	0	0	0	0	1	491	0	0	0	0
1992	12	607	0	3	0	0	0	0	0	64	535	1	0	0	4
1993	30	2,559	0	0	39	0	16	0	0	8	2,495	0	0	0	1
1994	20	972	0	0	0	0	0	0	0	162	799	10	0	0	0
1995	9	86	0	0	0	0	0	0	0	0	86	0	0	0	0
1996	20	3,791	0	0	0	0	0	0	0	12	3,779	0	0	0	0
1997	20	2,234	0	0	1	0	3	0	0	49	2,181	0	0	0	0
1998	30	2,094	2	0	40	2	91	1	0	27	1,927	1	2	0	1
1999	20	3,136	0	10	5	0	1	0	0	13	3,105	0	0	0	2
2000	20	2,577	0	1	0	0	2	0	0	161	2,413	0	0	0	0
2001	20	3,060	0	0	3	0	1	0	0	57	2,993	0	0	6	0
2002	21	1,549	0	0	0	0	0	0	0	154	1,390	0	0	5	0
2003	17	1,104	0	0	1	0	0	0	1	203	899	0	0	0	0

^a Total = all species

^b BB = black bullhead

^c CC = channel catfish

^d CP = common carp

^e DS = desert sucker

^f FM = flannemouth sucker

^g GS = green sunfish

^h LB = largemouth bass

ⁱ MF = western mosquitofish

^j RS = red shiner

^k SD =speckled dace

^l SMB = smallmouth bass

^m TL = blue tilapia

ⁿ WF = woundfin

The period from 2000 to 2004 was an extremely dry period compared with the rest of the last 30 years. The lowest flow year on record (1930-2005) was in 2002. Since BIO-WEST began studies on the Virgin River in 1993, there have been four relatively high flow years: 1993, 1995, 1998, and 2005. During early Recovery Team sampling efforts in the late 1970s and early 1980s, there were a string of relatively high flow years, including 1978-1980. With the exception of 2005, an examination of the fish community information collected by both BIO-WEST and the Recovery Team shows that these higher flow years tend to coincide with the presence of woundfin, Virgin River chub, and other native species near Halfway Wash and/or their highest collection numbers.

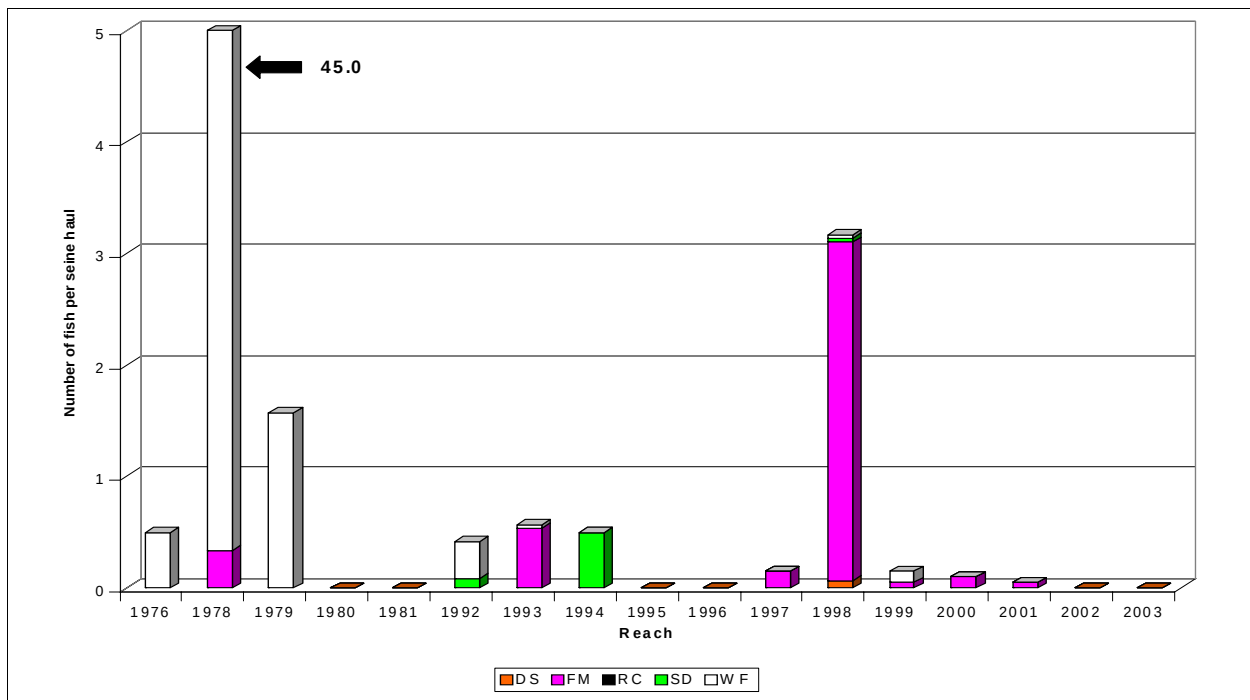


Figure 18. Number of native fish collected per sample during Recovery Team sampling efforts at the Halfway Wash station from 1976-2003. DS = desert sucker, FM = flannemouth sucker, RC = Virgin River chub, SD = speckled dace, WF = woundfin.

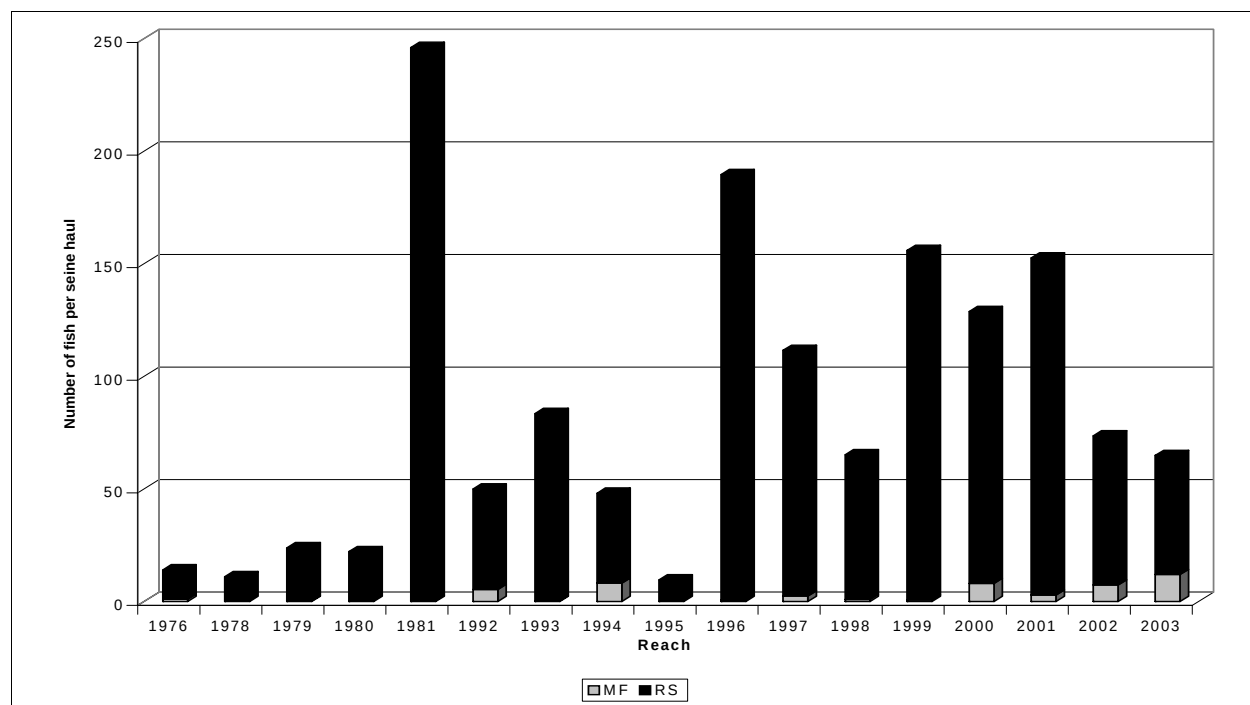


Figure 19. Number of red shiner and western mosquitofish collected per sample during Recovery Team sampling efforts at the Halfway Wash station from 1976-2003. RS = red shiner and MF = western mosquitofish.

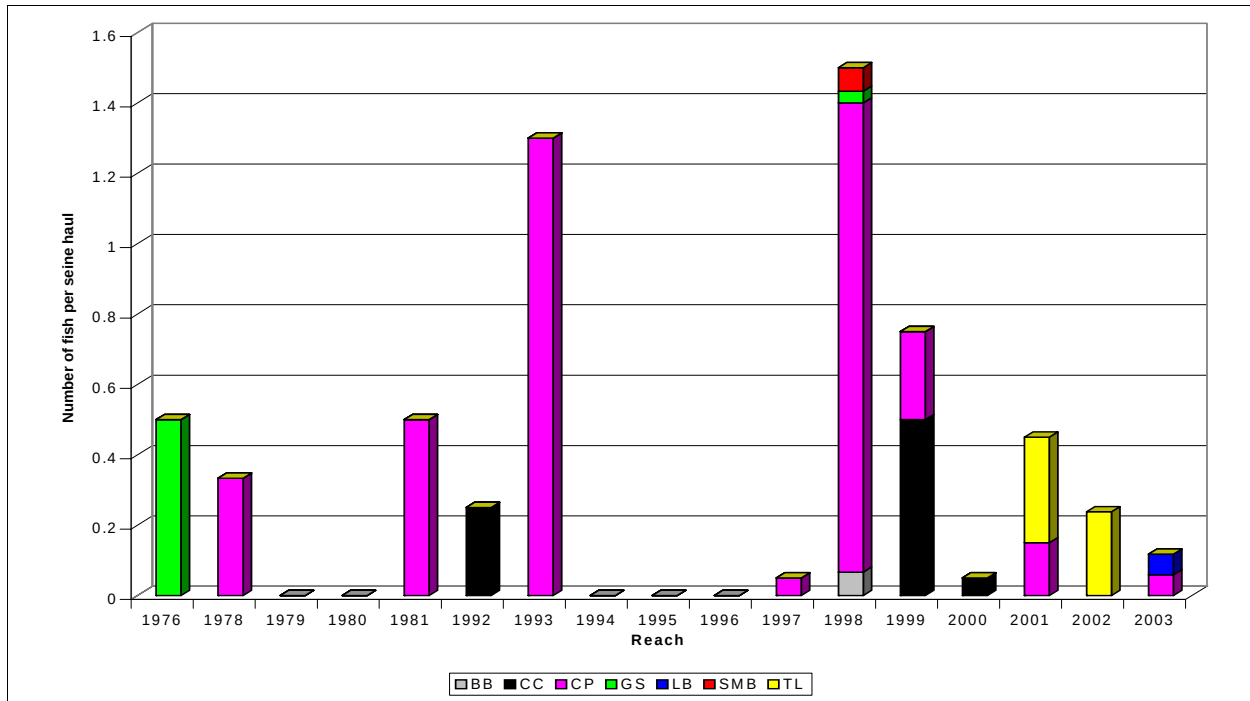


Figure 20. Number of nonnative fish other than red shiner and western mosquitofish collected per sample during Recovery Team sampling efforts at the Halfway Wash station from 1976-2003. BB = black bullhead, CC = channel catfish, CP = common carp, GS = green sunfish, LB = largemouth bass, TL = blue tilapia.

DISCUSSION

We did not collect any woundfin or Virgin River chub from Halfway Wash to Lake Mead during our sampling efforts in 2004 and 2005. In fact, we only collected three native fishes. Based on the historical data we were able to examine, we were not surprised that our collections were dominated by nonnative fishes. Cross (1975) did not collect woundfin or Virgin River chub below Riverside, NV, during his collection efforts from 1973 to 1975. Subsequent collection efforts by the Recovery Team near Halfway Wash, NV, showed that woundfin were present and perhaps even common. However, red shiner were not as abundant near Halfway Wash in the late 1970s as they have been over the last 10 years. Additionally, there was a series of high water years in the late 1970s that may have improved habitat in the Halfway Wash area or transported woundfin from areas of higher abundance upstream.

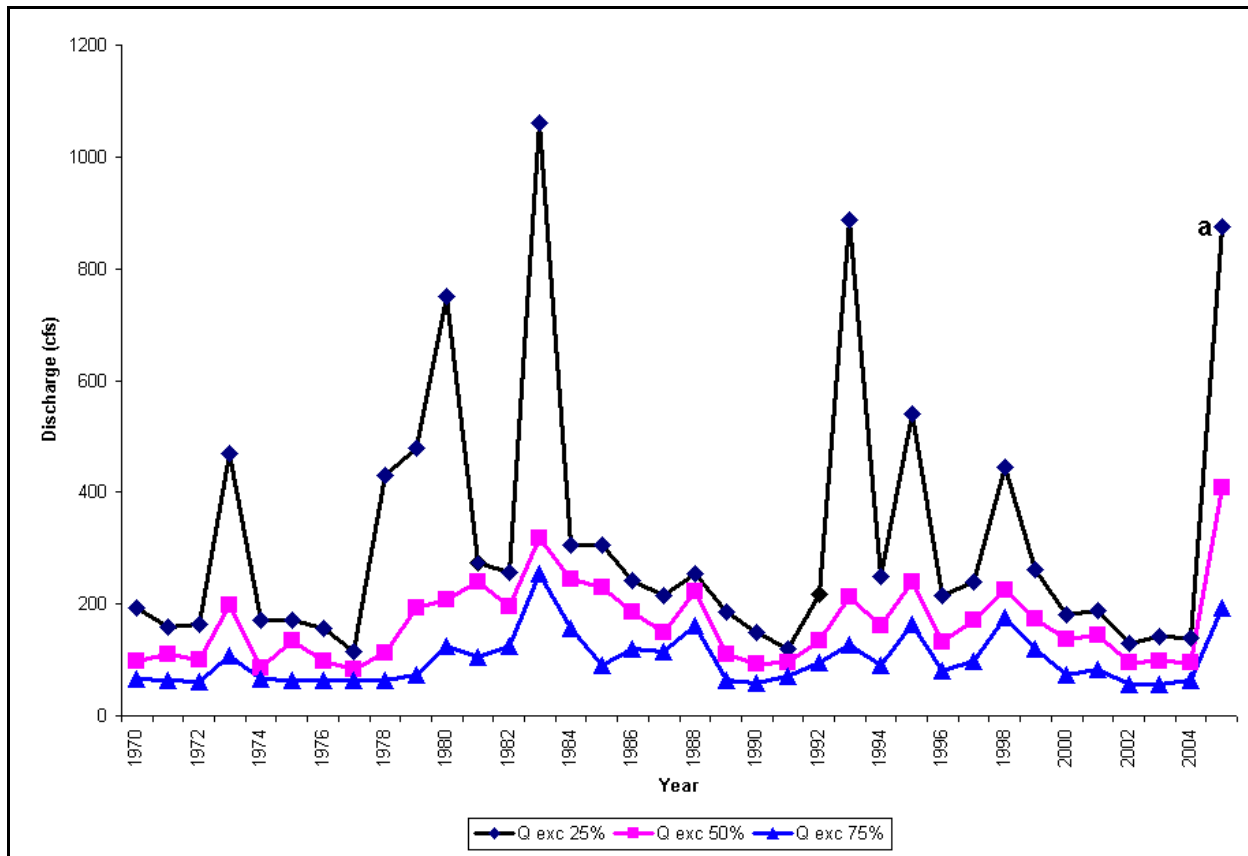


Figure 21. Discharges that were exceeded 25%, 50%, and 75% of the days in each water year from 1970-2005 at the USGS gage near Littlefield, AZ, on the Virgin River (gage # 09415000). ^a Data are provisional and missing 8 days of data, including the highest flows, from the January 2005 flooding.

In the last 12 years, the Recovery Team and BIO-WEST have sampled the area around Halfway Wash, and BIO-WEST has performed some surveys in downstream areas. While woundfin have been collected as far downstream as RM 39.5 and Virgin River chub have been collected as far downstream as RM 41.0, these species have only been found sporadically and in low numbers near and below Halfway Wash over the past 12 years. Additionally, the occurrence of Virgin River chub and woundfin near and below Halfway Wash has coincided with average or above average flow years, suggesting that these fish may be transported from upstream areas where they are more abundant. After they are transported into the area, they seem to be unable to persist over multiple years. The USFWS (2000) listed Halfway Wash as the lower extent of critical habitat for both the woundfin and Virgin River chub, because of the paucity of collections of those species downstream from Halfway Wash. Other native fish species show a similar pattern to woundfin and Virgin River chub in historical data since the mid-1970s. They have been found sporadically in low numbers near and below Halfway Wash, and their occurrence seems to coincide with years where flows were above average.

Woundfin, Virgin River chub, and other native fishes may also be transported downstream in lower-flow years, but they appear to be unable to persist for any length of time under those conditions. During low-flow years water diversion for upstream water rights in Mesquite, NV, Bunkerville, NV, and Riverside, NV result in extremely low flows, and even drying of the river near and below Halfway Wash. We found that the river was dry for at least 10 miles (16.1 km) below Halfway Wash during our July 2004 sampling trip (Figure 22). A portion of the river below Halfway Wash was also dry in 2002 (Holden and Golden 2004), and it probably dried in 2001 and 2003, as well. Holden et al. (2001) found that fall woundfin abundance in Recovery Team samples was significantly lower when median summer flows were below 50 cfs. Based on median summer flows at the USGS gaging station near Littlefield, AZ, minus the existing water rights at the Mesquite and Bunkerville Diversions, median summer flows in the Halfway Wash area have been considerably lower than 50 cfs since 1999. In addition to being more likely to be transported into areas near or below Halfway Wash in higher flow years, it also appears that woundfin, Virgin River chub, and other native fishes may also be more likely to persist in these areas during higher-flow years.



Figure 22. Dry river channel at the USGS gage near Overton, NV, in July 2004.

Similar to the previous 3 years, 2004 was a low-flow year, which may explain why we only found one native fish during our sampling efforts. The native fish community in the lower Virgin River was decimated during a 5-year drought that began in 1999 (Golden and Holden 2004). Few native fishes were found below the Bunkerville Diversion (RM 59.25), which is almost 18 miles (29 km) upstream from the Halfway Wash area between 2001 and 2004, and the once small but consistent woundfin population below Riverside, NV, appears to have been extirpated.

Conversely, 2005 was the highest water year since 1983. If accurate flow data can be calculated, it will probably be the highest water year in the past 35 years. We would have expected that native fishes would have had a good reproduction and recruitment year in 2005, which may have translated in transport of native fishes below Halfway Wash. Instead, we only found two speckled dace in almost 500 samples taken below Halfway Wash. We feel that two explanations exist for why we did not collect higher numbers of native fish below Halfway Wash in 2005, despite high flows and improved habitat. The first explanation is that the drought from 1999-2004 depleted upstream populations of native fish. Golden and Holden (2004) showed that by 2002 native fish populations between Beaver Dam Wash and the Bunkerville Diversion had been substantially depleted, and populations below the Bunkerville Diversion had essentially been extirpated. Therefore, fewer native fishes were available to take advantage of any improved habitat and flows conditions present in 2005.

Additionally, the peak flow in January 2005 is estimated to have been 35,000 to 40,000 cfs, which would be the highest natural peak flow since 1967 (35,200 cfs), and possibly the highest natural peak flow on record. When Quail Creek Diversion failed in 1989, an estimated 61,000 cfs passed through the lower Virgin River. Holden et al. (2001) implicated the 1989 peak flow in lowering native fish numbers in the lower Virgin River. Similarly, high peak flows in January 2005 probably caused transport and mortality of many fishes in the lower Virgin River. The combined effects of drought and the January 2005 flooding may have driven the lower Virgin River native fish populations to a low-enough level that few fish were available to be transported into the area below Halfway Wash. Native fish recruitment in upstream areas was probably stimulated by high spring and summer flows in 2005. The impact of this recruitment may not be seen downstream for a year or two.

While only three native fishes were found below Halfway Wash in 2004 and 2005, considerably more riverine habitat was available, compared with the habitat available during the 1993-1996 BIO-WEST collection period. Throughout most of the 1990s, the Virgin River ended near RM 34.0 at its confluence with Lake Mead. The backwater effect from Lake Mead rendered much of the habitat below Halfway Wash unsuitable for native fishes (USFWS 2000). In 2004 and 2005, we found that the 2 miles (3.22 km) below Halfway Wash and our entire Overton WMA sampling station had habitat that seemed suitable for native fishes. The decline in Lake Mead water surface elevation over the past 5 years has removed the influence of the reservoir on this section of the river, which is probably the main reason for this increase in habitat.

The declining lake elevation also created an additional 7 miles (11.27 km) of riverine habitat that had formerly been lake bed. Unlike the area immediately below Halfway Wash and in the Overton WMA, the majority of the habitat within the new 7-mile (11.27-km) section was generally poor for fish in 2004. The newly created 7-mile (11.27-km) section was dominated by areas with a narrow, entrenched channel or a wide channel choked with cattails and salt cedar. The extremely low flows below Halfway Wash probably caused the encroaching vegetation in these sections of river. These areas were poor habitat for native fishes, but they probably helped prevent blue tilapia from ascending the Virgin River in 2003 and most of 2004. The flooding in 2005 removed much of the encroaching vegetation and created some better fish habitat throughout the study area.

Golden and Holden (2004) speculated that Lake Mead was the continued source of blue tilapia migration into the Virgin River. Sampling efforts in 2004 and 2005 provided evidence supporting that assertion. In 2004 relatively large numbers of blue tilapia were collected immediately above Lake Mead, but no blue tilapia were collected upstream from this area between July and September 2004. The dense vegetation and low flows appear to have been a barrier to blue tilapia over summer and early autumn 2004. This is generally the time when low flows and turbidity, along with warmer water temperatures, promote blue tilapia migrations up the Virgin River. After a large spate event in October 2004, BIO-WEST collected a blue tilapia near RM 56.0, nearly 18 miles (29 km) upstream from the Above Lake Mead station, where they had been seemingly restricted to during the summer months. We believe that this spate event opened a channel through some of the dense vegetation in the lower Virgin River, which allowed blue tilapia to once again migrate upstream. Additionally, after the 2005 flooding removed all impediments to upstream migrations below Halfway Wash, we found blue tilapia were distributed throughout the study area, not just restricted to the area immediately above Lake Mead. Nonnative fishes moving upstream out of Lake Mead will continue to threaten the native fishes of the Virgin River until a fish barrier is constructed below the Bunkerville Diversion.

Our 2004 findings showed that the impacts of multiple drought years eliminated any native fish community that existed near and below Halfway Wash on the Virgin River. Our data support historical data indicating that any native fish community that formerly existed in this area may have been transient, resulting from downstream transport of fishes from upstream population centers (Holden and Abate 1999). Since the impacts of the drought depleted the upstream population centers (Holden and Golden 2004), even fewer native fishes were available to move downstream into the study area. We feel that periodic drying and extremely low flows are the primary factor responsible for the lack of a permanent native fish community below Halfway Wash. The high peak flows in January 2005 improved fish habitat throughout the study area, but they also may have negatively impacted upstream native fish communities. We may not see the beneficial impacts of the 2005 high spring runoff and summer flows on the fish community until next year.

RECOMMENDATIONS

Water development on the Virgin River below Halfway Wash could have both positive and negative impacts to the lower Virgin River fish community. Some of the alternatives for developing additional water rights on the lower Virgin River involve placing a diversion structure in the river. Placing a diversion near Halfway Wash could increase the frequency and duration of drying events in the river below the diversion. This increase would perpetuate the dominance of nonnative fishes in the area below Halfway Wash and probably eliminate the likelihood of ever establishing a permanent native fish community below any such diversion.

However, the same diversion could beneficially effect upstream native fish populations by preventing the upstream migration of nonnative fishes from Lake Mead. Water development alternatives that would increase the amount of water left in the river below the Bunkerville or Riverside diversions, so the water could be extracted near Halfway Wash, would also have a positive impact to the native fish community between Bunkerville Diversion and Halfway Wash. This community was decimated by the combined impacts of water use and drought from 1999-2004.

Similarly, any water development alternatives that would increase the amount of water left in the river to the Lake Mead confluence may assist with building native fish populations in this lower portion of the river. However, if a diversion was not built somewhere in the lower Virgin River, the upstream migration of nonnative fishes from Lake Mead will continue to be a threat. The recent discoveries of blue tilapia and striped bass in the lower Virgin River highlight the need to segregate the native fishes in the Virgin River from the large pool of nonnative fishes found in Lake Mead. Given these potential impacts of different water development alternatives, we provide the following recommendations to benefit the native fish community of the lower Virgin River.

1. Investigate options within existing water rights for maintaining more consistent flows in the lower Virgin River.

Below-average flow years create extremely low flows in the lower Virgin River, which appear to be a major factor limiting the permanent establishment of native fishes in this area. The drought that persisted from 2000-2004 eliminated native fish communities below the Bunkerville Diversion. The YOY flannelmouth sucker we collected in April 2004 was the first native fish collected near or below Halfway Wash since 2001. Any options for water development that might allow larger or more consistent amounts of water to be maintained in the lower Virgin River may assist in establishing more permanent native fish communities.

2. Make any structure a fish barrier if water will be diverted.

Sampling efforts in 2004 and 2005 support prior assertions that Lake Mead is indeed the continued source of blue tilapia colonizing the Virgin River. Additionally, it appears that other nonnative species, most notably striped bass but also common carp and channel catfish, are continually

migrating up the Virgin River from Lake Mead. The Virgin River Recovery Plan (USFWS 1995) outlines a plan to remove red shiner from the Virgin River through a series of renovations occurring in a step-wise downstream fashion. The Utah Division of Wildlife Resources has found that they cannot declare a river reach free of the targeted red shiner until the reach below it is free of that species. If we hope to remove red shiner from all of the critical habitat for Virgin River chub and woundfin, a barrier must be placed further down system than the Bunkerville Diversion.

Holden and Golden (2004) recommended investigating the construction of a fish barrier near Halfway Wash to assist in preventing blue tilapia from becoming established in the Virgin River. Now that striped bass have been found migrating up the Virgin River, this need may be even more imperative. Lake Mead is a continual source for many of the nonnative fishes that inhabit the Virgin River. If we ever hope to reduce or remove these species from the Virgin River and prevent new nonnative species from becoming established, we need to construct fish barriers that effectively prevent Lake Mead from introducing nonnative fishes.

3. Perform additional surveys in 2006.

While the period from 2000 to 2004 represented one of the worst low-flow periods throughout the Colorado River Basin in the last 500 years, the 2005 water year provided some extremely high-flow events. The high-flow events created better fish habitat throughout the lower Virgin River and also opened up a corridor for blue tilapia to migrate to the Bunkerville and possibly Mesquite Diversions.

Continued sampling below Halfway Wash may show that native fish utilize improved habitat below Halfway Wash following high-flow events. Additionally, pinpointing the timing and speed of blue tilapia and striped bass migrations could improve management decisions about the timing and location of rotenone treatments to prevent the establishment of these nonnative fishes in the Virgin River.

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