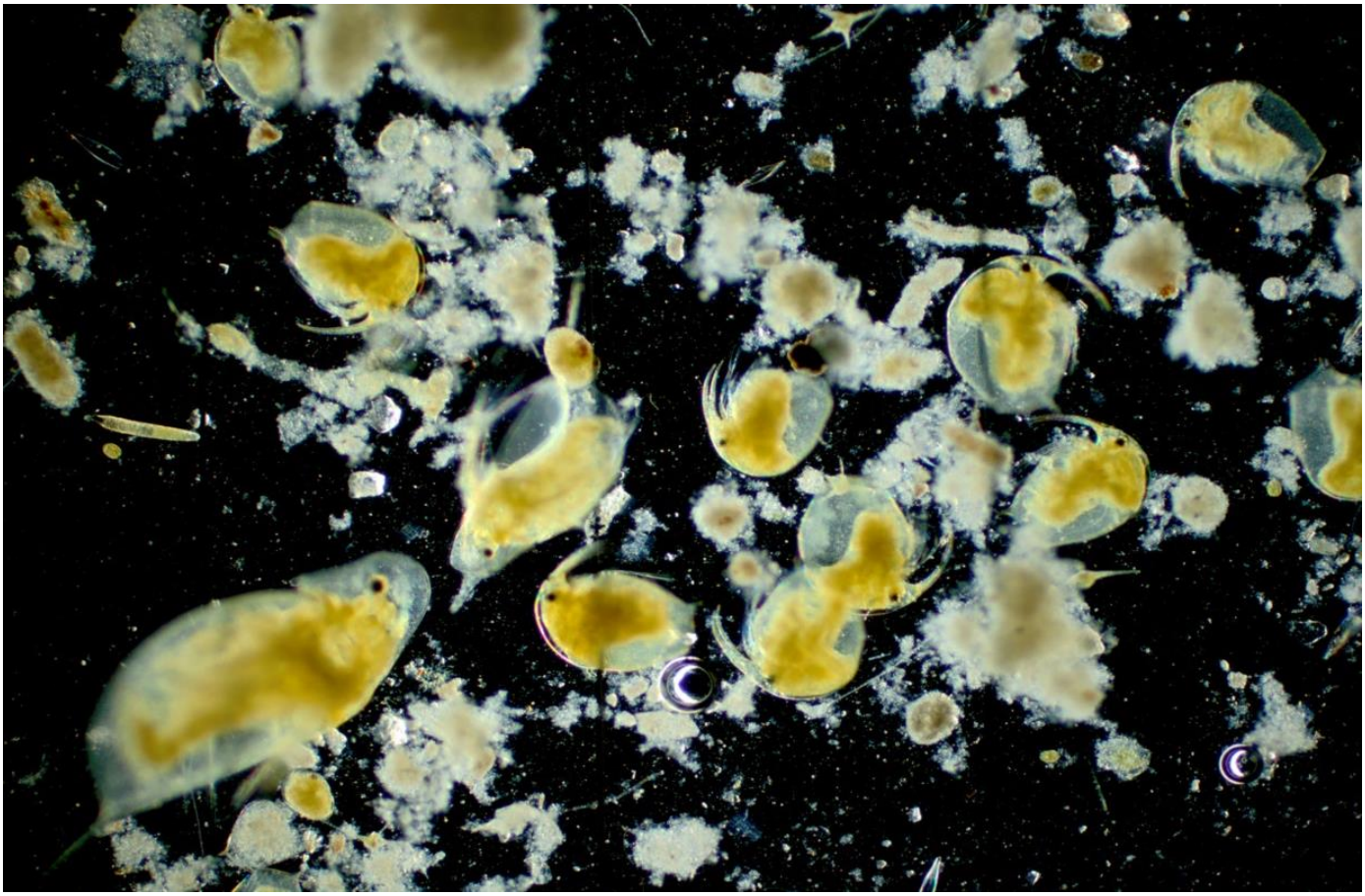
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Characterization of Zooplankton Communities in Off-Channel Native Fish Habitats: 2009–2011



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Lower Colorado River Multi-Species Conservation Program

Characterization of Zooplankton Communities in Off-Channel Native Fish Habitats: 2009–2011

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Multi-Species Conservation Program
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ACRONYMS AND ABBREVIATIONS

Achii Hanyo NFRF	Achii Hanyo Native Fish Rearing Facility
DO	dissolved oxygen
ha	hectare(s)
Imperial NWR	Imperial National Wildlife Refuge
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
mL	milliliter(s)
Overton WMA	Overton Wildlife Management Area
Reclamation	Bureau of Reclamation
UTM	Universal Transverse Mercator
YOY	young-of-year

Symbols

<	less than
µg	microgram(s)
µg/L	micrograms per liter

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INTRODUCTION

The lower Colorado River (LCR) is home to remnant populations of the endangered razorback sucker (*Xyrauchen texanus* [Abbott]) and bonytail chub (*Gila elegans*). Feeding behavior and composition of potential food items for the razorback and bonytail have been understudied and limited to Lake Mohave, Arizona-Nevada (Marsh and Langhorst 1988); Cibola High Levee Pond, Arizona-California (Mueller 2006; Marsh and Schooley 2005); and the hatchery setting (Papoulias and Minckley 1992). A series of native fish ponds are present on the LCR that encompass all five river reaches of the Lower Colorado Multi-Species Conservation Program (LCR MSCP) area and ranging from Lake Mead, Nevada, to the Imperial National Wildlife Refuge (Imperial NWR), Arizona. Some of these ponds are managed as sanctuaries where native fish can complete their life cycle in a relatively predator-free environment. Others function primarily as grow-out or rearing ponds with the intent that the fish in these habitats will eventually be stocked into the LCR. Examples of grow-out ponds include those located on various golf courses; off-channel backwaters of Lake Mohave, Arizona-Nevada; and ponds located on wildlife management areas.

Under the LCR MSCP, as a result of limited knowledge of the available food base in off-channel habitats, the need to characterize the zooplankton communities supporting native fish populations in these various habitats has been identified. The composition and abundance of zooplankton present in these habitats were analyzed to evaluate the potentially valuable nutritional availability to native fishes. A review of past studies shows a link between specific zooplankter organisms and sight and taste selective feeding habits of the razorback sucker and other closely related catostomids (Marsh and Langhorst 1988; Marsh 1987; Zaret and Kerfoot 1975; Miller and Evans 1965). Based on the literature, it was necessary to ascertain where potentially desirable food items may be present or absent in the grow-out habitats.

It is hypothesized that the results from this study will help managers assess the future potential to manipulate zooplankton communities for the purpose of maximizing growth and fitness of razorback suckers and bonytail chubs being reared in these managed habitats. Some habitats currently used to rear native fish show relatively high productivity. It may be possible to mimic these conditions in additional off-channel habitats where food resources are consistently deficient. The goal is to produce healthier cohorts of native fish as they are repatriated to the main river system and to glean insight into the quantity and quality of food items required to achieve optimal survival.

METHODS

Characterization of the zooplankton community in off-channel habitats of the LCR was conducted quarterly and began in October 2008, November 2008, or January 2009, depending on the availability of the site to be sampled, and concluded in July 2011. For most sites, sampling was conducted the final full week of each month. Thirty-three sites were sampled and included off-channel habitats comprised of either ponds or backwaters (table 1). The one exception was Beal Lake – a 91-hectare (ha) lake located by the Colorado River near Needles, California. Sites were organized in a north-south trajectory for this analysis (table 1). Sampling sites extended north as far as the Overton Wildlife Management Area (Overton WMA), Overton, Nevada, and south to the Imperial NWR near Yuma, Arizona (figure 1).

Zooplankton samples were collected using a 15-centimeter-diameter Wisconsin-style plankton net with 64-micrometer mesh. A single vertical tow was collected from the entire water column at each pond, and the contents were released into a 250-milliliter (mL) high-density polyethylene amber bottle. Each sample was preserved in Lugol's iodine solution at a rate of 0.3 mL solution per 100 mL of sample. Samples were collected from the same location in each water body from one sampling event to the next as much as possible to maintain consistency. The mean sampling depth (m) was calculated for each pond and included in the results.

Depth (m), temperature (degrees Celsius), dissolved oxygen in milligrams per liter, pH, and specific conductance (microsiemens per centimeter) were measured using a TROLL 9500 water quality instrument beginning at the start of the second year of sampling. Water quality instrumentation changed over to a YSI Pro-Series beginning April 2011. Water quality measurements were not included in this analysis based on issues related to changing over to a new instrument and issues with intermittent malfunctioning software.

The volume of sample concentrate was measured and appropriate aliquots were examined at 100 times on a Wilovert inverted microscope equipped with phase contrast. Taxonomic identification followed Pennak (various dates), Stemberger (1979), Ruttner-Kolisko (1974), and Edmundson (1959). Biomass estimates for cladocerans, copepods, and rotifers were based on established length/width relationships (Lawrence et al. 1987; McCauley 1984; Dumont et al. 1975). Biomass was computed for the appropriate number of individuals for each sample location, and the arithmetic mean biomass was multiplied times the species abundance to produce a species biomass for each sample (McCauley 1984).

Table 1.—LCR off-channel zooplankton collection sites with corresponding sample ID, reach number, and Universal Transverse Mercator (UTM) coordinates

Site name	Site ID	Reach	UTM
Overton Wildlife Management Area			
Honeybee Pond	HB	1	11 S 730902 4045788
Center Pond	CP	1	11 S 732022 4043075
Floyd Lamb City Park	FL	1	11 S 639420 4045086
Lake Mohave backwaters			
Yuma Cover	Yuma	2	11 S 712625 3933566
North Nine Mile	N9Mile	2	11 S 711117 3921603
Willow	Willow	2	11 S 711588 3921184
Nevada Egg	NV Egg	2	11 S 712036 3920917
Dandy	Dandy	2	11 S 712222 3920769
Nevada Larvae	NV Larvae	2	11 S 713051 3919845
Arizona Juvenile	AJ	2	11 S 717055 3920923
North Chemehuevi	N Chem	2	11 S 716181 3916488
Davis Cove	Davis	2	11 S 721294 3898932
Needles Golf Course Ponds			
	NGC 1	3	11 S 719143 3858421
	NGC 18	3	11 S 719252 3858472
Beal Lake	BL	3	11 S 726359 3849407
Office Cove Pond	OC	3	11 S 766669 3798382
Parker Dam Pond	PD	4	11 S 763474 3798425
Emerald Canyon Golf Course Ponds			
	EC 1	4	11 S 759130 3791001
	EC 9	4	11 S 759161 3790949
	EC 11	4	11 S 758376 3789931
Achii Hanyo Native Fish Rearing Facility Ponds			
	AA	4	11 S 745441 3769436
	BB	4	11 S 745456 3769463
	AC	4	11 S 745477 3769416
	A1	4	11 S 745476 3769298
	A2	4	11 S 745519 3769304
	A3	4	11 S 745586 3769297
	A4	4	11 S 745642 3769310
Imperial National Wildlife Refuge			
	I1	5	11 S 734111 3653638
	I2	5	11 S 734098 3653486
	I3	5	11 S 734263 3653019
	I4	5	11 S 734083 3652968
	I5	5	11 S 734326 3652916
	I6	5	11 S 734172 3652369

Percent composition for five divisions of zooplankton were calculated and graphed for each site sampled and each quarter. The divisions included: (1) *Daphnia* spp.; (2) cladocerans, not including *Daphnia*; (3) copepods; (4) rotifers; and (5) other (figures 2–67). Mean zooplankton biomass at the division level was calculated for each site and quarter and reported in micrograms per liter (µg/L) on the primary y-axis (figures 2–67). An estimate of mean zooplankter biomass for each site and quarter was computed by dividing the average total biomass by the average number of individual organisms. This value is represented by a superimposed line graph and scaled on the secondary (right-hand side) axis (figure 2–67).

RESULTS

Mean zooplankton biomass composition and abundance varied greatly depending on the site sampled. For example, total biomass ranged from an average of 289 micrograms (µg) dry weight per liter at Floyd Lamb City Park to an average low of 6. 9 µg dry weight per liter at Parker Dam Pond. Community composition varied among sites as well, with different groups of zooplankton dominating different sites. Zooplankton biomass (µg dry weight per liter) and composition (percent) were characterized for each site and quarterly sampling event when available (figures 2–67).

From approximately late September until early January annually, the Bureau of Reclamation (Reclamation) managed reservoir levels for downstream delivery operations. The result was an approximate 3-m decline in the elevation of Lake Mohave. Therefore, most Lake Mohave backwaters lacked data for October. Lake Mohave backwaters that had gone dry or were too shallow to sample during October included North Nine Mile, Willow, Nevada Egg, Dandy, Nevada Larvae, Arizona Juvenile, and North Chemehuevi.

Pond maintenance activities at the Achii Hanyo Native Fish Rearing Facility (Achii Hanyo NFRF) also resulted in missing data. Graphs for each site were organized from lowest to highest reach (1–5) (table 1). A brief description characterizing physical attributes and other pertinent information of each sampling site are included immediately preceding the resultant graphs.

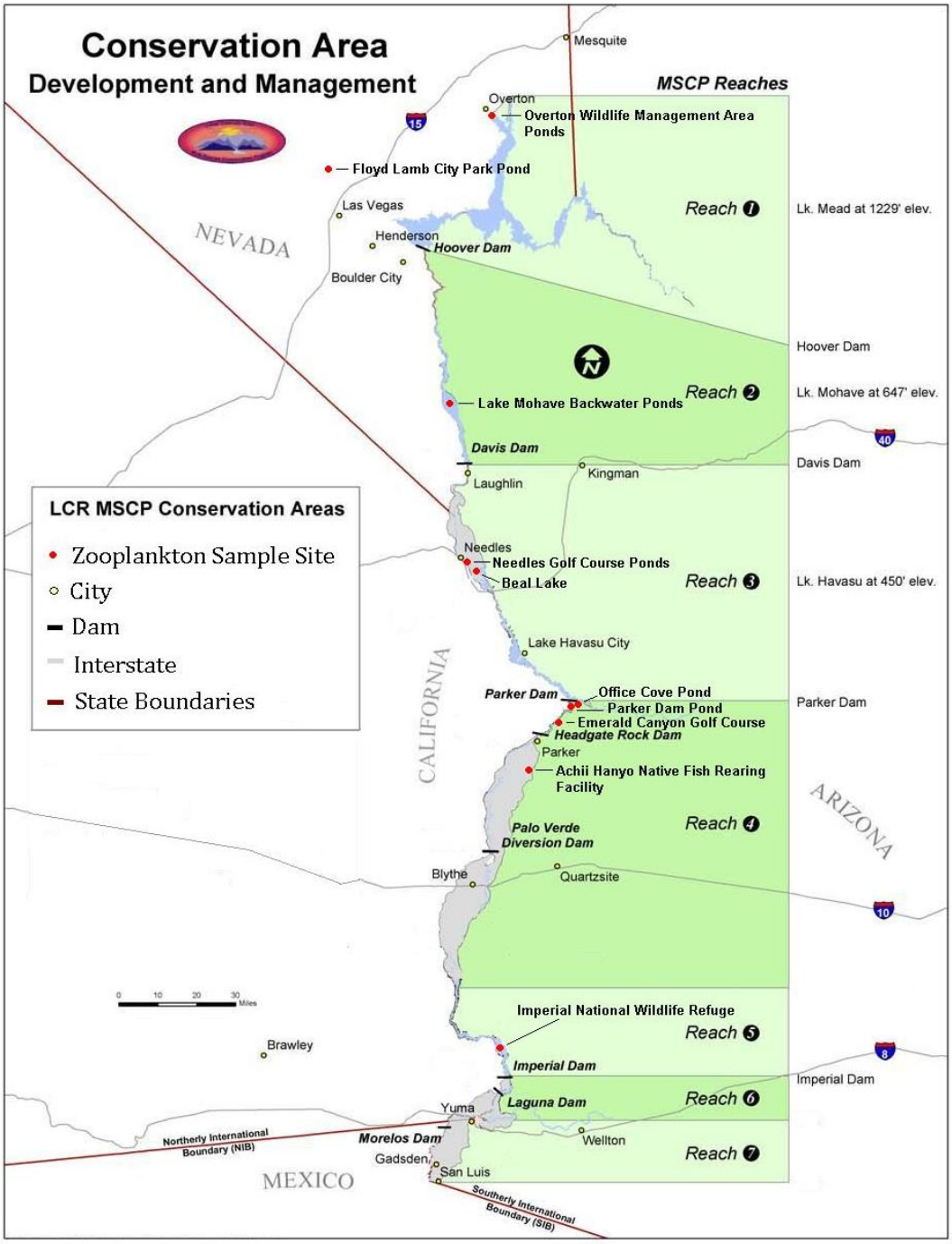


Figure 1.—LCR zooplankton characterization sampling sites.

Overton Wildlife Management Area

Honeybee Pond

Because of consistently shallow water depths (mean = 0.6 m), sampling was suspended at the end of the second year of the study. Copepods were the dominant zooplankter at this pond except for the October 2010 sampling. However, the overall biomass was < 25 µg/L.

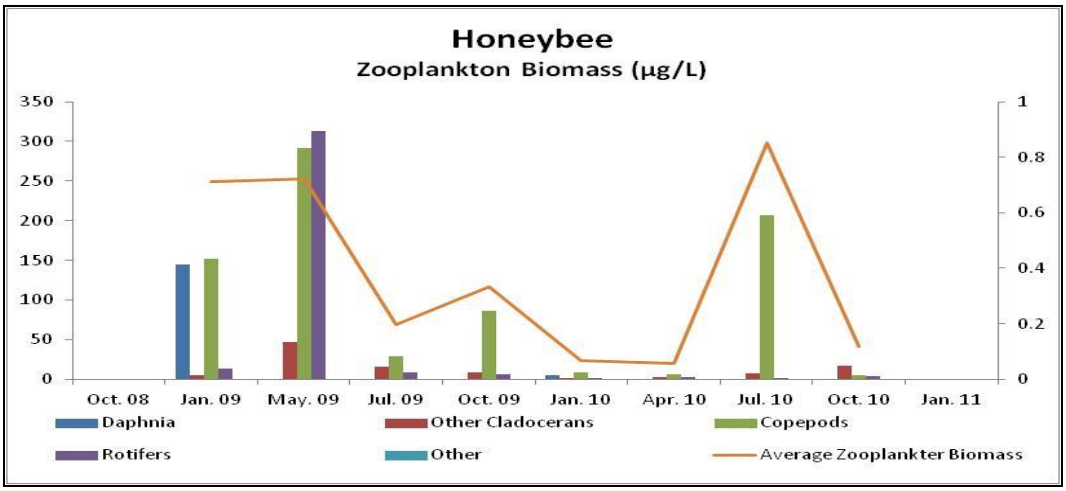


Figure 2.—Total mean biomass at Honeybee, Overton WMA (January 2009 – October 2010).

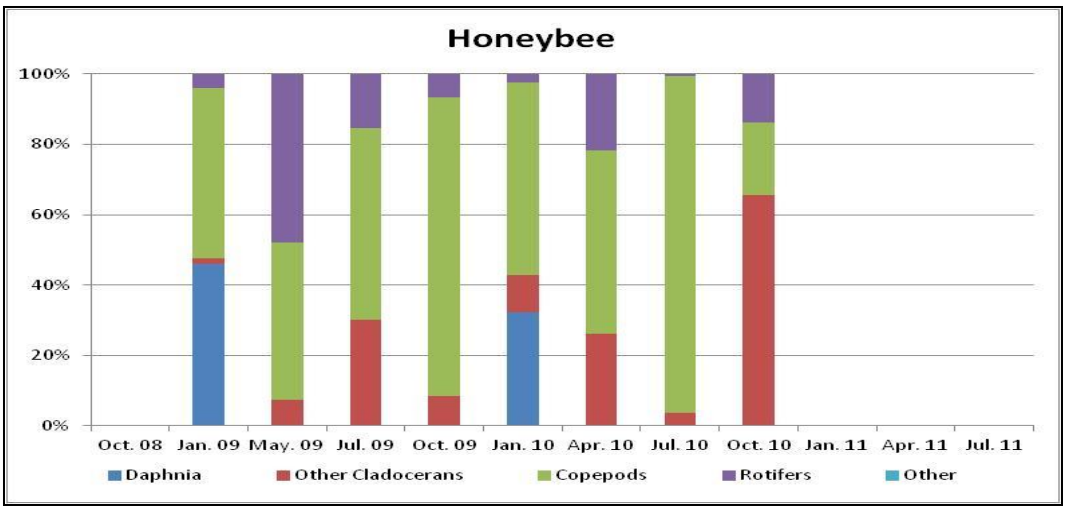


Figure 3.—Percent composition of zooplankters at Honeybee, Overton WMA.

Center Pond

Seasonal dynamics showed a cyclical pattern of relatively high biomass during winter months during the first 2 years of sampling. The percent composition of cladocerans was sporadic but consistently present during each sampling event. The mean sampling depth was 0.9 m.

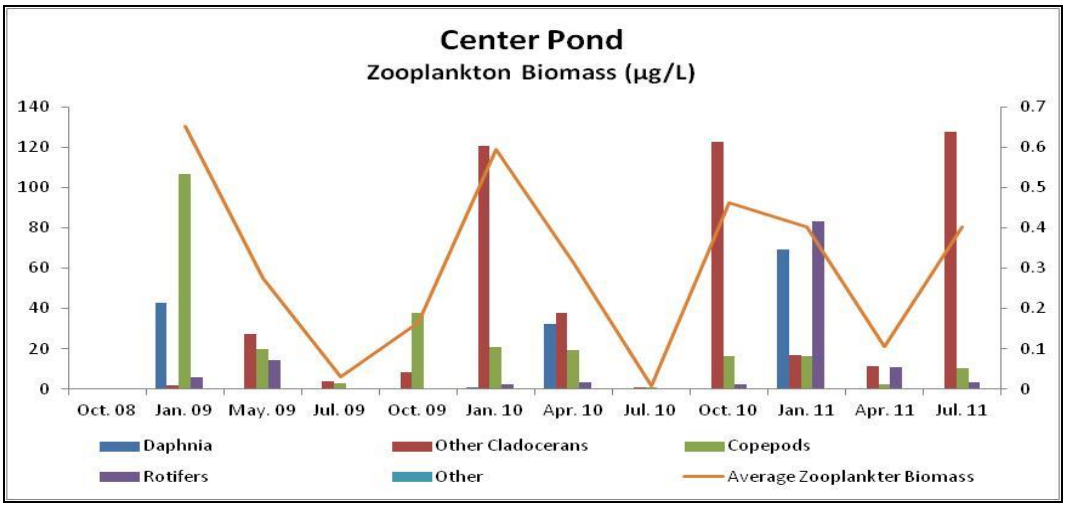
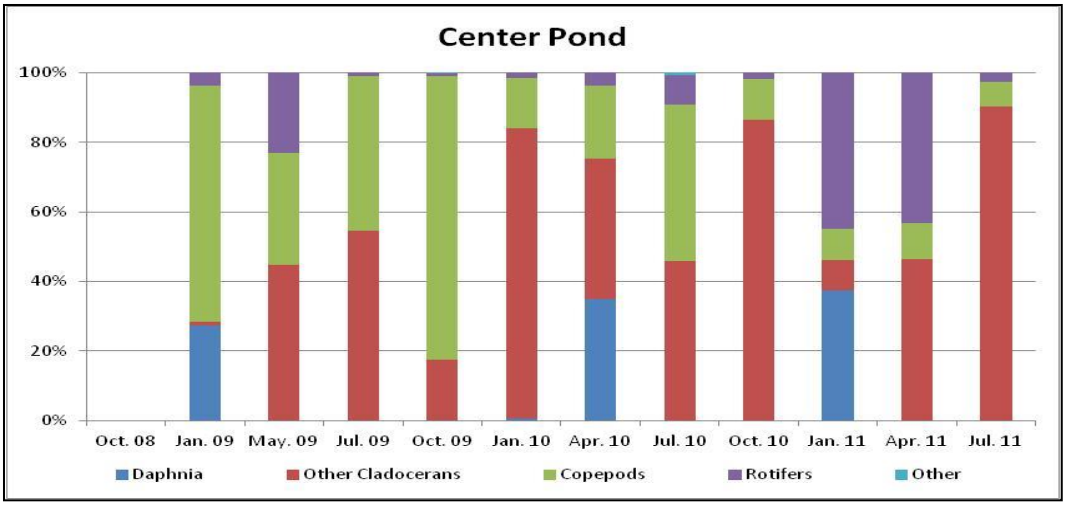


Figure 4.—Total mean biomass at Center Pond, Overton WMA (January 2009 – July 2011).

Figure 5.—Percent composition of zooplankters at Center Pond, Overton WMA.



Floyd Lamb City Park Pond

The lower pond at Floyd Lamb City Park is periodically stocked with razorback suckers by the Nevada Department of Wildlife for use in telemetry studies on Lake Mead. The pond is supplied by a combination of wells and artesian spring flows, making it unique from all other sites sampled in this report. April 2010 and 2011 showed the highest biomass and composition of large-bodied *Daphnia* spp. Overall biomass was significantly less for all other seasons, including May 2009. Other cladocerans, most notably *Bosmina* spp., showed the highest percent composition for all other seasons from July 2009 to July 2011. The mean sampling depth was 2.6 m.

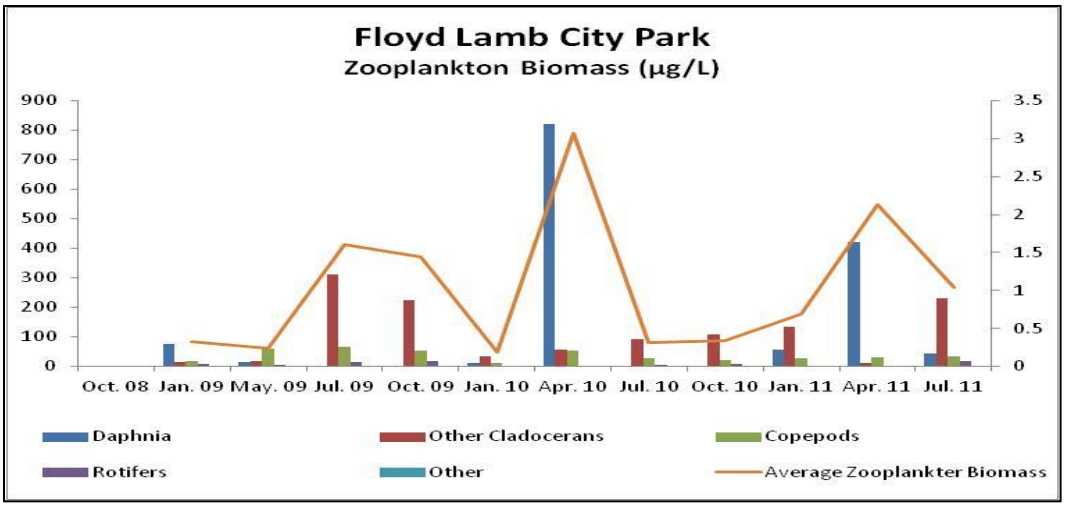


Figure 6.—Total mean biomass at Floyd Lamb City Park (January 2009 – July 2011).

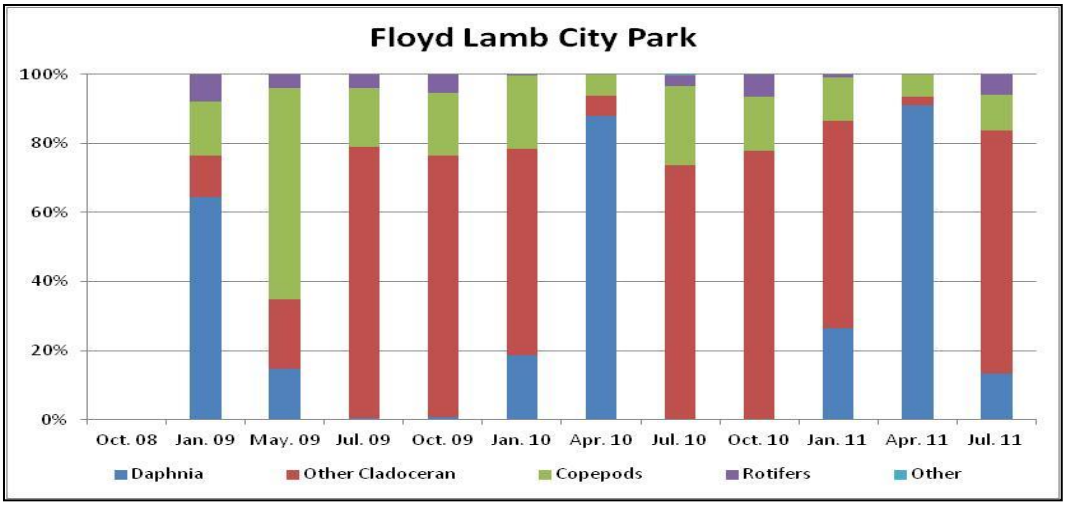


Figure 7.—Percent composition of zooplankters at Floyd Lamb City Park.

Lake Mohave Backwaters

Yuma Cove

Depending on reservoir elevations, Yuma Cove has approximate maximum depths of 1.5 to 4.0 m and a surface area of 0.9 to 2.1 ha. The mean sampling depth was 2.8 m. October 2010 sampling was curtailed due to the scheduled repair of the pond's lakeside berm. With the exception of samples collected in April and July 2011, copepods were the overall dominant zooplankter in terms of biomass and percent composition.

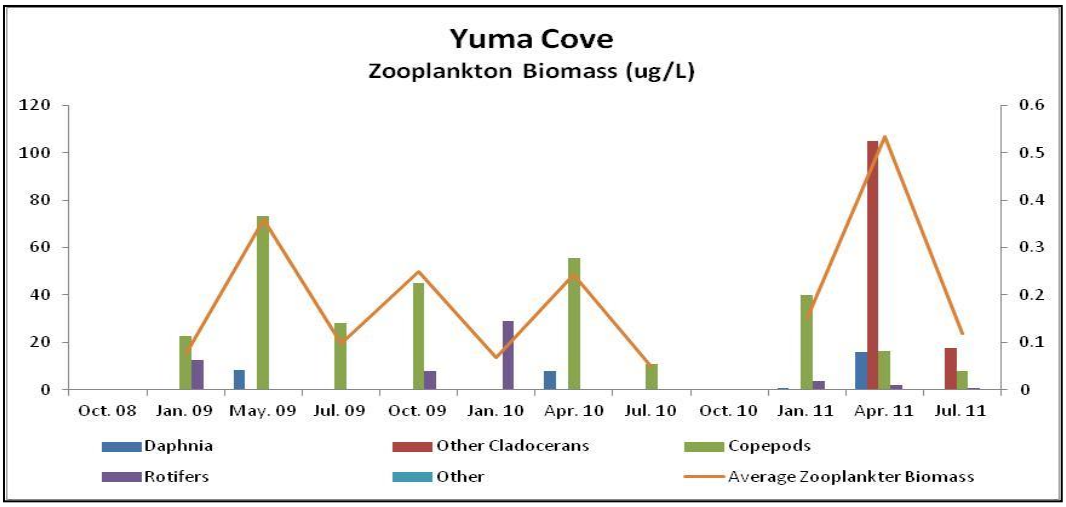


Figure 8.—Total mean biomass at Yuma Cove, Lake Mohave (January 2009 – July 2011).

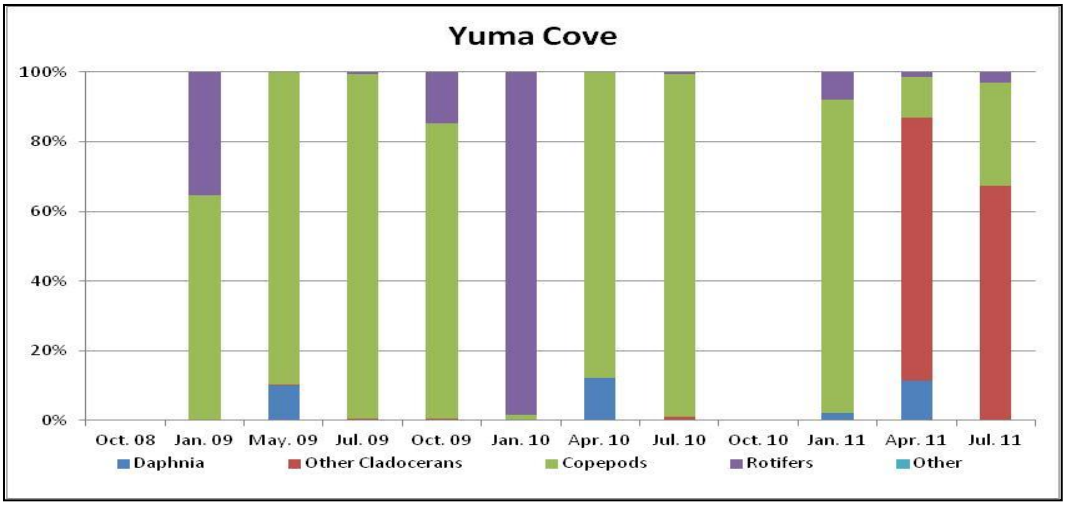


Figure 9.—Percent composition of zooplankters at Yuma Cove, Lake Mohave.

North Nine Mile

Pond is ephemeral, going completely dry during Reclamation river operations from October through December. At maximum pool, the surface area was approximately 0.3 ha. The mean sampling depth was 1.3 m. Ostracods (other category) were the dominant organisms present in January 2009, followed by a dramatic reduction in aggregate biomass for the remaining sampling. July sampling resulted in very few organisms in terms of mean biomass. Zooplankter composition showed rotifers to be the most abundant in summer sampling.

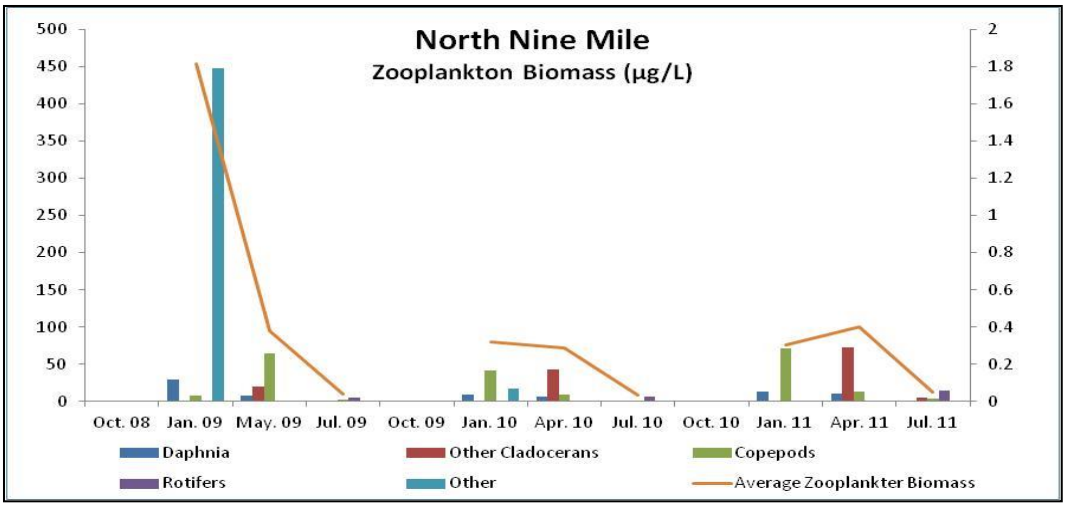


Figure 10.—Total mean biomass at North Nine Mile, Lake Mohave (January 2009 – July 2011).

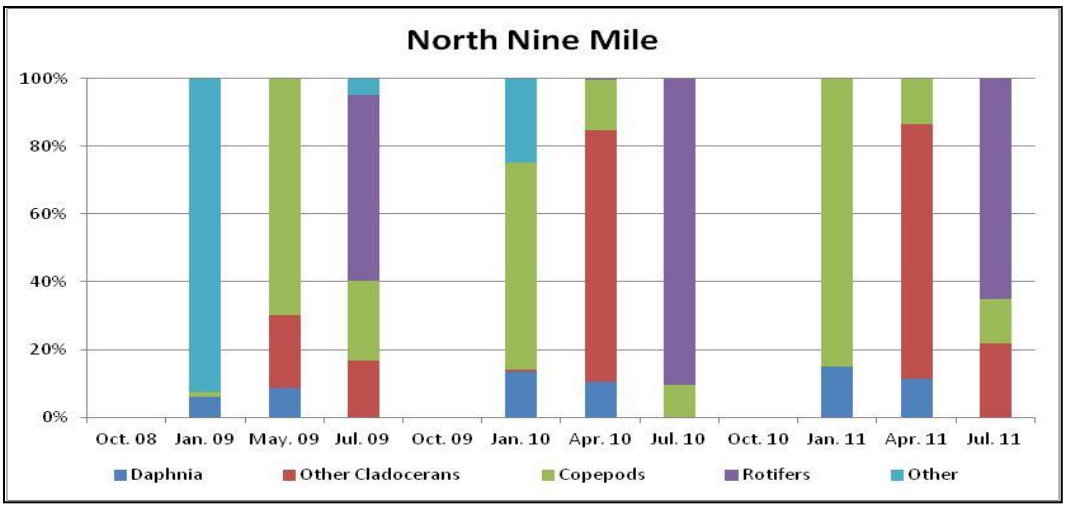


Figure 11.—Percent composition of zooplankters at North Nine Mile, Lake Mohave.

Willow

Unlike North Nine Mile, which is located in close proximity to Willow, ostracods (other category) did not contribute substantially to total mean biomass. Summer profiles showed a shift in composition from primarily rotifers in 2009 to almost exclusively copepods in 2010 and 2011. The full capacity surface area was approximately 0.4 ha. The mean pond depth was 2.0 m.

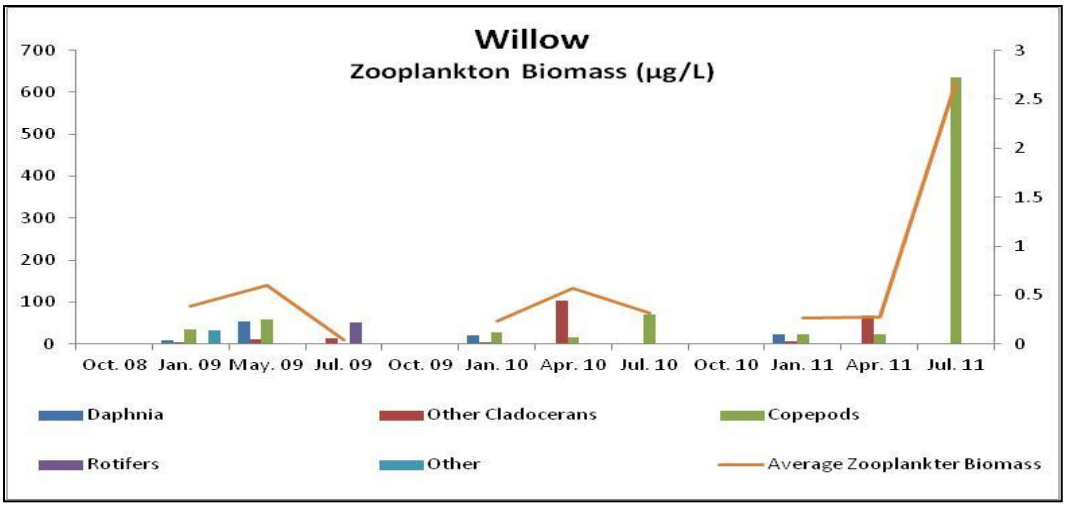


Figure 12.—Total mean biomass at Willow, Lake Mohave (January 2009 – July 2011).

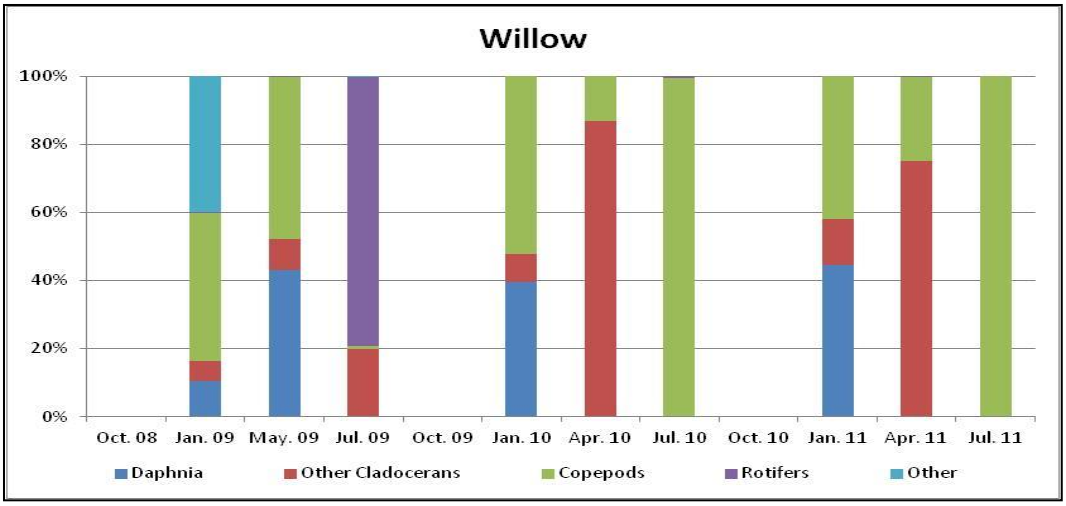


Figure 13.—Percent composition of zooplankters at Willow, Lake Mohave.

Nevada Egg

Samples collected in July across the span of the study yielded little biomass, and no sample was collected in April 2009. Of the samples collected in April of subsequent years, nondaphnid cladocerans were the most abundant zooplankter in terms of biomass and composition. As was seen at North Nine Mile in January 2009 (see figures 10 and 11), ostracods (other category) were the most abundant organisms in terms of both mean biomass and composition. The mean pond depth was 1.3 m.

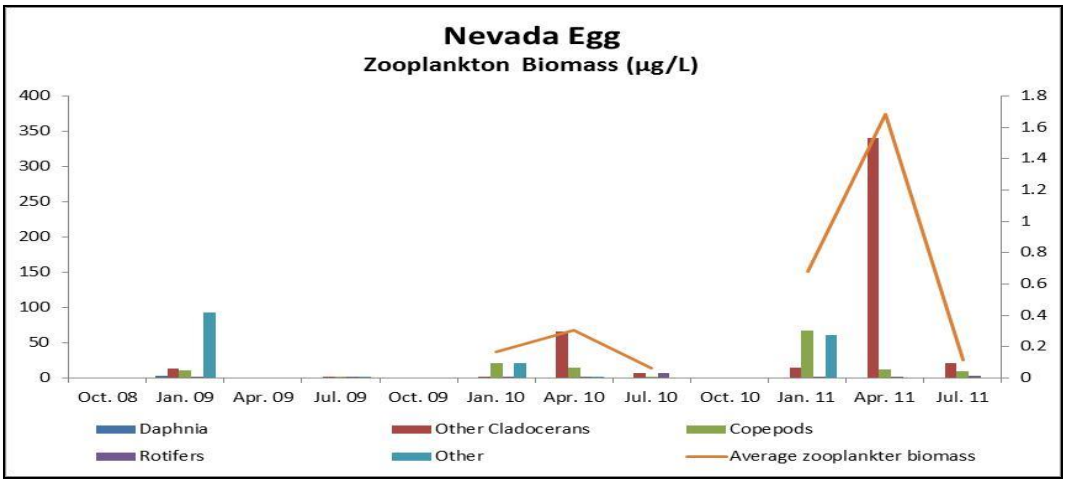


Figure 14.—Total mean biomass at Nevada Egg, Lake Mohave (January 2009 – July 2011).

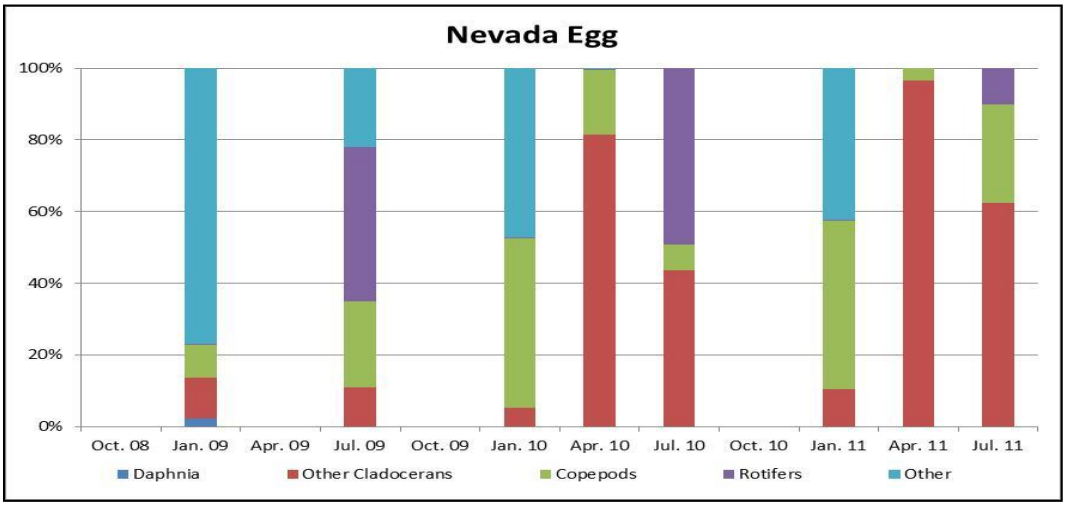


Figure 15.—Percent composition of zooplankters at Nevada Egg, Lake Mohave.

Dandy

Total biomass was relatively low from samples taken. Copepods dominated both biomass and composition during summer samples. Overall, copepods were the dominant zooplankter across seasons, although *Daphnia* spp. and other cladocerans were present during spring sampling. The mean sampling depth was approximately 2.2 m.

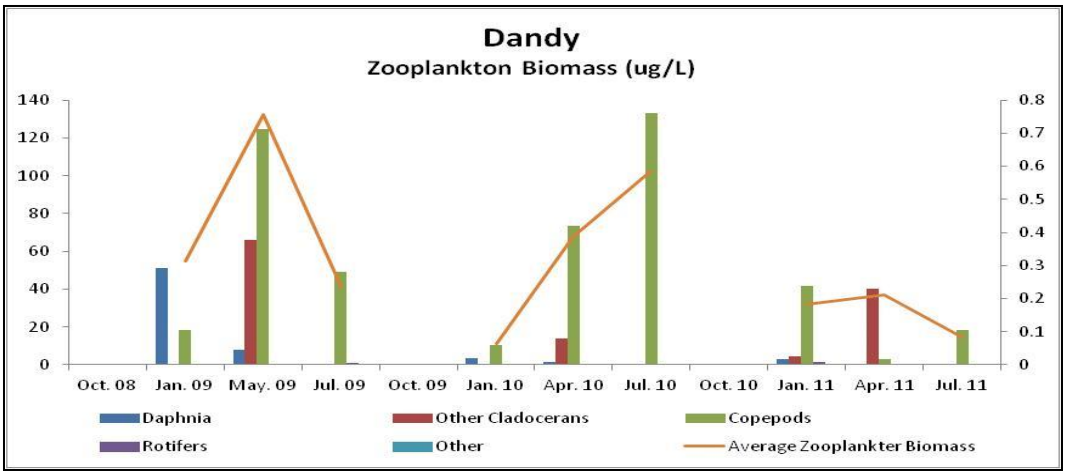


Figure 16.—Total mean biomass at Dandy, Lake Mohave (January 2009 – July 2011).

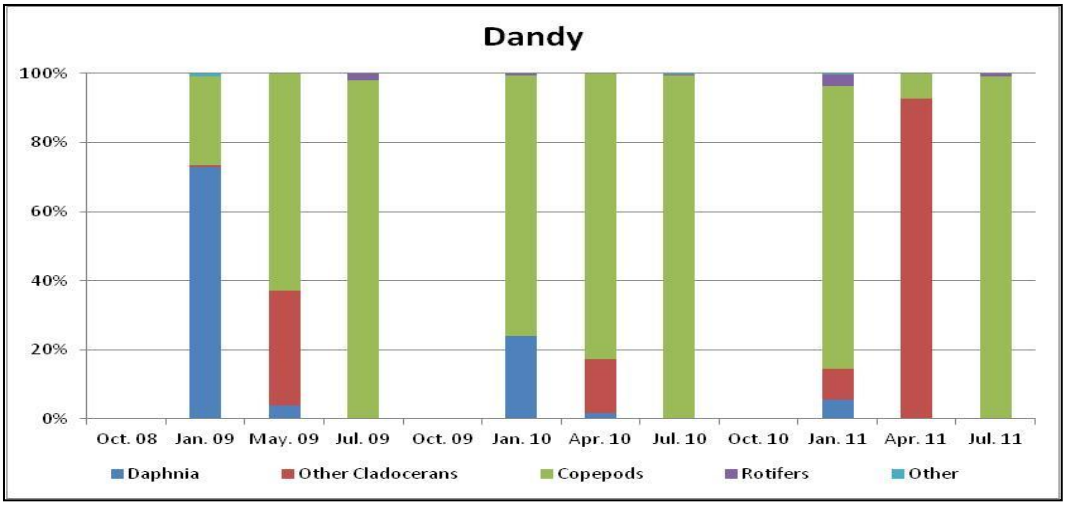


Figure 17.—Percent composition of zooplankters at Dandy, Lake Mohave.

Nevada Larvae

Among the smallest backwaters in terms of surface area (0.2 ha), no clear trends were observed in either mean biomass or seasonal composition. The mean pond depth was 2.3 m. Biomass was highest for copepods during July 2010. The most diverse species composition occurred during January sampling each year. By July of these years, composition was almost completely comprised of copepods.

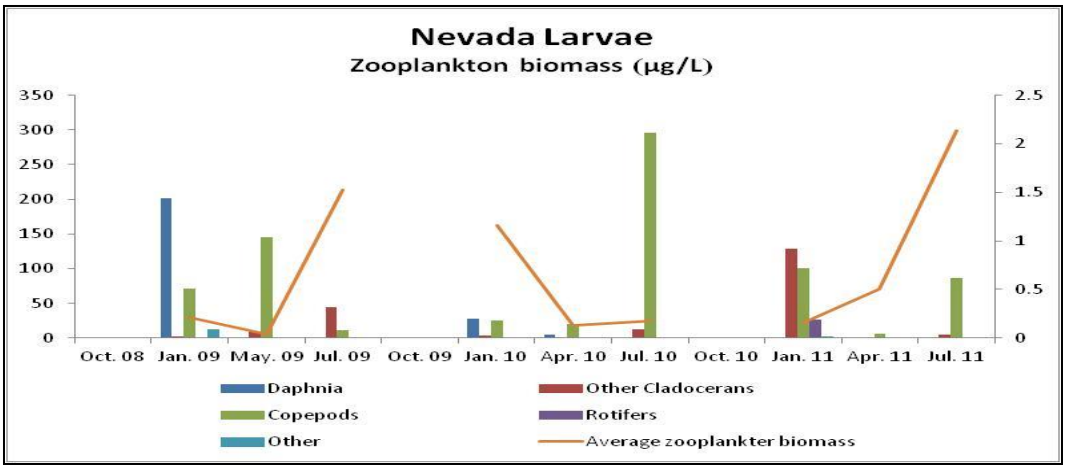


Figure 18.—Total mean biomass at Nevada Larvae, Lake Mohave (January 2009 – July 2011).

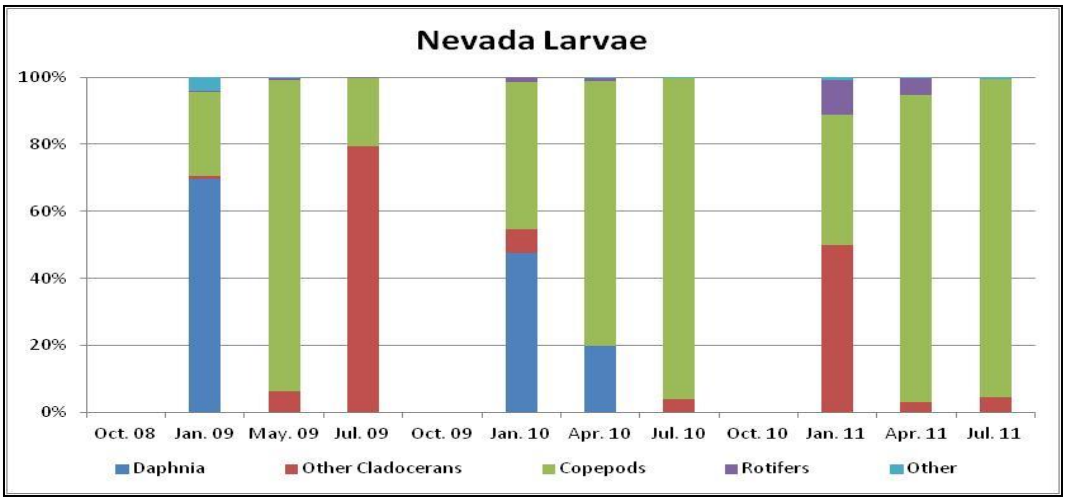


Figure 19.—Percent composition of zooplankters at Nevada Larvae, Lake Mohave.

Arizona Juvenile

The surface area at maximum capacity was approximately 0.4 ha. The mean sampling depth was 1.7 m. Substantial declines in total mean biomass occurred in summer months of each year. This phenomenon may coincide with common annual algal blooms that occur as ambient temperatures increase in this backwater. Sheer fish densities, coupled with mass algal mats, most likely contributed to low zooplankter biomass during spring and summer each year.

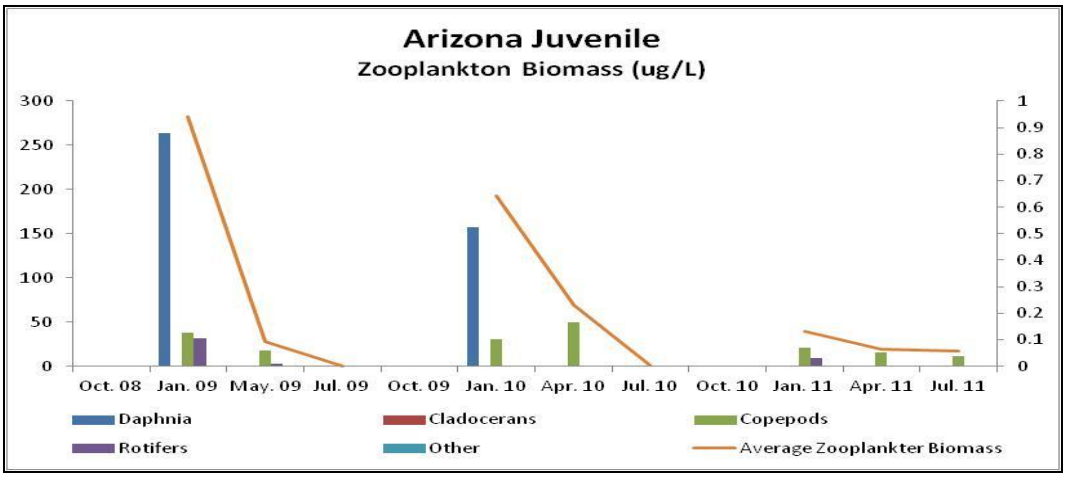


Figure 20.—Total mean biomass at Arizona Juvenile, Lake Mohave (January 2009 – July 2011).

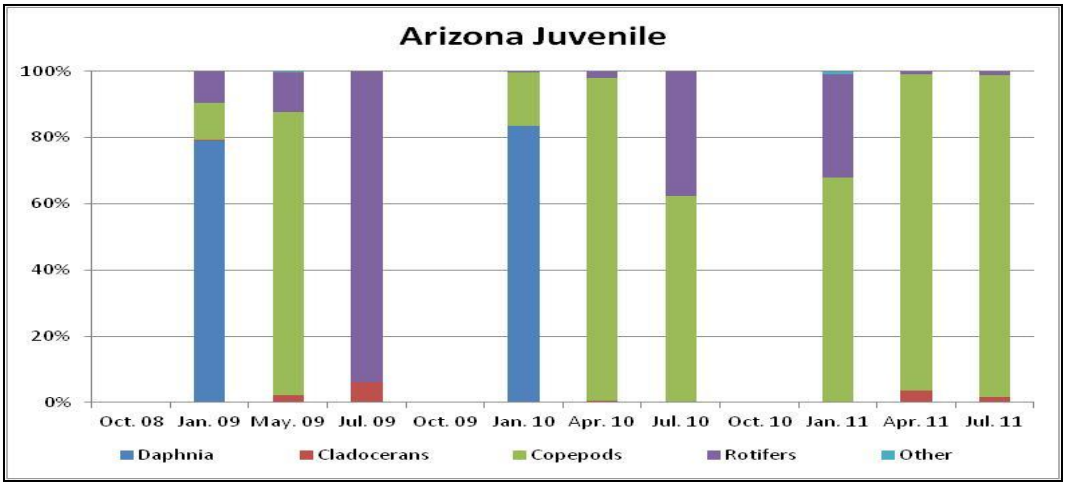


Figure 21.—Percent composition of zooplankters at Arizona Juvenile, Lake Mohave.

North Chemehuevi

The surface area (0.3 ha) was similar to Arizona Juvenile, but the sampling depth was deeper on average (2.4 m). *Daphnia* spp. were observed to have their highest abundances in January 2010 and 2011. In March 2010, a total of 200 razorback suckers were stocked (mean total length = 376 millimeters), which may have contributed to the decline in *Daphnia* and zooplankter biomass as a whole. In March 2011, a total of 111 razorback suckers were stocked (mean total length = 315). Declines in zooplankter biomass were observed but not to the degree of the previous year.

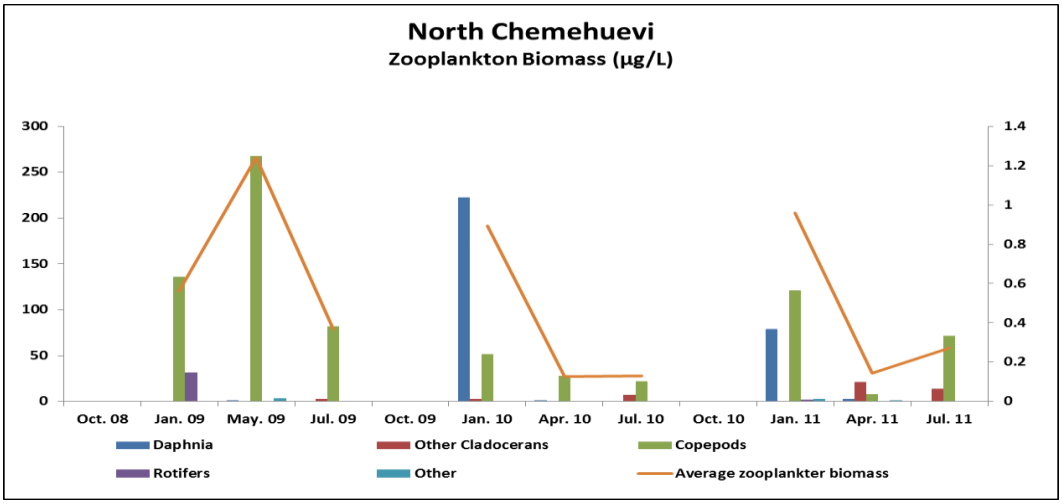


Figure 22.—Total mean biomass at North Chemehuevi, Lake Mohave (January 2009 – July 11).

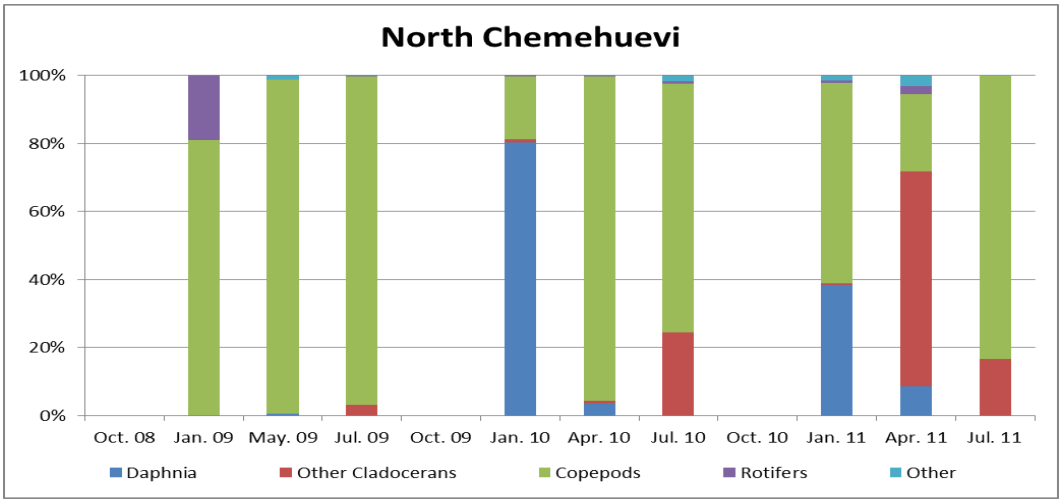


Figure 23.—Percent composition of zooplankters at North Chemehuevi, Lake Mohave.

Davis Cove

This backwater was added to our analysis beginning the second year of sampling. Overall zooplankton biomass was on average the lowest of any of the Lake Mohave backwaters sampled. The maximum surface area was larger than most Lake Mohave backwaters, at approximately 1.4 ha, and was comparable to Yuma Cove. The mean sampling depth was 3.9 m. April samples were comprised mostly of *Daphnia* and other cladocerans. All other sampling events showed copepods to be the most abundant zooplankter.

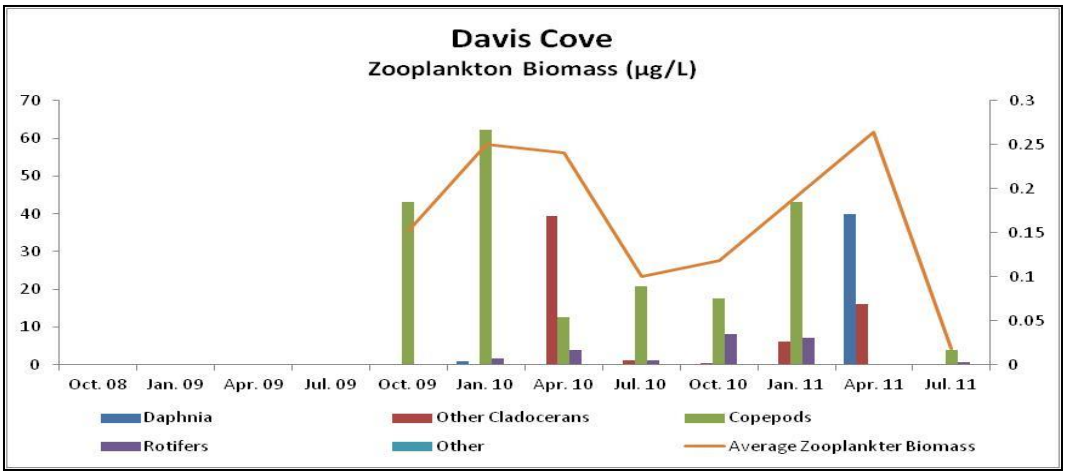


Figure 24.—Total mean biomass at Davis Cove, Lake Mohave (October 2009 – July 2011).

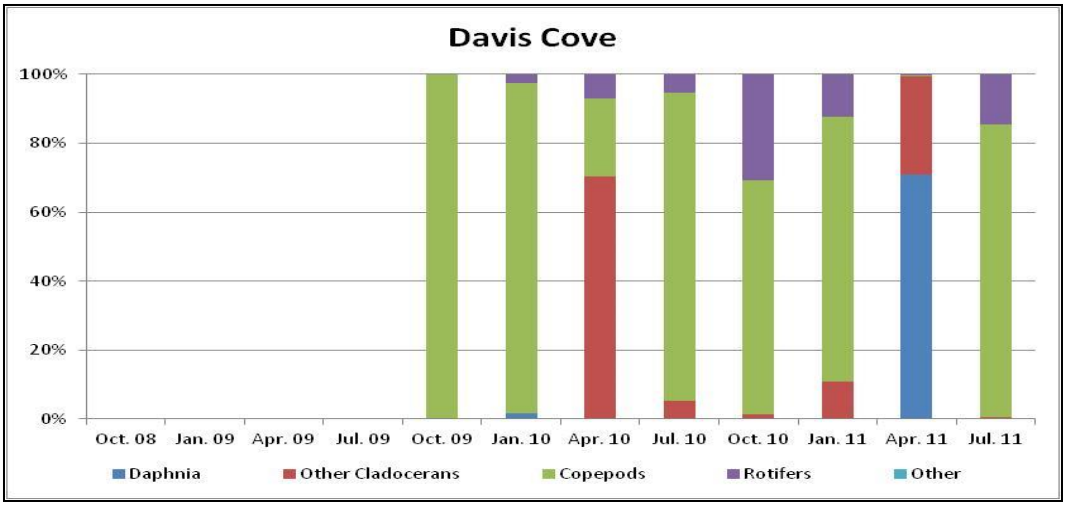


Figure 25.—Percent composition of zooplankters at Davis Cove, Lake Mohave.

Needles Golf Course Ponds

Needles Golf Course (Hole 1)

The total mean biomass was cyclical but relatively low, with the highest biomass occurring in winter and spring samples, followed by low values in summer of each year sampled. Summer samples were comprised primarily of rotifers. Presence of *Daphnia* was observed exclusively in January of each year. The pond surface area, at about 0.3 ha, resembled that of smaller Lake Mohave backwaters. The mean sampling depth was 1.8 m.

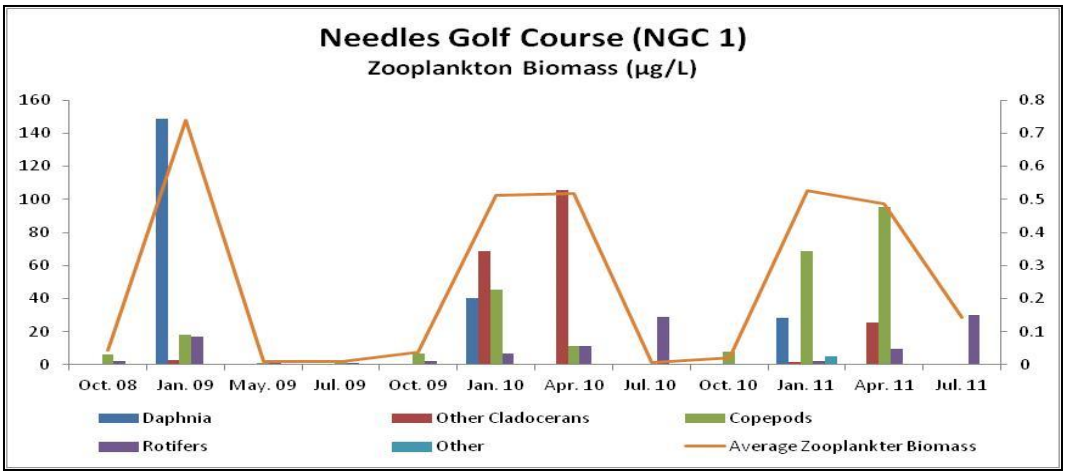


Figure 26.—Total mean biomass at NGC 1, Needles Golf Course Pond (October 2008 – July 2011).

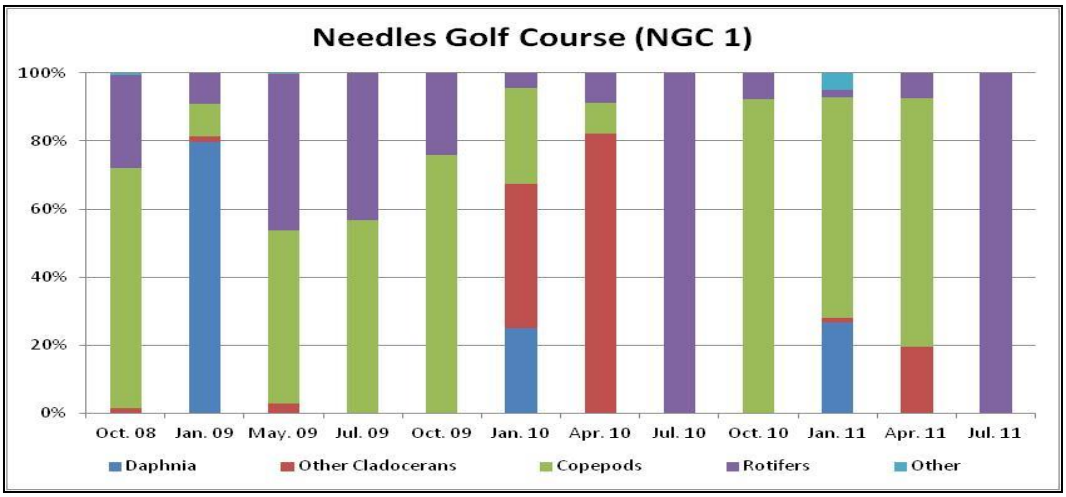


Figure 27.—Percent composition of zooplankters at NGC 1, Needles Golf Course Pond.

Needles Golf Course (Hole 18)

Located immediately adjacent to NGC 1, the biomass and composition of zooplankters was less diverse overall. Copepods and rotifers dominated all samples across the entire 3-year study. The pond is approximately twice the size of NGC 1 (0.74 ha), but the mean sampling depth was comparable at approximately 2.0 m. The two ponds at this site are connected by a large underground pipe where pumped groundwater serves as a common water source between the two.

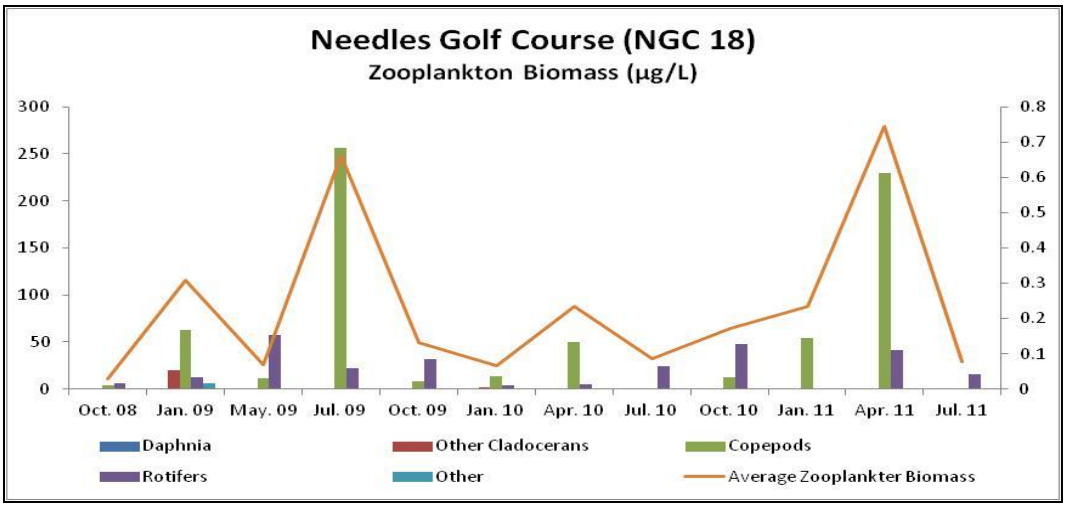


Figure 28.—Total mean biomass at NGC 18, Needles Golf Course Pond (October 2008 – July 2011).

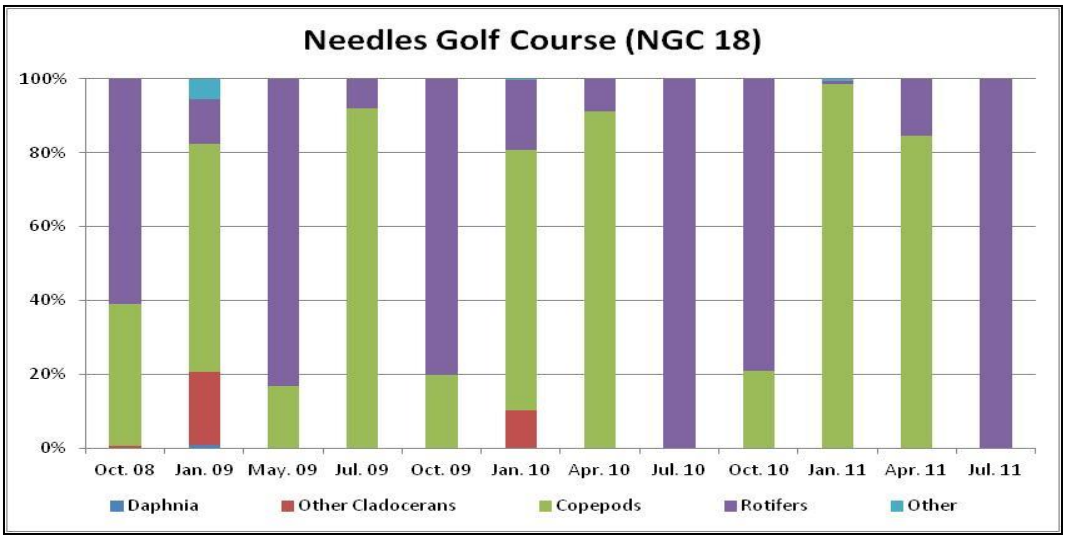


Figure 29.—Percent composition of zooplankters at NGC 18, Needles Golf Course Pond.

Beal Lake

Beal lake is approximately 91 ha in size, making it the largest backwater sampled on the LCR off-channel system. Biomass was consistently low throughout the study. The one exception occurred in April 2010, when *Daphnia* and other cladocerans were most abundant. From October 2008 to October 2010, copepods and rotifers were the only zooplankters detected in samples. Because of the large surface area of Beal Lake, three additional sample sites were added to the monitoring design since the conclusion of this study. These additional sites will provide a more representative zooplankton profile. The mean sampling depth was 1.5 m and was similar throughout the lake.

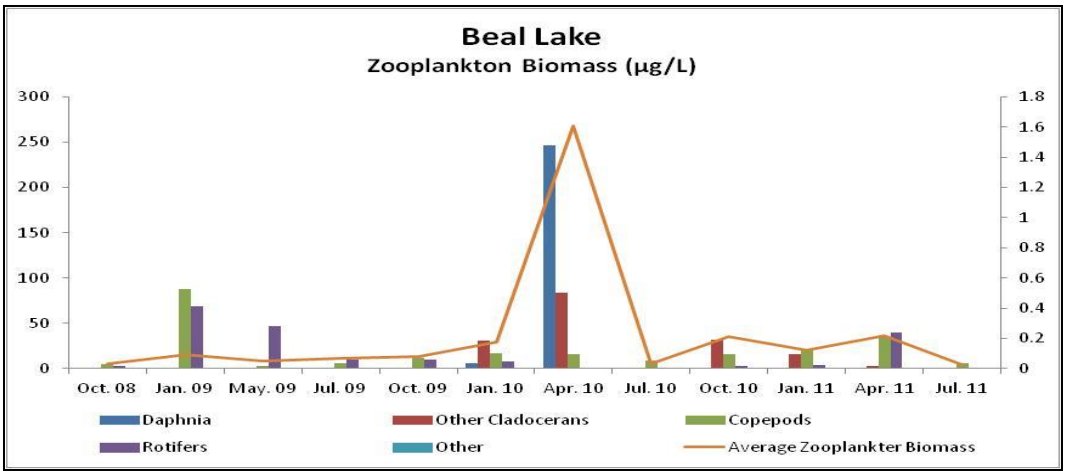


Figure 30.—Total mean biomass at Beal Lake (October 2008 – July 2011).

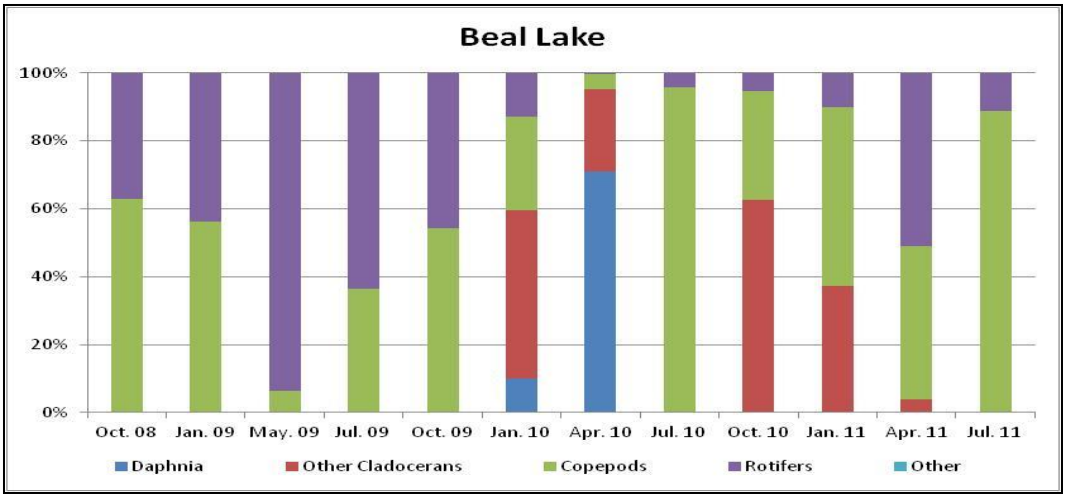


Figure 31.—Percent composition of zooplankters at Beal Lake.

Office Cove Pond

Biomass was relatively low throughout sampling due to the dominance of small-bodied rotifers. Rotifers comprised the bulk of composition except for January 2010, when copepods were most abundant. The surface area was approximately 0.92 ha. The mean sampling depth was 2.8 m.

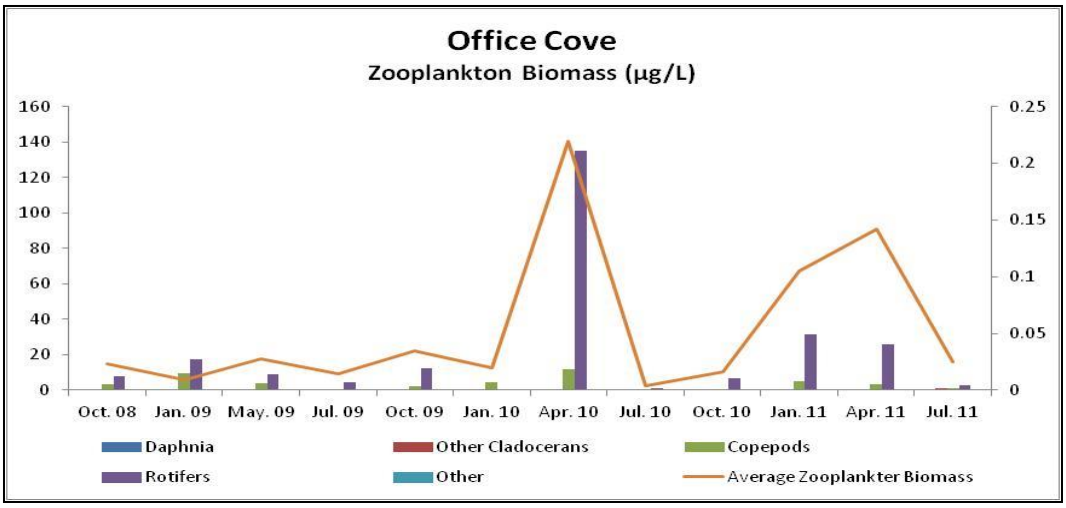


Figure 32.—Total mean biomass at Office Cove Pond (October 2008 – July 2011).

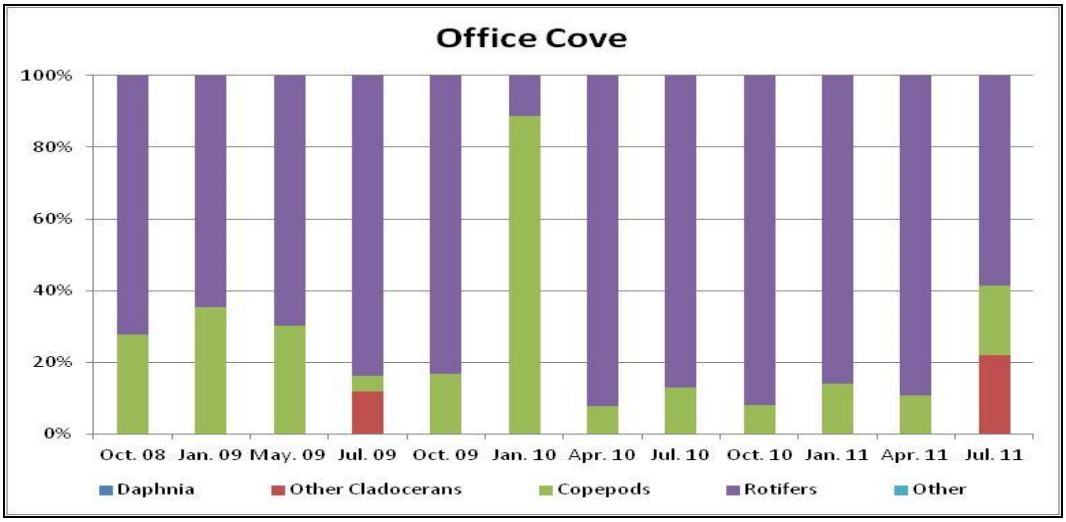


Figure 33.—Percent composition of zooplankters at Office Cove Pond.

Parker Dam Pond

Utilized as a bonytail sanctuary, this pond was the most depauperate of all sites sampled in terms of mean zooplankter biomass. On average, the depth of sampled water was one of the highest (3.5 m). It was also the smallest, at approximately 0.05 ha, in regard to surface area.

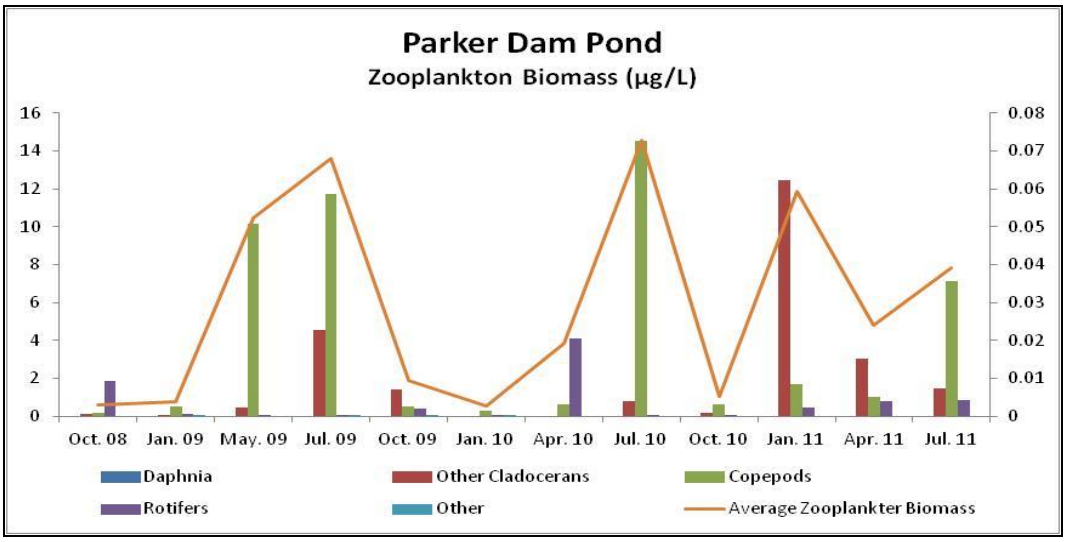


Figure 34.—Total mean biomass at Parker Dam Pond (October 2008 – July 2011).

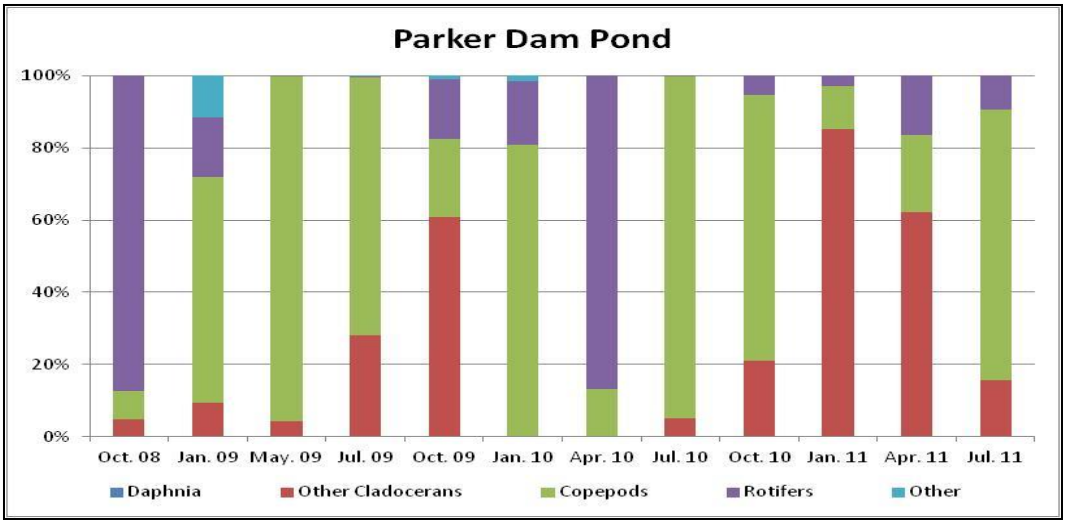


Figure 35.—Percent composition of zooplankters at Parker Dam Pond.

Emerald Canyon Golf Course Ponds

Emerald Canyon 1 (Hole 1)

Productivity was lowest in October 2009 and 2010 in terms of total mean biomass. Composition was limited to copepods and rotifers, and dominance of each fluctuated. The pond surface area was 0.43 ha. The mean sampling depth was 1.8 m.

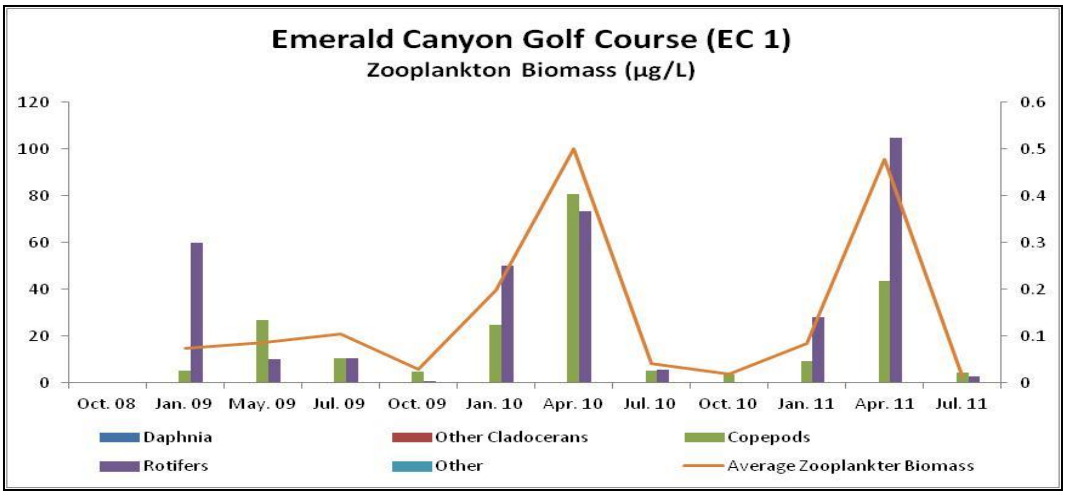


Figure 36.—Total mean biomass at EC 1, Emerald Canyon Golf Course (January 2009 – July 2011).

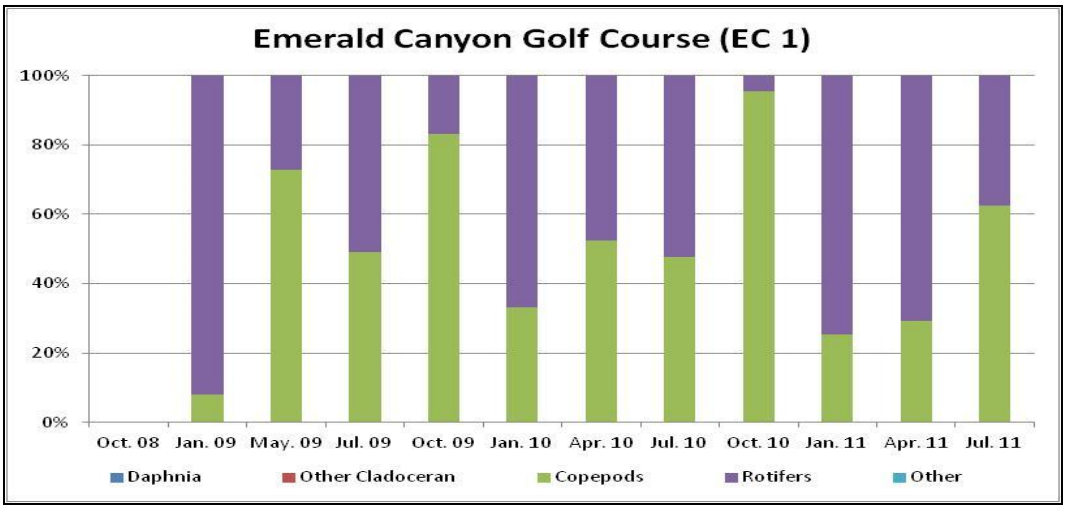


Figure 37.—Percent composition of biomass at EC 1, Emerald Canyon Golf Course.

Emerald Canyon 9 (Hole 9)

Located immediately adjacent to EC 1, mean biomass was much higher overall despite its small surface area (0.16 ha). April 2010 and 2011 contained the highest biomass and most diverse composition in this pond, followed by a subsequent depletion of zooplankters in summer samples. The mean sampling depth was 1.3 m.

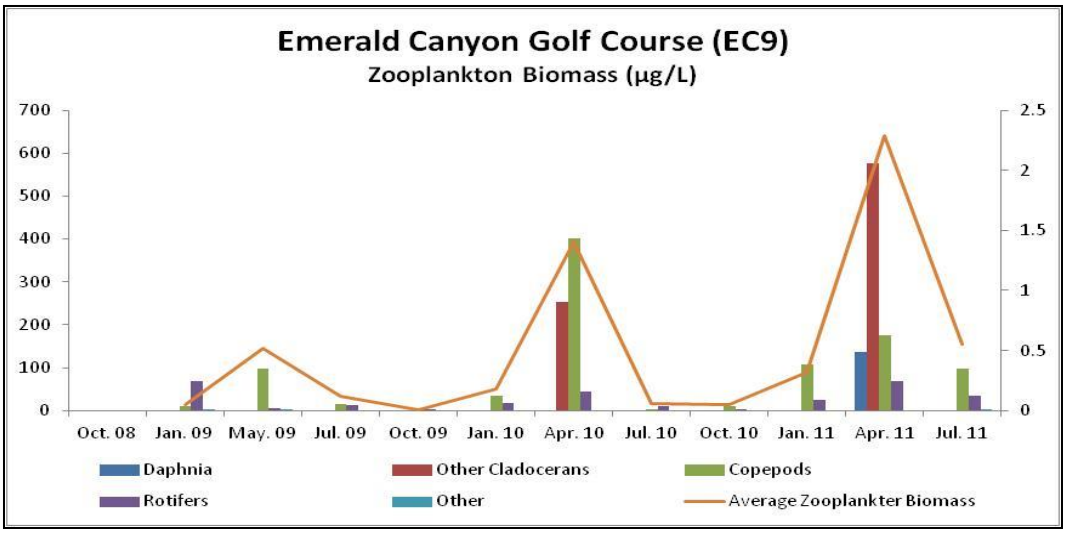


Figure 38.—Total mean biomass at EC 9, Emerald Canyon Golf Course (January 2009 – July 2011).

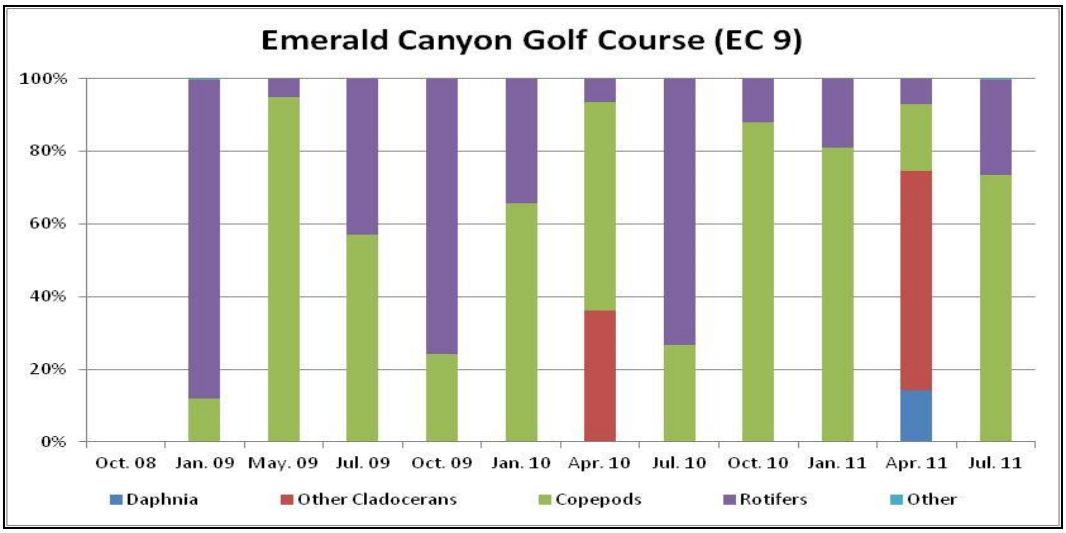


Figure 39.—Percent composition of zooplankters at EC 9, Emerald Canyon Golf Course.

Emerald Canyon 11 (Hole 11)

Biomass was virtually nonexistent prior to April 2010. An increase in zooplankton biomass appeared to coincide with the completion of golf course renovations. Cladoceran biomass peaked in October 2010 before a steady decline ensued. The mean sampling depth was 2.0 m. This pond is the largest of the Emerald Canyon ponds, at 0.58 ha, in terms of surface area. In terms of composition, cladocerans other than *Daphnia* comprised a representative amount of total zooplankters.

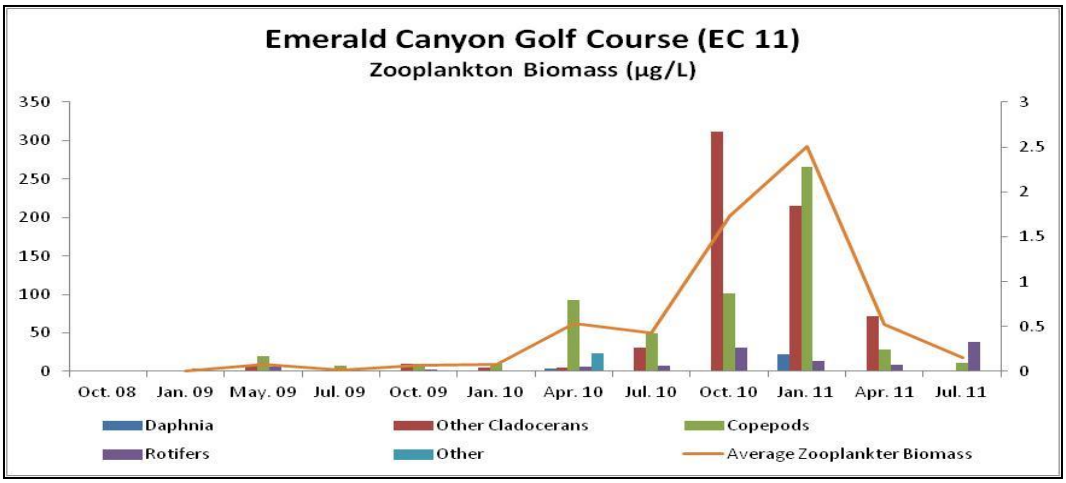


Figure 40.—Total mean biomass at EC 11, Emerald Canyon Golf Course (January 2009 – July 2011).

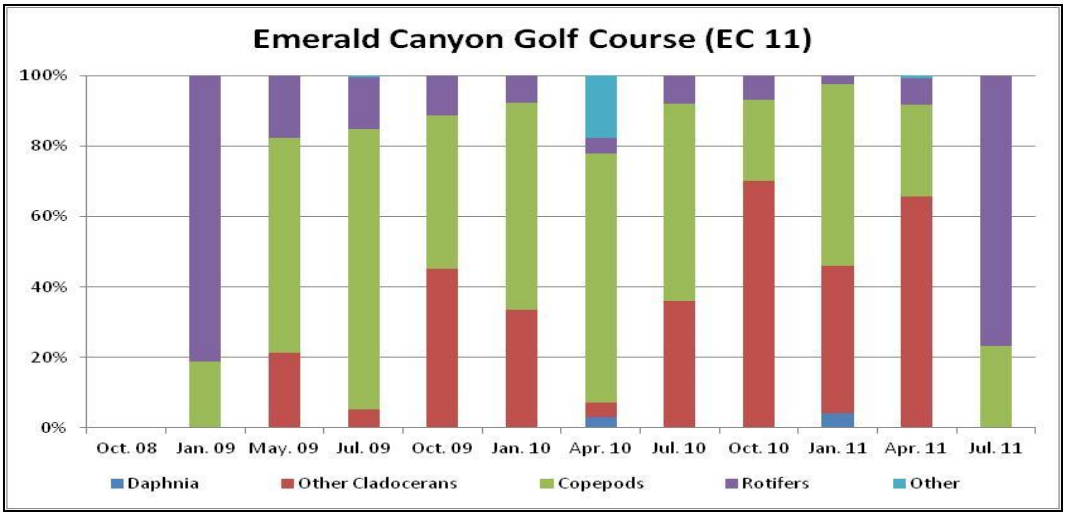


Figure 41.—Percent composition of zooplankters at EC 11, Emerald Canyon Golf Course.

Achii Hanyo Native Fish-Rearing Facility

Pond A

Achii Hanyo NFRF ponds are among the smallest off-channel habitats for rearing razorback suckers and bonytail chubs. Mean biomass was comprised mostly of rotifers and copepods. July 2009 mean rotifer biomass peaked at approximately 169 µg/L. Percent composition in January 2009 and 2011 and July 2011 was comprised almost entirely of copepods. The pond is one of the smallest in terms of surface area at 0.07 ha. The mean sampling depth was 1.2 m.

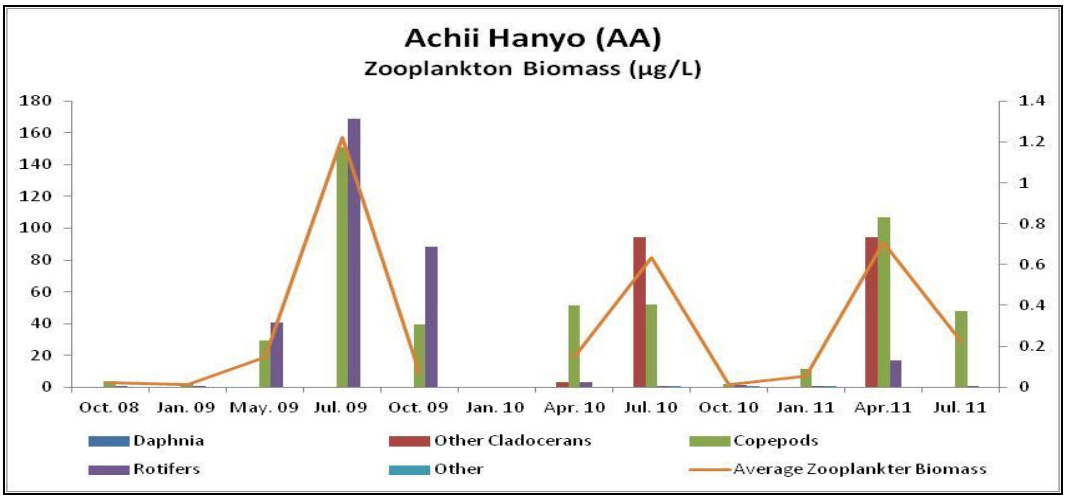


Figure 42.—Total mean biomass at Pond A, Achii Hanyo NFRF (October 2008 – July 2011).

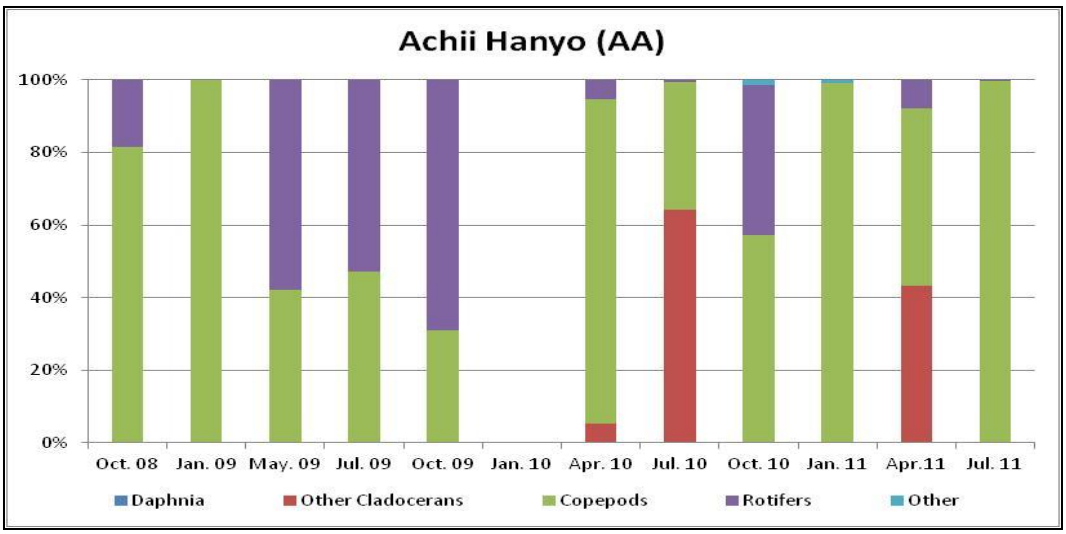


Figure 43.—Percent composition of zooplankters at Pond A, Achii Hanyo NFRF.

Pond B

Similar to Pond A, copepods and rotifers comprised the highest amount of mean biomass. Average zooplankter biomass declined each year between July and October and rebounded through winter and spring. April 2011 samples contained a higher composition of *Daphnia* that was not present in earlier sampling events. Likewise, July 2011 samples were dominated by ostracods (other category). The surface area was 0.11 ha, similar in dimensions to Pond A. The mean sampling depth was 1.1 m.

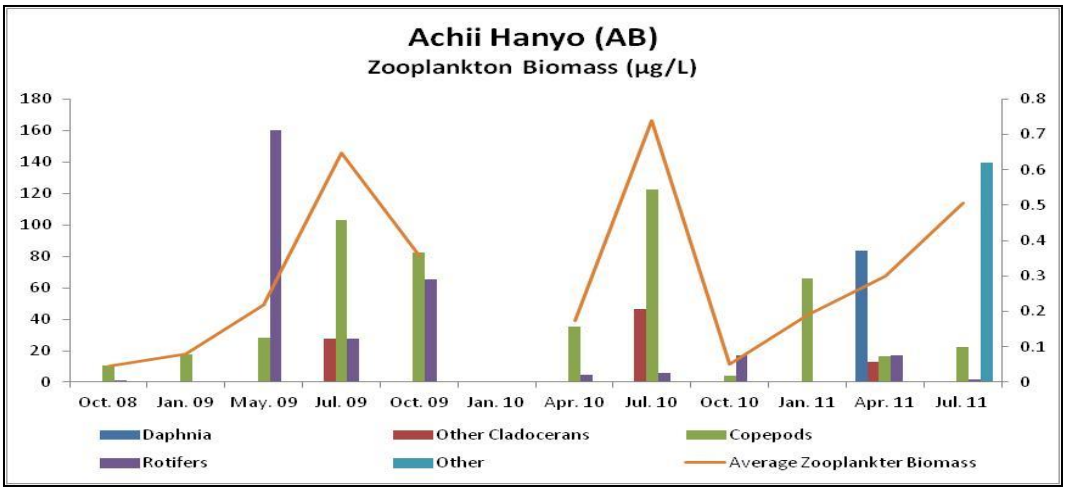


Figure 44.—Total mean biomass at Pond B, Achii Hanyo NFRF (October 2008 – July 2011).

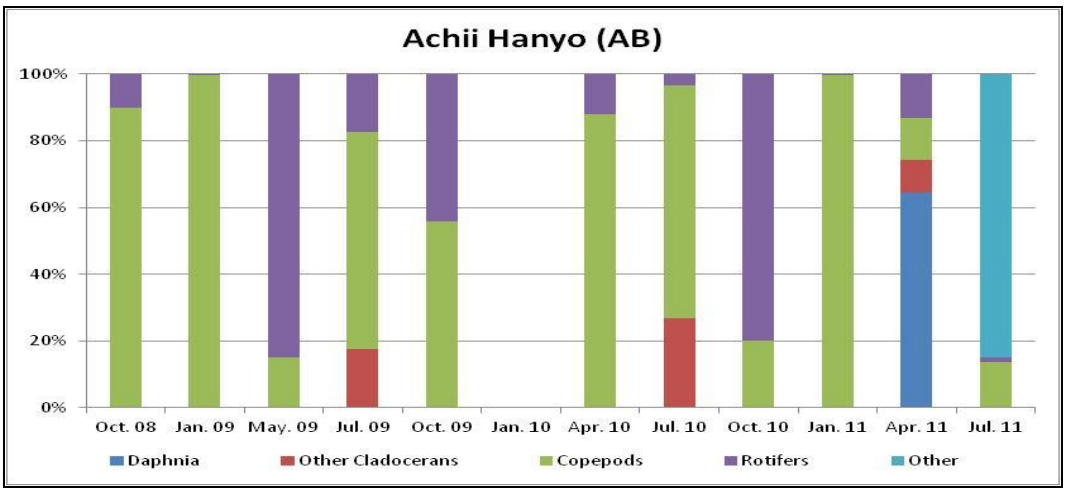


Figure 45.—Percent composition of zooplankters at Pond B, Achii Hanyo NFRF.

Pond C

Rotifers peaked at 277 µg/L during May 2009. As was shown for Ponds A and B, rotifers and copepods once again comprised the majority of zooplankter composition. As was the case for Pond A (see figures 42 and 43), *Daphnia* was not found in any samples collected. The pond surface area was 0.34 ha. The mean sampling depth was 1.1 m.

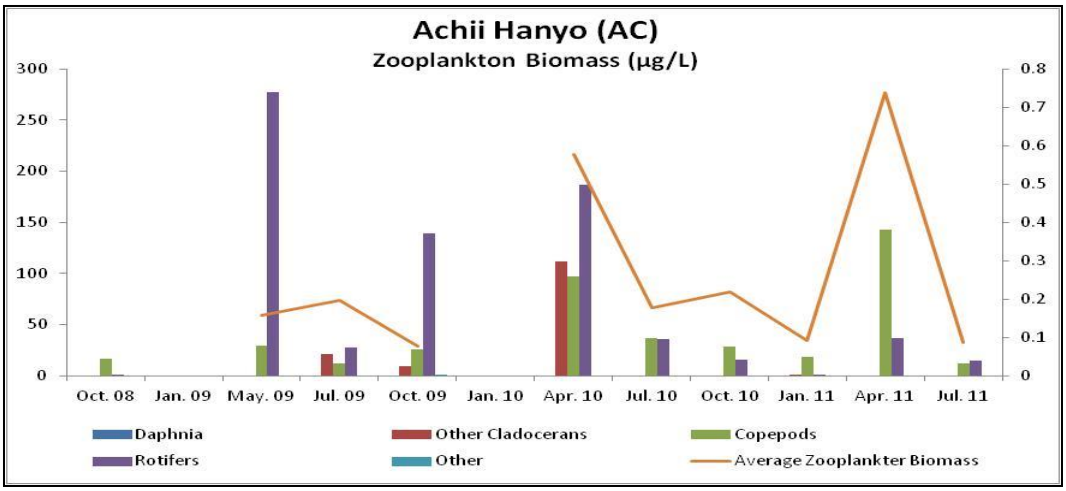


Figure 46.—Total mean biomass at Pond C, Achii Hanyo NFRF (October 2008 – July 2011).

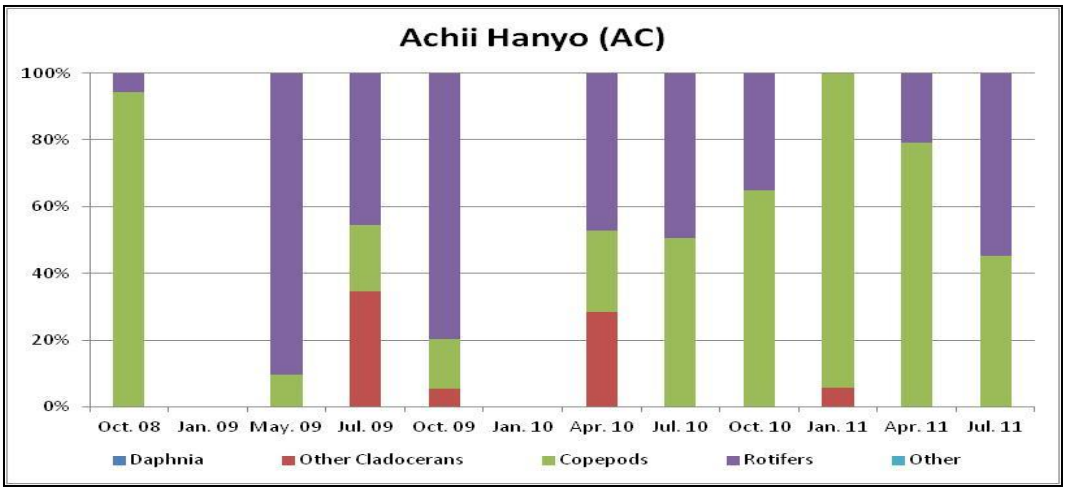


Figure 47.—Percent composition of zooplankters at Pond C, Achii Hanyo NFRF.

Pond 1

Consistent with other ponds at the Achii Hanyo NFRF, May 2009 biomass was dominated by rotifers. Similar to Pond B (see figures 44 and 45), *Daphnia* was the most prevalent zooplankter in terms of biomass and composition in April 2011. Excluding April 2011, overall composition was mainly comprised of copepods between January 2010 and July 2011. The south perimeter of the pond is lined with cottonwood trees, providing at least partial shade during daylight hours. The surface area was 0.17 ha. The mean sampling depth, at 1.4 m, was slightly higher than at other Achii Hanyo ponds.

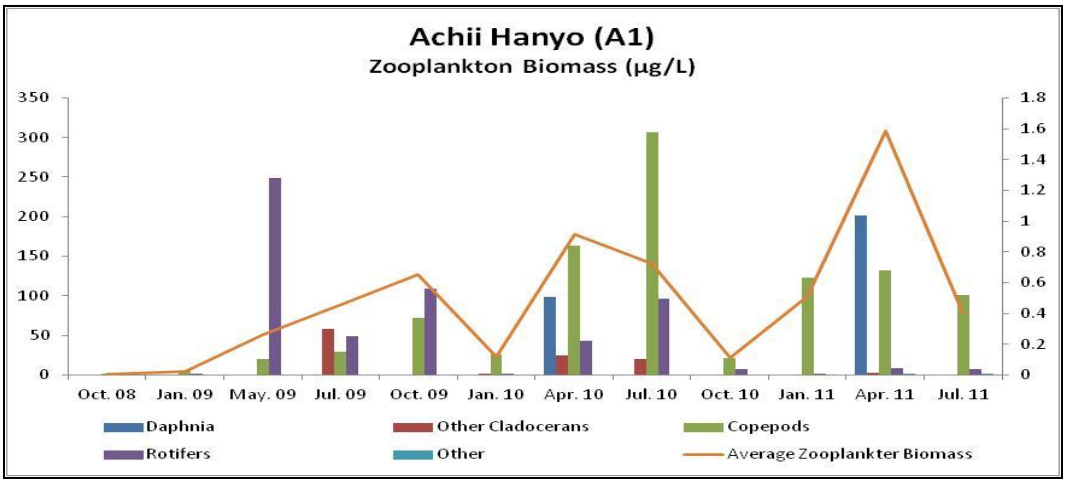


Figure 48.—Total mean biomass at Pond 1, Achii Hanyo NFRF (October 2008 – July 2011).

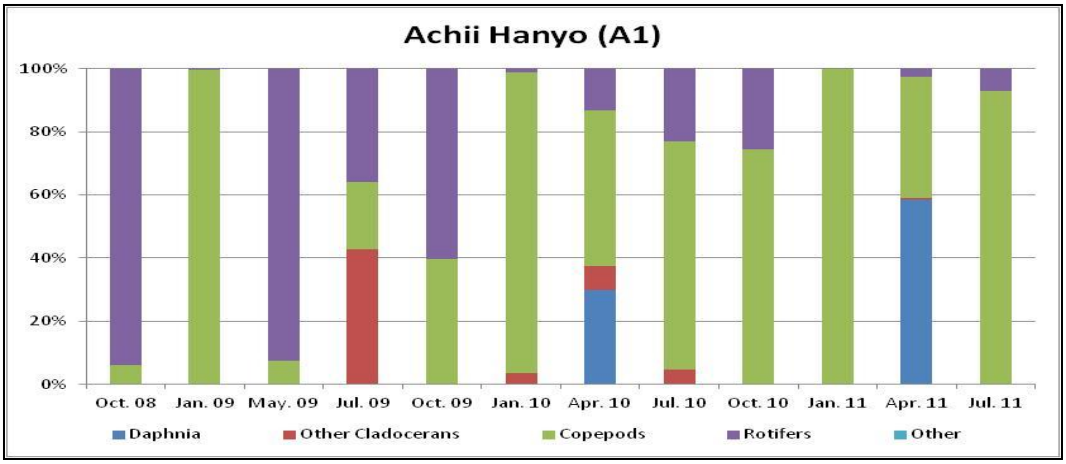


Figure 49.—Percent composition of zooplankters at Pond 1, Achii Hanyo NFRF.

Pond 2

May 2009 was highest for rotifer biomass at 393 µg/L. As has been illustrated in other Achii Hanyo ponds, rotifers and copepods were the dominant organisms documented. In the final year of sampling (January through July 2011), copepods were the primary zooplankter observed. The pond surface area was 0.37 ha. The mean sampling depth was 1.2 m.

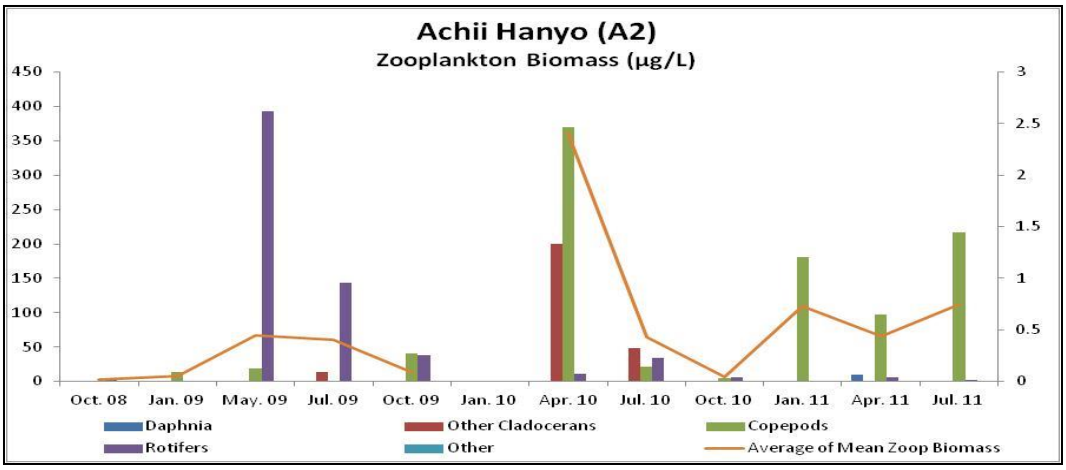


Figure 50.—Total mean biomass at Pond 2, Achii Hanyo NFRF (October 2008 – July 2011).

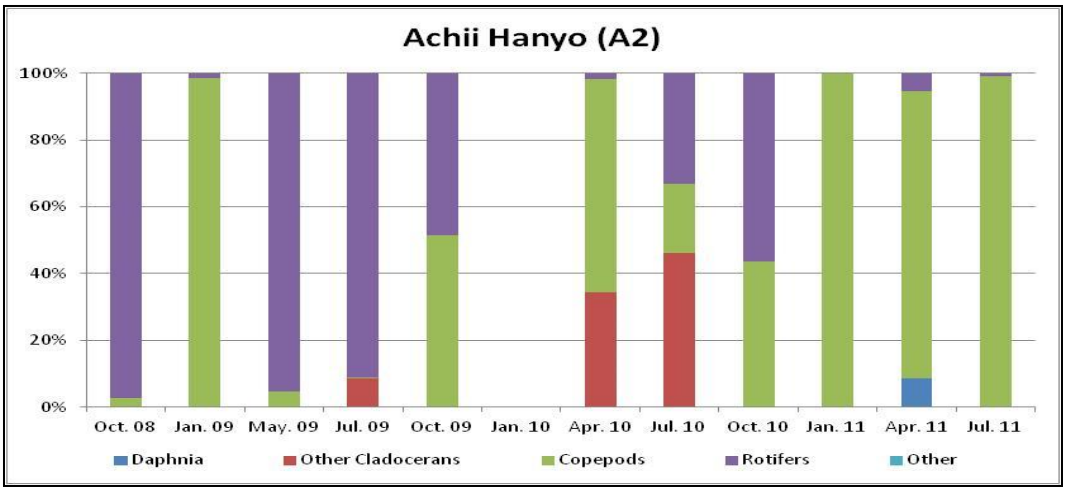


Figure 51.—Percent composition of zooplankters at Pond 2, Achii Hanyo NFRF.

Pond 3

Total zooplankton biomass for October 2008 was < 0.1 µg/L. Excluding October 2008, and with the exception of July 2009, copepods were the dominant zooplankter in terms of mean biomass and percent composition. The surface area was 0.55 ha, making it slightly larger than any of the other Achii Hanyo ponds in use. The mean sampling depth was 1.0 m.

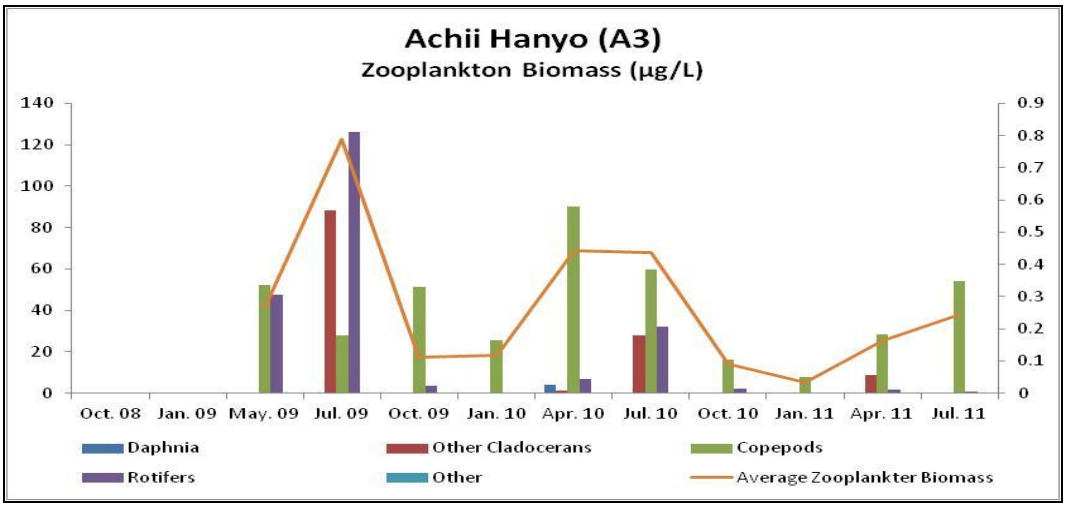


Figure 52.—Total mean biomass at Pond 3, Achii Hanyo NFRF (October 2008 – July 2011).

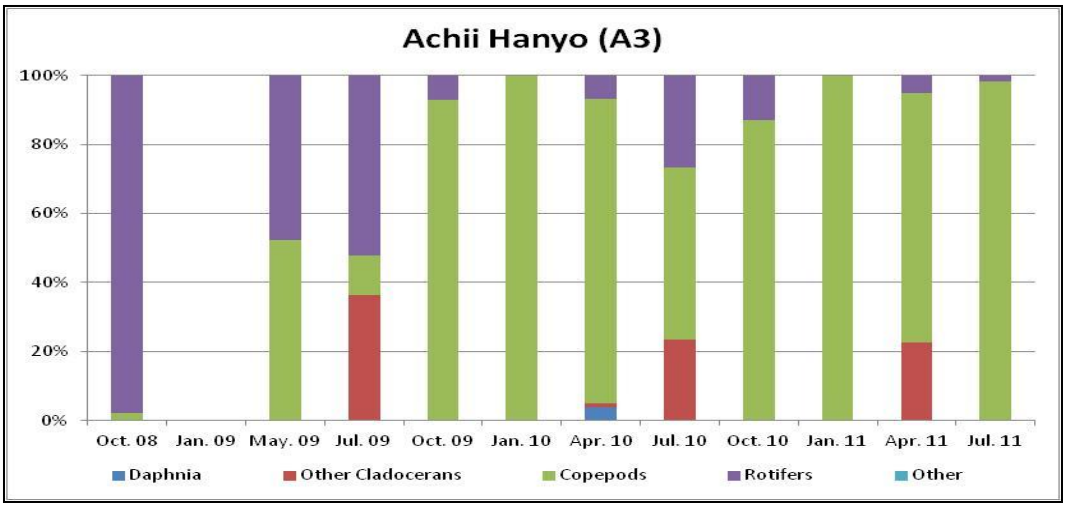


Figure 53.—Percent composition of zooplankters at Pond 3, Achii Hanyo NFRF.

Pond 4

Because this pond was not in service for much of the sampling iterations, little can be gleaned from the zooplankton profile. The July and October 2009 samples were unique from other Achii Hanyo NFRF ponds in that cladocerans were the most abundant zooplankters present. The surface area was 0.46 ha. The mean sampling depth was 1.3 m, consistent with other Achii Hanyo ponds.

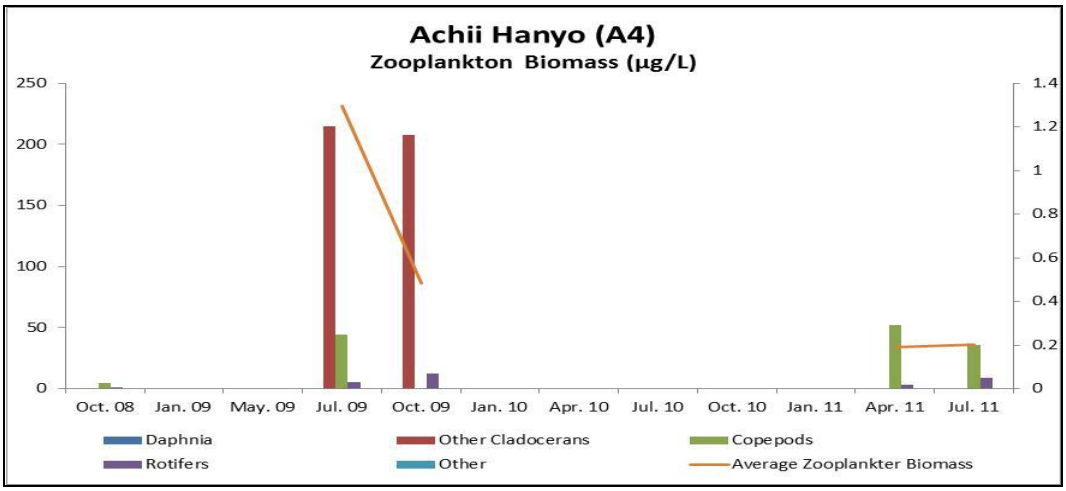


Figure 54.—Total mean biomass at Pond 4, Achii Hanyo NFRF (October 2008 – July 2011).

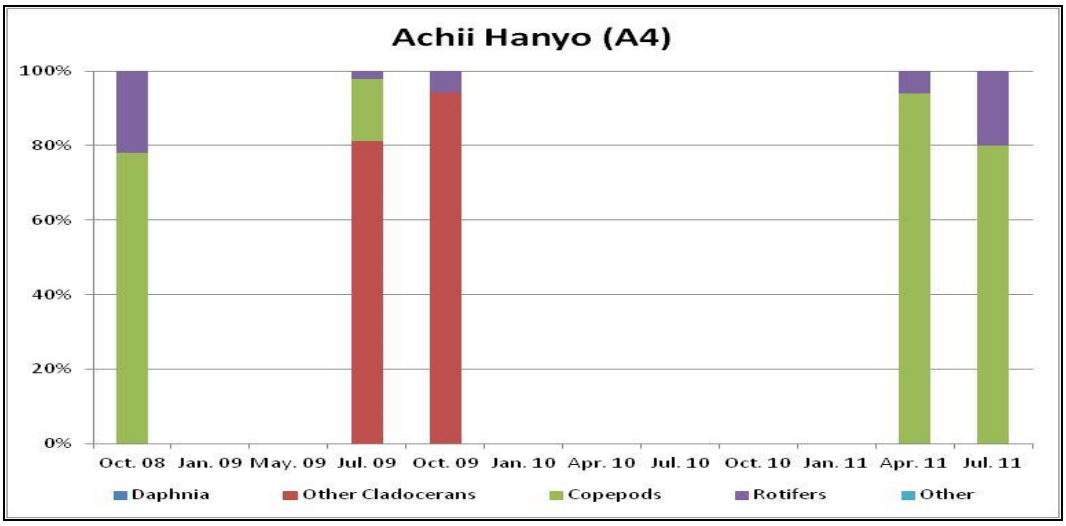


Figure 55.—Percent composition of zooplankters at Pond 4, Achii Hanyo NFRF.

Imperial National Wildlife Refuge

I1

Ponds in this system are considerably larger than other backwaters along the LCR, with surface areas ranging from 3.3 to 9.2 ha. Sample biomass was generally low for pond I1, except for July 2009, when copepods constituted the highest biomass. *Daphnia* and other cladocerans were found in modest quantities in cooler months, while summer composition was dominated by copepods. The pond surface area was approximately 3.7 ha. The mean sampling depth was 2.8 m.

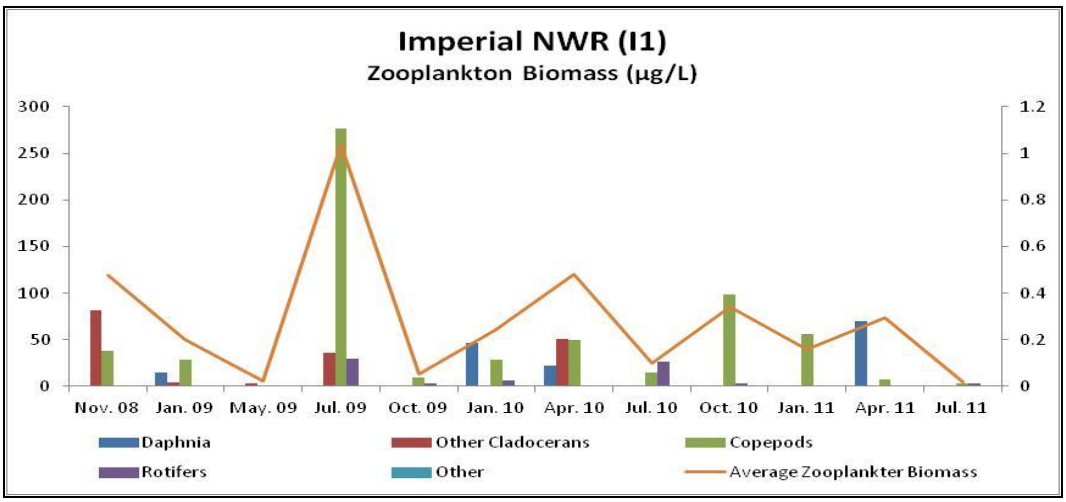


Figure 56.—Total mean biomass at I1, Imperial NWR (November 2008 – July 2011).

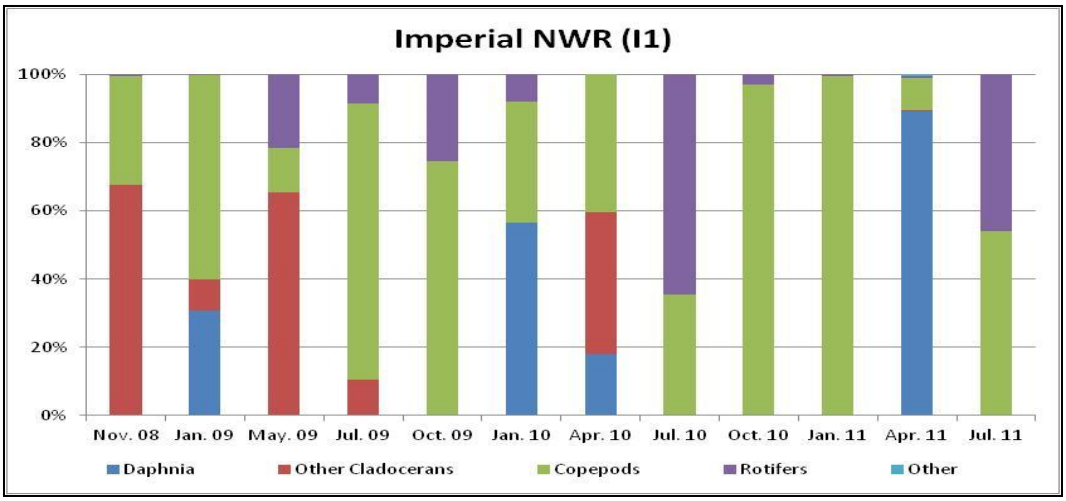


Figure 57.—Percent composition of zooplankters at I1, Imperial NWR.

I2

Overall mean biomass was low from the samples collected. Never did total biomass exceed 85 µg/L in any quarterly samples. In terms of composition, *Daphnia* was detected only during January sampling. Other cladocerans were found throughout the study, with a peak occurring in April 2011. The pond surface area was approximately 5.0 ha. The mean sampling depth was 2.6 m.

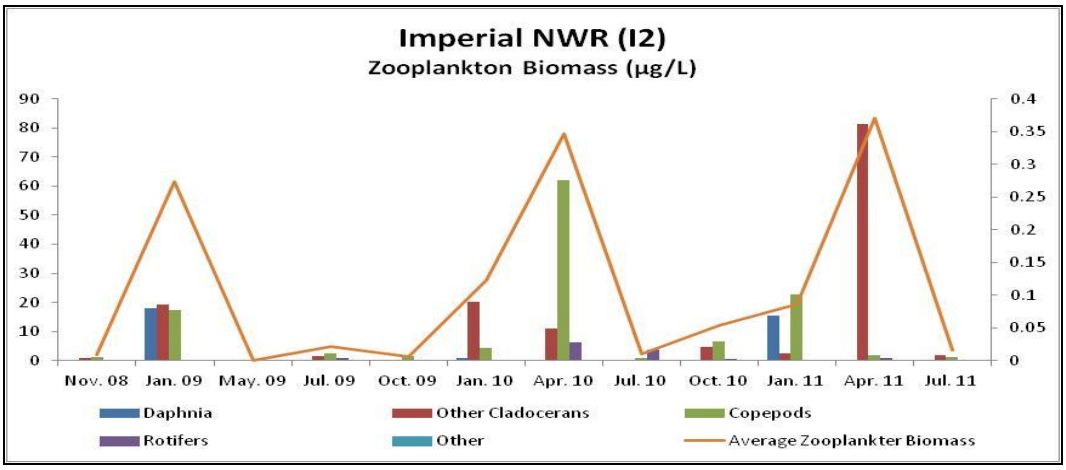


Figure 58.—Total mean biomass at I2, Imperial NWR (November 2008 – July 2011).

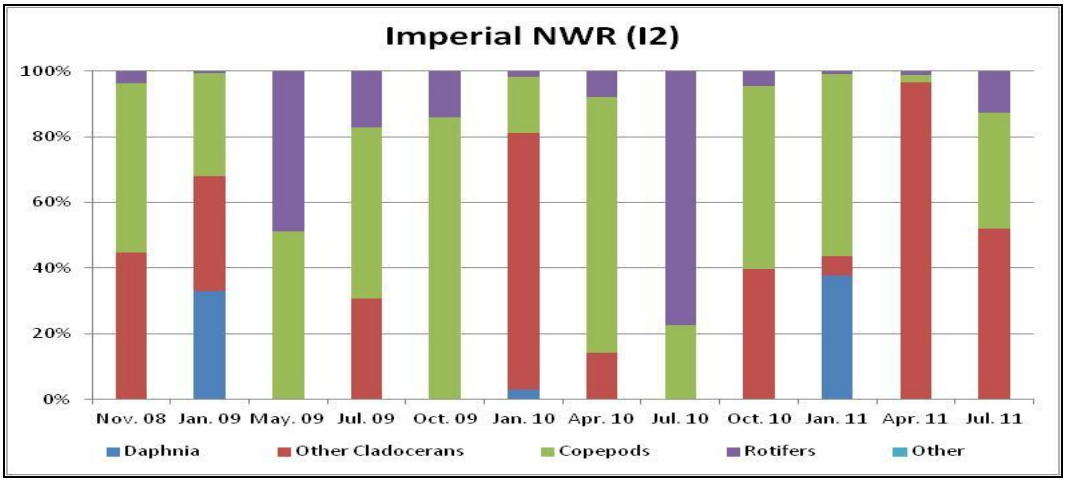


Figure 59.—Percent composition of zooplankters at I2, Imperial NWR.

I3

At 5.7 ha, pond I3 is one of the largest ponds on the Imperial NWR. Similar to pond I2 (see figure 58), pond I3 exhibited low overall mean biomass during the sampling period. Composition was relatively cosmopolitan, with spring samples yielding most diversity and the highest percentage of cladocerans. The mean sampling depth was 3.2 m.

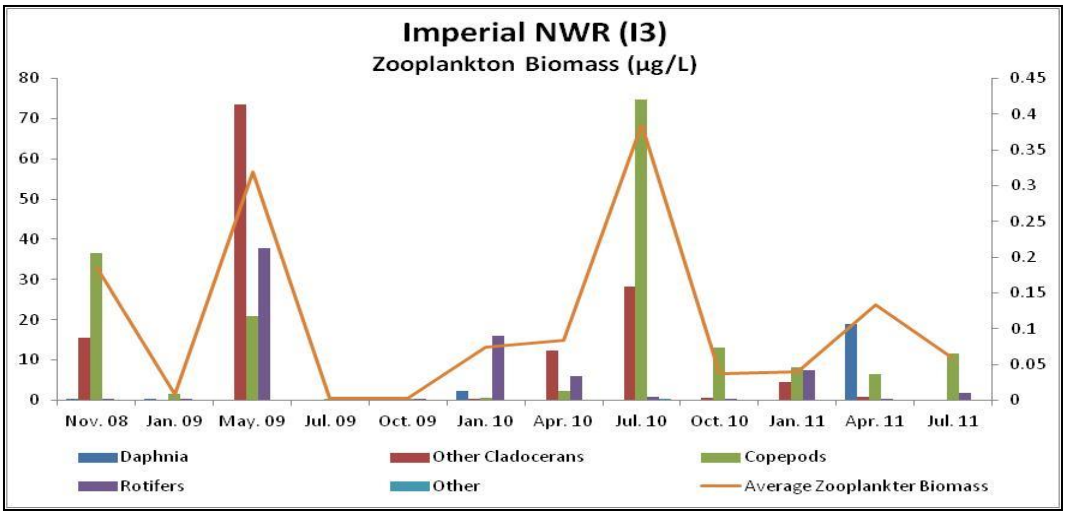


Figure 60.—Total mean biomass at I3, Imperial NWR (November 2008 – July 2011).

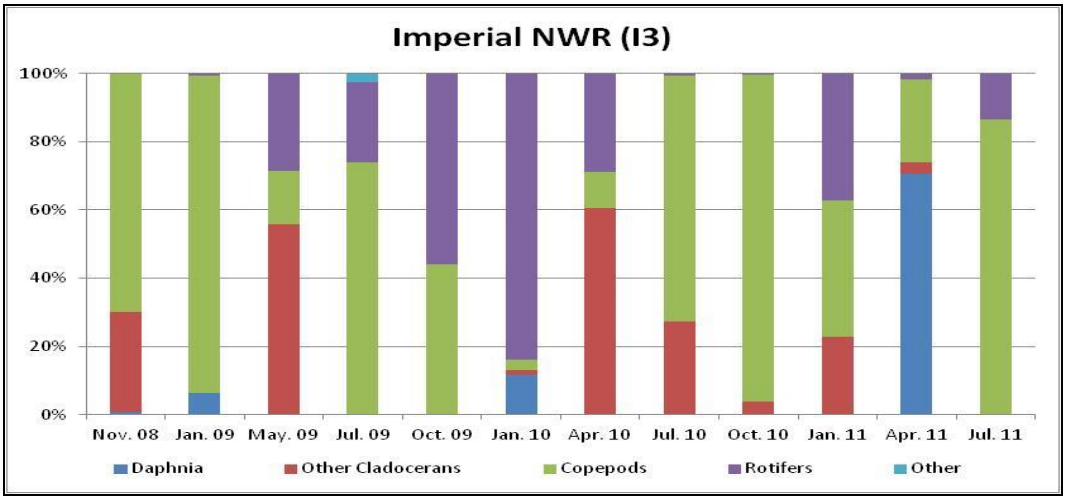


Figure 61.—Percent composition of zooplankters at I3, Imperial NWR.

I4

Mean biomass was consistently < 50 µg/L, except for April 2011, when other cladocerans reached nearly 191 µg/L. Cladoceran relative abundance was highest during spring months, although *Daphnia* was nearly absent across the spectrum of the study. The pond surface area was approximately 3.3 ha. The mean sampling depth was 2.7 m.

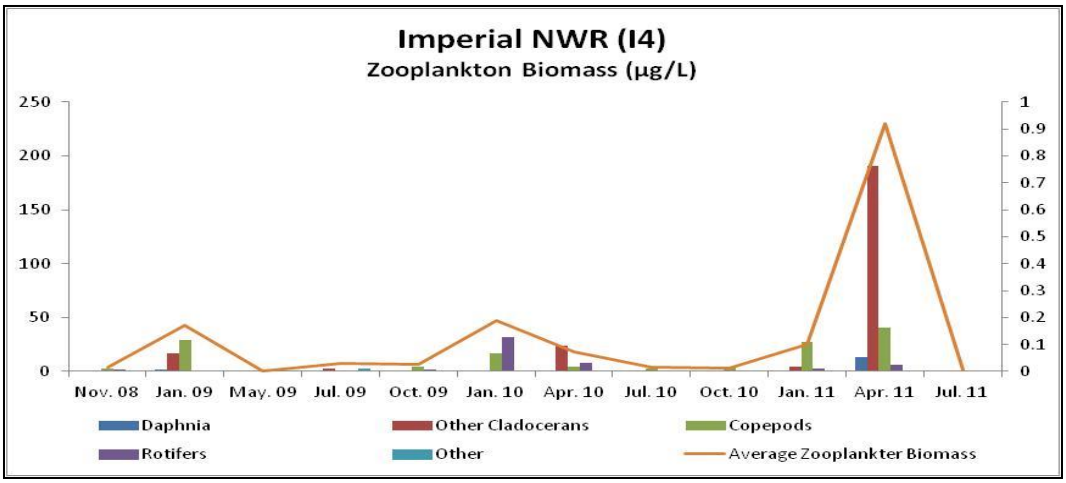


Figure 62.—Total mean biomass at I4, Imperial NWR (November 2008 – July 2011).

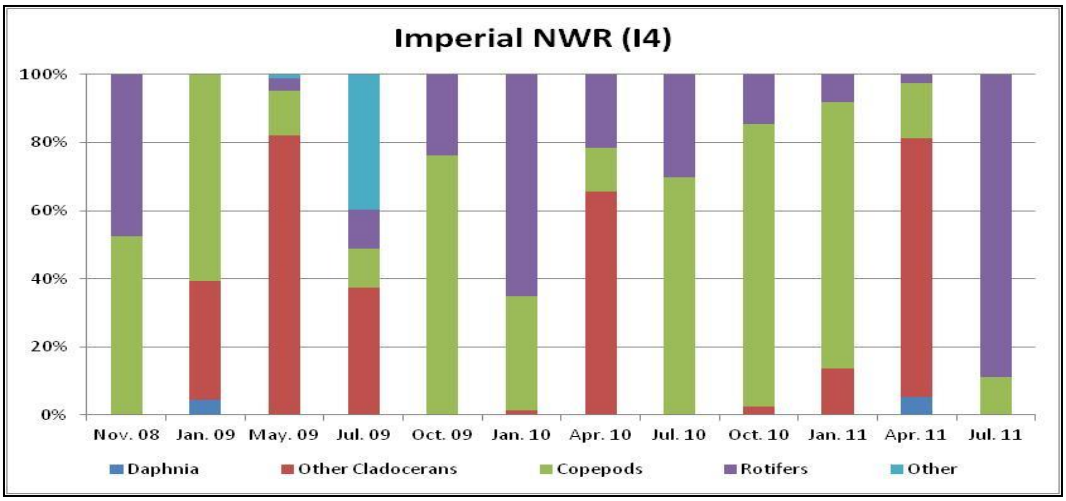


Figure 63.—Percent composition of zooplankters at I4, Imperial NWR.

I5

Consistent with the other ponds in the system, total mean biomass was low, especially during the July and October sampling events. Unlike other ponds at Imperial NWR, pond I5 zooplankton characterization was mostly copepods and rotifers. Ostracods (other category) were present in all July samples. This is the largest of the Imperial NWR ponds at 9.2 ha. The mean sampling depth was 2.4 m.

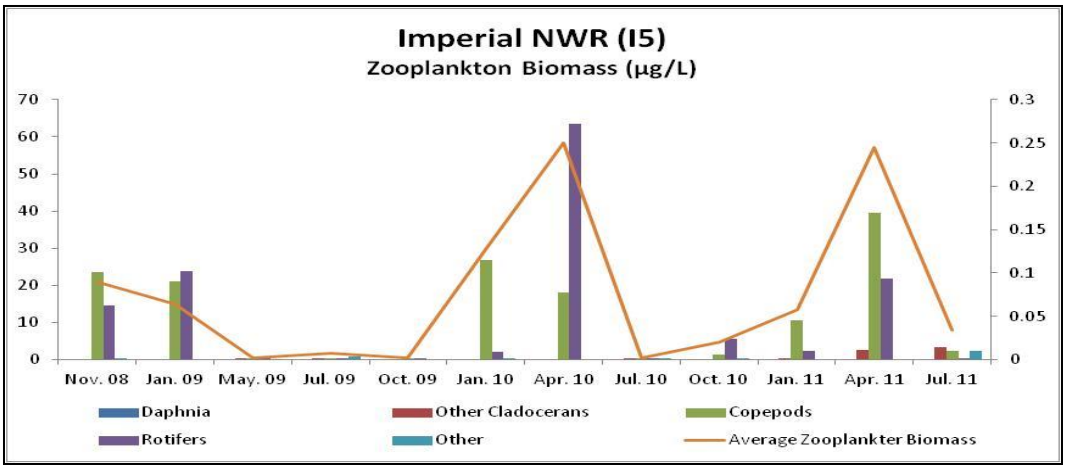


Figure 64.—Total mean biomass at I5, Imperial NWR (November 2008 – July 2011).

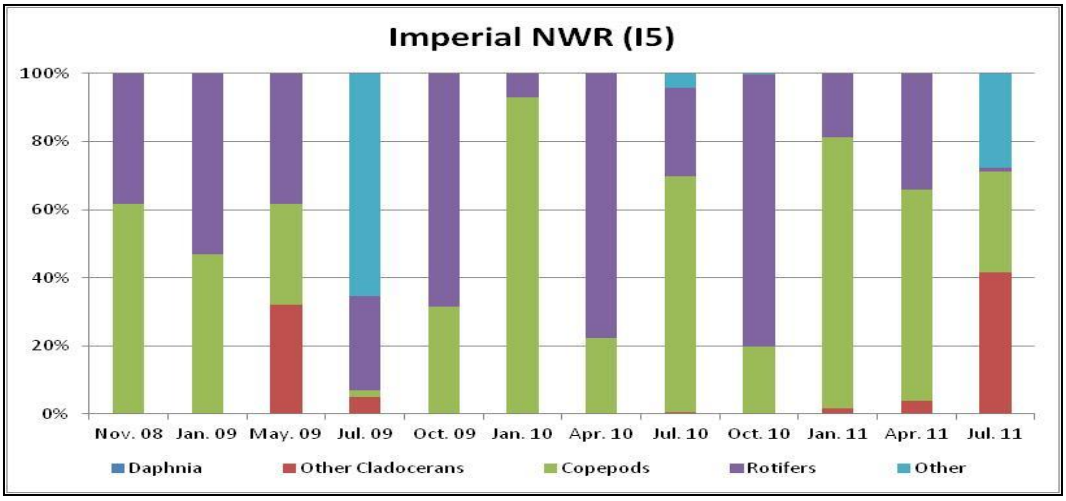


Figure 65.—Percent composition of zooplankters at I5, Imperial NWR.

I6

A similar trend of overall depauperate mean biomass was also observed in this pond. Notable exceptions to this trend occurred in January 2009, where *Daphnia* biomass exceeded 208 µg/L, and January 2011, when rotifers reached nearly 175 µg/L. The November 2008 and January 2009 samples contained the highest overall cladoceran biomass. Biomass of this magnitude, for this division, was not observed for the rest of the study. The pond surface area was approximately 3.7 ha. The mean sampling depth was 2.3 m.

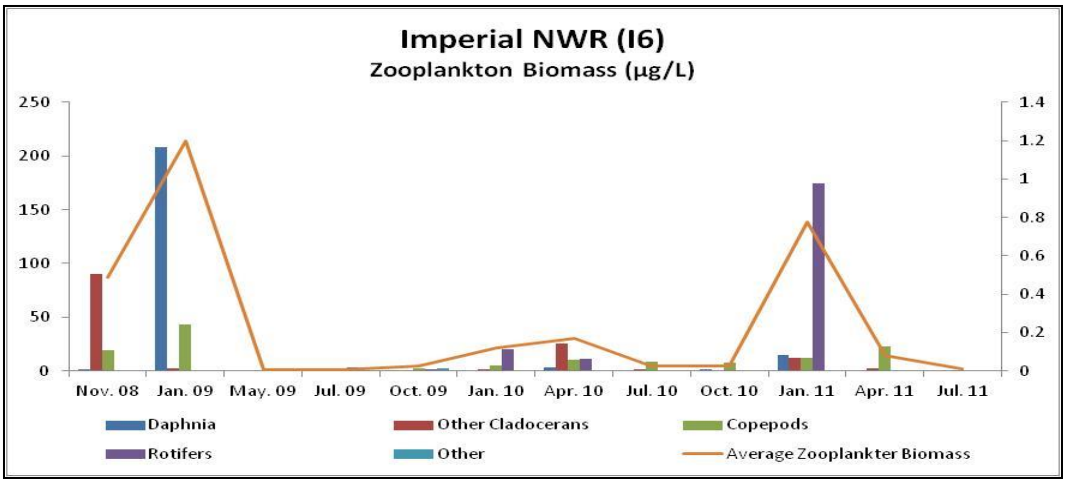


Figure 66.—Total mean biomass at I6, Imperial NWR (November 2008 – July 2011).

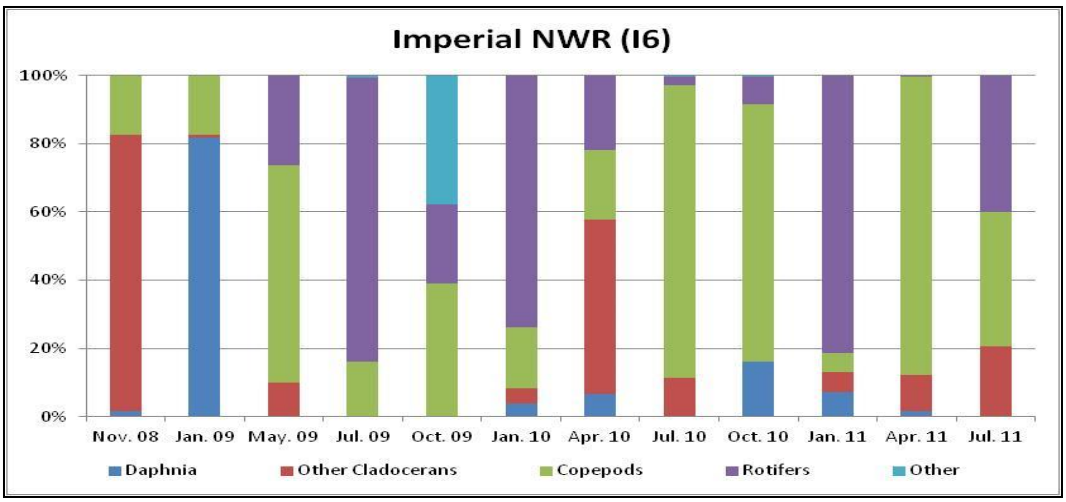


Figure 67.—Percent composition of biomass at I6, Imperial NWR.

DISCUSSION

The pattern of zooplankton abundance and distribution in ponds and backwaters of the LCR system for the 3-year study was largely unpredictable and variable. Relative consistency of zooplankton dynamics did however occur at Floyd Lamb City Park (see figures 6 and 7). Large-bodied *Daphnia* and other cladocerans from the family Bosminidae were highly abundant during the April sampling events of 2010 and 2011. Across all 33 ponds or backwaters sampled, only Floyd Lamb contained significant cladoceran biomass. The observed abundance of cladocerans may be a result of hydrological features not observed in other ponds and backwaters along the LCR system. The pond at Floyd Lamb is supplied by a combination of wells and artesian spring flows that may aid in the production of large-bodied zooplankters.

The aquatic ecology and fisheries literature has shown positive correlations between robust fish growth and sufficient abundance of cladoceran zooplankton (Clarke and Bennett 2007; Mills et al. 1989). In terms of razorback sucker food item availability, Marsh and Langhorst (1988) found a positive selection by larval fish for large-bodied *Bosmina* in the Yuma Cove backwater. Diversity of food items on the whole was also greater in this backwater than in nearby reservoir samples collected concurrently. At the time of their study, *Bosmina* and *Daphnia* spp. constituted two-thirds of the backwater sample. Interestingly, no cladocerans were detected in samples from January 2009 to January 2011 in this backwater. However, the composition of nondaphnid cladocerans were dominant in April (75 percent) and July (67 percent) 2011. Although composition shifted more toward cladocerans, biomass was relatively low (105 and 18 µg/L) in Yuma Cove during this time. Similarly, Marsh (1987) examined 34 adult razorback sucker stomach tract contents and found all had consumed *Bosmina* spp. They were also the most abundant food item in the diet. Zaret and Kerfoot (1975) attributed the conspicuous dark compound eye of *Bosmina* as a visual cue for fish to select this species in particular rather than the largest members of the zooplankton community alone. In contrast, because of physiological and evolutionary adaptations specific to razorback suckers, Miller and Evans (1965) postulated that taste is used as the primary feeding strategy.

The composition of zooplankters at Office Cove was almost exclusively organisms from the family Rotifera and changed little despite season (see figure 33). In the presence of high densities of planktivorous fish, small-bodied zooplankters such as rotifers have been shown to coexist and become more abundant than if fish were scarce or absent (Zaret 1980). Vanni (1987) suggested an adaptation of some zooplankton communities to mature and reproduce at a smaller size in the presence of fish that may, in turn, allow them to avoid predation. Therefore, the effect of razorback growth in ponds where biomass is comprised primarily of rotifers deserves further study in this regard.

Select Lake Mohave backwaters have undergone pre-stocking experimental fertilization regimes to assess potential shifts in zooplankton dynamics. Papoulias and Minckley (1992) found highly fertilized ponds were conducive to the presence of cladocerans, whereas medium and low treatments favored other zooplankters. The results showed growth rates of razorback suckers to be significantly greater in high-medium fertilization treatments than in low or unfertilized ponds.

Diversity and richness of zooplankton communities may enhance survival and growth rates in razorback suckers. Welker and Scarnecchia (2003) reported a positive correlation between zooplankton diversity and food niche in Catostomidae (breadth of suckers from the family) However, a caveat may exist where enriched conditions exhibit unstable, oscillatory dynamics known as the paradox of enrichment (Steiner 2005; Rosenzweig 1971). In part, this could explain the unstable dynamics of the zooplankton community exhibited throughout most of the study sites along the LCR. Moreover, the observations of Welker and Scarnecchia (2003) were from different segments of an open riverine system, whereas off-channel habitats are generally closed off from the main watershed. As a result, food resources may be either limited or finite, reducing overall diversity if food niche dynamics change based on resource depletion. High densities of fish stocked in a particular backwater or pond most likely exacerbate this process.

Overall, zooplankton biomass appears to be depressed during the harsh summer months in most of the study sites. As a consequence, Mueller (2006) noted when water temperatures exceed 35 degrees Celsius, razorback suckers will feed either on or from aquatic vegetation. In Parker Dam Pond, where bonytail chubs are the lone fish species, the availability of zooplankton was extremely low across seasons in comparison with other off-channel habitats (see figure 34). Bonytail chubs are omnivorous, making them more diverse than razorback suckers in terms of diet constraints. Mueller (2006) reported small, individual bonytail will feed on a variety of plants and insects. As they become larger, they will feed on crayfish, frogs, and fish (Marsh and Schooley 2005; McDonald and Dotson 1960). Therefore, the apparent lack of significant zooplankton biomass in Parker Dam Pond is most likely supplemented with other diet items.

During the present study, most of the ponds and some Lake Mohave backwater ponds were stocked with subadult razorback suckers ranging from a total length of approximately 300–400 millimeters. Larval fishes were initially reared at hatcheries where they were fed a manufactured diet before being released into the backwaters for continued grow-out. Fish were typically stocked from January through March. The numbers of fish stocked varied depending on the size of the backwater or pond. Consistent to most of these ponds was the presumed absence of other fish species. How dynamics of the zooplankton community are affected by introduction of razorback suckers across the system has yet to be determined.

Because a portion of LCR backwaters are stocked annually with razorback suckers, pond energetics may differ in response to fish presence. For example, the shift in the zooplankter community observed in the Arizona Juvenile backwater may coincide with increased fish densities as stocked razorback suckers successfully spawn large numbers of young-of-year (YOY) each spring. Prior to razorback stockings in 2010 and 2011, *Daphnia* spp. were the most common zooplankter. In February 2010, a total of 199 razorback suckers (mean total length = 378 millimeters) were stocked. In September of that year, 123 adult and 4,435 YOY razorback suckers were captured during the annual pond harvest. Increased fish densities were also observed in 2011. A total of 200 razorback suckers (mean total length = 417) were stocked in early January, 111 of which were harvested in May. An additional 1,150 larvae were also harvested during the spring, and 725 YOY were harvested in September.

Natural recruitment in Lake Mohave backwaters other than Arizona Juvenile was not observed during this study. Annual fish stockings occurred each spring at Dandy, Nevada Larvae, North Chemehuevi, Willow, and Yuma. These backwaters failed to produce evidence of recruitment that was observed in Arizona Juvenile over the same time interval. Larval fish have not been observed in these ponds despite concerted efforts to collect them. Reasons for these differences in observed success are not well understood, and a number of factors, including interacting effects, could be playing a role. For example, intraspecific or interspecific competition for food resources or predation may influence the lack of recruitment in particular backwaters. These variables deserve further study beyond the scope of this work.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE STUDY

The results from this study characterized the zooplankton community as highly variable in off-channel habitats of the LCR. This was the case regardless of distance from one pond or backwater to the next. Because of the dynamic attributes observed in these habitats, environmental variables other than the presence or absence of fish need to be addressed. Therefore, the phytoplankton community should be sampled alongside continued zooplankton sampling to quantify under what conditions ideal food items can be practically attained in a particular habitat. The ability to artificially culture zooplankters known to be selected by the razorback sucker and bonytail chub and infuse them into off-channel habitats can reasonably be attained only if a composite food chain model can be ascertained.

The opportunity to experiment with fertilization schemas has also shown promise in previous studies (Papoulias and Minckley 1992). A study by Reclamation was

initiated in 2011, testing five Lake Mohave backwaters for changes in primary productivity over time. Backwaters included in this study consisted of North Nine Mile, Willow, Nevada Egg, Nevada Larvae, and a control pond that was added to the matrix. Each was subjected to annual fertilization treatments and monitored through routine sampling. The goal of this ongoing study is to determine if a specific fertilization technique will yield and sustain large-bodied cladocerans such as *Daphnia* and *Bosmina* that have shown to be selected by the target fishes.

Characterization of the lakeside zooplankton community in Lake Mohave has been largely understudied considering its importance to the extant razorback sucker population. Relative abundance of zooplankton was conducted in 2000 and 2001, but information since has been lacking (Golden and Holden 2002). The Golden and Holden (2002) study should be repeated to ascertain a potential shift in zooplankton assemblages. The information gathered could benefit not only native fish researchers but could also provide valuable data to biological invasion experts who monitor and track the spread of quagga mussels (*Dreissena bugensis*) in the Lake Mead National Recreation Area.

The ability to optimize food resources in off-channel habitats is an important step in augmenting an imperiled population of native fishes. Information available from this work is expected to help management efforts that repatriate larger fish into the wild in an attempt to provide the potential for these fishes to survive predation pressures they encounter.

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