Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Monitoring and Research Priorities for the Imperial Ponds, Imperial Ponds Conservation Area

Five Year Plan: 2014 – 2018

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

November 2013

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National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

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Lower Colorado River Multi-Species Conservation Program

Monitoring and Research Priorities for the Imperial Ponds, Imperial Ponds Conservation Area

Five Year Plan: 2014 – 2018

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ACRONYMS AND ABBREVIATIONS

ac	acres(s)
Achii	Achii Hanyo Rearing Station
BONY	bonytail, *Gila elegans*
CI	confidence interval
DO	dissolved oxygen
DU2	Ducks Unlimited Habitat Complex
ft	foot/feet
gpm	gallons per minute
ha	hectare(s)
HCP	Habitat Conservation Plan
hp	horsepower
in	inch(es)
INWR	Imperial National Wildlife Refuge
IPCA	Imperial Ponds Conservation Area
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
mg/L	milligrams per liter
mm	millimeter(s)
PIT	passive integrated transponder
ppm	parts per million
RASU	razorback sucker, *Xyrauchen texanus*
Reclamation	Bureau of Reclamation
TL	total length
USFWS	U.S. Fish and Wildlife Service
WBNFH	Willow Beach National Fish Hatchery
WSE	water surface elevation
YAO	Yuma Area Office
YC	year class

Symbols

*	asterisk
±	both plus and minus operations
°C	degrees Celsius
<	less than
≤	less than or equal to
<	greater than
≥	greater than or equal to
%	percent
µS/cm	microsiemens per centimeter

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INTRODUCTION

The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is a partnership of Federal and non-Federal stakeholders responding to the need to balance the use of lower Colorado River (LCR) water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act. This is a long-term plan to conserve at least 26 species along the LCR from Lake Mead to the Southerly International Boundary with Mexico through the implementation of a Habitat Conservation Plan (HCP). Most covered species are State and/or federally listed special status species. The Bureau of Reclamation (Reclamation) is responsible for implementing the LCR MSCP over its 50-year term. A Steering Committee consisting of 56 entities has been formed, as described in the LCR MSCP Funding and Management Agreement, to provide input and oversight functions to support LCR MSCP implementation. Implementation of the LCR MSCP is accomplished partially through the creation of conservation areas along the LCR, by replacing nonnative vegetation with native vegetation, to construct habitat for LCR MSCP covered species. The Imperial Ponds Conservation Area (IPCA) is an example of one such conservation area.

The IPCA is located within the Imperial National Wildlife Refuge (INWR), which is owned and managed by the U.S. Fish and Wildlife Service (USFWS). The INWR is located about 30 miles north of Yuma, Arizona, at approximately River Mile 59 (figure 1). The INWR is owned and managed by the USFWS and consists of 25,125 acres of biologically diverse habitats, including wilderness, upland desert, riparian, marsh/wetland, and riverine. The IPCA encompasses a total project footprint of 132 acres, consisting of 80 acres of disconnected backwaters (the Imperial Ponds), 12 acres of managed marsh (Field 18), and 34 acres of fields planned for cottonwood-willow development (figure 2). The project is within INWR's 360-acre Martinez Lake Management Unit (previously identified in LCR MSCP reports as the Intensive Management Area). The Martinez Lake Management Unit is managed for numerous species, including waterfowl, marsh birds, native fish, riparian obligate bird species and other wildlife; the habitat includes marsh, backwater, cottonwood-willow, and seasonal wetland.

PURPOSE

The purpose of the IPCA is to create and manage habitat for both native fishes and terrestrial wildlife species covered under the LCR MSCP. Six backwater ponds, the Imperial Ponds, have been created for razorback sucker (*Xyrauchen texanus*) (RASU) and bonytail (*Gila elegans*) (BONY). Twelve acres of managed marsh for California black rail (*Laterallus jamaicensis*), Yuma clapper rail (*Rallus longirostris*), and western least bittern (*Ixobrychus exilis hesperis*) have

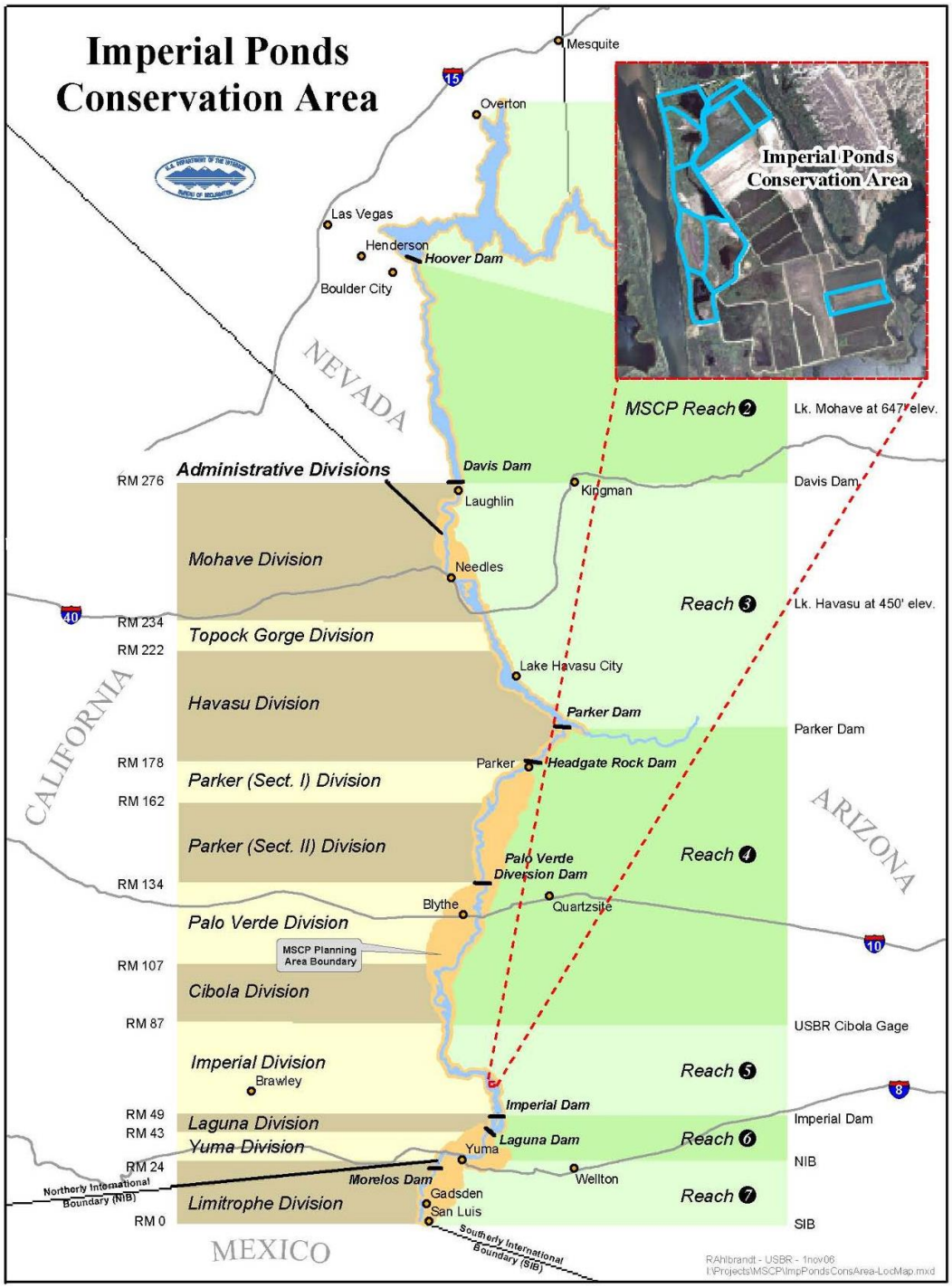

Figure 1.—Imperial Ponds Conservation Area, located within Reach 5 of the Lower Colorado River Multi-Species Conservation Program area.

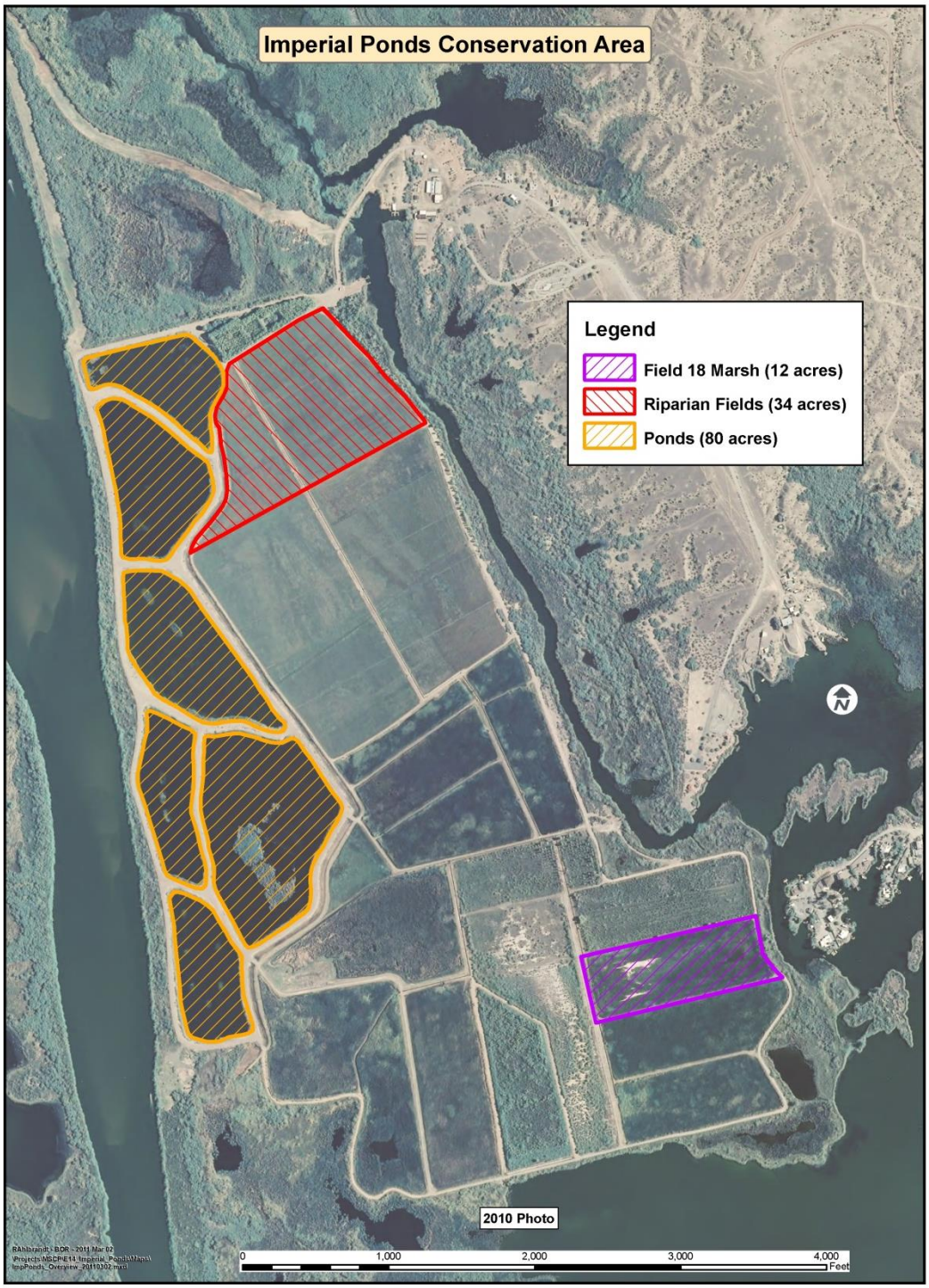

Figure 2.—Imperial Ponds Conservation Area.

been created. Thirty-four acres will be developed as riparian habitat for southwestern willow flycatcher (*Empidonax traillii extimus*), yellow-billed cuckoo (*Coccyzus americanus occidentalis*), and other LCR MSCP species as identified in the LCR MSCP HCP (Reclamation 2004).

The Imperial Ponds were created to provide refugia for BONY and RASU for the duration of the LCR MSCP program (September 2055). However, as stated in the HCP (Reclamation 2004), the Imperial Ponds may be used for fish production to aid the Fish Augmentation Plan (Reclamation 2006b), to conduct species research to increase understanding of BONY and RASU life cycles or habitat needs or both, and to evaluate constructed features of the project design (Reclamation 2008).

The purpose of this plan is to:

- Describe the history and development of the ponds
- Review monitoring results and management activities completed on the ponds
- Provide guidelines for actions and research to be completed on the ponds; study plans and statements of work will be developed for actions and research identified.

The plan should be reviewed annually and updated to include significant information as it becomes available.

BACKGROUND

Backwater Development

The USFWS, Reclamation, and Ducks Unlimited partnered in 2002 to build the Ducks Unlimited Habitat Complex (DU2) ponds within INWR's Intensive Management Area. The DU2 ponds provided about 35 surface acres of habitat, comprised of four ponds, referred to as Units 1, 2, 3, and 4 for native fish. They were constructed as partial fulfillment of Provision Number 3 (RPA3) in the 1997 Biological and Conference Opinion (USFWS 1997). Unit 2 was stocked with 668 RASU fingerling in 2003, and Unit 1 was stocked with 10,000 RASU fingerling in 2004. RASU populations declined to an estimated 25 (±7) individuals in Unit 2 by December 2003. Unit 1 was surveyed 1 month after stocking, and the population was estimated at 6,573 (95-percent [%] confidence interval [CI], 6,326 – 6,819) (Brouder and Jann 2004). In 2005, the ponds were drained, and 1,130 RASU were captured from Unit 1 and moved to Martinez Lake (Reclamation 2012).

Brouder and Jann (2004) suspected that anoxia and the establishment of non-native fishes were responsible for native fish losses. Hypoxic conditions were attributed to deficiencies in site design, including a single freshwater input and output for all four units, a hydrologic connection between ponds and the adjacent farm fields being fertilized with nitrogen, and dense, submerged aquatic vegetation overtaking the shallow ponds (Brouder and Jann 2004; Reclamation 2005). The LCR MSCP partnered with the INWR to expand the footprint of the existing DU2 ponds, renamed the Imperial Ponds, for inclusion as a Conservation Area under the LCR MSCP.

A panel of experts convened in 2005 to create a conceptual design for the reconstruction of the DU2 ponds (Reclamation 2005) to help envision the construction of six backwater ponds within the INWR's Intensive Management Area for use as native fish refugia. Several goals were outlined for the conceptual design, which included:

- Reconstructing the existing ponds to create backwaters that contained the physical, chemical, and biological conditions required to support native LCR fishes in a healthy condition
- Expanding the ponds' surface area or marsh or both
- Designing features with a target life of 50 years
- Designing a backwater complex that will be able to increase existing knowledge of managed habitat for LCR fishes (Reclamation 2005)

The reconstruction recommendations developed to meet these goals included increasing the number of ponds from four to six and increasing the total acreage by about 45 acres. It also included provisions for creating varying depth ratios throughout the ponds; constructing fish collection kettles, hummocks, spawning areas, and a boat ramp in each pond; and redesigning the water delivery infrastructure and drainage system using many of the features found at Cibola High Levee Pond, Cibola National Wildlife Refuge, Arizona and California (Reclamation 2005).

The first option for water delivery infrastructure included drilling additional wells onsite to pump 1,000 gallons per minute (gpm) of water per pond, a total of 6,000 gpm for the site (Reclamation 2008). Geotechnical investigations were conducted in December 2005 through January 2006 to determine the viability of drilling high-capacity production wells. The study suggested 700 to 1,000 gpm could be provided per production well and recommended a phased production well installation (Reclamation 2006). The additional wells would also necessitate increased electrical capacity, distribution lines, and piping. In cooperation with the INWR manager, option 1 was eliminated because of the additional infrastructure requirements. The second option was installing a pump fitted with a wedge-wire screen in the Martinez Lake Inlet Channel. The whole system

would comprise a pump with a wedge-wire screen of 0.02-inch (in) mesh Z-alloy with a compressed air back flush system to minimize the risk of nonnative introductions and biofouling while providing water flow up to 6,000 gpm.

Ponds As-Built

Construction of the Imperial Ponds was completed in 2007. The ponds were designed to maximize the acreage of the backwaters within the boundaries of the existing roads. Six ponds ranged in size from about 9 acres (ac) to 23 ac. Each pond was designed with varying water depths and diverse contours. The construction of the fish collection kettles could not be completed because of difficulties in excavating materials and settling of materials back into the kettles (Reclamation 2012). This element was removed from the design.

Fresh water was supplied from the Martinez Lake Inlet Channel. Water was conveyed through a single 24-in water main and discharged to each pond through an individual inlet pipe. Water input was adjustable at each inlet pipe and metered to record instantaneous and total flows.

Pond 1

Pond 1 is the northernmost pond totaling 9.2 surface ac. The western shore follows the river, and eastern shore is adjacent to the INWR cottonwood nursery and farm fields. The water inlet structure is located on the northwestern end, and the water outlet is on the southeast end of the pond. A single hummock is located to the west of the inlet pipe. Spawning areas were not initially constructed. The boat ramp is in the southeast corner of the pond (figure 3).

Reclamation's dive team constructed six, approximately 23 x 10 foot, spawning areas in 2010. A 1- to 3-in layer of sand was placed at each spawning site and covered with an 8-ounce geotextile. An 18-in layer of crushed gravel ranging from number 10 mesh sieve to a 10-in-square mesh sieve covered the geotextile. Spawning areas were constructed with a minimum distance of 92 ft between them. Spawning area one and two are on the eastern shore near the southern end adjacent to the farm fields. Spawning areas three and four are located along the north shoreline: area three is near the eastern shore, and area four is by the water inlet. Spawning areas five and six are located on the southern shoreline on the west side of the pond to the east of the hummock (figure 3).

Pond 2

Pond 2 is 12.3 surface ac. The northern shore borders Pond 1, the western shore follows the river, and the eastern shore is adjacent to the farm fields. The water inlet structure is located on the west side at the south end, and the water outlet is on the east side toward the north end of the pond. A single hummock is located

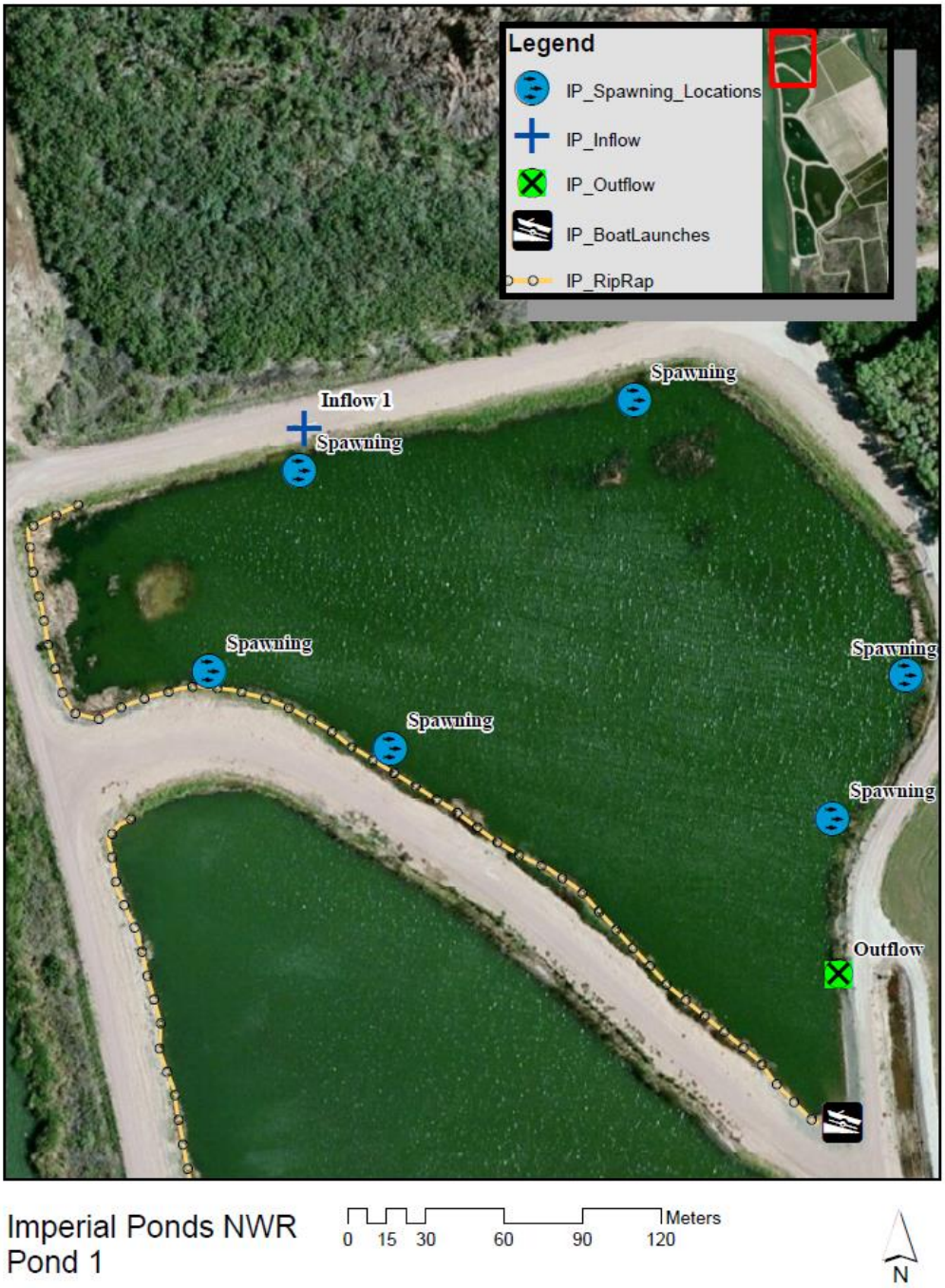

Figure 3.—Pond 1 features.

on the south end of the pond near the water inflow pipe. Spawning areas were not constructed. The boat ramp is on the north end, east side of the pond (figure 4).

Pond 3

Pond 3 is 14.2 surface ac. The northern shore borders Pond 2, the western shore follows the river, and eastern shore is adjacent to the farm fields. The water inlet structure is located on the north side, and the water outlet is on the east side at the south end of the pond. Two hummocks are located on the west side near the middle of the pond. Spawning areas were not constructed. The boat ramp is on the north end, east side of the pond (figure 5).

Pond 4

Pond 4 is a long, narrow pond that totals 8.2 surface ac. The northern shore borders Pond 3, the western shore follows the river, and the eastern shore is adjacent to Pond 5. The water inlet structure is located on the south side, and the water outlet is on east side on the north end. Three hummocks are oriented north to south in the middle of the pond. Spawning areas were not constructed. The boat ramp is on the north end, east side of the pond (figure 6).

Pond 5

Pond 5 is the largest pond at 22.7 surface ac. The northern shore borders Pond 3, the western shore is adjacent to Ponds 4 and 6, and the eastern shore is adjacent to the farm fields. The water inlet structure is located on the north side, and the water outlet is on the east side at the south end. Pond 5 has no constructed hummocks. Rather than construct a hummock, a large marsh area that existed in the southeast portion of the pond was left undisturbed during construction. Spawning areas were not constructed. The boat ramp is on the south end, east side of the pond (figure 7).

Pond 6

Pond 6 is 9.1 surface ac. The northern shore borders Ponds 4 and 5, the western shore follows the river, and the eastern shore is adjacent to the farm fields and Pond 5. The water inlet structure is located on the west side at the north end, and the water outlet is on the east side on the south end. Six hummocks exist throughout the pond. Spawning areas were not initially constructed. The boat ramp is on the southeast side of the pond (figure 8).

In February 2009, Marsh and Associates, LLC, installed a spawning area on the eastern shore toward the southern end. The area was about 10 × 20 ft, constructed of a base layer of 6- to 12-in-diameter cobble with an overlay of about a 1/2 ton of 3- to 8-in-diameter cobble (figure 8).

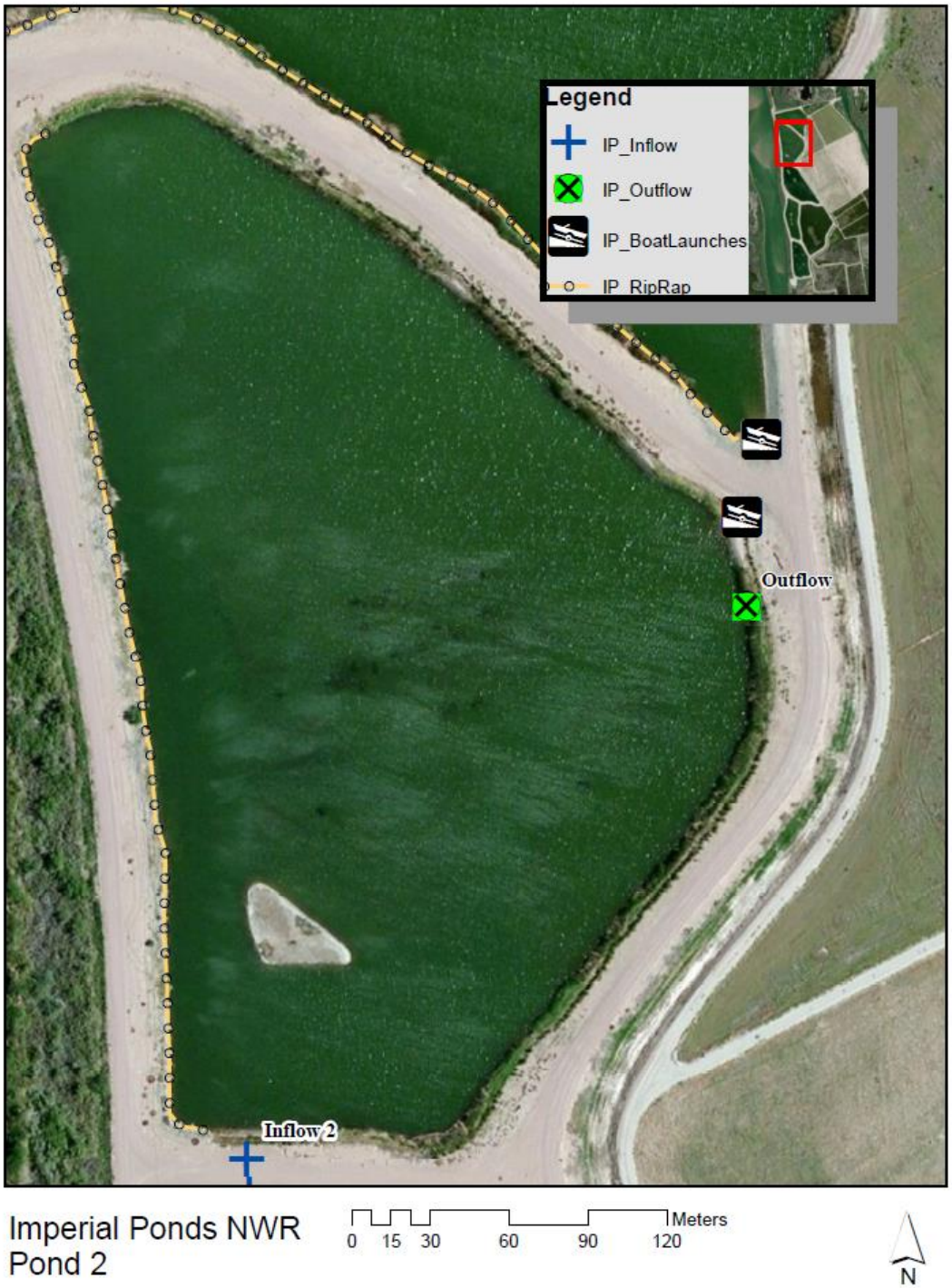

Figure 4.—Pond 2 features.

Figure 5.—Pond 3 features.

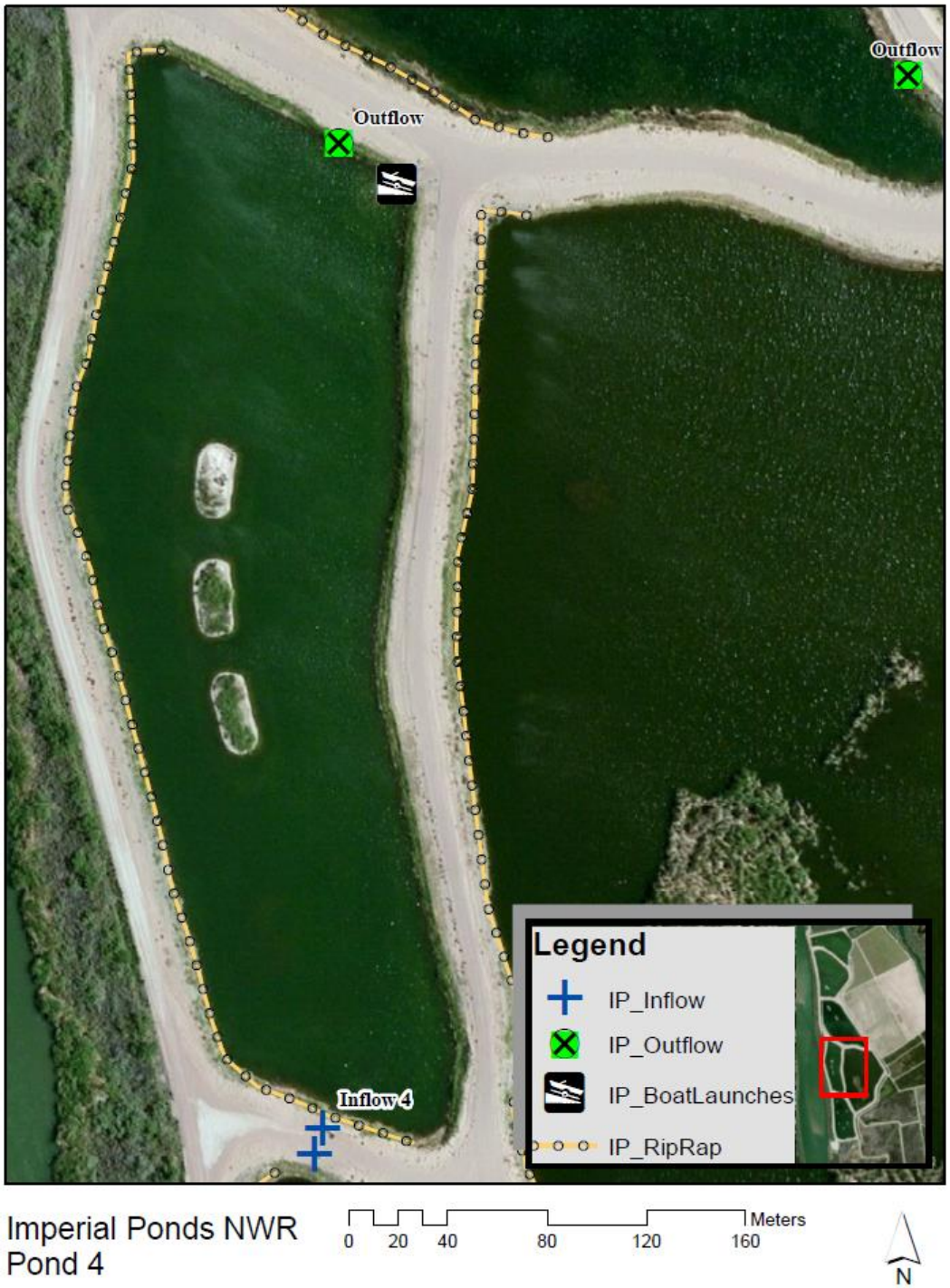

Figure 6.—Pond 4 features.

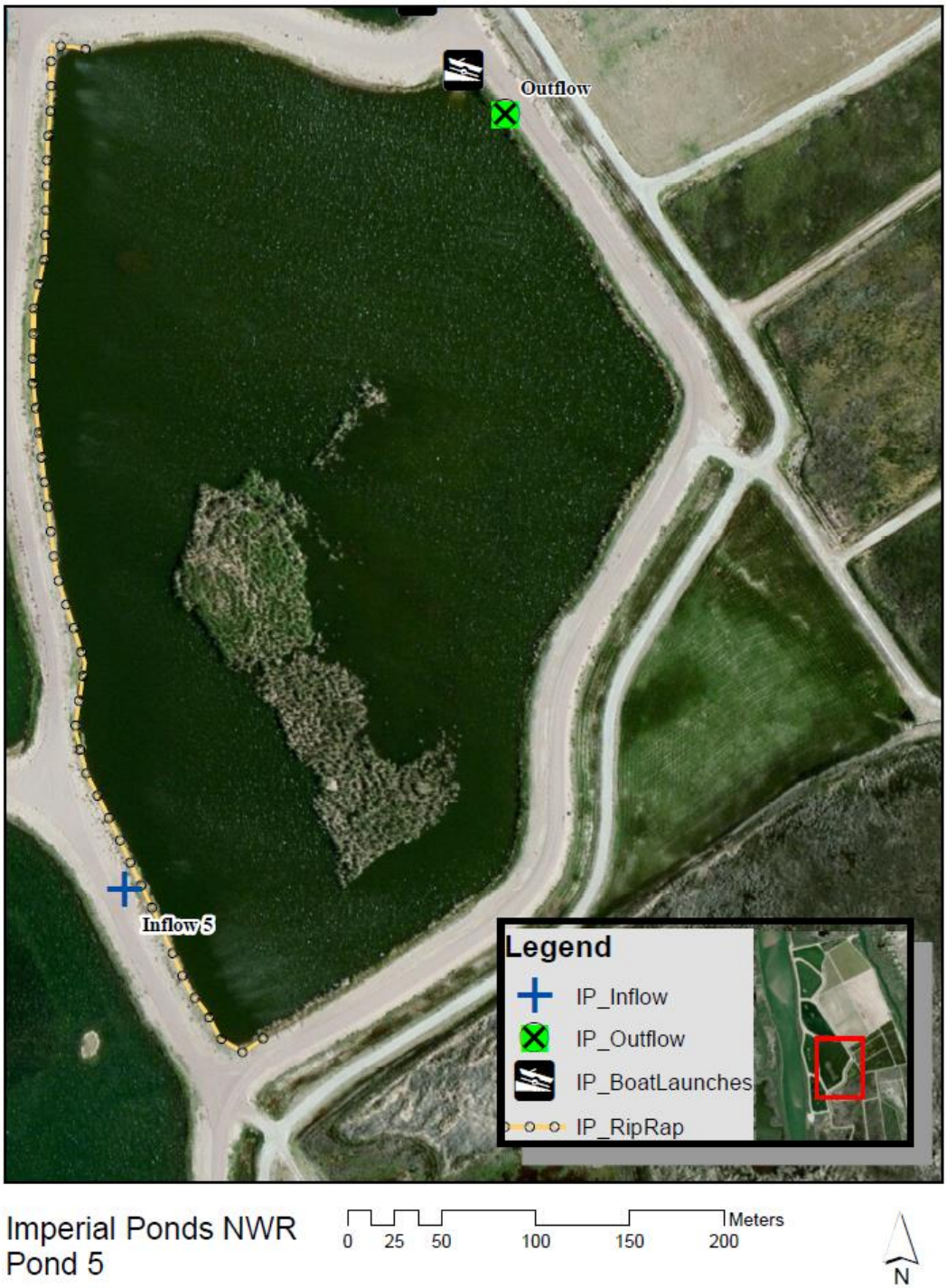

Figure 7.—Pond 5 features.

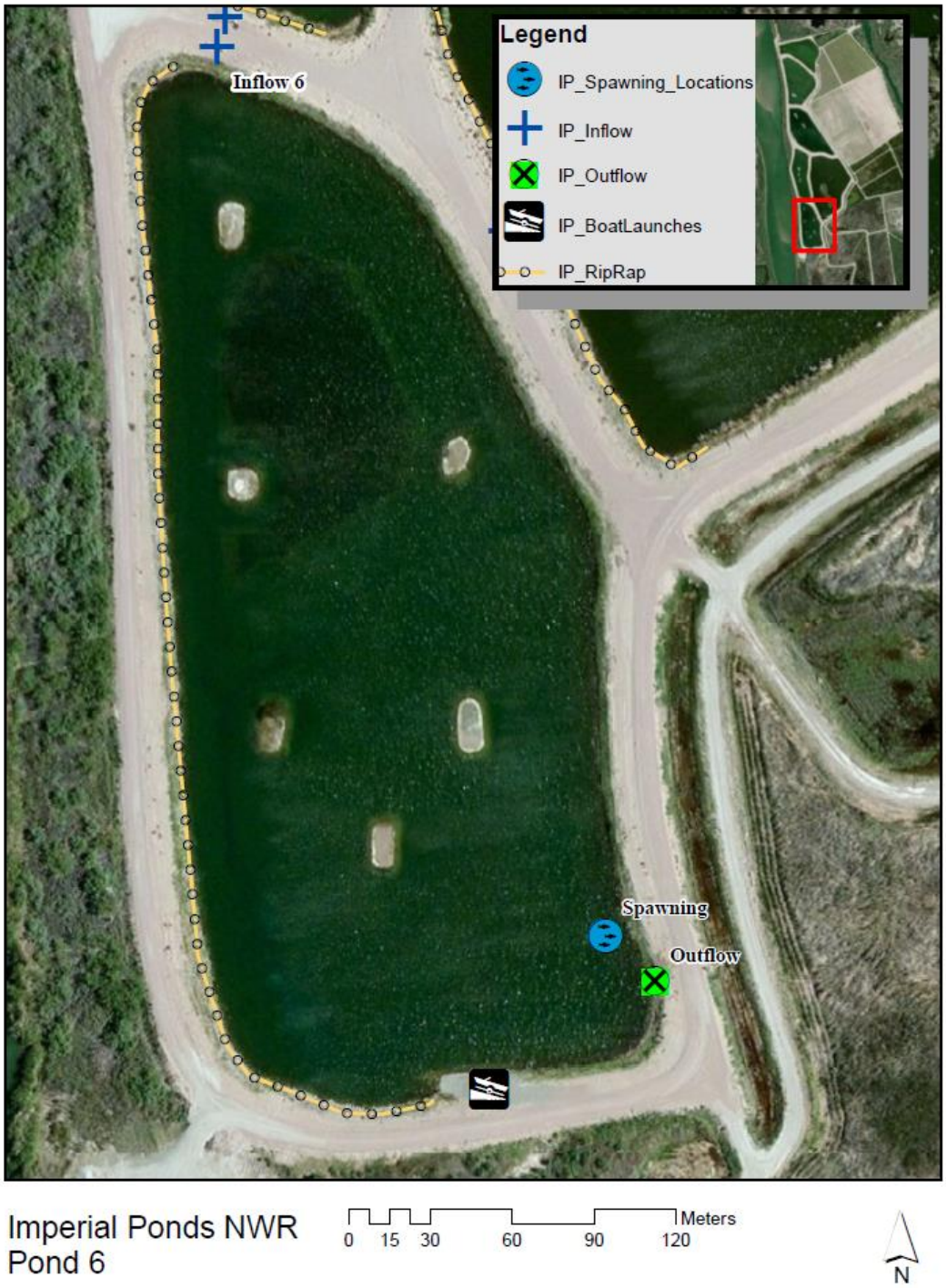

Figure 8.—Pond 6 features.

Background of Pond Management and Monitoring

The following sections summarize the management and monitoring activities that have occurred at the Imperial Ponds from September 2007 to May 2013, which include fisheries management and monitoring, water quality monitoring, and water supply management. Each pond is then treated separately in order to describe specific actions that took place at the respective ponds.

Fisheries Management and Monitoring

Fisheries management and monitoring from 2007 through 2013 included stocking BONY and RASU, monitoring stocked populations, documenting native fish recruitment, and characterizing the nonnative fish assemblages. An Imperial Ponds Fisheries Coordination Team was established to guide and prioritize species research and monitoring needs for BONY and RASU in conjunction with the LCR MSCP Fish Augmentation Plan (Reclamation 2006b).

Sampling to assess the nonnative fish assemblage was completed in September 2007. Western mosquitofish (*Gambusia affinis*) were collected from all six ponds, and common carp (*Cyprinus carpio*) were collected from Ponds 1, 2, and 3 (Kesnser et al. 2008). The Imperial Ponds Fisheries Coordination Team decided that neither western mosquitofish nor common carp were a concern for BONY and RASU and stocked Ponds 1 and 4 with RASU and Ponds 2 and 3 with BONY. The remaining two ponds were to be used for water management testing.

One year later, the first annual autumn sampling was completed from October 20 – 24, 2008. Western mosquitofish, common carp and four new nonnative species were detected in the ponds: bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), threadfish shad (*Dorosoma petenense*), and warmouth (*Lepomis gulosus*) (Kesner et al. 2010a). The detection of these new, nonnative species in the ponds prompted a discussion among the Imperial Ponds Fisheries Coordination Team that called for a complete renovation of all six ponds. Reclamation reviewed the proposed action and decided that a complete renovation of all six ponds was not practical because the means through which nonnative species entered the ponds was not known, a pond free of nonnatives to hold salvaged fish was needed, and renovation funds were not available. Reclamation proposed to pump water from Pond 1 to examine water management issues; evaluate renovation of the pond through dewatering to desiccate any fish, eggs, and larvae or both; and complete any required maintenance on the pond. Renovation by desiccation was not attainable because of groundwater percolation and freshwater seepage from the pond's banks. Renovation with rotenone was then attempted while the water level in the pond was lowered. Western mosquitofish persisted in the pond after renovation.

After the renovation, an in situ investigation was conducted to assess the ability of the wedge-wire screen to exclude 100% of nonnative fish in all life stages. Nonnative eggs and larvae were present in 97% of the entrainment samples. Larvae accounted for 99.5% of the catch (Normandeau Associates, Inc. 2010). Accordingly, the Martinez Lake water input through the wedge-wire screen was identified as a vector for nonnative fish passage into the ponds.

Before continuing with additional pond renovations, the water supply was switched from surface water (the 200-horsepower [hp] pump) to a groundwater well that was tied into the water delivery system. A renovation using rotenone was then attempted on Ponds 1 and 3 while the water level in the ponds was slightly above the full pool water elevation of 186 ft. The chemical treatment was completed in April 2010. The renovation was unsuccessful in Pond 1, but appeared to be successful in Pond 3, until the first nonnative fish was detected in November 2011.

BONY and RASU were removed from Ponds 2, 4, and 6 and transferred to Pond 1 from November 2010 through March 2011. Pond 1 is the only pond currently believed to have both BONY and RASU. BONY are still being collected from Pond 2 and moved to Pond 1. No native fish have been contacted in Ponds 4 or 6 since 2010.

Water Quality Monitoring

Water quality measurements have been collected monthly from the ponds since autumn 2007. Measured water physico-chemistry parameters include dissolved oxygen (DO), temperature, salinity, and pH. Management standards for these key water quality parameters will be established using both readily available information from the body of literature and findings from LCR MSCP research efforts through Work Task C32: Determination of water quality limits for BONY and RASU. These standards will be used as a guide to assist in future fishery management and may be modified as additional information becomes available. Until these standards are established, the Imperial Ponds Fisheries Coordination Team has been accepting the limits similar to standards set for similar species as proposed by Marsh & Associates. The established acceptable limits are currently as follows for the Imperial Ponds: average temperature less than 33.3 degrees Celsius (°C), median pH less than 9.0, and average DO greater than 4 milligrams per liter (mg/L); no standards were identified for specific conductivity (Kesner et al. 2008).

Physico-chemical parameters were recorded at three fixed locations (monitoring buoys) in each of the ponds and at three locations within the water column: near pond bottom, mid-water column, and just below the surface of the water. Readings were recorded around the AM and PM crepuscular period daily, and these profiles were collected once a month until the water temperature exceeded 27 °C; data were then collected twice a month. The water temperature was

highest in the summer months across all ponds, and specific conductivity levels, though different among the ponds, showed an increasing trend in all ponds over time. DO and pH were variable among ponds. Water physico-chemistry measurements are presented as an average or median of all readings taken within that month and are discussed in more detail by individual pond later in this document. A more extensive interpretation of results, including time of day and depth comparisons, are presented in the Imperial Ponds Water Management, May 2011 through May 2013 report (Reclamation 2013).

Water Supply Management

The water supply and drainage system was operated and managed to provide adequate habitat conditions for native fish. Water management of the ponds may be adjusted through the adaptive management process as information is developed through research and monitoring. The water supply system was designed to improve water quality, alleviate low levels of DO, decrease water temperatures, flush salts, and to maintain water elevations.

The initial water source for the Imperial Ponds was pumped from the Martinez Lake Inlet Channel, filtered by a 0.5-millimeter (mm) slot-size wedge-wire screen. A laboratory study was conducted on a similar wedge-wire screen (0.6 mm) with three surrogate species prior to installation. The results suggested that fish eggs less than 1 mm in diameter and larvae less than 5 mm in length passed through the screen. All larvae that passed through the screen were dead, and about 50% were physically damaged (Karcheskey and McDonald 2007). It was recommended that operation of the system should be avoided from mid-April to May when shad eggs and larvae are typically present (Reclamation 2008). Additionally, an in situ evaluation of the cylindrical wedge-wire screen system from April through July 2008 recorded nonnative fish eggs and larvae from numerous species in 97% of all samples. The results of that study cautioned against the use of the wedge-wire screen if the management goal is complete exclusion of nonnative fish (Normandeau Associates Inc. 2010).

The water supply for the ponds was subsequently changed in the summer of 2009 from the Martinez Lake Inlet Channel water supplied by the 200-hp wedge-wire screened pump to a groundwater source pumped by a 1,500-gpm well pump. The transition from Martinez Lake Inlet Channel water to groundwater supplied by the well decreased the water flow capacity by a minimum of 4,500 gpm. Water flow reporting often indicated the well was only pumping from 750 to 1,000 gpm. The single well was not capable of maintaining both acceptable water quality and a water surface elevation (WSE) of 186 ft for all of the ponds.

From November 2010 through March 2011, a single line was plumbed directly from the well to Pond 1 to isolate the input into Pond 1 from the rest of the water delivery system so that additional testing could occur using the original water delivery (200-hp wedge-wire screened pump from the Martinez Lake Inlet Channel) system without potentially contaminating Pond 1 with nonnative fishes.

In April 2011, a portion of the water from the 200-hp pump was diverted through a set of sampling manifolds and into an irrigation ditch to evaluate a secondary filtration system (sand filters) designed to augment the wedge-were screen. The results of this pilot study, under the conditions tested, suggested that sand filters could be an effective secondary filtration to the wedge-wire screen by potentially providing complete exclusion of eggs and larval nonnative fish (Karcheskey and McDonald 2011).

Prior to May 2011, water management was reactionary in response to the perceived needs of the native fishes that were present in these ponds. In May 2011, with the majority of the native fishes removed from Ponds 2 – 6, surface water additions ceased. The intent was to gain a better understanding of the physical, chemical, and biological characteristic of the ponds over a longer time period without any water management occurring in them. The study was completed in May 2013. Water physico-chemistry parameters, temperature, pH, and specific conductivity showed an increasing trend in ponds over time. The mean DO levels were adequate during this study period (Reclamation 2013).

Pond 1

Pond 1 was stocked with 305 RASU on November 5, 2007 ($\bar{x}$ total length (TL) = 445 mm, year class (YC) 04 from Willow Beach National Fish Hatchery (WBNFH) (table 1). RASU post-stocking survival was about 75% through April 2008, then survival began to decline. By October 2008, survival was about 8% (Kesner et. al 2008, 2010a). Water quality did not appear responsible for the decline in the RASU population. The reason for the decline is unknown.

Fourteen RASU were removed from Pond 1, coinciding with the dewatering in 2009, and were transferred into Pond 4. The pond was stocked with 43 BONY and 100 RASU in November 2010. An additional 20 BONY were stocked in January 2011, 29 BONY and 9 RASU in February 2011, and 20 BONY and 15 RASU in March 2011. Fish stocked during this time came from Ponds 2, 4, and 6. Another 21 BONY were stocked into Pond 1 from Pond 2 in November 2012.

Monthly population estimates have been generated for both BONY and RASU since March 2011. The first population estimate for BONY in Pond 1 was 70, in March 2011. The highest estimated population was 91, in May 2011, and the lowest was 10, in October 2011. The last estimate generated was 54, in August 2013 (figure 9). Estimates could not be generated for BONY for 14 of the 30 months because of low recapture rates (≤ 3).

The first estimate generated for RASU was 94, in May 2011. The largest population estimated in the pond was 198, in October 2011, and the lowest was 49, in December 2012. The last estimate was 105, generated in August 2013 (figure 10). Estimates could not be generated for 2 or the 28 months because of low recapture rates (≤ 3).

Table 1.—Stocking information for BONY and RASU
(Number of fish stocked, date stocked, location fish were reared, location fish were stocked, and average, minimum, and maximum length (mm) of the group stocked. * Numbers were obtained from IP database final: Database (Access 2007 – 2010) file and do not match numbers and sources reported previously in Imperial Ponds monthly reports.)

Date	Number	Species	Minimum	Average	Maximum	Source	Pond
11/5/2007	305	RASU	382	445	493	WBNFH	1
11/5/2007	272	RASU	382	445	493	WBNFH	4
12/12/2007	800	BONY	289	325	432	Achii[1]	3
12/12/2007	800	BONY	289	315	392	Achii	2
12/10/2008	60	RASU	348	469	540	Achii	2
1/15/2009	198	RASU	326	420	512	WBNFH	6
11/4/10	49*	RASU	450	533	612	Pond 2	1
11/4/10	43*	BONY	224	302	430	Pond 2	1
11/4/10	26*	RASU	470	547	605	Pond 4	1
11/4/10	23*	RASU	485	539	580	Pond 6	1
11/22/10	2*	RASU	550	560	570	Pond 6	1
1/31/11	20*	BONY	207	278	329	Pond 2	1
2/15/11	18*	BONY	100	180	306	Pond 2	1
2/15/11	5*	RASU	550	569	585	Pond 6	1
2/22/11	11*	BONY	162	269	347	Pond 2	1
2/22/11	4*	RASU	520	551	575	Pond 6	1
3/11/11	15*	RASU	485	551	592	Pond 6	1
3/11/11	20*	BONY	220	309	375	Pond 2	1

[1] Achii Hanyo Rearing Station.

Larval fish monitoring began in 2008, and 23 larval RASU were collected. No larvae were collected in 2009 and 2010 because no native fish were stocked in the pond following renovation efforts in 2009. Six spawning areas were added to the pond in May 2010. Larval collections resumed on Pond 1 in 2011, and zero BONY and 66 RASU larvae were collected and preserved for genetic analyses. Larval collections were continued in 2012 and 2013, and zero bony and one RASU larva was collected in both 2012 and 2013.

Monitoring and sampling for nonnative fish began in September 2007; western mosquitofish and common carp were collected from the pond. Three more nonnative species were detected in October 2008: bluegill, threadfin shad, and warmouth (Kesner et al. 2008). Autumn sampling did not occur in October 2009 or October 2010 because the pond was being dewatered and renovated. Western mosquitofish were collected from the pond during the November 2011 and November 2012 autumn sampling (table 2).

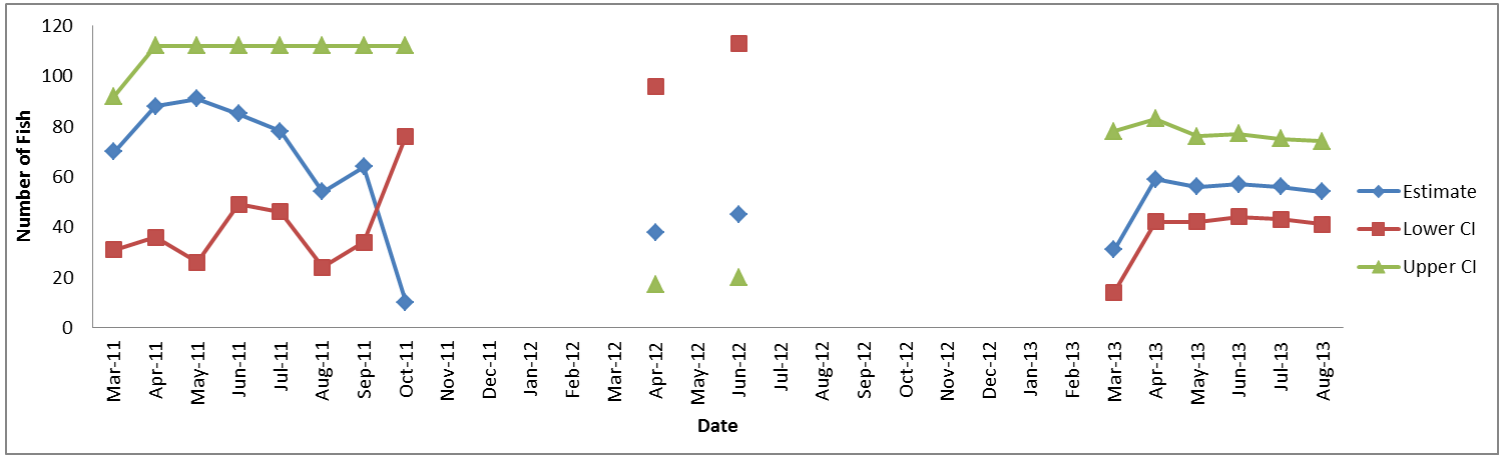

Figure 9.—Monthly population estimates for BONY in Pond 1.
Estimates reported with lower and upper 95% confidence intervals (CI). Estimates were not able to be generated for months where no data points are represented on the graph because of insufficient recaptures.

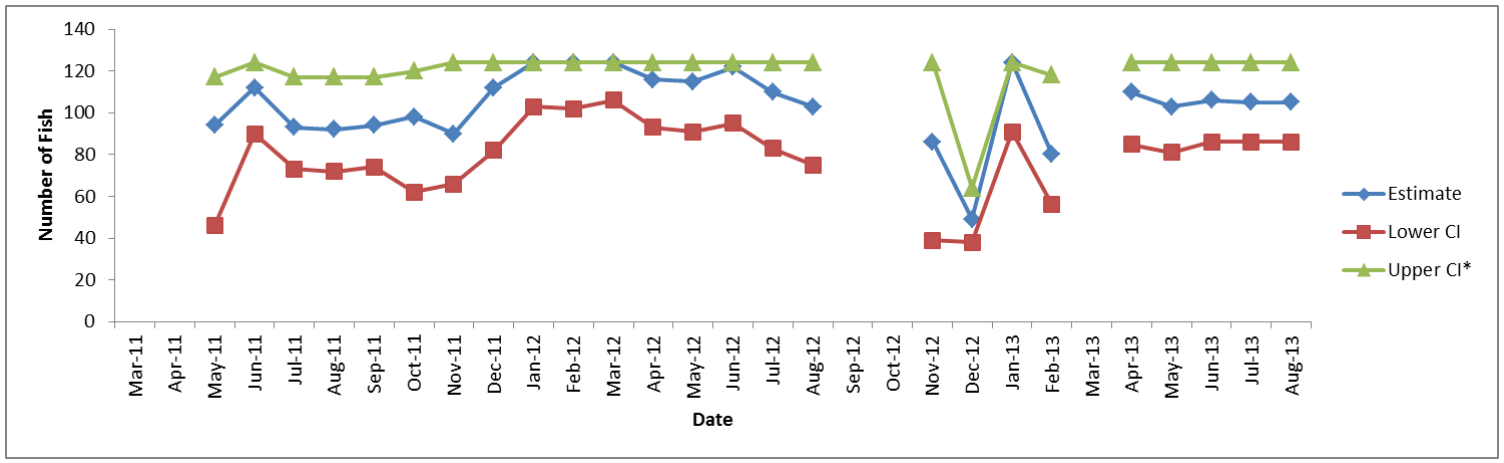

Figure 10.—Monthly population estimates for RASU in Pond 1.
Estimates reported with lower and upper 95% confidence intervals (CI). Estimates were not able to be generated for months where no data points are represented on the graph because of insufficient recaptures.

Table 2.—Fish captured (c) from Ponds 1 – 6 during autumn sampling: 2007, 2008, 2009, 2010, 2011, and 2013

(Years with an asterisk [*] indicate that no sampling was conducted during that year. A double asterisk [**] indicates that sampling gear would not target the species.)

Species	2007	2008	2009	2010	2011	2012
Pond 1						
Black crappie			*	*		
Bluegill		c				
Bonytail					c	c
Common carp	c	c				
Razorback sucker		c			c	c
Redear sunfish						
Threadfin shad		c				
Warmouth		c				
Western mosquitofish	c	c		**	**	**
Pond 2						
Black crappie						
Bluegill		c	c	c	c	c
Bonytail				c		c
Common carp	c		c	c		
Razorback sucker			c	c	c	c
Redear sunfish		c	c			
Threadfin shad		c	c			
Warmouth		c	c	c	c	c
Western mosquitofish	c	c	c	**	**	**
Pond 3						
Black crappie			c	*		
Bluegill			c		c	c
Bonytail						
Common carp	c	c	c			
Razorback sucker						
Redear sunfish			c			
Threadfin shad		c	c			
Warmouth		c				
Western mosquitofish	c	c	c	**	**	**
Pond 4						
Black crappie			c	c		c
Bluegill		c	c	c	c	
Bonytail						
Common carp				c		
Razorback sucker		c		c		
Redear sunfish		c	c	c	c	c
Threadfin shad		c	c	c	c	
Warmouth		c	c	c	c	c
Western mosquitofish	c				**	**
Pond 5						
Black crappie		*	*	*		
Bluegill						c
Bonytail						
Common carp						c
Razorback sucker						
Redear sunfish					c	c
Threadfin shad						
Warmouth					c	c
Western mosquitofish	c				**	**
Pond 6						
Black crappie		*	c			
Bluegill			c	c		c
Bonytail						
Common carp						c
Razorback sucker			c	c		
Redear sunfish			c	c	c	c
Threadfin shad						
Warmouth			c	c	c	
Western mosquitofish	c				**	**

Water was pumped out of Pond 1 in January 2009 to evaluate water management issues within the pond, to evaluate dewatering and pond desiccation as a renovation method, and to complete required maintenance on the pond. The pond water level dropped by about 9.8 ft (start WSE: 184.17 ft, ending WSE: 174.37 ft) over 13 days with a combined pumping time of 90.6 hours. Pumping was terminated when the limitations of the equipment were met (e.g., a mixture of sand and water was being pumped, creating a large depression in the pond without reducing the actual water elevation). The pond was not completely drained and desiccated because of groundwater percolations and freshwater seepage from the bank adjacent to Pond 2 (figure 11).

Renovation by means of desiccation was not possible, so a rotenone renovation was implemented. Rotenone at 4.0 parts per million (ppm) was applied April 29, 2009, with a followup application July 29, 2009, to Pond 1 at a WSE of 174.37 ft by means of backpack sprayers and slow-drip stations on the groundwater percolation areas. The renovation was not successful at removing western mosquitofish from the pond. The pond was then allowed to refill through groundwater percolations and freshwater seepage. When the pond reached a static WSE (i.e., WSE was not increasing or decreasing), the pond was treated for a second time with rotenone. The first application of rotenone was applied on February 17, 2010, with a followup application April 21, 2010. Rotenone was applied at 0.5 ppm (Kenect 2014, personal communication). Rotenone was dispersed by boat using a venture tube for open water areas, and pump sprayers were used along the shorelines and hummocks. The second rotenone renovation was also unsuccessful at removing western mosquitofish from the pond. Rotenone could not be applied to the entire surface of the pond because the shallow area in the western portion became overgrown with cattails when the pond was dewatered, preventing boat access. Annual autumn sampling has not identified any new nonnative species in Pond 1.

Water quality monitoring began in October 2007. No data were recorded from January 2009 through October 2009 when the pond was dewatered. In August 2010, September 2010, and March 2012, the monthly average of DO was below the set standard of 4.0 mg/L (see figure 12a). However, the maximum DO was above 4.0 mg/L for those months. The median monthly pH exceeded 9.0 during December 2007, the minimum pH recorded was 9.23, and the maximum pH was 9.63 (see figure 13a). The monthly average temperature never exceeded 33.3 °C, but has shown an increasing trend over time (see figure 14a). The monthly average specific conductivity increased after the pond was dewatered and filled in October 2009; it then decreased back to pre-dewatering levels by January 2012. These levels have remained somewhat consistent up to the present (see figure 15a).

Pond 2

Pond 2 was stocked with 800 BONY on December 12, 2007 ($\bar{x}$ TL = 315 mm, YC 05) from the Achii Hanyo Rearing Station (Achii) (see table 1). BONY post-stocking survival was estimated at about 4% by March 2008 (Kesner et al. 2008).

Figure 11.—Water pockets remaining on Pond 1 after dewatering (top) and a closeup of the water percolation sites throughout the pond (bottom).

Water quality did not appear responsible for the decline in the BONY population. The pond was stocked with 60 RASU on December 10, 2008 ($\bar{x}$ TL = 469 mm, YC 06) from Achii (see table 1). The population remained stable based on population estimates. An attempt was made to remove all BONY and RASU from the pond in response to changes in the water delivery system; they were then stocked into Pond 1. However, BONY continue to be collected in Pond 2. In November 2012, 21 BONY were collected and transferred to Pond 1. One BONY was collected and returned to Pond 2 in September 2013.

Larval fish monitoring occurred in January through May 2009 and 2010. No larvae were collected in 2009. Eleven RASU larvae and 1 BONY larva was collected in 2010.

Monitoring and sampling for nonnative fish began in September 2007. Western mosquitofish and common carp were collected from the pond (Kesner et al. 2008). Three more nonnative species were detected in October 2008: bluegill, threadfin shad, and warmouth (Kesner et al. 2010a). Redear sunfish (another nonnative species) was collected in October 2009 (see table 2) (Kesner et al. 2010b). A striped bass (*Morone saxatilis*) was collected and removed from the pond in April 2010. No other striped bass have been contacted since (Kesner et al. 2012).

Water quality monitoring began in October 2007. The monthly average DO was never calculated below 4.0 mg/L (see figure 12a). The median monthly pH was recorded above 9.0 during 22 of the 66 months sampled. Of the 22 months, the pH minimum and maximum range was above 9.0 six times: December 2007 (9.12 – 9.28), March 2008 (9.14 – 9.23), April 2008 (9.25 – 9.34), October 2008 (9.18 – 9.43), November 2008 (9.12 – 10.55), and July 2011 (9.68 – 10.07) (see figure 13a). The monthly average temperature never exceeded 33.3 °C, but has shown an increasing trend over time (see figure 14a). The monthly average specific conductivity has shown an increasing trend over time (see figure 15a).

Pond 3

Pond 3 was stocked with 800 BONY on December 12, 2007 ($\bar{x}$ TL = 325 mm, YC 05) from Achii (see table 1). BONY post stocking survival was estimated at 15% through March 2008 (Kesner et al. 2008). No BONY were collected during the annual autumn sampling, October 2008, and no BONY were contacted on remote passive integrated transponder (PIT) scanning units since June 2008. This pond was never surveyed for larval fish.

Monitoring and sampling for nonnative fish began in September 2007. Western mosquitofish and common carp were collected from the pond (Kesner et al. 2008). Two more nonnative species were detected in October 2008: threadfin shad and warmouth (Kesner et al. 2010a). Another two nonnative species were

collected in October 2009: black crappie and redear sunfish (see table 2) (Kesner et al. 2010b). The pond was renovated in February 2010. No nonnatives were collected after the renovation was complete or during the November 2010 autumn sampling effort. Bluegills were collected from the pond in April 2011 and during the autumn sampling in November 2011 and November 2012.

Pond 3 was renovated in 2010. The first application of rotenone was applied on February 17, 2010 at an application rate of 4.0 ppm with a followup application on April 21, 2010, at 0.5 ppm (Kenect 2014, personal communication.). Rotenone was dispersed by boat using a venture tube for open water areas, and pump sprayers were used along the shorelines and hummocks. The pond was sampled with trammel nets and hoop nets following the renovation. Bluegills were collected in April 2011 and have been collected on multiple occasions since. No other species of fish, including western mosquitofish, have been collected in the pond since the renovation.

Water quality monitoring began in October 2007. The monthly average DO was below 4.0 mg/L in October 2010 and March 2012 (see figure 12a). The median pH was recorded above 9.0 during 16 of the 66 months sampled. Of the 16 months, the pH minimum and maximum range was above 9.0 four times: December 2007 (9.57 – 9.63), July 2011 (9.48 – 9.95), October 2012 (9.11 – 9.47) and November 2011 (9.36 – 9.47) (see figure 13a). The monthly average temperature never exceeded 33.3 °C, but has shown an increasing trend over time (see figure 14a). The monthly average of specific conductivity has shown an increasing trend over time (see figure 15a).

Pond 4

Pond 4 was stocked with 272 RASU on November 5, 2007 ($\bar{x}$ TL = 445 mm, YC 04) from WBNFH (see table 1). RASU post-stocking survival was estimated at 75% in the first year (Kesner et al. 2008, 2012). Population estimates suggested stable populations from August 2009 through April 2010 (Kesner et al. 2012).

Larval fish monitoring occurred from January through May 2008, 2009, and 2010; no larvae were collected. Larval collection efforts were not made in 2011, 2012, or 2013.

Monitoring and sampling for nonnative fish began in September 2007. Western mosquitofish were collected from the pond (Kesner et al. 2008). Four more nonnative species were detected in October 2008: bluegill, redear sunfish, threadfin shad, and warmouth (Kesner et al. 2010a). Black crappie were collected in October 2009 (Kesner et al. 2010b). No new, nonnative species were detected during the November 2010 and November 2011 autumn samplings (see table 2).

Water quality monitoring began in October 2007. The monthly average DO was never calculated below 4.0 mg/L (see figure 12b). Monthly median pH was recorded above 9.0 during 19 of the 68 months sampled. Of the 19 months, the pH minimum and maximum range was above 9.0 four times: December 2007 (9.29 – 9.43), March 2008 (9.11 – 9.13), April 2008 (9.27 – 9.39), and June 2012 (9.18 – 9.67) (see figure 13b). The monthly average temperature never exceeded 33.3 °C, but has shown an increasing trend over time (figure 14b). The monthly average specific conductivity has shown an increasing trend over time (figure 15b).

Pond 5

BONY and RASU were not stocked in Pond 5. Monitoring and sampling for nonnative fish occurred in September 2007, and western mosquitofish were collected from the pond (Kesner et al. 2008). The pond was not sampled again until November 2011. Redear sunfish and warmouth were collected during this sampling event. Bluegill and common carp were collected in November 2012 (see table 2). In the late summer of 2009 and 2010, dead fish were observed floating on the surface of the water.

Water quality monitoring began in December 2007. The monthly average DO was below 4.0 mg/L in September 2010, September 2011, August 2012, and September 2012 (see figure 12b). The median monthly pH was recorded above 9.0 during 6 of the 64 months sampled. Of the 6 months, the pH minimum and maximum range was above 9.0 two times: July 2011 (9.31 – 9.88) and August 2013 (9.23 – 9.54) (see figure 13b). The average monthly temperature never exceeded 33.3 °C, but has shown an increasing trend over time (see figure 14b). The monthly average specific conductivity was the highest in Pond 5 and has shown an increasing trend over time (see figure 15b).

Pond 6

Pond 6 was stocked with 198 RASU on January 15, 2009 ($\bar{x}$ TL = 420 mm, YC 05) from WBNFH (see table 1). RASU post-stocking survival was 34.4% by June 2009 (Kesner et al. 2012). The fish were exposed to multiple handlings because of a data recording error, and this may have been a contributing factor to the initial mortality observed. RASU were removed from the pond and stocked into Pond 1 in response to changes in the water delivery system from November 2010 through March 2011. No native fish have been captured from the pond since March 2011. Larvae collections occurred in January through May 2010, and no larvae were captured from Pond 6.

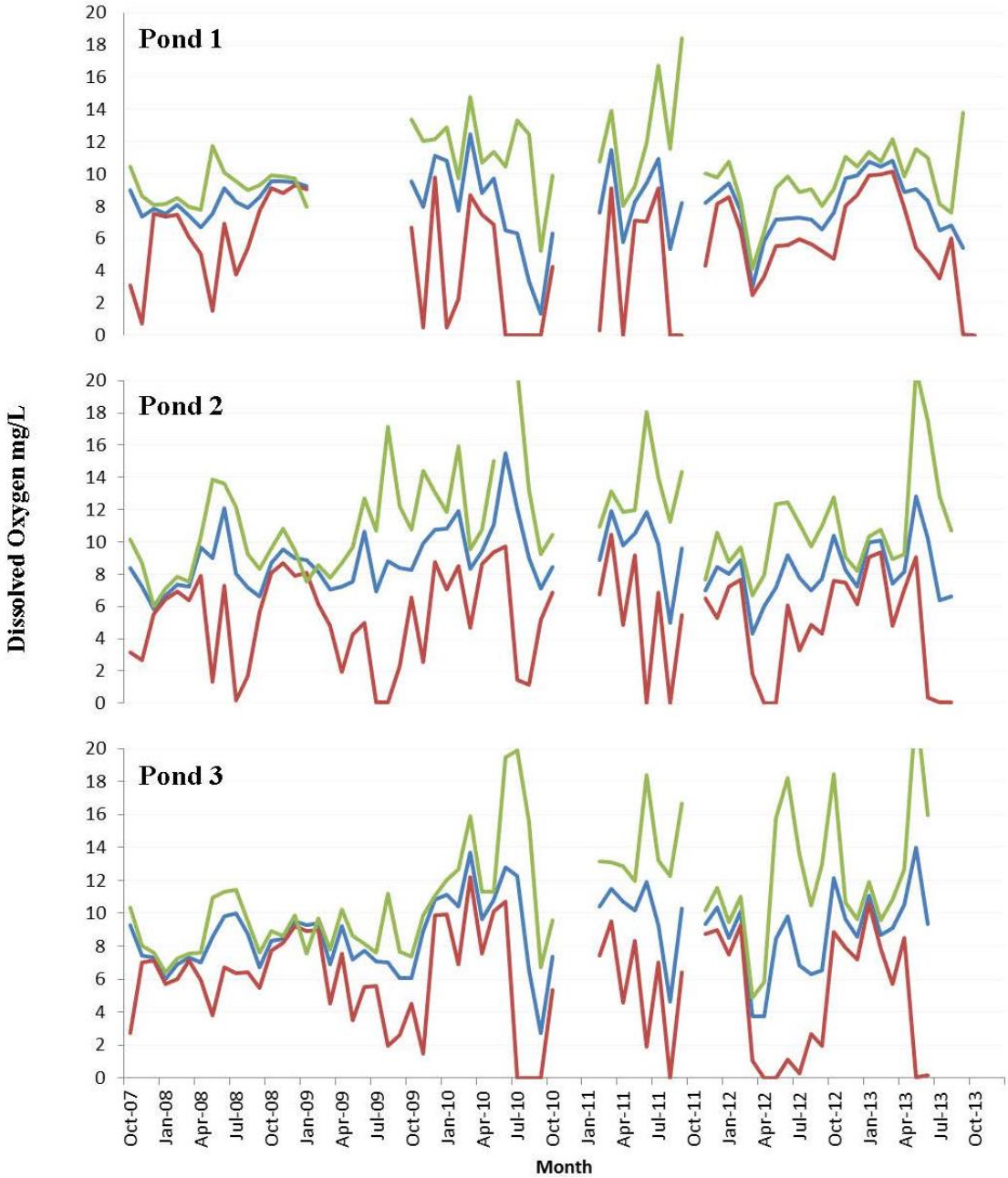

Figure 12a.—Monthly average, minimum, and maximum dissolved oxygen (mg/L) for Ponds 1, 2, and 3.
Average is the blue line, minimum is the red line, and maximum is the green line.

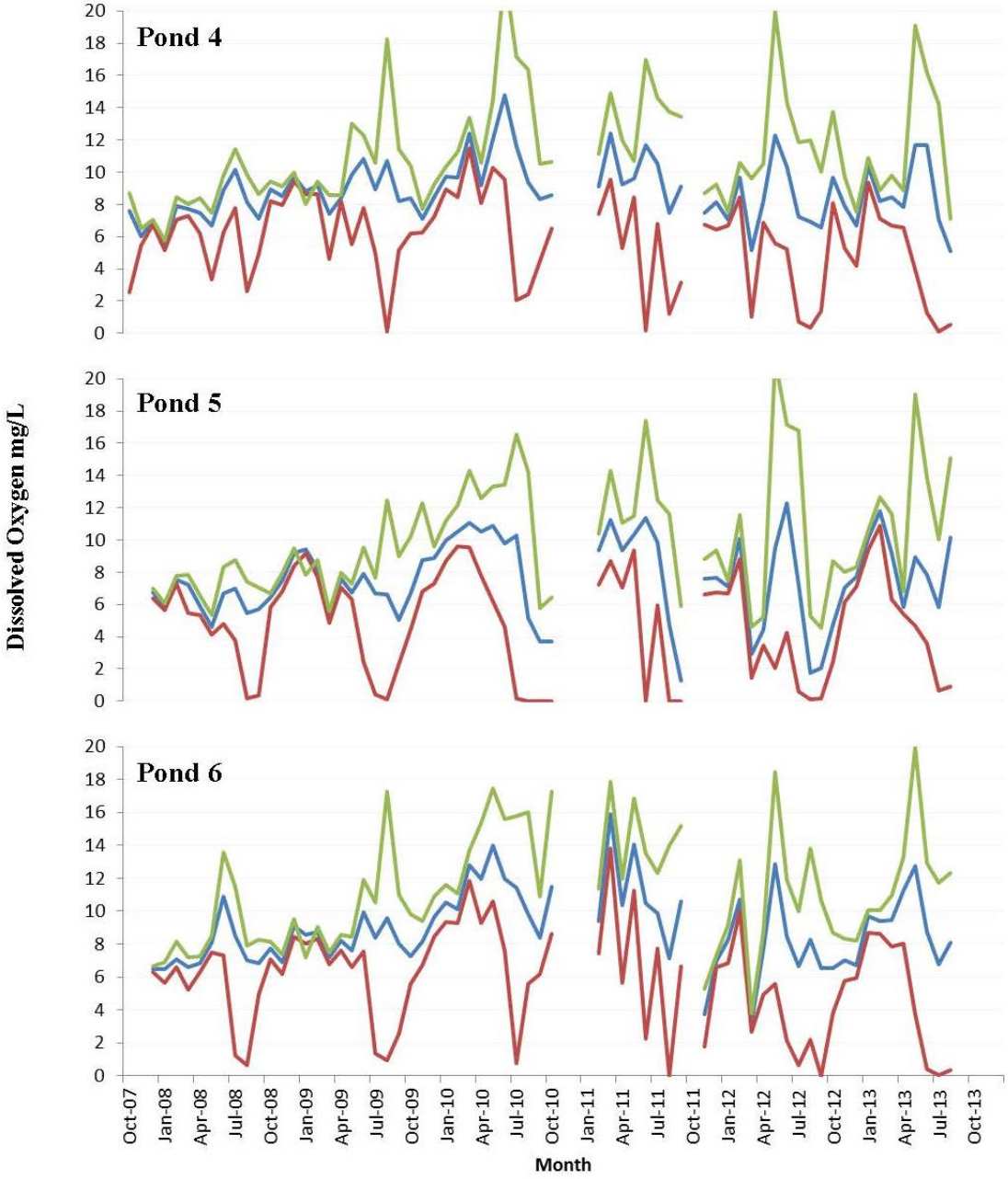

Figure 12b.—Monthly average, minimum, and maximum dissolved oxygen (mg/L) for Ponds 4, 5, and 6.
Average is the blue line, minimum is the red line, and maximum is the green line.

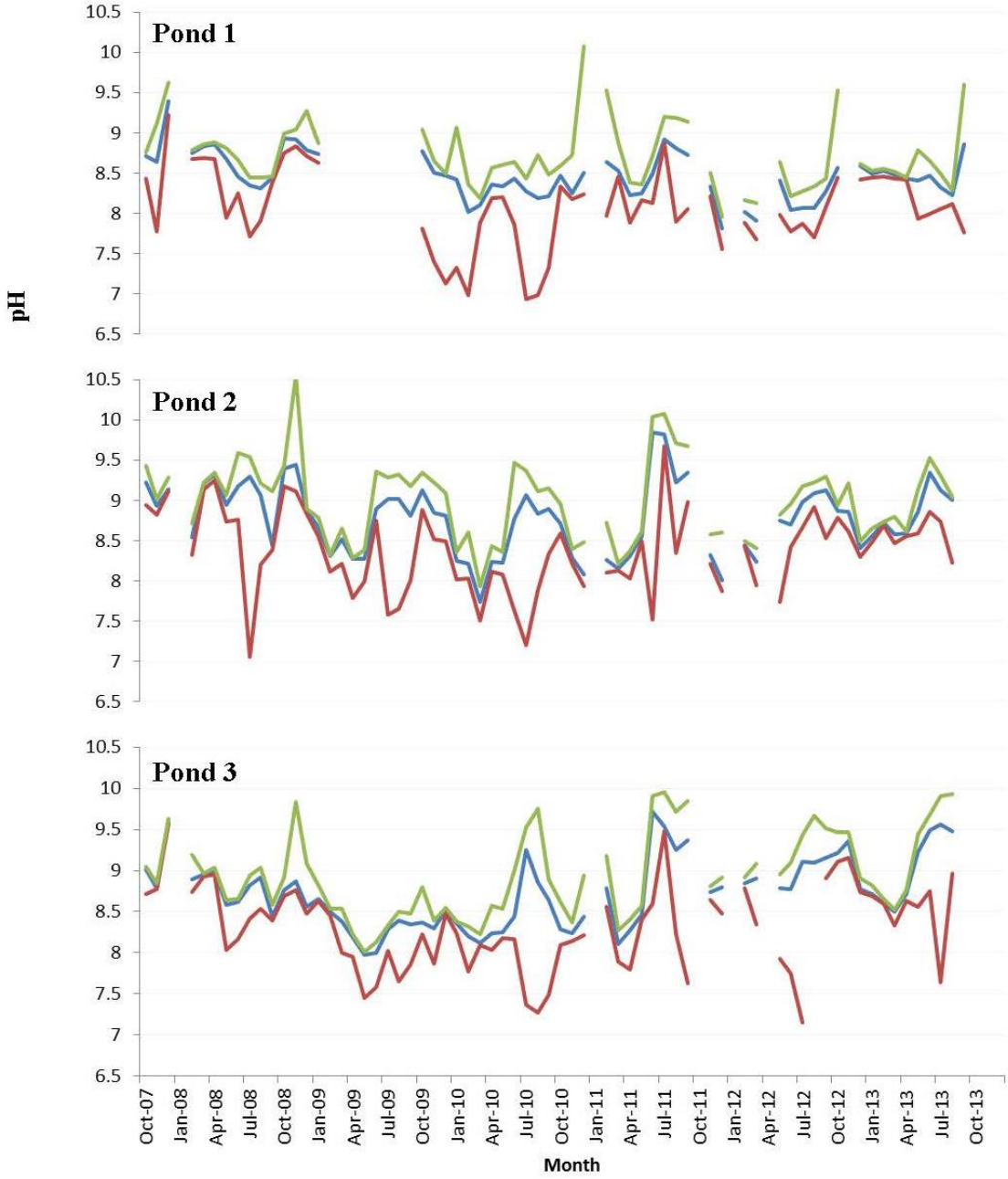

Figure 13a.—Monthly median, minimum, and maximum pH for Ponds 1, 2, and 3. Average is the blue line, minimum is the red line, and maximum is the green line.

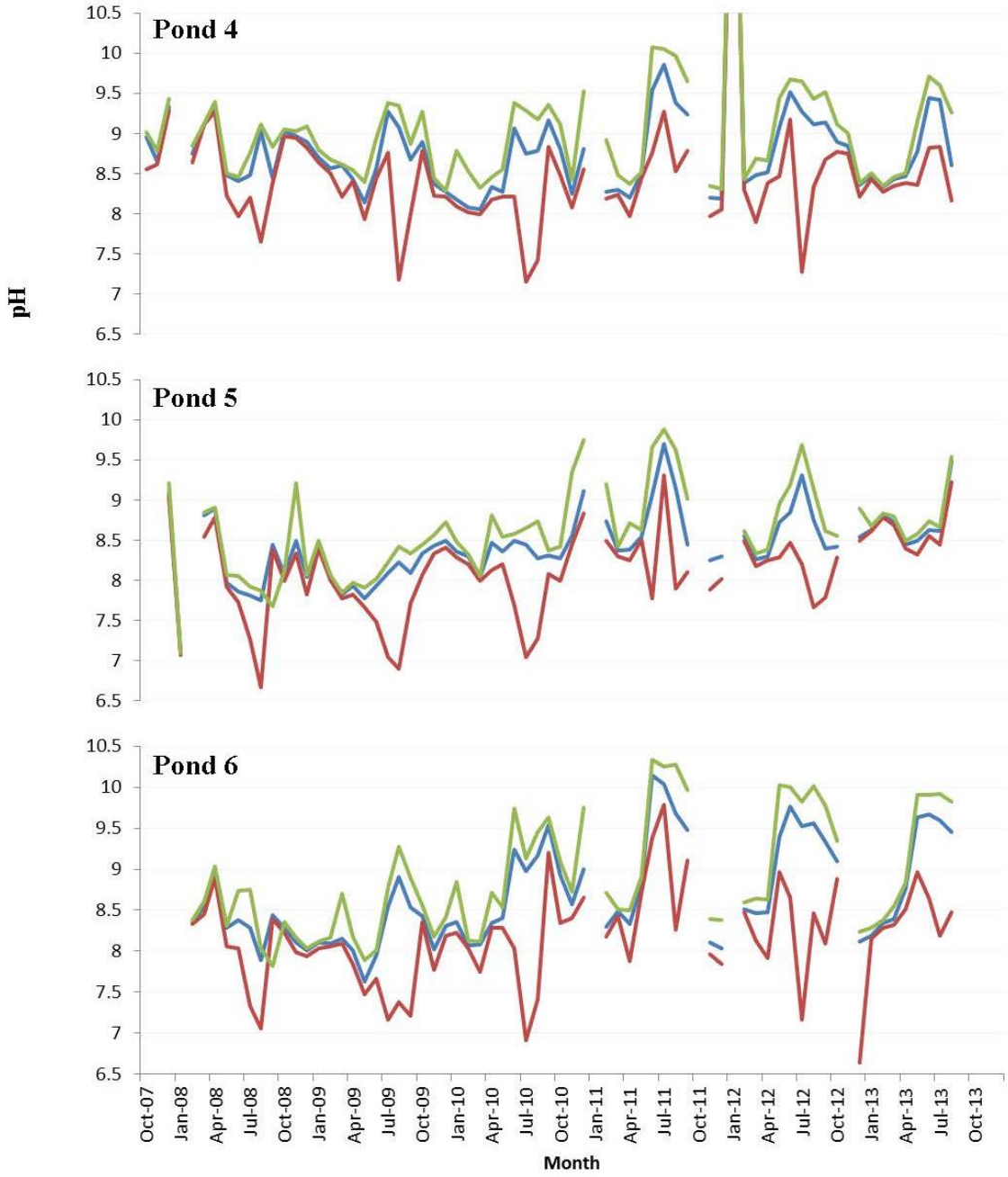

Figure 13b.—Monthly median, minimum, and maximum pH for Ponds 4, 5, and 6. Average is the blue line, minimum is the red line, and maximum is the green line.

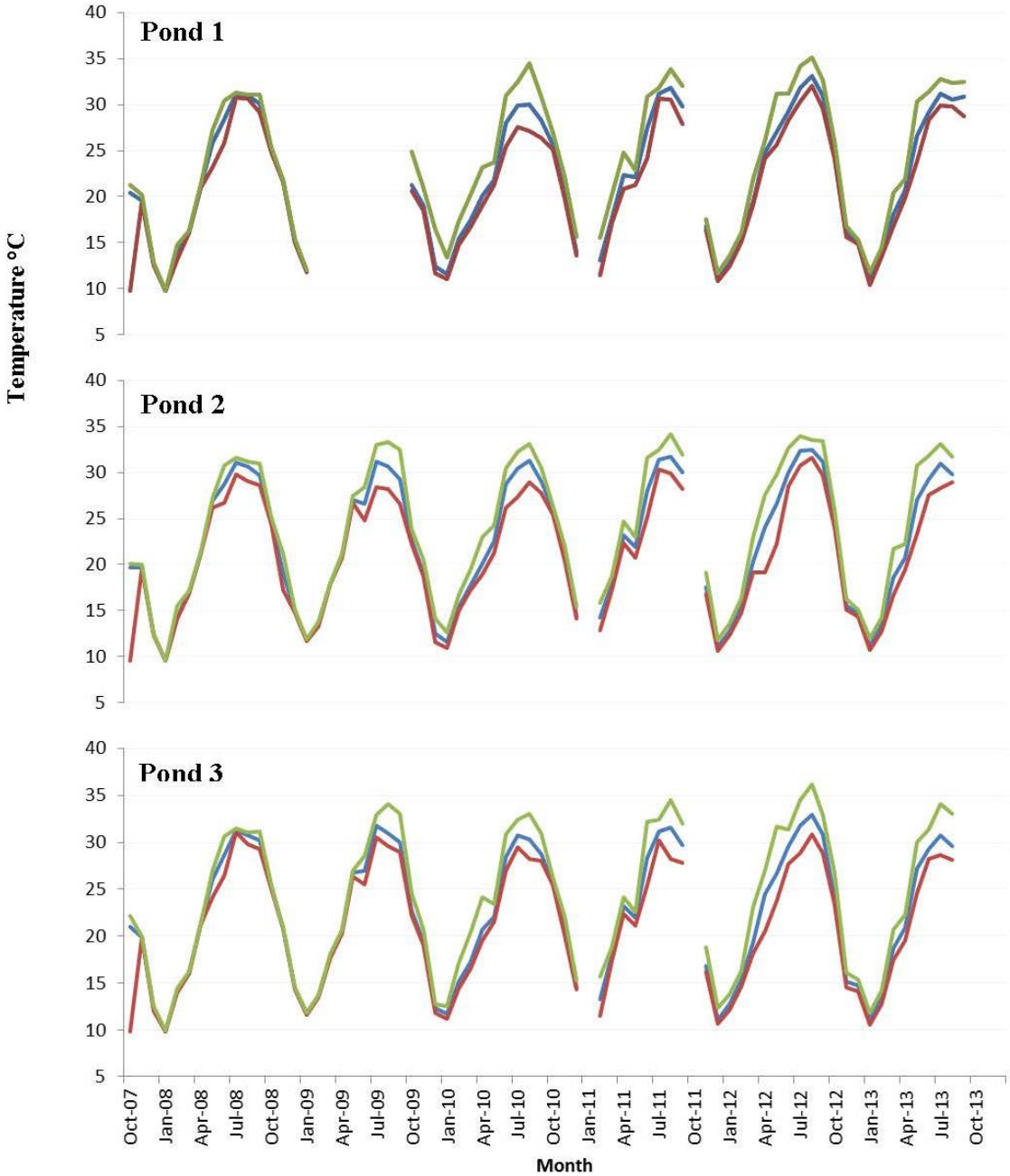

Figure 14a.—Monthly average, minimum, and maximum temperature (°C) for Ponds 1, 2, and 3.
Average is the blue line, minimum is the red line, and maximum is the green line.

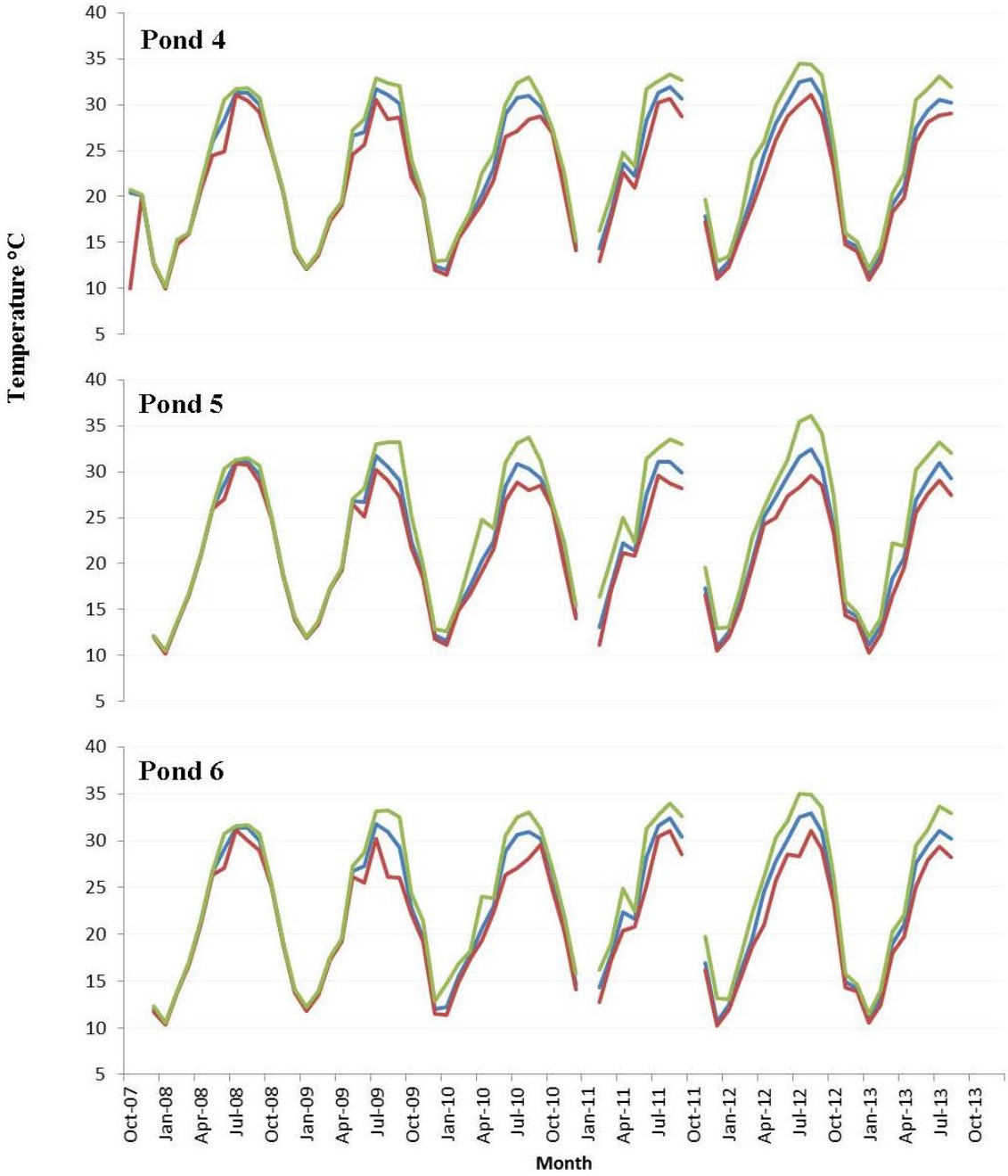

Figure14b.—Monthly average, minimum, and maximum temperature (°C) for Ponds 4, 5, and 6.
Average is the blue line, minimum is the red line, and maximum is the green line.

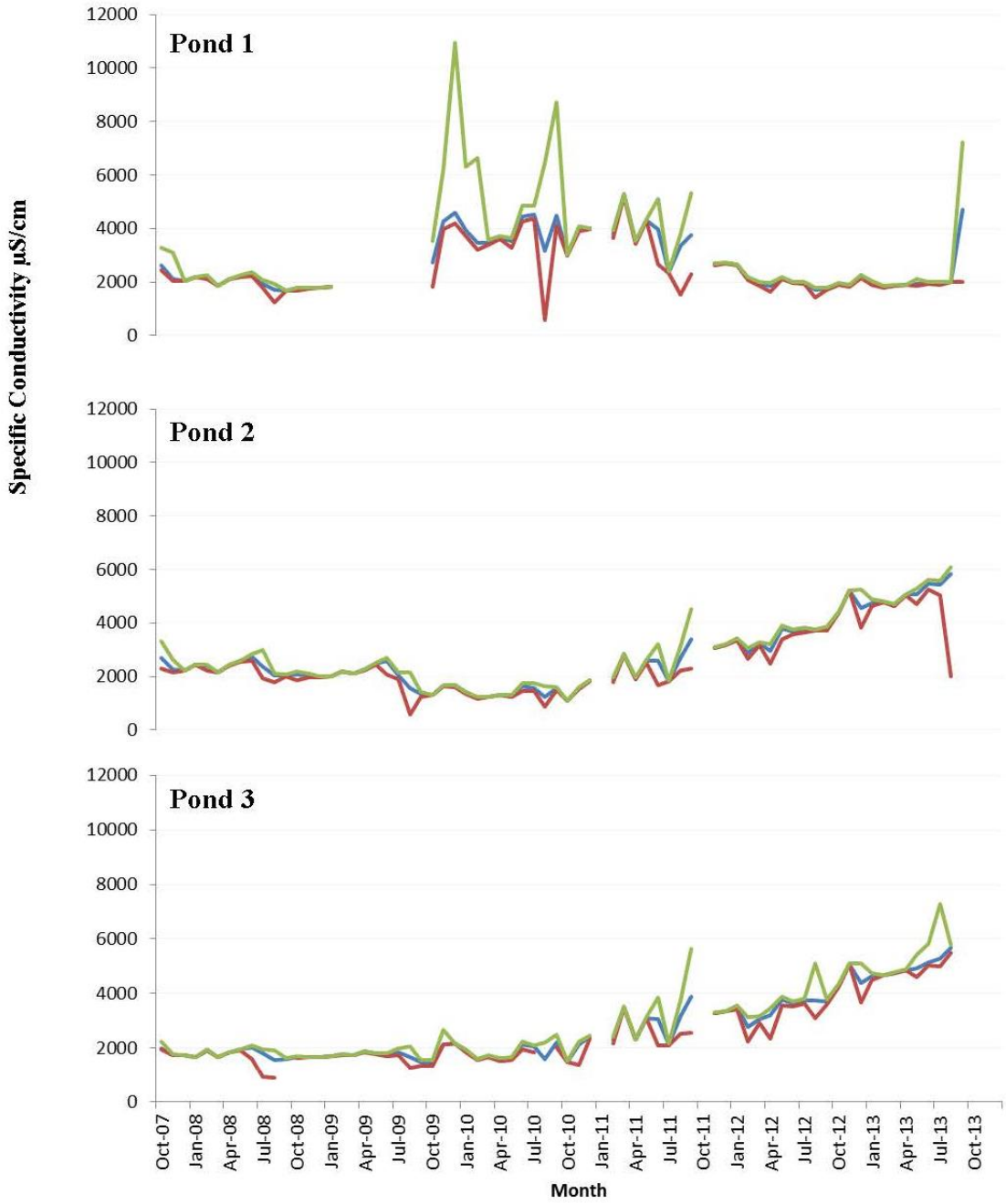

Figure 15a.—Monthly average, minimum, and maximum specific conductivity, for Ponds 1, 2, and 3.
Average is the blue line, minimum is the red line, and maximum is the green line.

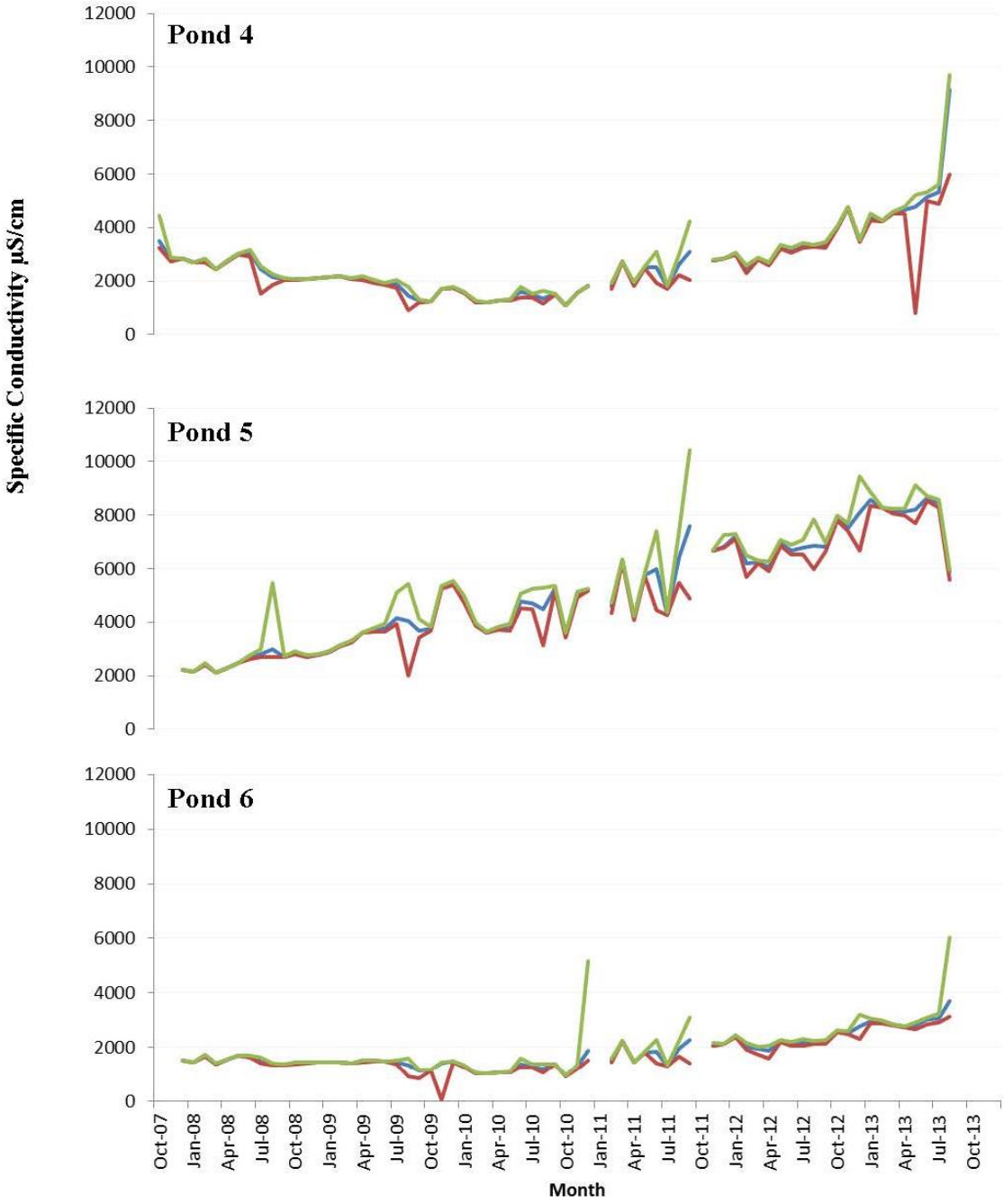

Figure 15b.—Monthly average, minimum, and maximum specific conductivity for Ponds 4, 5, and 6.
Average is the blue line, minimum is the red line, and maximum is the green line.

Monitoring and sampling for nonnative fish began in September 2007. Western mosquitofish were captured from the pond (Kesner et al. 2008). The pond was not sampled again until October 2009. At this time, black crappie, bluegill, redear sunfish, and warmouth were captured. No additional species were captured during the November 2010 and November 2011 sampling. Common carp were captured from the pond in November 2012 (see table 2).

Water quality monitoring began in December 2007. The monthly average DO was below 4.0 mg/L in November 2011 and March 2012 (see figure 12b). The median monthly pH was recorded above 9.0 during 16 of the 64 months sampled. Of the 16 months, the pH minimum and maximum range was above 9.0 two times: September 2010 (9.20 – 9.63) and July 2011 (9.79 – 10.25) (see figure 13b). Average monthly temperature never exceeded 33.3 °C, but has shown an increasing trend over time (see figure 14b). The monthly average specific conductivity has shown an increasing trend over time (see figure 15b).

FIVE-YEAR MONITORING AND RESEARCH PRIORITIES (2014 – 2018)

As a result of accumulated knowledge from the research and monitoring information that has been collected at the Imperial Ponds over the past 6 years, research priorities have been identified by the Imperial Ponds Fisheries Coordination Team. The following priorities include actions to implement infrastructure upgrades, to conduct research to investigate habitat (water quality) improvement options, and to undertake fisheries and other management activities. These priorities are intended to guide and inform the Imperial Ponds Fisheries Coordination Team on the actions that will take place at the Imperial Ponds into the near future.

Installation of a Second Well on Site

Reclamation is in agreement with the Yuma Area Office (YAO) to drill and establish an additional groundwater well for the ponds dedicated to native fishes, install a groundwater pump at the new well site, and connect the two wells (one new and one existing) to the existing pipe infrastructure for the ponds to provide redundancy as well as filtered water. The additional well is intended to add management flexibility to the water delivery infrastructure by providing additional nonnative-free water capacity to manage water quality in the ponds.

Actions

1. Drill and develop one new groundwater well (24-in diameter) based on geotechnical investigations previously completed by YAO.

2. Size, purchase, and install a groundwater pump in the well drilled under action 1, above, and connect the two groundwater wells to the piping infrastructure to provide water to the ponds. In the interim, connect one well to the pond infrastructure to allow limited operation until the second well is operational. Electrical upgrades may be required.

3. Develop standard operating procedures for the water delivery system to the ponds.

Investigate Options to Mitigate pH and Specific Conductivity in the Ponds

The Imperial Ponds Fisheries Coordination Team identified pH > 9.0 as a standard that, when reached, would initiate management actions. The ponds have exceeded this standard, in the summers of 2011 and 2012 in Ponds 2 – 6, when these ponds received no surface water input (Reclamation 2013). The pH values appear to be increasing over time with differences observed among ponds. A management standard has not been identified for specific conductivity; however, an increasing trend over time is apparent in all six ponds (LCR MSCP 2013).

Actions

1. Accept and manage water physico-chemistry ranges as they are identified and managed across all LCR MSCP conservation areas. Currently, the LCR MSCP staff is developing minimum management guidelines using existing information regarding habitat and site conditions for each of the LCR conservation areas.

2. Investigate water drawdowns as a way to mitigate for increasing specific conductivity levels over time in the ponds. During a study conducted on McAllister Lake, about 59% of the lakes volume was removed. The lake was naturally refilled from its subsurface connection to the river. The pretreatment mean of specific conductivity, 13,657.9 microsiemens per centimeter (µS/cm), showed a significant ($p < 0.001$) and linear reduction of 4,100.5µS/cm after each drawdown. The drawdown method is suggested as an acceptable technique for reducing salinity levels in seepage backwaters (Walker et al. 2007).

3. Investigate supplemental groundwater delivery as a way to mitigate for increasing pH levels over time. The current well has averaged a pH of 7.8 (true average as defined as -log_10 [(ΣC_j)/ (n)], where C is the concentration of hydronium ion and n is the number of measurements) from November 2011 through May 2013. The average pH of the well is below the standard that is being managed at Imperial Ponds. Supplemental groundwater delivery appeared to effectively lower pH levels from 9.74 in June to 9.04 by July in Pond 6 (Kesner et al. 2010b).

Renovation of the Six Ponds

Disconnected backwaters free of nonnative fish could provide habitat for a recruiting population of BONY and RASU (Reclamation 2004). Currently, the Imperial Ponds have a suite of nonnatives, including black crappie, bluegill, common carp, redear sunfish, threadfin shad, warmouth, and western mosquitofish. Ponds 1 and 3 have previously been renovated, but considerations for site preparation and post-renovation monitoring were not included in the plan and may have contributed to the unsuccessful removal of all fish from the ponds. In addition, the ponds will have a water delivery system that is well-water driven and assumed to be completely free of nonnative fish of all life stages, thereby eliminating a key vector for invasion and establishment of nonnative species.

Although maintaining 100% nonnative free backwaters is unlikely for extended periods, a rigorous effort should be made to attempt a complete renovation on all the ponds before additional stocking efforts are initiated. The renovation plan will address pre-stocking protocols, including details on site preparation as well as accepted protocols for treatments and intensive post-renovation monitoring. Lessons learned from previous renovations will guide our techniques and protocols to secure the best chances for success. Furthermore, renovation conducted well before additional stocking is scheduled will allow for longer term monitoring to assess success and possibly correct unsuccessful pond renovations, thereby giving stocked fish greater likelihood for establishment and recruitment.

Actions

1. Pre-renovation efforts will include removal of shoreline vegetation, cattails, and vegetation on the hummocks. A prescribed burn will occur to remove the marsh area in Pond 5.

2. Chemically renovate all six ponds with Prenfish® CFT Legumine™ (5-percent rotenone) Fish Toxicant. A single treatment will include two applications. Rotenone is more toxic to adult, juvenile, and larval fish than to fish eggs (Wynn and Masser 2010). A second application will be applied following the first application dependent on the results of a literature review of egg incubation times for the targeted nonnative fish.

3. River stage will be tracked, and pond water levels will be managed prior to, during, and immediately following renovation to reduce the possibility of subsurface river water invasion and the creation of "freshwater" refuge areas for target fish.

4. Post-renovation monitoring will include monitoring for all life stages of fish. Eggs may be pelagic or demersal and adhesive or nonadhesive. Monitoring methods should include the evaluation of dredge samples and plankton tows. Larval life stages will be evaluated from plankton tows, larval light traps, and hand collection by net and underwater fishing lights. Juveniles and adults will be monitored by minnow traps, baited/unbaited; hoop netting, baited/unbaited; and trammel netting.

5. Evaluate efficacy of renovation and identify successes and areas in need of improvement.

Stocking BONY and RASU into the Ponds

The primary purpose of the Imperial Ponds is to provide refugia for endangered BONY and RASU. However, as per the HCP (Reclamation 2004), the ponds may additionally be used for production to aid the Fish Augmentation Plan (Reclamation 2006b), species research to increase the understanding of life cycle or habitat needs or both, and research to evaluate habitat features to be incorporated into habitat design.

Actions

1. Pre-stocking monitoring for nonnative fish and assessment of water quality.

2. Stock ponds with BONY or RASU or a combination of the two species.

    a. Establish preliminary target population goals for each life stage for each species in each pond.

b. Evaluate potential stocking densities. Stocking rates (fish per hectare [ha]) were evaluated in the early to mid-1990s in Yuma Cove backwater, a backwater free of nonnative fish species, on Lake Mohave, Arizona. Wild larvae were stocked over 3 years: 1993, 500 larvae/ha; 1994, 3,600 larvae/ha; and 1995, 6,900 larvae/ha. Recovery rates were 91.5, 12.1, and 1.6%, respectively (Mueller and Burke, 2005).

c. Complete a literature review for stocking densities of BONY and RASU at any life stage. If literature is limited or does not exist, collect the appropriate data to make stocking density recommendations.

d. Evaluate stocking practices: seasonal, autumn, winter, spring; time of day, daylight compared to nighttime stocking; acclimated compared to nonacclimated stocking, and flow conditioned and predator conditioning.

e. Collect appropriate data prior to stocking. This should include fish species, length (TL), weight, sex (if identifiable), PIT tag number, general health of fish (wounds, parasites, and deformities), fin clip, location of origination, and pond fish were stocked to.

3. Identify sources of immediate post-stocking mortality to determine how to best target and prioritize solutions.

   a. Use a bio-energetics model of piscivorous bird predation, which would include performing counts of confirmed feeding of piscivorous birds on stocked RASU and BONY. The model should provide information on relative pressures that bird predation may be having on stocked fish.

   b. Evaluate latent mortality associated with stocking practices identified under stocking practices of BONY and RASU (action 2c, above). This work may involve holding a subset of BONY or RASU in net pens or a confined area of the pond and recording survival after 24, 48, and 72 hours. Longer durations may also be explored.

4. Post-stocking monitoring should use sampling techniques that will target all life stages of BONY and RASU. These techniques may include, but are not limited to, larval light trapping and hand collection, minnow traps, hoop nets, trammel nets, electrofishing, and remote sensing.

   a. Larval BONY and RASU (up to 100 per month) will be preserved in 95% nondenatured ethanol for genetic analysis.

b. Any BONY or RASU captured without a PIT tag ≥ 150 mm will be PIT tagged, measured (TL), weighed, assessed for general health, and a fin clip taken for genetic analyses.

5. Survivorship should be estimated for each size class as appropriate. If survivorship is good, begin development of a genetic management protocol. If survivorship is low, identify factors that may be contributing to low survival and evaluate options for mitigating low survival.

Water Management

Water management should include recording WSE of the ponds, recording water input and output of the ponds, monitoring physico-chemical parameters, and collecting appropriate water chemistry parameters.

Actions

1. A staff gage is located in each of the six ponds, and the WSE of the pond should be recorded on a weekly basis. A water level monitor can be installed in each pond to provide a more intensive reporting frequency if needed.

2. Water input to the ponds will be set up on an automated system and the quantity added to each pond recorded.

   Water pumped out of the ponds during water quality improvement investigations will be tracked as outlined in the statement of work for those studies. At the completion of the study, a schedule will be suggested and developed for water delivery to the ponds and adjusted as new information is learned.

3. Water physico-chemistry parameters and water chemistry monitoring will be outlined in the research statement of work for the mitigation of pH and specific conductivity. At the completion of this study, methods for collection and frequency will be established for long-term monitoring of water quality at the Imperial Ponds.

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