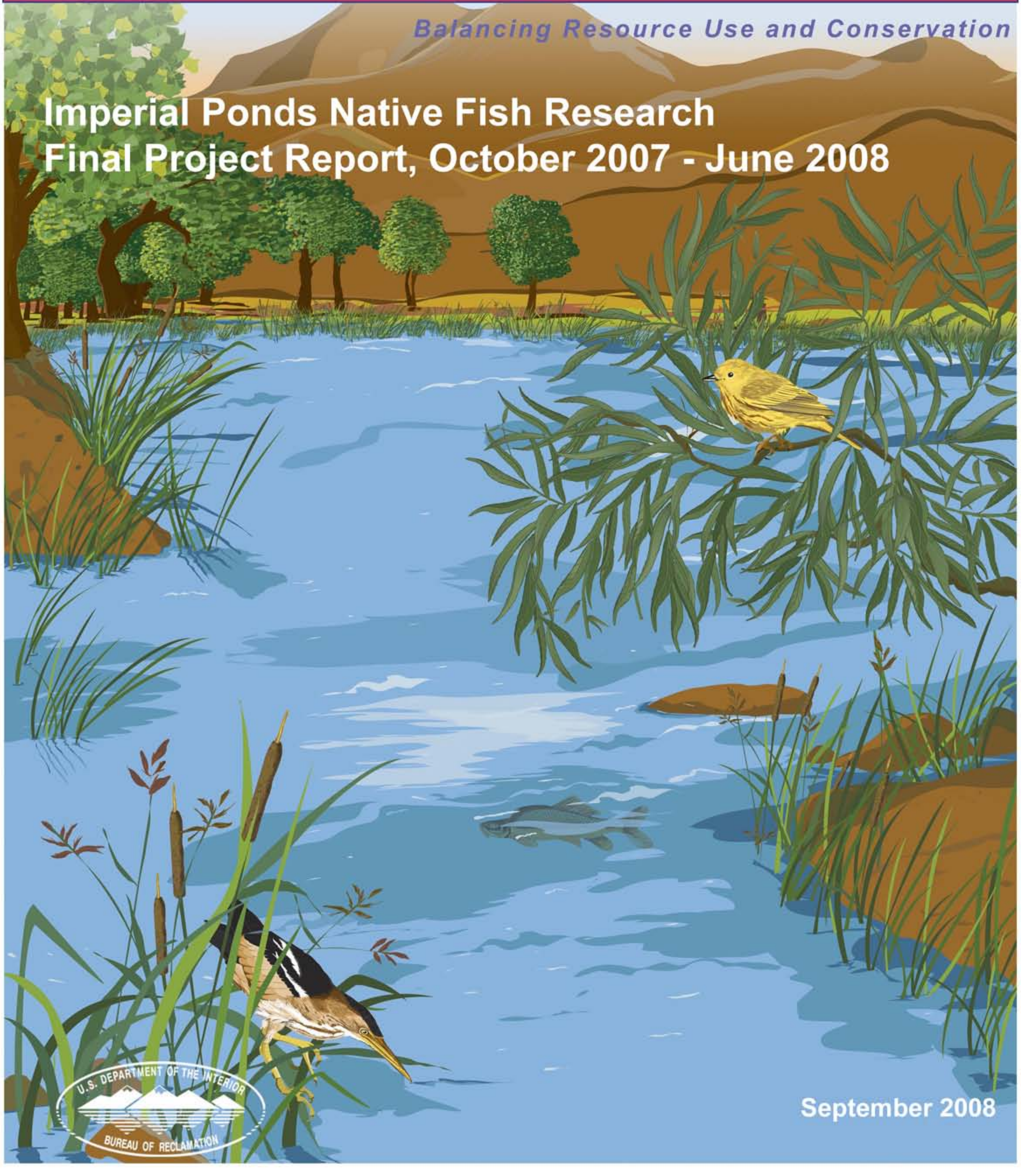
# Lower Colorado River Multi-Species Conservation Program

*Balancing Resource Use and Conservation*



## Imperial Ponds Native Fish Research
## Final Project Report, October 2007 - June 2008

September 2008

# Lower Colorado River Multi-Species Conservation Program
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# Lower Colorado River
# Multi-Species Conservation Program

## Imperial Ponds Native Fish Research
## Final Project Report, October 2007 - June 2008

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*In fulfillment of Agreement Number 08-FG-30-0001 between Arizona State University and Bureau of Reclamation, Boulder City, Nevada*

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

**September 2008**

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# Summary

Results from preliminary monitoring of six ponds on the Imperial National Wildlife Refuge (INWR) are mixed. The ponds were designed to provide suitable habitat for life cycle completion by bonytail *Gila elegans* and razorback sucker *Xyrauchen texanus*. However, nonnative fish were identified in all six ponds prior to native fish stocking. Common carp were captured in three ponds and mosquitofish were observed in all six. The impact of these species on native populations is unknown, and no new nonnative species has been captured or observed since stocking. Water physico-chemistry variables in all ponds have generally remained within acceptable limits where established; pH < 9, DO > 4 mg/l, and temperature < 33.3° C, and no signs of fish stress have been evident. Imaging sonar, portable eco-sounder, and swimming transects failed to provide adequate data to evaluate habitat use. However, the construction and deployment of remote PIT scanning units has provided population estimates for all ponds stocked with native fish. These units should also provide adequate habitat use data for PIT tagged fish beginning in autumn 2008. Estimated survival for razorback sucker is high, 75%, but estimated survival for bonytail is low, between 4 and 15%. Piscivorous birds are suspected in the decimation of bonytail stocks.

# Introduction

The razorback sucker *Xyrauchen texanus* and bonytail *Gila elegans* are both critically endangered native fish species endemic to the Colorado River system. Although a few, small (<500 individuals), remnant populations of razorback sucker still persist in the wild, recruitment is low or undetectable (Golden & Holden 2003, Marsh et al 2003, Minckley et al. 2003). In Lake Mohave, the wild population is outnumbered by a population of 'repatriated' fish (Marsh et al. 2005, Kesner et al. 2008). Although repatriation efforts in Lake Mohave have resulted in a new population of approximately 2,000 fish, long-term survival of released fish is still very low, approximately 1%. This low survival is likely due to piscivorous fishes, mainly striped bass (Karam et al 2008). No wild populations of bonytail exist and stockings of bonytail in Lake Havasu and Lake Mohave have not resulted in the establishment of measurable populations. Given the apparent difficulty of maintaining populations of native fishes in the presence of nonnative fishes, the establishment of native fish sanctuaries, aquatic habitats devoid of nonnative fish species stocked with one or more native fish species, may be a more efficient and economical method of maintaining populations of native species (e.g. Minckley et al. 2003).

At the request of the Bureau of Reclamation (BR) a group of native fish experts developed a template for the reconstruction of a series of ponds on the U.S. Fish and Wildlife Service (USFWS) Imperial National Wildlife Refuge (INWR) along the Colorado River north of Yuma, Arizona (USBR 2005). The new design comprised six ponds, hereon referred to as Imperial Ponds, with features thought to provide suitable habitat for life cycle completion by bonytail and razorback sucker (Fig. 1). Construction was completed in summer 2007, and razorback sucker were stocked into ponds 1 and 4 on November 5, 2007 (305 and 272 fish, respectively). Bonytail were stocked into ponds 2 and 3 on December 12, 2007 (800 and 801 fish, respectively). The Native Fish Lab at Arizona State University (ASU) was contracted to develop and implement a monitoring program for native fish stocked into Imperial Ponds.

This report presents the results of a one year preliminary study to support LCR-MSCP Work Task C-25: Imperial Ponds. This study had three main goals: (1) to determine the status of invasive species for each pond prior to native fish stocking and detect new invasions post-stocking, (2) to ensure maintenance of an adequate aquatic environment for native fishes by monitoring water physico-chemistry and recommending remedial action when necessary, and (3) to develop innovative techniques for monitoring abundance and habitat use of stocked native fishes. These three goals were achieved by two or more researchers conducting routine monitoring trips to Imperial Ponds from October 2007 to June 2008 (Table 1).

# Methods

## Invasive Species

An assessment of the nonnative fish community in each pond prior to native fish stocking was conducted from 24 to 26 September 2007. All six ponds were sampled using experimental gill nets, hoop nets, and electrofishing. Gill nets were constructed of five, 7.6 m panels with mesh sizes of 2 to 51 mm. Hoop nets had a 2.1 m center wing, measured 2.4 m long (7 hoops) with a 0.6 m diameter opening and were made of 13 mm mesh. Electrofishing was conducted using a Smith-Root SR-18H package with GPP 7.3 pulsator. The electrofisher output settings were approximately 12 amps at 340 volts and 20 to 25 amps at 170 volts pulsed DC. Both voltage settings were used in ponds 3 and 4, and 170 volts was used in all other ponds. Electrofishing was conducted along the entire shoreline and across the pond in multiple passes. All six ponds were sampled during the evening and overnight 24-25 September. Ponds with no or little catch were sampled a second time during the evening and overnight 25-26 September. Hoop nets have been deployed since February 2008 to assess additional invasions as well as to test the efficacy of the technique to capture native species for health and population assessment.

## Water Physico-chemistry

Water physico-chemistry at Imperial Ponds has been monitored on a monthly basis since September 2007 and twice a month since the beginning of summer 2008 (defined as when the mean water temperature exceeds 27° C). Monitoring from September 2007 through April 2008 was carried out using a Eureka Environmental Engineering (Austin, TX) Manta™ multi-parameter probe and monitoring from May 2008 through the present has been done with a Hanna Instruments® (Woonsocket, RI) HI9828 multi-parameter probe. Vertical profiles were recorded in 0.5 meter increments at three locations in each pond; inflow, mid-pond, and near the outflow. Nominal parameters measured include temperature, conductivity, total dissolved solids (TDS), dissolved oxygen (DO) and pH. Since December 2007, measurements have been taken at sunrise and sunset in order to capture the extremes of each variable being measured. Secchi Disk depth and pond elevation (staff gage level) have been recorded since April 2008.

## Population and Habitat Use Monitoring

The effectiveness of hoop nets at capturing native fish was evaluated in February, March and April 2008. Hoop nets were either double throated, 1.2 m long, 0.8 m diameter, 13 mm mesh nets or single throated, 1.2 m long, 0.8 m diameter, 38 mm mesh nets. Hoop nets were deployed in all four ponds with varying effort (Table 2). Starting in February, small, approximately one meter, sections of PVC pipe were used to keep hoop nets open and rigid in an attempt to increase native fish catch.

Several techniques were evaluated for their ability to measure habitat use. An imaging sonar, Imagenex Model 881A (Imagenex Technology Corp., Port Coquitlam, BC, Canada) on loan from BR was deployed in two ponds stocked with native fish on 13 December 2007 to determine if fish could be distinguished and counted within the sonar field. In addition, a portable fish finder (Fishin' Buddy® 4200) with a horizontal and vertical echo sounder was tested on 11 December 2007. The unit had a grayscale display that showed depth and distance to objects and can distinguish fish echoes from other objects. An alarm would sound when fish were detected. Alarm chimes were counted for set periods of time at locations within the ponds in order to determine if fish were present in a given area. In order to validate alarm counts the unit was tested in one pond with and one pond without known populations of large fish.

Snorkeling transects were done in Ponds 2 and 4 in order to assess the feasibility of detecting fish visually. Transects were done during routine monitoring trips in December 2007, and February and April 2008. They ranged in lengths from 70 to 150 meters and were swum during midday hours in order to make the best use possible of ambient light.

Spawning of adult razorback sucker stocked in ponds 1 and 4 was expected since fish stocked into these ponds averaged 445 mm total length at release. Therefore, larval collections were attempted from February through April 2008 during routine monitoring trips. Fishing lights rated to 250,000 candle power were deployed in the evening after dark and aquarium dip nets were used to capture larvae. Razorback sucker larvae were preserved in 95% ethanol for genetic analysis at ASU.

During the study year, a substantial amount of time and effort was expended on developing a cost effective remote PIT scanner unit for use in acquiring mark-recapture data, as well as diel and seasonal habitat preference of native fish in Imperial Ponds. Basic antenna design was based on Bond et al. (2007). In an attempt to create an antenna that was easy to deploy and maximized read range, five antennas with varying height, width, and wire type and size were built. Two different PIT scanners were also tested; a FS2001F-ISO portable scanner (Destron Fearing, Inc., St. Paul, MN) and a stripped down scanner for an Allflex® Series Panel Reader (Allflex USA, Inc., Dallas, TX). The final PIT scanner unit design consisted of 12 gauge stranded copper wire encased in 38 mm PVC pipe (2.3 m by 0.7 m, Fig. 2) attached to an Allflex® scanner. Each scanner was powered by a Power-Sonic® (Power-Sonic Corporation, San Diego, CA) 12 volt, 26 Amp-Hr. battery. The Allflex® scanner was stored in a submersible clear PVC tube. The battery was stored in a sealed, model 1520, Pelican™ case (Pelican Products, Torrance, CA) which also contained a data logger. Allflex® scanners sent tag data to the loggers via a serial cable. Data loggers recorded tag numbers and the date and time a tag was encountered. Data loggers used were prototypes provided by Cross Country Consulting Inc. (Phoenix, AZ) and were added to scanner units in June 2008. Prior to data logger installation, tag reads from Allflex® units were retrieved directly from the scanners, without date and time data.

Scanner units were deployed in different habitats within the ponds. They were placed off the rip-rap, on the hummocks, off *Typha* sp. or *Phragmites* sp. stands, off boat ramps or sunk in open water. The purpose of much of the work conducted thus far was to test different antenna configurations, scanner units, and fine tune the equipment. Sufficient mark-recapture data were collected during this process to estimate populations in all four ponds stocked using the single census modified Peterson formula (Ricker 1975).

# Results

## Invasive Species

Nonnative fish species were found in all six ponds during pre-stocking sampling. Mosquitofish *Gambusia affinis* were identified in all six ponds, and approximately 150 juvenile and 1 adult carp *Cyprinus carpio* were captured in ponds 1 and 3. One adult carp was also captured in Pond 2. In addition to fish species, bullfrog *Rana catesbeiana* tadpole were observed or captured in all ponds, and one beaver *Castor canadensis* was observed and one adult crayfish *Procambarus clarkii* was captured in Pond 5. Hoop netting efforts since native fish stocking have not revealed any new invasive species (Table 2), and no additional carp have been captured from Pond 2. Ponds 5 and 6 have not been netted, but no carp have been observed in these ponds since the onset of water physico-chemistry monitoring in October 2007. Mosquitofish continue to be observed in large numbers in all six ponds.

## Water Physico-chemistry

To date, most physico-chemical variable means (DO, temperature, conductivity, and TDS) for Imperial Ponds have remained within acceptable limits where established (Figs. 3-7); pH < 9, DO > 4 mg/l, and temperature < 33.3° C. One notable exception has been pH which reached values exceeding 9 in ponds 1, 2, 3, 4 and 5 at least once per pond since the start of monitoring. Mean pH for all ponds has ranged from 7.09 (Pond 5, January 2008) to 9.62 (Pond 3, December 2007). Mean DO has ranged from 4.55 (Pond 5, May 2008) to 13.43 mg/l (Pond 2, June 2008). A few measurements of DO were below the threshold (4mg/l) in ponds 1, 2, 3, 4 and 5. These low DO values were taken at or near the bottom of the pond (Figs. 8-12). The mean temperature for all ponds ranged from 9.75 (Pond 2, January 2008) to 31.22°C (Pond 2, June 2008). Mean TDS reached a maximum of 2,245 mg/l (Pond 4, October 2007) and a minimum of 820 mg/l (Pond 6, June 2008). Finally, mean conductivity ranged from 1,404 (Pond 6, March 2008) to 3,508 µS/cm (Pond 4, October 2007).

Secchi depth (in meters, m; 1 m = 3.28 ft) has remained relatively constant with the exception of pond 2 where depth has increased from 1.56 m in April 2008 to 2.70 m in June 2008 (Fig. 13). Water clarity in pond 6 was high enough that the Secchi disk was seen from the pond bottom on all occasions. This was also true for pond 5 in June (first trip) and pond 2 in June (second trip). Meanwhile, pond elevation has declined about 1.5 ft on average during the period April to June 2008 (Fig. 13).

## Population and Habitat Use Monitoring

Two razorback sucker and one bonytail were captured in hoop nets (Table 2). Both razorback sucker were ripe females captured on 28 February 2008. One female was 399 mm in total length (TL) and weighed 672 g, the other was 457 mm TL and weighed 910 g. The one bonytail of unknown gender was 352 mm TL and weighed 334 g. Total hoop netting effort was 86 net-nights (a net night is a single hoop net deployed for 24 hours). Nonnative fish bycatch was restricted to carp captured in ponds which were known to contain carp prior to stocking (ponds 1 and 3). Since native fish stocking, no carp have been captured in pond 2.

All sonar or visually based methods for obtaining abundance or habitat use either failed outright or have failed to date due to conditions in the pond. Fish were difficult to differentiate from background noise using imaging sonar. Even large objects placed in the pond (boat hook, anchor) could not be identified using imaging sonar. Alarm counts from the portable sonar unit failed to differ in ponds with or without populations of large fish. In addition, all snorkeling transects resulted in zero fish observed. It is possible that no fish were observed due to turbidity. Snorkeling transects are planned for winter months of 2008-09 when presumably turbidity will decrease.

A total effort of 180 minutes and 211 minutes were exerted during the 2008 larvae season in ponds 1 and 4, respectively. A total of 23 specimens were collected in Pond 1 while no specimens were collected by us in Pond 4.[1] There was concern that some of the specimens collected during April sampling in Pond 1 were larvae of carp. However, genetic screening determined that all 23 specimens were razorback sucker.

PIT tags were scanned in all four ponds stocked with native fish. There was a total of 1,469 tags recorded. Ponds 1 and 4 (stocked with razorback sucker) had notably more scans than those stocked with bonytail. Three population estimates were made for Ponds 1 and 4, two for Pond 3, and one for Pond 2 (Table 3). Two of the three estimated population sizes for ponds 1 and 4 were similar to each other and among time periods and were high enough that 95% confidence intervals included the number of fish stocked. The last estimates are quite different, the estimate for Pond 1 declined dramatically and the estimate for Pond 4 is higher than the number stocked. Population estimates for both ponds stocked with bonytail (ponds 2 and 3) are less than 25% of the fish stocked, although estimates for Pond 3 are markedly higher than for Pond 2.

[1] Reclamation biologists reported capture of a single larva in Pond 4 (J. Lantow, pers. comm.).

# Discussion

Results from preliminary monitoring of Imperial Ponds appear mixed. Population estimates based on remote sensing data indicate that survival for razorback sucker stocked in ponds 1 and 4 is high, at 75% each (April-May estimates). Moreover, remote sensing has proven an effective technique contacting a majority of estimated live fish in each pond at least once; 122 individual fish have been scanned in Pond 1 and over 200 in Pond 4. On the other hand, survival appears low in ponds stocked with bonytail. Based on stocking records and population estimates survival is 4% and 15% for ponds 2 and 3, respectively. This high level of mortality occurred over a few months (December 2007 to March 2008) without an observed mass die-off by refuge personnel or a known problem with water physico-chemistry. These losses occurred over winter and during this time flocks of Double-crested Cormorant *Phalacrocorax auritus* and American white pelican *Pelecanus erythrorhynchos* were observed occupying the ponds and surrounding wetlands (Fig. 14). Both species are known piscivores (Anderson 1991, Wire et al. 2001), and are the suspected cause for bonytail losses. At stocking bonytail were 125 mm smaller on average than razorback sucker at stocking, 320 mm and 445 mm respectively, increasing their vulnerability to bird predators. The problem may be exacerbated by low water turbidity making the fish more vulnerable to avian predators. However, there has been no direct evidence that avian predation is the cause. Scanning hummocks for excreted PIT tags and post-stocking observation of piscivorous birds are being considered to assess this potential problem.

Although larvae collections in Pond 1 provide proof of a successful spawning in at least one pond, no larvae were collected in Pond 4. The lack of larvae collected in Pond 4 may have been due to low light penetration in this highly turbid pond. Autumn sampling will determine if recruitment was successful in any pond.

Hoop netting was largely unsuccessful for catching native fish, especially for bonytail. One bonytail was captured in 62 net-nights. The low abundance of bonytail apparent from remote sensing data is partially responsible for the lack of success. However, BR captured two bonytail in 8 net-nights using small hoop nets equipped with wings. Autumn sampling will use hoop nets with wings and this may increase catch rate. If not, short (1-2 hour) trammel net sets will be used. Remote PIT scanner units will continue to play an integral part of abundance assessments in Imperial Ponds.

Two species of nonnative fish, mosquitofish and carp, as well as crayfish and beaver have all been present in at least one pond since the end of construction.  The impact of these inhabitants is unknown.  Although the removal of all nonnative species through chemical renovation is preferred, initial stocking of the ponds was undertaken in hopes of assessing the impact of these biotic invaders.  To date, no new species of aquatic invader has been detected in ponds 1 through 4 since the stocking of native species.  Some insights on the effect of nonnative species will be provided by comparative data on growth, survival and recruitment for bonytail and razorback sucker in ponds with carp (ponds 1 and 3) and without carp (ponds 2 and 4) during autumn 2008 sampling.  Chemical renovation of any or all ponds has not been ruled out, and will be conducted if deemed necessary for native fish life-cycle completion.

Finally, a decrease in the population estimate for Pond 1 and an increase in the population estimate in Pond 4 for May 2008 may have been due to bias caused by antenna placement within the ponds. Total remote sensing contacts with razorback sucker in ponds 1 and 4 have decreased as water temperatures have increased.  This may indicate razorback sucker movement in the pond has been reduced.  If so, bias in population estimates is likely due to the increased chance that antenna placement influences which fish are contacted in each pond (non-random sample).  Continuation of remote sensing and autumn sampling will provide additional estimates for comparison.

## Acknowledgments

BR, Boulder City, NV, provided electrofishing equipment and financial support as well as assistance in field surveys, specifically J. Lantow and T. Burke.  Monitoring of Imperial Ponds, as well as construction and maintenance of the ponds is guided by an ad-hoc group of biologists and engineers from BR, USWFS, and Arizona Game and Fish.  Field collections were authorized by appropriate permits issued by USFWS and the state of Arizona, and conducted under Institutional Animal Use and Care protocol no. 05-767R and 08-959R.

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Table 1. Routine monitoring trip dates and activities conducted by the Native Fish Lab at ASU on Imperial Ponds, Imperial NWR, AZ from October 2007 through June 2008.

| Trip Dates | Activities |
|---|---|
| 29-31 October 2007 | Collected water physico-chemistry data, electrofished, set minnow traps and deployed trammel nets |
| 5-6 November 2007 | Collected water physico-chemistry data and observed and assisted with razorback sucker stocking |
| 10-12 December 2007 | Collected water physico-chemistry data, observed and assisted with bonytail stocking, swam transects and tested portable fish finder |
| 21-24 January 2008 | Collected water physico-chemistry data, set hoop nets and tested prototype remote PIT scanner units |
| 11-14 February 2008 | Collected water physico-chemistry data, set hoop nets, swam transects, collected larvae and tested prototype remote PIT scanner units |
| 25-28 February 2008 | Set hoop nets and tested prototype remote PIT scanner units |
| 17-21 March 2008 | Collected water physico-chemistry data, set hoop nets, collected larvae and tested prototype remote PIT scanner units |
| 7-10 April 2008 | Collected larvae, swam transects, set hoop nets and deployed remote PIT scanners units |
| 21-24 April 2008 | Collected water physico-chemistry data, set hoop nets and deployed remote PIT scanner units |
| 19-21 May 2008 | Collected water physico-chemistry data and deployed remote PIT scanner units |
| 9-12 June 2008 | Collected water physico-chemistry data and deployed remote PIT scanner units |
| 23-26 June 2008 | Collected water physico-chemistry data and deployed remote PIT scanner units |

Table 2. Hoop netting effort and catch from Imperial Ponds. Collections were made between February and April 2008. A net-night is a 24 hours hoop net set.

| Pond | Net-nights | Native fish catch | Nonnative fish catch | Other catch |
|---|---|---|---|---|
| 1 | 16 | 2 | 91 carp | 1 bullfrog |
| 2 | 49 | 0 | None | 5 bullfrog, 2 crayfish |
| 3 | 13 | 1 | 11 carp | 2 bullfrog |
| 4 | 8 | 0 | none | none |

Table 3. Results from test deployments of remote PIT scanning units in Imperial Ponds from February to June, 2008. Population estimates are from paired monthly data using the modified Peterson formula (Ricker 1975). Confidence intervals (CI) are 95% CI except where the upper limit exceeded the number stocked, in which case the number stocked was used as the upper limit.

| Pond | PIT Scans | Unique PITs | Number stocked | Feb-Apr Estimate | Mar-Apr Estimate | Apr-May Estimate | May-June Estimate |
|---|---|---|---|---|---|---|---|
| 1 | 374 | 122 | 305 | 215<br>CI (122 - 305) | NA | 230<br>CI (103 - 305) | 129<br>CI( 64 - 281) |
| 2 | 32 | 20 | 800 | 29<br>CI (13 - 72) | NA | NA | NA |
| 3 | 128 | 83 | 800 | NA | 177<br>CI (65 - 443) | NA | 120<br>CI (54 - 301) |
| 4 | 935 | 208 | 272 | 221<br>CI (192 - 272) | NA | 205<br>CI (138 - 272) | 308<br>CI (170 - 272) |

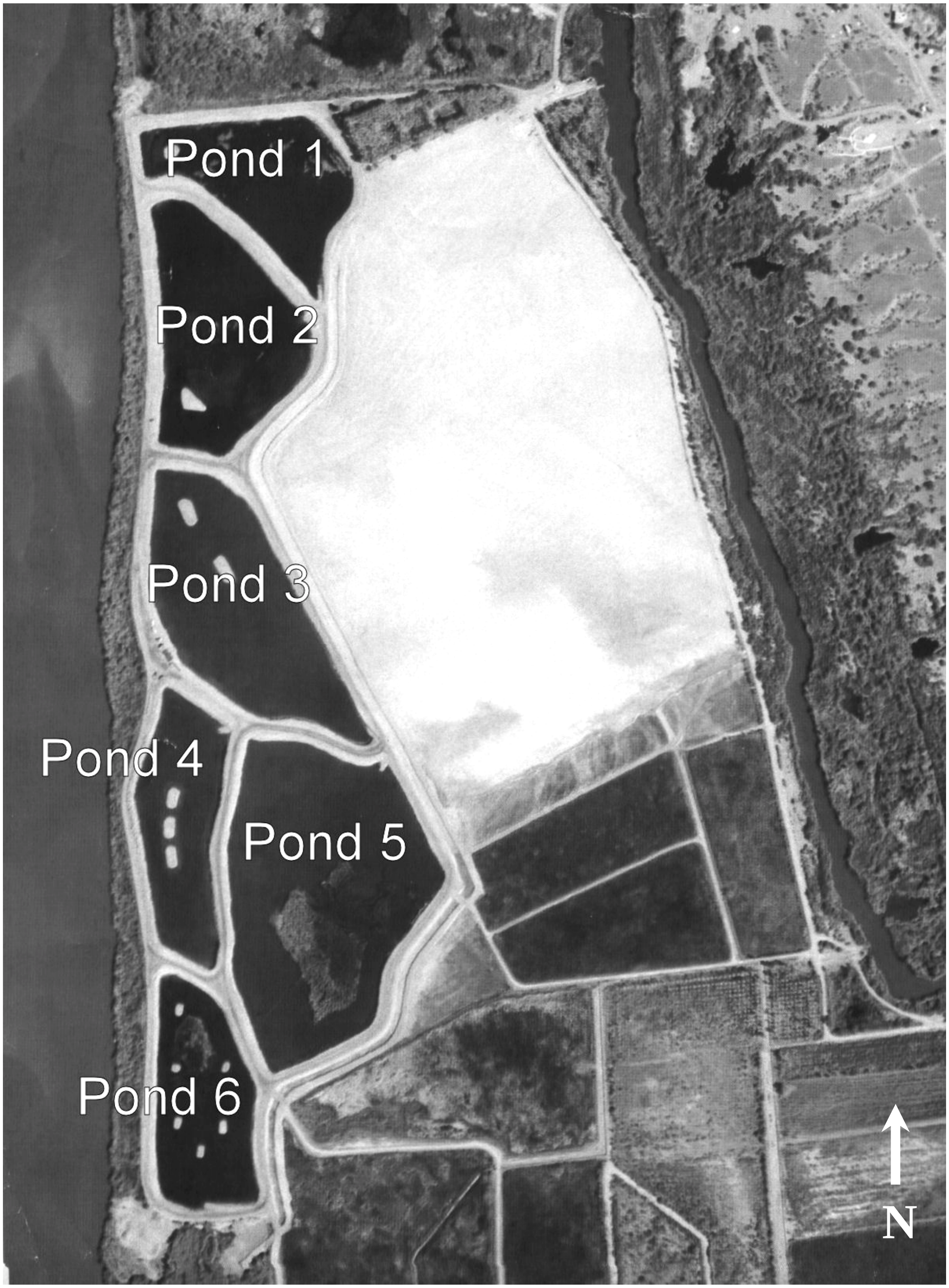


Figure 1. Satellite imagery of the six Imperial Ponds located at Imperial NWR, AZ.

Figure 2.  A remote PIT scanner antenna deployed at Imperial Ponds, Imperial NWR, AZ.  Note the Great Blue Heron *Ardea herodias* tracks in the soft sediment along the water's edge.

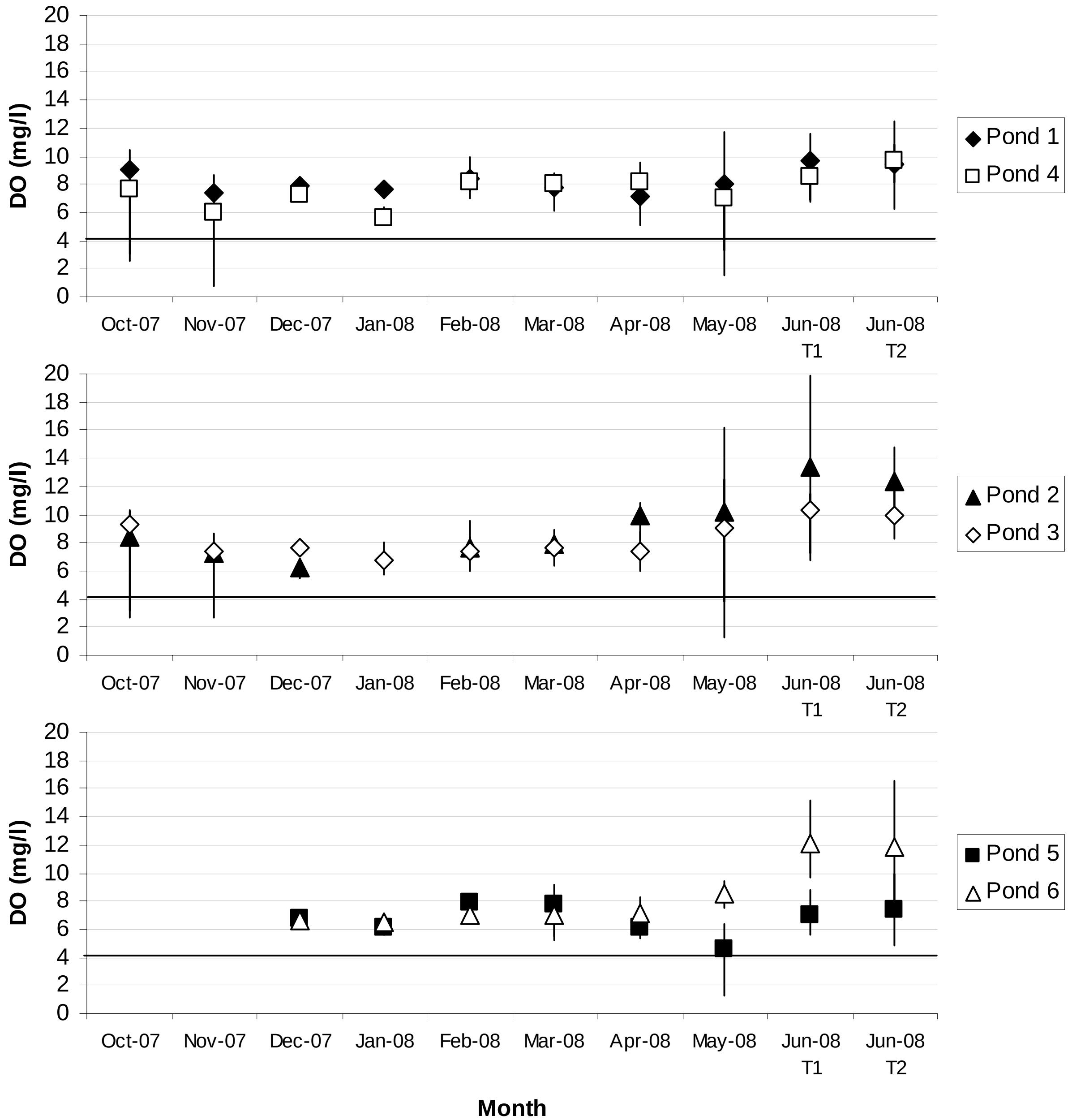


Figure 3. Mean dissolved oxygen and range (line projections) for ponds stocked with razorback sucker (top), bonytail (middle), and no fish (bottom), Imperial Ponds, Imperial NWR, AZ. All sampling trips to date are represented with the exception of September 2007. No water quality data were collected for Ponds 5 and 6 in October or November. The black horizontal line indicates the threshold value of 4 mg/L.

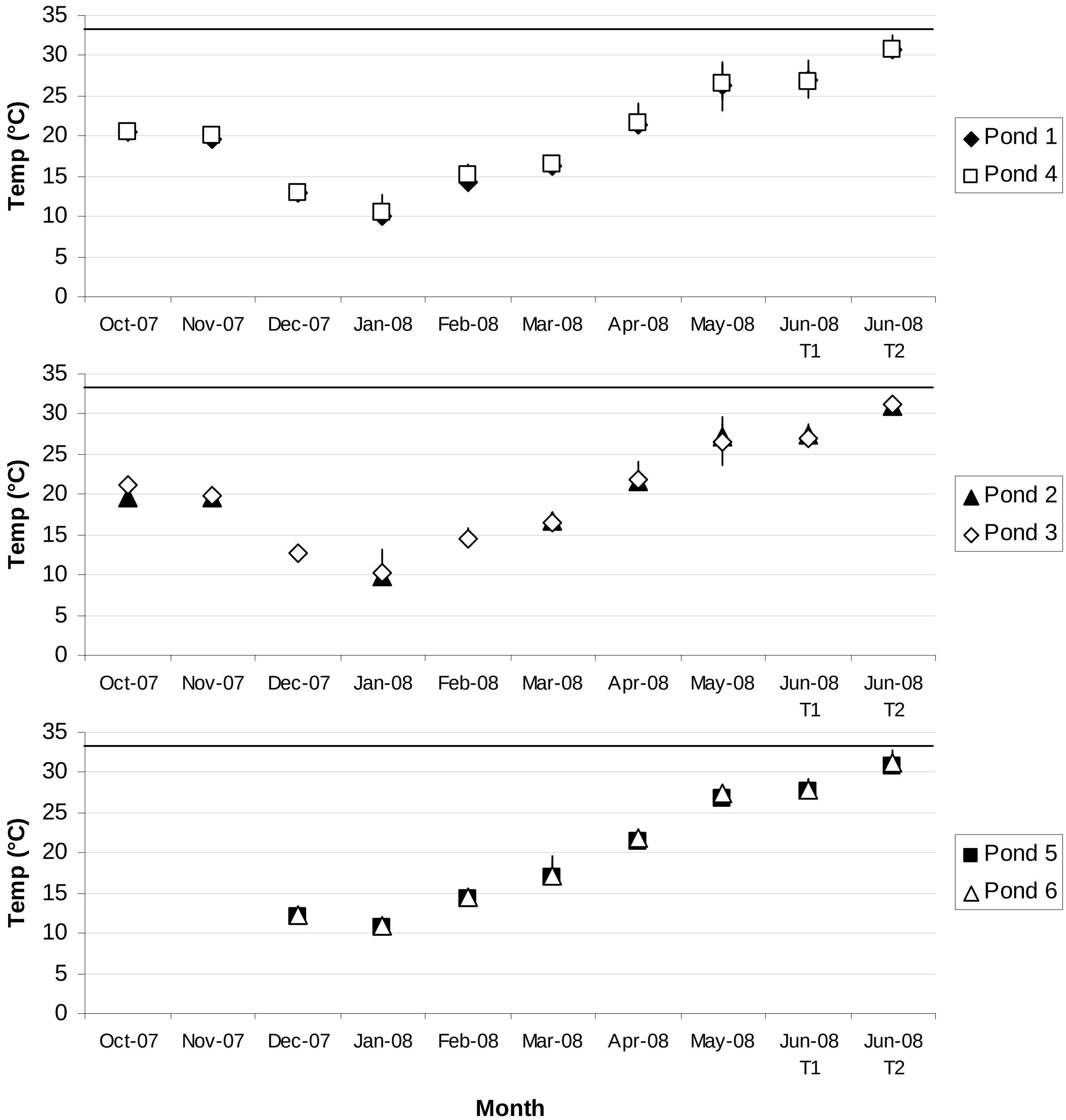


Figure 4. Mean temperature and range (line projections) for ponds stocked with razorback sucker (top), bonytail (middle), and no fish (bottom), Imperial Ponds, Imperial NWR, AZ. All sampling trips to date are represented with the exception of September 2007. No water quality data were collected for ponds 5 and 6 in October or November. The black horizontal line indicates the threshold value (33.3° C).

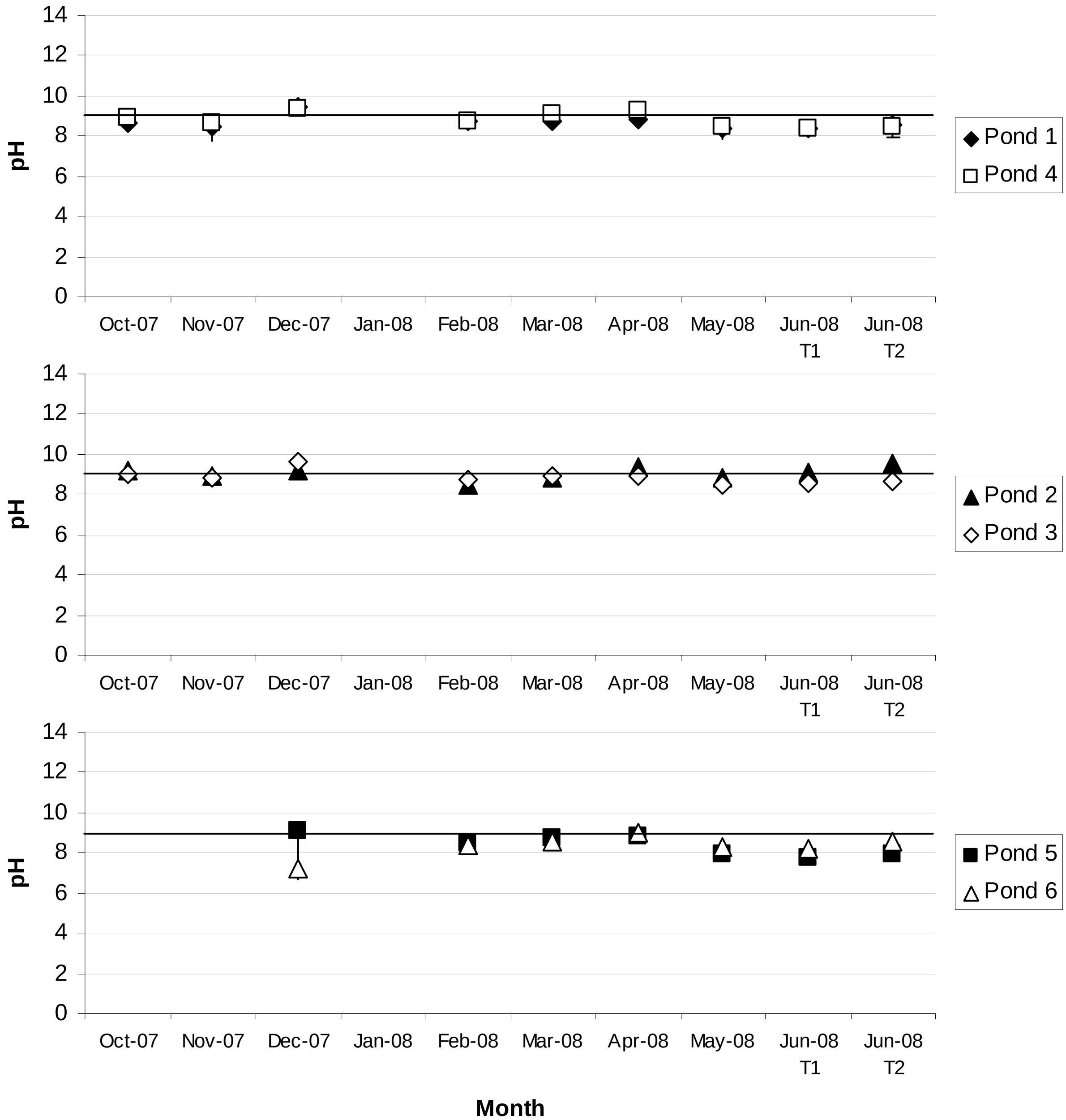


Figure 5. Mean pH and range (line projections) for ponds stocked with razorback sucker (top), bonytail (middle), and no fish (bottom), Imperial Ponds, Imperial NWR, AZ. All sampling trips to date are represented with the exception of September 2007. No water quality data were collected for Ponds 5 and 6 in October or November. No pH values were collected in January due to equipment failure. The black horizontal line indicates the threshold value of 9. All values less than 6 or greater than 12 were excluded because they were likely due to erroneous readings.

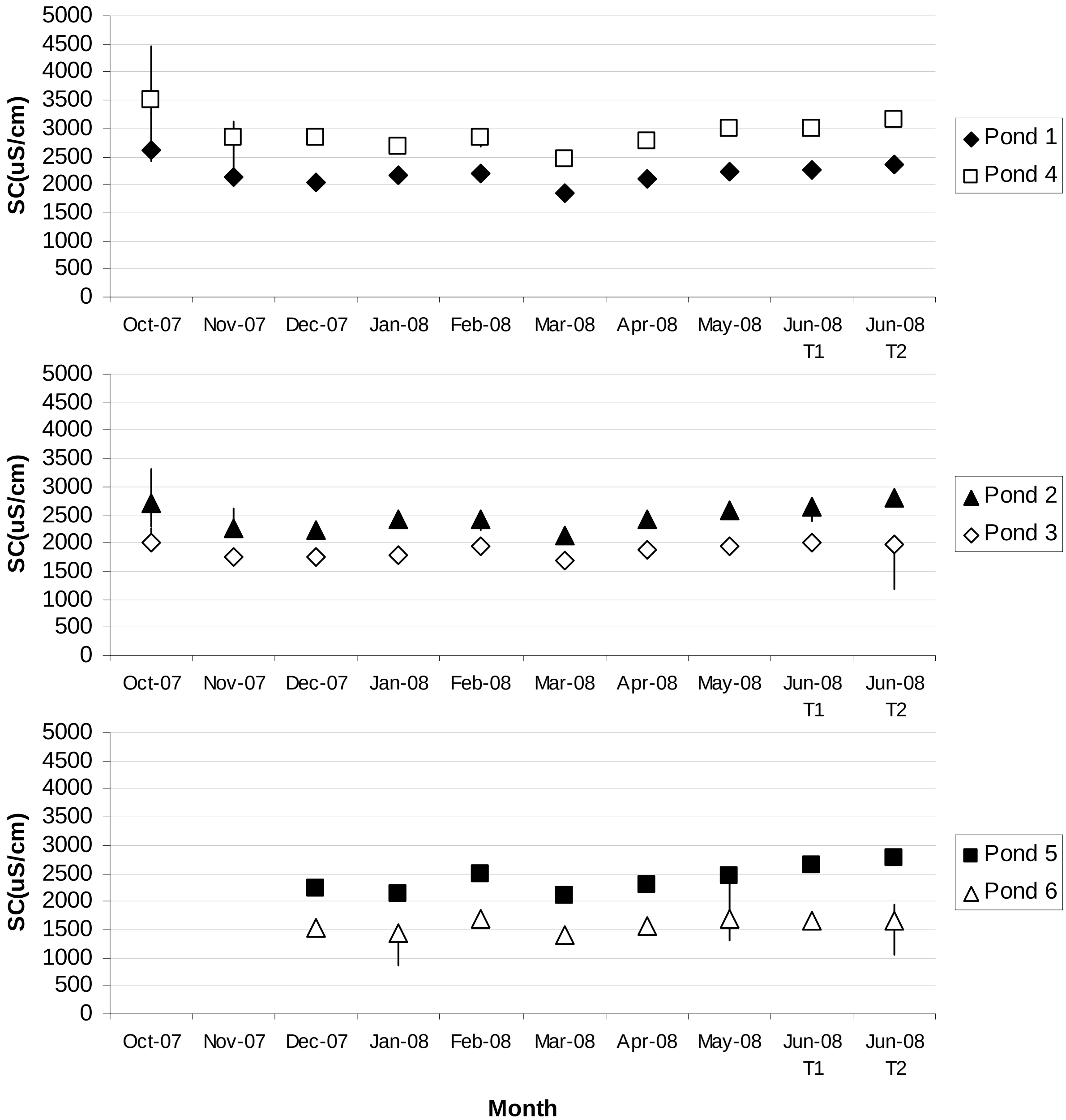


Figure 6. Mean conductivity and range (line projections) for ponds stocked with razorback sucker (top), bonytail (middle), and no fish (bottom), Imperial Ponds, Imperial NWR, AZ. All sampling trips to date are represented with the exception of September 2007. No water quality data were collected for Ponds 5 and 6 in October or November. No threshold value for conductivity has been established.

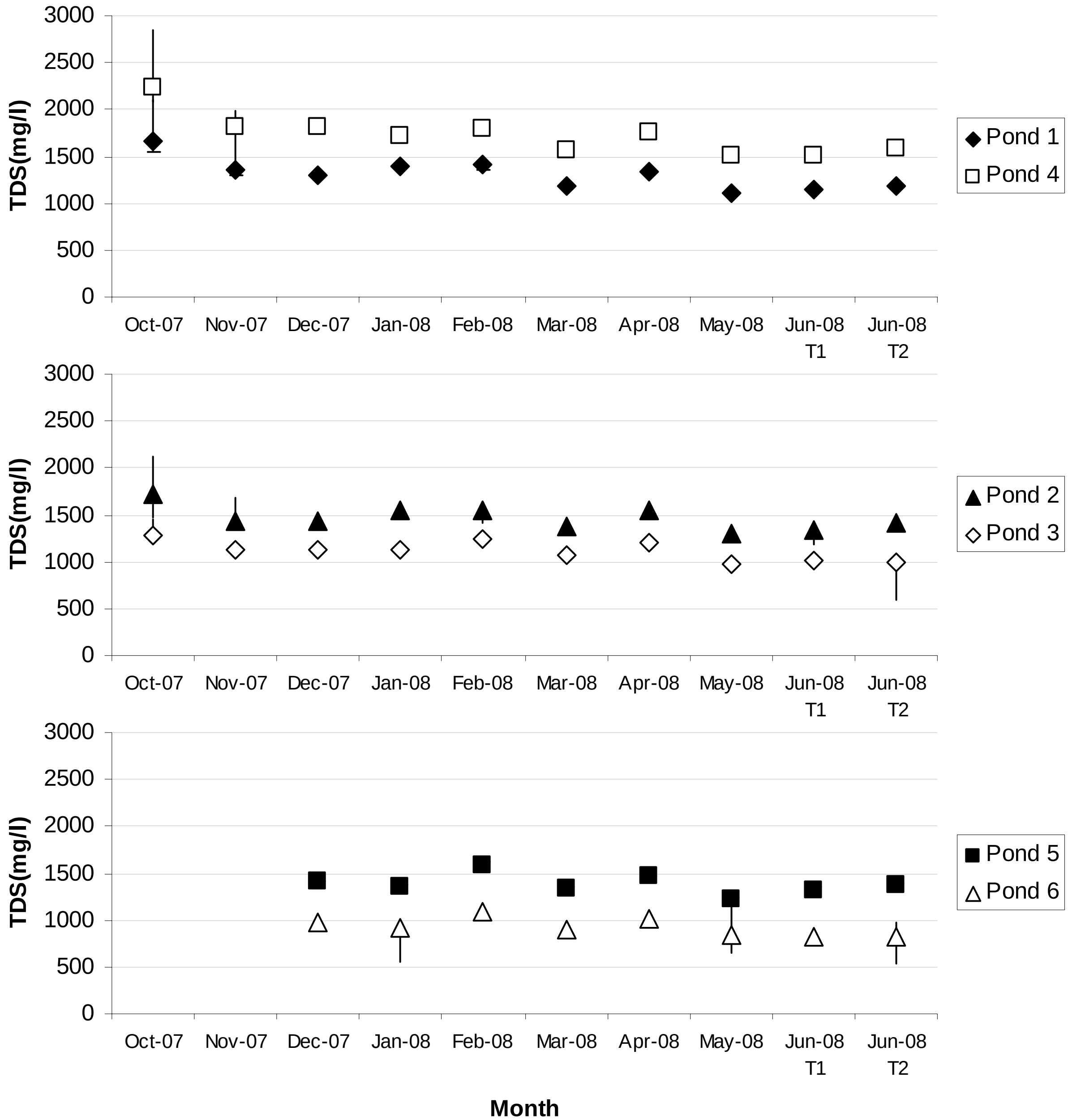


Figure 7. Mean total dissolved solids and range (line projections) for ponds stocked with razorback sucker (top), bonytail (middle), and no fish (bottom), Imperial Ponds, Imperial NWR, AZ. All sampling trips to date are represented with the exception of September 2007. No water quality data were collected for Ponds 5 and 6 in October or November. No threshold value for total dissolved solids has been established.

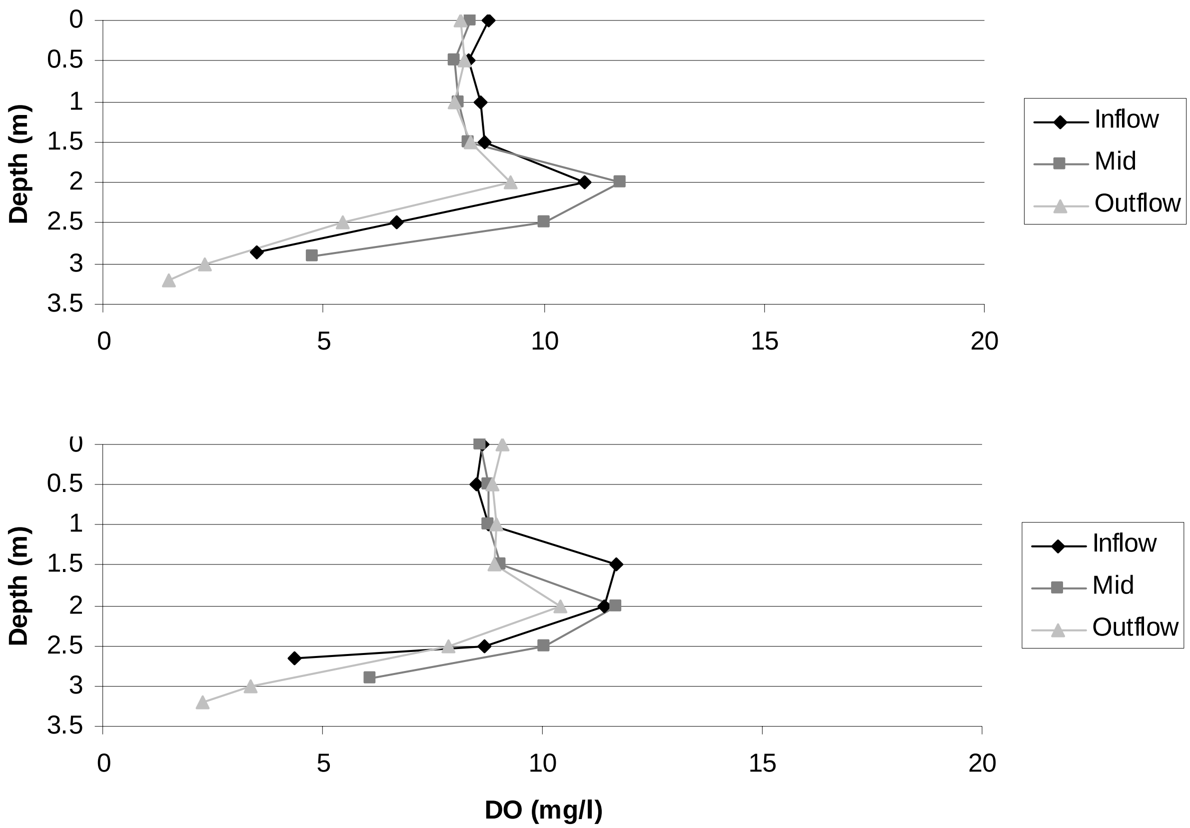


Figure 8. Dissolved oxygen (DO) profiles at dawn (top) and dusk (bottom) for Pond 1 in May 2008 from three monitoring stations in Imperial Ponds, Imperial NWR, AZ.

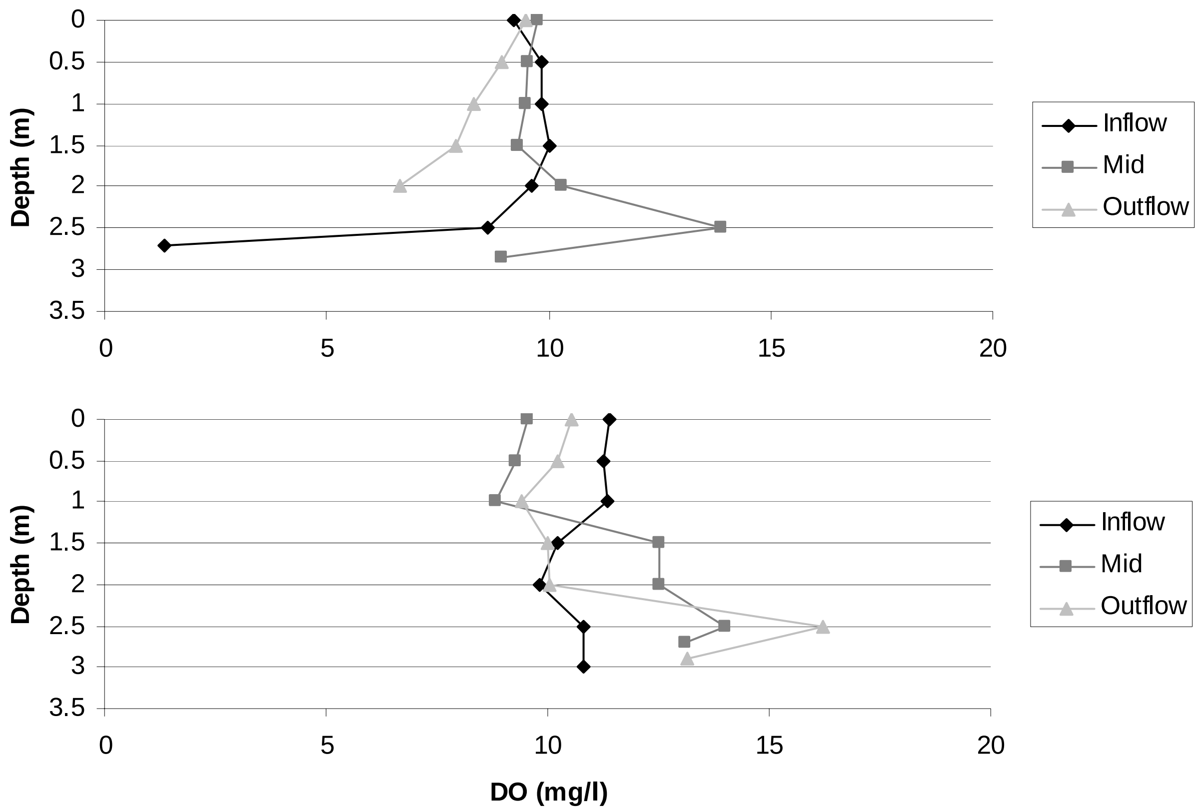


Figure 9. Dissolved oxygen (DO) profiles at dawn (top) and dusk (bottom) for Pond 2 in May 2008 from three monitoring stations in Imperial Ponds, Imperial NWR, AZ.

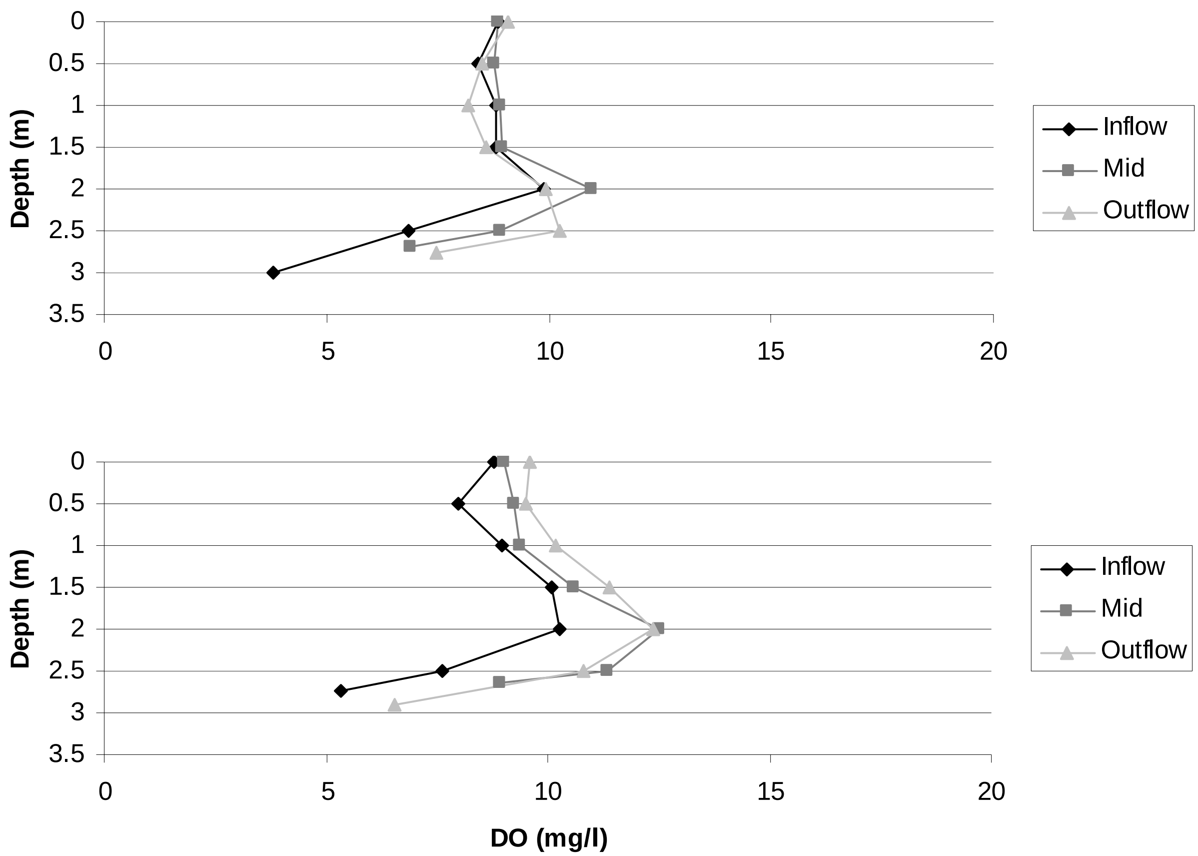


Figure 10. Dissolved oxygen (DO) profiles at dawn (top) and dusk (bottom) for Pond 3 in May 2008 from three monitoring stations in Imperial Ponds, Imperial NWR, AZ.

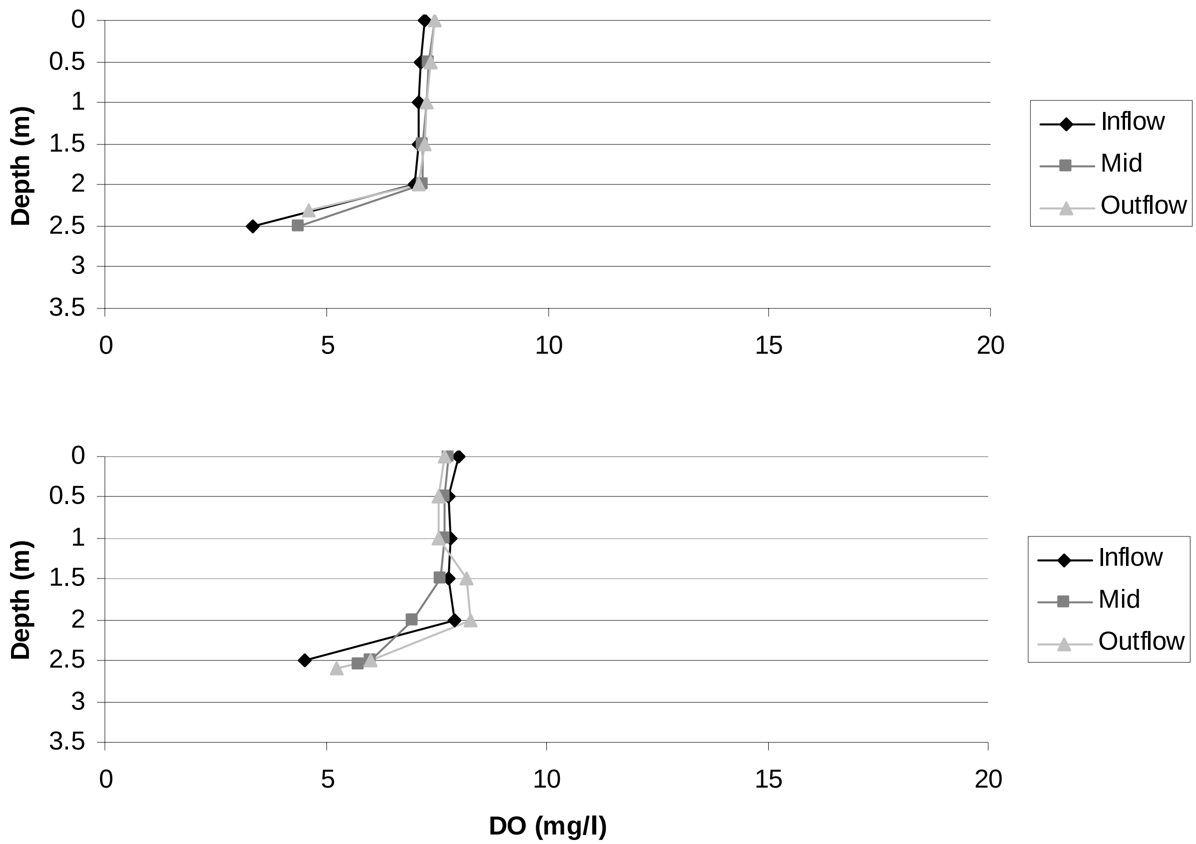


Figure 11. Dissolved oxygen (DO) profiles at dawn (top) and dusk (bottom) for Pond 4 in May 2008 from three monitoring stations in Imperial Ponds, Imperial NWR, AZ.

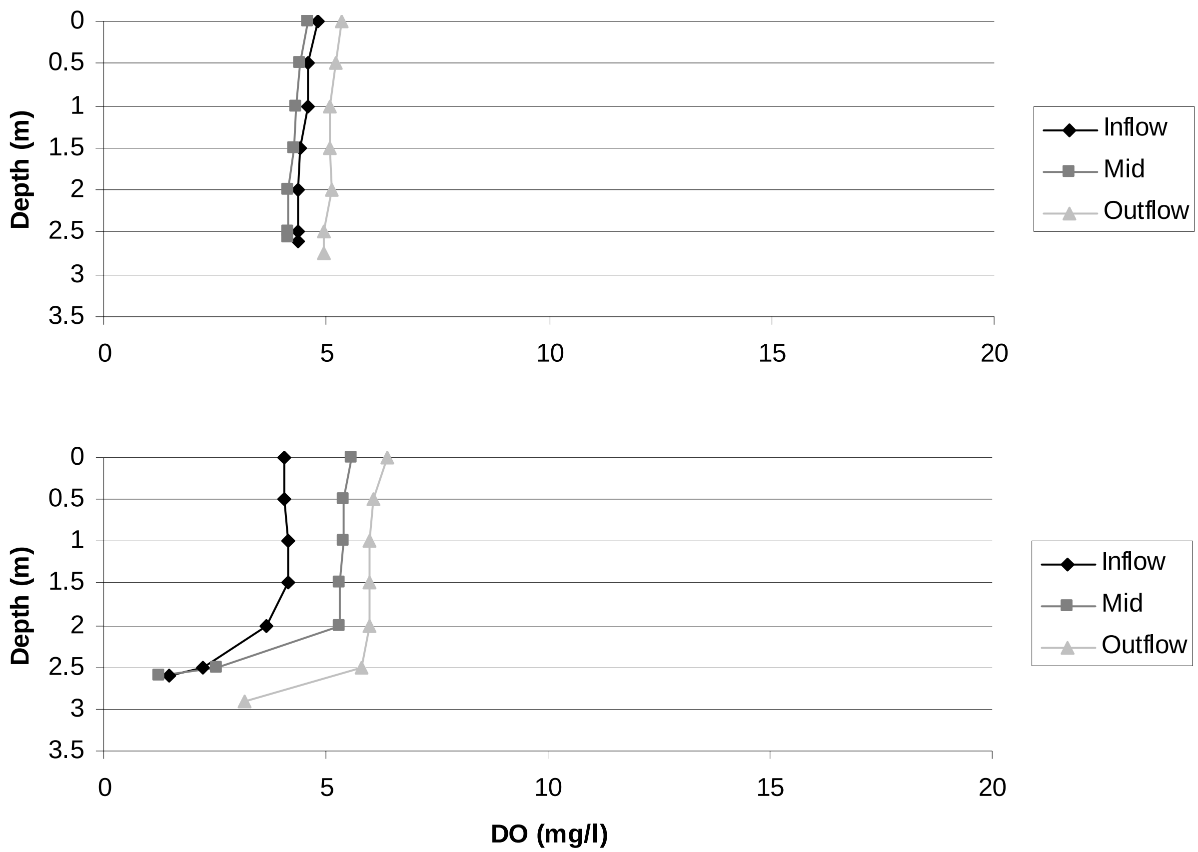


Figure 12. Dissolved oxygen (DO) profiles at dawn (top) and dusk (bottom) for Pond 5 in May 2008 from three monitoring stations in Imperial Ponds, Imperial NWR, AZ.

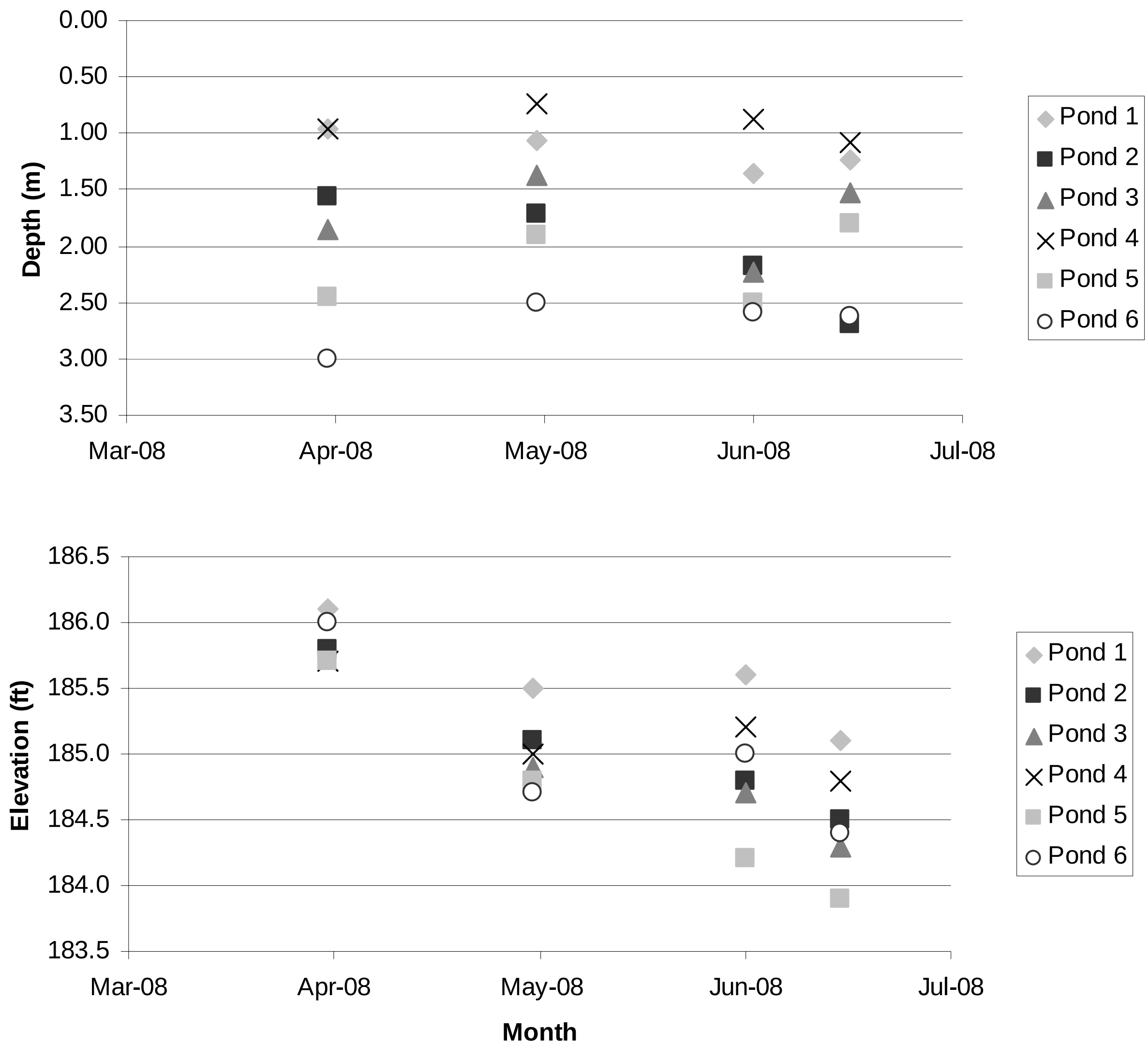


Figure 13. Secchi depth (top) and pond elevation (bottom) measurements for Imperial Ponds, Imperial NWR, AZ, from March to July 2008.

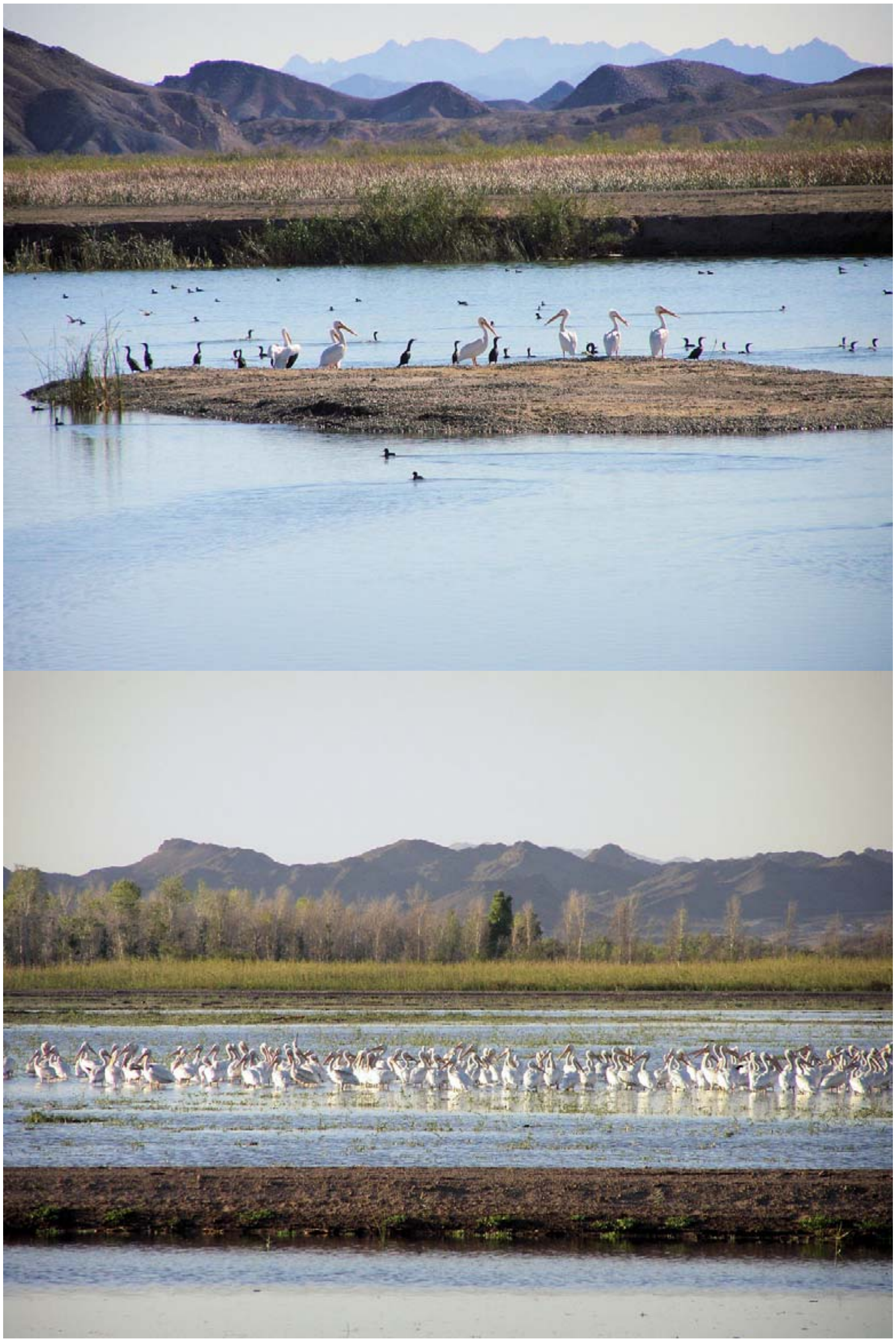

Figure 14. Photographs of American White Pelicans *Pelecanus erythrorhynchos* resting on hummocks (top) in Imperial Ponds and in the wetlands (bottom) near Imperial Ponds, Imperial NWR, AZ.