State of California
The Natural Resources Agency
DEPARTMENT OF WATER RESOURCES
Bay-Delta Office

Clifton Court Forebay Predation Study: 2013 Annual Progress Report

September 2015

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Abbreviations

AADAP	Aquatic Animal Drug Approval Partnership
ACC	Area Control Center
BDO	Department of Water Resources, Bay-Delta Office
BiOP	Biological Opinion
CCFFF	Clifton Court Forebay Fishing Facility
CCFPS	Clifton Court Forebay Predator Study
CEQA	California Environmental Quality Act
CHTR	Collection, Handling, Transport, and Release Facility
CPUE	Catch per Unit Effort
CVP	Central Valley Project (Federal)
CWT	Coded Wire Tag
Delta	Sacramento-San Joaquin Delta
DFD	Department of Water Resources, Delta Field Division
DFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
EROF	Equipment Request Order Form
ESA	Endangered Species Act
FDA	Food and Drug Administration
Forebay	Clifton Court Forebay
HTI	Hydroacoustic Technology Incorporated
INAD	Investigational New Animal Drug
ITP	Incidental Take Permit
MBTA	Migratory Bird Treaty Act
MOCC	Motorboat Operator Certification Course
MS-222	Tricaine -S
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
OP-2	Operations Procedure 2 – Lock-out/Tag-out
PCR	Polymerase Chain Reaction
PIT	Passive Integrated Transponder
PSL	Pre-screen Loss
QA/QC	Quality Assurance/Quality Control
RPA	Reasonable and Prudent Alternative
SAV	Sub-aquatic Vegetation
SCP	DFW Scientific Collecting Permit
SDFPF	John E. Skinner Delta Fish Protective Facility
SWP	State Water Project (California State)
TEP	Temporary Entry Permit
USFWS	U.S. Fish and Wildlife Service
WCA	Work Clearance Authorization

Executive Summary

This report details the implementation, issues, and results of the first year of the Clifton Court Forebay Predation Study (CCFPS). Specific study elements implemented as pilot level investigations in 2013 include salmonid survival studies, predatory fish sampling, biotelemetry, avian studies and creel surveys. Additional detail regarding the regulatory history and overall study design and methodology is available in the report entitled *Clifton Court Forebay Predation Study* (Wunderlich 2015).

A total of 410 juvenile Chinook salmon, with average weights from 7.5 g to 15.9 g, and average total length from 87 mm to 108 mm, were PIT tagged and released at the radial gates and Skinner Delta Fish Protective Facility (SDFPF) primaries in April and May of 2013. The percentage of fish entrained into the SDFPF that subsequently are successfully salvaged and taken to the release sites determines the facility efficiency. Facility efficiency was calculated to be 74%, for all releases combined, 76%, for Aqui-S 20E releases, and 71% for MS-222 releases. Using the average facility efficiency calculated for the release period in 2013, a PSL of 81.14% was calculated for all radial gates releases, and a PSL of 86% and 82%, respectively, was calculated for Aqui-S 20E treated Passive Integrated Transponder (PIT) tagged salmon and MS-222 treated PIT tagged salmon released at the radial gates. Due to unforeseen problems, no salmon were acoustically tagged during the pilot season.

A total of 67 predator sampling days were conducted between March 12, 2013 and December 31, 2013, resulting in the capture of 5 non-target fish and 579 predatory fish; 514 Striped Bass, 51 Largemouth Bass and 14 catfish. Striped Bass captured were grouped into four size categories, and total catch was found to be 2% for fish under 0.49 lbs, 55% for fish between 0.5 lbs and 1.49 lbs, 35% for fish between 1.5 lbs and 2.9 lbs, and 8% for fish over 3.0 lbs. Catch per unit effort (CPUE) was calculated for each month, for all species combined, and was found to be highest in September, at 1.13 fish per hour sampled, and lowest in May, at 0.27 fish per hour sampled. A single Striped Bass originally captured on June 11, 2013 was recaptured on October 25, 2013.

A total of 149 predatory fish were acoustically tagged, eight catfish, 18 Largemouth Bass, and 123 Striped Bass. Of the 149 total tagged fish, 10 were never detected by any of the receivers in the array, including two Largemouth Bass and eight Striped Bass. Of the 139 tagged fish that were detected, 29 were only detected in the intake channel, 32 were only detected at the radial gates, 14 were detected moving from the intake channel to the radial gates, 13 were detected moving from the radial gates to the intake channel, 35 were detected moving back and forth between the intake channel and the radial gates, and 16 were detected outside of the Forebay.

A total of 80 angler (creel) surveys were conducted between April 26, 2013 and December 31, 2013. During these surveys, a total of 1,191 anglers were observed fishing at the Clifton Court Forebay. Anglers fished a total of 2,806 hours and captured a total of 807 fish during the survey period. Anglers caught 632 Striped Bass, 104 catfish (not identified to species), and 27 Largemouth Bass, which made up 78%, 13%, and 3% of total catch, respectively. A single adult Chinook salmon was caught in October. Catch per unit effort (CPUE) for all species ranged from 0.15 in July to 0.37 in June, and averaged 0.29 for the entire survey period. When calculated for individual species, CPUE was found to range from 0.05 to 0.30 for Striped Bass, 0.00 to 0.10 in catfish, and 0.00 to 0.04 in Largemouth Bass.

A total of 89 avian surveys were conducted between April 5, 2013 and December 31, 2013. During these surveys, a total of 6,166 piscivorous birds were observed using the Forebay. The highest numbers of avian species were observed in the month of November. Of those 6,166 birds, the most common species observed at the Forebay were gulls (*Larus* sp.), double-crested cormorants (*Phalacrocorax auritus*), and American white pelicans (*Pelecanus erythrorhynchos*). Feeding behavior peaked in September at 67% of total birds observed actively feeding.

Bioenergetics modelling will be undertaken in 2015, following the collection of an appropriate amount of data to be used in the calculations. Genetics was initiated in December of 2013, but the bulk of the work was completed in 2014 for the pilot level effort, and as such it is included in the 2014 annual report. Subsequent annual reports will be compiled for each year that the study is undertaken. At the conclusion of the study a synthesis report, with more in depth analysis will be prepared.

1.0 Introduction

The Clifton Court Forebay Predation Study (CCFPS) is a multi-year effort comprised of experimental investigations that have been designed to gather as much information as possible to understand predation upon juvenile salmonids in the Clifton Court Forebay (Forebay). This report covers the first year pilot level effort conducted to help better define the full-scale study, beginning in 2014, and designed to further the understanding of behavior and movement of predatory fishes, salmonids, and piscivorous birds in the Forebay. The CCFPS includes the following elements: salmonid survival studies, predatory fish sampling, biotelemetry, genetics, creel surveys, avian studies and bioenergetics. CCFPS design and methodology is further discussed in the report titled Clifton Court Forebay Predation Study (2015).

The first year was planned as a pilot level effort to gather information on logistics, study needs, and feasibility of specific elements before launching a full-scale study.

The CCFPS will provide the opportunity to evaluate the effects of any Reasonable and Prudent Alternative (RPA) action (IV 4.2(2)) of the Biological Opinion (BiOp) and Conference Opinion on the Long-term Operations of the Central Valley Project (CVP) and State Water Project (SWP) (NMFS 2009) undertaken to reduce predation of ESA protected salmon and steelhead within the Forebay.

2.0 CCFPS Study Elements

2.1 Issues

The Forebay and S John E. Skinner Delta Fish Protective Facility (SDFPF) are State Water Project (SWP) facilities managed and operated by the DWR Delta Field Division (DFD), and as such, all CCFPS work conducted at these facilities is done in close coordination with DFD. However, SWP coordination protocols and call-in procedures, which had been in place historically, were changed significantly on the morning of January 25, 2013. All work on the CCFPS was suspended pending dissemination of the new SWP procedural requirements, as well as staff orientation and certification for the new procedures. The new SWP procedures were initiated to improve worker safety and included several elements that required significant lead time to prepare, prior to reinitiating work on the CCFPS. These procedures included successful completion of the Operational Procedure -2 (OP-2) eight hour course and exam for DWR staff and a four hour OP-2 Awareness course for contractors. The OP-2 course is only offered once per month, which prolonged successful completion by the DWR project team. The OP-2 Awareness course is offered on an as-needed basis in coordination with DFD. Additionally, an OP-2 certified DWR staff member was required to file an Equipment Request Order Form (EROF) to obtain an Okay to Work and associated Work Clearance Application (WCA) number for each task to be undertaken and an OP-2 certified DWR staff member was required to be present during field work at SWP facilities. The EROFs were required to be submitted a minimum of four weeks prior to initiation of work.

DFD provided a final procedural guide was provided to DWR Bay-Delta Office (BDO), and EROF's for elements within the CCFPS were filed with DFD in March and April 2013.

2.2 Salmonid Survival

2.2.1 Methods

For the 2013 pilot study, 1,600 Late-Fall and 550 fall run Chinook Salmon were requested from the Coleman National Fish Hatchery (NFH) for pick-up in January and April, respectively. A total of 100 salmon were scheduled to be acoustically tagged, and up to 1,500 salmon (a combination of fall and Late-Fall run) were scheduled to be tagged with passive integrated transponder (PIT) tags. Due to unforeseen complications, which are discussed in more detail below, no salmon were acoustically tagged. Fish releases, originally planned to begin mid-January 2013 and continue through May 2013, and did not begin until April 2013. No steelhead releases were planned for the 2013 field season, as data from previous studies were more recent for steelhead than for Chinook salmon, and it was determined that beginning with only Chinook salmon would be more useful and informative for refining the balance of the study years.

As part of the 2013 pilot study, two anesthetics, Tricaine-S (MS-222) and AQUI-S 20E (Eugenol), were used to compare relative efficacies. MS-222, when used as an anesthetic for fish, requires a 21 day holding period in any fish that could potentially be used for human consumption and the Food and Drug Administration (FDA) states that its use should be restricted to Ictaluridae, Salmonidae, Esocidae, and Percidae (FDA ANADA 200-226, 1997). AQUI-S 20E was developed in New Zealand as an anesthetic for use on food-fish without the holding period that is needed for drugs such as MS-222. AQUI-S 20E is currently being evaluated for efficacy as an anesthetic for fish species via an Investigational New Animal Drug (INAD) Exemption sponsored by the USFWS Aquatic Animal Drug Approval Partnership (AADAP) Program. The AADAP sponsored INAD allows investigators to use AQUI-S 20E as part of the clinical field trials to determine efficacy as an anesthetic for use in a variety of fish species (USFWS 2010). Data on the use of AQUI-S 20E for the salmon tagging and releases conducted within the CCFPS were compiled for inclusion in the 2013 INAD on December 13, 2012 (Study # 11-741-13-257F).

General data including start and end time, date, water temperature, source and destination tank, staff, anesthesia, and the electronic data file name were recorded by hand for each tagging event. All individual fish data including PIT tag number, fork length to the nearest mm, weight to the nearest 0.1 gram (g), and adipose fin clip status was recorded on a Panasonic Toughbook, into the “df direct” Microsoft Excel spreadsheet (by Destron Fearing) that is connected to a Biomark Destron Fearing FS2001-ISO data logger with hoop style antennae (Figure 1).This spreadsheet was set up to autofill the PIT tag number to avoid transcription errors. Discreet datasheets were maintained for each anesthesia method for each tagging event. In addition to the above data, time to reach the ”surgical plane”, defined as loss of equilibrium and reactivity to most external stimuli, for tagging and time to recover was recorded for fish that were anesthetized. Data on these fish was entered into the online data reporting forms for the AADAP INAD for AQUI-S 20E as part of the reporting requirements for participation in the INAD program.

Figure 1: PIT Tagging Station at CHTR 2013

A total of 886 juvenile fall run Chinook salmon were obtained from the Coleman NFH and transported to the DWR Collection Handling Transport and Release Facility (CHTR) located adjacent to the Forebay in Byron, California on December 20, 2012. They were held at CHTR until tagging and releases could begin. PIT tagging was conducted twice per week on Monday and Friday. Fish were PIT tagged in groups of 80 from April 15, 2013 through April 22, 2013. The number of fish PIT tagged was reduced beginning April 26, 2013 until May 10, 2013, to reflect a lower number of fish released at the SDFPF primaries. During each tagging event, an equal number of fish were anesthetized using MS-222 and AQUI-S 20E. Fish were randomly selected from numbered holding tanks and anesthetized to "surgical plane". Each fish was weighed to the nearest 0.1 g, total length was measured to the nearest millimeter (mm), and the adipose fin was removed immediately prior to tagging. Fish were tagged with Biomark HPT6 PIT tags, and placed in holding tanks based upon treatment and tagging date, so that they were released in the proper group and order (Table 1).

Table 1: Tagging and Holding Tank Protocol

Tagging Date	Source Tank #	Release tank # (AQUI-S)	Release tank # (MS-222)
4/15/2013	8	2	1
4/19/2013	8	4	3
4/22/2013	8	2	1
4/26/2013	8	4	3
4/29/2013	8	2	1
5/10/2013	8	4	3

Tagging on April 15th, 19th, and 22nd consisted of two taggers and one data recorder, with each tagger tagging an equal number of fish from each anesthetic group to minimize tagger effect between treatment groups. Tagging on April 26th, 29th and May 10th consisted of a single tagger and data recorder, due to the reduced number of fish.

Table 2: Tagging and Release Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
Tagging	PIT tag up to 80 fish				PIT tag up to 80 fish
Releases	Release ½ of previous Friday's tagged fish (20 at the radial gates; up to 20 at the SDFPF primaries)	Release ½ of previous Friday's tagged fish (20 at the radial gates; up to 20 at the SDFPF primaries)		Release ½ of Mondays tagged fish (20 at the radial gates; up to 20 at the SDFPF primaries)	Release ½ of Mondays tagged fish (20 at the radial gates; up to 20 at the SDFPF primaries)

Fish that were tagged on Monday were released on the following Thursday and Friday, and fish tagged on Friday were released on the following Monday and Tuesday, to reduce variance in the amount of time lapse between tagging and release to no less than 48 and no more than 72 hours. For each release, 20 fish from each anesthetic treatment group were randomly selected, scanned to confirm and record the PIT tag number, and placed into green[1] five gallon buckets, in groups of five fish per bucket, for transport to the release sites. Initially, a total of 10 fish from each anesthetic treatment group was released at the radial gates, and 10 fish from each anesthetic group was released at the SDFPF primaries (Figure 2), for a total of 40 fish released per day (Table 2).The number of fish released at the primaries was reduced to 5 from each treatment, to total 10 per release, following consultation with Javier Miranda regarding facility efficiency calculations.

[1] Green buckets were selected to reduce stress on the fish during transport.

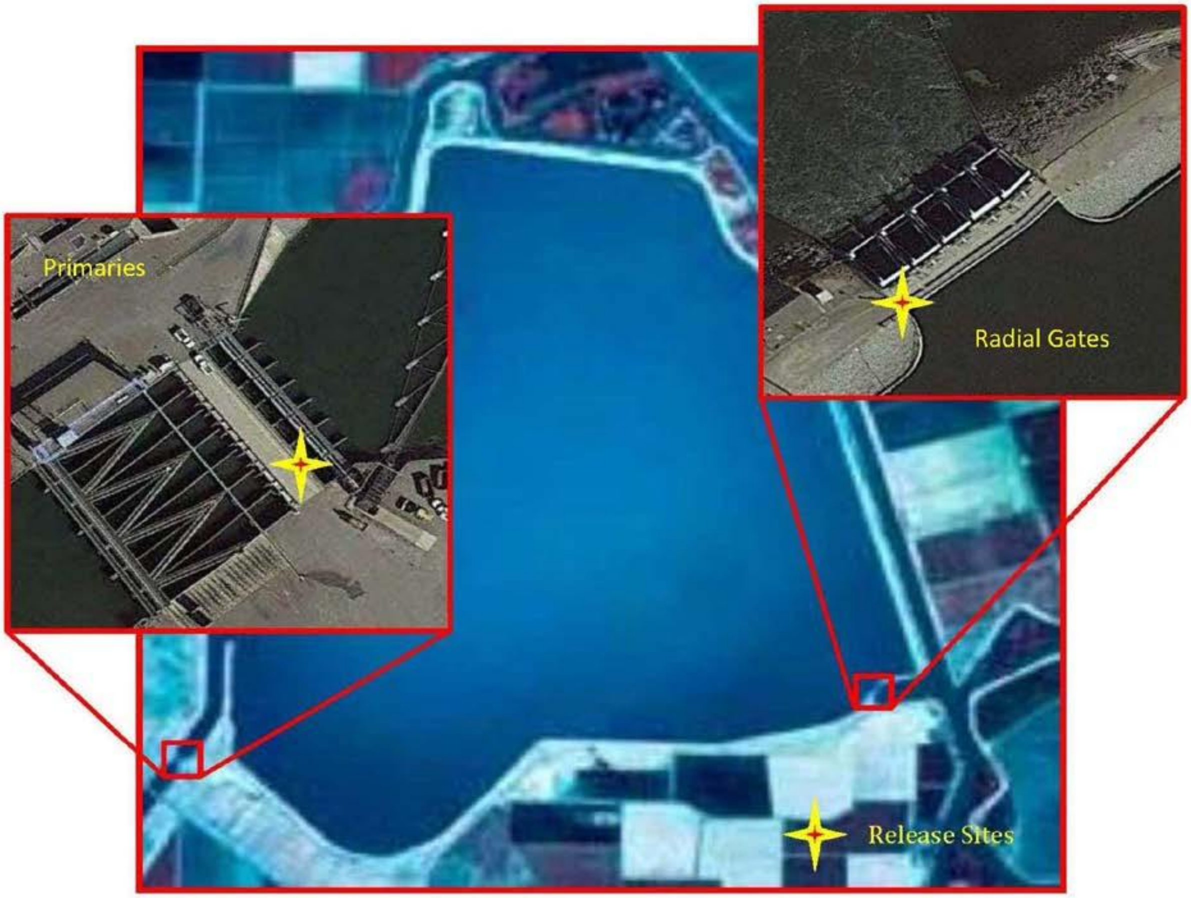

Figure 2: 2013 Release Sites

Releases were always done at the radial gates first, followed by the SDFPF primaries. Releases at the radial gates were planned to coincide with the earliest period of the day that the radial gates were open on the release day (Table 3). The area control center (ACC) was called to confirm the gate status prior to placing the fish into the buckets for transport.

Table 3: Radial Gates Scheduled Opening 2013

Date	Gates Open	Begin Release Time*	End Release Time	Gates Close
4/19/2013	0001	0645	0708	1230
4/22/2013	0115	0145	0230	1500
4/23/2013	0600	0540	0714	1145
4/25/2013	0700	0630	0750	1300
4/26/2013	0745	0752	0840	1345
4/29/2013	0016	0605	0620	0715
4/30/2013	0001	0555	0702	1230
5/3/2013	0105	0410	0510	1030
5/4/2013	0001	0530	0623	1330
5/13/2013	0001	0504	0602	0700
5/14/2013	0001	0504	0537	0745

* Release times were recorded from the time fish were loaded into buckets for transport, and are on average 20 minutes before actual arrival at gates. Gate schedule information was obtained from publicly accessible DWR reports (DWR 2013)

At the radial gates, fish were released by lowering the release bucket via a Spitzlift® hand-operated winch to just above the surface of the water immediately upstream of the open gate (Figure 3). Releases at the SDFPF primaries were done in the same manner, and bay selection was based upon which of the bays was actively flowing water, and was coordinated with the SDFPF Efficiency Studies to reduce resource requirements of both studies.

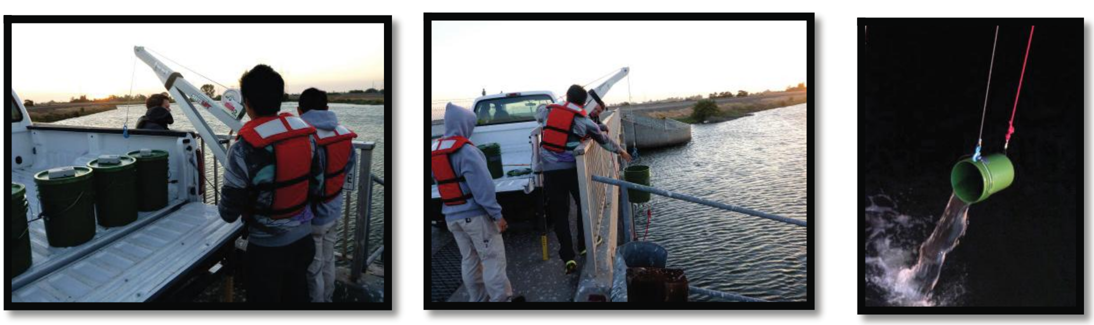

Figure 3: Fish Release at the Radial Gates

Following the releases, data regarding SDFPF Operational Criteria was recorded, as shown in Table 4. Data was only collected for five releases: April 26, April 29, April 30, May 3, and May 14, due to restrictions in access resulting from heightened security concerns.

Table 4: Types of Operational Criteria Collected in 2013

Date	Begin Release Time	End Release Time	Time Data Recorded	Temperature (°F)	Primary Head (Feet)	Secondary Head (Feet)
Velocity Ratios						
Primary Pipe A	Primary Pipe B	Primary Pipe C	Primary Pipe D	Secondary Pipe 1	Secondary Pipe 2	
Velocity (FPS)						
Bay 1	Bay 2	Bay 3A	Bay 3B	Bay 4A	Bay 4B	Bay 5
Sec. Channel 1	Sec. Channel 2L	Sec. Channel 2R				
Depth						
Primary Channel Upstream	Primary Channel Downstream	Bay 1	Bay 2	Bays 3A & 3B	Bays 4A & 4B	Bay 5
Sec. Channel 1 Downstream	Sec. Channel 2 Downstream	Sec. Channel 2L Upstream	Sec. Channel 2R Upstream			
Flow						
Primary Pipe A	Primary Pipe B	Primary Pipe C	Primary Pipe D	Secondary Pipe 1	Secondary Pipe 2	Sec. Channel 1
Sec. Channel 2	Primary Channel (BAPP)	Holding Tank 1	Holding Tank 2	Holding Tank 3	Holding Tank 4	Holding Tank 5
Holding Tank 6	Holding Tank 7					

2.2.2 Issues

Salmon releases are conducted at the radial gates which are located at the mouth of the Forebay and are operated remotely by senior operators at the DWR ACC, located at the Banks Pumping Plant. Since releases must be conducted when the gates are open and water is flowing into the Forebay, close coordination with the ACC is needed.

The initiation of salmon releases was originally planned for January 25, 2013. However, as described above SWP coordination protocols and call-in procedures, which had been in place historically, were changed significantly on the morning of January 25, and all work on the CCFPS was suspended pending dissemination of the new SWP procedural requirements.

DFD provided a final procedural guide to DWR Bay-Delta Office (BDO), and following submittal and approval of EROF's for salmon releases approval for the salmon releases was received on April 8, 2013, and the first salmon release occurred on April 19, 2013.

The salmon release plan included placing acoustic tags in 10 fish per week to be released in conjunction with the PIT tagged fish (Table 2). The acoustic tags selected for this project were HTI model 800 micro acoustic tags with integrated Biomark HPT9 PIT tags, which weigh 0.5g +/- 10% in air. To ensure that the weight of the acoustic tag did not exceed 5% of the total weight of the fish, a minimum weight threshold of 12 g was set for acoustic tagging. As of the April 29, 2013 tagging event, no fish had reached the minimum weight threshold, and acoustic tagging was not initiated.

SDFPF Operational Criteria was only collected for five of the releases due to miscommunications early in the process and DFD security concerns which severely restricted access.

2.2.3 Data Analysis

Estimates of pre-screen loss (PSL) were calculated using equations from Clark et al (2009) to maintain comparability to prior efforts. Salmonid PSL was calculated for Chinook salmon as:

$$PSL = \left[1 - \left(\frac{Rec_{rg}}{Rel_{rg} \times A \times F}\right)\right] \times 100$$

Recrg = # PIT tagged salmon recovered from radial gate releases

Relrg = # PIT tagged salmon released at the radial gates

A = PIT antennae detection efficiency

F = Facility efficiency estimated by trash rack releases

SDFPF salvage efficiency (*F*), defined as the proportion of PIT tagged salmon released within the SDFPF primaries that are successfully salvaged and released, was calculated for Chinook Salmon as:

$$F = \left[\frac{Rec_{tr}}{Rel_{tr} \times A}\right] \times 100$$

Rectr = # PIT tagged salmonids recovered from trash rack releases

Reltr = # PIT tagged salmonids released at the trash rack

A = PIT antennae detection efficiency

2.2.4 Results

A total of 410 fish were PIT tagged in groups of 25 to 40 fish per anesthesia method for each tagging day (Table 5). Average weights ranged from 7.5 g to 15.9 g, and average total length ranged from 87 mm to 108 mm.

Table 5: Tagging Efforts in 2013

Date	Number of Fish	Anesthesia Method	Average Weight (g)	Average Total Length (mm)
15-Apr-2013	40	AQUI-S 20E	7.5	87
15-Apr-2013	40	MS-222	7.5	87
19-Apr-2013	40	AQUI-S 20E	8.3	90
19-Apr-2013	40	MS-222	7.7	88
22-Apr-2013	40	AQUI-S 20E	8.5	90
22-Apr-2013	40	MS-222	8.9	91
26-Apr-2013	25	AQUI-S 20E	8.9	88
26-Apr-2013	25	MS-222	8.8	92
29-Apr-2013	30	AQUI-S 20E	10.0	96
29-Apr-2013	30	MS-222	10.0	95
10-May-2013	30	AQUI-S 20E	15.9	108
10-May-2013	30	MS-222	15.7	107

A total of 129 PIT tagged salmon were released at the SDFPF primaries to evaluate facility efficiency (Table 6). Of those 129 salmon, 91 PIT tagged salmon were determined to be recovered based upon detection by the PIT antennae located at the release sites.

Table 6: Fish Releases at the Radial Gates and SDFPF Primaries in 2013

Date	Fish Released at Radial Gates	Fish Released at SDFPF primaries
19-Apr-2013	20	0
22-Apr-2013	20	20
23-Apr-2013	20	20
25-Apr-2013	20	20
26-Apr-2013	20	10
29-Apr-2013	20	10
30-Apr-2013	20	9
3-May-2013	20	10
4-May-2013	20	10
13-May-2013	20	10
14-May-2013	19	10

The PIT tag detection efficiency was determined to be 0.96, or 96%, at the time of release (pers. Comm. J. Miranda). Facility efficiency (F_{all}) was calculated to be 0.74, or 74%, for all releases using the equation below.

$$F_{all} = \left[\frac{Rec_{tr}}{Rel_{tr} \times A}\right] \times 100$$

$$F_{all} = \left[\frac{91}{129 \times 0.96}\right] \times 100$$

$$F_{all} = \left[\frac{91}{123.8}\right] \times 100$$

$$F_{all} = 0.74 \times 100$$

$$F_{all} = 74\%$$

Using the facility efficiency, a PSL (for all treatment types combined, defined as PSL_{all}) of 81.14% was calculated based upon the release of 219 PIT tagged salmon at the radial gates. Of those 219 salmon, 29 PIT tagged salmon were determined to be recovered based upon detection by the antennae located at the release sites.

$$PSL_{all} = \left[1 - \left(\frac{Rec_{rg}}{Rel_{rg} \times A \times F}\right)\right] \times 100$$

$$PSL_{all} = \left[1 - \left(\frac{29}{219 \times 0.74 \times 0.96}\right)\right] \times 100$$

$$PSL_{all} = \left[1 - \left(\frac{29}{155.58}\right)\right] \times 100$$

$$PSL_{all} = [1 - (0.19)] \times 100$$

$$PSL_{all} = 0.81 \times 100$$

$$PSL_{all} = 81\%$$

Facility efficiency ($F_{Aqui\text{-}S}$) was calculated to be 0.76, or 76%, for Aqui-S 20E releases using the equations below.

$$F_{Aqui-S} = \left[\frac{Rec_{tr}}{Rel_{tr} \times A}\right] \times 100$$

$$F_{Aqui-S} = \left[\frac{46}{63 \times 0.96}\right] \times 100$$

$$F_{Aqui-S} = \left[\frac{46}{60.48}\right] \times 100$$

$$F_{Aqui-S} = 0.76 \times 100$$

$$F_{Aqui-S} = 76\%$$

Using the facility efficiency, a $PSL_{Aqui\text{-}S}$ of 86% was calculated based upon the release of 111Aqui-S 20E treated PIT tagged salmon at the radial gates. Of those salmon, 11 PIT tagged salmon were determined to be recovered based upon detection by the PIT antennae located at the release sites.

$$PSL_{Aqui-S} = \left[1 - \left(\frac{Rec_{rg}}{Rel_{rg} \times A \times F}\right)\right] \times 100$$

$$PSL_{Aqui-S} = \left[1 - \left(\frac{11}{111 \times 0.76 \times 0.96}\right)\right] \times 100$$

$$PSL_{Aqui-S} = \left[1 - \left(\frac{11}{80.98}\right)\right] \times 100$$

$$PSL_{Aqui-S} = [1 - (0.14)] \times 100$$

$$PSL_{Aqui-S} = .86 \times 100$$

$$PSL_{Aqui-S} = 86\%$$

Facility efficiency (F_{MS222}) was calculated to be 0.71, or 71% for MS-222 releases using the equations below.

$$F_{MS222} = \left[\frac{Rec_{tr}}{Rel_{tr} \times A}\right] \times 100$$

$$F_{MS222} = \left[\frac{45}{66 \times 0.96}\right] \times 100$$

$$F_{MS222} = \left[\frac{45}{63.36}\right] \times 100$$

$$F_{MS222} = 0.71 \times 100$$

$$F_{MS222} = 71\%$$

Using the facility efficiency, a PSL_{MS222} of 82% was calculated based upon the release of 108MS-222 treated salmon at the radial gates. Of those salmon, 13 PIT tagged salmon were determined to be recovered based upon detection by the PIT antennae located at the release sites.

$$PSL_{MS222} = \left[1 - \left(\frac{Rec_{rg}}{Rel_{rg} \times A \times F}\right)\right] \times 100$$

$$PSL_{MS222} = \left[1 - \left(\frac{13}{108 \times 0.71 \times 0.96}\right)\right] \times 100$$

$$PSL_{MS222} = \left[1 - \left(\frac{13}{73.6}\right)\right] \times 100$$

$$PSL_{MS222} = [1 - (.18)] \times 100$$

$$PSL_{MS222} = .82 \times 100$$

$$PSL_{MS222} = 82\%$$

Facility efficiency and PSL were calculated for each individual release (Table 7). Transit time for fish that were successfully salvaged ranged from one day to 46 days, so the facility efficiency for all release dates was used to calculate the PSL for each individual release date.

Table 7: PSL for Each Release by Treatment

Date	Treatment	RECtr	RELtr	A	F	RECgate	RELgate*	PSL
4/22/13	Aqui-S 20E	9	10	0.96	.76	3	10	59%
4/23/13	Aqui-S 20E	8	10	0.96	.76	3	10	59%
4/25/13	Aqui-S 20E	9	10	0.96	.76	2	10	73%
4/26/13	Aqui-S 20E	5	5	0.96	.76	1	10	86%
4/29/13	Aqui-S 20E	3	5	0.96	.76	1	7	80%
4/30/13	Aqui-S 20E	3	3	0.96	.76	0	15	100%
5/3/13	Aqui-S 20E	0	5	0.96	.76	0	10	----
5/4/13	Aqui-S 20E	3	5	0.96	.76	0	10	100%
5/13/13	Aqui-S 20E	3	5	0.96	.76	0	10	100%
5/14/13	Aqui-S 20E	3	5	0.96	.76	1	8	83%
4/22/13	MS-222	4	10	0.96	.71	3	10	56%
4/23/13	MS-222	10	10	0.96	.71	2	10	71%
4/25/13	MS-222	7	10	0.96	.71	1	10	85%
4/26/13	MS-222	2	5	0.96	.71	1	10	85%
4/29/13	MS-222	4	5	0.96	.71	2	13	77%
4/30/13	MS-222	6	6	0.96	.71	2	5	41%
5/3/13	MS-222	0	5	0.96	.71	1	10	------
5/4/13	MS-222	4	5	0.96	.71	0	10	100%
5/13/13	MS-222	5	5	0.96	.71	0	10	100%
5/14/13	MS-222	3	5	0.96	.71	2	10	71%

T-test comparisons were run within each treatment group as well as between AQUI-S 20E and MS-222 to determine if the variance in PSL was significant (Figure 4). For the AQUI-S 20E treatment, the difference between releases was determined to be significant ($P = <0.001$). Likewise, for the MS-222 treatment, the difference between releases was determined to be significant ($P = <0.001$). When compared to one another, however, there was no statistical difference between the MS-222 and AQUI-S 20E treatment groups ($P = 0.600$).

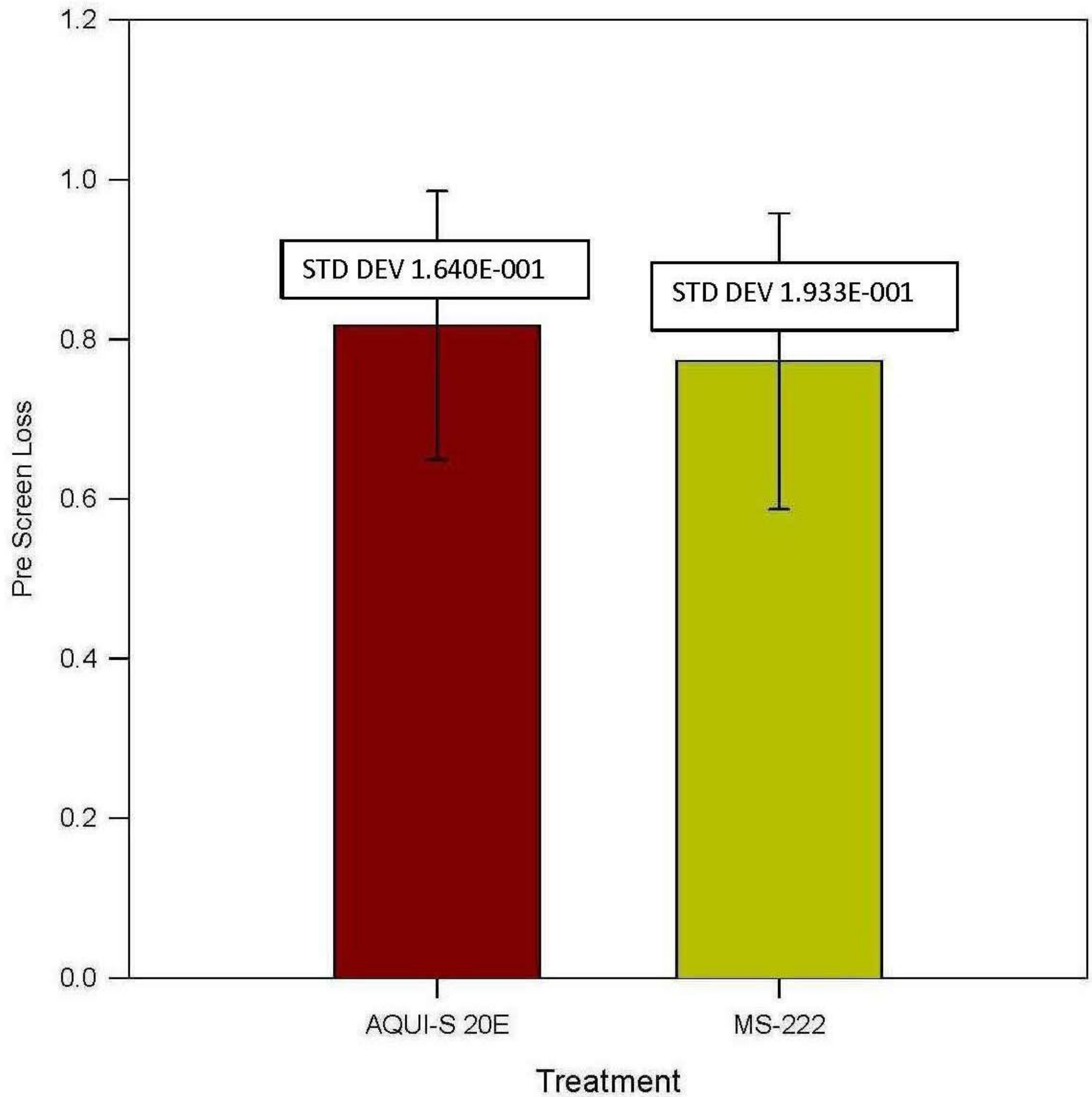

Figure 4: Pre Screen Loss for all Releases by Treatment

2.2.5 Discussion and Recommendations

PSL was estimated by releasing tagged juvenile Chinook salmon at the radial gates and comparing the numbers of Chinook salmon released to the numbers that are successfully detected at the release sites. The simultaneous release of large numbers of juvenile salmonids could potentially swamp the predator population inhabiting the study area, resulting in a biased (high) estimate of survival as a result of a reduction in predation mortality. Alternatively, releases of large numbers of juvenile salmonids could potentially attract predatory fish resulting in a biased (low) estimate of survival as a result of an increase in predation mortality. To avoid biases such as these, releases were conducted with small groups of fish over several weeks, from April through May 2013. PSL was then calculated for all fish released over the release period, as well as separately for each of the two anesthesia techniques used for side by side comparison. PSL was calculated to be 81.14 ± 0.19% for all fish, which is within the range of PSL found in prior studies, which ranged from 63% to 99% for Chinook salmon (Gingras 1997) and 82% for steelhead (Clark et al 2009). When PSL was calculated for AQUI-S 20E and MS-222, it was found to be 86 ± .16% and 82 ± .20%, respectively, and, based upon the t-test comparison there was not a significant effect resultant from anesthetic treatment.

While the PSL found in this study was not outside of the range of prior studies, it may not be indicative of total PSL for the entire time period that juvenile Chinook Salmon would be moving through the system, as releases were only conducted during the months of April and May, which represents just the latter portion of that time period. The study was originally planned to be conducted from January until May, however, issues that were discussed above resulted in significant delays in the initiation of the study. Therefore, limited conclusions can be drawn from this dataset.

It is recommended that these releases be repeated in coming years, for the entire span of the time period during which juvenile Chinook salmon could be encountered in the area, so that PSL is more representative. It is also recommended that future releases be conducted using steelhead in addition to Chinook salmon. No steelhead releases were conducted for the 2013 field season, as data from previous studies were more recent for steelhead than for Chinook salmon, and it was determined that beginning with only Chinook salmon would be more useful and informative for refining the balance of the study years.

2.3 Predatory Fish Sampling

2.3.1 Methods

For the 2013 Pilot Study, predators such as Striped Bass, Largemouth Bass, White Catfish, and Channel Catfish, were collected by either gill netting or hook and line sampling in the Forebay. Predatory fish were sampled twice weekly throughout the year, beginning in March 2013, to supply predatory fish for various study elements. Predatory fish were either sacrificed and preserved for use in the genetic analysis study element, or tagged as part of the mark-recapture and biotelemetry study element (discussed in detail in the Biotelemetry Section) and released at the location of capture. Temperature and dissolved oxygen, and location(s) of capture were noted for each sampling effort. Scale samples were collected from Striped Bass and Largemouth Bass, to be examined at a future date, to determine the age of the predatory fish sampled.

Collection of predators occurred primarily during the day, between the hours of 0600 and 1500, however, three of the sampling efforts were undertaken at night, between the hours of 1900 and 2400 (May 23, August 21 and September 19, 2013). All incidental species caught alive were measured, recorded, and immediately released at the location caught. Field staff were trained to quickly identify listed species and release live fish to minimize handling stress. Incidental take information was detailed in a supplemental report as part of the reporting requirements of the DFW Scientific Collecting Permits (SCP; SCP #'s 7744 and 10286).

The Forebay was split into sampling sections, following the same map as Gingras and McGee (1997; Figure 5). Sampling was conducted from a boat, when possible, to allow for coverage of a greater portion of the Forebay. Sampling locations were determined based upon accessibility and Forebay conditions. On sampling days when the boat was not available for use, sampling was conducted from the shoreline, primarily along the intake canal (Area 2) or adjacent to the radial gates (Area 1).

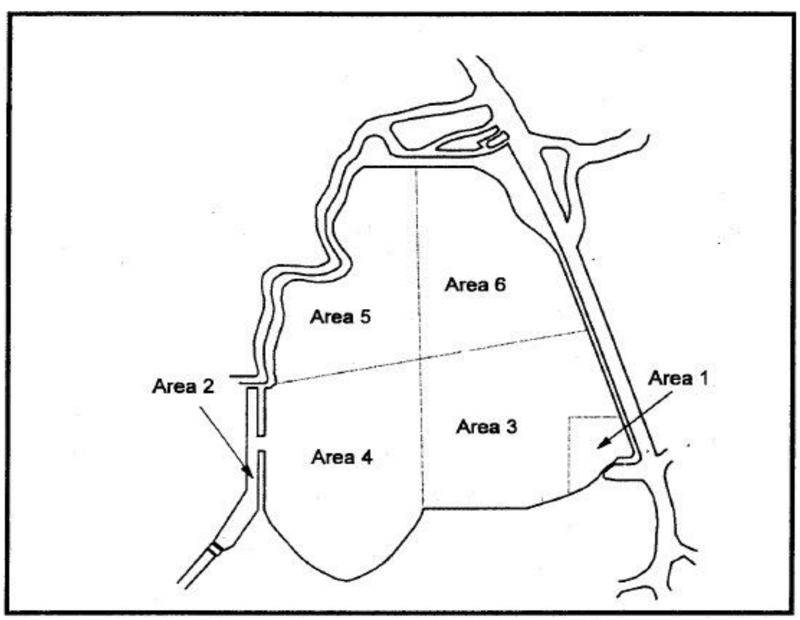

Figure 5: Sampling Map (Gingras and McGee 1997)

Hook and line sampling was conducted using standard rod and reel fishing equipment in accordance with standard DFW regulations for hook and line fishing, and employed a wide variety of bait and lure selections to maximize catch. Hook and line sampling was conducted on 67 sampling days, at various times during the day from March 12, 2013 until December 31, 2013. Gill netting was conducted on five sampling days within Forebay, from March 27, 2013 until October 25, 2013, using a monofilament gill net, measuring 30 meters (m) or less, with variable mesh sizes ranging from five centimeters (cm) to 15.25 cm. Gill netting was determined to have too great an impact upon the condition of fish to be useful for mark/recapture studies, and was suspended following the October 25th effort.

2.3.2 Issues

As stated above, the initiation of predator sampling was planned for January 30, 2013, but was delayed due to a change in SWP procedures/requirements. An EROF for predator sampling was filed with DFD on February 15, 2013, and the first predator sampling survey occurred on March12, 2013. Initially, EROF paperwork was filed on a monthly basis and restricted sampling days to those specifically requested on each monthly submission. However, due to the likelihood of unanticipated scheduling changes that could occur based upon inclement weather, equipment failure or staffing changes, and the long term nature of the project, in April 2013 DFD agreed to issue a WCA number which included no specific sampling dates that was valid for the balance of 2013. The WCA for predator sampling required the presence of an OP-2 certified DWR staff member at all times.

Predator sampling was conducted pursuant to the requirements of the DFW as outlined in SCP #7744. This permit is an individual permit issued solely to Veronica Wunderlich. This restricted staffing for sampling activities in that it required the SCP holder to be present during all sampling efforts. To allow for sampling when the SCP holder was not available, predator collection activities were temporarily conducted under a pre-existing SCP (SCP # 10286) issued to Javier Miranda that was not project specific but allowed for the same activities. A second entity wide permit which replaced the individual permit of the same number (SCP # 10286) was issued on November 27, 2013, which gave more scheduling flexibility for sampling efforts.

Predator sampling efforts were additionally constrained by availability of boats as well as qualified and approved boat operators. BDO has a clearly defined boat operator policy outlined in Section 2.6 of the Safety Guidelines, Policies, and Procedures for DCB Field Operations (January 2013 revision) that requires that each operator complete a multi-day field based Motorboat Operator Certification Course (MOCC) and demonstrate necessary skills on the BDO vessel in the presence of designated approved BDO operators. As many staff members on the CCFPS were not yet approved BDO operators, all predator sampling efforts needed to be scheduled around the availability of qualified boat operators, as well as OP-2 certified staff and the SCP holder. This required the careful coordination of multiple schedules across multiple ongoing projects.

In addition to the availability of boat operators, the availability of boats that could negotiate the variable conditions encountered in the Forebay proved to be a challenge. During a portion of the year, the Forebay becomes inundated with thick, and in some cases unnavigable, patches of submerged aquatic vegetation (SAV). When the SAV becomes thick, it is not possible to use the BDO jet drive boat. The second boat is a prop driven boat, and can be used in SAV to a greater extent; however this boat is borrowed from another group, and is not always available during the year. On June 30, 2013, the BDO jet boat was taken out of service. The second boat was acquired on August 11, 2013, and was used full time until November 30, when it was returned to the group from which it was borrowed.

2.3.3 Data Analysis

Data sheets were scanned and data was initially compiled into an excel spreadsheet to ensure that no data was lost while a database was under development. A database for acoustic tagged fish was completed in June 2014, and the acoustic tag data portion of the predator sampling data was transferred from the excel spreadsheet for analysis. A more comprehensive database for all predatory fish captured was completed in December 2014. Total catch, catch by species, and catch by size for each month and the year as a whole were compiled for the entire Forebay, and catchability, defined as catch per unit effort (CPUE) per sampling day was calculated using the equation:

$$q = \frac{C}{f \times a}$$

(q = catchability (fish caught per hours of sampling), C = catch, f = fishing effort which is defined as hours spent fishing per sampling day, and a = number of anglers during the effort)

Mean CPUE per month for all species combined was then estimated by:

$$q_m = \frac{\sum q_i}{d}$$

(q_m = mean monthly catchability, q_i = catchability for each day sampled in the month, and d = number of sampling days in the month)

Mean CPUE per month was then calculated for each species using the equation

$$q_{sp} = \frac{\sum\left(\frac{Csp}{f \times a}\right)_i}{d}$$

Seasonal CPUE was calculated for the four seasons defined as Winter (Jan 1 – March 19 and December 21-December 31), Spring (March 20 – June 20), Summer (June 21 – September 21), and Fall (September 22 – December 20), based upon the published[2] equinox/solstice dates for 2013.

Seasonal CPUE for all species combined was calculated by:

$$q_s = \frac{\sum q_i}{d}$$

(q_s = seasonal catchability, q_i = catchability for each day sampled in the season, and d = number of sampling days in the season)

2.3.4 Results:

A total of 67 sampling days were conducted between March 12, 2013 and December 31, 2013, resulting in the total catch of 584 fish, including 579 predatory fish and five non-target fish (Table 8, Figure 6). Of the 579 predatory fish, the majority were Striped Bass, at 514, followed by Largemouth Bass at 51. Catfish were only caught in May, June and July, and totaled only 14 fish for the year. Non-target fish species captured included Bluegill (*Lepomis macrochirus*) and Threadfin Shad (*Dorosoma petenense*), and were only caught during the gill net efforts. Only one fish, a Striped Bass, was recaptured during the 2013 predator sampling effort. The single recapture was a Striped Bass originally captured on June 11, 2013 and recaptured on October 25, 2013, having increased in size from 0.75pounds (lbs) (0.34 kilograms (kg)) to 1.0 lbs (0.45 kg) between captures.

Table 8: 2013 Predatory Fish Captures by Month

Month	Monthly Total	Striped Bass	Largemouth Bass	Catfish Sp	Other
March	101	96	5	0	0
April	25	23	2	0	0
May	25	17	3	3	2
June	34	26	1	7	0
July	43	37	2	4	0
August	82	81	1	0	0
September	82	80	2	0	0
October	69	50	16	0	3
November	38	33	5	0	0
December	85	71	14	0	0
All 2013	584	514	51	14	5

[2] Equinox/solstice dates from http://wwp.greenwichmeantime.com/longest-day/equinox-solstice-2010-2019.htm

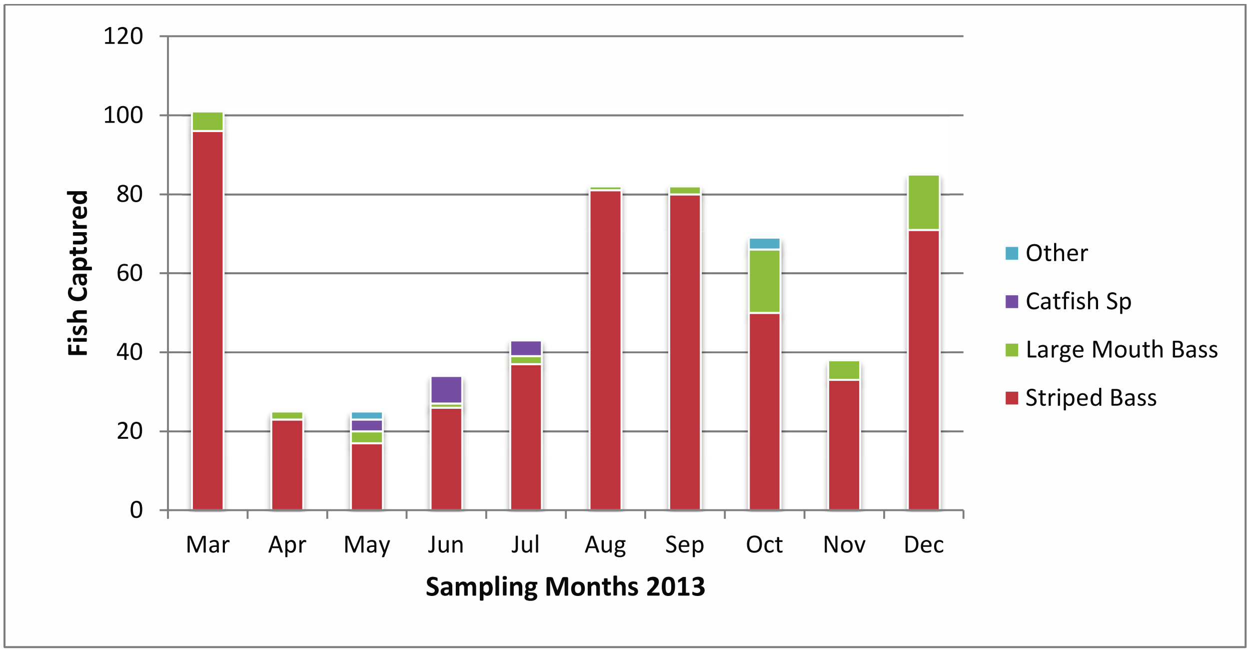

Figure 6: 2013 Predatory Fish Captures by Month

Fish captured during the 2013 effort ranged from 0.20 lbs (0.09 kg) to 10.05 lbs (4.56 kg) for Striped Bass, 0.40 lbs (0.18 kg) to 8.30 lbs (3.76 kg)for Largemouth Bass and 0.90 lbs (0.41 kg) to 7.05 lbs (3.20 kg) for catfish (Figure 7).

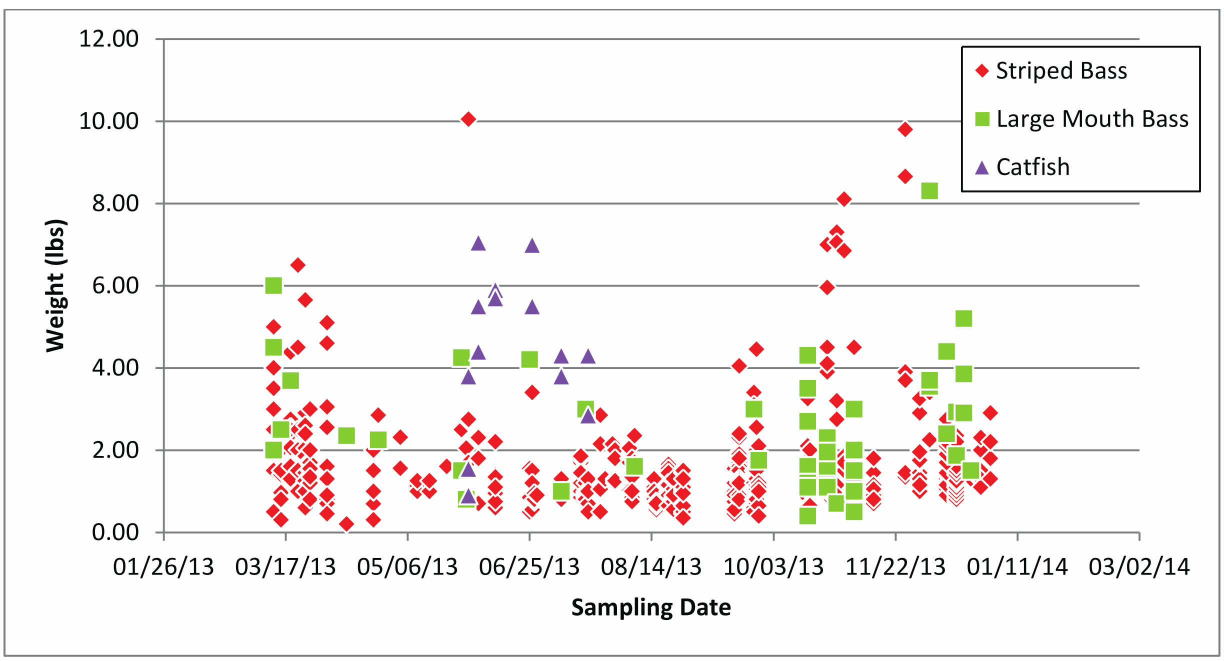

Figure 7: 2013 Predatory Fish Captures by Weight and Species

The majority of Striped Bass captured in 2013 at 55% of total catch, were in the 0.5 lbs (0.23 kg) to 1.5 lbs (0.68 kg) size class, with the highest catch of those fish occurring in August and September, at 65 and 52 fish respectively (Table 9, Figure 8). Fish in the 1.5 lbs (0.68 kg) to 3 lbs (1.36 kg) size class represented 35% of total Striped Bass catch, with the highest number captured in March at 55 fish, with the second highest catch occurring in December, at 32 fish. Fish over 3 lbs (1.36 kg) represented 8% of the total Striped Bass catch, with the bulk captured in March, at 14 fish, with the second highest catch occurring in October, at 10 fish.

Table 9: 2013 Striped Bass Captures by Size Class

Month	Fish <.5 lbs (0.23 kg)	Fish >.5 lbs(0.23 kg) and <1.5 lbs(0.68 kg)	Fish >1.5 lbs (0.68 kg) and <3.0 lbs (1.36 kg)	Fish >3.0 lbs (1.36 kg)
March	1	26	55	14
April	3	9	8	3
May	0	7	9	1
Jun	0	19	6	1
Jul	0	26	10	0
Aug	4	65	11	0
Sept	2	52	22	4
Oct	0	26	14	10
Nov	0	15	9	8
Dec	0	38	32	1
Total for Year	10	283	176	42

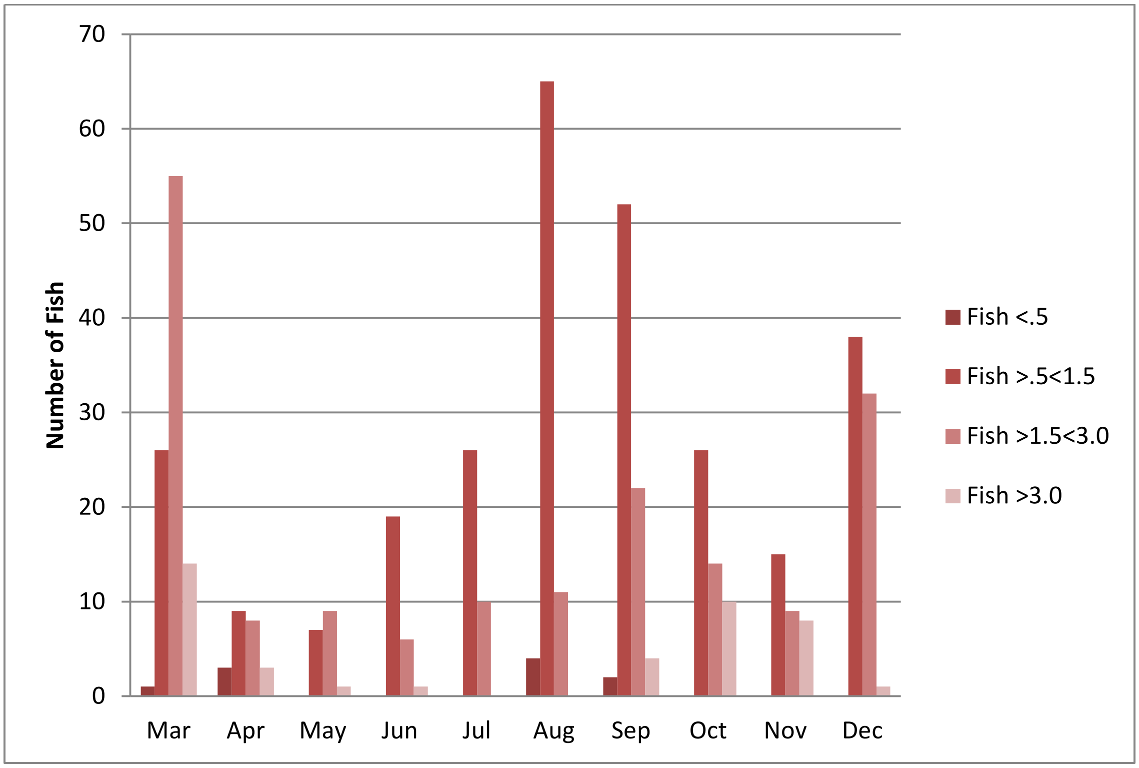

Figure 8: 2013 Striped Bass Captures by Size Class (lbs)

The August peak in capture of small (0.5 lbs/0.23 kg to 1.5 lbs/0.68 kg) Striped Bass coincided with a peak in temperature (Figure 9).

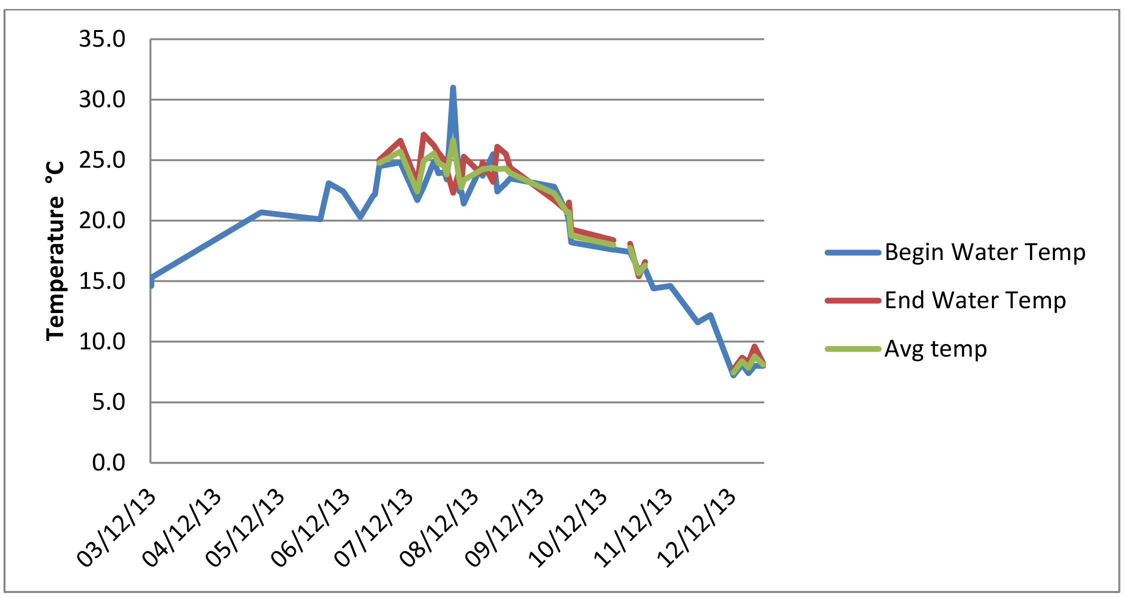

Figure 9: 2013 Sampling Effort Temperatures (°C)

Predatory fish were caught in Areas 1, 2 and 4 during the winter sampling period (Figure 10), with the bulk being caught in Area 2, at 53 fish.

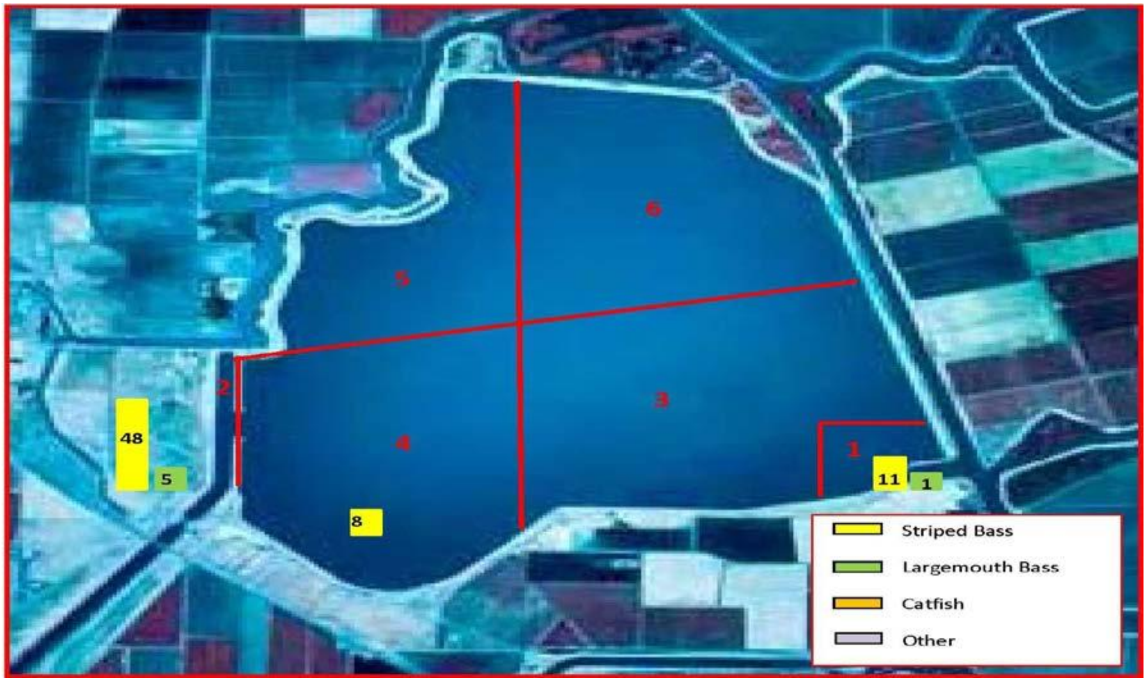

Figure 10: Winter 2013 Catch by Location and Species

Predatory fish were caught in Areas 1, 2, 3 and 4 during the spring sampling months of April through June (Figure 11), with the bulk being caught in Area 2, at 49 fish.

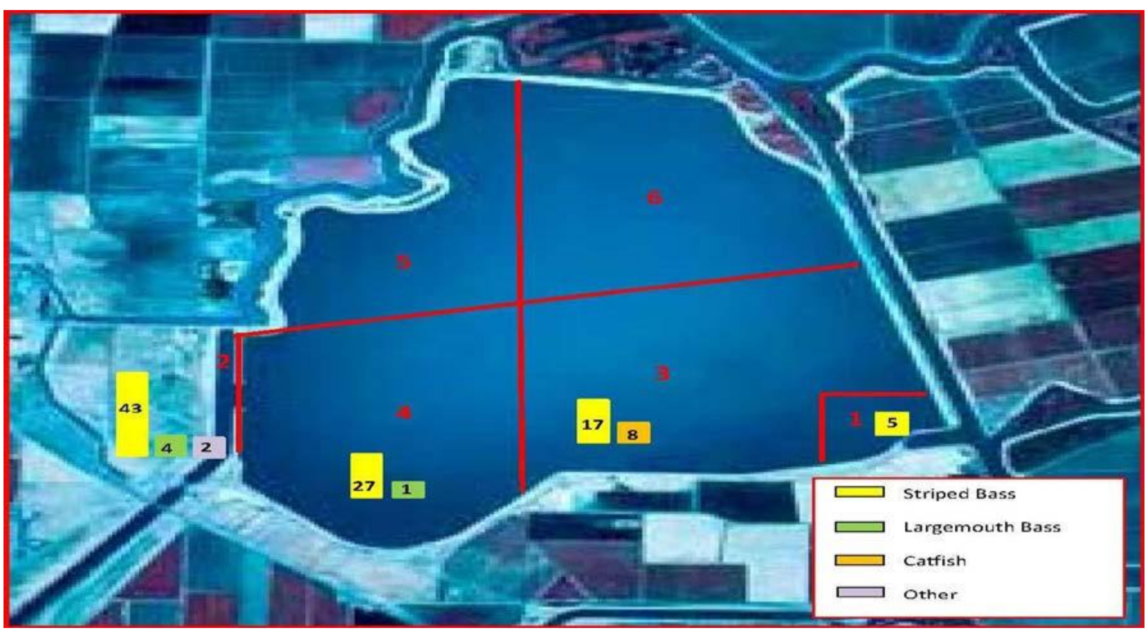

Figure 11: Spring 2013 Catch by Location and Species

Predatory fish were caught in Areas 1, 2, 3, 4 and 5 during the summer sampling months of July through September (Figure 12), with the bulk being caught in Area 2, at 98 fish.

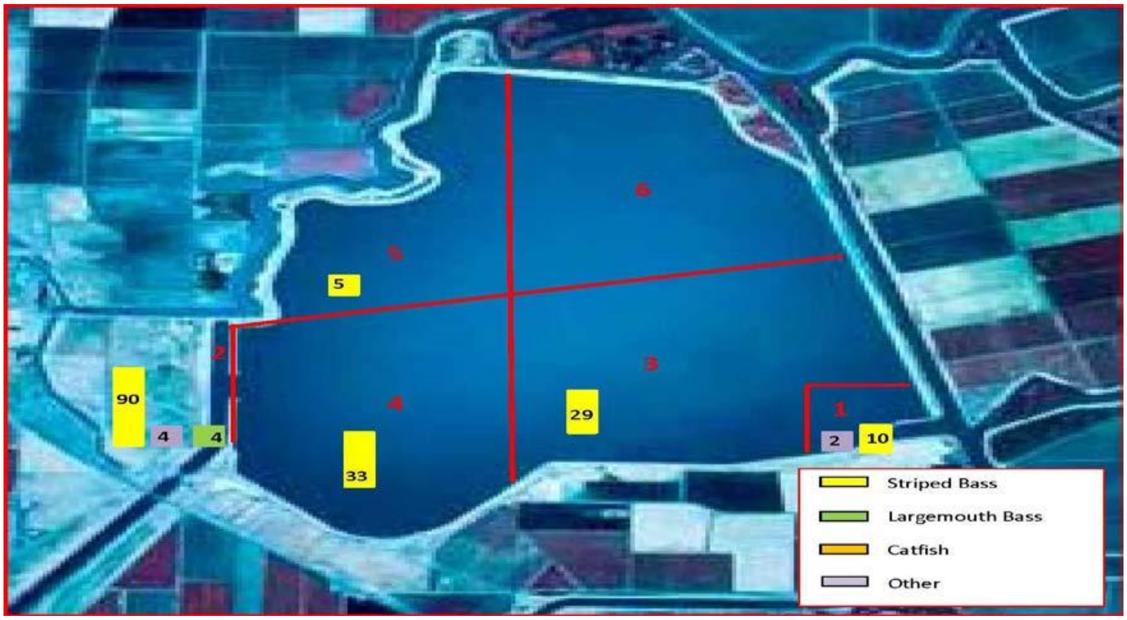

Figure 12: Summer 2013 Catch by Location and Species

Predatory fish were caught in Areas 1, 2, 3, and 4 during the fall sampling months of October through December (Figure 13), with the bulk being caught in Area 1, at 104 fish.

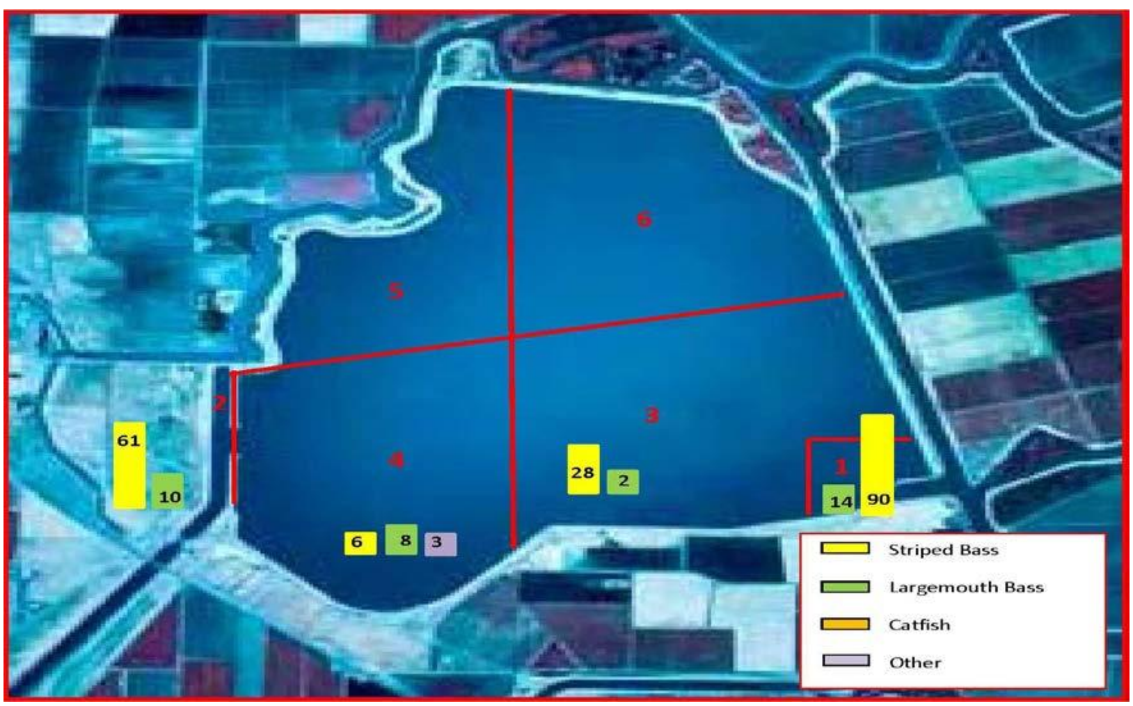

Figure 13: Fall 2013 Catch by Location and Species

CPUE per sampling day was calculated using the equation: $q = \frac{C}{f \times a}$. Mean CPUE per month was then estimated by: $q_m = \frac{\sum q_i}{d}$ (Table 10).

Table 10: Catchability (CPUE) for all Species Combined

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean	0.85	0.62	0.27	0.39	0.5	0.77	1.13	1.04	0.79	0.99
Single Sample Day	0.64	1.43	0.4	0.61	0.67	0.67	1.17	1.16	0.62	0.78
	1.10	0	0.19	0.71	0.65	0.58	1.00	1.10	0.89	0.51
	1.50	0.87	0.12	0	0.23	2.1	0.52	0.90	1.09	2.03
	0.95	0.19	0	0.46	0.22	1.87	2.14	1.02	0.58	0.85
	0.89	-	0.35	0.15	0.74	1.23	0.81	-	-	1.70
	-	-	0.3	-	-	1.35	-	-	-	1.79
	-	-	0.53	-	-	1.02	-	-	-	0.2
	-	-	-	-	-	0	-	-	-	0.62
	-	-	-	-	-	-	-	-	-	0.44

Seasonal CPUE was calculated for the four seasons (Table 11) defined as Winter (Jan 1 – March 19; December 21-31), Spring (March 20 – June 20), Summer (June 21 – September 21), and Fall (September 22 – December 20).

Table 11: Catchability (CPUE) for all Species by Season

Season	Sampling Days	Seasonal CPUE
Winter (Dec 21 – 31 and Jan 1 - Mar 19)	5	1.07
Spring (Mar 20 - Jun 20)	16	0.59
Summer (Jun 21 - Sep 21)	19	0.72
Fall (Sep 22 - Dec 20)	16	1.05

Mean monthly CPUE was then calculated for each species using the equation[3]:

$$q_{sp} = \frac{\sum \left(\frac{Csp}{f \times a} \right)_i}{d}$$

CPUE was found to be highest for Striped Bass in March, at 1.18 fish per hour, followed by September and August at 1.10 and 0.98 respectively (Table 12). For Largemouth Bass, CPUE peaked in October, at 0. 08 fish per hour, and for catfish, CPUE peaked in July at 0.22 fish per hour.

Table 12: Monthly Catchability (CPUE) By Species

Monthly CPUE	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Striped Bass	1.18	0.80	0.23	0.36	0.40	0.98	1.10	0.90	0.74	0.88
Largemouth Bass	0.04	0.03	0.07	0.03	0.03	0.02	0.02	0.08	0.07	0.06
Catfish	0.00	0.00	0.00	0.13	0.22	0.00	0.00	0.00	0.00	0.00

[3] See Section 2.3.3 for a full explanation of the CPUE calculation.

2.3.5 Discussion and Recommendations

The 2013 predator sampling effort in the Forebay served multiple purposes, including providing fish for the acoustic tagging studies discussed below, mark/recapture studies using non-acoustic tags such as PIT and Floy tags to investigate population size and gather basic data for future bioenergetics modelling, and to investigate species catchability and seasonal distribution in the Forebay.

The largest numbers of predatory fish were captured in March, with a second peak in total catch occurring in the months of August and September. This pattern was mirrored in total Striped Bass catch, but the distributions were shifted for the three primary size classes investigated. The largest size class of Striped Bass (over 3.0 lbs/1.36 kg) was captured in all sampling months except July and August, with total numbers caught peaking in October and November, indicating that the largest Striped Bass may be leaving the Forebay in the summer months, then returning in the Fall and Winter. The next smaller size class Striped Bass, between 1.51 lbs (0.68 kg) and 2.99 lbs (1.36 kg), were caught in every month sampled, peaking in March and then again in September and December. The size class Striped Bass, between 0.5 lbs (0.23 kg) and 1.5 lbs (0.68 kg) were caught in every month sampled, with a peak in August and September. Striped Bass under 0.5 lbs (0.23 kg) were only captured in March, April, August and September. Throughout the year this size class dominated all but two of the sampling months, March and May, and represented 56% of the total Striped Bass catch for the year. This may be indicative of a thriving population of smaller Striped Bass, including fish less than 3.0 lbs (1.36 kg), which remains in the Forebay year round. While there appear to be some trends in seasonality and residency, due to the variables in sampling, such as shore versus boat based angling, a wide range of sampler experience, and gear selection, these trends need more robust examination before a strong conclusion can be drawn. Residency can be more thoroughly investigated using biotelemetry, as described below.

The overall catch and peak catch for Largemouth Bass and catfish were different than those of Striped Bass, with Largemouth Bass caught in every month sampled, peaking from October through December, with an increase noted in March as well. Catfish were only caught during the months of May, June and July, and very few catfish were caught during the sampling effort. This, however, is not necessarily indicative of a small or strongly seasonal catfish population. Kano (1990) showed a very large population of White Catfish present throughout the year in 1983-1984, and catfish continued to be caught by anglers interviewed for creel throughout 2013. It is likely that variables in sampling, such as shore versus boat based angling, a wide range of sampler experience, gear selection, and limitations in other available capture methods that are known to target catfish significantly affected ability to catch catfish. Kano (1990) employed hoop nets that were deployed for long periods of time, and greatly increased his ability to capture catfish. This technique is not currently available to this project.

It is important to note that sampling was not conducted during the first two months of the year, due to issues discussed in the above issues section, and as such, the data for the winter months is incomplete. March of 2013 had the highest Striped Bass catch of the study period, with a CPUE of 1.18 for Striped Bass, and a CPUE of 0.85 for all species. The following December had a comparable all-species CPUE at 0.99, and a Striped Bass CPUE of 0.88. It is not possible to know what January and February of 2013 would have shown for catch and CPUE, but those two months are important for collecting and analyzing data as they are within the outmigration season for juvenile Chinook salmon and steelhead.

While there do appear to be some seasonal trends in catch by species and size class, the lack of data for January and February, as well as limitations with sampling access due to a variety of issues, including boat access and SAV, it is important to collect more data over several years to determine if these trends are significant. Additionally, the apparent seasonal shift in location of the catch was biased by the limited accessibility during times when a boat could not be used due to poor conditions on the Forebay or the lack of access to a boat. Shore sampling is restricted in access to primarily area 2, with some limited access to areas 1 and 4. Although other areas, including 3, 5 and 6 can technically be reached via the shore, in general those areas are not fishable due to the extent of the shallow water, thickness of weeds and prevailing wind direction making casting very difficult and limited in distance. As such the bulk of the fish that are captured during shore sampling efforts were in area 2, which may bias the catch in species and size class availability. We recommend that shore sampling and boat sampling continue to be indicated within the data taken in future years so that the level of effort can be better addressed for differential catch. Additionally, sampling should be conducted consistently throughout all months of the year, as originally proposed in the study plan, to adequately evaluate the seasonality of the catch. In addition, angling methods to target catfish should be reevaluated for future study years to maximize catfish capture. It is also recommended that additional sampling techniques be pursued, such as electro-fishing, or use of other styles of nets and/or seines.

We also recommend that use of the gill net be reevaluated as a tool for gathering additional population size and distribution information, in conjunction with study elements that are not adversely affected by the resulting condition of the fish. We recommend that the gill net be employed at least twice per month for the genetics study planned to begin in 2014, as the study element will not be adversely affected by injuries sustained using this method of collection. .

2.4 Biotelemetry

2.4.1 Methods

Placement of an acoustic receiver array was initiated in 2012 to track the tagged predators (and salmon) described in previous sections of this report. Due to the amount of lead time anticipated for temporary entry permit (TEP) acquisition for units planned on properties not owned by DWR, the array was designed to be deployed in phases. The initial phase consisted of nine units within and immediately adjacent to the Forebay. These nine units were placed at the following locations IC1, IC2, IC3, RGD1, RGU1, WC1, WC2, WC3 and ORS1 (Figure 14). These locations were selected to provide data regarding directionality of movement relative to the radial gates as well as for determining immigration and emigration into and out of the Forebay, and movement toward and away from the SDFPF. The first nine units were installed between January and March 2013.

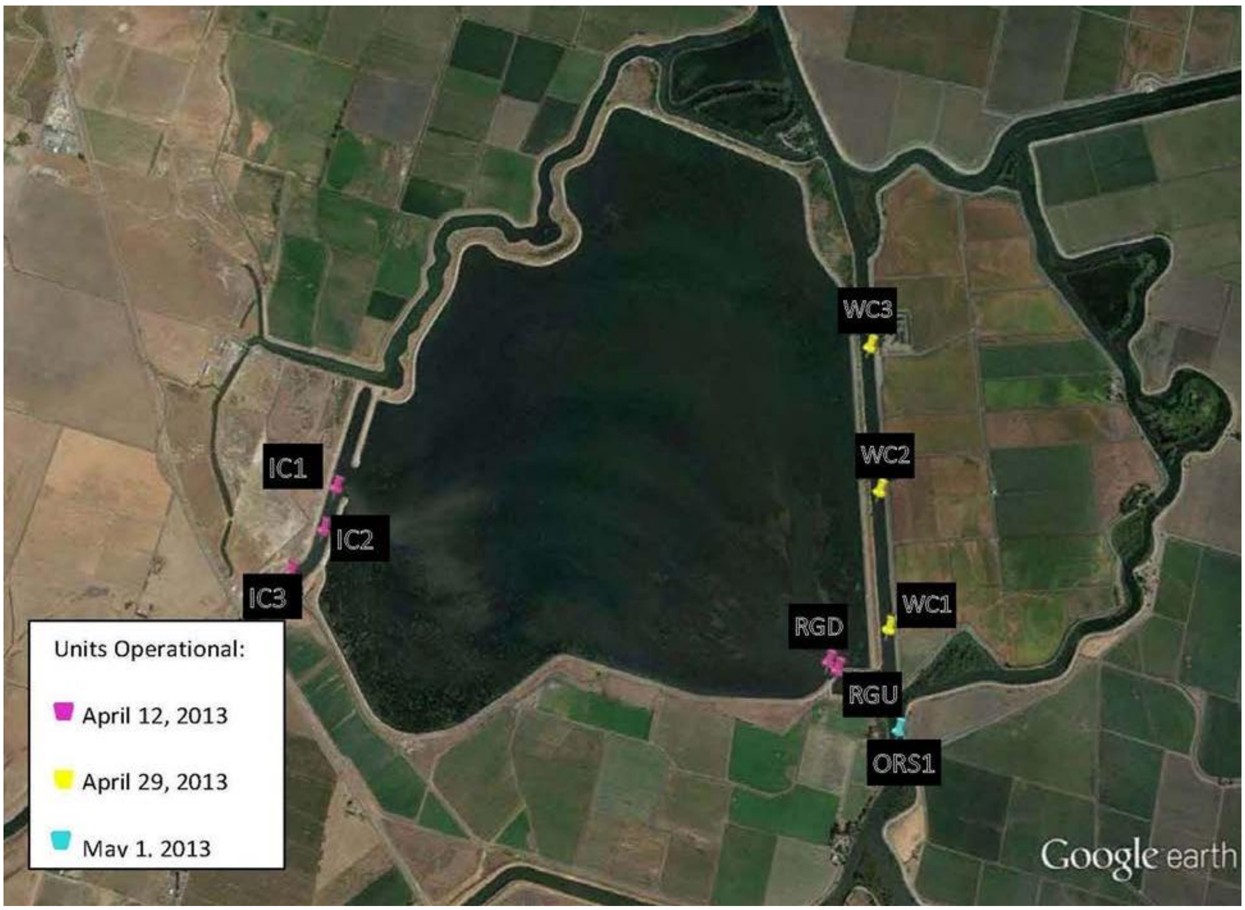

Figure 14: Receiver Array Deployed in 2013

Each of these units was deployed using an HTI Model 295x datalogger, powered by a 12-volt (two six-volt sealed deep cycle batteries wired in series) connected to a solar panel to ensure continued operation (Figure 15). A beacon tag was deployed near each hydrophone to document ongoing functionality of the unit.

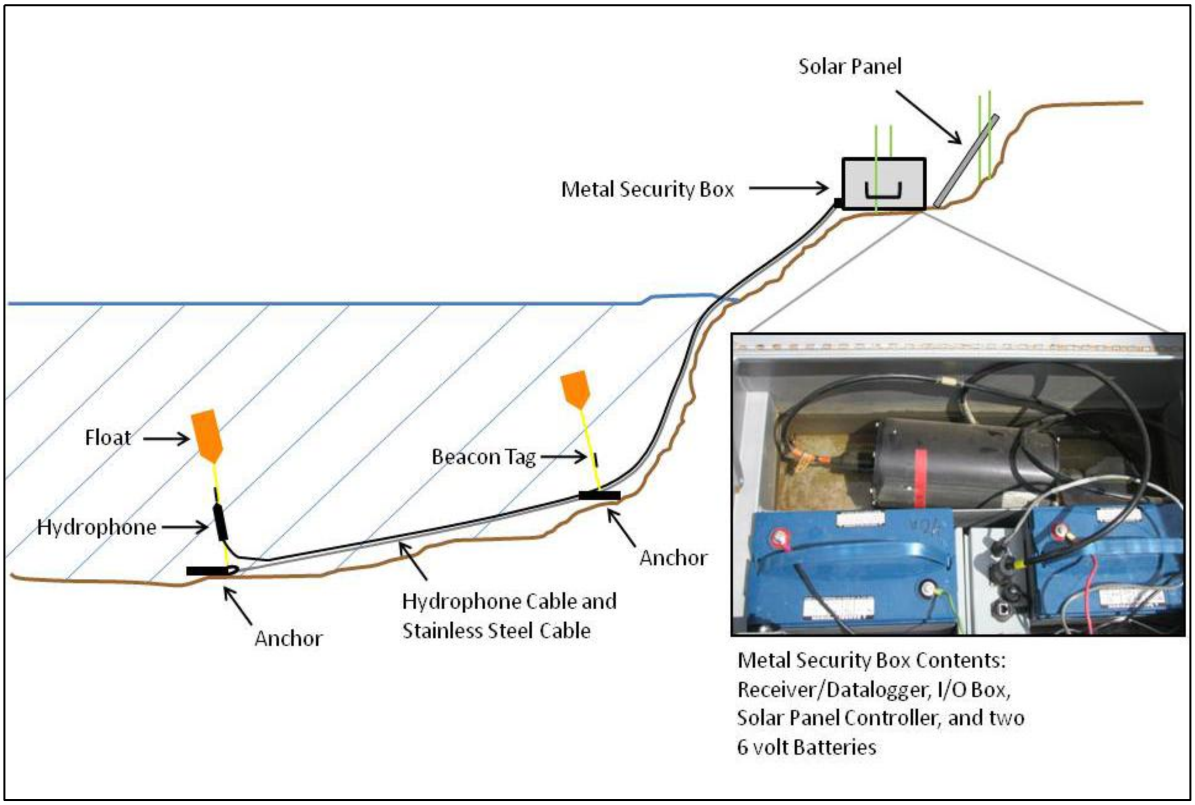

Figure 15: Model 295x Receiver Site Schematic

The phase one locations were all fully operational by May 1, 2013, with the first five (IC1, IC2, IC3, RGU1, and RGD1) collecting data beginning on April 12, 2013, the second three (WC1, WC2, and WC3) on April 29, 2013, and the last location (ORS1) on May 1, 2013(Depicted in pink, yellow and blue respectively; Figure 14). Once all locations were operational and collecting data, daily maintenance visits were initiated with data downloaded once per week, when possible.

Tag codes for 2013 were predetermined by HTI, with sub code 22 for Striped Bass less than 1.5 lbs (0.68 kg), sub code 6 Striped Bass over 1.5 lbs (0.68 kg), and sub code 1 for non-Striped Bass (catfish and black bass species). At the beginning of each month, up to seven HTI 795LG/ Biomark HPT9, 17 HTI 795LY/ Biomark HPT9, and seven HTI 795LZ/ Biomark HPT9 acoustic/PIT combination tags were programmed with codes from the lists provided by HTI. Tags that were not used the prior month were rolled forward into the new month. Following tag programming, each tag was checked for functionality via a tag "sniffer" or a hydrophone attached to an HTI 395 mobile data logger. Up to 31 predatory fish captured during the sampling efforts that were larger than 0.5 lbs (0.23 kg) were tagged with HTI/ Biomark combination acoustic/PIT tags as well as a secondary external Floy tag (Table 13).

Table 13: Maximum Number of Predatory Fish to be Acoustically Tagged Each Month.

HTI Tag Type	Fish Size Range lbs(kg)	Striped Bass	Black Bass	Catfish	Total Tags per Month
795LG – sub code 22	>0.5 (0.23) to <1.5 (0.68)	7	0	0	7
795LY – sub code 1 (non-Striped Bass); sub code 6 (Striped Bass)	>1.5 (0.68) to <3.0 (1.36) (Striped Bass) >1.5 (0.68) (non-Striped Bass)	7	5	5	17
795LZ – sub code 6	>3.0 (1.36)	7	0	0	7
Total Fish per Month		21	5	5	31

Internal tagging followed procedures based on methods described in Wingate and Secor 2007, and incorporated the use of new anesthesia methods as part of the INAD for Aqui-S 20E (USFWS 2011; Study #'s 11-741-13-243E, 11-741-13-177F, 11-741-13-176F, 11-741-13-175F, 11-741-13-174F, 11-741-13-039, 11-741-13-013, 11-741-13-040, and 11-741-13-012). All captured predatory fish that were not acoustic tagged, were tagged with Biomark HPT9 PIT tags so that they could be identified in the event of recapture or salvage.

Acoustic tagging was conducted on 33 predator sampling days, at various times during the day from May 3, 2013 until December 27, 2013. Initially, only acoustically tagged fish were fitted with secondary external Floy tags (model FM-84 Laminated Internal Anchor Tags) applied via a small incision placed on the opposite side of the abdomen from the surgical incision. However, following the discovery of a PIT tagged fish (in this case a salmon) within a captured predator and subsequent investigation into the potential for PIT tag signal collision resulting in false negatives, secondary external Floy tags were applied to all captured fish.

To minimize invasiveness of the external marking procedures, the Floy tag model was switched from a single FM-84 Laminated Internal Anchor Tag to the less invasive FD-68B T-Bar Anchor (applied to the dorsal side of the fish via injection). To minimize the potential loss of visible tags from tag shedding, two Floy tags were applied to each fish, one on either side of the dorsal fin. After the fish was tagged, scale samples were taken, and the fish was placed into a recovery net at the point of capture, and monitored until swimming normally. Once the fish was deemed fully recovered it was released.

2.4.2 Issues

Installation of phase one of the receiver array was initially planned to begin on January 9th, 2013, however due to scheduling conflicts, limitations in available trained and qualified boat crews, and the changes in SWP coordination protocols and call-in procedures, installs were delayed significantly. Once the new SWP procedures were in place, EROF's for the receiver install work were submitted, and WCA's were received on March 25th, 2013. Installation of the first nine receivers was initiated on April 5th, 2013.

Acoustic tagging required surgical technique training and at the inception of the project, only one fully trained and experienced tagger was available, making scheduling of tagging efforts challenging. Training sessions to bring additional taggers onto the project were initiated in March.

A comprehensive list of tag codes for the acoustic tags was provided by HTI at the beginning of the sampling year. This code list included specific sub codes that were pre-designated to differentiate the categories of fish receiving tags as part of the CCFPS. These sub codes allow for quick identification of the fish from different studies and expand the number of unique codes that can be used in the greater Delta for concurrent studies. During initial tag programming, a group of 22 tags were coded without the sub code and subsequently placed in fish that were released into the system. The mistake was identified, procedures for programming and double checking tags were refined, and a glitch in the software was identified and corrected to prevent further release of tags without sub codes. Unfortunately, for the life of the 22 tags released, the main tag codes have been rendered unusable by any other studies in the Delta region.

The initial receiver array was made up of older model HTI 295 dataloggers, which were not sync-able to one another, required physical visits to check, download data, and conduct maintenance. Several of the units also experienced multiple failures, which resulted in limited data loss and gaps in the overall data set. Furthermore, access problems resulting from a significant structural failure resulting in one of the radial gates becoming dislodged and subsequent construction, as well as boat access problems such as loss of navigability during times of high SAV load, and lack of access to qualified boat operators, led to some units not being checked and downloaded as often as was preferred and caused delays in correcting problems when identified.

2.4.3 Data Analysis

All tagging data were recorded onto Rite-in-Rain datasheets that were scanned onto the DWR server and transcribed into an excel spreadsheet. Release dates and times for each acoustic tagged fish were sent to HTI on a weekly basis. Tags were identified by tag type so that they can be removed from the search list as their batteries, which have different lifespans based upon type, reach the end of life. Data downloaded from the acoustic receivers was transferred to HTI staff via jump drive and analyzed when they returned to their office in Seattle.

Data was analyzed by uploading each hour long file from each receiver into the MarkTags® software and identifying tags that had been detected by the hydrophone. Each tag signature identified by the software has a visual beginning and end which are marked via electronic bookmarks and show which tag and what time it was detected (Figure 16). This information was initially processed by an automated program and then verified by trained technicians.

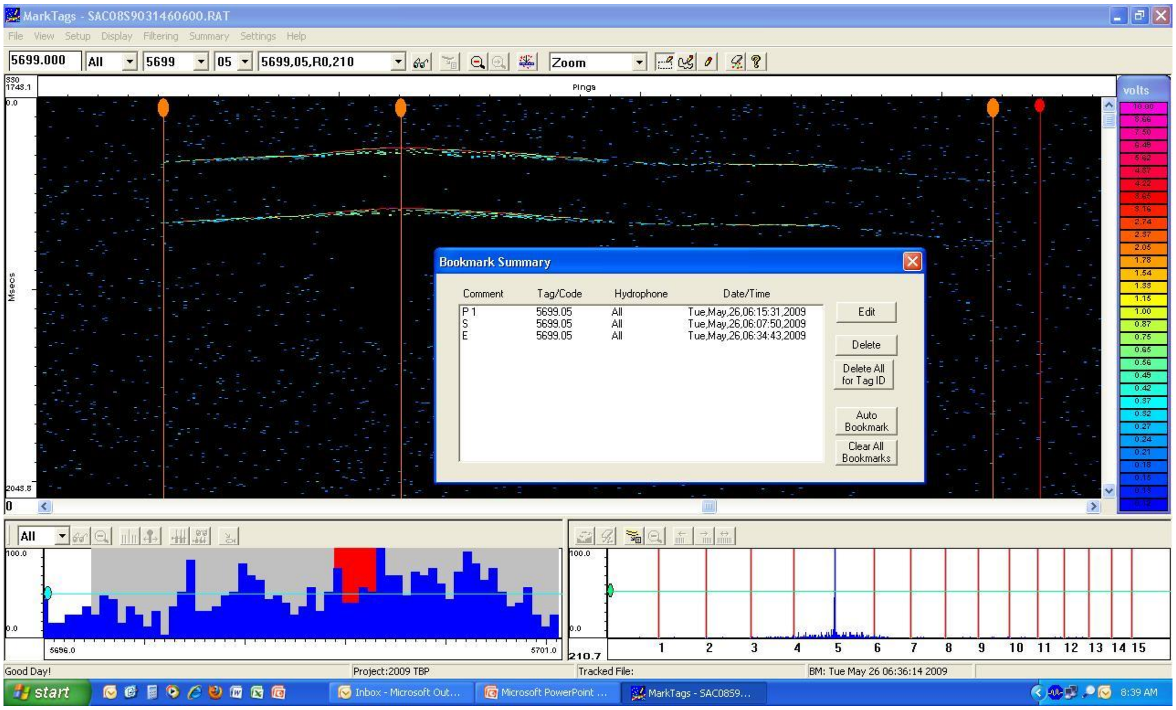

Figure 16: MarkTag Screenshot Displaying a Tagged Fish (2009 K. Clark)

Once analysis via MarkTags® was complete, the acoustic data was placed into a database which allowed for a secondary quality control phase, consisting of checking for tags that appeared to be detected by any hydrophone prior to release. Following verification of the data, the database was fully populated and returned to DWR. The database allowed for determination of the first and last detection of each tagged fish at each receiver location. By looking at all of the receiver stations chronologically, a tagged fish can be “observed” as it moves through the array over time. This can be further visualized using programs such as EON fusion (Figure 17).

A list of acoustic tags released into the Forebay was compiled and compared to a list of acoustic tags detected by the receivers in the array. Then each tag confirmed as being detected in the array was analyzed for first and last detection at each receiver, so that gross movement through the array as well as movement across, into and out of the Forebay, could be identified.

Figure 17: ScreenShot of EONFusion tracks showing Acoustically Tagged Fish at the Tracy Fish Facility

2.4.4 Results

A total of 149 predatory fish were acoustically tagged; eight catfish, 18 Largemouth Bass, and 123 Striped Bass (Table 14). The target number of 31 acoustically tagged fish per month was never achieved during 2013 tagging efforts. The highest number of acoustically tagged fish occurred in October and the lowest number occurred in May, at 26 and 12 fish, respectively. Of the 149 total tagged fish, 10 were never detected by any of the receivers in the array, including two Largemouth Bass and eight Striped Bass. As these fish were not necessarily tagged and released within range of the deployed receivers, it is possible that a fish could be active in the Forebay, but never be detected. Since no mobile monitoring was conducted in 2013, it was not possible to detect fish outside of the range of the array.

Table 14: Acoustic Tagged Fish in 2013

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Largemouth Bass	1	1	1	1	2	5	2	5	18
Catfish Species	1	5	2	0	0	0	0	0	8
Striped Bass (LG)	2	8	7	7	7	7	6	7	51
Striped Bass (LY)	7	3	7	7	7	7	7	7	52
Striped Bass (LZ)	1	0	0	0	4	7	7	1	20
All Species	12	17	17	15	20	26	22	20	149

Of the remaining 139 acoustically tagged fish, 16 were detected on receivers inside and outside of the Forebay, indicating that they emigrated from the Forebay. Of those 16 fish that emigrated, two returned to the Forebay at a later date in 2013 (Table 15).

Table 15: Acoustic Tagged Fish Detected Outside of Forebay

				Date Detected Inside Forebay				Date Detected Outside Forebay				
Species	Tag Number	Location Captured/ Released	Date Released	Intake Canal 3	Intake Canal 2	Intake Canal 1	Radial Gates Downstream	Radial Gates Upstream	West Canal 1	West Canal 2	West Canal 3	Old River South 1
Largemouth Bass	9015.01	Area 2	5/28/2013	5/28/2013	5/29/2013	5/31/2013	6/28/2013	6/30/2013				6/30/2013
Striped Bass (LY)	6221.06	Area 4	5/30/2013	6/5/2013	6/5/2013	6/5/2013	6/2/2013	6/28/2013	6/28/2013	6/28/2013	6/28/2013	7/9/2013
Striped Bass (LG)	7909.22	Area 3	5/30/2013	**11/2/2013**	9/16/2013	9/16/2013	5/30/2013	9/17/2013	9/17/2013			
Striped Bass (LY)	6529.06	Area 3	5/31/2013	6/19/2013	6/9/2013	6/9/2013	5/31/2013	9/23/2013	11/4/2013	11/4/2013		
White Catfish	8119.01	Area 3	5/31/2013		6/17/2013	6/17/2013	5/31/2013	6/28/2013	6/28/2013	6/28/2013	6/28/2013	6/28/2013
White Catfish	6523.01	Area 3	6/4/2013				6/5/2013			10/14/2013		
Channel Catfish	6775.01	Area 3	6/11/2013				6/11/2013	7/1/2013	7/1/2013	7/1/2013	7/1/2013	7/1/2013
Striped Bass (LG)	9785.22	Area 3	6/11/2013				6/11/2013	7/2/2013	10/12/2013	10/14/2013	10/12/2013	7/2/2013
Striped Bass (LY)	6501.06	Area 2	6/11/2013	6/21/2013	6/19/2013	6/19/2013	6/15/2013	6/29/2013	6/30/2013			6/30/2013
Striped Bass (LY)	6025.06	Area 1	6/26/2013	6/27/2013	6/27/2013	6/27/2013				6/29/2013		
Striped Bass (LG)	6845*	Area 3	8/6/2013	8/16/2013	8/13/2013	8/12/2013	8/17/2013	8/26/2013	8/26/2013			
Striped Bass (LG)	7097*	Area 3	8/6/2013				8/6/2013	8/13/2013	8/13/2013			
Striped Bass (LZ)	9525.06	Area 3	9/25/2013		9/27/2013	9/27/2013	9/28/2013	10/30/2013	10/30/2013	10/30/2013	10/30/2013	
Striped Bass (LZ)	5857.06	Area 3	10/17/2013	10/19/2013		10/19/2013	10/17/2013	11/4/2013	11/4/2013	11/4/2013	11/7/2013	
Striped Bass (LY)	6165.06	Area 1	10/18/2013	10/30/2013	10/30/2013	10/30/2013	10/24/2013	11/2/2013	11/30/2013	11/30/2013	12/3/2013	
Striped Bass (LY)	7481.06	Area 1	11/5/2013			**11/23/2013**	11/5/2013	11/10/2013	11/10/2013	11/11/2013	11/13/2013	

*Tags programmed without subcode; bold red type and grey highlight indicates fish that returned to the Forebay

Of the 139 tagged fish that were detected, 29 were only detected in the intake channel, 32 were only detected at the radial gates, 14 were detected moving from the intake channel to the radial gates, 13 were detected moving from the radial gates to the intake channel, 35 were detected moving back and forth between the intake channel and the radial gates, and 16 were detected outside of the Forebay. The single recaptured Striped Bass was caught in the vicinity of the radial gates, which is the same general location of its original capture, although the fish was detected in the intake canal as well, indicating that it moved back and forth across the Forebay.

2.4.6 Discussion and Recommendations

Of the 149 tagged predatory fish, ten remained undetected by the receiver array. Based upon the fish that were detected, several behavioral patterns are beginning to emerge as the acoustic data is compiled and analyzed. Of the 139 tagged fish, approximately 44%, 61 fish, were only detected in a single location, either the intake channel or the vicinity of the radial gates, and approximately 44%, 62 fish, were detected moving between the intake channel and the radial gates, in either one direction or back and forth. The remaining approximately 12%, 16 fish, were detected leaving the Forebay. Of this 16 fish, two returned to the Forebay.

The 2013 data set shows immigration and emigration as well as residency, both localized, remaining in a specific portion of the Forebay, as well as more broad roving behavior, moving multiple times across the Forebay. The tags employed in this project will continue to provide data for up to three years per individual fish, allowing for a much better picture of these behaviors over time. The data set expressed in this interim report shows a limited picture in that the fish detected have not all been in the system for the same amount of time, and no tags have been in the system for more than eight months. For instance, fish tagged in November or December have only been detectable for one to two months, not long enough to discern their short-term or ultimate behavioral strategies. It is important to note that currently this data set is very limited in its scope as these tags are intended to provide long term data on individual fishes, allowing for a better understanding of movement behaviors over multiple seasons and years.

The current receivers deployed within and adjacent to the Forebay will be upgraded to units that can be remotely monitored and time synced for improved accuracy, and the balance of the array will be deployed in subsequent years. A sub-set of predatory fish should be held in the lab for the purposes of tag retention studies and tagger quality control, to ensure that the data collected is as accurate as possible. Ten of the 149 fish tagged were never detected following release. It is likely that a fish can remain undetected in the Forebay throughout the study period, if it remains in the central portion of the Forebay, which is outside of the range of the currently deployed array. Therefore, mobile monitoring surveys should be instituted to cover areas of the Forebay that are not currently covered by the array.

2.6 Creel Surveys

2.6.1 Methods

Roaming angler (creel) surveys were planned for three days a week, two week days and one weekend day, and were conducted either in the morning (0900 until noon) or the afternoon (noon until 1600). While anglers can access the Forebay throughout the evening hours as well, no surveys were conducted at night, due to safety concerns. Survey days and time periods were randomly selected by rolling dice, with each side of the die associated with a day or time (Table 19).

Table 16: Creel Survey Selection

Die Side	1	2	3	4	5	6
Weekday	Monday	Tuesday	Wednesday	Thursday	Friday	Re-roll
Weekend Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday
Time	Morning	Morning	Morning	Afternoon	Afternoon	Afternoon

A total of 80 roaming surveys from the tip of the Fisherman's Point peninsula to the Radial Gates along the public access pathway (Figure 20) were conducted between April 26, 2013 and December 31, 2013.

Figure 18: Creel Survey Route

2.6.2 Issues

SWP coordination protocols and call-in procedures for work conducted at the Clifton Court Forebay were changed significantly on the morning of January 25, and all work on the CCFPS was suspended. DFD provided a final procedural guide to the DWR Bay-Delta Office (BDO), and the EROF for creel surveys was filed with DFD in March 2013. Approval for creel surveys was received on March 20, 2013, and the first creel survey did not occur until April 26, 2013 due to logistical complications with initiating the surveys.

Creel surveys were planned to continue year-round from the radial gates to the tip of fisherman's point, however, on July 8, 2013 the radial gates suffered a significant structural failure resulting in one of the gates becoming dislodged. As a result of this structural failure, the area in the vicinity of the radial gates was closed to recreational anglers, while DFD worked to evaluate the extent of the damage and make repairs. Access to the area did not reopen in 2013, and may have resulted in fewer anglers using the Forebay. Surveys were also limited to daylight hours due to safety concerns.

Additional issues with the 2013 effort included a map (Figure 21) that was too divergent from the map used for predator sampling, making the CPUE's incomparable to a great extent. Additionally, the landmarks on the map are hard to distinguish, reducing accuracy of angler placement.

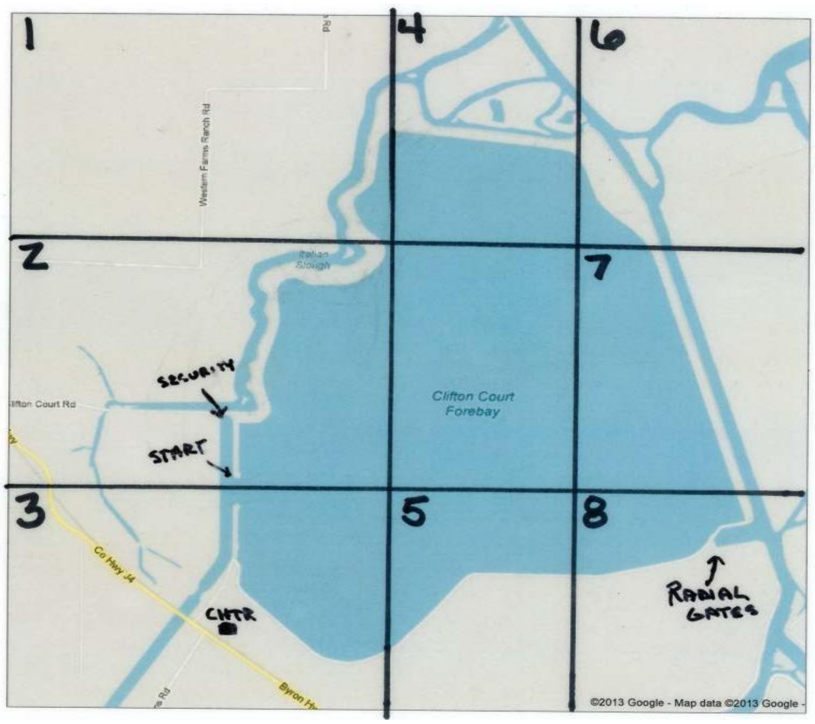

Figure 19: Creel Map 2013

2.6.3 Data Analysis

Data sheets were scanned and data was initially compiled into an excel spreadsheet to ensure that no data became lost while a database was under development. A database for creel surveys was completed in May 2014, and the creel data was transferred from the excel spreadsheet for analysis. Total catch, catch by species, and catch by location for each month and the year as a whole were compiled for the entire Forebay, and catchability, defined as catch per unit effort (CPUE) per sampling day was calculated using the equation:

$$q = \frac{C}{f \times a}$$

(q = catchability (fish caught per hours of sampling), C = catch, f = fishing effort which is defined as hours spent fishing per sampling day, and a = number of anglers during the effort)

Mean CPUE for all species per month was then estimated by:

$$q_m = \frac{\sum q_i}{d}$$

(q_m = mean monthly catchability, q_i = catchability for each day sampled in the month, and d = number of sampling days in the month)

Mean CPUE per month was then calculated for each species using the equation

$$q_{sp} = \frac{\Sigma\left(\frac{Csp}{f \times a}\right)_i}{d}$$

2.6.4 Results

A total of 1,191 anglers were observed fishing at the Clifton Court Forebay in 2013. Anglers were found to fish in the greatest numbers on Saturdays and Sundays (Figure 22) and averaged 14 anglers per day throughout the year, with the highest numbers of anglers present in June (Figure 23).

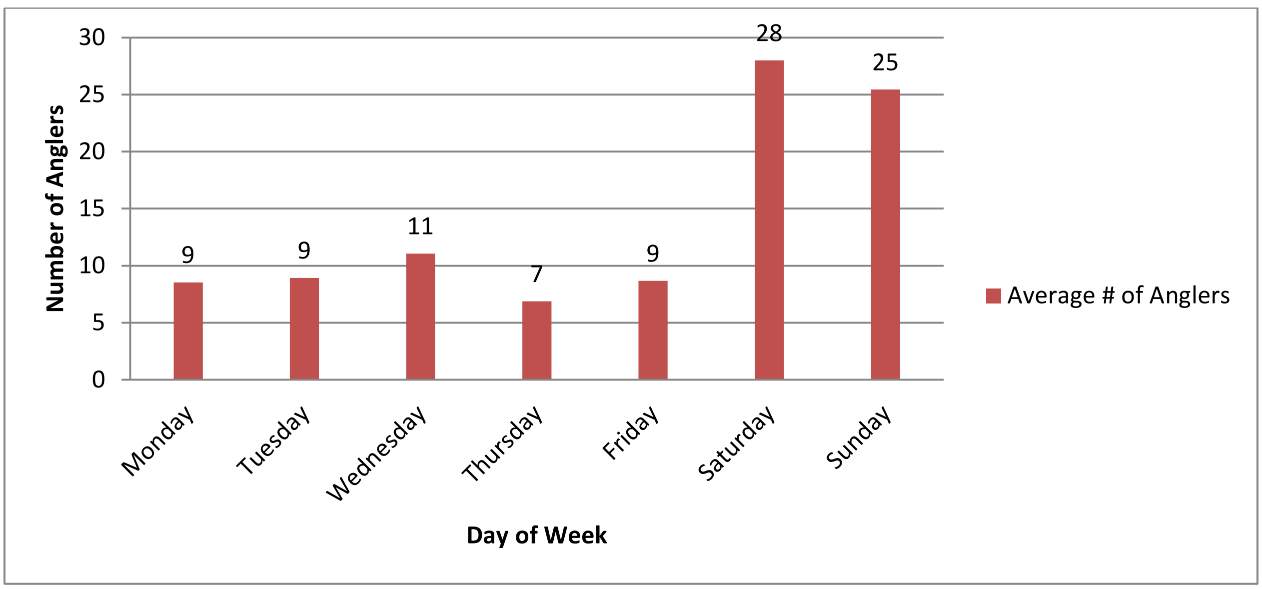

Figure 20: Average Number of Anglers by Day of Week in 2013

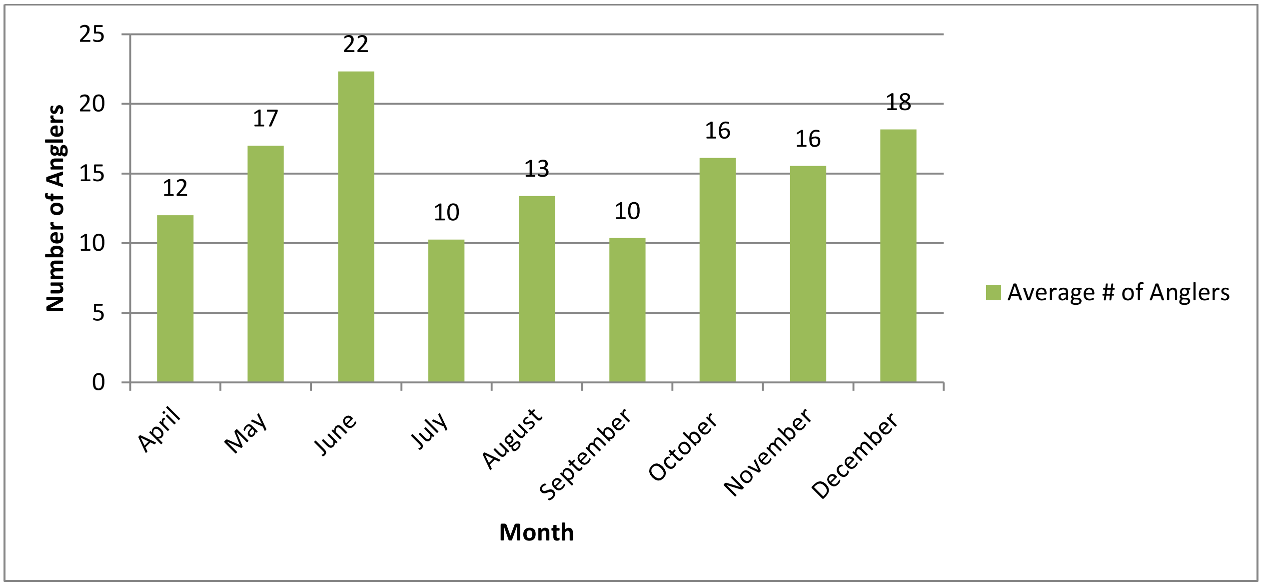

Figure 21: Average Number of Anglers by Month in 2013

Anglers fished a total of 2,806 hours over the survey period, with the greatest number of hours spent in Area 2 and the least number of hours spent in Area 5, at 2,068 and 47 hours respectively (Table 20). The second most frequented fishing location was area 8, at 337 hours. This area was closed to the public during the radial gate repairs, which likely shifted the effort to Area 2. During months when access was available to both areas, such as May and June, hours spent in Area 8 were similar to hours spent in Area 2. Note that although Area 5 is technically closed to the public, there were fishermen observed and surveyed in the area. Five months had eight or fewer surveys conducted, while the remaining four months had greater than 12 surveys conducted (Figure 24).

Table 17: Hours Fished by Month and Location in 2013

Month	Area 1 Northwest Corner	Area 2 Fisherman Point	Area 4 North Center	Area 5 South Center	Area 6 Northeast Corner	Area 7 Northeast Center	Area 8 Radial Gates Vicinity
Apr	0	3.25	0	0	0	0	30.5
May	0	101.34	0	6	0.66	0	100.57
Jun	4	129.04	0	33.5	0	0	157
Jul	0	78.32	0	4	3	9	40
Aug	12	391.56	14.5	0	0	55.5	5.5
Sep	11.92	234.14	39.75	3.5	36	16	0
Oct	0	246.15	17	0	10	11.5	0
Nov	23.75	492.53	0	0	18	9	3
Dec	0.25	391.4	0	0	0	3	0
Year	51.92	2067.73	71.25	47	67.66	104	336.57

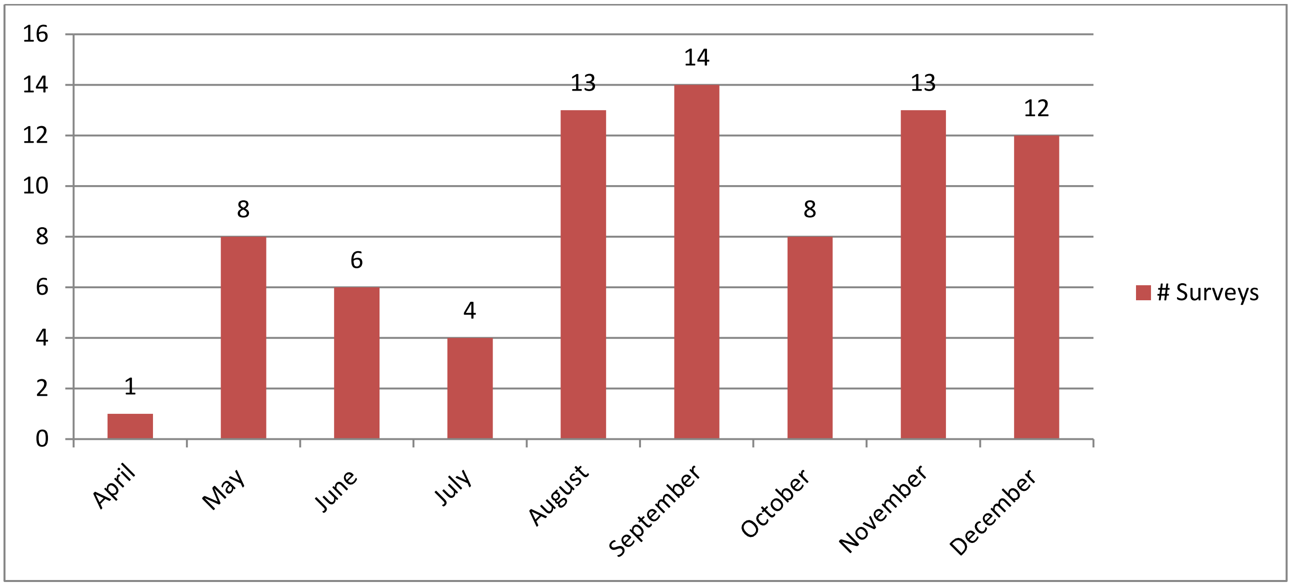

Figure 22: Number of Surveys per Month in 2013

Anglers that were interviewed captured a total of 807 fish during the survey period, with the catch ranging from 11 fish in April to 195 fish in November (Table 21). None of these fish were recaptures.

Table 18: Total Catch by Location and Month in 2013

Month	Area 1 Northwest Corner	Area 2 Fisherman Point	Area 4 North Center	Area 5 South Center	Area 6 Northeast Corner	Area 7 Northeast Center	Area 8 Radial Gates Vicinity	All Sites Total
Apr	0	0	0	0	0	0	11	11
May	0	18	0	2	0	0	43	63
Jun	2	21	0	8	0	0	88	119
Jul	0	15	0	0	3	1	1	20
Aug	11	70	8	0	0	16	0*	105
Sep	13	65	10	0	3	8	0*	99
Oct	0	87	4	0	0	9	0*	100
Nov	38	154	0	0	3	0	0*	195
Dec	0	95	0	0	0	0	0*	95
Year	64	525	22	10	9	34	143	807

* Radial gate outage and access limited

CPUE was calculated for total catch captured at each location by month, and was found to range from 0.15 in July to 0.37 in June for all sites combined (Table 22). CPUE was highest for Area 1 in September and November, at 1.09 and 1.60, respectively, and Area 6 in July at 1.00 (Figure 25).

Table 19: CPUE by Location and Month in 2013

Month	Area 1 Northwest Corner	Area 2 Fisherman Point	Area 4 North Center	Area 5 South Center	Area 6 Northeast Corner	Area 7 Northeast Center	Area 8 Radial Gates Vicinity	All Sites Total
Apr	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.33
May	0.00	0.18	0.00	0.33	0.00	0.00	0.43	0.30
Jun	0.50	0.16	0.00	0.24	0.00	0.00	0.56	0.37
Jul	0.00	0.19	0.00	0.00	1.00	0.11	0.03	0.15
Aug	0.92	0.18	0.55	0.00	0.00	0.29	0.00*	0.22
Sep	1.09	0.28	0.25	0.00	0.08	0.50	0.00*	0.29
Oct	0.00	0.35	0.24	0.00	0.00	0.78	0.00*	0.35
Nov	1.60	0.31	0.00	0.00	0.17	0.00	0.00*	0.36
Dec	0.00	0.24	0.00	0.00	0.00	0.00	0.00*	0.24
Year	1.23	0.25	0.31	0.21	0.13	0.33	0.42	0.29

*Radial gate outage and access limited

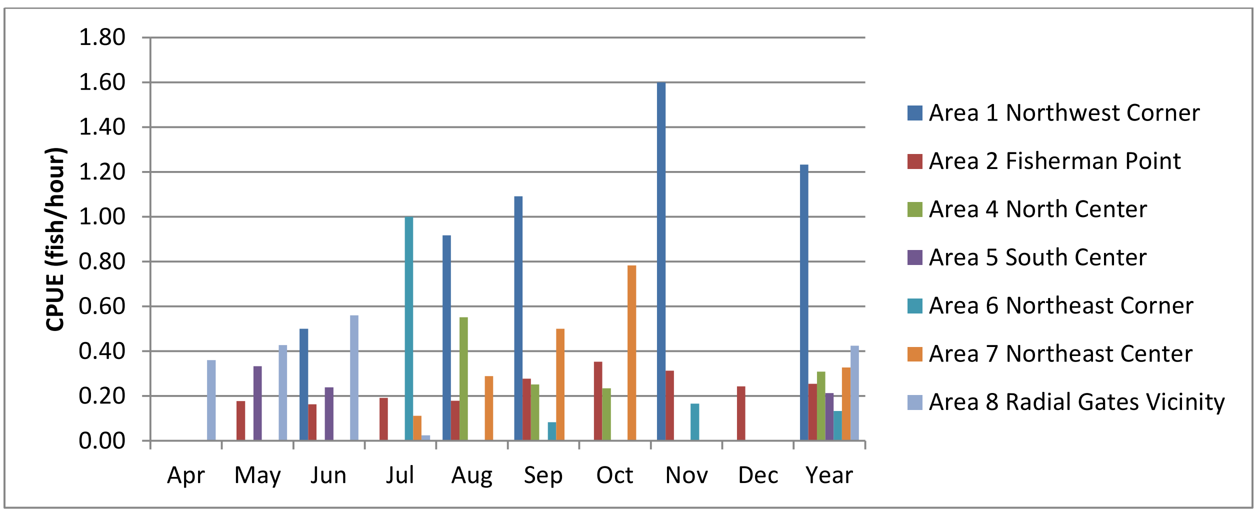

Figure 23: CPUE by Location and Month in 2013

Anglers caught 632 Striped Bass during the survey period, which made up 78% of the total catch of 807 fish. The second most commonly caught fish was catfish[4], at 104 fish, followed by Largemouth Bass, at 27 fish, or 13% and 3% of the total catch, respectively (Table 23). A single adult Chinook salmon was caught in October.

[4] Catfish were not identified to species during the creel surveys, unless the survey crew was able to see the fish caught. Often, anglers did not specify the species. For this reason all catfish were pooled into a single group.

Table 20: Total Catch by Species and Month in 2013

Month	Hours Fished	Unknown	American Shad	Bluegill	Carp	Chinook Salmon (Adult)	Crappie	Perch	Small Mouth Bass	Largemouth Bass	Catfish (Any)	Striped Bass	Total Catch
Apr	33.8	0	0	0	4	0	0	0	0	0	1	6	11
May	208.6	1	0	0	0	0	0	1	0	8	11	42	63
Jun	323.5	0	0	3	1	0	0	0	0	4	31	80	119
Jul	134.3	0	0	0	0	0	0	0	0	0	13	7	20
Aug	479.1	0	0	0	0	0	0	0	2	3	37	63	105
Sep	341.3	1	0	0	0	0	0	0	0	5	4	89	99
Oct	284.7	1	1	6	0	1	0	0	2	2	2	85	100
Nov	606.8	20	7	9	0	0	1	0	0	0	5	153	195
Dec	394.7	0	0	3	0	0	1	0	0	5	0	86	95
Year	2806.6	23	8	21	5	1	2	1	4	27	104	632	807

Angler catch of Striped Bass peaked in November at 153 fish, while Largemouth Bass catch peaked in May, and catfish peaked in August, with 8 and 37 fish, respectively (Figure 26).

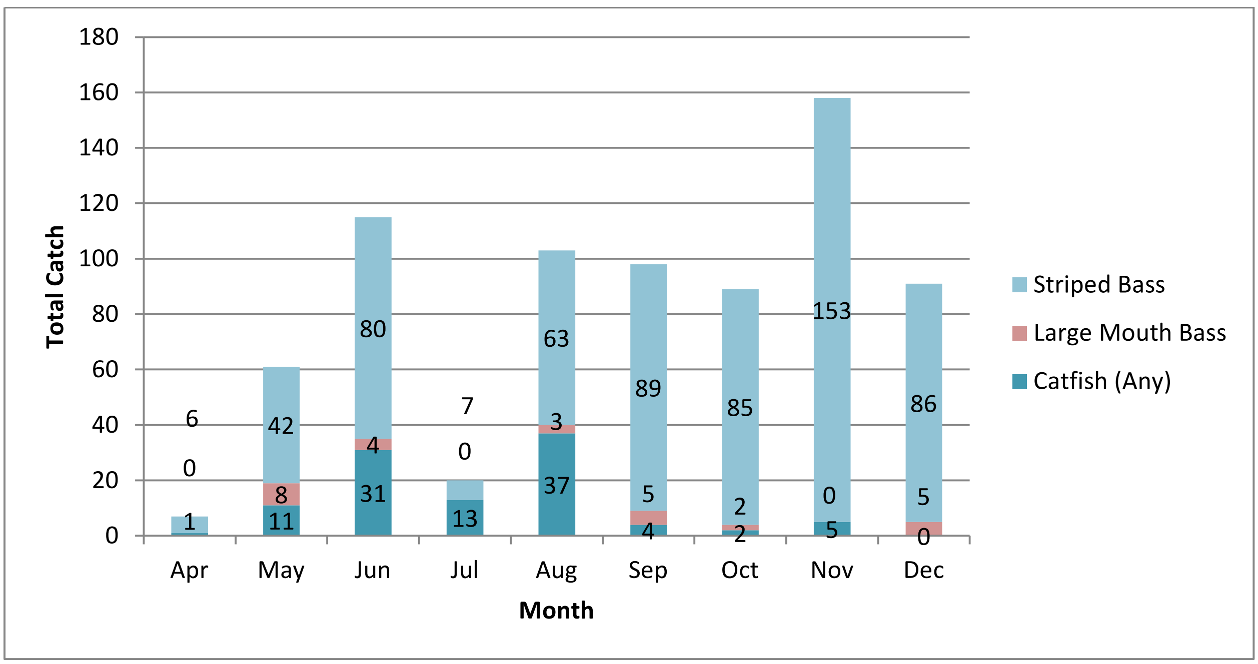

Figure 24: Total Striped Bass, Largemouth Bass and Catfish by Month in 2013

CPUE for total catch ranged from 0.15 in July to 0.37 in June and averaged 0.29 for the entire survey period. When calculated for individual species, CPUE was found to range from 0.05 to 0.30 for Striped Bass, 0.00 to 0.10 in catfish, and 0.00 to 0.04 in Largemouth Bass (Table 24, Figure 27). CPUE for Striped Bass peaked in October at 0.30, which does not correspond with the November peak in numerical catch However hours fished in November were nearly double those fished in October, which accounts for that difference.

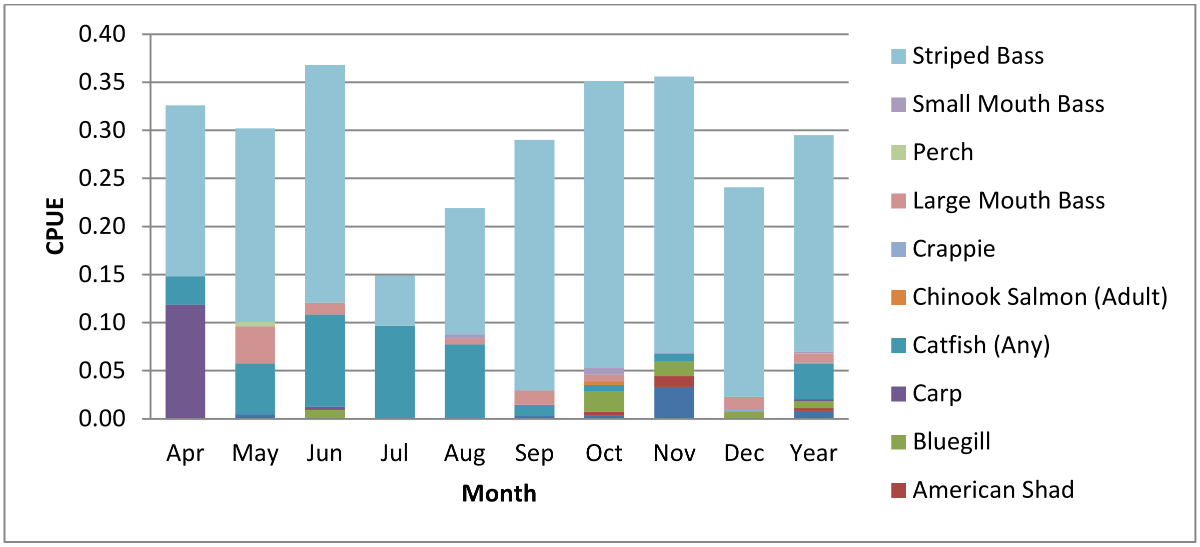

Figure 25: CPUE by Species and Month in 2013

Table 21: CPUE by Species and Month in 2013

Month	Hours Fished	Unknown	American Shad	Bluegill	Carp	Chinook Salmon (Adult)	Crappie	Perch	Small Mouth Bass	Largemouth Bass	Catfish (Any)	Striped Bass	Total Catch
Apr	33.75	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.03	0.18	0.33
May	208.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.20	0.30
Jun	323.54	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.25	0.37
Jul	134.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.05	0.15
Aug	479.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.13	0.22
Sep	341.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.26	0.29
Oct	284.65	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.30	0.35
Nov	606.78	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.32
Dec	394.65	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.22	0.24
Year	2806.63	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.22	0.29

When calculated based upon fishing location, the two highest Striped Bass CPUE were found in Area 1 in September and November, at 1.09 and 1.60 respectively (Table 25, Figure 28). The lowest calculated CPUE for Striped Bass was noted in Areas 8 and 2 in July, at 0.03 and 0.05 respectively.

Table 22: CPUE for Striped Bass by Month and Location in 2013

	Area 1 Northwest Corner	Area 2 Fisherman Point	Area 4 North Center	Area 6 Northeast Corner	Area 7 Northeast Center	Area 8 Radial Gates Vicinity
Apr	0.00	0.00	0.00	0.00	0.00	0.20
May	0.00	0.14	0.00	0.00	0.00	0.28
Jun	0.00	0.09	0.00	0.00	0.00	0.44
Jul	0.00	0.05	0.00	0.67	0.00	0.03
Aug	0.92	0.11	0.14	0.00	0.13	*
Sep	1.09	0.26	0.25	0.00	0.38	*
Oct	0.00	0.29	0.24	0.00	0.78	*
Nov	1.60	0.23	0.00	0.17	0.00	*
Dec	0.00	0.22	0.00	0.00	0.00	*

* Radial gate outage and access limited

It is important to note that access to Area 8, which had the highest CPUE for Striped Bass in comparison to other areas from April through June, was closed to the public for repairs to the radial gates, from mid-July through the end of the year.

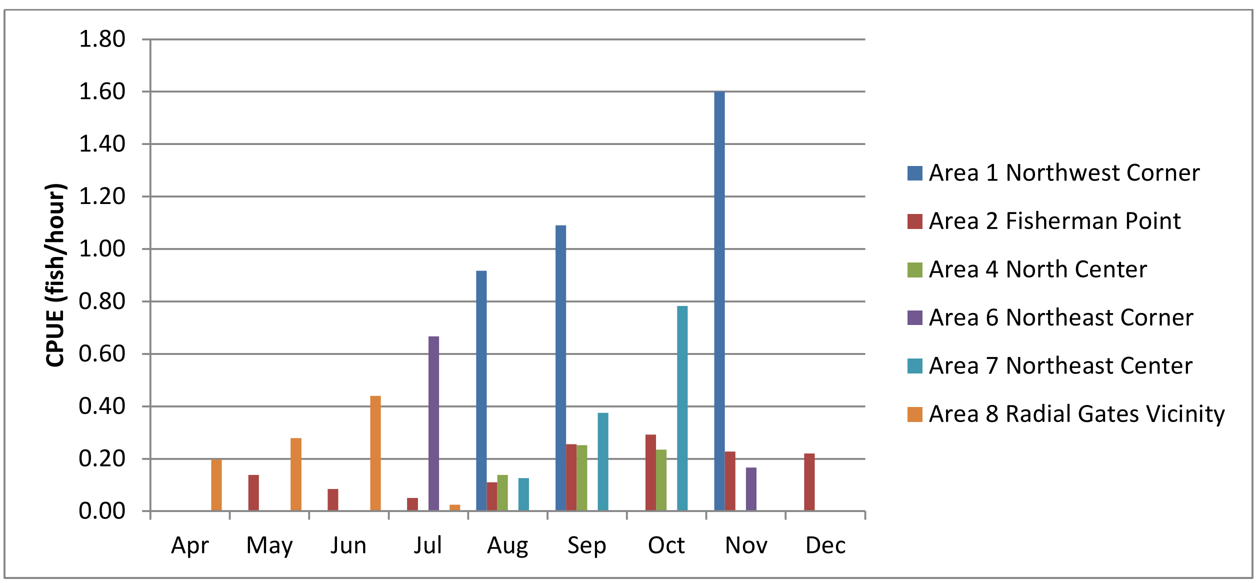

Figure 26: CPUE for Striped Bass by Location and Month in 2013

When calculated based upon fishing location, the Largemouth Bass CPUE was found to be highest in Area 1 in June, at 0.50 and Area 7 in September, at 0.13 (Table 26, Figure 29). CPUE for Largemouth Bass remained at or below 0.05 for the balance of the locations across all months during which they were caught.

Table 23: CPUE for Largemouth Bass by Month and Location in 2013

	Area 1 Northwest Corner	Area 2 Fisherman Point	Area 5 South Center	Area 7 Northeast Center	Area 8 Radial Gates Vicinity
Apr	0.00	0.00	0.00	0.00	0.00
May	0.00	0.03	0.00	0.00	0.05
Jun	0.50	0.00	0.03	0.00	0.01
Jul	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.01	0.00	0.00	*
Sep	0.00	0.01	0.00	0.13	*
Oct	0.00	0.01	0.00	0.00	*
Nov	0.00	0.00	0.00	0.00	*
Dec	0.00	0.01	0.00	0.00	*

* Radial gate outage and access limited

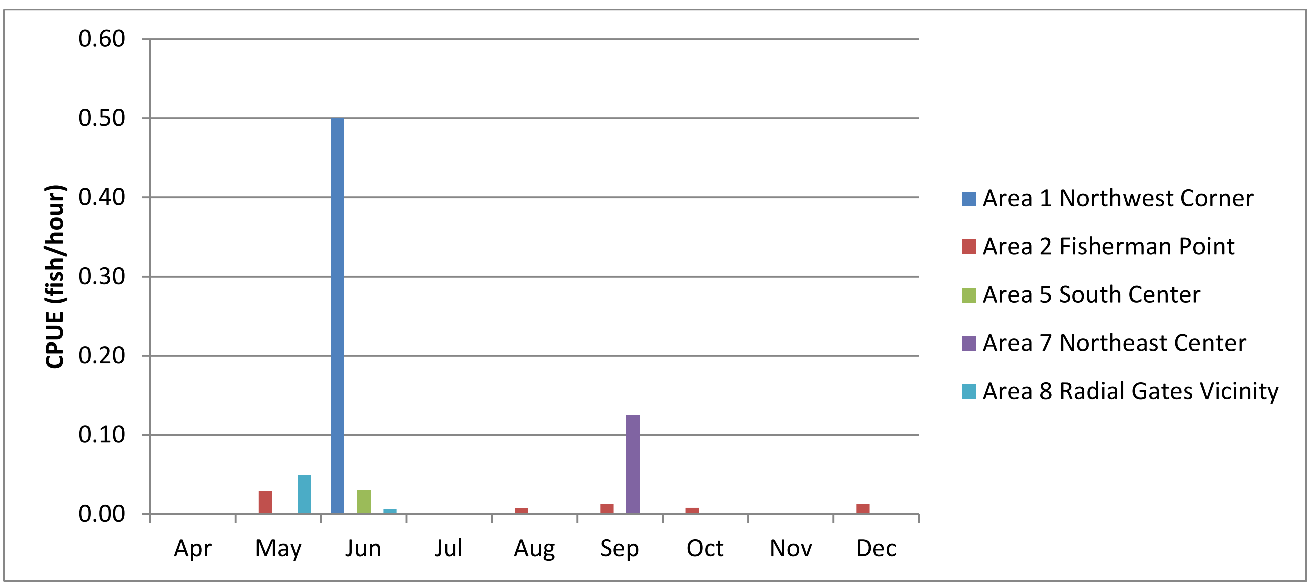

Figure 27: CPUE for Largemouth Bass by Month and Location in 2013

When calculated based upon fishing location, the catfish CPUE was found to be highest in Area 4 in August, at 0.41, followed by Area 5 in May and Area 6 in July, at 0.33 (Table 27, Figure 30). CPUE for catfish was lowest in Area 2 in April, May, and September through November, at or below 0.01.

Table 24: CPUE for Catfish by Month and Location in 2013

	Area 2 Fisherman Point	Area 4 North Center	Area 5 South Center	Area 6 Northeast Corner	Area 7 Northeast Center	Area 8 Radial Gates Vicinity
Apr	0.00	0.00	0.00	0.00	0.00	0.03
May	0.01	0.00	0.33	0.00	0.00	0.08
Jun	0.05	0.00	0.21	0.00	0.00	0.11
Jul	0.14	0.00	0.00	0.33	0.11	*
Aug	0.06	0.41	0.00	0.00	0.13	*
Sep	0.00	0.00	0.00	0.08	0.00	*
Oct	0.01	0.00	0.00	0.00	0.00	*
Nov	0.01	0.00	0.00	0.00	0.00	*
Dec	0.00	0.00	0.00	0.00	0.00	*

* Radial gate outage and access limited

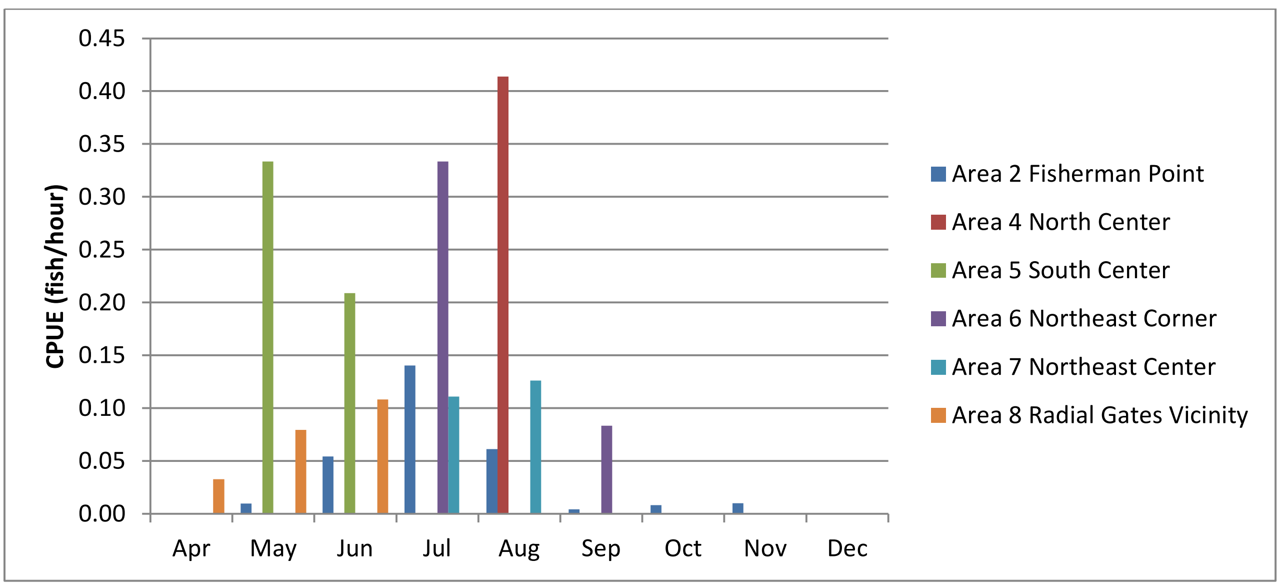

Figure 28: CPUE for Catfish by Month and Location in 2013

2.6.5 Discussion and Recommendations

Fishing at the Forebay by the public is restricted to the shore, from Fisherman Point to the Radial Gates, which reduces an angler's ability to reach the "hot spots" that are accessible by boat. In turn this reduces the portion of the total predatory fish population accessible within the casting envelope of approximately 100 feet from the shore. The bulk of anglers stay within this portion of the shore, however a small number of anglers fish along the portion of the shore that is beyond the Radial Gates, and some anglers have been observed wading into the Forebay in the vicinity of the Radial Gates. Anglers that were observed along the shore were asked to participate in the creel survey, but were not required to do so. Additionally, anglers that were in the water or along the wing walls protruding from the base of the Radial Gate structure were considered inaccessible and not included in the survey, to ensure the safety of the survey team. Most anglers that were encountered were willing to participate in the survey, with only 14 anglers refusing to do so during the 2013 survey effort.

Anglers that were interviewed during creel surveys fished a total of 2,806 hours and captured a total of 807 fish during the survey period. Anglers caught a wide variety of fish including carp, shad, sunfishes, bass and catfish. Striped Bass, catfish and Largemouth Bass were most often targeted and caught, with 632 Striped Bass, 104 catfish, and 27 Largemouth Bass, which made up 76%, 13%, and 3% of the total catch, respectively, caught during the survey period. A single adult Chinook salmon was caught in October.

CPUE for the total catch for all sites combined ranged from 0.15 in July to 0.37 in June and averaged 0.30 for the entire survey period. When calculated for individual species, angler CPUE was found to range from 0.05 to 0.30 for Striped Bass, 0.00 to 0.10 in catfish, and 0.00 to 0.04 in Largemouth Bass. CPUE varied by month and location, with the highest the total catch CPUE being recorded in Area 1 in September and November.

Area 1 is a small area along the Northwest Corner of the Forebay, and is not heavily used. However, due to the restricted access to the radial gates area from August through the end of the year, the fishing pressure shifted to other areas, such as Areas 1, 4 and 6. Restrictions also likely resulted in decreased fishing activity at the Forebay, as the Radial Gates appears to be one of the often selected locations for anglers.

We recommend that surveys continue year round, as originally planned, to gain a better understanding of angler trends before, during and after the restriction to access to the radial gates vicinity. It is also recommended that surveys continue to be conducted on weekdays and weekends to increase the number of anglers included in the survey and to cover a truly representative cross section of anglers including the regular/experienced anglers and the occasional/inexperienced anglers. It is also recommended that the creel map used during 2013 be replaced with the map used for predator sampling so that the CPUE for both efforts can be used together to provide a more complete picture.

2.7 Avian Surveys

2.7.1 Methods

Avian point count surveys, in the vicinity of the radial gates and the vicinity of the trash rack, were initiated on April 5, 2013, and were scheduled three days per week, including two week days and one weekend day. Surveys were conducted during one of three randomly selected time periods, morning (from just before sunrise until 0900), midday (1000 until 1200) or afternoon (from 1300 until 1600). The radial gates area was split into two separate survey areas to ensure adequate coverage on both sides of the structure.

Survey days and time periods were randomly selected by rolling dice, with each side of the die associated with a day or time (Table 28). A total of 89 surveys were conducted between April 5, 2013 and December 30, 2013. Of those 89 surveys, 30 were morning, 39 were midday and 20 were afternoon. Surveys were not conducted at night due to lack of visibility, safety concerns, and the fact that only one of the focal species, black-crowned night heron (*Nycticorax nycticorax*), are nighttime foragers.

Table 25: Randomized Survey Selection Process

Die Side	1	2	3	4	5	6
Weekday	Monday	Tuesday	Wednesday	Thursday	Friday	Re-roll
Weekend Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday
Time	Morning	Midday	Afternoon	Morning	Midday	Afternoon

Each survey was conducted by a minimum of two biologists for 20 minutes per survey location, using a Kowa TSN-821M spotting scope or Nikon 8x42 Monarch binoculars from predetermined vantage points (Figure 31 and 32) to ensure adequate coverage.

Figure 29: Avian Survey Trash Rack Location

Figure 30: Avian Survey Radial Gates Locations (SW & NE)

2.7.2 Issues

SWP coordination protocols and call-in procedures for work conducted at the Clifton Court Forebay were changed significantly on the morning of January 25, and all work on the CCFPS was suspended. DFD provided a final procedural guide to DWR Bay-Delta Office (BDO), and the EROF for avian surveys was filed with DFD in March 2013. Approval for avian surveys was received on March 20, 2013, and the first avian survey occurred on April 5, 2013.

Avian surveys were planned to continue year-round at the radial gates and the trash racks: however, on July 8, 2013 the radial gates structure suffered a significant failure resulting in one of the gates becoming dislodged. As a result of this structural failure, the area in the vicinity of the radial gates was closed to avian survey crews beginning August 1, 2013 while DFD worked to evaluate the extent of the damage and make repairs (Figure 33). This closure limited avian surveys to the trash rack site. Access to the radial gates was regained on November 15, 2013, and surveys were resumed at the radial gates location. Due to this temporary loss of access, 39 of the 89 surveys conducted during 2013 have no data for the radial gates area.

Figure 31: Restricted Access in the vicinity of Radial Gates

2.7.3 Data Analysis

All data was recorded onto Rite-in-Rain data sheets. Data sheets were scanned and data was initially compiled into an excel spreadsheet to ensure that no data became lost while a database was under development. Total numbers of species observed were compiled by month, location and behavior. Time spent feeding versus non-feeding were calculated by species, location and month.

2.7.4 Results

A total of 89 surveys were conducted between April 5, 2013 and December 31, 2013 and bird sightings totaled 6,166 piscivorous birds. Higher numbers of avian species were observed in the month of November and of those 6,166 birds sighted, the most common species observed at the Forebay were gulls (*Larus sp.*), double-crested cormorants (*Phalacrocorax auritus*), and American white pelicans (*Pelecanus erythrorhynchos*) (Table 29). While efforts were made to ensure that birds were not double counted during each survey effort, it is likely that the same birds were often observed at the Forebay on subsequent days.

Table 26: Avian Species Observed at all Locations in 2013

Species	Apr	May	Jun	Jul	Aug*	Sep*	Oct*	Nov	Dec	Total 2013
American White Pelican	93	52	29	3				98	190	465
Belted Kingfisher	1								1	2
Black-Crowned Night Heron									6	6
Caspian Tern		1								1
Clark's Grebe	1	3	4	1				8		17
Common Goldeneye	11							48	31	90
Common Merganser									4	4
Common Tern			1							1
Double-Crested Cormorant	62	63	45	47	13	13	41	279	566	1129
Eared Grebe	3	1					1	20	71	96
Forster's Tern	2									2
Great Blue Heron	2	12	7	2	3	9	15	8	14	72
Great Egret	1	2	2	3	1	11	25	29	131	205
Green Heron				1				1		2
Gull sp.	392	53	21	4	126	2	58	1726	1406	3788
Hooded Merganser								3		3
Horned Grebe									2	2
Osprey		1	1	1			1			4
Pied Billed Grebe	4	1	3	6	2	27	22	30	48	143
Snowy Egret				3	3	25	15	17	25	88
Tern (Unidentified)	4	4	7							15
Western Grebe	2	10	5				1	10	3	31
All species	578	203	125	71	148	87	179	2277	2498	6166

* Radial gate outage and access limited

Gulls were present during all of the months surveyed, however their numbers peaked in November and December, at 1,723 and 1,406 birds respectively (Figure 34), with the bulk of the gulls observed in the vicinity of the Trash Racks in November (Figure 35).

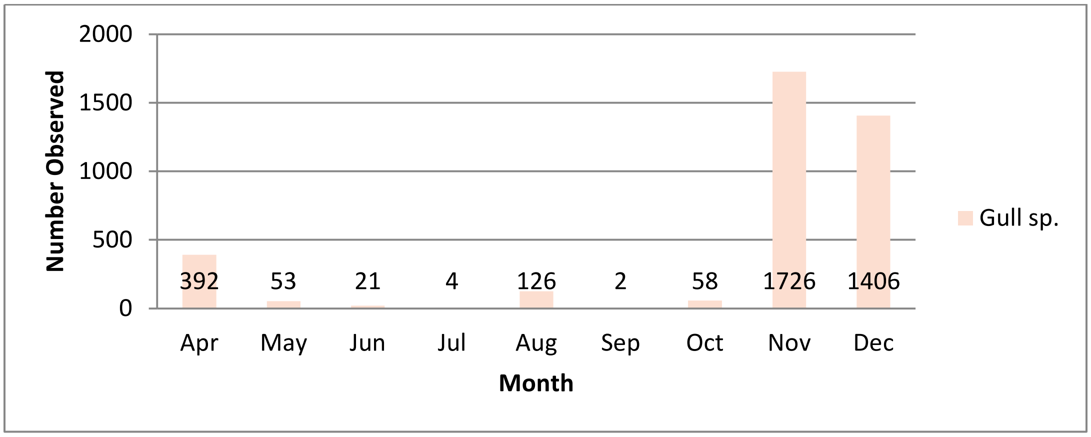

Figure 32: Gull Observed at all locations in 2013

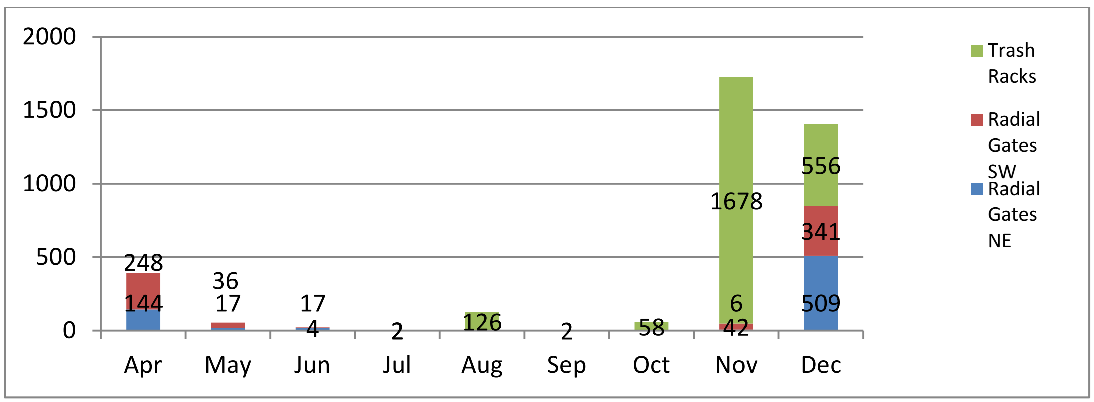

Figure 33: Gulls Observed by Location in 2013

American white pelicans were only present from April until July, and again in November and December (Figure 36), and were only observed in the vicinity of the trash racks in November and December (Figure 37).

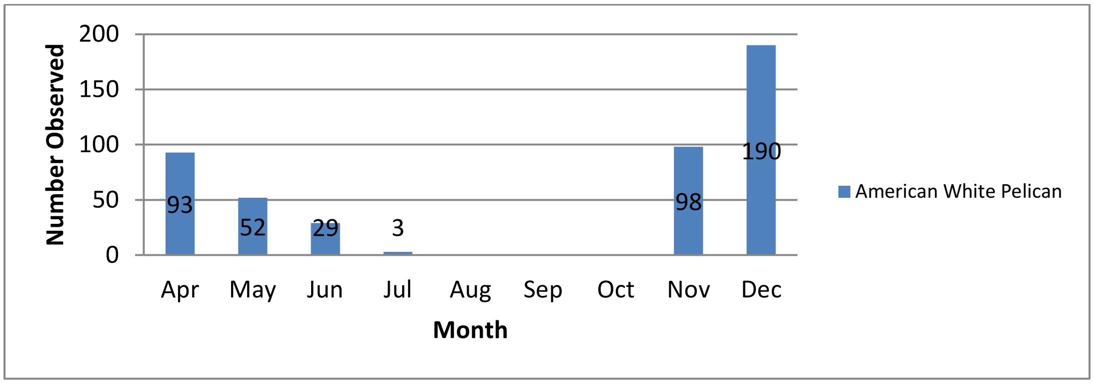

Figure 34: American White Pelicans Observed at all Locations in 2013

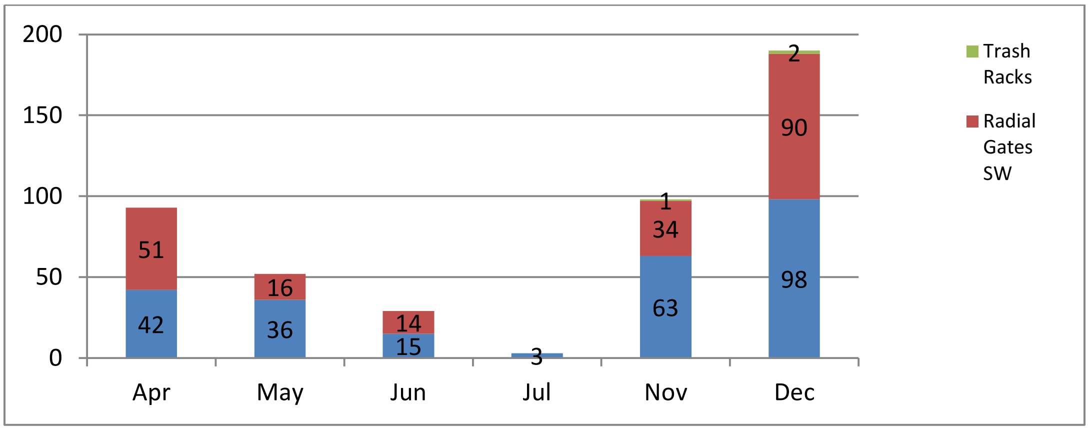

Figure 35: American White Pelicans Observed by Location in 2013

Double-crested cormorants were present during all of the months surveyed (Figure 38), with their numbers peaking in November and December, and were observed at all of the sites throughout the survey period (Figure 39).

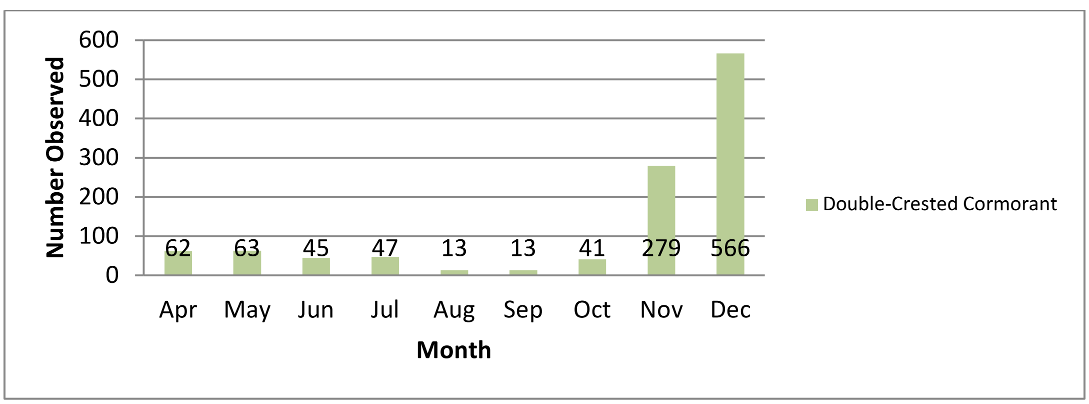

Figure 36: Double-Crested Cormorants observed at all Locations in 2013

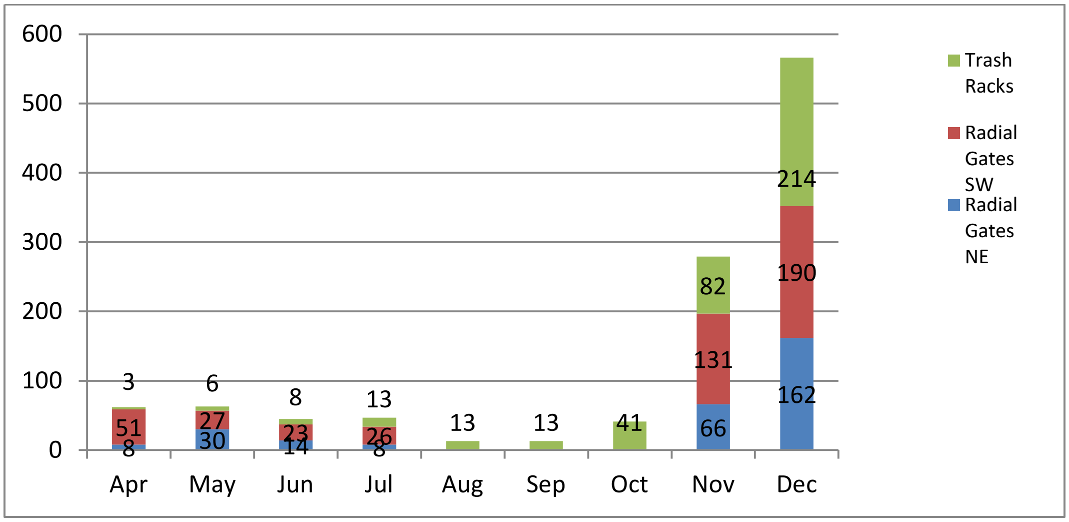

Figure 37: Double-Crested Cormorants Observed by Location in 2013

Several grebe species were observed during the survey, with population of the more commonly observed species, pied billed grebe (*Podilymbus podiceps*) and eared grebe (*Podiceps nigricollis*) peaking from September through December (Figure 40).

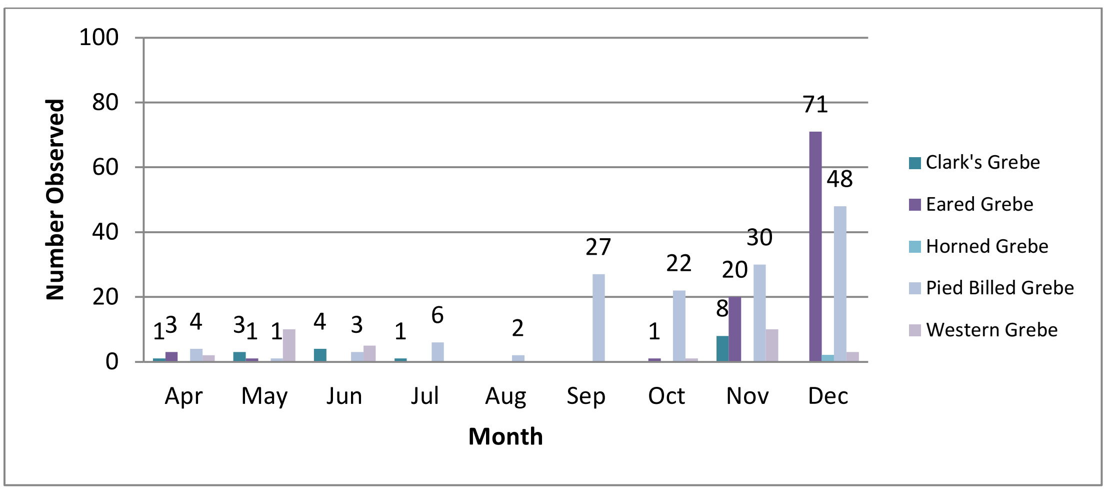

Figure 38: Grebe Species Observed at all Locations in 2013

Multiple heron and egret species were also observed during the survey, with the most commonly observed species, great egret (*Ardea alba*) and snowy egret (*Egretta thula*) peaking from September through December (Figure 41).

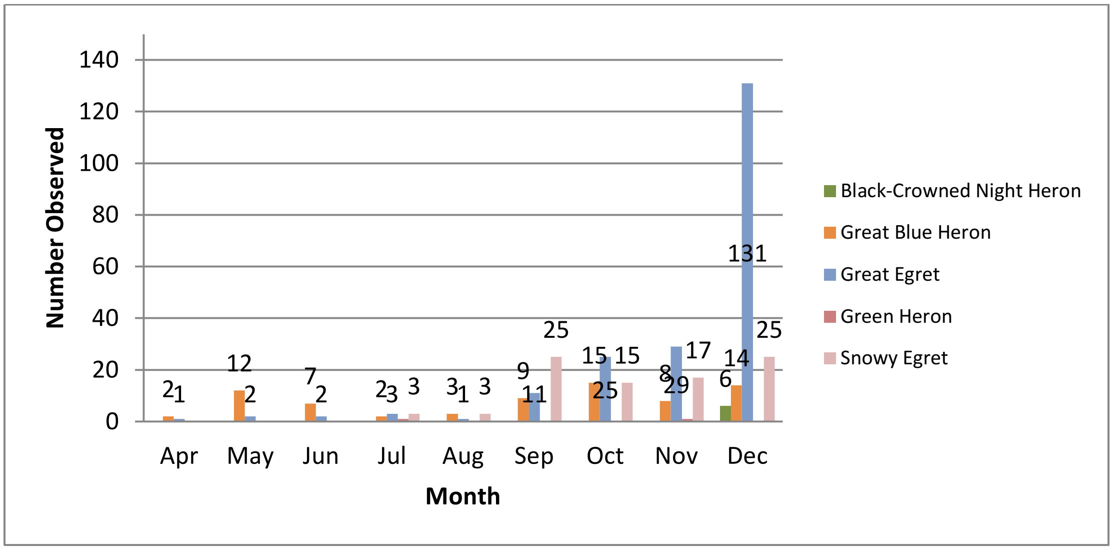

Figure 39: Herons and Egrets Observed at all Locations in 2013

Tern species were only observed from April until June, and were relatively uncommon, with numbers less than ten individuals (Figure 42).

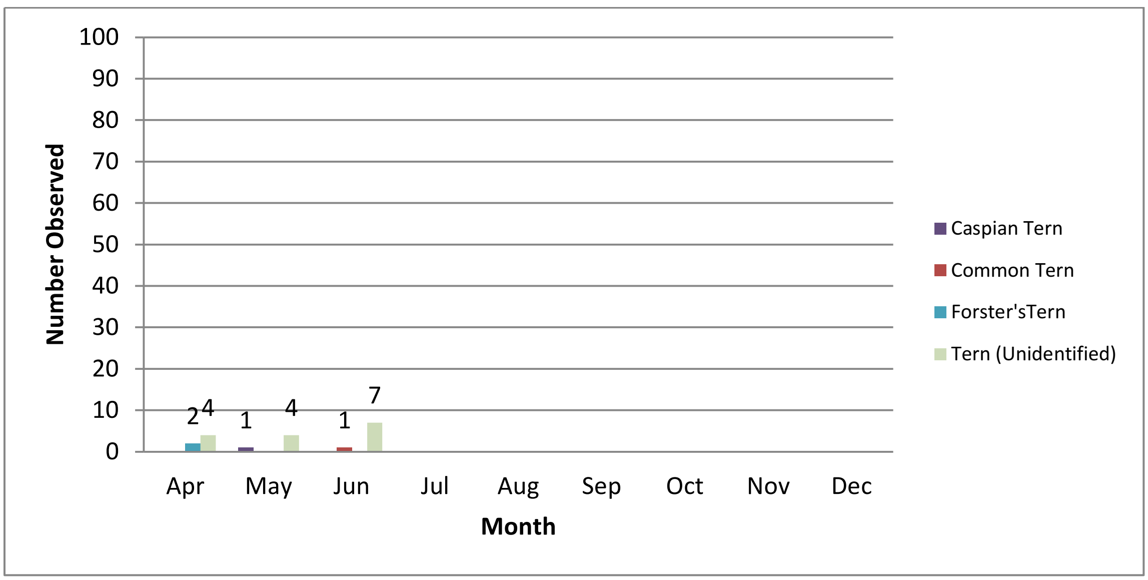

Figure 40: Terns Observed at all Locations in 2013

The most common of the other piscivorous birds observed was the common goldeneye (*Bucephala clangula*), with numbers peaking in November and December (Figure 43).

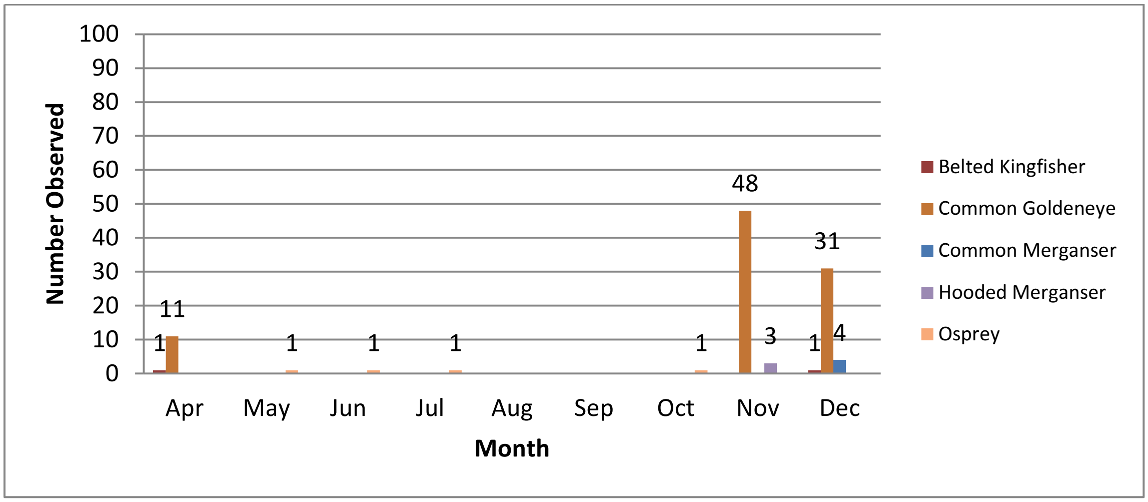

Figure 41: Other Piscivorous Species Observed at all Locations in 2013

At the trash racks, overall bird numbers including gulls peaked in November, with the fewest birds observed in April and May (Table 30).

Table 27: Avian Species Observed at the Trash Racks in 2013

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2013
American White Pelican								1	2	3
Belted Kingfisher	1								1	2
Black-Crowned Night Heron									6	6
Clark's Grebe	1		1					3		5
Common Goldeneye	1							37	18	56
Double-Crested Cormorant	3	6	8	13	13	13	41	82	214	393
Eared Grebe							1	2		3
Great Blue Heron	1		2		3	9	15	5	9	44
Great Egret					1	11	25	29	121	187
Green Heron								1		1
Gull sp.				2	126	2	58	1678	556	2422
Hooded Merganser								2		2
Osprey			1				1			2
Pied Billed Grebe	2		1		2	27	22	20	13	87
Snowy Egret					3	25	15	15	19	77
Western Grebe	2	3	3				1	5	3	17
All Species	11	9	16	15	148	87	179	1880	962	3307

At the radial gates, bird sightings peaked in December and were at their lowest in July (Tables 31 and 32). No observations were made at the gates from August through October, due to lack of access to the site.

Table 28: Avian Species Observed at the Radial Gates NE in 2013

Species	Apr	May	Jun	Jul	Nov	Dec	2013
American White Pelican	42	36	15	3	63	98	257
Clark's Grebe				1	5		6
Common Goldeneye	3				5	11	19
Double-Crested Cormorant	8	30	14	8	66	162	288
Eared Grebe	2				10	55	67
Forster's Tern	2						2
Great Blue Heron		8	3	2	2	2	17
Great Egret	1	2	2	1		6	12
Green Heron				1			1
Gull sp.	144	17	17		6	509	693
Hooded Merganser					1		1
Horned Grebe						2	2
Pied Billed Grebe	2	1	1	4	5	22	35
Snowy Egret				1	1	5	7
Tern (Unidentified)	2	1	4				7
Western Grebe		4			1		5
All Species	206	99	56	21	165	872	1419

Table 29: Avian Species Observed at the Radial Gates SW in 2013

Species	Apr	May	Jun	Jul	Nov	Dec	2013
American White Pelican	51	16	14		34	90	205
Caspian Tern		1					1
Clark's Grebe		3	3				6
Common Goldeneye	7				6	2	15
Common Merganser						4	4
Common Tern			1				1
Double-Crested Cormorant	51	27	23	26	131	190	448
Eared Grebe	1	1			8	16	26
Great Blue Heron	1	4	2		1	3	11
Great Egret				2		4	6
Gull sp.	248	36	4	2	42	341	673
Osprey		1		1			2
Pied Billed Grebe			1	2	5	13	21
Snowy Egret				2	1	1	4
Tern (Unidentified)	2	3	3				8
Western Grebe		3	2		4		9
All Species	361	95	53	35	232	664	1440

During the spring months, April through June, feeding behavior peaked in May at 31% of total birds observed actively feeding (Table 33). Eight species of birds were observed to be feeding during 50% or more of the observations during one or more spring months, including belted kingfisher (*Megaceryle alcyon*), Clark's grebe (*Aechmophorus clarkii*), eared grebe, Forester's tern (*Sterna forsteri*), great blue heron (*Ardea herodias*), great egret, pied billed grebe, and Western grebe (*Aechmophorus occidentalis*).

Table 30: Percent of Observed Birds Feeding at all Locations in Spring 2013

Month	April			May			June		
Species	Total	Feeding	% Feeding	Total	Feeding	% Feeding	Total	Feeding	% Feeding
American White Pelican	93	5	5%	52	12	23%	29	2	7%
Belted Kingfisher	1	1	100%						
Caspian Tern				1		0%			
Clark's Grebe	1	1	100%	3	3	100%	4	3	75%
Common Goldeneye	11	4	36%						
Common Tern							1		0%
Double-Crested Cormorant	62	19	31%	63	26	41%	45	15	33%
Eared Grebe	3	2	67%	1		0%			
Forster's Tern	2	2	100%						
Great Blue Heron	2		0%	12	6	50%	7		0%
Great Egret	1		0%	2	1	50%	2		0%
Green Heron									
Gull sp.	392	17	4%	53	3	6%	21		0%
Osprey				1		0%	1	1	100%
Pied Billed Grebe	4	2	50%	1	1	100%	3	1	33%
Tern (Unidentified)	4	1	25%	4	1	25%	7	4	57%
Western Grebe	2	2	100%	10	10	100%	5	1	20%
Grand Total	578	56	10%	203	63	31%	125	27	22%

During the summer months, July through September, feeding behavior peaked in September at 67% of total birds observed actively feeding (Table 34). Seven species of birds were observed to be feeding during 50% or more of the observations during one or more Summer months, including Clarks' grebe, great blue heron, great egret, green heron (*Butorides virescens*), osprey (*Pandion haliaetus*), pied billed grebe, and snowy egret.

Table 31: Percent of Observed Birds Feeding at all Locations in Summer 2013

Month	July			August*			September*		
Species	Total	Feeding	% Feeding	Total	Feeding	% Feeding	Total	Feeding	% Feeding
American White Pelican	3		0%						
Clark's Grebe	1	1	100%						
Double-Crested Cormorant	47	12	26%	13		0%	13	3	23%
Great Blue Heron	2	1	50%	3		0%	9	3	33%
Great Egret	3	1	33%	1		0%	11	9	82%
Green Heron	1	1	100%						
Gull sp.	4		0%	126		0%	2		0%
Osprey	1	1	100%						
Pied Billed Grebe	6	5	83%	2	1	50%	27	23	85%
Snowy Egret	3	2	67%	3	3	100%	25	20	80%
Grand Total	71	24	34%	148	4	3%	87	58	67%

* Access to radial gates restricted.

During the fall months, October through December, feeding behavior peaked in October at 17% of total birds observed actively feeding (Table 35). Seven species of birds were observed to be feeding during 50% or more of the observations during one or more fall months, including belted kingfisher, Clark's grebe, eared grebe, great blue heron, green heron, hooded merganser (*Lophodytes cucullatus*), pied billed grebe, and Western grebe.

Table 32: Percent of Observed Birds Feeding at all Locations in Fall 2013

Month	Oct*			Nov			Dec		
Species	Total	Feeding	% Feeding	Total	Feeding	% Feeding	Total	Feeding	% Feeding
American White Pelican				98	6	6%	190	33	17%
Belted Kingfisher							1	1	100%
Black-Crowned Night Heron							6		0%
Clark's Grebe				8	7	88%			
Common Goldeneye				48	12	25%	31	11	35%
Common Merganser							4		0%
Double-Crested Cormorant	41	2	5%	279	48	17%	566	16	3%
Eared Grebe	1	1	100%	20	9	45%	71	42	59%
Great Blue Heron	15	9	60%	8	1	13%	14	1	7%
Great Egret	25	4	16%	29	9	31%	131	1	1%
Green Heron				1	1	100%			
Gull sp.	58		0%	1726	4	0%	1406	1	0%
Hooded Merganser				3	3	100%			
Osprey	1		0%						
Pied Billed Grebe	22	12	55%	30	15	50%	48	28	58%
Snowy Egret	15	3	20%	17	5	29%	25	3	12%
Western Grebe	1		0%	10	8	80%	3	2	67%
Grand Total	179	31	17%	2277	128	6%	2498	141	6%

* Access to radial gates restricted.

Feeding behavior was observed in double-crested cormorants during eight of the months surveyed (Figure 44). Feeding was most often observed in May when 41% of double-crested cormorants observed were feeding (Table 33).

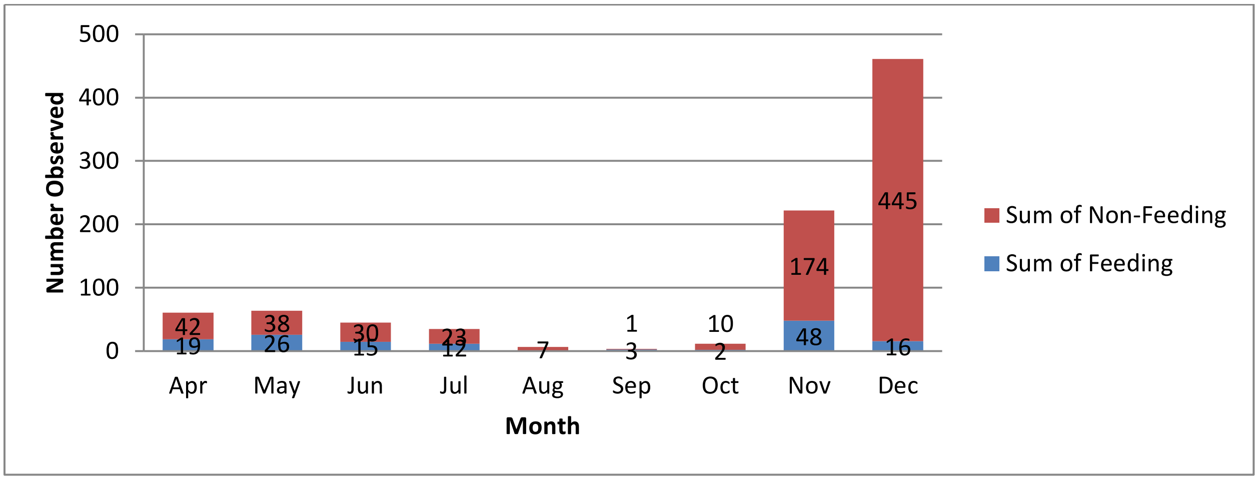

Figure 42: Double Crested Cormorant Feeding Behavior in 2013

American white pelicans were observed feeding during five of the months in which they were present during surveys (Figure 45). Often the feeding behavior observed consisted of stealing from other birds in the vicinity of the radial gates.

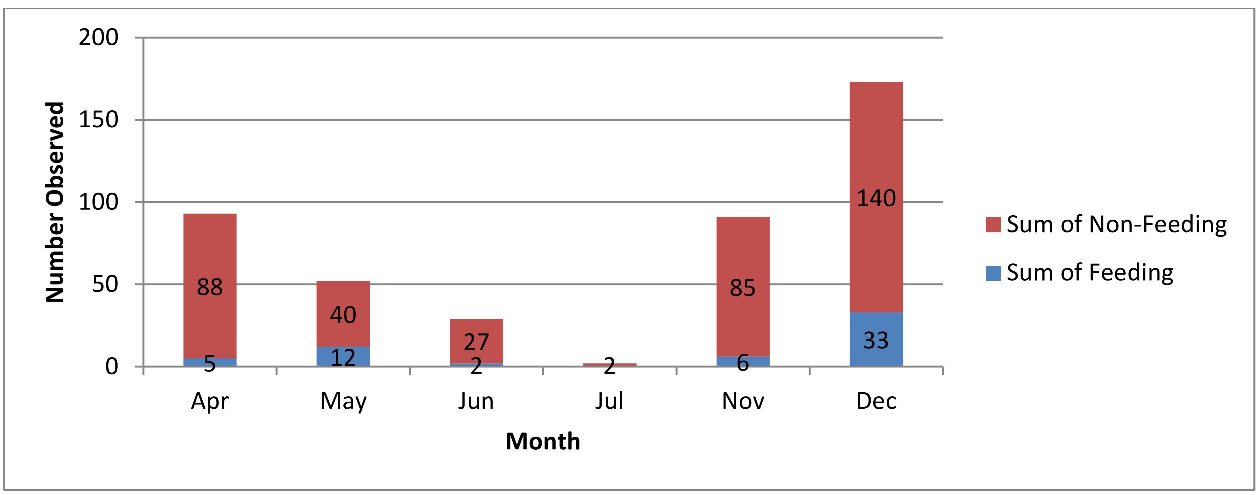

Figure 43: American White Pelican Feeding Behavior in 2013

Gulls were present in large flocks during several of the months surveyed, but were very rarely observed feeding during surveys (Figure 46).

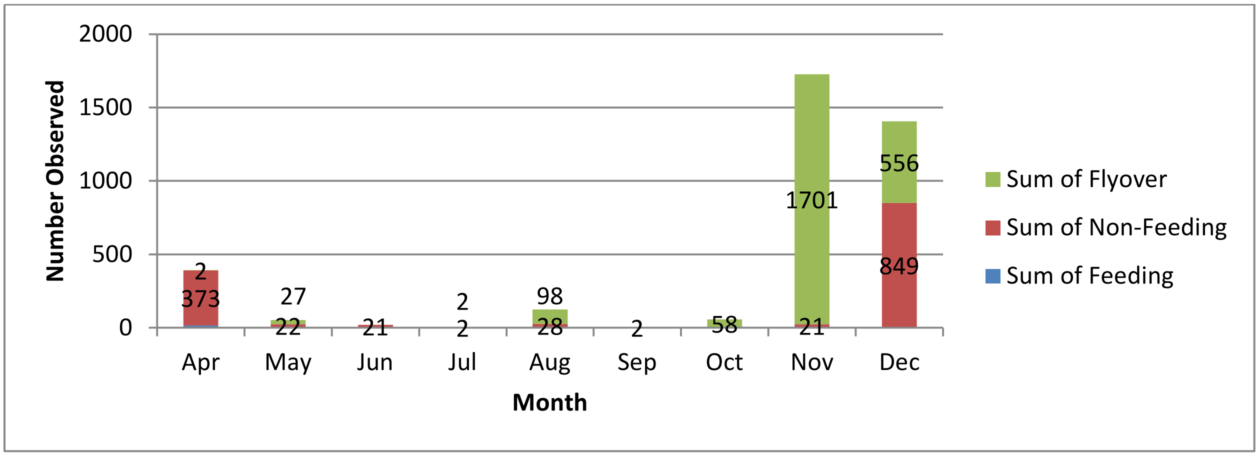

Figure 44: Gull Behavior in 2013

Feeding behavior was primarily observed in the vicinity of the trash racks from September through December (Figure 47), and flyovers of large numbers of birds were observed in November and December. In the vicinity of the radial gates, feeding behavior was observed in all months surveyed (Figure 48) and fewer flyovers were observed than at the trash rack.

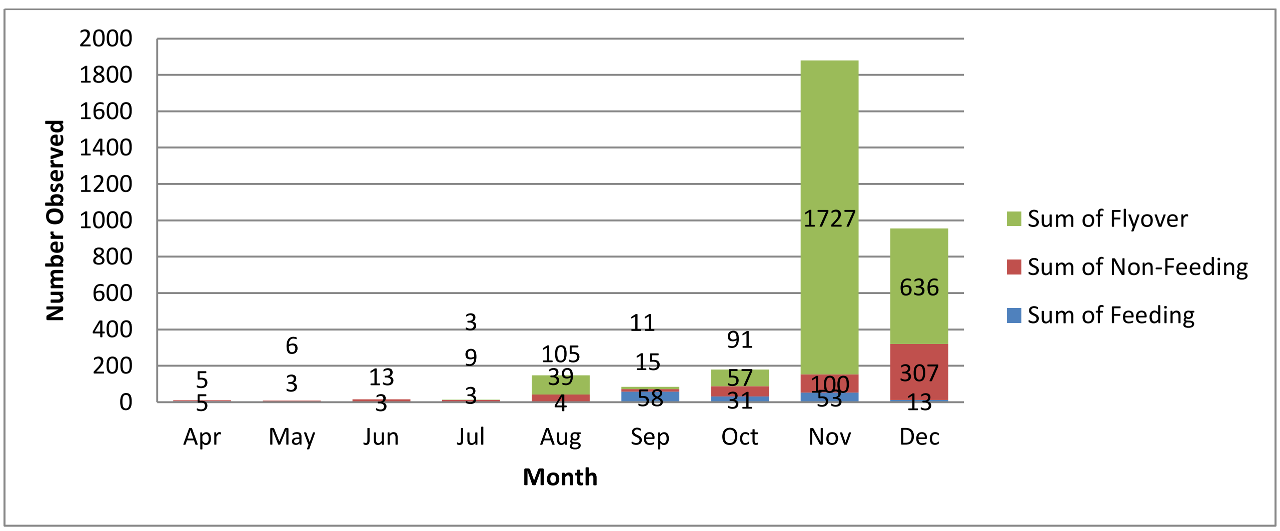

Figure 45: Behavior at the Trash Racks in 2013

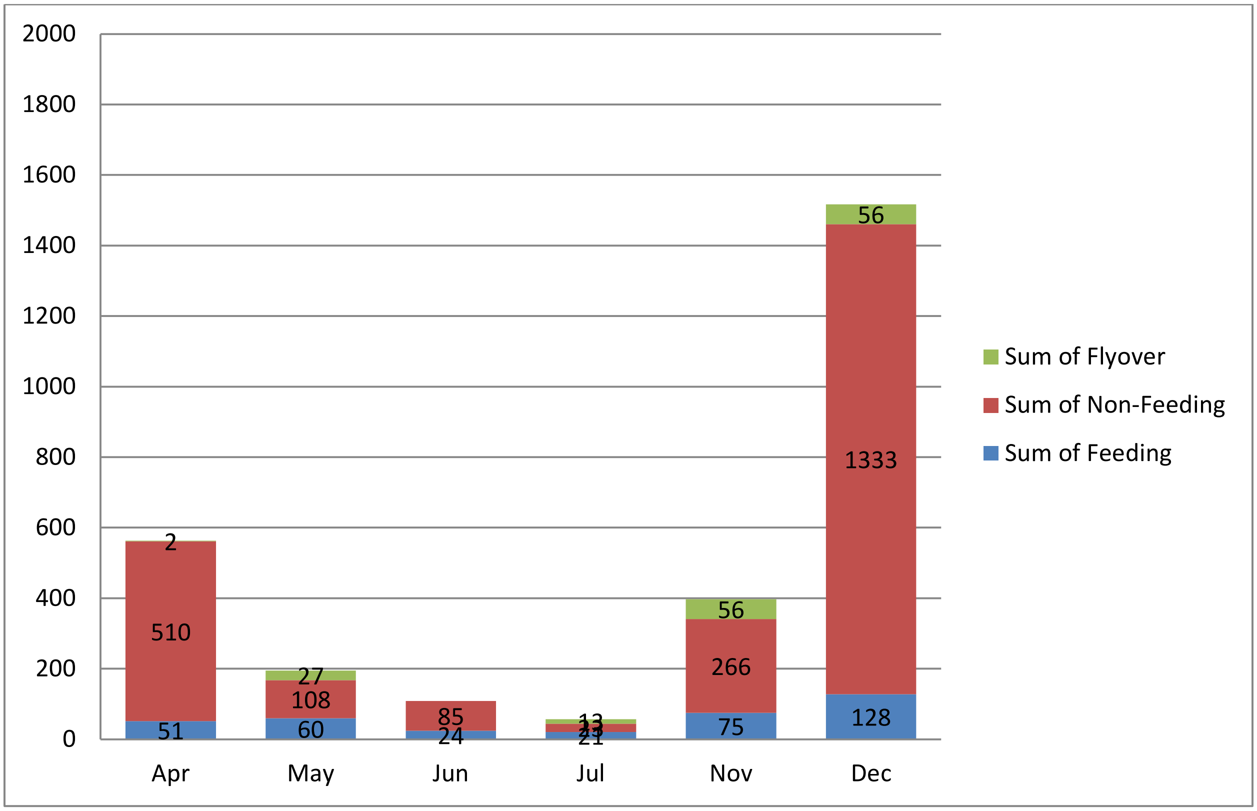

Figure 46: Behavior at the Radial Gates Sites in 2013

2.7.5 Discussion and Recommendations

Double-crested cormorants, gulls and American white pelicans were the most commonly observed birds during avian surveys. All three of these species were most abundant in the months of November and December. Gulls and double-crested cormorants were present throughout the survey period, with the lowest numbers observed in July and September, and August and September, respectively. Pelicans showed stronger seasonal patterns, and were only present six of the nine months surveyed at the radial gates. However, they may still have been present in the three other months and have gone undetected due to the loss of access to the radial gates sites from August through October. Undetected cormorants and gulls were also likely in that time period.

Grebes and herons were the second most commonly observed group of birds, with an apparently strong seasonal trend of increasing populations from September through December. Terns were only observed from April to June, in very small numbers. Goldeneyes were observed primarily in November and December, with some birds also observed in April. A single osprey was observed from May through July and another sighting was made in October. Mergansers and kingfishers were observed infrequently.

Overall seasonal trends appeared to indicate increased population sizes, primarily in the fall months. The data set, however, is incomplete as no surveys were conducted from January through March, and surveys were restricted to the trash racks from August through October.

Feeding behavior was observed throughout the year, with up to 31% of birds observed feeding in the Spring, up to 67% of birds observed feeding in the Summer, and up to 17% of birds observed feeding in Fall. Cormorants were observed feeding during all but one of the survey months. It is likely that they would have been observed feeding in all months had the radial gates been accessible. Pelicans were observed feeding in all months that they were present. Gulls were rarely observed feeding, and were often observed flying over the sites in November and December. General feeding behavior for all species was most often observed from September through November. This indicates that cormorants and pelicans may be having a greater predatory impact on fish than gulls; however, additional data is needed to determine relative predation pressure from these species. Grebes, herons and egrets often displayed high percentages of feeding behavior, often more than 50%, and may also represent a significant level of predation pressure on fishes in the Forebay. Identification of prey species was not possible during the surveys, and could include any of the fish species present at the time of the feeding event, including common species such as Striped Bass, as well as listed species such as Chinook salmon.

While the data collected during 2013 indicates some possible seasonal trends in presence and feeding behavior, no strong conclusion can be drawn at this time, due to a number of factors. These factors include; lack of surveys in the winter months, when juvenile salmon would be coming through the system and the limited access to the radial gates from August through October. Surveys will continue year round at all three sites to see if these trends become more apparent.

2.8 Bioenergetics Modelling

2.8.1 Background

A bioenergetics model is a mass-based equation that can analyze how food consumed by an animal is either used for growth or metabolic processes, or excreted as waste (Ney 1993, Brandt and Hartman 1993). This can be a powerful tool in that it can allow for an understanding of the quantitative impacts of predation upon a population of prey given existing information on metabolic needs, digestion rates and predation habits of a predator species. This approach has been used to better understand the predator-prey dynamics between fish species such as Striped Bass and Threadfin Shad (*Dorosoma petenense*) in Lake Powell (Vatland et al 2008), and Lake Trout (*Salvelinus namaycush*) and Rainbow Smelt (*Osmerus mordax*) in Lake Champlain (LaBar 1993), as well as predation by piscivorous birds such as double-crested cormorants (Seefelt and Gillingham 2008) in northern Lake Michigan.

The relative impact of predation upon salmonids by fish and birds in the Forebay is an important factor in addressing pre-screen loss. These impacts can be evaluated in a quantitative manner using bioenergetics modeling. Work on the bioenergetics modeling was not undertaken in 2013.

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