MVSD River Otter Study DRAFT

July 2018

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Introduction

The North American River Otter (*Lontra canadensis*) is a semi-aquatic mustelid endemic to North America, a keystone carnivore and a sentinel for environmental contamination. Although the species is highly dependent on freshwater, otters traverse through and forage within a variety of habitats that include terrestrial, marine, estuarine, and freshwater ecosystems. They predate an array of species such as native and non-native freshwater, anadromous, and marine fishes, waterbirds, crustaceans and amphibians.

Very little is known about the current status, distribution, and ecology of river otters in California. Historically documented, but shortly thereafter extirpated from much of their range in the early 20th century, populations were offered protection through fur trapping restrictions in 1961. Since then, and only just within the past few years, a selection of research has been published on populations in California, with these studies limited to Northern California, the San Francisco Bay Delta, inland mountainous regions of the state and the San Francisco Bay Area.

The River Otter Ecology Project (ROEP), monitors ~225 linear km of coastal, wetland, riverine and reservoir in Marin County, California, using noninvasive methods, for population, health, prey and dispersal information. Moorhen and McNabney Marshes comprise ROEP's initial site outside Marin County, and make an interesting contrast to Marin sites, in part because river otters were never extirpated from the Martinez area, and because Moorhen Marsh is a constructed treatment wetland built in the 1970s with only one directional flow into Peyton Slough. McNabney Marsh is heavily managed by tide gates operated offsite by a third party. Both McNabney Marsh and Peyton Slough are affected by Shell Martinez Refinery stormwater discharges that typically occur before, during, or immediately after wet weather events.

Habitat description

Moorhen Marsh is a 21-acre, constructed wetland dependent solely on treated effluent as its primary water source. The Shell Martinez Refinery surrounds it on two sides, and Interstate 680 borders the north side. Native wildlife species dependent on the wetland for habitat include the western pond turtle, North American river otter, mink, North American beaver, and many species of birds including marsh wren, San Francisco common yellow-throat, Suisun song sparrow, green heron, snowy egret, grackle, Canada goose and black-crowned night heron.

McNabney Marsh is a restored, muted tidal wetland located east of I-680 in Martinez. MVSD and the East Bay Regional Park District jointly own the 138-acre wetland, with an agreement that gives MVSD responsibility for its management. In 2009, as part of remediation for an oil spill, tidal flows were re-introduced to McNabney Marsh through a tide gate structure, resulting in shifts in plant and wildlife species, abundance and distribution.

North American river otters have been regularly sighted in the MVSD wetlands since at least 2005, including a group of 9 river otters observed by MVSD Biologist, Kelly Davidson, in Moorhen Marsh in 2011. One river otter was reported to the California Roadkill Observation System as a mortality on Waterbird Way, adjacent to McNabney Marsh, in 2011; however, until 2016 there were no formal surveys or monitoring for river otters on these properties.

Project Goals

MVSD and ROEP partnered in September 2016 to:

- Noninvasively gather information on river otter presence, abundance and habitat use within Moorhen and McNabney Marshes,
- Document sex ratios as possible,
- Document pup emergence and survival; and to
- Advise on mitigations for disturbance in otter habitat due to pre-construction and construction activities for a 2017-2018 habitat enhancement and maintenance project in Moorhen Marsh including vegetation removal, dewatering, pond excavation and other activities, if necessary.
- In June 2017, ROEP initiated a prey species study, running from June 2017 to June 2018, and the results are included in this report.

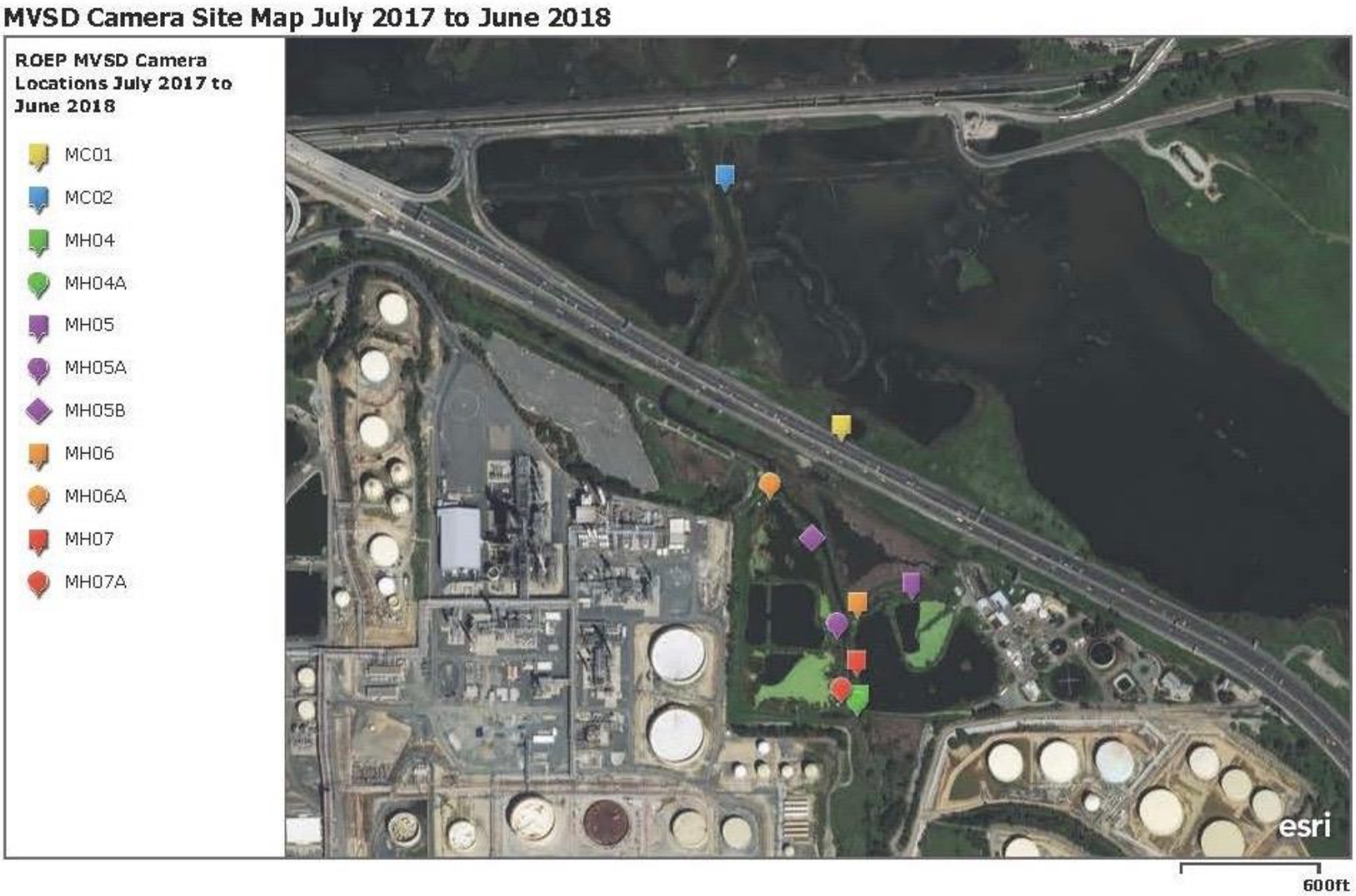
Methodology

ROEP surveyed Moorhen and McNabney Marshes on foot, marking likely otter corridors/paths (as determined by their proximity to water and otter sign such as scat and wallowing places), dens, latrine sites and wallows, using Collector for ArcGIS (ESRI). ROEP placed six motion detector, infrared Bushnell trail cameras at latrine sites, in wildlife corridors and at crossovers between the two marshes (Peyton Slough and culverts under Highway 680), and one camera dedicated to moving from place to place as needed. Cameras were programmed to record video both day and night.

Surveys and camera checks were conducted weekly and, beginning in September 2016. ROEP collected, viewed and documented videos including otter activity. We noted other wildlife, saving videos of other animals that were of particular interest, such as North American beaver. Documentation of otter videos includes date, time, number of otters seen in each video and unusual behavior, such as mating and pregnancy. Identifying traits, if any, are noted, such as a particular otter with an ocular defect that eliminates eye shine at night in that individual. Cameras were adjusted as necessary for better video. Video is catalogued and stored in multiple locations for backup.

When emergent vegetation removal began at Moorhen Marsh on January 25, 2017, one camera was used solely for "roaming", and was deployed in various spots to record otter reaction to vegetation pulling and pond turtle fencing. Those placements are indicated in Figure 1 by colored icons.

Figure 1: Camera Sites, Moorhen and McNabney Marshes, 2018



Results

1) **Use of Peyton Slough rather than culvert to traverse Highway 680**
Beginning in May 2017, the wetland area north of the culvert under Highway 680 dried as a result of CDFW's requirement that the tide gate in McNabney Marsh remain inoperable until the end of nesting bird season. Otters ceased using that egress, though other wildlife continued to use it, using Peyton Slough to pass under the highway. Please see Figures 2, 3, and 4.

2) **Phase A and B Effects on Otter Use of Moorhen Marsh**
Unsurprisingly, the otters changed their habits in response to the ongoing restoration work at Phase A and Phase B, including vegetation cutting, draining the ponds, excavation and construction. While the otters never completely abandoned the area, they naturally avoided dried ponds and heavy construction. The otters continued to use Peyton Slough to get to the Martinez Shell Refinery property. Please see Figures 5 and 6.

3) **Use of McNabney Marsh**
During this study period, there was no change in spatial use of McNabney Marsh, though detection numbers fluctuated, with lows in December 2017 through March 2018 and modest increases in April, May and June 2018. Please see Figures 5 and 6.

4) **Birth and Young**
No pregnant otters nor juvenile otters were observed during this report study period. While the Shell Martinez Refinery property is apparently still being used by the otters, it seems unlikely they would choose to den there during Moorhen Marsh restoration construction.

5) **Mortalities**
No otter mortalities were encountered during this report study period.

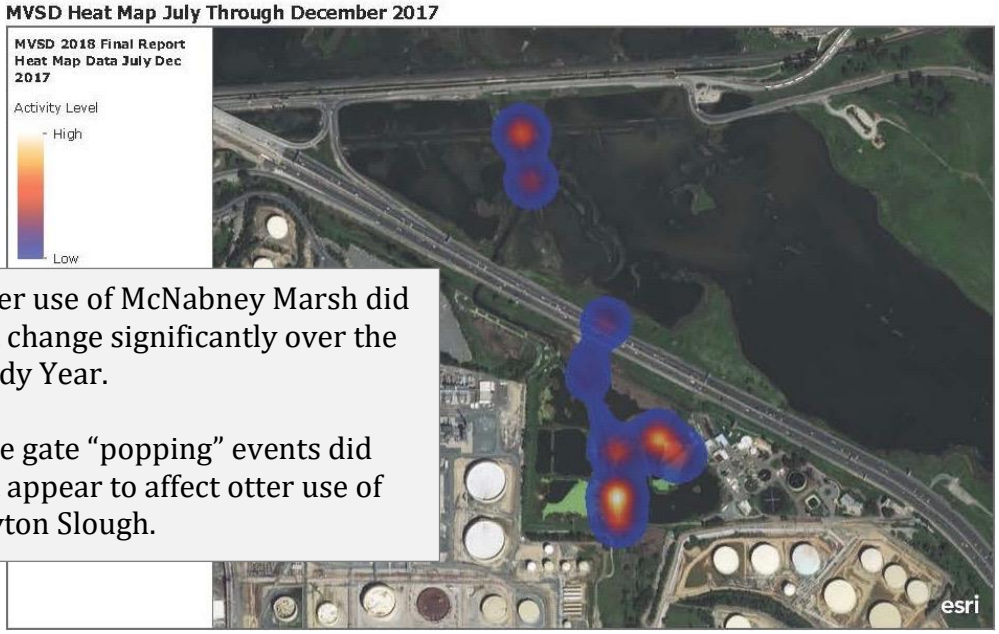
6) **Other Animals Detected**
Beaver, mink, gray fox, red fox, muskrat, opossum, Canada goose, grackle, and raccoons

Discussion, Finding #1

Note: Heat map data includes camera trap videos, sightings by ROEP technicians and biological monitors and scat deposits.

Figure 2: Heat Map July – December 2017

MVSD Heat Map July Through December 2017



Otter use of McNabney Marsh did not change significantly over the Study Year.

Tide gate "popping" events did not appear to affect otter use of Peyton Slough.

Figure 3: Heat Map January – June 2018

MVSD Heat Map January Through June 2018

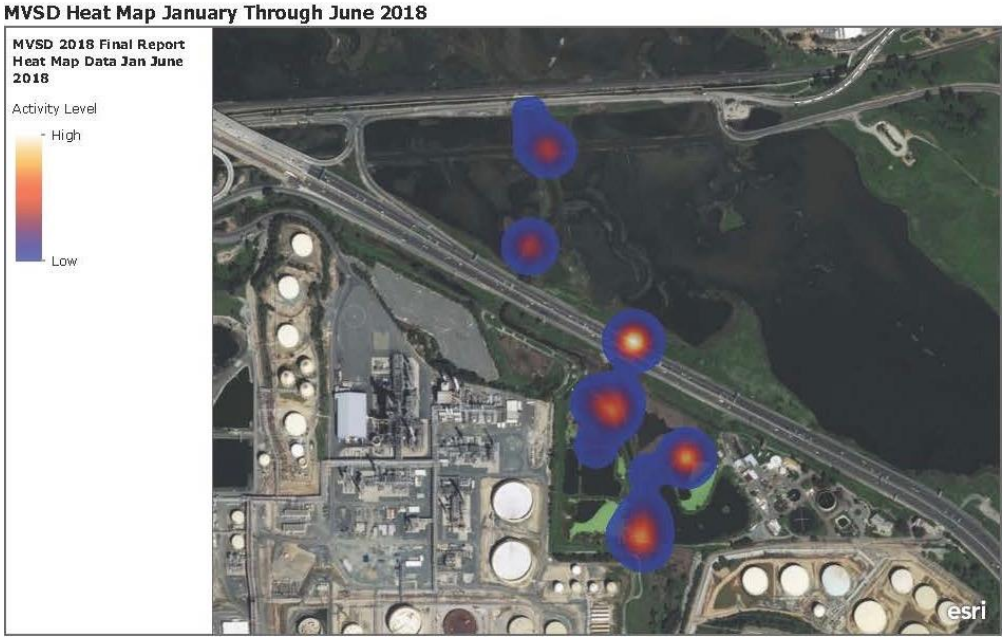


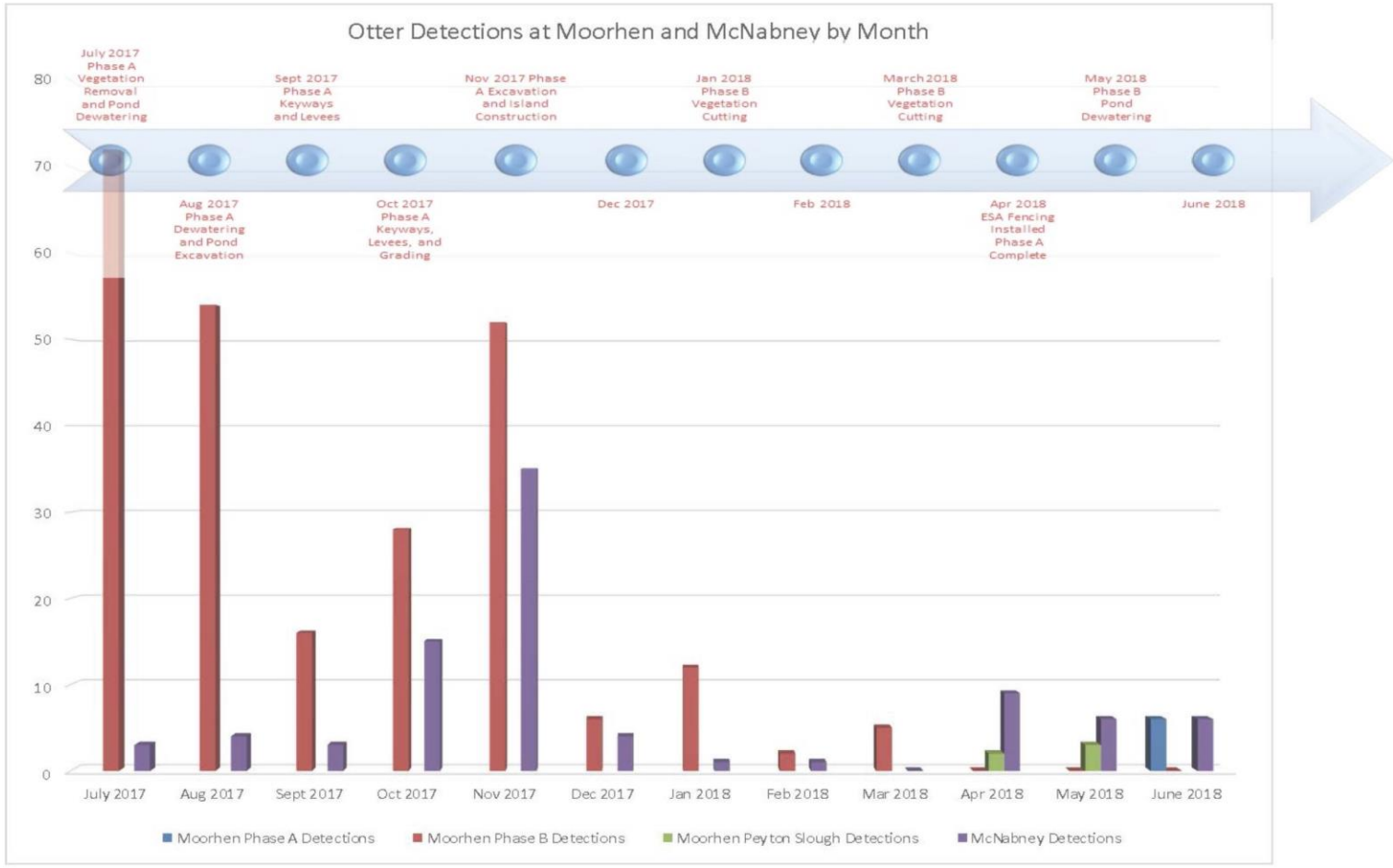
Figure 4: Highway 680 Culvert Detections by Month (MC01)

Year 2016-2017			Year 2017-2018	
N/A	N/A		July-17	2
N/A	N/A		Aug-17	2
Sep-16	12		Sep-17	2
Oct-16	13		Oct-17	2
Nov-16	21		Nov-17	1
Dec-16	13		Dec-17	0
Jan-17	8		Jan-17	0
Feb-17	7		Feb-18	1
Mar-17	10		Mar-18	0
Apr-17	36		Apr-18	1
May-17	1		May-18	3
Jun-17	6		Jun-18	6
Total	**127**		**TOTAL**	**20**

Beginning in May 2017, when the wetland on the McNabney Marsh side of the culvert dried, the otters began using Peyton Slough to travel under Highway 680 on a much more regular basis. They continued to do so during the rainy season.

Discussion, Finding #2

Figure 5: Otter Detections by Month

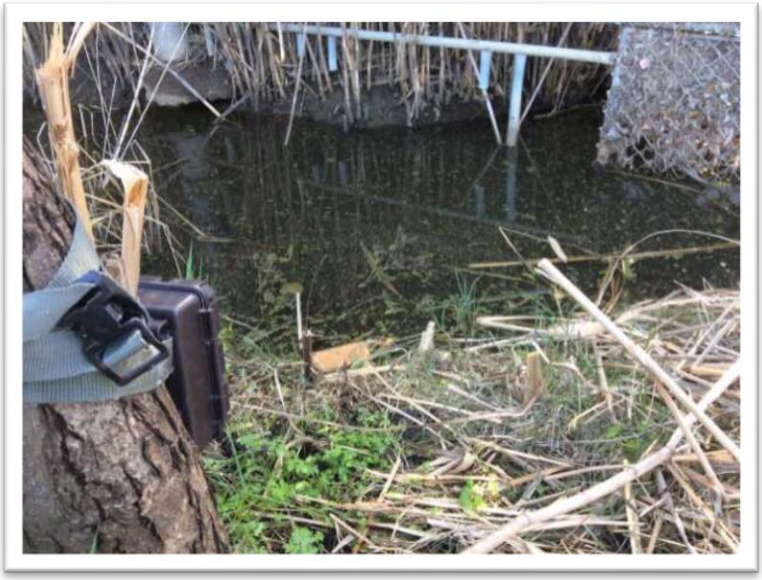


Beginning in July 2017, with Moorhen Marsh Phase A vegetation removal and pond dewatering, through excavation, heavy equipment work, grading and construction, the otters continued to appear in Moorhen Marsh Phase B through November 2017.

There was a significant decrease in otter detections in both Phase B and McNabney Marshes during December, 2017 through March 2018. This is consistent with other sites monitored by ROEP and coincides with otter births and mating. Additionally, Phase B vegetation cutting began in January 2018. As expected, and as experienced during vegetation cutting during 2017 otter usage of the area changed. No signs of otter activity were found except at Camera 7 on Peyton Slough, where a corridor and an occasional single otter scat were noted. This continued through March.

In February 2018, one of the biological monitors reported seeing a single otter in Peyton Slough near the car bridge. This was one of our first clues that the otters were still using Peyton Slough within Moorhen Marsh. We placed a camera to better capture otter use of the area. Since we were not seeing them in the ponds at Moorhen Marsh, the question arose as to what the singleton was doing and whether otters were still using the Slough to traverse Moorhen Marsh to the Shell Refinery property.

In March 2018, vegetation cutting began in preparation for Endangered Species Act fencing installation (for Western pond turtles) and pond dewatering. Unsurprisingly, otter detections in Phase B dropped off completely. Cameras were pulled for a few days at a time, intermittently, to make way for various construction needs, so the record is not complete. We feel satisfied that despite this, our findings reflect the actualities of the area. As of this date otters are not using Phase B.

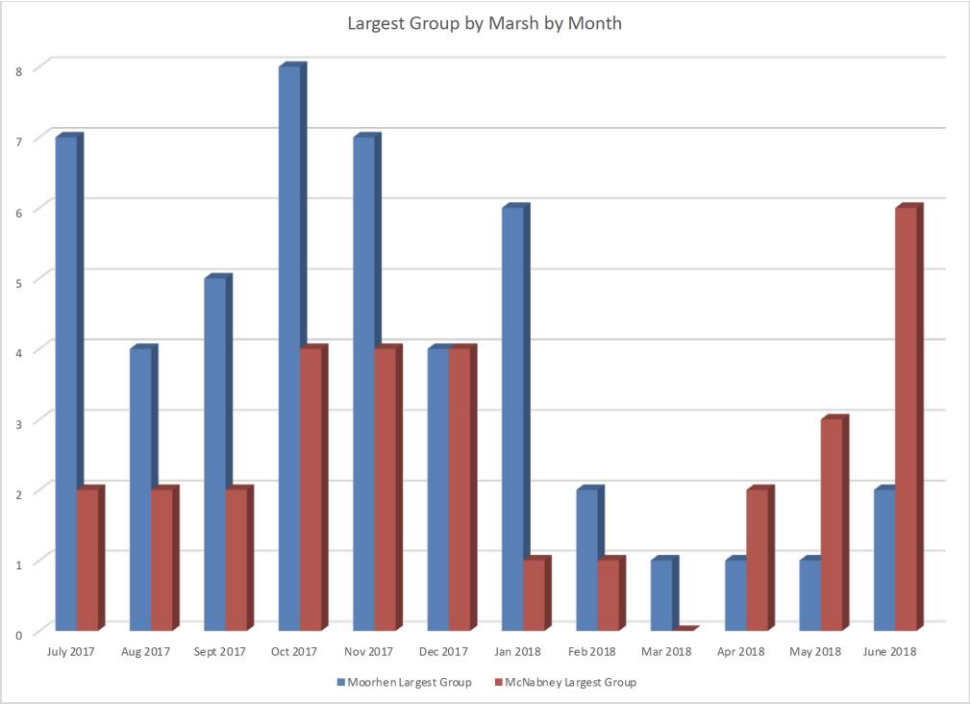


In April 2018, with completion of Phase A, and with Phase B vegetation cutting complete, we recorded 2 videos of river otters in Peyton Slough. The cameras were moved from Phase B to Phase A to capture otter returns there, except for one camera kept facing the Shell Martinez Refinery property, which continues to be of interest because of continued river otter use.

On May 20, Karen James, a ROEP contractor, observed 5 otters feeding in Peyton Slough near the car bridge. ROEP cameras detected 3 videos of a single otter near the Shell property in May. Apparently, the Shell Martinez Refinery property has habitat or feeding opportunities of importance to the otters.

During the final 2 weeks of June 2018, (the last month of our monitoring project), the otters returned to Pond C (Phase A). A large latrine site was discovered near the Peyton Slough (Camera 5B) on June 13. Our final camera check included videos of otters heading into Pond C. A biological monitor also reported seeing three otters using the man-made island in Pond C.

Figure 6: Otter Groups by Marsh



Otter Group sizes varied by marsh, by season, and depending upon construction activities in Moorhen Marsh. During the summer through early winter, group sizes ranged from 4 to 8 otters detected on camera at once. This is a reduction from a group size of 11 otters seen in Moorhen Marsh in 2016. Otter detections in Moorhen Marsh during winter through Phase B vegetation cutting, dewatering and construction declined to a low of zero in March, but increased slightly to 2 otters in June 2018, at the end of this study period. Generally, the numbers of otters seen both in groups and numbers of detections are encouraging, considering the extensive restoration activities in Moorhen Marsh.

In McNabney Marsh, the largest group was seen just before the study period ended, 6 otters traversing under Highway 680 through the culvert (Camera MC01). This is an encouraging sign, after low group numbers ranging from one to zero detected in January through March 2018.

Discussion: Finding #3

In McNabney Marsh, detections fluctuated more or less in line with the Phase B detections through March 2018. In April, May and June 2018, detections in the marsh increased slightly, culminating in June with sightings at both the culvert and the footbridge. (Please see Figure 6)

Finding #4: No otter mortalities have been discovered since our last report.

Finding #5: Other animals: Beaver, mink, gray fox, red fox, muskrat, opossum, Canada goose, grackle, and the omnipresent raccoons.

Recommendations:

1) Continue monitoring for population numbers, birth and pup emergence and survival as the restoration is completed and after. Pay particular attention to whether the otters continue to use the Shell Martinez Refinery Property.

2) Continue to monitor egress to Shell Martinez Refinery property during construction/restoration. It would be useful to get permission to survey the Refinery property in the Peyton Slough area when the study resumes in 2019.

3) Continue prey species analysis on a regular basis. It would be interesting to explore whether a study on otter presence and/or abundance impacts *Procambarus clarkia* (red swamp crayfish) abundance would be possible.

4) Consider genetic analysis on this population of river otters if there's a desire to discover matrilines, sex ratios and relatedness among animals. The information could serve as a baseline and comparison to similar studies currently in progress through ROEP at San Francisco State University.

Video links: All videos included with the final report. Videos will be mailed upon report approval.

Otter Hops ESA Fencing, MH05B
Six otters at MC01, June 2018
Otter using Peyton Slough to reach refinery property, M04A

River Otter Prey Species Study, MVSD 2017 – 2018

Prepared by Stori Oates

Background

River Otters are important predators on fishes, aquatic birds, and invertebrates, and can therefore have significant influence on the structure of local ecosystems (Bouley et al., 2015). Furthermore, as opportunistic predators that forage near the apex of the trophic pyramid, river otters are critical bioindicators of ecosystem health (Kruuk, 2006). Understanding temporal relationships between predators and prey is critical for recognizing factors that might limit the success of this top carnivore (Kruuk and Conroy, 1987). The need for research on the diet of river otter populations also is important to conserving these top carnivores as diet has direct implications for protecting other aquatic resources. As a potential keystone species in the San Francisco Bay Area aquatic habitat (Bouley et al., 2015), this study has enabled us to gain a better idea of the role river otters might play in the Peyton Slough Wetlands Complex food web.

Diet Characterization Methods

To characterize the diet of river otters using Moorhen and McNabney Marshes, fecal samples (n=49) were collected from known latrine sites during 2017 through 2018 (Table 1). Fecal samples were bagged individually, labeled, and stored at -20°C. Individual samples then were soaked in warm water and denture cleaner (Efferdent, Pfizer Consumer Healthcare, Morris Plains, New Jersey) for > 30 minutes and agitated to separate mucilaginous material from undigested prey remains (Crait and Ben-David, 2006). Samples then were washed with water through three nested sieves (2 mm, 1 mm, and 0.5 mm; Murie and Lavigne, 1985). Recovered fish otoliths, scales, and skeletal material were sorted and stored dry, and arthropods (e.g., insects, crustaceans) were preserved in 70% isopropyl alcohol (Lance et al., 2001). Otoliths, scales, bone, insects, and crustaceans were examined under a dissecting scope and identified to the lowest taxon possible using taxonomic keys (Morrow, 1979; Harvey et al., 2000; Lagler 1947; Oates et al. 1993; Daniels 1996) and photo references. Prey taxa were enumerated using the greatest number of left or right otoliths, insect wing pairs, and crustacean antennules. Otoliths recovered from samples were measured parallel to the sulcus from the anterior tip of the rostrum to the posterior edge (Lance et al., 2001). Measurements were recorded to the nearest 0.1 mm using digital calipers.

To compensate for degradation of otoliths during digestion, they were graded based on condition of external morphological features (Tollit et al., 1997). Otoliths were scored as having a low, medium, or high degree of digestion. If degraded, the length of each otolith was increased by a correction factor of 30.8%. This correction factor was based the results of a captive feeding study, where the average degradation in length of fish passing

through the digestive tract of American mink (*Mustela vison*) was 30.8% (Brzeziński and Marzec, 2002). Otoliths graded as high were included in the enumeration of minimum number of individuals (MNI) per sample, but were not included in the measurements.

Standard length and mass of fishes were estimated using species-specific linear regressions of otolith or bone length from published studies (Harvey et al., 2000; Gürsoy Gaygusuz, 2008). When regression relationships for fish species were not available, relationships for similar species were used; however if relationships for similar species were not available, the average mass reported in the literature of that fish species was used. Length and mass measurements of all insect and crustacean species also were obtained using this method.

Seasons in coastal northern California are not clearly defined by severe climate variables; therefore data were organized into periods of low and high rainfall, and were based on water flow levels in local streams (Josselyn, 1983). Periods of low rainfall occurred during May through October and periods of high rainfall occurred during November through April.

To determine if seasonal food habits of river otters could be described adequately, cumulative number of prey taxa recovered in each sample was plotted against the randomly pooled number of samples. One hundred random samples were re-sampled using the vegan R package version 2.5-2 (Oksanen et al., 2018) to create a mean and variability estimate for each sample. If the curve reached an asymptote or displayed a reduction in variability, an adequate sample size was reached (Ferry and Cailliet, 1996).

The following indices then were used to describe the seasonal prey array consumed by river otters (Krebs, 1999):

Species Richness: S = Number of prey species

Species Diversity: $H' = \left| \left(\sum (pi * \log_2 pi)\right) \right|$, where Pi = proportion of species i

Index values were calculated for each sample, generating a seasonal mean and variance estimate.

Importance of individual prey taxa in river otter diet also was determined for each season using a modified index of relative importance (IRI; Pinkas et al., 1971):

IRI = (Mean %Number+ Mean %Mass)* %Frequency Occurrence.

Originally, prey volume was used in the above equation; however, it was replaced by prey mass because volume can be difficult to measure (Hyslop, 1980). IRI values were calculated for each sample, generating a seasonal mean and variance estimate for all prey species.

Diet Characterization Results

Of the 49 fecal samples collected from river otters in Moorhen and McNabney Marshes, California during 2017-18, all contained at least one prey item. Two taxa were identified to species, one to genus, four to family, two to order, and one to class; and individual fecal samples contained 1 to 5 prey taxa (mean = 1.7551, SE = 0.12553; Fig. 1). Of 193 individual prey occurrences, 165 (85.5%) were crayfish, 23 (11.9%) were fishes, and 5 (2.6%) were insects. Red swamp crayfish (*Procambarus clarkia*) was the predominant crayfish prey species, sand sole (*Psettichthys melanostictus*), Cyprinidae (carps and minnows), Cottidae (sculpins), and Cyprinodontiformes (toothcarps) were the predominant prey fish species that could be identified below class, and darner dragonfly nymph (Aeshnidae) was the predominant insect species consumed by river otters.

It appeared that mean number of species (S) recovered per fecal sample was greater in the wet season (mean = 2.29, SE = 0.286) than the dry season (mean = 1.54, SE = 0.118) and mean diversity of prey taxa (H') consumed by river otters was greater in the wet season (mean = 0.635, SE = 0.099) than the dry season (mean = 0.246, SE = 0.055). However, cumulative prey curves indicated that insufficient fecal samples were collected during the dry (Fig. 2a; n = 35) and wet (Fig. 2b; n = 14) seasons to statistically compare temporal variations in river otter diet.

Eight prey taxa were identified in fecal samples collected during the dry season, however, approximately 97% of the total mean IRI was comprised of only one prey taxa, red swamp crayfish (Table 2; Fig. 3a). Unidentified teleost was the next most important taxa consumed, but accounted for only 2% of the overall mean IRI. Nine prey taxa were identified during the wet season. Similar to the dry season, the majority of prey taxa consumed during the wet season were comprised of red swamp crayfish, followed by Cyprinodontiformes (toothcarps) and unidentified teleost (Table 3; Fig. 3b). Unfortunately, temporal variations of prey taxa importance could not be compared because insufficient fecal samples were collected.

Summary

River otters foraging in or near Moorhen and McNabney Marshes appeared to be opportunistic carnivores that consumed fishes, crustaceans, and insects. The most important prey species consumed by river otters during the 2017-18 sampling period was the red swamp crayfish, an invasive species that is abundant in the San Francisco Bay Area (USFW, 2015). Fishes were the second most important prey species and included sculpins, flatfishes, carp/goldfish, toothcarps, perch-like fishes, and a juvenile sturgeon (*Acipenser* spp.). The juvenile sturgeon was identified tentatively from two dorsal scutes, but needs further validation to confirm the species.

River otter numbers decreased during most of the wet season (December, 2017 through March, 2018) once vegetation cutting, pond dewatering, and construction started. Although it appeared river otters still foraged in the Peyton Slough Wetlands Complex, fewer fecal samples were recovered making diet characterization difficult. Additional samples should be collected to further characterize the diet of river otters foraging in or

near the Peyton Slough Wetlands Complex.

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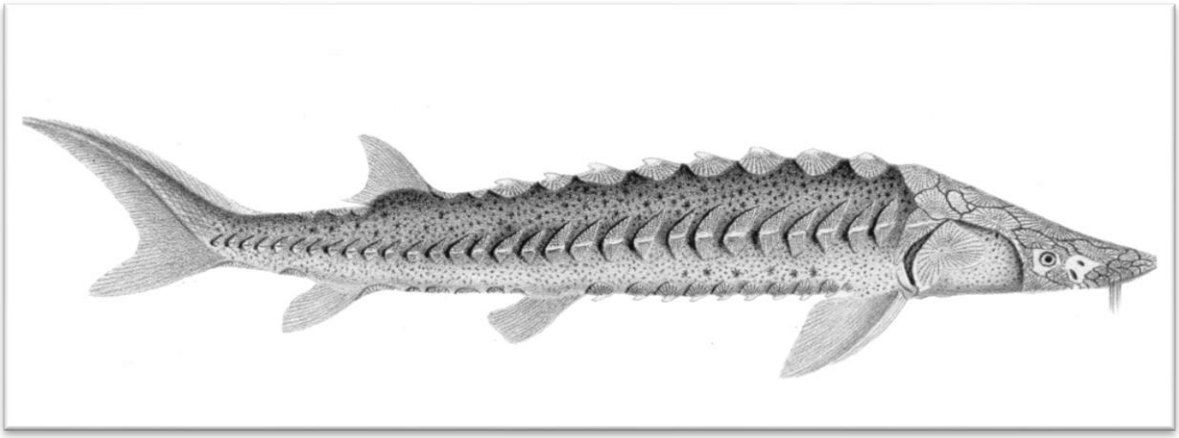
Tables and Figures

Table 1. Number of fecal samples collected in Moorhen Marsh and McNabney Marsh, California between May 2017 and March 2018.

Season	Month	Number of Samples
Dry (May-October)	May	0
	June	0
	July	11
	August	5
	September	5
	October	14
	TOTAL	35
Wet (November-April)	November	9
	December	3
	January	0
	February	0
	March	1
	April	1
	TOTAL	14



Green sturgeon (*Acipenser medirostris*)

Table 2. Mean and standard error (SE) of percentage number (%N) and percentage mass (%M), percentage frequency of occurrence (%FO), and mean and standard error (SE) of index of relative importance (IRI) of prey taxa identified in fecal samples of river otters collected in Moorhen Marsh and McNabney Marsh, California during the 2017 dry season (May-October; n = 35). Prey taxa are listed in order of decreasing IRI.

Prey Taxa	%N		%M		%FO	IRI	
	Mean	SE	Mean	SE		Mean	SE
Procambarus clarkii	86.728	3.622	88.196	3.674	1.000	174.92	7.2
Unidentified Teleost	6.065	3.515	8.010	3.694	0.229	3.217	1.625
Cyprinidae	1.596	0.771	1.039	0.538	0.114	0.301	0.149
Aeshnidae	2.619	2.932	0.008	0.013	0.086	0.225	0.252
Psettichthys melanostictus	2.000	***	2.324	***	0.029	0.124	***
Cottidae	0.317	***	0.351	***	0.029	0.019	***
Cyprinodontiformes	0.357	***	0.002	***	0.029	0.010	***
Perciformes	0.317	***	0.025	***	0.029	0.010	***

Table 3. Mean and standard error (SE) of percentage number (%N) and percentage mass (%M), percentage frequency of occurrence (%FO), and mean and standard error (SE) of index of relative importance (IRI) of prey taxa identified in fecal samples of river otters collected in Moorhen Marsh and McNabney Marsh, California during the 2017-18 wet season (November-April; n = 14). Prey taxa are listed in order of decreasing IRI.

Prey Taxa	%N		%M		%FO	IRI	
	Mean	SE	Mean	SE		Mean	SE
Procambarus clarkii	64.926	7.461	77.349	7.699	1.000	142.276	14.176
Cyprinodontiformes	15.788	3.819	0.130	0.050	0.357	5.685	1.382
Unidentified Teleost	6.786	1.937	8.387	2.205	0.286	4.335	1.184
Cyprinidae	2.579	2.625	3.842	4.251	0.143	0.917	0.982
Cottidae	1.984	1.050	4.163	8.354	0.143	0.878	1.343
Psettichthys melanostictus	4.762	***	2.432	***	0.071	0.514	***
Acipenser spp.	0.794	***	3.689	***	0.071	0.320	***
Aeshnidae	2.381	***	0.007	***	0.071	0.171	***

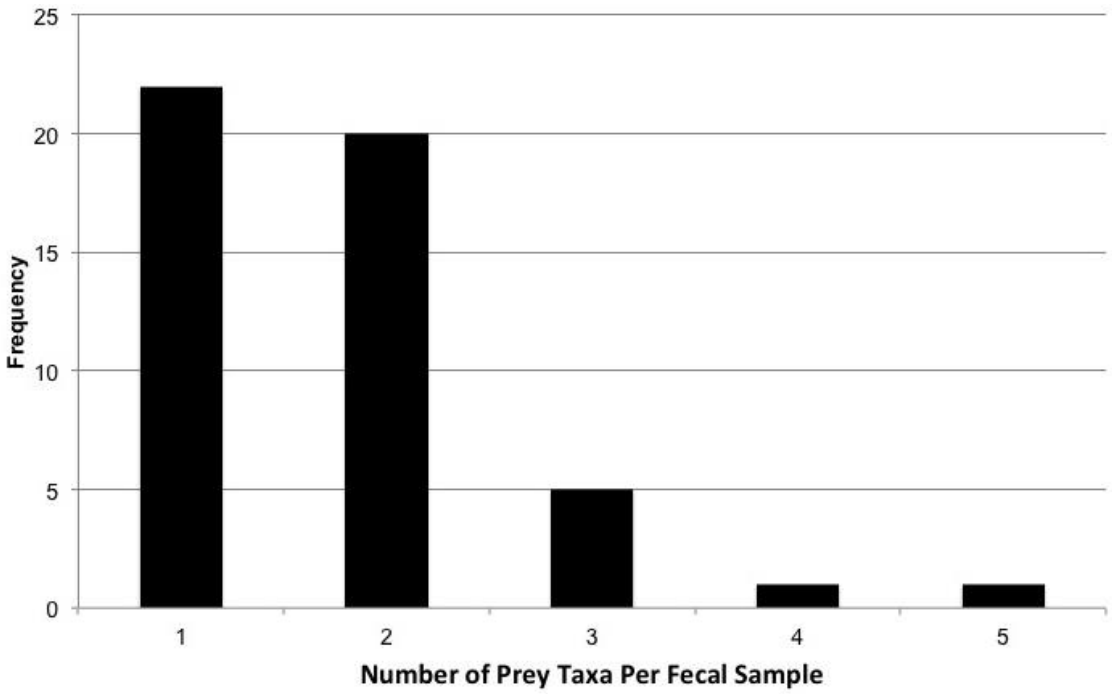


Figure 1. Frequency of number of prey taxa per river otter fecal sample collected from Moorhen and McNabney Marshes, California during the 2017-2018.

Red swamp crayfish (*Procambaris clarkii*)

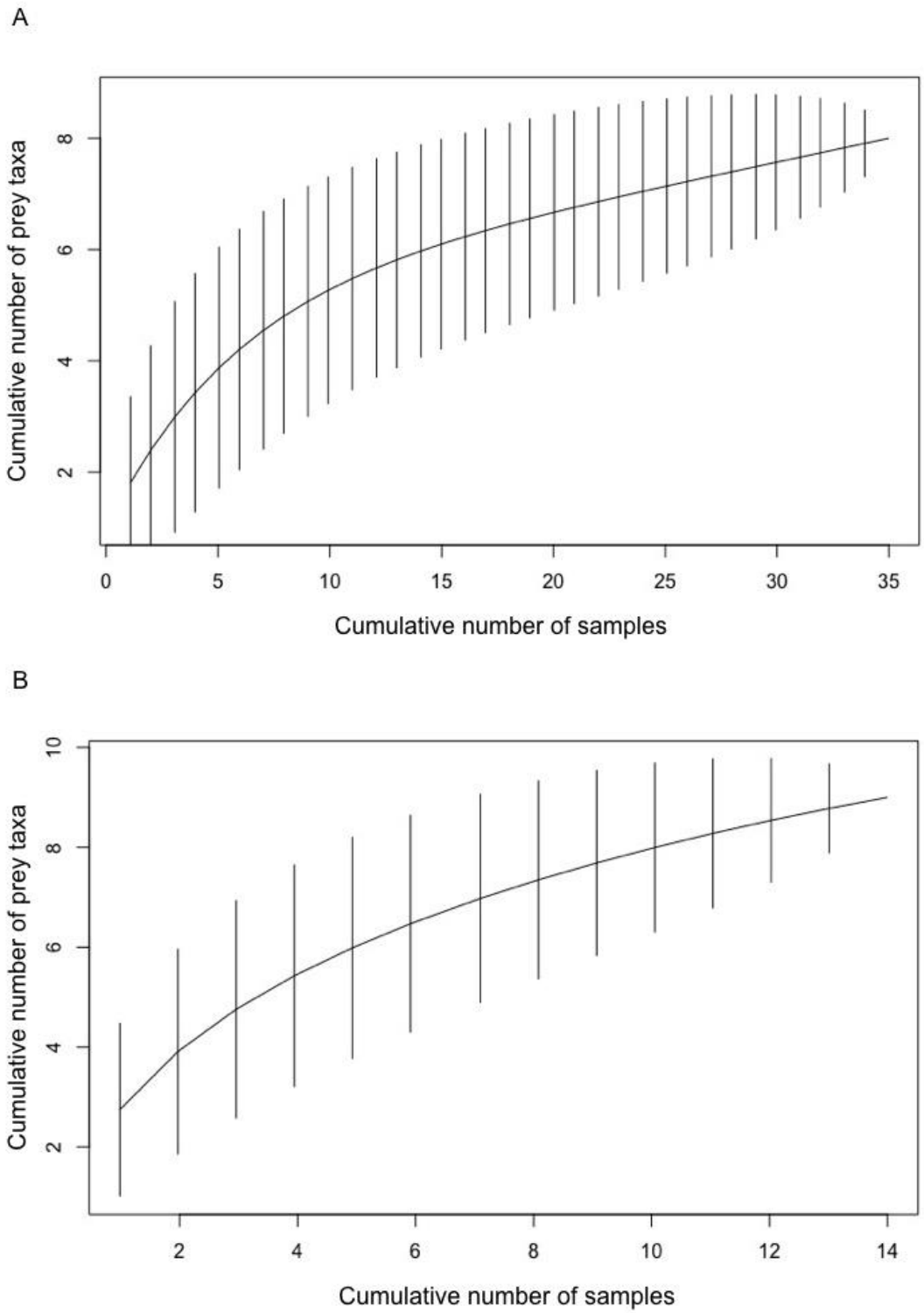


Figure 2. Cumulative number of prey taxa per fecal sample with standard error bars collected during the 2017-18 dry (A) and wet (B) seasons in Moorhen Marsh and McNabney Marsh, California.

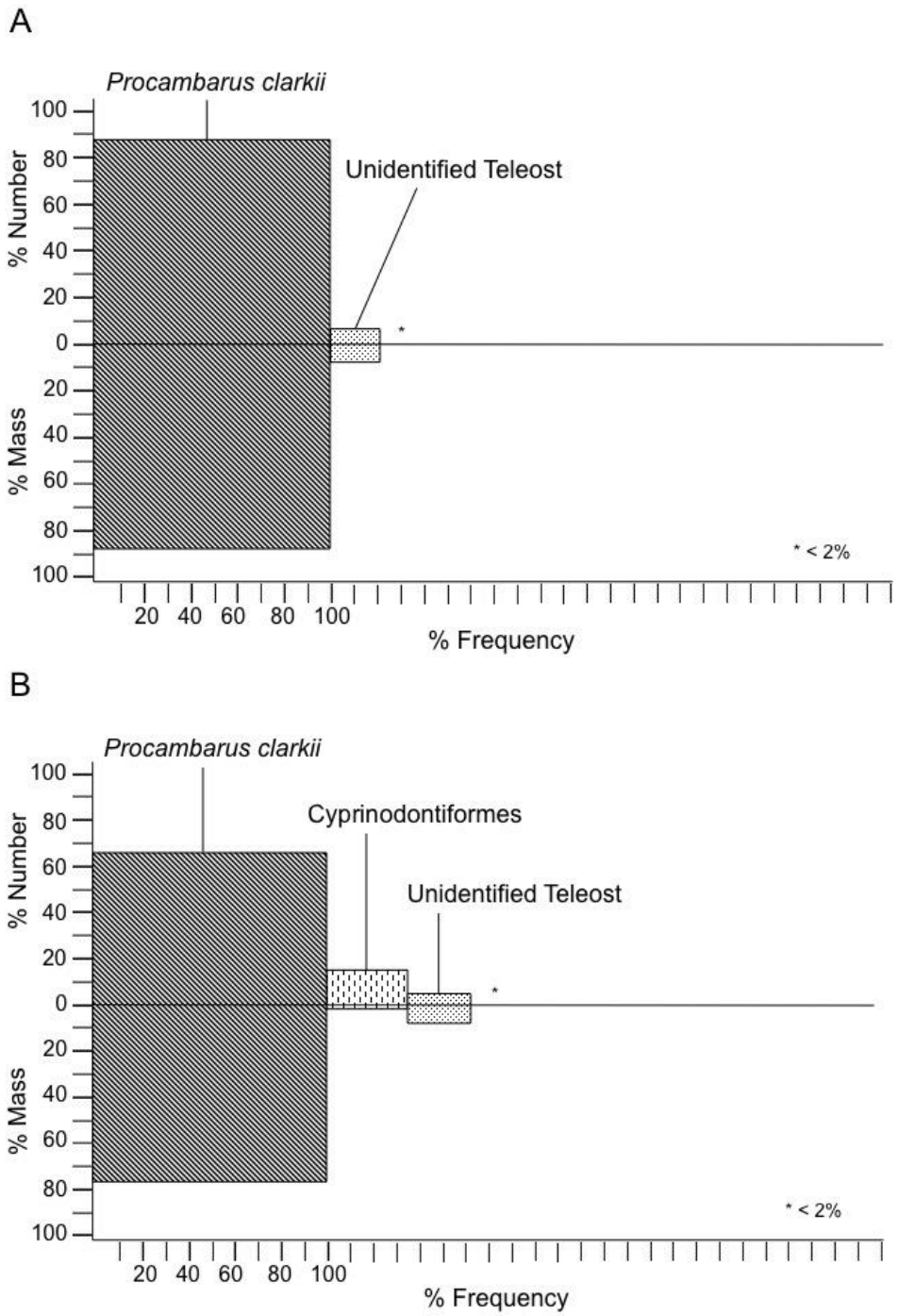


Figure 3. Mean percentage number (%N), mean percentage mass (%M), and percentage frequency of occurrence (%FO) of prey taxa identified in fecal samples of river otters collected in collected in Moorhen Marsh and McNabney Marsh, California during the 2017-18 dry (A) and wet (B) seasons. Only prey comprising >2% of the total mean IRI are depicted.