North American River Otter (*Lontra canadensis*) Predation on Brown Pelicans (*Pelecanus occidentalis*) at Abbotts Lagoon, Point Reyes National Seashore, California

May 1, 2024

Terence Carroll[1], Research Director, River Otter Ecology Project
Megan Isadore, Executive Director, River Otter Ecology Project

River Otters with Pelican Carcass, Abbotts Lagoon, September 24, 2023
Photo by Everett Clark

[1] PO Box 103, Forest Knolls, CA 94933
terence@riverotterecology.org

Introduction

North American river otters (*Lontra canadensis*), a recovering species in the San Francisco Bay Area (Schempf and White 1977; Bouley et al., 2015), are opportunistic predators whose diet varies seasonally according to availability of prey species (Melquist et al., 2003; Penland and Black 2009). At Abbotts Lagoon in Point Reyes National Seashore (PRNS), river otters consume mainly fish and water birds, with the frequency of bird predation increasing in the wet season, generally November to April (Oates et al., 2019). Beginning in the fall of 2018, River Otter Ecology Project (ROEP) has observed and documented otter predation on Brown Pelicans (*Pelecanus occidentalis)* at Abbotts Lagoon. This predator-prey relationship had previously been observed and documented in 2006 at Rodeo Lagoon in the Golden Gate National Recreation Area (Salman 2007), and in 1998 at Lake Tolowa in Del Norte County (D. Jaques, personal communication, November 30, 2023), but not, to our knowledge, at Abbotts Lagoon.

Brown pelicans are also a recovering species, having been removed from Endangered Species Act (ESA) protection in 2009 (USFWS 2009, Jacques et al., 2016). Pelicans are present at Abbotts Lagoon during the nonbreeding season, May to December, using the lower lagoon as a resting site but not to roost. Salman (2007) hypothesized that eutrophication of Rodeo Lagoon had reduced fish stocks, and that river otters began consuming pelicans as a supplemental or replacement food source. The same eutrophication condition does not exist presently at Abbotts Lagoon, and river otter predation on pelicans there likely represents a different relationship between predator and prey, and consequently may have different ecological and management implications.

At Abbotts Lagoon, river otters consume both fish and water birds year-round (Oates et. al., 2019), and their predation of pelicans may be an extension of an existing pattern of prey choice, rather than a response to changes in abundance of prey species, as hypothesized by Salman (2007) at Rodeo Lagoon. River otters are opportunistic predators, but their prey selection is heavily influenced by the energetic costs of foraging in aquatic environments, including thermoregulation costs (Kruuk 2006). As a result, they tend to favor larger, less-agile prey species, and employ repetitive use of successful foraging routes (Blundell et al., 2001; Kruuk, 2006; Thompson and Stelle, 2014, Day et al, 2015.). In addition, river otters can gain a thermoregulatory advantage from catching larger prey that can be consumed on the shoreline (Kruuk 2006), including pelicans.

In terms of ecosystem recovery and function, an important question is whether the pressure from river otter predation at Abbotts Lagoon is having a substantial localized negative impact on pelicans. The local persistence of this predator-prey relationship over a number of years suggests not. However, no baseline studies have been carried out to quantify the extent or impacts of this predation. We hypothesize that river otter predation of pelicans at Abbotts Lagoon occurs at a low level with little relation to the local abundance of pelicans. We further hypothesize that, in the aggregate, the pelicans are tolerant of the predation, and do not respond to it by altering their pattern of use of the area, either spatially or over time.

Study Area and Methods

Study Area

Abbotts Lagoon (38°06'54.0"N 122°57'10.8"W) is a complex of 3 connected lagoons on the coastal portion of the Point Reyes peninsula (Figure 1). The lower lagoon is the largest and deepest of the 3, and is used by Brown pelicans as a resting place. The middle lagoon is separated from the lower lagoon by a rock outcropping, and is connected to it by a narrow channel spanned by a footbridge. The upper lagoon, the smallest of the 3, is fed by several small freshwater streams, and is separated from the middle lagoon by an earthen berm. For this study, we collected data at the lower lagoon, and along portions of the middle lagoon shoreline immediately adjacent to the footbridge.

Carcass Data Collection

For this study, we established 4 survey areas along the perimeter of the lower lagoon and small portions of the middle lagoon near the footbridge (Figure 2). From June through November 2023, we surveyed the perimeter of the lagoon approximately every 7 to 10 days. On each survey, we documented each predated pelican carcass we found, photographing it and mapping its location using Survey123 (ESRI, Redlands CA). To avoid double-counting, we used a fluorescent non-toxic permanent marking pen to mark the beak and larger bones of each documented carcass.

We assumed that carcasses found on the first survey were from pelicans predated prior to the study period, and did not include them in the data used for this study. In addition, from June through August, survey area B on the southwestern side of the lagoon was inaccessible due to a seasonal closure to protect nesting Western snowy plovers (*Charadrius nivosus nivosus*). Survey area C, at the southern end, was also inaccessible due to inundation of the area, and the need to reach it by crossing a stream that we determined was too wide and deep to safely ford. During June through August, therefore, on each survey we used binoculars or a spotting scope to scan areas B and C, and used Survey123 to record the locations of any suspected carcasses. During our first survey of areas B and C in September we verified or discounted the presence and location of those carcasses.

Pelican Presence and Abundance Data

On each survey, we used Survey123 to record our count of the number of resting pelicans present at the lagoon, and the approximate location of the largest grouping. As a proxy for pelican abundance, we used data from eBird [eBird 2023]. Specifically, we used eBird's Average Count data point for the week immediately preceding each survey date. Average Count represents the weekly average of the number of pelicans reported by observers who included Brown pelicans on a checklist of birds seen that they submitted for Abbotts Lagoon.

Data Analysis

For carcass data collected in survey areas B and C on our first survey in September, we matched carcasses found to the survey dates on which our visual scans first identified those suspected carcasses. For other carcasses found on in areas B and C on that survey, we used the condition of

the carcass to estimate how long ago the pelican had been predated, and we accordingly assigned those carcasses to a survey date in July or August.

To assess the relationship, if any, between pelican abundance and predation by river otters, we used R to calculate the Spearman's Rank Correlation between the eBird Average Count and our count of carcasses for each survey period. We considered a *p*-value <.05 to be significant.

To assess whether pelicans, in the aggregate, altered the spatial pattern of their use of the lagoon in response to predation, we mapped our observations of the largest groupings in ArcGIS Pro 3.1 (ESRI, Redlands CA). We the used ArcGIS Pro's Mean Center function to determine the central point of those groupings for each month of the study period.

To assess whether the predation of pelicans was concentrated in particular areas of the lagoon, we used the ArcGIS Pro Optimized Hot Spot Analysis tool on the mapped locations of the carcasses. The tool performs a series of tests and operations on the spatial data to aggregate the points within the cells of a fishnet grid, and then produces a Getis-Ord Gi* statistic for each cell. The resulting z-scores and *p*-values describe the extent of the data's spatial clustering. We considered a *z*-score greater than 1.96 and a *p*-value less than .05 to be significant.

Results

Carcass Data Collection

During the study period we completed a total of 19 surveys. The first 10 surveys covered only Survey Areas A and D, with visual scanning of the opposite shoreline. The remaining 9 surveys covered the entire perimeter of the lower lagoon. Over the course of the surveys, we counted a total of 73 pelican carcasses, representing the number of individuals predated by river otters during the study period. Carcass counts on individual surveys ranged from a low of 0 to a high of 11 ($\overline{x}$ = 3.84, *SD* = 3.24) (Table 1). The locations of the carcasses are shown in Figure 3.

Pelican Presence and Abundance Data

Our counts of pelicans present on the lower lagoon ranged from a low of 0 to a high of 300 ($\overline{x}$ = 35.47, *SD* = 67.46). Weekly Average Counts from eBird ranged from a low of 5.20 to a high of 73.48 ($\overline{x}$ = 36.55, *SD* = 17.77) (Table 1).

Data Analysis

The Spearman's Rank Correlation between eBird Average Count and our count of carcasses for each survey period showed a moderate positive correlation between the two, with $r(17) = .60$, $p = .006$. The spatial pattern of pelican use of the lagoon showed no apparent response to predation over time, with the monthly mean centers of pelican grouping all remaining in the northern half of the lagoon throughout the study period (Figure 4).

The ArcGIS Pro Optimized Hot Spot Analysis Tool aggregated the carcass location points into 44 grid cells (Figure 5). From the calculation of the Getis-Ord Gi* for each cell, no *z*-scores

exceeded 1.96, and all *p*-values were > .05, indicating that the carcass locations were not significantly clustered in any part of the lagoon shoreline.

Discussion

Results of our study show that river otters predated Brown pelicans on a consistent basis throughout the study period. On 17 of our 19 surveys, we found carcasses of pelicans that had been predated since the prior survey. In addition, the 73 carcasses we identified likely represents a conservative estimate of the true extent of predation levels. Given the inaccessibility of survey areas B and C until September, as well as the likelihood of scavengers carrying off carcasses between surveys, we assume that some number of carcasses went uncounted.

Contrary to our first hypothesis, we found a moderate correlation between pelican abundance at the lagoon and the level of predation by river otters. It may be that larger groupings of pelicans resting on the lagoon have more isolated individuals around the periphery of the group, facilitating predation by river otters. The apparent correlation may also be an artifact of our use of weekly abundance counts, rather than the actual number of pelicans present during a predation event. In 2023, we observed and documented a total of 9 river otters, including 3 adult females and 6 pups. Further study over multiple years would be required to assess whether the apparent correlation persists, given variability in local river otter abundance from year to year.

Consistent with our second hypothesis, we found no evidence that, in the aggregate, pelicans responded to predation by river otters by altering their pattern of use of the lagoon. As shown in Figure 4, the monthly mean center of pelican groupings moved generally southward over the course of the study period, but never moved south of latitude 38°06'54.0"N, roughly the middle latitude of the lower lagoon. No pelicans were observed south of that point at any time during our surveys. During the summer months, the surface area of the lower lagoon recedes due to evaporation, seepage, and diminished inflows (Kratzer et al., 2006). The southward movement of pelican groupings over time is consistent with movement to the deeper area of the lagoon. The persistence of the groupings in northern half of the lagoon suggests that, in the aggregate, pelicans are not moving to avoid predation.

Our analysis of the spatial distribution of pelican carcasses around the lower lagoon did not show significant clustering in any area. Any given location where we found the carcasses may not be indicative of predation occurring in close proximity. From observational reports and photographic evidence, we have documented that river otters sometimes tow or drag carcasses for some distance before consuming them. The presence of carcasses along the southern shoreline of the lower lagoon, where pelicans are unlikely to be present, also illustrates this dynamic.

Predation of Brown pelicans by river otters is a novel phenomenon, and no similar studies exist to which to compare our results. Salman (2007) reported finding 30 pelican carcasses at Rodeo Lagoon, but he collected data mainly in the months of October and the following March. Our

research camera at Rodeo Lagoon captured video of rivers otters predating a pelican in July 2023, and the concurrent ongoing predation there and at Abbotts Lagoon presents a valuable research opportunity for studying this phenomenon in greater depth. A comparative study at the two lagoons could yield insight into the importance of pelicans as a prey species for river otters, and into the effects of predation on local pelican populations. It could also offer insight into pelican behavior in the presence of a novel predator.

This study serves as a baseline from which to increase and enrich our understanding of an emerging predator-prey relationship between two recovering species in the San Francisco Bay Area. Investigation of links among pelican habitat use, river otter predation behavior, and any consequent trophic subsidies may be a useful avenue for future research.

Educational Opportunities for Local Students

A college intern assisted with the field work for this study. In the course of our research, we also collaborated with a UC Santa Cruz graduate student on documenting the scavenging of pelican carcasses by coyotes.

Acknowledgements

Funding for this study was provided by The Neubacher Fund for Marine Science at Point Reyes National Seashore, and by generous private donations to River Otter Ecology Project. We are very grateful for the able assistance of Amanda Lipari-Maxson in collecting and recording the data used in the study. We also thank Matt Lau, Nils Warnock, and Tom Gardali for their valuable suggestions and insight. Research was performed under River Otter Ecology Project's current NPS permit #PORE-2021-SCI-0014.

Literature Cited

Blundell, G. M., Maier, J. A., & Debevec, E. M. (2001). Linear home ranges: effects of smoothing, sample size, and autocorrelation on kernel estimates. *Ecological monographs*, *71*(3), 469-489.

Cosby, H., & Szykman Gunther, M. (2021). Variation in diet and activity of river otters (*Lontra canadensis*) by season and aquatic community. *Journal of Mammalogy*, *102*(2), 520–529. https://doi.org/10.1093/jmammal/gyaa165

Day, C. C., Westover, M. D., & McMillan, B. R. (2015). Seasonal diet of the northern river otter (Lontra canadensis): what drives prey selection?. *Canadian Journal of Zoology*, *93*(3), 197-205.

[eBird 2023]. eBird: An online database of bird distribution and abundance [web application]. eBird, Cornell Lab of Ornithology, Ithaca, New York. Available: http://www.ebird.org. (Accessed: December 2023).

Jaques, D. L., & Logic, P. E. (2016). California Brown Pelican Monitoring Summary 2014 The Year of the Blob.

Kratzer, C.R., Saleh, D.K., and Zamora, Celia, 2006, Assessment of Hydrologic and Water Quality Data Collected in Abbotts Lagoon Watershed, Point Reyes National Seashore, California, during Water Years 1999 and 2000: U.S. Geological Survey Scientific Investigations Report 2005–5261, 35 p.

Kruuk H. (2006). Otters: Ecology, behaviour and conservation. Oxford, UK: Oxford University Press.

Melquist, W.E., P.J. Polechla, and D. Toweill. 2003. River otter. pages 708-734 in G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Second edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

Oates, S, Isadore, M., Carroll, T. 2019. Seasonal Food Habits of the North American River Otter (Lontra canadensis) in Point Reyes National Seashore and Peyton Slough Wetlands Complex, California. Technical Report. https://riverotterecology.org/wpcontent/uploads/2019/07/FinalReport_Diet_070319.pdf

Penland, T. F., & Black, J. M. (2009). Seasonal variation in river otter diet in coastal northern California. *Northwestern Naturalist*, 233-237.

Salman, T. (2007). River Otter predation on Brown pelicans at a lagoon in the Golden Gate National Recreation Area. Report to the National Park Service.

Schempf, P. F., White, M. (1977). Status of six furbearer populations in the mountains of northern California. San Francisco, CA: USDA Forest Service, California Region 5. 51 p.

Thompson, L., & Stelle, L. L. (2014). Prey preference of the North American river otter (Lontra canadensis) evaluated based on optimal foraging theory. *IUCN Otter Specialist Group Bulletin*, *31*(1), 15-29.

[USFWS 2009] U.S. Fish and Wildlife Service. 2009. Draft post-delisting monitoring plan for the brown pelican. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. 19pp.

Table 1. Dates of lagoon surveys, with the number of new pelican carcasses identified, the eBird-computed average pelican count for the prior week, and the number of pelicans counted during the survey.

Survey Date	Count of New Carcasses	eBird Weekly Average Pelican Count	ROEP Survey Pelican Count
6/6/2023	1	5.20	10
6/15/2023	0	14.75	19
6/25/2023	1	12.91	10
7/7/2023	3	56.57	40
7/14/2023	3	41.77	15
7/22/2023	4	73.48	15
7/29/2023	4	33.09	0
8/8/2023	11	35.85	6
8/15/2023	4	67.83	7
8/26/2023	4	44.37	72
9/5/2023	0	30.13	33
9/15/2023	7	51.90	22
9/26/2023	6	42.37	65
10/8/2023	10	44.58	300
10/15/2023	8	28.50	10
10/21/2023	2	30.18	0
11/1/2023	1	32.29	0
11/12/2023	1	28.10	5
11/26/2023	3	20.56	45
Mean	3.84	36.55	35.47
SD	3.24	17.77	67.46

Figure 1. Map of the study area at Abbotts Lagoon, showing the lower lagoon in relation to the middle and upper lagoons, and the surrounding area.

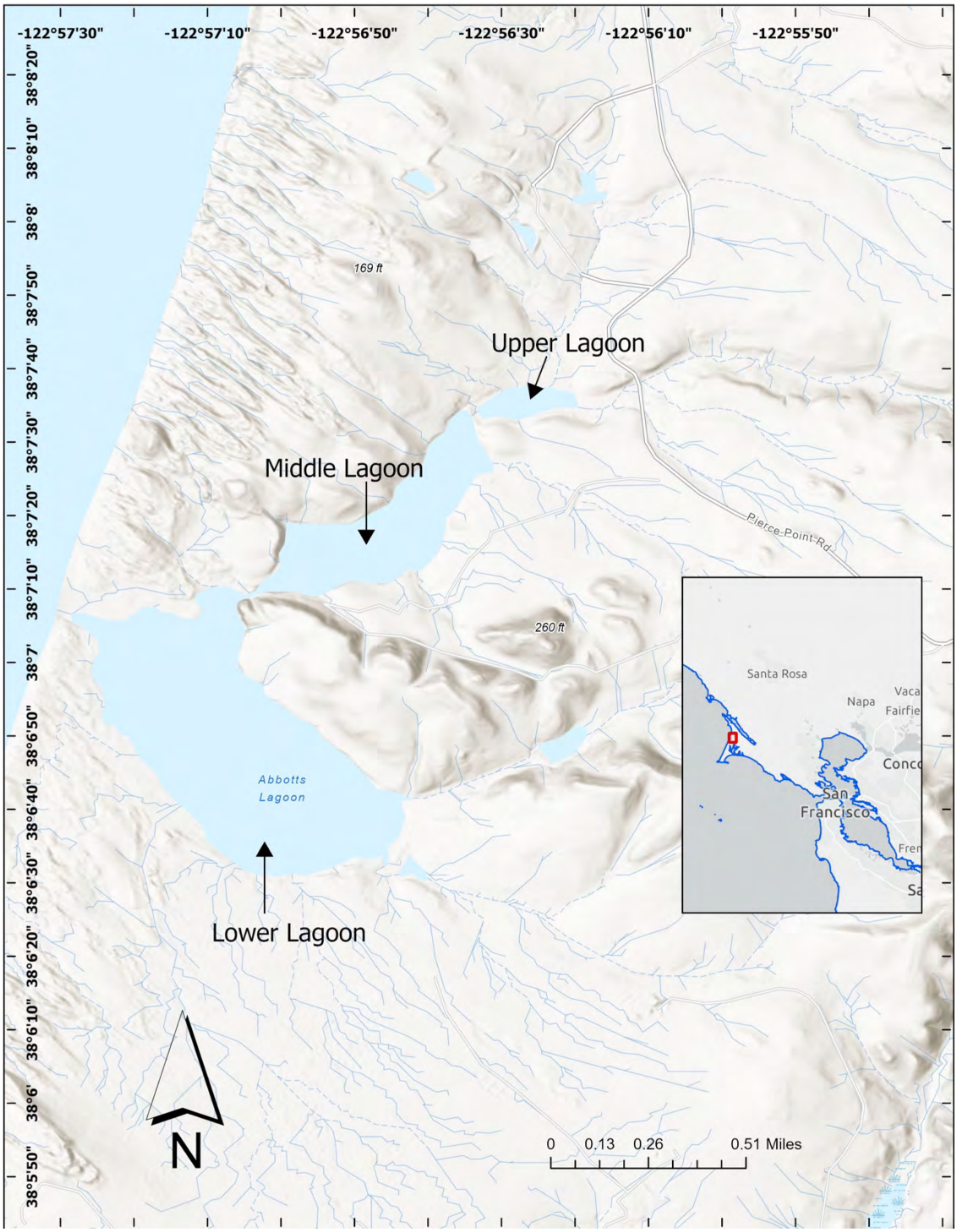

Figure 2. Locations and extents of the four survey areas used during data collection for the study.

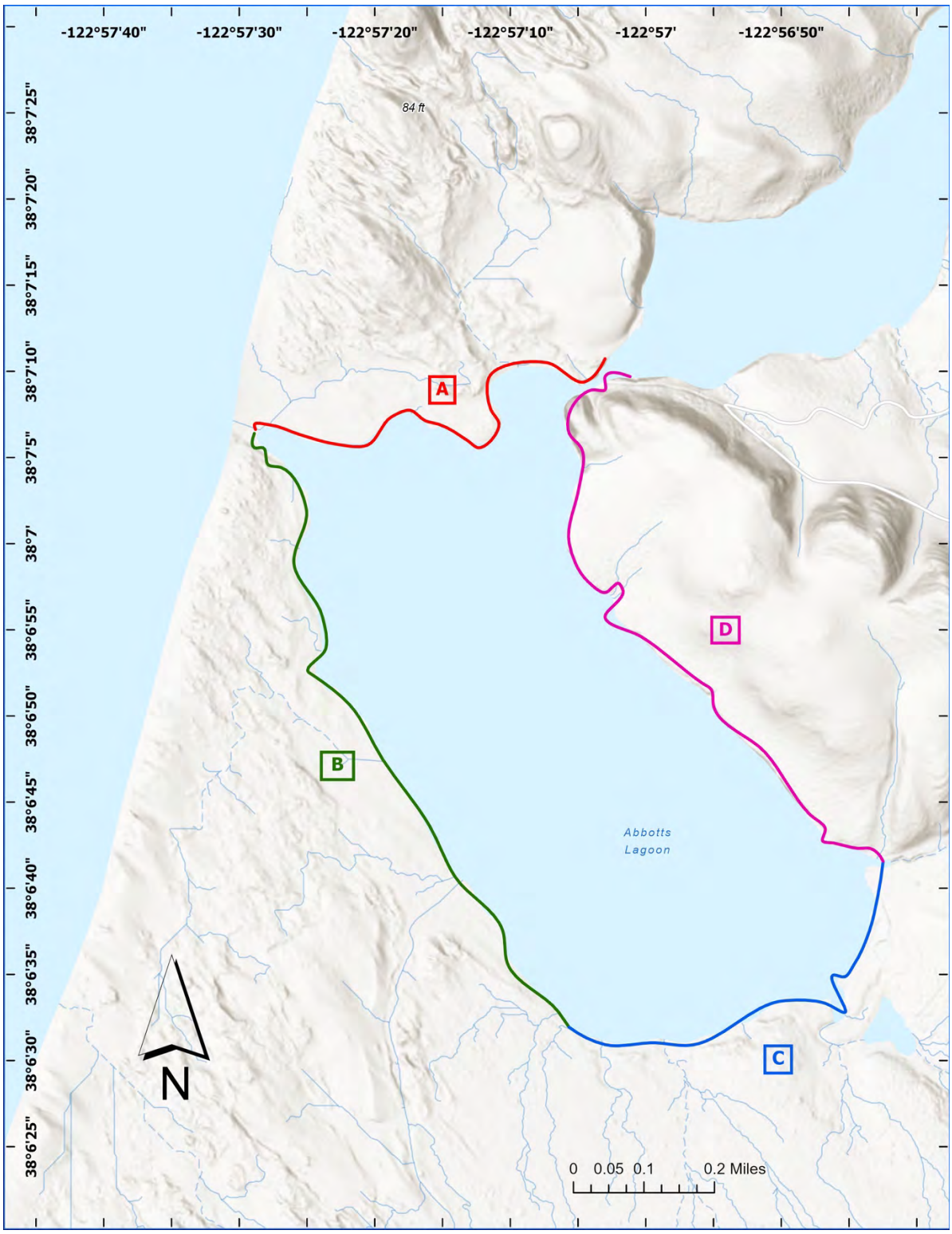

Figure 3. Locations of the 73 Brown pelican carcasses documented during June through November 2023 at Abbotts Lagoon.

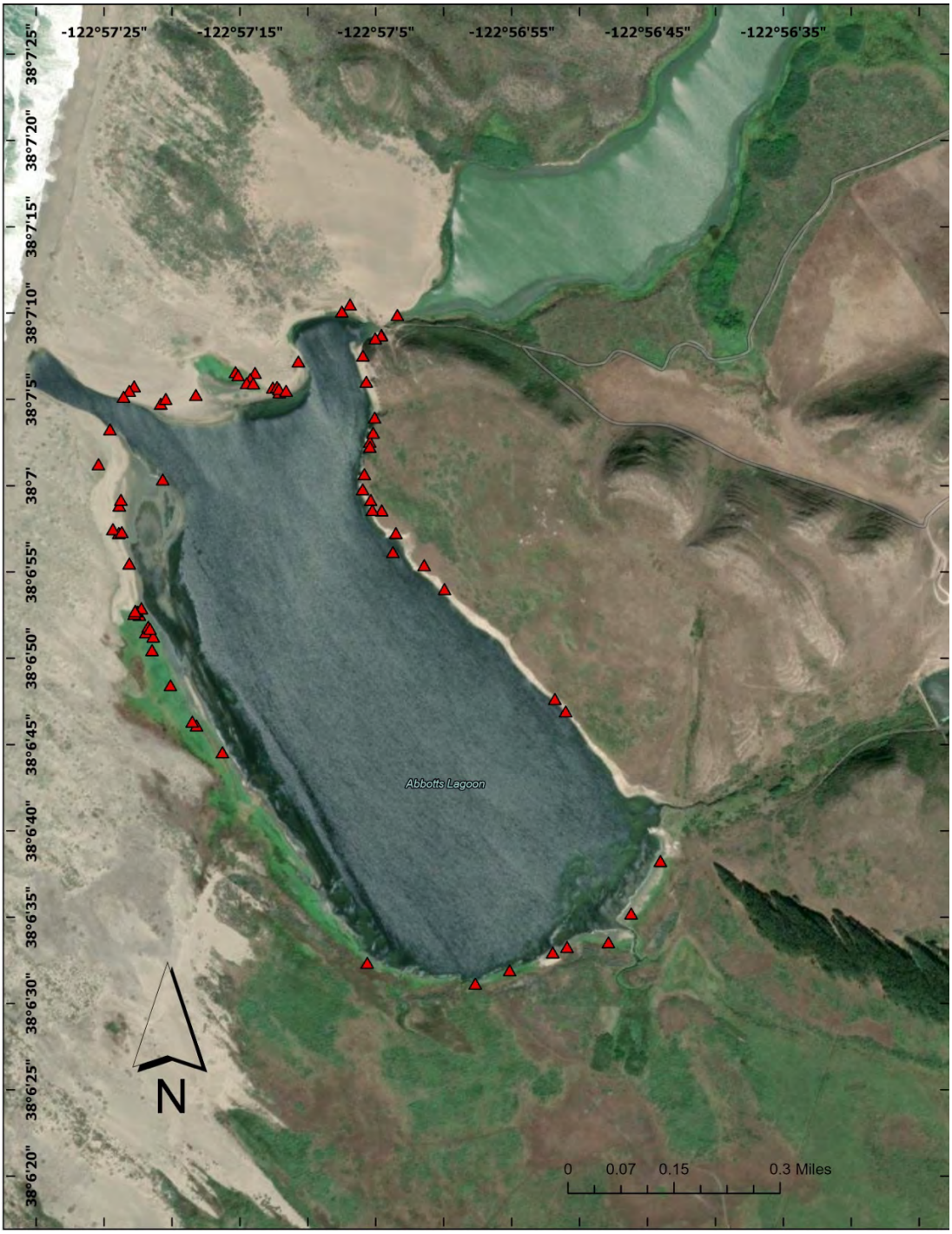

Figure 4. Monthly mean center locations of Brown pelican groups resting on the lower lagoon.

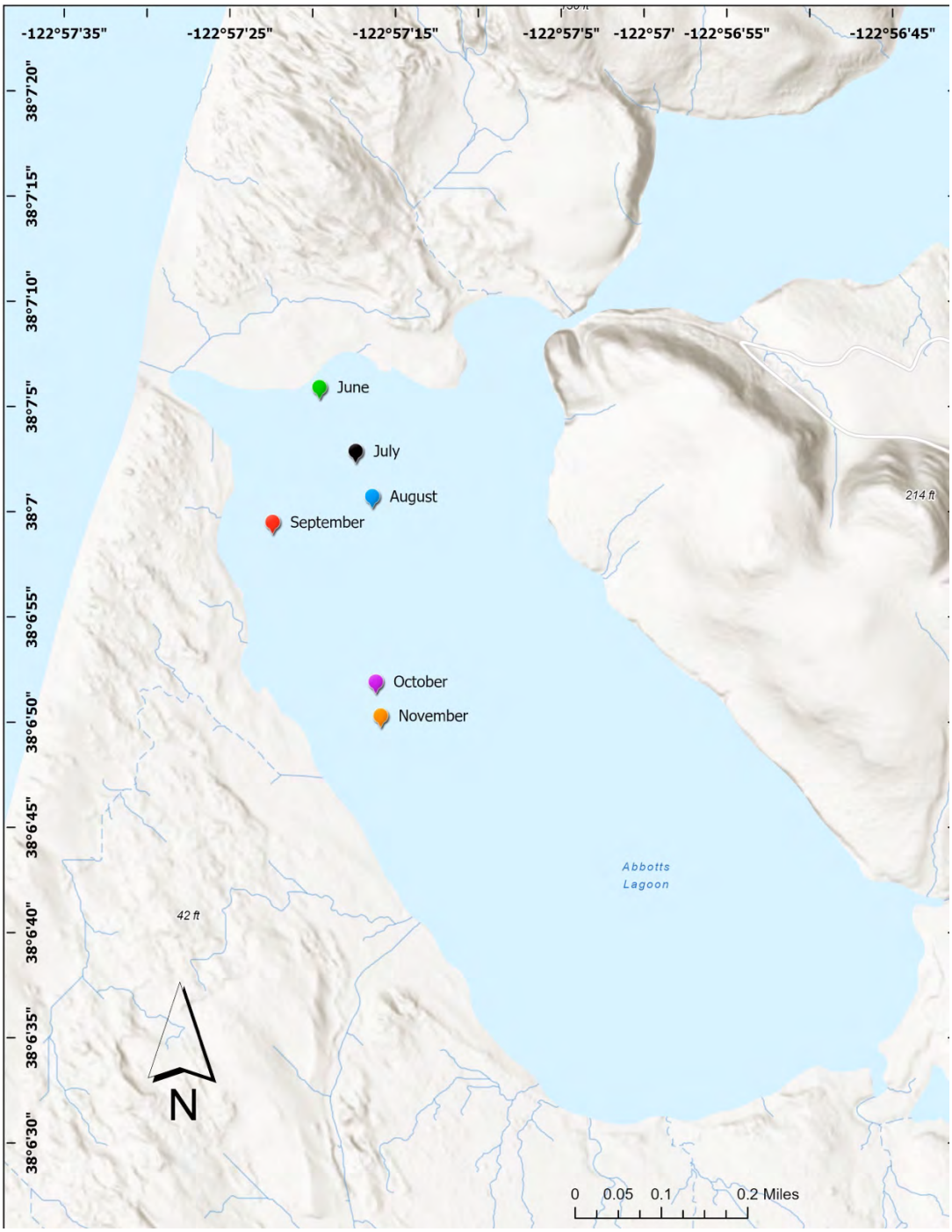

Figure 5. Results of Optimized Hot Spot analysis of the distribution of Brown pelican carcasses around the lower lagoon. Grey squares show the fishnet grid cells into which carcass locations were aggregated. Grid cells with no carcass locations are not shown.