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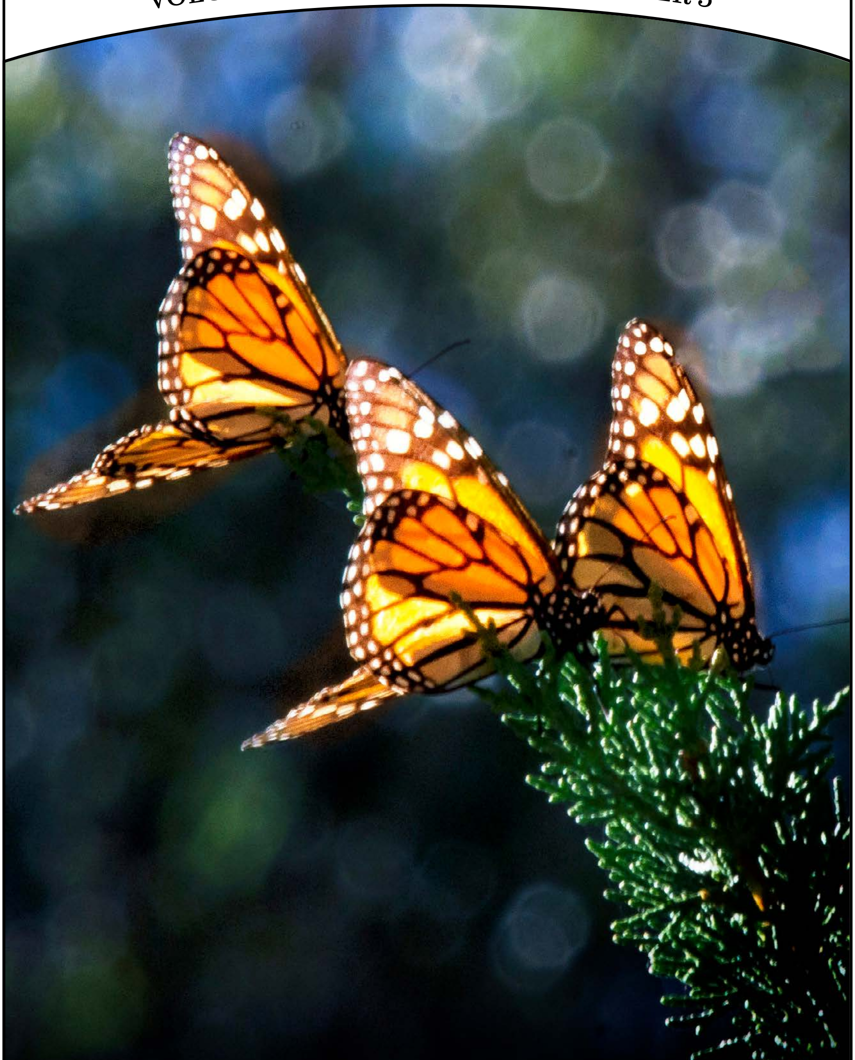

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Notes from the Editor

Our summer issue contains a number of excellent articles, including a couple on taxonomic groups that are often under-represented in the Journal—invertebrates and raptors. Dr. Stephen Goldberg, a frequent amphibian contributor to *California Fish and Wildlife*, included an interesting note on the reproduction of Cascades frog, a candidate species for listing under the California Endangered Species Act (CESA). Another frequent contributor, Dr. Vernon Bleich (former Editor-in-Chief of this Journal) provided two submissions—a note on Woodhouse's toad locations suggesting that major storm events have likely facilitated expansion of the species in California as well as an obituary for Robert L. Vernoy, a long-time biologist for the Department. Dr. Travis Longcore, from the University of California, Los Angeles, and his co-authors presented a thought-provoking essay on Monarch butterflies and their use of non-native trees when overwintering in California. Next, Dr. Barbara Clucas, from the well-known Wildlife Department at Humboldt State University, developed, along with several of her students, a new method for monitoring raptors in agricultural areas using camera traps and artificial perches. And finally, Dr. David Boughton of the National Marine Fisheries Service at the Southwest Fisheries Science Center, provided a review of the striped bass in coastal California—a non-native species introduced in California in the late 1800s for sport fishing.

Our editorial team gained another excellent member recently. Mario Klip joined the Department in 2012 with the North Central Region. He obtained a PhD in Environmental Sciences Policy at the University of California, Berkeley in 2018, with a focus on black bears, and he completed his master's in biology at Sonoma State University in 2012. Mario had a very different career before joining CDFW; prior to working with wildlife and conserved lands, he worked in the IT industry, and he holds a bachelor's in international management and marketing and master's in in management accounting from the University of Amsterdam. He moved from the Netherlands to California for various projects and ended up in Silicon Valley and held various senior positions before drastically change careers to pursue a life-long passion focused on wildlife. He is passionate about conducting applied research to better inform wildlife and land use decisions.

We also had a wonderful guest editor for the raptor manuscript in this issue. Carie Battistone received two degrees from the University of California, Davis: a bachelor's in Wildlife Biology and a master's in Avian Ecology. She currently serves as CDFW's Statewide Raptor Conservation Coordinator, a position she has had for over 10 years. In this coordinator role, Carie manages CDFW's efforts related to conservation, policy, regulation, and research for raptor species in California.

A reminder that many of the Journal's Special Issues will be coming out this year! We have explored the impacts of fire, cannabis, and human recreation on fish and wildlife resources. The recreation issue came out in April, and the others will be out later this summer. Additionally, we are now accepting submissions for two new special issues—one on the California Endangered Species Act (CESA) and one on Human-Wildlife Interactions. If you would like to find out more about our Special Issues, please see our webpage: https://www.wildlife.ca.gov/Publications/Journal/Special-Issues.

Ange Darnell Baker, PhD
Editor-in-Chief
California Fish and Wildlife Journal

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A novel method using camera traps to record effectiveness of artificial perches for raptors

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Agricultural areas can benefit from the reduction of rodents by raptors, yet many croplands and pastures do not provide adequate perching structures needed by raptors to hunt effectively. Many artificial raptor perches have been constructed as a solution to this deficiency, however, monitoring the benefits of these perches has proved challenging. We developed a method using artificial perches and camera traps mounted on poles that allows for 24-hour monitoring of perch utilization. We tested the new method in an agricultural area in northern California and demonstrated its ability to facilitate accurate species identification and to quantify raptor use and activity. Three of the six raptor species observed at the site utilized the artificial perches: American kestrels (*Falco sparverius*), red-tailed hawks (*Buteo jamaicensis*), and red-shouldered hawks (*B. lineatus*). We did not document any rodent predation events from the perches; but we did observe American kestrels using perches to hunt for invertebrates. Overall, we found that using camera traps mounted on poles can successfully monitor artificial perches and can be easily used to study the effectiveness of hunting perches for raptors in agricultural areas.

Key words: agriculture, artificial perches, *Buteo jamaicensis, Buteo lineatus,* camera traps, *Falco sparverius*, foraging, pests, raptors, rodents

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Raptors have the potential to provide an important ecosystem service in agricultural areas by removing rodent pests (Kay et al. 1994; Whelan et al. 2008). Certain raptor species are skilled rodent specialists and will hunt in human-modified landscapes including cropland and pastures (e.g., barn owls (*Tyto alba*) and red-tailed hawks (*Buteo jamaicensis*); Pearlstine et al. 2006; Kross et al. 2016). However, some agricultural areas lack appropriate structures for raptors to perch on. A possible solution to increase the attractiveness of agricultural areas is to augment these areas with artificial perches, which many raptor species are known to use (Hall et al. 1981; Reinert 1984).

Studies of artificial perches for raptors have examined perch use (Askham 1990), effect of perch installation on rodent population numbers (Kay et al. 1994; Wolff et al. 1999; Sheffield et al. 2001) and how perch setup features such as perch height (Kim et al. 2003) and surrounding habitat (Kross et al. 2018; Wong and Kross 2018) affect use. Monitoring raptor use of perches has proved challenging in part because observer presence may impact perch use. Forren et al. (1984) attempted to remotely monitor raptor perch use with a mechanical spring device that recorded use, but this method required the perch to be checked every day, and raptors could not be identified to species. Wong and Kross (2018) used camera traps to monitor perch use by placing cameras on ground level tripods angled up to view perches, but this method sometimes failed (e.g., cameras were knocked over). Additionally, this method could make species identification difficult and lead to theft or vandalism of equipment because of unsecured ground placement. Kross et al. (2018) attached cameras to pre-existing fence t-posts and angled them upwards to face artificial perches. This method improved equipment security but periodically experienced cattle interference.

We developed a new method for monitoring artificial perch use by raptors utilizing camera traps attached to poles adjacent to perches. By placing cameras on poles at the same height of the perch, we obtained clear photos and decreased the likelihood of camera theft, vandalism, or interference. We tested the new method in an agricultural area in northern California, which consisted of two habitat types: an open grassland field with cattle and a semi-open grassland surrounded by forest. Our objectives were 1) to determine how effective the perches were in attracting raptors to use them in the two habitat types and 2) to demonstrate that camera traps mounted on poles could successfully monitor raptor use of artificial perches, and 3) to capture photos of sufficient quality to identify raptors to species.

METHODS

Study area

We conducted our study at the Leavey Ranch property located between the cities of Arcata and Blue Lake, California (40.874, -124.008; elevation: 40 m). The climate in this area is characterized by wet winters and dry summers. The average annual rainfall is approximately 120 cm and temperatures range from 4–22 °C across the year. The property contains 52.6 ha of rangeland that is fenced, bordered by forests and the Mad River, and is bisected by a two-lane road (Figure 1). During our study, approximately 100 domestic cows were fenced in the northern section of the rangeland, and two bulls and two horses were fenced in the southern section of the rangeland. The northern section of the rangeland is open and relatively flat while the southern section is semi-open with sporadic trees and closely surrounded by secondary forestland composed primarily of coastal redwood (*Sequoia sempervirens*), tan oak (*Notholithocarpus densiflorus*) and Douglas fir (*Pseudotsuga menziesii*). At the time of the study, both sections had ground vegetation consisting of vari-

Figure 1. Study area map of Leavey Ranch in Humboldt County, California with artificial perch locations in the northern open grassland section (n = 3) and southern semi-open grassland sections (n = 3). Imagery was collected by The National Agriculture Imagery Program (NAIP; 2012).

ous grass species; however, the northern section had more bare ground (likely due to cattle grazing; Figure 1). Raptor species in this area include American kestrels (*Falco sparverius*), red-tailed hawks (*Buteo jamaicensis*), red-shouldered hawks (*B. lineatus)*, great horned owls (*Bubo virginianus*) and barn owls (*Tyto alba*). Small mammal prey include Botta's pocket gophers (*Thomomys bottae*) and California voles (*Microtus californicus*).

Artificial perch setup

We constructed the artificial perches using 3 m long hollow metal poles for the stands and 60 cm long wooden dowels of 3 cm diameter for the perches (Figure 2a; Appendix I). Perches were attached to the poles using a PVC tee piece bolted to the top end of the pole. We constructed the camera trap poles by using 3 m long hollow metal poles for the stands and then attaching the cameras to a L-bracket bolted to a modified cylindrical sliding mechanism (made from a metal electrical conduit connector) that could be slid up and down the poles (Figure 2d). Once the camera almost reached the top of the pole, it was held in place by a bolt approximately 7.5 cm from the top and an additional bolt at the top prevented the cameras from being pushed too far up and off the pole (Figure 2c). The bolt at the top of the pole also served to prevent any wildlife inadvertently entering the pole, which is a concern with open-topped pipes (Harris et al. 2019). In addition, epoxy (J-B Weld) was adhered to the metal cylinder to provide a structure that the hoisting pole could push on when moving the camera up the pole, and we attached a carabiner clip with plastic zip ties to the L-bracket to aid in retrieving the camera. This setup allowed for cameras to be activated on the ground, attached to the L-bracket, hoisted up the pole, and then later slid down the pole when checking the camera and collecting the data. We used a 1.5 m long wooden stick with a hook on the end to slide the camera up the pole, to release the camera trap from the bolt, and to slide it down the pole (Figure 2b).

To set up the perches and camera poles, we secured a metal t-post into the ground using a post-pounder and then attached the poles to the t-post using two U-bolts (the first near the top of the post and the second closer to the ground). We first installed the perch pole and then set up the camera pole 3m away (Figure 3). We placed the camera pole so that the camera trap would face one end of the wooden perch. We faced cameras north, or not directly east or west when possible, to prevent interference from sunlight (Wearn and Glover-Kapfer 2017). We secured the camera pole with the U-bolts after we slid the camera up the pole and adjusted it to point at the perch. See Appendix I for more details about artificial perch and camera poles and estimated cost of parts and equipment.

Data collection and analysis

Visual raptor surveys.– We conducted raptor surveys twice before we set up the perch stations (on 24 and 25 September and 1 and 2 October 2018) and twice after the perches had been set up for three weeks (on 22, 23, 29 and 30 October 2018); the first day of surveys were in the southern section of the rangeland and then the northern section on the day after. Survey objectives were to determine which species of diurnal raptor species were using the study areas (since owls are unlikely to be seen during the day). On each survey day, six survey crews of four members were spread across the southern or northern section of the rangeland (approximately 100–200 m apart). Surveys started between 1340–1410 hours.

Each crew had one person recording the data and three observers scanning and listening for raptors for 30 minutes (all observers were trained to identify raptors by sight and sound). We recorded raptors when they were seen or heard within the section including those perched on the ground or structures/trees or flying. Weather conditions were consistently mild across all survey days with temperatures ranging 18–25 °C, and no precipitation or strong wind.

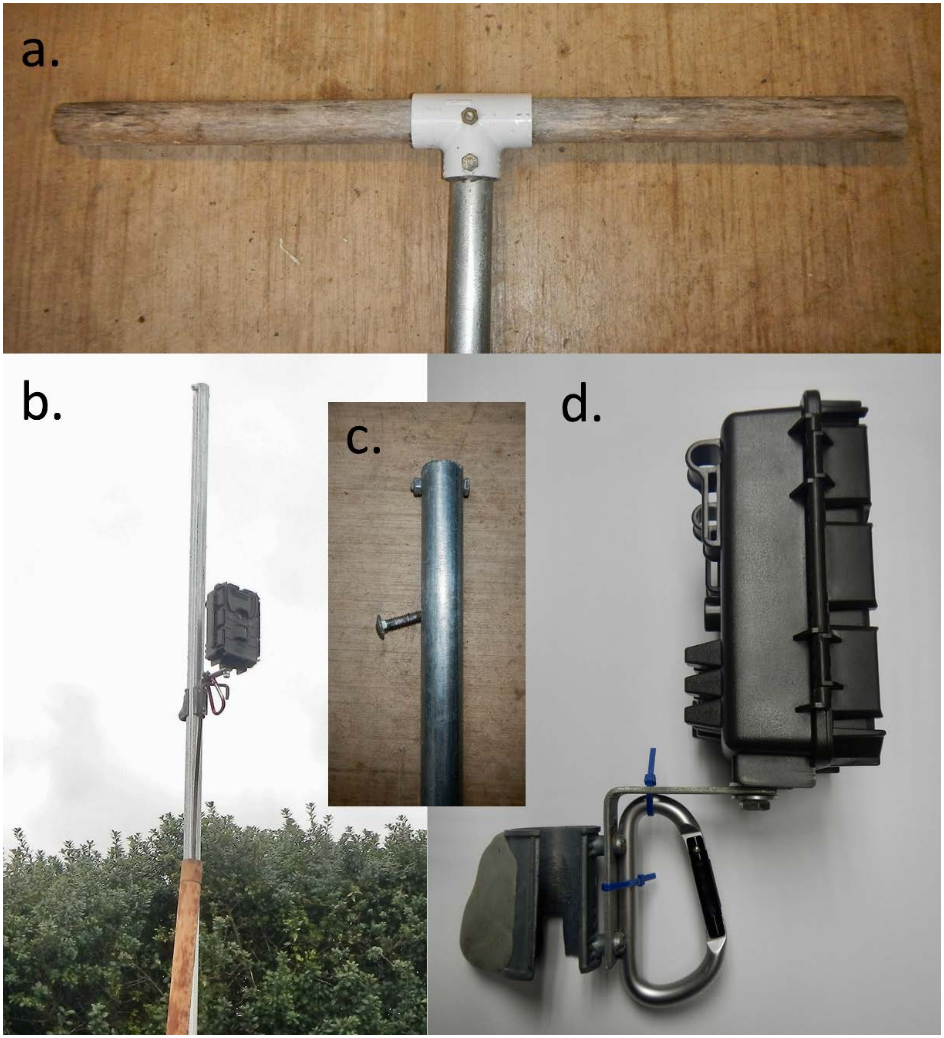

Figure 2. Artificial perch and camera trap pole and attachment setup used at the Leavey Ranch, Humboldt County, California, from September–October 2018: a. Artificial perch consisting of wooden dowel connected to pole with PVC tee and bolts, b. Camera trap attachment on pole with demonstration of using wooden pole with hook to hoist up or retrieve, c. Top of camera trap pole with bolts to hold camera in place, and d. Camera trap attachment including the L-bracket and bolt to hold the camera, a cylindrical metal electric conduit connector attached to L-bracket with one side of the connector cut open to allow it to pass the holder bolt on the pole (see c.) and the other side cut only partially to allow it to rest on the holder bolt, and epoxy on the connector and a carabiner zip-tied to the L-bracket to aid in hoisting and retrieving the camera.

We tallied the presence of raptors seen during the surveys by combining all records from across the six survey teams for a given section (northern or southern). That is, on a given survey day if one or more groups observed one individual or multiple individuals of a species, it was counted once as the species being present during the survey.

Artificial perch camera surveys.–We established six artificial perch and camera pole stations along fence lines or by tree stumps: three in the southern section of Leavey Ranch on 1 October 2018 and three in the northern section on 2 October 2018 (Figure 1). Stations were approximately 100–200 m apart within the southern and northern sections.

The camera traps were activated and hoisted into position on the pole to record triggered still image data for 28 days. We used Bushnell camera traps (Trophy Cam HD E2, Model #119836) programmed to take three photos per trigger with a 10-second interval between successive triggers. We checked cameras weekly to replace memory cards and batteries when necessary.

Figure 3. Artificial perch and camera trap pole stations on Leavey Ranch in Humboldt County, California from September–October 2018 set up: a. Along fence (semi-open grassland), b. Adjacent to nest box (open grassland), and c. Adjacent to tree stump (semi-open grassland).

We reviewed perch camera trap photos and recorded the perch station, date, time, and species corresponding to each instance a raptor was detected. We summarized the data into five types: 1) species seen at each station, 2) the latency to raptor perch use (in days), 3) the total number of raptor photos (as a measure of perch use activity), 4) the number of raptor perching events (defined as a series of photo detections of a raptor separated by no longer than 5 minutes between consecutive photos), and 5) hunting behavior of the raptors (defined as direct evidence of attacking, handling and/or consuming prey).

We also established camera traps (Bushnell Trophy Cam HD E2 Model #119836) on the ground to capture ground predation events. We placed the cameras within 1 m of the base of the artificial perch pole, facing outwards from the fence or tree stump (Figure 3). The cameras were attached to rebar pounded into the ground (0.5 m off the ground) and secured to fencing with a cable lock when possible.

Given the small sample size, our analyses were descriptive. We compared the species of raptors that used the perches to those that were seen during raptor surveys to determine perch use by species active in the area. We also compared the species of raptors that used perches between the open grassland with cattle versus semi-open grassland. We used t-tests to determine if there were more perching events in the northern versus southern sections, first comparing all species pooled together and then each species separately.

RESULTS

We recorded six species of diurnal raptors during our visual raptor surveys with red-tailed hawks and American kestrels (*Falco sparverius*) being the most active in the area (Table 1). Of these diurnal species, three used the artificial perches, with American kestrels recorded most often (Table 1).

Table 1. Number of surveys when raptor species were observed during visual surveys (n = 4 surveys per section) and number of perching events on artificial perches captured by camera traps (n = 3 perches per section for 28 days) in open grassland (northern section) and semi-open grassland surrounded by forest (southern section) on Leavey Ranch in Humboldt County, California from September–October 2018.

	Number of surveys when species observed		Number of perching events	
Species	North	South	North	South
American kestrel	4	2	6 (2[a])	30
Red-tailed hawk	3	4	2 (3[a])	0
Red-shouldered hawk	0	2	2	0
Northern harrier	2	1	0	0
Cooper's hawk	0	1	0	0
Rough-legged hawk	1	1	0	0
Great horned owl	NA	NA	0 (3[a])	0
Total Number	*4*	*6*	*10 (8[a])*	*30*

[a]On nest box next to perch

Five of the six artificial perches were used by at least one species of raptor (Table 1; Figure 4). Latency to perch use ranged from within 2 to 23 days from installation, with American kestrels using perches the fastest (Table 2). In total, across the 28-day survey period, we captured 185 photos on perch camera traps of perched raptors and recorded 48 raptor perching events. Eight of these perching events in the northern section were of raptors perching on an adjacent nest box rather than the perch (Figure 3b). We did not record any raptor predation events (or attempts) on rodents on the perch camera traps or ground camera traps. The American kestrel was the only species seen handling and consuming prey, which were all invertebrates (Table 2). We also captured several instances of birds perching on the camera pole itself (n = 6; American kestrels, black phoebes, *Sayornis nigricans,* and

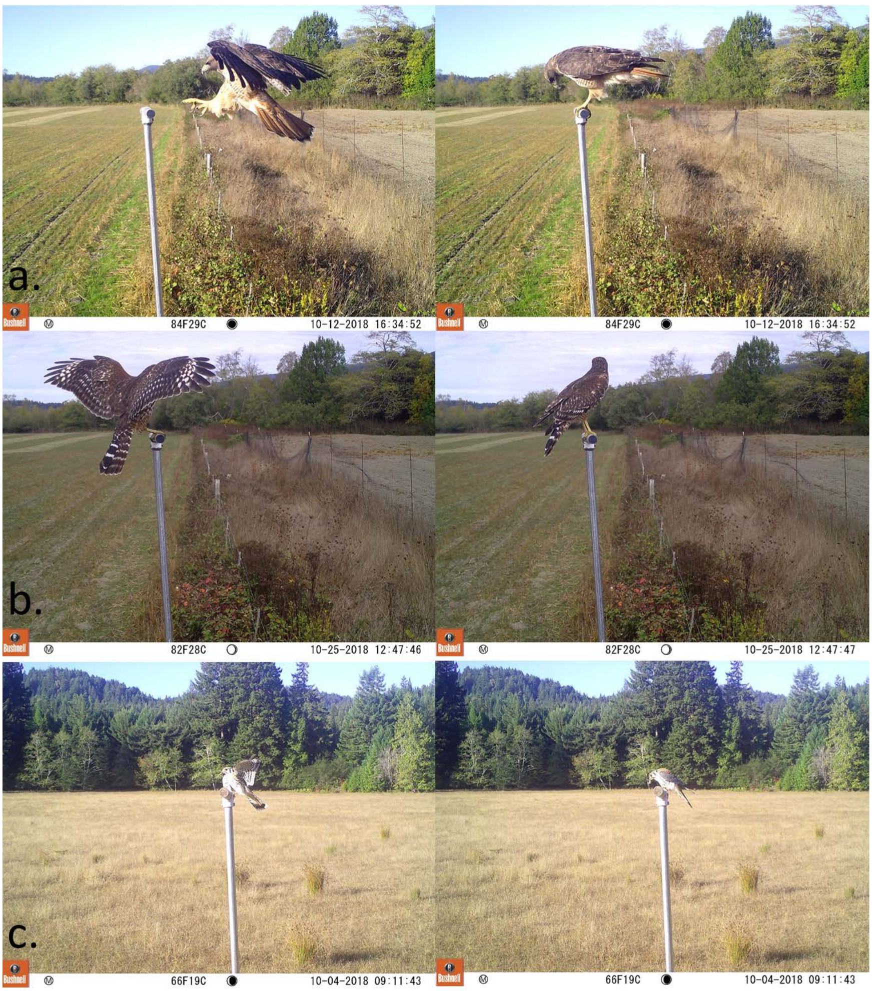

Figure 4. Example camera trap photos of raptors using artificial perches on Leavey Ranch in Humboldt County, California from September–October 2018: a. red-tailed hawk (open grassland), b. red-shouldered hawk (open grassland), and c. American kestrel (semi-open grassland) with insect prey.

Steller's jays, *Cyanocitta stelleri*); however, in most of these instances the bird used the artificial perch immediately before or after. We did not detect any interference by livestock on the perches or camera poles.

Although we recorded more perching events in the semi-open grassland perches than the open grassland perches, there was not a significant difference ($t_6 = 0.541$, $P = 0.607$). Species that used perches varied between the habitat types. American kestrels used perches in both the semi-open and open areas, while red-tailed hawks and red-shouldered hawks only used perches in the open areas. There was not a significant difference in perching events for American kestrels between the two habitat types ($t_6 = 0.987$, $P = 0.361$).

DISCUSSION

Raptors used the majority of the artificial perches in both open and semi-open grassland. Camera trap photos taken of raptors using the artificial perches were clear and could be used to identify individuals to species. While our sample size was small, we found that our novel method of using camera traps provided an efficient way to monitor artificial perch use and identify bird species using the perches.

We only observed American kestrels foraging on invertebrates from perches and did not document any evidence of predation on rodents either from the perch cameras or ground cameras. However, given the quality of the photos obtained with this method, we are certain that a raptor with a rodent in its talons or beak would be clearly visible and perhaps identifiable to genus (e.g., a gopher versus a mouse). Several studies have attempted to determine the effects of perch installation on rodent population numbers (e.g., Kay et al. 1994; Wolff et al. 1999). Our camera pole method could allow researchers to directly quantify the number of rodents removed due to the presence of artificial perches.

Table 2. Number of total raptor perch photos and raptor handling/consuming prey on perch photos from camera trap (n = 3 perches per section for 28 days) in open grassland (northern section) and semi-open grassland surrounded by forest (southern section) and average latency to perch (in days) for each species (excludes perching on nest box) on Leavey Ranch in Humboldt County, California from September–October 2018. All prey in prey consumption photos were invertebrates.

	Total perch photos		Consuming prey photos		Average latency to perch in days (+/-SD)
Species	North	South	North	South	All perches
American kestrel	24 (5[a])	122	11	69	7.2 (6.3)
Red-tailed hawk	6 (13[a])	0	0	0	11[b]
Red-shouldered hawk	6	0	0	0	23[b]
Great horned owl	0 (9[a])	0	0	0	NA
Total for all species	*36 (27[a])*	*121*	*11*	*61*	*10 (9.2)*

[a]On nest box next to perch
[b]Only landed on one perch

The lack of rodent predation events during our study does not indicate that perches are unable to provide a mechanism to increase raptor predation on agricultural pests. Rather, it may be that the length of our study (28 days) was too short to allow raptors to get accustomed to hunting from them. Our study was also limited to only one season (autumn), so for American kestrels it may coincide with a time period when they focus more on invertebrates (e.g., Collopy and Koplin 1983). For larger raptors, it may be that the perch height (3 m) was not sufficient given that height preference has been recorded from 6.3 m to 12.3 m on natural and human-made structures (Leyhe and Ritchison 2004; Worm et al. 2013). Our camera pole method was shown to work with 6 m perches in a previous study (B. Clucas, Humboldt State University, unpublished data). However, if 6 m poles are used in particularly windy areas, the sturdiness of the camera pole should be considered so wind does not cause the camera to take photos due to the pole swaying.

Despite this study's limitations, we demonstrated that the elevated camera trap mechanism is an effective tool for monitoring wildlife utilization of artificial perches. This mechanism allowed for the collection of clear photos of wildlife, well above ground level. Although deployed in tandem with artificial raptor perches for our study, this camera setup may be beneficial to other wildlife professionals who require monitoring of features above what typical ground camera deployments can capture (e.g., tree cavities, bat boxes).

ACKNOWLEDGMENTS

This study was conducted by the Fall 2018 Wildlife Techniques and Scientific Methods class at Humboldt State University—51 wildlife students, instructor (B.C.), and graduate student assistant (T.S.). We thank all the students for aiding in data collection and Anthony Desch for his invaluable assistance in designing and constructing the artificial perches and camera trap poles. We also thank the Humboldt Area Foundation and Leavey Ranch staff (in particular Aleda Cloud) for access to their property. Allen Fish and an anonymous reviewer contributed constructive and helpful reviews of the manuscript. This research was made possible by financial support from the Humboldt State University Department of Wildlife and was approved by the Humboldt State University Animal Care and Use Committee (IACUC # 16/17.W.65-A).

Author Contributions

Conceived and designed the study: BC and TS
Collected the data: BC, TS, JC, AD, SD, LD, MMG, SHKL, SL, KJK, KMK, KAL, JAM, EASM, AMP, MS, AS, and ST
Performed the analysis of the data: BC, TS, JC, SD, AD, LD, MMG, SHKL, SL, KJK, KMK, KAL, JAM, EASM, AMP, MS, AS, and ST
Authored the manuscript: BC
Provided critical revision of the manuscript: BC, TS, JC, SD, LD, MMG, SHKL, SL, KJK, KMK, KAL, JAM, EASM, AMP, MS, AS and ST

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APPENDIX I.

Estimated cost to construct and deploy an artificial perch and adjacent camera pole with camera trap. Prices will vary depending on location, brand and quality.

Equipment	Item	Quantity	Price per unit	Cost
Artificial Perch	Wooden dowel (60cm x 3cm diameter)	1	$5	$5
	PVC tee	1	$2	$2
	Bolts and nuts	2	$0.50	$1
	Pole (3m x 2.6 diameter EMT*)	1	$10	$10
	Metal t post (2.4m)	1	$7	$7
	U bolt with plate and nuts (inside diameter 3.5cm, inside height 10cm, thread length 6.3)	1	$2	$2
Subtotal				***$27***
Camera Trap Pole	Pole (3m x 2.6 diameter EMT*)	1	$10	$10
	Pole bolts and nuts	2	$1	$1
	Metal t post (2.4m)	1	$7	$7
	Electric conduit (EMT* set screw coupling)	1	$2	$2
	L bracket (6.5 cm)	1	$1	$1
	Carabiner clip	1	$4	$4
	Zip ties	2	$0.50	$1
Subtotal				***$26***
Camera trap	Camera trap (Bushnell Trophy Cam)	1	$110	$110
	SD card (16gb)	1	$8	$8
	AA batteries	8	$1.25	$10
Subtotal				***$128***
Total Cost				**$181**

*EMT = Electrical metallic tubing

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Notes on reproduction of Cascades frogs from California

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Cascades frogs (*Rana cascadae* Slater, 1939) occur in three disjunct areas: (1) the Olympic Mountains of Washington, (2) the Cascades Mountains of Washington and Oregon and (3) the Klamath-Siskiyou Mountains in northern California (Dodd 2013). *Rana cascadae* is now nearly extinct from the northern end of the Sierra Nevada (Lassen, Plumas, Shasta and Tehama counties, California; Thomson et al. 2016) and is listed as vulnerable by NatureServe Explorer (2019). Factors responsible for the disappearance of *R. cascadae* in the southern part of its range are discussed in Fellers and Drost (1993).

Information on reproduction of *R. cascadae* is limited. *Rana cascadae* males appear at breeding sites as ice melts; in Oregon, breeding begins in March and April (Briggs 1987). Slater (1939) reported spawning in Washington occurred from May 20 to July 10, but dates vary depending on snowfall.

In this paper, I present data from a histological examination of *R. cascadae* gonadal material from Plumas County, California. Utilization of museum collections for obtaining reproductive data avoids euthanizing specimens and eliminates the need for collecting permits from state and federal authorities. In the case of the nearly extinct *R. cascadae* in California, histological information on timing of events in its reproductive cycle will prove useful in subsequent attempts to reestablish this species in its former range.

I examined a sample of 36 *R. cascadae* collected 1954 to 1972 in Plumas County (39.9927°N, 120.8039°W) California consisting of 11 adult males (mean snout-vent length, SVL = 43.9 mm ± 6.9 SD, range = 28–53 mm), 16 adult females (mean SVL = 56.4 mm ± 6.9 SD, range = 45–70 mm), and 9 unsexed subadults (mean SVL = 27.2 mm ± 9.1 SD, range = 17–40 mm) from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA (Appendix). An unpaired *t*–test was used to test for differences between adult male and female SVLs (Instat, vers. 3.0b, Graphpad Software, San Diego, CA).

A small incision was made in the lower part of the abdomen and the left testis was removed from males and a piece of the left ovary from females. Gonads were embedded in paraffin, and sections were cut at 5 µm and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreibman 1997). Histology slides were deposited at LACM.

The testicular morphology of *R. cascadae* is similar to that of other anurans as described in Ogielska and Bartmanska (2009a). Within the seminiferous tubules, spermiogenesis occurs in cysts which are closed until the late spermatid stage is reached; cysts then open and differentiating sperm reach the lumina of the seminiferous tubules (Ogielska and Bartmanska 2009a). Six of seven *R. cascadae* males from August and all four from September exhibited spermiogenesis (sperm formation) in which sperm cysts were open and clusters of sperm were present in the lumina of the seminiferous tubules. A ring of germinal cysts was located on the inner periphery of each seminiferous tubule. The seminiferous tubules of one August *R. cascadae* male (LACM 76645, SVL = 38 mm) contained germinal cysts, but no sperm. The smallest male *R. cascadae* in my sample (LACM 76643) measured 28 mm SVL and contained a few small sperm clusters in the lumina of most of the seminiferous tubules. Clusters of spermatids were present in those seminiferous tubules that lacked sperm. On the basis of sperm being present in most seminiferous tubules, I considered this *R. cascadae* to be an adult, although it is not known if it would have joined the breeding population. Wright and Wright (1970) reported adult males of *R. cascadae* measured 50–58 mm in body length. My smallest male to exhibit full spermiogenesis (lumina of seminiferous tubules lined with sperm or clusters of metamorphosing spermatids) measured 40 mm SVL, was from August (LACM 76649), and is ten mm smaller than the minimum size for *R. cascade* male maturity in Wright and Wright (1970).

The mean SVL of *R. cascadae* females was significantly larger than that of males ($t = 4.6$, $df = 25$, $P < 0.001$). The ovarian morphology of *R. cascadae* is similar to that of other anurans in being paired organs situated on the ventral sides of the kidneys, and in adults, ovaries are filled with diplotene oocytes in various stages of development (Ogielska and Bartmanska 2009b). Mature oocytes are filled with yolk droplets and the layer of surrounding follicular cells is thinly stretched. Two stages were present in the spawning cycle (Table 1): (Stage 1) "Ready to spawn" in which mature oocytes predominate and (Stage 2) "Not in spawning condition" in which previtellogenic oocytes predominate. All seven *R. cascadae* females from June, one from August, and seven of eight from September exhibited Stage 1 "Ready to Spawn" ovaries. One September female exhibited Stage 2 "Not in Spawning Condition" (SVL = 48 mm, LACM 76621) and contained previtellogenic oocytes. It may have spawned earlier in the year. The smallest mature *R. cascadae* female (ready to spawn) measured 48 mm SVL (LACM 76632) and was from September. Wright and Wright (1970) reported adult females of *R. cascadae* measured 52–74 mm in body size.

Varying amounts of atresia were noted in eight of fifteen (53%) *R. cascadae* spawning females (Table 1). Atresia is a widespread process occurring in the ovaries of all vertebrates (Uribe Aranzábal 2009) and is common in the amphibian ovary (Saidapur 1978). It is the spontaneous digestion of a diplotene oocyte by its own hypertrophied and phagocytic granulosa cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmanska 2009b). See Saidapur and Nadkarni (1973) and Ogielska

Table 1. Two monthly stages in the spawning cycle of 16 adult female cascade frogs.

Month	N	(1) Ready to spawn	(2) Not in spawning condition
June	7	7	0
August	1	1	0
September	8	7	1

et al. (2010) for a detailed description of the stages of follicular atresia in the frog ovary. Atresia plays an important role in fecundity by influencing numbers of ovulated oocytes (Uribe Aranzábal 2011).

Regarding my sample of 9 juveniles, I am unable to ascertain when they would have reached adult size. However, according to Wright and Wright (1970) newly metamorphosed *R. cascadae* measured 20-24 mm. Five of my *R. cascadae* juveniles were in the 17–23 mm range and were likely young of the year. Four of these were from August and one from September.

The absence of female *R. cascadae* samples from early spring did not allow a complete description of monthly stages in the ovarian cycle. However, previous work (Slater 1939, Briggs 1987) indicates reproduction commences shortly after *R. cascadae* emerge from winter inactivity. Regarding the *R. cascadae* females in spawning condition from later in the year, August and September (Table 1), it is plausible they would have kept their ripe eggs until spring before spawning. This appears to be the case for *R. boylii* from California as reported by Goldberg (2019) in which females from autumn with mature oocytes apparently delay spawning until spring (Zweifel 1955). The retention of mature oocytes over winter allows *R. cascadae* to spawn soon after emergence from hibernation and avoids delay from needing to undergo a period of yolk deposition.

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APPENDIX

Thirty-six *R. cascadae* examined from Plumas County, California borrowed from the herpetology collection of the Natural History Museum of Los Angeles County, Los Angeles, California, USA.

LACM: 13408, 13409–13411, 13413, 13414, 13419, 13422, 13426, 14915, 74422, 76617–76624, 76626, 76627, 76629, 76632, 76634, 76638, 76641–76643, 76645–76652.

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Nearly all California monarch overwintering groves require non-native trees

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Monarch butterflies (*Danaus plexippus*) are in steep decline and threatened by loss of breeding habitat, loss of wintering habitat, pesticide use, and climate change (Pelton et al. 2019; Schultz et al. 2017). The population that winters along the coast of California has declined 97% since the 1980s (Pelton et al. 2019) and Schultz et al. (2017) conclude that this population, or at least the overwintering phenomenon, is at a high risk of extinction within 50 years. Factors associated with this decline include land use most strongly, encompassing increasing use of pesticides (e.g., glyphosate herbicide and neonicotinoid insecticides) and coastal development, and then less so climate, which remains a looming threat (Crone et al. 2019; Espeset et al. 2016). Historically, the largest threat to overwintering groves was development (Lane 1981[1984]) but recent analysis of overwintering survival (Pelton et al. 2019) suggests that grove quality itself is also in decline through senescence (Pelton et al. 2016). Protecting and managing wintering habitat is a top conservation priority (Pelton et al. 2019; Western Monarch Working Group 2018).

Preferred winter roosting habitat for monarchs in California is made up of groves of trees that provide particular microclimatic conditions that protect the butterflies from winter storms (Leong 2016; Leong et al. 1991; Weiss et al. 1991). Overwintering groves can provide suitable microclimates with different tree densities, species composition, and topography (Leong et al. 2004), but essential features, including a windbreak to protect against winter storms and a range of sunlight from full to filtered to shaded, must be present (Leong 1990). At nearly every overwintering site on the current landscape, those conditions are created by exotic trees, and in particular by eucalyptus species (Bell et al. 1993; Leong 1990; Nagano and Lane 1985; Nagano and Sakai 1987; Pelton et al. 2016). This need for the structural properties provided by eucalyptus has long been known by California monarch experts (Bell et al. 1993):

> Conflict between Monarch habitat conservation and Eucalyptus removal for native revegetation arises when the tree removal occurs in proximity to a Monarch overwintering habitat. Since the entire grove of trees serves as Monarch habitat, even selective tree removal around the margins of groves may have adverse effects on the habitat. At a time when current political and development pressures imperil Monarch habitats statewide, the butterflies cannot afford to lose these prime Eucalyptus habitats to a political battle between native and non-native species. Some native plant advocates assert the Monarchs will go elsewhere if their Eucalyptus habitats are destroyed. But the decline of Monarch populations in areas where Eucalyptus groves were developed suggests otherwise.

This statement is still true today, and managers should not hesitate to use eucalyptus species thoughtfully to create and maintain overwintering habitat for monarch butterflies. To do otherwise would threaten the mass overwintering of monarchs in California. Our reasons for this assessment follow.

With few exceptions, the overwintering monarch phenomenon in California is dependent on non-native trees, particularly eucalyptus planted in the mild coastal zone. Only a handful of extant sites are made up predominantly of native trees (Fiscalini Ranch Preserve in Cambria, Point Lobos State Natural Preserve, George Washington Park in Pacific Grove; Pelton et al. 2016). The monarchs have made their choice, and we have to work with that choice for effective conservation and management. The success of these overwintering sites in attracting and retaining monarchs is a function of appropriate microclimate. Groves must provide good shelter from wind and a varied light environment ranging from full sun to deep shade. The structure of groves, not the species composition, is the primary determinant of microclimate.

The only areas where truly native trees could be used are the few native Monterey pine (*Pinus radiata*) and Monterey cypress (*Cupressus macrocarpa*) forests in the Monterey Peninsula–Point Lobos area, Cambria, and Año Nuevo (Griffin and Critchfield 1972; Lane 1981[1984]). It is possible that scattered small monarch aggregations were found on native oaks (*Quercus agrifolia*) and sycamores (*Platanus racemosa*) in coastal locations to the south historically, but only a few sites have been documented (Nagano and Lane 1985). After eucalyptus trees were introduced in the 1850s (Butterfield 1935), they expanded the distribution of suitable monarch overwintering conditions while the extent of native conifers was reduced through development and disease (Millar 1998). Today, monarch overwintering groves are predominantly composed of eucalyptus trees, even within the range of the two native roost tree species. Outside that narrow Central Coast region, overwintering sites are created by eucalyptus species (Pelton et al. 2016). Even Monarch Grove Sanctuary in Pacific Grove, one of the premier overwintering sites, is utterly reliant on eucalyptus trees despite its location within the native Monterey pine forest.

Eucalyptus species have proven to be excellent for providing the necessary grove structure. The variability of growth forms within and between species and their rapid growth make for a more resilient grove. For example, eucalyptus will respond to canopy openings by pushing out epicormic branches, sealing up the edges of groves against the wind. Understory recruitment, stump sprouting/coppice behavior, and fire recovery can be rapid. In addition, blue gum eucalyptus (*Eucalyptus globulus*) come into flower in January, providing copious nectar resources.

Pine and cypress have issues that reduce their utility in developing overwintering habitat today. Monterey pines are not reliable for long-term habitat because of pine pitch canker mortality. Monterey cypress grow more slowly than eucalyptus. Both Monterey pine and Monterey cypress lose their lower branches as they mature, hence middlestory and understory trees are critical for wind shelter, especially at the edges of groves. These trees are susceptible to drought, especially south of their narrow natural ranges, based on interpretation of their history (Millar 1999).

Trees where monarchs are found aggregated during the winter (cluster trees) are only a small component of the habitat; trees providing wind shelter, often well away from the cluster trees, are absolutely critical. While monarchs may have some preference for clustering on pines and cypress *when available* (Griffiths and Villablanca 2015), this observation does not indicate that native trees alone are superior, or even adequate, to produce monarch overwintering habitat throughout the California coast.

Until now, persistence of suitable monarch habitat has largely been an accident. Forest dynamics within planted groves have produced light gaps with adequate wind shelter. Explicit management of groves *within a specified footprint*, including deliberate planting of eucalyptus, will be required going forward. While blue gum eucalyptus is currently the dominant species in most monarch groves, diversifying to other eucalyptus species is desirable to create resiliency against pests, diseases, and drought. These principles have been applied at Monarch Grove Sanctuary in Pacific Grove, with success in establishing critical wind shelter, are being applied at several other sites including Ardenwood Regional Park (Fremont, Alameda County) and Gibbs Park (Huntington Beach, Orange County), and are being considered in site management plans that are being developed as of 2020 (S. Weiss, personal observation).

Not all recent guidelines have been as clear about the utility of eucalyptus in creating habitat conditions needed for monarch overwintering. In 2012, The Xerces Society introduced a new position on overwintering habitat, stating that, "As eucalyptus trees age and become decadent, a long-term plan should be developed to restore a monarch grove to provide habitat with native trees" (Xerces Society Policy on Eucalyptus Management at Monarch Overwintering Sites, 2012). In 2017, guidelines for wintering site management were issued, which articulated a preference for planting "only native tree species" and gave a rationale (Jepsen et al. 2017):

> The Xerces Society recommends planting trees that are native to your geographic region. Recent studies suggest that monarchs do not have a preference for eucalyptus trees (Griffiths and Villablanca 2015), and that they may shift to native trees during adverse weather conditions. Ideally, restoration plantings at overwintering sites would consist of only native tree species. If this is not possible, ensure native trees are included in any planting plan.

We would emphatically state that restoration plantings of only native trees, especially for windbreak functions, will not provide monarch overwintering habitat except in extraordinarily limited circumstances. Despite some caveats in the recommendations, these particular statements of preference for "only native species" have been, in our experience, seized upon by some stakeholders as a rationale to block or reduce the use of eucalyptus in overwintering site management. This unfortunate outcome has been reinforced by a rigid preference to promote only native plant species in conservation practice. For example, California State Parks has strong policies favoring the removal of exotic plant species, which leads to a presumption that eucalyptus should be removed and concomitant resistance to planting eucalyptus within the context of management of monarch overwintering sites (see California State Parks Department Operations Manual, Policy 0310.7.2 Removal of Established Populations of Exotic Plants).

We agree that some plantings of native trees could be included, especially as potential cluster trees to give fine-scale alternatives to the monarchs, but the options for creating effective long-term windbreaks with only locally native trees are extremely limited beyond a small area on the Central Coast. The promotion of locally native trees as alternatives to non-native trees in producing necessary microclimatic conditions for winter roosts is not supported by the history of monarchs in California or by the Griffiths and Villablanca (2015) study cited by Jepsen et al. (2017) in support of such a proposition. Griffiths and Villablanca (2015) looked at roost choice within the zone protected from wind and exposed to enough filtered sunlight. They did not investigate the attributes of the trees that created this area, which Leong calls the "cluster arena" (K. Leong, California Polytechnic State University, San Luis Obispo, personal communication). Within the cluster arena, Griffiths and Villablanca (2015) showed that monarchs used native trees more as roosts during some periods and eucalyptus trees more as roosts during other periods. Their results do not support a conclusion that replacing all trees at those overwintering sites with native species would preserve the microclimate, and the study was not designed so that it could support that conclusion. Similar results have been found at Monarch Grove Sanctuary in Pacific Grove over longer time periods (Weiss 2019). Furthermore, it is not possible to extrapolate from the Griffiths and Villablanca (2015) study to locations without native conifer species (e.g., any location farther south). Indeed, they admonish in their discussion, "This recommendation [to use native conifers] would not be appropriate for Southern California since we have not evaluated data from that region and because the native conifers are not suited to that climatic region."

We also concur that eucalyptus groves that support monarch overwintering must be managed to preclude the spread of trees into habitat outside the area needed for the grove. Issues of eucalyptus management are discussed in the Xerces guidelines (Jepsen et al. 2017).

The coastal monarch overwintering phenomenon in California expanded with the planting of eucalyptus and, in that sense, it is an unnatural situation, but eucalyptus has sustained the population, which might otherwise have been extirpated by development. The historic range of native coastal conifer forest has been dramatically reduced, and examples of groves of all-native trees supporting substantial monarch overwintering numbers outside the natural ranges of Monterey pine and Monterey cypress are limited to a few examples in well-sheltered riparian zones (see site descriptions in Pelton et al. 2016). Monarchs responded to a landscape dramatically altered by human activity and took advantage of the microclimate of eucalyptus groves as their native conifer groves were decimated. If we want the western monarch population to survive, we should not hesitate to plant eucalyptus trees (of several species depending on site characteristics) as part of well-formulated and long-term management plans for overwintering sites,

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Striped Bass on the coast of California: a review

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Striped Bass (*Morone saxatilis*), a non-native, anadromous fish introduced to California in 1879, is a popular sport fish and piscivorous predator in the San Francisco Bay/Delta ecosystem, but comparatively little is known about its distribution and ecology in estuaries and rivers of the California coast. Here we review recent scientific papers, consultant reports, and correspondence to evaluate its distribution in coastal estuaries and rivers, evidence for local reproduction, and scope for impacts on native fishes, especially salmonids. Striped Bass is extremely rare in the ocean along the north coast, and has not turned up in extensive surveys of Humboldt Bay, the Eel River estuary, or the Russian River estuary. It is, however, a perennial feature of seining surveys in estuaries south of the Golden Gate and along Monterey Bay, usually sporadically and as a very small proportion of total catch. It has become quite common in the Carmel River estuary, and is occasionally caught in the ocean further south. Small upstream migrations, possibly for spawning, have been observed in the Salinas River and Carmel River, but no evidence of eggs or larvae has been found—perhaps due to a lack of ichthyplankton surveys anywhere except in Elkhorn Slough. However, the species' reproductive ecology is not a good match to the hydrologic structure of most coastal stream systems, requiring a large long river where adults can spawn, in combination with an extensive, ramifying estuarine system where larvae can accumulate. One potential good match is the Salinas River system, especially in its historic form as the Salinas River/Old Salinas River Channel/Elkhorn Slough complex of the 19th century. Despite the modest presence of the species on the coast between the Golden Gate and Carmel, it still has scope for large impacts on emigrating salmonids, due to its extreme piscivory at larger size-classes and its ability to exploit migration bottlenecks as feeding grounds. Most likely the individuals observed in coastal estuaries originated in the San Francisco Bay/Delta system and use local systems opportunistically for foraging, but the hypothesis of local reproduction cannot be ruled out without further study.

Key words: estuary, impacts, naturalized species, salmonids, Striped Bass

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Striped Bass (*Morone saxatilis*) is a native fish of the Atlantic and Gulf Coast that was transplanted into California's San Francisco Estuary in 1879 and has since become naturalized (Scofield 1930). The species was actively stocked and initially very successful, supporting a commercial fishery by 1888 and an annual catch of more than 1.2 million pounds by 1899. Being facultatively anadromous, Striped Bass soon expanded into the ocean and could be caught up and down the Pacific coast, with two individuals each weighing six pounds caught by seine off of Redondo Beach near Los Angeles in September 1894 (Smith and Kendall 1898; Dill and Cordone 1997), and half a dozen individuals trapped by the U.S. Bureau of Fisheries off the mouth of the Columbia River in the Pacific Northwest in 1906 (Scofield and Bryant 1926). The species appears to have self-established a commercially fishable population in Coos Bay, Oregon by 1922 (Morgan and Gerlach 1950) and was eventually caught off the west coast of Vancouver Island, British Columbia in 1971 (Forrester et al. 1972).

The success, abundance, and broad distribution of Striped Bass have generated concerns about its impacts on native fish species in California, especially since subadults and adults are highly piscivorous (Thomas 1967; Loboschefsky et al. 2012). That said, the conditions necessary to support viable populations of the species appear to be rather restrictive on the Pacific coast. Two self-sustaining populations still occur in the San Francisco Estuary, one breeding in the Sacramento River and the other in the San Joaquin Delta (Moyle 2002), but the only other documented reports of wild-established, self-sustaining populations appear to be in Coos Bay, Oregon, and smaller populations in the nearby Coquille, Siuslaw, and Umpqua systems (Morgan and Gerlach 1950; Parks 1978; Karas 2016). The species has formed self-sustaining populations in several reservoirs where it was planted, notably Millerton Reservoir on the San Joaquin River, the system of reservoirs in the lower Colorado River (Dill and Cordone 1997), and San Antonio Reservoir in Monterey County (MCWRA and USACE 2001). Many other attempted introductions to reservoirs or coastal estuarine systems have failed (Dill and Cordone 1997).

Here I review scientific literature and consultant reports on the occurrence and potential impacts of *M. saxatilis* in the estuaries of the larger river systems along the coast of California. Since the listing under the Federal Endangered Species Act of coastal Steelhead (*Oncorhynchus mykiss*), Coho Salmon (*Oncorhynchus kisutch*), and Chinook Salmon (*Oncorhynchus tshawytscha*) stocks in the late 1990s, and recognition of the importance of coastal estuaries to the rearing of juveniles of these species (Smith 1990; Bond et al. 2008; Koski 2009), there is great value in better understanding the occurrence and potential impacts of Striped Bass in estuaries and rivers of the California coast. Here I consider three general questions: (1) Where do Striped Bass occur on the California coast? (2) Do they comprise locally reproducing populations, strays from the Golden Gate, or both? and (3) What is the general scale or scope of their potential impact on coastal salmonid populations?

DISTRIBUTION IN COASTAL RIVERS AND ESTUARIES

The questions raised above are not new. Scofield (1930), in his treatise on California Striped Bass, observed that:

> At the present time the bulk of the striped bass is confined to the San Francisco Bay region and along the coast to a distance of 75 miles to the north and to the south of the Golden Gate. To the south, excellent hook-and-line fishing is enjoyed most of the year at Marina

> Beach, Salinas River, Elkhorn Slough (all in Monterey Bay), Waddell Creek and many unnamed beaches. To the north, Bolinas Bay, Bodega Bay and Russian River all afford fine bass fishing.
>
> Many interested individuals contend that the striped bass which occur in the coastal waters south of the Golden Gate are of a separate race from those of the San Francisco Bay region. The bass, for instance, that inhabit Monterey Bay and its flanking sloughs and rivers, are believed to spawn there year after year. These rather serious contentions on the part of several interested sportsmen led to a study of the population of these fish occurring in this region several miles south of the Golden Gate. The results of this study seemingly disproves the theory that they are a separate population. For instance, no evidence of bass fry was obtained during the spring or summer when they should have been found in great quantities if the mature fish spawned in these southern regions. The smallest bass observed were in their second year or three inches in length and larger. The large bass examined during May, or about the time spawning was in progress in the San Francisco Bay region, contained ovaries in mature condition, but they were far from ripe. Over 95 per cent of the fish examined were females. None of the males were in ripe condition. Another fact noted as a result of seine hauls in Salinas River and Waddell Creek during May, 1927, was the complete absence of the third and fourth year classes. The second, sixth, seventh and eighth year groups were quite evident while the fifth year class was represented by only a few individuals. Samples of specimens received from anglers in this region were well over twenty inches in length, which classed them at five years of age or older. An interesting point was made when sportsmen reported that good catches of large mature bass are made in the spring until May, after which time they apparently disappear and as a consequence very few are taken. Late in July and early August these large bass again appear in Monterey Bay and are caught in considerable numbers. It is not probable that these fish refuse to take the hook during May and June, for in San Francisco Bay anglers have no difficulty in making substantial catches during this period. […]
>
> All of these points seemingly indicate that the movement of the striped bass along the southern coast of California is entirely seasonal, and the spring months reveal a migration of mature bass back to San Francisco Bay for the purpose of spawning. (Scofield 1930, pp. 53-55)

Although the above account documents the regular occurrence of the species along the coastal flanks of the Golden Gate by an early date, Scofield concluded they were wholly migrants from the San Francisco Estuary. In contrast, thirty years later Skinner (1962) noted that "In California a few striped bass spawn in the larger coastal rivers, the Russian River particularly, and formerly the Salinas River. A few apparently persist in Elkhorn Slough, which enters Monterey Bay, and spawn there also. The major tributaries to San Francisco Bay are the principal spawning grounds, however…" Unlike Scofield, he did not describe any specific observations to back up the claim. Both views are consistent with the species' behavior in its native range on the Atlantic coast, where fish move broadly between natal and non-natal estuaries (Grothues et al. 2009).

In the years since these reports, the abundance of *M. saxatilis* in the San Francisco Estuary drainage system has declined significantly (Stevens et al. 1985; Dill and Cordone 1997; Feyrer et al. 2007), but what is the status of the species on other drainages along the coast? Recent estimates of recreational catch from the California Recreational Fisheries Survey show, not surprisingly, that the greatest catch is from the inland portion of the San Francisco Bay Area, nearly 800,000 individuals during the period 2004 – 2019 (Figure 1, top left). However, over 100,000 have also been recovered in the coastal ocean (<3 miles from shore) in each of the Bay Area and Central Coast districts (Figure 1, top middle), and on the order of 1000s of Striped Bass were captured during this period from the Channel Islands district and from the Bay Area district >3 miles from shore. Smaller numbers (100s) were estimated for capture in inland waters of the Central Coast, and smaller numbers still (<100) in the inland waters of the South Coast and further offshore (>3 miles) in the Channel Islands district and the South Coast.

Notably, estimated catch is zero for all inland and marine waters north of the Bay Area (Figure 1, top, Wine and Redwood districts). This reflects a lack of records in the

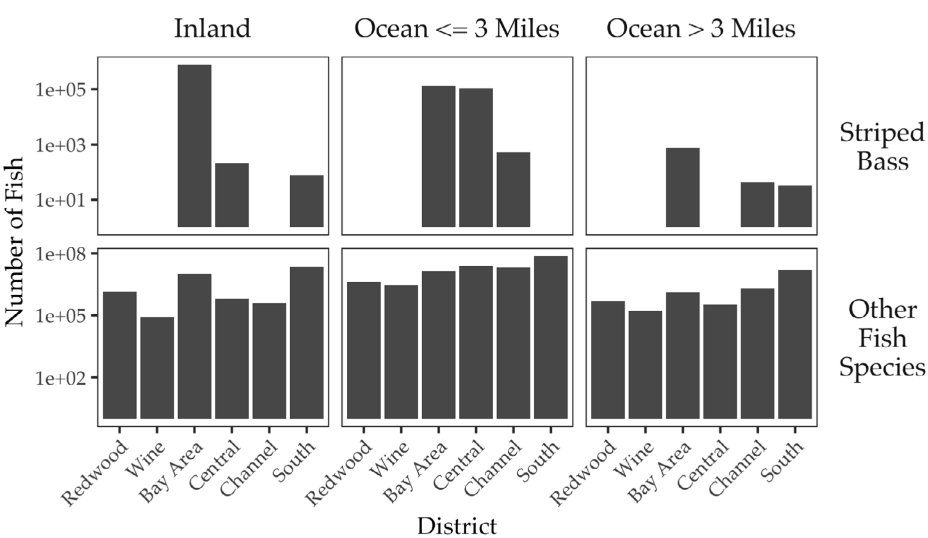

Figure 1. Estimates of total numbers of Striped Bass in the recreational catch for 2004 – 2019, in coastal regions from north to south (top). For reference, numbers of fish from all other species are also shown (bottom). Regions from north to south are Redwood (Humboldt, Del Norte Counties, except Shelter Cove area after 2007), Wine (Mendocino County, Shelter Cove Area after 2007, Sonoma County before 2008), Bay Area (Marin, Solano, Napa, Contra Costa, Alameda, Santa Clara, San Mateo, San Francisco Counties; Sonoma County after 2007), Central (San Luis Obispo, Monterey, Santa Cruz Counties), Channel (Ventura, Santa Barbara Counties), and South (San Diego, Orange, Los Angeles Counties). Estimates are from the California Recreational Fisheries Survey (CRFS); see https://wildlife.ca.gov/Conservation/Marine/CRFS for methods and https://www.recfin.org for data.

RECFIN database for interviews with recreational fishers from the North Coast who have captured Striped Bass. However, Ed Roberts (California Recreational Fisheries Survey, California Department of Fish and Wildlife, personal communication), who has monitored recreational fisheries in the Redwood district since 2007, has heard of Striped Bass being taken occasionally from the beaches between Enderts Beach south of Crescent City all the way down to Shelter Cove in Humboldt County, but not from Mendocino County. His staff have encountered them twice: once in 2009, caught by an angler from the surf near Humboldt Bay (Samoa), and once in 2018 from the surf at Gold Bluffs beach north of Mad River. Both records were verified by staff but did not end up in the RECFIN database, due to a language barrier preventing an interview in the 2009 case, and the interview being made in a pilot study for a new sampling procedure in the 2018 case.

Overall this suggests the species ranges broadly in the ocean, but declines in abundance with distance from the Golden Gate, and would most likely use coastal estuaries and rivers in the zone directly flanking the Golden Gate, encompassed by the Russian River on the north and Morro Bay on the south (Figure 2). Below I summarize evidence of Striped Bass occurrence in the major stream systems from Mad River in the north to San Diego Bay in the south, giving more focused attention to the region flanking the Golden Gate. For the most part these data come from generalized seining surveys with no correction for capture effort or efficiency; I therefore summarize not just the number of Striped Bass captured during a survey, but also the total number of fish species captured to give a sense of the scale or effectiveness of the sampling. Most samplers did not include age or length data but when reported it is included in the narrative.

Mad River.—Osborn (2017) sampled fish from four sites in the estuary, using two to three beach seines per site in June and January from mid-2014 to mid-2016. She found 33 fish species but did not find Striped Bass. Ed Roberts (California Recreational Fisheries Survey, California Department of Fish and Wildlife, personal communication) reports observing Striped Bass in the Mad River while conducting snorkel surveys in the late 1990s.

Humboldt Bay.—Gottshall et al. (1980) reviewed twenty years of published surveys, unpublished trawl data, and various other records of fish occurrence in Humboldt Bay. They found accounts of 110 fish species captured from the bay, including 45 species taken by recreational fishers. For Striped Bass they found "One questionable record from Bay; a fish reported caught over 90 years ago" (Gottshall et al. 1980:229).

More recently, Cole (2004) sampled fish from 321 sites around the periphery of the bay from September 2000 to November 2001 using a variety of nets and sampling techniques, and also conducted a total of 41 trawls using three different types of trawl within the bay. She identified 67 species of fish but Striped Bass was not among them. Shaughnessy et al. (2017) sampled fish from four sites using two to three beach seines per site in June and January from mid-2014 to mid-2016. They found 23 fish species but did not find Striped Bass.

Eel River.—Gleason et al. (2010) reviewed a half-century of fish surveys in the Eel River estuary (Murphy and De Witt 1951; Monroe et al. 1974; Puckett 1977; Cannata and Hassler 1995; Gilroy 2002). These surveys collectively documented 47 fish species using the Eel River estuary, including five introduced species and 14 anadromous species, but Striped Bass was not among them. The surveys by Puckett (1977) and Cannata and Hassler (1995) were especially thorough (see Table 9 in Gleason et al. 2010), sampling in winter, spring, summer, and fall of 1973-74 and 1994-95 respectively. They sampled in each of the McNulty and Hawk Sloughs, the lower channel including North Bay, Salt River, middle channel, and the upper channel as far as Fernbridge, and together documented 33 species total, but no Striped Bass.

More recently, Scheiff et al. (2013) sampled fish using seines at seven sites in McNulty Slough and two in Hawk Slough during each of fourteen months from January 2008 to June 2009. They identified 23 species of fish but did not report Striped Bass.

Mendocino Coast.—In the estuaries of Ten Mile River and Big River, Osborn (2017) sampled fish from four sites each, using two to three beach seines per site in June and January from mid-2014 to mid-2016. She found 17 fish species in Ten Mile River and 32 in Big River, but did not find Striped Bass in either system. Higgins (1995) sampled fish from

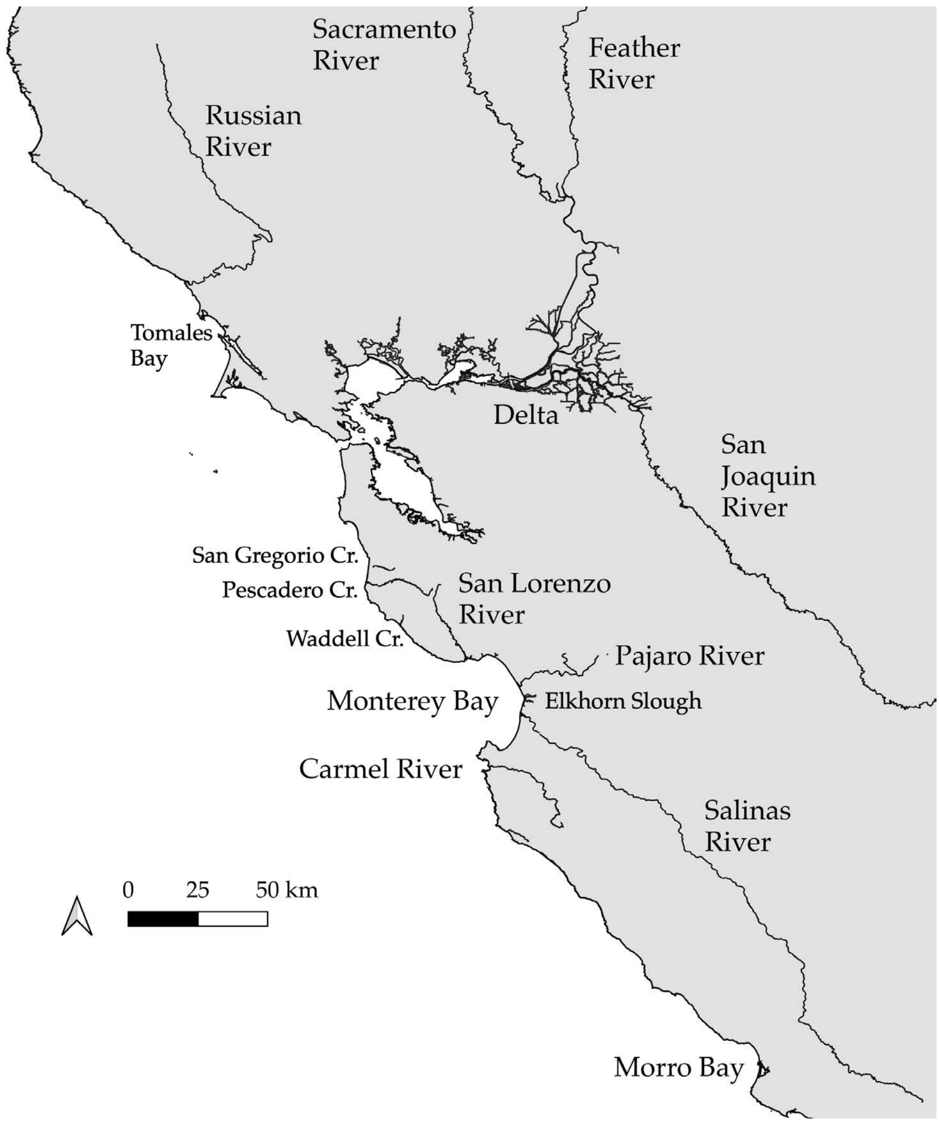

Figure 2. The San Francisco Bay-Delta region and coastal flanks of the Golden Gate.

seven sites in the Garcia River estuary monthly from June to August 1995, and captured 11 species total but no Striped Bass. In the Gualala River estuary, ECORP and KHE (2005) characterized fish diversity by sampling an average of ~20 seine hauls in each of 13 months between June 2002 and October 2003 (Table 1). They captured 12 species of fish but Striped Bass was not among them.

Table 1. Occurrence of Striped Bass in seining surveys of the estuary of Gualala River (ECORP and KHE 2005).

Month	Lagoon Status[a]	Number of Fish Species Reported	Striped Bass Reported?
Jun 2002	Closed	8	No
Jul 2002	Closed	6	No
Aug 2002	Closed	6	No
Sep 2002	Closed	6	No
Oct 2002	Closed	5	No
Nov 2002	Open	4	No
Feb 2003	Open	6	No
May 2003	Unknown	7	No
Jun 2003	Open	9	No
Jul 2003	Closed	6	No
Aug 2003	Closed	7	No
Sep 2003	Closed	7	No
Oct 2003	Closed	7	No

[a] Inferred from Table 2.1 in ECORP and KHE (2005).

Russian River.—Nearly a century ago, Scofield and Bryant (1926) reported a 57-pound bass caught in the Forest Pool on October 1924, a 32- and a 54-pound bass caught near Monte Rio on 27 February 1925, and several 40- and 45-pound bass taken elsewhere in the Russian River in 1925. As noted earlier, Skinner (1962) asserted a spawning population once existed in the Russian River, but Shapovalov (1944) asserted that Striped Bass enter the Russian River irregularly; neither author provided supporting evidence.

In more recent years, the estuary of the Russian River was sampled for fish diversity in 1992–93 and 1996–2000; sampling occurred in 33 months over this period, mostly in the summer and fall (Table 2). Forty-seven species of fish were identified, but *M. saxatilis* was not among them. The estuary was sampled for fish again during 2003–2005 (Table 2), identifying 38 species, but again *M. saxatilis* was not among them.

Upstream from the estuary, Chase et al. (2005) used an electrofishing boat to sample fish from Wohler Pool, a 5-km impoundment on the river backed up by a rubber dam at river kilometer 40. Over the five years of annual sampling available (Chase et al. 2000, 2001, 2002, 2004, 2005), between 13 and 21 species were caught annually, but only one Striped Bass, an adult, was caught over the period (Table 3). This low abundance was in great contrast to three other introduced predators, Sacramento Pikeminnow (*Ptychocheilus grandis*), Smallmouth Bass (*Micropterus dolomieu*) and Largemouth Bass (*Micropterus salmoides*),

Table 2. Occurrence of Striped Bass in seining surveys/otter trawls of the Russian River estuary (Goodwin and Cuffe 1993; Roth et al. 1997, 1998, 1999, 2000; Martini-Lamb 2001; Cook 2004, 2005, 2006).

Month	Lagoon Status	Number of Fish Species Observed		Striped Bass Observed?
		Seining	Otter Trawls	
Jun 1992	Closed/Open	6	-	No
Jul 1992	Open	5	-	No
Aug 1992	Closed/Open	5	14	No
Oct 1992[a]	Closed/Open	5	-	No
Nov 1992	Closed/Open	5	8	No
Mar 1993[a]	Open	7	-	No
Apr 1993	Open	7	5	No
May 1993	Open	7	-	No
Jul 1996	Closed/Open	6	10	No
Aug 1996	Closed/Open	10	9	No
Sep 1996	Closed/Open	6	14	No
Oct 1996	Closed/Open	10	10	No
Nov 1996	Open	5	-	No
May 1997	Closed/Open	12	14	No
Jun 1997	Closed/Open	12	17	No
Jul 1997	Open	8	9	No
Aug 1997	Closed/Open	6	9	No
Sep 1997	Closed/Open	8	11	No
Oct 1997	Closed/Open	9	11	No
Nov 1997	Open	4	12	No
Aug 1998	Open/Closed	8	9	No
Sep 1998	Open/Closed	11	13	No
Oct 1998	Open/Closed	8	12	No
Nov 1998	Open	4	5	No
Jun 1999	Closed	2	5	No
Jul 1999	Open	7	11	No
Aug 1999	Open	5	3	No
Sep 1999	Closed/Open	8	5	No
Oct 1999	Closed/Open	7	14	No
Nov 1999	Closed/Open	5	7	No
Sep 2000	Closed/Open	8	11	No
Oct 2000	Closed/Open	8	10	No
Nov 2000	Closed/Open	5	7	No
Aug–Oct 2003	Closed/Open	22	-	No
May–Aug 2004	Closed/Open	31	-	No
May–Oct 2005	Closed/Open	23	-	No

[a] Some electrofisher sampling as well.

Table 3. Occurrence of Striped Bass in boat-electrofishing surveys of Wohler Pool, a rubber-dam impoundment on the Russian River at river kilometer 40 (Chase et al. 2000, 2001, 2002, 2004, 2005).

Month	Number of Fish Species Observed	Striped Bass Observed?
Aug 1999	13	Yes (1 fish)
Aug 2000	20	No
Aug 2001	21	No
Aug 2003	18	No
Aug 2004	19	No

which regularly showed up in surveys. Chase et al. (2005) also reported that in 2002, one subadult Striped Bass was observed moving downstream through the fish passage structure on the dam, which has a video monitoring system. Upstream further still, Striped Bass were planted in 1967 in Lake Mendocino (Dill and Cordone 1997), a reservoir on the East Fork about 153 km upstream of the ocean. The species is still stocked there (USACE 2019) and was perhaps the source of the few individuals observed at Wohler Pool.

Bodega Bay to Golden Gate.—A few records were found of Striped Bass in the various embayments and coastal streams north of the Golden Gate. Fong (1996) observed an unspecified number of Striped Bass in Big Lagoon, an intermittent tidal lagoon in southern Marin County, and Ettlinger (2017) captured four individuals in Lagunitas Creek, a tributary of Tomales Bay, during the 2017 operation of a rotary-screw trap from mid-March to late May. The RECFIN dataset (Table 4) has 14 accounts of recreational fishers catching Striped Bass in Tomales Bay in 2018 and 2019, and one account for Bodega Bay in 2014.

San Gregorio Lagoon.—In order to document Steelhead survival and growth in the lagoon of San Gregorio Creek, south of Half Moon Bay, Atkinson (2010) conducted seining surveys five times from the beginning of July 2005 through the end of October, and seven times from mid-February 2006 to the beginning of November. In the process she captured 11 species of fish, including Striped Bass, the only non-native species in the sample. Of the 11 species, Steelhead had the highest capture rate, while Striped Bass ranked ninth, and Coho Salmon tenth. Striped Bass were only captured during three consecutive sampling events in May, June, and July of 2006, when the estuary was intermittently open and closed due to breaching. Twenty-five individuals were captured, ranging in size from 75 mm to 174 mm Standard Length, which are consistent with age 1 fish (Scofield 1930, p. 40).

Pescadero Lagoon.—Huber (2018) made 410 seine hauls in the lagoon of Pescadero Creek between July 2011 and September 2013, catching a total 15 species. Of the 18,142 fish he caught, three were Striped Bass. Jankovitz (2015, 2017, 2018; Jankovitz and Diller 2019) sampled the lagoon in 15 months during the period June 2014 to October 2018, mostly as two-day seining events to make mark-recapture estimates of steelhead abundance (Table 5). He generally reported capture of three to seven fish species per occasion, but Striped Bass was not reported from any of them.

Waddell Creek.—During their decade-long study of Steelhead and Coho Salmon in Waddell Creek, Shapovalov and Taft (1954) observed that "The Striped Bass enters the lagoon only occasionally, but at such times may remain for over a month. In former years this species was reported by local residents on occasion to have ascended about a mile into the flowing water of the stream, but since the start of the experiments, in 1933, no individuals of this species have been seen above the limits of tidewater. No evidence has been gathered

Table 4. Accounts of recreational catch of Striped Bass taken from "inland" coastal habitats during the period 2004 – 2019, from interviews in the RECFIN database.

Water Body[a]	Interview Site[b]	Trip Date	Total Catch	Primary Target Species
Bodega Bay	Westside launch ramp	11 Jul 2014	1	California halibut
Tomales Bay	Lawson's Landing	15 Jul 2018	1	California halibut
		8 Jun 2019	1	Bivalve class
		3 Jul 2019	1	California halibut
		3 Aug 2019	1	California halibut
		4 Aug 2019	7	California halibut
	Miller Park launch ramp	8 Aug 2018	1	California halibut
		9 Sep 2018	1	California halibut
		31 May 2019	1	California halibut
		26 Jun 2019	1	California halibut
		21 Jul 2019	1	California halibut
		31 Jul 2019	1	California halibut
		5 Aug 2019	14	California halibut
		9 Aug 2019	1	California halibut
		28 Aug 2019	1	California halibut
Elkhorn Slough	South jetty	11 Apr 2016	1	Surfperch family
		22 Jul 2018	2	Striped bass
Alamitos Bay	Davies launch ramp	27 Oct 2012	1	Kelp bass
Newport Bay	Davey's Locker	22 May 2005	1	Unidentified fish
Mission Bay	Dana Basin launch ramp	30 Apr 2011	1	California halibut
San Diego Bay	Chula Vista launch ramp	21 May 2017	1	Unidentified fish

[a] Inferred from interview sites where Striped Bass was recorded in catch.
[b] Omits interviews on San Francisco Bay or San Pablo Bay (n = 2802), two coastal interviews marked as inland but judged to be marine (Santa Cruz Marina side jetty, Oceanside launch ramp), and all trips not marked as inland (Ocean, ocean <= 3 miles, ocean > 3 miles, bay, not known; n = 2569).

to show that the species spawns in Waddell Creek." They reported records of occurrence of the species in the creek or estuary in May 1927 (unknown number), November 1931 ("two dozen"), April 1932 (two fish), March 1934 (one fish), April 1935 (47 fish), and June 1939 ("several"). In recent times, a single large individual (79 cm Fork Length) was captured in Waddell Creek estuary on 13 August 2008, during a routine seining survey for juvenile salmonids (A. Osterback and J. Kiernan, University of California Santa Cruz and NMFS SW Fisheries Science Center, personal communication). This was the only individual caught during 2008–2009, when the estuary was surveyed approximately monthly from August to November of each year.

Table 5. Occurrence of Striped Bass in seining surveys of the estuary of Pescadero Creek (Jankovitz 2015, 2017, 2018; Jankovitz and Diller 2019).

Month	Lagoon Status	Number of Fish Species Reported[a]	Striped Bass Reported?
Jun 2014	Closed	6	No
Jul 2014	Closed	5	No
Oct 2014	Closed	7	No
Jul 2016	Open	3	No
Oct 2016	Closed	6	No
Nov 2016	Closed[b]	4	No
July 2017	Open	5	No
Aug 2017	Open	5	No
Sep 2017	Open	4	No
Oct 2017	Closed	5	No
Nov 2017	Open	5	No
Jul 2018	Open	6	No
Aug 2018	Open	6	No
Sep 2018	Open	5	No
Oct 2018	Closed	4	No

[a] Sampling focused on Steelhead, and species lists were reported as "Other fish species captured during this sampling included <list of species>" suggesting that reporting may be incomplete.
[b] Eight days after major fish kill event.

San Lorenzo River.—The estuary of the San Lorenzo River was regularly sampled for fish in summer and fall during 2008–2016 (HES 2017 and earlier annual reports). Of 26 seining surveys, *M. saxatilis* was observed in six of them: once in 2010 and five of the eight surveys during 2015–2016 (Table 6). In each of these latter years, one survey caught dozens of fish while the remaining surveys caught bass in the single digits.

Pajaro River.— The estuary of the Pajaro River has been annually sampled for fish diversity via seining during 2012–2018 (Alley and Steiner 2016; Alley 2017; Alley 2018; earlier annual reports by same authors). Four Striped Bass were caught in 2012 when the lagoon entrance was closed, but the species has not been observed since (Table 7). Overall fish diversity was also highest in 2012 at 15 species captured, declining to 7–9 species in subsequent years. Ken Oda (Marine Region, California Department of Fish and Wildlife, personal communication) reports that "during the course of conducting fisheries-independent surveys, I observed anglers targeting and catching Striped Bass from shore as well as small boats in the Pajaro estuary."

Well upstream at the source of Pajaro River, Casagrande (2010) sampled San Felipe Lake with gill nets in 32 hours of sets during seven sampling periods from December 2004 through November 2006. She captured 647 individuals and 12 species of fish, including two Striped Bass with lengths 290 mm and 360 mm Standard Length. Five additional species

Table 6. Occurrence of Striped Bass in seining surveys of the estuary of the San Lorenzo River in Santa Cruz (HES 2017 and earlier annual reports).

Month	Lagoon Status	Number of Fish Species Observed	Striped Bass Observed?
Jun 2008	Open	11	No
Oct 2008	Closed/Open	10	No
Jun 2009	Open	10	No
Sep 2009	Closed	8	No
Oct 2009	Open	3	No
Jun 2010	Open	11	Yes (1 fish)
Jul 2010	Open	5	No
Oct 2010	Closed	3	No
Jun 2011	Open	11	No
Oct 2011	Open	15	No
Jun 2012	Open	11	No
Sep 2012	Closed/Open	7	No
Jun 2013	Open/Closed	9	No
Jul 2013	Closed	8	No
Sep 2013	Open	6	No
Jun 2014	Newly Closed	12	No
Jul 2014	Newly Closed	7	No
Sep 2014	Closed	7	No
Jun 2015	Closed	8	Yes (37 fish)
Jul 2015	Closed	4	No
Aug 2015	Open	6	Yes (3 fish)
Oct 2015	Closed	6	Yes (1 fish)
Jun 2016	Open/Closed	11	No
Jul 2016	Newly Closed	11	Yes (2 fish)
Aug 2016	Newly Closed	11	Yes (28 fish)
Sep 2016	Open	9	No

were documented from seining surveys, but Striped Bass was not among them, confirming that gill nets are a more effective form of capture. The bass were caught in 2006, and two adult Chinook Salmon (*Oncorhynchus tshawytscha*) were captured in 2005 as part of the same study, indicating migratory access (and attraction) from the ocean sometimes occurs. Casagrande (2011) sampled 10 sites in five different water bodies of the upper Pajaro River basin, between 26 June and 7 August 2011. Using a combination of electrofishing, seining, and gillnetting, he captured a total of 19 species, including 19 Striped Bass ranging from 310 mm to 550 mm Standard Length. Striped Bass were captured at two sites on the Pajaro River using gillnets, one at the confluence with Miller Canal and the other immediately upstream of Carnadero Creek confluence, both downstream of Felipe Lake via Miller Canal. The species was not observed at the other eight sites, which were in tributaries.

Elkhorn Slough.—Yoklavich et al. (2002) summarized data on the fish fauna of Elkhorn Slough in the 1970s through 1990s. Creel surveys in the 1970s (Cailliet et al. 1977) reported catches of *M. saxatilis* in both the western and eastern parts of the slough (west of Highway 1, near Kirby Landing, respectively), though at much lower rates than many native species such as surfperches, rockfishes, sculpins and flatfish. In contrast, later in the 1980s and 1990s the species was not reported in creel censuses (Marine Recreational Fishing Statistics Survey, cited in Yoklavich et al. 2002), though the data were not strictly comparable due to differences in reporting techniques. Juvenile and adult *M. saxatilis* were caught in otter trawls conducted during the 1970s, but like the creel surveys, were not observed in subsequent trawls conducted in the 1980s and 1990s (Yoklavich et al. 2002). More recently, the RECFIN dataset (Table 4) has two accounts of recreational fishers catching Striped Bass from the south jetty.

Salinas River.—Scofield and Bryant (1926) report that Striped Bass were "fairly abundant" in the mouth of the Salinas River by 1896; at this time the lower river would have had its old configuration of running north parallel to the coast, connecting with Elkhorn Slough and discharging to the ocean just north of the present engineered harbor entrance at Moss Landing (Gordon 1996). Five fish weighing 15 pounds or greater were captured at an unspecified location on Salinas River on 9 June 1921 (Scofield and Bryant 1926, Fig. 14), about a decade after the river changed configuration to its present mouth in 1909-1910.

MCWRA and USACE (2001) report that experimental stocking of Striped Bass was initiated in 1971 in San Antonio Reservoir, on a major tributary of the Salinas River approximately 180 km upstream of the mouth of the estuary. Regular annual plants were conducted from 1976 into the 1980s but were later discontinued. A small self-sustaining population appears to have persisted until at least November 2014, when M. Michie posted a video on YouTube of a large Striped Bass being caught in the reservoir. However, it has not been documented in the reservoir since the recent drought.

In recent times, the lagoon of the Salinas River was sampled for fish four times during 1990–1991 and one to three times annually during 2002–2014 (Table 8). *M. saxatilis* was captured in 12 of the 23 months sampled during these periods. From fall 2009 to fall 2013 it was captured in nine out of 11 months surveyed, including May 2011, April 2012, and April 2013, which coincides with the early spawning season of the species for three consecutive years. The species was not found in April 2014, at the height of the drought when the lagoon had been closed continuously for 15 months (HES 2015). Only three species of fish were observed during sampling: Threespine Stickleback (*Gasterosteus aculeatus*), Tidewater Goby (*Eucyclogobius newberryi*), and Prickly Sculpin (*Cottus asper*). J. Casagrande (National Marine Fisheries Service, personal communication) reports that anglers still commonly capture Striped Bass in Old Salinas River Channel, and that in March 2012, a large number of Striped Bass carcasses was were found in the channel of the Salinas River near Chualar after reservoir releases were cut back for emergency repairs.

Carmel River.—Striped Bass was one of six fish species observed by Dettman (1984) during biological surveys of the Carmel Lagoon in 1982. Casagrande (2006) seined the Carmel Lagoon on 27 July 2006 for Steelhead and reported capturing one Striped Bass (37 cm Fork Length). From 2010 to 2017, a hook-and-line removal project conducted by California Department of Fish and Wildlife removed a total of 551 Striped Bass from Carmel Lagoon in the summers and falls (Table 9). During visual-encounter surveys on 10 June

Table 7. Occurrence of Striped Bass in seining surveys of Pajaro River estuary (Alley and Steiner 2016; Alley 2017; Alley 2018; earlier annual reports by same authors).

Month	Lagoon Status	Number of Fish Species Observed	Striped Bass Observed?
Oct 2012	Closed	15	Yes (4 fish)
Oct 2013	Slightly Open	9	No
Oct 2014	Closed	7	No
Sep–Oct 2015	Closed	7	No
Sep–Oct 2017	Open	9	No
Oct 2018	Open	10	No

Table 8. Occurrence of Striped Bass in seining surveys of Salinas River estuary (Gilchrist et al. 1992; Krafft et al. 2012, 2013; Leal et al. 2014; HES 2015).

Month	Number of Fish Species Observed	Striped Bass Observed?
Aug 1990[a]	9	No
Apr 1991[b]	3	No
Jun 1991[b]	9	No
Aug 1991[a]	18	Yes (3 fish, 27-30 cm SL)
Sep 1991[a]	16	Yes (17 fish, 24-44 cm SL)
Fall 2002	10	No
Fall 2003	10	No
Fall 2004	11	No
Fall 2005	11	Yes (6 fish)
Fall 2006	4	No
Fall 2008	11	No
Fall 2009	13	Yes (1 fish)
Fall 2010	11	No
May 2011	10	Yes (4 fish)
Aug 2011	7	No
Oct 2011	12	Yes (11 fish)
Apr 2012	14	Yes (41 fish)
Jul 2012	9	Yes (31 fish)
Oct 2012	5	Yes (3 fish)
Apr 2013	7	Yes (8 fish)
Jul 2013	14	Yes (47 fish)
Oct 2013	14	Yes (8 fish)
Apr 2014	3	No

[a] Gillnets used at some stations, seines at others.
[b] Gillnets only.

Table 9. Removals of Striped Bass from Carmel Lagoon, summer and fall 2010–2017 by hook-and-line capture (Anderson 2010, 2011, J. Casagrande, National Marine Fisheries Service, personal communication).

Year	CPUE (fish/hr)	Number of Striped Bass Removed	Size Range (TL in cm)
2010	0.79	143	31 - 92
2011	0.87	69	36 - 96
2012	0.725	88	–
2013	0.605	82	–
2014	1.33	62	–
2015	0.33	13	–
2016	0.02	32	–
2017	1 Seine	62	–

2016, Stoddard (2016) observed schools of approximately 9–11 fish and 15–20 fish at two locations, well upstream of the estuary (near Schulte Bridge and Quail Lodge); but not at two other sites where the species had been reported by local residents. Local anglers and Steelhead enthusiasts first observed Striped Bass upstream of the estuary in 2013 and have since observed the species as far upstream as river kilometer 30 (Boughton and Ohms 2018). Some of these fish were visually estimated to be as small as ~12 cm, consistent with age 1 fish (Scofield 1930). However, Ken Oda (Marine Region, California Department of Fish and Wildlife, personal communication) reports that "my co-workers and I never hooked or observed 1+ sized Striped Bass during the Carmel River surveys or caught fish in that size range in the Carmel, Pajaro, or Salinas [Rivers] during the open fishing season," a sample he estimates to be well in excess of 1000 fish. His father used to catch Sacramento Pikeminnow (*Ptychocheilus grandis*) in the former San Clemente Reservoir on the Carmel River, back in the 1960s, and he cannot help but wonder if that is what was actually observed by local anglers and steelhead enthusiasts. Pikeminnows are native to the Sacramento and San Joaquin River systems and, due to a Pleistocene freshwater connection, also to the Pajaro and Salinas Rivers, but according to Moyle (2002) they are not found in the Carmel River.

Morro Bay.—Scofield and Bryant (1926) reported *M. saxatilis* was planted in Morro Bay in 1916 and again in 1919, but no follow-up information was found. During 1968–1970, the bay was sampled every month for fish using a variety of techniques, with sampling effort distributed throughout the bay and entrance (Fierstine et al. 1973); 66 species were captured but *M. saxatilis* was not among them. Horn (1980) sampled Morro Bay via four nighttime and four daytime beach seines on each of four occasions throughout 1974–1976 (Table 10). He captured 21 species overall, but Striped Bass was not among them. Williams et al. (2013) sampled fish from Morro Bay using a variety of seining and trawling methods in April, August and November of 2005–2007 and in May of 2008. They reported 22 species but no Striped Bass.

Southern California.—Along the coast further south, Striped Bass are sometimes captured in the ocean but do not commonly occur in estuaries or inland (Allen et al. 2006). The Santa Ynez River estuary in Santa Barbara County was sampled for fish in 1997 and 1999 (Robinson et al. 2009). Sixteen species were identified, none of which were *M. saxatilis*. Williams et al. (2013) sampled San Diego Bay in April and July of 2005, 2008 and 2012,

Table 10. Occurrence of Striped Bass in seining surveys of Morro Bay (Horn 1980).

Month	Number of Fish Species Observed	Striped Bass Observed?
Feb 1976	13	No
May 1975	16	No
Aug 1975	11	No
Nov 1974	16	No

using methods similar to their Morro Bay survey, and found 48 species but no *M. saxatilis.* For the period 2004-2019, the RECFIN dataset (Table 4) has accounts of recreational fishers catching one Striped Bass each in Alamitos Bay, Newport Bay, Mission Bay, and San Diego Bay.

In the early 20th Century, the California Department of Fish and Game introduced Striped Bass to Newport Bay, Anaheim Bay, Bolsa Chica River, Sunset Beach in Orange County, and Mission Bay at San Diego, but none of these plants appear to have persisted (Dill and Cordone 1997). The Department again introduced the species to Newport Bay in the 1970s, but the population eventually failed (Allen et al. 2006). Although adult Striped Bass may occur irregularly in southern California estuaries (Monaco et al. 1990), the only location that appears to have a self-sustaining population of *M. saxatilis* is the Colorado River.

Overall the species appears to be widespread: rarest north of the Golden Gate, sporadically seen in estuaries on the coast south of the Golden Gate and in Monterey Bay, and quite common in the Carmel River estuary but then rarely seen further south. Occurrence is intermittent, often coinciding with periods when the estuaries are opening and closing in the late spring and summer. Occurrence may be underestimated due to the prevalence of seining, which appears to be less effective than gill nets at sampling the species. Striped Bass have also occasionally been observed significant distances upstream in the larger river systems, suggesting attempts to spawn.

Local Reproduction?

The various sampling techniques described above, mostly seining, were only suitable for detecting subadults and adults, which may have migrated from elsewhere and thus do not demonstrate local reproduction. Although sizes were generally not reported, sizes that were reported were typically >15 cm and always >10 cm, indicating fish at least a year old and usually much older. Yoklavich et al. (1992) described one of the few studies capable of detecting whether *M. saxatilis* has actively reproduced in a coastal system. Ichthyoplankton in Elkhorn Slough were collected monthly via trawls from September 1974 through September 1976 at five different stations distributed from the harbor entrance to inland near Kirby Landing. *M. saxatilis* was not reported among the 29 taxa of larvae and eggs that were observed, despite the presence of adults in Elkhorn Slough during this same general time period (Yoklavich et al. 2002). TES (2000) also conducted an extensive survey of Elkhorn Slough ichthyoplankton, sampling for 24 hours at biweekly or shorter intervals from March 1999 through February 2000, at two locations in front of water intakes at Moss Landing Harbor, for a total of 42 samples of 40 m^3 of water each. They also made six monthly samples using oblique tows or push nets at four stations distributed throughout Elkhorn Slough, filtering ~40 m^3 of water for each sample. At the two harbor locations 66 taxa of fish were identified, while in the slough 53 taxa were identified (not all identified to species), but *M. saxatilis* larvae were not reported.

Short plankton tows were conducted in the Russian River estuary from 1996–1998 in the summer and fall months (Table 11), a period bracketed by high rainfall and streamflows in 1995 and 1998. Only four species of fish (juveniles and larvae) were detected, and *M. saxatilis* was not among them. The tows were aimed at characterizing the invertebrate community before and after lagoon breaching events and took place in shallow water (1 m) just above the river bottom at one location (Willow Creek). The four species of fish observed—Sacramento Sucker (*Catostomus occidentalis*), Threespine Stickleback (*Gasterosteus aculeatus*), Prickly Sculpin (*Cottus asper*), and Bay Pipefish (*Syngnathus leptorhynchus*) all tend to be bottom-dwellers, indicating the tows were probably not particularly effective at detecting *M. saxatilis* larvae if they were present.

Puckett (1976) surveyed the downstream migrations of juvenile anadromous fishes in the Eel River periodically from 1959 through 1970 on the mainstem Eel River, its middle and south forks and on the Van Duzen River. He generally used funnel nets with mesh sizes scaling from 3.8 cm down to 1.3 cm within the funnel, and captured fourteen species of anadromous fish, but no larval Striped Bass were reported. However, it is not clear that the funnel nets had sufficiently fine mesh to capture Striped Bass larvae if they were present.

Eldridge and Bryan (1972) extensively sampled larval fish in Humboldt Bay in 1969. They made biweekly oblique and bottom trawls at 5 stations throughout the bay for a total of 118 tows during January to December 1969. Thirty-seven species of larval or juvenile fish were collected, but Striped Bass larvae were not reported.

To understand the potential for local reproduction, it is helpful to consider the particular life-history requirements of Striped Bass. Although subadults and adults tend to be specialized on piscivory (Shapovalov and Taft 1954; Thomas 1967; Loboschefsky et al. 2012), they have wide tolerance for temperature, salinity, and habitat structure, and move readily between fresh, brackish, and marine systems to follow foraging opportunities (Calhoun 1952; Sabal et al. 2019). In contrast, the requirements for spawning, eggs and fry are rather constrained. In the Sacramento River system, spawning begins in April after water temperatures exceed 14°C; it peaks in May and extends through June (Moyle 2002); in the San Joaquin River it peaks about 15 days earlier (Stevens et al. 1987), while in Coos Bay Oregon it begins and peaks a month later (Morgan and Gerlach 1950), perhaps due to cooler climate. A key constraint is that the species requires flowing freshwater to spawn. Adults not already in freshwater move upstream and form large spawning aggregations on the surface in the main current. In Coos Bay and the San Joaquin River, they spawn in tidally influenced freshwater reaches just outside the estuary, but in the Sacramento system adults may move some distance upstream to spawn (Moyle 2002).

Striped Bass are broadcast spawners that release vast numbers of small eggs (hundreds of thousands to more than 2 million eggs/female) into the water column (Scofield 1930). A key requirement is that eggs and larvae remain suspended in the current until reaching habitat suitable for larval feeding. Adults are never observed to spawn in still or stagnant water (Skinner 1962). Eggs are slightly negatively buoyant and without a current on the order 0.3 m/s (Reinert et al. 2004), will sink to the bottom where they perish from anoxia. River currents can be sufficient but the back-and-forth movement of tidally influenced rivers

Table 11. Occurrence of Striped Bass larvae in plankton tows conducted in the Russian River estuary (Roth et al. 1997, 1998, 1999).

Month	Number of Sampling Events	Number of Fish Species Observed	Striped Bass Larvae?
Aug 1996	1	0	No
Sep 1996	2	1	No
Oct 1996	2	0	No
May 1997	2	3	No
Jun 1997	4	0	No
Aug 1997	2	0	No
Sep 1997	2	0	No
Oct 1997	3	0	No
Nov 1997	1	0	No
Aug 1998	1	0	No
Sep 1998	4	3	No
Oct 1998	4	0	No

and estuaries is also highly suitable (Skinner 1962). Hatching normally occurs after 48 to 60 hours depending on temperature, and the resulting larvae subsist on yolk and drift with the current for another 200 hours, after which they must soon feed or die. So ideally 10–11 days after spawning a larval *M. saxatilis* finds itself in suitable feeding habitat—generally recognized to be estuarine waters with abundant microinvertebrates, or certain reservoirs. Thus, Moyle (2002) described Striped Bass as having three fundamental requirements to complete their lifecycle: (1) a large cool river for spawning, with water velocities swift enough to suspend eggs and larvae in the water column until they become free-swimming, (2) a productive estuary where larvae and juveniles accumulate and can prey on abundant invertebrates, and (3) a relatively large body of water with abundant small fishes for subadults and adults to prey on. The latter may be an estuary such as San Francisco Bay, a reservoir, or the Pacific Ocean.

The combination of (1) and (2) above is rare in the coastal area flanking the Golden Gate: The only large rivers are the Russian, Salinas, and perhaps Pajaro rivers (Figure 2), whereas the only large, productive estuaries with the type of tidal influence benefiting Striped Bass would be Elkhorn Slough, Morro Bay and perhaps some of the embayments north of the Golden Gate such as Bolinas Bay or Bodega Bay. None of these bays and estuaries have freshwater tributaries expected to be large and swift enough for spawning. On the other hand, the rivers that *are* potentially large enough for spawning probably have unsuitable estuaries—typically long, narrow bar-built estuaries that maintain swift river currents during the rainy season and develop sand-bar barriers closing them off from tidal influence in the dry season (Rich and Keller 2013; Behrens et al. 2015). An egg/larva drifting for 10 days at 0.3m/s covers about 250 km; in these bar-built estuaries most such propagules would likely drift out to sea during the open estuary phase or accumulate in the perched pool of still, stratified water that builds up during the closed phase. Some rivers such as the Russian River undergo a multi-week cycle of closing, perching, opening and draining, but such dynamics seem likely to sluice midwater larvae out to sea rather than circulating them between fresh and brackish waters.

The one exception that might just prove the rule is the Salinas River in its original configuration, when the permanent sand-bar that used to be at the location of the current mouth would sluice water and larvae northward along the Old Salinas River Channel into Tembladero, Moro Cojo, and Elkhorn sloughs (Figure 3). This extensive, branching embayment would have had complex tidal circulation patterns mixing with the freshwater inflow (e.g., see Figure 19 in Beller et al. 2009), and is the only such embayment that received flow from a large coastal river system, other than the San Francisco Bay/Delta itself. In its current configuration the interaction between the river and complex of sloughs occurs along a vestigial channel controlled by an outlet gate and a tide gate (Figure 3), and the bulk of the river flow typically breaches the sandbar directly into the ocean upstream of these gates, bypassing the sloughs. We can get a sense of whether reproduction is being attempted in this current configuration from data collected upstream of the estuary during 2010–2014 (Table 12). Upstream migration of adult Striped Bass has been detected at a weir 4 km from the ocean in every year that fish movement was monitored, although the annual totals were small (≤ 11 fish). No *M. saxatilis* have been captured moving downstream at three rotary-screw trapping sites considerably further upstream (103–175 km from the ocean; Table 12), although in one of these years (2014) lack of downstream surface flow would have prevented access by migratory Striped Bass. These traps are operated more within the expected season of reproduction than the weir (March to May versus January to March for the weir), and have commonly captured other bass present in the Salinas system (*Micropterus* spp.), suggesting that if Striped Bass were moving this far upstream they would have been observed, at least occasionally (though in the drought year 2014, lack of surface flow would have prevented such movement). Reproduction further downstream would likely result in eggs floating out to sea or settling to the bottom of the estuary depending on whether the estuary is closed or open. To sum up, though Striped Bass are caught in the Old Salinas River Channel and a small number of appear to attempt immigration annually, perhaps to spawn, I find no substantial evidence for successful reproduction in the Salinas River or the complex of sloughs in their current configuration.

Potential Impacts on Salmonids

The most likely impact of *M. saxatilis* on local salmonids is piscivory of juveniles rearing in the estuaries or emigrating through them (Shapovalov 1936), but clearly subadult and adult *M. saxatilis* are likely to move up into freshwater sections of the river to forage as well. Piscivory is age-dependent. The younger, smaller Striped Bass (≤ 40 cm Total Length) seined from Waddell lagoon by Shapovalov (1936) had fed mostly on small crustaceans (63% of stomach contents); and on smaller fish, especially gobies (26%). The larger fish (40–49 cm) were much more piscivorous, with 85% of stomach contents consisting of salmonids, sculpins, or unidentified fish remains. Scofield (1928) observed that in the ocean, "Bass will follow a school of fish for miles if the water is clear. Where there are sea gulls and pelicans flying over the water one is sure to find a school of small fish, and there also will always be a school of feeding bass." More recently, Loboschefsky et al. (2012) compiled extensive records from diet studies of Striped Bass in the San Francisco Estuary system, and found that while age-1 fish consumed mostly invertebrates, by age 2 their diet was mostly fish, and from age 3 onward their diet was almost entirely fish (Table 13). However, they do exhibit some flexibility in feeding: Ken Oda (Marine Region, California Department of Fish and Wildlife, personal communication) reports stomach contents for 43 Striped Bass subsampled from fisheries-independent surveys conducted from 2010 to 2020 along Monterey Bay sandy

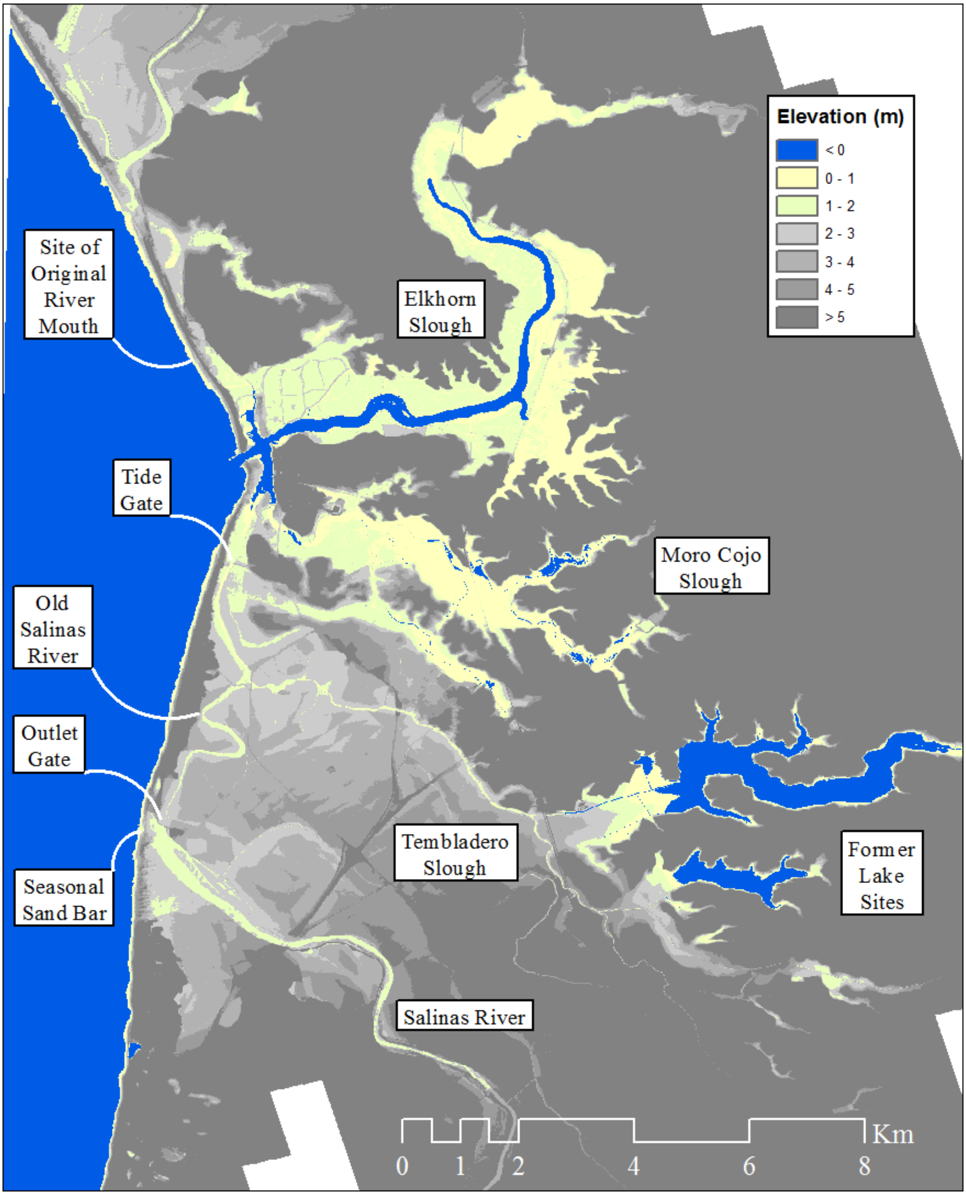

Figure 3. High-resolution topography/bathymetry of the Salinas Estuary/Elkhorn Slough complex (Data from OCMP 2019). In the 19th century, the seasonal sand bar at the current mouth was permanent, and the river ran northward behind the sand dunes to connect with Tembladero Slough, Moro Cojo Slough and Elkhorn Slough before discharging to the ocean north of the current harbor entrance. Currently, flow along this pathway is regulated by an outlet gate at the current estuary and a tide gate at Moss Landing.

Table 12. Movements upstream of the estuary by Striped Bass in the Salinas River system, 2010–2014 (Cuthbert et al. 2010; Krafft et al. 2012, 2013; Cuthbert et al. 2014a, 2014b; Leal et al. 2014).

Year	Location[a]	Dates of Operation[b]	# Species Captured	Striped Bass Observed?	TL (cm) mean (range)
2010	Salinas R.	Mar 12–May 28	14	No	
	Nacimiento R.	Mar 12–Jun 1	15	No	
	Arroyo Seco R.	Mar 18– Jun 1	10	No	
2011	Upstream Passage	Jan 19–Feb 17	6	Yes (1 fish)	41
	Salinas R.	Mar 12– May 20	9	No	
	Nacimiento R.	Mar 12– Jun 1	16	No	
	Arroyo Seco R.	Mar 12– May 31	9	No	
2012	Upstream Passage	Nov 30– Apr 2	6	Yes (6 fish)	47 (43–50)
	Salinas R.	Mar 23– May 5	11	No	
	Nacimiento R.	Mar 23– May 31	16	No	
	Arroyo Seco R.	Mar 13– May 14	10	No	
2013	Upstream Passage	Dec 1–Apr 1	7	Yes (4 fish)	43 (25–59)
	Salinas R.	Flows too low			
	Nacimiento R.	Mar 14– May 31	15	No	
	Arroyo Seco R.	Flows too low			
2014	Upstream Passage	Nov 26–Apr 1	6	Yes (11 fish)	51 (35–70)
	Salinas R.	Flows too low			
	Nacimiento R	Mar 15– May 31	11	No	
	Arroyo Seco R.	Flows too low			

[a] Rotary screw trap operations 175 km upstream of the ocean (Salinas R., Nacimiento R.) or 103 km upstream of the ocean (Arroyo Seco R.). Upstream passage monitored at weir/Vaki system 4 km upstream from the ocean.

[b] Dates with Nov or Dec refer to previous calendar year.

beaches throughout the year. The entire sample of stomachs (100%) "contained [Pacific mole crab] *Emerita analoga* in various stages of digestion. One of the stomachs contained a Barred Surfperch [*Amphistichus argenteus*], and two contained Northern Anchovies [*Engraulis mordax*]." This suggests an ability for the species to consistently exploit locally abundant prey species that happen to not be fish.

The only other recent information for stomach contents of Striped Bass caught on the coast flanking the Golden Gate is from the Carmel lagoon and river. Of 243 adults (31–96 cm Total Length) sampled from the lagoon in the years 2010–2014 (Anderson 2010, 2011, 2014), 66% had empty stomachs; only 9% had discernable fish in them; and only 1% had fish identifiable as salmonids (Table 14). As with a similar finding of 74% empty stomachs for Striped Bass caught in 1935 in San Francisco Bay, "the fact that the fish were taken by hook and line may be a factor, in that the fish caught may have been the particular individuals that were hungry and therefore taking bait, out of a large number of fish present" (Shapovalov 1936, p. 266). However, another 22 Striped Bass were sampled via spear gun from Carmel River in 2017, and these too had mostly empty stomachs (59%), though 32% had discernable fish (CRSA 2017). In this case the stomachs were also screened for presence of DNA markers for Steelhead (Table 15). Five of the 7 stomachs with fish inside them tested positive for Steelhead DNA. Interestingly, half of all the other stomachs (empty + invertebrates) also tested positive for Steelhead DNA, suggesting that those Striped Bass had recently eaten and digested Steelhead (Brandl et al. 2016). If so, then 60% of the 22 Striped Bass had recently consumed one or more Steelhead. This high percentage should be interpreted cautiously, however, as it stems from a single sampling occasion that may simply represent an opportunistic encounter between a school of Steelhead and of Striped Bass, rather than an overall mean rate of predation. In addition, CRSA (2017) noted that

Table 13. Estimated per–capita consumption of fish by Striped Bass in the San Francisco Estuary (Loboschefsky et al. 2012).

Stage	Age	Sex	Proportion of Fish in Diet[a]	Per-Capita Annual Consumption of Fish (kg)[b]	Steelhead daily YOY equivalents[c]
Subadult	1	–	2.5%–12.2%	0.03–0.22	n/a
	2	–	78.5%–82.1%	3.22–4.99	1.5–2.3
Adult	3	F	All adults: 98.7%–99.9%	8.4–11.8	3.8–5.4
		M		6.9–9.3	3.2–4.2
	4	F		12.6–16.8	5.8–7.7
		M		10.3–13.9	4.7–6.3
	5	F		17.5–22.1	8.0–10.1
		M		13.7–18.6	6.3–8.5
	6	F		22.2–27.7	10.1–12.6
		M		16.2–23.0	7.4–10.5

[a] Loboschefsky et al. (2012) and references therein.
[b] Estimated using Wisconsin-style bioenergetics model from growth and temperature data by Loboschefsky et al. (2012). Ranges for annual total consumption in years 1981–2003 (ages 1–2) or 1969–2004 (ages 3–6).
[c] Estimated here as average daily consumption if all prey fish were young-of-the-year (YOY) Steelhead with FL = 80 mm and weight = 6 g.

Table 14. Number of Striped Bass with different stomach contents, from fish removed from Carmel Lagoon (Anderson 2010, 2011, 2014). Most fish recovered from stomachs were unidentifiable, but numbers of recognizable steelhead are reported in parentheses.

Year	Empty	Crustaceans	Fish (SH)[a]	Other
2010	51	19	13 (1)	29
2011	50	7	10 (2)	2
2014	59	3	0	0
Total	160	29	23 (3)	31

[a] Includes bass with both fish and crustaceans in stomachs.

Table 15. Stomach contents of 22 Striped Bass captured in the Carmel River in summer 2017a (CRSA 2017).

Stomach Contents	Steelhead DNA Detected?	Number of Fish
Empty	Yes	7
	No	6
Fish or Fish + Invertebrates	Yes	5
	No	2
Invertebrates Only	Yes	1
	No	1

[a] Locations: Quail Lodge, Robinson Canyon Bridge, Garland Park, Rio Road. Lengths: 41–78 cm.

Steelhead were the most abundant fish in the reach where the Striped Bass were speared, and it is possible that environmental DNA in the water may be finding its way into their stomachs to generate the positive result from empty stomachs.

Very few diet studies from elsewhere in California have identified prey fish to species. Two exceptions are Michel et al. (2018) and Stompe (2018), who isolated DNA from Striped Bass stomachs and used it to determine presence/absence of common prey species. Michel et al. (2018) sampled Striped Bass over two years from three locations on the lower San Joaquin River, in late April/early May during the peak of smolt emigration season. They analyzed DNA from 186 stomachs of Striped Bass ranging from 15 to 65 cm Fork Length, and found that 4.8% of stomachs tested positive for Chinook Salmon and 2.2% tested positive for Steelhead; the proportions did not differ significantly between the two years of the study. The distribution of Striped Bass among the three sites was patchier than other introduced predators such as Largemouth Bass (*Micropterus salmoides*). For example, in 2015 the density at one site, where Old San Joaquin River branched from current San Joaquin River, averaged 1200 Striped Bass per km compared to 20–35 per km at the other two sites, leading to estimates of substantially higher predation at this site versus the others (~0 versus 24 salmon consumed per day per kilometer of river channel; Michel et al. 2018).

Stompe (2018) used genetic techniques to estimate relative abundance of different fish species in the diet of Striped Bass obtained from sites on the Sacramento River near Chico and near Sacramento. For fish from these two locations the percent index of relative abundance (%IRI; Pinkas et al. 1971) of stomach contents was 17% and 4.6% for Chinook Salmon, and 0% and 0.2% for steelhead, respectively. The main diet items for the slightly smaller fish caught at Chico (mean Fork Length = 32 cm) were non-crayfish macroinvertebrates (%IRI = 78%), while the main diet items for the larger fish caught near Sacramento (mean Fork Length = 48 cm) were Threadfin Shad (*Dorosoma petenense*) (%IRI = 55%) and crayfish (%IRI = 26%).

For the Striped Bass caught near Chico, the diet had much more overlap with Sacramento Pikeminnows (*Ptychocheilus grandis*) caught at the same location than to Striped Bass caught near Sacramento (Pianka's (1974) dietary niche breadth overlap = 0.998 vs 0.023, respectively), confirming the view of Moyle (2002) and many others that the species is highly opportunistic in the species of fish it preys on. This can lead to "hot spots" of predation in areas where salmonids become concentrated. For example, Sabal et al. (2016) found that relative to other areas, Striped Bass had higher per-capita consumption rates of emigrating Chinook Salmon at a point on the Mokelumne River where both species were aggregated by a diversion dam with a fish ladder. They estimated that the Striped Bass consumed between 8% and 29% of the emigrating salmon population at that point.

Similarly, the estuaries and lower mainstems of coastal rivers could be potential hot-spots for predation on emigrating and rearing salmonids, depending on prey vulnerability and abundance relative to other fish species. To get a sense of the scope for impact, I converted the annual consumption of fish per Striped Bass, estimated by Loboschefsky et al. (2012) for each age class, into daily "*O. mykiss YOY* equivalents," assuming a standard YOY weight and size of 6 g and 80 mm Fork Length. This scope for impact ranges from 1.5 fish to over 12 fish consumed per predator per day depending on age class, if steelhead YOY made up the entire fish component of Striped Bass diet (Table 13). Of course, these estimates were made for the San Francisco Estuary system and would differ for the coast due to differences in temperature and ability of Striped Bass to feed to capacity (Loboschefsky et al. 2012), as well as availability of other fish species.

Pertinent Questions and Future Directions

Although the species did not show up in recent fish surveys of the Russian River Estuary or Morro Bay, it turned up frequently in all the major tributaries of Monterey Bay as well as the Carmel River. It is occasionally seined in large numbers and in the Carmel Lagoon, 551 individuals were removed from the river over 8 years, indicating the potential for large impacts on juvenile salmonids. Interestingly, though the species was observed in Elkhorn Slough in the 1970s, since then the only observations are by anglers despite several intensive fish surveys.

I found no evidence for local reproduction either historically or recently, but very few studies capable of detecting it have been conducted. Based on habitat, the likeliest spot for local reproduction is probably the Salinas River, especially in years when the timing of sandbar formation and the operation of the outlet gate from the estuary to Old Salinas River Channel would tend to shunt eggs and larvae into the Old River / Elkhorn Slough system (Figure 3). However, neither eggs nor larvae of *M. saxatilis* have ever been detected in Elkhorn Slough or Moss Landing Harbor (part of the Old Salinas River Channel) despite extensive sampling of ichthyoplankton.

There are two types of studies that could be pursued to definitively settle the question of local reproduction. The first, like that of Yoklavich et al. (1992), would consist of a sustained effort to sample the ichthyoplankton of lower rivers or estuaries over a number of years. The sporadic occurrence of larger size classes of *M. saxatilis* in the seining surveys described above suggest that spawning, if it does occur, may be very irregular; thus sampling would need to continue for 5 years to a decade to establish if successful recruitment is occurring. The second and perhaps simpler and more powerful type of study would examine the otolith microchemistry of adults or subadults captured in the river of interest. The elemental isotopes in the inner parts of the otolith should provide information on the geology of the natal stream, which could be used to determine if fish originated in the Sacramento Basin, San Joaquin Basin, or the local coastal basin where it was caught.

Piscivory of juvenile salmonids, especially ESA-listed Steelhead and Coho Salmon, seems likely and the scope for it quite large, but the true level of impact is not known. The diet data from the Carmel system suggests that fish often have empty stomachs (66% and 59% in Table 13 and Table 14 respectively) and may therefore have trouble catching food. These proportions of empty stomachs are comparable to historic studies in Coos Bay Oregon (49.6% of 1018 stomachs empty in 1948-50; Morgan and Gerlach 1950) and San

Francisco Bay (50.4% of 4551 stomachs in 1957-61; Thomas et al. 1967). However, the 47 Striped Bass seined from Waddell Creek by Shapovalov (1936) in 1935 had a much lower proportion of empty stomachs, only 15% (lumping empty stomachs with those only containing sand or debris).

The data also indicate a potential for non-negligible consumption of *O. mykiss* and a willingness to move upstream out of the estuary, perhaps to forage. Striped Bass are clearly opportunistic foragers, and in many estuaries *O. mykiss* are the prey species with the most biomass, especially during smolt migration season or when the estuary is in its closed phase. Future diet studies would help clarify this impact, especially if they were spread across the various river systems and seasons, and used unambiguous genetic techniques like those of Stompe (2018) to identify fish prey items down to species. Since hook-and-line sampling may bias the sample toward fish with empty stomachs, it would be preferable to sample fish via gill netting, spear fishing, or some other method that does not depend so strongly on a hungry fish. Gill netting appears effective (Casagrande 2010, 2011) but may pose unacceptable bycatch mortality on Steelhead.

Even if salmonids avoid predation, however, Striped Bass may prevent them from effectively exploiting estuarine habitat. Presence of Striped Bass may inhibit feeding behavior by salmonids in the estuary, or simply lead them to flee upstream. This sublethal effect may have outsized impacts, by preventing the population as a whole from exploiting the high-growth opportunities in the estuary. This in turn could depress size-at-ocean-entry and subsequent marine survival (Bond et al. 2008), or undermine the resilience provided by alternative life-history pathways (Koski 2009).

Although the recent data do not rule out local reproduction, they are largely consistent with the idea of anadromous migrants from the San Francisco Bay, foraging in the ocean between the Golden Gate and Carmel and occasionally entering estuaries to feed. This hypothesis could be definitively tested with a suitably designed acoustic-telemetry study. On the Atlantic Coast, Grothues et al. (2009) used acoustic tags to track the movements of Striped Bass captured and released in two small estuaries in New Jersey and Maine, each lacking access to suitable upstream spawning habitat. They found their tagged fish exhibiting a broad diversity of behaviors, including taking up residency in non-natal estuaries, moving upstream during spawning season and then abruptly exiting to the ocean, moving upstream during spawning season and then taking up residency in the estuary, and moving back to a known self-sustaining population in Delaware Bay. They even found fish moving between the two estuaries of the study—in New Jersey and Maine—which are separated by 700 km of coastline, two major coastal cities, a large self-sustaining population in the Hudson River, and innumerable smaller estuaries similar to the ones used in the study. Perhaps California Striped Bass are similarly opportunistic, roving, and crafty.

If so, then the primary management implication is that as long as Striped Bass inhabit the San Francisco Bay/Delta ecosystem, they are likely to show up in coastal rivers and estuaries, especially in the area flanking the Golden Gate, and impact native fish populations to some lesser or greater degree. Efforts to recover salmonids by restoring cool spring flows to managed rivers may also tend to attract mature Striped Bass for spawning, but there is little evidence that such spawning will lead to self-sustaining populations. It is likely, however, to increase the predation pressure on local salmonid populations, as well as other vulnerable fish species such as Tidewater Goby. Efforts to remove Striped Bass via hook-and-line removal, spearfishing, seining, or other methods seem likely to reduce this impact, but would be required in perpetuity. Such removal activities may also have direct impacts on native fish themselves via capture or habitat disturbance, and so the real question is whether such impacts are greater or smaller than the benefits to local species of ongoing Striped Bass removal or harvest.

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Locality records for Woodhouse's toad: have wet washes in a dry desert led to extralimital occurrences of an adaptable anuran?

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Woodhouse's toad (*Anaxyrus woodhousii*), also referred to as the Rocky Mountain toad, is an adaptable bufonid that disperses readily into newly disturbed habitats (Ryan et al. 2017). It has a broad geographic distribution in North America, ranging in elevation from below sea level to elevations of about 2,500 m (Storer 1925; Stebbins 1951; Sullivan 2005; Goodward and Wilcox 2019). In California, *A. woodhousii* is native to the Lower Colorado River Valley in southeastern Imperial County (Storer 1925; Appendix A). In 1905 and 1906, Colorado River waters broke through a partially constructed canal and flooded the Salton Sink (McCollom 2000; Ross 2020). As a result, *A. woodhousii* likely became established in the Imperial Valley, Imperial County; it could have arrived earlier, however, when the Colorado River overflowed its banks on previous occasions (NOAA 2010; CDWR 2013; SSA 2017; Lynch and McNeece 2020; Ross 2020) and its presence unconfirmed.

In general, amphibian movements are occasional and limited (Sinsch 1990; Blaustein et al. 1994). Long-distance dispersal by anurans may be more common than historically assumed, however, in part because logistical realities often limit the size of study areas (Smith 2003). Distances over which specific taxa can disperse are often poorly known (Smith and Green 2006), but many species of bufonids are capable of long-distance movements (Smith and Green 2005). Whatever event(s) contributed to the establishment of extralimital populations more than 70 km west of the Colorado River, *A. woodhousii* had been confirmed in the Imperial Valley by the mid-1920s (Appendix A).

By the late 1920s, the documented presence of Woodhouse's toad had expanded westward from the Imperial Valley to Harper Well, located along San Felipe Creek, and also in Imperial County (Appendix A). Additionally, Glaser (1970) described a single record of Woodhouse's toad near Mecca, Riverside County, suggesting the geographic range of *A.*

woodhousii was expanding northward into the Coachella Valley of Riverside County, and he further noted the potential for the occurrence of Woodhouse's toad near the Colorado River in the Palo Verde Valley, Riverside County. Apparently unbeknownst to Glaser (1970), at least nine specimens had been collected in the Coachella Valley (ARCTOS 2018; VertNet 2020; Appendix A) by the time he published his monograph on the amphibians and reptiles of Riverside County. Although some additional specimens were collected near Mecca from 1930 to 1970, compelling evidence that *A. woodhousii* did not become widely distributed in the Coachella Valley was provided by Goodward and Wilcox (2019) who noted, "It appears this species [Woodhouse's toad] did not get established or persist in the Coachella Valley with the 1905-06 [breach of the canal] or earlier floodwaters that created temporary wetlands in the Salton Sink."

Within five years of Glaser's (1970) publication, Woodhouse's toad was numerous in channels and ditches near Mecca in the Coachella Valley, and Keasler et al. (1975) reported that the species was encountered only where irrigation was occurring. More recently, Goodward and Wilcox (2019) described the occurrence of *A. woodhousii* as throughout the Coachella Valley, and further affirmed the close association of Woodhouse's toad with irrigated agriculture; they also noted its association with anthropogenic ponds, golf resorts, and urbanized areas. In this note, I describe the heretofore unreported presence of Woodhouse's toad in the Santa Rosa Mountains on the western edge of the Coachella Valley, and outside the range of the species depicted by Goodward and Wilcox (2019). Further, I offer comments on the probable role of extreme weather events in expanding the geographic range of *A. woodhousii* in southeastern California.

On 3 August 1977, I captured, photographed, and released a single *A. woodhousii* (Figure 1) at Upper Sumac Spring (33.4549 N, 116.2207 W, ~780 m above sea level) in the Santa Rosa Mountains, Riverside County; based on its size, I suspected the specimen was an adult male. At that time, water was present in a small (1 × 1.5 × 0.25 m) pool. Upper Sumac Spring is in Sumac Canyon, which drains a large portion of the eastern slope of the Santa Rosa Mountains, and an expansive alluvial fan is contiguous with irrigated agricultural land (~6 m above sea level) near the mouth of the canyon. I observed no toads during spring and summer 1975 and 1976 (two visits per year, respectively), when I inspected Upper Sumac Spring to ascertain the presence of surface water at that location. Available information (Jones et al. 1953, 1957; Weaver et al. 1970) indicates the spring long has been a dependable source of surface water used by desert bighorn sheep (*Ovis canadensis nelsoni*); thus, an earlier, albeit previously unreported, presence of *A. woodhousii* at Upper Sumac Spring cannot be ruled out.

In September 1976, Tropical Storm Kathleen deposited unusually high rainfall in and near the Imperial and Coachella valleys (Appendix B), and 1976 was the first of several years of above-average precipitation that increased availability of surface water in many canyons on the eastern slope of the Santa Rosa Mountains (Wehausen et al. 1987). The storm yielded 16.18 cm of rain at Deep Canyon ($\overline{x}_{\text{September}}$ = 1.40 cm) and 13.31 cm of rain at Thermal ($\overline{x}_{\text{September}}$ = 0.81 cm), located 35 km northwest and 29 km north of Upper Sumac Spring, respectively (WRCC 2020). Following that storm, water flowed almost continuously in Sumac Canyon and other major canyons on the east side of the Santa Rosa Mountains until May 1977 (V. C. Bleich, personal observation). The flow of water in Sumac Canyon had subsided by the time I visited Upper Sumac Spring in August 1977, at which time intermittent pools remained in the bottom of the drainage.

Figure 1. Dorsal (A) and lateral (B) photographs of Woodhouse's toad (*Anaxyrus woodhousii*) captured at Upper Sumac Spring, Santa Rosa Mountains, Riverside County, California, on 3 August 1977; identification confirmed by R. B. Loomis, California State University, Long Beach.

Geographic expansion of *A. woodhousii* westward from the Colorado River to the Imperial Valley and, subsequently, northward to the Coachella Valley, was facilitated by suitable habitat created as land was irrigated for agricultural purposes, and the concomitant development of canals and ditches (Goodward and Wilcox 2019; Keasler et al. 1975) and, potentially, golf courses and urbanized areas. Additionally, Goodward and Wilcox (2019) noted that Woodhouse's toad likely dispersed northward along the channelized Whitewater River during surface flows. The early presence of *A. woodhousii* at Harper Well, and more recently at Upper Sumac Spring following Tropical Storm Kathleen, however, compelled me to hypothesize that dispersal of *A. woodhousii* throughout the Imperial Valley and Coachella Valley, but particularly to extralimital locations isolated from irrigated agriculture, has been facilitated by extreme rainfall events.

Application of the Path Distance Function in Google Earth Pro yielded a distance of ~8.8 km—as measured along the canyon floor—and a mean slope of 8.7% between Upper Sumac Spring and the nearest irrigated agricultural land. The continuous flow of water in Sumac Canyon for ~8 months following Tropical Storm Kathleen likely resulted in conditions suitable for *A. woodhousii* to disperse westward into the canyon and eventually reach Upper Sumac Spring. In contrast, San Felipe Creek is an intermittent stream, the eastern terminus of which historically reached the Salton Sink, but now is contiguous with irrigated agricultural fields in the western Imperial Valley. Application of the Path Distance Function yielded a distance of ~17.0 km (mean slope = 0.21%) from Harper Well (~34 m below sea level) to the existing shoreline of the Salton Sea (~70 m below sea level)—a surrogate for the probable distance to suitable habitat following formation of the Salton Sea in 1905—and a distance of ~8.4 km (mean slope = 0.33%) from Harper Well to the nearest agricultural activity (~62 m below sea level) in the western Imperial Valley. Although the date that *A. woodhousii* first arrived at Harper Well cannot be determined definitively, Mendenhall (1909) described the presence of "good water" and an abundance of mesquite (*Prosopis* sp.) several years prior to publication of his research.

Keasler et al. (1975) did not identify extreme rainfall events as important to the dispersal of Woodhouse's toad or the subsequent increase in its geographic distribution, but Goodward and Wilcox (2019) alluded to that possibility. The severity and widespread occurrence of such events over much of the Imperial and Coachella valleys (Appendix B), however, suggests major storms have played prominent roles in the geographic distribution of the species. Since 1963—when *A. woodhousii* was first reported from the Coachella Valley—8 of 13 (62%) weather stations in the vicinity of the Coachella or Imperial valleys have recorded maximum annual rainfall ranging from 223% to 347% of mean annual rainfall on record, 6 of 13 (46%) have recorded maximum monthly rainfall ranging from 93% to 243% of mean annual rainfall on record, and 7 of 13 (54%) have recorded maximum one-

Figure 2. Flooding at Ocotillo, Imperial County, California, 40 km SSW of Harper Well, Imperial County, following Tropical Storm Kathleen. This image exemplifies the vast areas covered by flowing or standing water associated with the severe, albeit infrequent, rainfall events that likely have contributed to the dispersal of Woodhouse's toad (*Anaxyrus woodhousii*) in or adjacent to the Imperial and Coachella valleys, California (FEMA 1989).

day rainfall ranging from 68% to 196% of mean annual precipitation on record (WRCC 2020). Many of these extreme rainfall events probably yielded widespread runoff like that resulting from Tropical Storm Kathleen (Figure 2).

Periodic severe rainfall events similar to those emphasized above likely have contributed to the widespread distribution of Woodhouse's toad in the Imperial and Coachella valleys, and particularly in locations normally isolated from potentially suitable habitat by dry canyon bottoms (e.g., Upper Sumac Spring) or intermittent creeks (e.g., Harper Well). Intense weather events result in stepping-stone habitat—wherein survival of a species may be enhanced for a period of time (Bleich et al. 1990) and is analogous to the springs described by Goodward and Wilcox (2019)—that allowed, and continues to allow, *A. woodhousii* to expand in distribution and reproduce in areas otherwise unavailable in the absence of torrential rainfall. Thus, the westward expansion of *A. woodhousii* into Sumac Canyon and its presence at Upper Sumac Spring likely were results of extreme rainfall and subsequent runoff associated with a major storm event, and at least one similar event most likely explains the presence of Woodhouse's toad at Harper Well early in the 20th Century. Whether populations remain at Upper Sumac Spring or at Harper Well, or others have become established and persist at additional springs in the Santa Rosa Mountains, or at heretofore unconfirmed locations in the West Chocolate, East Chocolate, Orocopia, Chuckwalla, Little San Bernardino, or Fish Creek mountains—each of which is proximate to the Salton Sink and the Imperial or Coachella valleys—is not known.

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This paper is dedicated to the memory of D. A. Hardin—an outstanding pianist, natural historian, and educator—in recognition of his decades of service to the residents of the Owens Valley, Inyo County, California. I thank the late R. B. Loomis (California State University Long Beach) for confirming the identification of the *A. woodhousii* photographed at Upper Sumac Spring in 1977; the late B. H. Banta (Southwest Biological Associates) for fruitful discussions regarding the herpetofauna of the Santa Rosa Mountains; and the late B. Blong (California Department of Fish and Game) for sharing his knowledge of the Santa Rosa Mountains and providing extensive opportunities to explore that geographic area. Field work in the Santa Rosa Mountains was funded, in part, by California Department of Fish and Game Federal Aid in Wildlife Restoration Project W-26-D (Wildlife Habitat Development), and manuscript preparation was supported by the Eastern Sierra Center for Applied Population Ecology. R. B. Loomis, I. Chellman, J. Garwood, and an anonymous reviewer provided helpful comments on the manuscript. This is Professional Paper 115 from the Eastern Sierra Center for Applied Population Ecology.

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APPENDIX A. MUSEUM RECORDS FOR *ANAXYRUS WOODHOUSII*

Museum records (ARCTOS 2018, VertNet 2020) documenting the dispersal of *A. woodhousii* from the Lower Colorado River Valley, Imperial County, to the Imperial and Coachella valleys, Imperial (I) and Riverside (R) counties, California, respectively. Also shown are the years during which *A. woodhousii* was recorded at Harper Well, Imperial County, and at Upper Sumac Spring, Riverside County. *A. woodhousii* remains widespread in the Imperial Valley and has spread to numerous locations throughout the Coachella Valley (Goodward and Wilcox 2019).

General Location	Specific Location	Year	Institution	Specimen Number
Near Colorado River (I)	Potholes	1910	MVZ[a]	Herp 1842, 1844
	5 mi NE Yuma	1910	MVZ	Herp 1843
	Yuma Indian Reservation	1912	CAS[b]	Herp 33422
Imperial Valley (I)	Imperial	1926	UMMZ[c]	Herp 64925, 64926, 71483
	El Centro	1929	LACM[d]	Herp 12054
	SE Corner Salton Sea	1930	SDMNH[e]	Herp 14517
W of Imperial Valley (I)	Harper Well	1929	CAS	SUA 3033, 3034
		1929	SDMNH	Herp 1753, 1754
		1939[f]	MVZ	Herp 31539, 31540
Coachella Valley (R)	Indio	1930	SDNHM	Herp 14431–14437
		1966–1972	LACM	Herp 105740, 105741
	Mecca and vicinity	1963–1970	LACM	Herp 12038, 62331, 62332, 88518, 91837, 91838, 105736–105739
		1970	UCM[g]	62331, 62332
	Whitewater River Delta	1983	CCBER[h]	Herp 14838–14840
N of Coachella Valley (R)	N of Present-day I-10	1964–1969	MVZ	Herp 98624
			LACM	Herp 74562; 88509–88515; 91834–91836
		1973	AUM[i]	Herp 22728
Santa Rosa Mtns. (R)	Upper Sumac Spring	1977	This paper	

[a] Museum of Vertebrate Zoology, University of California, Berkeley
[b] California Academy of Sciences
[c] University of Michigan Museum of Zoology
[d] Natural History Museum of Los Angeles County
[e] San Diego Museum of Natural History
[f] Erroneously reported by Goodward and Wilcox (2019) as the date *A. woodhousii* initially was collected at Harper Well
[g] University of Colorado Museum of Natural History
[h] Cheadle Center for Biodiversity and Ecological Restoration, University of California, Santa Barbara
[i] Auburn University Museum of Natural History

APPENDIX B. EXTREME ANNUAL, MONTHLY, AND DAILY RAINFALL IN AND PROXIMATE TO THE IMPERIAL AND COACHELLA VALLEYS

Available records of maximum rainfall amounts (in cm) recorded at 13 weather stations in or near the Imperial and Coachella valleys, Imperial County (I) and Riverside County (R), California (WRCC 2020). For each station, the year, month, and day with maximum rainfall are reported, respectively. This summary of extreme precipitation events also includes the mean annual rainfall at each station, and the percent of mean annual rainfall accounted for by each annual, monthly, and daily maximum on record. The extreme rainfall events associated with these records (e.g., tropical storms, monsoonal thunderstorms, etc.) likely have played, and continue to play, a role in the dispersal of *Anaxyrus woodhousii* in southeastern California, and particularly to areas isolated for extended periods by vast expanses of dry land, such as Sumac Canyon, Riverside County and Harper Well, Imperial County.

Station	Mean Annual Rainfall	Maximum Annual Rainfall (Year)	Percent of Mean Annual Rainfall	Maximum Monthly Rainfall (Month Year)	Mean Rainfall Same Month	Percent of Mean Annual Rainfall	Maximum Single-day Rainfall (Month Year)	Percent of Mean Annual Rainfall	Years on Record
Gold Rock Ranch (I)	9.91	19.15 (1992)	193	9.27 (Jan 1995)	1.65	94	6.73 Aug 1971)	68	1964–1996
Calexico (I)	6.83	23.70 (1905)	347	9.60 (Aug 1977)	1.04	141	7.14 (Dec 1982)	105	1904–2010
El Centro 2 SW (I)	6.45	18.64 (1992)	289	13.03 (Sep 1933)	0.66	202	6.50 (Sep 1939)	101	1932–2012
Imperial Coop (I)	7.21	17.98 (1906)	249	15.54 (Feb 1905)	1.22	216	10.36 (Sep 1939)	144	1901–2012
Imperial Airport (I)	5.97	13.34 (1977)	223	9.53 (Aug 1977)	0.71	160	5.64 (Sep 1976)	94	1962–2012
Brawley 2 SW (I)	6.73	20.78 (1939)	309	17.14 (Sep 1939)	0.64	255	9.91 (Oct 1932)	147	1910–2007
Yuma Date Orchard (I)	8.99	24.26 (1926)	270	16.18 (Aug 1909)	1.75	180	9.19 (Aug 1909)	102	1905–1929
Niland (I)	6.63	20.52 (1983)	310	10.03 (Jul 1968)	0.46	151	6.73 (Jul 1968)	102	1914–2012
Mecca 2 SE (R)	7.92	25.81 (1983)	326	14.40 (Sep 1976)[a]	0.74	182	10.76 (Sep 1976)[a]	136	1905–2012
Thermal Airport (R)	7.52	22.02 (1976)[a]	293	13.31 (Sep 1976)[a]	0.81	177	8.20 (Sep 1976)[a]	109	1950–2012
Indio Fire Station (R)	8.36	27.56 (1939)	330	22.76 (Sep 1939)	0.79	272	16.38 (Sep 1939)	196	1894–2012
Deep Canyon (R)	14.45	47.80 (1983)	331	22.23 (Sep 1983)	1.75	154	9.09 (Sep 1982)	63	1963–2016
Palm Springs (R)	13.94	34.85 (1983)	250	21.41 (Jan 1943)	2.87	154	11.61 (Jan 1943)	83	1906–2012

[a] Tropical Storm Kathleen

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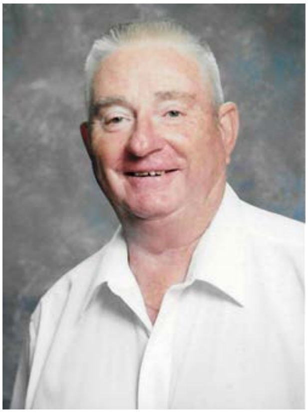
In Memoriam: Robert L. Vernoy (1926–2020)

Hunters and other conservationists familiar with the eastern Mojave Desert lost one of their strongest supporters on March 7, 2020 with the passing of Robert L. Vernoy, retired California Department of Fish and Game (CDFG) Wildlife Biologist. A California native and a veteran, Bob grew up in Cherry Valley before serving in the Army Air Corps during World War II.



Bob was employed by CDFG for 41 years, and served in a variety of capacities in the deserts of southeastern California prior to his retirement in 1989. He began his career in 1949 as a Game Conservation Aid at CDFG's Imperial Waterfowl Management Area near the southeast corner of the Salton Sea, at a salary of $180.00/month, and where he became a proficient heavy equipment operator. Bob also worked at the Brawley Game Farm for 7 years before becoming manager of the Valley Center Game Farm in San Diego County. He next transferred to the Chino Game Farm, and then spent several years at the Mojave River Hatchery, but returned to the Chino Game Farm in 1965 to oversee the closure of that facility. Following closure of the Chino Game Farm, Bob was assigned to a "pool" position, where he participated in a variety of wildlife management activities throughout southern California, and during which he became heavily involved in mitigating the impacts of the Santa Barbara oil spill in January and February of 1969.

In 1970, Bob promoted to Assistant Wildlife Manager-Biologist, and was assigned to the Desert Wildlife Management Unit (DWMU) in San Bernardino County, where he established an office at his home in Victorville. During the 20 years he held that position, he was an important contributor to the Department's efforts to ensure water was available for all species of wildlife inhabiting the eastern Mojave Desert and, thereby, ensuring that hunters would have access to high-quality opportunities to pursue Gambel's quail, chukar, mourning dove, and other upland game, as well as mule deer and, eventually, bighorn sheep. Few individuals realize Bob's dedication to maintaining the 350 wildlife water developments (often referred to as quail guzzlers) in the DWMU. In his own words, though, he acknowledged, "I was only able to inspect or make repairs to these units about once every other year."

Bob also performed inspections and maintained the many dozens of desert springs located in the DWMU to ensure surface water was available for all wildlife, and on which mule deer and bighorn sheep were especially dependent. Add to these activities the annual brood counts to assess quail and chukar production, dove surveys, raptor surveys, data collection and oversight of the mule deer hunting season in eastern San Bernardino County (now Zone D-17), participation in aerial surveys for bighorn sheep, and the ever-increasing number of environmental documents upon which to review and comment, and he was one busy biologist. Zone D-17 has become well-known for producing large mule deer and it has continued to produce animals that are among the largest taken in California each deer season, a point that Bob was immensely proud of.

Bob's interest in data acquisition and his thoroughness in maintaining records, his presence in the field talking and interacting with hunters throughout the upland game and deer seasons, and his close working relationship with local wildlife protection personnel paved the way for increased hunter interest in, and appreciation for, the eastern Mojave Desert. His area of responsibility included the majority of San Bernardino County, and extended from the Riverside County line on the south to the Inyo County Line on the north, and from the Los Angeles County line eastward to the Colorado River, and actually included a large portion of southeastern Inyo County. Located within this vast region were the first two areas to be opened to the hunting of bighorn sheep in California since 1878: Old Dad Peak and the Marble Mountains. To date, 7 of the 11 zones that have been opened to bighorn sheep hunting are within what once was the DWMU.

Bob was the wildlife biologist for the DWMU when Dick Weaver conducted the only in-depth and statewide assessment of bighorn sheep in California, and Bob lent his expertise and knowledge to assist in that effort from 1970 to 1972. Following completion of that assessment and prior to Bob's retirement, a total of 21 wildlife water developments were constructed specifically to help conserve bighorn sheep within the DWMU. During his time as the Unit Manager, Bob worked closely with personnel assigned to CDFG Federal Aid in Wildlife Restoration Project W-26-D and members of the Society for the Conservation of Bighorn Sheep on each of those projects. Construction of each bighorn sheep water development depended largely on volunteer labor and provided hundreds of interested individuals with opportunities to be involved directly with bighorn sheep, and likely resulted in many life-long commitments to conservation that, in all probability, would otherwise not have occurred.

During the early 1980s and following development of several of those wildlife water sources, bighorn sheep in the eastern Mojave Desert were the beneficiaries of increased interest within CDFG. Bob participated in numerous helicopter surveys, and helped collect data that resulted in the reintroduction of bighorn sheep to the Eagle Crags, Whipple Mountains, Argus Range, Sheephole Mountains, Bullion Mountains, and the northern Bristol Mountains, as well augmentations of bighorn sheep populations in the Avawatz Range and Chuckwalla Mountains. Bob was an integral part of, and an active participant in, those translocations, and ensured that critically important tasks were carried out effectively and efficiently.

Bob also played a pivotal role during the conservation of bighorn sheep by serving as an observer in dozens of aerial telemetry flights that otherwise would not have occurred, and participating in numerous helicopter surveys upon which the program to reintroduce desert bighorn sheep to vacant ranges was based. Data gathered during those flights also led to the opening of bighorn sheep hunting in California, and Bob was a primary author of management plans for bighorn sheep populations at Old Dad Peak and the Marble Mountains that were required by the state legislature; those plans remain current and are relied on each year. In addition, he prepared management plans for several other areas within the DWMU that eventually became bighorn sheep hunt zones.

Bob also was an important contributor to the annual Bighorn Sheep Hunter Clinic that bighorn sheep hunters are required to attend, and he proposed the initial (1987) Hunter Clinic be held at CDFG's Camp Cady Wildlife Area. That venture evolved into an annual event sponsored by the Society for the Conservation of Bighorn Sheep, and was a tradition that lasted 25 years. Bob had management responsibility for the Camp Cady Wildlife Area, and ensured the bunkhouse and associated facilities always were in top condition for the annual hunter clinic, which was an in-depth and extensive affair that, following supper, extended well into the evening and generally continued the following day. During those Hunter Clinics Bob and many other individuals—most of whom volunteered their time—generously shared information on bighorn sheep occupying the hunt zones, geography, hunting techniques, equipment, desert safety, taxidermy, photography, and regulations, and by far exceeding the minimum requirements that had been specified by the state legislature.

Bob Vernoy understood the importance of habitat and the value of habitat management or enhancement to assuring the availability of resources needed by all wildlife. He was a friend of hunters and other outdoorsmen, and he fulfilled his role in conservation very capably. He was a quiet man, and did not have a penchant for accolades. Following retirement, Bob was recognized by the Society for the Conservation of Bighorn Sheep with the Bicket-Landells Award, named in honor of BLM Wildlife Biologist Jim Bicket and Helicopter Pilot Don Landells who died while conducting a bighorn sheep survey at Clark Mountain on 6 October 1986; Bob had been scheduled to join the survey crew on the morning of the accident.

The authors of this tribute both were assigned to Federal Aid Project W-26-D, and we had the privilege of knowing and working with Bob Vernoy for many years. One of us eventually became Bob's supervisor, and the other filled the position created by Bob's retirement. Bob was a kind and generous person, a dedicated employee, a fine naturalist from whom we learned a great deal about the Mojave Desert, and an individual for whom we, and many others that knew or worked with him, had the utmost respect. Collectively, desert wildlife in general—and bighorn sheep in particular, along with California's sportsmen and the public in general, have been the beneficiaries of Bob Vernoy's many contributions to wildlife conservation. Hopefully, his dedication and efforts on behalf of wildlife will not be forgotten.

—Vernon C. Bleich, CDFG (Retired), Bismarck, North Dakota, *and* Andrew M. Pauli, CDFG (Retired), Apple Valley, California.

INFORMATION FOR AUTHORS

The California Fish and Wildlife Journal (CFWJ) is a peer-reviewed, scientific journal focused on the biology, ecology, and conservation of the flora and fauna of California and surrounding areas, and the northeastern Pacific Ocean.

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Front. Monarch butterflies (*Danaus plexippus*) at Pismo Preserve, Pismo Beach, CA. Photo by Steve Corey (CC BY-NC-ND 2.0)

Back. Mated pair of American Kestrels (*Falco sparverius*) at Central Park, California City, CA. Photo by Phillip Cowan (CC BY-ND 2.0).

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