Department of Land and Natural Resources

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Hamakua Marsh State Wildlife Sanctuary

Waterbird Report, 2019

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Introduction

Hamakua Marsh State Wildlife Sanctuary has been identified by the U.S. Fish and Wildlife Service as a core wetland for the recovery of the four endemic and endangered waterbirds: the Hawaiian Coot (*Fulica alai*), Hawaiian Duck (*Anas wyvilliana*), Hawaiian Gallinule (*Gallinula galeata sandvicensis*), and Hawaiian Stilt (*Himantopus mexicanus knudseni*; USFWS, 2011). Monitoring the waterbirds for abundance, habitat use, and nesting success remains imperative for informing wetland managers on affective habitat manipulations and predator control efforts that may lend to the recovery of Hawaii's four endangered waterbirds.

Methods

Survey.—A census technique was employed to count all waterbirds present using the direct count method. Waterbird surveys were conducted using consistent observation lines to maintain consistency amongst different observers. When conducting waterbird surveys observers walked along the stream edge paralleling Hamakua Drive from Basin A toward Basin D (intersection of Hamakua Drive and Kailua Road). Basin A is on the southeast corner of the wetland and Basin D is toward the northwest (Figure 1).

Observers also recorded ancillary environmental data: cloud cover, vegetation cover, rainfall, wind and gust speed, water level, and the degree of human influence. Cloud cover was estimated as a continuous percentage between 0 and 100 by tens. Vegetation cover was ranked in discrete categories from 0 to 3: 0 = open water, 1 = 26–50% cover, 2 = 51–75% cover, and 3 = ≥75% cover. Rainfall was recorded in discrete categories of 0 = no rain, 1 = mist or fog, 2 = drizzle, and 3 = light rain. Wind and gust speed were recorded as Beaufort categories: 0 = no wind, 1 = smoke drifts (4–7 mph), 2 = wind felt on face, and 3 = leaves, small twigs in constant motion (8–12 mph). Water level was recorded as a discrete category ranging from 0 to 3, where 0 = dry, 1 = lower than normal, 2 = normal, and 3 = higher than normal. Human impact was recorded as ranging from 0 to 2: 0 = indirect, 1 = moderate, and 2 = heavy.

Chicks and fledglings were recorded separately for each of the endangered wetland birds and all banding information observed was recorded. Specific nesting activities measured include: pairing, territory, and survival rates of chicks to fledgling stage.

Habitat Use. —Microhabitat was assessed for all the endangered birds encountered. Microhabitat was identified as: *stream*, *stream bank*, *open mudflat*, *vegetation*, *0–3" water*, *3–6" water* and *>6" water*. *Stream* is defined as stream water that is deeper than the tarsal-tibiotarsal joint (i.e., joint not visible) for stilts and water deep enough for the coot or gallinule to be swimming; *stream bank* is stream water not deeper than the tarsal-tibiotarsal joint (i.e., joint visible) in stilts, or coots and gallinules observed standing on vegetation inside the stream channel or in shallow enough water where swimming is not allowable; *open mudflat* is defined as exposed or bare soil with no emergent vegetation; *vegetation* is emergent vegetation with small pockets of mudflat or water present; *0–3" water* is water no deeper than the tarsal-tibiotarsal joint (i.e., joint visible) for stilts and walking in water for coots and gallinules; *3–6" water* is deeper than the tarsal-tibiotarsal joint (i.e., joint not visible) for stilts and swimming for coots and gallinules; and *>6" water* is such that no part of the leg is visible in the stilt, for the coot and gallinule depth of water was estimated by reading the nearest water gauge.

Productivity.—Each endangered waterbird species' productivity was measured by dividing all the chicks and fledglings observed by the total birds observed for that species for each survey.

Nesting success.—Hawaiian Stilt nests were monitored by the University of Hawaii at Manoa from February through August in 2019. Nest success was monitored using Bushnell No-Glow Aggressor HD Trophy cameras placed at least 3 m from the nest, mounted on a 2" x 1" furring strip, and secured with a camera strap. Cameras were programmed to take two images back-to-back immediately upon infrared motion activation. Cameras were programmed to have a five second delay between each activation. One control photo was taken every hour using field scan mode to monitor for timing of flooding. Cameras were checked weekly for battery life and SD card data retrieval and were removed either immediately after a nest was confirmed failed or 10 days after a nest was confirmed successful.

Fledging success.—Endangered waterbird fledging success was measured using this formula: (# of observed fledglings/# of observed chicks) x 100 = % fledgling success. Fledglings and chicks were mapped each survey to aid in identifying each brood's chicks to fledging ratio.

Figure 1. Map of Basins A, B, C, and D in Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

Results

A total of 45 surveys were conducted in Hamakua Marsh State Wildlife Sanctuary in 2019. The water level fluctuated throughout the year with peak water levels in February, May, and October. Average waterbird abundances fluctuated throughout the year with average coot, gallinule, and stilt abundances peaking in November, December, and November, respectively (Figure 2).

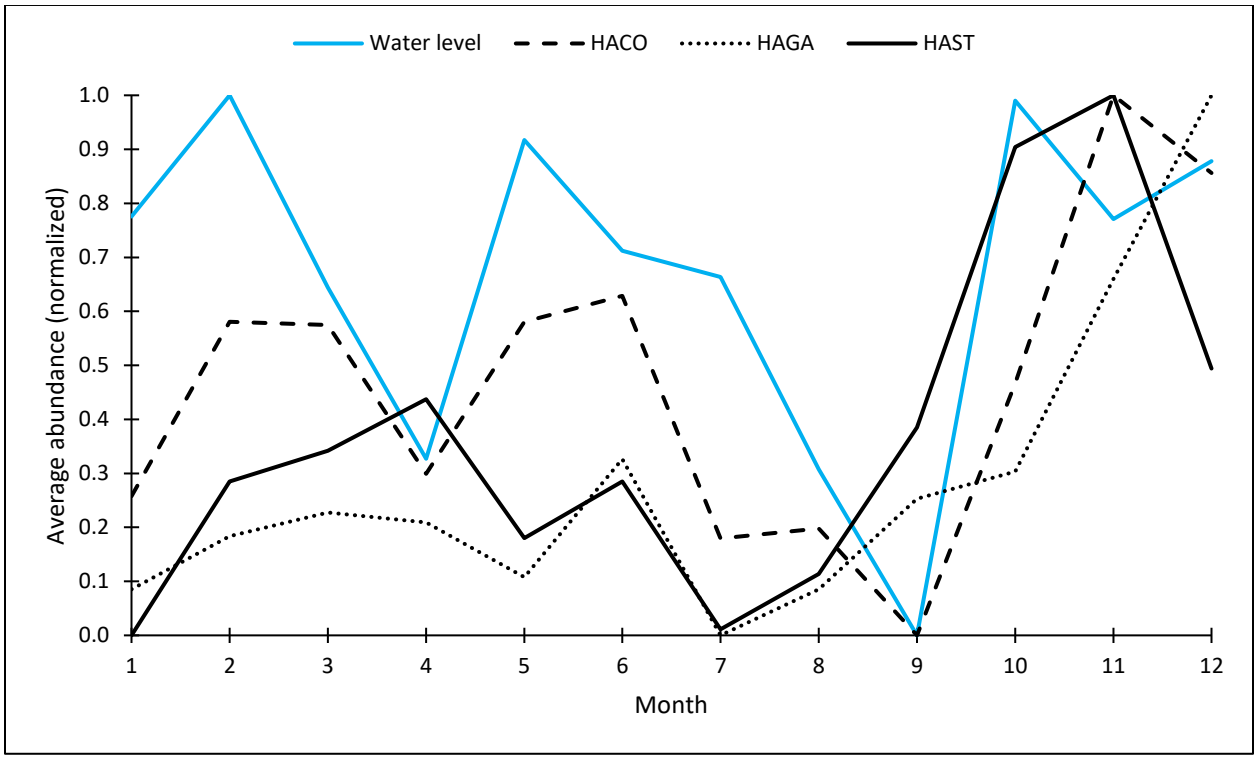

Figure 2. Water level in Basin A and average waterbird abundances for coot, gallinules, and stilts by month in 2019 at Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii. Data was normalized on a scale of 0–1.

Mean abundances (range) in 2019 for Hawaiian Coot, Hawaiian Gallinule, and Hawaiian Stilts were 29.8 (19–41), 71.9 (49–110), and 40.0 (19–84) individuals, respectively. Basin B had the highest abundances of coots, gallinules, and stilts (Figure 3).

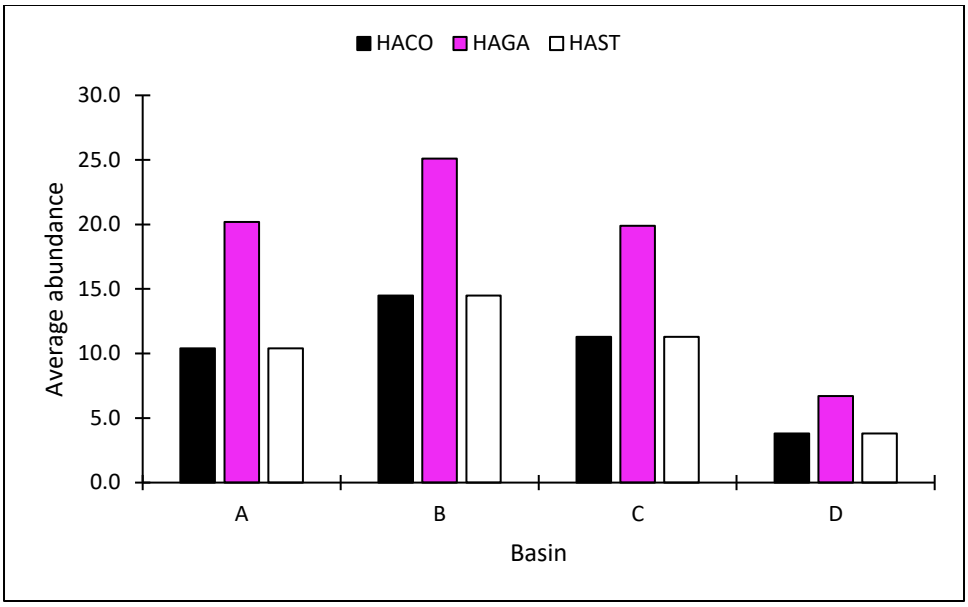

Figure 3. Average abundances of coots, gallinules, and stilts in Basins A, B, C, and D at Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

Habitat utilization differed by species. The Hawaiian Coot was found in stream and water >6" deep in 56.4% of the observations; the Hawaiian Gallinule was found in mudflat/vegetation and the stream bank in 69.2% of the observations; and the Hawaiian Stilt was found in mudflat/vegetation and 0–3" water in 74.7% of the observations (Figure 4).

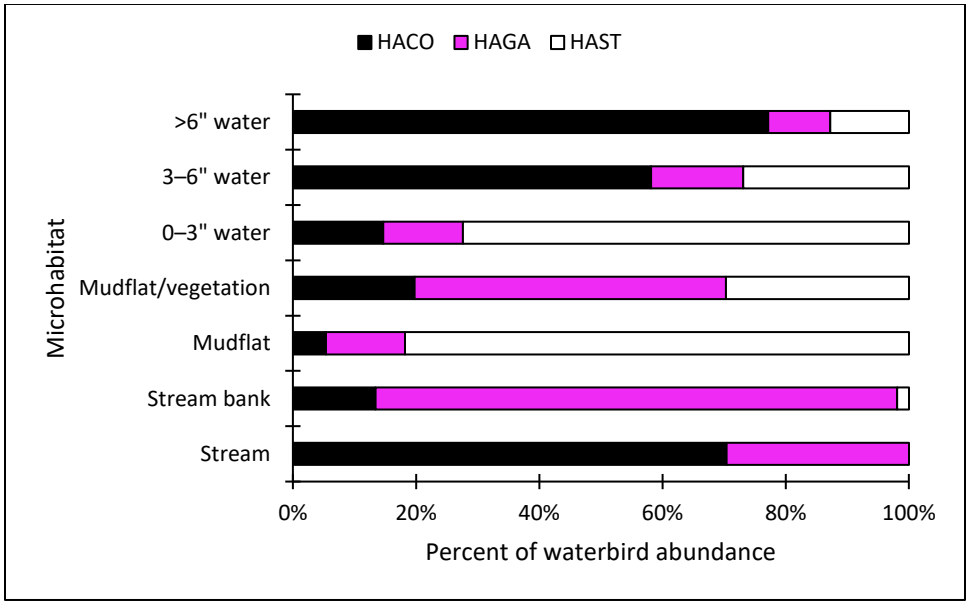

Figure 4. Percent of coots, gallinules, and stilts in seven microhabitats found within Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

Hamakua Marsh supports an average of 4.8, 8.6, and 4.8 coots, gallinules and stilts per hectare, respectively (Figure 5). Basin C has the average highest density of coots, gallinules, and stilts.

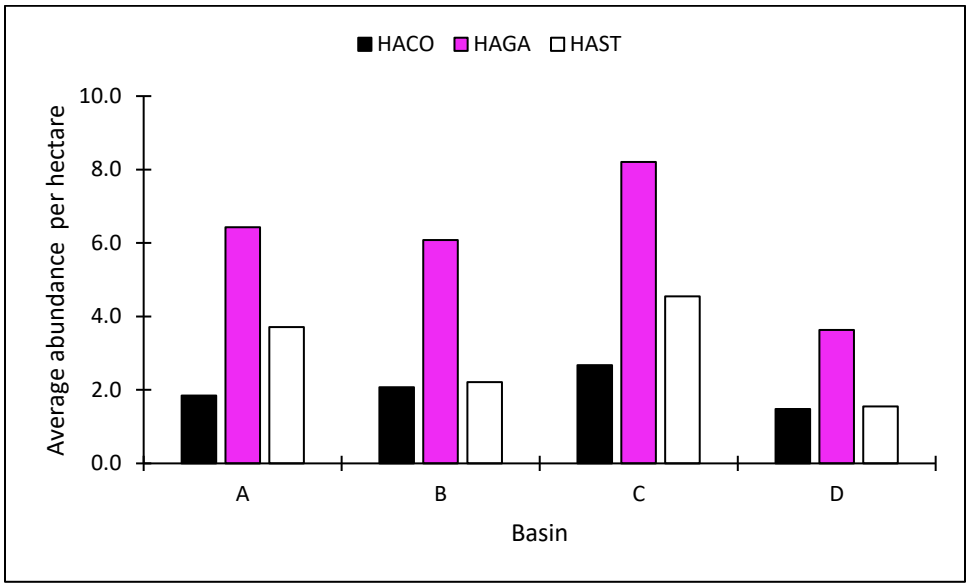

Figure 5. Average abundance of coots, gallinules, and stilts per hectare in Basins A, B, C, and D in Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

Productivity.—Coot, gallinule, and stilt productivity changed throughout the year. Average chick observations during 2019 for coots, gallinules, and stilts were 2%, 13%, and 7% of the observed population, respectively (Figure 6). Coot juveniles ranged from 0–11% of observations during surveys; gallinule juveniles ranged from 0–41% of observations during surveys; and stilt juveniles ranged from 0–25% of observations during surveys (Figure 7). The peak month for juvenile presence as a proportion of the population for coots, gallinules, and stilts was May, December, and May, respectively. The phenology of nesting was seasonal for coots and stilts and year-round for gallinules (Figure 7). Coots had chicks in March through June as well as December, stilts had chicks in April through September, and gallinules had chicks every month of the year.

Nesting success.—Nineteen stilt nests were monitored with cameras by UH Manoa and 68% of nests were successful. One nest was depredated by an unknown predator, 3 flooded, 1 abandoned, 13 hatched, 1 had an unknown fatality (Appendix 1).

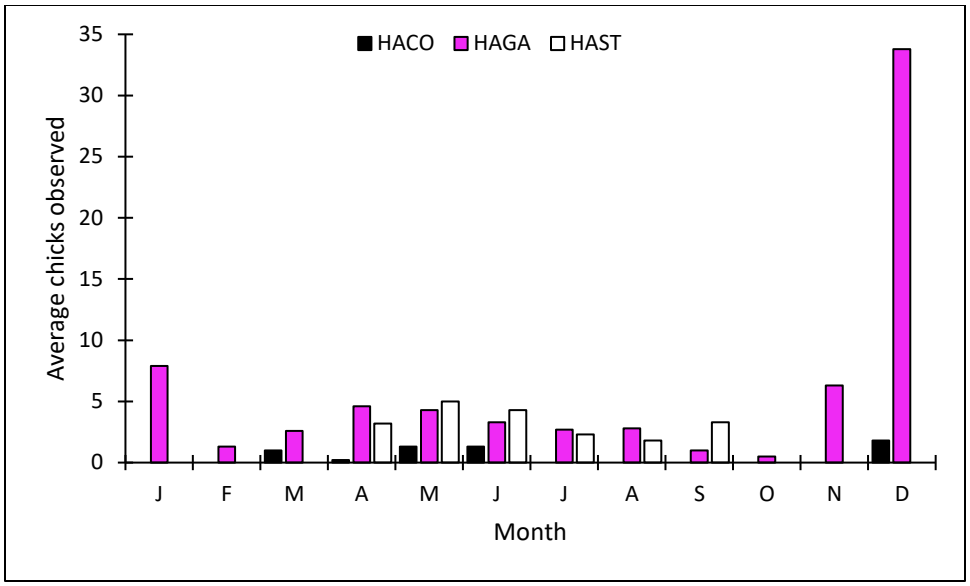

Figure 6. Average number of coot, gallinule, and stilt chicks observed at Hamakua Marsh Wildlife Sanctuary by month in 2019.

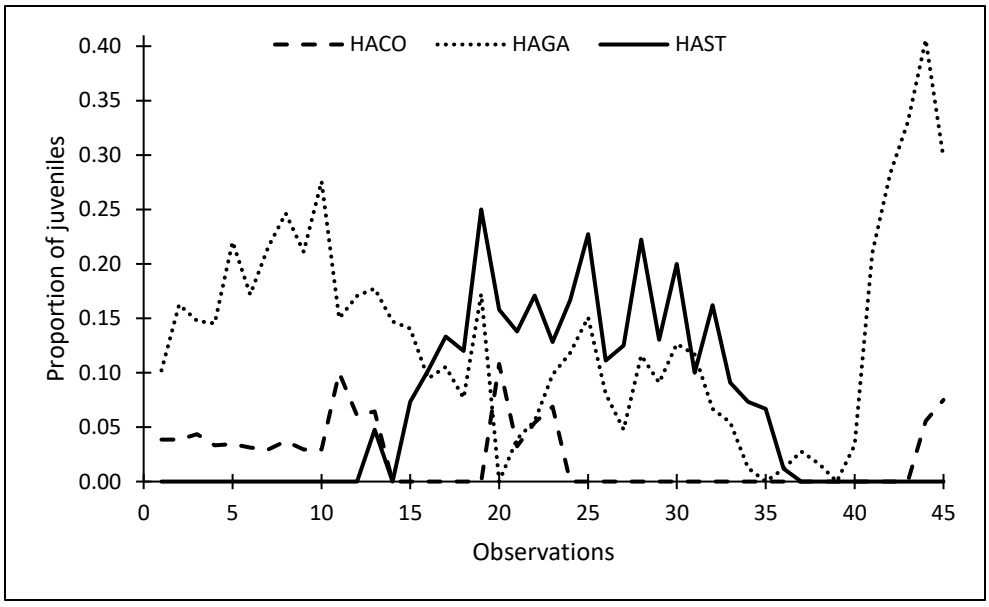

Figure 7. Proportion of coot, gallinule, and stilt juveniles observed in the population at Hamakua Marsh Wildlife Sanctuary in 2019.

Fledging success.—Nesting success in Hamakua Marsh State Wildlife Sanctuary from 2007 to 2019 ranged from 50–82%, 44–97%, and 8–87% for coots, gallinules, and stilts, respectively. For 2019 coots, gallinules, and stilts had an overall fledging success rate of 23%, 61%, and 74%, respectively (Table 1). Fledging success in 2019 for coots and gallinules was below average (58% and 75%, respectively), but above average for stilts (62%). Coot fledging success was below average, and coot fledging abundance was 3 which is below the average of 5 fledglings. Gallinule fledging success was below average, fledging abundance was 60 which is above the

average of 40 fledglings. Stilt fledging success was above average, fledging abundance was 20 stilts which is above the average of 12 fledglings.

Table 1. The number of observed chicks, fledglings, and percent fledging success for coots (HACO), gallinules (HAGA), and stilts (HAST) in 2007 through 2019 in Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

	HACO			HAGA			HAST		
Year	# chicks	# fledglings	% success	# chicks	# fledglings	% success	# chicks	# fledglings	% success
2007	2	1	50%	41	30	73%	16	13	81%
2008	—	—	—	33	24	73%	13	1	8%
2009	3	2	67%	47	40	85%	38	29	76%
2010	11	9	82%	56	49	88%	9	6	67%
2011	14	9	64%	28	25	89%	4	2	50%
2012	—	—	—	31	24	77%	5	4	80%
2013	6	3	50%	43	25	58%	15	13	87%
2014	8	6	75%	95	77	81%	34	7	21%
2015	12	8	67%	62	42	68%	10	7	70%
2016	—	—	—	43	36	84%	42	32	76%
2017	11	6	55%	67	65	97%	12	9	75%
2018	13	7	54%	36	16	44%	16	7	44%
2019	13	3	23%	98	60	61%	27	20	74%
Total	**93**	**54**	**58%**	**680**	**513**	**75%**	**241**	**150**	**62%**

Nests were observed on occasion when conducting routine waterbird surveys. Broods of endangered waterbirds were mapped and followed until fledging numbers could be calculated. Brood distribution of coots, gallinules, and stilts in Hamakua Marsh spanned the length of the marsh (Table 2) with 5, 27, and 14 coot, gallinule, and stilt broods, respectively.

Table 2. The number of observed broods of coots (HACO), gallinules (HAGA), and stilts (HAST) for Basins A, B, C, and D in 2019 in Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

	Basin A	Basin B	Basin C	Basin D	Total
HACO	2	1	2	0	**5**
HAGA	11	7	5	4	**27**
HAST	2	9	2	1	**14**
Total	**15**	**17**	**9**	**5**	**46**

Predator control.—Predator control in Hamakua Marsh State Wildlife Sanctuary in 2019 consisted of 124 mongooses, 8 black rats, and 11 cats. Cats were not recorded throughout the year when trapped and euthanized due to USDA-WS restrictions on cat euthanasia (Table 3). From 2007–2019, an average of 127 mongooses were trapped and euthanized per year. In 2019, 124 mongooses were trapped with peak trapping in February, July, and November (Figure 8). The USDA-WS does not include trapping effort in their reports.

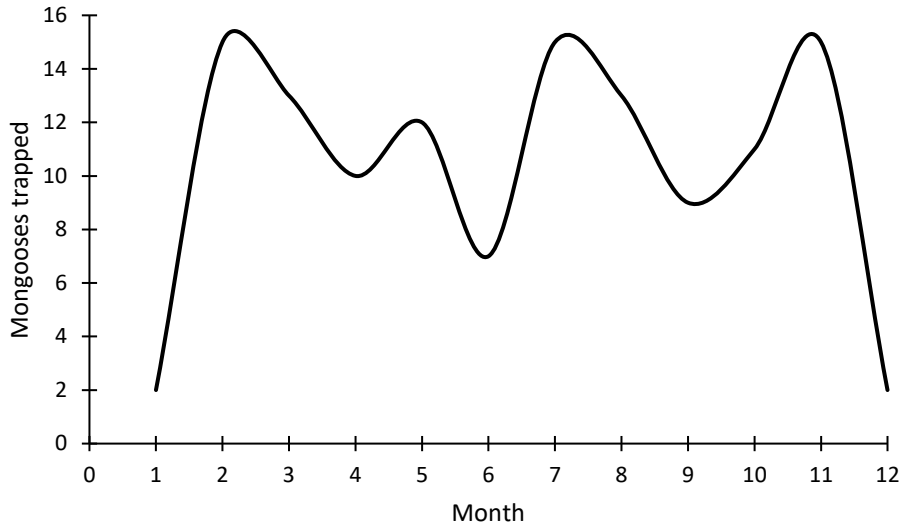

Figure 8. The number of mongoose trapped by month at Hamakua Marsh Wildlife Sanctuary in 2019.

Table 3. Predator control numbers from 2007–2019 at Hamakua Marsh Wildlife Sanctuary, Kailua, Oahu, Hawaii.

Year	Mongooses	Cats	Rats	Dogs	Chickens	Ducks	Pig
2007	24	7	0	0	0	0	0
2008	94	10	7	0	71	68	0
2009	206	22	72	0	17	19	1
2010	139	11	131	0	39	13	0
2011	123	15	156	0	44	4	0
2012	155	15	158	2	11	6	0
2013	163	14	214	2	4	7	0
2014	54	2	98	4	3	0	0
2015	78	9	52	0	0	0	0
2016	133	6	35	0	0	0	0
2017	195	6	34	0	0	0	0
2018	163	10	15	0	0	0	0
2019	124	11	8	0	29	0	0

Habitat manipulation.—Habitat management techniques consisted of disking in all basins in Hamakua Marsh in 2019 on three different occasions. Disking occurred in January, August and October and was the highest habitat management frequency recorded (Table 4). Usually the interior wetland area is manipulated once during the year, yet in 2019 the habitat was selectively manipulated on three separate occasions mainly avoiding stilt nesting season (March–August).

Table 4. Habitat manipulation operations and techniques used within the wetlands at Hamakua Marsh Wildlife Sanctuary, Kailua, Oahu, Hawaii from 2003–2019.

Year	Habitat manipulation
2003	Woody vegetation removed (i.e., mangrove)
2004	Woody vegetation removed (i.e., mangrove); tilling
2005	Limited tilling

2006	Tilling post-breeding 2005
2007	No tilling
2008	No tilling
2009	Increased vegetation removal; tilling post-breeding 2008
2010	Tilling post-breeding 2009
2011	No tilling
2012	Tilling post-breeding 2011
2013	No tilling
2014	Limited tilling
2015	Limited tilling
2016	No tilling
2017	Basin A was completely mowed and tilled; Basin B perimeters were tilled, interior left alone; Basin C interior was tilled leaving perimeters with buffer vegetation; Basin D was partially mowed and tilled in the interior.
2018	All Basins were mowed; Basin D tilled.
2019	Half of Basins A and B were disked in January; Half of Basin A and all of basins B, C, and D were disked in August; Half of Basin A and all of Basins B, C, and D were disked in October, but avoided disking center pickleweed islands in B and BolMar in Basin C.

Discussion

Coot abundance increased with water level increases and decreased with water level decreases. Gallinule abundance remained stable through the increase and decrease in water levels. Stilt abundance increased with decreasing water levels; opposite of coot relationship in regards to the water level. The only juxtaposition is an increase in stilt abundance after nesting season which occurred at the same time as an increase in water level. Stilt average abundance before and during nesting season was 33 and jumped to 56 after nesting season. The sudden increase in stilts may have been due to the drought conditions in Kawainui Marsh and more advantageous foraging opportunities in Hamakua Marsh as rainfall in October halted the drought conditions in Hamakua Marsh. The average water level in Basin A moved from 0 to 20.3 inches in September and October, respectively. The dry period began in May 2019 with water levels slowly decreasing until October 2019. The hydrologic drawdown coupled with punctuated flooding likely initiated an increase in invertebrate abundance, likely providing foraging habitat for stilts.

Gallinules are the most abundant waterbird in all the basins; stilts are the second most abundant; and coots are the least abundant waterbird in Hamakua. Habitat availability may explain the differences in the mean abundances of coots, gallinules, and stilts. Although microhabitat area was not measured, mudflat/vegetation is the most dominate habitat type available within the marsh and gallinules prefer the mudflat/vegetation habitat type.

Coots prefer habitats that provide deeper water although 21.7% of observations identified coots moving or foraging on mudflat/vegetation. The stream and ponds >6” offer the best microhabitats for coots. The stream, >6” deep water ponds, and mudflat/vegetation explained 78.1% of coot observations. Gallinules prefer microhabitats that provide cover or easy escape from potential predators, like the stream bank, which provides quick access to protection in the stream. Mudflat/vegetation, stream bank, and stream accounted for 81.9% of gallinule observations. Stilts prefer open areas in mudflat/vegetation and shallow bodies of water 0–3” deep. Stilts and gallinules were predominately found in mudflat/vegetation, but gallinules are often seen hiding in the vegetation, whereas stilts are found in the vegetation but on the fringes

of open shallow water ponds. Mudflat/vegetation, 0–3” water, and mudflat explained 88.3% of stilt observations.

The density of coots, gallinules, and stilts were greatest in Basin C. Further analyzing habitat and invertebrate availability in each basin may elucidate the reason Basin C supports the greatest density of coots, gallinules, and stilts. Basin C offers the greatest diversity in microhabitat type with deep water and a 100% more diverse vegetation structure with *Batis maritima* and *Bolboschoenus maritimus* dominating the area; Basins A, B, and D largely consist of only *B. maritima*. Managing Basins A, B, and D to replicate C may enhance waterbird density. Although, Basin C had the second least observed coot, gallinule, and stilt broods throughout the year meaning Basin C may provide great foraging habitat, but less than optimal nesting habitat compared to Basins A and B.

Optimizing foraging and nesting habitat for waterbirds can be diametrically opposed, as improving foraging habitat may decrease nesting habitat. Gallinule nests (6) have been found in pickleweed (*B. maritima*) that had not been mechanically manipulated in 2019. Those six nests were found in pickleweed that was on average 45.5 cm above the water line. When planning habitat management for waterbirds in wetlands those manipulations for optimizing foraging may include disking and tilling, but for areas that nesting is encouraged pickleweed needs manipulation no more than once annually. Foraging for coots, gallinules, and stilts takes place in more open habitat especially for stilts and coots and to optimize foraging habitat vegetation manipulations are recommended. During habitat manipulations plant leaves are severed and decompose providing detritus for food and structure for microorganisms which provide food for macroinvertebrates, thus increasing invertebrate forage for waterbirds (Kaminski and Prince, 1981). In another study, it was posited that aquatic invertebrate mass and diversity was greatest in habitats that offered more detrital matter (Gray et al., 1999). Manipulations of vegetation may increase macroinvertebrate availability, but certainly increase accessibility to invertebrate prey when vegetation is thick (Gawlik, 2002; Chastant and Gawlik, 2018). The pickleweed in Hamakua Marsh can grow densely when not mechanically manipulated potentially prohibiting waterbirds from accessing prey.

In 2020, the goal will be to document key predators in the nesting and pre-fledging phases of coots, gallinules, and stilts. To elucidate key predators in nests of coots, gallinules, and stilts, camera traps will be setup to capture predators occupying nest sites and their behaviors. To understand the impact potential predators may impose on waterbird chicks before fledging, radio transmitters will be attached to day old chicks and followed daily to track their fate. Predation will be determined through forensic evidence (i.e., timing, location, footprints, bite marks, feces, etc.) surrounding the dead bird.

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Appendix 1. Hawaiian Stilt nest fates and hatching success for the 2019 nesting season in Hamakua Marsh State Wildlife Sanctuary on Oahu, Hawaii.

# of nests	Predated	Flooded	Abandoned	Hatched	Unknown
19	1	3	1	13	1