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THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

PRELIMINARY REPORT ON THE
ECOLOGY OF THE LIGHT-FOOTED CLAPPER RAIL
AT MUGU LAGOON, VENTURA COUNTY, CALIFORNIA¹

BY

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ABSTRACT

Ecology of the Light-footed Clapper Rail (*Rallus longirostris levipes*) is being studied at Mugu Lagoon, U.S. Navy Naval Missile Testing Center, Ventura County, California. Studies commenced in February 1989 and are continuing presently. Secondary study sites include Carpinteria Salt Marsh, Santa Barbara County; Tijuana Slough, San Diego County; Salton Sea, Imperial County; Upper Newport Bay and Seal Beach NWR, Orange County; California.

Twelve clapper rails were captured at Mugu Lagoon in 819 trap hours, for a success rate of 0.8 rail per 5 hour effort with 15 traps set. All rails captured were measured, weighed, banded with U.S. Fish and Wildlife Service bands and individually color banded. Ten of the 12 rails were fitted with backpack

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transmitters. Telemetry studies commenced on 28 August 1989 and are ongoing. Rails with radio units were tracked at 3-5 day intervals, at which time location, activity, habitat utilization, and territory characteristics were noted. Nearly 700 location points have been collected for the radioed rails in 60 days of tracking.

Eight active nest sites, of 6 breeding pairs, were found. Seventy-one eggs were produced from active nest sites, for a mean clutch size of 8.9 ± 1.6 (SD). Two nests failed, whereas 6 of the 8 (75%) active nests were successful. The mean number of eggs pipped per successful nest was 5.2 ± 2.32 . Pipping success was 44% for eggs in active nests. Two "dump" eggs were located in old rail nests.

Cracked, dimpled, and crushed eggs were found in six of the active nests. Preliminary results from contaminant analysis of addled eggs, suggest elevated levels of DDT, DDE, and PCB's. Forty-three eggshell samples were collected from addled and hatched eggs.

Nest manipulations were tried at three nest sites, after a low hatching success was observed in early clutches. Thirteen eggs were removed, of which 4 viable eggs were artificially incubated at the San Diego Zoo's Avian Propagation Center. Removed eggs were replaced with dummy eggs with no observed problems. Two eggs successfully pipped at the zoo and were returned to their respective nests along with the two other viable artificially incubated eggs. A possible three chicks hatched from the manipulated eggs.

Mortality was documented for 5 of the 10 radio telemetered rails. Raptor predation possibly accounted for three of the deaths and mammalian predation for one. The fifth recovered rail died of an undetermined trauma. Unbanded rail remains were found, of which three were possible raptor kills and one was killed by a mammal.

Relatedness and maternal lineages are being examined through blood and tissue sample analyses that show haploid, maternally inherited mitochondrial DNA. A total of 39 blood samples from four rail sub-populations were obtained from light-footed clapper rails through-out its

California range. An additional 15 blood samples were obtained from a population of Yuma Clapper Rails (R. l. yumanensis). Tissue samples were obtained from four sub-populations of light-footed clapper rail for DNA studies.

Mammalian predator trapping was conducted at Mugu Lagoon from 1 April to 14 July 1989 for a total of 1032 trap nights over a period of 55 nights. A capture rate of 0.01 predators per trap effort was obtained at Mugu Lagoon. Carpinteria Salt Marsh was trapped for 7 nights, with 8 traps per night for a trap success of 0.32 predators per trap effort. Feral cats accounted for 78% of predators trapped at Carpinteria and 42% at Mugu Lagoon. Night surveys were conducted at Mugu Lagoon using high powered lights. Feral cats were the most numerous (82%) of mammalian predators observed at the lagoon.

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Introduction

The original goals of this study were to determine the population dynamics and habitat use of Light-footed Clapper Rails (*Rallus longirostris levipes*) at Mugu Lagoon and Carpinteria Salt Marsh. Surveys conducted early in the study revealed the Carpinteria population of Clapper Rails had been extirpated, consequently this study will focus on Mugu Lagoon. Research objectives are to determine: 1) rail habitat requirements in a pickleweed (*Salicornia virginica*) dominated tidal system, 2) rail home range and territory characteristics, 3) juvenile dispersal rates, 4) relatedness and maternal lineages among individuals of the population, and 5) mortality factors.

Methods

This two year study was started in February 1989 and is entering its second year of data collection. This preliminary report covers data collected during the first year of the study.

The major study site is located at Mugu Lagoon, Naval Weapons Testing Center, Ventura Co., California. Secondary sites of data collection are Carpinteria Salt Marsh, Santa Barbara Co; Tijuana River National Estuarine Research Reserve, San Diego Co; Imperial Wildlife Area, Wister Unit, Salton Sea, Imperial Co; Seal Beach National Wildlife Refuge and Upper Newport Bay State Ecological Reserve, Orange Co., California.

Movements of Light-footed Clapper Rails are being determined with the aid of radio telemetry and marking individuals with a unique combination of color leg bands. The transmitters are carried on a backpack harnesses that is fitted with a biodegradable breakaway link that allows the transmitter to slip off the rail after approximately eight months. The transmitter unit weighs less than four percent of the bird's weight and has a minimum battery life of eight to nine months. Rails were captured using drop-door welded wire traps, mist nets, and hand-held dip nets used from kayaks during high tide. Rails with failed radios were recaptured and radios replaced for continued observations.

Tracking of transmitted rails has been conducted on foot, from vehicles on existing surface roads, and from kayaks during high tides. Movements of individual radioed and color-marked rails have been intermittently monitored from sunrise to sunset observation periods. Radioed bird locations have been determined at two to five day intervals. Locations of focal animals have been plotted on field maps (reduced 1" = 200') of the study area during the observation periods.

Habitat use of Light-footed Clapper Rails was being determined by direct observation, augmented by telemetry. Observed locations and plant species used by radioed and color-marked Clapper Rails were plotted on field maps of the study area. These location points, along with physical and vegetative components, will be transferred onto overlays for aerial photographs. Habitat data will be plotted onto separate overlays to display plant species, elevation, rail location, tidal prism parameters, and human developments.

To determine relatedness and maternal lineages of Clapper Rails at Mugu Lagoon, Seal Beach, Upper Newport Bay, Tijuana Slough, and the Salton Sea, approximately one cc of blood was drawn from the brachial vein with a needle and collected in capillary tubes. The blood samples were chilled in the field, then frozen as soon as possible. Additional tissue samples from recovered rails, along with the blood samples, have been sent to Dr. Rob Fleischer (University of North Dakota) for analysis.

Measurements and descriptive data were taken during the trapping and handling of rails, including sex, moult, and morphological characteristics of rails at all study sites following Baldwin et al. (1931; Appendix 1).

Timing of the onset of the nesting season was determined by direct observations of rails gathering nest material or copulating. Breeding season was considered to be from nest building through the last documented hatching of eggs. Nest sites were found by observing rails during incubation exchanges or by systematically searching habitat where rails were duet clapper vocalizing. Nests were visited at three to four-day intervals. Data collected during each visit included number of eggs, condition of eggs (cold, warm, cracked, crushed, pipped), egg weight (nearest 0.1 g), egg size (nearest 0.01 mm), condition of nest, and defense or presence of adults. Weighing of the eggs was done at each nest visit to determine the amount of weight loss during incubation. This information was gathered to aid in egg manipulations and artificial incubation techniques if captive breeding is proposed in the future. If an egg had a small dimple or crack, an effort was made to repair the damage by the placement of wax over the damaged area. Waxing of the damaged area reduces the amount of water loss that would occur from the exposed membrane. A nest was considered successful if it pipped one egg. This definition was used because I was not able to determine time of independence of the precocial Clapper Rail chicks.

All visited nests were guarded against mammalian predation by the placement of Tomahawk live traps baited with wet cat food. These traplines were set to minimize the possibility of predation caused by nest visits. Trapping was conducted every two to three days, depending on access into

the restricted portion of the naval base. All predatory mammals captured were removed from the naval base.

Manipulated clutches were transported to the San Diego Zoo's Avian Propagation Center in a hot water bottle-regulated portable incubator. Temperature of the portable incubator was regulated by the heat of the hot water bottles and monitored by two mercury thermometers placed near the eggs. Artificial eggs were replaced in nests to reduce the possibility of adult abandonment when half the clutch was removed. Two types of dummy eggs were constructed from plastic eggs of approximately the same dimensions and were painted a similar color as Clapper Rail eggs. The two models were constructed to determine if rails would accept a lighter than normal egg. These lighter eggs may not cause as much dimpling or cracking of the adjacent real eggs when they are placed together. Transportation from Mugu Lagoon and back was by automobile.

Addled eggs were collected and sent to laboratories to determine presence of possible contamination within the clutch. Eggshell samples were obtained from addled eggs and from hatched eggs. These eggshell samples will be measured for thickness and compared to pre-DDT era (<1947) eggs in the collection of the Western Foundation of Vertebrate Zoology.

Mortality sources of adult, juvenile, and nestling Clapper Rails were determined through necropsies and field observations of recovered rails at nest sites and with the aid of radio telemetry. Necropsies were performed by Dr. Kent Osborn of the San Diego Zoo's Pathology Department. Potential avian and mammalian predators were noted at every occurrence during observation periods.

Monthly nocturnal surveys using 1-million-candlelight-powered spotlights were conducted from vehicles and on foot to determine presence and population trends of potential mammalian and avian predators at Mugu Lagoon and Carpinteria Salt Marsh.

RESULTS

Light-footed Clapper Rail Trapping

Twelve Light-footed Clapper Rails were trapped, measured, and individually color marked at Mugu Lagoon (Table 1). Ten of the rails were fitted with backpack radio transmitters. Rail trapping was concentrated from 25 August to 25 October 1989, during which time 15 trapping efforts were conducted, with an average of 15 drop-door traps set per effort. Twelve rails were

captured in 819 trap hours, for an average effort of 68 hours per rail captured. Trapping success was 0.8 rails per 5 hours effort with 15 traps set. The two main rail activity periods (sunrise and sunset) and all tide conditions were trapped evenly. Trapping was successful in all tide levels and at either sunrise or sunset. Success was enhanced by placing the traps near the rail's preferred cover (Atriplex sp. or Juncus sp.). Capturing rails with dip nets from kayaks during high tides was not attempted because rail habitat was not sufficiently inundated to allow use of this method at Mugu Lagoon.

Movements

Radio telemetered and color-banded rails were monitored with the first capture on 27 August 1989, and have continued through the present. Of the 10 telemetered rails, only 4 are currently being tracked. Five rails have died and another slipped free of its radio harness but continues to be observed on a regular basis. There have been approximately 700 location points collected during 60 days of tracking. No rails have left Mugu Lagoon and they are generally staying within 200 m of their capture points. Juveniles have shown a greater tendency to roam during the fall/winter period than the adults. Diurnal roost sites have been mainly in dense saltbush (Atriplex watsonii) and spiny rush (Juncus acutus), with Salicornia used for foraging during crepuscular periods. Detailed analyses of location data, habitat utilization, and movements will be conducted at the end of the two year study.

Nesting

Nesting behavior (carrying nesting materials) was first observed on 20 March 1989. After this first sign, observations of copulations, gathering of nest material, and interspecific territory defense were noted during the breeding season (20 March-27 June). Nest searches began on 18 April and continued to the end of June. Eight active nests, belonging to six breeding pairs, were located over the breeding season; renesting (1 replacement and 1 second clutch) attempts accounted for two of these nests. Nests were in a variety of elevations and vegetation types. Tall pickleweed is the dominant plant species chosen by nesting clapper rails at Mugu Lagoon. Other plant species chosen for nest sites included saltbush and spiny rush. One nest was in a duck blind wall, which was surrounded by dense cordgrass (Spartina foliosa).

The total number of Light-footed Clapper Rail eggs documented at Mugu lagoon was 73. The mean clutch size of the 8 active nests was 8.9 ± 1.64 (SD; range = 7-11). The average clutch size of initial nesting attempts was $8.3 \pm$

1.50 (range = 7-10, n = 6) and 10.5 ± 0.70 (range = 10-11, n = 2) for renesting attempts. Two "dump" eggs were located in old rail nests and were not used to calculate the average clutch size.

Six of the eight (75%) active nests were successful. Nest failure was documented at two (25%) nests. Both of these failures were the rails' first nesting attempt. The average number of eggs pipped per successful nest was 5.2 ± 2.32 (range = 3-8, n = 6). A total of 31 (56%) eggs possibly pipped from the 55 eggs laid in the 6 successful nests (Appendix 2 - 9). If total nest failure eggs are included, the pipping success drops to 44%. These pipping figures are giving eight eggs the benefit of the doubt that they pipped due to not finding them addled in the nest after the brood had fledged. One pierced addled egg was found at the E "M" Avenue nest, 3 m from the nest. This egg was probably removed from the nest by the attending adults, because the size of the pierced hole was equal to the diameter of a rail's beak. A second addled egg was 8 m from the SE "M" Avenue nest. This egg was bloated from being in water and there was no sign of the egg being pierced. Both addled eggs were found after the adults and chicks were gone from the incubation nest. Another problem with giving pipped eggs a successful rating is that adults might remove the dead chicks as well as eggs. I found two dead hour-old chicks in a nest with unpipped eggs and a live chick. With this in mind, the successful hatch rate of Light-footed Clapper Rail eggs at Mugu Lagoon is most likely to be lower than 44%.

Problems with the eggs were documented early in the incubation period at six nesting sites (G1, G2, SE "M" Ave., E "M" Ave., "L" Ave., Blind 43). Eggshells at G1, E "M" Ave., "L" Ave., and Blind 43 showed signs (dimpling, cracks, or crushing) of being abnormally thin. Three of the less damaged eggs were coated with wax in areas of damage to repair cracks or dimples. The G2 nest with 11 eggs only pipped 2; the remaining 9 eggs had loose air cells. The SE "M" Ave. nest produced round eggs and one egg's air cell was in the small end of the egg (normal position for the air cell is at the large end of the egg). Twenty-three addled eggs were collected from the six problem nests for contaminant analysis. Patuxent Wildlife Research Center received eight of the samples and the Joseph M. Long Marine Laboratory in Santa Cruz received 15. Preliminary results from the Long Marine Laboratory samples showed elevated levels of organochlorine pesticides (DDT and DDE) and polychlorinated biphenyls ("PCB's"). These contaminant levels are said to be in the area of reproductive failure for Peregrine Falcons (Falco peregrinus) and brown pelican (Pelecanus occidentalis) (Wally Jarman, pers. comm.). More details on contaminant levels from both labs are expected soon.

Forty-one eggshell samples collected from addled eggs and at fledged nest sites are currently being measured for thickness. These results will be

compared to thicknesses of pre-DDT era eggs, to determine degree of thinning perhaps related to organochlorine contamination. Measurements of length and width in Mugu rail eggs will also be compared to historical eggs collected at the Western Foundation of Vertebrate Zoology.

Nest Manipulations

On 13 June, after determining the low rate of hatching success, 13 eggs were removed from 3 clutches (G2, SE "M" Ave., 17th St.) and transported to the San Diego Zoo's Avian Propagation Center. Two nests had empty (light) replacement eggs and the other water-filled dummies (heavy). The dummies were accepted at all three nests, with no signs of rejection. The removal and transporting of the 13 eggs took 5 hours and 9 minutes, during which time the eggs were artificially incubated in a portable incubator maintained at a temperature of $36.3 - 36.6^{\circ}\text{C}$. The eggs were candled on arrival at the zoo and the five viable eggs placed in a Lyons forced air incubator. The four viable eggs were weighted and candled at the zoo on 15 and 18 June (Appendix 5 & 9). On 18 June, 2 eggs from the SE "M" Avenue nest pipped. All four eggs were returned to their respective nests that afternoon. The return transport time was 4 hours and 17 minutes, with the artificial incubation transport case kept at $36.3 - 36.6^{\circ}\text{C}$.

A summary of manipulations at individual nests is presented below.

G2 nest: Five eggs were removed from the clutch of 11. No eggs were placed in the incubator because each had large floating aircells and degenerating vitelline membranes (pers. comm., Jackie Good, Senior Keeper). Upon opening these eggs, they were determined to be old eggs in an advanced state of degeneration.

17th Street nest: Five eggs were removed from the clutch of 10, of which 2 were initially placed in the incubator. One of the set (incubated) eggs was removed on 15 June due to an indistinct yolk, later determined to be degenerating vitelline membrane. The three eggs not set were all addled with ruptured vitelline membranes. Incubation of the one viable egg from this clutch was half way through development and appeared normal. On 18 June, the one viable artificially incubated egg was returned to the 17th Street clutch. The nest was checked on the 21 June. The egg had lost 0.3 g in weight and appeared to be developing normally. On 24 June, the egg had four star pips, and the chick was heard vigorously squeaking and chirping. On 27 June, the adults and chicks were nearby the nest vocalizing to each other. Only eggshell fragments and dummy eggs remained in the nest that day.

SE "M" Avenue nest: Three eggs were removed from the clutch of seven. All three eggs were set and the embryos were approximately one-half to two-thirds developed. In one of the three eggs, the aircell was at the small end of the egg, but was developing normally. The 3 eggs replaced back in the SE "M" clutch of 7 were checked on the 21 June, 3 days after replacement. At that time, two dead hour-old chicks were in the bottom of the nest along with a third live chick, and one egg was missing (#1, #3, or one of the 2 pipped transported eggs). The egg that had the air cell in the small end of the egg had a 8 x 10 mm dimple in the large end and showed signs of dehydration. Of the two remaining eggs, one was pipped and the other was not. The dead chicks were collected and necropsies performed by Dr. Kent Osborn. Death in one female chick was determined to be hatching death associated with lung hyperemia, consolidation, and possible pneumonia. Necropsy of the other chick, a male, revealed hatching death associated with umbilicus defect (Incomplete seal), and lung hyperemia. On 24 June, the SE "M" nest, contained 1 unknown addled egg 8 m from the nest. There were no signs of adults, chicks, or whole eggs in the nest. Eggshell fragments were collected along with the unknown egg (possibly egg #4, due to not being pipped on the 21 June).

Of 3 eggs returned to the SE "M" Avenue nest, of which 2 pipped at the zoo, it is difficult to determine if any fledged. There were two dead chicks along with one live chick found in the nest. There was also one egg missing that same day. The two pipped eggs may have hatched, both died, one removed and one lived, one removed and one died, or one dead and one lived. The egg with the air cell in the small end was found that same day with a large dimple. The next nest check revealed an egg 8 m from the nest. The egg that was found was bloated and in poor shape, so it was impossible to determine which egg it was.

In summary, 13 eggs were removed from 3 clutches, of which 4 viable eggs were artificially incubated at San Diego Zoo. Two of the 4 eggs pipped at the zoo, then all 4 were returned to their respective nests that afternoon. With follow-up nest checks it was determined that the lone egg returned to the 17th Street nest pipped and fledged. It is difficult to determine if any of the transported eggs returned to the SE "M" Avenue nest fledged. Optimistically three of the four viable eggs may have fledged.

Mortality

Mortality was documented for 5 of the 10 radio telemetered rails. A summary of these deaths follows.

Remains of rail #498, an adult female from the West "M" Avenue area, were recovered, on 14 September 1989. This female had been radio telemetered for 18 days and showed no signs of problems. Her remains were located on top of a berm, approximately 50 m north of her documented home range. The carcass was well consumed, with no severed tendons or feathers. There were fresh avian feces on top of the plucked feather pile. The cause of death was probably predation by a raptor.

The remains of rail #500, an adult female from the South "L" Avenue area, were found on 15 November 1989. The radio transmitter was placed on this bird 47 days prior to its death. This rail was active the morning of its death and no signs of problems were observed up to that day. Three Short-eared Owls (*Asio flammeus*) were flushed from the remains in a dense clump of spiked rush. The radio transmitter antenna wire was stripped of its protective coating and curled like a piece of ribbon drawn through a pair of scissors (an indication of a raptor's beak). The breast bone of the rail was well notched, also supporting a raptor predation. None of the feathers and bones collected were sheared or cut, as would be typically done by a mammalian predator.

The remains of rail #640, a juvenile male from the South "M" Avenue area, were recovered on 22 November 1989. This rail had been radio telemetered for 35 days and showed no signs of any problems. The remains were found in pickleweed 25 m southeast of a small building. The remains were approximately 75 m north of the rail's home range and looked to be a few days old. Again, the remains showed no signs of being severed or bitten, but associated sign (curled antenna) indicated predation by a raptor.

Rail #610 was located on 15 January 1990 under a clump of spiked rush in the "G" Street area, where the rail was regularly observed. This juvenile male was captured on 7 September 1989 and had been carrying its transmitter for 130 days. No abnormal behavior or signs were observed during its transmittered period. No obvious signs of predation were detected. The carcass was placed on ice and transported to the San Diego Zoo's Pathology Department the next morning. The necropsy results showed a pulmonary hemorrhage and a mild hemorrhage on the right thigh caused by a probable trauma. Cause of the probable trauma is undetermined. The rail had not eaten prior to its death and had a low to moderate amount of subcutaneous fat.

Remains of rail #614, a juvenile female, were located on 29 January 1990. This rail had been recaptured twice to replace faulty transmitters and during both handlings the rail appeared vigorous and healthy. She was first captured on 4 October 1989, in the area of South "L" Avenue. This rail

carried a transmitter for 117 days before her death. The cause of mortality was most likely a mammalian predator. Scattered feathers and a section of the rail's severed bill were at the base of a steep berm. The radio transmitter and a severed portion of a wing were discovered 30 m away on a low mound. Numerous cut feathers were found with the section of mandible.

The remains of four unmarked Clapper Rails were recovered during fall and winter. Three of the remains were piles of feathers similar to the telemetered rails presumed killed by raptors. The weathered (old and dried) remains of one rail included severed primaries typical of a mammalian predator. All four unbanded rail remains and the five telemetered rail remains will be deposited in the collection of the Western Foundation of Vertebrate Zoology (Los Angeles, California).

In summary, five telemetered rails were recovered, of which three were probable raptor kills, one was killed by a mammal, and the cause of death of one is undetermined. Four unbanded Clapper Rail remains were found; three appeared to be killed by raptors and one by a mammal.

Relatedness and Maternal Lineages

Blood and tissue samples were collected from four sub-populations of Light-footed Clapper Rails and from a population of Yuma Clapper Rails (*Rallus longirostris yumanensis*), to examine haploid, maternally inherited mitochondrial DNA. Blood samples were collected from 10 Light-footed Clapper Rails at Mugu Lagoon. An additional 44 samples were collected from Clapper Rail populations at Seal Beach National Wildlife Refuge (n = 10), Upper Newport Bay State Ecological Reserve (n = 9), Tijuana River National Estuarine Research Reserve (n = 10) and the Salton Sea-Imperial Wildlife Area, Wister Unit (Yuma clapper rails, n = 15). These blood samples, along with one tissue sample from a recovered dead rail at Newport Bay, have been sent to Dr. Rob Fleischer's laboratory at the University of North Dakota. Three addition tissue samples (Mugu, Seal, Tijuana) have been obtained and are waiting to be shipped to the lab. Analyses are schedules to be performed in the summer/fall of 1990.

Predator Trapping and Surveys

Placement of mammalian predator live traps at Mugu Lagoon commenced on 1 April and continued until 14 July 1989. The total of trap nights was 1032, during the 55 nights of trapping. The mean number of traps set per trap night was 19 (range = 5 - 24). The number of predators captured per trap effort was low, at 0.01. The number of non-predators (California ground

squirrel, Citellus beecheyi) captured per trap effort was 0.12. The following numbers of animals were removed from Mugu Lagoon: 1 (8%) longtailed weasel (Mustela frenata), 5 (42%) domestic cats (Felis domesticus), 5 (42%) opossum (Didelphis marsupialis), and 1 (8%) domestic dog (Canis domesticus). The ground squirrels that were trapped were released at their point of capture.

Predator trapping at Carpinteria Salt Marsh was done from 5 July to 19 July 1989, for 7 nights, to develop an impression of the number of mammals using the marsh. The total number of trap nights was 56, with 8 traps set per night. The number of predators detected at Carpinteria was greater than Mugu Lagoon. Carpinteria had 0.32 predators captured per trap effort as compared to 0.01 at Mugu. There were 14 (78%) feral cats and 4 (22%) opossum removed from Carpinteria over the 7 nights of trapping.

Monthly predator night surveys were conducted at Mugu Lagoon starting in June 1989 and are continuing (Table 2). The month of December was missed due to conflicting schedules of survey members. Feral cats were the most numerous (82%) mammalian predator observed during the surveys. It is interesting to note that no red fox (Vulpes fulva) were observed at Mugu during the surveys, as there was a population present in the late 1970's and early 1980's (Matt Klope, pers. comm.). Coyote are regularly observed at Mugu Naval Base by night patrolman and I have heard them, but none were observed on the surveys.

Night surveys were conducted at Carpinteria Salt Marsh during June and July. The Carpinteria surveys were discontinued because a poor estimate of animal numbers was obtained; observers walking the perimeter of the marsh, gave the animals time to hide or leave the area, thus making observations with the spotlights impossible.

LITERATURE CITED

Baldwin, S. P., H. C. Oberholser, and L. G. Worley. 1931. Measurements of Birds. Vol. II. Cleveland Museum of Natural History.

Table 1. Age, sex, identification bands, transmitter frequencies, and status of light-footed clapper rails captured at Mugu Lagoon, Ventura Co., California, 1989.

DATE OF CAPTURE	BIRD # USFWS BAND	AGE	SEX	COLORED LEG BAND		RADIO FREQUENCY(MHz)	STATUS
				RIGHT LEG	LEFT LEG		
08/26/89	825-39497	JUV	F	WHITE/WHITE UPPER	WHITE	164.123	ALIVE
08/27/89	825-39498	AD	F	RED/WHITE UPPER	RED	164.562	DEAD
08/29/89	825-39499	AD	M	WHITE/WHITE UPPER	RED	164.047	ALIVE
08/29/89	825-39500	AD	F	RED/RED UPPER	WHITE	164.539	DEAD
09/07/89	825-39610	JUV	M	BLACK/WHITE UPPER	BLACK	164.297	DEAD
09/07/89	825-39609	AD	M	BLACK/RED UPPER	WHITE	164.253	ALIVE
10/04/89	825-39613	JUV	M	GREEN/WHITE UPPER	----	164.199	ALIVE
10/04/89	825-39614	JUV	F	BLACK/WHITE UPPER	----	164.440	DEAD
10/04/89	825-39615	AD	F	RED/WHITE UPPER	RED	NONE	UNKNOWN
10/17/89	825-39639	JUV	M	WHITE/WHITE UPPER	----	164.273	ALIVE
10/18/89	825-39640	JUV	M	RED/WHITE UPPER	----	164.476	DEAD
10/25/89	825-39641	AD	F	WHITE UPPER	RED	NONE	ALIVE

Table 2. Results of night surveys conducted at Mugu Lagoon, Ventura Co., California, June 1989 -January 1990.

Species	Numbers observed during:						
	June	July	August	September	October	November	January
Coyote (<u>Canis latrans</u>)	0	0	0	0	0	0	0
Red fox (<u>Vulpes fulva</u>)	0	0	0	0	0	0	0
Virginia opossum (<u>Didelphis marsupialis</u>)	0	0	1	1	0	1	1
Feral cat (<u>Felis domestica</u>)	1	2	4	0	4	3	4
Great-horned owl (<u>Bubo virginianus</u>)	0	0	0	2	0	0	1
Common barn-owl (<u>Tyto alba</u>)	0	0	0	1	1	0	0
Burrowing owl (<u>Athene cunicularia</u>)	0	0	0	1	1	0	0
Short-eared owl (<u>Asio Flammeus</u>)	0	0	0	0	0	0	1
Small rabbits (<u>Sylvilagus spp.</u>)	58	24	44	17	26	15	38
Black-tailed jack rabbit (<u>Lepus californicus</u>)	4	3	4	3	4	2	4

Appendix 1. Trapping form used in taking measurements of light-footed clapper rails during the 1989 trapping season.

LIGHT-FOOTED CLAPPER RAIL TRAPPING DATA FORM

DATE:_____ TIME:_____ BIRD #:_____
LOCATION:_____ AGE:_____ SEX:_____
TRAPPER(S):_____

RIGHT LEG:_____
LEFT LEG:_____

WEIGHT:_____

EXPOSED CULMEN:_____
LENGTH OF BILL FROM GAPE:_____
HEIGHT OF BILL AT NOSTRILS:_____
WIDTH OF BILL AT NOSTRILS:_____
INTERORBITAL WIDTH OF HEAD:_____

RIGHT MIDDLE TOE:_____
HIND TOE:_____
RIGHT MIDDLE TARSUS WIDTH/LATERAL:_____
RIGHT TARSOMETATARSUS:_____

RIGHT WING CHORD, CURVED/FLAT:_____
LENGTH OF #7 PRIMARY:_____
LENGTH OF #1 SECONDARY:_____
LENGTH OF OUTER RIGHT TAIL:_____
BODY/COVERTS, AMOUNT OF MOULT:_____

TRANSMITTER FREQUENCY:_____
BLOOD TAKEN:_____

Appendix 2. Light-footed clapper rail egg weights (g) at Blind 43 nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number								
	1	2	3	4	5	6	7	8	9
04/22/89 ^a									
04/23/89	21.8	22.8	22.6	22.7	22.8	22.6	22.3	21.8	23.3
04/29/89	21.1	22.0	21.6	21.9	20.9	22.0	21.3	21.0	22.7
05/03/89	20.7	21.5	21.1	21.4	19.4 ^b	21.5	21.1	20.7	22.5
05/06/89	20.5	21.2	20.5	21.2	18.6	21.2	20.8	20.6	22.5
05/10/89	20.0	20.7	19.4 ^c	20.9	17.9 ^c	20.7	20.3	20.1	21.9
05/13/89	19.7	20.2	-- ^d	20.5	17.2	20.3	19.9	19.8	21.7
05/16/89	19.6	20.1	--	20.5	16.5	20.2	19.8	19.7	21.6
05/20/89	19.3	19.5	--	20.0	15.1	19.7	19.2	19.3	21.2
05/22/89 ^e	19.2	19.3	--	19.9	14.6	19.6	19.0	19.1	21.0

^a Nest located, no measurements taken.

^b Egg #5 dimpled, 5 x 5 mm

^c Egg #3 crushed, 11.18 x 11.28 mm in center of the egg. Eggs #3 & 5 waxed.

^d Egg #3 presumed crushed and removed by adults. Eggshell fragments collected

^e All 8 eggs collected after 31 days of incubation.

Appendix 3. Light-footed clapper rail egg weights (g) at W "M" Avenue nest, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number						
	1	2	3	4	5	6	7
04/18/89 ^a							
04/23/89	22.6	21.4	21.8 ^b	21.8	21.5	21.2	20.9
04/25/89 ^c							
04/29/89 ^d							

^a Nest located, no measurements taken.

^b Egg #3 was the only egg not pipped. Egg #3 presumed hatched.

^c Female brooding, no measurements taken.

^d Eggshell fragments collected.

Appendix 4. Light-footed clapper rail egg weights (g) at E "M" Avenue nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number									
	1	2	3	4	5	6	7	8	9	10
04/24/89	23.2	22.1	22.0	23.0	23.8	22.0	22.2	23.0	23.0	21.3
04/29/89	22.5	21.6 ^a	21.6	22.5	23.4	21.5	21.7	22.6	22.4	20.8
04/30/89	22.3	21.2 ^b	21.5	22.4	23.2	21.5	21.6	22.6	22.3	20.7
05/03/89	21.4 ^c	20.8	21.2	22.2	-- ^c	21.2	21.3	22.3	22.0	18.9 ^c
05/06/89	20.2 ^d	20.3	20.8	22.0	--	20.9	20.9	21.9	21.7	--
05/09/89	-- ^e	19.8 ^e	20.4 ^e	20.3	--	20.3 ^e	20.6	21.3 ^e	21.2 ^e	--
05/13/89 ^f										

^a Egg #2 dimpled, 0.7 x 0.7 mm.

^b Egg #2 waxed, 0.1g of wax applied.

^c Egg #1 dimpled, 13 x 13 mm, Egg #10 had a large dent with fluid loss-egg removed. Egg #5 was missing from the nest.

^d Egg #1 dimple grows to 12.54 x 10.82 mm.

^e Eggs #2,3,6,8,9 pipped. Egg #1 missing.

^f Egg #4 addled in the nest. Egg #7 pierced and 3 m from nest.

Appendix 5. Light-footed clapper rail egg weights (g) at 17th Avenue nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number									
	1	2	3	4	5	6	7	8	9	10
06/05/89 ^a										
06/06/89	22.0	22.9	22.1	20.8	22.0	21.3	22.2	22.5	22.5	21.8
06/10/89	21.5	22.3	21.5	20.2	21.5	20.8	21.7	22.0	22.2	21.3
06/13/89	^b	---	^b	19.95 ^b	^b	---	---	---	21.90 ^b	---
06/15/89		---		19.85		---	---	---	^c	---
06/17/89		21.7		---		20.0	21.1	21.3		20.6
06/18/89		---		19.7 ^d		---	---	---		---
06/21/89		---		19.4		19.6	20.7	21.0		20.1
06/23/89		20.9		19.0 ^e		19.3	20.6 ^e	20.6 ^e		20.0
06/24/89		^f		^f		^f	^f	^f		^f
06/27/89 ^g										

^a Nest located. no measurements taken.

^b Eggs * 1,3,4,5,9. manipulated. Eggs *4 & 9 viable. weights taken at San Diego Zoo.

^c Egg *9 removed from incubator, no development.

^d Egg *4 weight taken at San Diego Zoo. Egg *4 placed back into nest.

^e Eggs * 4,7,8, pipped.

^f Eggs * 2,4, 6,7,8,10, well pipped.

^g Eggshell fragments collected. Adults and chicks vocal in nest area.

Appendix 6. Light-footed clapper rail egg weights (g) at G1 nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number						
	1	2	3	4	5	6	7
04/29/89	23.1	21.9	23.1	22.7	22.8	20.9	23.2
05/03/89	22.2	21.0	22.3	21.9	22.0	20.5	22.5
05/06/89	-- ^a	20.8 ^a	22.2	22.1	21.7	20.3	22.5
05/07/89	--	19.5 ^b	22.2	22.0	-- ^b	20.3	22.3
05/10/89 ^c	--	--	22.0	21.6 ^c	--	20.0	22.3

^a Egg #1 missing. Egg #2 has 12 x 14 mm crushed area.

^b Egg #2 collected, crushed area increases in size. Egg #5 missing.

^c Nest checked at 0809 all eggs cold, no sign of adults. Egg #4 pipped. Check the nest at 1658, eggs cold, no sign of adults, all 4 eggs collected.

Appendix 7. Light-footed clapper rail egg weights (g) at G2 nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number										
	1	2	3	4	5	6	7	8	9	10	11
06/05/89 ^a											
06/06/89	23.4	22.8	22.1	23.0	21.7	23.5	22.4	23.4	23.1	23.7	23.3
06/10/89	22.6	22.1	21.6	22.7	21.3	22.9	22.0	22.7	22.7	23.1	22.7
06/13/89	---	^b	---	^b	^b	---	---	^b	^b	---	---
06/17/89	21.4		20.5 ^c			21.8 ^c	20.8 ^c			^c	21.4
06/21/89	20.8										21.0 ^d
06/23/89	20.6 ^e										
06/24/89 ^f											
06/27/89 ^g											

^a Nest located, no measurements taken.

^b Eggs # 2, 4, 5, 8, 9 manipulated. All 5 eggs had loose air cells. No weights taken.

^c Eggs # 3, 6, 7 collected after candling-loose air cells. Egg # 10 missing and presumed crushed. Eggshell fragments collected.

^d Egg # 11 pipped.

^e Egg # 1 pipped.

^f Adult brooding 2 chicks in nest. Eggshell fragments collected.

^g Eggshell fragments collected. No sign of adults or chicks.

Appendix 8. Light-footed clapper rail egg weights (g) at L Avenue nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number									
	1	2	3	4	5	6	7	8	9	10
04/25/89	21.1	22.2	23.8	23.6	24.0	23.4	21.8	21.3	22.7	24.5
04/29/89	21.5	21.5	22.9	22.9	23.4	22.6	21.2	20.7	22.1	23.7
05/03/89	20.9	20.8	22.1	21.7	22.7	21.9	20.8	19.9	21.4	23.0
05/06/89	20.7	20.7	21.9	21.7	22.5	21.7	20.6	19.7	21.2	22.8
05/10/89	20.3	20.2	21.4	21.3 ^a	22.1	21.2	20.2	19.2 ^a	20.9	22.4
05/13/89	19.7	19.7	19.7	20.4	21.7	20.6	19.8 ^b	18.6	20.4 ^b	21.8
05/15/89	18.9 ^c	---	---	---	---	---	---	---	---	---
05/20/89				^d						

^a Eggs #4 & 8, slight hairline fractures on small end of egg.

^b Eggs #7 & 9, pipped.

^c Egg #1 hatched, chick weight given. No other measurements taken due to not wanting to disturb the adults during hatching.

^d Egg #4 addled in the nest. Eggs #2, 3, 5, 6, 7, 8, 9, 10, presumed hatched. Eggshell fragments collected.

Appendix 9. Light-footed clapper rail egg weights (g) at SE "M" Avenue nest site, Mugu Lagoon, Ventura Co., California. 1989.

Date of Visit	Weight (g) of Egg Number						
	1	2	3	4	5	6	7
06/05/89 ^a							
06/06/89	22.9	22.9	22.4	23.0	23.6	23.8	22.7
06/10/89	22.5	22.3	22.1	23.0	23.3	23.3	22.3
06/13/89	---	21.85 ^b	---	---	22.80 ^b	---	21.85 ^b
06/15/89	---	21.70 ^c	---	---	22.65 ^c	---	21.75 ^c
06/17/89	21.3	---	20.8	22.5	---	22.4	---
06/18/89		21.4 ^d		---	22.35 ^d	---	21.5 ^d
06/21/89				22.5		22.2 ^e	21.5 ^e
06/24/89 ^f							

^a Nest located, no measurements taken.

^b Eggs #2,5,7, manipulated. Weights taken at San Diego Zoo.

^c Eggs #2,5,7, weights taken at San Diego Zoo.

^d Eggs #2,5,7, weights taken at San Diego Zoo. All 3 eggs returned to the nest.

^e Egg #6 pipped. Egg #7 (manipulated egg) 8 x 10 mm dimple. 2 dead chicks and one live chick in the nest with the eggs.

^f Unknown egg found 8 m from nest. No sign of adults or chicks.

Ledig, D. 1990. Preliminary report on the ecology of the Light-footed Clapper Rail at Mugu Lagoon, Ventura County, California. CA Dep. Fish and Game, Sacramento. Contract FG8555 Final Report. 11 pp. + appendices.

ERRATUM

Abstract and page 1:

Replace the study site names, "U.S. Naval Missile Testing Center" and "Naval Weapons Testing Center", with the correct name, "Naval Air Station, Pt. Mugu".