Development of Methods for Monitoring Seabirds on Castle Rock NWR

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REPORT TO

Coastal Program at Humboldt Bay
U.S. Fish and Wildlife Service
and
Cooperative Fisheries Unit
Humboldt State University
U.S. Geological Survey

SUBMITTED BY

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BACKGROUND

Castle Rock National Wildlife Refuge is a 6.4 ha island located 0.8 km off the coast of Crescent City, California. Castle Rock is the second largest seabird breeding-colony along the California coast, the largest Common Murre colony in the California Current, and hosts more than 100,000 seabirds. Eleven different species are known to have nested on this island including: Common Murre (*Uria aalge*), Brandt's (*Phalacrocorax penicillatus*), Pelagic (*Phalacrocorax pelagicus*), and Double-crested Cormorants (*Phalacrocorax auritus*), Pigeon Guillemots (*Cepphus columba*), Cassin's (*Ptychoramphus aleuticus*) and Rhinoceros Auklets (*Cerorhinca monocerata*), Tufted Puffins (*Fratercula cirrhata*), Western Gulls (*Larus occidentalis*), and Fork-tailed (*Oceanodroma furcata*) and Leach's Storm Petrels (*Oceanodroma leucorhoa*) (Carter et al. 1992). The Aleutian Cackling Goose (*Branta hutchinsii leucopareia*) population has recovered from less than 800 in 1974 to more than 100,000 today (U.S. Fish and Wildlife Service 2001) and large numbers (~20,000) of geese have been roosting overnight on Castle Rock in the spring. These geese have the potential to alter habitats at the island. Brown Pelicans (*Pelecanus occidentalis*) have also roosted at Castle Rock in great numbers (1-2,000) during the fall.

Castle Rock is situated midway along the U.S. Pacific Coast between two other major seabird colonies in the California Current: the Farallon Islands off the central California coast to the south and Three Arch Rocks off the Oregon coast to the north. Unlike the Farallon Islands, Castle Rock is much closer to shore and thus closer to many types of anthropogenic threats. However it is far enough off shore that observations or protections from the mainland have been very limited. Research and monitoring have been taking place at the Farallon Islands since 1971 (Ainley and Boekelheide 1990) and Three Arch Rocks has been a National Wildlife Refuge since

1907, while Castle Rock does not have a history of monitoring or conservation-based management and was privately owned until 1979 (it became a National Wildlife Refuge in 1980). The status of breeding seabird populations at Castle Rock are poorly known (except Common Murres) and cannot be assumed to mimic those of other seabird colonies such as the Farallon Islands or Three Arch Rocks (Parker 2005).

Good estimates of the abundance of Common Murres and cormorants using the surface of Castle Rock can be obtained using aerial photos (Capitolo et al. 2006). Pigeon Guillemots and Tufted Puffins have been surveyed by boat because they are active diurnally at and around Castle Rock (Carter et al. 1992; Jaques and Strong 2001). However the burrow-nesting nocturnal species (Rhinoceros and Cassin's Auklets, Fork-tailed and Leach's Storm-petrels) are not easily seen because they are at sea feeding during the day and only come to the island between sunset and sunrise when they relieve their mate of incubation duties or feed their young. Further, human activity on the island has been very restricted with very few landings (Table 1). The burrow systems can be destroyed or badly damaged when stepped on by people which necessitates restriction of human visitation and also limits access for monitoring. Common murres are sensitive to the presence of people during the breeding season which prevents researchers from visiting the island from April to August (Thayer et al. 1999; Carter et al. 2001). Therefore nocturnal species have posed a very difficult challenge to study or monitor for trends. Based on past surveys conducted after the nesting period, Castle Rock probably still hosts substantial numbers of these burrow-nesting species; Castle Rock was the largest breeding colony of Rhinoceros auklets in California at the time of the last state-wide seabird survey (Carter et al. 1992). Despite the importance of this colony to these species in California, the current status of auklets and storm-petrels on the island is unknown.

OBJECTIVES

Our first objective was to develop a non-invasive mechanism to establish long and short term monitoring of the seabirds on Castle Rock. This mechanism needed to:

- Allow the estimation of population and breeding phenology parameters of Common Murres (e.g. number of eggs hatched, average time parents spend at the nest-site, and number of chicks fledged per pair) as is estimated for Common Murres at the Farallon Islands and at other colonies such as Point Reyes and Devil's Slide Rock in Central California.
- Provide a means for detecting the presence/absence of less visible seabirds (auklets and storm-petrels) and a method to estimate site (burrow) occupancy rates as well as the population and breeding parameters as described for Common Murres above.

Using advanced video camera technology developed during this investigation we can now view the seabirds on the island without causing the disturbance associated with having people on the island. Our second objective was to establish a long-term, forward looking monitoring program on this very important seabird island. Our third objective was to make information about the seabirds on Castle Rock and their specific activities available to the public. This report details our efforts to meet objective one.

METHODS

Partnerships

In order to accomplish these objectives, several partnerships were established. The U.S. Coast Guard, Group Humboldt Bay donated their time and the use of their helicopters to transport project personnel and equipment to and from the island. Additionally, their involvement has led to dialogs and information development for their pilots concerning the

sensitivity of seabird colonies to aircraft overflights on the north coast of California. This led to the production of a pamphlet that can be distributed to new pilots. The literature details things that pilots can do to minimize the impact their aircraft have on breeding seabirds.

The National Park Service (NPS) has also assisted in developing a public outreach component of the project. We located the mainland site in Crescent City to receive the video signal from Castle Rock at a NPS building (containing administrative offices and a visitors center). The visitors center now displays a 107cm television monitor with a live video feed from the Castle Rock cameras for the public to view (up to 400 people per day).

Camera Development

Initial Deployment of Video Equipment in 2006. – In February of 2006 personnel were transported to Castle Rock by a Coast Guard helicopter to perform the primary installation of the camera equipment (Table 2, Figures 1-3) on the island. The installation was completed prior to any nesting attempts by Common Murres and thus avoided impacts from anthropogenic disturbance.

The video from the cameras during the breeding season was sent via microwave to a receive-site located in a National Park Service building in downtown Crescent City. At the receive-site we installed a matching uhf transmitter/receiver and yagi antenna to receive/transmit commands to the island. A matching microwave dish antenna along with a microwave radio receiver was installed to receive video from the island. We also established three computers at the receive site. One computer was used to send and receive uhf commands, one to receive the video and digitally archive it (Digital Video Recorder; hereafter DVR), and one computer to receive video and route it to an internet streaming service for the public to view at

http://www.humboldt.edu/~rtg1/research/castle_rock.html. The latter two computers were supplied by Humboldt State University.

Video Equipment Removal in 2006. – In October of 2006 the cameras and radio equipment were removed from the island for normal maintenance and repair (Figure 4). By the time of this visit to the island all species of breeding seabirds using Castle Rock had finished any breeding attempts.

Re-deployment of Video Equipment in 2007. – In late March of 2007 the camera system was reinstalled for the 2007 breeding season. The computer-motherboard, uhf transmitter/receiver, yagi antenna, microwave radio and fresh batteries were all reinstalled on the island (Figure 5). The thermal-imaging camera and color daytime camera from the 2006 season were reinstalled along with an additional backup color daytime camera (on loan from the camera contractor for this season only). The mast for the daytime camera was modified to accommodate a second camera. Stakes were driven into the ground marking the center of plots used to monitor auklets located on the grassy terrace. The stakes aided in locating the plots when using the thermal camera. In early April of 2007 a second trip to the island was made; the thermal camera was adjusted to proper focus and the microwave panel antenna was adjusted to increase quality of video reception on the mainland. The installation was again completed before any breeding attempts by Common Murres to avoid impacts from anthropogenic disturbance.

Video Equipment Removal in 2007. – In October of 2007 the cameras, motherboard and radios were again removed from the island for winter maintenance and repair. During this visit

to Castle Rock researchers also made detailed counts of the total number of auklet burrows on the eastern side of the island (where the majority of auklets breed on Castle Rock).

System Capabilities in 2006

Although multiple cameras were installed only one camera at a time could send video back to the mainland. The daytime camera had the ability to pan 360°, tilt ~120°, and zoom from wide-angle to telephoto views providing close-ups of areas on the island hundreds of meters distant from the camera. This allowed us to focus on fish being brought to the island by Common Murres. The thermal imaging camera has the ability to pan and tilt, but cannot zoom. Both cameras had miniature windshield wipers complete with windshield wiper fluid to clean the lens of each camera. The microphone provided sound from the immediate area (within approximately 5-10 meters) and was only operational when the daytime camera was being used (sound was unavailable when using the thermal-imaging camera during the 2006 season).

The charge capacity of the batteries allowed the cameras to operate 24 hours a day. At the mainland receive site the DVR digitally recorded the video signal coming from the island to removable hard-drives 24 hours a day. The removable hard-drives were exchanged when full and brought back to the lab for video review and archiving. Cameras were controlled (moved left/right, zoomed in, etc.) from Arcata (HSU), allowing researchers to actively observe birds on the island.

The thermal-imaging camera was sensitive to heat emitted by the landscape and any animals present. It had a view of the large grassy terrace on Castle Rock where the majority of Cassin's and Rhinoceros Auklet burrows were located. Cassin's and Rhinoceros Auklets could be seen on camera at night along with Western Gulls, Aleutian Cackling Geese, Brown Pelicans,

Brandt's Cormorants and Common Murres. Burrow entrances could also be distinguished on camera when the air escaping burrows was of a different temperature than the ambient air temperature on the island (most of the time).

System Capabilities in 2007

All three cameras functioned properly and were used daily during the 2007 season. Video quality being received on the mainland was good. The microphone was installed so that it could be used with both the daytime cameras and the thermal imaging camera; we were able to record audio at night (which will further aid in detecting the presence/absence of storm-petrels). Vegetation obscured the thermal camera's view of some burrow entrances by mid-May as in 2006.

Camera and Burrow Locations

During the February 2006 visit to Castle Rock spatial information was collected with a Trimble Pathfinder Pro GPS to aid in future production of geographic information system (GIS) layers and geo-referenced aerial photographs of the island. More spatial information was collected on the island during the October 2006 visit to Castle Rock to exactly locate auklet burrow entrances on the grassy terrace of the island.

Evaluation of Burrow Cavities

During the October 2006 and October 2007 visits to the island we used a flexible burrow camera (the "Peeper Video Probe System" manufactured by Sandpiper Tech) to probe into auklet burrow entrances. This allowed estimation of a rate of one auklet burrow entrance leading to

more than one auklet nesting cavity, and vice versa. These estimates of auklet burrow connectivity will be used when estimating breeding auklet populations based on burrow entrance counts and occupancy rates.

Outreach

A partnership with the interpretive staff at the NPS Crescent City visitor's center has allowed us to provide local public access to the video coming from Castle Rock. A 107 cm television screen provided by Humboldt Bay National Wildlife Refuge provides the public with viewing of the live video feed. A "project description" below the television provides information about the video to visitors; visitor center staff answer questions from visitors.

On a more global scale, online access to live video coming from Castle Rock has been established using funding provided by Humboldt State University. A live video stream including audio can be seen 24 hours a day from April to October at http://www.humboldt.edu/~rtg1/research/castle_rock.html. See the New Initiatives section below for plans of further outreach aimed at integrating video from this project into elementary school programs.

RESULTS

Objective 1 – Develop non-invasive mechanism to establish long and short term monitoring of the seabirds on Castle Rock

We have successfully installed a remotely operated video camera system that allows researchers to observe seabirds on Castle Rock without disturbance. The system operates 24 hours a day during the breeding season. The first requirement of this objective (the mechanism

must allow for the estimation of population and breeding phenology parameters of Common Murres) has been met by using the daytime color video camera to observe pairs of Common Murres throughout the breeding season. The second requirement of the objective (detect presence/absence of less visible auklet and storm-petrel species nesting on Castle Rock and estimate burrow occupancy rates along with breeding parameters) has been met by observing these species using the thermal-imaging camera at night throughout the breeding season.

Objective 2 – Establish a long-term, forward looking monitoring program

Common Murre Monitoring. – From 19 May to 29 June of 2006, the daytime camera was used to observe plots of Common Murres breeding sites in which individual pairs of breeding birds were observed repeatedly (hereafter "productivity plots"). Each productivity plot consisted of approximately 50 breeding sites. Over 50 hours of direct observations using the daytime camera were made during the 2006 season. The observations made in the productivity plots included egg laying dates and number of eggs hatched. Parameters such as breeding phenology and hatching success will be estimated using these data.

Sixty Common Murre breeding sites were monitored from 28 April to 13 July 2007. Data on breeding phenology, hatching and fledging success, and number of chicks per pair were collected. In addition, fish brought to the colony by murres that were seen on video are being examined frame-by-frame to achieve accurate species identification and provide insight as to what Common Murres breeding on Castle Rock were eating; information that would other-wise be impossible to collect. Species composition of prey delivered to chicks is also currently being obtained from over 75 hours of diet observations made during the 2007 chick-rearing period.

Information on chick feeding rates and the number of mate arrivals and departures were also collected from 3 all-day time budget surveys recorded and archived on video.

Nocturnal Monitoring. – Using the thermal-imaging camera, approximately 1500 hours of night-time video were recorded and archived during 2006 and more than 1700 hours were recorded and archived during 2007. By examining the night-time video we will estimate auklet burrow occupancy rates and other information that can help determine the annual health and size of these breeding seabird populations. During the 2006 breeding season the thermal-imaging camera focused on one of three main study plots each night and every fourth night scanned the entire field of view (night one: camera views plot 1 all night, night two: camera views plot 2 all night, ... night four: camera scans entire burrow nesting area all night). Each plot consisted of about 30 auklet burrow entrances. During the 2007 breeding season three plots were repeatedly viewed throughout the season with the camera focusing on one of the three plots each night (same as 2006 except the night where the entire burrow nesting area was scanned was eliminated). Occupancy information was gathered for burrows in each of the three main study plots for both years including identifying the species using the burrow and timing/frequency of arrivals and departures. Over 3300 individual observations of auklet arrivals and departures have been made using archived video. The presence of mice (probably *Peromyscus maniculatus*) on the island was detected on the night-time video during both seasons and the frequency of mouse visitation to auklet burrows was estimated. Interactions between auklets and predators (Western gulls) and roosting species (Brown pelicans, Aleutian Cackling Geese) have been documented.

Objective 3 – Make available to the public information about seabirds and their specific activities on Castle Rock

The television screen installed at the Redwood National Park visitor's center in Crescent City displays a live video feed coming from the cameras on Castle Rock during the breeding season. Signage below the television monitor explains the project and identifies those involved while visitor center staff answer questions from visitors. Further, a live video stream can also be accessed by the public during the breeding season on a computer with internet access at the following url: http://www.humboldt.edu/~rtg1/research/castle_rock.html.

Camera/System Problems

On May 3, 2006 the microwave dish antenna on the island (responsible for transmitting video) was damaged by an unknown cause. The dish part of the antenna was separated from the feedhorn (the part of the antenna that actually transmits the signal). The feedhorn remained intact. As a result, the video quality reaching the mainland was reduced and remained highly variable in quality for the rest of the 2006 breeding season. This presented problems when examining video, making it harder to identify fish, observe Common Murre productivity plots, and differentiate auklet species at night. A more robust type of microwave antenna was used to transmit the video signal from the island during the 2007 season and there were no problems during the 2007 season.

After the primary installation in 2006 the daytime camera was intermittently unable to pan or zoom. As the season progressed, the proportion of time increased where the daytime camera was unresponsive. This problem seriously limited our ability observe the Common Murre productivity plots and observe fish being brought back to the colony. The camera contractor

repaired the faulty camera during the winter of 2006/2007 and loaned us a second, backup color camera for the 2007 season. No similar difficulties were experienced during the 2007 season.

The lack of a zoom lens on the thermal-imaging camera has limited our ability to reliably identify an auklet to species. Auklets outside of our plots (further than approximately 20-30 meters from the camera) cannot be reliably identified to species. Currently, no zoom lens is available for the thermal video camera so this remained a limitation for the 2007 season.

Vegetation on the island's grassy flat obscured the camera's view of auklet burrow entrances. This was particularly problematic after the roosting Aleutian Cackling Geese had left the area in mid-May, and the vegetation was no longer grazed by the geese. Burrow entrances as seen on camera were used to align the night-time video with a template of labeled burrows that distinguished individual burrows from each other (Figure 6). Obscured burrow entrances therefore presented a problem when analyzing video by preventing individual burrows from being labeled. This problem was overcome during the 2007 breeding season by developing new software that enabled researchers to reliably and repeatedly align the labeled burrow template to video even when burrow entrances were obscured (Figure 6).

ANALYSES

We are currently examining a second season of Common Murre productivity plot data to estimate demographic parameters. The number of pairs of Common Murres observed in productivity plots during the 2007 season was 60. Many more observations of fish being brought back to the colony by Common Murres was obtained during 2007 than in 2006 because the two daytime cameras remained fully functional for the duration of 2007. The Common Murre

productivity and diet data obtained from Castle Rock will be compared to other Common Murre breeding colonies in the California Current.

Using the thermal-imaging camera we collected video of three plots that will yield burrow occupancy and auklet arrival/departure data for both 2006 and 2007. An estimate of the total number of auklet burrows on Castle Rock will be combined with an estimate of burrow occupancy rates (estimated from video observations) to produce a breeding population estimate for both auklet species on Castle Rock in the 2007 breeding season. It's also possible for the interactions between roosting species and auklets to be examined for impacts of large numbers of roosting species on auklet's access to burrow entrances. The video will also be examined for any signs of breeding storm-petrels on Castle Rock, particularly listening for their vocalizations in 2007; no storm-petrels have yet been identified.

We expect to produce two-three masters' theses and subsequent manuscripts from these data, and data collected in 2008. Consequently the theses and manuscripts will not be available until 2009. Although we anticipate making recommendations for long-term monitoring, the writing of a specific monitoring plan will be the responsibility of Castle Rock National Wildlife Refuge and beyond the scope of this initial effort.

Budget

As of March 1, 2008

Operation costs for the first 2 years have included the initial purchase of hardware as well as cost associated with the development of the techniques. Although this system/equipment probably has a finite life-expectancy, future expenses will be restricted to environmentally induced damage, yearly maintenance, and biological review of the resulting video. Because we have used so much "in-kind" equipment and services, the exact annual cost is difficult to assess.

Actual costs for future operation include video review (~ $12,000.00 to $18,000.00, depending on scope), report writing (~ $3,000.00), and camera maintenance (~ $23,000.00), plus transportation, project administration and oversight.

Coastal Program Dollars Spent

SeeMore Camera System (Including receiving and transmit sites)	$ 37,846.19
Batteries	$ 845.91
SeeMore- System refurbishment	$ 2,550.61
Miscellaneous Supplies	$ 1,097.12
Travel	$ 563.24
Payroll and Benefits	$ 8,568.97
Indirect Cost	$ 7,659.90
Total	**$ 59,161.94**

In-Kind Contributions

Item	Contributor
Helicopter transportation	US Coast Guard
Zodiac transportation	Humboldt State University
Streaming Computer	Humboldt State University
Digital Video Recorder	Humboldt State University
Large Screen TV	Humboldt Bay National Wildlife Refuge
Project Supervision	Richard Golightly / HSU
Vehicle transport	Humboldt State University and California Department of Fish & Game

NEW INITIATIVES

We have submitted proposals to continue monitoring in 2008. These have included proposals to the California Department of Fish & Game and the species at risk program directed by U.S. Fish and Wildlife Service (FWS). A separate FWS proposal was also submitted to the California-Nevada Operations Office (CNO) that would allow development of a public outreach program aimed at elementary school students.

PRESENTATIONS ASSOCIATED WITH THIS PROJECT

- Cunha, M.J., R.T. Golightly, G.J. McChesney and E.T. Nelson. Using a remote thermal imaging camera to observe burrow-nesting seabirds on Castle Rock NWR in northern California. . Presentation. U.S. Fish and Wildlife Service. June 2007.
- Cunha, M.J., R.T. Golightly, G.J. McChesney and E.T. Nelson. Using a remote thermal imaging camera to observe burrow-nesting seabirds on Castle Rock NWR in northern California. Pacific Seabird Group, Asilomar, CA. February 2007.
- Cunha, M. J., R.T. Golightly, G.J. McChesney and E.T. Nelson. Estimating numbers of breeding Auklets on a colony that cannot be accessed by traditional methods. (Poster). Pacific Seabird Group. Blaine, WA. February 2008.
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- Eigner, L.E., G.J. McChesney, and R.T. Golightly. Prey use of Common Murres (Uria aalge) at two colonies in California. (Poster). Monterey Bay National Marine Sanctuary. Monterey, CA. April 2008.

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Table 1: Personnel visit dates to Castle Rock NWR to install, provide maintenance or remove cameras for winter service cycle.

Date	Personnel	Reason for Visit
23-Feb-06	6	Initial installation.
25-Feb-06	2	Retrieve thermal camera for adjustment.
Mar-06	2	Reinstall thermal camera.
06-Aug-06	3	Repair microwave antenna.
29-Oct-06	5	Remove equipment for winter maintenance.
28-Mar-07	3	Reinstall equipment for 2007 season.
02-Apr-07	3	Adjust thermal camera.
29-Oct-07	6	Remove equipment for winter maintenance and count burrows.

Table 1. Components of the Remote Video System on Castle Rock.

Item	Quantity	Description
Color Video Camera	1	Robotic video camera capable of panning left/right up/down and zooming from wide-angle views to telephoto close-ups. Producing color video during the day. During the 2007 season 2 color video cameras were installed.
Thermal Video Camera	1	Robotic video camera capable of panning left/right up/down but of fixed focal length (no zoom). Producing grayscale video based on long-wave infrared light (heat) during the night.
Microphone	1	Provides sound to the video signal.
12-volt AGM battery	2	Approximately 175 amp-hours in total.
Solar Panels	3	Charges batteries.
Charge Controller	1	Regulates charge coming from solar panels when charging the batteries.
Plastic Container	1	Houses batteries and charge controller.
Computer Motherboard	1	Controls system on the island.
Uhf transmitter/receiver	1	Converts commands to move and power cameras on the island to and from Uhf.
Yagi Antenna	1	Connects to the uhf transmitter/receiver to send/receive commands on the island.
Microwave Video Transmitter	1	Converts video to a microwave signal.
Microwave Dish Antenna	1	Connects to microwave transmitter to broadcast video to mainland receive site.
Weatherproof Electrical Box	1	Houses uhf transmitter/receiver, computer motherboard and microwave video transmitter.
Camera Mast	2	3.8 cm steel galvanized pipe secured to the rock with lag bolts approximately 1.2 m tall for mounting the camera on.
Main Mast	1	3.8 cm steel galvanized pipe secured to the rock with lag bolts approximately 2.1 m tall and re-enforced with guy lines for mounting the antennae and electrical box on.
Solar Panel Frame	1	Secures solar panels to the rock and main mast.

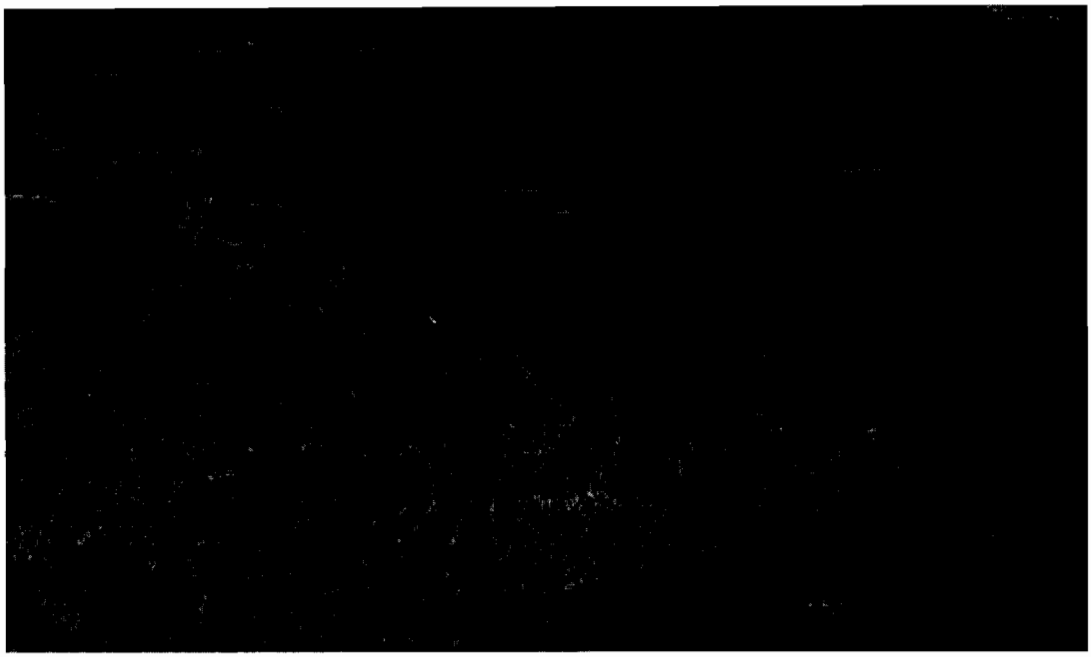

Figure 1. The Rocky Slope on the North side of Castle Rock where the camera equipment was installed. The video transmitting antenna and solar panels can be seen at left and the daytime camera at the bottom of the rocky slope at right.

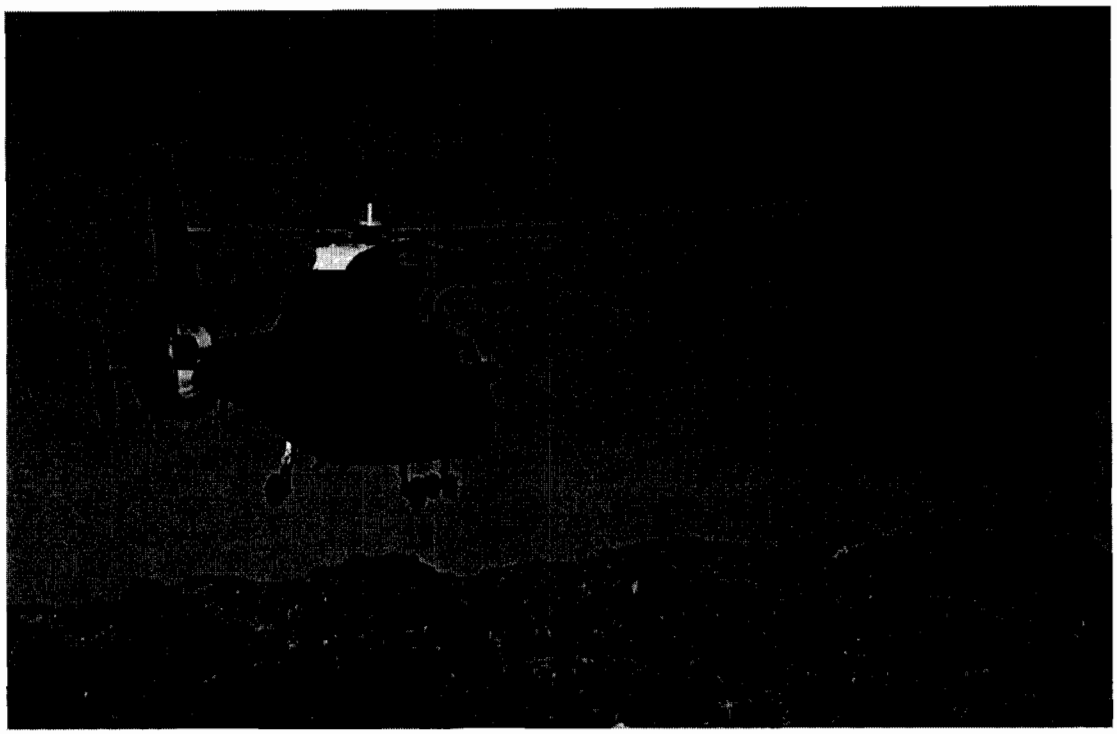

Figure 2. U.S. Coast Guard helicopter landing on Castle Rock to transport equipment and personnel for the initial camera installation on Feb 23, 2006.

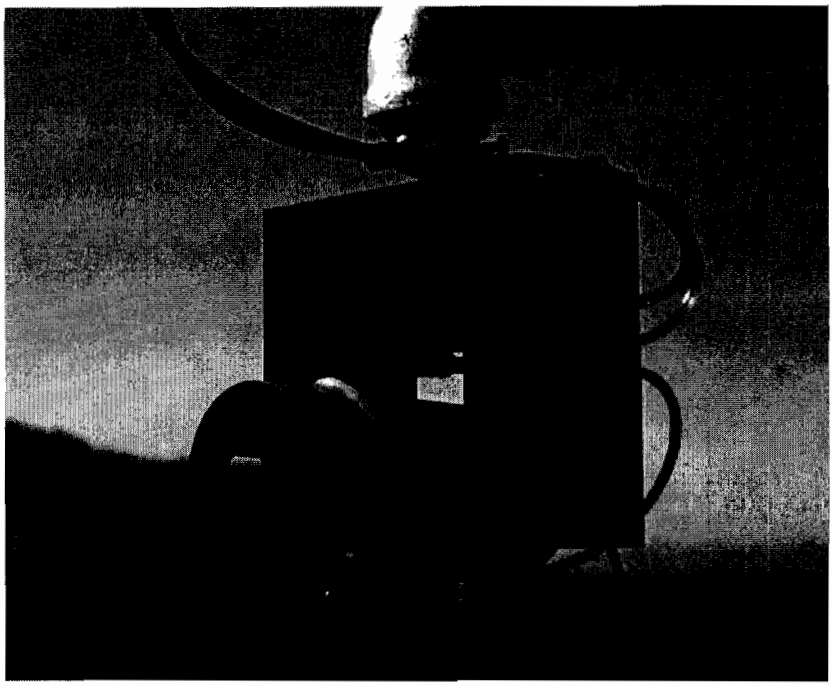

Figure 3. Close-up of one of the daytime video cameras installed on Castle Rock in 2006 and 2007.

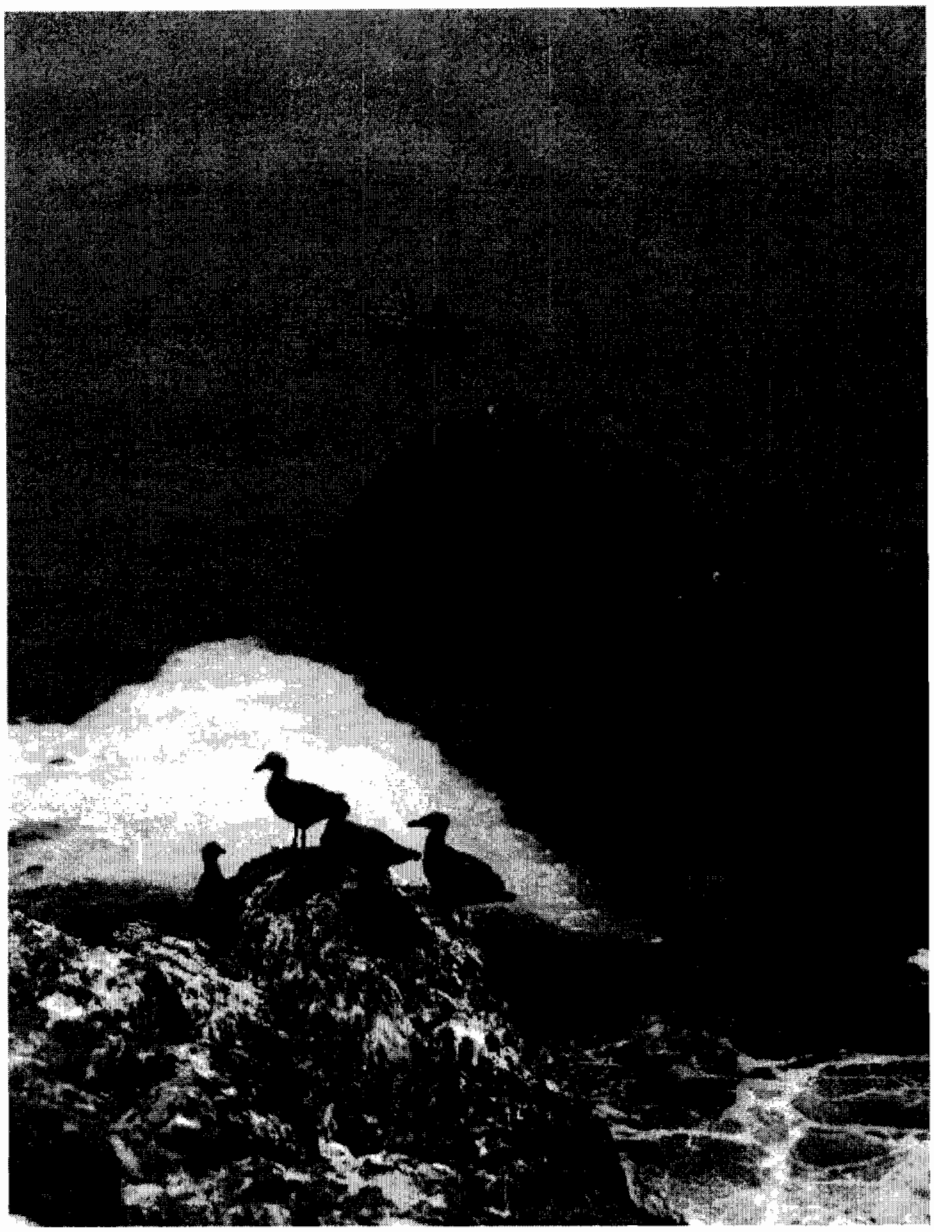

Figure 4. August 6, 2006 juvenile Western Gull chicks in foreground and the (HSU) Zodiac that transported personnel to Castle Rock to repair the microwave antenna.

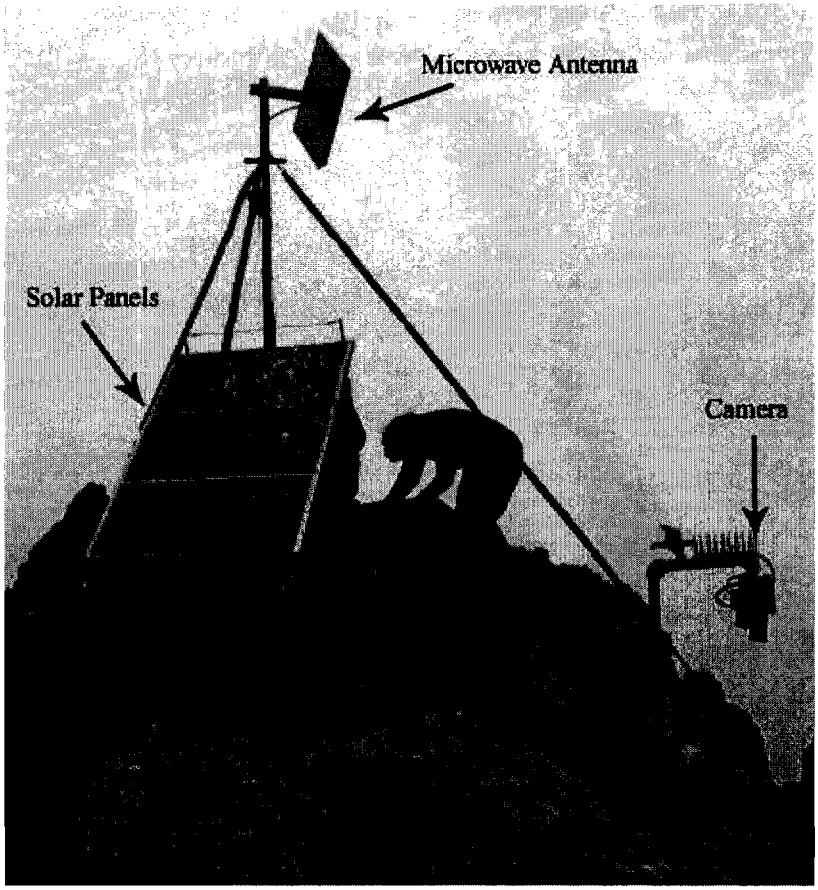

Figure 5. Main Mast and Thermal Camera on Castle Rock National Wildlife Refuge in 2007.

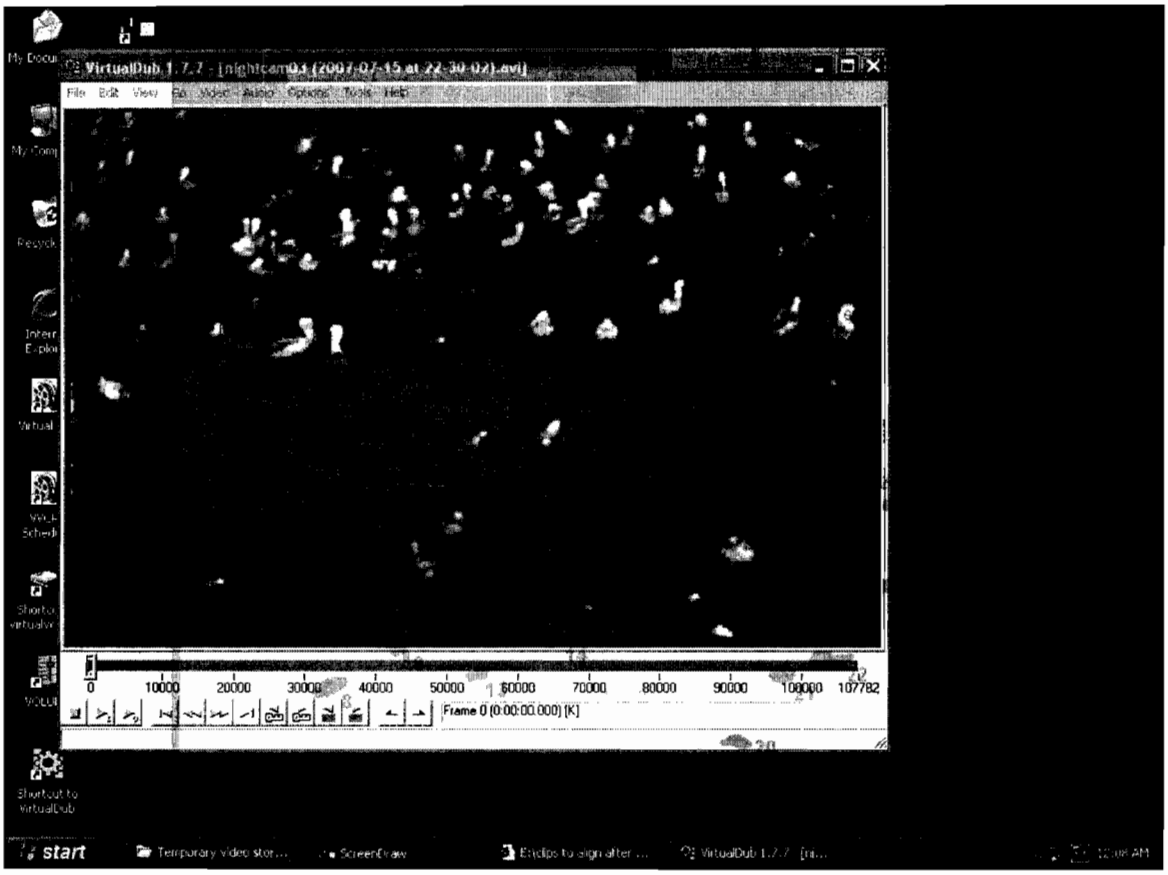

Figure 6. Screenshot showing transparent labeled burrow template overlaying night-time video allowing researchers to number individual burrows and locate burrow entrances even when burrow entrances were not visible on camera. Template is aligned with video by using auklet arrival/departure events and other landmarks like the horizon and rocks.