# Video Monitoring to Identify Predators and Incubation Behavior of Black-crowned Night-Herons at Alcatraz Island, San Francisco Bay, California


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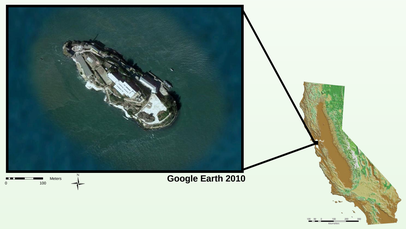
## INTRODUCTION

Black-crowned Night-Herons (*Nycticorax nycticorax*) have nested on Alcatraz Island, an important breeding ground for the San Francisco Bay Area population, since at least the mid-1980s. Nest predation has increased in recent years. For example, during the years of 1998 – 2010, nest predation rates were 4.7 times greater than those of 1990 – 1997. Our study objective was to identify nest predators using videography and evaluate variation in incubation constancy, nest activity, and incubation behaviors. This information improves our understanding of Night-Heron nesting ecology and will allow wildlife managers to make better-informed decisions regarding actions needed to improve nest survival.

Photo by B. Armbrister




## METHODS

- A random sample of nests ($n$ = 22) was selected for fine-scale video-monitoring in May – July of 2010.
  - Twelve video systems consisted of micro-cameras with infrared vision and DVRs (Figure 1).
  - Cameras were installed ~1.0 m from nests (set at seven frames/sec) in two different habitat types (Figure 2).
  - Incubation constancy (% of contact time between brood patch and eggs) and nest attendance (% of time adult bird was at nest) was calculated.
  - Six behavior categories: Resting, Vigilance, Active Vigilance, Preening, Nest Maintenance, Egg Turning.
- A stratified random sample of 11 dates was selected across nests (ranged from one to six days per nest) and we computed: (1) activity ratio indices (active to inactive behaviors; deviation from mean); (2) incubation constancy indices (deviation from mean); (3) nest attendance; and (4) frequencies of departures per hour.
- Two-step modeling approach:
  - Step 1, we modeled factors that influence indices of incubation constancy (IC) and activity (AI).
  - Step 2, we modeled IC and AI as explanatory factors for nest fate (successful [defined as hatching one or more chicks] and unsuccessful).
- Calculated averages (weighted ± SE) of six general behaviors (Figure 3) for each light period.
- Calculated average (weighted ± SE) departure frequency and attendance for each light period.

**Table 1. Variables of incubation constancy and activity models in the first step of the model analysis.**

| Variable | Abbr. | Description | Type |
|---|---|---|---|
| Incubation Constancy | IC | Percent of time of contact between brood patch and eggs | response* |
| Activity Index | AI | Index based ratio of active and inactive behaviors | response* |
| Light Period | LPer | 6 categories(early light [start time sunrise], mid-light, late light early dark [start time sunset], mid-dark, late dark) | explantory (fixed) |
| Nest Age | NAge | Number of days elapsed from first egg laid | explantory (fixed) |
| Nest Habitat | Hab | Nest placement | explantory (fixed) |
| Clutch Size | CSize | Number of eggs in nest | explantory (fixed) |
| Bird ID | BID | Identification of individual | explanatory (random) |
| Date | Date | Ordinal date | explanatory (random) |

*IC and AI were also explanatory covariates for nest fate model in second step of the analysis.


Figure 1. Camera Installation


Figure 2. Habitat Types


Figure 3. Night-Heron Nesting Behaviors

**Table 2. Model evidence for incubation constancy (IC), activity (AI), and nest fate. K = parameters, LL = log-likelihood, AICc = Akaike's Information Criterion, $w$ = model probability, ER = evidence ratio.**

| Response | Model* | K | LL | ΔAICc | $w$ | ER |
|---|---|---|---|---|---|---|
| IC | LPer | 9 | -1191.8 | 0.0 | 0.45 | |
| | Hab | 5 | -1196.2 | 0.9 | 0.28 | 1.6 |
| | null | 4 | -1197.8 | 2.0 | 0.16 | 2.7 |
| AI | Hab × LPer | 15 | 259.1 | 0.0 | 0.92 | |
| | NAge × LPer | 15 | 256.4 | 5.4 | 0.06 | 14.5 |
| | LPer | 9 | 249.3 | 7.5 | 0.02 | 43.2 |
| | Hab | 5 | 212.4 | 73.2 | 0.00 | >1000 |
| | null | 4 | 211.1 | 73.8 | 0.00 | >1000 |
| Nest Fate | IC | 2 | 12.7 | 0.0 | 0.67 | |
| | IC + AI | 3 | 11.5 | 2.0 | 0.24 | 2.7 |
| | null | 1 | 19.9 | 4.5 | 0.07 | 9.6 |

* Model sets for IC and AI consisted of single variable models and interactions (6 models per set). All models for IC and AI consisted of year and date as random effects. Null model for IC and AI consisted of random effects only. For all sets, models with AIC values greater than the null model were not included in table.

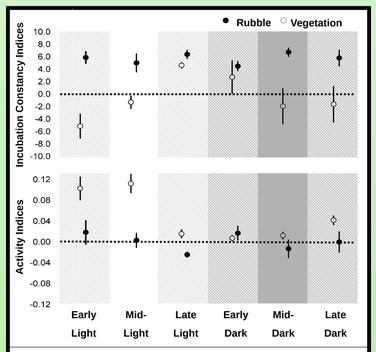



Figure 4. Weighted averages of indices (SE) for incubation constancy and activity by habitat type and light period.

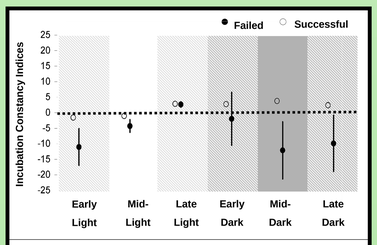



Figure 5. Weighted averages of indices (SE) for incubation constancy by nest fate.

## PRELIMINARY RESULTS

### Model Analysis

**Step 1. Incubation and Activity.**

- Top model for incubation constancy (IC) included light period, but model with habitat also showed evidence (Table 2).
- IC was lowest during early light, mostly because of nests in vegetation habitat (Figure 4).
- Top model for activity (AI) was interaction between habitat and light period (Table 2).
- AI was highest during early and mid-light, especially in vegetation (Figure 4).

**Step 2. Nest Fate.**

- Top model for nest fate consisted of IC; also evidence of additive effect of IC + AI (Table 2).
- Nests with higher IC, averaged across light periods, more likely to be successful (Figure 5).

### Predator Identification

- Recorded five egg-stage and three nestling-stage predations (complete) by ravens (Figure 6a – b). .
- Recorded Night-Herons removing eggs from one nest and nestlings from two (Figure 6c – d).
- Nest predation sign differed (Figure 7a – d).
- Raven predation activities were greatest during the early light period (Figure 8), when IC was lowest and AI was highest.

### Nesting Behaviors

- Parents were most vigilant during the early and mid-light periods (Table 3).
- Nest maintenance was greater during the early light period (Table 3).
- Egg turning occurred more frequently during early light and early dark periods, near sunrise and sunset.

### Nest Attendance.

- Attendance was highest during mid- to late light and lowest during early light (Figure 9).
- Frequency of nest departures by Night-Herons was greatest during early and mid-light (periods of most recorded predation activity by ravens).


Figure 6. Video images of ravens consuming eggs (a) and nestlings (b) and Night-Herons removing eggs (c) and nestlings (d) from Night-Heron nests.


Figure 7. Sequence of raven predation on a Night-Heron nest. Raven ate one egg at the nest (a) and removed the other two (c – d).

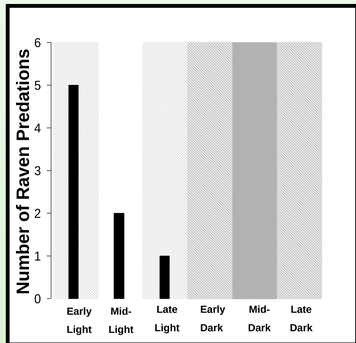



Figure 8. Number of raven predations by light period. Most predation activity took place during early morning hours, when Night-Herons demonstrated lowest IC, and highest AI and nest departure rates.

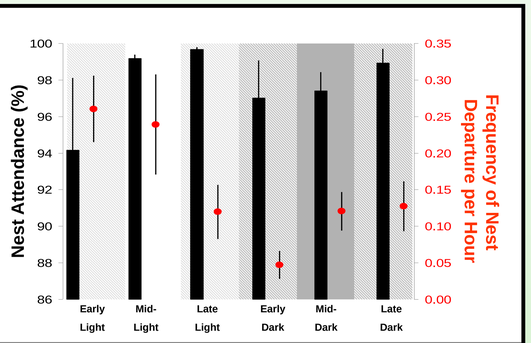



Figure 9. Nest attendance by light period (black columns with SE). Frequency of nest departure per hour during different light periods (red dots with SE).

**Table 3. Weighted average (SE) percentage of behaviors by light period.**

| | Light Period | | | | | |
|---|---|---|---|---|---|---|
| Behavior | Early light | Mid-light | Late light | Early dark | Mid-dark | Late dark |
| Resting | 77.3 (2.4) | 81.8 (2.0) | 91.0 (1.3) | 89.7 (2.3) | 88.8 (2.3) | 89.1 (2.3) |
| Vigilance | 7.2 (1.5) | 7.1 (1.4) | 2.9 (1.0) | 3.4 (0.6) | 2.6 (0.4) | 1.3 (0.3) |
| Active Vigilance | 0.2 (0.2) | 0.1 (0.1) | 0.1 (0.0) | 0.3 (0.1) | 0.0 (0.0) | 0.0 (0.0) |
| Preening | 1.2 (0.3) | 3.6 (0.6) | 1.4 (0.2) | 1.0 (0.2) | 0.7 (0.2) | 1.3 (0.3) |
| Nest Maintenance | 5.9 (0.8) | 3.3 (0.5) | 1.5 (0.3) | 0.2 (0.1) | 0.1 (0.1) | 1.3 (0.3) |
| Egg Turning | 1.2 (0.2) | 0.9 (0.1) | 0.7 (0.1) | 1.5 (0.2) | 0.6 (0.1) | 1.4 (0.1) |

## CONCLUSIONS

- Video-monitoring offered fine-scale data to identify relationships between incubation patterns and predation. This method of monitoring is a valuable management tool for the unambiguous identification of predators of avian species of conservation.
- We found that characteristics of incubation behavior explained variation in nest fate. Ravens are visually-cued predators that appear to find Night-Heron nests at times when Night-Herons are most active and incubation constancy is lowest.
- These findings are of conservation concern because raven populations are increasing throughout North America, largely because of anthropogenic subsidies, especially in California, which may elevate predation rates on Night-Heron nests. Interactions between predator species and incubation behavior should be considered in management strategies.
- Further video-based research on incubation behavior as related to (1) species-specific predation, (2) number of birds incubating a clutch, (3) micro-habitat characteristics, and (4) nest predator abundance would be important to understanding reproduction of Night-Herons and other species. Additional information on nestling feeding rates as related to predation activity would also be beneficial.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