

**Protocol for Crested Auklet Restoration
Research Fieldwork Proposed on Gareloi in 2011**

**Ian L Jones
Dept. of Biology
Memorial University
St. John's, Newfoundland, A1B 3X9, CANADA**

**Polaris Applied Science, Inc.
12525 – 131st Court NE
Kirkland, WA 98034-7713**

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The 2011 field season will be the third year of fieldwork on Gareloi Island to determine if breeding densities of Crested Auklets can be increased by removal of vegetation blocking access to subterranean nesting habitat. After vegetation removal at the end of the 2009 season, a substantial increase in Crested Auklet numbers and breeders was observed in 2010, but occurred on both “manipulated” plots, where vegetation had been removed, and the adjacent “unmanipulated” plots, where no vegetation removal occurred. This treatment-independent increase in numbers could well be the result of an unanticipated “large area response” to vegetation removal on the manipulated plot. Reasons for this response could include the attractiveness of a devegetated area to prospecting auklets and also reflect the large volume of subterranean nesting habitat provided when vegetation is removed from a relatively small area on the colony’s surface. Either of these effects could result in increased surface activity in both the manipulated plot and adjacent unmanipulated plot. A similar increase could also occur due to inter-annual variation in colony attendance, with all areas of the colony experiencing increases similar to what was observed on the experimental plots independent of the manipulation.

Fieldwork in 2011 will help determine if the increase in numbers observed in 2010 was due to vegetation removal, and not an unrelated interannual variation in colony numbers or attendance. This will be accomplished by providing one more year of observations from the eight plots devegetated in late 2009 and the first year of post-manipulation monitoring for 60 new plots devegetated in 2010. We also will assess the areal extent of the response of Crested Auklets to devegetation by examining spatial variation in Crested Auklet surface activity and numbers in areas surrounding manipulated plots and elsewhere in the colony.

Observations in 2011 will also provide additional information on the magnitude of the Crested Auklet response to vegetation removal, especially since the plots devegetated

in late 2010 had lower pre-manipulation densities than the plots established in 2009. The 2011 observations when combined with those from 2010 will allow a more accurate approximation of the increase in nesting activity provided by the restoration technique, assisting in the determination of the extent of any future restoration activities.

1. Assessment of 2009 study plots A, B, C and D

1.1. Capture - mark- recapture: population estimates

The capture-mark-recapture data gathered in 2009 and 2010 indicated the number of individuals visible and standing on the surface on all plots increased by an average of 476%. This large increase occurred even though the 2009 study plots were established in areas with existing high densities of Crested Auklets. To determine if the observed increase is sustained in 2011, we will again measure the ratio of banded to unbanded birds seen on the surface of each plot as was done in 2009 and 2010 (Conners and Jones 2009, Jones et al. 2011).

In 2011 we will conduct counts on four of the eight plots each day throughout June and July, except during high winds and rain, to obtain a mean value of the ratio that best reflected the true proportion of previously marked Crested Auklets on each plot. Counts of banded to unbanded individuals will be taken every 10 minutes for four hours during the morning activity period (1100h - 1500h) through June and July and during 1.5 hours in the evening activity period (2100h - 0000h) during July only. The number of Crested Auklet individuals using the surface of each plot (N_{surface}) will then be estimated using the maximum count from each day as:

$$N_{\text{surface}} = \text{number marked and resighted at least once} \times (1/(\text{mean decimal proportion observed marked during resighting activity}))$$

1.2. Capture-mark-recapture: breeding population estimates

The capture-mark-recapture data gathered in 2009 and 2010 indicated the number of breeding pairs increased by an average of 180% between years. Our observations in 2011 will determine if this increase can be maintained and if the

large number of nonbreeders present in 2010 begins breeding in 2011, further increasing breeding densities.

To estimate the number of breeding individuals using each plot, we will also measure the ratio of banded to unbanded individuals ('breeders' identified as Crested Auklets arriving at each study plot with a chick meal as indicated by the presence of a distended throat pouch). This method gives an indication of the number of individuals that successfully reached the chick rearing stage. Any marked individual seen delivering food at least once will be identified as a 'breeder', and the total number of marked breeding individuals will be determined. Cumulative counts will be performed continuously during four 30-minute intervals during the morning activity periods (1130h - 1200h, 1230h - 1300h, 1330h - 1400h, 1430h - 1500h) during July, recording birds with and without food, and with and without color marks. The number of Crested Auklet adults that are raising chicks (N_{breeders}) on each plot will be estimated using the maximum count from each day as: $N_{\text{breeders}} = \text{number of marked birds seen delivering food at least once} \times 1/(\text{mean decimal proportion of marked to unmarked birds delivering a chick meal})$. For each plot, the number of active breeding sites (i.e., breeding pairs) that reach the chick rearing stage will thus be estimated as half the number of individuals delivering chick meals (N_{breeders}).

To obtain another estimate of the effect of devegetation, we will compare the 2011 total counts of birds delivering food loads per hour (both marked and unmarked individuals) with those from the same plots in 2009. The 2011 observations will be conducted at the same time as the feeding watches in 2009 and provide an indication of the magnitude of increase in breeding activity two years after devegetation.

1.3. Capture-mark-recapture: resighting band combinations

In 2009, 614 Crested Auklets were banded with unique combinations of three color Darvik (PVC) leg bands on the eight study plots. In order to estimate the number of Crested Auklets using each plot we will record all band combinations observed

during the Crested Auklet activity period between 1100-1500h HADST, during June and July, except during days of heavy rain and wind. For each marked bird we will note which half of the plot it was sighted within and whether it was carrying a chick meal.

1.4. Movement of marked Crested Auklets

The data on movement of marked birds indicates that individuals seen in both 2009 and 2010 tend to remain on the same plot with little movement to adjacent plots. To continue our analysis of Crested Auklet inter-annual movement at the southeast colony site, we will determine the plots frequented by color-marked individual birds again in 2011. Only birds with a clear plot preference in a plot-pair (seen on only one plot in 2011) will be used in the movement analysis, although we will record birds that frequent the border between adjacent plots. We will tally birds that return to the same plot side (e.g., Am to Am) as in 2009 and 2010, the same plot-pair but different side plot (e.g., Am to Au), and those that switch to an entirely different plot-pair between years (e.g., Am to Cu).

1.5. Crested Auklet nesting crevice counts

While both the capture-mark-recapture and time-lapse images indicated a considerable increase in Crested Auklets in 2010, the number of Crested Auklet nests visible from surface counts declined while the number of Least Auklet nest crevices increased. This change in observed nests may be due to Crested Auklets moving to newly available subterranean cavities while the increase in Least Auklets nests could be due to decreased competition with Crested Auklets for nests near the surface. The crevice counts conducted in 2011 will allow us to determine if this patterns persists a year after vegetation removal. Searchers will again attempt to locate visible Crested and Least Auklet active breeding sites (indicated by the presence of an incubating adult, or an egg in an appropriate location) within plot boundaries.

1.6. Breeding success

All nests located during crevice counts will be rechecked to determine breeding success. In 2010 breeding productivity did not differ between control and manipulated plots, suggesting that the removal of vegetation or peat had no deleterious (via e.g., disturbance) or enhancing (not expected) effects on the ability of Crested or Least Auklets to incubate eggs to hatching.

All active nests located during the crevice counts will be marked on hand drawn maps following the 2009 and 2010 procedures (see Connors and Jones 2009) during the period June 10 – June 20. These accessible, active breeding sites will be rechecked once (during the period July 10-15) to evaluate hatching success on each half of the four study plots. Crested Auklet hatching success will again be measured by the proportion of nests (with an egg or incubating adult) found that produced a nestling (as indicated by the presence of a living or dead nestling or hatched eggshells).

1.7. Crested Auklet surface counts (Reconyx cameras) at study plots

Images from time-lapse Reconyx cameras in 2009 and 2010 showed a substantial increase between years, providing an independent confirmation of the increase detected using the capture-mark-recapture technique. Reconyx images from 2011 will assist in determining whether the increase is due to habitat manipulation or inter-annual variation in colony attendance and if numbers continue to increase more than one year after habitat manipulation.

Four Reconyx time-lapse cameras will be placed adjacent to plot pairs A, B, C, and D in early June in the same locations and with the same fields of view as in 2009 and 2010 (Connors and Jones 2009). Cameras will again be programmed to make a digital image every five minutes between 0900-1500h HADST every day until July 25th. By viewing images, maximum auklet counts will be recorded for each plot for each day of camera monitoring. Auklet surface counts are indicative of the amount of time birds were spending on the surface (Jones 1992) and the intensity of surface

activity, but provide at best a weak indicator of the breeding population size. We will scroll through each day of photographs, choosing time periods with the highest number of birds present, counting the number of auklets. When the daily maximum number of birds is identified, the number for each species (Least and Crested) will be noted. To compare between plot types (control versus manipulated) and years (2009 – 2010 - 2011) we will use Generalized Linear Models with negative binomial distributions.

In addition to the above, we will assess variation in auklet surface densities in areas surrounding vegetated and unvegetated plots to determine the extent of the “halo effect”, the spatial extent of Crested Auklet response to devegetated plots. This will be done by comparing the existing imagery from 2009 and 2010 to see if it provides evidence for the extent of the “halo effect”. The 2011 images will allow assessment of interannual variation in the halo effected areas for the two years after devegetation.

2. Assessment of new plots delineated and monitored in 2010

2.1. Crested Auklet surface counts at study plots (Reconyx cameras)

The 60 plots established in 2010 were monitored with time-lapse Reconyx cameras during the 2010 breeding season. Continuing the monitoring in 2011 to determine the response to habitat manipulation will assist in interpreting the increase observed on the old 2009 plots in 2010, allow assessment of increases in surface densities when low nesting density plots are devegetated, and also provide a larger sample size for assessing the effect of devegetation on the surface densities of Crested Auklets.

To measure activity on the plots devegetated in 2010, 10 Reconyx time-lapse cameras, programmed to make a digital image every five minutes between 0900-1500h HADST, will be rotated approximately every four days (weather dependent) among the 30 newly established plot-pairs so the mean image date will be the same

for all plots. Cameras will be placed on a tripod at a distance far enough to capture both control and manipulated plots (approximately 20 meters from the center of each 20m x 10m plot pair). All camera positions and orientations will be at the locations recorded in 2010 using a handheld GPS instrument, compass bearing, and tripod height.

Additionally in 2011, we will attempt to assess spatial variation in Crested Auklet density in relation to the plots devegetated in late 2010. This will allow us to better identify devegetation as the variable increasing Crested Auklet densities. In 2011, twenty-two Reconyx cameras will be positioned to measure surface activity on randomly located 10 by 10 m plots > 50 m from a devegetated plot (from 2010) (10) and immediately adjacent to the control side of each 2010 plot-pair (10). The twenty new cameras will be used to investigate a potential "halo effect" of attraction of birds to areas adjacent to vegetation-modified areas. At the end of the season, a stake with each respective plot and camera number will be replaced at the center of each tripod location (for both the 2010 and 2011 plots). Each plot will be photographed for as many days as possible in June and July. Both Crested and Least Auklets will be counted in each image. Images from periods where fog or rain reduced visibility will be discarded. We will calculate the daily average and the maximum count of surface activity for each species on each plot.

2.2. Crested Auklet nesting crevice survey - 2010 plots

The number of Crested Auklets nesting on the 60 new plots delineated in 2010 will be rechecked to measure a change in nest density on devegetated and control areas. This data will allow us to better interpret the pattern observed on the old plots in 2010 where there was a decrease in visible Crested Auklet nests and an increase in visible Least Auklet nests.

To estimate the number of auklets breeding on each of the 30 new plot pairs delineated in 2010, we will search for visible Crested and Least Auklet active

breeding sites (indicated by the presence of an incubating adult, or an egg in an appropriate location) located within plot boundaries and mark their locations on hand drawn maps following 2009 and 2010 procedures (see Conners and Jones 2009) during the period June 10 – 20.

2.3. Crested Auklet nesting crevice survey - 2010 plots

Since no banding occurred on the 2010 plots, no ratio of banded to unbanded birds can be obtained. We will conduct observations of feeds per hour on the 2010 plots in the same way as on the 2009 plots. The observations will be conducted at the same time of day as those done on the 2009 plots in 2009 and 2011 and will provide an index of breeding activity. These feeding watches will provide information on post-devegetation nesting densities on plots that had extremely low densities before manipulation.

3. Determining the spatial extent of Crested Auklet response to devegetated plots (the “halo effect”) from images of study plots

Observations made in 2010 showed that the spatial response of auklets to the removal of vegetation was greater than anticipated, with the area surrounding a manipulated plot also supporting higher densities of birds on the surface. As mentioned above, Reconyx cameras will be deployed in 2011 to specifically examine the extent of the “halo effect”. Additionally, as mentioned above in the plot-specific protocols, post-field analysis of images, both existing and obtained in 2011, will be conducted to determine if the imagery obtained by the Reconyx cameras deployed to monitor plot activity, can be used to assist in delimiting the extent of the “halo effect”.

4. Assessment of unmanipulated plots both adjacent to and distant from the 2009 and 2010 plots

In order to assess spatial variation at locations other than the study plots, in 2011 Dr.

Ian Jones will conduct an assessment of unmanipulated plots, both adjacent to and distant from the 2009 and 2010 plots, to better determine the effect of the manipulated plots on surface densities. He will record presence or absence of breeding auklets on each circular (8 m radius) plot based on the presence of one or more of;

- birds standing on the surface,
- adult vocalizations from underground,
- wear,
- displacement and trampling of vegetation and mud near crevice entrances,
- feathers shed from adults' brood patches,
- chick calls,
- droppings,
- feathers,
- dandruff, and
- spilled chick meal remains

He will also estimate density using his standardized method of determining nesting density (0, 1-10, 11-100 or >100 occupied crevices on a 10 m by 10 m area centered on the survey point) that he has used on Gareloi and other Aleutian Islands.

Vegetation cover will be estimated for each plot (by percentage to the nearest 5%) for the following categories: *Elymus* sp., *Calamagrostis* sp. (likely also including *Poa* sp. at some locations), *Puccinellia* sp., *Carex* spp., Herb (mostly *Anemone narcissiflora*, *Lupinus nootkatensis* and *Angelica lucida*), *Salix* spp., *Empetrum nigrum*, Heath (mostly *Cassiope lycopodioides*), Moss, Lichen, Fern, *Juncus* sp., Grass spp.).

Dr. Ian Jones did similar plot assessments in 2006 on Gareloi, and some of the plots sampled in 2006 will be resampled in 2011 to determine temporal changes in auklet density and vegetative cover.

5. Assessing rate of revegetation of 2009 and 2010 devegetated plots

In order to assess short-term rates of revegetation, the 2009 and 2010 plots will be examined and photographed to determine if any revegetation is occurring one and two years after devegetation. These observations will complement the longer-term observations of succession discussed above (#4) and allow estimation of the temporal extent of the restoration benefits of devegetation.

6. Personnel

Fieldwork in 2011 will involve a crew of four on Gareloi throughout the months of June and July (late May drop off, early August pickup as in 2010). A fifth person, Heather Major, was on the island in 2010 and will assist with orientation of the new crew early in the 2011 field season.

References

- Conners, M., and I.L. Jones. 2009. Evaluating the feasibility of Crested Auklet enhancement via habitat restoration at Gareloi Island, Aleutian Islands. Unpublished report for Keesal, Young & Logan and Polaris Applied Sciences, 23 pp.
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