EFFECTIVENESS OF SOCIAL STIMULI IN ATTRACTING LAYSAN ALBATROSS TO NEW POTENTIAL NESTING SITES

RICHARD H. PODOLSKY[1]

University of Michigan, School of Natural Resources, Ann Arbor, Michigan 48109 USA

ABSTRACT.—Seabird colonies usually grow as first-time breeders join existing groups. I tested the hypothesis that the presence of conspecifics, specifically the sight and sound of established breeders, was the stimulus responsible for first-time breeders to join existing colonies. The attractive power of conspecifics was tested by presenting to conspecifics models of Laysan Albatross (*Diomedea immutabilis*) in several behavior postures, with accompanying recordings of vocalizations. I found that Laysan Albatross landed more frequently in areas where both albatross models and vocalizations were present than in areas with only visual stimuli or no vocal stimuli. Landing albatross and those on the ground were found nearer to the artificial social stimuli than would be expected from a random distribution. Three-dimensional models were more attractive than two-dimensional models, and paired models were more attractive than single models for both three-dimensional and two-dimensional models. Three-dimensional models in a sky-pointing posture were the most attractive overall, whereas models in head-forward posture were the most attractive two-dimensional models. Albatross exhibited courtship behavior closer to the models than would be expected from a random distribution. The implications of attraction to endangered bird management and restoration are discussed. *Received 3 April 1989, accepted 14 August 1989.*

COLONIAL seabirds probably use the sight and sound of conspecifics to select a breeding site (Darling 1938; Lack 1954, 1966; Orians 1966; Evans and Cash 1985). The presence of breeding conspecifics is a strong indicator that a site is safe and productive. This hypothesis, first proposed by Darling (1938), predicts that prebreeding colonial birds are attracted to the stimuli associated with an active group of conspecifics (Klopfer and Hailman 1965). Subsequent studies of breeding-site selection by colonial birds (Buckley 1979, Buckley and Buckley 1980) and noncolonial birds (Cody 1981) have focused on the role of vegetation structure, presence of competitors and predators, and environmental productivity.

Darling (1938), Lack (1954, 1966), and Orians (1966) hypothesized that the social stimuli associated with an active colony, such as sight and sound of conspecifics, attract individuals to a breeding site. They argued that for prebreeders the presence of breeding conspecifics indicates that a locality is both safe and productive relative to unused localities. This predicts that colonial birds will be more likely to settle in localities that already have breeding conspecifics.

Fretwell and Lucas (1969) suggested that the fitness of colonial organisms increases with an increase in the number of conspecifics up to a point. Then it declines because of density-dependent factors such as increased competition, predation, or disease. According to Fretwell and Lucas, colonial birds should continue to join groups of conspecifics until the groups reach such a size that density-dependent factors begin to operate.

I tested the conspecific attraction hypothesis by observing the behavior of Laysan Albatross in the presence of experimentally presented social stimuli. My specific objective was to learn about the mechanisms involved in the formation of Laysan Albatross colonies by observing albatross behavior in the presence and absence of models and recorded vocalizations. My second objective was to derive information that could be used to encourage nesting of Laysan Albatross.

METHODS

Study areas.—The experiments were conducted at Kilauea Point, the northernmost point on the main Hawaiian Island of Kauai, from December 1982 to April 1983. Kauai, at the northwest end of the main Hawaiian Island group, is 5 million years old and of volcanic origin (although no active volcanism has occurred for 3 million yr) (Carlquist 1970).

Fig. 1. A live albatross (indicated with arrow) visits a pair of two-dimensional models in 1 of 12 study plots.

Since the winter of 1975–1976, Laysan Albatross have visited and attempted to breed at two locations on Kauai: (1) a volcanic crater on the windward (northeast) shore which includes the 13.4-ha USFWS Administrative Facility at Kilauea Point and an adjacent area known as Crater Hill, and (2) the U.S. Navy Pacific Missile Range Facility at Barking Sands, a low sand dune area on the leeward (southwest) shore (Zeillemaker and Ralph 1977, Byrd and Telfer 1979, Telfer 1980). The establishment of these two relatively recent colonies has been hampered by dog predation, human disturbance, and periodic outbreaks of avian pox (Telfer 1980).

Approximately 400,000 Laysan Albatross nest in the northwest Hawaiian Islands, and a small colony exists on the main island of Niihau (Berger 1981). Nesting of the Laysan Albatross in the main Hawaiian Islands was first observed on Moku Manu Islet off Oahu in 1947 (Fisher 1948). Laysan Albatross bones have been found in subfossil deposits on Kauai and Molokai, which indicates that breeding possibly occurred in the main islands before the arrival of the Polynesians 1,500 yr ago (Olson and James 1982a, b).

Three study areas (ca. 30 m × 100 m) were established at Kilauea Point. In each area, visual social stimuli (albatross models) and auditory stimuli (recorded albatross vocalizations) were presented to simulate the sight and sound of an established Laysan Albatross colony.

Visual stimuli.—The albatross models were realistic three-dimensional (3-D) forms and stylized two-dimensional (2-D) forms. Three 3-D models were duplicated from a life-size original, hand-carved from basswood. The 3-D models were all in the *sky-pointing posture* with wings close to the body, head pointed skyward, and neck fully extended. The sky-pointing posture is a static display performed during Laysan Albatross courtship (Moir 1946, Meseth 1968). Two-dimensional models were in two postures: sky-pointing and head-forward. The *head-forward posture* is a resting posture of a standing albatross. The 2-D models

were hand-cut from three-quarter-inch plywood and painted realistically with latex paint.

Auditory stimuli.—A recording of Laysan Albatross vocalizations was played from 0600–1800 every other day at 12 experimental plots at Kilauea Point. The original albatross vocalizations were recorded at Midway Island and included all the vocalizations described for Laysan Albatross by Sparling (1977).

Field placement of the stimuli.—Eighty-one albatross models and twelve speakers were placed so that each model and speaker had an equal probability of attracting an albatross. The resulting density of models per m² was 50% of the density of Laysan Albatross at the breeding colony on Midway Atoll. This was done to minimize the possibility that albatross would avoid the experimental areas because they appeared saturated. Fisher (1966) found ca. 1 albatross per 5 m² in the colony on Midway Atoll in December 1962. The 81 albatross models in the three study areas resulted in a density of ca. 1 model per 10 m².

The four speakers in each study area were placed 25 m apart in a linear arrangement down the long axis of each field. Each of the four speakers was located in the center of an experimental plot, and each was camouflaged with vegetation. Three speakers per area were encircled by six different albatross model sets, and one speaker was not encircled by models. The six albatross model sets present on each experimental plot were (1) a single 2-D sky-pointing model, (2) a single 3-D sky-pointing model, (3) a pair of 2-D sky-pointing models, (4) a pair of 3-D sky-pointing models, (5) a single 2-D head-forward model, and (6) a pair of 2-D models—one sky-pointing, one head-forward. The two models in a pair were positioned to face each other at a distance of 30 cm.

The albatross models in each plot were placed every 4.4 m in a circle around a speaker. Each circle of models had a diameter of 10 m, and a radius of 5 m from the centrally placed speaker. The order in which the models appeared on the circle was randomized for each experimental plot. Each circle of models contained one empty space in which no models were set (Fig. 1).

Data collection.—Visitation behavior of Laysan Albatross was compared in three contexts: (1) Kilauea Point, with albatross models and recorded vocalizations, (2) Kilauea Point, with models but no vocalizations, and (3) Crater Hill, an adjacent control area with no models or recorded vocalizations. All observations were made with binoculars and spotting scope by two observers in the top of the Kilauea Lighthouse tower. The lighthouse is 20 m tall and is located on a cliff 70 m above the Pacific Ocean. All experimental plots at Kilauea Point and the reference area at Crater Hill could easily be seen from the top of the tower.

The location and behavior of albatross in the air and on the ground were monitored for Kilauea Point and Crater Hill for a total of 362 h from 1 December 1982 through 30 April 1983. We collected data on the

TABLE 1. The observed and (expected) number of albatross that landed on study area.

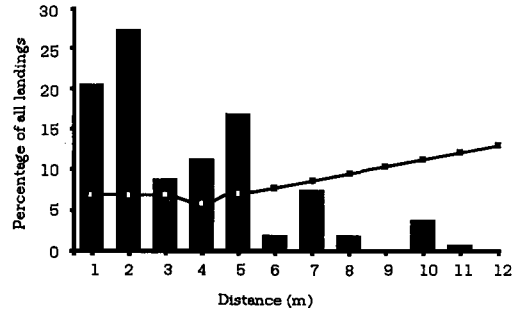| Study area (stimuli)	Total fly-by	Total landed	Landed per hour ($\times 10^{-2}$)
No visual/no auditory	877	16 (46)	4.3
Visual only	1,300	68 (69)	18.5
Visual and auditory	1,053	86 (55)	23.8
Total	3,240	170	—

Fig. 2. The percentage of albatross landings at 1-m intervals from the albatross models. The bars are observed landings. The line is expected landings if random ($\chi^2 = 256.66$, df = 11, $P < 0.001$, $n = 154$ landings).

total number of albatross flying over the two areas, the location of all albatross at the moment of landing, and the location and behavior (standing, sleeping, sitting, preening, or courting) of all albatross on the ground. A *courting albatross* was defined as an individual involved in a courtship dance with one or more albatross or individuals posturing to one or more models (Meseth 1975, Lefebvre 1977). Data on flying and landing albatross were collected continuously. Data on albatross on the ground were collected at 15-min intervals by the scan method (Simpson and Simpson 1977).

The test for attraction.—The distance from each albatross to the nearest stimulus was recorded for all birds on the ground and at the moment of landing at Kilauea Point. The observed distribution of albatross at a particular distance from the artificial stimuli was compared with the expected distribution. I calculated the expected distribution by multiplying the proportion of total area available at successive 1-m distances from the stimuli by the total number of albatross observed. If albatross were distributed closer to the stimuli than expected (assuming a random pattern of visitation), attraction was assumed to have occurred. Conversely, if albatross were farther from the stimuli than expected, I assumed disinterest (Marler 1968). The relative attractiveness of the different stimuli was measured by comparing the number of bird observations closest to each stimulus with a random expected number of observations. I estimated the expected number of bird observations for each model type by calculating the proportion of each model type of all 81 models multiplied by the total number of albatross observations. Because there was an equal number of each model type, the expected number of albatross observations was the same for all model types.

Data analysis.—Data were analyzed on the University of Michigan Amdahl 470V/8 computer using M.I.D.A.S. (Fox and Guire 1976) and a Sharp EL-512 programmable calculator. Statistical tests performed were the Chi-square test and the Z-test (Zar 1974). Assumptions of normality and homoscedasticity of parametric models were examined by analysis of variance, residual analysis, scatter plots, skewness and kurtosis coefficients, and tests for homogeneity of variances. Nonparametric statistics were used when these assumptions were violated. Probability levels of <0.05 were considered significant.

RESULTS

The percentage of albatross that landed varied significantly between the experimental and reference areas (Table 1). At Crater Hill, where visual and auditory stimuli were not presented, only 16 (1.8%) of 877 albatross observed flying actually landed. When only the visual stimuli were presented at Kilauea Point, 68 (5.2%) of 1,300 flying albatross landed, whereas 86 (8.2%) of 1,053 flying albatross landed on days when both the visual and auditory stimuli were presented ($\chi^2 = 38.73$, df = 5, $P < 0.01$, Table 1). Albatross landed significantly closer to visual stimuli than expected from a random pattern of landing, which indicated that they were attracted to the stimuli before landing ($\chi^2 = 256.66$, df = 11, $P < 0.001$; Fig. 2).

Of 601 observations of albatross on the ground at Kilauea Point, 55% were observed within 3 m of a stimuli. Overall, albatross were significantly closer to the stimuli than the expected distribution ($\chi^2 = 649.79$, df = 11, $P < 0.001$, Fig. 3).

Albatross on the ground were attracted to some models more than others. Of the albatross on the ground at Kilauea Point, 28% were closest to the pair of 3-D sky-pointing models (Fig. 4). This was a significant departure from the expected distribution of 12.5%, and it indicates that albatross exhibited choice among stimuli ($\chi^2 = 235.98$, df = 7, $P < 0.001$).
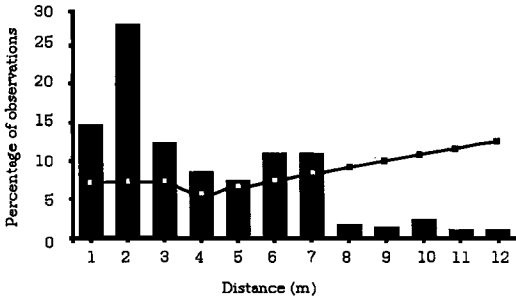
Fig. 3. The percentage of albatross observations on the ground at 1-m intervals from the albatross models. The bars are observed albatross distribution. The line is expected albatross distribution ($\chi^2 = 649.79$, df = 11, $P < 0.001$, n = 601).
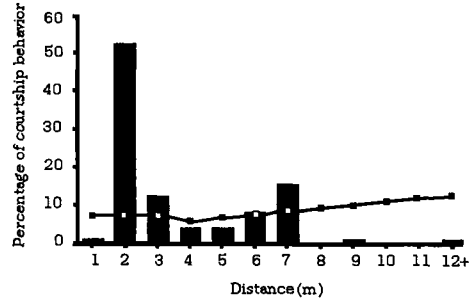
Fig. 5. The percentage of courtship behavior observed at 1-m intervals from the albatross models. The bars are the observed distribution of courtship behaviors. The line is the expected distribution of courtship behaviors ($\chi^2 = 347.57$, df = 11, $P < 0.001$, n = 97).

Albatross were more attracted to 3-D sky-pointing models than to 2-D sky-pointing models ($z = 3.11$, $P < 0.001$). When the attractiveness of all single models is compared with all paired models, albatross were significantly closer to the paired models than to the single models ($z = 7.44$, $P < 0.001$).

Of the 95 observations where albatrosses were closest to the speakers, 76% occurred on days when the speakers were on versus 24% on days when the speakers were off ($z = 0.9521$, $P < 0.01$). Of the 97 observations of courtship at Kilauea Point, 66% occurred within 3 m of a visual stimulus. Overall, albatross courted significantly closer to the models than the expected pattern ($\chi^2 = 347.57$, df = 11, $P < 0.001$, Fig. 5).

DISCUSSION

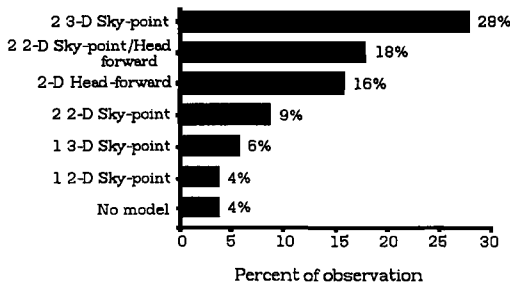Models and vocalizations attracted both flying Laysan Albatross and those on the ground. Many

Fig. 4. The percentage of observations of albatrosses closest to each albatross model type ($\chi^2 = 235.98$, df = 6, $P < 0.001$, n = 601).

seabirds, and albatross in particular, spend several years visiting potential breeding sites before reaching sexual maturity (Fisher and Fisher 1969, Podolsky 1985). I demonstrated that their behavior during this prospecting period can be manipulated. It is likely that sustained artificial stimulation of a prospected site for several years could result in the establishment of a breeding colony. One or two pairs of Laysan Albatross have unsuccessfully attempted to breed at Kilauea Point each year since the attraction experiments.

Both models and vocalization playbacks of seabirds have been used to attract birds to suitable nesting sites: Little Terns (*Sterna albifrons*; Britton 1982, Kotliar and Burger 1984), Common Terns (*S. hirundo*) and Arctic Terns (*S. paradisaea*) (Kress 1983), Black Skimmers (*Rynchops niger*; Slaydon 1981), White-tailed Tropicbirds (*Phaethon lepturis*; Wingate 1978), Atlantic Puffins (*Fratercula arctica*; Kress and Nettleship 1988), Leach's Storm-Petrels (Podolsky and Kress 1989), and Dark-rumped Petrels (*Pterodroma phaeopygia*; Podolsky and Kress in prep.). In several of these studies, however, models, sound, or both were used in conjunction with either predator control or substrate modification. Together these studies indicate that nest-site selection can be manipulated.

The receptivity of Laysan Albatross to the artificial social stimuli may be explained by their dependence upon colonial breeding. Alexander (1974) and Hoogland and Sherman (1976) proposed that coloniality evolves when the advantages of group breeding outweigh the disadvantages. They argue that there may be only

three evolutionary advantages to coloniality: lower susceptibility to predation (Hamilton 1971), improved foraging, and an increase in the probability of meeting or gaining a mate. Because albatross are colonial breeders, the sight and sound of conspecifics at a particular site is a strong indication that the site is worth visiting. My results support strongly the importance of conspecifics in the breeding-site selection process among albatross and perhaps other colonial birds. Visual and auditory displays function in a variety of contexts. These may include mate attraction (Tinbergen 1953, 1959), mutual mate assessment (Nisbet 1973, 1977; Simpson 1973), maintenence and strengthening of the pair bond (Smith 1977), coordination of intrapair activities such as nest relief and feeding of the young (Smith 1977), development of species recognition (Norton-Griffiths 1967; Beer 1970, 1975), synchronization of colonial breeding (Darling 1938), and attraction of prebreeders and first-time breeders to the colony (Lack 1954, 1966; Orians 1966; Podolsky and Kress 1989).

Both the landing behavior and the distribution of albatross on the ground at Kilauea Point indicate that albatross were attracted to the artificial stimuli. Albatross appeared significantly closer to pairs of models than to single models, to 3-D models than to 2-D models, and to sky-pointing models than to head-forward models. I suggest that Laysan Albatross are sensitive not only to the realism of the stimuli but to the social grouping and behavioral state of the stimuli as well. The active speakers were also a point-source of attraction. This pattern of "choice" is difficult to interpret because of the diversity of functions that have been attributed to courtship displays.

There are presently 60 species of endangered colonial birds; of these, 30 are seabirds (King 1981). Many are endangered because of the destruction of their colonies by introduced predatory mammals (King 1981). Attraction of prospecting birds to safe sites shows great potential for managing threatened seabirds. This is especially true where prebreeders are known to prospect at predator-free sites or at sites where predators have been eliminated. To the extent that the data reported for Laysan Albatross are applicable to other colonial birds, attraction by way of simulating social stimuli may aid in their management and restoration. Attraction programs could augment other management efforts that include habitat restoration, control of exotic mammals, and reestablishment of populations by way of translocation.

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