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CENSUS TECHNIQUES AND METHODS FOR MONITORING POPULATION TRENDS AND REPRODUCTIVE SUCCESS OF MARINE BIRDS:

A PRELIMINARY ANNOTATED BIBLIOGRAPHY

by

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Key words: Marine Birds, Seabirds, Colonial Waterbirds
Census Techniques, Monitoring Techniques,
Population Trends

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Abstract

Census and monitoring technique or quite varied and in many ceres poorly worked out for seabirds. This annotated bibliography draws together 79 published and unpublished sources which are helpful in designing and conducting such activities. It will also serve as a basis for such material which can be updated and conested.

Introduction

Alaska, with probably 40-80 million nesting seabirds, is one of the world's most important seabird areas. Many of the species which nest along Alaska's coast have a limited range and in many cases, Alaska has nearly the entire world's populations. While overall population numbers are huge, this does not mean that we need not concern ourselves with their walfare. While some species number in the millions and nest widely (Murres, Black-legged Kittiwake, Tufted Puffin), other populations are restricted to a few sites (Red-legged Kittiwake) or at low population levels (Whiskered Auklet, Aleutian Tern).

Little scientific work or even basic inventions had been done on this resource until the mid-1970's. At this time, interest in seabirds was heighten due to the increased realization of the significance of the resource brought out by the Alaska lands dedate and establishment of the Alaska Maritime Naional Wildife Refuge. Also the potential for harm to seabird populations was increasing drematically from oil development, fisheries depletion of prey stocks, and gill-net mortality, increasing tourism, etc.

Seabirds have varied nesting behavior and use a variety of habitats. A census or monitoring technique used for one species usually will not work for another. In fact, different techniques must often be used for the same species in different locations. A species that nests in burrows at one location, may nest in talus at another, and rock crevices at a third. Good censusing and monitoring techniques have not been worked out for many species.

This bibliography is intended to bring together the published and unpublished literature that may be helpful to the monitoring and censusing of Alaskan seabirds. Many of the papers presented here are about species which nest far from Alaska. While some of these are about quite different species, the techniques used in studing them may be applicable to the Alaskan situations.

~~This report covers both published and unpublished literature.~~ We felt that it was absolutely essential to include unpublished material since it represents a large part of the material available on Alaskan species.

We have not included colony catalogs in this review. Many of these have been done and while some of these give biref discriptions of methods, they are primarilly a complication of results. ~~Usually data is~~ from many investigators using varied techniques. We did not feel these would be appropriate for this review.

We hope that this report will be useful to you, and we ~~would~~ welcome any comments, additions or suggestions that could improve ~~upon~~ it~~'s effort.~~

METHODS AND ORGANIZATION

The annotated section, which makes up the main protion of the bibliography, is arranged by author and year of publication. Thus, the citation codes are in ascending authorship and chronological order. The annotation itself is usually from the original publication and the source is identified by one of the following alpha codes:

AA Author's (Authors') Abstract

AC Author's (Authors') Conclusions

AD Author's (Authors') Discussion

AM Author's (Authors') Methods

AR Author's (Authors') Results

ARD Author's (Authors') Results and Discussion

AS Author's (Authors') Summary

An "F" preceding any of the above source codes indicates "From", noting that some modification has been made in the Author's (Authors') Abstract, Summary, etc. This modification usually relates to shortening the abstract or summary, slightly changing sentence structure or standardizing abbreviations. Unmarked annotations were developed by the compiler.

ANNOTATED BIBLIOGRAPHY

A01 ADAMS, N. J. 1982a. Subantarctic skua remains as an aid for rapidly assessing the status of burrowing petrels at Prince Edward Island. Cormorant 10: 97-102.

A02 ADAMS, N. J. 1982b. Subantarctic skua prey remains as an aid for rapidly assessing the status of burrowing petrels at Prince Edward Island. Cormorant 10: 97-102.

Identification of prey remains provided useful information on the approximate densities of different species of burrowing petrels within preferred habitat areas. The data may be subject to bias if individual skuas within localized areas exhibit prey specialization. It is suggested that a better indication of the relative densities of burrowing petrel species might be obtained by determining the search effort, expressed as remains found per unit time within a particular area.

A03 ANDERSON, D. W., and I. T. ANDERSON. 1976. Distribution and status of brown pelicans in the California current. Amer. Birds 30: 3-12.

Dispersion patterns and population trends of California brown pelicans

(*Pelecanus occidentalis californicus*) were studied through the use of National Audubon Society Regional Reports and Christmas Bird Counts from 1949 through 1974. Data were then compared to our own and other sources of information. Christmas Bird Count population indices for brown pelicans off California suggest historical fluctuations in relation to fluctuations of major food fish, but also a long-term, general decline from the mid-1950's, some recovery in the mid-1960's, and a continuation of the decline through 1972-74. FAS

A04 ANDERSON, S. H., P. H. GEISSLER, and D. K. DAWSON. 1980. Coastal and marine data base. U.S. Fish and Wildlife Service. FWS/OBS-80/39. 54 pp.

A05 ARBIB, R. S. 1979. On the art of estimating numbers. Amer. Birds 26: 706-712.

The author concludes that it is possible for observers "to improve dramatically their estimating skills, to the extent that they will be able to 'count' flying and quickly-glimpsed flocks up to 50 individuals with no more than two per cent error, up to 100 by no more than three per cent error, and a flock of 1000 or more with less than five per cent error." A simple training program is outlined which makes use of such common household items as rice grains, beans, puffed cereals, sunflower seeds, etc., as the objects to be counted.

B01 BEAVER, R. D., and V. LEWIN. 1981. Scheduling censuses of breeding white pelicans (*Pelecanus erythrorhynchos*) in northern Alberta. Can. Field-Nat. 95: 198-201.

In May 1976 and June 1977 aerial surveys were flown over Birch Lake in northeastern Alberta to determine the numbers of white pelicans (*Pelecanus erythrorhynchos*) occupying nests. Ground counts conducted concurrently with the 1977 aerial surveys revealed that the aerial counts included some pelicans not occupying nests. Pelicans that were present but not occupying nests were loafing birds, either non-breeders, mates off the nest, or both. Evening rather than morning census flights are preferable, because the number of such loafing pelicans appeared then to be lower. Censuses to record numbers of incubating pelicans in northern Alberta should be conducted in late May or early June during the peak of the incubation period. AA

B02 BEDARD, J. 1969. The nesting of the crested, least, and parakeet

auklets on St. Lawrence Island, Alaska. Condor 71: 386-398.

Thirty quadrats, 14.2 m to a side were marked out on the slopes of Sevuokok Mountain (17) and Kongkok Basin (13). The 14.2 m dimension proved the most adequate for covering the stripe-like stretches of nesting habitat and provided an easy-to-handle surface value of 200 m^2. Censuses were conducted from a vantage point that was always more than 40 m from the quadrat to minimize possible disturbances. This meant elimination of total randomness in selecting the quadrat location. All censuses were conducted between 05:00 and 08:00 during the few days preceding laying, coinciding with a minimum daily attendance of immature birds in the colony and maximum activity of breeding birds on the surface of the slope. Tallies were made every 30 min during the 3 hr period, on three successive days. Between 5 and 20 tallies per species were available for each quadrat. In a few quadrats prominent boulders protruding above the surface were used as landing spots by birds nesting beyond the quadrat boundaries. After a disturbance an abnormally high tally was obtained in such quadrats. For this reason, the standard procedure in averaging census values was to ignore the highest count in each quadrat, thus correcting for the aberrant series of counts without affecting the normal ones. It is also obvious that low census figures do not have as much importance as the high ones since partial or complete disturbances were common during the censuses (passage of a gull, a fox, etc.). The average density figures were obtained by averaging the second, third, and fourth highest census figures for each quadrat. To render values of density comparable between quadrats, the average densities had to be corrected for two unrelated variables affecting them: (1) percentage of the quadrat occupied by the birds, with correction to 100 per cent occupancy whenever needed, and (2) thickness of the mantle of rocks on the slope, with correction to a uniform depth of one meter. FAM

B03 BIRKHEAD, T. R., and D. N. NETTLESHIP. 1980. Census methods for murres, Uria species: a unified approach. Canadian Wildlife Service Occ. Pap. 43.

Methods are presented for estimating (a) population size and (b) population status of common murres (Uria aalge) and thick-billed murres (U. lomvia). Four colony types in which murres breed are described and methods for estimating population size for major colony types are presented. Population status can be determined only through the use of study plots within selected study colonies. Two methods of determining population status are described. Type I counts provide a precise record of the number of breeding pairs on study plots, but require at least 6 weeks to complete. Type II counts provide a record of mean numbers of individuals on study plots and take only 10 days to complete, but the results are more difficult to interpret than those for type I. The geographic location of study colonies, frequency of counts and potential sources of error are discussed. AA

B04 BUTLER, R. G., and D. MULLER-SCHWARZE. 1978. Penguin census by aerial photo-graphic analysis of Cape Crozier, Ross Island. Antarctic. J. U. S. 12: 25-27.

B05 BUCKLEY, P. A., M. GOCHFIELD, and F. G. BUCKLEY. 1977. Efficacy and timing of helicopter censuses of black skimmers and common terns on Long Island, N.Y.: a preliminary analysis. Proc. Conf. Colonial Waterbird Group 1977: 48-61.

Helicopter and ground census data are contrasted for black skimmers and common terns in two colonies on the Jones Beach strip, Long Island, N.Y. for 1974-1977. Findings include, aside from raw population data: (1) all skimmers along this 20-mile barrier beach apparently form one breeding population; (2) increasing steepness of phenology curves as colony sizes increase suggests either a high degree of social facilitation or a narrow optimal time for egg-laying and presumably for chick-raising by skimmers, or both; (3) sometime around 15-16 June appears to be optimal for aerially censusing skimmers on the South Shore of Long Island; (4) it is reasonable to attempt a skimmer population assay across an entire season, with only +5% error, from only one helicopter census at the optimal time; (5) an empirical, multiplicative conversion factor of 0.92 applied to counts of adult common terns yields a good approximation of the actual number of breeding pairs present across an entire breeding season with an error of -12% to +18% for the present study; (6) an empirically derived regression equation reduces this error to 14±%; (7) for future studies of this kind, we propose measures of observer accuracy (% deviations in predicted Xs from observed Xs) and of observer precision (regression r^2 values). Additional work refining and extending these findings is urged. AS

B06 BYRD, G. V., R. H. DAY, and E. P. KNUDTSON. 1983. Patterns of colony attendance and censusing of auklets at Buldir Island, Alaska. Condor 85: 274-280.

Daily and seasonal colony attendance patterns and census techniques for crested (*Aethia cristatella*), least (*A. pusilla*), and whiskered (*A. pygmaea*) auklets were examined at Buldir Island, Alaska. Two daily peaks in colony activity were found throughout the breeding season: the first in the morning and early afternoon and the second just before dark. A new technique for estimating auklet populations was developed, based on the net movement of birds to and from the talus nesting area during the two peaks of activity. The new "Net Movement" technique yielded considerably higher estimates than those obtained using Bedard's (1969) method of estimating auklet populations by observation. Both techniques have advantages and disadvantages for censusing auklets, depending on circumstances. AA

B07 BYRD, G. V. 1984. Diurnal auklets in the Bering Sea—the problem of determining population trends. Unpubl. Admin. Report, U. S. Fish and Wildlife Service, Homer, Alaska. (Prepared for a conference of Monitoring Seabird Populations in the Alaska Outer Continental Shelf Region, sponsored by Minerals Management Service, Anchorage, Alaska, November 15-17, 1984.)

By means of a detailed literature review, the author discusses the "where," "when," "how frequently," and "how to" of monitoring auklets in the Bering Sea. The "how to" section includes activity patterns at colonies, age-related activity patterns, monitoring schemes based on counts of birds, and other methods of monitoring. A step-down outline for a population monitoring scheme is presented.

C01 CAIRNS, D. 1979. Censusing hole-nesting auks by visual counts. Bird-Banding 50: 358-364.

Data from daily and seasonal occurrences of hole-nesting black guillemots, Atlantic puffins, and razorbills are used to determine optimum count times, correction factors, and expected errors for the estimation of breeding populations from visual counts. The relative stability of early morning guillemot counts in three study areas suggests that such counts can provide reasonably precise indices of colony size if they are repeated several times. However, differences in attendance patterns among colonies will preclude the direct estimation of true breeding population from visual counts. The attendance of puffins and razorbills at the colony fluctuated widely, and visual counts of these species are of limited use as population indicators. AS

C02 CARTER, H. R., K. A. HOBSON, and S. G. SEALY. 1984. Colony-site selection by pelagic cormorants (Phalacrocorax pelagicus) in Barkley Sound, British Columbia. Colonial Waterbirds 7: 25-34.

To determine the size of nesting populations of pelagic cormorants, all colony sites in an area must be located. This can be done only by thoroughly searching all coasts so that the small colonies in inconspicuous sites are found. Such searches, however, must be conducted over several years so that the sites that are not used annually also may be identified. We suggest that a census be undertaken in early June to determine which sites the "early" breeders are using, followed by a second census in mid to late July to determine the sites being used by "late" breeders. Nest and site failures that may have occurred and possibly resulted in the merging or switching of colony sites may then be identified. Nesting should be confirmed in "suspected" sites so that the numbers of active nests in all sites can be determined. We must modify the view that all colonies are stable entities. Pelagic cormorants appear to have a-dynamic colony structure that is most noticeable in small colonies. Although these small colonies may contribute relatively little to the overall nesting population size in some years, in certain areas they are the only source of new birds. They represent the response of nesting pelagic cormorants under certain environmental conditions and should not be ignored in censuses. One census of only the "key colonies" every 3-5 years, as suggested by Manual and Campbell (1979), clearly is not sufficient to monitor total pelagic cormorant populations. FARD

C03 CRAIGHEAD, L., and J. J. HICKEY. 1977. A census of Pribilof seabirds: some aspects of daily ledge attendance. Pac. Seabird Group Bull 4(1): 24. (Abstract only)

See HICKEY and CRAIGHEAD (1977).

C04 CUSTER, T. W., and R. G. OSBORN. 1977. Wading birds as biological indicators: 1975 colony survey. U.S. Fish and Wildl. Serv. Spec. Sci: Rep. Wildl. 206.

The use of wading birds to their full potential as biological indicators requires further exploration. Survey and reproductive success methods need to be tested, the survey of colonies repeated, available historical information assembled, and habitat requirements measured. FAA

D01 DESGRANGES, J. L. 1979. A Canadian program for surveillance of great blue heron (*Ardea herodias*) populations. Proc. Colonial Waterbird Group 3: 59-68.

A series of inspection tours of heronries throughout Canada was started in 1979. The short term objective of this program is to provide annual indications of fluctuations in great blue heron populations in Canada. The medium term objective is to identify, through analysis of these fluctuations, research priorities on the autoecology of the great blue heron, its regional nesting particularities and the main causes of mortality. We shall then be able to make recommendations with a view to protecting and managing these populations. The long term objective is to perfect our knowledge of great blue heron distribution and abundance and to present this information in the form of an atlas. The methods used are simple so as to permit recruitment of amateur naturalists to collect the data, thus considerably reducing manpower requirements and program costs. Their flexibility constitutes another important asset, since they could be adapted to the availability of participants and to regional differences in the nesting biology of the great blue heron. Lastly, they were designed to cause the least possible disturbance within the colonies. The precision of results obtained from those methods was tested and proved satisfactory.

A simple model, based on the relative importance of chick mortality within broods and total brood losses, is presented which will serve as an aid in identifying the potential causes of mortality. AS

E01 ERWIN, R. M. 1977[a]. Recommended census technique for estimating seabird breeding numbers. Mass. Coop. Wildl. Res. Unit., Univ. of Massachusetts, Amherst. Unpubl. MS.

Not seen.

E02 ERWIN, R. M. 1977[b]. Population and colony site dynamics in selected

Massachusetts waterbirds. Proc. Conf. Colonial Waterbird Group 1977: 19-25.

Using a turnover index derived from island biogeographic studies, colony site turnover rates were calculated for least and common terns, herring gulls, and black-crowned night herons. Population growth rate, disturbance (predation, man), and gull competition were felt to contribute to colony site turnover but unknown factors (food supply changes, anti-predator strategies, etc.) were also felt to be significant. Suggestions for applying colony turnover indices to management programs, studies of demic exchange among breeding groups, and community interactions are made. FAS

E03 ERWIN, R. M. 1980. Censusing waterbird colonies: some sampling experiments. Trans. Linnaean Soc. New York 9: 77-86.

The results of several small-scale ("within-colony") and large-scale ("among-colonies") sampling procedures in colonial waterbird colonies are examined. In general, strip transect methods (20% sample) appeared to be superior to point-centered quarter or quadrat sampling methods both in the field and using an artificial population model. Further, the strip transect is equally effective under three spatial regimes (random, clumped, uniform) while the quarter method is suggested only when nests are randomly distributed. Regression analyses of (aerial) adult estimates vs. selected nest counts revealed high variability both among species and "among censuses" for a given species. Observer differences in estimation ability probably account for much of the variance. Large differences in the adult/nest ratio were found among species because of differences in nesting vegetation density, plumage color, colony attendance, behavior, etc. Three statistical treatments of the data used in the least squares regression analyses revealed that, as a safeguard, census data should be log transformed before further statistics are applied. AA

As illustrated by these results (and those of others before), any breeding census of waterbirds, whether at the single-colony or regional level, will yield only an approximation of the total number actually nesting throughout the season. Setting a goal of high census accuracy is not only unrealistic, then, but may be counterproductive because of the disturbance induced. The most important factor in obtaining systematic sampling results is probably observer consistency. A given observer's estimate may be quite inaccurate but as long as he is consistent (high precision), his "bias" can be calculated and corrections made accordingly. Using the same observers repeatedly allows comparisons among years with the emphasis on the relative, rather than absolute, numerical changes. FAD

E04 ERWIN, R. M. 1981. Censusing wading bird colonies: an update on the

"flight-line" count method. Colonial Waterbirds 4: 91-95.

Thirteen mixed-species heronries (10 in Florida, two in Virginia, one in North California) were studied in 1980 as part of a project begun in 1979 aimed at evaluating the "flight-line" census method. Standardized counts of snowy and cattle egrets, Louisiana and little blue herons flying to and from the nesting colony were made for three hr periods, followed by a nest count of the colony. Significant differences were found in the flight rates (number of birds per nest x hour) of the four species at the Chincoteague colony. However, when cattle egrets and Louisiana herons were compared at all 13 colonies, their respective flight rates were in opposite rank to those at Chincoteague. Colony differences, then, may mask species differences. A linear regression model showed a strong fit ($R^2 = 0.92$) between the hourly flight number (3 hr means) and the nest number, but point estimates (single colony) had very large confidence limits. A given colony might be over-or underestimated by a factor of 2, using the regression equation as a predictive model. A more appropriate application of the method would be to determine region-wide (e.g., state), rather than colony-specific, population estimates. "Total" estimates for all (n = 13) colonies were within 10% of the actual nest number. AS

E05 ERWIN, R. M. 1982. Observer variability in estimating numbers: an experiment. J. Field Ornithol. 53: 159-167.

The effects of observer differences, prior experience, training, and numerical magnitude on accuracy in estimating numbers of birds from photographs were examined. Groups of 10 vertical photographs of waterfowl were shown on 5 consecutive days to 3 observers in each of 3 experience groups: inexperienced, those with past experience, and those with recent experience. Results from reinforcement tests showed that, because of marked individual differences, the effects of experience level and training on estimation accuracy were not statistically significant. Without reinforcement, however, experienced observers were more accurate than inexperienced observers. The most apparent pattern was for inexperienced observers (n = 6) to underestimate across all numerical ranges, but most strongly when N 1000. Observers with recent experience (n = 3) only underestimated when numbers were small (300). Despite large errors made on individual photographs by all observers, the overall deviations (summed over 50 photos) were very low. Eight of the 9 observers' estimates were within 10% of the total count when reinforcement was given. Density of the birds on the photographs appeared to have a very limited effect on both accuracy and tendency to underestimate. The results are discussed in relation to findings by perceptual psychologists and to applications for bird censusing. AS

E06 ERWIN. R. M., and T. W. CUSTER. 1982. Estimating reproductive success in colonial waterbirds: an evaluation . Colonial waterbirds 5: 49-56.

To estimate reproductive success in a population one ideally would like to determine the number of young fledged per nesting female. However, this is difficult because often (1) the adults are not individually marked, (2) the colony is not visited daily, and (3) the investigator is unable to monitor all young until they fledge. If adults are unmarked and successful renesting occurs, reproductive success will be underestimated. If a colony is not visited daily and nests are initiated and lost between visits, reproductive success will be overestimated. The Mayfield method is one approach to overcoming this latter problem. Finally, nestling colonial birds are often able to move away from the nest site well before fledging and thus avoid being detected. To overcome this problem capture-recapture methods and enclosures have been used. In this paper we discuss these limitations and evaluate methods of dealing with them. AA

E07 EVANS, P. G. H. (ed.) and the Census Committee. nd. [1981]. Auk censusing manual. The Seabird Group, 13 pp.

The major objective of this manual is to describe the methods presently considered best for estimating the numbers of individuals or breeding pairs of auks at colonies or at study plots within colonies. Techniques are grouped into three levels of intensity: (1) "Whole Colony Assessment" (one-time visit to the colony), (2) Study Plot Estimates—Annual Surveillance (counts repeated several times during the season to provide a more accurate measure of population size and to detect status changes over a period of years), (3) Detailed Population Studies (generally the domain of the research biologist). Techniques are detailed for four species: common murre, razorbill, black guillemot, Atlantic puffin.

F01 FERNS, P. N., and G. P. MUDGE. 1981. Accuracy of nest counts at a mixed colony of herring and lesser black-backed gulls. Bird Study 28: 244-246.

The average number of nests missed during the first count was 17% (range, 5-49). The efficiency and accuracy of nest counts can be improved by marking the rims of each nest with spray paint during an initial pass through the colony, and determining the ratio of marked to unmarked nests during a second count. The number of nests missed is probably largely dependant on the type and amount of vegetation in the nesting colony. Kadlec and Drury (1968) found that "over 95 percent of the herring gull nests were found on the first search and virtually all of them were found in two searches."]

G01 GASTON, A. J. 1984. Notes for Alaskan seabird meeting on monitoring

methods. Unpubl. Admin. Report, Canadian Wildlife Service, Ottawa. (Prepared for a conference on Monitoring Seabird Populations in the Alaska Outer Continental Shelf Region, sponsored by Minerals Management Service, Anchorage, Alaska, November 15-17 1984.)

Monitoring is defined as "The detection of changes in population occurring over time." Monitoring nearly always involves sampling, which leads the investigator to consider (1) what and where to sample, and (2) how to sample. To illustrate the rationale followed by the Canadian Wildlife Service in setting up their seabird monitoring program, the author uses the cliff-nesting thick-billed murre and the burrow-nesting ancient murrelet as examples. A useful reference.

G02 GASTON, A. J., D. N. NETTLESHIP, and R. G. B. BROWN. 1983. A seabird program for eastern Canadian Wildlife Service, Ottawa.

"Although adequate descriptions of most monitoring techniques are already in existence ... we recognize that no amount of writing can replace first-hand experience in communicating methodologies between field workers. In addition, experienced observers are usually more adequate and more rapid in conducting surveys than those new to the species concerned. We therefore urge that monitoring be conducted by a small cadre permanently (though not exclusive) assigned to this activity, and that all parties sent into the field to monitor existing baseline study plots include at least with monitoring techniques for the species involved, having been trained by someone with experience. We do not believe that any progress can be made with monitoring unless these procedures are adhered to."

Monitoring techniques may be classified into four categories: (1) fixed study plots, marked on the ground or on photographs of the site, within which numbers of birds or occupied burrows are counted--usually used for large colonies; (2) entire colony counts, where all birds or nests are counted--suitable for small colonies; (3) aerial photographic counts--suitable for conspicuous birds breeding on open sites; (4) extensive aerial surveys followed by ground counts--required for species nesting in small, ephemeral colonies. Two types or levels, of monitoring are distinguished in the Canadian scheme: (a) detailed observations over at least one full breeding season, including baseline data on reproductive success as well as plot or colony counts; (b) rapid monitoring involving only counts of birds, nests or occupied burrows and taking no more than 2 weeks.

G03 GASTON, A. J., D. G. NOBLE, and M. A. PURDY. 1983. Monitoring breeding biology parameters for murres _Uria_ spp.: levels of accuracy and sources of bias. J. Field Ornithol. 54: 275-282.

We performed replicate observations on breeding thick-billed murres, using the Type I method of Birkhead and Nettleship (1980) to test the comparability of results obtained by different observers and the accuracy with which timing of breeding, numbers of eggs laid, and breeding success could be determined. All of the critical parameters appeared to be relatively insensitive to observer bias and to differences in the amount of time devoted to observation beyond a certain point. Some systematic biases in the method can be corrected to improve the accuracy of final results. The accuracy of all the estimates is higher when hatching success is high than when many eggs are lost.

On the basis of these findings the level of effort recommended for this type of monitoring by Gaston and Nettleship (1981) of 3 h per day for a plot supporting 80 breeding pairs of murres appears very adequate and should yield figures for total eggs laid within 5% of the true number. AS

H01 HANSSEN, O. J. 1982. Evaluation of some methods for censusing larid populations. Ornis Scand. 13: 183-188.

Three different methods for censusing larid populations are described and evaluated against population estimates of four larid species on two skerries in the Ostfold archipelago, SE Norway. When the birds were censused from the highest point in the colony during five minutes after arrival, the best estimate was obtained. For morning censuses during the incubation period, all values were in a range of ± 10% of the estimated breeding populations. Morning censuses were also quite robust against differing experience of the observers. Time of day did not influence the census results significantly. AA

HO2 HARRIS, M. P. 1976, The present status of the puffin in Britain and Ireland. Briti Birds 69: 239-264

The difficulties of interpreting counts of birds have already been stressed, but these counts are all we can hope to get in many colonies where burrows are inaccessible. To be of greatest use they should be undertaken several times a year and comparisons made between the annual maxima in spring or late summer. The most useful are those made early in the season, when breeders first return to the colonies and congregate on the sea below. Unfortunately few people visit colonies at this time. The late counts include breeders and immatures and bear only a complicated and ill-understood relationship to the number of breeding paris. However, if they are made several times a year during approximately the same weeks, annual coimparisons of maxima are still possible. Whenever counts are made it is imperative to record the time (evening or very early morning always give the highest counts), weather conditions and, separately, the numbers of birds on land and on the water. Actual counts should be expressed as individual birds, and if any attempt is made to convert to paris to the method used must be explained in detail. FAC

H03 HARRIS, M. P., and S. MURRAY. 1977. Puffins on St. Kilda. Brit. Birds 70: 50-65.

The easiest method of detecting population changes is to count the numbers of occupied burrows in fixed areas [the authors used permanently staked belt transects which were 3 m or 6 m wide], provided that those sampled are fairly representative of the colonies as a whole. This method is capable of detecting changes on the edges of colonies if transects go completely across a colony, but alloow neither total population estimates to be made nor accuracy to be asessed. To overcome these drawbacks, future monitoring will include a series of smaller quadrats spread through the colony. The number, size and dispersion (conpletely random or stratified) will be decided by field trials [This paper illustrates the difficulty of detecting population changes even at well-studied sites]. FAC

H04 HARRIS, M. P., and C. S. LLOYD. 1977. Variations in counts of seabirds from photographs. Brit. Birds 70: 200-205.

Photographs of seabird colonies are valuable aids for plotting changes in the extent of colonies, or the distribution of birds within a colony, and for checking unexpectedly high or low counts made under rushed or adverse conditions. In some situations (e.g. gannets nesting on the tips of stacks or in large colonies where a human intruder would cause unacceptably high disturbance), aerial photography is the only practical way of obtaining a count. For guillemots and kittiwake nests, however, counts made from photographs are undoubtedly less accurate than those made in the field, and care must be taken in comparing those made by different people. AC

H05 HARRIS, M. P., and S. MURRAY. 1981. Monitoring of puffin numbers at Scottish colonies. Bird Study 28: 15-20.

The number of puffin burrows in sample areas of seven Scottish colonies were counted more or less annually between 1974-1980. Most populations appeared stable but that on the Isle of May was expanding rapidly. It is concluded that the best results come from experienced observers counting small areas of the colony early in the season. Long belt transects running across colonies are needed to show if the colony is expanding or contracting its area, but randomly positioned quadrats have the advantage of giving results of known accuracy. Random monitoring will detect annual changes of 20%. A decline of 30% between one season and the next at one colony could not be attributed to a disaster as the birds returned the next year. AS

H06 HARRIS, M. P., S. WANLESS, and P. ROTHERY. 1983. Assessing changes in the numbers of guillemots Uria aalge at breeding colonies. Bird Study 30: 57-66.

Counting seabirds presents considerable practical problems but it is basically no different from counting any other animal population. Statistical methods based on adequate sampling are essential. It is to the question of how to obtain meaningful samples that this paper is addressed. A series of recommendations if offered. AA

(1) The population to be monitored should be delimited and unambiguously marked on photographs or maps. (2) As many sample plots as can be counted in the available time should be randomly selected as outlined in our methods. (3) The number of guillemots present should be counted between 0700-1200 hours GMT on at least five days every June. (4) The counts should be well spaced out thoroughout the sampling period. All plots should be counted on each date. (5) Counts should be made regardless of

weather as long as conditions allow accurate counting. AR

H07 HICKEY, J. J., and F. L. CRAIGHEAD. 1977. A census of seabirds on the Pribilof Islands. Pp. 96-195 In Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators. Vol. 2. NOAA, Boulder, Colorado.

A census of seabirds nesting on the Pribilof Islands, principally St. George Island, was undertaken in the summers of 1975 and 1976. Ledge-nesting species were estimated from cliff photographs by means of a stratified sampling technique, the counts being adjusted with correction factors for variation in daily and hourly ledge attendance for counts of thick-billed murres. Crevice-nesting species on cliffs of St. George were estimated by using species-proportion figures based on counts of 63 reference ledges. Quadrat and flight counts were used to estimate the least auklets at a large inland colony. FAA

H08 HODGES, A. F. 1977. Counts at kittiwake colonies. Bird Study 24: 119-125.

H09 HUNT, G. L., Jr. Monitoring studies for the Pribilof Islands. Unpubl.

Manuscript, Univ. of California, Irvine. (Prepared for conference on Monitoring Seabird Populations in the Alaska Outer Continental Shelf Region, sponsored by Minerals Management Service, Anchorage, Alaska, November 15-17 1984.)

"The great challenge of monitoring efforts will be to design statistical means of detecting subtle changes in rates [of population trands and reproductive success] despite the background 'noise' of short-tern fluctuations from natural causes." [Makes six recommendations for future Pribilof seabird monitoring efforts.]

H10 HUTCHINSON, A. E. 1979. Estimating numbers of colonial nesting seabirds: a comparison of techniques. Proc. Colonial Waterbird Group 3: 235-244.

Four basic inventory methods available for estimating numbers of nesting gulls and cormorants (direct nest counts, ground visual estimates, aerial visual estimates, and counts from photographs) were compared. Nest counts, with a ± 5% error, proved to be the most reliable technique for estimating numbers of breeding gulls. Predictions from photo counts offer a second choice but the error increases to ± 33%. Ground and aerial visual estimates give a relative appraisal of the total population size but with errors of ± 71 and ± 140% respectively, these 2 techniques proved to be unacceptable for accurately predicting nesting populations. For cormorants, nest counts again proved to be the most reliable technique with a ± 5% error. Predictions from photo counts offer a close second choice with an error increases to ± 12%. Aerial, visual estimates with a ± 56% error and ground, visual estimates, with a ± 82% error, again were unacceptable predictors of nesting populations but could be used to give relative population estimates. In most cases, any inventory of colonial nesting birds will combine various modifications of any or all of the above mentioned techniques. The ultimate selection will depend on the over-all objectives of the project, the desired reliability, the species involved, the available money, manpower, and time. The particular advantages and disadvantages of each inventory technique must be considered and the technique may change from colony to colony. However, a primary objective in all inventories should be to establish meaningful estimate with a known reliability and furthermore, one that could be duplicated or compared to in the future. If these basic standards cannot be met, the necessity of inventorying at all is open for question. FAS

I01 IRONS, D. B. 1983. Techniques for low-maintenance, long-term data collection using time-laspe photography. Pac. Seabird Group Bull. 10: 56. (Abstract only)

Time-laspe photography is a relatively low-cost and low-effort method of collecting biological data. The period of time a roll of film will last is the limiting factor as to how long a camera can run without attention. Most movie cameras have a maximum time-lapse interval of one frame per minute, which allows a roll of film to last up to 2 1/2 days. Another limiting factor is battery life. Batteries last up to several days. Recently we developed techniques that permit a camera to operate up to eight months without attention. The period of time a roll of film will last can be increased by lengthening the interval between photographs with an inexpensive external intervalometer. The auddition of a solar panel increases battery life. These techniques drastically reduce effort needed to maintain time-lapse cameras, thereby greatly increasing the possible uses of time-lapse photography for collection of biological data. AA

J01 JONES, E. 1980. A survey of burrow-nesting petrels at Marquarie Islands based on remains left by predators. Nortornis 27: 11-20.

K01 KADLEC, J., and W. DRURY. 1968. Aerial estimation of the size of gull breeding colonies. J. Wildl. Manage. 32: 287-293.

Counts on photographs and visual estimates of the numbers of territorial gulls are usually reliable indicators of the number of gull nests, but single visual estimates are not adequate to measure the number of nests in individual colonies. To properly interpret gull counts requires that several islands with known numbers of nests be photographed to establish the ratio of gulls to nests applicable for a given local census. Visual estimates are adequate to determine total breeding gull numbers by regions. Neither visual estimates nor photography will reliably detect annual changes of less than about 25 percent. AA

K02 KARTASCHEW, N. 1963. Review of methods of censusing Laridae and Alcidae. Pp. 105-116 In A. Formozov and Y. Isakov (eds.), Organization and methods of censusing birds and harmful rodents. Isreal Program Sci. Transl., Jeruselem (1967).

This is an interesting and informative overview of the various census techniques available as of 1963. Provides a good historical perspective.

L01 LEHNHAUSEN, B., and J. NELSON. 1982. An attempt to monitor storm-petrel populations in southeast Alaska. Pac. Seabird Group Bull. 9: 72-73. (Abstract only)

Precise estimates of storm-petrel population parameters are difficult because these birds are burrow nesters, nocturnal, and patchily distributed within habitats. Permanent line transects have been used for sampling colonies. Some of the problems with this technique are long-term disturbance of plots, difficulty in placement of transects, clumped distribution of nests, and difficulty in statistical testing of results. We attempted to overcome some of these problems by developing a sampling scheme of random plots. In 1982 we gathered population data on storm-petrels at St. Lazaria and Petrel islands in southeast Alaska. On St. Lazaria Island, 130 2-m^2 plots in four habitat strata were sampled, counting all burrows and determining burrow contents. On Petrel Island, 80 2-m^2 plots in three strata were sampled. We then calculated burrow occupancy, species ratios, and population size. Stratification resulted in a small increase in precision of the estimates, so that data could be analyzed as a simple random sample. Sample sizes on both islands were large enough so that a population change of 10% or greater could be statistically detected in subsequent years. Some of the problems with random samples are large sample sizes and observer biases. [See Lenhausen and Nelson (1983) for a detailed discussion.] AA

L02 LEHNHAUSEN, W. A., and J. W. NELSON. 1983[a]. An attempt to monitor storm-petrel populations in southeast Alaska. Pp. 284-294 (Appendix E) In J. W. Nelson and W. A. Lehuhausen, Marine bird and mammal survey of the outer coast of southeast Alaska, summer 1982. Unpubl. Admin. Report, U. S. Fish and Wildlife Service, Anchorage, Alaska.

312pp.

The report provides the supporting data for the abstract of Lehnhausen and Nelson (1982).

L03 LEHNHAUSEN, W. A., and J. NELSON. 1983[b]. A summary of processes followed in designing a scheme for monitoring populations of storm-petrels. Pp. 296-305 (Appendix F) In J. W. Nelson and W. A. Lehnhausen, Marine bird and mammal survey of the outher coast of southeast Alaska, summer 1982. Unpubl. Admin. Report, U. S. Fish and Wildlife Service, Anchorage, Alaska. 312pp.

This report document the thought process and rationale followed in designing the monitoring scheme described by Lehnhausen and Nelson (1983[a]).

L04 LLOYD, C. 1975. Timing and frequency of census counts of cliff-nesting auks. British Birds 68: 505-513.

Regular counts of the numbers of razorbills (Alca torda) and guillemots

(Uria aalge) in a colony throughout the breeding season give valuable information on the variation in attendance. Counts of this kind were made at six of the colonies covered by the annual population monitoring scheme. Most counts were made between 08.00 and 12.00 hours to avoid variation due to diurnal attendance patterns. Counts were least variable during the nesting period and only slightly more variable at other times during the month of June. Providing this month coincides with the nestling period for most birds in the colony, census counts can most conveniently be carried out in June. An error of 17% to 46% in razorbills and 13% to 26% in guillemots must be expected if only a single count is made at a colony; with five or ten counts this error is considerably reduced (5% to 17% for razorbills and 4% to 8% for guillemots with ten counts). The accuracy of counts made during Operation Seafarer in 1969-70 and the annual census at a sample of colonies since are assessed. AS

M01 MANUWAL, D. A., D. ANDERSON, E. KNODER, D. NETTLESHIP, and S. G. SEALY. 1975. Seabird colony census techniques. Unpublished Preliminary Draft, Pacific Seabird Group. 18 pp.

Recommended census techniques are outlined for 38 species of the eastern North Pacific. Very general.

M02 MCCRIMMON, D. A. 1978[a]. The Colonial Bird Register, a computerized

U. S. data base. Ibis 120: 121. (Abstract only)

The National Audubon Society and the Cornell Laboratory of Ornithology organized the Colonial Bird Register as a computerized data base for the collection and dissemination of information about colonially nesting birds. Numerous state and federal agencies, ornithological organizations, as well as private individuals currently census and survey colonies on the coasts of the United States, Alaska and the Great Lakes. The Colonial Bird Register assumes a role as a central organization for the dissemination of much of this data. The Register also encourages the standardization of data collection, helping to assure maximum comparability of information. AA

M03 MCCRIMMON, D. A., Jr. 1978[b]. The Colonial Bird Register: an active and operational national data bauk. Pac. Seabird Group Bull. 5: 53. (Abstract only)

Since 1975, a variety of private, state, regional, and federal projects have surveyed nesting colonies of seabirds throughout North America. The Colonial Bird Register is a unique computerized national data bank for the efficient dissemination for much of this information. FAA

M04 MCCRIMMON, D. A., Jr. 1976. A review of some methods and considerations for the assessment of breeding populations of colonial waterbirds. Proc. Texas Fish-Eating Birds Conf. 4: 36-49.

This paper considers some general recommendations which should be attended to when population assessment of colonially nesting waterbirds is attempted. Evaluations and examples of several colony sampling methods, transect, quadrat, and point-quarter center, are presented. The potential utility of flightline movements for predicting colony nest density is discussed. FAA

M05 MINEAU, P., and D. V. WESELOH. 1981. Low-disturbance monitoring of herring gull reproductive success on the Great Lakes. Colonial Waterbirds 4: 138-142.

A method by which the gross reproductive output of herring gull colonies can be assessed with a minimum of effort and disturbance is presented. Following the method, the number of chicks surviving to a median age of 21 days can be determined with a 95% confidence of ± 10%. A colony specific "chick condition" is also presented. Examples from the Great Lakes are used throughout. AS

M06 MORRISON, M. L., and R. D. SLACK. 1977. Population trends and status of

the olivaceous cormorant. Amer. Birds 31: 954-959.

Regardless of the causative factors, the collaboration of various surveys and literature sources has shown analysis of Audubon Christmas Bird Count data to be extremely useful in identifying population trends in wintering cormorant populations. FARD

M07 MURPHY, E. C. 1979. Monitoring populations of breeding seabirds. Final report. U. S. Fish and Wildlife Service Contract 14-16-0001-78119.

M08 MURPHY, E. C., M. I. SPRINGER, D. G. ROSENEAU, and A. M. SPRINGER. 1980. Monitoring population numbers and productivity of colonial birds. Pp. 142-272 In Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators. Vol. 1.

This report is an excellent example of how to gather information for a monitoring study, analyze the data, and present the results. Data collected at Cape Thompson and Bluff in 1975 are summarized and compared with similar data gathered in previous years. Good descriptions of census methods and statistical procedures. It should be required needing for anyone contemplating setting up a monitoring program.

N01 NETTLESHIP, D. N. 1976. Census techniques for seabirds of arctic and eastern Canada. Canadian Wildlife Service Occ. Paper 25. 33 pp.

This paper reports on the various census techniques that have been used and tested during a lengthy study of the breeding and pelagic distributions of seabirds in the western North Atlantic and adjacent parts of the Arctic Ocean by the Canadian Wildlife Service's program "Studies on northern seabirds". Emphasis is on census techniques used to estimate population size and monitor changes in bird numbers at colonies of individual species within the families Procellariidae, Hydrobatidae, Sulidae, Phalacrocoracidae, Laridae, and Alcidae. The methods employed for gathering quantitative information on bird numbers at sea are also briefly reviewed. The immediate purpose of this manual is to attempt to standardize census procedures used by investigators in the study region, in the hope that the techniques will be sufficiently precise to measure real changes in numbers within individual colonies and be sufficiently rigid to reduce observer error to a minimum, thus making the data more valuable in identifying substantial numerical changes and geographical shifts of species populations. The methods described are group-specific, not species-specific, in that the census procedures outlined can be extended to species breeding in similar situations or habitats in other geographic areas. AA

N02 NETTLEHSIP, D. N. 1978. Population analysis of colonial nesting seabirds from photography. Ibis 120: 119. (Abstract only)

Procedures used to census colonial nesting seabirds in the past have varied widely, ranging from simple visual impressions of bird numbers to ground counts of nests. This variation in census reliability and accuracy has often made it impossible to make precise comparisons between population estimates made in different years. To avoid similar difficulties in the collection and interpretation of data in the future, a standardized census method is required to reduce individual observer bias to a minimum and to provide a permanent and precise record of the distribution and numbers of nesting birds (Nettleship, 1976).

The technique of population analysis from photography provides an effective solution for monitoring certain cliff-face (gannet, kittiwake, Brunnich's guillemot) and cliff-top (gannet, gulls, guillemot) nesting species. The accuracy of the method varies with the species involved, but in most cases it does provide a precise and permanent record of numbers and distribution of breeding birds which can be used to identify numerical changes and geographic shifts of species population. Moreover, detailed information on infra-colony structure and nesting habitat usage can also be determined. FAA

NO3 NEWMAN, A. 1983[a]. the effect of sampling design on estimates of reproductive success. Pa. Seabird Group Bull. 10: 47-48. (Abstract only)

In order to monitor changes in the reporductive success of seabirds, it is important to determine the proper variance and confidence intervals associated with the mean success rates observed in study nests. The proper equations depend on the dampling methods used to select the study nests. Four commonly used sampling methods are representative sampling, simple random sampling (SRS), clustered random sampling, and stratified random sampling. Hypothetical examples are used to illustrate the large potential effect of each of these sampling methods on the variance and confidence intervals for a single set of reproductive success data. For representative samples, statistical estimates of variance and confidence intervals are not possible. For a typical clustered random sample, the 95% confidence interval was twice as wide as the simple ramdom sample interval when the covariance between success and cluster sizse wad moderate. However, the clustered smaple's interval was reduced to half the SRS interval when the covariance was high. Stratified sampling reduced the SRS confidence interval only slightly. These results illustrate how inappropriate use of SRS estimates can affect the

sensitivity and reliability of seabird monitoring programs. FAA

N04 NEWMAN, A. 1983[b]. Natural variation in black noddy egg size. Pac. Seabird Group Bull. 10: 52 (Abstract only)

Egg size depends on many aspects of the bird's environment, and it may provide an integrated picture of a bird's condition prior to egg-laying. To use egg size as an effective index of the pre-laying condition of seabird populations, natural variation in egg measurements must be both low and predictable. Egg size measurements may be a useful monitoring tool, especially for remote colonies that are infrequently visited. FAA

N05 NEWMAN, A. n. d. Monitoring manual--reproductive success study--general methods. Draft Unpublished Administrative Report, U. S. Fish and Wildlife Service, Honolulu, HA.

N06 Nisbet, I. C. T., and W. H. DRURY,. 1972. Measuring breeding success in common and roseate terms. Bird-Banding 43: 97-106.

N07 NYSEWANDER, D. R., D. J. FORSELL, P. A. BAIRD, D. J. SHIELDS, G. J.

WEILER, and J. H. KOGAN. 1982. Marine bird and mammal survey of the eastern Aleutian Islands, summers of 1980-81. Unpubl. Admin. Report, U. S. Fish and Wildlife Service, Anchorage, Alaska. 134pp.

The authors describe a sampling technique used to count puffin burrows. Formulas are recommended for converting the sample plot estimates to total population estimates for an entire island.

P01 PRATER, A. 1979. Trends in accuracy of counting birds. Bird Study 26: 198-200.

The consistency of the trend between observers, and the damping down of fluctuations if all observations are averaged, indicate that the overall counts are likely to provide reasonably good comparisons between counts, and possibly even fairly accurate total assessments."

R01 RICHARDSON, M. G., G. M. DUNNET, and P. K. KINNEAR. 1981. Monitoring seabirds in Shetland. Proc. Royal Soc. Edinburgh 80B: 157-179.

The programme for ornithological monitoring in Shetland has concentrated on selected species of cliff-nesting seabirds and inshore waterfowl. Sample study sites throughout Shetland have been selected and standard counting methods derived. These have taken account of factors such as logistics and accessibility, the effects of weather and observer error and of the seasonal and diurnal variations in the numbers of birds. Changes in seabird and waterfowl numbers between 1975-79 have been observed. These, with the exception of the bird mortality following the Esso Bernicia oil spill, have been attributed to natural variation. From the scale and local differences between these as yet short-term observations, estimates are presented of the minimum percentage change required in either numbers of birds or their nests before such natural variation is exceeded. The problems of interpreting changes in numbers are discussed. The number of dead birds picked up in Sullom Voe after the Esso Bernicia spill corresponded closely to that estimated from the monitoring counts before and after the incident. AA

S01 SAVARD, J.-P. L., and G. E. J. SMITH. 1982. Comparison of survey techniques for burrow-nesting seabirds. Pac. Seabird Group Bull. 9: 65-66. (Abstract only)

The accuracy and efficiency of four survey methods (quadrats, transects, point-centered quarter and Batchelor's) were compared in a rhinoceros auklet (Cerorhinca monocerata) colony. Transects of 1 x 50 m averaged 61 min for completion and the point-centered quarter method averaged 5 min per point. Rectangular plots and transects oriented perpendicular to the shore yielded more precise estimates than parallel transects. Systematic sampling tended to be more precise than random sampling. The point-centered quarter method tended to overestimate burrow density whereas the Batchelor's method slightly underestimated it. Quadrats and transects closely approximated a complete count. Small quadrats (2 x 2 m) were more effective per area sampled than larger ones. [see SAVARD and SMITH (1985) for a detailed discussion.] AA

S02 SAVARD, J.-P. L., and G. E. J. SMITH. 1985. Comparison of Survey Techniques for burrow-nesting seabirds. Can. Wild. Serv. Progr. Notes 151. 7 pp.

The accuracy and efficiency of four survey methods (quadrat, transect, point-centered quarter, and Batcheler's) are compared in two colonies of burrow-nesting seabirds. Plots and transects oriented parallel to the shoreline were more variable than those oriented perpendicularly. Small plots provided a more precise estimate of burrow density than large plots for a similar sampling effort (total area sampled). Systematic sampling yielded more precise estimates than random sampling. Both plotless techniques over-estimated the density of burrows in one area and showed no significant difference in the other. Estimates derived from quadrats and transects were more accurate than those obtained from the point-centered and Batcheler's methods. AA

S03 SCHREIBER, E. A., and R. W. SCHREIBER. 1977. Gulls wintering in Florida; Christmas Bird Count analysis. Fla. Field Nat. 5: 35-40.

We find the Christmas Bird Count [CBC] data for the 3 most common gulls wintering in Florida difficult to interpret and present this analysis in part as a caution to others attempting similar studies. We believe that CBC's can in some cases be extremely useful as an index to population trends of certain species (i.e., brown pelicans; Schreiber and Schreiber 1973, Anderson and Anderson 1976). However, as with all new methods, a need for caution exists in the use of CBC's and the means of analysis. [The authors discuss the problems and recommend ways to minimize these problems and potential biases.] FAD

S04 SCHREIBER, R. W., and E. A. Schreiber. 1973. Florida's brown pelican population: Christmas Bird Count analyses. Amer. Birds 27: 711-715.

The complitation of data in this study indicates that the Christmas Bird

Counts, when analyzed as birds per ten party hours, provide a reliable index to the wintering bird populations of a region, at least for a species as conspicuous and well known as the brown pelican. It also clearly indicates the need for data collected in a consistent manner on the annual number of active nests and their level of productivity over long periods of time, and for reliable reporting of the data in the scientific literature. A valuable addition to the Christmas Bird Counts would be reporting of the ages (immature, subadult, adult) of the pelicans sighted. [See SCHREIBER and SCHREIBER 1983.] FARD

S05 SCHREIBER, R. W., and E. A. SCHREIBER. 1983. Use of age-classes in monitoring population stability of brown pelicans. J. Wildl. Manage. 47: 105-111.

The brown pelican (Pelecanus occidentalis) population on the west coast of Florida was censused for 8 years. Annual and seasonal fluctuations in total numbers of birds and age-class composition occurred. The population was highest in summer-fall and lowest in fall-winter. Adults were most common during the breeding season. The ratio of immatures to adults reflected productivity in nesting colonies and techniques for gathering accurate data are outlined. Fluctuations in the population were related to temperature, but additional data on food availability are needed to understand the population stability of this species. Total counts of individuals and age-class ratios are useful in determining population stability, but surveys of large geographic areas with sizable numbers of birds are required for accuracy. AA

S06 SKIRA, I. J., and J. E. WAPSTRA. 1980. Occupation of burrows as a means of estimating the harvest of short-tailed shearwaters in Tasmania. Emu 80: 233-238.

The breeding population was estimated by counting the number of occupied and unoccupied burrows along permanent transects, each 2 m wide. The use of permanent transects instead of randomly allocated plots reduced disturbance and reduced the amount of time required. Five transects, each 100 m long, were adequate for obtaining accurate estimates of occupation. This method had pratical advantages, and produced statistically reliable results.

S07 SLOTHOWER, R. E., and A. L. SOWLS. 1984. Catalog of Alaskan seabird colonies: an update. Pac. Seabird Group Bull. 10: 56-57. (Abstract only)

The U. S. Fish and Wildlife Service published a Catalog of Alaska Seabird

Colonies in 1978. Since then, important new data have been gathered and will continue to be acquired in the future. Work on archiving data, developing a computer file, and incorporating new and historical data is now being done. The goal is to have the best information available for resource menagement decisions and scientific study. To handle the large amount of information, a computer format has been developed which will allow: 1) standard format, 2) continuous updating of information, 3) manipulation and searching of large quantities of data, 4) automated indexing of archived reports, and 5) production of standard and customized reports and maps. FAA

S08 SOOTS, R. F., and J. F. PARNELL. n.d. Analysis of the use of the point-center quarter method in estimating colonial seabird nesting populations. Rep. Ann. Meeting Amer. Orinthol. Union, Haverford, PA. Unpubl. MS.

Not seen.

S09 SOUTHERN, W. E., and L. K. SOUTHERN. 1981. Colony census results as indicators of pre-hatching perturbations. Colonial Waterbirds 4:

143-149.

Direct nest count data, clutch size calculations, and nest density were examined to determine if one or more of these parameters were appropriate indicators of stressed colony conditions. The number of nests present in colony subdivisions varied annually and these changes were not necessarily in response to perturbations. Intense disturbance or extensive habitat alteration, however, may result in reduction in the number of breeding paris. A decline of more than 0.10 in nest density may serve as an indicator of colony disturbance early in the nesting cycle. Similarly, comparative clutch size data for two or more years appear as useful indicators of colony disturbance.

The number of eggs out of nests or borken provides a poor indication of disturbance whereas the number of empty nests appears to provide stronger evidence of prior disruptive events. Use of these procedures could provide an assessment technique for ascertaining if colonies are being detrimentally inpacted prior to an investigator's visit. Field testing of this possibility remains to be done. AS

S10 STOWE, T. J. 1982. Accuracy of measuring trends in seabird numbers. Seabird Report 1977/81/6: 35-38.

The model suggests that trends of small magnitude can be detected in numbers of guillemots at a study plot by current methods of census and analysis, especially where nine years data have been assembled. The value of the results will continue to improve as further years data are included. While visits each year are not essential the recommendation to undertake at least five counts per visit is strongly supported. For razorbills *Alca torda* calculated rates of change will be less accurate since coefficients of variation are higher than those for guillemot. Counts of kittiwakes *Rissa tridactyla* have lower coefficients of variation giving greater accuracy. Variations in counts have received considerable attention, but are not found to produce insurmountable obstacles. There remains the less considered question of the degree to which changes at selected study plots represent changes in the colonies themselves, or in the population at large. FAD

S11 STOWE, T. J. 1982. Recent population trends in cliff-breeding seabirds in Britain and Ireland. Ibis 124: 502-510.

The findings of an annual sample census of four species of cliff-breeding seabirds at study plots in selected British and Irish colonies are presented. The results have shown that the census is capable of measuring accurately changes of small magnitude. The problem of whether study plots can be used to infer colony and population change is discussed and comparison made with the findings of other census work. FAS

T01 TAYLOR, R., and P. WILSON. 1982. Counting penguins from the air. Antarctic 9: 366-368.

Aerial photography is by far the easiest reliable way to count breeding pairs at many Ross Sea Adelie penguin colonies. Analysis of the photographic results is a technique of undoubted value for obtaining an accurate and permanent record of the numbers and distribution of penguins in many colonies on the same day. The technique will allow future population levels to be compared reliably. AA

T02 TSCHANZ, B. 1983. Census methods for guillemots Uria aalge in a highly structured breeding habitat. Fauna Norv. Ser. C, Cinclus 6: 87-104.

Census methods for guillemots _Uria aalge_ breeding in highly structured habitats were developed and examined in 1978-1980 on Vedoy (Lofoten, Norway). Of 702 ledges with breeding units in 1978 85% were still in use in 1980, some were not used in 1979, only some in both years and others were newly occupied or re-occupied. Adult birds were counted on all ledges three times per season from below the cliffs and also in random samples from above to obtain conversion factors for the birds not seen from the coast. The diurnal attendance pattern of adult birds on the ledges was investigated with hourly counts over several days. Conversion factors of 0.65 for calculating the number of breeders from the number of sitting birds (breeders and sham-breeders) were also determined. It is concluded that counts should be done on as many ledges as possible and regularly over the whole breeding season and also that the same census method should be used over years before population trends can be worked out. AA

V01 VAN GESSEL, F. W. C. 1978. An estimation of the population density of shearwaters breeding on Broughton Island, New South Wales. Corella 2: 52-53.

A circular plot having an area of 314.2 m^2 was employed for easy field work and sampling. Burrows were counted within a radius of a 10 m length of rope, rotating the rope until the whole area had been covered. Sample plots were randomly selected within a colony. Average burrow density was $0.331/m^2$ and the coefficient of variation was 30%.

W01 WANLESS, S., D. D. FRENCH, M. P. HARRIS, and D. R. LANGSLOW. 1982.

Detection of annual changes in the numbers of cliff-nesting seabirds in Orkney 1976-80. J. Anim. Ecol. 51: 785-795.

(1) This paper reports on a 5-year project set up in Mainland, Orkney, Scotland to assess annual and longer-term changes in numbers of four seaird species against a pattern of temporal variability. (2) Between five and ten standardized counts of individual guillemots Uria aalge, razorbills Alca torda, kittiwakes Rissa tridatyla and fulmars Fulmarus glacialis and apparently occupied nests and sites of kittiwakes and fulmars were made in fixed plots at five colonies in the month of June from 1976 to 1980. (3) Analyses of variance were used to test for changes in numbers between years. The method's sensitivity using five or ten counts per year was assessed by calculating the power of the two-tailed t-test for specified proportionate changes in the mean counts. (4) Between 1976 and 1980 there were significant differences between annual colony means in all the species and categories counted. Interaction of colonies with years for all categories (except kittiwake nests) indicated unidirectional change but at different rates. For kittiwake nests, interaction indicated opposing trends in the colonies. All colonies showed mean annual increases in numbers of individual guillemots, razorbills and fulmars and fulmar sites (except Costa Head). There were mean annual decreases at all colonies (except Mull Head) in numbers of kittiwake nests and individuals. (5) Five counts per year were sufficient to detect proportionate changes of ± 30% for guillemots and kittiwakes (nests and individuals) and fulmar (individuals). To achieve this

precision for razorbills, ten counts would need to be made in a shortened sampling period. Fulmar sites were borderline, probably partly because of the subjectivity involved in defining this category. AA

W02 WANLESS, S., and M. P. HARRIS. 1984. Effect of date on counts of nests of herring and lesser black-backed gulls. Ornis Scand. 15: 89-94.

Counts of nests of herring and lesser black-backed gulls Larus argentatus and fuscus made every three days indicated that the number of clutches increased by 12% per day during the main laying period. A single count grossly underestimated the population until laying of first clutches was completed by which time the earliest laid clutches had hatched. Censuses should be made as late in the season as possible. A suggested counting method is detailed. AA

W03 WIENS, J. A., R. G. FORD, and D. HEINEMANN. 1984. Information needs and priorities for assessing the sensitivity of marine birds to oil spills. Biol. Conserv. 28: 21-49

The size of breeding populations at specific colonies is of critical importance and should be determined with as great an accuracy as possible. FAS

Species Index

Method Index