Birds: complete counts—ground-based photo counts for seabirds

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Inventory and monitoring toolbox: birds

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Department of Conservation
Te Papa Atawhai

Synopsis

Some bird species, especially large seabirds, build particularly large and obvious nests, or are themselves large and obvious. Photos can be used to make counts of such birds or their nests (Bibby et al. 2000; Gibbons & Gregory 2006), especially if the birds breed in relatively open and easily viewed areas. This approach is particularly suitable for counting colonial surface-nesting seabirds (penguins, albatrosses, gannets, etc.) and estimating changes in their populations over time. Numerous colonies have been counted over many years, using photos taken periodically from fixed points (e.g. see Cunningham & Moors 1994; Moore 1999, 2002, 2004). Historical photos of bird colonies are also valuable data sources—they can be used to set up photopoints retrospectively, with the view shown in an old photo used to locate the original photopoint. Repeat photos and new counts can then be compared with the original.

Ideally, photo counts are combined with ground-based counts within the colony to 'ground-truth' the estimates derived from the photos (i.e. calculate appropriate variances). However, this may not be possible if access is poor because of cliffs, ledges, inaccessible beaches, etc., or if disturbance is likely to result in increased predation or nest and chick abandonment.

Assumptions

- The view of a colony from a photopoint is typical of the colony as a whole (e.g. in terms of density and distribution of nests and/or adults).
- Counts have small errors in terms of precision (normal variation) and accuracy (biases) (Bibby et al. 2000; Hatch 2003).
- Individual birds can be distinguished from others in the colony (i.e. the birds shown in the photo are not just a blurry collection of shapes).
- Nesting birds (i.e. those sitting on eggs or chicks) can be distinguished from non-breeders sitting on empty nests.
- Either numbers of birds do not vary with time of day or stage of the breeding season, or surveys are standardised to control for potential variation.
- If the objective is to extrapolate counts at colonies to the whole population and examine trends between years, then the proportion of breeding birds to non-breeders within the population must remain constant.

Advantages

- Time required in the field is minimal—all that is required is a map and guide to the locations of the photopoints, example photos, camera and film.
- Historical photos can be used to detect long-term population change. In contrast, historical colony ground counts done using unknown sampling methods may not be comparable with counts done using new methods.
- A permanent record of the colony is created.

- Counting off the photos can occur at a later date.
- Counts can be replicated and/or repeated using different observers or methods.
- It is possible to ground-truth photo counts by comparing them with ground counts. Once ground-truth information is available, it can be used to support interpretation of photos when ground counts are not available.

Disadvantages

- Nesting birds and non-breeders may not be easily separable, i.e. it might be hard to tell from the photo which birds are on nests and which are non-breeders.
- Oblique views might not include the whole colony, and the distant part of the colony will tend to be poorly differentiated.
- Photo quality may vary with light and weather conditions, the lens, film or camera used, and printing exposure. Recording equipment (lens, film, digital resolution, camera settings) should be standardised as much as possible.
- Bias introduced by the counter affects count total and quality.
- Numbers of birds in a colony may vary with time of day. This mainly affects counts of non-breeders as they are more mobile. Non-breeders might also be confused with breeders, or obscure them.
- Numbers of birds also vary over the breeding season, particularly in relation to breeding success, e.g. non-breeders or those whose nests fail might either remain at the colony or depart as the season progresses.
- Counts vary from year-to-year, so an assessment of trend should be based on multiple years. For example, if birds are in poor condition, their breeding frequency can change and the effects of this, especially for biennially-breeding birds, can continue for many years. In mixed-species colonies, the various species may be indistinguishable in the photos.

Suitability for inventory

Colonial seabirds often nest on cliffs, islands or rock stacks that are inaccessible to humans; are prone to disturbance when visited; and they often congregate in dense colonies of many thousands of birds. Thus, photos may be the only practical inventory method available. Photos of coastlines also offer a suitable means of determining presence or absence of colonies—information that can be used for comparisons over time. Photos from fixed points in a colony are an excellent way to create an inventory of colony boundary changes. Provided inter-nest distances remain the same, these boundary records can be used to infer population change.

Suitability for monitoring

Surface-nesting seabirds, such as albatrosses, are often large birds with striking white plumage. Many species build large, obvious nests that are usually regularly spaced within the colony. These attributes, and the fact that simply visiting the colonies can cause significant disturbance and nest failure, mean that photos can be very useful when attempting to calculate population estimates.

Photo counts have potential for detecting population trends over periods greater than 10 years, between study periods more than 10 years apart, and/or during periods of rapid change in numbers (e.g. changes of > 10% per year). The method is particularly useful when combined with historical photos and when modern ground counts are available (to increase certainty when interpreting the photo counts; e.g. see Moore 2004).

To get an estimate of colony size at a specific time, photo counts should be done for at least 3 consecutive years. This is particularly important for biennially-breeding species for which poor breeding years can affect colony attendance. Annual variations in colony size (within, for example, a regime of 3-year bursts of sampling separated by longer intervals) should be incorporated within any trend model. For seasonal variation, however, it is better to control for this as part of the survey design rather than crudely 'average it out', as the latter does not guarantee comparability between surveys widely spaced in time that have different seasonal mixes. Sampling variation (i.e. counting errors and daily variation in colony attendance) should be measured by repeated sampling and counting within a season for at least a subset of photopoints, if not all.

Experienced counters can exhibit observer error of 6–10% (Bibby et al. 2000), e.g. replicated counts of mollymawk colonies varied by 6.6% (CV) (Moore 2004). Hence, the method is not always suitable for monitoring fine-scale changes over a short period. However, if there is a need to measure fine-scale changes, greater precision can be achieved by repeated sampling—so this is not a limitation of the method itself.

When you intend to compare new photos with historical ones, the new photos should be taken on the same date as the earlier ones. When studying trends over several years, photos should be taken close to the peak of colony attendance or egg-laying to limit the effect of nest failures on counts. If this is not possible, correction factors can be applied using the rate of change in numbers during the breeding season at study areas over several years (e.g. see Moore 2004).

Skills

Anyone can take photos of seabird colonies with minimal training, provided they have access to sample photos and information on how to find the photopoints. Workers need to be able to:

- Operate camera equipment and understand the different lens requirements for different views
- Negotiate difficult terrain and be comfortable taking photos from exposed positions
- Navigate to and locate photopoint positions, or locate the exact spot from which historical photos were taken by comparing terrain features
- Replicate the views in the sample photos and not omit any section of colony

Counting birds visible in photos requires skill and training, and/or an on-the-ground knowledge of the species. Workers need to be able to:

- Distinguish breeding birds from non-breeders by familiarising themselves with the posture and shape of birds sitting on nests
- Distinguish birds from rocks and tussocks

- Work in a meticulous and careful way for long hours whilst 'counting the dots' (i.e. the birds) on the photos
- Look through a binocular microscope for long periods without suffering from eye strain (whilst counting)
- Operate appropriate computer software (if counting using digital technology)
- Accurately record count data in computer files

Resources

It is hard to make specific recommendations of equipment suitable for photographing seabird colonies given the rapid technological advances seen in recent years. However, digital imaging formats are now preferred over more traditional film formats (black and white, colour negative and colour positive) for the following reasons:

- Cost (over time film is significantly more expensive than flash memory particularly when quality enlargements are required)
- Flexibility (digital images can be checked for accuracy, exposure, etc., as soon as they are taken)
- Ease of interpretation (images can be joined, interpreted and counts potentially automated using a computer)

Ideally, a digital SLR (dSLR) camera should be used to capture images, although any digital camera will be suitable provided it has sufficient resolution (5–7 megapixels) and a lens of suitable focal length to capture accurate images from colonies close to the observers (use 35–50 mm or digital equivalent) and far from them (use 200–500 mm or digital equivalent). Always use a tripod when colonies are some distance from observers. This will ensure image clarity.

Take photos at a time of day that ensures even lighting and exposure to maximise image quality. The best time will vary depending on the orientation and aspect of individual colonies. These recommendations should be recorded in the notes describing each photopoint. Depending on the sampling design, photos can be repeated monthly or at key times during the breeding season (e.g. during early incubation or chick rearing). However, the reality is that timing of photo counts usually varies between years, depending on when staff arrive at the colonies (particularly those on isolated islands), the time available to staff, weather and sea conditions.

If photos are taken using traditional film, the standard procedure is to print them as 8 × 10" prints. From these, the nests and birds are counted by marking the photos or overlays whilst viewing the prints under a binocular microscope (Moore & Blezard 1999a,b). Birds and nests can be counted from colour slides by projecting the image onto a white sheet or other suitable projection screen. With digital photos, it is possible to work electronically throughout the analysis process (see below).

In summary, the following equipment is required to get the photos:

- Camera and lens appropriate to the colonies being counted
- Spare batteries
- Tripod and long lens for distant viewpoints

- Film (< 200 ASA), if using traditional methods
- Memory cards or laptop for downloading digital images
- GPS and detailed instructions for finding photopoints
- Sample photos from previous surveys and any notes or instructions about each photopoint
- Other field equipment that is appropriate for the conditions

For counting photos you need:

- Large black and white prints and plastic overlays on which to mark nests with permanent markers whilst counting through a binocular microscope
- Colour slides, projector and A3 sheets of paper for marking nests whilst counting off a projected image
- Digital software (e.g. Adobe Photoshop) to mark nests on image files displayed on a computer screen

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).

Attributes to record when taking photos:

- Observer's name and contact details, colony location (including GPS coordinates), photopoint number, date and time pictures taken
- Weather conditions
- Identification numbers or file names of the images taken at each photopoint
- Any observations made at the colony (e.g. proportions of the target species present, breeders/non-breeders, birds on eggs)

Attributes to record when counting photos:

- Total number of birds on nests for each species present
- Total number of other birds (i.e. non-breeders) in the colony for each species present
- Estimates of colony coverage (accounting for blind spots, overhangs, slope, etc.) from each photopoint and potential variance introduced by overlapping images

Ground truthing of photo-based surveys may be required. Ground-truth data need to be cross-referenced with the photographic records, then stored appropriately (see 'Data storage').

An example of the mollymawk photo recording sheet can be found in Moore & Blezard (1999a). Data are recorded in Moore & Blezard (1999b).

Data storage

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely, also as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, along with copying and data backup for security.

Summarise the results in a spreadsheet or equivalent. Arrange data as ‘column variables’, i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen, identity, etc.) in columns, with each row representing the occasion on which a given photopoint was sampled.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions. Store the copy at a separate location for security purposes.

Images derived from traditional film stock (negatives, transparencies and prints) should be labelled and catalogued with sufficient identifiers to link them with relevant field sheets. All images should be stored in archival conditions (acid-free plastics and papers, in cool conditions, etc.) to minimise fading, fungal growth and undue wear and tear. If possible, these images should be scanned electronically and stored as per the recommendations for digital images.

Digital images should be stored in an electronic catalogue with appropriate, meaningful labels linked to relevant field sheets. All electronic images should be copied and/or backed up, preferably offline if the primary storage location is part of a networked system.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.

Results are best summarised in a spreadsheet (e.g. Excel). Columns in the spreadsheet should capture all data recorded on the field sheets because the influences of factors such as observer variation (particularly those counting the birds) need to be accounted for in any analysis.

Results can be presented in a number of ways. Distribution maps of colony position can be drawn (e.g. Moore 2004). Total numbers at each colony per year can be graphed to illustrate change over

time; and regression lines or a log scale graph can be used to illustrate positive or negative growth rates.

Detailed statistical analysis of population trends requires specialist skills, and conservation managers should seek advice on the best ways to analyse counts. Consistent measurement of colony size over time means that questions of trend, rates of change and predictions of future population status can be addressed by analysis of repeated measures using mixed models.

Case study A

Case study A: using ground-based photos for monitoring mollymawk colonies on Campbell Island

Synopsis

Photos of mollymawk colonies on Campbell Island were available from the 1940s to the 1980s. They showed that some colonies had decreased markedly in size (Moore & Moffat 1990). More recently, Waugh et al. (1999) presented preliminary analyses concentrating on selected colonies. Colonies dominated by Campbell mollymawks (*Thalassarche impavida*) declined between the 1970s and early 1980s, yet were stable or gradually increasing before and after that period. In contrast, the grey-headed mollymawk (*Thalassarche chrysostoma*) colonies apparently declined continuously from the 1940s to the 1990s. More intensive analysis of photo data from the majority of colonies was used to determine current status, quantify changes in population size and examine long-term trends.

Objectives

- Have the populations of Campbell mollymawks and grey-headed mollymawks changed since the 1940s?
- How do trends shown by photos compare with ground counts of colonies?
- Can photos be used as a monitoring tool?

Sampling design and methods

- Photopoints were set up at mollymawk colonies in 1987, repeating photo views from the 1940s and increasing photo coverage of most colonies. The view from each photopoint was selected in an attempt to maximise the area of the colony counted.
- Photos were taken at different times of the breeding season during several years, but were taken consistently in mid-October in most years during the late 1980s and 1990s.
- Ground counts of colonies were conducted in 3 years—1995, 1996 and 1997.
- Photos were counted by three observers, each of whom repeated the main historical photo series.
- Colonies were divided into zones to obtain count subtotals.
- The main counting unit was the occupied nest.

- Counts were converted to a mid-October value.

Results

Between the 1940s and 1990s, there was an 82–88% (1.5–2.7% p.a.) decrease (apparently a continuous decline) in nest numbers at three grey-headed mollymawk colonies (Fig. 1). Campbell mollymawk numbers fluctuated over the same 55-year period. One colony showed an increase of 11% in nest numbers between the 1940s and 1966, a decrease of 47% by the 1980s, followed by a gradual recovery of 3.2% p.a. (Moore 2004).

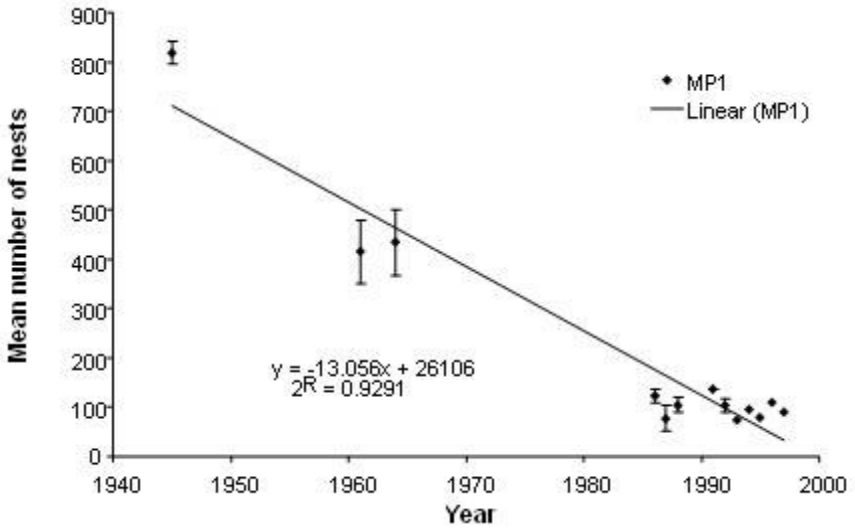

Figure 1. Trends in the number of nests at Courrejolles Isthmus mollymawk colony.

This colony is dominated by Campbell mollymawk. Ground counts were compared with photo counts off aerial photos and photos taken from photopoint MP11 in the 1980s and 1990s. Counts are combined totals of Campbell and grey-headed mollymawk nests.

The combined use of photo and ground counts was useful for monitoring the mollymawk populations as this combination dove-tailed the historical period (photos only) with the modern period (photos and ground counts). Photo counts allowed long-term trends of colonies to be followed. They also enabled assessment of inaccessible colonies—at Campbell Island where the largest mollymawk colonies were on the inaccessible Courrejolles Peninsula. Ground counts provided evidence on species composition and provided survey coverage of whole colonies.

References for case study A

Moore, P.J. 2004: Abundance and population trends of mollymawks on Campbell Island. *Science for Conservation 242*. Department of Conservation, Wellington. 62 p.

Moore, P.J.; Moffat, R.M. 1990: Mollymawks on Campbell Island. *Science & Research Internal Report 59.* Department of Conservation, Wellington. 43 p.

Waugh, S.M.; Weimerskirch, H.; Moore, P.J.; Sagar, P.M. 1999: Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophrys* and *D. chrysostoma* at Campbell Island, New Zealand, 1942–96. *Ibis 141*: 216–225.

Case study B

Case study B: use of ground-based photos for monitoring rockhopper penguin colonies on Campbell Island

Rockhopper penguin (photo: J.L. Kendrick).

Synopsis

Comparisons of photos taken in the 1980s with photos taken in the 1940s suggested a dramatic decline had occurred in the extent of rockhopper penguin colonies (*Eudyptes chrysocome*) on Campbell Island. Thompson & Sagar's study (published 2002) was conducted to assess the current population status, the extent of the apparent decline and the factors that might have been responsible for the decline.

Objectives

- What was the total population of rockhopper penguins in the 1940s and 1980s?
- Were the population trends similar in different colonies?
- What was the rockhopper population during this study?
- Can the changes be linked to a cause?

Sampling design and methods

Nesting densities were measured in penguin colonies, as were the perimeters and areas of colonies—past and present boundaries. Photopoints were established at the colonies for ongoing monitoring.

Results

During the 1940s, there were 1.6 million rockhopper penguins on Campbell Island. The total population declined by 94% to 103 000 in 1985.

Changes were correlated with sea surface temperature—with warmer sea surface temperatures, especially in the 1945–55 period, came declining penguin numbers. This conclusion was supported by evidence of an expansion of colonies during the 1960s when there was a brief cooling of sea surface temperature. It was thought that changes in the food supply were associated with the temperature changes and were causing the population decline (Cunningham & Moors 1994). The apparently atypical fish diet was seen as support for a change in diet of penguins at Campbell Island. However, it has since been shown from feather analysis that, since the 1940s, diet has not changed. Rather, a decrease in productivity had occurred and it was a lack of food that caused the decline (Thompson & Sagar 2002).

Photos were taken at the penguin colonies in 1996 and cursory comparisons by Peter Moore suggest the decline has continued since the mid-1980s.

References for case study B

Cunningham, D.M.; Moors, P.J. 1994*:* The decline of rockhopper penguins *Eudyptes chrysocome* at Campbell Island, Southern Ocean and the influence of rising sea temperatures*. Emu 94*: 27–36.

Thompson D.; Sagar, P. 2002: Declining rockhopper penguin populations in New Zealand*. Water & Atmosphere 10*(3): 10–12.

Full details of technique and best practice

There is no generic best practice manual for ground-based photo counts of seabirds as each species has its own set of techniques, problems and assumptions. Nevertheless, some general rules apply (see Bibby et al. 2000):

- Photopoints should be placed so that there is a direct, unobstructed view of the majority of the colony—ideally slightly above the birds where the terrain is relatively flat and at a more oblique angle when working on steeper slopes. Several photopoints may be required to cover large colonies.
- Observer safety is paramount. Therefore, photopoints should be set back from cliffs and be on firm, level ground.

- Photos should be taken at times of peak colony attendance (e.g. at end of egg laying), or on the same date as an early photo. These photos should be repeated on different days so that short-term variation in colony attendance and lighting conditions can be included in the sampling variance of any trend model. Particular attention should be paid to recording details of the colony's periphery.
- Photos should be taken during the middle of the day, as colony attendance tends to be at its most stable at that time, and this limits the problem of non-breeders being mis-counted as breeders.
- Photo counters should receive training or be familiar with the nesting colonies and bird behaviour. (Note: inexperienced workers produce the least accurate counts.) Quantification of counting errors should be part of the sampling protocol.

References and further reading

Bibby, C.J.; Burgess, N.D.; Hill, D.A.; Mustoe, S. 2000: Bird census techniques. 2nd edition. Academic Press, London. 302 p.

Cunningham, D.M.; Moors, P.J. 1994: The decline of rockhopper penguins *Eudyptes chrysocome* at Campbell Island, Southern Ocean and the influence of rising sea temperatures. *Emu 94*: 27–36.

Gibbons, D.W.; Gregory, R.D. 2006: Birds. In Sutherland, W.J. (Ed.): Ecological census techniques: a handbook. 2nd edition. Cambridge University Press, Cambridge. 336 p.

Hatch, S.A. 2003: Statistical concepts for determining trends with applications for seabird monitoring. *Biological Conservation 111*: 317–329.

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Moore, P.J. 2004: Abundance and population trends of mollymawks on Campbell Island. *Science for Conservation 242*. Department of Conservation, Wellington. 62 p.

Moore, P.J.; Blezard R. 1999a: Photos of Campbell Island mollymawk colonies. A guide to photopoints, historical comparisons, and counting mollymawks. *Department of Conservation Technical Series 17*. Department of Conservation, Wellington. 106 p.

Moore, P.J.; Blezard, R. 1999b: Counting Campbell Island mollymawk colonies from photos—data supplements. *Science & Research Internal Report 169*. Department of Conservation, Wellington. 35 p.

Moore, P.J.; Moffat, R.M. 1990: Mollymawks on Campbell Island. *Science & Research Internal Report 59*. Department of Conservation, Wellington. 43 p.

Thompson D.; Sagar, P. 2002: Declining rockhopper penguin populations in New Zealand. *Water & Atmosphere 10*(3): 10–12.

Waugh, S.M.; Weimerskirch, H.; Moore, P.J.; Sagar, P.M. 1999: Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophrys* and *D. chrysostoma* at Campbell Island, New Zealand, 1942–96. *Ibis 141*: 216–225.

Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-146272 Standard inventory and monitoring project plan