CENSUS TECHNIQUES FOR SEABIRDS OF ARCTIC AND EASTERN CANADA

D.N. Nettleship

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SEABIRD CENSUS TECHNIQUES

Table of Contents

INTRODUCTION

It is impossible to be interested in the sea without becoming aware of the presence of vast numbers of marine-associated bird populations (i.e., seabirds, shorebirds, waterfowl). What may be less obvious is how endangered these populations have become due to the acceleration of certain human activities (e.g., mining and drilling, oil spills, toxic chemicals, fishing, domestic and industrial sewage) in marine water areas most critical to the reproduction and survival of marine birds. Precisely how these forms of pollution are affecting marine water systems and marine life is by no means clear. However, what is clear is the likelihood of continued and increased development of natural resources, often in areas only recently believed to be inaccessible, and so the immediate requirement is for a carefully integrated research program to form a basis on which to measure and assess changes in the marine ecosystem. The threat to seabird populations in arctic and eastern Canada is particularly evident as extensive areas of the continental shelf and arctic islands are beginning to be subjected to oil and gas drilling and mining. Thus it is essential that a monitoring system sufficiently sensitive to detect real population changes in bird numbers, both at sea and at breeding colonies, be developed to establish a baseline for the comparison of population changes over long periods.

In the present paper are reported 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 (see Brown and Nettleship 1975). The accuracy of these methods is variable differing with the species involved,

survey conditions (e.g., nature of nesting habitat, weather, etc.) and objectives (see p. 4). In general, techniques based on counts of nests (e.g., gannet, kittiwake) are more reliable than those using other measures of population. Possible error is highest when estimates of numbers require the use of a sampling procedure or correction factor (e.g., correction for diurnal activity patterns, egg loss and replacement, etc.). Clearly much remains to be done to elucidate, measure and correct major sources of census error in order to produce precise estimates of population (for review see Swartz 1966, Nisbet 1973, Drury 1973-74, Cramp et al. 1974). However, 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 of sufficient precision to measure real changes in numbers within individual colonies and be sufficiently rigid to reduce observer error to a minimum making the data more valuable in identifying substantial numerical changes and geographical shifts of species populations.

GENERAL SEABIRD CENSUS TECHNIQUES

During each census certain information is to be routinely recorded. In addition to type of census (e.g., boat or land), these general notes include:

1. Date and Time - record these precisely. If census is spread over a period of time give the exact interval, e.g., 0730 - 11.45 hours*. Moreover, if a series of counts is made through the day record each count spearately giving appropriate time.

   * (note whether DST, ADT, AST, etc.)

2. Locality - note the identity and location of the census area with precision. It is most important that the location be accurately defined in order that comparisons can be made by other observers in the future.

3. Weather - give a complete description of the weather at the time of the census (temperature, cloud cover, precipitation, wind and seasurface) and note if significant changes in weather have taken place during the previous 48 hours. Assess wind with an anemometer if available and seasurface conditions according to the Beaufort Scale:

Scale	Wind	General Features
0-1	light airs	sea mirror-like, or with scale-like ripples
2-3	gentle breeze	wavelets form, a few scattered 'white horses'
4-5	fresh breeze	small to moderate waves, numerous 'white horses'
6-7	near gale	sea heaps up, foam blown from breaking waves
8-9	gale	high waves, foam blown in well marked streaks down wind.

CENSUS OF BREEDING BIRDS AT COLONIES

1. Selection of census techniques

The intensity and precision of any seabird census will be determined mainly by the species involved and the accessibility of the breeding colonies and nesting habitats and to some extent by time, weather conditions, topographic features of the area and manpower. However, in general, the aims of a census program should assist in identifying the most suitable method. For example, a survey of breeding birds over a large geographic region may mean using a less precise and time-consuming technique, whereas if the prime objective is to assess possible change in local population levels a detailed permanent census plot system is the most adequate procedure. Furthermore, colony size will also influence the technique selected - in small colonies (<2000 pairs) direct counts of all birds and/or nests should be made; if the colony is larger only a proportion of the total population should be censused according to the appropriate counting method listed for each species (see section 4).

2. Description of colony

Describe each colony in detail giving as much information as possible about the structure of the colony and associated habitat and physical features, including:

a. General Sketch Map - to show the location of each colony or area censused ensuring that comparative counts can be made in the future (Fig.1-3). If an area is large and the associated bird distribution small and/or aggregated draw an inset map showing the nesting sites in relation to distinct natural features of the total region.

b. Detailed Sketch Map - to define the limits of the colony and show the census methods (Fig.1-3). In preparing any sketch map of the limits of a colony show these boundaries in relation to main features of the region such as gullies, streams, fault lines, crevices, etc., as these permanent reference points or landmarks will be invaluable to other observers in future years.

c. Photographs - to provide a permanent record of colony size, structure and location, and can be used to accurately draw boundaries of colonies and study plots. Where photographs are taken of a colony, be sure to record: location, date and time, and weather conditions.

d. Extent of Each Census - to describe the completeness and exactness of the census. Were any areas overlooked or inaccessible and if so, to what extent (i.e., proportion of total colony not censused, etc.)?

3. Phase of the Breeding Cycle

The census of breeding birds at colonies is normally conducted during the middle and last half of the incubation period of the species involved although in some cases the best time for census activities is at an earlier (e.g., Black Guillemot) of later phase (e.g., Leach's Storm-Petrel) of the breeding cycle (see section 4 for details). However, even where the timing of breeding of a species is well known, it is important to estimate the phase of the breeding cycle for the population at the time the census is made - that is, by recording the nest contents (e.g., 4 eggs, or 2 eggs + 2 chicks, or 4 chicks, etc.) for an adequate sample of nests examined at random within the census area. This information will assist in the interpretation of the census and increase its comparative value.

4. Comments

Record and comment upon any outstanding or unusual features of the colony, particularly those concerning census procedures and condition of nesting habitats and birds. For example, the occurrence of high bird-mortality within the colony (accurate counts of broken and/or deserted eggs and dead and/or dying birds should be made with comments on the suspected or known causes) or the presence of avian and/or mammalian predators at the colony. It is imperative to record information which will facilitate a repeat census of the colony in the future, one which would be virtually identical to the baseline census and, therefore, permit a precise measurement of change in bird numbers.

CENSUS TECHNIQUES FOR INDIVIDUAL SPECIES

NORTHERN FULMAR *Fulmarus glacialis*

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony (topography, physical features, vegetation, etc.).
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony (use main physical features as land-marks), and
   (b) outline and estimate the total nesting area.
4. Photograph each colony.

Census Techniques

It is usually difficult to determine the actual numbers of breeding pairs at a fulmar colony because of the presence of prospecting birds (non-breeders and immatures) which may occupy ledges for several years before producing an egg. Consequently, the most satisfactory census method is to make a detailed survey of each colony and count all apparently occupied nest sites in the colony or census plots. Although this gives the number of 'nest-site holders' rather than the number of 'true breeders' (i.e., pairs that occupied a site and laid 1 egg), it does provide a reliable index of population size.

Time of Census

The best time to census is the middle and last half of the incubation period when breeding birds sit tight and many pairs are together on the ledges.

LEACH'S STORM-PETREL *Oceanodroma leucorhoa*

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony (topography, physical features, vegetation, and cover, etc.) and divide into sub-areas according to burrow density, if necessary.
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony (use main physical features as land-marks) and sub-areas, and
   (b) outline and estimate the total nesting area.
4. Photograph each colony.

Census Techniques

A. Counts of burrows in accessible habitat

Counts of burrows allow an accurate measure of the size of the breeding population in a colony, though it may be impossible to count or estimate numbers at small colonies with a low density and patchy distribution of burrows. In general, the best method is a systematic count and inspection of all burrows to determine the number of occupied burrows (i.e., burrows with an egg or chick). When colonies are large the determination of abundance will depend on sampling the total nesting area (or sub-areas) using one of the following methods (N.B., methods are given in descending order of reliability):

1. Line transect method:

Place fixed line transects (assign each line a letter: A, B, C...) across the colony from edge to edge to ensure total coverage of the colony and to detect changes in numbers at the periphery in future years. Number of transects will depend on colony size and time

availability, although a minimum of 3 transects comprising at least 30 quadrat samples is required.

Permanently mark each transect line by placing stakes or some suitable marker at both ends of the line and at regular intervals along the line if the transect is extremely long. Mark points along the line at 1 metre intervals and use each point as a corner of a 1 x 1* metre quadrat (if transect is very long, select sample quadrats at regular intervals along the line beginning at the front of the colony). Measure the following characters within each quadrat:

(a) burrow number and status - count all burrows in quadrat and determine status of each: active (with egg, chick, etc.) or inactive (unoccupied). Record inaccessible burrows, but note nest not checked. Avoid disturbance of nesting birds as they may desert. Also use extreme caution when examining a nest as the single egg is very fragile.

(b) habitat description - describe habitat of each quadrat: vegetation and cover, angle of slope, position within colony (peripheral edge or central region).

(c) distance from front of colony - i.e., record distance from furthest side of quadrat to origin of transect line.

2. Sub-area sample method:

Make direct counts of burrows in as many 1 x 1* metre quadrats

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*quadrat size can vary based on nest density:

e.g., high density - 1 x 1 m.

medium density - 5 x 5 m.

low density - 10 x 10 m.

within the defined sub-area as time permits (minimum of 10 quadrats per area or sub-area). Select quadrats at random, although samples should be as typical of the sub-area as possible, and record:

(a) burrow number and status - same as method 1.

(b) habitat description - same as method 1.

(c) distance from front of colony - same as method 1.

B. Counts of birds in inaccessible habitat

There is no method to reliably determine or estimate population size at nest sites which are inaccessible or unclimbable. Attempts to provide an index of the population can be made using capture-recapture methods or flight-activity and/or flight-call rate, but both techniques have serious shortcomings: the first because of movement of non-breeding birds between colonies and the second from large changes in daily and seasonal activity patterns.

C. Time of Census

Census during the last half of the incubation period and maintain disturbance to a minimum, as this species deserts readily during incubation.

GANNET Morus bassanus

A. Census Techniques

Procedures used to census Gannets in the North Atlantic have ranged from simple visual impressions of bird numbers from both land and sea to detailed ground counts of nests (e.g., Nettleship 1975a). Counts by observers on the ground are not possible at most colonies because of the inaccessibility of the nesting habitat. Moreover, at large colonies the division of the colony into small sections and systematic search is difficult. The most satisfactory method of population analysis is from aerial photography (see Nettleship 1975a, b): a series of over-lapping photographs are taken during the incubation period from a light fixed-wing aircraft using a 70 mm camera with standard lenses (100 or 150 mm) and black and white film (Plus-X professional) at a distance from the colony of about 550 to 600 m. Nesting areas are delimited on 18 x 25 cm glossy enlargements and individual nests are counted under a hand lens (8x) using a plastic grid overlay. Since only attended nests are counted, and the status of each nest is unknown, this assessment of breeding population represents the number of 'nest-site holders' rather than the number of 'true breeders' (i.e., pairs that built a nest and laid 1 egg).

B. Time of Census

Census during the last half of the incubation period (North American colonies: late June to mid-July).

GREAT CORMORANT Phalacrocorax carbo

DOUBLE-CRESTED CORMORANT Phalacrocorax auritus

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony (topography, physical features, etc.).
3. Make detailed sketch map (to scale) on each colony showing:
   (a) limits of the colony based on natural features,
   (b) outline and estimate of total nesting area, and
   (c) in mixed-species colonies show distribution for each species within the total nesting area.
4. Photograph each colony.

Species Identification

It is difficult to distinguish between these two species unless at close range, especially after early June. The less common Great Cormorant is often misidentified as Double-crested. Diagnostic features are:

1. body size - Great is slightly larger (20-30%) than the Double-crested.
2. bill size - Great bill is considerably longer and wider than the Double-crested.
3. throat-pouch colour

   Great - yellowish gular pouch with white hind border.

   Double-crested - orange-yellow gular pouch which lacks a white hind border.

Census Techniques

A. Counts of nests in accessible habitats

   Accurate nest counts are possible in a single-species colony by making direct counts of all nests located on either cliff ledges or in trees. However, in mixed-species colonies some difficulty may be experienced in establishing species identity for nests where owners are absent. When

censusing keep disturbance to a minimum and make the count from a distance if possible, as gulls may take eggs or small young.

B. Counts of nests in inaccessible habitats

Where it is not possible to census a colony from land (e.g., tree-top nesting colony with thick undergrowth and/or diffuse nature) or sea (e.g., top of unclimbable rock stack), an accurate count can be made by aerial photography using a 70 mm camera with standard lenses (100 and 150 mm) and black and white film. Individual nests are visible on 18 x 25 cm glossy enlargements.

C. Time of Census

The ideal time to census single-species colonies is mid-way through the nestling period when young are too large to be taken by gulls and yet too underdeveloped to leave the nest prematurely. Mixed colonies should be visited early in the nesting season when breeding plumages are distinct making each species more recognizable (Atlantic Canada : late May).

GULLS Larus spp.

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony (topography, physical features, vegetation, cover, etc.) and divide into sub-areas according to density if nests are scattered or clumped.
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony and sub-areas (use main physical features as landmarks or reference points,
   (b) estimate total nesting area, and
   (c) species composition: single-species colony or associated with other gulls and non-gull species. If colony is mixed, outline the distribution of each species within the colony if possible.
4. Photograph each colony.

Census Techniques

Gull census figures can be derived from several methods, including: (1) full nest count (a nest is considered to be any structure more elaborate than a simple scrap - it must have some built-up edge to qualify); (2) nest estimate using line-transect techniques to sample the total nesting space; (3) breeding-pair estimate by a boat count of adults standing or flying over the colony multiplied by the ratio of nests to adults recorded on control areas selected prior to the boat count; (4) boat count of adults alone; or (5) aerial estimation and photography. The selection of a technique will depend largely upon accessibility of the colony, time availability, and the degree of precision required. The most satisfactory method is a direct count of all nests in the colony, but a sampling precedence may be required at very large colonies or where nests are located in dense vegetation. Counts of birds alone should be restricted to where nests are not visible and inaccessible or when time is at

a premium, as estimates derived from these techniques are imprecise and subject to a high degree of error.

A. Counts of nests in accessible habitat

1. Open land areas

Make a detailed survey of the entire area of the colony and count all nests. Survey colony systematically and mark each nest counted with spray-paint to avoid an omission or double count.

2. Dense vegetation

The number of nests in dense vegetation may be estimated by performing the following work sequence:

(a) delineate the colony boundaries (occupied area),

(b) divide the colony into sub-areas based on density (density estimate determined by using binoculars to observe birds flying away and/or roosting), and

(c) sample colony or sub-areas using one of the following methods (N.B., methods are given in descending order of reliability):

Method 1: Line Transect (Strip Transect)

Place 2 fixed transect lines (10 metres apart)* across the colony from edge to edge to ensure total coverage of the colony or sub-area. The number of transects will depend on the colony size and time availability, although several transects should be done. Permanently mark each transect by placing stakes or some suitable marker at both ends of the line or at regular intervals if the transect is extremely long. Mark points along the transect lines at 10 metre intervals and count the number of nests in each 10 x 10 metre quadrat* (if transect is very long, select sample quadrats at regular intervals along the lines beginning at the front edge of the colony or sub-area). Record data for each quadrat separately

*quadrat size can vary based on nest density

and in order. An estimate of the total number of nests in the colony is extrapolated from the transect nest density figures.

Method 2: Control Samples

Record the number of individuals present (N_i) in representative control areas where the number of breeding pairs (N_p) is known (based on the number of nests) and use this ratio ($k = N_p/N_i$) to calculate the total number of pairs in the colony.

Method 3: Quadrat Samples

Count the number of nests within sample 10 x 10 metre quadrats*. The number of quadrats sampled will depend on colony size and time availability. Select quadrats at random, although samples should be as typical of the colony or sub-areas as possible. Once nest density of these areas is known, the data are extrapolated for the entire colony.

3. Cliff-ledge sites

Make a detailed survey from land and/or sea and count all nests. Only actual nests are to be counted; do not confine "whitewash" loafing sites with nests. In general, the number of nests can be accurately determined and consequently the number of breeding pairs.

B. Counts of birds in inaccessible habitats

1. Small colonies

In colonies with sparse vegetation the numbers of birds and location of nests can be determined by observing the nesting area through binoculars from a distant vantage point. When vegetation is dense it may only be possible to count birds roosting or flying in the area.

*quadrat size can vary based on nest density

2. Large colonies

Where a large colony can be viewed from a distant vantage point, visually divide the nesting area by natural topographic features into small sections and count the birds in each area. In cases where the size of the colony and/or the terrain do not allow a visual count, take a series of over-lapping photographs of the colony to attempt to determine the number of adult gulls present from black and white glossy print enlargements.

3. Aerial estimation and photography

Gull populations nesting on cliff and flattish ground areas can also be measured by aerial estimation and photography. The procedure is simple: make identification of species, estimates of gull numbers and location of colony as the aircraft passes close to each colony. Photographs can be taken at large colonies to count the number of gulls or to supplement the visual estimate. While the accuracy of visual estimates and those based on the counts of gulls in photographs is low (see Kadlec and Drury 1968, and Drury 1973 for a detailed review of errors inherent in aerial censuses), the information does provide some indication of the size of individual colonies and an estimate of the numbers of gulls in geographic regions. Attempts to determine the numbers of breeding pairs from visual counts of individual gulls in attendance at the time of the aerial census are not profitable as numbers of birds present at the colony varies within any single day, as well as at different times of the nesting season. Thus, where the relationship of visually estimated and/or counted numbers of gulls to actual numbers of nests is not known, estimates are to be given as number of individual birds seen or counted.

C. Time of Census

The census should be made when most birds are in the late stages of incubation.

BLACK-LEGGED KITTIWAKE Rissa tridactyla

Distribution Maps

1. Mark locations of all colonies on general sketch maps.
2. Describe each colony (topography, physical features, etc.).
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony (use main physical features as landmarks), and
   (b) outline and estimate the total nesting area.
4. Photograph each colony.

Census Techniques (all habitats)

The kittiwake can be censused with relative ease by either making a count of nests from the land and/or sea or using aerial and boat photography. Only actual nests are to be counted (i.e., a structure with sufficient nesting material to retain eggs); do not confuse "whitewash" loafing sites with nests.

A. Counts of nests at the colony

Make a detailed survey and count all nests. Nest counts can be made from vantage points along the cliff top and/or from the sea below the cliffs. Large colonies can be censused by dividing the total nesting area into small sections using natural topographic features as reference points and counting the nests in each section. The nest count for each region should be the mean value of at least three separate counts.

B. Counts of nests on photographs

A reliable census can be made by taking a series of over-lapping photographs from either a boat below the cliffs or a light aircraft around the colony. The nests are readily distinguishable on black and white glossy print enlargements (usually 28 x 36 cm photos) and can be

systematically counted to provide a reliable means of monitoring a breeding kittiwake population.

C. Time of Census

Census during the middle and last half of the incubation period.

TERNS Sterna spp.

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony (topography, physical features, vegetation, cover, etc.) and divide into sub-areas according to density if nests are scattered or clumped.
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony and sub-areas (use main physical features as landmarks),
   (b) estimate total nesting area, and
   (c) composition: single-species colony or associated with other terns and/or gulls. If a mixed-species colony, outline the distribution of each species as very seldom does complete integration occur.
4. Photograph each colony.

Census Techniques

Visits to colonies should be of short duration (20 minutes) and special care taken to avoid unnecessary disturbance. If the colony is large it may be safe to extend this time period if disturbance is local and birds in adjacent areas remain on their nests. However, birds in small new colonies are very susceptible to desertion after some disturbance and so extreme caution should be exercised.

A. Counts of nests in accessible habitat

Direct counts of all nests may be possible at small or scattered colonies, but a sampling procedure may be required at large colonies. When sampling the total nesting area use one of the following methods (N.B., methods are given in descending order of reliability):

Method 1: Line Transect (Strip Transect)

Place 2 fixed transect lines (5 metres apart)* across the colony from edge to edge to ensure total coverage of the colony or sub-area. The number of transects will depend on the colony size and time available, although several transects should be done. Permanently mark each transect by placing stakes or some suitable marker at both ends of the line or at regular intervals if the transect is extremely long. Mark points along the transect lines at 5 metre intervals and count the number of nests in each 5 x 5 metre quadrat* (if transect is very long, select sample quadrats at regular intervals along the lines beginning at the front edge of the colony or sub-area). Record data for each quadrat separately and in order. An estimate of the total number of nests in the colony is extrapolated from the transect nest density figures.

Method 2: Control Samples

Record the number of individuals present (N_i) in representative control areas where the numbers of breeding pairs (N_p) is known (based on the number of nests) and use this ratio ($k = N_p/N_i$) to calculate the total number of pairs in the colony.

Method 3: Quadrat Sample

Make direct counts of nests in as many 5 x 5 metre quadrats* within each colony or sub-area as time permits. Select quadrats at random, although samples should be as typical of the colony or sub-area as possible. Once nest desnity of these areas is known, the data are extrapolated for the entire colony.

B. Counts of birds in accessible and inaccessible habitats

Counts of birds are easier than counts of nests. Incubating birds may be counted from a distant vantage point using binoculars without causing disturbance. Where birds are nesting in habitats with uneven terrain or

*quadrat size can vary based on nest density

dense vegetation the best method (at least for Arctic and Common terns) for obtaining replicable estimates of breeding pairs is to count the number of birds loafing away from the colony and then estimate the number of birds that fly up over the nesting area when flushed, less 10%; the census should be made soon after the main peak of egg-laying (for complete details see Nisbet 1973). Since attendance varies with time of day, time of season and weather conditions, a careful note must be made of these parameters at time of census.

If time is available and the nesting area accessible, establish control areas within the colony where the number of breeding pairs (N_p) is known (based on the number of nests) and then record the number of individuals present (N_i) in these areas. Use the ratio N_p/N_i to calculate the total number of pairs for all areas censused.

c. Time of Census

Census during the last half of the incubation period when making actual counts of nests or soon after the main peak of egg-laying for counts of birds.

ALCIDS

The Alcids are a varied and difficult group to census with precision. In general, the number of birds present at a colony varies within very wide limits with time of day, between days (phase of the breeding cycle) and weather conditions. This variation in attendance at the colony severely limits the value of counts unless associated correction factors are determined, especially for Razorbills, murres and puffins.

The method for calculating the necessary correction factors (k) is given in the individual species accounts. It must be noted that these correction factors vary with time, nature of the nesting habitat and weather conditions, and so several correction factors may have to be derived where significant differences in census conditions occur. For example, a new correction factor is required for each 2-hour period during the day and where the phase of the breeding cycle has changed. Furthermore, it is useful to derive a k value for several control areas under identical conditions (time of day, etc.) to assess variation in k between areas, especially between areas with large (>30 pairs) and small (10 pairs) groups.

In general Razorbill and murre counts are based on egg and/or nest counts alone or, where total egg counts are not possible (e.g., certain murre legdes), by determining the ratio of birds present on control ledges and the total number of eggs and/or young on the same ledges, and using this ratio to calculate the number of pairs for inaccessible colonies. Black Guillemot number estimates are from counts of birds seen during a systematic survey of the coast early in the breeding season. Puffins in accessible habitats are censused using grid and line-transect procedures.

RAZORBILL Alca torda

Distribution Maps

1. Mark locations of all nests and/or nesting concentrations on general map.
2. Make detailed sketch map (to scale) or each nesting area showing exact location of nest-sites and limits of the colony based on main physical features of the area.
3. Photograph the nesting area.

Census Techniques

The Razorbill usually nests in scattered pairs, sometimes mixed with murres, on rock ledges, in crevices, under boulders and in broken cliffs. Birds on ledges are easily observed and counted, but birds nesting in other habitats are often not visible from a distance. In these cases an egg and/or chick count may be the only feasible counting method.

A. Counts of birds and/or eggs and chicks in accessible habitat

Make a direct count of the numbers of birds on the nesting areas and then systematically search the areas for incubating birds, eggs or chicks to determine the number of breeding pairs. When colonies are too large to search thoroughly or insufficient time is available establish control areas within the nesting areas and:

1. record the numbers of birds on all nesting areas including those present (N_i) in the control areas where the number of breeding pairs (N_p) is known (based on the number of eggs and/or chicks), and
2. use this ratio ($k = N_p/N_i$) to calculate the number of pairs for all areas censused.

N.B. As this ratio (N_p/N_i) varies with time and weather conditions, several correction factors (k) may have to be derived where a significant change in census conditions occurs (e.g., time of day - new k value required for each 2 hour period; different phase of breeding cycle; etc.).

B. Counts of birds in inaccessible habitat

When breeding sites are inaccessible make direct count of birds on the nesting areas and nearby locations. Although such counts are inadequate to assess the number of breeding pairs, they may provide a rough index of numbers, especially if the counting procedure is standardized for time of day, phase of breeding cycle and weather conditions.

C. Time of Census

Counts should be made in the second half of the incubation period.

MURRES Uria spp.

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony: topography, physical features, etc.
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony based on the main physical features,
   (b) actual ledges occupied by birds, and
   (c) estimate of total nesting area.
4. Photograph each colony.
5. At mixed-species colonies be careful in making species determination and note precisely the limits for each species.

Census Techniques

A. Counts of birds and/or eggs and chicks in accessible habitat

Although counts of individual birds on bare rock ledges or open nesting sites are relatively easy to make, estimates of the number of breeding pairs are more difficult. At small colonies where the nesting ledges are clearly visible the eggs and chicks may be counted to give a reliable estimate of the number of pairs. However, when colonies are extremely large and eggs and chicks are not easily seen, the best method is to establish control ledges within the total nesting area and:

1. make direct counts of the numbers of birds on all ledges in the colony (do not correct for birds alighting and departing during the count unless flushing occurred because of observers presence) including those present (N_i) on the control ledges where the number of breeding pairs (N_p) is known (based on a count of the total number of eggs and/or chicks), and

2. use this ratio ($k = N_p/N_i$) to calculate the number of pairs for all colonies censused.

   N.B. Derive a k value (N_p/N_i) for several control areas under identical conditions (time of day, etc.) to assess variation between areas, especially between control ledges with large (>30 pairs) and small (10 pairs) groups.

B. Counts of birds in inaccessible habitat

At colonies where egg and/or chick counts are not possible, the preferred method is an individual count of adults. Accurate counts can be made of either all birds present at the colony (small colonies) or the number of individuals in clearly delineated study plots or subdivisions (large colonies) within the colony. Since the necessary correction factors cannot be derived (because of the inaccessibility of the nesting ledges) an estimate of the size of the true breeding population is not possible. However, even though the counts do not represent the entire population they can be used as an index of colony size from which repeat censuses made under the same conditions (i.e., time of day, phase of breeding cycle and weather) can be compared.

C. Population analysis from photography

Murre populations nesting on steep cliffs or flat-topped surfaces can often be measured and analyzed from aerial photography: a series of over-lapping photographs are taken during the last half of the incubation period from a light aircraft using a 70 mm camera with standard lenses (100 or 150 mm) and black and white film (Plus-X professional) at a distance from the cliff of about 200 to 250 m. Individual birds can be systematically counted on 18 x 25 cm glossy enlargements using a hand lens (8x) or binocular microscope and plastic grid overlay. Where the relationship of numbers of murres to actual numbers of eggs and/or chicks

is known (i.e., control areas established prior to aerial photography), an estimate of the number of breeding pairs can be calculated. If correction factors are not available the count can still be used as an index of the population (see above). Moreover, this census method provides a permanent and precise record of the distribution and numbers of birds at individual colonies which could be extremely valuable in the future.

D. Time of Census

Census during the last half of the incubation period.

BLACK GUILLEMOT Cepphus grylle

Census Techniques (all habitats)

Nest-sites of Black Guillemots are difficult to count as they are usually hidden in inaccessible rock crevices or sheer cliffs and boulder beaches. Some nests can be located during the incubation period by watching adult movements in the early morning and evening, and during the chick-rearing period by watching adults returning with food for their young. However, this method is time consuming and cannot be easily used over large geographic areas.

The best census method for obtaining standardized counts of breeding populations is to census the coast systematically early on calm mornings (i.e., good weather conditions and not windy) before egg-laying when pairs are displaying on the sea. Make counts from a boat on the water or from cliff-top vantage points and:

1. mark locations of birds seen on the sea along the coastline and record whether solitary or associated with another Black Guillemot; and
2. when a nest-site is identified (e.g., bird seen departing from a rock crevice) make a detailed map to show the exact location of the site and describe the main physical features of the nesting area for future reference.

Time of Census

Census early in the breeding season before egg-laying (see above).

ATLANTIC PUFFIN Fratercula arctica

Distribution Maps

1. Mark locations of all colonies on general sketch map.
2. Describe each colony (topography, physical features, vegetation) and, if necessary, divide each colony into sub-areas according to burrow density.
3. Make detailed sketch map (to scale) of each colony showing:
   (a) limits of the colony (based on main physical features) and sub-areas (if present), and
   (b) estimate of total nesting area.
4. Photograph each colony.

Census Techniques

A. Counts of burrows in accessible habitat

Census of puffins presents special problems because they usually nest in burrows in the ground. The best method to determine breeding population size is to count the occupied burrows (i.e., burrows with an egg, chick, nest material, defecation stains, etc. - see Nettleship 1972).

An inspection of all burrows may be possible at small colonies, but these cases are the exception, and the determination of abundance usually depends on sampling the total nesting area (or sub-areas) using one of the following methods (N.B., methods are given in descending order or reliability):

1. Line transect method:

   Place fixed line transects (assign each line a letter: A, B, C,...) across the colony from edge to edge to ensure total coverage of the colony and to detect changes in numbers at the periphery in future years (e.g., from maritime cliff-edge inland to where burrow density is zero). The number of transects will depend on colony size and time availability, though a minimum of three transects comprising at least 30 quadrats is required.

Permanently mark each transect line by placing stakes or some suitable marker at both ends of the line and at regular intervals along the line if the transect is extremely long. Mark points along the line at 5 metre intervals and use each point as a corner of a 5 x 5 metre quadrat* (if transect is very long, select sample quadrats at regular intervals along the line beginning at the front of the colony). Measure the following characters within each quadrat:

(a) burrow number and status - count all burrows in quadrat (record a hole as a burrow only when it is at least half a metre in length) and determine status of each: active (with egg, chick, nest material, defecation stains, etc.) or inactive (unoccupied). Record inaccessible burrows, but note nest status not determined.

(b) briefly describe habitat of each quadrat: vegetation, angle of slope, position within colony and/or sub-area.

(c) distance from front of colony - i.e., record distance from furthest side of quadrat to origin of transect line.

An estimate of the total number of breeding pairs in the colony is extrapolated from the line transect occupied burrow density figures.

2. Sub-area sample method:

Make direct counts of burrows in as many 5 x 5 metre quadrats* within the defined sub-areas as time permits. Select quadrats at random, though samples should be as typical of the sub-area as possible, and record:

(a) burrow number and status - same as method 1.

(b) habitat description - same as method 1.

(c) distance from front of colony - same as method 1.

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*quadrat size can vary based on burrow density

B. Counts of burrows in rock scree or boulders

It is often difficult to distinguish a burrow from a natural cavity in this habitat (e.g., Grant and Nettleship 1971), but careful examination of holes for signs of excavation and other nesting activities does make it possible to accurately record number of burrows (use methods described in section A: Counts of burrows in accessible habitat). In rocky habitat quadrat size may have to be adjusted to the local conditions, where boulders are very large or nest density exceptionally low.

C. Counts of birds in all habitats

There is no method sufficiently accurate to determine or estimate population size from counts of birds standing on the colony during one day. Puffins not only display large daily and seasonal fluctuations in colony attendance, but also vary in a quasi-cyclical fashion throughout most of the breeding cycle, the length of which appears to differ between colonies (4 to 5 days at Witless Bay, Newfoundland - Nettleship 1972). This means that counts made when peak numbers are present might be more than 100 times the counts made at the same time two days later (see Nettleship 1972: 248). Therefore, if counts of birds must be used to census the colony (e.g., where the terrain is difficult or inaccessible), make systematic counts of the number of birds standing on the colony through the day (i.e., morning: early, mid and late; afternoon: early, mid and late; and evening) from a hidden viewpoint for several consecutive days (total days required will depend on features of the cycle: length and phase when census initiated) early in the breeding cycle (ideal time is during the pre-laying period). Use the count when peak numbers were present as an index of population size.

When accessible colonies cannot be censused by burrow count methods (e.g., lack of time or difficult terrain) a reliable estimate of population can be made by executing the following technique:

1. establish control areas* (areas within the colony where the number of breeding pairs (N_p) is known - based on number of burrows with eggs or young),
2. make direct count of the number of birds standing on the colony (or representative sections) when peak numbers are present (determine peak using method described above) which includes individuals (N_i) on the control areas, and
3. use this ratio ($k = N_p/N_i$) to calculate the number of pairs for all colonies censused.

D. Time of Census

Counts of birds should be done early during the pre-laying period. Estimates of burrows can be made from late in incubation onward, though the census time at each individual colony should be standardized. Special care must be taken during the incubation period as extended distrubance will cause nest desertion.

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*N.B. It is essential to establish control areas in all habitats occurring within the total nesting area (e.g., maritime slope, flattish ground, etc.) as the relationship between the distribution of adults and the distribution of nest sites differs between habitats.

CENSUS OF BIRDS AT SEA

Quantitative observations of seabirds at sea provide a reliable estimate of bird numbers, diversity and numerical ratio of species which can be used as a measure of populations over either a small or expansive water area of coast or sea. Whether the intent is to perform a regular route census between two close geographic points for an index of species occurrence (e.g., Nettleship and Tull 1971) or the observations are part of a series of systematic surveys of the distributions of seabirds at sea used to help clarify aspects of individual species' pelagic ecology (e.g., Brown and Nettleship 1975), the method is the same. The procedure requires the observer to record birds observed along the coast (inshore and offshore) or at sea (pelagic) in a standardized manner based on a 10-minute observation period (for comprehensive review of procedure see Brown and Nettleship 1975). Observations should be made from a moving ship, but 10-minute watches from a stationary vessel are acceptable provided that it is made clear in the records that the ship was not moving. There are four basic things to note for each 10-minute watch: Time, Position, Species & Numbers and Weather Conditions.

1. Time - record the time at start of the 10-minute watch (note whether DST, ADT, AST, etc.).
2. Position - record the position at start of the 10-minute watch (a map showing the exact route would be most useful).
3. Species & Numbers - count and identify all birds sighted during the 10-minute watch. Give an estimate of the accuracy of identification and count (e.g., murre sp. - could have been a Razorbill; 100 eiders - ± 10%). Add anything significant about their behaviour - e.g., following the ship, feeding, sitting on the water, direction of flight. Also note plumage differences (e.g., ages in gulls, colour phases in fulmars and jaegers).

4. Weather Conditions - record weather conditions during watch and make a point of noting anything such as fog, rain, high seas, sun-glare, etc., which may have hampered observations.

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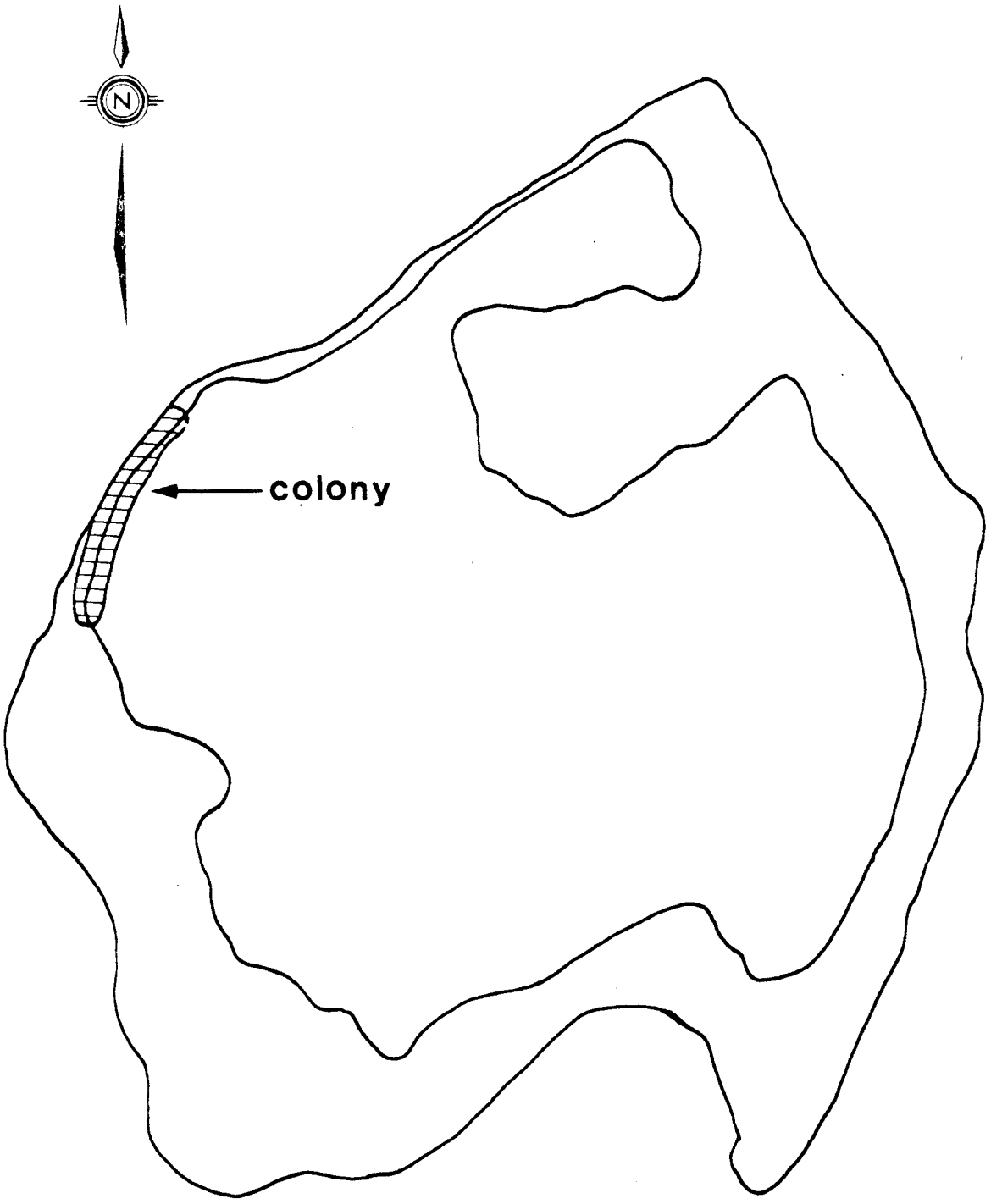
Figure 1. Sketch Maps of Black-legged Kittiwakes on Outer Birch Island, northshore of the Gulf of St. Lawrence.

a. General Sketch Map of colony

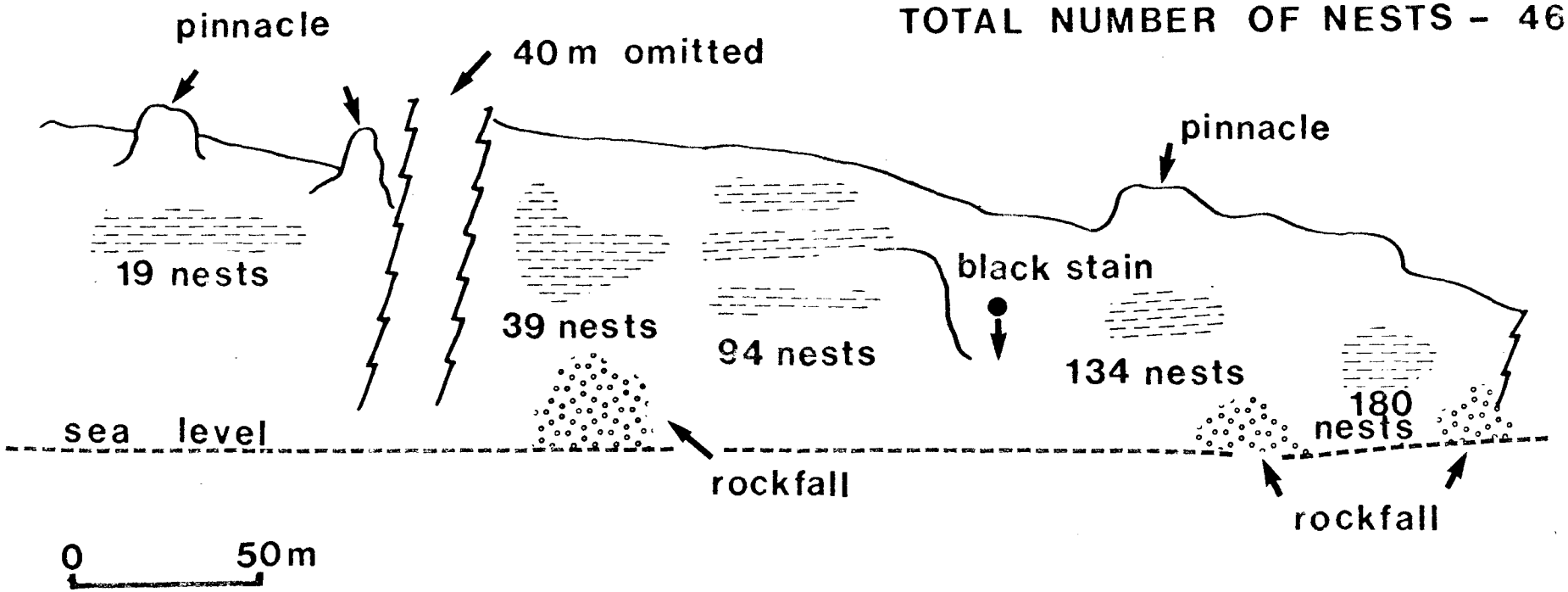
b. Detailed Sketch Map showing distribution of nests on cliffs of the colony



NESTING AREA

0 500 m

OUTER BIRCH ISLAND
10 JUNE 1972 (1700 hrs EDT)

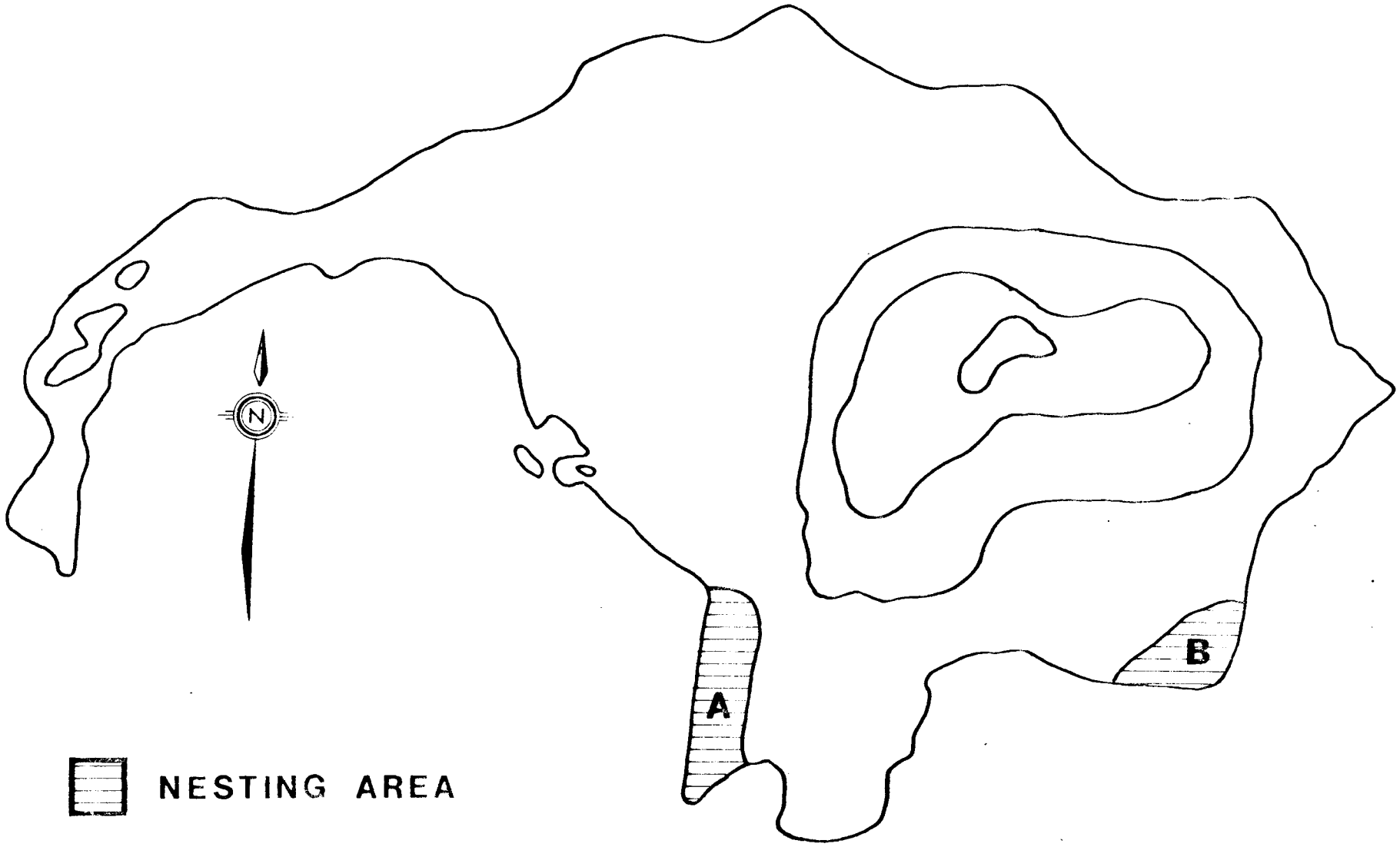


OUTER BIRCH ISLAND
KITTIWAKE COLONY
10 JUNE 1972 (1700 hrs EDT)

Figure 2. Sketch Maps of Herring Gull colonies on Inner Birch Island, northshore of the Gulf of St. Lawrence.

a. General Sketch Map of colonies A and B

b. Detailed Sketch Map showing line transect census method (distribution of quadrats and nests) on colony A



INNER BIRCH ISLAND
11 JUNE 1972 (1400 hrs EDT)

Number of eggs/nest	Quadrat 1	2	3	4	5	6	7	8	9	10	11
0	0	4	8	8	10	5	11	4	9	5	0
1	0	1	0	0	1	2	2	2	2	0	0
2	0	1	1	0	0	0	1	2	2	0	0
3	0	1	0	1	0	1	0	0	0	0	0
nest total	0	7	9	9	11	8	14	8	13	5	0

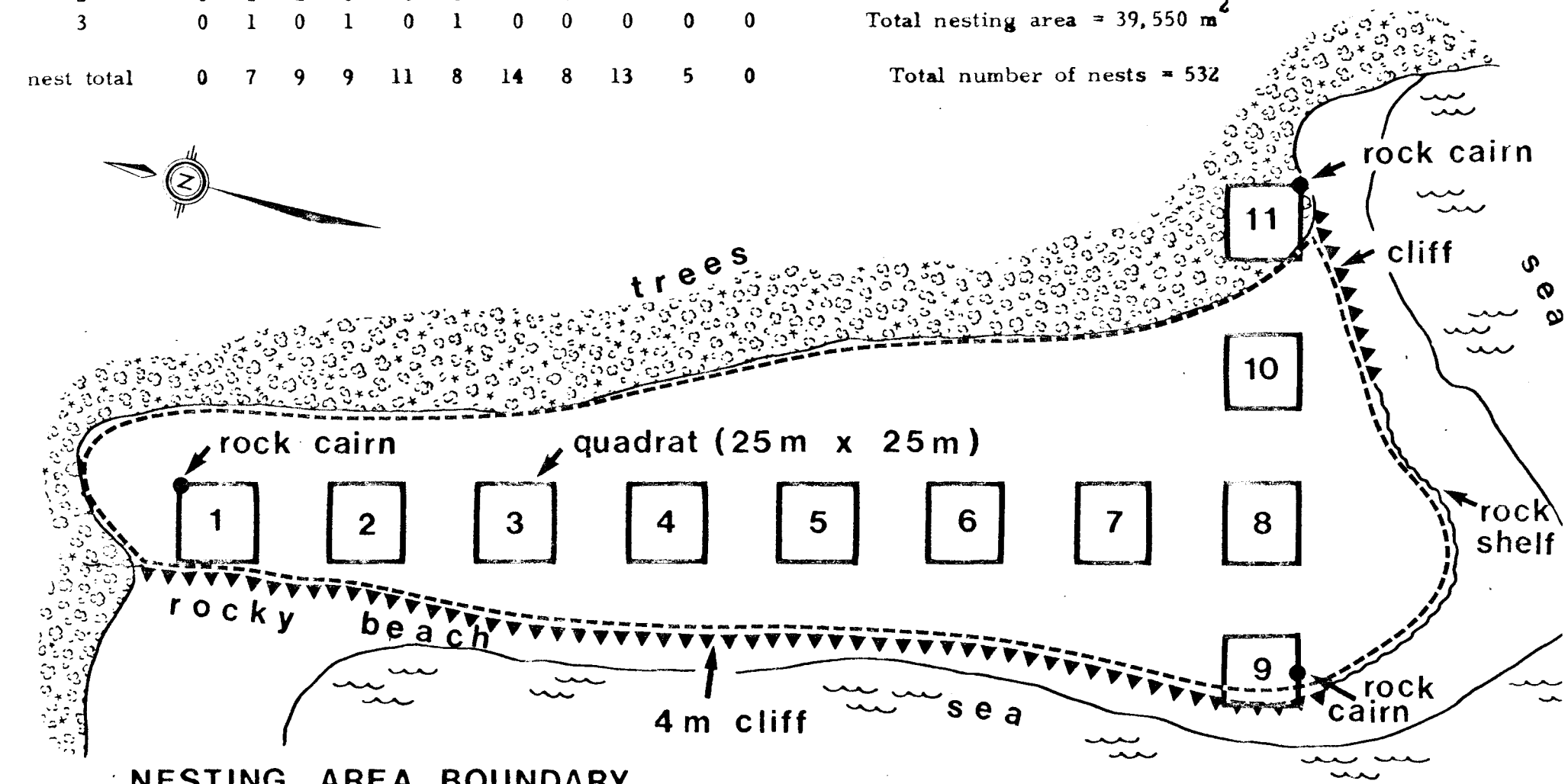
NEST ESTIMATE:

Total number of nests in quadrats = 84

Total area sampled = 6,250 m^2
(quadrat 11 excluded from nest estimate)

Total nesting area = 39,550 m^2

Total number of nests = 532

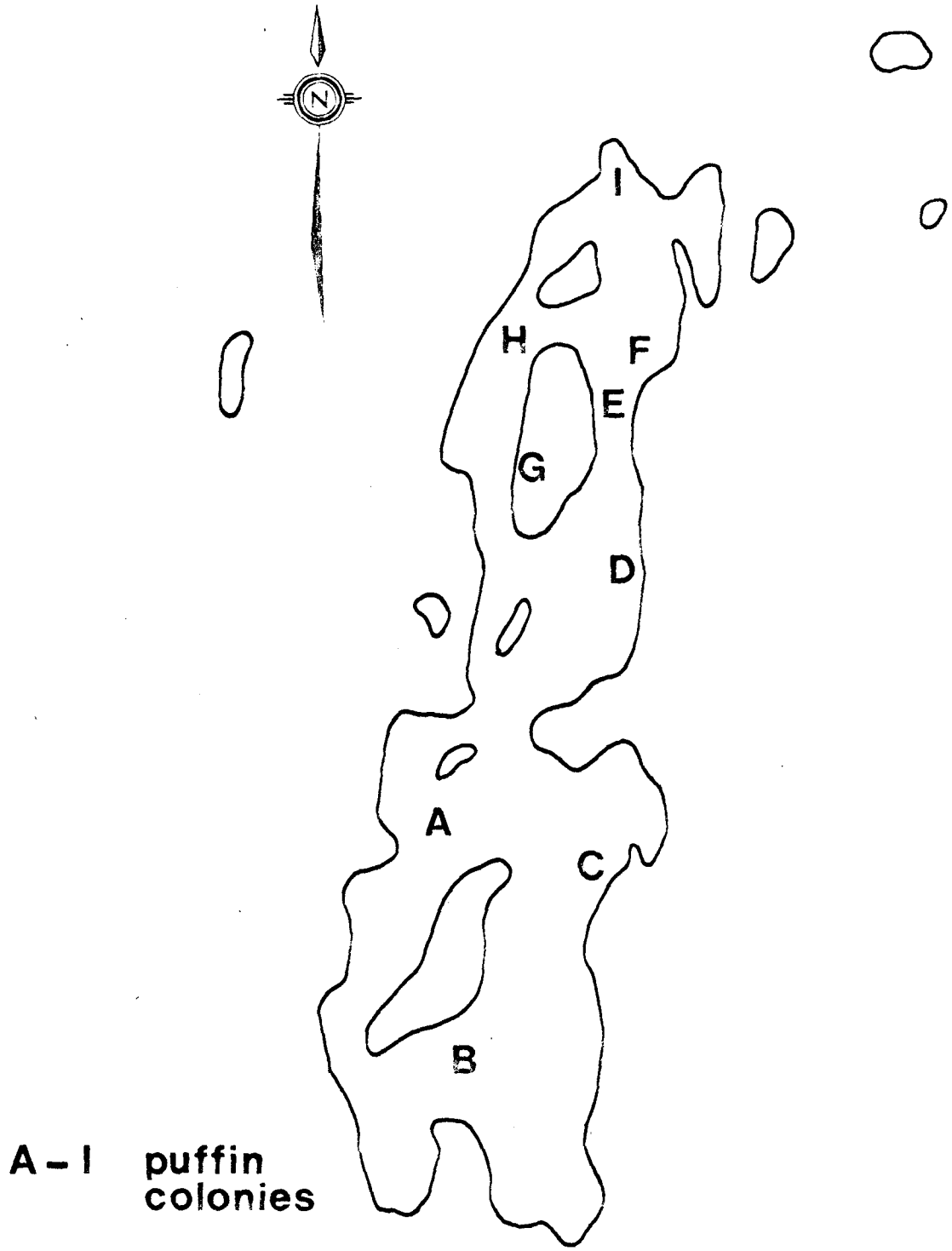


INNER BIRCH ISLAND
HERRING GULL COLONY 'A'
11 JUNE 1972 (0800-0900 hrs EDT)

Figure 3. Sketch Maps of Atlantic Puffin colonies on Wolf Island, northshore of the Gulf of St. Lawrence.

a. General Sketch Map showing approximate locations of colonies

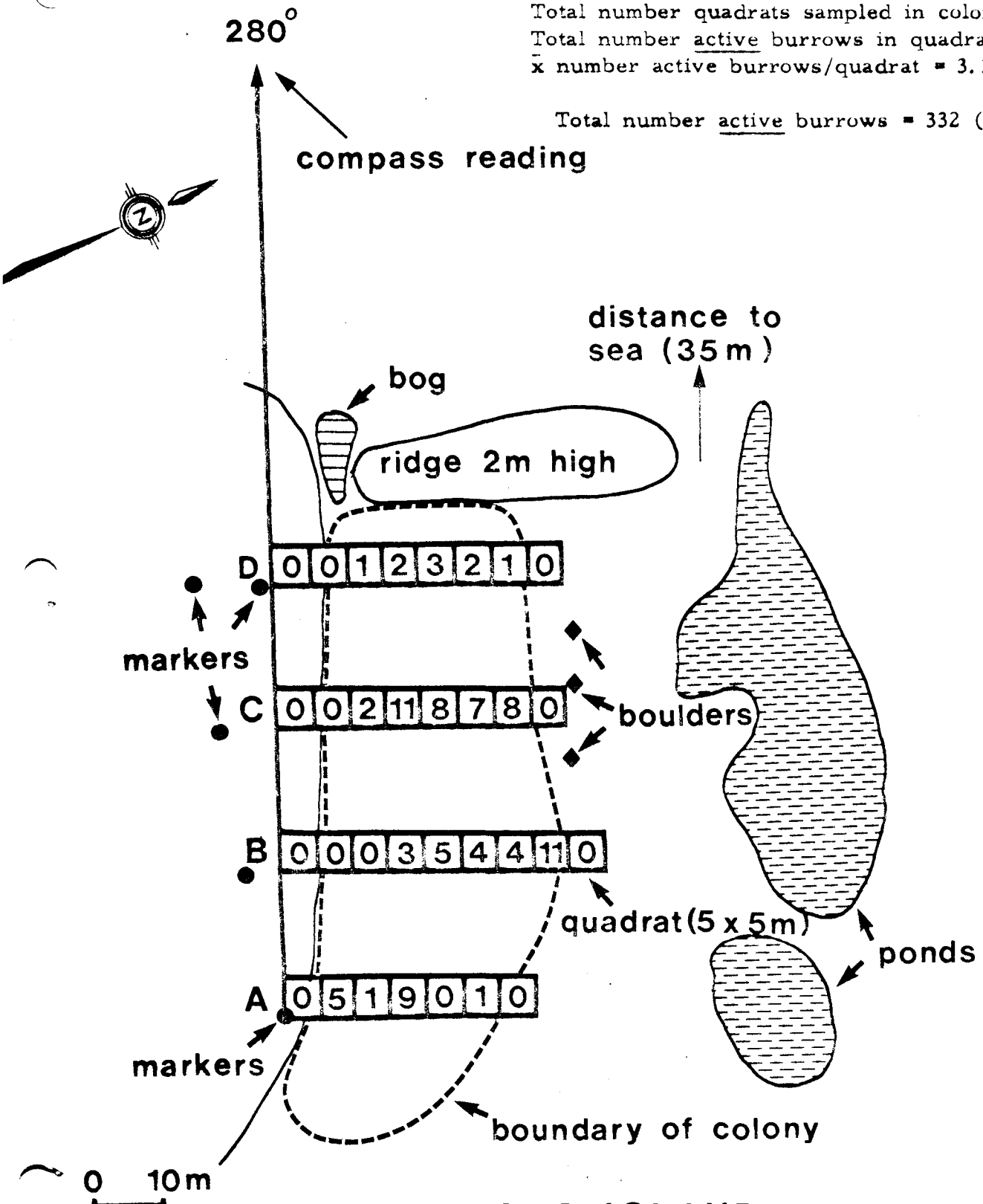
b. Detailed Sketch Map showing line transect census method (distribution of transect lines (A-D), quadrats and active puffin burrows) on colony A


N
I
H
F
E
G
D
A
C
B
A – I puffin colonies
0
500 m
WOLF ISLAND
28 – 29 JUNE 1972

BURROW ESTIMATE:

Total number quadrats (5x5 m) in colony = 98
Total number quadrats sampled in colony = 23
Total number active burrows in quadrats sampled = ...
$\bar{x}$ number active burrows/quadrat = 3.39

Total number active burrows = 332 (98x3.39)



WOLF ISLAND
PUFFIN COLONY 'A'
28 JUNE 1972