Although many methods of counting seabirds at sea use transects
of fixed width or else determine distance to each sighting (e.g.
Heinemann 1981, Griffiths 1982), others use transects with no
set width (e.g. Bailey 1966, Shuntov 1972, Brown et al. 1975).
These are comparable to Powers' (1982) "estimates of density" and
"indices of relative abundance". Powers (1982) established that
estimates of abundance are at least twice as large as estimates
of density for birds sitting on the water but are roughly
equivalent for flying birds. While all counting methods for
seabirds are affected by a great number of environmental
variables (Bailey & Bourne 1972), this note considers only one,
wave height, which may have two major effects on estimates of
relative abundance. First, the distance to the visible horizon
is a function of swell height as well as observer height above the
water, assuming other weather conditions are not limiting. More
seabirds, especially larger species, should be seen during calm
conditions than when the effective horizon is reduced during
swells. Second, birds will spend a proportionally longer period
hidden behind swells as swell height increases so that more time
will be needed to detect each bird.

If the visual horizon v (in metres) = 3 838 h, where h is eye
height (in metres) above the sea surface (Bowditch 1966,
Heinemann 1981), then the effective visual horizon vs for a swell
of s metres can be calculated as vs = 3 838 (h - s). Figure 1
shows the effective horizons for eye heights of 2, 3, 5 and 10 m
under swell conditions from 0 to 8 m. An observer with a 10 m
eye height would lose 33 % of his or her viewing area in one m
swell and 45 % in 2 m swell. An observer with 5 m eye height
would lose 45 % of viewing area in one m swell and 63 % in two m
swell.

This model assumes that the observer maintains a constant height.
A more complicated model for observations from a ship might
include length and height of swell. However for an observer at
eye height h, in swells of height s, the extremes of observer
height will be h + (s/2) and h - (s/2) with a mean height of h so
that the original equation presented is a reasonable approximation
of reality.

Most transects with fixed observation widths use distances of less
than one km. Swells would have to be very large relative to eye
height before the effective visibility is less than the transect
width. This suggests that transects of fixed width are
relatively insensitive to swell height.

In addition to limiting the visible horizon, swells create troughs
which conceal birds (Dixon 1977). Techniques which use
instantaneous scans of set areas (e.g. Gould et al. 1982) to assess bird numbers are likely to miss birds in troughs and behind waves. The higher the swell, the more birds will be hidden at any one time so that instantaneous scans of bird numbers make proportionally greater underestimations of bird numbers with increasing swell height.

Since the effective horizon is sharply diminished in even moderate swell and since detectability of birds, especially small species, falls off sharply with increasing distance (e.g. Dixon 1977) transects without fixed limits or estimated distances to birds are likely to be biased both in species' composition and absolute numbers. In conclusion, fixed widths or estimates of distance and angle to first sighting (Burnham et al. 1980) should be features of all methods of counting birds at sea.

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Figure 1
Effective horizon for eye heights of 2, 3, 5 and 10 m under swell conditions from 0 to 8 m.