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A COMPARISON OF METHODS FOR COUNTING SEABIRDS AT SEA IN THE SOUTHERN OCEAN

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Abstract.—Two methods for counting seabirds from ships were compared during a research cruise in the marginal ice zone of the northwestern Weddell Sea in the Southern Ocean (European Polarstern Study 1988/1989—EPOS). The basic difference between the two methods concerns the way in which birds in flight are recorded. Methods using continuous counts of all birds crossing the transect area in flight result in bias in density estimates because they measure flux rather than density. In the Southern Ocean the continuous method has been used as the standard in the BIOMASS program. To avoid bias due to bird movement, the Scottish Seabirds at Sea Team (SAST) recommended the snapshot method which uses instantaneous counts of birds in flight at specific time intervals to cover consecutive subsectors of the census area. Comparative investigations during EPOS showed that continuous counts resulted in bird density estimates about twice as high as densities derived from snapshot counts. The level of bias caused by continuous counts fluctuated widely between and within species. Effects of different variables such as species-specific behavior, ship's speed, and windforce are difficult to separate. The use of instantaneous counts of birds in flight is strongly recommended because they yield better estimates of both relative and absolute densities of seabirds at sea.

MÉTODO COMPARATIVO PARA CONTAR AVES MARINAS EN LOS OCÉANOS DEL SUR

Sinopsis.—Se compararon dos métodos para contar aves marinas durante un crucero de estudios realizado en la zona marginal congelada de la parte noroeste del Mar Weddell. La diferencia básica entre los dos métodos consiste en la forma en que las aves a vuelo son registradas. El método que consiste en conteos continuos de todas las aves que cruzan el área de un transecto resulta en sesgos en los estimados de densidad. Esto se debe a que mide el flujo en vez de la densidad. En los océanos del sur el método de conteo continuo ha sido lo estándar para el programa BIOMAA. Para evitar sesgo, debido al movimiento de aves, el Conjunto de Aves Marinas Escocés (SAST) recomendó el método de conteos instantáneos (Tasker et al. 1984) el cual utiliza conteos de aves a vuelo a intervalos de tiempo definidos, para cubrir subsectores del área a ser censada. El estudio comparativo mostró que los conteos continuos dieron origen a unos estimados de densidad cerca del doble que las densidades derivadas de conteos instantáneos. El nivel de sesgo causado por los conteos continuos fluctuó ampliamente entre varias especies. El efecto de diferentes variables tales como conducta particular de algunas especies, la velocidad del barco, y la velocidad del viento fueron muy difíciles de separar. Se recomienda la utilización de conteos instantáneos debido a que este método ofrece mejores estimados tanto de densidad relativa como absoluta de las aves marinas que se encuentran a vuelo en el mar.

Standard methods for recording bird observations in the Southern Ocean from a moving ship have been published by the BIOMASS Working Party on Bird Ecology (1984). The Working Party recommended the use of 10-min time blocks to record birds within a 300-m wide transect, in a 90° forward quadrant to one side of the bow. All birds sitting in, or flying over, the transect band were to be included in the counts, only birds following and circling the ship should be disregarded. The BIOMASS recommendations reflected the basic elements of methods of many different studies. Some authors who used BIOMASS (-like) methods presented results in terms of relative abundance such as number of birds per time unit or per distance travelled (e.g., Griffiths et al. 1982, Heinemann et al. 1989, Mochizuki and Kasuga 1985, Starck 1985, Woehler et al. 1990). Others, however, used absolute densities such as numbers of birds or biomass per km^2 (e.g., Ainley et al. 1984, Griffiths 1983, Hunt 1985, Ryan and Cooper 1989a, Shuntov et al. 1982, Zink 1981).

In a review of different counting methods, Tasker et al. (1984) argued that, if counts were to be expressed as numbers per unit area, then a method of reducing bias caused by flux of birds through the transect band during a counting period was needed. During a given period, more birds cross a transect area than there are birds present at any given moment. Such bias can be avoided by recording birds in flight not continuously, but in a "photographic" manner. Tasker et al. (1984) proposed a standardized approach in which birds flying across the transect should be counted by means of a series of instantaneous (snapshot) counts of consecutive parts of the transect area. The snapshot method was first used in Alaskan studies (Gould et al. 1978). The frequency of snapshot counts is determined by the speed of the ship and the distance viewed ahead, and is chosen in such a way that subsequent snapshots cover the whole transect area during each 10-min count (Gould and Forsell 1989, Tasker et al. 1984). Snapshots should be as instantaneous as possible for a maximum reduction of any remaining bias due to bird movement in the time needed for the snapshot observation (Gaston et al. 1987a).

Other elements of the standardized approach proposed by Tasker et al. (1984) are basically the same as in other methods. As in the BIOMASS recommendations, birds sitting and/or actively feeding in the transect band, or in smaller subsectors, are counted continuously. Numbers of such stationary birds in the transect band can be used directly for density calculations when assuming that most diving birds will surface during the time that the observer scans the transect band (Gaston and Smith 1984). Tasker et al. (1984) also recommend the use of 10-min time blocks and a fixed transect, usually 300 m wide, viewed in a 90° bow-beam arc ahead of the moving ship.

During the Antarctic summer of 1988–1989 the European Polarstern Study (EPOS) conducted a multi-disciplinary research program on productivity of Antarctic waters in the marginal ice zone of the Weddell Sea (Hempel et al. 1989, Hempel 1992). Observations of birds, seals, and as far as possible, whales were part of the project to assess biomass of, and energy- and carbon fluxes to the top predator component in the ecosystem (Schalk et al. 1990, van Franeker 1992). As these objectives demand the best possible estimates for absolute animal density, methods for bird observations were designed using snapshot counts. Unfortunately, all previous studies of pelagic distribution of Antarctic seabirds are based on methods using continuous counts of birds in flight. No published data are available on field studies comparing quantitative differences between results of the snapshot and the continuous method. Therefore, during this study, simultaneous with the snapshot method, the method of continuous counts of birds in flight was applied whenever possible. This paper compares the results of the two methods.

METHODS

Seabird observations were made from the German icebreaker Polarstern during its second voyage of the European Polarstern Study (EPOS, Leg 2). Investigations were conducted from November 1988 to January 1989 in the area between the tip of the Antarctic Peninsula and the South Orkney Islands. Four north-south transects were made between 57°S and 62°S, three of them along 49°W and one along 47°W. The ice edge moved from approximately 59°S to 61°S in this period, so all transects covered areas of both open water and sea ice (van Franeker 1992).

Birds were observed from an outdoor observation post installed centrally on top of the bridge (eye height 21.8 m). This outdoor position was chosen because it gives a maximum angle of clear view and permits the additional use of sound to detect less conspicuous animals. Birds were counted in 10-min time blocks in a 300-m wide transect, comprised of 150 m on each side of the ship. This narrow transect band on each side of the ship was chosen because in the initial phase of field work I noticed that individuals of inconspicuous species were easily missed at greater distances (for example, prions and storm petrels, but also larger petrel species under moderate viewing conditions, and penguins swimming or sheltering behind ridges on deformed ice). The difficulties of detecting birds at distances over about 150 m were also noted by Briggs et al. (1985), Dixon (1977), and Wiens et al. (1978). The small transect width might have caused a bias if birds had avoided the ship, but none of the relatively abundant species in this study appeared to show such behavior (Griffiths 1982; pers. obs.). Full compliance with standard methods by counting a narrow (150 m) transect in a 90° arc on one side of the ship only, was rejected as the expected gain in accuracy would not outweigh the disadvantages of a 50% reduction of the survey area. Bird densities were not so high as to cause problems in scanning a 180° area. Furthermore, the wide angle of view had a clear advantage in the identification of ship-associated birds which have to be omitted from counts. The non-standard angle of view does not affect the comparison between methods. All observations were made by the author, preventing potential bias due to variable observer precision (Ryan and Cooper 1989b).

Detection of birds was done with unaided eye; binoculars (10 × 40) were used for confirmation of species or for details of age and plumage, for example. In snapshot counts (see below) binoculars were sometimes used to scan the census-area for smaller flying birds at distances over 150 m. Distances were determined using a range-finder as described by Heinemann (1981). For each 10-min count, information was also collected on ship and environmental parameters (e.g., position, speed, ice cover, wind). Harrison (1983) was followed for nomenclature of bird species.

All stationary birds (swimming, sitting on ice, or actively feeding) within the transect limits were counted continuously. Flying birds were counted in snapshot counts as described by Tasker et al. (1984) of the Seabirds at Sea Team (SAST method). Usually, 10 snapshot counts per 10-min observation were made, in which the speed of the ship determined the forward limit of the snapshot area within a range of 150–300 m ahead. Longer or shorter forward distances were avoided by adapting the frequency of the snapshot counts. A continuous count of birds flying across the transect band was also made (BIOMASS method), but was dropped when bird densities were too high to keep a proper record of both methods. Birds following and circling the ship were omitted from both snapshot and continuous counts. Newly arriving potential ship-followers were included only if their first sighting fell within a normal snapshot or continuous count of the transect area.

Densities were calculated as the sum of stationary plus snapshot birds per surface area (SAST-densities) or as the sum of stationary plus continuous birds per surface area (BIOMASS-densities). SAST and BIOMASS names are used only for convenience to refer to basic differences in field methods, and not to the way in which data were analyzed. BIOMASS does not advocate direct transformation of count data to densities, although this is regularly done (see introduction). Differences in total densities are expressed as the factor by which BIOMASS methods overestimated densities as compared to those derived from SAST methods (BIOMASS/SAST factor). As differences between BIOMASS and SAST method are caused by birds in flight only, stationary birds were sometimes excluded in data analysis. In such cases, the differences between densities of birds in flight are given as the continuous/snapshot factor. Correlations between these factors and variables were tested for significance by weighted simple linear regression (GENSTAT; Payne et al. 1987).

RESULTS AND DISCUSSION

Snapshot and continuous methods were conducted simultaneously in 615 (out of 704) 10-min observation periods, covering a transect area of 460 km^2. Ice was present in 351 of these counts (232 km^2 of transect area). Table 1 gives information on total densities of individual species as derived from different methods and on the factor by which BIOMASS overestimates SAST-density. BIOMASS- and SAST-densities include the same figure for stationary birds (listed as percentage of SAST-density) and differ only because of different estimates for flying birds. Uncommon species and penguins have been omitted. As penguins are essentially stationary, they are judged the same by SAST or BIOMASS counts (BIOMASS/SAST factor is always 1). Only in a few cases were penguins porpoising so quickly that they might be considered as moving across the transect. Counting porpoising penguins by snapshot methods may be useful in situations where a large proportion of the penguins shows such rapid movement.

BIOMASS-densities were often twice as high as SAST-densities, but

TABLE 1. Comparison of densities (n/km^2) of main seabird species according to different counting methods. EPOS Leg 2; 615 10-min counts. Density of stationary birds expressed as percentage of SAST-density. Differences between methods expressed as BIOMASS/SAST factor (see text).

Species		BIOMASS density	SAST density	(Stationary)	BIOMASS/ SAST factor
Black-browed Albatross	*Diomedea melanophris*	0.100	0.037	(24%)	2.7
Grey-headed Albatross	*Diomedea chrysostoma*	0.020	0.011	(0%)	1.8
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	0.011	0.007	(0%)	1.6
Southern Giant Petrel	*Macronectes giganteus*	0.082	0.030	(23%)	2.7
Southern Fulmar	*Fulmarus glacialoides*	1.666	0.910	(36%)	1.8
Antarctic Petrel	*Thalassoica antarctica*	0.052	0.017	(0%)	3.1
Cape Petrel	*Daption capense*	2.899	1.375	(48%)	2.1
Snow Petrel	*Pagodroma nivea*	1.027	0.465	(14%)	2.2
White-chinned Petrel	*Procellaria aequinoctialis*	0.048	0.022	(0%)	2.2
Antarctic Prion	*Pachyptila vittata*	2.235	1.568	(16%)	1.4
Wilson's Storm-petrel	*Oceanites oceanicus*	0.975	0.526	(25%)	1.9
Black-bellied Storm-petrel	*Fregetta tropica*	0.285	0.202	(5%)	1.4
Arctic Tern	*Sterna paradisaea*	0.139	0.120	(87%)	1.2
All non-penguins		9.60	5.31	(30%)	1.8

the difference varied among species (Table 1). Behavioral differences of birds, such as flight speed, and proportions of time spent on water or in the air are sources of variation. Species-specific bird behavior varies with weather conditions, season and type of environment, indicating that variation in the BIOMASS/SAST factor is likely to occur even within a single species (Tasker et al. 1984). In addition to bird-related variables, observer- or ship-associated factors may influence results. Ship's speed especially was considered to be a possible, influential factor, because at slower speeds more birds would be expected to fly over the transect band (resulting in a larger BIOMASS/SAST factor) if the distance viewed ahead remains the same.

Table 2 attempts to give some insight into the most influential factors of the large number of interacting variables affecting the results. For a selected number of species, BIOMASS/SAST factors were calculated at different speeds of the ship. To illustrate the effect of variable proportions of stationary birds, the same was done excluding all stationary birds (continuous/snapshot factor). The effects of the proportion of time spent by birds on the water are illustrated by differences between the BIOMASS/SAST and corresponding continuous/snapshot factors. If all birds had been flying, the difference between BIOMASS and SAST methods would have amounted to an average error in density estimate of 2.2 for all non-penguin species (range 1.3–5.6). During EPOS, 30% of all birds were stationary, reducing this average to 1.8 (range 1.2–4.3). Higher percentages of stationary birds would further lower such figures.

The expected negative correlation between the speed of the ship and the BIOMASS/SAST or continuous/snapshot ratios was often present, but nowhere significant (Table 2). Snow Petrels (*Pagodroma nivea*) even showed a fairly strong reversed correlation. Correlations may have been confounded by the fact that ship speeds during EPOS were strongly correlated to different environments, with slower speeds occurring in increasingly dense pack ice conditions. The absence of albatrosses in the slower speed categories is illustrative. The high BIOMASS/SAST factors of Cape Petrels (*Daption capense*) and Southern Fulmars (*Fulmarus glacialoides*) at ship speeds below 5 knots (=heavy pack ice conditions) can be explained from the fact that these species foraged in open water north of the ice (van Franeker 1992) and commuted at high flight speeds over ice between colonies and feeding areas. This is also seen in the low percentages of stationary birds of these species during low ship speeds in the ice. In a similar way, the reversed speed relationship in Snow Petrels is likely to be the result of species's tendency to remain in close association with icefields and to cross larger stretches of open water at higher flight speeds (Griffiths 1983, Zink 1981). This would result in an increased BIOMASS/SAST factor in open water areas, where ship speed was also high.

Another variable that is likely to affect BIOMASS/SAST factors is the speed of the wind. In higher winds, increased flight speeds and reduced proportions of stationary birds would both be expected to cause an increase

TABLE 2. Influence of ship speed and proportion of stationary birds on differences in results of BIOMASS and SAST methods. Density stationary birds expressed as the percentage of SAST-density. Sign of correlation with ship speed indicated by + or − signs. None of the correlations significant.

	Ship's speed category (knots)					
	<5	5–7.5	7.5–10	>10		All
Average ship speed:	4.0	6.2	8.8	10.9		8.1
n counts:	80	125	284	126		615
Black-browed Albatross						
BIOMASS/SAST factor	–	–	3.8	1.9	–[a]	2.7
Cont/snapshot factor	–	–	5.0	2.1	–[a]	3.3
Stationary %	–	–	30	21		24
Cape Petrel						
BIOMASS/SAST factor	4.3	2.7	2.0	2.2	–	2.1
Cont/snapshot factor	5.6	2.7	3.0	3.3	–	3.1
Stationary %	29	0	49	49		48
Southern Fulmar						
BIOMASS/SAST factor	3.8	2.1	1.9	1.6	–	1.8
Cont/snapshot factor	3.8	2.1	2.4	2.0	–	2.3
Stationary %	0	0	36	44		37
Snow Petrel						
BIOMASS/SAST factor	2.0	1.8	2.5	2.5	+	2.2
Cont/snapshot factor	2.2	2.0	2.7	2.7	+	2.4
Stationary %	12	15	15	13		14
Antarctic Prion						
BIOMASS/SAST factor	1.3	–	2.0	1.2	+	1.4
Cont/snapshot factor	1.3	–	2.1	1.3	+	1.5
Stationary %	0	–	10	18		16
Wilsons Storm-petrel						
BIOMASS/SAST factor	1.8	2.2	1.9	1.6	–	1.9
Cont/snapshot factor	1.8	2.4	2.3	1.8	–	2.1
Stationary %	8	14	35	19		24
All non-penguins						
BIOMASS/SAST factor	2.1	2.0	2.0	1.6	–	1.8
Cont/snapshot factor	2.4	2.3	2.5	1.8	–	2.2
Stationary %	20	23	33	28		30

[a] Correlations tested in speed categories 8, 9, 10, and >11 knots.

in BIOMASS/SAST factors. Table 3 examines the effect of wind speed. As expected there is some tendency to a reduced proportion of stationary birds in higher wind speeds. Nevertheless, BIOMASS/SAST and continuous/snapshot factors show no evident relation to wind speed. The erratic nature of results, like the sudden high factors at windforce 9, may be due to small sample size and influence of directions of wind and bird movement. A possible explanation for the weak relationship may exist in a significant correlation between wind speed and ship speed during EPOS. Increased wind speed would increase the BIOMASS/SAST factor, but

TABLE 3. Influence of windspeed on differences in results of BIOMASS and SAST methods (all non-penguin species). Correlation with windforce: *, $P < 0.1$ and **, $P < 0.01$.

	Windforce (Beaufort scale)								
	1	2	3	4	5	6	7	8	9
n counts:	49	87	131	101	128	71	18	13	15
BIOMASS/SAST factor	2.4	1.9	2.0	1.8	1.5	1.6	2.0	1.5	10.1
Cont/snapshot factor	2.8	2.8	2.7	2.3	1.6	2.0	2.1	1.6	10.1
Stationary %	22	49	44	35	13	36	10	3	0*
Average ship speed (knots)	6.4	7.6	7.3	8.5	8.1	9.3	10.1	9.5	11.4**

the simultaneous increase in ship speed would have the opposite effect. To reverse the conclusion: a possible relation between ship speed and BIOMASS/SAST factors in Table 2 is confounded by, amongst other factors, wind speed.

All this discussion serves to show that BIOMASS/SAST factors are influenced by a complex range of interacting variables of bird behavior, environmental conditions and the ship. Without a large number of controlled experiments it is of little use to try to discuss further contributions of individual variables. The data presented give an impression of the differences in results of methods using continuous versus snapshot counts of birds in flight, under the range of conditions encountered during EPOS Leg 2.

CONCLUSIONS

The results show that a considerable error is made when deriving density estimates for birds at sea from shipcounts that include all flying birds crossing the transect (BIOMASS methods). For the average situation during EPOS Leg 2, the BIOMASS method overestimated densities of birds capable of flight by a factor of 1.8 as compared to counts based on instant snapshots of birds in flight (SAST method). Depending on species, particular environmental conditions and associated bird behavior, and ship-related variables, this factor ranged as high as five. Consequently, continuous counts of birds in flight will lead to significant but unpredictable overestimates of seabird densities, which is especially harmful when density estimates are used to derive sizes of populations and their food requirements.

It might be argued that BIOMASS-like methods are useful for comparisons of "relative abundance" (whether expressed as numbers per time-unit or distance travelled, or as numbers per km^2). The results of this study, however, indicate that even then misleading results may occur. For example, variations in the proportions of stationary birds and flight speeds in relation to ice conditions strongly affected BIOMASS results and increased overestimates of some species in ice areas. A wide range of variables may cause similar effects, distorting estimates of relative abundance in time or space. From their analysis of effects of relative movement of birds (depending on speeds and directions of both bird and ship) Spear et al. (1992) also concluded that uncorrected continuous counts will lead to errors in relative abundances.

In the above statements, results from the snapshot method were used as the reference to express the size of the error made by the method using continuous counts of birds in flight. This might suggest that SAST densities are considered as true or absolute densities. Clearly this is not the case, as the SAST method faces a number of the same problems encountered by any ship-based method of counting birds at sea. Any observer can miss or double-count individual birds (Ryan and Cooper 1989b). Some seabird species are strongly attracted to ships (Griffiths 1981, 1982) and, although it is possible to a reasonable extent to identify and keep track of birds associated with the ship (e.g., from plumage characteristics, flight pattern and/or group composition), some double-counting may occur. An unavoidable error in density estimates may also result if flying birds deviate from their course to pass closer to the ship's bow or wake, or to avoid the ship (Griffiths 1982). Such errors occur in all ship-based census methods (though several of them are likely to have more pronounced effects in continuous methods), and further investigations to improve field or analytical methods are needed.

The point to be made here is that the snapshot method provides a simple way of largely eliminating bird flux as a major source of bias in pelagic seabird censuses. Densities derived from snapshot methods will be closer (not equal) to the "real" densities and are a more sound basis for both quantitative and qualitative studies of seabird distribution. Such advantages remain, even if specific circumstances or research aims (Haney 1985, Tasker et al. 1985) would require changes to other elements of standard methods (e.g., changes in duration of count, transect-width or angle of observation).

Alternative methods have been proposed to eliminate the important bias from flux in continuous counting methods. Adding to earlier work by Wiens et al. (1978) and Gaston et al. (1987b), Spear et al. (1992) propose the use of continuous counts, but to eliminate the bias of bird flux by correcting observed numbers for the effects of relative movement. The method requires accurate determination of the speed and direction of flight of each bird, relative to speeds and directions of both the wind and the ship. As it is impossible to determine all these variables during seabird counts, Spear et al. (1992) suggest the use of average flight speeds for each species for a range of different wind speeds and relative wind directions. This leaves the direction of flight of individual birds to be determined. The claim by Spear et al. (1992) that such a method would yield an estimate of absolute densities for species not attracted to ships seems unjustified. Firstly, there are rather few species whose movements (attraction or avoidance) seem completely unaffected by ships; even small changes in flight direction can have considerable effects in the proposed correction method. It would be very hard to determine to which species the method can be safely applied. Secondly, the use of average flight speeds for a range of relative wind speeds and directions is an incorrect generalization, as flight speeds of many bird groups depend on (the interactions of) many more variables than just wind speed and direction (for example: height and directions of waves and swell; whether or not birds are searching for food or on the move; group behaviors; variable moulting stages of flight feathers; and variations in body weights caused by, e.g., food loads carried for chicks). In summary, the method of Spear et al. (1992) is applicable only to a small and uncertain range of species, offers no correction for flux in all other species, and invokes assumptions that invalidate the claim of absolute densities. Apart from that, the major problem in the field is that the method requires time consuming records of flight direction of individual birds which will affect the accuracy of counts in general. The authors quote Haney (1985) in rejecting the snapshot method because it would not be feasible to detect all species equally well at distances greater than 300 m. This objection is irrelevant as the forward distance of snapshot counts can be set as desired by adapting the frequency of the snapshots. The method proposed by Spear et al. (1992) may be an option for specialized studies of particular species (for example, some alcids) but is not a serious alternative for snapshot counting methods in quantitative studies of pelagic seabird communities.

There is little point at this stage in discussing published studies of Antarctic seabird distribution (see introduction) in the light of BIOMASS/SAST factors calculated from EPOS data. It has been shown that such factors vary strongly under a wide range of variables, the separate effects of which will be hard to detect without controlled experiments. The complexity of interactions indicates that care should be taken when comparing between BIOMASS-like and snapshot studies. The function of data presented in this paper is to supply some understanding in background and order of magnitude of differences between the different methods. I strongly recommend the snapshot method because there is an increasing demand for quantitative descriptions of the role of top predators in ecosystems (Croxall 1987, Siegfried and Croxall 1987).

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LITERATURE CITED

AINLEY, D. G., E. F. O'CONNOR, AND R. J. BOEKELHEIDE. 1984. The marine ecology of birds in the Ross Sea, Antarctica. Ornithological Monographs No. 32. American Ornithologists' Union, Washington, D.C.

BIOMASS WORKING PARTY ON BIRD ECOLOGY. 1984. Recording observations of birds at sea (rev. edn.). BIOMASS Handbook 18. 17 pp.

BRIGGS, K. T., W. B. TYLER, AND D. B. LEWIS. 1985. Comparison of ship and aerial surveys of birds at sea. J. Wildl. Manage. 49:405–411.

CROXALL, J. P. (ED.). 1987. Seabirds: feeding ecology and role in marine ecosystems. Cambridge Univ. Press, Cambridge, United Kingdom. 408 pp.

DIXON, T. J. 1977. The distance at which sitting birds can be seen at sea. Ibis 119:372–375.

GASTON, A. J., AND G. E. J. SMITH. 1984. The interpretation of aerial surveys for seabirds: some effects of behaviour. Occ. Paper No. 53. Can. Wildl. Serv., Ottawa, Ontario, Canada. 18 pp.

———, B. L. COLLINS, AND A. W. DIAMOND. 1987a. The 'snapshot' count for estimating densities of flying seabirds during boat transects: a cautionary comment. Auk 104:336–338.

———, ———, AND ———. 1987b. Estimating densities of birds at sea and the proportion in flight from counts made on transects of indefinite width. Occ. Paper No. 59. Can. Wildl. Serv., Ottawa, Ontario, Canada.

GOULD, P. J., C. S. HARRISON, AND D. J. FORSELL. 1978. Distribution and abundance of marine birds—south and east Kodiak Island waters. Pp. 614–710, *in* NOAA. Annual report of Research Unit No. 337, Annual reports of principal investigators for the year ending March 1978, Vol. 2, Boulder, Colorado.

———, AND D. J. FORSELL. 1989. Techniques for shipboard surveys of marine birds. Tech. Rep. 25. U.S. Fish and Wildlife Service, Washington, D.C.

GRIFFITHS, A. M. 1981. Biases in censuses of pelagic seabirds at sea in the Southern Ocean. Pp. 189–196, *in* J. Cooper, ed. Proceedings of the symposium on birds of the sea and shore, 1979. African Seabird Group, Cape Town, South Africa.

———. 1982. Reactions of some seabirds to a ship in the Southern Ocean. Ostrich 53: 228–235.

———. 1983. Factors affecting the distribution of the Snow Petrel (*Pagodroma nivea*) and the Antarctic Petrel (*Thalassoica antarctica*). Ardea 71:145–150.

———, W. R. SIEGFRIED, AND R. W. ABRAMS. 1982. Ecological structure of a pelagic seabird community in the Southern Ocean. Polar Biol. 1:39–46.

HANEY, J. C. 1985. Counting seabirds at sea from ships: comments on interstudy comparisons and methodological standardization. Auk 102:897–898.

HARRISON, P. 1983. Seabirds. An identification guide. Croom Helm Ltd. Beckenham, United Kingdom. 448 pp.

HEINEMANN, D. 1981. A range finder for pelagic bird censusing. J. Wildl. Manage. 45: 489–493.

HEINEMANN, D., G. HUNT, AND I. EVERSON. 1989. Relationships between the distributions of marine avian predators and their prey, *Euphausia superba* in Bransfield Strait and southern Drake Passage, Antarctica. Mar. Ecol. Prog. Ser. 58:3–16.

HEMPEL, G. (ED.). 1992. Weddell Sea ecology. Results of EPOS European "Polarstern" Study. Springer-Verlag, Berlin, Germany. 333 pp.

HEMPEL, I., P. H. SCHALK, AND V. SMETACEK (EDS.). 1989. The Expedition Antarktis VII/3 (EPOS Leg 2) of R.V. "POLARSTERN" in 1988/89. Berichte Zur Polarforschung 65. 199 pp.

HUNT, G. L. JR. 1985. A preliminary comparison of marine bird biomass and food consumption between the southeastern Bering Sea and parts of the Southern Ocean. Pp. 487–492, *in* W. R. Siegfried, P. R. Condy, and R. M. Laws (eds.). Antarctic nutrient cycles and food webs. Springer-Verlag, Berlin, Germany.

MOCHIZUKI, H., AND I. KASUGA. 1985. Seabirds in the Australian sector of the Southern Ocean, January and February 1984. Trans. Tokyo Univ. Fisheries 6:155–165.

PAYNE, R. W. ET AL. 1987. GENSTAT 5 Reference Manual. Clarendon Press, Oxford, United Kingdom. 749 pp.

RYAN, P. G., AND J. COOPER. 1989a. The distribution and abundance of aerial seabirds in relation to Antarctic krill in the Prydz Bay region, Antarctica, during late summer. Polar Biol. 10:199–209.

———, AND ———. 1989b. Observer precision and bird conspicuousness during counts of birds at sea. S. Afr. J. Mar. Sci. 8:271–276.

SCHALK, P. H., T. BREY, U. BATHMANN, W. ARNTZ, D. GERDES, G. DIECKMANN, W. EKAU, R. GRADINGER, E. NÖTHIG, S. B. SCHNACK-SCHIEL, V. SIEGEL, V. S. SMETACEK, AND J. A. VAN FRANEKER. 1990. Towards a conceptual model for the Antarctic marine ecosystem. ICES C.M.1990/L:30.

SHUNTOV, V. P., D. F. KIRLAN, L. V. BATYTSKAYA, S. Y. GLEBOVA, AND N. G. KOLESOVA. 1982. General regularities of quantitative distribution of sea birds in the South Ocean. Biologya Mor. Akad. Nauk SSSR 2:3–11.

SIEGFRIED, W. R., AND J. P. CROXALL. 1987. Techniques for assessing interactions between seabirds and food resources in the Southern Ocean. BIOMASS Sci. Ser. 7:107–116.

SPEAR, L., N. NUR, AND D. G. AINLEY. 1992. Estimating absolute densities of flying seabirds using analysis of relative movement. Auk 109:385–389.

STARCK, W. 1985. Seabird observations in the region of the South Shetland Islands and South Orkney Islands in December 1983–January 1984. Pol. Polar Res. 6:167–173.

TASKER, M. L., P. HOPE JONES, T. DIXON, AND B. F. BLAKE. 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101:567–577.

———, ———, B. F. BLAKE, AND T. J. DIXON. 1985. Response to J. C. Haney. Auk 102:899–900.

VAN FRANEKER, J. A. 1992. Top predators as indicators for ecosystem events in the Confluence zone and marginal ice zone of the Weddell and Scotia Seas, Antarctica, November 1988 to January 1989 (EPOS Leg 2). Polar Biol. 12:93–102.

WIENS, J. A., D. HEINEMANN, AND W. HOFFMAN. 1978. Community structure, distribution and inter-relationships of marine birds in the Gulf of Alaska. Final reports of principal investigators, vol. 3. NOAA, Boulder, Colorado.

WOEHLER, E. J., C. L. HODGES, AND D. J. WATTS. 1990. An atlas of the pelagic distribution and abundance of seabirds in the southern Indian Ocean, 1981 to 1990. ANARE Res. Notes 77:1–406.

ZINK, R. M. 1981. Observations of seabirds during a cruise from Ross Island to Anvers Island, Antarctica. Wilson Bull. 93:1–20.

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CONCEPTUAL LEGISLATION TO ESTABLISH A NATIONAL INSTITUTE FOR THE ENVIRONMENT (NIE)

Legislation was introduced on 6 Aug. 1993 by George Brown (D-CA) and Jim Saxton (R-NJ), along with a bipartisan group of 40 original (now 52) co-sponsors, for the creation of a National Institute for the Environment (NIE) as an independent establishment with a mission to improve the scientific basis for making decisions on environmental issues. The purpose is to advance the concept of the NIE, but the bill does not contain the structural elements nor authorization levels necessary to establish the NIE. These will be added following hearings, which are expected to occur in the fall.

The bill would set the duties of the Institute to: (1) increase scientific understanding of environmental issues by supporting credible, problem-focused research on environmental resources, environmental systems and environmental sustainability; (2) assist decision making by providing ongoing comprehensive assessments of current environmental knowledge about the environment; (3) to serve as the nation's foremost provider and facilitator of current and easy-to-use scientific information about the environment; (4) strengthen capacity to address environmental issues by sponsoring higher education and training; (5) to foster the interchange of scientific information about the environment among scientists, decision makers, and the public in the United States and foreign countries; (6) to identify and seek to address emerging environmental issues, including all scientific, technological, and societal aspects.

The NIE would carry out its duties by providing contracts, cooperative agreements, and grants to scientists, engineers, and other researchers regardless of whether they are from government or private sector institutions. It would not have its own laboratories, nor would it have duties for regulation or management of the environment.