Briggs,K.B. 1982. The breeding population of Oystercatchers in north-west England. *Naturalist, Leeds* 107: 61-65.
Briggs,K.B. 1984. The breeding ecology of coastal and inland Oystercatchers in north Lancashire. *Bird Study* 31: in press.
Emlen,S.T. and Oring,L.W. 1977. Ecology, sexual selection and the evolution of mating systems. *Science* 197: 215-233.
Graul,W.D. 1973. Adaptive aspects of the Mountain Plover Social System. *Living Bird* 12: 69-93.
Harris,M.P. 1967. The biology of Oystercatchers *Haematopus ostralegus* on Skokholm Island, S. Wales. *Ibis* 109: 180-193.
Harris,M.P. 1970. Territory limiting the size of the breeding population of Oystercatcher (Haematopus ostralegus) - a removal experiment. *J. Anim. Ecol.* 39: 707-713.
Heppleston,P.B. 1972. The comparative breeding ecology of Oystercatchers (*Haematopus ostralegus* L.) in inland and coastal habitats. *J. Anim. Ecol.* 41: 23-51.
Leach,H.I. 1980. Successful multiple nest-use by Oystercatchers. *Br. Birds* 73:220.
Nevin,W.S. and Ticehurst,N.F. 1951. Bigamy of Oystercatcher. *Br. Birds* 44: 208-209.
Newton,I. 1979. *Population Ecology of Raptors*. T. and A.D. Poyser, Calton.
Ticehurst,N.F. 1950. Bigamy of Oystercatcher. *Br. Birds 43: 307-309.*

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FLUCTUATIONS IN THE NUMBER OF WINTERING WADERS AT BURNTISLAND BAY, THE FIRTH OF FORTH: A COMPARISON WITH BIRDS OF ESTUARIES DATA

by John and Catrina F. Barrett

INTRODUCTION

Evaluation of the importance of particular sites as wintering grounds for waders has been based largely on counts made at high water, for example for the Birds of Estuaries Enquiry (BoEE) (Prater 1981). Such counts have been carried out on set dates in order to obtain meaningful total counts for estuaries, regions and countries. In winter, little work has been done to compare the data obtained from these counts with data collected at other times, although fluctuations in numbers during spring migration have been documented (e.g. Ferns 1981). Goss-Custard (1981) showed that for Oystercatchers *Haematopus ostralegus* on the Exe estuary, south-west England, roosting and low water counts corresponded closely. However this may not be the case for other species or areas. In large estuaries, a number of individual sites may be important. Counts carried out on roosts at high water may not identify those sites which are important feeding areas for waders, and monthly counts may miss seasonal fluctuations in numbers. The purpose of this study was to establish if these variations existed, and if they could affect any conservation assessment of a site.

THE STUDY AREA

Burntisland Bay is the second largest expanse of intertidal flats (1.7 km²) on the north shore of the Outer Forth (Figure 1), the largest being Largo Bay (2.3 km²). Burntisland Bay is composed of a variety of substrates. These include sandy mud with large numbers of lug-worms *Arenicola*, cockles *Cerastoderma*, razor-shells *Ensis* and mussels *Mytilus*, silty sand with eel-grass *Zostera* and *Mytilus*, and areas of coarse-grained sand and shell-sand. Two major roost sites exist within the Bay, one on a railway embankment and the other on a sandy beach.

METHODS

Counts of waders were made from set points at various tidal stages between October 1979 and March 1980 in Burntisland Bay (Barrett 1981). For compatability, the same observer also made the BoEE counts for this site. Five counts were carried out at high water on spring tides, eight of feeding birds at low water and fourteen at high water on other than spring tides. On six of these occasions, counts of feeding birds were made at periods up to two hours on either side of high water. On each occasion the numbers counted during one day were very similar, with little immigration or emigration being observed, so the maximum count for each of these days was used for analysis. On one day (9 March 1980) a complete tidal cycle was observed to see if large numbers of birds moved to or from the Bay. Where numbers varied during this day the largest of the counts was used in the analysis.

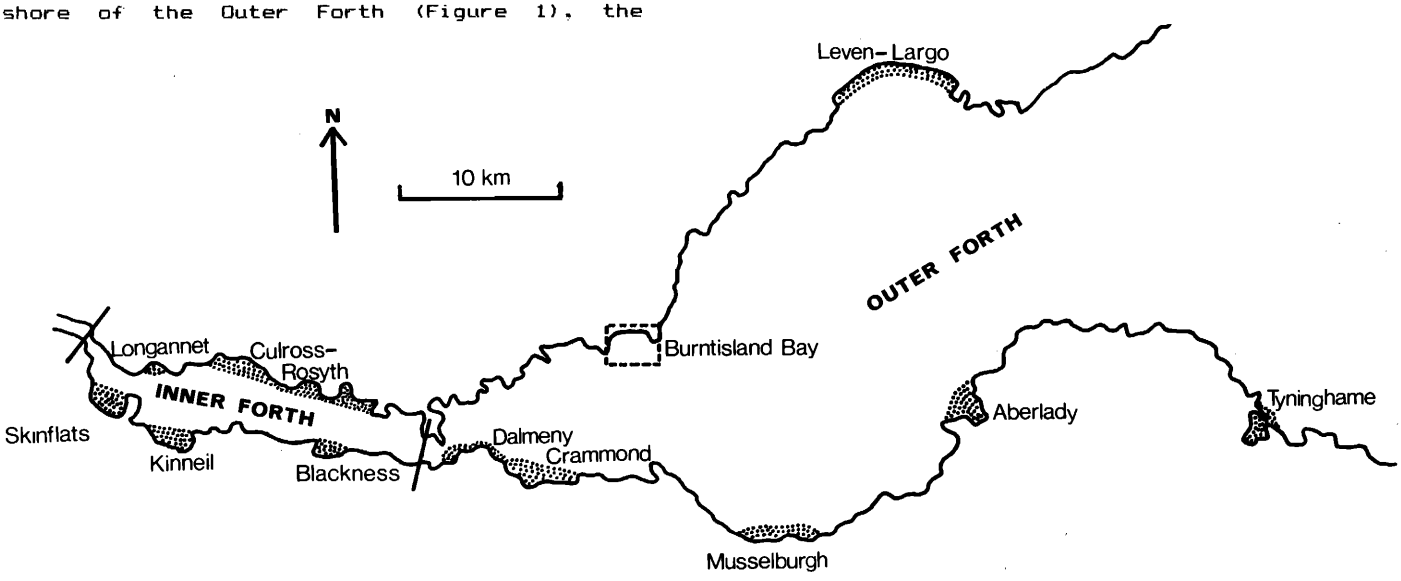

Figure 1. The location of Burntisland Bay in relation to other Firth of Forth intertidal sites

Table 1. High and low water counts on 9 March 1980

		High Water (roosting birds)	Low Water (feeding birds)
Oystercatcher	*Haematopus ostralegus*	285	120
Knot	*Calidris canutus*	750	0
Dunlin	*Calidris alpina*	450	422
Bar-tailed Godwit	*Limosa lapponica*	520	712
Curlew	*Numenius arquata*	180	10
Redshank	*Tringa totanus*	440	202
Turnstone	*Arenaria interpres*	18	22

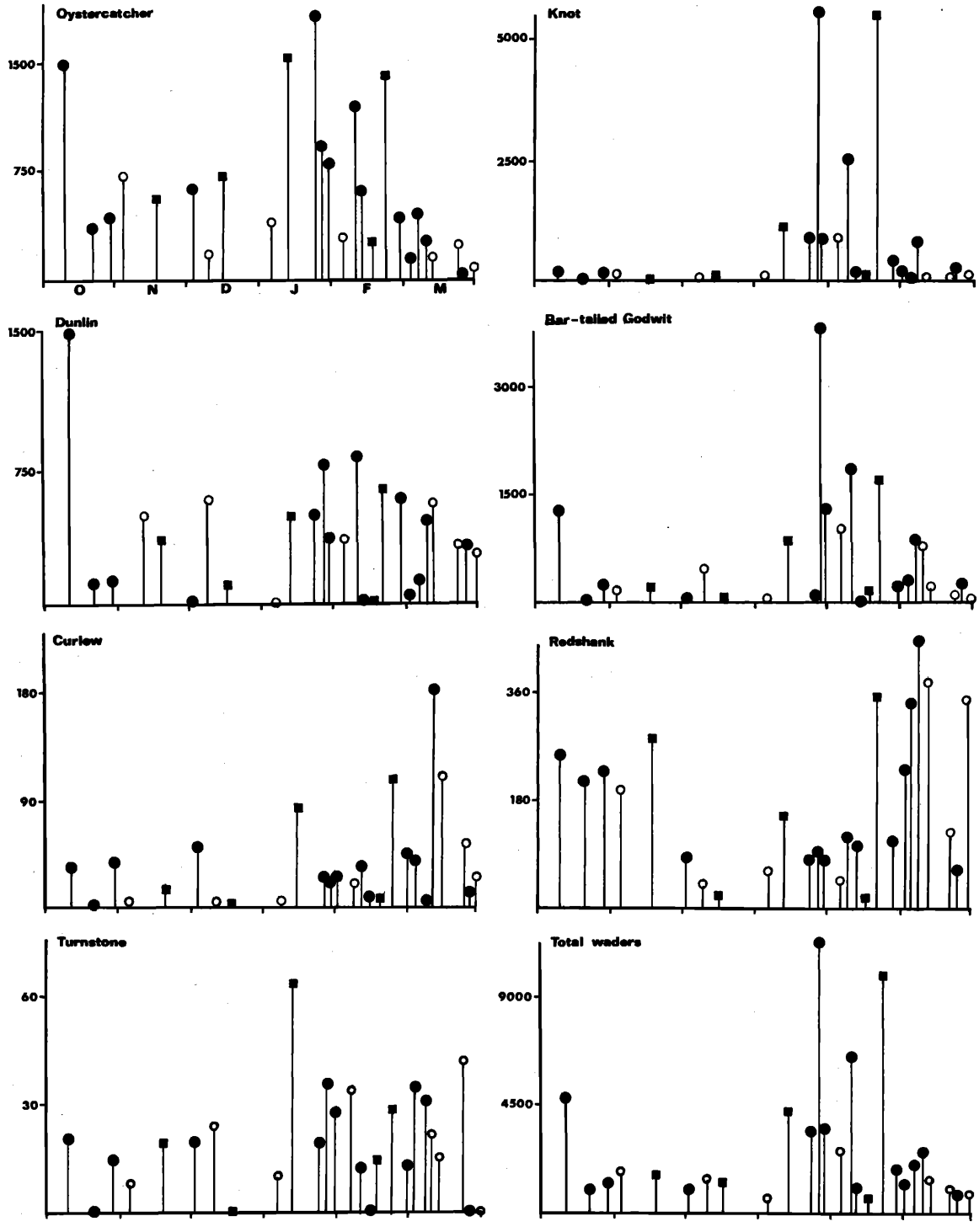

Figure 2. Variation in the numbers of the seven principal species, and the total number of waders, in Burntisland Bay between October 1979 and March 1980. Counts at different tidal stages are: ■ high water spring tide roost counts (equivalent to BoEE), ● high water neap tide roost counts, and O low water feeding counts.

Table 2. Comparison of BoEE counts with the mean of other high water counts in January and February 1980

	JANUARY		FEBRUARY		JANUARY & FEBRUARY	
	BoEE count	Mean of neap counts (n=3)	BoEE count	Mean of neap counts (n=3)	Mean BoEE counts (n=2)	Mean of neap counts (n=6)
Oystercatcher	1500	1169	250	902	875	1036
Knot	1030	2350	53	2130	542	2240
Dunlin	450	523	0	493	225	508
Bar-tailed Godwit	834	1651	105	883	470	1267
Curlew	80	22	6	46	43	34
Redshank	150	83	18	171	84	127
Turnstone	63	27	14	13	39	20
All Waders	4107	5828	446	4638	2277	5233

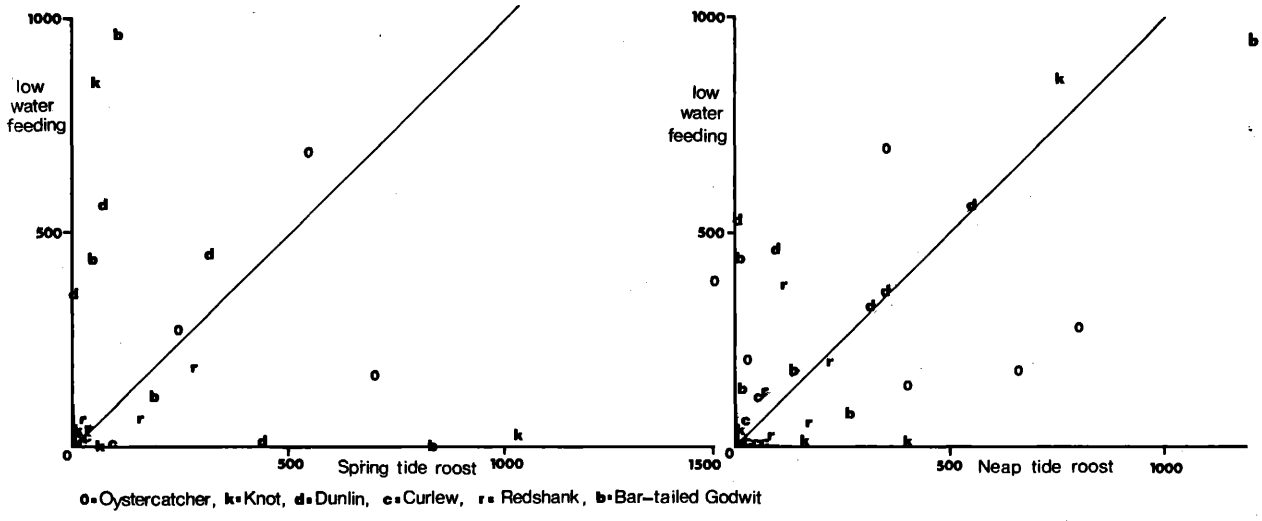

Figure 3. Comparison between high water spring and high water neap tide roost counts and the nearest (by date) low water feeding count. Solid lines show equal numbers of roosting and feeding birds. o = Oystercatcher, k = Knot, d = Dunlin, c = Curlew, r = Redshank, b = Bar-tailed Godwit.

It would have been preferable to have made regular counts at adjacent sites. This was not possible in the time available, and effort was concentrated on one area rather than have fewer counts at a number of sites. Unfortunately, there was uneven coverage through the study period, with a greater number of counts during the second half of the winter. The mean numbers of birds recorded on high water counts during January and February (other months were excluded due to insufficient data) were used for comparison with the BoEE counts for those months.

RESULTS AND DISCUSSION

Table 1 compares low and high water counts on a single day, and Table 2 compares BoEE counts with other high water counts. Figure 2 shows the numbers in winter of the seven principal species, and the total numbers of waders counted at Burntisland Bay. Seasonal fluctuations in numbers were found for all species, particularly when more frequent counts were made during the second half of the winter. The numbers of feeding Oystercatchers were usually less than those of roosting birds (Table 1, Figures 2 and 3). A resident population of approximately 150-400 birds was supplemented by roosting birds arriving from elsewhere just before high water. These birds often fed for a short period on the falling tide before dispersing to other feeding areas. Few Knots *Calidris canutus* fed in Burntisland Bay, and highest numbers were usually roosting birds. Alternative roosts at Seafield and Kirkcaldy were often used, especially on high spring tides when the area of the roost at Burntisland Bay was considerably reduced. Maximum numbers of roosting birds in the Bay occurred on lower tides, when the area of the roost was larger. The numbers of feeding and roosting Dunlins *Calidris alpina* were similar (Table 1, Figures 2 and 3), suggesting that the population might be discrete from those on other Forth mudflats. Likewise, da Prato and da Prato (1979) found counts of Dunlins fairly constant over the tidal cycle on rocky shores in East Lothian, also in the Firth of Forth. However, colour-marking has shown there to be some turnover at Burntisland Bay, with birds marked at Musselburgh, Dalmeny and Aberlady Bay being recorded there in the same winter (Symonds *et al* 1984). The numbers of feeding and roosting Bar-tailed Godwits *Limosa lapponica* were similar. Their pattern of occurrence in the Bay over the winter was like that of Knots (Figure 2). Although the numbers of feeding and roosting Curlews *Numenius arquata* were usually similar, the peak count of 180 birds on 9 March 1980 consisted largely of birds coming into the roost from outside the Bay. On some occasions Curlews flew inland at high water to feed on rough pastures and stubbles. This is a feature in many estuaries (e.g. da Prato and da Prato 1979, Townshend 1979, Barrett 1983). The numbers of feeding and roosting Redshanks *Tringa totanus* were similar, although the peak counts of 440 roosting birds on 9 March 1980 arose through an influx to Burntisland Bay at high water. Colour-marking at other sites on the Forth has suggested little inter-site movement (Symonds *et al* 1984). Turnstone *Arenaria interpres* numbers remained fairly constant. Other species recorded in small numbers included Ringed

Plover *Charadrius hiaticula*, Golden Plover *Pluvialis apricaria*, Grey Plover *Pluvialis squatarola*, Sanderling *Calidris alba*, Purple Sandpiper *Calidris maritima*, Snipe *Gallinago gallinago*, Black-tailed Godwit *Limosa limosa* and Spotted Redshank *Tringa erythropus*.

Fluctuations in numbers can arise through one or more of the following:

a) differential use by feeding and roosting birds. Over a single tidal cycle, for example 9 March 1980 (Table 1), the numbers of feeding and roosting birds showed considerable variation between species. Numbers of Dunlins, Bar-tailed Godwits and Turnstones were similar at low and high tide. There were more Oystercatchers, Curlews and Redshanks roosting than feeding, whilst Knots used the Bay exclusively as a roost site on that day. Over a larger time scale, however, these patterns showed a degree of variability (see Figures 2 and 3).

b) seasonal variations in numbers. These can be due to the changing use of sites within the Forth, or to inter-estuarine movements of birds. For example, Knots marked at Teesmouth in October were recorded in the Firth of Forth later in the same winter (Symonds 1980).

c) major short-term influxes of birds. For example Curlews on 9 March 1980 and Knots on 27 January and 22 February 1980. These may be associated with use of a site either for feeding or roosting. Through colour-marking, Pienkowski and Clark (1979) showed that Knots move freely around the Forth Estuary using a variety of sites during the winter.

d) different numbers roosting on spring and neap tides. Numbers are compared in Table 2. (The tide on 13 February 1980, which should have been a spring, did not reach its predicted height and is regarded as a neap in this comparison.) At Burntisland Bay a high spring tide greatly reduced the available ground on which birds can safely roost and birds often had to leave the Bay to find other, safer, roosts. On high neap tides more waders remained to roost, as they are not forced to move elsewhere by the rising tide. This has been noted at other sites in the Forth and elsewhere (e.g. Furness 1973, Tyson 1982).

Does a monthly BoEE count miss any major fluctuations in numbers? Figure 2 indicates that, for some species and in some months, large numbers of birds are overlooked. For example, in January and February the peak numbers of Knots and Bar-tailed Godwits were far greater than the numbers recorded on BoEE counts (5500 and 5500 compared with 1030 and 53 for Knots; and 3712 and 1800 compared with 834 and 105 for Bar-tailed Godwits). However, for some species, for example Dunlins and Oystercatchers, the differences were much smaller, whilst for others such as Redshanks and Turnstones, most major fluctuations were, in this instance, identified by the BoEE counts.

Insufficient counts on spring tides were made to permit detailed examination of whether BoEE counts are representative of other spring tides or give a reliable estimate of the average numbers of roosting waders during each monthly period. However, BoEE counts at Burntisland Bay are unlikely to be reliable for the latter purpose in view of the differences in usage on neap and spring tides (Table 2). For most species, the BoEE counts gave underestimates, although this was not always so; for example the BoEE count in January 1980 probably overestimated the average numbers of roosting Curlews and Turnstones.

The differences between BoEE and other counts would affect any assessment of the importance of Burntisland Bay to wintering waders, particularly with regard to Knots and Bar-tailed Godwits. At times during January and February 1980 the Bay was used by about 5% of the Scottish wintering Knot population (463 represents 1% of the Scottish wintering population, Prater pers. comm.), and over 2% of the British wintering Bar-tailed Godwit population (450 represents 1% of the British wintering population, Prater (1981)). The BoEE counts did not reflect this importance.

Any assessment of the importance of a site for wintering waders must take account of both feeding and roosting potential. Out of necessity, most assessments of sites have been based on counts of roosting birds. Feeding counts are time consuming and often underestimate numbers. Few counters can devote the extra time needed to carry these out. Da Prato and da Prato (1979) listed many of the difficulties involved in low water feeding counts, but also stressed the importance of feeding counts in assessments. In Burntisland Bay, a comparison was made between high spring and high neap tide roost counts and the nearest (in time) low water feeding count (Figure 3), to see which roost counts most closely reflected low water feeding counts. There was no relationship between high spring tide counts and numbers of feeding birds ($r=0.027$, $p>0.1$). However, there was a correlation between high neap tide counts and feeding numbers ($r=0.63$, $p<0.001$), presumably because feeding birds stayed to roost at high water. Even so, there were still some large differences between numbers feeding and roosting in several species. If this was the case then we would recommend two counts to be carried out each month, one as the normal BoEE count and another roost count on a high neap tide. This, at least in the case of Burntisland Bay, would provide more useful data for a conservation assessment of a site and might be a more acceptable method to counters than low water feeding counts. Further work seems required to substantiate this system, and to examine its validity at other sites.

Burntisland Bay and the Forth

The BoEE counts provide data on which to evaluate the importance of the Firth of Forth in relation to other estuaries. However, the data from Burntisland Bay suggest that BoEE counts should not be used to formulate importance ratings of sites which also act as feeding areas, within an estuary. Bryant and McLusky (1975) found that the BoEE-based rankings of sites within the Firth of Forth (Skinflats (1st), Culross-Rosyth (2nd), Longannet (3rd) and Kinneil (4th)) was different from a ranking based on feeding studies (Kinneil (1st), Skinflats (2nd), Culross-Rosyth (3rd) and Longannet (a major roost site) very low in rank of feeding importance). The BoEE data for Burntisland Bay from 1971/72 to 1979/80 (Figure 4) show that less than 2,000 waders were present prior to 1978/79, with an apparent increase in numbers in 1978/79 and 1979/80. This increase may be associated partly with a general trend of increasing numbers of waders in the Outer Forth and decreasing numbers in the Inner Forth at this time (Figure 5). Changes of this kind suggest that sites should be reassessed to monitor their changing importance to wintering waders.

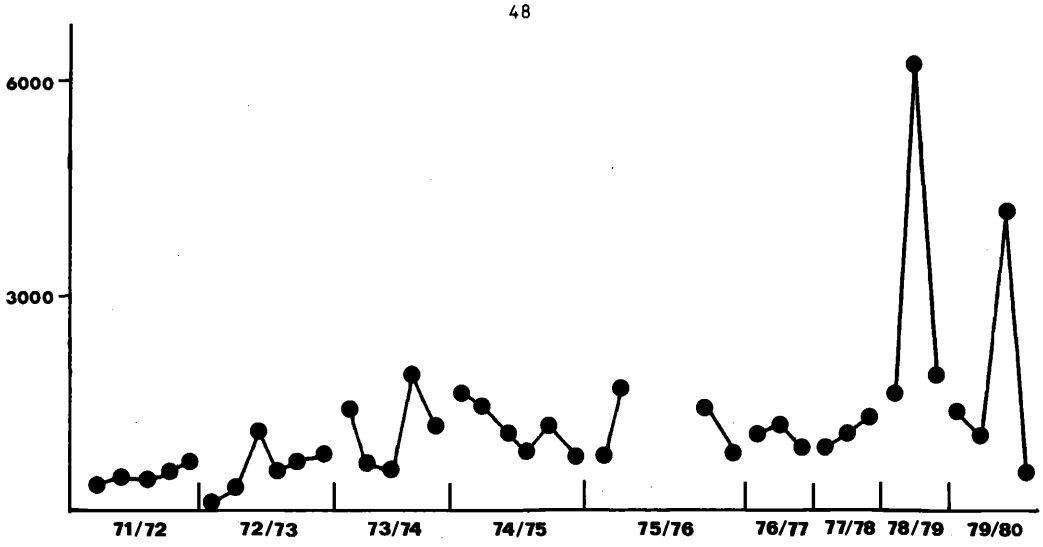

Figure 4. Total numbers of waders in BoEE counts at Burntisland Bay between 1971/72 and 1979/80

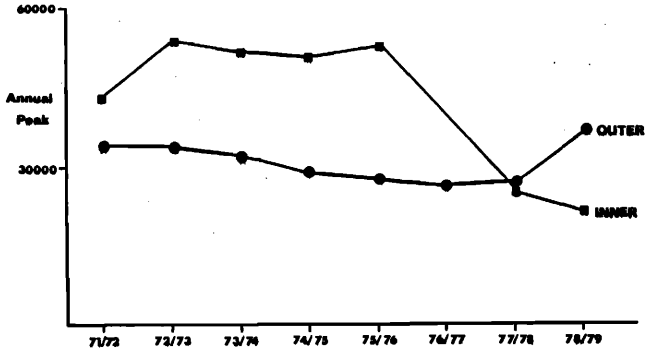

Figure 5. Annual peak numbers of waders (from BoEE counts) for the Inner and Outer Forth Estuary between 1971/72 and 1979/80. A complete count was not available for 1976/77 for the Inner Forth.

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SUMMARY

Frequent counts of wintering waders made at Burntisland Bay in the Forth Estuary during the winter of 1979/80 suggested that, at least for some species, BoEE counts failed at times to detect major fluctuations in numbers. For Knots and Bar-tailed Godwits the single monthly BoEE counts were unlikely to give a good indication of the average numbers of birds utilising Burntisland Bay during the monthly period. We suggest that neap tide roost counts provided a better assessment of numbers using the site. This has implications for assessing the conservation value or importance of sites for wintering waders.

REFERENCES

Barrett,C.F. 1983. Wader and wildfowl counts for Culbin, Findhorn Bay and Burghead Bay in 1982/83. Unpublished report to the Nature Conservancy Council, Inverness.

Barrett,J. 1981. A survey of wintering waders in Burntisland Bay, Firth of Forth, 1979/80. Unpublished report to the Nature Conservancy Council, South East Scottish Region.

Bryant,D.M. and McLusky,D.S. 1975. Invertebrate and bird fauna of the Forth Estuary mudflats. Unpublished report to the University of Stirling and the Nature Conservancy Council.

Ferns,P.N. 1981. The Spring migration of Dunlins through Britain in 1979. *Wader Study Group Bull.* 32: 14-19.

Furness,R.W. 1973. Roost selection by waders. *Scot. Birds* 7: 281-287.

Goss-Custard,J.D. 1981. Oystercatcher counts at roosts and feeding grounds. *British Birds* 74: 197-199.

Pienkowski,M.W. and Clark,H. 1979. Preliminary results of winter dye-marking on the Firth of Forth, Scotland. *Wader Study Group Bull.* 27: 16-18.

Prater,A.J. 1981. *Estuary Birds of Britain and Ireland*. Poyser, Calton.

da Prato,E.S. and da Prato,S.R.D. 1979. Counting wintering waders on rocky shores in East Lothian, Scotland. *Wader Study Group Bull.* 25: 19-23.

Symonds,F.L. 1980. Wader movements within and through the Firth of Forth: some preliminary results. *Edinburgh Ringing Group Report* 7: 17-30.

Symonds,F.L., Langslow,D.R. and Pienkowski,M.W. 1984. Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. *Biol. Conserv.* : in press.

Townshend,D.J. 1979. The importance of field feeding to the survival of wintering male and female Curlews *Numenius arquata* on the Tees Estuary. Pp 261-274 In *Feeding and Survival Strategies of Estuarine Organisms*, eds N.V.Jones & W.J.Wolff. Plenum Press, New York.

Tyson,C.F. 1982. Observations on feeding shorebirds in Findhorn Bay, February-March 1982. Unpublished report to the Nature Conservancy Council and British National Oil Corporation.

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