matters arising

Upwelling by icebergs

NESHYBA[1] argues for the importance of iceberg melting below the thermocline in introducing nutrient rich water into the surface layer. I believe she overrates this effect. She assumes that icebergs melt as a single piece and does not even consider calving as part of the deterioration process. Icebergs that are protected from wave action by sea ice are observed to deteriorate little. Icebergs begin to undergo rapid deterioration when they emerge from the sea ice into the open sea[2]. Wave action progressively melts a groove at the waterline by turbulent mixing. I have observed these grooves to have a depth of up to 7–10 m. The sides of the iceberg then fail, producing a large number of small icebergs and 'growlers' and much fine brash. These small icebergs and growlers, which in most cases would be less than 30 m long and have a maximum draft of 20–25 m, are subject to the same erosional forces. Although no hard figures exist at this time, I would estimate that more than 80% of the melting of an iceberg takes place in a surface layer no deeper than 20 m which is in most cases shallower than the main thermocline.

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Cadmium in seabirds

I FEEL that the article on cadmium in marine animals by Bull *et al.*[1] contains a number of misstatements. Seabirds do not generally contain higher residues than marine invertebrates; as long ago as 1956 Mullin and Riley[2] reported that molluscs may contain up to 500 mg of cadmium per kg in their digestive organs and renal glands, a level not yet equalled by birds, and Holdgate[3] reported much the same levels in healthy guillemots *Uria aalge* from British waters as Bull *et al.*[1] do for other marine animals.

Anderlini *et al.*[4] only investigated six, not seven, bird species, and then only looked at the eggs, which contain little cadmium, for three of them; they included birds from the Atlantic as well as the Pacific and Antarctic. In the three species where they tested the livers, the most novel finding was perhaps not so much the presence of a mean level of 53 mg of cadmium per kg in ashy petrels *Oceanodroma homochroa* from the polluted coast of California, as that of nearly half as much (means of 20–28 mg per kg) in the livers of snow petrels *Pagodroma nivea* resident in the Antarctic pack ice and Wilson's petrels *Oceanites oceanicus* breeding in Antarctica and migrating into different northern oceans. Similarly, the main point of interest about the puffins *Fratercula arctica* examined by Parslow *et al.*[5], only one of which was taken alive at a colony as reported by Bull *et al.*[1], was that the two healthy birds from remote west coast colonies contained much more cadmium than the six mainly found washed up on beaches from the east coast. They also reported surprising levels in a herring gull *Larus argentatus* (12 mg per kg) and a Manx shearwater *Puffinus puffinus* (24 mg per kg) as well as the fulmar *Fulmarus glacialis* liver level of 159 mg per kg actually quoted by Bull *et al.*[1] which is higher than any reported by the latter from the same laboratory when they claimed 'considerably higher levels than any previously found'; the ashy petrel mean is in fact also near their highest liver level.

In addition to their references to past evidence for the normal occurrence of high cadmium levels in pelagic seabirds, Bull *et al.*[1] also seem a little careless in their discussion of their own observations on the occurrence of cadmium in sea-skaters *Halobates micans*. They state 'some of the areas where the higher cadmium residues occur, for example off the coast of West Africa, have little industrial activity, but have upwelling currents of cold water which bring to the surface nutrients, and possibly cadmium too. Areas of ocean upwelling are known to be important wintering locations for pelagic seabirds.' Leaving aside the question whether the bird species quoted do in fact winter in upwelling areas, the map published by Bull *et al.*[1] shows no particular concentration of cadmium in *Halobates* in such areas, but in fact an apparently random distribution of levels above 25 mg per kg throughout the area sampled including the centre of the Sargasso Sea, which is more celebrated for sinking water than upwelling.

Bull *et al.*[1] attribute to me the statement that individual birds are becoming increasingly contaminated with cadmium through feeding in areas of local pollution around the British coast. In point of fact, I ended the paragraph which I devoted to cadmium[6] 'it would appear that like some other marine animals pelagic seabirds may accumulate exceptional amounts of this element, whose effects are still obscure'. This statement attributed to me comes from the next paragraph summarising observations of heavy metals in general, though as Holdgate[3] reported up to 13 mg per kg cadmium in dead guillemots washed up in western Britain in the autumn of 1969 when the level in normal birds was low, it seems possible that there may be some local pollution with cadmium as well as other metals of birds frequenting our offshore waters. If this is the case with either cadmium or any other pollutant it seems doubtful whether it will be detected by looking at birds from remote breeding stations which feed elsewhere, rather than at individuals dying on the spot. It would also be helpful if Monks Wood Experimental Station could place all their other estimations of pollutants on record.

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