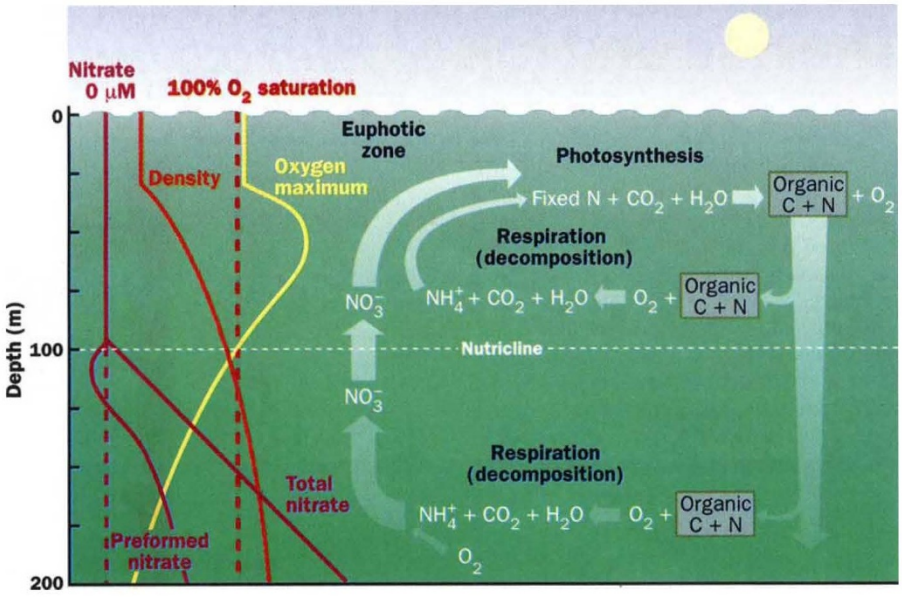

FIG. 2 Typical vertical profiles of density, total nitrate, 'preformed' nitrate and dissolved oxygen in the upper 200 m of the Pacific Ocean. *Rhizosolenia* mats[2], collected by divers in the upper 20 m, are found at depths much shallower than the nutricline (or sharp vertical gradient in nitrate). Vertical transport of nitrate to shallow depths by floating mats could provide the preformed nutrients required to form the shallow oxygen-maximum layer (the zone of supersaturated oxygen at about 50 m). The negative values of preformed nitrate at depths of 100–120 m (at the top of the nutricline) show that something is consuming it — either microbial activity, or the algal mats.

The new findings could also help to explain how a shallow layer of water supersaturated in oxygen is formed about 50 metres down. The gradual accumulation of oxygen implies that there is an extra input of nutrients over and above that taking part in the recycling system in the euphotic zone (photosynthesis using up nutrients and producing oxygen, decomposition and respiration consuming oxygen and generating ammonia). In the jargon, an input of 'preformed' nutrients is required. Such nutrients are lacking from the waters of the upper nutricline, so some nutrient source in addition to vertical mixing is required to create the supersaturated oxygen. My own recent hypothesis was that zooplankton migrating vertically transport nutrients contained in organic matter[5]. However, the vertical transport of NO_3 via floating diatom mats may be a less complicated alternative means of providing the required nutrients.

The process might explain yet another recent observation. Towards the top of the nutricline lies a layer that is surprisingly short of preformed NO_3 (see figure). This has been attributed to uptake of nitrate by microbes as they assimilate dissolved organic carbon[6], but it could equally well be due to uptake of nitrate by migrating *Rhizosolenia* mats at this depth.

The debate is far from over. Some or all of the above processes may influence the transport and cycling of nutrients, oxygen and carbon in the upper ocean, but too few details are known for them to be properly included in the basin-scale biogeochemical models. Can enough nitrate be transported up in this way, and is the 'elevator' fast enough? Calculation of the rate of NO_3 input from the mats is indirect and uncertain. It will depend on the abundance of mats, their migration rates and distance, and the excess NO_3 taken up per unit carbon. The distribution and vertical movements of *Rhizosolenia* mats are poorly known; they can certainly be collected at all depths reached by divers, but do they go deeper? They are rarely sampled in water bottles and, in the North Pacific, individual *Rhizosolenia* cells of the species found in the mats are normally found only at depths much shallower than the nutricline (E. Venrick, personal communication).

It may be that the broad investigation of the processes involved in nutrient cycling and carbon flux in the open ocean planned by the Joint Global Ocean Flux Study will answer some of these questions. Until then, the concept of the algal dumb waiter will provide much food for thought. □

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DAEDALUS

Military airlift

LAST week Daedalus proposed a novel sky-platform for communications and surveillance. It was based on the principle that the downwash of air from a helicopter spreads out beneath it in a conical fashion, and ultimately impacts a wide circle of land. A set of blowers distributed over such a circle, all aimed upwards towards the point of a cone, could create an exactly reversed upward flow of momentum. Converging to a point high in the sky, it could levitate a solid object at that point.

Daedalus is now working out how to get his platform up there. The obvious method is to start it at a very low altitude, and push it upwards by means of a narrow circle of extremely powerful blowers. As it rose, these would be turned down, while concentric circles of ever more distant blowers would be successively switched on. The whole sequence would be, in effect, the reversed-flow mirror image of the broadening and weakening of the high pressure area under a helicopter as it rises. The maximum height of lift would be determined by the radius of the largest circle of blowers. An array of 20 km across should be able to loft a platform about 10 km into the sky.

This simple airlift process cries out for other applications. At first, Daedalus hoped it could be used to launch spacecraft; but he soon realized that air-momentum transfer would fail as soon as the craft was rising much faster than the speed of sound. Even so, modern rockets burn about half their fuel to reach this speed, so airlift could replace much of the big expensive first stage. Asymmetric airlift could apply useful sideways thrust to an airborne platform. Accordingly, a simple passenger-carrying glider could be lifted to altitude and accelerated in any chosen direction, to glide down to an airfield hundreds of kilometres away. This could form the basis of a noiseless and terrestrially powered civil aviation system.

But Daedalus is drawn back to his original musings on air defence. A computer-controlled web of airlift blowers could be targeted devastatingly onto an invading aircraft. A concentrated blast of air-momentum could suddenly increase its lift or, in downward reverse-thrust mode, could cancel it. Imposed asymmetric flows of momentum could steer the intruder sideways out of its course, or even bring it to a dead stop in the sky, when it would fall like a stone. A widespread array of blowers would be hard to attack, and, anyway, could survive the loss of many elements. Apostles of non-violent resistance should approve. David Jones