BUOYANT FLAKE EXPERIMENTATION

# Introduction

Guidance was sought for the design of experiments to validate the concept of using buoyant flakes, strewn upon nutrient-deficient ocean regions, to provide the supplementary nutrients required by marine life, in particular the phytoplankton at the bottom of the food chain. When provided with ultra-slow release nutrients lacking at the sunlit ocean surface, prolific yet balanced ecologies of marine life can form in otherwise barren, dark blue waters.

The effects of such supplementary nutrition are not confined to increasing marine productivity and biodiversity:

* The proliferation of phytoplankton typically turns the water turquoise, thereby increasing its albedo and cooling the planet ;
* the chemical DMSP released by phytoplankton contributes to cloud formation, to rainfall that brings with it airborne nutrients, and to the nucleation of marine clouds that also cool the planet;
* the conversion by photosynthetic phytoplankton of oceanic carbonic acid, and thence atmospheric carbon dioxide, into neutral biomass slows or reverses harmful ocean acidification;
* the sinking of dead organic material (including marine faeces, shells and body parts) enhances the carbon pump that sequesters carbon in the deeper ocean strata, including those of the hypoxic (low oxygen) sediments where they may later be converted into limestone and fossil fuels.

This guidance is confined mainly to laboratory-scale experiments devised to iterate an optimal flake composition and structure for the required task. As the potential ways to generate buoyant flakes with varying mineral payload are endless, the task will be ordered by each of the several objectives in turn, commencing with buoyancy.

Given that many experiments are likely to be required before an acceptable ‘recipe’ for flake composition and production is found, tentative guidance will also be offered as regards the most cost-effective and efficient laboratory arrangement.

Whilst Floridan phosphatic clay waste is likely to be the optimal single source of flake mineral nutrients, consideration will also be given to substitutes thereto and to complementary and simulating mineral sources.

# Suggested Laboratory Arrangements

The laboratory experiments are likely to be undertaken at the Indian National Institute of Oceanography in Dona Paula, Goa. As land there appears to be at a premium, as the roofs of the main building tend to be gratifyingly flat, and as the required laboratory will be required to simulate the sunlight conditions of the Arabian Sea, it may be convenient to construct a temporary laboratory on the roof.

The lab might consist of little more than a lightweight wooden frame, clad in transparent corrugated sheeting for its roof and lower walls, with plastic flywire for ventilation on the upper walls. Low wooden frames would support the glazed aquaria, under which there would be spread dark blue cloth to simulate the colour of the ocean. As well as an extension cord and powerboard for power and lighting, UV lighting might be required to replace the solar UV light interrupted by the roofing, as it is important that the phytoplankton and buoyant flakes experience a light regime as close as possible to that of the central Arabian Sea.

The aquaria would consist of ‘open’, glazed aquaria, filled with brine and covered in something like a hinged and wire-framed hood of stretchable, sheer pantyhose fabric. The fabric and brine are designed to deter insects, algae and wildlife, whereas the brine is also used to control the temperature of the pristine Arabian seawater and marine life enclosed in labelled, ~150mm diameter transparent plastic containers spaced slightly apart on end within each aquarium. A small pump, sensor, actuator and refrigerator may thus be required to keep the brine at the same (seasonal?) temperature as the average top 500mm of pristine Arabian Sea water. Because of the corrosive nature of brine, a diaphragm pump is probably best used for this. The ~600mm long containers might be made from Perspex/acrylic tubing with acrylic bases glued to them. Each container would have a cover of sheer fabric, fixed with a rubber band to prevent liquid being splashed amongst different containers. The splashing would be caused by a small propeller or paddle wheel inside each container that is designed to simulate breaking wave and lightly abrasive mutual actions in the central Arabian Sea on the buoyant flakes. A separate propeller, possibly on the same shaft, might gently agitate the deeper water in each container. The supplementary lighting would have to compensate for the shading effect of roof and two layers of sheer fabric. A tiny electric motor might be used to power all shafts in a given aquarium using a single drive belt. Depending on its surface area, each aquarium might contain containers performing many different experimental combinations at the same time.

# Prototype Flake Manufacture

Possibly the easiest and cheapest way to make modest amounts of flake is to finely spray with, or dip the rice husks in, thin rice water ‘glue’, then roll them in, or otherwise cover them with, a mixture of hot melt lignin powder adhesive, mineral mix, and (possibly) leavening agent. These raw flakes are then heated in an oven, with infra-red lamps, concentrated solar, or microwaves until the leavening agent generates gas bubbles within the coating, the flakes dry out, and the lignin melts sufficiently to form a hot melt glue that binds the mineral powder to itself and the husk, whilst leaving sealed gas pockets in the matrix to provide additional buoyancy. This process may be repeated, should additional layers of mineral be thought desirable. Note, that for industrial-scale husk transportation and flake manufacture, the husks may have been hot-rolled flat with ricewater glue in order to reduce their volume and hence to reduce their cost of transportation.

Regarding the materials to be used in prototype flake manufacture, whilst Floridan phosphatic clay waste and red mud left over from alumina refining may be the preferred, or main, mineral components, many other minerals could be used to simulate these. Some are mentioned in the long descriptive document titled *Organic Mariculture and Biosequestration*. However, for prototype production, a convenient iron-rich product is that used to colour cement and thence concrete, as this is made from a mixture of iron oxides. Phosphate source rock, or that containing the mineral apatite, when finely ground, could provide a superior, if wasteful of a high-grade material, source of both phosphorus and silica. Regrettably, few mineral deposits or waste piles, except the Floridan phosphatic clay wastes, include significant proportions of selenium and the other trace elements required by phytoplankton. Provided that the other essential nutrients for phytoplankton are present, it is to be hoped that the presence of the buoyant cyanobacteria *Trichodesmis* in the Arabian Sea may proliferate to provide the necessary amounts of reactive nitrogen nutrient from the air to supplement it for all the proliferating marine life there. The most cost-effective leavening agent is likely to be ammonium carbonate, from which the ammonium fraction might be recovered from the warming and drying flakes. Otherwise, just use a more standard leavening agent, such as sodium bicarbonate.

# Experimentation

It is thought that a good way to arrive at something close to an optimal flake composition, structure and recipe is to seek to ‘locally’ optimise each flake requirement in turn, starting with what is the most important requirement – #1 -buoyancy, which is itself a function of flake composition and closed-cell aeration. Once sufficient buoyancy has been established, then the optimisations to be worked through in succession might well be: #2 - flake longevity on the ocean surface of approximately a year under simulated Arabian Sea surface conditions; #3 – rate and degree of flake colonisation by phytoplankton and their predators; #4 – evenness and rate of nutrient extraction from the flakes or its effect on ‘oceanic’ albedo change; #5 – optimal flake oceanic coverage (try first in the range 0.02-2%) for Central Arabian Sea waters; #6 – optimal mineral and structural flake composition to remedy the (?seasonal) ocean surface nutrient deficiencies, first of the furthest South Western extent of Indian Exclusive Economic Zone (EEZ) waters, then those of the Central Arabian Sea, the Bay of Bengal, and regions further South; #7 – greatest nitrogen-fixing capability; #8 – biodiversity effects; #9 - effect upon the digestive tract of small fish, if any; #10 – sealed tube, mesoscale carbon pump effects at different depths; and #11 – the multifarious effects of sea trials at increasing scale and flake density.