**CONCEPTUAL CLIMATE RESTORATION SOLUTIONS**

**– Order of Magnitude Estimates of their Potential**

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INTRODUCTION

Winwick Business Solutions P/L has conceptualised several methods by which the climate and oceans might be restored. Whilst the nature of each method’s likely effects has been documented (only roughly because of the absence of sufficient experimentation and modelling), it is now appreciated that those interested, including potential funding agencies, research groups and interested communities, would appreciate a greater measure of quantification. Hence, this attempt to estimate the order of magnitude of the effects of each method after it had been deployed to its reasonable maximum extent. Being more difficult to quantify, their timing, cumulative and synergistic effects will be covered even more briefly. And as changes in quantification caused by passing multiple tipping points, climate sensitivities and hysteresis effects are even more difficult to estimate, these will not even be estimated.

BUOYANT FLAKE OCEAN FERTILIZATION (BFOF)

The dissemination of nutrient-bearing buoyant flakes over ocean surface waters that are deficient in one or more key nutrients in order to increase phytoplankton growth, ocean biomass and biodiversity is a method of climate improvement that has been long known. At Woods Hole Oceanographic Institute in July 1988, John Martin stated humorously *(but with serious intent)* in a lecture his iron hypothesis: “give me a half a tanker of iron *(scattered over ocean surface waters and absorbed by phytoplankton)* and I will give you an ice age”. Now, our Buoyant Flakes will not only carry iron oxide waste, but also phosphatic clay waste, opaline silica (in rice husks) and micronutrients required by phytoplankton. The algae the flakes nutriate would also brighten the dark sea surface, nucleate solar-reflecting (cooling) marine cloud, increase marine biomass (fish, mollusc and crustacean stocks), and sequester atmospheric carbon dioxide – at first in the euphotic (sunlit) zone, then by virtue mainly of diel vertically migrating (DVM) species, such as krill, lanternfish and bristlemouths, into the ocean depths where it would stay for up to millennia (depending on depth and location).

Now rice husk production is around 130Mt/yr and has little in the way of beneficial use. Rice husks contain ~17% silica. If 100Mt/yr of husk is made available for climate restoration use, and the husks are turned into buoyant flakes containing a mix of about 60% husk, 15% lignin glue, and 25% minerals that would make 167Mt/yr of flake. Now, the iron-rich red mud tailings from alumina refining contain about 47% iron, whilst Florida’s phosphatic clay wastes residual to phosphate extraction contain about 10% phosphorus. Hence, the rice husks would be adding 17Mt/yr of opaline silica to the surface ocean whilst, if each mineral were to be half of the 42Mt of minerals added to the husks, then each year we would be adding 10Mt of iron and 2Mt of phosphorus to the ocean surface, most of which would be taken up by living organisms. Furthermore, because the nutrients would mainly end up in oceanic biomass, they would tend to be recycled many times by the food chain and thus multiply oceanic biomass and its beneficial effects. **10Mt/yr of iron would fill many of Martin’s tankers,** and would be disseminated thinly over most of the oligotrophic seas, not just the Southern Ocean.

Such nutrient supplementation would tend to render most dark blue seas into becoming a lighter, green or turquoise colour. The increase in albedo caused by this is not readily determined except by multi-spectral measurement by satellite over cloud-free areas, though an appreciation of its potential effectiveness might be gained simply from viewing photographs of algal blooms caused by blown dust or volcanic plumes. However, as algal blooms from over-zealous nutrient supplementation are to be avoided, the actual gain in albedo would be considerably less. Now, open ocean has an albedo of about 0.06, whilst green grass has one of 0.25. Omitting the important factors of cloud cover and cloud albedo, this means that turquoise waters nutriated by buoyant flakes might have an average daytime albedo of around 0.12, effectively doubling that of open, cloud-free ocean. The cooling effect of this in watts per square metre is to be determined, but is likely to be substantial.

Additional to this cooling effect would be that provided by the DMS emissions of the additional phytoplankton that would cause additional marine cloud nucleation and hence additional albedo.

Over the entire ocean such additional ocean biomass would result in an increase in carbon flow to the depths of the marine Biological Pump. This flow tends not to extend greatly to deep waters where the water is warm and well-oxygenated, because of bacterial action. However, in cooler waters, and particularly when facilitated by DVM species, the flow is likely to be considerable. It is thought that the DVM activity of the ~400Mt of Antarctic Krill, *Euphausia superba*, on its own is capable of sequestering large amounts of carbon as respired carbon dioxide or carbonaceous faeces, whilst it digests its nightly meal consumed near the sea surface, at depths of around a kilometre. Assuming that its average gut content is 5% of its bodyweight, that half of this gut content is water, and that half of that is carbon, this means that Antarctic krill could be sequestering 400 x 0.05 x 0.5 x 0.5 = 5MtC/day or some **18Mt of CO2 equivalent per day**. Following long term Buoyant Flake supplementation over most of the global ocean, an expanded krill habitat, and sequestration by the other DVM species, might increase this sequestration rate several times over.

SEATOMISERS

Seatomisers are designed for several purposes: to enhance the evaporation of seawater and the off-planet, long wave radiation the extra water vapour provides as it condenses around cloud-making altitude; to generate reflective, if short-lived fog; to increase marine cloud formation and thickening such that Earth’s albedo and its cooling effects are increased; to release reflective sea salt aerosols into the atmosphere; to sublimate nanoparticles of ferric chloride into the atmosphere (above the sprayed seawater droplets) such that by photocatalysis they photo-oxidise atmospheric methane and smog into less-harmful water and CO2; and, by taking account of weather forecasts and farmers’ needs, and by controlling the seawater spray droplet size distribution and rate of production to influence where, when and how much precipitation occurs downwind.

None of these effects, or other ones, can be reliably estimated, even to an order of magnitude, without there being proper experimentation, development and modelling. However, as Salter has estimated that the energy cost of generating cloud condensation nuclei (CCN) from seawater is some nine orders of magnitude less than the solar energy it would reflect when airborne for a few days, the trade-off is likely to be an excellent one even if none of the other benefits are considered.

ICE SHIELDS

Sea ice thickening by means of the Ice Shields design concept is claimed to result in net benefit across its many likely effects. The main benefits include: increasing polar albedo with its global cooling and weather stabilising effects; sequestering carbon dioxide and oxygen in the abyssal depths by virtue of those gases becoming concentrated in the frigid brine left over for ice formation that flows down each forming ice mountain in the colder seasons and sinks by gravity to the seabed, whence its CO2 content can react with seabed carbonates to form benign, long-lived and slightly alkaline bicarbonate; glacial stabilisation; cryogenic habitat restoration; methane emission suppression and/or harvesting; coastal stabilisation; increasing krill numbers and hence their carbon sequestration capacity and the size of the marine food chain; AMOC recovery; increasing bright snowpack and water resources; reducing ocean stratification; and making large amounts of renewable energy available in the warmer seasons, some of which might be used locally to make food or to oxidise ebullient atmospheric methane and smog.

Most of these effects, and other ones, also cannot be reliably estimated within an order of magnitude without there being proper experimentation, development and modelling. However, it should be possible to estimate the energy cost of the seawater pumping required to make a lenticular ice mountain of given height-depth and size under a given set of weather conditions. Thus, knowing the power that is deliverable by, say, a single, floating 2.5MW Arctic Ocean wind turbine in Arctic winter winds, is should be possible to theoretically calculate the areal rate at which the shallow waters of the Arctic could be covered and maintained in a grounded, linked and close-packed array of 500m height+depth ice shield lenses, each having an inclination angle above water (probably less below) of, say, four degrees and freezing some 80% of the pumped water (temporarily ignore below-water melting which will be low once the array has grounded or else is deep enough to repel warm surface currents).