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The Impacts of Megaengineering Projects

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Chapter 81
Sea Art: The Mediterranean Sea Terrace Proposal

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81.1 Precursor Art Forms

Space Art proponents have mostly opted to construct various symbolic artifacts in extraterrestrial space that could be visible from Earth's surface with the naked eye. Using various plastic film and dense textile envelopes, Air Art's advocates have already exploited some of the possibilities of heated and compressed air (or other safe-to-use gases) as well as natural winds. Land Art projects usually result from different personal interpretations of natural and anthropogenic landscape significance and their deliberate alteration (Tufnell 2006). To date, few artists have attempted geographically large-scale Sea Art and yet such a revolutionary, but obviously down-to-Earth, art-form is far more readily realizable nowadays with available technologies than Star Art (Infante, 1992).

81.2 Oceanic Art Progenitors

Artworks were installed in the ocean near Tobago, West Indies, during 1969 by Peter Hutchinson and Dennis Oppenheim and Christo installed eleven flamingo-pink floating plastic collar-mats, covering approximately 600,000 m^2 (6,456,000 ft^2) in a placid lagoon of Florida's Biscayne Bay in 1983 (Spies & Volz, 1985). Installations of this type were christened "Oceanographic Art" and they are best characterized as purely large-scale projective decoration efforts. Sea Art, however, is a form of seawater sculpting by aquatic terracing focused on the 70% of Earth's surface that is ocean. Seemingly, and perhaps actually, the originator of Sea Art is the renowned German architect Frei Otto, who first contemplated the concept c.1953 (Nerdinger, 2005). In our team's view, Sea Art has a practical, commercially useful aspect that Oceanographic Art lacks and, therefore, is of interest to 21st century adherents of Macro-engineering (Badescu, Cathcart, & Schuiling, 2006).

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81.3 Staircase Farming "Land Art"

About 5000 years ago, the Earth-atmosphere's methane concentration started to increase markedly and its main source was human cultivation of rice in flatland paddies; about 2000 years ago humans commenced growing rice in watery paddies on laboriously terraced hillsides. Terracing refers to the bench (terrace) constructed in the form of a ridge and channel the entire earthen surface of which is cultivated as a farm field. For example, the spectacular tourist attraction of hillside rice paddy terrain at Ifugao in northwest Luzon (Philippines) is preserved as a UNESCO World Cultural Heritage site (Scarborough, 2003). UNESCO's dedication reflects people's unwillingness to accept the natural duration of their outdoor physical creations since, currently, a global financial undertaking helps to prevent natural erosion and human reconstructive actions, obviously causing decay of the old anthropogenic terrain.

Methane is a greenhouse gas and the anthropogenic contribution to the atmosphere causes some enhanced global warming and, consequently, also contributes to the on-going rise worldwide of the ocean's level (Ruddiman, 2006). Perhaps half of all living humans eat rice and the microorganisms inhabiting anoxic rice field soils contribute between 10 and 25% of annual methane emissions; by 2030, there might be five billion persons nourished by rice consumption (Khush, 2005; Normile, 2008). Artificial wetlands on shaped hillsides have in the past, and continue today, to contribute to the ocean's instability in terms of volume and surface. By 2100 our world's ocean could elevate by as much as 1 m (39.3 in) relative to its present-day level, thereby directly affecting the world's coastline (Harff, Hay, & Tetzlaff, 2007). Worst-case global warming geophysical scenarios focused on the invasion of land by seawater were devised by artists such as Terry Schoonhoven and Helen Mayer Harrison and Newton Harrison (Harrison ˆ Harrison, 1993). By September 1994 Quarry Cove, a part of the Yaquina Head Outstanding Natural Area near Newport, Oregon served to permanently remove a minute volume of seawater from the ocean (Thompson, 1996) yet far short of the anti-global sea level rise management and sand dune fixation macro-project proposed during 2008 by geoscientists (Badescu, Cathcart, & Bolonkin, 2008).[1]

81.4 Sea Terracing

About 4300 years ago, urban governments commenced construction of monumental edifices and massive infrastructures following the post-Ice Age natural stabilization of our world's ocean (Day, Gunn, & Folan, 2007). About 2.2% of this planet's land that is 10 m (32.8 ft) or less in elevation above the world-ocean's current level probably supports 10% of all humans and about 13% of all human population designated as "urban" (McGranahan, Balk, & Anderson, 2006). Humanity's activities (to make and earn a living) will "globalize" the Mediterranean Sea, viz., its seawater, organic and inorganic contents, and periphery (Blondel, 2006; Dora, 2007). Mediterranean Sea Basin nation-ecosystems have several expensive 20th century ameliorative macro-project options available, possibly, someday, including even Atlantropa's institutional realization as basically contrived by Herman Sorgel (1885–1952) after World War II (Vleuten & Kaijser, 2006).[2] However, recent material properties R&D and newer industrial products stemming directly from advanced material technologies, particularly, technical textiles and flexible impermeable films exhibiting high-performance, purely functional, and precisely woven or non-woven fabrics, offers teamed artist/macro-engineers the prospect of a cheap Mediterranean Sea Basin anti-sea level rise barrier macro-project hung underwater (Cullen, 2005). A fabric artwork and barrier, the Gibraltar Strait Textile Barrage (GSTB), could replace the discontinued and/or postponed MOSE (Modulo Sperimentale Elettromeccanico) macroproject to save Venice (Italy) with a facility of costly operationally complex-to-manufacture-and-maintain storm surge gates (Rinaldo et al., 2008).

The Strait of Gibraltar connects the North Atlantic Ocean and the Mediterranean Sea, making it inevitable that the Mediterranean Sea will rise as our world's ocean elevates. The GSTB will likely be draped on a 20 km (12.4 mi)-long alignment between Tarifa in Spain and Ksar e' Sghir in Morocco, creating an aerial and submarine fabric artwork somewhat imitative of Christo's "Valley Curtain, Rifle, Colorado, 1970–1972", which was macro-engineered by Ernest C. Harris (1915–1998) (Vaizey, 1990). Its sole purpose will be to insure the maintenance, for a long period of future historical and geological time, the present-day Mediterranean Sea Basin's seawater level; in other words, this artwork would preclude any future erosion of valued land-based artworks encompassed by the urban fabric of North Africa and southern Europe. The GSTB's structural, mechanical and hydro-dynamical physics was first preliminarily demonstrated in 2007 (Cathcart & Bolonkin, 2007). Basically, the seawater-impervious Gibraltar Strait Textile Barrage replicates, in a critical Mediterranean Sea Basin setting, Christo's temporary suspended fabric curtain, the Pacific Ocean end of "Running Fence".[3]

81.5 Gibraltar Strait Textile Barrage

"Valley Curtain" was punctured regularly at numerous places to prevent its being torn asunder by strong up-valley and down-valley windstorms. Coincidentally, a watery version of "Valley Curtain", concocted by the UK engineer Andrew Noel Schofield, was offered as a Thames River Storm Surge Barrier during 1971–1972. The GSTB will be impervious to seawater, safely sealed to the rocky sidewalls and sedimentary seafloor of the Gibraltar Strait. Consequently, the GSTB will bow or "billow" like a ship's sail eastwards from the selected construction/emplacement/installation site because of marine and aerial (seasonal winds) pressures acting directly on the GSTB. There are differences in seawater elevations on a two-sided, bottom-anchored and virtually vertical suspended membrane and natural currents such as North Atlantic Ocean tidal solitons. Indeed, prevailing seasonal winds normally flowing along the Gibraltar Strait will pile approximately 5–6 mm (0.19–0.23 in) of seawater on the GSTB's west face. To cope with these natural environmental forces, macro-engineer planners must draw on the installation experience with heavy wire nets, floatation systems and their seabed moorings derived from World War II antisubmarine net installation in strategic harbors and that documented experience offered by the 100 km (62.1 mi) -long World War I antisubmarine Otranto Strait Barrage (1915–1919).

From its western approaches, the GSTB will have the characteristic of an architectural deception resembling an English Garden or zoo landscape architect's geo-textile "ha-ha" (also known as a "sunken fence") in that, without warning light-buoys and radar reflectors, ship navigators will visually misapprehend the true nature of the plotted sea-route ahead. Those mariners, such as private-sector fishermen and yachtsmen, piloting their boats without benefit of up-to-date navigational charts that indicate clearly the GSTB's presence, will have no inkling *via* normal optical clues that a 1 m (3.28 ft) drop in sea level occurs in the Gibraltar Strait. Mariners without radar readouts using the eastern approaches will visually spy a 1 m (3.28 ft)-high tensioned fabric wall spilling some seawater caused by wave overwash, which if made of clear or aquamarine-colored material might be almost invisible until closely sighted.

The total area of the vertically draped GSTB is about 200 km^2 (76.6 sq mi) but only approximately 20,000 m^2 (215,000 ft^2) will be constantly exposed to the air and material-degrading sunshine on its eastern face while the GSTB's submerged western face will be required to continually resist a 1 m (3.28 ft) seawater hydraulic head. The GSTB artwork, if built to be the first true Sea Art, will be mechanically lifted by shore-based winches gradually only as much as the North Atlantic Ocean actually rises, it will act as an active compensation mechanism to accommodate the anticipated 21st century ocean changes in volume and surface.

81.6 Textile Barrage Structural and Material Design

The GSTB textile barrage structure and material have to be strong enough in order to support the nearly 1 m (3.28 ft) water hydraulic pressure difference which remains constant along the height *h*, Fig. 81.1. The brittle fracture of the membrane would

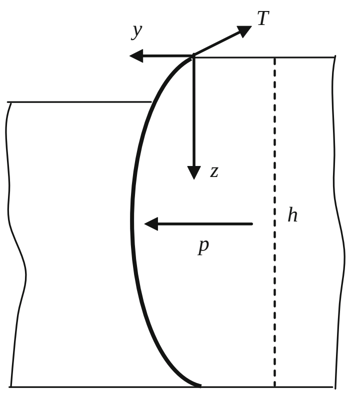

Fig. 81.1 Scheme of the textile barrage (*side view*)

cause the propagation of a damaging surprise tsunami wave and has thus to be avoided by a proper barrage structural and material design.

Considering the scheme reported in Fig. 81.1 and indicating with *y(z)* the barrage deflection, from classical structural mechanics we have:

$$\frac{d^2 y(z)}{dz^2} = -\frac{pL}{T_H} \tag{81.1}$$

where p is the pressure difference, L is the barrage length (along x) and T_H is the horizontal component of the tension T. Equation (81.1) can be easily integrated with the boundary conditions $y(z = 0) = y(z - h) = 0$. The real height H of the barrage can be calculated as:

$$H = \int_0^h \sqrt{1 + \left(\frac{dy}{dz}\right)^2} dz \approx \int_0^h \left\{1 + \frac{1}{2}\left(\frac{dy}{dz}\right)^2\right\} dz = h + \frac{p^2 L^2 h^3}{6T_H^2} \tag{81.2}$$

Accordingly we find:

$$T_H = \frac{pLh}{\sqrt{6\varepsilon}}, \varepsilon = \frac{H - h}{h} \tag{81.3}$$

The mean tension in the barrage will thus be

$$T = \frac{1}{h}\int_0^h \frac{T_H}{\cos\left(\frac{dy(z)}{dz}\right)} dz \approx \frac{T_H}{h}\int_0^h \left\{1 + \frac{1}{2}\left(\frac{dy}{dz}\right)^2\right\} dz = T_H \frac{H}{h} \tag{81.4}$$

Consequently, noting that the ultimate tension per unit length $T_u/L = \sigma_u t$ is the product of the material strength σ_u and barrage thickness t, we expect a minimum thickness:

$$t = \frac{pH}{\sigma_u \sqrt{6\varepsilon}} \tag{81.5}$$

Due to the huge physical size H, the GSTB composing material has to be sufficiently strong, for example, steel, Kevlar or carbon nanotubes, or alternatively the structure itself has to be sufficiently thick. Graphene sheets are ideal candidates in this context, thanks to their great mechanical strength, impermeability and natural two-dimensionality.

Considering $H \approx 1\,\text{km}, \varepsilon \approx \sigma_u/E \approx 0.1 - 0.01$ (E is the material Young's modulus) and $p \approx 10$ KPa, we deduce for realistic macroscopic, thus defective, graphene sheets ($\sigma_u \approx 10$ GPa, see Pugno, 2007) $t \approx 1 - 4$ mm (for defect-free graphene sheets, $\sigma_u \approx 10$ GPa, we would expect $t \approx 100-400*$ m); for comparison, for steel membranes ($\sigma_u \approx 10\,\text{GPa}$)$t \approx 1 - 4\,\text{cm}$.

81.7 Artwork Preservation Paramount

The proposed Gibraltar Strait Textile Barrage is an artwork intended to preserve extant artworks within the Basin of the Mediterranean Sea. It is a means to improve humanity's ability to apply macro-engineering principles which skirt or correct a near-term future global oceanographic problem impairing the economic usefulness of low-elevation coastal land. It is a practical and low-cost example of Sea Art for the 21st century that preserves humanity's ancient and modern heritage situated in the multi-cultural Mediterranean Sea Basin.

Notes

1. Al Nakheel Properties continuing commercial artificial island construction effort, which does extend Dubai's sandy shoreline seaward, more than offset all the temporary $T_u/L = \sigma_u t$ Mohamed El-Kassas renewed a call for Sorgel's dam in Issue 919, 23–29 October 2008, of Egypt's *Al-Ahram* – see: http://weekly.ahram.org.eg/print/2008/919/sc3.htm.
2. Here, it is interesting that Christo intends to complete a horizontally-laid 9.5 km (5.9 mi)-long fabric covering of the State of Colorado's Arkansas River valley by 2013 (Christo & Jeanne-Claude, 2008).
3. A 170 m (558 foot) section of Christo's "Running Fence" plunged into the Pacific Ocean from a place bordering Bodega Bay in Northern California (O'Doherty, 2010).

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