Viorel Badescu · Richard B. Cathcart
Editors

# Macro-engineering Seawater in Unique Environments

## Arid Lowlands and Water Bodies Rehabilitation

Springer

*Editors*
Prof. Viorel Badescu
Candida Oancea Institute
Polytechnic University Bucuresti
Spl. Independentei 313
060042 Bucuresti, Romania
e-mail: badescu@theta.termo.pub.ro

Richard B. Cathcart
Geographos
W. Olive Avenue 1300
Burbank, CA 91506-2225, USA
e-mail: rbcathcart@gmail.com

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# Treeing the CATS: Artificial Gulf Formation by the Chotts Algeria–Tunisia Scheme

**Nicola M. Pugno, Richard B. Cathcart and Joseph J. Friedlander**

## 1 Introduction

The Chotts Algeria–Tunisia Scheme (CATS) is a grand design to form a man-excavated new Mediterranean Sea gulf to be shared by Tunisia and Algeria. It is well known that closed and nearly closed seawater volumes fluctuate in response to changes in local aerial regional evaporation and precipitation rates. The Zone of Chotts, bordering the Sahara at 32–35 North Latitude by 5–10 East Longitude, shared by Algeria and Tunisia, is an aggregation of playas that currently exist under a high-evaporation/low-rainfall regime (often >20:1); nowadays these particular playas are subjected to sporadic ephemeral floods. The mean annual rainfall is $\sim$90–120 mm in southern Tunisia and Algeria, with high inter-annual variability. The rainy season extends from November to February, with summertime winds emanating from the northwest, and from the southwest during wintertime and Spring—that is, blowing from the aridified, desolate and mostly uninhabited Sahara landscape. The mean regional evaporation is $\sim$2,500–3,100 mm/year in both southern Tunisia and Algeria (Jean-Pierre et al. 2010). The terrain of the Chott Gharsa and Chott el Jerid is undergoing some ground subsidence ($\sim$0.001–0.27 mm/year) caused by local tectonic movements. (The word "terrain" is cognate with "terrace", a relationship of some vital importance in our chapter's exposition.) We intend the CATS to be a landscape recovery macro-project, a grand

N. M. Pugno (✉)
Politecnico Di Torino, Turin, Italy
e-mail: nicola.pugno@polito.it

R. B. Cathcart
Geographos, Burbank CA, USA

J. J. Friedlander
Shave Shomron, Israel

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design of possibly future international significance in the Basin of the Mediterranean Sea. The CATS has been under public consideration for more than a century—the novelist Jules Verne first mentioned a fictional scientific version of it in his published works in 1877s *Hector Servadac*. Tunisia, in area, is one of the smallest ecosystem-nation on the African continent. Yet, much of its national terrain is salt-encrusted and salt-saturated arid soil wasteland that is unfit for human settlement at this time. If we do connect the Zone of Chotts with the Mediterranean Sea, then Tunisia and Algeria will gain a new seacoast caused by the anthropogenic creation of a new gulf. Northern Africa had previously experienced a similar transformational geomorphic event: the 14 March 1869 commencement of the now $\sim$200 km$^2$ Great Bitter Lake in Egypt (32.39°E Long. by 30.37°N Lat.), when the Mediterranean Sea's water first began to flow into the salty dry basin during the construction of the Suez Canal. The first, basic iteration of the Suez Canal landscape shaping effort required the removal of $\sim$74,000,000 m$^3$; if dug, the CATS would require, minimally, the rapid and largely automated industrial excavation of $\sim$85,500,000 m$^3$. Earth-moving machinery is larger and more efficient today than equipment used a 100 years ago and we expect the CATS macro-project to be physically doable at reasonable cost (Haycraft 2000). Ultimately, it is possible that our artificial gulf will become a major twenty-first century northern African industrialization seaport, Port Tritonis, potentially almost equivalent to the Mainport Rotterdam (51°55′51″N Lat. by 4°28′45″E Long.) logistics node in The Netherlands, that is close to existing and developed future markets. In Europe, Mainport Rotterdam alone, as the largest seaport and major industrial complex there, accounts for >100 million tonnes of containerized and liquid cargo yearly. However, whereas Mainport Rotterdam is served by canal and river barges, highway carrying motor vehicles, airports and multiple railroad networks throughout Europe, the prospective Port Tritonis could be served only by automobiles, trucks, trains and aircraft.

## 2 The Big Picture

By $\sim$2100, our world's ocean could elevate by as much as 1 m relative to its present-day level thereby directly affecting the world's populated coastline (Harff et al. 2007); $\sim$81,000 years ago the Mediterranean Sea's level was $\sim$1 m above its current level (Dorale et al. 2010). Sea level is a major factor influencing the role of sedimentary processes of the Mediterranean Sea Basin (Fischer and Garrison 2009). Still, to mid-2010 AD, there is little unambiguous oceanographic evidence that a truly catastrophic global sea level rise is in the offing (Leuliette and Miller 2009). Minimally, the Mediterranean Sea's $\sim$13,000 km-long Basin strand could be markedly affected by global sea level rise; maximally, the Basin's strand could be as much as 46,000 km (Lejeusne et al. 2010). The crudest monetary estimate of the minimal total cost in 2010 value USA dollars [USD] for coastal protection against a 1 m rise in sea level (2010 USD costing one million/lineal kilometer) tells us that plan's cost–benefit ratio is excellent because if could off-set 13 trillion dollars of possible future coastal damage (Anthoff et al. 2010; Kuleli 2010). Is it really, then, so difficult for extra-basin human populations to fathom that geographically important region's *weltanschauung* of *weltschmerz*? (We decline to adopt *weltanschauung* with the connotation of "visionary"; instead, we adopt the more prosaic "concept of the world" conveyed by the term which still is not precisely encompassed by any English-language word.) We agree with John Brinckerhoff Jackson (1909–1996) that a "landscape" is "…a composition of man-made or man-modified spaces to serve as infrastructure or background for our collective existence" (Jackson 1984, p. 8).

Submarine archaeological sites, such as inundated harbors, ancient fishponds and crumbled buildings, indicate that the Mediterranean Sea's level during Roman times was ~1 m or more below the region's present-day sea-level (Lambeck et al. 2004). To accommodate an expected future 1 m ocean rise during the twenty-first century caused by climatic forcing, tectonic activity, anthropogenic effects and glacio-isostatic adjustment (Fig. 1), Greek experts have boldly proposed a 4.5 km-long solid causeway-barrier be emplaced to isolate the inner and outer Thessaloniki Bays at enormous, yet uncalculated, monetary expenditure and environmental cost (Perissoratis and Georgas 1994; Poulos et al. 2009). Such ugly localized


**Fig. 1** Hypothetical 1 m ocean rise in the Mediterranean area. Credit: Center for Remote Sensing of Ice Sheets. Haskell Indian Nations University; http://www.cresis.ku.edu/sites/default/files/sea-level-rise/images/mediterranean/mediterranean_1m.jpg; https://www.cresis.ku.edu/data/sea-level-rise-maps ©Copyright 2010 CReSIS

blocking macro-project constructions—planned emergency “techno-fixes”—may not be undertaken if the future earth–ocean sea-level rise is physically excluded from affecting all Mediterranean Sea Basin nations (at modest regional or spread global cost of less than 2010 USD 10 billion).

According to Bohannon (2010), a 1-m future rise of the Mediterranean Sea’s level will submerge ~30% of the Nile River’s delta. The land adjacent to Venice, Italy, is even more obviously affected, as is the famous vacationer’s strand zone of southern France’s popular beach communities.

The ultimate form of “landscape architecture”, a term coined *circa* 1858, is Macro-engineering; as overtly implied during 1984 by J.B. Jackson, “landscape” combines civil engineering and landscape architecture to honor the first century of the profession’s formal existence, the American Society of Landscape Architects (organized 1899) designated the year 1964–1965, beginning June 28, the Centennial Year of Landscape Architecture. However, it was not until *circa* 1964 that “Macro-engineering” was neologized and found immediate professional acceptance worldwide amongst civil and military engineers. Herein, we apply macro-engineering to remaking the seacoast and inland landscapes of Tunisia and Algeria, at least the alluvial plains containing desert saline playas which border the southern foothills of the Atlas Mountains and the northwestern margin of the Grand Erg Oriental. Our proposed macro-project, of course, has a firm linkage to the ongoing and announced macro-projects discussed thoroughly at the “Impacts of Human Activities on Dynamic Coastal Processes, Tokyo, Japan, 7–11 September 2009” (“Coastal Dynamics 2009” is the sixth international specialty conference on this subject). Tunisia, ~0.1% of the earth’s land area (163,610 km$^2$), was one of the first North African ecosystem-states to actively resist the encroachment of the Sahara, desertification and salinization (Borowiec 2003; Goudie 2003).

A comprehensive technical definition of any macro-project should be judiciously phrased to highlight the concept that it is of unusually large scale, both geographically and economically, has an inherently unique character, provides a variety of useful localized earth–biosphere effects, and changes fundamentally the conditions for a society–ecosystem’s growth and development (in human terms). Because it may have some of the local aura of “magic” by making something or some activity possible that was impossible before its execution, the particular macro-project can also be defined as “super important”, “super costly”, yet inexpensive at any price in terms of its overall effects, affective for an entire ecosystem-nation’s human population, and possibly never really tried before anywhere on Earth during the twenty-first century. There are useful sub-categories of macro-projects—some that are good, beneficial and positive or even essential; there are other macro-projects that are bad, harmful, damaging or undertaken for purposes enhancing individual or societal prestige amongst all aware peoples. For example, in ancient times, “…modifying the signs of nature, especially through the construction of canals, was an arrogant act which later classical authors usually associated with tyrants” (Dora and della 2007).

Francois Charles Marie Fourier (1772–1837), in 1808, cogently remarked that human armies of industrious tool-armed persons would someday boldly subjugate the Sahara: "They will execute works the mere thought of which would freeze our mercenary souls with horror. For instance, the combined order will undertake the conquest of the great desert of Sahara; they will attack it at various points by ten and twenty million hands if necessary; and by dint of transporting earth, cultivating the soil and planting trees everywhere, they will succeed in rendering the land moist, the sand firm… They will construct canals navigable by vessels, where we cannot even make ditches for irrigation, and great ships will sail [on them]…" (Gide 1970). (After its dedication, and when it first opened to international oceanic shipping on 17 November 1869, the Suez Canal was immediately found to be too narrow and shallow to efficiently accommodate the marine traffic then desirous of passage. Obviously, this was a Suez Canal macro-project planning shortfall.)

By 1877, Donald Mackenzie published *The Flooding of the Sahara*, a geographical tome proposing an excavation from northern Africa's North Atlantic Ocean strand to the "…below sea-level central Sahara", thus permitting an [impossible] submersion with canal-imported seawater of a large region of that infamously hostile hot desert (Koger 1999). (To inspect Mackenzie's rare tome describing this potential macro-engineering fiasco, a scanned copy of his complete book can be conveniently accessed by the worldwide public: http://www.ia310843.us.archive.org/0/items/floodingsaharaa01mackgoog/floodingsaharaa01mackgoog.pdf. Therein, the most important particulars of the Sahara flooding scheme, as Mackenzie assessed them, can be perused at pages 255–263; 279–287 and 304–308 of this "portable document format", invented in 1993, and since 1 July 2008, an open standard for personal computers.) Before Mackenzie, however, heroic French macro-engineers had contemplated a similar transformative project macro-plan, but for another northern Africa locale; their speculated artificial "la mer interieure" was to be situated entirely within modern-day Algeria and Tunisia (Dora and della 2007) and was promoted by the adventurous macro-engineer Francois-Elie Roudaire (1836–1885).

In 1950, the population of the Mediterranean Sea Basin was ~170 million Europeans (73%) and 63 million North Africans (27%); by 2025, due to a profound demographic shift, there could be 305 million Europeans (44%) and 381 million North Africans (56%). world war II causalities in Europe, which caused a labor shortage needed to service Europe's obsolete industries, and post-world war II Muslim immigrants to France from Algeria as well as a prospering Germany's 1950s Muslim guest-worker national labor policy, together with high birthrates amongst European Muslims and low birthrates amongst traditional Europeans are the chief causes of the remarkable demographic shift (Caldwell 2009). A rising European standard of living, although not a precise measurement of how people live, was a social concept that first became widely used *circa* 1902, and certainly affected everyone in postwar Europe. The African Union was proclaimed on 1 March 2001 and on 29 October 2004 Europe's leaders signed a European Union Constitution. Currently, a demographic shift in Europe seems to presage an epoch—occurring, perhaps, sometime *circa* 2010 to 2050—that will alter Europe's still distinctive culture: post-world war II Europe has been colonized by Muslims mainly from North Africa. By 2010–2050, Muslims in southern Europe

(Spain, France and Italy) may form ~25% of the total population and working Muslim adults may total ~40% of the available labor force. This means, apparently, that the Gibraltar Strait Textile Barrier and its associated infrastructure developments discussed below in Sect. 3 may find decisive future acceptance amongst voting citizens of southern Europe and northern Africa since by 2050 North Africa's population should exceed southern Europe's by close to 100 million persons.

Signatories to the Barcelona Convention, an international agreement to protect the Mediterranean Sea, including Tunisia and Algeria as parties in good standing to the 1976 convention, declared in their January 2008 "Almeria Declaration" to ban any further construction on the 100 m of land nearest the present-day Mediterranean Sea's saltwater. (Marine power, particularly wave and tidal energy developments would not need to be transmitted great distances (with losses) if the human population lives with <100 km of the ocean, thus conforming to the mantra of efficiency, since efficiency is associated with increased profits or productivity, individual discipline and superior macro-management.) This declaration is a strong social response to the repulsive fact that ~40% of the Basin's strand is already disfigured by highways, railways and buildings. And, there are significant seawater and seabed pollution macro-problems lurking below the Mediterranean Sea's surface (Dachs and Mejanelle 2010; Mukerjee 2010). On 13–14 July 2008, the President of France inaugurated a new political/economic initiative for uniting the peoples and economies of the Mediterranean Sea Basin with practical macro-projects via a "Barcelona Process: Union for the Mediterranean" (Zewail 2008), with headquarters located in Barcelona, Spain. The Mediterranean Solar Plan, for example, is a planned macro-project encouraged by the Mediterranean Union to install a vast array of concentrating solar power facilities in the Sahara (Pearce 2009); some of the long-distance power transmission facilities (cables) will pass through Tunisia, across the Mediterranean Sea, then meeting the power grid of Sicily. We do not anticipate that CATS will interfere with the planning of this power-line system, due to be completed by 2050.

## 3 Mediterranean Sea Terracing

About 4,300 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 et al. 2007). About 2.2% of this planet's land, that is 10 m 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 et al. 2006). Humanity's activities (to make and earn a living) will "globalize" the Mediterranean Sea—its seawater, organic and inorganic contents, and periphery (Blondel 2006; Dora and della 2007).

Twenty-first century Mediterranean Sea Basin state-ecosystems still have several expensive twentieth century-conceived 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 and van der Kaijser 2006). 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 artists/macro-engineers the prospect of a cheap Mediterranean Sea Basin anti-level rise sea barrier macro-project hung underwater by a very strong super-rope (Cullen 2005). A fabric artwork and barrier, the Gibraltar Strait Textile Barrage (GSTB), could supplement or replace eventually the MOSE (Modulo Sperimentale Elettromeccanico) macro-project to protect Italy's historic Venice from ocean inundation with an installed facility of costly, operationally complex-to-manufacture-and-maintain storm movable surge gates currently scheduled for completion *circa* 2014.

The Strait of Gibraltar (Fig. 2) connects the North Atlantic Ocean and the Mediterranean Sea, making it inevitable that the unobstructed Mediterranean Sea will rise as our world's ocean elevates caused by climate regime disruptions (Beddoe et al. 2009). The GSTB will likely be dependently draped on a 20 km-long horizon-to-horizon 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 designed structurally by Earnest C. Harris (1915–1998) (Vaizey 1990). If and when constructed, its sole purpose will be to ensure the maintenance, for a long period of historical time, the existing

**Fig. 2** Gibraltar Strait, appearing as if gazed at by a person flying in an aircraft looking eastward from above the North Atlantic Ocean. The strait is about 13 km wide and is the only natural gap in the topographic barriers that separates the Mediterranean Sea from the earth's world-ocean. Source: http://www.earthobservatory.nasa.gov/IOTD/view.php?id=3926

Mediterranean Sea Basin's common sea-level; in other words, this artwork would preclude any future erosion of valued land-based artworks encompassed by the urban fabrics of North Africa and southern Europe. The global reinsurance industry, almost 75% of which is "…underwritten by companies in Germany, Switzerland and the United States [of America]" (Sturm and Oh 2010), will likely restructure their Mediterranean Sea Basin risk exposure after the Gibraltar Strait Textile Barrier macro-project we propose is constructed. The GSTBs structural, mechanical and hydro-dynamical physics was first preliminarily demonstrated in 2007 (Cathcart and Bolonkin 2007). Basically, the seawater-impervious Gibraltar Strait Textile Barrage replicates, in a crucial Mediterranean Sea Basin setting during a critical climatic change event-process, Christo's temporary suspended fabric curtain in Colorado. [Here, it is interesting to note, that Christo intends to complete a horizontally laid 9.5 km-long fabric covering of the State of Colorado's Arkansas River valley by 2012 (Christo 2008). Such a covering might be assumed to have some moisture-retention capabilities—that is, containment of evaporated freshwater, rather like the underlying impermeable lining of major freshwater irrigation canals.] Emplacement of the GSTB will not, in any significant way whatsoever, hinder the future tunnel boring machine [TBM] excavation of a Gibraltar Strait Tunnel should that become internationally desirable and economically affordable within the continuously evolving geopolitical context of the Mediterranean Union (Pliego 2005; Silva et al. 2006).

## 4 Gibraltar Strait Textile Barrage, the World's First Sea Art

"Valley Curtain" was punctured regularly at numerous places to prevent its being torn asunder by strong up-and-down valley winds. [Christo's famous "Running Fence" of 1976 in Marin County, California, had commenced and terminated in seawater (O'Doherty 2010).] Coincidentally, a watery version of "Valley Curtain", concocted by the UK expert 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 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 (differences in sea elevations on a two-sided, bottom-anchored and virtually vertical suspended membrane and natural currents such as North Atlantic Ocean tidal solitons) and aerial (seasonal winds) pressures acting directly on the air-exposed GSTB segment. Indeed, prevailing seasonal winds flowing generally west-to-east along the fetch of the Gibraltar Strait will pile approximately 5–6 mm of seawater on the GSTBs 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 anti-submarine net installation in strategic harbors and that documented previous experience offered by the ~100 km-long World War I anti-submarine 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—absent warning light-buoys and effective radar reflectors—ship navigators will visually misapprehend the true nature of the plotted sea-route ahead. Those mariners, such as small-scale, private-sector fishermen and yachtsmen, piloting their boats without benefit of up-to-date navigational sea-charts that indicate clearly the GSTBs presence, will have no inkling *via* normal optical clues that a 1 m drop in sea-level occurs at the Gibraltar Strait. Mariners without radar readouts using the eastern approaches will visually spy a 1 m-high tensioned fabric wall spilling some seawater caused by wave over-wash, which if made of clear or aquamarine-colored barrier material might be almost invisible until closely sighted.

The total area of the vertically draped, pendulous, GSTB is about 200 $km^2$ but only approximately 20,000 $m^2$ will be constantly exposed to the air-corrupting and material-degrading UV-strong sunshine on its eastern face while the GSTBs submerged western face will be required to continually resist a 1 m chemically complex hydraulic head of seawater. The world-ocean's seawater acidification persistent, if slow, trend must be monitored carefully. The GSTB artwork—if built, the world's first true commonly visible Sea Art—will be mechanically lifted by shore-based winches gradually only as much as the North Atlantic Ocean actually rises—it will, therefore, act as an active, scalable compensation mechanism to accommodate the real-time twenty-first century ocean changes in measured volume and surface area.

## 5 GSTB Structural and Material Design

The GSTB textile barrage structure and material have to be strong enough in order to support the nearly 1 m water hydraulic pressure difference, which remains constant along the height $h$ (Fig. 3). The brittle fracture of the membrane would

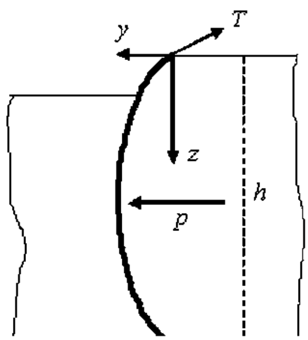



**Fig. 3** Vertical sectional scheme of the tensioned GSTB (side view)

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

Considering the macro-engineering scheme to be installed at the geographical place imaged in Fig. 2 and reported in Fig. 3, and indicating with $y(z)$ the barrage deflection, from classical structural mechanics we have:

$$\frac{d^2y(z)}{dz^2} = -\frac{pL}{T_H} \tag{1}$$

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 (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:

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

Accordingly we find:

$$T_H = \frac{pLh}{\sqrt{6\varepsilon}}, \quad \varepsilon = \frac{H-h}{h} \tag{3}$$

The mean tension in the GSTB will, thus, be

$$T = \frac{1}{h}\int_0^h \frac{T_H}{\cos\left(\frac{dy(z)}{dz}\right)} dz \approx \frac{T_H}{h}\int_0^h \left\{1 + \frac{1}{2}\left(\frac{dy}{dz}\right)^2\right\} dz = T_H \frac{H}{h} \tag{4}$$

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

$$t = \frac{pH}{\sigma_u\sqrt{6\varepsilon}} \tag{5}$$

The mass $M$ of the GST Barrage can thus be calculated as:

$$M = \rho LHt = \frac{\rho p H^2 L}{\sigma_u\sqrt{6\varepsilon}} \tag{6}$$

where $\rho$ is the material density. The optimal design can be deduced to minimize its weight, according to:

$$\frac{\partial M}{\partial H} = 0 \quad \Rightarrow \quad \varepsilon = \varepsilon^* = \frac{1}{3} \tag{7}$$

At the optimal shape $\varepsilon^*$ corresponds to a thickness:

$$t^* = \frac{pH}{\sqrt{2}\sigma_u} \tag{8}$$

Equation (8) shows that to further reduce the weight of the barrage, and thus its thickness, we can reduce its size $H$ and/or increase the material strength $\sigma_u$.

The material strength $\sigma_u$ for a barrage having micro-structural (e.g., texture) size $q$ (the "fracture quantum") and containing an elliptical hole of half-axes $a$, perpendicular to the applied tension, and $b$ can be determined according to Quantized Fracture Mechanics (Pugno 2006) as:

$$\frac{\sigma_u}{\sigma_{ideal}} = \sqrt{\frac{1 + 2a/q(1 + 2a/b)^{-2}}{1 + 2a/q}} \tag{9}$$

where $\sigma_{\text{ideal}}$ is the ideal (defect-free, theoretical) strength ($\sim$100 GPa for industrially-produced carbon nanotubes). Equations (9) and (8) show that plausible defects can reduce the strength and increase the thickness by 1–3 orders of magnitude.

Due to the huge physical size $H$, which must even accommodate the Earth's natural curvature, the GSTB composing material has to be sufficiently strong, e.g. steel, Kevlar or carbon nanotubes, or alternatively the structure itself has to be sufficiently thick throughout it full extension. Graphene sheets are ideal candidates in this geographical and structural 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 $p \approx 10\,\text{KPa}$, we deduce for realistic macroscopic, thus inevitably defective, graphene sheets ($\sigma_u \approx 10\text{GPa}$, see Pugno 2006) $t \approx 1 - 4\,\text{mm}$ (for defect-free graphene sheets, $\sigma_u \approx 100\,\text{GPa}$, one would expect $t \approx 100 - 400\mu\text{m}$); for comparison, for steel membranes ($\sigma_u \approx 1\,\text{GPa}$) $t \approx 1 - 4\,\text{cm}$.

We conclude that Kevlar and even graphene sheets are ideal as tensioned textile barrage material; their astounding super-strength, and consequently reduced thickness, consequently minimizes material consumption and maximizes flexibility, e.g. allowing rolling (expected to be useful during transportation to the work-site).

## 6 Artwork (Southern Europe and North Africa) Preservation Paramount

The proposed Gibraltar Strait Textile Barrage is a deformable physical construction intended to preserve extant as well as near-term future social artworks within the Basin of the Mediterranean Sea that are near seawater. It also is a means to improve humanity's ability to apply macro-engineering principles which skirt or correct a possible near-term future global oceanographic macro-problem impairing the future economic usefulness of southern Europe and northern Africa's low-elevation coastal lands. It is a practical and low-cost example of Sea Art for the twenty-first century that preserves humanity's ancient and modern cultural heritage situated in the multi-cultural Mediterranean Sea Basin, which is subject to earthquakes, tsunamis and even hurricanes (Bilham 2009; Weisse and von Storch 2009).

The two most essential reasons why the GSTB ought to be built are: (1) all European Union and Mediterranean Union members now hope to link Europe's and North Africa's super-smart 2050 electric power grids (Strahan 2009) and (2) construction of solar power concentration electricity generation facilities in North Africa will quickly modernize ordinary life-styles as well as rapidly change traditional national geopolitical outlooks of the peoples living in that generally arid region (Trieb and Muller-Steinhagen 2008). A third necessarily vital reason (3) to build the GSTB is to steady the micro-tidal Basin's sea-level in order to permit reliable macro-engineering assumptions about the CATS macro-project elucidated in this chapter.

## 7 The Mediterranean Sea Basin CATS Macro-Project

Disregarding the ultimate cause of future effective sea-level rise, a practical subject of great geoscientifical controversy, one prospect looms menacingly obvious: marine inundation of the Mediterranean Sea Basin's present-day strand poses a major threat to the long-term welfare of its permanently resident human populace. Besides freshwater reservoir storage, it is practicable to channel large quantities of seawater into some of our world's great interior drainage basins that lie below present-day sea-level in order to dynamically control our world-ocean's volume (Newman and Fairbridge 1986); for example, a naturally capacious potential sink adjacent to the Mediterranean Sea is Egypt's Qattara Depression. An artificial potential sink is envisioned at another low-elevation region, the most eastern part of the Zone of Chotts, which extends westward from Tunisia into Eastern Algeria and consists of Chott Gharsa (Fig. 4, 34.08°N Lat. by 10.05°E Long.; 620 km$^2$ with a maximum depth below present-day world sea-level of $\sim$10–25 m), Chott el Jerid (34.00°N Lat. by 10.00°E Long.; 5,400 km$^2$ with a maximum positive elevation of $\sim$10–25 m ASL) and Chott Melrhir (31.00°N Lat. by 7.00°E Long.; 1,100 km$^2$ surface with a maximum negative sea-level elevation of $\sim$40 m below global sea-level (BSL).

Chott el Gharsa would overflow the watershed, flowing into Chott Melrhir at a level of minus 5 m. Water levels >25 m would result in linkage with the Chott el Jerid (Fig. 5) a halite saltpan bordered by a remarkably concentric region of gypsum flats encircled by a sandy sabkha, and the Chott el Fejej, and a water level exceeding 37 m above extant world sea-level would result in the inter-connection of the entire seawater-filled Zone of Chotts (Figs. 5, 6) with the nearby Mediterranean Sea. A "Chott" is a salt flat within a hydrological basin separated from the Mediterranean Sea. The mean annual temperature for the Zone of Chotts is 20.9°C.

**Fig. 4** Chott el Gharsa. Source: http://www.upload.wikimedia.org/wikipedia/commons/c/c5/Chottelgharsa1.jpg; Wikipedia Commons by Jaume Ollé. Creative Commons Attribution 3.0 Unported License


**Fig. 5** Map of northern Africa's famous Zone of Chotts. Source: http://www.upload.wikimedia.org/wikipedia/commons/7/72/Chott_el_Jerid.jpg Released under the GNU Free Documentation License

The mean yearly rainfall ranges between 89 and 150 mm. Evaporation in the Zone of Chotts is at a maximum during the dry season (between April and November), reaching between 2,500 and 3,100 mm/year. It is a closed topographic region distinguished by high evaporation and low rainfall regimes. Under some UNO Climate Change models projected changes in yearly temperature move

**Fig. 6** Chott el-Jerid with naturally channeled brine accumulation. http://www.commons.wikimedia.org/wiki/File:Chott_el-Jerid_1117.jpg Source: By Gorik Francois. Licensed under Creative Commons Attribution ShareAlike 2.0 License

upward (by +3 to +4°C) and annual rainfall is reduced (by 10–20%). Should those event-processes ever happen, it would greatly benefit our offered CATS macro-project.

With a population of >10 million humans, sovereign Tunisia, independent since 1956–1957, is bordered by the Mediterranean Sea (1,148 km-long coastline), Libya (459 km) and Algeria (965 km).

Filling Chott Melrhir (Fig. 7, −40 m BSL) in Algeria with seawater by harnessing, sequentially, the major Chotts existing in Tunisia is the goal of the "Chotts Algeria–Tunisia Scheme" (CATS) macro-engineering effort. Treeing the CATS means, simply, that we recognize this particular macro-project grand-scale design (Kaya 1991) for artificially enclosed seas to be really difficult of accomplishment, rather like getting all herded contentious wild cats into one peaceful, or at least controllable and containable, group holding pen.

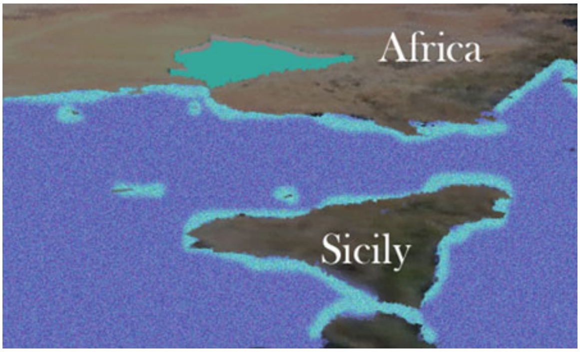
During the historic period from 1957 until about 1988, nuclear energy researchers in the USA and the former USSR considered the mundane purposes achievable using mundane tools—peaceful nuclear explosives (PNEs) (Hess 1962). Super-computerized simulations of crater dimensions resulting from 200, 400 and 800 kiloton yield nuclear explosions have been done to study the feasibility of connecting the Mediterranean Sea with the Qattara Depression by a PNE-excavated channel (Toman 1980). Earthwork comprises two operations: (1) the cutting down of the elevations projecting above the level of the proposed surface and (2) the filling up of the hollows lying below the proposed surface. CATS will involve, mostly, the

**Fig. 7** Chott Melrhir imaged by earth-orbiting satellite. Source: http://www.upload.wikimedia.org/wikipedia/commons/0/0b/Chott_Melrhir_SPOT_1195.jpg

former activity. Tunisia is one of the smallest in area of all independent states in Africa. Nevertheless, sometime before 1962, Tunisian scientists comprehensively proposed a "Chotts Depression Scheme" to serially blast huge craters in the Chott el Fejej and Chott el Jerid, both wastelands which are above present-day world sea-level, and subsequently inundate the resulting depression with 27.5 to 38.5% salinity seawater (Feistel 2008) channeled from the close-by Mediterranean Sea (Fig. 8). Minimally, ~5,400 km$^2$ plus the 620 km$^2$ Chott Gharsa west of the small-scale seaport of Gabes was planned for future unnatural ocean water inundation. It was also then foreseen and contemplated that Algeria's below world-ocean sea-level Chott Melrhir (1,100 km$^2$) could, eventually, be connected to form a linked chain of synthetic mini-seas covering 7,120 km$^2$ of previously air-exposed Zone of Chotts landscape. (That would be ~35.5 times bigger in area than Egypt's Great Bitter Lake.) Planted along the 34° North parallel of latitude, the colossal channel-depression was to have been formed inexpensively *via* multiple PNEs and the Chotts Depression Scheme, which we have renamed CATS, was to result, finally, in a real-world recreated Lake Tritonis (Fig. 9) of ancient Mediterranean Sea Basin mythology. While the transforming Chotts are being filled by inflowing seawater

**Fig. 8** One possible configuration of a Zone of Chotts seawater submergence macro-project—perhaps the foundational first iteration of a future Port Tritonis? Original artwork by Joseph J. Friedlander. Base image from Orbiter

**Fig. 9** Artist-author Joseph J. Friedlander's space image-like concept of ancient mythology's supposed Lake Tritonis. Port Tritonis realized and materialized?




from the micro-tidal Gulf of Gabes, where Spring tides have amplitude of $\sim 1$ m, a large amount of hydropower, which entails a true cascade of seawater spinning turbines, can be generated. However, that will only be a temporary phenomenon.

Subsequently, because of the dry inland climate, these shallow bodies of introduced seawater, brought to Mediterranean Sea level, would endure rapid aerial evaporation, increasing the salinity to +200% salts, thus producing a continuous flow of seawater punctuated by tidal seawater movements through the excavated connecting channel; Tunisian macro-engineers naturally visualize that cheap and reliable hydrokinetic electricity would thereby be produced as a direct result of this constant current, a steady inflow much like a river's flow (Kahn 2009). Of course, the continuously incoming seawater's flow would not come close to the current speed within the Strait of Messina, the gap in southern Europe's land between Calabria on mainland Italy and Sicily. If the natural Tunisian terrain has a water flow resistance of over 0.6 kg/m$^2$ for an unlined canal with a 20 cm/km slope—that is, a gradient of 2/10,000—unlined bank erosion will be unlikely to occur (Litrico and Fromion 2009). Since the 3.2 Richter-scale Earthquake in southern Tunisia, with an epicenter in the mining basin near Gafsa (Karaloui et al. 2009) on 28 December 2009, it is obvious that unlined canals would endure longer without maintenance than more complicated structures; nevertheless, concrete-lined channels are best from the perspective of restriction of geographical effects. Today, hydropower-generated electricity accounts for barely 1% of overall energy production in 2010 Tunisia. The wind energy resource present in the Gulf of Tunis is promising for future development and some dredged material might be shipped northwards to be used to form artificial islands bearing masts equipped with wind turbines. Such a facility could efficaciously complement the anticipated solar power concentrators in the desert to the south of Tunis (Orstein et al. 2009).

How best to produce hydrokinetic electricity in the existing wastelands of Algeria and Tunisia? First, a man-made channel (100 m vertical bank to vertical bank width by ~175,000 m-long with a constant depth of 5 m) must be excavated by (1) yet-to-be-built floating nuclear-powered dredgers (Cathcart 2008) or automated Bucketwheel excavators similar to that once used to partly dig the Sudan's incomplete Jonglei Canal. The now idle and damaged Sudan Bucketwheel dug at a maximum consistent rate ~3,000 m$^3$/h (Collins 1990). Self-propelled canal-construction machinery is custom-built to specific job requirements and can be designed to perform in a number of applications. Canal builder's use of continuous concrete slip-form pavers can be labor and cost-saving and prevents most infiltration of canal-carried fluids into the soil and groundwater underneath the canal. Very roughly, approximately 85,500,000–100,000,000 m$^3$ of rock fragments and loose quaternary sediments (aeolian, lacustrine and sabkha deposits) must be removed to join Gabes (human population ~250,000) with Algeria's Chott Melrhir. Supposing the need to redistribute 85,500,000 m$^3$ of material using a highly automated Bucketwheel-type mechanical self-moving digger that can shift ~280,000 m$^3$/week, then excavation for the CATS might require a constructive time period of between 5 and 6 years to complete. (A floating nuclear-powered dredger could, probably, remove 350,000 m$^3$/week and compete the initial phase in 0.5 and 1.5 years.) We think it is reasonable to suppose that CATS' macro-engineers will assume that the elongated arm of the Chott el Jerid, the Chott Fejej that extends eastward towards the coastal city of Gabes, should be utilized as a direct route for the concrete-lined seawater channel. The cost of the CATS' initial digging phase ought not to exceed 2010 USD 1 billion. This estimated cost might be reduced somewhat if beneficial uses can be found for dredged material (US Army Corps of Engineers 2005) in, say, nearby salt-marshes (Allen and Pye 2009).

During the middle construction phase, the spoils from the channel mining, heaped in usefully sited mounds (artificial earth sculpture, landscape as artwork) by design, form gigantic geometrical berm-bordered ponds wherein seawater might be deposited temporarily to create permanent pumped storage electrical power plants (Hiratsuka 1993), perhaps employing a hydraulic turbine deriving energy from an inlet within the reservoir (Kouris Paul 2000), after the reduction of the Chott el Jerid ground surface elevation above sea-level by 20 m above sea-level (ASL), making it $\sim 3$ m below the present-day Mediterranean Sea level ultimately. Basically, that part of the gulf-creation macro-project necessitates removal of $1.072 \times 10^{11}$ $m^3$ of material. Full excavation of the Chott el Jerid might be profitably postponed until after the channel reaches the first topographical place below the present-day sea-level Chott, namely Chott Gharsa. The GSTB in Sect. 5 will, thus, maintain a stable macro-engineering planning context for the channel and the trained seawater inlet facing the micro-tidal Gulf of Gabes since Tunisia's strand will be mostly unaffected by the generally anticipated, but nevertheless, uncertain future global sea-level rise macro-problem. The two trickiest dredger working-life moments will happen when the automated nuclear-powered dredger meets the two places where the dug channel will eventually enter the below sea-level Chotts since a gushing seawater flow could either wedge the dredger in the gap between the elevation-reduced Chotts—that is, Chott el Fejej and Chott el Jerid—and the below sea-level Chotts—Chott Melrhir and Chott Gharsa—or the unmanned dredger could be wrecked or severely damaged by simply falling over unnatural waterfalls. Not to be ignored is the likelihood of seasonal gusting winds affecting the handling of the unanchored floating dredgers.

## 8 Hydrokinetic Electricity Production, Navigation and Pollution

Several prefabricated floating railroad bridges with pre-installed tidal stream energy machines ought to be towed into their ideal final installation sites, and thereafter sunk to form a ship-passable pierced land transportation causeway. Rotation of the energy-generation mechanisms within this permeable barrier will thereby produce an interminable hydrokinetic electricity supply that the poorest people living in western region of central and southern Tunisia may wish to sell out-of-country, use themselves and/or share with neighboring folks situated in southern Algeria.

The introduction of a new source of income will certainly help improve the nutrition of the people through diet diversification. On 22 April 2009, Tunisia ratified the "UN Convention on the Non-navigational Uses of International Watercourses", which is an international legal framework for more specific bilateral and regional treaties relating to the use, management and preservation of trans-boundary water resources such as the Complex Terminal Aquifer (Edmunds 2003; Kamel 2008). CATS would seem to qualify for future discussion and inclusion. Improved harmonization between Tunisia and Algeria's anti-Sahara migration and desertification control strategies and the legitimate socio-economic development of local rural communities living and working (pastoral and mining) in the Sahara to the south will be a major challenge for CATS macro-engineers because the CATS could instigate a land-rush episode. It is easy for us to imagine a new public relations program that touts CATS as a “resurrection of the granary of Rome” (Davis 2007) combined with a concerted public-government organization effort toward regional industrialization. Such reinvigoration of a region—in fact, the macro-engineering-induced conversion of J.B. Jackson’s “anti-landscape”, which he defined in 1984 as a man-modified space that once served as infrastructure for collective existence but that has, over recorded history, ceased to do so—making the CATS a truly resurrected northern African “landscape”. Port Tritonis, somewhat resembling mainport Rotterdam in layout, is the ultimate possible expression of such a macro-management effort.

There is a single Mediterranean Sea Basin precedent—although not fully comparable—at Italy’s Ischia Island. The unique man-made Harbour of Ischia’s (Fig. 10) historically fascinating macro-engineering story is fully recounted elsewhere in this book (see Chap. 10.1007/978-3-642-14779-1_1). A small boat and yacht harbor, Port d’Ischia, was dug during the 1850s by macro-engineers who flooded a land-locked volcanic crater that could be connected to the Tyrrhenian Sea economically. Harbor-formation workers needed about 2 years for digging the very short channel with hand tools, pony carts and wheelbarrows. The Romans had an expression: “Multorum minibus magnum levatur onus” [“by the hands of many a great load is lightened”]. Luckily, the construction site work leaders and laborers followed the surface trace of a <10,000 year-old volcanic eruptive fracture that made their excavation effort simple and physically less difficult.


**Fig. 10** Ischia Harbor. Source: *Inset* art by Joseph Friedlander; background art by Norman Einstein, modification under the GNU free documentation license. Courtesy Wikipedia Commons at http://www.upload.wikimedia.org/wikipedia/commons/7/73/Capri_and_Ischia_map.png

Excavation and submersion by imported seawater of Chott el Fejej-Chott el Jerid and Chott Melrhir facilitates profitable commercial coastal and high-seas shippers, encouraging them to serve new seaports built along the new far-inland strand, perhaps mineral and agricultural exportation would flourish. It will be incumbent on Tunisian authorities to become vigorously involved in the promotion, design, construction, procurement and operation of these new port facilities at all strata, with particular attention to the most recent developments in applicable design and building methods and how these must be economically integrated with operational requirements and, of course, environmental considerations. Channel walls and embankments will become places of new riparian vegetation and ship-generated wake washes will cause sediment and seawater movements unrelated to natural hydrodynamic processes, causing anthropogenic shoreline erosion, for instance (Garel et al. 2008). For example, fast ferries—some are easily capable of speeds of ~40 knots in water depths <10 m—produce very-long-period low-amplitude waves which are very energetic and can build in height rapidly close to the shore and then break suddenly; this nature of confined wash waves generated by fast ferries is such that their presence would endanger beach-goers and, probably, should not be allowed to ply the artificial bay produced by CATS. The effect of living channel vegetation will be evident on the seawater's velocity, turbulence and longitudinal mixing because emergent vegetation reduces the magnitude of longitudinal shear dispersion while submerged vegetation has a wake zone. And, barge-mounted drilling oilrigs could float unobstructed from one exploration work site to another drill site rather easily.

Essentially, what will be created by Tunisian macro-engineers and others is a semi-enclosed marine system bounded by land with only a regulated inlet (Tagliapietra et al. 2009); the inland coastal ocean-connected CATS marine system will be incomparable as not even the 75 km-long Arabian Canal now under construction in Dubai will be similar. Tunisia's climate regimes will change, perhaps unpredictably (Enger 1991). Too, it is possible there may be some macro-project planner worries over potential future hydro-seismology owing to seawater loading of the wind-deflated depression's earth-crust surface since seawater is less dense than the materials that have been forcefully removed by human in the Chott el Fejej and Chott el Jerid and redistributed. Seawater circulation, the long-term pattern of seawater motion remaining after the irregular seawater movements involved in wind drift, seiches, and other short-term phenomena are averaged, in the CATS will likely be counter-clockwise just like Egypt's Great Bitter Lake (30°20′N Lat. by 32°23′E Long., Fig. 11) (Touliabah and Taylor 2004; El-Bassat 2008).

One unique import, fertile foreign silt, would be obtained and carried ~2,700 km by slurry pipeline to the vicinity of Gabes, Tunisia, from the new freshwater reservoir submarine delta created by the Aswan High Dam at the border of Egypt and Sudan or, perhaps, from some closer place (Abulnaga and El-Sammany 2004); this silt importation macro-engineering idea was first bruited in 2004 (Cathcart and Badescu 2004). Large-scale reservoir desiltation serves two interests because (1) such lake sediment mining effort prolongs the operational period of the Aswan High Dam Reservoir and (2) the mineral-rich silt extracted, especially if

**Fig. 11** Great Bitter Lake, Egypt. Source: NASA earth observatory. This saline lake is a possible physical analogue for CATS. The Great Bitter Lake accommodates north–south/south–north international shipping using the Suez Canal

widely spread on arid land to appropriate fresh-soil profiles, could provide suitable soil base material for covering extant barren salt-flats in Tunisia and Algeria (Brandt 2000). Macro-engineers have the useful example of hundreds of lakes, including the Veeranam in Cuddalore, India, that are planned to be de-silted during the early-twenty-first century just to increase their holding capacities for vitally-needed collected normal rainwater runoff.

Eventually, the budding academic and industrial technopole of Gabes, Tunisia, could become the home of an all-digital electronic Second Library of Alexander to serve well the employed and settled citizenry of a newborn major industrial complex. Ships that use ballast water, and once used stones, can be adapted to use appropriately formulated thick mud slurry consisting of Nile River freshwater and Aswan High Dam Reservoir sediment that is stabilized for transport in slightly modified ship holds. In other words, there are at least two means to transfer material from Egypt to Tunisia and Algeria. FCM Fourier's "hands" can be supplemented with robust solar-powered robotic outdoor earth-moving equipment, off-spring of those semi-automated machines NASA R&D has devised and roughly constructed for the exploration of the far-distant planet of Mars (Badescu 2009).

Realistically, the materialized CATS inland oceanographic creation would not be easily predictable in its hydraulic behavior. CATS will certainly have many of the distinguishing characteristics of the USA's Great Salt Lake in Utah and the Salton Sea in California (O'Connell 2001) as well as Urmia Lake in Iran. Tunisia's Gulf of Gabes is the major marine region of energy dissipation for present-day—that is to say, known and experienced—Mediterranean Sea tides (Tsimplis 1995). Local tides in today's Mediterranean Sea generally have a small range of ~1 m. Strand conditions have changed greatly from those of ancient times, as close examination by geological expert Roland Paskoff (1933–2005) has indisputably revealed (Paskoff 1991). If saltwater aquaculture were to be developed in the submerged Chotts, then the clean-up of incoming seawater is, seemingly, a mandatory subsequent industrial activity (see http://www.ars.usda.gov). The presence of CATS may cause further tourist development on the 514 $km^2$ Djerba Island—the most famous vacation attraction situated in southern Tunisia—as an international yacht racing locale (Anane et al. 2008), especially if Port Tritonis becomes actualized during this century, to facilitate the industrialization of North Africa and the northern Sahara.

Today's Mediterranean Sea level, 1 m higher than in olden Roman times, masks a rubbish-strewn (underwater) seascape and a badly contaminated volume of seawater (Guillaumont 1995) laden with floating plastic wastes. It is a saddening geographical fact that to our species' almost everlasting shame, vast regions of the Mediterranean Sea Basin's submarine continental shelf is burdened with rotting man-made marine debris. A strong ocean seawater current moving finally towards Chott Melrhir through the long artificial channel and other capacious seawater lagoons that were once unpopulated Chotts will, of course, redistribute this junk, garbage and other unidentifiable stuff unless remedial measures are simultaneously undertaken to prevent any pollution of Chott Melrhir. The way in which these various materials may be brought to Chott Melrhir is by the primary wave system built up in the form of a pressure maximum at the bow and the stern of a moving watercraft and a pressure minimum develops along the hull of the vessel. This distribution of pressure will cause a seawater level elevation at the bow and a drop amidships. As a consequence of the pressure distribution of the primary wave system, a secondary wave system builds up with shorter wave periods compared with the long wave periods of the primary system. The whole process results from the complex interaction of both wave systems. Every vessel, whether streamlined or not, passing through the Gabes-Chott Melrhir Channel of the CATS will generate ship waves and return currents that hit the vertical banks of the channel, causing slosh and propelling suspended and floating debris forward towards the watercraft's destination. As a result, some bank damage doubtlessly will occur. However, since the vertical banks of the channel are concreted there

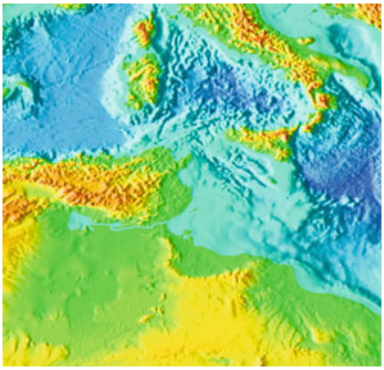


**Fig. 12** Two views of a canal-connected flooded Zone of Chotts. Above, an expansive view of a near-term future possibility, base image courtesy NOAA. Available at http://www.ngdc.noaa.gov/mgg/image/2minsurface/1350/ 45N000E. jpg. below, Fig. 13, conceivable areas of rain enhancement after Enger and Tjernström (see text)


**Fig. 13** Two views of a canal-connected flooded Zone of Chotts. Above, an expansive view of a near-term future possibility, Base Image courtesy NOAA. The *green-color* edging to the completed CATS indicates where increased rainfall may be expected to fall with some regularity. Notice that southern Algeria is benefited too by the increased rainfall effect

will be no bank slumping caused by soil instabilities, nor any need for costly time-tabled maintenance dredging. Like the Suez Canal, scheduled ship and barge convoys will traverse the CATS channel one-way, with the Chott Melrhir serving as a safe large vessel turning basin (Figs. 12, 13).

Ships, probably balanced using foreign ballast water, and entering the completed CATS, can be expected to transfer and deposit plants and marine animals from their places of origination (http://www.invasions.si.edu/ballast.htm; http://www.invasivespecies.gov and http://www.globallast.imo.org). Consequently, there are likely to be algal blooms and exotic mineral interactions producing, in effect, a horizontal bubbly lamp a la the still popular "Lava Lite®" effect; this unique graduated coloration effect ought to be quite detectable in earth-orbiting satellite images of North Africa. Marine mucilage and microbial pathogens may become established in the CATS (Danovaro et al. 2009) and the invasive seagrasses and algae of the *Caulerpa* family could strongly affect the hydrodynamics and sedimentation rate in CATS (Hendriks et al. 2010).

A familiar pong at the beaches of CATS will be caused by odiferous DMS (dimethylsulfide) produced by microbes. Alternatively, all CATS seawater inputs could be filtered so as to resemble the world's largest seawater pool, the USD 3.5 million hotel swimming pool built at San Alfonso de Mar resort in Chile, and completed in 2007 that is 8.9°C warmer than the Pacific Ocean (Anon. 2010).

## 9 Political Aspects

Disputes of a geopolitical nature are bound to arise with the inundation by seawater of this large low-lying arid region. Since CATS will be an artificial, virtually enclosed new marine system, lengthening Tunisia's present-day 1,148 km-long shoreline, and increasing its offshore 8,250 $km^2$ continental shelf national territory, how ought it to be apprehended and categorized by the experts of extant international law? And, Algeria's new inland seacoast bordering the former Chott Melrhir must be contiguous with Tunisia's, subject to foreign control of trade just like Africa's disadvantaged, landlocked states (Faye 2004). [The place furthest from the ocean in Africa is located at 26.17°E Long. by 5.65°N Lat. (Garcia-Castellanos and Lombardo 2007).] Is it possible that the national economy of Chad, once the site of a Holocene Lake Mega-Chad (Bouchette et al. 2010) could become positively affected, induced by a new source of income caused by CATS-fostered ecotourism? Development of Port Tritonis will entail the same kind of considerations as that being made for Mainport Rotterdam—that is, environmental impacts caused by routine shipping operations which often pose threats to natural habitats and economic losses to adjacent tourist regions. Port management at Port Tritonis will, of course, necessitate aspects of sustainable shipping and efficient seaport management in the form of pollution controls (van Gils and Klijn 2007). Like Mainport Rotterdam, Port Tritonis will require some land reclamation from the ocean (Hommes et al. 2009). Figure 14 is a speculative rendering of one landfill pattern becoming the literal foundation for massive future harbor and industrial development.

The Caspian Sea is the "…largest totally enclosed water body on earth…" (Ibrayev et al. 2010); nowadays, there are strong arguments over the Caspian Sea's


**Fig. 14** A speculative vision: Tunisia's Chotts as the landfill enhanced "Mainport Rotterdam" of a future industrially developed North Africa. Note the strategically convenient natural geography of Djerba Island

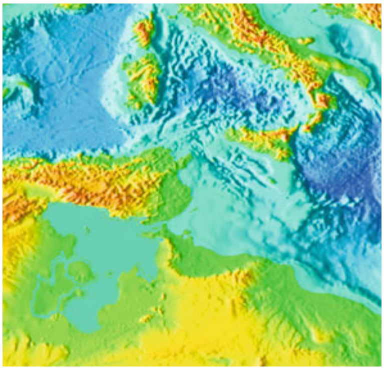


**Fig. 15** A vertical view of a possible future island-spotted saline Lake Tritonis created to supplant our Zone of Chotts CATS macro-project by magnificent spatial enlargement. It might be created by a coastal dam/seawater pumping facility. Artwork by author-artist Joseph J. Friedlander from a base image courtesy NOAA. Source: http://www.ngdc.noaa.gov/mgg/image/2minsurface/1350/45N000E.jpg

divided geopolitical status. Likewise, Tunisia shares a 965 km-long co-terminus border with Algeria. Logically, there must be a strong bi-lateral treaty and binding UNO-brokered international legal accords before a grossly revamped Chotts Algeria–Tunisia Scheme (CATS) ever becomes a fabulous Lake Tritonis-like facility publicized by the worldwide leisure industry (Fig. 15).

## 10 Conclusions

We outline the macro-engineering properties of our proposed CATS, which are intended to transform favorably the traditional livelihoods of persons chiefly living and working in western Tunisia and southern Algeria. If the imported seawater can be processed for cleanliness, then seafood, derived from local aquaculture may be a sustainable industry (Corbin 2007). Processing of seawater is, after all, considerably easier than the creation of seawater from a batch of chemicals poured from laboratory glass-jars, as the chemist Thomas Alvin Boyd (1888–1989) elucidated with his charming popular scientific essay published more than 80 years ago (Boyd 1929). Basically, with the physical realization of CATS, we create new seaports and tourist beaches that might resemble, but will be far more voluminous and extensive, than those existing at Algarroba, Chile, at the San Alfonso del Mar coastal hotel complex (Anon. 2007; Valdemoro and Jimenez 2006). Various floating structures, including oil drilling rigs may intrude on the CATS region to explore for new national wealth that could benefit markedly the citizens of two North Africa nations. Clearly, as macro-engineers, we do not apprehend the CATS as a vain national fantasy quest for valuable natural resources (Allan 1983). Instead, we think and believe CATS is a doable dream macro-project with positive economic consequences for Tunisia and Algeria. And, furthermore, that Port Tritonis is a worthy final act of stimulated macro-engineering imagination.

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