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Guanabara Bay: For all hopes to a new awakening of paradise

In attention to our readers, we are launching a special edition on Guanabara Bay, bringing together already posted PARTS I and II of the macro-engineering study/proposal plus unpublished PARTS III and IV. The lives of almost 9 million souls are directly or indirectly affected by the Guanabara Bay ecosystem, a fact that immediately justifies our concerns about the current state of its waters. We hope this edition will inspire those who care about the preservation of the environment, looking for ways to guarantee a more egalitarian society and, above all, more concerned with their legacy for future generations.

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Guanabara Bay

Proposals for a Territory of Exclusion Born from Paradise — Part I, The Present-Day Mess

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Abstract: Exclusion Territories are geographical areas under the action of degenerative environmental phenomena of anthropogenic origin, which compromise quality of life in general. One of the greatest examples of such areas is the Guanabara Bay and its surroundings, the scene of some of the worst disastrous incidents and locale of frequent episodes of human misery. This article presents a brief description of the main characteristics of the region, providing some technological suggestions of biogeographic recovery to be adopted by public policies that intend to align themselves with the good practices of ecological economy, sustainability and quality of life. The work falls within the context of macro-engineering *cum* eco-innovation applied to the preservation and management of water sources and water bodies that serve productive purposes as natural niches and breeding grounds.

Key words: Exclusion Territories, Guanabara Bay, waste management, quality of life.

Resumo: Territórios de Exclusão são áreas geográficas sob ação de fenômenos ambientais degenerativos de origem antropogênica, os quais comprometem a qualidade de vida em geral. Um dos maiores exemplos de zonas desse tipo é a Baía de Guanabara e seu entorno, palco de alguns dos piores incidentes desastrosos e de frequentes episódios da miséria humana. O presente artigo descreve sumariamente as principais características da região, fornecendo algumas sugestões tecnológicas de recuperação biogeográfica a serem adotadas por políticas públicas que pretendam alinhar-se às boas práticas de economia ecológica, sustentabilidade e qualidade de vida. O trabalho se insere no contexto da macroengenharia *cum* eco-inovação aplicada à preservação e à gestão das fontes hídricas e dos corpos de água que servem a propósitos produtivos como nichos naturais e criadouros.

Palavras-chave: Territórios de Exclusão, Baía de Guanabara, gestão de resíduos, qualidade de vida.

1. Introduction

The 1979 James Bond epic ***Moonraker*** featured the awe-inspiring scenery of beautiful Rio de Janeiro as well a nearby secret locale X where aero-spacecraft transports are launched. Gathered genetically perfect youths (representative of all humankind) were to ride these craft and eventually dock with an Earth-orbiting space-station. There, they would await the impending deliberate extermination of all the unfit and ugly human beings isolated below before their triumphant return to Earth's biosphere for its repopulation! Brazil's ever-failing leadership might wish they could be isolated from those, both rich and poor, dwelling next to a polluted and offensive bay!

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The Guanabara Bay (in *Tupi* Indian language, Guanabara means “the breast of the sea”), the old postcard slogan of one of the most beautiful cities in the world, is today an aquatic chemical and rubbish dump, a great marine cesspool in the open. It is nowadays a symbol of social exclusion in Brazil, with 50 of its 55 tributaries becoming black ditches draining 15,000 liters of untreated sewage per second. Virtually all tributaries suffered corrections of flow, which accelerated the process of natural sedimentation. Among the more than ten million inhabitants living in its surroundings, it is estimated that at least one third live in slums (shantytowns), and another third live without basic sanitation and minimal urban infrastructure. This population makes Guanabara Bay (GB) one of the most important coastal environments in the country from a social, economic and environmental point of view [1-3]. Despite its beauty, importance as a tourist and economic center (Grande Rio megalopolis), GB sometimes stinks and often is an eyesore. Without a dry season, ~2.1% of Rio de Janeiro State — including the state capital and Niteroi — are blessed with Koppen’s Af climate [4]. Like most modern-day cities Rio de Janeiro is domed by an aerial heat island [5].

GB was also named *Rio de Janeiro* (“*rio*” is the Portuguese word for “river”) by André Gonçalves, Captain of the Portuguese fleet arrived at the waters of the *Tupis*. Obviously, it is foolish to think, as many people want, that Portuguese navigators would have confused GB with a river, since the word "*rio*" was used at the time to designate any mass of water, and that Portuguese navigators, highly competent and perhaps the greatest in history, were extremely experienced cartographers, cosmographers and observers, who would scarcely make such a mistake.

Guanabara Bay bathymetry resembles a sea-shell. It was filled with seawater first approximately 6,000 years ago as the post-Ice Age ocean rose [6]. The geographical beauty of the region has long been exalted. As Saint-Hilaire (1779-1853) said,

"*Qui serait capable de décrire les beautés de la baie de Rio de Janeiro, ce port qui, de l'avis de l'un de nos amiraux les plus savants, pourrait contenir tous les navires de l'Europe*?"

Why has an ecosystem of such importance and obvious charms been left aside, absolutely abandoned by the authoritative public power? There is a perverse combination of factors. On one hand, the low-level of education of the people precisely allows people with limited perhaps shriveled humanistic capacity to be raised to power, in addition to the constant presence of unbridled corruption. After years of anthropological and social studies, we are led to theorize that poverty imposed for a long time becomes a state of mind that completely dominates a population; malleable people adapt to misery in order merely to survive, as if they were made insensible by political morphine, by empty promises, and do-nothing concretely to change; they get used to the worst health and sanitation scenarios, and re-elect the most cynical politicians for crumbs called aid, but which are actually payoff-like handouts. We suppose this is how Latin governments impose their sovereignty: establishing poverty as a state of mind, while dominators do everything to keep things as they are or escape to far-pleasanter places, someday including a nearby Space Station or even a terraformed Mars. As Paulo Cezar Carrijo said in a news release on July 25, 2018,

"A legal imbroglio called Justice of Work costs 5 billion dollars a year to the country. Therefore, there is no lack of money to do what has to be done. What is lacking is shame in the face of all of us […]. The people who polluted streams, rivers and seas with their trash are also the same as electing inept and corrupt rulers”. (https://marsemfim.com.br/baia-de-guanabara-entenda-poluicao/; accessed on March 04, 2019).

On the other hand, cargo ships in Rio de Janeiro, whose unregulated and non-oversight companies, and their careless employees, show little zeal for the encompassing environment, which is one of the world's most eutrophic ecosystems, wash their infected basements within GB water without any authority condemning this fact. Indeed, people throw sofas, mattresses, sinks and all kinds of objects into the rivers, making the bay a true cesspool. This shows the more than obvious conclusion that education, law, health, and citizenship go hand-in-hand in a socially developed nation.

GB shoreline dwellers need wise marine spatial planning done by persistent and courageous planners and their coworkers uninterrupted by the nonsense instructions of ignoramus politicians and inept bureaucrats! There are exploitable opportunities for those endowed with vivid prospection visions and willpower. Fortunately, there are people whose voices seem to win listeners little-by-little. International pressure and personal networks have contributed to mobilize not only academics and intellectuals in general, but also the population. The purpose of this article is to expand the modest ranks of those who embrace socio-environmental causes, presenting a doable proposal for GB's recovery (and, please, do not ever say there is no money for the tasks needed!) [8]. The Petrochemical Complex of Duque de Caxias ought to be held wholly responsible, in perpetuity, for the long-term health maintenance of the mangrove region situated on the west side of the southward-facing GB. The upper estuary nearby is targeted by local fisheries of diadromous species.

2. Oceanographic Report

GB is in fact a fan-shaped lagoon in *cul-de-sac* (Figure 1). It is the result of a tectonic depression formed in the Cenozoic period. There is only a relatively strait access to the open sea, which narrows water circulation. Nevertheless, the resurgence phenomenon, strongly influenced by the wind tension and by the Brazilian Current (BC), may carry South Atlantic Central Water (SACW) into the GB up to 15 km, accordingly February 2001 thermohaline indices reported by Bérgamo [7]. The fact that SACW can be advected into the interior of GB only 15 km inside is not enough to bring relevant renewal, since such waters do not reach the more distant and polluted shores of the bay to the north and northwest. Moreover, the circulation of seawater in the most remote areas is almost totally restricted to the small speeds of tidal movements in the innermost estuary.

GB covers an area of 384 km^2, in maximum measures 30 km long from north to south against 28 km from east to west, containing >100 islands and still maintaining the little that remains of the ancient mangroves that characterized most of its perimeter border of about 131 km. There are 53 sandy beaches and a 30-40 m deep central channel (see Figure 2) [8]. As hinted above, the water circulation in GB is greatly influenced by tidal currents of semi-diurnal type, with a maximum amplitude of 1.4 m. With tidal current velocity of about 0.1 m/s in the shallower interior, an entrance 1.6 km wide, and a sandbank located in this entrance, the renewal of water at the GB's interior limits becomes negligible if contrasted with the volume of organic sewage discharged per second from the contaminated rivers.

The influence of wind is considerable in GB's fresh and saltwater regimes. Carvalho showed that the wind field has fundamental role in the essential hydrodynamics of GB, changing the field of velocity of the northern portion and shifting the surface elevation field, demonstrating that the environmental management of GB must obligatorily consider the interaction between all water and the various winds [9]. Rio de Janeiro's population and infrastructure has never been blown by a tropical cyclone although this may change owing to global and regional climate regime changes since the first recorded South Atlantic Ocean cyclone reached land in the State of Santa Catarina in March of 2014. Have Brazilian politicians and bureaucrats considered the catastrophic outcome of such future storminess?

3. A Socio-Environmental Conundrum

An intricate reality has offered difficult barriers to overcome in terms of environmental recovery and preservation in Brazil, notably in the State of Rio de Janeiro, perhaps the Brazilian federation unit most affected by corruption in the last 30 years. In this State, the disregard for waste management, especially solid waste, becomes evident when one overflies GB. In 2002, CONAMA Resolution 307, later amended by Resolution 348/2004, determined that the solid waste generator was responsible for its management. This determination represented an important legal framework, determining responsibilities and stipulating the segregation of waste into different classes, making their referrals for recycling or adequate final disposal mandatory. The greatest advance in terms of legislation came when the Federal Government, through Law N# 12 305/2010, instituted the National Solid Waste Policy (NSWP), by which it created the necessary instruments for Brazil to face the main environmental, economic and social problems that arise when the management of solid waste is done inappropriately [10-11]. However, the exercise of the law and of the recommendations instituted did not come close to being effective. The amount of garbage carried to GB made it impractical to fish in several locations. Typically fishing communities such as the former *Porto da Piedade*, whose fishermen are mostly descendants of slaves, are today in pervasive poverty. Only in some areas is it still possible to carry out a modest subsistence fishery (see Figure 3 in appendix).

Residential sewage dumps are the main aggressors of the GB biome. As is known, the disposal of domestic sewage in any aquatic environment causes reduction of dissolved oxygen, pH changes and turbidity, being these dumps treated or not. In addition, industrial heavy metal dumps have been reported since 1988. The many studies of the types of pollutants and their proportions present in GB are well-known, so that it is enough to emphasize here the near-absence of sanitary conditions and sewage treatment in the poorest areas around GB, thus reflected by the high infant mortality of 23.9% in some locales, compared to other areas where the infant mortality is 4% due to the effective working existence of sewage disposal systems [12]. It is also noteworthy that in 2000 the town of Tubiacanga was the community most affected by the oil spill in GB, considered the second worst environmental accident in the region, with 1.3 million liters dumped in the waters, mangroves and bay beaches. This environmental disaster, added to more recent ones involving suddenly breached waste-impounding dams belonging to rich mining companies, did not produce the national commotion that would be expected. It seems that government neglect, besides being a mark of Brazilian management, has already infiltrated the *modus vivendi* of the communities, configuring widespread popular indifference.

The most expressive GB recovery initiative was the cooperation between the Inter-American Development Bank, the Japan Bank for International Cooperation (JBIC) and the government of Rio de Janeiro State, which elaborated the Program for Remediation of Guanabara Bay (PRGB), begun in 1994. The program proved to be a fiasco, thanks to local corruption and typical discontinuity of Brazilian politics when there is a change of government. From the large set of sewage treatment plants planned, several unities were not concluded or not connected to the sewage collect/disposal system. Not even the 2016 Olympic Games left a positive legacy for society, since health and sanitary interventions were very close to the ridiculous. Although the international community has recognized the urgency of actions to effectively conserve the marine and coastal ecosystems, mainly after the Rio+20 Conference, very little has been done from the practical point of view. “The Future We Want” document, from Rio+20 Conference, shall remain pure exercise of rhetoric if mankind does not seriously begin to think as a species, radically changing the current market model and combating the harmful effects of economic globalization. Until slightly more than a decade ago (that is, pre-2007), official maps omitted the shantytowns (slums called “favelas”)!

In short, characterized as a real territory of social exclusion, the GB is becoming the scene of an environmental devastation increasingly more difficult to reverse, especially in face of the apathy of the majority of the populace and the irresponsibility of the public power. Looking at the Brazilian reality, since it is a rich country, although burdened with one of the worst distributions of monetary wealth in the world, one should seek alignment with the UNEP Strategic Directions (2017-2020), and the Regional Seas Conventions and Action Plans, concentrating investments in the ecological protection of the coastal environments, guaranteeing quality of life and social development for those who live there.

In future, owing to anticipated future global sea-level rise, there might occur a 40 m retreat — a migration inland — of Rio de Janeiro’s famed beaches, meaning the *calçadão*, the bike-lane and the twin paths of sea-fronting Avenida will disappear beneath the high-tides. In other words, the remake of the 1984 movie ***Blame it on Rio*** will have to build a suitable new set for the eroded and submerged natural beach where the film-stars previously paraded[13]!

4. Technological Prospects

Several studies have been produced on GB, motivated mainly by the current situation of environmental degradation [14]. Such studies generally point to the more traditional measures of long-term solution since usually their authors are not macroproject minded! In fact, the conventionally designed depollution process, based only on a network of treatment plants, shall take a long time to show satisfactory results owing to the extensive replumbing of a large metropolitan region; there shall be a need for comprehensive educational programs to change the ingrained bad sanitary habits of the population, as well as vigorous enforcement measures regarding ship and industry evictions in GB. It is a very time-consuming task, too long to hope for any improvement for seaside communities to take place, considering that there is almost no truly effective environmental management in Brazil at the present time. This perception led us to conceive a macrosystem of pipelines transporting oceanic water under pressure to the generally stagnant shallow northern area of the GB, creating a suitable piped artificial current capable of accelerating, when it exits the pipe, the massive renewal of the seawaters and promoting a more immediate bubbled oxygenation for the reactivation of the artisanal fishery, bringing long-term economic relief to the upper estuary fishing communities.

Nowadays, large-scale engineering interventions to divert ocean water within intra-continental water bodies are not yet common actions, although there is a growing emphasis on inter-basin water transfer megaprojects for environmental, economic and social purposes because of noticeable climate regime change. Our megaproject is addressed to all of these purposes, with the reminder that ten million people today are affected directly or indirectly by GB's deplorable conditions. Of course, it must work with other devices and long-term measures. However, in Latin America one has to take great care to make things happen as they should be, since socio-political history of that world region's countries is not among the most encouraging. For instance, Rodrigues *et al.* applied an interesting historical classification of water legal treatment in Brazil [15], in which three distinct phases are identified as 1) the navigability phase, 2) the hydroelectricity phase, and 3) the environmental phase (the current phase). We note that in all of them management mistakes were evident and have been recognized at least by the Brazilian engineering community. In most cases, mistakes are made by neglecting the negative effects of geographically large-scale projects [16], which are announced only on the side of the benefits that unfortunately serve the dominant minorities more than civilians who need broad public policies. The poorest populations are those most affected by the negative impacts (expropriation, environmental pollution, etc.).

That is not the case with our proposal. The benefits of our presently defined macroproject to accelerate GB's seawater quality recovery are almost immediate for both fishing and tourism, and it could bring back the profitable activities that would occupy a large part of today's idle local working class. Here, it is worth noting that the Ipanema Submarine Outfall, first installed by 1974, still releases untreated waste-water that during flood tide enters GB! The periods of discharge of oceanic water would be articulated with the tidal cycles in order to counter-balance the acceptable levels of the GB seawater condition. The forceful current induced by the pipelines would act in anti-clockwise flow from the northeast shore of the GB, benefiting the most critical areas and forcing oxygenation in *Fundão* channel and *Praia de Ramos*. The favelas-bordered *Fundão* channel, an artificial mini-estuary created between 1949-1952 by the linking of eight islands with landfill, is characterized by oil and sewage-polluted seawater and mildly radioactive sediment. *Fundão* Island is home to *Cidade Universitária* campus and the Rio Science Park since 2003. Solid waste containment barriers, even simple racks, placed at river mouths would prevent garbage from flowing into the ocean, while an effective system of selective collection and recycling would direct the accumulated debris to proper disposal. As in Tokyo, it is possible to add polyester fiber screens in three layers for E. coli filtration in the estuarine zones. Strategically positioned biological stations would monitor GB's ecological dynamics, making periodic measurements on water quality and indicators related to the activity of micro-organisms, fauna and flora in general. Can we, someday in the near-future, expect technical counseling from technically knowledgeable mentors working, since 2015, at the *Museo do Amanhã* (Museum of Tomorrow)?

One negative aspect, however, should be studied cautiously. GB has a hybrid bed, partly consisting of mud in the inner mangroves and variable sizing sand on the banks of the islands and on the edges closer to the ocean. Thus, the transfer of ocean water should take into account a filtering process that prevents the traffic of large amounts of sand, so that the balance of mangroves is preserved. Over time, with the set of sewage treatment plants in operation, the stabilization of the freshwater/saltwater mix shall occur naturally. Only then shall we be able to await the results of education in the new generations of young people, certainly more engaged in questions of humanity's survival on this beautiful and mistreated planet.

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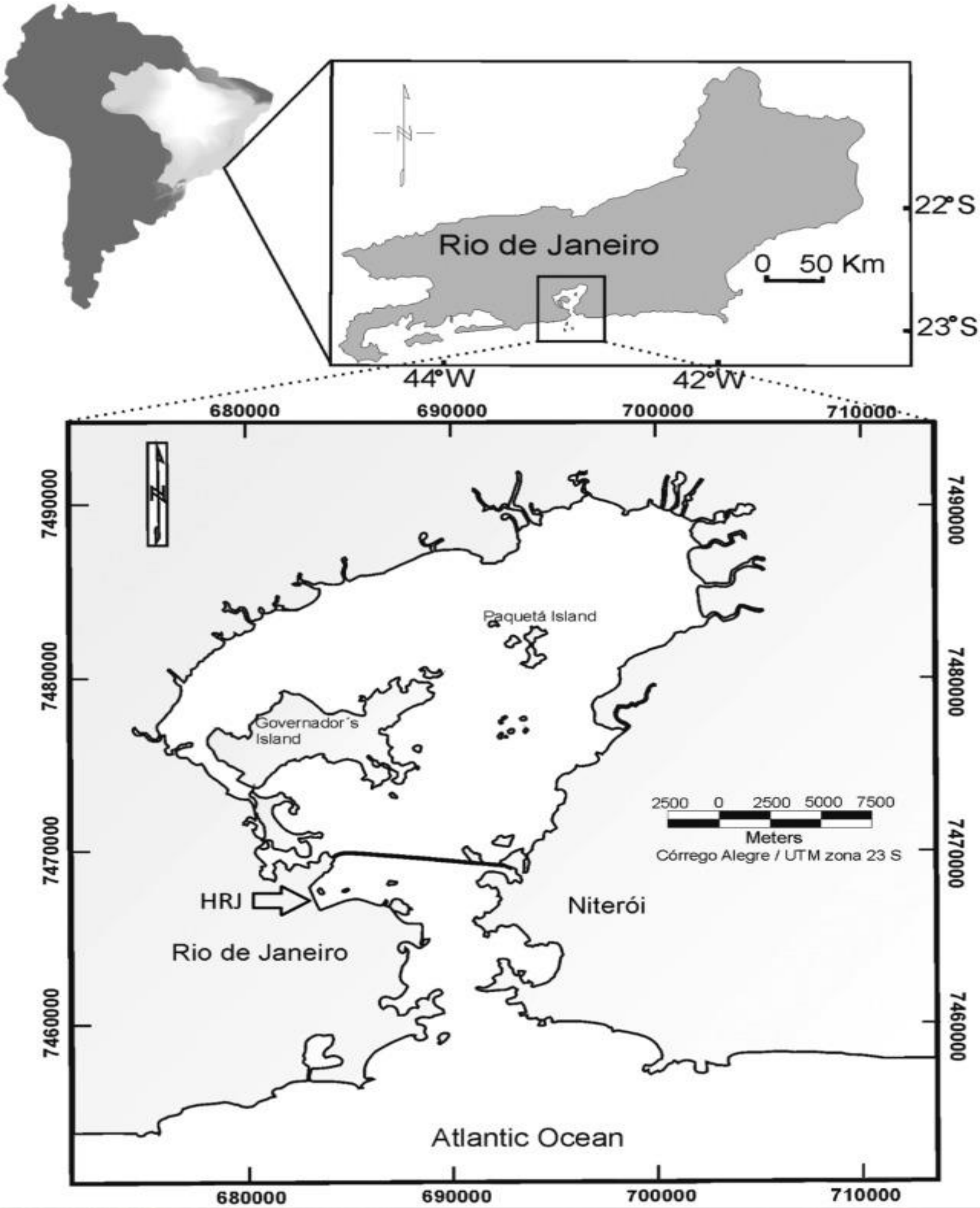

Figure 1 – Guanabara Bay location.

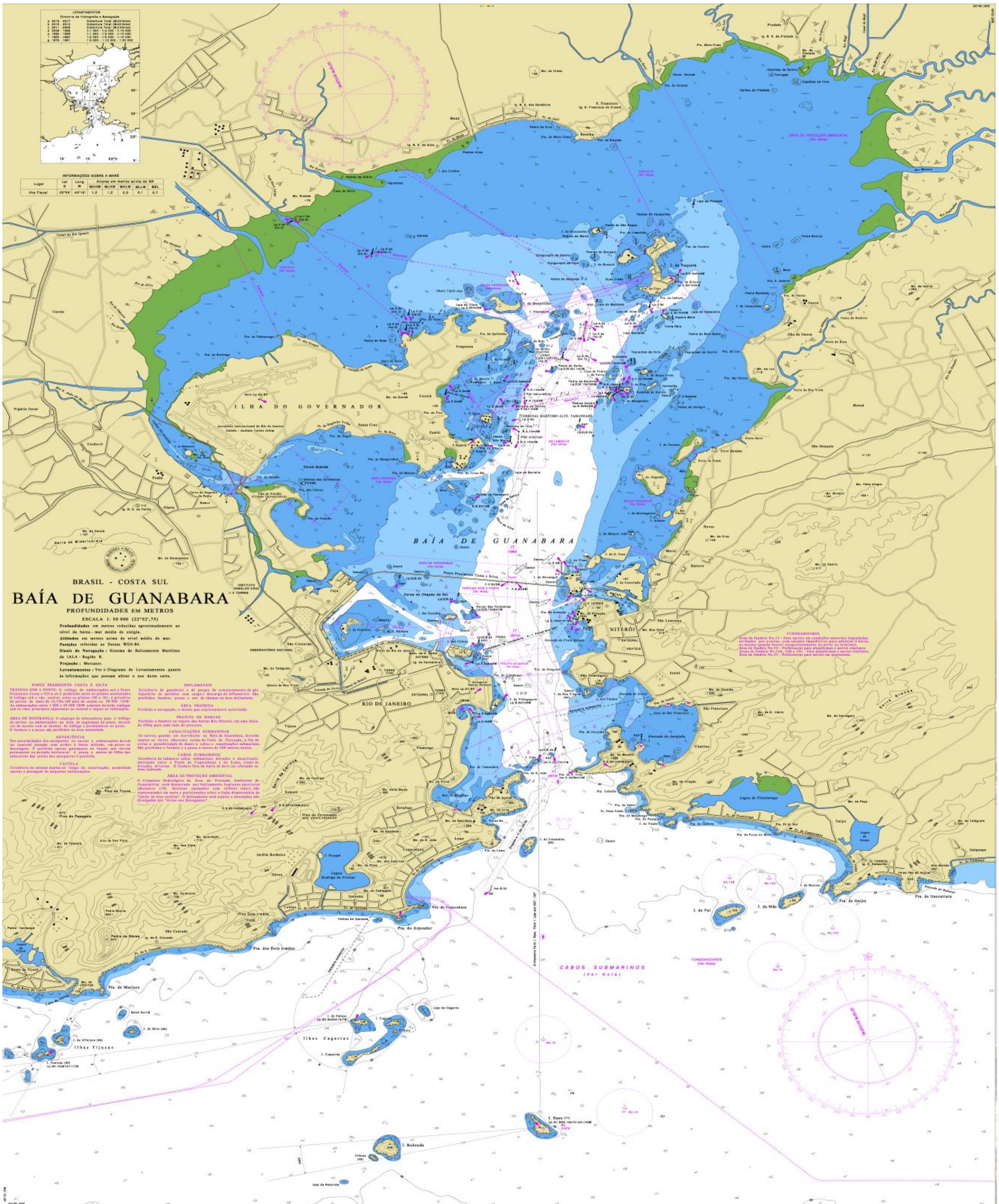

Figure 2 – Nautical chart of the Guanabara Bay (**Source**: Hydrography Center of the Brazilian Navy).






Figure 3 – *Praia de Mauá*'s selected portraits: traces of paradise. Although unsuitable for bathing, *Praia de Mauá*, or *Guia de Pacobaíba*, still houses fishermen; friendly people, hopeful for a new beginning among the herons (Copyright ® 2019, Serpa and Cathcart).

Guanabara Bay

Proposals for a Territory of Exclusion Born from Paradise — Part II, For a Macro-Engineering Covenant

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1. Introduction

One of the most surprising and inexplicable facts is the absence of wise and timely investments in necessary environmental recovery, when it is known that classical physics offers sufficient theoretical and experimental evidence to account for most of the environmental problems [1-4], and that humanity's survival for a little more Geologic Time in Earth will depend on such investments. More than that, people go hungry by millions, suffering from diseases caused by disgustingly poor water quality; despite this, it seems few anywhere are thinking seriously of large-scale application of technically simple and low-cost fluid pumping devices that hold the possibility to extinguish the daily existential agonies of bayfront-sited people worldwide. Our Earth is a marine habitat, especially for residents of its Southern Hemisphere [5]! In fact, on the basis of the ratio of maximum length of the major bay axis (~30 km) to the entrance width (~1.5 km) — in this particular instance, about 20 — GB qualifies oceanographically as an **enclosed sea** characterized by markedly inhibited tidal flushing, a non-oceanic sea-wave climate, variable seawater salinity and temperature vertical and horizontal structure, a marginal sedimentary basin as well as a pollutant trap, with a unique and distinctive aquatic ecosystem different from the South Atlantic Ocean adjacent. This enclosed sea is a relatively quiescent seascape, the external seawater flow is micro-tidal and the exchange between GB and the ocean is the most important hydrodynamical mechanism for the transport and dispersion of pollutants as well as substances such as nutrients and deposited sediments. Wherever pollutants are retained in the GB for some time, entrapment of the effluvial of GB's urban syndrome streams is the essential cause [6]. The bay-bottom is festooned with macroscopic trash. Tidal measurements done by Sanches Dorta during AD 1781 commenced near the entrance to GB close to Rio de Janeiro. Interfering modern landfills such as Fundão Island and the nearby International Airport have already slowed the normal seawater circulation of the western part of the GB. Because of the intentionally designed dimensions of its present-day main navigation channel, dug to accommodate the largest passing ocean-going vessels, the intensity of shipping and the maneuverability of the various types of vessels, it may be that alterations of the central navigation channel amplified the tide somewhat in the farthest reaches of uppermost GB. Certainly, rapid settlement of the steep slopes of the suburb of Niteroi City after the construction of the 8.8 km-long over-water section of the Rio-Niteroi Bridge intensified GB sedimentation after its completion during 1974 AD. Possibly the installed submarine sewage outfall situated in Jurujuba Sound deflects currents. In any case, we have foreseen that GB seawater movements post-device emplacement, may cause circulatory reactions as yet undiscerned by macro-imagineers. However, it was L.M. Mayr who anticipated the true possibility that very shallow areas of the GB can be flushed by a cleansing tide-induced seawter circulation [7]; we are first to appreciate that simple seawater pumping devices may in future improve on Nature's extant tidal regime at GB.

Guanabara Bay (GB) and its landscape surround—Nature's physiographic artwork already hugely modified by industrious and ecologically thoughtless humans—is hereby characterized a real-world territory of social exclusion, "aquacide" [8] as proposed by Roger H. Charlier (1921-2018) and even a possible 21st Century future place for "disaster tourism" [9] due to the increasingly visible pollution of its shallowest, most inland seawater mass. As a coastal body of seawater body belonging to a country with severe eco-social disfunctions, nowadays GB is a watery cast-off aquatic waste-bin of unwanted and unneeded anthropogenic exogenous substances. Since even Petrobras and others [10] may not care much about the actual poisoning of the Bay by petrochemical emissions, spills and dumped infrastructure castoffs, nevertheless we still maintain the hope that, as a foreign researcher as well as a proud citizen, we can together establish and disseminate to the immediate region's despoliation-beset human community a doable mechanical means to rehabilitate that coastal landform whose current state of near-term social abandonment affects, at different levels, about ten million human beings, both Brazilians and visitors.

Film-makers in Hollywood have "…been largely responsible for 'inventing' a specific image of Rio de Janeiro for world consumption" (11, page 52). 2017's ***Geostorm***, at time 1.06.23 shows Rio de Janeiro beachgoers dressed as 1962's "The Girl from Ipanema" (AKA, Helo Pinheiro) instantly frozen to death because of errant beamed-energy operations of a sabotaged world weather control satellite command-post. If instead we presume that GB is truly a reflection of prevailing local human consciousness [12], set to a modern-day song music superseding the still popular *bossa nova* jazz, then some substitute must please the cariocas and others; it cannot be virtual hang-gliding over Rio de Janeiro backgrounded by a nearly 60 year-old enjoyable tune [13]! Claude Levi-Strauss (1908-2009) unkindly epitomized the narrow GB entrance/exit channel as an ugly toothless human mouth; shamefully, today in the 21st Century period of our world's ocean losing "breath" due to basin-scale hypoxia, he might perhaps have added that the GB has aquatic halitosis [bad-breath] in the form of polluted and contaminated seawater during its ebb-tide "exhalations" (14)!

Whilst there is always curative hopes, certainly there is no single technological GB recovery solution solving all eco-social ills at once. Political will, education and waste management in a broad context of environmental governance are among the main promoters of a sustainable project for the recovery of coastal or inland seawater bodies with effectiveness on the long term. It is high time to understand that we need to tenderly modify our Earth-world's beloved regions such as GB .

2. The SIBEO Perspective

In the PART I of our work, we discussed the possibility of a macroproject comprised of pipelines transporting oceanic water, under pressure, to the stagnant shallow northernmost areas of the GB, creating a suitably piped artificial non-tidal seawater current capable of massive renewal of bay waters, thus promoting a more immediate bubbled oxygenation for the rehabilitation of fisheries. In search of similar experiences, fortuitously we have been offered an interesting proposal: the SIBEO initiative originating in Mexico.

The Wave Energy-Driven Seawater Pump (SIBEO in Spanish language) developed at the National University of Mexico (UNAM) may be an viable alternative to cleanse and improve the level of oxygenation in stagnated areas of GB by injecting open-ocean seawater abstracted from the surf-zone of the South Atlantic Ocean coastline, from Maricá to Itaipuaçú municipalities, allowing the unmolested passage of living marine organisms and reinvigorating the fisheries of bay-bordering municipalities (see Figure 2). Since SIBEO uses the available ever-renewing kinetic-energy of sea-waves, the operational monetary costs are thus very low. Certainly, financial affordability is a key requisite for any GB macro-project! Enhancing the hydrodynamics of GB seawater circulation, treating ghastly in-tributary organic sewage sent into GB with UV and heated carbon dioxide bubbles [15-16] and utilizing physical boom barriers/racking filters to preclude debris carelessly thrown into the contributory degraded rivers from entering an contaminating the GB might induce the once truly glorious mangrove forests to recover, a fostered rehabilitation result. Only ~30% of GB's pre-Columbian mangrove forest still exists [17], only 0.00694226% of the Earth-biosphere's estimated 1,152,361 km^2 total [18]. In face of similarities among the developing countries with respect to their environmental problems arising exclusively from overall inadequate water-seawater management, we think that efforts towards a Brazil-Mexico R&D technological co-operation would bring great benefits to both nations, as well as important gains in empirical Science advancement. A covenant on coastal waters governance for the countries of Latin-America could emerge from this international cooperation.

3. Physical Principles

The formalism for hydrodynamical modeling given by Czitrom *et al*. [19-20] came from Daniel Bernoulli's theorem, according to which, throughout any current line, the sum of the kinetic, piezometric and pressure energies is constant. In fact, this theorem is an extension of the principle of energy conservation. Czitrom and his co-workers begin with two non-linear time-differential equations coupled by an air-compression term (the fourth term of both equations) to be submitted to numerical integration:

$$\left(\chi_1 + L_1(1+\varepsilon_1) + \frac{T}{\cos\theta}\right)\ddot{\chi}_1 + \frac{\dot{\chi}_1^2}{2} + \left(\frac{K_1}{2} + f_1\right)\dot{\chi}_1|\dot{\chi}_1| + \frac{P_A - \rho g H}{\rho}\left[\left(1 - \frac{A_1\chi_1 - A_c\chi_2}{Vo}\right)^{-\gamma} - 1\right] + g\cos\theta\chi_1 = W; \quad (1)$$

$$\left(\chi_2 + L_2\left[\frac{A_c}{A_2}(1+\varepsilon_1) + \frac{L_c}{L_2}\right]\right)\ddot{\chi}_2 + \frac{\dot{\chi}_2^2}{2} + \left(\frac{K_2}{2} + f_2\right)\chi_2|\chi_2| + \frac{P_A - \rho g H}{\rho}\left[\left(1 - \frac{A_1\chi_1 - A_c\chi_2}{Vo}\right)^{-\gamma} - 1\right] + g\chi_2 = 0, \quad (2)$$

where:

1)- χ is the surface displacement in either duct with respect to the equilibrium level in compression chamber;
2)- Subscripts 1, 2 and *c* correspond, respectively, to resonant duct, exhaust duct and compression chamber;
3)- L_1 and L_2 are the resonant and exhaust lengths;
4)- Vo is the compression chamber volume;
5)- γ is the air compressibility;
6)- ρ is the seawater density;
7)- $g\cos\theta$ is the reduced gravity due to the inclination of resonant duct at compression chamber;
8)- W is the wave forcing computed by the resonant duct equation (1).
9)- A is the surface area.

Coupled, equations (1) and (2) incorporate Bernoulli's theorem by the second and fifth terms. Simulations were well performed by Czitrom *et al*. [1], with a model seawater pump driven by sea-waves of various spectra imitating the real world-ocean surface and testing the response of the system to each frequency component, so that there is no need to summarize this point. It is enough to note that, since in practice Bernoulli's theorem is not rigorously verified because of the presence of viscosity (friction) and formation of vortexes along the ducts, the coupling includes a non-linear third term that are not in Bernoulli's equation in order to account for friction and vortex losses, and radiation damping. This damping term includes the factor

$$\left(\frac{K_1}{2} + f_1\right)$$

also to allow energy extraction from the system. Lastly, the first term accounts for the inertia, and the restoring force on the oscillating system is assigned by the compression of the air-chamber combined to the gravitational force.

A brief refresher on Daniel Bernoulli's Theorem

To induce a certain current in a known and mapped stagnant area of the GB we must play by the rules established with Bernoulli's theorem. There is a tangential acceleration caused by a pressure difference in the direction of motion. Contrary to what one may mistakenly intuit, a lower pressure causes a higher velocity. A simple, reasoned deduction of Bernoulli's equation from Newton's law is sufficient to clarify this fact. Now, let us take a very little Salami-slice piece of seawater held within an impermeable walled duct (Figure 1). This infinitely small mass element moves as a full conduit to which any mass variation is given by

$$dm = \rho A ds.$$

According to Newton's law, we may write

$$F = dma = \rho A ds \frac{dv}{dt}.$$

But, $F = AdP$, where P is the pressure, so that

$$A \frac{dP}{ds} \delta s = \rho A \delta s \frac{dv}{dt}.$$

Simplifying, we gain

$$\frac{dP}{ds} = \rho \frac{dv}{dt} = \rho \frac{dv}{ds}\frac{ds}{dt} = \rho v \frac{dv}{ds}.$$

Then,

$$dP = \rho v dv.$$

We can integrate this expression along the path z in the flux trajectory, such as

$$\int_z dP = \rho \int_z v dv,$$

so reaching the formal result of Daniel Bernoulli's theorem

$$P_{z_1} - P_{z_2} = \frac{\rho}{2}\left(v_{z_2}^2 - v_{z_1}^2\right),$$

an equality that clearly shows the relationship between increasing pressure and decreasing velocity. So, the GB SIBEO device must govern this relationship to gauge the seawater current mainly to refresh the internationally notorious most northern parts of Brazil's polluted upper GB. In fact, as described in Czitrom et al., the experimental pump implemented was just fully instrumented with seawater height-sensors and piezoelectric pressure sensors. Also, the device was prepared to measure the fluid's flow rate through the pump.

5. The *Organum Hydraulicum* in a Preliminary Approach

Organum Hydraulicum is the name we gave to the set of ducts that make up our macro-version of the SIBEO system, because the configuration of the discharge of sea water resembles the tubes of a church organ. The system was conceived for an average tidal volume of 268,000,000 cubic meters (m^3). The hourly flow needed to induce the anthropogenic tide, assuming 20% of the total value, would be 53,600,000 cubic meters per hour (m^3/h), which provides approximately 14,889 cubic meters per second (m^3/s).

The Bresse-Forchheimmer equation relates the diameter of the water duct in *m* (*D*) to the flow in m^3/s (*Q*) and the operating period of the system in hours per 24 hours (*x*), so that

$$D = C\sqrt{Q}\sqrt[4]{x}\ ,$$

where C is a constant[1]. Applying this formula for the calculation of the total pipe diameter[2], considering a realistic value of the constant C (= 0.75) and an operating period of 8 hours for every 24 hours, we obtain

$$D = 0.75\sqrt{14{,}889}\sqrt[4]{0.3333} \simeq 69.535m\ .$$

This is equivalent to 12 ducts of 5.8 *m* in diameter. Although the resonance compensation system directly influences the efficiency control, it is important to have a notion of the loss of charge per duct. Williams-Hazen's formula,

$$J = 10.641 \times c^{-1.852} \times D^{-4.87} \times Q^{1.852}\ ,$$

allows estimating the loss of load J in meters per meter (*m*/*m*), c being a constant that expresses characteristics of the internal surface of the duct (for concrete with a good finish, c = 130). Thus,

$$J = 10.641 \times 130^{-1.852} \times 5.8^{-4.87} \times 1{,}241^{1.852} \simeq$$

$$\simeq 0{,}133 m/m.$$

This would result in a loss of approximately 4 kilometers to be regulated by the compression chambers.

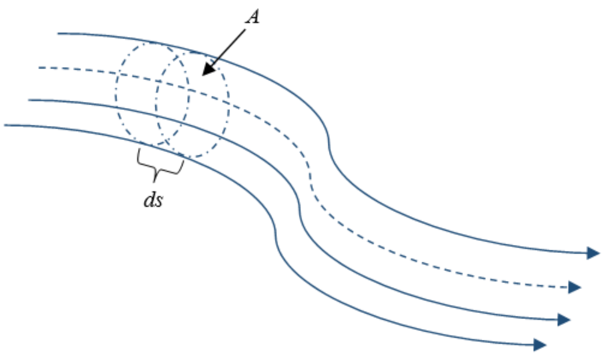

Figure 1 – A small segment of seawater flux.

6. Technical Features

The most efficient geodetic trajectory for the resonant pipeline would cover approximately 30 kilometers, coming from the South Atlantic over the lagoon of Maricá, passing through the locality of Jardim Catarina and arriving at the northeast border of the GB in the immediate vicinity of the present ecological station (Figure 3). It is a place dominated by lowlands, interspersed by reliefs of low altitude. Except for some odd geological obstacle, most of the path chosen crosses a relatively free region. The route was designed taking into account the least possible urban impact and the lowest load losses. Also, the choice of the pipeline entrance zone was guided by the large supply of ocean waves in the area; it is well known the force of waves in the municipality of Maricá, which suffers occasional damage caused by the invasion of the sea. Thus, the great exposure of the coast of Maricá to the storm waves (swelling) of the southern quadrant makes this locale ideal for exploitation of the sea oscillation mechanical energy. An automatic system of floodgates in the vicinity of the lagoon of Maricá, comprising all 12 ducts, will allow the control of the influx of sea water according to the periods of tide. As in former SIBEO project, since the wave frequency changes in time, large variable volume compression chambers will be installed to adjust resonance.

[1] The constant C is still controversial, seeking to reflect the relationship between investment cost and operating cost.

[2] Strictly speaking, the Bresse-Forchheimmer formula calculates the diameter of the rebound pipe in everyday cases of hydraulic projects. However, since in the project discussed there is no conventional suction pumping system and taking into account there will always be an elevation of the water from the sea level, we extrapolate the application of the formula, not ruling out possible further adjustments.

Compared to the so-called "Great Man-made River", the ambitious Libyan irrigation network with more than 3,700 kilometers of pipelines, the *Organum Hydraulicum* will require a much smaller amount of prestressed concrete pipes, something around 360 kilometers, weighing between 70 and 90 tons each pipe unit. We expect that cranes of about 450 tons will be needed for the installation of concrete cylinders.

7. Final Remarks

It is not a question of sweeping the waste into the open sea. All measures to control dumping in GB should be concomitant with the implementation of the proposed anthropogenic sea dynamics. Environmental education certainly underlies these measures, in addition to a major effort to oversee the companies that currently pollute GB. The cost of implementing the project, although certainly high, is justified by the non-measurable social gain, as well as the medium-to long-term economic return of tourism and fishing activities**,** reminding that sanitation measures drastically reduce public health costs**.**

The beach system of the locality of Maricá is very dynamic, causing extreme events of storm and arrival of sea water beyond the coastline. All Maricá beaches are classified as exposed, which is why this project may include protection devices mainly on a critical point of the coast, the beach of Barra de Maricá, providing even the stabilization of waves for surfing. As can be seen, the gains are many, not only for the municipalities on the edge of GB, but for a whole region rich in tourism potential. It remains to be seen whether, behind the insidious corruption that punishes us for so many decades, there is true will and manhood for this important step towards social development.

8- Acknowledgements

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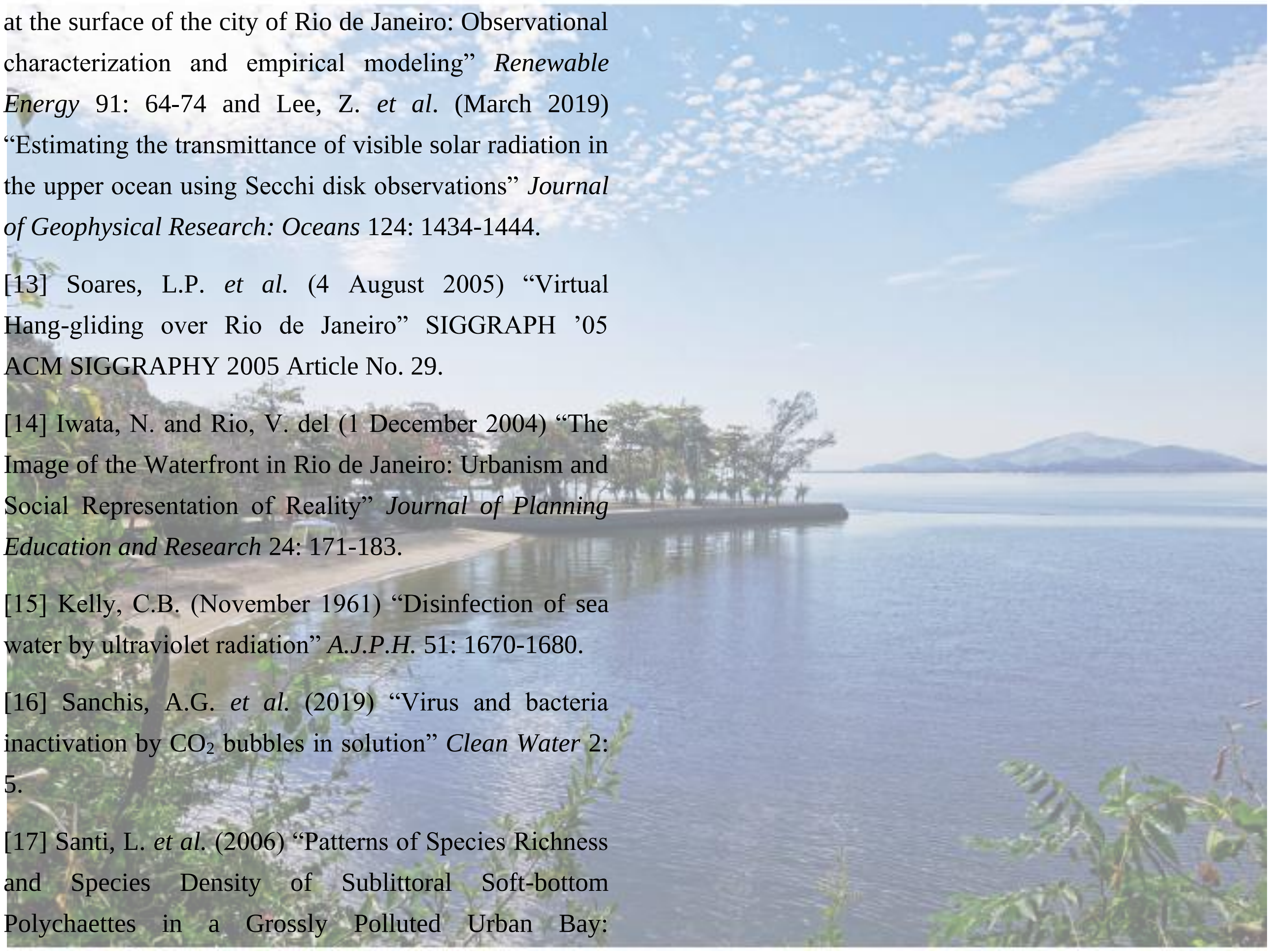

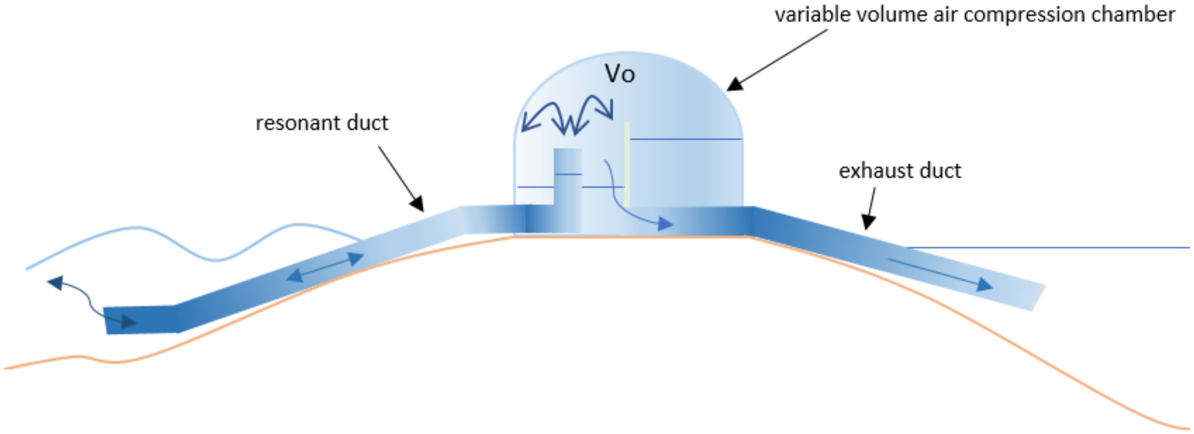

Figure 2 – The scheme of SIBEO engine.

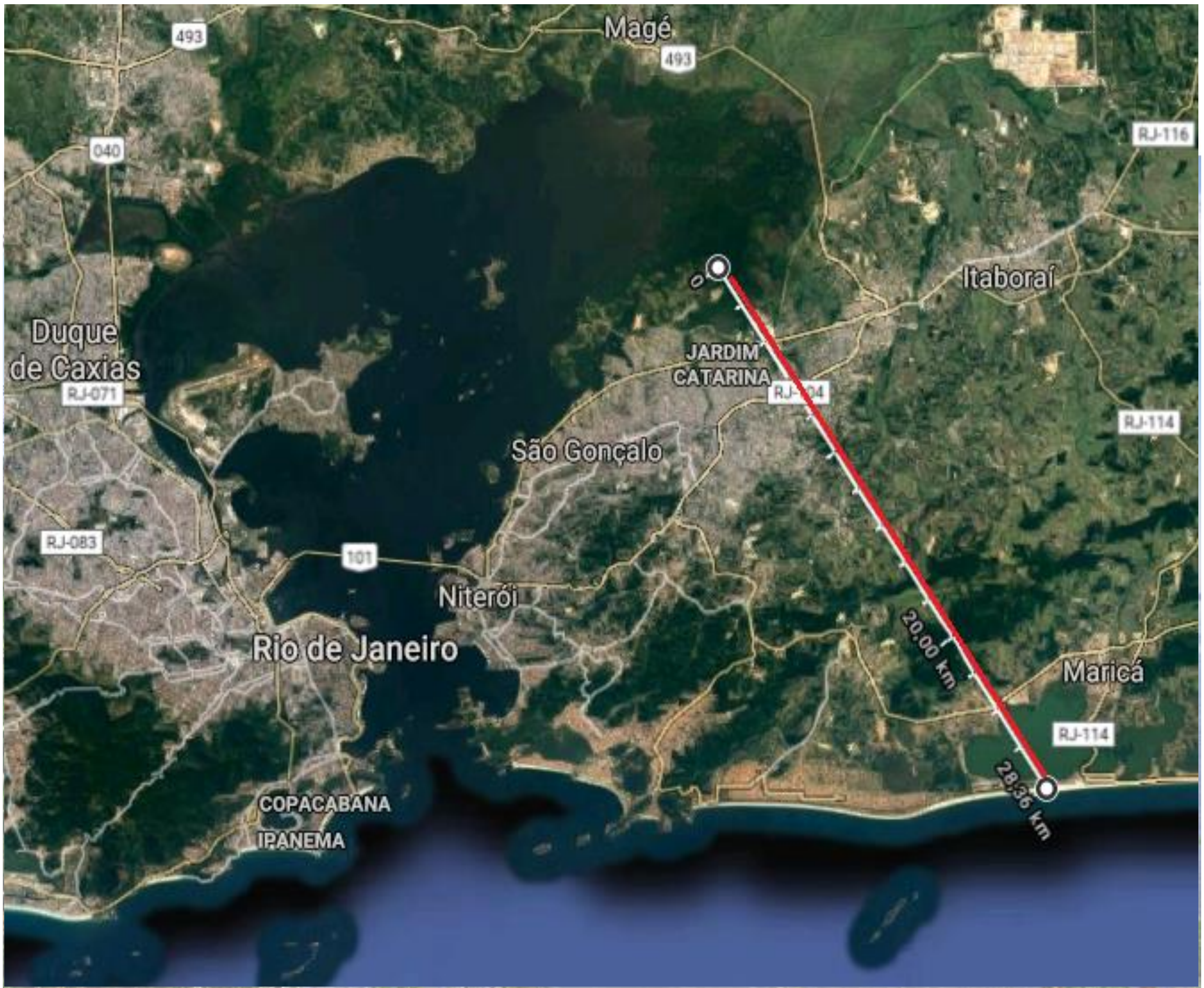

Figure 3 – The most efficient geodetic path.

Guanabara Bay

Proposals for a Territory of Exclusion Born from Paradise — Part III, Supplementary Macro-Project Add-Ons to a Vital Brazil Covenant

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1. Introduction

Previously, the authors have elucidated in two CALIBRE-published reports many of the fundamental facts that inevitably will affect all future macro-projects emplaced within Brazil's Guanabara Bay (GB). To make our adopted purpose and plan clear to CALIBRE's readers, we adopted an idealized macro-project case: a first order description of fluid transport expressed as our presumed "flushing time" of GB. Ordinarily, "flushing time" implies complete renewal of the inland sea-like bay's seawater content using a simplified tidal-prism methodology, a methodology which assumes the whole of the seawater retained inside GB at low-tide, during the period between tides (slack-water) and after high-tide is normally well mixed. However, in the real-world, no such transport time-scale can be valid for all periods of time, allplaces within the GB's fluid volume, and its constituents, and no *ad hoc* single Macro-engineering time-scale ever fully describes all the actual ongoing fluid transport processes therein! Certainly, tidal flats with shallow-sloping bathymetry retain the same seawater that inundated the area during previous high-tides. With these caveats in mind, we now prognosticate an extended GB and adjacent regional future premised primarily on the fulfillment — that is, actualization — of our December 2019 anti-pollution SIBEO infrastructural guideline plan described in Part II — that is, its timely installation and enthusiastic public institutionalization. Our current basic design which is, so far, conveniently centered on GB north of the Rio de Janeiro-Niteroi Bridge, where the average seawater depth is ~5.7 m, serves to complement another already suggestedlandscape improvement scheme, one that offers a remarkably Green infrastructure design, the "Green Guaratiba Plan" for an urban watershed west of Rio de Janeiro [1].

2. A Brief Synthesis on Historical and Technical Motivations

GB has supported many people's livelihoods for centuries, and it was only in 1923 that it ceased to be the main access of the city of Rio de Janeiro to the *Serra dos Orgãos* (Figure 2), its magnificent natural mountainous background[1]. In 1639 there were already 110 sugar factories around the GB, the main port being the *Porto Grande de Magepe* or *Porto da Piedade*. In 1696, other ports were created, notably *Porto da Estrela*, *Porto do Suruí* and *Porto de Mauá* (also called *Guia de Pacobaíba*). Since then, although some structures have been abandoned or replaced, GB has been the basis of numerous enterprises ranging from artisanal fishery to the construction of vessels. Unfortunately, a large part of the enterprises that depend on water quality are now impaired.

When we think of the ***Organum Hydraulicum*** (OH), we imagine the creation of a relatively smooth anthropogenic flow that would grant a greater momentum to the GB water mass, increasing its oxygenation and moving the areas of low circulation, assisting some geophysical-geomorphological features favorable to a macro-engineering project for environmental reconstitution. The most interesting of these features is that there is a central depression in the bottom of the bay, from the open sea connection to the Paquetá Island, which ends up benefiting the island. In this submerged channel, as if by order of *Nhanderuvuçú* (the supreme God in *tupi-guarani* mythology, creator of everything, also called *Nhamandú*, *Yamandú* and *Nhandejara*), the clean ocean water is pulled from the mouth of Guanabara Bay to Paquetá Island; the beaches of *Moreninha* (in front of the *Dona Polucena* Street Fire Department) and *José Bonifácio* (in front of the local water company **CEDAE**), besides having greater hydrodynamic circulation, are further from polluted

[1] It appears in the Diary of Pero Lopes de Souza (1497-1539), Portuguese navigator and military, that from the far reaches of the GB it was possible to see "very high and beautiful mountains" [21].

rivers that flow into the bay, which explains their almost permanent availability for bathing.

Also, considering the large amount of untreated sewage discharged into the bay, the replacement of 50% of water in the GB, taking the relatively short residence time of 11.4 days [20], is one of the main factors that explain why water quality is not worse than the registered. In contrast, the water renewal is not isotropic, with lower circulation and longer residence time in the furthest regions as in the northeast sector, which causes accumulation of organic and inorganic pollutants.

Lastly, oceanic dolphins of the species *Tursiops truncatus* (“flipper dolphin” or “bottle nose”) that commonly frequent the external Cagarras Islands have been observed at the GB islands. Generally the appearing of dolphins in the GB occurs with the species “gray dolphin” of the genus *Sotalia*. Also, the species *Steno brendanensis*, commonly known as “rough-toothed dolphin”, has also been seen in the inlets of Flamengo, Botafogo and Icaraí. These facts are clear indications that there is still salvation for the GB, and that some of the timid measures previously adopted seem to have had some positive effects. In addition, the indisputable beauty of the geographic landscape compels us to the highest feeling of the duty to preserve such a majestic place (Figures 3-9).

For us, the above described features offer enough motivation to think of a viable GB recovery plan. However, for OH to work in an environmentally correct manner, it will be necessary to associate it with other intense sanitation measures and, eventually, with other technologies; otherwise, we would just be pushing trash into the Atlantic Ocean.

3. GB…Whenever! (Soon we hope!)

Emplacement of the South Atlantic Ocean seawater-importation pumps and long-distance pipeline (SIBEO), debouching, somewhat subdued, into the uppermost part of northeastern GB east of Paquetá Island, probably will immediately cause at its operational start-up some obvious hydrodynamical results: (I) a lowering of the seawater temperature; (II) a slight increase of the seawater salinity; (III) a change in the pH — most likely increased; (IV) more out-flowing tidal seawater will slowly erode the bay-floor’s sediment bed, first shifting the silt, then the fine clay and finally some of the superficial low-mass sand grains. We suppose these physical and chemical changes to be publicly tolerable since, at present, GB is characterized by *all* experts as constantly exhibiting eutrophic to hypertrophic conditions, including the frequent occurrence of toxic biota red-tides! GB is contaminated by floating plastic debris which fosters the growth of pathogenic bacteria [2-3]. Junk discarded within GB has made the life-maintenance style of traditional fishers almost impossible to sustain. Seawater circulation in the central and uppermost western part of GB is hindered by Governador Island — at GB’s mouth the maximum seawater velocity is ~0.8 to 1.5 ms^{-1} whilst in the narrow channel west of that large island the maximum seawater current is <0.3 ms^{-1} [4]. The existing GB has an area of ~384 km^2 of which ~84% is shallower than 10 m, but thousands of years ago, when the South Atlantic Ocean level was significantly higher than today, GB could have had an area then as large as 800 km^2; in future, if the GB-adjacent region’s sea-level ever does rise again, it will repeat this submergence oceanographical event-process, possibly doubling the area of GB [5]. In the meantime, of course, there remains considerable cultural-time to formulate and distill workable macro-project plans and useful — if, perhaps, “temporary” in terms of Earth’s Geologic Time — structural constructions to be completed by a willing and politically willful Greater Rio de Janeiro citizenry!

4. Post-SIBEO Serpa-Cathcart Seawater Importation Infrastructure for GB

To maximize the physical effectiveness of our GB plumbing macro-scheme, we suppose herein that some supplemental — that is, a follow-up mega-project built when it becomes desirable and affordable — technologies could be added to it that are cost-effective, spectacularly pleasing and low-cost in terms of up-front monetary building costs as well as post-construction maintenance monetary costs. Happy taxpayers are the best social foundation for any and all governments, worldwide!

A ~10,000 m-long trans-GB floating highway bridge situated beyond the eastern coast of Paquetá Island, essentially connecting northernmost Niteroi in the vicinity of S. Goncalo to GB’s northeast coast somewhere along the highway linking Mage and D. Caxias, which always skirts the preservation park boundaries of the extant mangrove forest, could serve to thwart further unwarranted intrusions into the mangrove zone. (Two of the world’s longest pontoon highway bridges, the Lacey V. Murrow Floating

Bridge completed in 1940 and the Homer M. Hadley Floating Bridge completed in 1989,are located on non-placid Lake Washington, State of Washington, USA.) Any conventional bridge design would require foundations inserted into the seabed of GB which are costly and complex but also have a negative influence on life-forms nearby [6]. Anchorage can be secured with inflated anchors to maintain a steady pontoon highway bridge which successfully counteracts the waves, seawater currents and winds that sweep GB from the North and Northeast during Spring and Summer with average monthly velocity of ~5 ms^{-1}. The Rio de Janeiro-Niteroi Bridge, opened to vehicular traffic by March 1974, was configured to withstand 90 ms^{-1} wind gusts, especially from the South and Southeast associated with autumn and winter. Nevertheless, crosswinds often set the three continuous spans (200, 300 and 200 m-long) steel twin-box-girders into vortex-induced oscillations mainly due to a high-elevation structural profile projecting above the GB [7]. In brief, insufficient parametric wind design [8] has created a functionality macro-problem resolved only with costly additional special engineering.

Since six rivers empty into the uppermost segment of the vast GB, plenty of unused freshwater is available to, for example, camouflage the trans-GB floating highway bridge in pleasantly attractive anthropogenic cloud formations — a la the Homogenitus clouds which shrouded the nublious exposition pavilion structure installed in Switzerland's Lake Neuchatel during 2002, the revered pier-like "Blur Building". For all carioca's it is simply an pun-opportunity not to be *mist*, an architectural special-effect that does not obscure the mobile vehicle driver's view nor interfere in any other important way with traffic flow. Different from the Rio de Janeiro-Niteroi Bridge, the always becloudedtrans-GB floating highway bridge will offer novel vaporous minute-by-minute rearrangements of itself dependent on prevailing GB weather conditions — that is, all natural, thoroughly Green [9-10]. A 10,000 m-long cloud, 500 m wide and 100 m thick will bulk at 5,000,000,000 m^3 but only be composed of ~200 m^3 of water! Suffused with artificial illumination during nighttime, the pontoon highway bridge could act as an attraction for tourist, residents and fish. The world's first underwater restaurant opened during 2019 on Norway's southernmost landscape projecting into the stormy North Sea at the village of Baly. Its meter-thick concrete walls have become an artificial reef. (Its acrylic windows are kept clear marine life growths and offer diners a view of the seabed as it changes with time. (A few maritime underwater parks elsewhere — such as the Guadalupe Underwater Archaeological Preserve in the Dominican Republic — have even installed faux shipwrecks as visual entertainments for SCUBA). Might not such a restaurant (or museum) facility be installed at the eastern part of Paquetá Island after that island is linked to the floating pontoon highway bridge? The changing colors of the illuminated bridge might be utilized to impress those who can see it at night the ambient state of the fluid in GB — say, for example, a color-coded display linked to sewage outfall contents, especially outfalls extending from the favelas as well as the nearby commercial, chemical processing and agricultural landscapes.

The most important use aspect of our proposed additional infrastructure features is the attachment to the pontoon undersides of submerged seawater pumps which are highly directional in function. During an over-tide, as the ebb-tide commences, an as yet undetermined number of such encapsulated machines might be operated to increase the speed of the ebbing seawater's movement towards the slow-flow zone north of Governador Island. Please see "Submersed Jet Pump Method for Generating a Stream of Water", USA Patent 5,478,208 awarded on 26 December 1995 to Hirunao Kasai and Katutoshi Yoshinaga. It is also possible, maybe even ultimately necessary, for such economical jet-pumps to be emplaced on the easternmost section of the existing Rio de Janeiro-Niteroi Bridge so as to forcefully direct imported ocean seawater — certainly < 269,000,000 m^3 per over-tide — toward westernmost GB's most limpid and stagnant narrow channel waters. And, by encouraging aquatic life-forms, strategically placed wave-powered seawater aerators can be enormously helpful in the general, carioca mass-participation good Samaritan effort to clean GB of its most evident seawater chemical and particulate pollution — SEE, for example, USA Patent 3,758,083,"Wave-powered Aerator" issued to William E. Palmer on 30 December 1971. (The devices might double as navigational buoys marking dredged channels and safe boat havens!) At least ten species of seaweed are adversely affected by excessive dissolved nitrogen and phosphorus enhanced by untreated sewage dumping into GB. Better cleansing of the volume of seawater within GB should promote healthier and more vigorous seaweed growth. The whole effort proposed in this section of our paper is meant enhance Brazil's international brand image positively [11].

5. Serpa-Cathcart Exo-GB "Cagarras Islands Monumental Seawater Fountain" Proposal

Many Rio de Janeiro visitors seek to ascend to the superb viewpoint afforded by Cristo Redentor (constructed 1922-1931) atop Corcovado Mountain in Tijuca Forest National Park [12] to enjoy the spectacle of Ipanema Beach as well as the six small offshore islands forming the Cagarras Islands, on a clear day an easily visible archipelago. The highest topographical elevation of the islands, ~79 m, is the tippy-top of Cagarras. This group of six rocky islands, totaling ~523 hectares, has been governmentally administered as a *natural* monument since 2010. The iconic Cristo Redentor became an international symbol for Brazil's national economic lift-off when, on 14 November 2009, the UK-published international financial news periodical ***The Economist*** offered a glossy cover-art photo-shopped image of Cristo Redentor as an anthropomorphized 21st Century rocket, pushed by its multiple ignited engines, blasting its tail-fires onto its sublime hard-rock launchpad as the entire Cristo Redentor was launched heavenward! (But, by 26 September 2013, that same well-regarded economic journal published a story asking "Has Brazil Blown It?", and a still-online WWW image portrays the concrete statue of Christ moving erratically above the city of Rio de Janeiro, hopeless lost amidst still another national economic quandary.)

"Monument" is interchangeable with "memorial"; hencewe humbly propose a fountain-monument be considered by the public and officials for near-term future placement atop Cagarras Islands celebration of Guanabara Bay's potential SIBEO macro-project cleansing [13-15]! That is, the remarkable absence of untreated sewage flows anywhere in GB. Such a seawater-spewing fountain would welcome arriving and departing visitors aboard ships to Rio de Janeiro whenever cruise ships pass Cagarras Islands as they enter and exit Guanabara Bay.

"A traditional fountain (Latin-*fonts*) refers to a system where water is drawn from a source, fills a basin of some kind, and is drained away….By modern pumping and pressure water can be forced into the air though a *jet* or multiple jets, such as the famous water fountain of Lake Geneva, Switzerland. Light can also be added for traditional decorations" [16]. Strangely, the text referenced mentions at pages 66-71 "Water Fountains of Buenos Aires" by Jose Esteban Castro, but not even one significant Brasil fountain is described therein! In Switzerland, the vertical-spraying "*Jet d'Eau*" was installed during 1886 at the location where Lake Geneva overflows into the upper reach of the Rhone River, which ultimately debauches into the Mediterranean Sea on France's southern coast. From a partially submerged liquid pumping station, it spurts 500 liters/second of freshwater to an altitude of! 140 m, pushed by twin 500 kW water-pumps consuming ~1 MW of electricity. It memorializes the 600th Anniversary of the Swiss Confederation's establishment. During the nighttime it is lit by focused spot-lamps totaling 9 kW. (In the USA, at Las Vegas, State of Nevada, the famed "Fountains of Bellagio" are, perhaps the most spectacular in the world, use 75. MW of electricity to propel illuminated jets of freshwater ~74 m into the air.) We prefer, however, the tastefully simple unadorned beauty of the extant "*Jet d'Eau*" watery exemplar. (Here, we feel it is incumbent on us to mention one regionalized mega-project of intentional climate regime change known popularly as "Marine Cloud Brightening", first proposed during 1990 by John Latham in the UK, the goal of which is to launch masses of sprayed seawater in the open-air to deliberately brighten stratus clouds for weather modification purposes [17]. In a small way, therefore, our proposed island-based seawater fountain may prove to be a significant test of an anti-global warming technology!) Therefore, we suppose, from the highest topographic elevation on Cagarras Islands, a Herrenknecht AG-fabricated "Vertical Shaft Sinking Machine", via surface remote control, excavate a capacious circular seawater storage tank, ~18 m in diameter, into the rocky island. This German machine is almost inconspicuous whilst in operation and is not merely clean technology but very quiet technology when operational — that is, an industrial device designed to dig as silently as is technically possible.

Projecting into the atmospheric boundary-layer over the seawater-holding tank might be a visible slim columnar tower resembling the Lugano, Switzerland architect Andrea Jasci Cimmini's nostalgic "Lighthouse" mini-hotel rod, GPS receiver-beacon and cellular telecommunications Swizzle Stick-like open-air structure (Figure 1**)**, a simulacrum of an obsolete and often isolated infrastructure once inhabited by courageous persons [18].

Since, increasingly, people are living in a period of human history when more and more robotized infrastructures exist to serve civilization — almost crewless bulk carrier, for example — Rio de Janeiro may need such an electronics tower to safely instruct shipping computers for their movement into and out of

Guanabara Bay's various big-ship harbors. At the present-time the archipelago remains situated in only slightly seawater-diluted raw-sewage discharged constantly in great quantity from the South Zone of Rio de Janeiro by the inadequate and ageing Ipanema marine outfall. It is our desire, and fervent hope, that as soon as Rio de Janeiro's sewage disposal becomes more and more benign through proper and full technical treatment, our "Cagarras Islands Monumental Seawater Fountain" will subsequently shoot its "perpetual" seawater jet higher and higher into the smog-free air outside picturesque Guanabara Bay!

Current means for the disinfection of seawater, which reduce bacterial loading in the aquatic medium and avoids blooms of potentially pathogenic micro-organisms, includes the application of anti-biotics, ozone aeriation, physical filtration, heating, and UV radiation. However, each of these cleaning techniques has specific disadvantages for economically suffering modern societies — high monetary costs, hard-to-service sophisticated equipment, waste toxic residues, et cetera. The first systematic investigation into inhibitory effects of natural solar-radiation (sunlight) was reportedly done during 1887 [19]. The UV-B portion of the solar spectrum is the most bactericidal. So, we suggest as an economically feasible and certainly viable option, that all contaminated seawater, extracted directly from the South Atlantic Ocean in the vicinity of Cagarras Islands, be processed by being subjected to intense exposure to mirror-amplified sunlight as well as secondary solar-powered bactericidal treatment using the photovoltaic-lit immersed lamps and lamps suspended above the non-turbid seawater in the cylindrical underground tank. As the fecal coliform bacteria count diminishes incrementally to a safer-for-human-exposure levels, then the pumped seawater fountain will be adjusted to periodically "launch" de-polluted seawater higher into the blue sky in the form of an informational, even inspirational, flowing-fluid display for all those nearby to observe and appreciate! Thank you.

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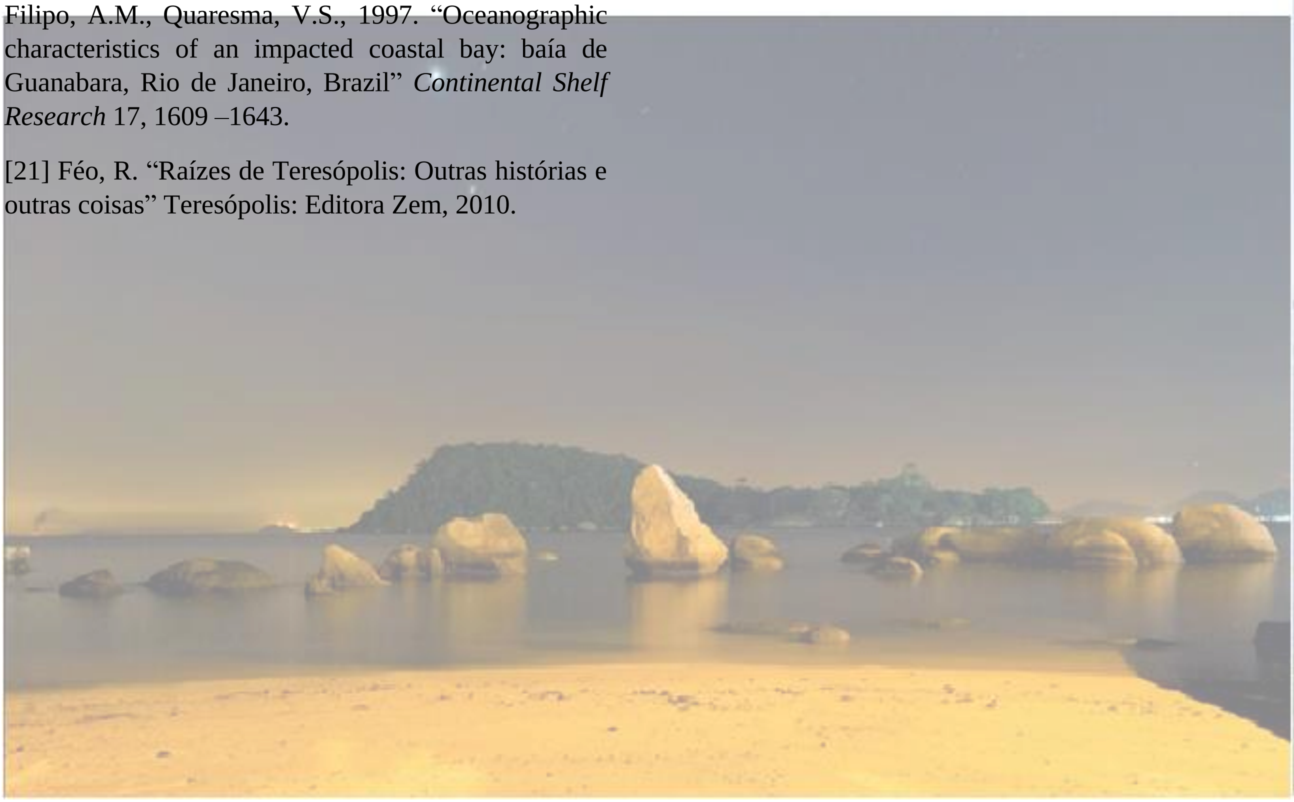

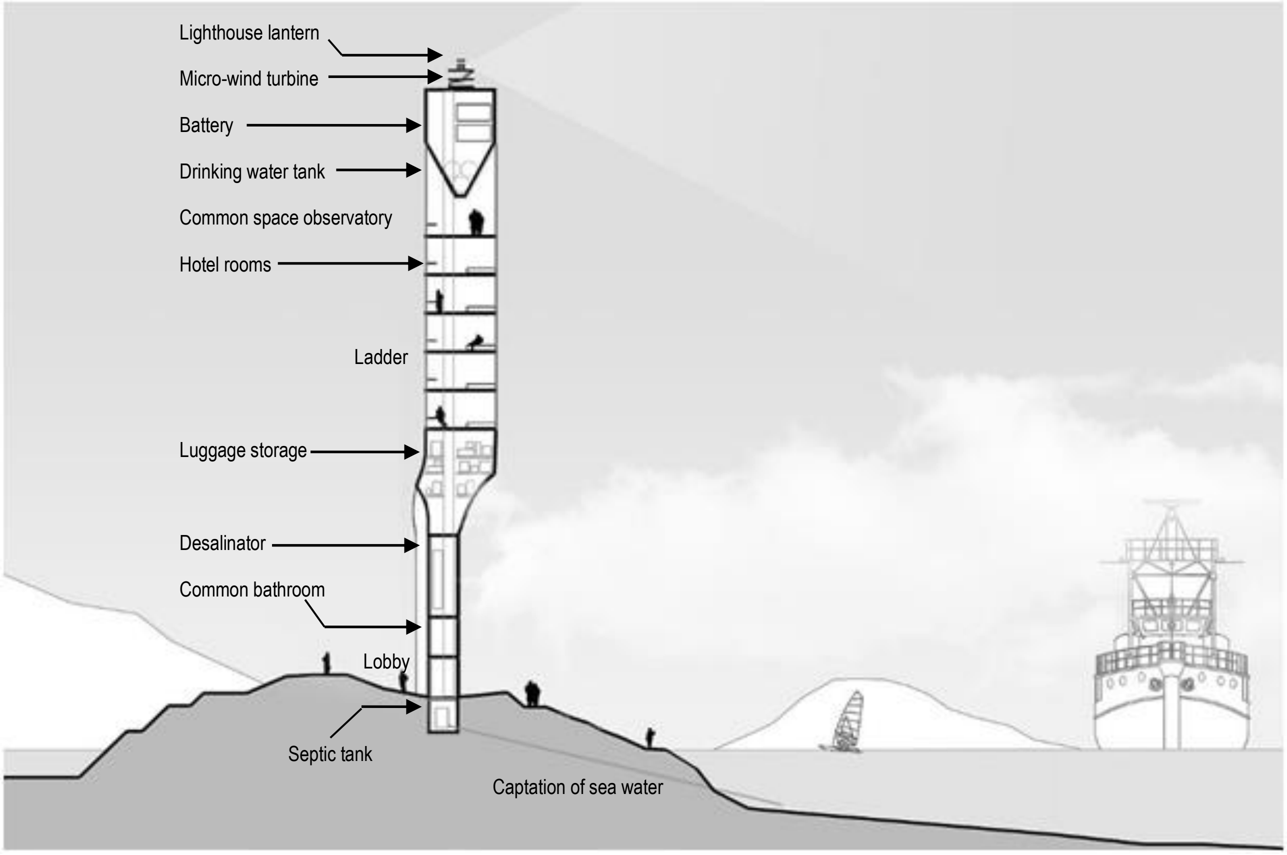

Figure 1 – The slim columnar tower.

Figure 2 - *Serra dos Orgãos*, highlighting the famous << Dedo de Deus>>. By Nilo Serpa, 2016.

Figure 3 - Guanabara Bay near Santos Dumont Airport. By Nilo Serpa, 2019.

Figure 4 - Guanabara Bay near Santos Dumont Airport. By Nilo Serpa, 2019.

Figure 5 - Paquetá Island overlooking Brocoió Island in the background. By Leonardo Martins, 2015.

Figure 6 - GB after sunset. By Tan Yilmaz, 2015.

Figure 7 - A corner in GB. By Julio Pinon, 2018.

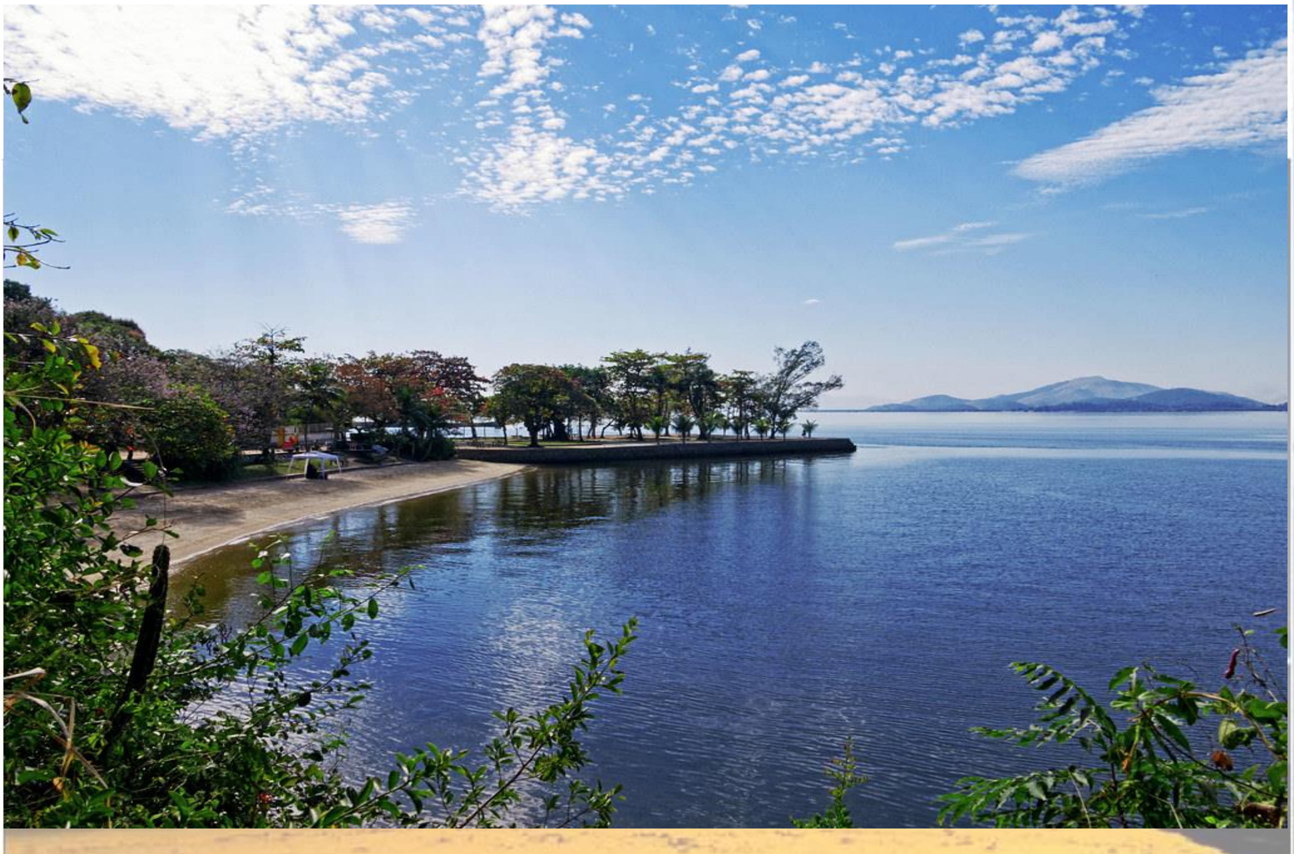

Figure 8 - Paquetá Island. By Leonardo Martins, 2011.

Figure 9 - Ponta das Pedreiras, Paquetá Island. By Antonello, 2011.

Guanabara Bay

Proposals for a Territory of Exclusion Born from Paradise — Part IV, Macro-Imagineering an Overland Fresh-water Bulk Transport System for Rio de Janeiro, Brazil, with the Use of F.A. Pecero's H_2O Tires

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1. Introduction

For dryland rural regions of southeastern India reliable tire-like containers might well serve the daily freshwater needs of agriculturalists mainly resident in numerous villages. Long-distance textile hoses may serve as carriers of imported bulk freshwater supplies to southeastern India from rivers descending the slopes of the Western Ghats to the Arabian Sea [1-2] whilst in Brazil's coastal cities, in this case specifically Rio de Janeiro facing the South Atlantic Ocean, systematized floating sea-going dracones may be a more appropriate scheduled bulk freshwater delivery conveyance. By employing such durable bag and dragtechnologies, neither vast ecosystem-state need import any freshwater from outside their present-day national territories to serve their citizenry's everyday potable and irrigation freshwater needs or legitimate wants. Both technologies entail strong impervious textiles and films joined into mobile and semi-fixed fluid transport devices — lengthy horizontal floating bags and tire-shaped bags rolling over the landscape — that durably fulfil the fresh-water supply service requirements of the respective territorialized human makers and users. Just as Dr. Serpa and his foreign colleague Cathcart [3] have proposed recently, the mechanical instigation of a supplemental artificial seawater "over-tide" of Guanabara Bay that could flush human wastes from the bay seawards, dracones might be necessary to supply a flushing action for the six major natural streams and anthropogenic channels entering Guanabara Bay which deposit therein putrescent human wastes on an almost unfathomable geographical scale [4]. Indeed, a disaster impends resembling the tailings-dam breach aftermaths in Minas Gerais.Since Rio de Janeiro may become a destination for some of Brazil'sfuture climate change refugees, it is necessary to prepare now for that possible eventuality by increasing the amount and availability of fresh-water for needful human uses.

Owing to the presence in human brains of the ventromedial prefrontal cortex [5] human attitudes can be changed not only by our actual experiences but also by hypothetical imagined exo-somatic experiential events — or, in this particular instance, our profoundly useful capability for individual and social group-organized humanitarian Macro-Imagineering [6]. Such "symbolic fantasies", apparently, set humans apart from other species of life humans know to be extant with the Earth-bioshell [6-7]. Landscape and seascape visualizations represent real-world places and ground-truth in three-dimensional perspective views with variable emphasizes on realism. For example, photogrammetrically-derived digital terrain models of the territories of India and Brazil could help many lay-persons to comprehend better the stressful ambient risks of their current environments and, possibly, their future environments during and after societal living adjustments to Nature's climate change that is somewhat augmented by Homo sapiens' presence in the Earth's bioshell. Therefore, the potential benefits of Macro-Imagineering, done in the style of focused and organized visualizations, are multifold: presentations that are so significantly intriguing to lay-persons that they are an attraction; predictive for all diligent examiners and, thusly, promoting anticipation; strong stimulant for "what-if"-style thinking by everyone closely involved and, it is to be hoped, simply adaptable to various news-media means, print and broadcast, of public-servicecommunications! Whilst these mega-projects are ideals of Macro-Engineering solutionism, the authors do not intend ever to limit or circumscribe public participation or non-expert assertions to be ultimately imbricated in their final, pre-project risk and remediation goals; 21st Century fidelity to purely historical references are impossible of recreation.

2. The India Case Study

Retired from the teaching faculty of the Department of Organic Chemistry, Indian Institute of Science, Bengaluru, Karnataka, India, Dr. Saraswathi N. Balasubrahmanyam suggested the use of wind-powered water-pumps and topography-compliant contour canals as a means of transporting in enormous bulk freshwater diverted from several free-flowing rivers still entering the Arabian Sea — wasted runoff — within watersheds situated on only the western slopes of the southwest monsoon-intercepting Western Ghats [7-8].Solar-powered or even geothermally-powered fluid pumps filling lengthy tensioned-textile freshwater distribution hoses might well serve along with Balasubrahmanyam's water-moving dedicated wind-farms. Run-of-river hose intakes might be rather inconspicuously sited and camouflaged; topographic low-elevation Western Ghats wind-gaps might serve to efficiently pass durable hydrostatically-pressured hoses. Hoses composed of artificial fabrics would convey freshwater in voluminous bulk to the eastern slopes of the Western Ghats where gravitational flow downhill should reduce any further long-distance requirement for liquid pumping. Installation of such a regional hose-based mega-project can be taken to be equivalent in function to human blood-vessels [9-10]. Flexible hoses have the characteristic to elongate and flex whilst being subjected to slow or rapid ground surface failure, whatever the initiating cause. Furthermore, hoses may be equipped with sensor systems that clue those persons and automated machines monitoring infrequent macro-problems within Balasubrahmanyam fresh-water shifting operational context. Well informed human and drone patrols by the system's tenders should obviate any mega-problems initiated by Nature or disordered cultural disruptions.

Usage of hoses on the eastern slopes of the Western Ghats could be very advantageous because of the ancient presence in the long-settled landscape there of thousands of ready-made potential hose outtake reservoirs ("tanks") [11]. As vast systems of interconnected, hand and machine dug reservoirs, tanks are a truly remarkable farm irrigation feature inherent to semi-arid southeastern India that are complemented by other required freshwater control infrastructure — canals, weirs, field-terraces, check-dams, gravel-mulched farm fields, wall and vegetation bordered farm fields as well as additional associated facilities. Wherever tanks are absent but needed, or are inconveniently sited, rolling tire-shaped portable freshwater reservoirs, invented by Francisco Alcalde Pecero (1941-2004) may be utilized: SEE, for instance, his USA Patent 4,036,254, "Container that can be displaced by rotary force", awarded 19 July 1977.

Beyond landscape tank storage capacity to which S.N. Balasubrahmanyam alluded directly, there is also the possibility of using floating fabric dracones — long fabric/film ocean-going floating bags containing freshwater of less density than seawater — optimally configured to receive freshwater brought downhill from higher-elevation watersheds elsewhere, filling dracones that might be shuttled into and temporarily lodged at secure offshore moorings within Palk Bay [12-13]. Or, like Venezuela's Golfo de Cariaco (Figure 1), Palk Bay, which separates geographically India and Sri Lanka, could be covered by a floating desalination factory supplying Pecero Tires onshore for economical uphill distribution to holding tanks and stabilized Pecero Tire Installations situated far inland [14]. Balasubrahmanyam's fresh-water supply mega-project, realized at a large geographical scale, might be apprehended as, roughly, comparable in the production of new wealth as India's comprehensive national railway system built during AD 1870-1930 [15]!

2. The Brasil Case Study

Waste, rubbish, refuse and other such unwanted and undesirable stuff are all cultural terms: they refer to the status of matter within Brasilian and other world societies. Its deliberate burial in landfills or dumped into the adjacent coastal South Atlantic Ocean disorders the Brasilian culture whilst its recovery by garbology experts ultimately radically disorders Brazil's archaeological strata [16]. However, whenever such materials are ignored by the voting public, allowed to endure until decomposed by Nature to the point of mere invisibility, yet still strewn physically within Rio de Janeiro's prevailing urban landscape, Guanabara Bay and immediately offshore South Atlantic Ocean seascape, insanitary informal housing — *favelas*, illegal self-built housing (erected by wage-less *catadores* and other similar social status squatting destitute *cariocas*) not connected to the uncommonly spottycity service infrastructure (sanitation, fresh-water supply, waste-disposal) — contrived by desperate persons evicted from tenements tabled to be demolished are usually blamed, alleged to be the "deplorable cause", by a few duly-elected responsibleauthorities and their insecure bureaucratized public-servants [17]! In Rio de Janeiro, the first instance of the *favela* phenomena was evident by AD 1898; the unofficial settlements spread more widely from AD 1940 and by AD 1970 the shantytowns had become widespread, even decorating the landscape beyond the metropolitan periphery [18]!

However, there is always hope. International meetings of persons — some self-labeled as activist Greens — extraordinarily attentive to the Earth-bioshell's current and emerging anthropogenic macroproblemsmet in Rio de Janeiro during AD 1992 and AD 2012. Still Guanabara Bay remains a trashy mess; it is doubtful that Copa America (14 June to 7 July, 2019) had or will have any beneficial downstream environmental improvement effects either [19]! This is especially disconcerting for Brasilian citizen Dr. Nilo Serpa and a concerned foreigner (RBC) when it is well-known that management consulting and advertising are strong industries in today's Rio de Janeiro [20].

Perhaps all of the region's citizenry who have a strong interest in Guanabara Bay's healthfulness could organize themselves under the auspices of the *Museu do Amanhã* (opened to patrons on 17 December 2015) into a special-interest group that is very effective socially? This could greatly expand the efforts currently being made; there are conservation units located at the innermost region of Guanabara Bay, covering part of the municipalities of São Gonçalo, Itaboraí, Magé and Guapimirim. Much of the original biodiversity of Guanabara Bay is still found within the limits of the Guapi-Mirim and Guanabara reserves, currently called "Arca de Noé" (Figure 2). These areas remain preserved mainly due to the fact that their rivers pass through less populated cities, being, therefore, less subject to receiving large amounts of sewage and debris. In addition, the good conditions of the preserved areas are very important to boost the local economy, especially the fisheries (it is estimated that more than 2 thousand families live on the commercialization of fish and crustaceans; imagine how many more families would be living on fishing throughout the bay shore!).

The museum's leadership first presented ultra-pessimistic narratives bolstered by viewable displays about ***catastrophic*** future climate change [21] but offered visitors, finally, a rather ambiguous prospective "Tomorrow" that seemed to rather emphasis a return to some indefinable, old-fashion, pre-Science Brazilian way of living and thinking; that message counters, but only partly, the more positivist 21st Century outlook afforded by the forward-thinking leadership at the Rio Science Park (opened 2003) on *Fundão* Island within the confines of the campus of the Federal University of Rio de Janeiro [22].Bolstering of a community sense of regional identity with the communication of credible climatic and cultural information and data about the true social status of other Science-minded members of the new group could effect a wonderful result [23]! Vulnerable persons must be consulted about constructions that improve waste water drainage, fire risks as well as the everyday risks of illness, injury, loss of personal property through robbery and the impossibility of government compensation.Guanabara Bay fisher-folk face grave risk of bodily harm, both short-term and long-term, because of the bay's current polluted seawater condition, which is internationally known since the televised broadcasts of the 2016 Olympics [24]. Certainly, local fishers ought to easily qualify asexperts on their community and Guanabara Bay fishing-grounds, providing a reliable source of techniques and investigative skills and whose trusted faculty for deciding correctly (wisely) is accorded authority and befitting social status by peers or other higher social status public members in a specific well-distinguished domain of Guanabara Bay scientific and technological knowledge. For example, fishers might serve in crowd-sourced bathymetry mapping [25] necessary for improvement of the pollution condition of Guanabara Bay proposed in this journal by Dr. Nilo Serpa and Cathcart. The world's first submarine sculpture park was emplaced in Molinere Bay, Grenada during AD 2006; the second similar park was set into its position in Mexico's National Marine Park of Cancun, the Museo Subaquático de Arte. Might not Guanabara Bay someday also have that kind of popular entertainment venue freely available to the public, domestic and international travelers?

As to citizen housing [26]: the AD 2007 Tim Festival held in Rio de Janeiro is widely remembered for its innovative musical display of seaworthy steel shipping containers from 16 September to 18 November. Rio de Janeiro's healthful Koppen-Geiger climate classification portends future widespread us of Inflatable Architecture for homes and even refurbished factories and attractive offices [27-28]. (We recommend perusal of Sharon Francis' delightful ***Bubbletecture**: **Inflatable Architecture and Design***, published by Phaidon, 2019, 287 pages.) Rio de Janeiro has a poor record in rainwater harvesting [29] that may be improved significantly with deployment of new technologies. Possibly even a romantic underwater restaurant, such as the facility designed by the design firm **Snohetta** and installed inside a small Norway bay, presenting diners with superb views of the adjacent seabed and its lively as well as delightful biota would spark an urgent renewal to clarify the seawater of Guanabara Bay. Additionally, like Singapore in Asia, it is foreseeable that some South American coastal cities such as Rio de Janeiro will, almost inevitably, seek to expand superficially onto the nearby and generally calm seawater in the form of floating platforms used for residences and solar-power generation [30-31]. Architectural potential may exist even in the colorful plastic wastes removed from Guanabara Bay! We can only imagine, of course, how such structures and buildings fabricated of recycled plastics might truly appear whenever materialized: perhaps Brazil needs an empathic architectural team collectively brimming with the vivid artistic inspiration of Mr. Helio Oiticica (1937-1980)? We anticipate that Pecero H_2O Tires, in some extreme topographic landscapes could be hauled upwards to needful favella residents by using a simple and inexpensive funicular railway. The world's steepest funicular railway, negotiating an incline of 110%, opened for commercial business in Switzerland during AD 2017 to serve the town of Schwyz and the village of Stoos. However, instead of a railway, a simple haul-ramp would seem to be quite sufficient to serve rugged parts of Rio de Janeiro. After all, a boat haul road, the *diolkos* built across the Isthmus of Corinth in ancient Greece, served its operators well until, much later, the Corinth Canal was finally dug [32]!

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Figure 1 - Shown in this screen-shot computer-generated map, the suggested floating desalination raft covering the Golfo de Cariaco in northeastern coastal Venezuela has an area of 623 square kilometers! Such a gigantic barge facility could produce huge quantities of freshwater desalinated from seawater for local use. The authors thank Dr. Matt McCarthy, Biological Oceanography, College of Marine Science, University of South Florida at St. Petersburg, FL, USA for his preparation of this excellent case illustration.

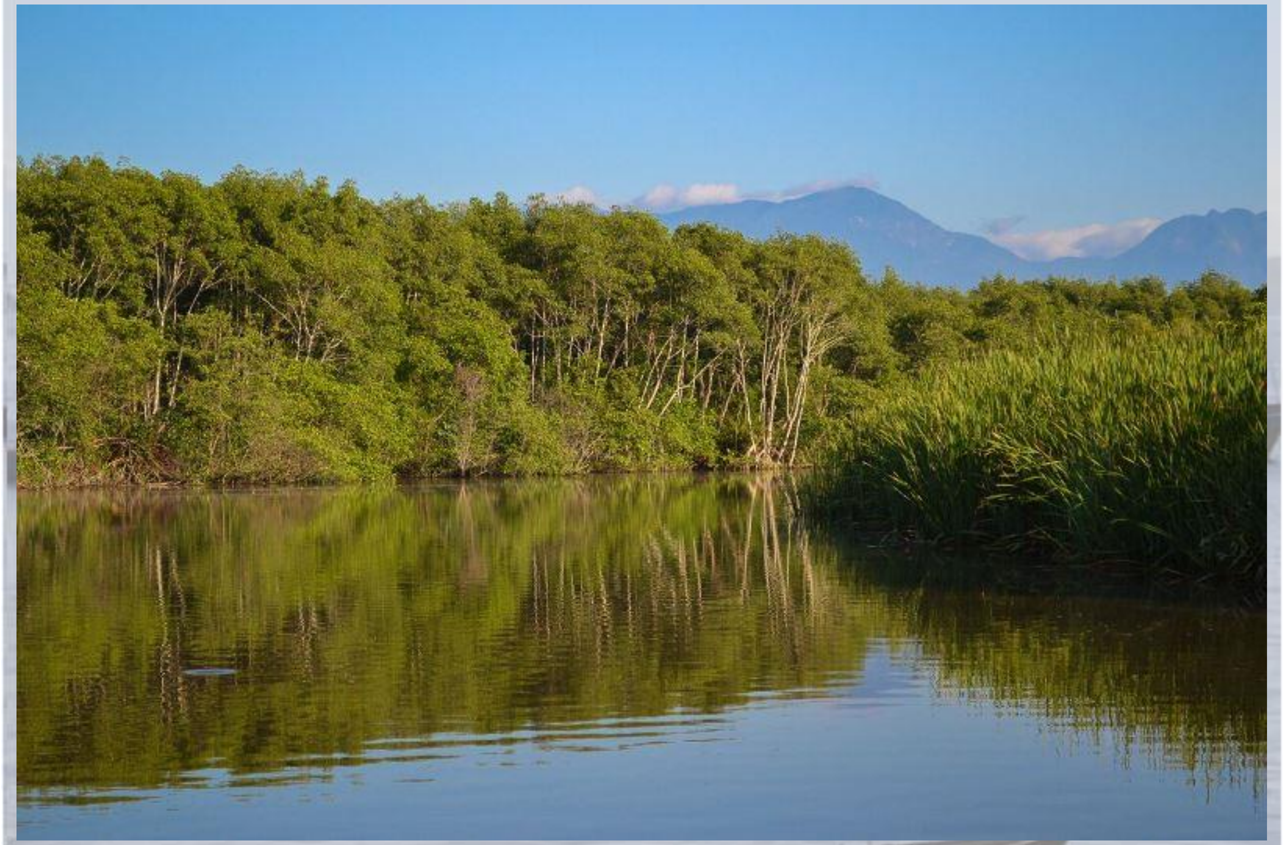

Figure 2 - View of part of the "Arca de Noé". From **Instituto Chico Mendes de Conservação da Biodiversidade** (ICMBio team), 2017.