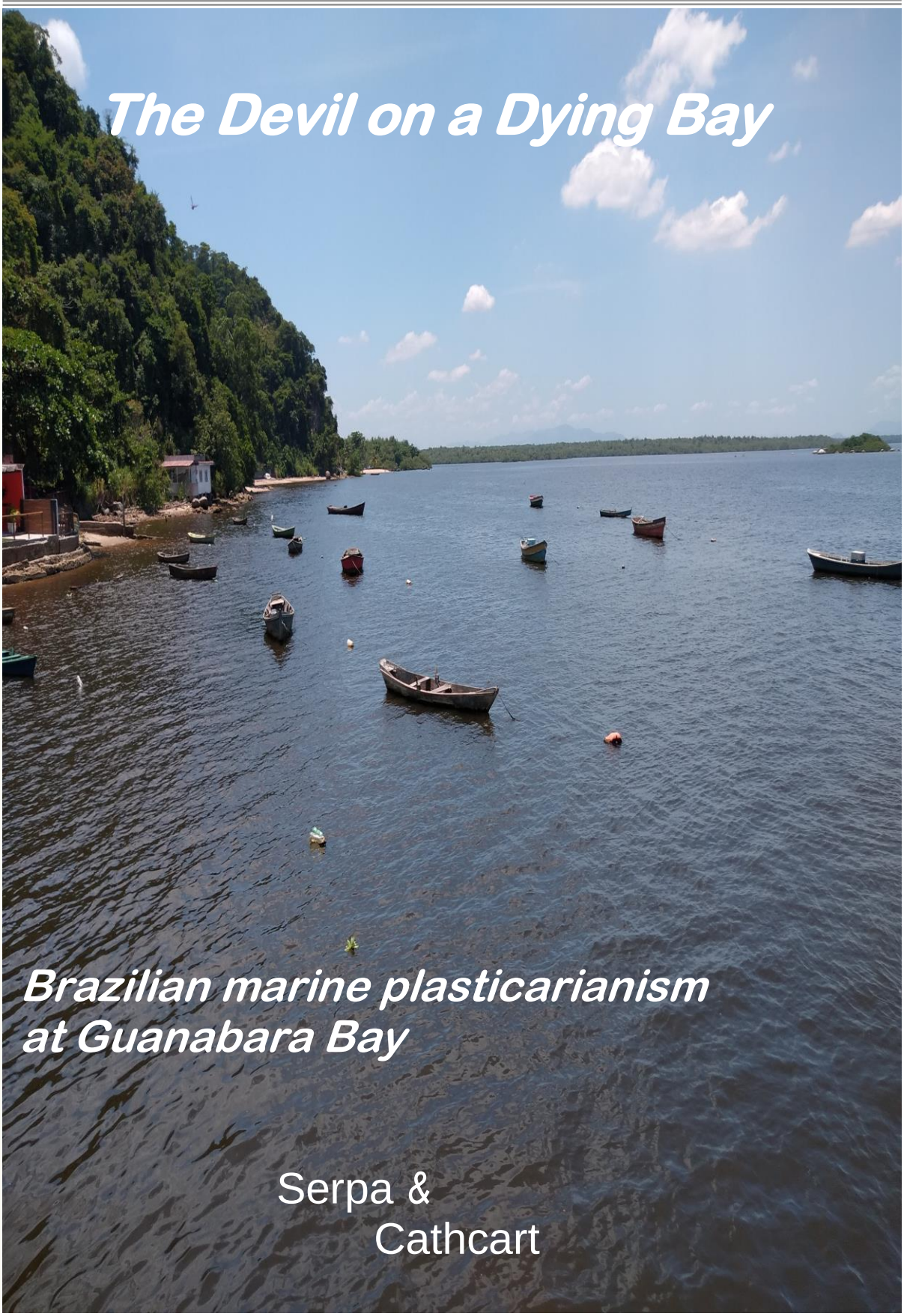
Revista Brasiliense de Engenharia e Física Aplicada

Vol. 6 suplemento - Fevereiro 2021



ISSN 2526-4192

The Devil on a Dying Bay

Brazilian Marine Plasticarianism at Guanabara Bay

Nilo Serpa[1], *Centro Universitário ICESP*, Brasília, Brasil.

Richard B. Cathcart, *GEOGRAPHOS*, Burbank, California, USA

Received: _04/01/2021_/ Accepted: _16/01/2021_ / Published: _06/02/2021_.

Abstract: This article provides an overview of the known current situation of Guanabara Bay with respect to its pervasive plastic waste pollution, continuing the paired authors' previous works. In addition, the study opens up a broader public discussion on the fundamentals of global degradation, proposing a review of environmental education curriculums including the correct appropriation of the concept of entropy among adults and young people as well. In this sense, the authors deepen the concept and emphasize the importance of considering it in critical reflections on our present-day and future worldly behaviors and actions. Lastly, the work provides some significant and important relevant data and useful references, tracing some lines of thought for building viable solutions, so that the reader can start or continue further studies on the topic addressed herein.

Key-words: Guanabara Bay, entropy, plastic waste, environmental education, global degradation, consumerism.

Resumo: O presente artigo fornece um apanhado geral da situação atual da Baía de Guanabara com respeito à poluição por resíduos plásticos, dando continuidade aos trabalhos anteriores dos autores. Além disso, o estudo abre uma ampla discussão sobre os fundamentos da degradação global, propondo uma revisão dos projetos de educação ambiental incluindo a apropriação correta do conceito de entropia por adultos e jovens. Nesse sentido, os autores aprofundam o conceito e ressaltam a importância de considerá-lo nas reflexões críticas sobre os nossos comportamentos e ações. Por último, o trabalho fornece dados e referências relevantes, traçando algumas linhas de pensamento para a construção de soluções viáveis, de modo que o leitor possa iniciar ou prosseguir estudos complementares sobre o tema.

Palavras-chave: Baía de Guanabara, entropia, resíduos plásticos, educação ambiental degradação global, consumismo.

[1] **Corresponding Author's E-Mail Address:** nilo.serpa@icesp.edu.br

CALIBRE – Revista Brasiliense de Engenharia e Física Aplicada, ISSN 2526-4192.
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Prolog

For someone like me, born and raised in the city of Rio de Janeiro, it is sad to see the current state of Guanabara Bay (GB for short). Of course, life always finds ways to overcome adversity and, thanks to some geomorphologic and oceanographic characteristics of the basin that comprises GB, I am still surprised by some gray dolphins beyond Paquetá Island (I remember the days when it was possible to swim since the Governador Island to Paquetá Island in good waters). My old friend Richard Cathcart and I have devoted considerable time to an original and very broad work, with observations and suggestions that can inspire a community of scientists and decision-makers to come together to rescue GB's environmental quality, returning health and means of survival for the countless families that inhabit its shore.

Certain that many have read our articles, we offer this study, including particular emphasis on environmental entropy, and a photographic collection of some paradise vestiges that, stubbornly, impress us and invite us to share a telluric feeling of preservation.

Nilo Serpa

1. Introduction

Even so disfigured by all kinds of anthropogenic pollution, Rio de Janeiro's famed Guanabara Bay (GB) still offers beauty and hope to its shoreline inhabitants for better days after AD 2020. Certainly, unlike the idyllic days of the indigenous tribes who sailed its clean, clear and calm tidal bay waters; we can still imagine the canoes of the *Tamoio* fishermen in a warm morning arriving at the beaches loaded with fresh fish—an image of Paradise! —but also the imaginable evenings from which a seawater night mirror reflects the monuments of civilization with less turbidity.

The literature on pollution of the seas is vast and tends always to grow, particularly with regard to plastic waste [1, 3, 5, 6, 8, 10]. The pollution caused by the accumulation of plastic in river estuaries, soils and oceans is perhaps the main signature of consumerism and slouch, traces of a radically aggressive and possibly lethal inhuman modern-day consumerist life-style. That plastics have revolutionized modern life is indisputable. However, with its use, a very common fact in Earthly human culture occurred: the adverse effect of widespread geographical generalization. By exploring the numerous applications of plastics, guided almost exclusively by economic motivations, industrious human beings created what we could call "*plastisphere*", something as if little by little we were plasticizing our whole globular world as the late artist Christo once did with a spinnable classroom globe.

On one hand, there are the so-called "microplastics", solid particles of polymers with length less than 5 mm originating from anthropic activities, classified among the main pollutants of waters, with capacity to alter the composition of certain components of the oceans. On the other hand, there are readily visible plastic macro-objects, constituents of urban and industrial waste. There are two critical aspects to be considered with regard to plastic macro-objects: I) the heap of pieces, such as bags, bottles, etc., the dwell time of which affects ecosystems in different ways, creating obstacles to animals, poisoning soils and accumulating putrefied matter; II) the formation of a microbiotic film (biofilm) covering those pieces, producing new ecosystems that interfere with the outer ecosystem with unpredictable consequences. Since most of these materials are largely recyclable, if not replaced by biodegradable materials, the absence of effective waste management policies — which logically include alternative practices to the use of plastics — and lack of environmental education are the main causes of global ocean degradation. Evidently, this education must bring up the concept of entropy, making it understood in all its applicable broadness.

This study continues the work carried out by the authors in several previous publications, bringing aspects of environmental education and an overview of the current situation in GB with regard to the pollution by polymeric residues, outlining some rational ways of intellectual reflection to help build workable solutions.

2. A titbit on entropy

The concept of entropy continues to produce a lot of confusion in science. First of all, there is a semantic problem involving the words "order", "disorder" and "chaos". When talking about advancing entropy, it is said there is increase in disorder. Commonly, however, disorder is a synonym for mess or disarray. It turns out that, from the point of view of thermodynamics, disorder is sameness, non-difference at a fundamental level. So, in the sense of Gibbs' universe, chaos (the sameness) is most probable. Order is just the opposite; an ordered universe is a macro-physical state where different structures are distinguished, such as galaxies, star systems, clusters of galaxies, binary stars, and so on. In his milestone book, *The Human Use of Human Beings*: *Cybernetics and Society*, Wiener explained in a very clear manner the intricacies of entropy:

"As entropy increases, the universe, and all closed systems in the universe, tend naturally to deteriorate and lose their distinctiveness, to move from the least to the most probable state, from a state of organization and differentiation in which distinctions and forms exist, to a state of chaos and sameness" [47].

But there is a suitable difference in our viewpoint. Although Wiener recognized that the universe as a whole tends to run down, the "local enclaves whose direction seems opposed to that of the universe at large" are in fact not regions of temporary tendency to order but new spontaneous "zero-marks" of entropy progress originated from complexities reflecting interactions among boundaries of different equilibrium states (attractors). Each zero-mark, a ground zero of evolution, is a low entropy start in relation to the sequence of increasingly entropy states that will follow. So, it is with the life of each individual and with the species. The point is that the low entropy zero-mark is relative and depends on the adjacent complexity. For instance, the low entropy zero-mark of the emergence of life is different from the low entropy zero-mark of the Big Bang. Thus, from each zero-mark the corresponding entropy will only grow over time.

So, everything is moving towards thermal extinction, the impossibility of productive actions and energy transformations. This is the major difference between the mechanistic view and the thermodynamic view of the universe; for mechanics everything is reversible because there is no computation of time as a physical quantity that is both creative and degenerative. The reader will find an interesting and complete discussion on this subject in reference [48].

2.1 Keynes's devil

We could establish a ground-zero for Homo sapiens' plastic civilization. Since the first celluloid object, global entropy has been growing at an alarmingly fast rate. Not only due to the tactile accumulation of plastic waste, but also due to pollution related to the manufacturing processes of the various polymeric materials, as well as the gradual degradation of the plastic that eventually releases methane and ethylene into the world's air and waters. It is believed that, since polymeric materials are very recent, Nature does not yet know how to get rid of them,

assuming that more bacteria and fungi that decompose matter shall develop new enzymes to degrade them. The concrete problem is that we are certainly producing plastic waste at absurd annual rates, so it is doubtful that biological adaptations shall occur in the time we need to erase our tracks of destruction. Plastic production is expected to triple by AD 2050 [49]. Considering that some aquatic species like Krill are already able to subprocess microplastics into nanoplastics, this forecast offers us a somewhat shadowy prospective. It seems that the price of civilization is its self-destruction.

So, we call "Keynes's devil" (alluding to the theories of J. M. Keynes) the psychosocial model that adopts extreme consumption as an inevitable form of social expression. The demonic effect of this behavior is that it leads to self-destructive results. The same technology that brings practicality and comfort to our daily lives turns against us, not for the technology itself, but for its indiscriminate and abusive application by careless and uninformed human beings.

2.2 The concept of entropy and the environmental education

Let us now be more pragmatic in our thoughts. Entropy, in its evidenced environmental effects, results from processes whose time scales depend on each designated system considered and on their interactions with the environment. Furthermore, the sameness's we are suggesting is the culmination of any entropic process. A highly entropied medium will be unable to be productive or provide usable energy, such as the Aralkum, the desert that now occupies the place of the erstwhile majestic Aral Sea, a sad case of the supremacy of Keynes's devil.

Pollution by polymeric materials is one of the processes that leads to that state of productive environmental incapacitation, either by poisoning of soils and waters, or by obstruction of vital ecological niches. Only by understanding how entropy is present around us can we expect to have lucidity in dealing with global and regional environmental issues that have been noticed.

In short, the poisoning of soils and the world's ocean is a fast means for rendering these planetary environments useless as further sources of vital energy. Understanding entropy as part of a universal evolutionary law forged in time, we can also understand that human intelligence is a powerful device to slow its inevitable advance, as well as diabolical to speed it up. It is duty of formal education to clarify all this, from the early years of learning youth.

3. The "Plasticarianism"

With the intentional addition of the '*-arian*" ending to "plastic" the noun "Plasticarianism" was generated. Initially this word indicated a person who accepted and enjoyed plastics but, approximately over the last decade, its essential meaning has mutated into an individual's or group's basic oppositional stance to the Earth-bioshell polluting presence of uncontrolled industrial-scale waste plastic deliberately discarded or simply lost by

consumers. Mined petrochemicals are the feedstock for making plastics. Consumer used and discarded plastic is blown by wind and moved by water flowing through landscapes into the world's ultimate trash receptacle, the world's ocean [1-2]; about 1% of microbial cells in the world-ocean surface microlayer inhabit plastic debris, making that debris an unnatural habitat for oceanic flora [3]. Freshwater runoff from streams and rivers which debauch into Rio de Janeiro's GB carry floating plastic debris which, upon natural comminution, becomes a major microplastic [4] contamination macro-problem within the Holocene gulf [5] as well as the adjacent continental-shelf [6]. Plastics are malleable materials which, paradoxically, are not very disposable, that is not cheaply processed industrially into immateriality and requalification via standardized recycling schemes [7]. Marine microorganisms have opportunistically adapted to microplastic debris in both freshwater and seawater as a surface for colonization [8] and potential degradation [9]. Microplastics — flecks of plastic < 5 mm — are undetectable even by the NASA submeter-resolution Earth-orbiting satellites imagery as detailed "Popcorn Clouds" surely are (Figure 1), and the particles, because of smallness, are entirely unseen by human eyes (microscopic) unless viewed closely using normal eyesight aids!

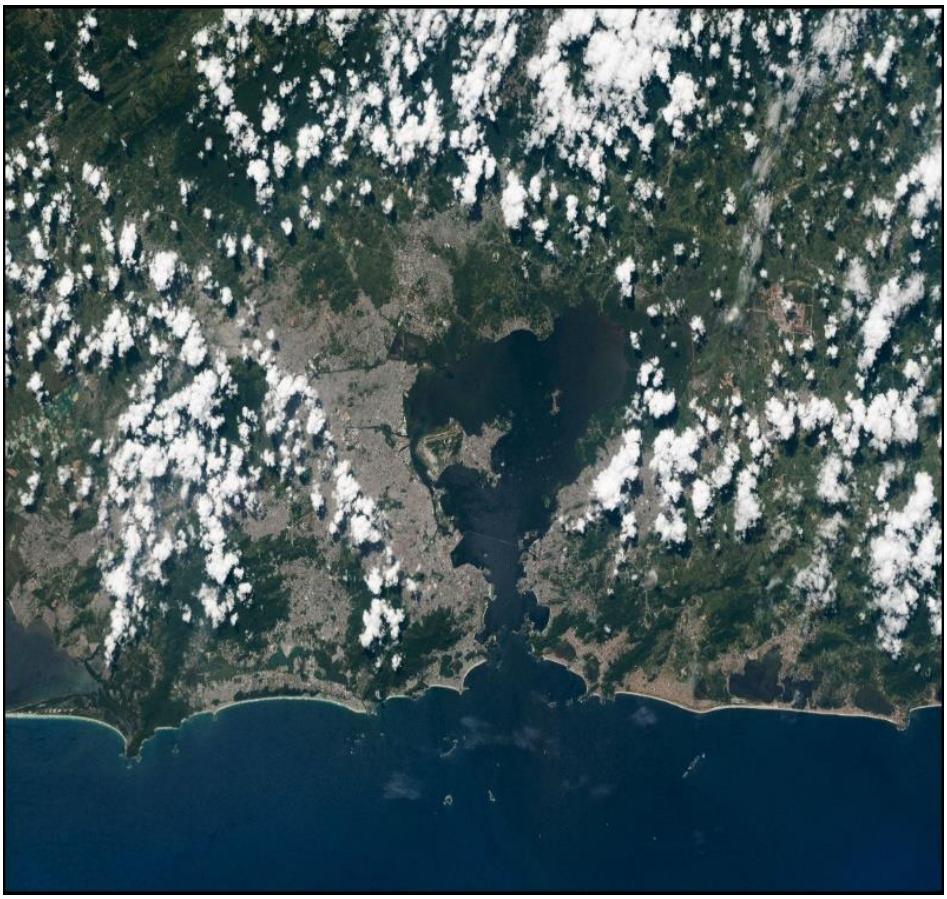

Figure 1. An International Space Station Astronaut photograph, ISS062-E-113274 acquired 25 March 2020 illustrates "Popcorn Clouds" above the landscape of Rio de Janeiro and São Gonçalo. Because of the differing heat capacities of land and seawater, this cloud type forms above landscapes only. Notice the absence of Popcorn Clouds over GB!

Figure 2. A part of a larger image produced by the famous Indonesia-born artist Ferdi Rizkiyanto. He welcomes the possibility of a "zero-plastic seafloor" (Google Image.) The authors of this CALIBRE article are Plasticarianism adherents. Human behavior is the ultimate cause of Brazil's 21st Century marine plastic debris mega-problem. Plastics, both macroscopic and microscopic exit GB via tidal seawater movements, piped sewage disposed offshore in outfalls, ocean-going commercial shipping (ballasting seawater adjustments and things tossed overboard for convenience of dumping and, of course, GB-based commercial and sport fishing vessels as well as private-sector island tours by small-craft boating). Tentatively, we designate such temporal interactions as cyborgs when attached to functioning machines and, otherwise, merely a potential stratigraphic indicator phenomenon in unsolidified GB sediments.

4. Possible Sea-level variations at Rio de Janeiro

Laboratory chemical experiments have demonstrated that children's visible LEGO bricks probably could retain identifiability after immersion in seawater for as long as 1,300 years [10] — so, as yet, there is no

scientifically known limit on the amount of time microplastics could theoretically reside within GB! Concurrently, there is increasing strand development associated with tourism, industry, transportation, aquaculture, business and governmental skyscrapers, favellas and other neighborhood residential use types as well as coastal defenses in the GB. With the advent and proliferation of more artificial structures, co-occurring local biodiversity and bio-distribution will change because of the newly introduced anthropogenic habitats [11]. Possible structural failures of geographically large structures and buildings on the present-day GB strand might cost more money to "cure" or remediate this macro-problem than the horrible aftermath of the Fundão Dam's failure on 5 November 2015 [12-13]. In the opinion of oceanographer Dr. Charles W. Finkl microplastic pollution of the world's ocean is significantly more important than climate change, natural and anthropogenic: "The ocean…has…become a garbage dump that is affecting marine life in adverse ways. Microplastics are found in the tissue of caught and bred fish and in other organic materials that are consumed by humans. The adverse effects of microplastic laden fish are not known and most people are completely unaware of the problem that poses for their long-term health. Failure to deal with plastic pollution, micro and macro-plastics, will eventually become a greater problem than climate change at the present rate of dumping in the ocean as artistically suggested in Figure 2. Whatever happens to GB is emblematic of what could happen to our world's ocean. This microcosm could be an interesting case study that points the way to feasible global clean-up or ecological disaster" [14].

Nevertheless, we desire to describe, briefly, the effects of commonly postulated changing climate-induced seawater, tide, and other ancillary effects as represented in GB at Rio de Janeiro, Brazil. A slow and imperceptible rise in sea-level will offer no exhilarating rides for surfers! The only shocking evidence will be damage to items designed for subaerial use but never to be impacted by seawater. Permanent inundation, obviously, will amplify the unwanted distribution of errant plastic objects and granulo-plastics (particles).

Strong ambiguity in many global mean sea-level rise projections and shoreline impacts exists on timescales relevant to infrastructure and regional planners. Such controversial anticipations are a novel investigative activity because prognostications involve assumed and presumed natural and human actions with time-delays, irreversible losses, and much intellectual uncertainty. Essentially, real-world local sea-level rise entails physical displacement of parts of terrestrial coastal landscapes such as the largely urbanized GB strand, which then becomes submerged beneath an influx of extra-gulf, world-ocean seawater [15]. Sea-level rise in the Southern Hemisphere must accurately represent the distribution of seawater conforming to a changing Earth geoid, including mass self-attraction and mass loading effects related to a changing Antarctica because those effects cause sea-level rise or fall by ~20-25% on that specific half-world geographical scale [16]. Super-computer modeling results are often quite unsatisfactory and especially so when outputs are applied to a specific geographical locale where, for example, modelers ignore important local phenomenon such as land subsidence [17]! Worse still, when postulating global climate change modelers sometimes predict a future Earth-bioshell that is radically altered from present-day scientifically known conditions. Resolutely, we recognize that many familiar geophysical process-

events can utterly invalidate costly super-computer models, making the mathematical models irrelevant to the needs and requirements of a thriving Southern Hemisphere human civilization. For example, “The combined effects of hydrate melting and sub-hydrate gas release [from the world-ocean seafloor] would result conservatively in a global sea-level fall of 10-146 cm. Such a mechanism may off-set some future sea-level rise associated with thermal expansion of the ocean” [18-19]. Unfortunately, many planetary and astronomical factors contribute to aspects of climate-change that affect Brazil’s coastline still remain unexamined [20]!

Former landscapes that are currently classified as coastalscapes due to the Holocene post-Ice Age global mean sea-level rise have been referred to now by geographer Jerome E. Dobson as “Aquaterra” [21]. A region of the Earth-crust that is increasingly open to archaeological researchers, “Aquaterra” is a coastal region that is part strand and part seafloor. Aquaterra has an area that is at least equivalent to that of South America and refers to areas that existed when civilization commenced technologizing on landscapes above current sea-level [22]. Seaports of a kind existed thousands of years ago but the oldest is yet to be discovered. It has been shown, however, that humans opposed ocean ingress with protective sea-wall construction at lest as far back in time as circa 5,000 BC [23]! Given the surmised population demography of Brazil during ancient times [24-25], the ~20,000-year submergence of Brazil’s continental shelf since the Last Glacial Maximum, there may be former seaports, now submerged, that are yet to be discovered on seaward approaches to GB; it reached its present-day morphological configuration circa 4,000 BC and has evidenced geologically its slow sea-level rise since circa 1000 AD. Or, more probably, ancient seaports may yet be found by archaeological explorers below the present intra-gulf seawater surface of GB.

5. Benefic/Salvific Infrastructural Prospects at GB?

A truly astounding mass of plastic bags and plastic bottles accumulates on the inner and outer edges of the great Governador Island in GB, many stretches of which were bathing sites until the mid-twentieth century. This picture is repeated in so many other locations where the old beaches have become repulsive garbage dumps. Besides municipal trash collection and sand-grooming of Rio de Janeiro’s beaches, natural UV sky-radiation is the most important physical factor governing the residence-time (humanly visible appearance) of plastics left on beaches by inconsiderate bathers [26]. Such thoughtless persons apparently retain little concept of “psychological ownership” [27] and consequently are the secondary cause of beach sand contamination by obvious macro- and barely visible microplastic pieces that eventually deteriorate into unseen microplastic fragments. The vast swathe of urban landscape surrounding the GB, with its massive raw-sewerage runoff from landslide-prone favellas situated on steep slopes [28-29], is the primary cause of unwanted microplastics in beach-sand and seawater/sediment. Not only a more fervid public recognition of a spatially vast regional environment macro-problem is needed by the citizenry and their political representatives, but what is also urgently required is

intentional unfettered reclamation. That is, a technological clean-up rescue by professionals and citizens of the GB area is required to forestall a collapse of the ecosystem into an undesirable state! If Rio de Janeiro's beaches require artificial nourishment via sand dredging, then the dredged sand must be cleansed of plastic contamination to the degree technically feasible [30]. Since 2015, the "NASA Earth Science Division-Rio de Janeiro Partnership" has resulted in rebound to natural process-events and prudent preparations for near-term impacts of climate change [31].

Plastic refuse in rivers, storm-drains and non-piped raw sewage flows that enter the tidal GB are sometimes impeded by floating or suspended barriers (nets) that can be made more effective [32]. Macroscopic marine plastics, designated as collectible community waste, can become more useful than in the past by chemical conversion into hydrogen fuel and other high-value carbons [33]. Thus, gathering of macro-plastics by fisher-folk for such purpose provides a financial reward for its removal timely from GB. Extraction of macro-plastics will reduce additional loading of microplastics in GB's seawater-column and loose bottom sediments shortening the depuration period for commercially farmed edible mussels [34]. Catharsis cost reduction is a Win-Win depuration proposition for GB mussel aqua-culturists! In an effort to increase the purification of Gulf seawater, we suggest several civic macro-projects: (I) installation of a removable filter curtain with a mesh fine enough to trap bits of plastic up to 1 cm in diameter. The filter curtain could be dropped from the bridge itself or pulled into place from the shoreline. If emplaced along the length of the Rio de Janeiro-Niteroi Bridge, which itself temporarily blocks tidal flow, and if weighted at the bottom the filter curtain could provide a liftable seal from the seawater's surface to the gulf's seafloor. When rewound, the filter curtain could be stored on the bridge structure in a decorative and protective housing or in an inconspicuous nearby shoreline warehouse. The barrier would be rolled up or shifted sideways after high-tide has peaked in the upper Guanabara Bay. Such conventional and scheduled operation could cause episodic anthropogenic flushing of the GB. (II) Next, we note a floating cleaning technology, which needs considerable macro-imagineering development, that was first proposed in 2018 AD by our esteemed chemist colleague in India Dr. S.N. Balasurrahmanyam. This concept involves a kilometer-long floating rotating boom with micropores through which some sticky biodegradable exudate flows. The exudate collects plastic particles as surface water flows by the boom. Additionally, required is some method for sloughing off the collected microplastics into a ship's hold for subsequent industrial-scale recycling. At present, such anti-pollutionary devices are not included in typologies of coastal infrastructure [35].

Increase of Rio de Janeiro's population during the 21st Century will require more harbor infrastructure that will be more extensively developed [36-37]. In addition to expelled bilge-water and other contributing effluents, including the ingredients of smog's aerial fallout from increased emissions by bay and ocean-going shipping, considerably more artificial night-lighting will reshape marine habitats in the entire seawater-column of the shallow GB [38]. Reflecting on future expansion of city-lighting, it might be prudent to consider whether pole-lit streets and parks paralleling the GB should be equipped with UV lamps that could be directed toward bay waters. A worthwhile

question might focus on whether the surface seawater layer UV-radiation could reduce or annihilate some of the infectious microbial life-forms inhabiting the gulf and known by medical experts to adversely affect local fisher-folk health? Seaport expansion will inevitably entail some significant, geographically large-scale berthing zone and navigation channel dredging [39] and that, in turn, means enormous mechanical resuspension of GB's undeniably polluted sediments [40]. Rather than spilling contaminated sediments onto the inner continental-shelf outside GB [41], dredged materials could be sacked in strong storable bags that are amenable to use as retention sea-walling or artificial island foundations [42].

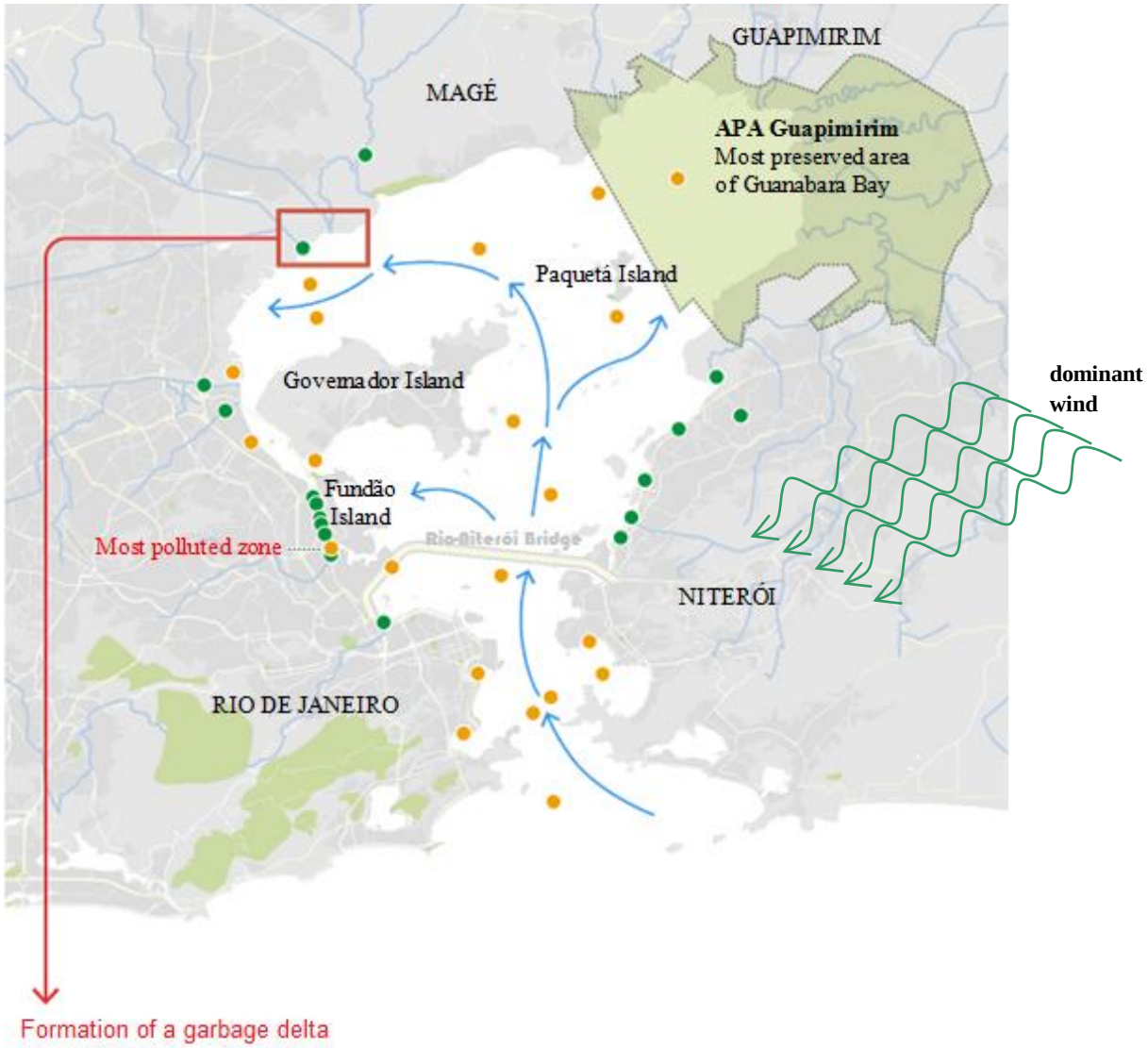

Figure 3. Schematic view of the present-day state of GB. Green dots indicate eco-barriers, while yellow dots indicate monitoring stations. Blue line shows the direction of entry of the South Atlantic Ocean tidal current. The preserved area of Guapimirim is only possible due to the southeast dominant winds (wavy lines on the right) that push garbage towards the Governador Island (Source: adapted from Ana Lúcia Azevedo, *O Globo – Rio*, 2019).

In 1948, plans were activated to link eight small named islands forming an archipelago within GB which had the result, after 1952, of today's inclusive Fundão Island. Approximately 3.2 x 10^6 m^3 were used to consolidate the islands into an interlinked landfill with an area of about 5.96 x.10^6 m^2. Sitting on this island is Rio de Janeiro's most outstanding public university. The navigable channel separating the island from the mainland remains highly polluted as well as avoided by the informed and wise public.

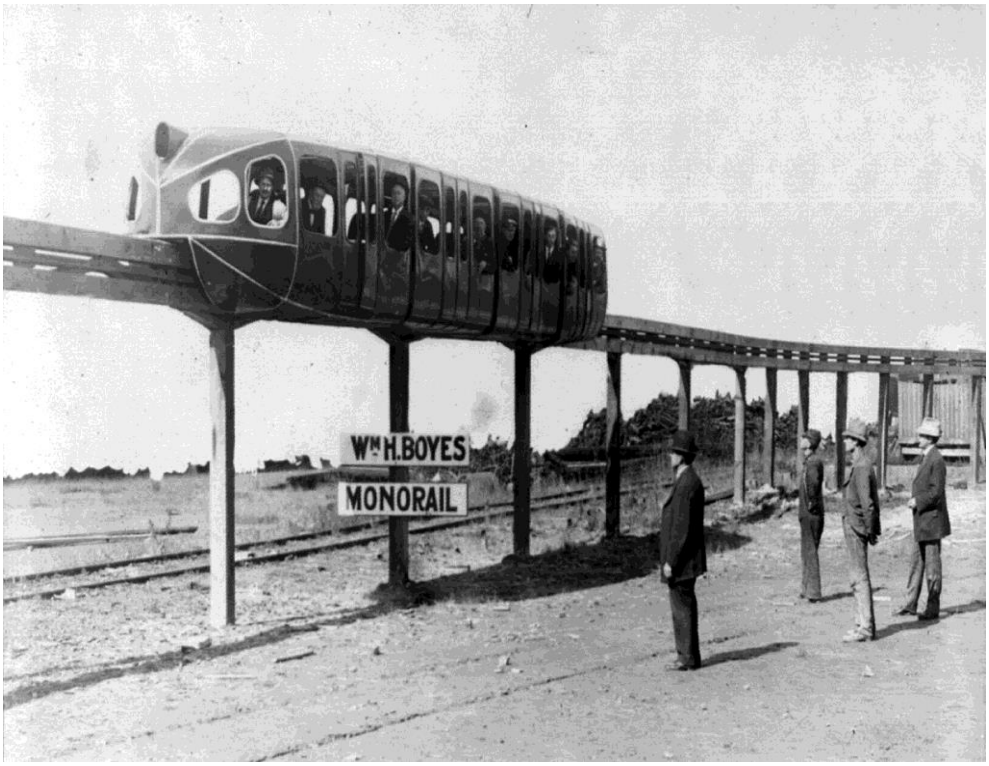

Figure 4. The passenger cars were moved on a singular wooden superstructure. Even the supporting pylons were made of wood. How very 21st Century "Green Architecture"! (Google Image.) Since there is a normal twin-rail track opposite the circa 1911 AD viewers, we suppose these gentlemen are standing on a tidal-flat that is only submerged during extremely stormy weather causing seawater surges or during the very highest elevation of the year's tidal range. Or, it is a picture of the William H. Boyes Monorail before it reaches, or after it exits, the Seattle, State of Washington, USA tide-flat.

Some of the hyperbolic popular news-media reports about rapid and drastic future sea-level rise purveyed are, in fact, overly dramatized pernicious "pathological Science" (as distinct from indisputable Pseudoscience based on scientific falsehoods) as first discussed by Irving Langmuir (1887-1965) in his famous 18 December 1953 speech to assembled colleagues. With slowly rising GB seawater levels, it can be reasonably expected that authorities will regularly and thoroughly assess the need for strand, harbor and GB protection, comparing present-day properly forecast stormy-weather events and, longer-term, upcoming local sea-level so that necessary infrastructure and its maintenance will be undertaken in a timely manner. Around the world's ocean coastlines, transport routes are subject to hazard risk review by macro-imagineers due to variously purported sea-level rise process-events, in the

example of the strand-sited old railroad connecting Los Angeles and San Diego, California, USA. Thus, macro-engineers—those who carry out the plans devised by macro-imagineers—must eventually respond similarly with removal and emplacement of obsolete waterfront infrastructure [43]. "Most people know of the Seattle [State of Washington, USA] ALWEG monorail built for the city's 1962 World's Fair (Century 21 Exhibition), but few know of the first Seattle monorail, built and exhibited by William H. Boyes in 1911 along the tide-flats of the city" [44] (see Figure 4).

When Hyperloop was announced in AD 2013, Internet commentators showed some renewed enthusiasm for this not-so-new form of passenger and cargo transportation. Hyperloop is a macro-imagineering concept that is being developed, megaproject by megaproject, into various plans and actual macro-projects for very high-speed, fixed-guideway, intercity surface and tunnel transportation, using capsule-like vehicles that operate in sealed partial-vacuum metallic or concrete tubes. Las Vegas, State of Nevada, USA is building a tunneled version of Hyperloop which will become initially operational in AD 2023. With regard to Brazil, might it not be possible to reconceptualize the transportation artery first macro-imagined by Charles-Edouard Jeanneret (1887-1965), also known as "Le Corbusier", during his 1929 career-formative visit to Rio de Janeiro? "In 1929…Le Corbusier was visiting Rio and took the opportunity to make sketches of some urban ideas for the city. His proposals showed some essential differences in terms of city images, and two conflicting urban design models based on divergent theoretical movements appeared Corbusier's controversial suggestions emphasized the architectural object. Although Corbusier's proposal was never built, its design principals guided most of the urban and architectural projects implemented in Rio, from the 1930s to the 1960s. Modern Architecture was established and became a sort of consensus among designers" [45] (see Figure 5).

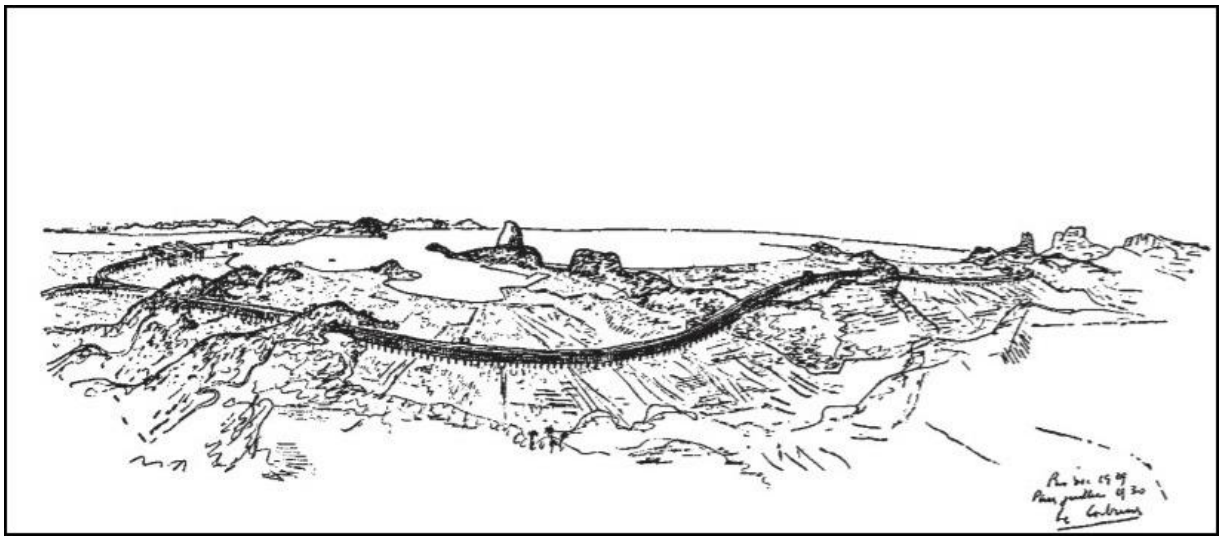

Figure 5. Notice the motorway snaking through downtown Rio de Janeiro connecting its famed South Atlantic-facing beaches, crossing via Fundão Island to Governador Island! This above-ground structure would be considered undesirable today because it obstructs views, shades other infrastructure and more or less has the function of a fence! In a previous paper [46] the authors tried to obscure our "Organum Hydraulicum" wherever possible by placing it underground in the Niteroi neighborhood of GB.

It is humbly suggested here that a 21st Century revision for 20th Century Le Corbusier's architectural idea be constituted by digging a subterranean Hyperloop-like tunnel featuring vehicles that may resemble those of Las Vegas! Passengers and small freight items and mail could be moved quickly underground, avoiding the vehicular traffic-jams that are so often encountered on the streets and major highways of Rio de Janeiro, Brazil. It is time to make obsolete televised favela tourism [50], clean GB, and offer hope to the despairing populace of one of the world's greatest cities!

5.1. The logic of the Organum Hydraulicum

The *Organum Hydraulicum* (OH), a macro-version of the SIBEO system we presented previously [28], is among the accessible and applicable macro-engineering solutions for GB. Although its feasibility depends on the constructive expertise of the engineers involved, the challenge is proportional to that of the construction of the Itaipú binational hydroelectric plant, unless the technology for hydroelectric projects is already well known. However, the logic of OH seems undoubted. In addition to the topographic and coastal conditions favorable for its implantation, there is also the propitious aspect of the dominant GB winds that blow towards Governador Island from the APA Guapimirim (Figure 3), something that would contribute to the OH-induced surface hydrodynamics. Let us not forget that the OH proposes to oxygenate and renew more quickly the water in GB — since the great damage caused is due to the organic sewage discharged untreated, and the presence of the Duque de Caxias oil refinery - REDUC —, according to a tidal management plan, and not to sweep the solid garbage out (the amount of solid waste, mainly plastic, is really impressive as we can see in Figures 6, 7 and 8); it is a mega-device to support a very broad environmental policy, including several governance and education measures. Let us REDUC's negative influence on GB!

Someone could object that the simple implementation of all the appropriate policies would be enough to solve the problem without the need for such a device. But the regional and national reality is much more dystopian than imagined. If we really had the right educational policies, it would take generations for the necessary habits to be acquired by society, therefore, a long-term megaproject. In addition, such policies, associated with health policies, would need to constitute Policies of State and not of discontinuous governments; unfortunately, Brazil is a long way from that maturity. Finally, there is a lot of obvious and non-obvious corruption in the social institutions, a fact that does not allow to guarantee the correct destination and use of the funds required for long-term megaprojects. Anyway, OH needs to be a tripartite initiative of rapid execution, with participation of several stakeholders: civil society — people with a lifelong passion for environmental preservation —, government agencies — environment departments in collaboration with ministerial entities —, and private companies — national and foreign organizations with interests in the exploration of tourism, watersports in general, sport-fishing as well as commercial fishing.

Figure 6. Garbage beach in GB (Source: Custódio Coimbra, *Agência O Globo*, 2019).

Figure 7. Aerial view of the garbage beach in GB (Source: Custódio Coimbra, *Agência O Globo*, 2019).

Figure 8. Garbage dump on the banks of an estuary, openly accessible by vulnerable children (Source: author's private collection).

6. Reminiscences of Paradise

The sequence of photos below (Figures 9 to 15) is taken from the region close to the Guapimirim Ecological Station (APA Guapimirim), at the historic Porto da Piedade, one of the most important and busy seaports of Brazil-Colony, whose movement was due to the arrival of the untallied wealth from the State of Minhas Gerais and the intense embarkation and disembarkation of passengers on the first railway in Brazil. Still today, the village of the seaport is a stronghold of surviving fishing families descended from slaves freed by the Aurea Law. This haven of Paradise keeps memories of the time when fishing was a lucrative activity very close to the shoreline. Today, fishermen need to go far afield if they want to catch whitings and mullets.

Figure 9. Fishing boats in Porto da Piedade, municipality of Magé (Source: author's private collection).

Figure 10. Fishing boats in Porto da Piedade, municipality of Magé (Source: author's private collection).

Figure 11. Mangrove in Porto da Piedade, municipality of Magé (Source: author's private collection).

Figure 12. Mangrove in Porto da Piedade, municipality of Magé (Source: author's private collection).

Figure 13. Mangrove beach in Porto da Piedade, municipality of Magé. Although not permanently recommended for swimming, the shore seems to benefit from the central tide current of GB, as shown in Figure 3 (Source: author's private collection).

Figure 14. Mangrove in Porto da Piedade, municipality of Magé (Source: author's private collection).

Figure 15. Pier of Porto da Piedade, municipality of Magé (Source: author's private collection).

7. Final comments

In reference [48] we find for the first time the term "*Ur-entropy*", the eternal entropy that has always accompanied us in everything we do and in everything around us. It is surprising that such a fundamental principle is missing from the syllabus of schools, probably due to the fact that, in our finite condition, we deal very badly with the idea that everything has an end. Truly, the "end" seems an abhorrent topic of popular conversation. This does not mean that we must accelerate the end of things, especially our lives. As thinking beings capable of engendering culture, we should strive to find ways to evolve by creating new, even revolutionary complexities regarding the relationship between man and the Earth-bioshell. This is not only technically and culturally feasible; it is absolutely necessary for us to offer an attractive and healthy positive legacy to all future human generations, particularly those luckily situated on the beautiful shore of GB.

The plastic civilization has already exhausted itself in what it could do without major damage, and has long since crossed the borderline between the reasonable and the absurd. Some timid initial steps towards slowing *Ur-entropy* and to deceive Keynes's Devil have been taken in recent years. In spite of the irreversibility of some predatory anthropic actions, such as the devastation of the Amazon forest and the depletion of important freshwater sources worldwide, it is not everything is lost. The German NGO One Earth One Ocean (OEOO), founded ten years ago by Munich IT entrepreneur Günter Bonin, organized in 2020 AD a major cleaning operation

in GB with the participation of 160 fishermen at approximately US$20 per person (this attitude certainly deserves our applause; even so, it is somewhat embarassing that the initiative of a foreigner is necessary for such a simple realization, which should come from charitable Brazilian entrepreneurs themselves!). Also, some companies have been pro-active in Green-approved practices, such as replacing throw-away plastic cups with waterproof paper-made bags, but we need much, much more to beat the insidious Keynes's Devil. The key, as always, lies in full and honest education, free from the taboos of pseudoscience and in keeping with the modernity of scientific research. GB may still be a paradigmatic example of a new civilization that has learned to control the universal advance of entropy, leaving behind the absolute domain of polymers.

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