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Marine Environment and Public Health

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1. Introduction

The oceans represent a significant source of biological diversity, water, biomass, oxygen, and other important aspects to human health [1-3]. The quality of the ocean is essential for maintaining the planet, and thus to public health. However, the complex and fragile evolutionary stabilization of the ocean and coastal regions has been disrupted by human activities in a short time scale [4]. The vast majority of waste produced by human activities for centuries has reached the oceans, even over long distances and in inhospitable places [3, 5]. In recent decades there have been evident the vast scope of the changes of the marine environment caused by anthropogenic activities, as well as the many responses to these changes that tend to impact ecological processes, putting endangered species susceptible and producing various diseases in the human population [3, 6]. These changes are not restricted to oceanic scale, but are strongly associated with the continents, consequently, strong pressure on the health of terrestrial ecosystems, with impacts on socioeconomic and cultural activities and, finally, to public health. Recently, the trend has grown to incorporate the term health within the definitions of environmental health. The term health of the oceans, the second definition of the Panel on Health of the Oceans (HOTO/GOOS), refers to the condition of the marine environment from a perspective of adverse effects caused by anthropogenic activities, in particular: habitat destruction, changes in the proportion of sedimentation, mobilization of contaminants and climate changes [7, 8].

Indeed, the human utilization of ocean environment has negatively and extensively impacted the ecological system that people are connected. The human activities in coastal zones, such as agricultures, urban development, fisheries, coastal industries and aquacultures, have contributed to chemical, physical and ecological impacts that may be interconnected [8, 9]. For example, the human activities cited generate a significant input of chemical pollutants (e.g. metals, persistent organic pollutants, nanoparticles, radionuclides and nutrients) that is known to impact the biodiversity and the marine ecological system [3, 10].

Marine microbiological pollution represents an expressive impact on biodiversity and human health. The microbiological activity in coastal environment can result in direct impact in human health, but can trigger the biodiversity loss, degradation of ecosystem function and impact in recreation, tourism and human wellbeing [1, 2, 6, 11, 12]. Marine pollution, such as nutrients input, runoffs, and regional and international navigation by ships can load new pathogens to the environment, and the climate change may exacerbate their effects and establishment in an area. For example, the oceans have been identified as the source of introduction of *Vibrio cholerae* that resulted in outbreaks in South America [11, 13]. Potential pathogens from the Family Vibrionaceae and Aeromonadaceae have been frequently identified in coastal humans and marine top predators. It is important to highlight that pathogens of these families are not associated with fecal contamination [1, 3].

The current scenario on the conservation of the oceans has been reflected in numerous human diseases related to marine life. The relationships of the oceans to human activities and public health is already consensus; however, its mechanisms are not well understood due to its complexity. These relationships include the focus on climate change, toxic algae poisoning and chemical and microbial contamination of marine waters and fish (Figure 1) [4, 14, 15].

The marine environment provides valuable benefits for human activities, including protein sources and economic activity through fisheries, aquaculture and navigation. Furthermore, there are the economic benefits from tourism, culture, biomedicine, recreation activities and renewable energy [4, 16]. The oceans represent a great source of biodiversity and play a vital role in water and biogeochemistry cycle. Other human benefits from the oceans are clear, and important for human wellbeing, such as artistic inspiration, increased physical activity and therefore fitness, reduced levels of stress and simply the harmony as a result of healthy oceans and their stable biodiversity [3].

The relationship between public health and the health of the oceans are also growing due to increasing number of people living in coastal areas, mainly in tropical and subtropical regions [1, 3, 4]. In these regions, increases vulnerability to social and environmental stability resulting from natural disasters that involve the ocean and health. It is estimated that world population has reached 6.6 billion in 2007, with a projected growth to 9.3 billion by 2050, developing countries are primarily responsible for this increase [17]. Approximately 65% of the human population lives within 159 km of shoreline with growth estimated at 75% for 2025. In coastal regions the oceans remain an important source of protein, quality of life, recreation, and are an integral part of economic activities in various localities [6, 18].

Coastal residents are highly vulnerable to climate variability and extreme events. As an example, the event of a tsunami in Indonesia has caused at least 175,000 deaths in 2005. In addition to the physical impacts on the health effects of these events, epidemics occur frequently due to the favorable conditions that follow extreme phenomena, and that end up being magnified by the conditions of social and environmental vulnerability of affected populations [4]. Various infectious agents found in marine hosts including bacterial, viral and protozoan result in infectious diseases in humans [19]. The effects of climate and

temperature on disease vectors, such as the growing prevalence of malaria following El Niño events also have been suggested [20].

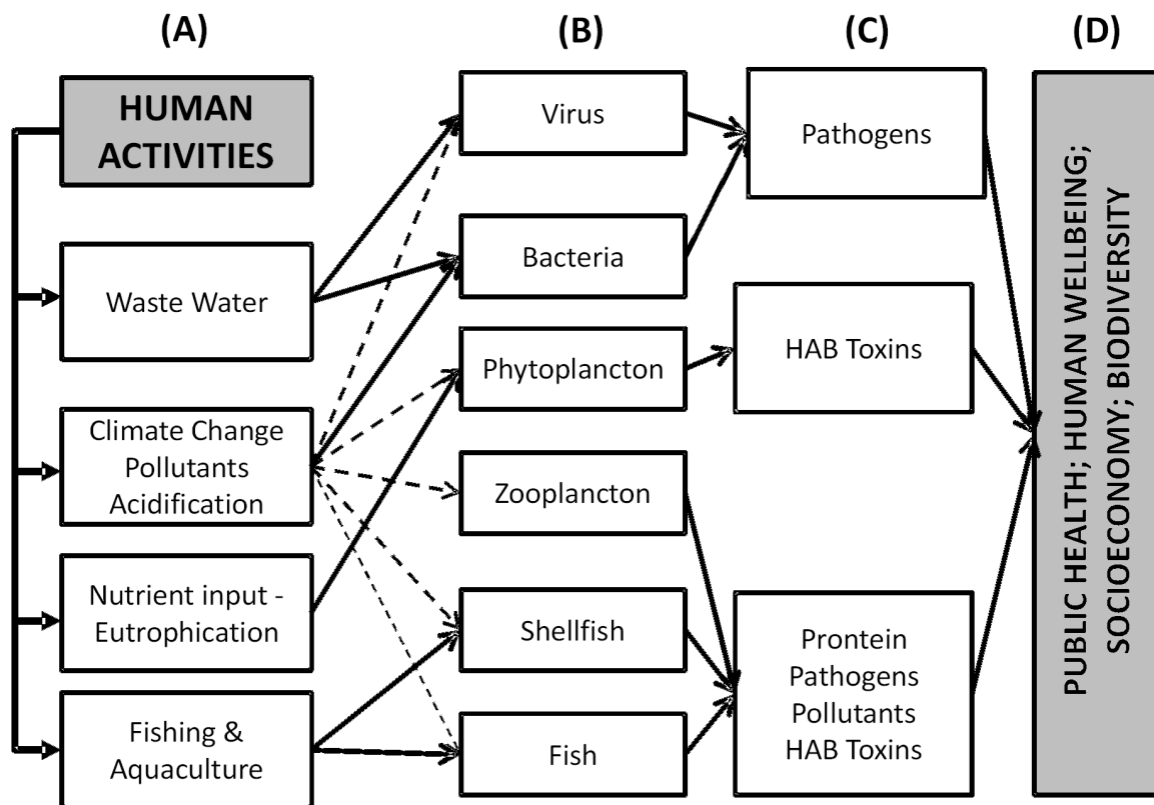


Figure 1. Schematic illustration of the anthropogenic pressures impacts (A) of the marine environment (B) and the subsequent result of the marine biodiversity alterations (e.g. pathogens, HABs) (C) on human health and biodiversity, wellbeing and socioeconomic relationships.

2. Climate variations

The oceans play an extreme important role in the climate by the storage and transportation of heat around the globe. The interaction of the ocean currents and atmospheric winds operate regulating the climate. The marine ecological processes are dependent of the variation of the temperature, as the availability of nutrients that is associated with this factor, and tend to maintain the ecologic stability [4]. An example of an extreme inter-annual variability is the El Niño Southern Oscillation (ENSO).

ENSO is a semi-periodic variability of the inter-annual climate cycle that occurs in intervals of 2-7 years as a result of the discontinuity of the up-welling system in the eastern Equatorial Pacific, forced by the change in wind pattern [20, 21]. The ENSO results in changes in the oceanic temperature and in the atmospheric pressure in the Pacific basin. However, the impacts of the ENSO are not limited to the Pacific Basin, but can influence many continental and marine regions around the globe by changing the atmospheric circulation that disturb temperature and precipitation pattern, resulting in extreme periods and intensity of drought and heavy rains in different areas [20].

Climatic variations triggered by El Niño events are associated with ecosystem changes that results in impact on public health. These climate variations influence the population density and dispersal pattern of vectors, for example, mosquitoes and rodents, which tend to cause infectious diseases in epidemic proportions, such as malaria, dengue and hantavirus [20, 22, 23]. In addition, other diseases such as leishmaniasis and cholera outbreaks have often been associated with this climatic event [23].

Besides the problems related to ENSO events, other extremes events such as drought, have more insidious effects on health for the loss in agricultural production and, consequently, for severe nutritional disorders [4]. Therefore, it is not only direct impacts, but also because it tends to aggravate the socioeconomic structure of the societies affected, causing an amplification of the impacts on public health. In cases of drought triggered by climate variations associated with ENSO forests tend to become more vulnerable to fires, resulting in the massive loss of biodiversity and respiratory diseases linked to poor air quality [22].

The occurrence of El Niño in 1997-1998 resulted in the deaths of more than 21,000 people in 27 countries around the world. Altogether, 117 million people were affected. The occurrence of morbidities as a result of the pressures of these phenomena have affected around 540,000 people, while 4.9 million people were displaced from their homes, becoming homeless [24].

Like the variations, understood as an intrinsic property of the climate system, responsible for natural variations in the patterns observed in geographical scales, global climate changes occur due to temperature rise caused by anthropogenic emissions of greenhouse gases during decades.

Global climate change may have both direct and indirect effects on public health [1, 25]. The greenhouse gases, naturally present in low concentrations in the atmosphere keep the earth's average temperature around 15°C. Without this mechanism of regulation of the global atmospheric temperature, the Earth's average could be -18°C and the planet would freeze, preventing the extensive existing biodiversity [26]. However, the anthropogenic release of greenhouse gases has increased the global temperature resulting in catastrophic effects on human and environmental health, while causing socioeconomic and cultural upheavals [27].

Focusing on disorders caused by the effects of climate change in the long term in the oceans, the Intergovernmental Panel on Climate Change (IPCC) points as main influences the level rise of the oceans, the global temperature increase, the varying levels of salinity, the changes in the circulation of water masses, the decreasing concentration of oxygen, the sea level rise, and probable increase in intensity and frequency of hurricanes and cyclones [28].

One of the most discussed of global warming on the oceans is increasing the sea level. This can have catastrophic effect of introducing salt water into fresh water systems in the continent, affecting the quality and availability of this for consumption [1]. Moreover, according to the fourth IPCC report [28], there is observational evidence that an increase in the number of tropical cyclones in the North Atlantic, which began around 1970, is

associated with increased surface temperature of the sea. Global warming may also promote changes in the general pattern of fecal-oral infections and foodborne illness. It is hoped that the wide geographic distribution (by both the altitude and latitude) of organisms that transmit disease (vectors) not only increase the potential for transmission, but also change the dynamics of the life cycle (e.g., reproduction, survival and potential of infection) of vectors of parasitic infectious organisms [23, 25, 26, 29].

The imbalance in ecological relationships, due to climate change may alter the natural mechanisms of control of vectors and their host organisms, and populations of parasites. In addition, more frequent droughts and rising sea levels may force human populations to migrate to areas where infectious organisms are located, but that currently produce little impact on people. Additional effects include impacts of global change on agriculture, reductions in the ozone layer, economic impacts and increased vulnerability to disease and malnutrition. The many effects of climate change will affect all life forms on Earth, including all its biodiversity and ecological processes.

3. Extreme events

Due to the increasingly human populations residing on coastal regions, extreme events such as tsunamis, tornadoes, cyclones, storms and floods tend to mobilize international public attention due to increased social vulnerability [18, 30, 31]. Extreme events of the same magnitude and similar characteristics, impact differentially the different population groups depending on their level of vulnerability [1, 3, 4, 32]. While the rich industrialized nations suffer most from economic loss as a consequence to natural disasters, the poor and developing countries often suffer from extensive loss of life, incidence of diseases, and loss of social and physical structures [30]. An example is the Indian Ocean tsunami event in 2004, which triggered a series of tsunamis responsible for approximately 220,000 deaths, Indonesia being one of the countries most affected with more than 400,000 homeless.

Natural disasters force a temporary condition of people living in crowded conditions with poor sanitation, poor management of human waste, impoverished nutrition, and incidence of waterborne diseases, low immunity and susceptibility to infectious diseases such as pneumonia, cholera, dengue, malaria, addition of trauma resulting from the magnitude of the events [32]. In addition, extreme events can also interfere in the continuity of health services due to impacts on infrastructure, or force changes of priority in health policies. Some infectious diseases may be aggravated by malnutrition or hunger-related as a result of human migration. Recent studies show that the destructive power of hurricanes has grown around the world, dramatically raising its frequency in the last two decades in the Atlantic [33, 34]. Often the ability to anticipate and respond to natural disasters is based on understanding of climate systems, which depend on the complex interaction of the atmosphere, the continents and oceans. However, usually the main importance is focused on developing and improving measures to prevent population to environmental extremes, there is a need to improve the socioeconomic conditions in order to reduce these impacts.

The Brazilian coast present 8,698 kilometers long of extension, covering about 514,000 square kilometers. The heterogeneity and vulnerability of this coastal region is obstacle for environmental management, principally due to the proportion of the population living in this environment (18%). As an example, 16 out of 28 metropolitan regions in Brazil are located along the coast. Coastal erosion is particularly a phenomenon that results in an elevated risk to the large number of people inhabiting coastal areas along the Brazilian coast [35, 36]. Despite of the widespread range or coastal eroded regions, the configuration of the magnitude of the disasters are not equally distributed. Environmental influences (e.g. wind, wave and wave partners and trends) have been identified as the developer to seashore erosion, but human intervention in the morphodynamic of river mouth or sedimentary flux has influenced such disasters. In Atafona beach, São João da Barra (northern coast of Rio de Janeiro state) the coastal erosion has dramatically impacted the region [37]. The landward advance of the sea has already caused several consequences for local residents, including habitation loss, economical impacts, and historic and touristic impairments. In places where before there were houses and streets, and an established local commerce, is now part of coastal water or shows a scenario of destruction: about 400 houses in 16 blocks away have been demolished by the power of the waves (Figure 2). Atafona is located at the south side of the Paraíba do Sul River, the main river of the Rio the Janeiro state. The environmental variables and anthropogenic influences are thought to trigger the disasters that have been observed since 1950 [37]. The reduction of the fluvial discharge, as result of the human activities along Paraíba does Sul River, has contributed to the degradation of the coastal zone in Atafona. The sea level rise triggered by the climate change probably may influence increasing the impact in the coastal.

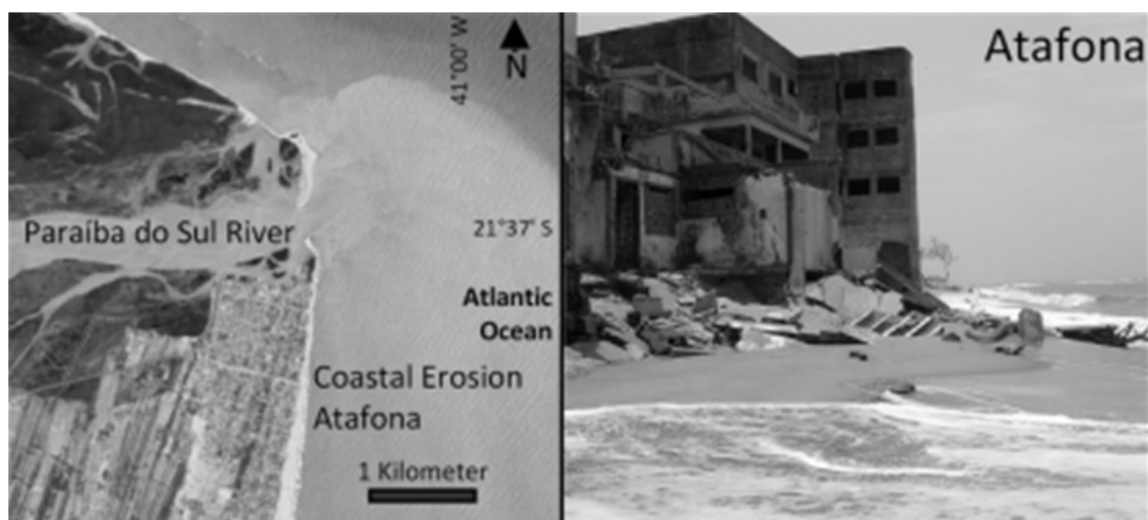


Figure 2. Images showing the coastal erosion caused by the sea energy in Atafona, São João da Barra, northern Rio de Janeiro state, Brazil. Downloaded from: http://viafanzine.jor.br/site_vf/pag/1/na_terra_fotos.htm

4. Harmful algal bloom

The toxins produced by toxic algal blooms (HAB - Harmful Algal Bloom) have the ability to bioconcentrate through the food chain. Therefore, humans, like many other animals that

occupy the highest scales of this chain are vulnerable to the adverse effects of these toxins [3, 38]. The greatest risk of poisoning and gastrointestinal infections are linked to sea food consumption, especially of bivalve mollusks (mussels and oysters), because they are filter feeders, which makes these organisms accumulate large amounts of HABs. Bathers are also exposed to the effects of blooms of toxic algae by ingestion and inhalation of "spray" produced by the action of breaking waves containing HABs [39].

Worldwide, sea weed toxins have been associated with cases of human poisoning and animals fatalities [38, 40]. Moreover, massive blooms of toxic and nontoxic algae can cause sharp decrease of oxygen (hypoxia) in place of occurrence, resulting in massive death of marine life and affecting recreation, fish commerce, tourism and public health [38]. From 5000 species of phytoplankton, about 300 occur in massive blooms and slightly more than 80 are known to be toxic [3, 41]. The HAB species are classified as toxin producers (can contaminate sea food or kill fish) and as high biomass producers (can cause hypoxia or anoxia and die off of marine life, when reach high concentrations) [42]. The "toxic producers" HAB species can cause shellfish poisonings and potential impacts on public health, and the "high biomass produces" are thought to promote massive mortalities of fish and reductions in yields in deteriorated environments.

Some blooms of toxic algae can persist in the environment due to the inhibiting power of the toxins on the growth of other phytoplankton species, or reduce the predation of zooplankton. The human poisonings caused by exposure to HABs cause serious problems to human health, which can lead to death or produce sequels. However, it is not uncommon physicians in coastal regions, where most cases occur, erroneously diagnose the symptoms of poisoning, or attributed other factors to them [43]. In addition, there is evidence that colorectal cancer is strongly associated with the ingestion of biotoxins produced by marine microalgae through the consumption of bivalve mollusks [44]. There are five recognized types of poisoning caused by ingestion of HAB: paralytic shellfish poisoning (PSP), neurotoxic shellfish poisoning (NSP), diarrhetic shellfish poisoning (DSP), amnesic shellfish poisoning (ASP) and ciguatera poisoning (CFP) [1, 3, 4, 6, 38, 39]. Different from the other four types of HAB poisoning the CFP is caused by the ingestion of reef fishes contaminated by toxins produced by dinoflagellates. Therefore the toxin can enter in the food chain and impact top predators, such as humans [42].

Although there is record of HABs before the transformation of coastal ecosystems by anthropogenic activities, in recent decades has increased dramatically the number of problems associated with HABs around the globe. However, part of this growth is associated with the growth of environmental monitoring. A potential route of spread of these organisms lies in the transport of ballast water in ships. In addition, bivalve mollusks commercially introduced for aquaculture in the countries can also carry the organism in various ways [45]. Global environmental changes such as the destruction of reefs, nutrient enrichment of coastal waters by nitrogen and phosphorus, as well as global climate change, may serve to explain the increase of red tides reported worldwide, as well as the growth of human diseases related with exposure to marine toxins or associated with the events. Also, cholera outbreaks have been associated with HABs from the knowledge that marine

copepods are capable of carrying the bacteria *Vibrio cholerae*, feed of algal blooms. Therefore, these blooms can lead to spread of cholera and outbreaks associated with the frequency of flooding and extreme events [46]. Shuval [40] estimated that marine biotoxins associated mainly with blooms of toxic algae cause an estimated 100,000 to 200,000 cases of severe poisoning annually worldwide and approximately 10,000 to 20,000 deaths and a similar number of very severe cases with neurological sequel, such as paralysis. Furthermore, HABs events can produce mass deaths of marine organisms and cause heavy economic losses, mainly in the extractive fishing, aquaculture and tourism [1, 4, 43].

In Brazilian coastal water, toxic algae bloom has caused impacts on biodiversity and resulting economic impairment, principally on aquaculture and fishery activities. In Baía de Todos os Santos, Bahia state (Brazilian coast), a massive mortality of fishes and shellfishes was registered in 2007. About 50 tons of fishes and shellfishes were killed, which resulted in negative consequences for fisheries and aquaculture, due to the prohibition to commercialize organisms for consumption from this contaminated area. Similarly, in Florianópolis, Santa Catarina state, southern Brazil, an harmful algal bloom of pseudonitzschia were identified, resulting in a preventing official measure to protect the population against the effect caused by the event. Despite the identification of harmful algal blooms in coastal regions of Brazil and their association with impacts on biodiversity, few studies have focused to understand the impacts on human health. However, cases of human death have been registered associated with consumption of water from reservoirs with bloom of cyanobacteria potentially hazardous.

A drastic epidemic gastroenteritis outbreak was registered in Itaparica, region of Bahia State associated with the flooding of a Dam reservoir in 1988. From about 2,000 gastroenteritis cases identified, 88 resulted in death along a period of 42 days. Bacterial, toxicological and virological analyses were conducted in fecal and blood samples from the patients, and drinking water was examined for microorganisms and metals. Clinical results were also reviewed to understand and identify the etiologic agent. The laboratory analyses indicated that the source of the epidemiology was water from the Dam, which revealed the presence of high concentrations of toxin produced by cyanobacteria (genus *Anabaena* and *Microcystis*). The cases of infectious disease were restricted to the areas supplied by drinking water from the dam. Also in 1996, 54 fatalities were recorded in Caruaru (Pernambuco state, northeastern Brazil) in hospitalized patients with chronic renal failure. During hemodialysis sessions, the patients received untreated water contaminated with cyanobacteria.

5. Microbial pathogenic pollution

The microbiological activities are of great importance for many ecological processes in the marine ecosystem. Their functions are essential for the maintenance of biogeochemical cycles required for the maintenance of life [48]. Marine ecosystem provides a natural habitat for a range of microbial pathogens such as bacteria, viruses and parasites. Some pathogens inhabit the water, while other can live attached to particles or inside of marine organisms.

High concentrations of these microbes within coastal waters should indicate that the water or even seafood may be contaminated by human waste [1, 49]. However, the use of indicator microbes to test the quality coast waters for recreation and sea food consumption has been questioned, particularly in the subtropical and tropical marine environments, mainly in areas with no point source of contamination identified [1, 50]. An example is bacteria species from the families Aeromonadaceae and Vibrionaceae that are naturally inhabitants of the marine environments. Many species of this family are not related with fecal contamination of coastal waters; therefore, the use of enteric bacteria as indicators of microbiological water quality is strongly limited [1, 50]. *Vibrio* species, especially *V. cholerae*, *V. parahaemolyticus*, and *V. vulnificus*, are frequently associated with infectious diseases through the ingestion of shellfish or even fish [42, 50, 51]. *Vibrio* and *Aeromonas* species are clinically important for humans and biodiversity health, causing gastroenteritis of infections through the open wounds resulting in septicemia. A large number of people worldwide have been impacted by the infections of pathogenic microbes in coastal waters. More than 170 million cases of respiratory and enteric impairments associated with recreation and seafood consumption coastal waters contaminated with infectious microbes have been reported [52]. In the United States (USA) 33% of shellfish harvesting waters are impacted by micropathogens. Currently, 62% of the coastal beaches of the Rio de Janeiro state (Brazil) are classified as inappropriate for recreation, principally due to contamination with fecal bacteria. In addition, 20,300 recreational beach warnings were reported in USA in 2008 due to the fecal microbe presence in coastal waters [53].

In Table 1 we present some results of bacteriological surveys (Aeromonadaceae and Vibrionaceae species) that have been carried out with many specimens of marine mammals, seabirds and sea turtles from Brazilian coast. The microbiological samples were collected during a long term beach monitoring program for research and conservation of marine mammals, seabirds and sea turtles. This monitoring program has been conducted since 1999 by the GEMM-Lagos from the National School of Public Health (ENSP/FIOCRUZ). The bacteriological analyses were conducted in the *National Reference Laboratory for Bacterial Enteroinfections* (LRNEB) from the Oswaldo Cruz Institute (IOC/FIOCRUZ). The samples were collected through the sterilized swabs introduced carefully in the mouth, eyes, nostrils, genital slit, anus and open wounds of sick or recently dead animals. Twenty species of bacteria were detected in the animals sampled, five and 15 belonging to the family Aeromonadaceae and Vibrionaceae respectively. The most prevalent microbial species at the marine animals sampled were *Vibrio alginolyticus* and *Aeromonas caviae*, both representing 69% of detection. Green sea turtle (*Chelonia mydas*), Guiana dolphins (*Sotalia guianensis*) and Kelp gull (*Larus dominicanus*) presented 65, 45 and 35% of the 20 species of bacteria found in the analyses, respectively.

Interestingly, the three more affected species share the same habitat preferences. Both marine species are commonly observed in coastal waters of Rio de Janeiro state and prey on coastal marine food. Kelp gull are commonly found in high density consuming rest of human food at the beach, and coastal dead fishes. It is important to highlight that humans are exposed to the feces of this bird during recreation on the beach. All green sea turtles

sampled were juveniles and use coastal waters mainly to eat sea algae. Many specimens have been found sick and associated with the ingestion of marine debris [54, 55]. Guiana dolphins use coastal estuarine waters where they prey on fishes, squids and shrimps. The most important conservation problems of the species is the accidental mortality in fishing nets, but persistent pollutants seems to be also a problem for the conservation of this species [10, 56, 57]. Simultaneous occurrence of different species isolated were observed in the species sampled what could reveals the possibility of synergic actions. Considering that these bacteria are recognized as emergent pathogens, and the relevance of the findings for public health in light of the growing area of "ocean and human health" we would like to emphasize the importance of this investigation, which indicates the aquatic environment as a possible route of transmission among marine biota, which includes humans. Aquatic animals are prone to bacterial infections in the same way as land animals, especially when they are under stress condition. Disease may occur systemically or be confined to external surfaces such as the skin or gills specially by pathogenic bacteria which are ubiquitous in the environment, or may form part of the normal internal bacterial flora of an aquatic animal [51].

In the marine ecosystem, the distribution of a viral or bacterial pathogen is directly determined by its virulence, as well as the number of susceptible hosts available. This balance between pathogen and host generates and maintains the variety of both groups. In some occasions, this delicate and normal relationship breaks, mainly due to the forces of aggression on the environment or environmental imbalances, resulting in the abundance of pathogens and increased vulnerability on marine biodiversity and public health [48]. Physical, chemical and biological marine environment may influence the number and diversity of marine microbes. However, Wang et al. [58] observed that high levels of organochlorine pollutants have been found in the tissues of Hong Kong's cetaceans, this class of chemical can cause immunosuppression, with an increased vulnerability to bacterial infections. Aquatic mammals are animals sensitive to changes in their habitat and for that reason considered excellent health indicators in environmental monitoring programs.

Ingestion of inadequately cooked seafood exposes people to parasitic infections, particularly with anisakids and cestodes, which reports increase of parasitic contamination in shellfish from polluted waters [1, 59]. In addition, many studies have shown human pathogens emerging in the marine environment and associated with infectious diseases in marine mammals exposed to polluted waters including: giardiasis, papillomavirus, brucellosis, lobomycosis, toxoplasmosis, etc.[60, 61].

Shuval [40] estimated that each year about 2.5 million clinical cases of hepatitis infections occur globally, with about 25,000 deaths and 25,000 cases of liver deficiencies associated with consumption of contaminated seafood, especially mussels. Moreover, this author estimated an overall economic impact of 7.2 billion per year associated with these conditions. Iwamoto et al. [62] showed the report to CDC during 1973 to 2006, 188 outbreaks of seafood-associated infections, causing 4,020 illnesses, 161 hospitalizations, and 11 deaths, were reported to the Food-Borne Disease Outbreak Surveillance System. Most of these seafood-associated outbreaks (n=43; 76.1%) were due to a bacterial agent; 40 (21.3%)

outbreaks had a viral etiology, and 5 (2.6%) had a parasitic cause. Therefore it is necessary to address appropriate studies to characterize the impact over the ocean's capacity to maintain environmental quality important to the health of marine population and the microbiological hazards present in marine ecosystems to prevent outbreaks by seafood consumption and recreational use of these waters.

BACTERIA FAMILY (BELOW)	BACTERIA SPECIES(BELOW)	WHALES	DOLPHINS	SEABIRDS	SEA TURTLES
		<i>Megaptera novaeangliae</i> <i>Eubalaena australis</i> <i>Balaenoptera acutorostrata</i>	<i>Stenella frontalis</i> <i>Sotalia guianensis</i> <i>Pontoporia blainvillei</i> <i>Delphinus sp.</i>	<i>Sula Leucogaster</i> <i>Larus dominicanus</i> <i>Spheniscus magellanicus</i>	<i>Chelonia mydas</i> <i>Lepidochelys olivacea</i> <i>Caretta caretta</i>
AEROMONAD ACEA	<i>A. veronii</i>				
	<i>A. caviae</i>				
	<i>A. hydrophila</i>				
	<i>A. media</i>				
	<i>A. trota</i>				
VIBRIONACEAE	<i>V. alginolyticus</i>				
	<i>V. vulnificus</i>				
	<i>V. parahaemolyticus</i>				
	<i>V. cincinnatiensis</i>				
	<i>V. fluvialis</i>				
	<i>V. furnisii</i>				
	<i>V. mimicus</i>				
	<i>V. harveyi</i>				
	<i>V. mediterranei</i>				
	<i>V. aestuarinus</i>				
	<i>V. pelagius</i>				
	<i>V. campbellii</i>				
	<i>V. hepatarius</i>				
	<i>V. coralliiticyus</i>				
	<i>V. fischeri</i>				

Table 1. *Vibrio* and *Aeromonas* species isolated from marine mammals, seabirds found sick on the beaches along the coast of Rio de Janeiro state, southeastern Brazil.

6. Bioinvasion in coastal systems

The bioinvasion, refers to some exotic species introduced into a new environment, and which for the absence of natural controls such as parasites and diseases, become extremely harmful to local biodiversity, especially in disturbed habitats [11, 63]. When a species introduced into a new environment has success in establishing itself and its population increases, it tends to compete and eliminate native species, or cause damage to local ecology and affect socio-economic pattern and public health [45]. The bioinvasion is considered one of the most important threats to biodiversity and integrity of marine ecosystems, especially in coastal regions. However, this question had deserved attention only after the signing of the Convention on Biological Diversity in June 1992. Bioinvasions have occurred in all regions of the world, and the largest carrier of exotic species to new areas is navigation, where the ballast water of ships acting as a “vector” for introduction of species [63].

Climate change, nitrogen deposition and contaminants in the marine environment appear to help the successful accommodation of invasive species in a new habitat, especially microorganisms [11, 64]. Several marine species have caused heavy economic and ecologic impacts in a habitat invaded. Once established, the elimination of exotic species in the new habitat is very costly or even impossible, therefore, the policies related to bioinvasion have been linked to measures to prevent introduction of exotic species [65]. The exchange of ballast water of ships in coastal areas of a new marine ecosystem is considered the main introduction factor for alien species [11, 63]. One of the main problems of bioinvasion related to public health is the introduction of toxic algae that cause poisoning and other pathogens such as *Vibrio cholerae*, which causes of infection [13, 63, 64].

In 1991, cholera appeared in Latin America, and until recently caused more than 1.2 million of infections and 12,000 deaths. It is believed that Peru served as an entry in the South American continent [63]. However, Brazil has achieved the highest number of cases across the continent in 1993 and 1994, most recently in 1999 on the coast of Paraná, with 467 confirmed cases [13]. There is scientific evidence showing that the first cases of cholera occurred in the coastal ports, which suggests that outbreaks or epidemics could have been caused by the ballast water of ships arriving from endemic areas [63]. In a study conducted by the National Health Surveillance Agency (ANVISA) in 2002 detected the presence of *Vibrio cholerae* and *Escherichia coli* in high proportions in samples collected from ballast water of ships in various ports of Brazil, supporting the hypothesis of ships as carriers of the pathogen [13].

7. Environmental contaminants

Chemical contamination is one of the main challenges for the conservation status of the marine environment. Environmental contaminants have compromised the quality of water and air, affecting biodiversity in ecosystems, contaminating food and endangering human health. The vast majority of waste produced by anthropogenic activities inevitably reaches the oceans and is widely dispersed and may even reach free regions of the release of pollutants, such as the Antarctic region [3, 5, 12, 66, 67].

Approximately 80% of the contamination that reaches the oceans has their emission sources on the continents, via air routes, direct discharges into the oceans by effluents, industrial, agricultural and other sources [68]. The ocean contamination is associated with the concentration of people living in coastal regions around the world [18]. The contaminants of highest concern are those that have environmental persistence, are capable of long-range transport, can biomagnify in food chain and bioaccumulate in humans and animal tissues and have potentially significant impacts on humans and environmental health [66, 69-71]. The sources and amount of emissions are also extremely important. Persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs) and some metals present the chemical characteristics mentioned above.

The human activities have considerably altered the geochemical and biogeochemical cycles of the metals in nature, especially during the last and current century. Once the environment, the metallic elements can occur in various chemical forms and thus may increase or decrease its toxic properties [1, 72]. Mercury, which has been associated with various human health problems, is used in wide range of industrial processes. When released into the environment, bacteria can quickly transform its inorganic form in inorganic mercury (methyl-mercury). Methyl-mercury can concentrate in the marine food chain, and may cause cytotoxic effects, kidney and brain of those exposed [10, 57, 72]. Concentrations 1-2 mg / kg brain tissue may cause neurological damage. Furthermore, due to its ability to cross the placental barrier, methyl-mercury becomes extremely harmful to fetuses exposed [1]. Due to the extensive contamination with mercury, individuals consuming fish (principally predator species) frequently exhibit the highest levels of methyl-mercury in their tissues. Top predator species such as marine mammals, sharks and seabirds present extremely high concentrations of mercury in their tissues, and people that consume meat of organisms from these groups generally are exposed to high concentrations.

The human vulnerability for persistent contaminants in the ocean is strongly linked to the origin and trophic position of the marine food consumed. An example of this is people in Iraq and Japan, which may have higher levels of 50-100 ppm of methyl-mercury in hair samples, when the average concentration of this compound in humans is less than 1 ppm [73]. Cadmium also has the ability to bioaccumulate in the marine environment and is often found in biological samples taken from this environment. Cadmium is recognized as a human carcinogen; however, the increased risk is related to human exposure to this element can lead to proteinuria and renal failure.

Arsenic and lead are also potentially harmful to human and environmental health. These are usually found in living organisms and marine sediments, industrial discharges being a major source of environmental emissions. Several related contaminants have been found in tissues of marine organisms, and in some cases these have been associated with adverse effects on the exposed organisms [3]. One of the variables which can cause confusion and lack of causal association studies is the presence of mixtures of a considerable range of these specific contaminants present in the oceans. This mixture could cause adverse effects acting in concert, and perhaps at low levels, which could obscure associations in studies using only specific contaminants.

Persistent organic pollutants (POPs) pose potential risks to human health and the environment. Exposure to POPs can cause serious human and environmental health impacts including certain cancers, birth defects, dysfunctional immune and reproductive systems and greater susceptibility to disease [1, 70].

The main human exposure to POPs in the oceans is through fish consumption [74]. One of the most relevant POPs even today is the pesticide DDT, which despite its commercialization and application banned in most countries, is still used in some tropical and subtropical nations for vector control, such as malaria [69, 75, 76]. According to the International Agency for Research on Cancer (IARC), DDT is possibly carcinogenic and sub-acute exposures may cause problems in the central nervous system and also impair the immunological integrity. Similarly, PCBs (polychlorinated biphenyls) have caused severe impacts on the exposed organisms and public health, mainly through fish consumption [74].

PAHs are pollutants of great environmental persistence, and together with its derivatives have important carcinogenic, mutagenic and genotoxic [71]. PAHs are formed by thermal transformation of fossil fuels. Thus, forest fires, industrial processes and petrochemical activities are major contributors to environmental contamination by PAHs [1, 71]. These can also be formed naturally, but anthropogenic is that is causing concern. PAHs are highly soluble and rapidly absorbed through the lungs, the intestines and the skin of experimental animals, regardless of route of administration. The carcinogenic effects of some PAHs Of crucial importance to environmental and public health, fish consumption is the main source of human exposure relating to ocean pollution.

8. Oceans for public health and well-being

The oceans have a valuable relationship with human wellbeing through ecosystem services, the source of discoveries for pharmacology and biomedicine, cultural values, and simply the satisfaction of people, which stems from the harmony of healthy oceans and their stable biodiversity. The marine ecosystem services include the stabilization of the coast, the regulation of nutrients and climate, and the management of pollutants, energy resources, and natural products of values for biomedicine, tourism and recreation. Therefore, besides the importance of the quality of the oceans to maintain the integrity of biodiversity residing in this biome, oceans also produce beneficial effects and essential for the maintenance and stability of terrestrial ecosystems to the welfare and human health [2, 3, 42].

The coastal regions provide an important natural place for human leisure, which contribute for both physical and psychological benefits. There is medical evidence showing that the access to natural environments improves health and wellbeing, prevents disease and helps the development of recover from illness. Coastal environments stimulate fitness and leisure activities (e.g. swimming, surfing and coastal walking, beach sports) [42]. These physical and mental exercises can prevent cardiovascular diseases and help to reduce obesity and cancer [42]. In addition, the leisure activities may help to prevent or improve many mental health issues, such as reduction of stress.

Great efforts have been made to evaluate the complex economic values of environmental services and natural resources. Generally, the conservation of the ecosystem is considered more economically profitable than the economic values arising from the acquisition and use of its resources, which often leave severe environmental liabilities [30, 77]. Constanza et al. [77] showed that while the coastal areas cover only 8% of global land surface, the services and benefits from this area are responsible for approximately 43% of the total value of global ecosystem services valued at 12.6 trillion dollars.

In the last six decades there has been a growing interest in bioactive substances with properties derived from marine organisms [1, 4, 16, 78]. Already in the 1950s Bergman and Feeney [79] discovered two drugs of importance to medicine (ARA-C and ARA-A), based on nucleoside present in marine sponges (*Tectitethya crypta* and *Streptomyces antibiotics*). Formulated synthetically from the discovery of these researchers, the Ara-C is indicated for the treatment of non-lymphocytic leukemia, the leukemia meninges and chronic myelocytic leukemia, whereas the Ara-A is indicated for the treatment of viral infections caused by *Herpes simplex* and *Herpes zoster* [4, 43, 80]. Another valuable contribution of importance to medicine was the discovery of azidothymidine, AZT. This synthetic derivative, originating from marine sponges, is currently still one of the most effective drugs in the treatment of acquired immunodeficiency syndrome (AIDS) [43, 80]. From the work of these researchers, scientists began to explore marine biodiversity and its potential for the discovery of new bioactive compounds, aimed at advancement of pharmacology and biomedicine in the treatment of diseases known to cause severe damage on the population. The success of the discovery of new bioactive compounds and their pharmacological effects, extracted from marine organisms has been demonstrated from formulations of new anticancer treatments, and infectious diseases and inflammation [81]. However, much emphasis has been attributed to the discovery of anti-cancer compounds derived from marine organisms due in large part to the availability of funds for supporting studies aiming to find new compounds. The oceans are rich source of chemical and biological diversity, with hundreds of thousands, maybe even millions of new species are still unknown, especially micro-organisms that represent a great opportunity for the discovery of new species and new chemicals. Another approach of extreme importance is the study of marine organisms as a basis for discovery in biomedicine. Research on the natural history, taxonomy, physiology and biochemistry of marine organisms has served as a model for biomedical research to elucidate issues relevant to the physiology, biochemistry and human disease.

9. Conclusions

The pressure of human activities on marine environment generates ecosystem modifications that affect the people depending on the vulnerability of the population exposed. The past and current human development needs great modification to ensure the stabilization and homeostasis of the ocean. In addition, it is important to better understand the dynamic of the marine processes which can contribute to prevent the risks associated with human exposure. It includes the development of a system capable to generate information of a wide range of complex environment processes that should be used to prevent human and

biodiversity impacts. Climate change and other anthropogenic pressures have the ability to influence many environmental factors, important for human health, such as fisheries, HABs, pathogens and contaminants. Environmental models are required to better understand the ocean and ecosystem dynamics, their role on climate change, as well as to prevent impacts resulting from the modifying of ecosystems. The development of indicators is needed to establish measures to study and prevent the impacts of the changes in the oceans on human health. The conservation of the marine environments, principally those with no apparent alterations, are greatly encouraged to avoid human and biodiversity.

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