FATE OF MARINE ECOSYSTEM AND ITS BIODIVERSITY IN ANTHROPOCENE EPOCH

By

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ABSTRACT

Humans have always ignored the sanctity of nature and exploited its resources thoughtlessly. Though humans solely depend on the natural resources but put meager efforts for integrated solution to couple with the natural environment. Now the environment has become overstressed; tropic chains and various biogeochemical cycles in the nature are being interrupted; ecological services are becoming disturbed. Human society has been influenced directly or indirectly by oceans, providing a unique set of goods and services including moderation of climate, food, valuable minerals and medicines, waste disposal, as a large sector for commerce related to fisheries, tourism and shipping and source of employment for a significant population including jobs on ports, harbours and other coastal industries. At present more than 50% of the world's population is residing in the coastal areas which is likely to rise by 75% in 2025. The coastal areas are globally threatened ecosystems associated significantly with environmental and economic costs and will be facing increased water temperature, sea level rise, severity in the frequency and intensity of cyclones / storms, declines in fisheries and coral reefs, coastal habitat loss and displacement of coastal inhabitants.

INTRODUCTION

With the advent of 21st century, we have entered the Anthropocene Epoch, today the mother earth is under siege by the human race. Humans have always ignored the sanctity of nature and exploited its resources thoughtlessly. Though humans solely depend on the natural resources but put meager efforts for integrated solution to couple with the natural environment. We have evolved a culture based on the market economy that has made the society to concentrate only upon more production and consumption, exploiting natural resources indiscriminately and dumping obnoxious by-products in the environment, relying on the nature to recycle. Now the environment has become overstressed; trophic chains and various biogeochemical cycles in the nature are being interrupted; ecological services are becoming disturbed.

The human eye has witnessed dramatic events with the advent of industrial revolution in 1700s when the global population was approximately 800 million. Since then population pressure kept on rising to 2.5 billion in 1950, crossing 6.7 billion in 2008. In the last 150 years 40 percent of the known oil reserves have been exhausted, in the 20th century the use of fossil fuel increased by twenty folds, fulfilling 86% of the world's energy and is likely to rise by 44% till 2020, more than half of the accessible fresh water has been consumed. The total global catch of ocean fish increased from 18.5 million metric tonnes in 1950 to 121 million metric tonnes in 1996, an increase of about 400% and now has gone down to 90 million per annum in 2009. In 2008, the FAO estimated that roughly half of the world's 523 assessed fishery stocks are "fully exploited," meaning that they are harvested at rates near their maximum sustainable limits, while another 28% are "overexploited or depleted," meaning that they are being harvested at rates not sustainable in the long term. The stocks of many high value groundfish have decreased by 70 to 80 % in the last 20 years. According to the "Red List" compiled by the World Conservation Union, 844 animals and plants are known to have gone extinct in the last 500 years (Figures are probably a big underestimate). The current estimate for the pace of extinctions is about 1,000 times faster than the usual natural rate, making the present era the sixth Mass Extinction; after the 5th mass extinction that occurred 65 million years back due to an asteroid collision with Earth, wiping-out dinosaurs along with many other species. The other four mass extinctions occurred about 205, 250, 375 and 440 million years ago. All mass extinctions, except the present 6th one, were due to natural causes.

Human society has been influenced directly or indirectly by oceans, providing a unique set of goods and services including moderation of climate, food, valuable minerals and medicines, waste disposal, as a large sector for commerce related to fisheries, tourism and shipping and a source of employment for a significant population including jobs on ports, harbours, other coastal industries.

The oceanic ecosystem is a key component of the earth system, covering approximately 70% of the earth's surface and playing a major role in regulating the Earth's climate and biogeochemical cycles. Oceans play a vital and pivotal role in the distribution of life sustaining water throughout our planet. The oceans are the planet's largest reservoir of water transferring huge amounts of water around the hydrological cycle. Infact the oceans "dominate the hydrological cycle, for they contain 97% of the global water inventory". The ocean circulation through evaporation and precipitation regulates heat and rainfall distribution around the globe hence controlling flooding and drought in various regions.

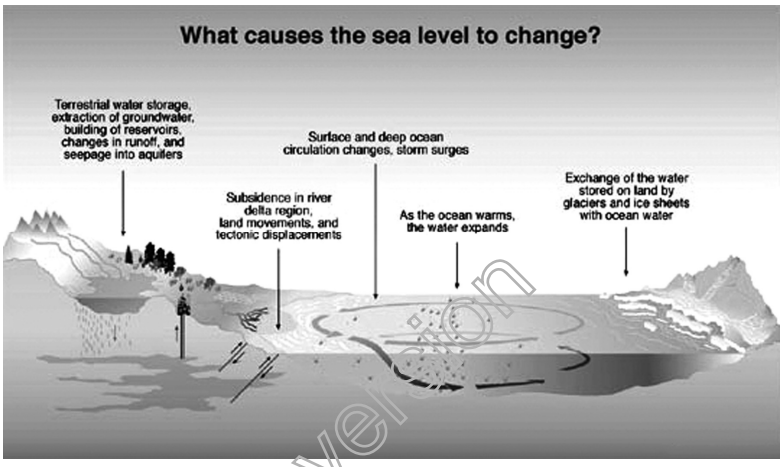

Figure 1. Schematic view of components responsible for change in sea level (Source: IPCC, 2004)

At present more than 50% of the world's population is residing in the coastal areas and is likely to rise to 75% by 2025. These coastal areas are threatened ecosystems on the globe associated significantly with environmental and economic costs and will be facing increased water temperature, sea level rise, severity in the frequency and intensity of cyclones/storms, declines in fisheries and coral reefs, coastal habitat loss and displacement of coastal inhabitants.

Marine ecosystem and its biodiversity are threatened by the fact that many of the goods and services are exploited in a non-judicious and unsustainable manner to an extent that their structure and function is being jeopardized. Threats to marine ecosystem include;

- Changing climate
- Destruction of habitat
- Pollution
- Over exploitation of resources
- Bio-invasion through introduction of non-native species

Changing climate

As a result of the intensified greenhouse effect due to increased emissions of CO_2 and CH_4, **average global temperatures** have increased by ~0.6°C, and 11 of the 12 years from 1995 to 2006 ranked among the 12 warmest years since the year 1850. The sea level has also risen by 0.17 meter due to increase in the global temperature and according to the IPCC prediction the sea level will rise further by 0.2 to 0.6 meters by 2100. The organisms unable to adapt warmer waters will move into new areas/regions from their original habitat while coral communities will

be facing severe consequences due to even modest warming. Corals reefs are referred as the most productive ecosystems on the globe and yet are the most threatened among all marine ecosystems. The temperature rise will lead to bleaching of corals, a process of breakdown in the symbiotic relationship between corals and its algae (zooxanthellae). Due to bleaching the coral appear white, losing growth and reproduction that ultimately lead to death. Worldwide, mass bleaching events occurred during 1998 affecting 80 percent of the corals in the Indian ocean, 20 percent of which died out. During 2005 severe bleaching occurred in Carribbean due to rise in water temperature. In the last three decades 80 percent of the corals have been lost in Carribbean alone.

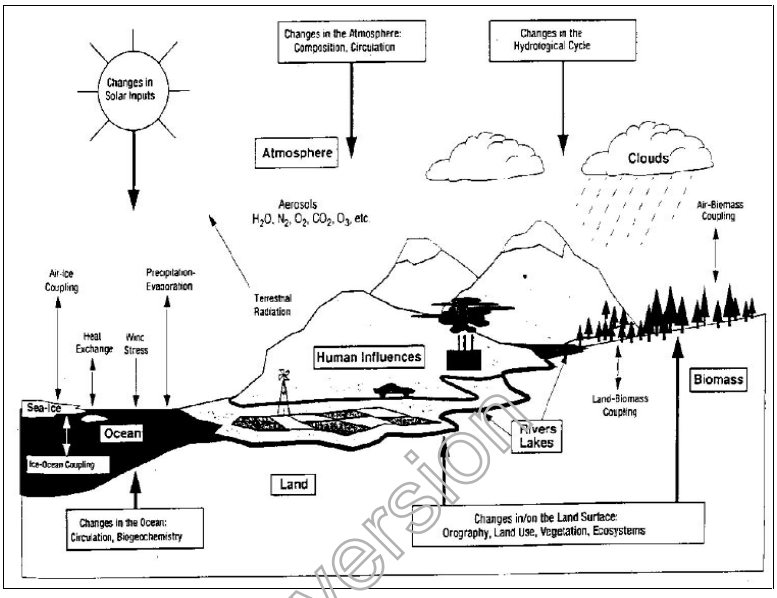

Figure 2. Schematic view of the components of the global climate system (Source: IPCC, 1996a)

The **pH of sea water** is also changing and it is becoming acidic due to increasing CO_2 level in the ocean. It is estimated that current CO_2 level is 380 parts per million which is 30 percent higher than pre-industrial value (CDIAC 2004) and it is predicted that the rate will be tripled by the end of this century. This state of acidic change will be damaging for the organisms performing photosynthesis and animal having calcium carbonate shells e.g. plankton, corals, clams, oysters, shrimps and crabs etc. Increased acidity will reduce the process of calcification which is vital to the biology and survival of certain marine organisms. Less alkaline or acidic state will severely damage the marine food web and trophic levels, as these organisms provide food sources or habitats for other organisms. The phytoplankton play a tremendous role for human beings as their photosynthesis yields oxygen for us besides they are at the base of oceanic food webs and support the global fisheries.

The other major important change expected is in the **global ocean circulation system**, called the thermohaline circulation. This circulation system often referred as conveyor belt that enables warm water to move northwards at the surface of Atlantic Ocean and cold, deep water to move southwards into the Indian and Pacific oceans. The conveyor transports heat into the North Atlantic. Any climate change induced variation in water temperature e.g. greater fresh water input due to melting of ice or higher rainfall would damage the circulation pattern Figure 3).

Similarly, the wind patterns influence the coastal upwelling and biological productivity. Change in the wind pattern will create significant impact through hypoxia events (low oxygen zones) e.g. reported hypoxia events in the Pacific Northwest coast, South America, Southern Africa and North Africa.

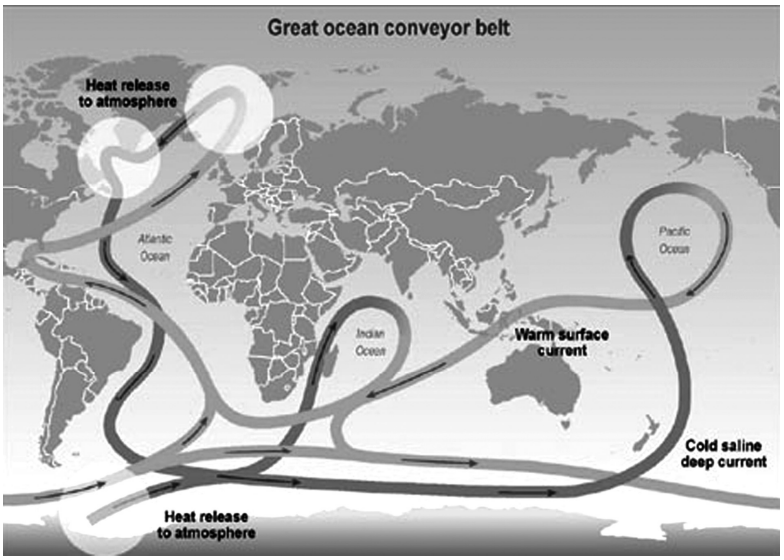

Figure 3. Oceanic conveyor belt (Source: IPCC, 2004)

Destruction of habitat

Habitat loss, destruction or fragmentation is referred as a **modern crisis of marine ecosystem** which is one of the major threats to marine biodiversity. The critical areas include estuarine, swamps, marshes and coastal wetlands, these are the most productive areas serving as nurseries and breeding grounds for nearly all marine species and nesting sites for waterfowl. They also act as buffer for the inland areas against storm, flood and waves, support food production for humans and filter out pollutants. Mangrove swamps and forests are particularly important in this regard. It is estimated that since 1960 approximately 1 kilometer of coastline has been developed every day causing permanent alteration, damage to valuable habitat. There are various sources of habitat destruction including coastal developments and land reclamation for tourism, housing, urban centres, industry, aquaculture, deforestation and mining, injurious fishing techniques like bottom trawling, dynamite or poisoning. Hulls and anchors of boats, container ships and tankers also cause significant damage to the marine habitat.

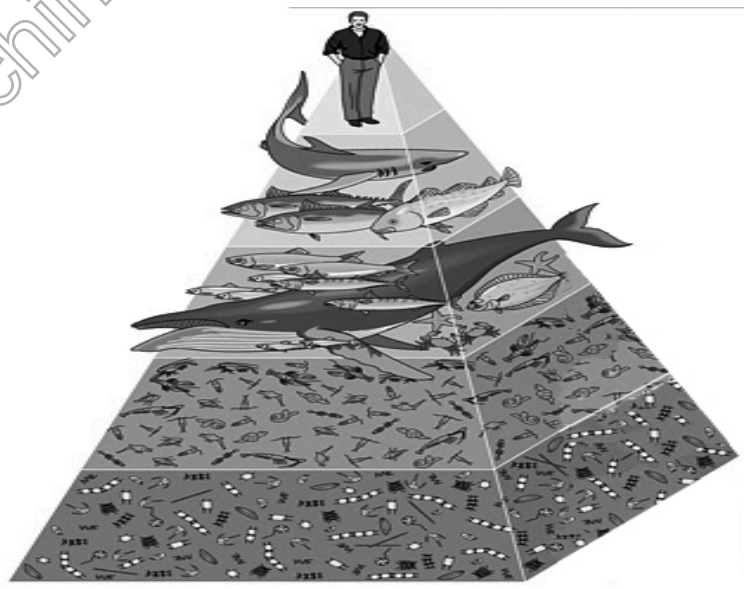

Figure 4. Marine food web or food chain, Human on top of the web, the primary producers autotrophs at the bottom, secondary producers, primary consumers, secondary consumers and tertiary consumers.

According to the current data 20% of the **global coral areas** have been destroyed and there is no evidence of recovery. It further predicts that 24% of the reefs are under imminent risk of collapse and further 26% are under a longer term threat of collapse. And the threat is mainly due to anthropogenic activities including coastal development, destructive fishing techniques, inland pollution and global climate change.

The current **global mangrove area** has now fallen below 15 million hectares, down from 19.8 million hectares in 1980 (FAO 2004). Hence during the last three decades approximately 25% of the global mangrove area i.e. 4.8 million hectares have disappeared from the Earth's surface. The estimated rate of loss of mangrove areas is from 0.67 to 1.03 per cent since1980 to 2005. The rate indicates decline in mangrove areas by 1000 km^2 per year.

Pollution

Pollution has been degrading the pristine wilderness of marine ecosystem since long. It is a serious threat to the global oceans particularly the coastal areas which are most productive areas of the marine environment. Approximately 80% of pollution in marine environment is derived from land-based and human-induced activities. Pollution is responsible for significant effects (lethal and sub-lethal) on marine biodiversity, influencing all the trophic levels i.e. from primary producers to predators on top of the food web. Pollutants, originating from both land and sea disturb the ecosystem functioning through interference in the structure of marine communities.

There is a vast range of types and sources of marine pollutants including organic and inorganic pollutants entering the marine ecosystem through sewage and industrial out falls, rivers inputs, aquaculture activities, spills and accidental flows from cargoes etc. Urbanization of coastal areas with ever increasing population growth, rapid development and weak legislation is the very reason for rise in the level **of marine toxic pollution**. This includes Organochlorine compounds which are a form of persistent organic pollutant (POP) in the environment usually comprise of PCBs (Polychlorinated Biphenols) and Dicholorodiphenyl trichloroethane (DDT), chlordane (CHL), and hexachloro cyclohexane (HCH). Other toxic compounds of particular concern from crude oil are Polycyclic aromatic hydrocarbons (PAHs), Butyltin (BTs) [mono-(MBT), di-(DBT) and tri-butyltins(TBT)]. Higher level of **heavy metals** [Lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), chromium (Cr), mercury (Hg), nickle (Ni) and iron (Fe)] concentration is another major concern in the coastal waters. These transition metals are required sometimes in small amount for metabolic activities but have toxic effects in higher concentration. And source of all these toxins is again anthropogenic activities including vehicular emission, agricultural (fertilizers, insecticide, pesticides), waste discharge from industries, incineration, leaching from dumpsites and landfills, mining, marinas/harbours and shipping industry. The bioaccumulation and biomagnification of these intractable natured toxic pollutants are capable of posing immunotoxic risk, interfering and damaging respiratory, reproductive and nervous systems in molluscs, crustaceans, fishes, shore birds and are transferred to top predators including marine mammals as well as humans, if consumed.

Sedimentation in a marine ecosystem is a form of pollution having a close and direct link to its biodiversity. The sedimentation loads in coastal areas increases greatly due to dredging and mining activities, poorly managed agricultural land, deforestation, reclamation and construction activities. Sedimentation in coastal waters severely affects the marine environment by;

i) affecting benthic organisms physically e.g. due to smothering

ii) restricting larval settlement due to reduction in amount of suitable substrate.

iii) reducing visibility as well as photosynthesis due to increased turbidity.

Tolerance to sedimentation greatly varies among all marine organisms group, including Ascidiacea, Hydrozoa, Porifera, Anthozoa, Bryozoa, Polychaeta, Echinodermata, Crustacea, Mollusca etc. And the differences in response bring changes in community pattern.

Eutrophication is defined as increased level of nutrients (nitrogen or phosphorus compounds) in a water body that leads to high primary production. It is one of the most common and destructive pollutants in the coastal areas where nutrient loading is prevalent. Various kinds of terrestrial waste discharge, including fertilizer, detergents, domestic and industrial sewage and agricultural runoff lead to eutrophication and hypernutrification.

Eutrophication is responsible for phytoplankton blooming in the aquatic environment. And both toxic and non-toxic blooming are harmful for a healthy coastal area. Toxic algal blooming is responsible for a number of health hazards to humans as they enter the aquatic food web. Non-toxic phytoplankton blooms are responsible for clogging of fish gills and depleting oxygen, creating an anoxia or hypoxia state leading to mortality, reducing growth rates and altering behaviour and distribution of fishes.

Over exploitation of resources

Marine fisheries besides a major source of protein to the humans, play a significant role in the oceanic food web and maintain the biological health of oceanic ecosystem. People have fished since the dawn of human history and in present time it is a vital industry that earns over $85 billion annually. The total global catch of ocean fish increased from 18.5 million metric tonnes in 1950 to 121 million metric tonnes in 1996, an increase of about 400% and now has gone down to 90 million tonnes per annum in 2009.

Presently China contributes 25% of the catch, while 70% of the global catch is landed by only 12 nations. In 2008, the FAO estimated that roughly half of the world's 523 assessed fishery stocks are "fully exploited," meaning that they are harvested at rates near their maximum sustainable limits, while another 28% are "overexploited or depleted," meaning that they are being harvested at rates not sustainable in the long term. The stocks of many high value groundfish have decreased by 70 to 80 % in the last 20 years. The FAO warns that the rising demand for fish and fish products, combined with shrinking global catches from declining stocks, will soon lead to the point where there will be a shortfall of fish for human consumption of more than 20 million tonnes each year. Average annual consumption of fish caught in marine and inland waters could fall from 10.2 kilograms per person in 1993 to somewhere between 5.1 and 7.6 kilograms by 2050. This threatens the one billion people, mostly in developing countries, who rely on fish as a principal source of protein.

It is estimated that about 40% of the global annual fish catch i.e. 38 million tonnes is considered as bycatch and left un-managed or unused. This huge quantity of dead or dying fish and other marine organisms are being thrown back to the sea. This is a major damage to the marine biodiversity by altering the sensitive balance of ecosystem and putting several species at risk of extinction besides long term food security and livelihood of fishers. According to a report in Annual review of Environment and Resources 2008, one third of the world's total marine catch is not feeding humans, but livestock including poultry, pig and even farm raised fish. This "forage fish" comprises of sardines, anchovies, herrings etc. In wild these are small schooling fish which serves as an important source of food for other fish species, birds and marine mammals playing vital role in marine food web.

Bio-invasion

Bio-invasion is currently recognized as a major cause of biodiversity loss the world over, second only to habitat destruction. The problem of bio-invasion has attained an enormous dimension in recent times due to faster means of transport, increased international and overseas travel and trade. Alien species are either intentionally introduced for certain purpose which may become invasive after escaping into the natural ecosystems, or more frequently they are unintentionally transported as stowaways, as contaminants with trade commodities or in bilge and ballast water

of ships. The latter is considered as the most important source of the introduction of marine invasive species. In the worst cases, the invasive species may entirely modify the structure and function of an ecosystem resulting in large-scale transformation of environmental conditions of the area.

Non-native, non-indigenous, alien or exotic refers to a species or race that does not occur naturally in an area, i.e. it has not previously occurred there, or its dispersal into the area has been mediated by humans (UKINC 1979 ; IUCN 1987; Holmes & Simon 1996). These non-native, alien species may become invasive and cause depletion of indigenous biodiversity and have the potential to alter the ecological and the environmental conditions.

Ship's ballast water is a major vector for dispersal of invasive marine species around the globe and is one of the most pressing issue / challenge for the marine scientists.

Shipping industry is vital for world trade and is the back bone of commercial transportation by moving 80 percent of the world's commodities. But this trade is causing continued change in the oceanic environment especially the port waters and estuarine ecosystems. This is done through introduction of non-indigenous organisms including phytoplankton, zooplankton, worms, larval mussels, juveniles of crabs and fish, minute jelly fish besides harmful microorganisms (bacteria, viruses). According to the records, a carnivorous North American comb jellyfish was transported to Black Sea, a toxic Japanese dinoflagellate to Australia, Chinese mitten crab to Britain and Europe. Introduction of such non-native organisms have cost millions of dollars in remedial action besides deep and broad ecological damage.

CONCLUSION

Human beings, the oceanic ecosystem and the climate are inextricably linked. Interactions between oceanic water masses drive the climate; about half of global atmospheric oxygen is derived from oceanic ecosystem; and large sectors of the global economy depend on ocean related commerce, including fisheries, tourism, and shipping.

Humans never have believed that they will damage the oceanic ecosystem or will deplete its vast resources but now it is becoming apparent that anthropogenic activities have significantly impacted the oceanic ecosystem. Human induced activities are altering the structure and function of marine ecosystem and its biodiversity is declining very rapidly. Ecosystem and biodiversity need space to develop and recover.

Healthy marine ecosystem is essential for the well being of human society, as it plays a vital role in the functioning of the earth system and provides a great variety of the ecosystem goods and services necessary for the sustenance of human society. Therefore, maintaining marine ecosystem is of vital importance and the interdependence of biodiversity protection and associated ecosystem services should be a priority for concerted action at national, regional and global levels. The oceanic ecosystem can be referred as a **"common heritage of mankind"** hence its judicious exploitation and protection is the responsibility of all the nations, in the north and in the south, rich and poor.

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