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Dead Zones in the Ocean

Shivakrishna A*, Edla AP and Nathaniel TP

The Indian Council of Agricultural Research, Central Institute of Fisheries Education, India

***Corresponding author:** Avadootha Shivakrishna, ICAR, Central Institute of Fisheries Education, Versova, Mumbai, India, Email: avadootha.frmpa804@cife.edu.in

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Abstract

The dead zone, a hypoxic zone, is a region of low oxygen that results from runoff of high nutrients, such as nitrogen and phosphorus. Most of the marine life cannot survive in hypoxic conditions. Dead zones in the coastal oceans have spread exponentially since the 1960s and have serious consequences for ecosystem functioning. The formation of dead zones has been exacerbated by the increase in primary production and consequent worldwide coastal eutrophication. Enhanced primary production results in an accumulation of particulate organic matter, which encourages microbial activity and the consumption of dissolved oxygen in bottom waters. Dead zones have now been reported from more than 400 systems, affecting a total area of more than 245,000 square kilometers, and are probably a key stressor on marine ecosystems. Many factors influence the formation of dead zones in oceans. These Dead zones are reversible when the oxygen availability is revived. Dead zones are generally found near highly populated areas and even near coastlines. There are four types of dead zones that are Permanent, Temporary, Seasonal and Diel Cycling. Dead Zones have a profound and diverse effect on the marine environment.

Abbreviations: OMZs: Minimum Zones; MPIMM: Max Planck Institute; NIO: National Institute of Oceanography; SDU: Southern Denmark.

Short Communication

Our oceans occupy nearly 71% of the earth's surface and represent 90% of the biosphere holding nearly 97% of the total water on earth. Despite this mind-blowing numbers, only 20% of the world oceans have been mapped and studied till date. However, it is proven fact that these massive water-bodies maintain climate equilibrium by acting as a massive carbon sink sequestering atmospheric carbon while providing 70% of the oxygen we breathe. From drifting microscopic planktons to the world's largest animal, the ocean hosts a diverse range of biome flourishing with life and nutrients through deep and wide stretches of its extension. They provide a livelihood for millions of people around the world in sectors of food, energy, mining and transport. They are inseparable entities for human life. Humans, in reply, have accelerated the rate of ocean deterioration during the industrial revolution. Nitrogen usage is dramatically increasing since 1985. Globally humans release about 160 million metric tons of nitrogen every year. Oceans are getting acclimated with the harmful waste of anthropogenic origin such as Agriculture, Mining, Sewage, Industrial effluents, transportation, etc. containing a rich source of nitrogen, phosphorus & other nutrients, which in water leads to eutrophication, characterized by massive blooms of phytoplankton. These outbursts of plankton at the top of the food chain utilize all oxygen for their proliferation in the system leading to a hypoxic condition, causing death to other animals in the food chain. Finally, the bloom destabilizes by utilizing the nutrients and disappears leaving behind inanimate zones. This phenomenon of formation of oxygen less zones in water bodies and are called as "Dead zones". Many factors influence in the formation of dead zones in oceans. They may be natural, manmade or combination of both and vary in size ranging from 1sq.km to 20,000 sq. km. Dead zones are observed naturally in oceans, which include the Bay of Bengal, Atlantic west of South Africa. These Dead zones are reversible when the oxygen availability is revived. This article sheds light on the characteristic features and impacts of dead zones.

Distribution

Dead zones are generally found near highly populated areas and even near coastlines. Dead zones are not just seen in oceans but in many freshwater bodies too. The first dead zone to be located was, Chesapeake Bay in the east coast of U.S. Since then many dead zones have been reported in the Baltic Sea, Scandinavia's Kattegat Strait, the Black Sea and the northern Adriatic Sea. At present, there are approximately 405 dead zones in the world and many more are in the rise. The Arabian Sea hosts the largest dead zone in the world, 'The Gulf of Oman'- 63,700- Sq. miles and the second largest being 'The Gulf of Mexico'- 6000 Sq. miles. These oxygen minimum zones (OMZs) characterized by Hypoxia, which is a low level of dissolved oxygen and Anoxia, which is near zero levels of oxygen, occurs in the water column at intermediate depths of 200 to 1000 m.

Types of Dead Zones

Since dead zones are reversible, they are classified based on their occurrence period. Some dead zones last longer than others, some only exist for a short time before disappearing. Thus, scientists have categorized Dead Zones into 4 broad types: Permanent, Temporary, Seasonal and Diel Cycling. Permanent dead zones are areas experiencing constant hypoxia throughout the year, e.g. The Black Sea in Europe, Calico basin in Venezuela, Kyllaren Fjord in Norway. Temporary dead zones are characterized by hypoxia lasting from hours to days. A 300 square kilometer dead zone found in near Oregon is one of its kinds. This dead zone is seen only in summers and that too for a specific time. Seasonal Dead zones are areas with seasonal hypoxia occurring every year, during the warm months (May-August) governed by Oxygen solubility [1-5]. Oxygen is more soluble in cold water, and solubility decreases as temperature increases during warm months, e.g. Seta Island Sea in Japan, Baltic Sea in Northern Europe and The Chesapeake Bay in the US. Diel cycling dead zones are characterized by a specific seasonal dead zone that becomes hypoxic only during the night e.g. Waquoit bay and Wells inlet in the USA. Causes and the formation of Dead Zones: The dead zone is progressed through the formation of hypoxic zones in the water column. There are two main factors for dead zone occurrence; they are man-made/ anthropogenic and Natural. The natural process occurs in n fjords, deep basins, open ocean and upwelling areas due to, slow water mixing and circulation, Changes in the weather pattern, High algal growth favored by an increased load of carbon and nitrogen causing altered native life composition. Human-induced factors are mainly attributed by the changes made during the industrial revolution, which includes, construction of dams altering the course of rivers flow, induction of global warming through human activities, oceanic pollution through the discharge of nutrient-rich waste favoring eutrophication and alteration in the marine environment via overfishing etc. These factors act together synergistically to boost the formation of hypoxic zones leading to the formation of dead zones. Initially, the surplus of carbon and nitrogen load deposited in the ocean by the above factors leads to eutrophication- a condition where there is an unprecedented increase in the growth of primary producers, algae and planktons. Their proliferation in the shallow water column favors the progression of hypoxia in four phases. In Phase One, the algal blooms utilize all the oxygen in the water and DO levels get depleted if the water column stratifies. In Phase two there is stratification induced hypoxic stress-causing mass mortalities to aquatic life. In Phase three the hypoxic zones become seasonal or periodic depending on the oxygen availability and in phase four hypoxic zone expands leading to Dead zone formation.

Effects of Dead Zones

Dead Zones have a profound and diverse effect on the marine environment. Despite causing mortalities seasonal and diel dead zones may cause problems to the organisms in the long run. This chronic hypoxic condition may alter the natural physiology of the animals causing change is sex determination and differentiation. It has been found that hypoxic conditions favor the development of testes in juvenile female fishes in course of growth to adapt themselves better to the resource available. It is natural female fishes need more nutrients, energy and favorable environmental conditions to achieve their reproductive success, compared to male fishes. A study found fish developed reproductive organs more similar to testes instead of ovaries when living in hypoxic conditions. Low oxygen content in water leads to reproductively problems in marine organisms by decreasing the size of reproductive organs, many eggs and spawning activity. Hypoxia causes Sexual deformities in fish [5] and Shrimp, make them grow more slowly, or stop growing in larger dead zones fishes try to escape the suffocating locations but often become unconscious halfway and eventually die.

Pelagic species will experience habitat compression when hypoxia makes deeper alterations in the nutrient biogeochemical cycle. It can shift dominant fish stocks from demersal to pelagic. Slow-moving Creatures like Clams, oysters and other bivalves can survive for hours to days by closing their shells, ceasing to filter water, and going into a dormant state in hopes that normal oxygen conditions will soon improve however, they too will die if hypoxia lasts long enough. With the initial lowering of oxygen concentrations, worms and other animals that burrow deep in the mud will migrate closer to the surface in search of more oxygen this makes them more vulnerable to fish that are capable of surviving temporarily in low oxygen conditions. Similarly, when fish and mobile invertebrates that rely on hiding from predators along the bottom swim out of a hypoxic area in search of more oxygen, they generally become more vulnerable to larger fish that will eat them. Hypoxia can harm biodiversity, ecosystem function, and human wellbeing. In the black sea, the commercial fisheries diversity declined from some 25 fished species to about 5 in 20 years (the 1960s to 1980s), while anchovy stocks and fisheries increased rapidly [6-10]. This makes it harder to find bigger shrimp, inflating the price of large shrimp for consumers. Thus, Hypoxia Affects the Food Chain, economy and overall well-being of the environment.

Impacts of Dead Zones

Environmental Impacts: This eventually sparks the eutrophication process. Marine organisms die or suffer serious health problems as algal blooms create toxins which are absorbed by marine life. Social Impact: Humans are exposed to toxins through contaminated water or fish. Eutrophication is greatly caused by contaminated local water from factories, farms, sewage, homes, etc., entering the ecosystem and disturbing its cycles. Economic impact: The fish industry takes the greatest hit in terms of the economic effect caused by eutrophication favored decline in fish populations affecting fishing industries.

Dead Zones in Indian Waters

Dead zones are found in the in middle of Bob- 100 to 400 in-depth and are steadily growing with around 60,000 square kilometers dead zone [11-14]. This research was conducted as cooperation between the University of Southern Denmark (SDU), the Max Planck Institute (MPIMM) for Marine Microbiology in Bremen and the National Institute of Oceanography (NIO) of India. "The Bay of Bengal has long stood as an enigma because standard techniques suggest no oxygen in the waters, but, despite this, there has been no indication of nitrogen loss as in other 'dead zones' of the global ocean". The study demonstrates that oxygen is not 'completely' removed from the dead zone of the Bob, but is present in very small amounts.

How to Fix a Dead Zone?

Since dead zones are reversible, hypoxic conditions were disrupted in the fall by tropical storms or cold fronts which increase wind and wave action, which increases mixing in the entire water column. The Black Sea was once the largest dead zone in the world, but during 1991-2001, fertilizers stopped entering the ecosystem resulting in a reversal. In the U.S., dead zones have also been reduced in the Hudson River and San Francisco Bay following clean-up efforts. The following steps can be followed to prevent the occurrence of dead zones in the ocean;

- Voluntarily stopping fertilizer and waste runoff into lakes, rivers, and streams.
- Using fewer fertilizers and adjusting the timing of fertilizer applications
- Monitoring of septic systems and sewage treatment facilities
- Building wetlands around the rivers would encourage the natural denitrification that occurs in such ecosystems.
- Buffering rivers with grasses to absorb the nitrates would also help.
- Enact laws to prevent fertilizer and waste runoff.

These solutions are relatively simple to implement and would significantly reduce the input of nitrogen and phosphorus.

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