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CONNECTING OCEAN AND SPACE: SOLUTIONS FOR THE SUSTAINABLE FUTURE OF MANKIND

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Abstract: The rise in global population, industrialization, and consequent environmental damage have threatened the survival of humans and the entire biosphere on land. Both outer space and the ocean have a load of hidden secrets. With advanced technology, we have been able to explore both of them roughly to the same extent and we are likely to uncover more. The present study provides a perspective on the current status, limitations, and prospects of the oceans and outer space as sustainable resources for mankind.

***Index Terms* – patents, aquanaut, microgravity, marine resources, outer space, solar cells**

I. INTRODUCTION

We, humans, are a curious species on Earth. Human beings have been exploring the earth, oceans, and recently far outer space. The rising population on earth has led to the idea of finding space or even deep oceans as an alternative sustainable resource for the future (Times Higher Education, 2022; 1). Both outer space and oceans are largely unexplored which makes one wonder as to which is more beneficial for us, the voids of space or the depths of the ocean (Earl, 1986; 2).

II. WEALTH OF OCEANS AND THE OUTER SPACE: SUSTAINABLE FUTURE

Innovation comes from the unknown. While the oceans are predictable to some extent after years of research, the opposite is true for outer space. Even a tiny piece of stone floating around in outer space creates inquisitiveness for space explorers. The name given to our planet Earth, viz., 'The Blue Planet' is justified not only visually when astronauts observed a blue sphere from space, but also due to the earth's oceans covering over 70% of the earth's surface. Our life on land is highly reliant on life underwater ranging from the surface of oceans to deep-sea life. In addition, oceans play a key role in regulating the weather and climate on earth (Takahashi, 1991; 3). The balance in the earth's atmosphere is also a contribution of the oceans as they absorb almost 50% of carbon dioxide and half of the oxygen in the atmosphere is released by marine photosynthetic organisms. While the oceans are vital for life on earth, the influence of space on our planet remains enigmatic. With the universe growing each second, our knowledge of its constituents keeps changing rapidly. The most popular model of outer space predicts that the universe comprises dark energy, dark matter, and normal matter (including stars, galaxies, planets, human beings, and all other visible objects).

Space exploration allows scientists to see everything that's in front of them. In recent years, space exploration is making enormous progress in looking out at great distances using dynamic telescopes, leading to discoveries about the vast universe (Britannica, 2022; 4). Space research has led to the development of a Global positioning system (GPS), accurate weather prediction, solar cells technology, and ultraviolet filters. Space exploration by humans has advanced our knowledge about comets, meteors, and asteroids, and even predicting if asteroids are going to hit the earth. A massive asteroid collision with the earth could be disastrous, mimicking a situation similar to what happened with the dinosaurs on this earth. The satellites deployed in space play a critical role in interpreting climate change and calamities, ocean monitoring like sea surface height, and disaster management.

Despite the advent of modern space technologies, over 96% of the visible universe, "the dark matter" remains unknown to humans. This calls for enormous efforts of space scientists, aerospace, and aeronautical engineers to shed light on the dark matter of the universe.

III. CHALLENGES OF EXPLORING THE OCEANS AND OUTER SPACE

Our perception of ocean exploration needs serious rethinking. Even though it might seem like we have discovered the environment inside the great depths of our oceans, more than 95% of it is still unexplored. Charting water temperatures, water levels, or colors is something we've been doing for years; however, the decline in light penetration below 200 meters makes imaging difficult to impossible, thus, most of the ocean depths remain hidden. Moreover, exploring the deep abyss of oceans is dangerous due to the increasing pressure with increasing depth of oceans and seas. Ocean exploration missions worldwide have unraveled several marine species with economical and medicinal benefits such as food, anti-cancer, anti-microbial, etc., which is just the tip of the iceberg and less than10% of the life underwater. Oceans offer a valuable and sustainable source for the survival of mankind and future generations. Currently, when the earth is undergoing changes including global warming and climate change, it is necessary to learn about our home planet just as much about the outer universe. The protective ozone layer's depletion due to global warming has resulted in harmful effects of UV rays to threaten marine ecosystems. Scientists have discovered a decrease in phytoplankton production and severe damage to the early developmental stages of marine animals. These effects of UV exposure could eventually lead to severe implications on the marine food chain. The importance of the marine food chain is often overlooked. Thus, the protection of ocean habitats is crucial as they could eventually affect their connected food webs and balance in the atmosphere. The "Inner Space" is a project that must be focused more over the much longer "Outer Space" project. We are still unaware of the secrets that lie below the thick layers of this blue vastness; they may disappear before we even knew they existed.

The exploration of oceans and space draws many parallels. For example, before the outer space journey, astronauts are required to undergo scuba diving experience to provide a similar condition to what they are about to experience in the conditions of microgravity in space. This can be easily achieved by their training underwater in a neutral buoyancy training facility with analogous conditions of pressure, temperature, movement, and visibility. Whether we talk about deep-sea submarines or spacecraft in space, survival in both of these deadly environments can be strenuous with health hazards due to extreme conditions of temperatures and pressure. Both outer space and deep oceans pose opposite extremes of temperature (Figure 1). As shown in figure 1, the temperature at altitudes beyond the Earth's atmosphere is exceedingly high (Red zone in the heat map of Fig.1A), while as we go deeper toward the ocean beds, the temperature reaches the freezing range (Dark blue zone in the heat map of Fig.1B). Exposure to charged particles of radiation is a serious health risk in outer space faced by astronauts, which is shielded by our atmosphere of the earth and thus not seen on earth. These can lead to long-term health problems like cataracts, skin cancer, etc., due to which astronauts are usually not allowed to stay up in space for more than six months. Microgravity is another cause of havoc in space missions. To prevent the breaking down of muscles, kidney stones, and muscle loss, astronauts are required to undergo exercise for at least 4 hours a day. Due to these limitations, the maximum time a person has spent in space is 420 days. Similarly, the ocean poses severe risks including a pressurized environment and high humidity, which can cause lung damage and bends, infections, paleness, vitamin D deficiency, and nitrogen narcosis/ depth intoxication in ocean divers and aquanauts. Over 500 humans have been to space, while only three humans have been able to go to the bottom of the ocean to date, with the longest record of a human underwater being 31 days.

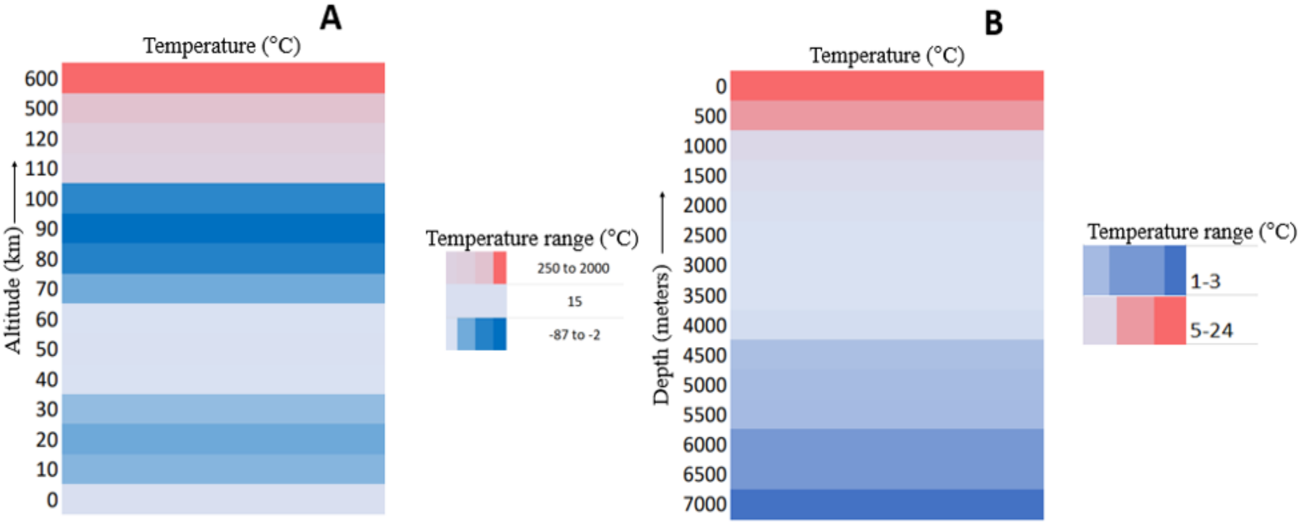

Figure 1. Temperature (degree Celsius) difference across ocean depth (meters) and space altitude (kilometer). The data for temperature difference across the depth of ocean and space altitude was collected from https://www.eoas.ubc.ca/courses/atsc113/flying/met_concepts/03-met_concepts/03a-std_atmos/index.html. The heat map was generated using Microsoft Excel. The color code for the temperature range is indicated by the color scale on the right. **Panel A** is a temperature heat map among different altitudes in space whereas **Panel B** is a temperature heat map across the increasing depth of the ocean.

Regardless of the expansion of our knowledge about underwater and space, there is a huge gap in our knowledge that requires future research. To date, space exploration has been facilitated by rockets with a speed of 1 mile an hour and a fuel efficiency of 13 meters per gallon, which is very low. It costs millions of dollars altogether to get the spacecraft into outer space; moreover, the time required for a successful space mission is indefinitely long. Similarly, very few underwater habitats have been explored, the renowned one being the Mariana Trench, the deepest trench with a depth of 10,984 m (6.82 miles) harboring marine living organisms, including microbes (THE, 2022; 1). Further advancement in marine technology related to ocean satellites, deep sea submarines, and sonars will help us to discover more of the ocean surface and map a greater percentage of the ocean's floors.

IV. Status of Ocean and Space Research

In this study, the quantum of the research in the areas of space and oceans was compared using patent and publication searches. The analysis showed that the research output of both patents and publications is greater in the area of space compared to ocean research (Table 1; Figure 2). Accordingly, space exploration funding dominates the ocean exploration budgets by 150 folds (The Center for American Progress CAP, 2013; 5) (UNESCO, 2020; 6). This variation is due to dissimilar conditions faced by aquanauts. High cost, lack of investment, limited technological advancements and extraordinary physical challenges block us from peering up and trying to discover what is "out in space" and peering down and trying to discover what is "beneath the ocean". Solutions to our greatest challenges may be miles beneath us through discovering a whole new universe here on earth.

Table 1: Summary of the number of patents and publications related to space and ocean research. The patent data was extracted from Google patents while the publications data was obtained using the PubMed search engine using the indicated keywords related to space and ocean (data as of October 2022).

Areas	Search Keyword	Number of Patents	Number of Publications
SPACE	Astrobiology	134	5840
	Planetology	335	374
	Microgravity	69160	12529
	Satellites	133606	45041
	Space research	135828	224152
	Outer-space	136358	7737
	Space colonies	163188	1885
OCEAN	Paleoceanography	16	87
	Mariana Trench	273	189
	Oceanology	29750	6862
	Marine resources	73233	30379
	Aquaculture	112808	42411
	Ocean technology	132724	29301
	Marine food	135829	32806

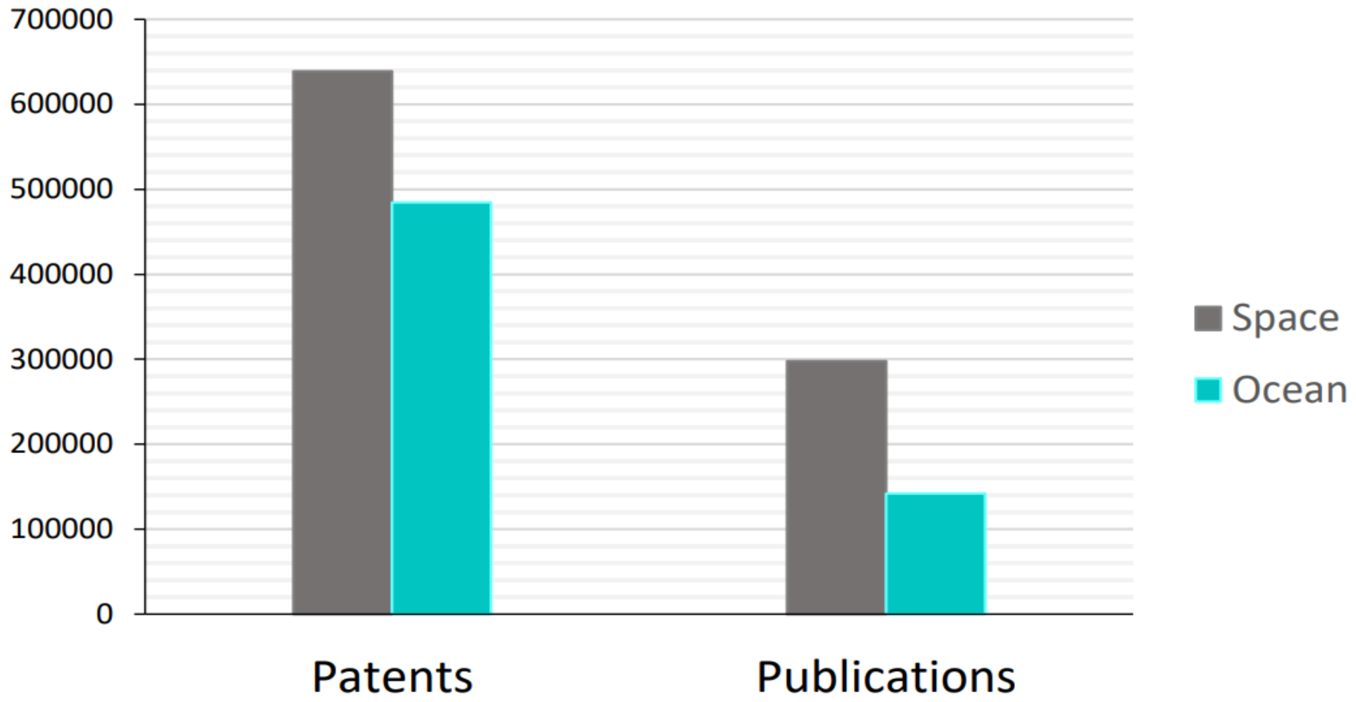

Figure 2: The total number of patents and publications related to space and ocean research. The data in table 1 were summed up and the total patents and publications in space (grey bars) and ocean (green bars) research are shown. Updated as of October 2022.

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