THE OCEANS

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Summary

Covering some 71 per cent of the surface of the Globe, oceans are regarded as the last remaining major frontiers on Earth for the exploration and development of resources which are capable to sustain mankind in the future. Throughout the world, there is mobility on the part of people to coastal areas and with them go their social and economic activities. Indeed, most large cities are ports, either near a river mouth or on a bay. However, while today half of the world's population is living within about 100 km of the shore, in the past the oceans were considered a hazardous environment for Humans due to their strong currents, storms, tidal waves and ice. The ability to make increased yet more effective use of the oceans has only come from advances in such sciences as physical oceanography, marine chemistry, marine biology and marine geology and the development of ocean engineering. Yet, such headway in that direction has been accompanied by mounting concerns for the health of the oceans due to the discharge of wastes, the accidents at sea, the destruction of such habitats as coral reefs and even due to climatic changes.

The modern era of ocean sciences began in the years preceding the Second World War, and resulted in a basic understanding of the open oceans, continental margins and the marginal seas. More recently, several major international programs have been investigating the role of the oceans in global cycles of carbon and nutrients.

The carbon cycles involve the uptake of carbon dioxide by plants that use it in the photosynthetic process. Carbon dioxide is returned to the ocean water primarily through the respiration of plants, animals and bacteria and secondarily by the breakdown of dissolved organic materials by enzymes present in the cells of organic tissue.

A rapid rate of carbon dioxide consumption which results from an increase in phytoplankton leads to an increase in pH as bicarbonate ions change to carbonate ions. A high rate of respiration which produces unusually high concentrations of carbon dioxide drives the pH to lower levels, approaching a neutral value of 7. Extreme ranges of pH are rare in the oceans due to the buffering capacity of the carbon system that quickly restores the water to values within the pH 8.1–8.3 range. This process is very important as most marine life survives only within this narrow pH range.

Another factor that is very important for life in the oceans, and in fact for all life on Earth, is temperature. Oceans play a major role in controlling temperatures, both in air and in seawater. For instance, evaporation provides a continuous air conditioning effect on tropical sea surface temperatures. On the other hand, warm currents such as the Gulf Stream and the Kuroshio warm the high latitudes. In short, the oceans make the climate on Earth tolerable for living organisms.

The climate, however, has been altered by human activities like the burning of fossil fuels and the clearing of forests. These activities release a large quantity of carbon dioxide into the atmosphere. As the major greenhouse gas, the build-up of carbon dioxide has started to warm the earth with some detrimental effects. Eventually, on the order of several thousand years, all of the released carbon dioxide will be absorbed by the oceans but the process has still not been thoroughly investigated. International cooperation is needed for us to fully understand and solve this problem.

1. Introduction

There is a tide in the affairs of man,
Which, taken at the flood, leads on to fortune;
Omitted, all the voyages of their life
Is bound in shallow and miseries
On such a full sea are we now afloat;
And we must take the current when it serves,
Or lose our ventures.
Shakespeare in *Julius Caesar*

The oceans cover 70.9 per cent of the surface of the Planet Earth, or rather, the Planet Ocean. Indeed, of all the bodies in the solar system and of all the planets of which Humans are aware, only the Earth is wet. Observed from space, the Earth is distinguishable as the blue planet, the one with the ocean as its most dominant external feature. In fact, if the surface of the Planet Ocean were perfectly smooth, - that is, it were laid flat and smoothed out - its solid mass would lie under more than two-and-a-half kilometers of seawater.

The first crust of the Earth is thought to have formed about 4.6×10^9 years ago. Gases that had been trapped inside, including water vapor, soon burped to the surface and formed the atmosphere. Initially the clouds were too hot to produce rain, but after millions of years, the upper clouds cooled enough to form rain, hot rain that is. The rain boiled on the hot crust and revaporized for millions of years until the crust became cooler, thereby allowing some fresh water to accumulate in basins. As a result, the embryo ocean was born some 4×10^9 years ago! As water was then starting to accumulate, the ocean grew deeper and deeper. The weathering and the dissolution, or breaking up, of rocks by rain, the accumulation of water, outgassing and the activity of hydrothermal vents added dissolved salts and transformed fresh water into seawater.

Marine science, or oceanography, as it is often called, refers to the scientific investigation of the oceans, their biota, or plant and animal life, and physical boundaries with the solid Earth and the atmosphere. It is no different from other scientific fields in its use of scientific methods: descriptions lead to the formulation of hypotheses and the testing of these using sophisticated experimental design. In some areas of ocean research the descriptive stage is far from being completed in great part because of the vastness of the oceans. Furthermore, as in other earth sciences, the testing of hypotheses can only occasionally be accomplished by the traditional type of laboratory experiment where the determining variables can be controlled. More commonly, a 'biogeochemical experiment' must be employed where the experiment is performed by nature itself, and the scientist is restricted to observations of its various phases at limited times and locations.

Oceanography embraces all studies pertaining to the sea and integrates all the knowledge gained in the marine sciences that deal with such subjects as ocean boundaries and bottom topography, the physics and chemistry of seawater, the types of currents and the many phases of marine biology. The close interrelation and inter-dependence of the individual marine disciplines have long been recognized. As scientific problems in the oceans tend to involve more than one science, their solutions often call for collaboration among oceanographers with different backgrounds, experiences and skills. Aside from this, because of the large scope of many oceanic processes and the fact that their occurrence and location seldom occur within the limits of one state's jurisdiction, marine science depends heavily on international co-operation.

Processes and phenomena covering a wide range of space and time scales are characteristic of the ocean. To forecast future changes demands that we look at the longer-term events in the oceans. In turn, this forces us to focus more on the larger space scales. In terms of time, in order to guarantee the sustainability of the marine environment and its biota, we must look beyond the immediate issues and concentrate on those that can arise within our own lifespan, and even beyond.

In our exploration of particular topics related to different aspects of the oceans, this TOPIC aims at setting a tone comprehehensible to a wide group of non-specialists. More in-depth descriptions follow in the ARTICLES of this TOPIC.

2. History of Oceanic Research

Legend has it that as early as the year 2500 B.C., Pharaoh Sahure in ancient Egypt sent an expedition through the Red Sea to the Land of Gods (a tree-covered area, perhaps in eastern Africa), and that the ships returned laden with precious goods: myrrh, gold and silver alloys as well as timber. After the Egyptians, the Phoenicians assumed undisputed supremacy over the Mediterranean as Phoenician ships sailing out of ports on the Lebanese coast pushed beyond the Strait of Gilbratar in the last millennium before Christ. In the seventh century B.C., Phoenician royal ships left the Red Sea and headed south until they rounded the Cape of Good Hope and, three years later, reappeared in the Mediterranean. This was two thousand years before the Chinese Navigator Cheng Ho, known as the Eunuch of the Three Jewels in the Ming Dynasty, rounded the Cape along with his 27 000 men in 60 ocean-junks in the early 1300's A.D.. The better known Portuguese ships rounded the Cape in 1488 A.D. and ten years later navigator Vasco da Gama (1460-1524) and his fleet discovered the sea route going around Africa to India.

Partly forgotten by many is the fact that the Vikings from the then inhospitable coasts of Scandinavia reached North America in 992 A.D.- five centuries before Columbus! The first circumnavigation of the globe was accomplished by Portuguese navigator Ferdinand Magellan (1480-1521) and his fleet, which left the port of Seville on 20 Sept., 1519 with five ships. He discovered the channel between the South American continent and Tierra del Fuego which still bears his name. Magellan was to die in the Philippine Islands during a battle with the natives and only one ship with 18 his crew made it home three years later.

At about the time the Egyptians were trying to find the Land of Gods, Eridu divers on the southern shore of the Persian Gulf were collecting pearl shells around 2450 B.C.. Once King Nimrod had established the Babylonian monarchy, demand for pearls increased, but divers without any breathing aids could not go much deeper than about 46 m (150 feet). They had to resort to the use of breathing tubes made from reeds, hollowed bones and even inverted buckets. Even Alexander the Great is reported to have descended in a primitive diving bell called 'Colimpha' in about 330 B.C..

In a discussion entitled 'Problems Pertaining to the Ears', Aristotle (384-322 B.C.) wrote, '…in order that these fishers for sponges may be supplied with a facility of respiration, kettles are let down to them in the water so that they may not be filled with water, but with air'. In the sixteenth century, the great artist/scientist Leonardo da Vinci (1452-1519) got into the act: '…a breastplate of armour together with hood, doublet, and hose, and a small wine-skin for use in passing water, a dress for armour, and the wine-skin to contain the breath, with half a hoop of iron to keep it away from the chest. If you have a whole wine-skin with a valve from the 'ball' when your deflate it, you will go to the bottom, dragged down by the sacks of sand; when you inflate it, you will come back to the surface of the water. A mask with the eyes protruding made of glass, but let its weight be such that you raise it as you swim'.

The first advance in modern global observation, however, dates back at least to the HMS Challenger expedition in 1872-1876. The Challenger was a 2300-ton sailing ship with auxiliary steam power. Funded by the British Royal Society, the expedition systematically investigated the oceans making observations every 200 miles. At each station, the depth to the seafloor and temperatures at various depths were measured by lowering a sounding rope over the side. Water samples were collected, and the bottom was dredged for rocks and deep-sea marine life. It seemed most bizarre to the people of the time that the middle of the oceans was not found to be the deepest part. This was nevertheless the first hint of the vast mid-ocean ridge system that was so central to the seafloor spreading concepts that would be proposed later on. Altogether 715 new genera and 4417 new species were identified. In contrast, the types of sediments on the seafloor were found to be unusually lacking in diversity especially when compared with their terrestrial equivalents.

The truly modern era of ocean sciences began in the years preceding World War II. In the early 1940's, the threat of submarine warfare was the impetus which provided the imperative to understand the marine environment. Since then, large international programs have yielded much more information, especially about the open oceans. These programs include the International Geophysical Year (IGY) program, the Geochemical Ocean Sections Study (GEOSECS), the Tropical Ocean Global Atmosphere (TOGA) experiment, the Joint Golbal Ocean Flux Study (JGOFS) program, the World Ocean Circulation Experiment (WOCE), the Global Ocean Ecosystem Dynamics (GLOBEC) program, the Climate Variability and Predictability (CLIVAR) program and the Global Ocean Observing System (GOOS).

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Biographical Sketch

Born in Changhwa, Taiwan, on 22 April 1949, **Prof. Chen-Tung Arthur Chen**, his wife and two daughters are currently residing in Kaohsiung, where he has been Professor at the Institute of Marine Geology and Chemistry since 1986. After receiving his B.Sc. degree in Chemical Engineering from National Taiwan University in 1970, Prof. Chen was awarded his Ph.D. degree in Chemical Oceanography from the University of Miami in 1977. In the same year, he was appointed Assistant Professor in the College of Marine Sciences of Oregon State University, where he was later promoted to Associate Professor in 1981. He served as visiting professor at National Sun Yat-Sen University (NSYSU) in Kaohsiung, Taiwan, and as Chargé de recherche (CNRS), Université Pierre et Marie Curie in Paris during 1984-1985. During this period, he founded the Institute of Marine Geology at NSYSU, and served as its director until 1989 when he was made Dean of the College of Marine Sciences, a position he held until 1992.

Prof. Chen has sat on numerous international committees, including the Scientific Committee on Oceanic Research and the World Ocean Circulation Experiment. He also served as one of the executives of the Scientific Steering Committee of the Joint Global Ocean Flux Study (JGOFS) between 1992-1995. Just prior to that, he had helped to form the Joint JGOFS / LOICZ Marginal Seas Task Team in 1991, and served as its chairman until 1995. Prof. Chen is at present one of the editors of Oceanography Journal and associate editor of Marine Chemistry. Besides having more than 150 of his own scientific papers published, Professor Chen was awarded the highly-coveted Biowako Prize for Ecology from Japan in 1997.