SECTION 101

THE CASE FOR OCEAN COLOR

by

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INTRODUCTION

The potential for providing world-wide, repeatable ocean color data affords, for the first time, a means for the oceanographer to assess water mass properties and productivity in meaningful terms. Color together with surface temperature can define water masses, delineate upwelling areas, determine regions of productivity and detect certain other constituents in in the water. Most of the emphasis has been on productivity on developing a means of determining the condition of fisheries based on monitoring the first link in the food chain in the sea. This paper, however, attempts to introduce the concept that monitoring the plankton producing areas of the world is important to assessing the exchange of $CO_2/O2$ on a world-wide basis as a part of a lift-support system.

DISCUSSION

People who have seen both the major oceans of the world usually contend that the Atlantic is green and the Pacific is blue. Visual impression of characteristic or dominant colors of the various seas is acknowledged by the names such as Red Sea, Yellow Sea, Black Sea which were assigned by ancient observers. Color variations also played an important part in assisting early navigators to traverse the unmapped expanse of the oceans by locating familiar water masses.

The usually subtle contrasts in color are generally emphasized when viewed at some level above the surface. Some of these variations have been reported visually from aircraft altitudes and occasionally recorded on film or by spectrometers. In fact, Colonel John Glenn (reference 1) reported seeing the Gulf Stream on the first manned Mercury flight in 1961. Large scale ocean fronts have also been noted on imagery obtained from satellites as high as geosynchromons altitudes.

The color of the oceans is determined by the reflective, absorptive and scattering properties of the water as well as the atmosphere above. Light irradiating the sea surface undergoes reflection and refraction. The reflected portion is characterized by properties which permit its use for describing the shape of the reflecting surface, i.e., the use of glitter for describing the sea or wind conditions at the surface. The refracted portion penetrates the sea and, in the absence of scattering, is eventually extinguished by absorption. Actually, the light is subjected to scattering by particles of all sizes from molecules through collodial particles to large bubbles, or in the shallow water, even the bottom. About 50% of the incident light is backscattered upward on the high seas.

Of importance is that in many cases the absorption is selective and the scattering is spectral so that the backscattered light differs markedly from "white light" giving the upwelling light characteristics which can be utilized to describe the bulk properties and constituents of the water.

In clearest ocean water the effective path length is quite long and the upward scattered light is strongly blue. Where the water contains many absorbers and scatterers (particularly in coastal regions and upwelling areas) the shift is toward the green portion of the spectrum. In some areas with heavy concentrations of suspended material washed in from the shore, reds, browns and yellows may predominate.

Significant absorvers and scatters in certain portions of the oceans are minute plants and animals termed plankton. Plankton consists of three categories: Diatoms (plants), Dinoflagellates, and a miscellany of minute forms termed Nanoplankton.

A good deal of emphasis has been placed on assessment and monitoring areas of productivity on plankton growth of the basis that they constitute the fundamental initial linking the chain of life in the sea. It is essential to monitor these areas of potential productivity for the purposes of concluding as to the "health" of the biological matter in the area.However, a significant characteristic of these plankton is that they have a capability of transforming light energy to glucose through the process of photosynthesis. During the photosynthesis process, carbon dioxide is absorbed and oxygen is released. This process is shown in very simplified form below:

$$\underset{\text{(from the air)}}{H_2O + CO_2} \quad + \quad \underset{\text{(solar radiation)}}{\text{light energy}} \qquad 1/6\ (C_6H_{12}O_6) \ + \ \underset{\text{(to the air)}}{O_2}$$

(derived from reference 2)

Of course, in respiration the opposite basic effect results. Nevertheless, this process is an important link in maintaining the oxygen and carbon dioxide levels; in essence a fundamental component of the life support system of earth. The importance of the oceans and the planktons within the oceans in the oxygen carbon dioxide cycle is acknowledged. The largest amount of CO_2 exchange involves the oceans. Data have shown a seasonal variation and indicate that considerably more CO_2 exchange takes place in the southern hemisphere than in the north. Data, however, are obtained only sporadically and piecemeal.

A system is required to make assessments on a global basis and monitor conditions with sufficient frequency to note changes of significance to the life support system.

Since plankters play an important part of the O_2/CO_2 cycle, assessment of their health and extent can provide information to assist in interpreting world O_2/CO_2 conditions.

Currently, data on biological activity is collected in small samples in certain selected areas, principally in the spring of the year. Efforts are then made to project the data samples to make judgements on conditions of the whole population. These estimates can be off by several orders of magnitude (reference 3).

Similarly, although conventional oceanographic observations include color determinations the samples are obtained at single points at infrequent intervals to make more than broad generalizations or categorizations of world ocean colors (reference 4). The dynamics are completely lost in the technique. In fact, measurements involve subjective judgements of an observer on the color which prevails.

Experiments (reference 5) have indicated a potential for remote sensing of ocean color which would provide large area (or world wide) coverage at a high enough repeat time to furnish needed information for making judgements on conditions of chlorophyll producing areas of the world. Considerable work still continues to be required in this area but the payoff of creating a capability for monitoring world wide extent and change of parameters which constitute an important part of the world life support system appears large.

CONCLUSION

The world oceans are an important segment of the O_2 and CO_2 cycle. The pytoplankton with the properties of photosynthesis (chlorophyll production) absorb CO_2 and produce oxygen. The greatest exchange takes place between the atmosphere and the ocean. The use of remote sensing and unique facilities afforded by satellite coverage provide for acquiring data which can be used to develop a base map of chlorophyll producing areas and monitoring changes which may be significant to the balance of CO_2 and O_2 production in the world. In essence the technique could be considered equivalent to a guage providing information on life support systems aboard spacecraft.

REFERENCES

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