THE SHALLOW SEA-A NEW CHALLENGE TO TELEMETRY AND COMMUNICATION

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Summary. A preliminary study of the environmental and operational parameters requisite to the design and development of low cost simplified communication and telemetry devices usable in the shallow waters of continental shelves is presented. Specific requirements peculiar to the needs of Ocean Resource Utilization Programs in underdeveloped countries lacking both economic and technological capabilities for using current off the shelf devices are outlined. The environment in which this equipment must operate is defined, first physically and then subjectively, and operational aspects of this type of endeavor are described in terms of the individuals involved. Finally, some design parameters are suggested with a general consideration of the potential market as these programs increase in scope and number. It is hoped that feedback from this paper will generate future specific designs and quantitative criteria on which to base more detailed development work.

Introduction. Certainly, during the last decade, few other technologies can equal the sophistication, range, and reliability achieved by telemetry and communication. The matchless performance of guidance systems below the sea and on the space missions; the clarity and fidelity of voice and video transmissions from the surface of the moon; and the superb flow of data from other parts of our solar system, appear to leave little to be desired from an application viewpoint. It may be worthwhile, however, to stand off for a moment from this headlong rush towards expensive perfection, and consider the possibilities for cornmunication and telemetry instrumentation development in other areas of human endeavor, perhaps more mundane and less dramatic than space missions, but still important perhaps vitally - to the future of our civilization. One of those field is Ocean Resource Utilization programs, particularly in the underdeveloped areas of the world.

The ever increasing rate of utilization of terrestrial food sources makes it inevitable that Man will soon turn to the sea in a massive effort to develop new resources; the alarming yearly decrement in fisheries yield dictates that new resources will be the result of husbandry and production rather than the capture and processing of wild stocks. Ocean Resource Utilization Programs are beginning to appear in increasing numbers, organized into units of widely varying complexity. Certain kinds of deep sea and military research programs, undersea transport and well funded university research projects are already highly sophisticated and technologically well advanced. These categories of ocean research programs are excluded from both the scope and intent of this paper, as are the projects for seabed mineral extraction and petroleum production. The purpose of this paper is to relate and hopefully orient some research and development efforts in telemetry and communications to a particular kind of Ocean Resource Utilization Program. These programs are specifically oriented to the requirements of those areas which, for a variety of reasons, confine their efforts in marine resource development to low cost, labor intensive, pragmatic projects which can respond rapidly and directly to the needs and aspirations of their populations.

This effort is best described as a form of pioneering in the litteral sense or more appropriately “oceaneering” and is directly analogous in methodology and philosophy to the Westward Movement in the United States during the early part of the last century. A previous paper (1) has developed this concept more fully and may be referred to for specific details. In essence, the oceaneering effort consists of the involvement of a segment of a country’s or area’s population drawn from a wide variety of non-marine disciplines (engineers, architects, scientists, technicians, craftsman, etc.) at all levels (illiterates to PhD’s) in highly practical projects. Example are: Areefs (Artificial Reefs) (2), Low cost undersea habitats (3), man-operated vehicles (4), and shallow water mariculture or “seafood farming” (5). While the extent and variety of projects may vary from program to program as a function of the interest and capabilities of the participants, all programs appear to have two firm limitations imposed by the physiological and economic facts of life. The primary limitation, the ability of man to work and live comfortably in the sea without a sophisticated life support system, confines many of these relatively simple operations to the shallow seas, that is to say, the nearshore continental shelves of the world. The economic limitation result from the fact that most of the programs have the greatest utility in under developed areas which do not have the financial resources to provide expensive and sophisticated equipment to the participants. Let us examine, then, the parameters which could be useful in considering research and development efforts necessary to the production of simple but rugged communication and telemetry equipment to be used in the operations of Ocean Resource Development programs as outlined.

The Environment. Unlike many other current technologies, telemetry and communication are no strangers to bizarre environmental conditions. Reentry temperatures, lunar vacuum, ionization fields, and brutal distances are common parameters to the design of spacecraft and communication systems. The ambient conditions prevailing in the shallow seas of the continental shelf pose no great design problems in terms of strength of materials, excessive temperature changes or power requirements. Rather, consideration must be given to the participants in the program and their ability to utilize equipment efficiently under their specific working conditions. Man, and his relation to the sea has been most aptly described by Ambrose Bierce, the great American satirist of the last century, who wrote “Ocean--a body of water occupying two thirds of a world made for man - who has no gills.” Albano has stated the situation in which a Scuba diver, or even a skin diver with only mask and fins, finds himself, most concisely. He writes: “In fact, the moment the diver goes underwater he is in an environment that is about 60 times more viscous, more than 800 times as dense, and having a thermal conductively 25 times more than to which he is accustomed” (6).

Some selected physical characteristics of the marine environment, as compared to the atmosphere are shown in table I.

Characteristic	Air	Sea Water	Factor
Viscosity (poise)	1.793×10^{-4}	138×10^{-4}	60
Density (g/ml)	1.225×10^{-3}	1.026×10^{-3}	800
Coefficient of thermal conductivity (kcal/cm x hr °C/cm2)	2.3	53.0	25
Sound velocity cm/sec.	340×10^{2}	1.460×10^{2}	5

TABLE I Comparative Physical characteristics of Air and Seawater at 15°C (adapted from Albano: Principles and Observations on the Physiology of the Scuba Diver.

Electromagnetic radiation, in general, is attenuated so rapidly that only equipment whose cost and application would be beyond the economic and technological capabilities of the participants in these programs would be operationally feasible. This equipment already exists and need not enter into this discussion. Some thought, however, should be given to the physical interaction of visible light with sea water, since, regardless of its shortcomings, it and sound appear to be the only methods of wireless communication and telemetry that hold any promise for low cost practical systems designs. Light transmission, even at the short distances involved in these application, will vary considerably with depth and turbidity factors. Red, yellow, and blue light are absorbed sequentially as a function of depth or distance. Total intensity at sea falls off so rapidly for example, that at 50 meters only 10% of the surface intensity remains. The contrast problem, which of course will have a direct bearing on visual communication and navigation is acute. The contrast is decreased considerably due to the Tyndall Efect and the fluorescence (Ramen Effect). As a matter of comparison, it can be pointed out that where, for example, a black object can be distinguished from its background at 30 to 40 kilometers in the atmosphere (and even further in space, as discussed by H. Rose(7)), 30 to 40 meters is exceptionally good resolution in clear ocean water. In the shallow shelf environment close to shore, which is the probable location for a typical marine resource development operation, nearshore currents, waves, and shoreline effluents would set a more realistic estimate of functional visibility of from 5 to 12 meters.

Consider another aspect of the environment. The sites where artificial reefs are built; where the water is shallow enough for non-decompression diving and where it is most likely that habitats and man-powered vehicles will operate are close enough to shore for sea and land interaction to be felt. Capricious currents, heavy bottom swells and jagged reef and rock formations make it inevitable that men, machines and their equipment will be subjected to intensive pounding, scrapping and banging, and must be designed to withstand heavy abuse.

Operational Aspects. We have considered briefly the environment in which communication equipment designed for Ocean Resource Utilization Program must operate. Let us now examine what is that we require of the equipment. It is possible to specify two modes and a number of different interaction. The passive mode may be defined as the one way transfer of environmental or operational data from a sensor to an evaluator and/or controller. The active mode may be defined as a two-way path for transfer of information and instructions or questions between two or more individuals or stations.

In general, operational requirements for the passive mode present no great difficulties. Instrumentation for sensing the various environmental parameters are readily available over a wide range of price and resolution. Extreme accuracy in this application is not required, nor are extensive recording facilities. The primary transmission of environmental data will be from the various fixed sensors to either fixed receivers (on board the habitat or ashore) over hard lines or to the support vessel(s). In either case only essential information or operationally necessary data will be relayed to the working divers.

Figure 1 illustrates the modes and some of the possible interactions. On the basis of the environmental discussion in the previous section it is again obvious that only two media have any utility for data transfer or communication. Only sound and light instrumentation appear feasible when cost and ease of operation are considerations. There is, of course, one obvious exception which can yield excellent low cost information transfer between two fixed points, e.g., fixed habitats, fixed environmental sensors and possibly fixed shore stations or communication posts. That is hard wire phone and closed circuit TV links. In an uncommon case where this type of communication is possible no problem exists. In general, however, the operational situation can be expected to appear as follows:

A number of divers will be working within an area in which they will be in varying degrees of visual contact with each other and with their control post or habitat. At times they will be close enough for physical contact as well. It is not likely that they will be in visual contact with their support vessel on the surface and if they are using vehicles (wet subs, diver propulsion units, etc.) they may well be out of visual contact most of the time. In any project requiring the coordinated effort of a number of persons over a long period of time subtantial amounts of information and instruction must be transferred from person to person and additional information and instructions must be received from central control points either on the surface or from a habitat. Each diver is fitted out with the minimum equipment required for survival and function and any additional communication equipment must conform to the restriction of volume and weight allowed. It should be indicated at this point that the standard diver communication equipment currently being manufactured and sold does not perform satisfactory unless highly skilled individuals are using it and its operation involves training and diving gear not readily available to a project of this type. The limited use it could have would not justify the expense. From the figure it can be seen that information transfer and environmental data acquisition can vary in complexity from simple hand signals as devised by the U.S. Navy (8) to complex surface to station to diver voice or code relay systems.

Design Parameters. The intent of this paper is to provide merely the conceptual framework within which tentative designs may be developed as a result of subsequent researchs. It is suggested that an entirely different approach to this problem, many orders of magnitude away in sophistication from the usual telemetry research programs (as exemplified, for example by Taylor in his Vanguard/Place design)(9) is indicated. First order approximation solutions involving optico-mechanical display systems employing information elements such as modified annunciator units, deaf-mute and Indian Sign language(10) in the visual mode and direct water transmitted audio signals appear to present reasonable experimental areas of investigation. Tentative specification are:

1) Equipment which can be easily manipulated by touch, under water and preferably utilizing only one hand.

2) All functions on on/off or go/no go basis without requirement for user adjustments for range, frequency, clarity, etc.

3) Modular construction to eliminate service problems of any complexity.

4) Low cost, essentially expendable units which do not require long life (i.e. - most small oceanographic equipment is lost long before it is used up).

5) Self powered (except for habitat or boat installation) units.

6) Wireless (except possibly between fixed units).

7) Limited range. Most operations will involve ranges of a few feet to possibly 100 yards. Beyond those ranges the program will be sophisticated enough to use the standard equipment.

8) Narrow environmental range. No environmental extremes would exceed those imposed on a diver with a practical (for this type of program) operating limit of 100 feet or roughly three atmospheres.

Other parameters no doubt will suggest themselves as further investigation is made. It is highly probable that from the wealth of electro-mechanical and optical devices that our civilization is so replete with there is already instrumentation which, with some modification, could be adapted to this specific purpose.

Conclusion. This paper has been an attempt to bring to a focus some of the problem and design situation inherent in a very basic ocean resource utilization program. It is difficult to say whether two widely disparate fields (from the point of view of economics and technology), such as Oceaneering and Telemetry can find a common meeting ground in the development of the type of equipment suggested. From one point of view of this equipment would act in a feedback fashion to stimulate further ocean resource developments, or at least would facilitate them to the point where finally a large and perhaps lucrative market could be developed. only further investigation, into both the marketability and practicability of low cost oceaneering communications intrumentation will provide the answer to that question.

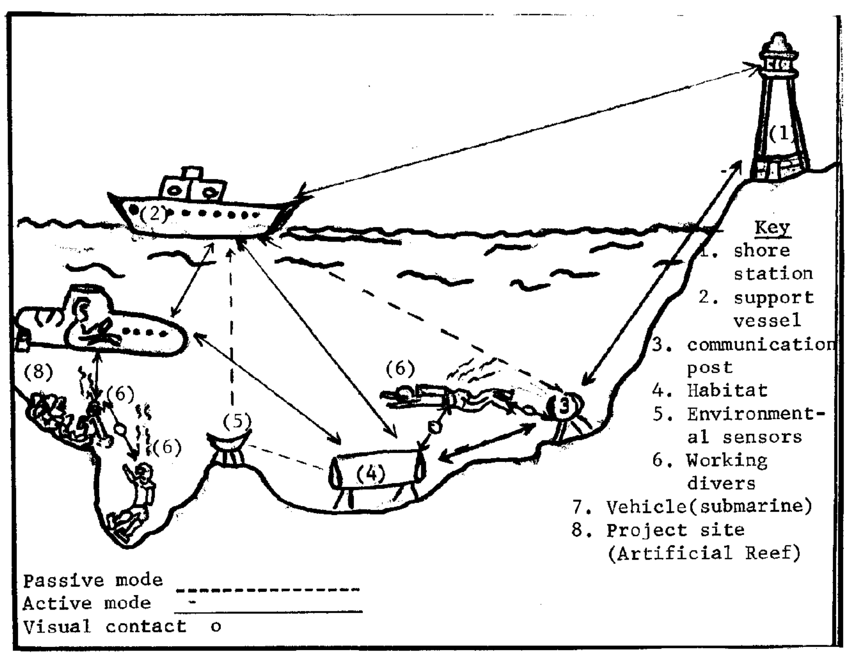

Figure I - Diagram illustrating the operational modes and relationships for shallow water oceaneering projects.

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