THE UNITED STATES NAVAL WAR COLLEGE

COURSE IN NAVAL WARFARE

RESEARCH PAPER

Cdr Donald R. Jones

Class of June 1961

NAVAL WAR COLLEGE
Newport, R. I.

THE EXPLOITATION OF INNER SPACE--
PRIME ELEMENT OF NATIONAL STRATEGY

1 March 1961

THE EXPLOITATION OF INNER SPACE--
PRIME ELEMENT OF NATIONAL STRATEGY

ABSTRACT

The paper under consideration essays to establish that optimum knowledge of the oceans of the world is a prime and requisite element of sea power. Proposed herein is that this knowledge of inner space (i.e., the aqueous envelope of the earth extending from the surface of the ocean to its floor) is necessary not only for national defense purposes, but for ensuing exploitation of the oceans' vast food, mineral and energy resources. To this end, it is submitted that scientific and technological activities in oceanography must be broadened and increased considerably; initially to strengthen our military posture and ultimately, in concert with other nations, to satisfy the needs of the burgeoning populations of the world and the demands of an increasing industrial society.

The role of oceanography in naval operations is assessed with respect to the past, present and future, particularly in connection with anti-submarine warfare. The Navy's recognition of the environmental influence is shown to be a belated one despite the trenchant heritage of environmental investigations left by Matthew Fontaine Maury.

Military and scientific programs for oceanographic research in the future are outlined, as well as attention invited to some of the major problems being encountered in the implementation of these programs. A primary stimulus to recent governmental awareness of the needs of oceanography appears to stem from the Soviet challenge in this area, which is formidable and very much a part of their relentless drive for technological supremacy.

Apart from the considerations of this serious threat, the exploitation of inner space is seen as the primary challenge to be met for the assurance of Man's future. The demands for and attention to outer space notwithstanding, the oceans of our planet contain the key to survival.

TABLE OF CONTENTS

INTRODUCTION

The impact of science and technology on the balance of world power has in the last two decades been one of unbelievable proportions. The creations of the scientific mind, however, have suffered a belated recognition by both national and military leaders. That science-technology has only recently been recognized by some leaders as perhaps the major weapon in the arsenal of national survival can only be attributed to the launching of the first earth satellite by the Soviet Union. The response to this dramatic challenge in billions of dollars for missile and satellite projects is indeed an extraordinary reversal of a national policy that in 1939 allocated a mere $6,000 for the study of uranium fission![1] The recognition by the United States government, that research in new and old fields of science is a fundamental source of national strength, has, however, not as yet achieved a balanced and comprehensive perception.

Oceanography, as one of the several basic and applied disciplines of the science spectrum, particularly has been one characterized by a relative lack of attention to its needs. The inadequate appreciation of environmental effects upon naval operations has been rather unique, when one considers that the oceans are the natural operational medium of the United States Navy. Of even greater concern, however, is the role that the oceans play in the realms of maritime strategy, natural resources and climate control. In view of the extensive knowledge required in all the complex facets of oceanography--involving the application of many areas of science and technology--time is already late to begin vitally needed studies.

---

[1] Arthur Holly Compton, Atomic Quest, p. 28.

The purpose of this paper, therefore, is to invite attention to some of the more important relationships between oceanography and sea power, both with regard to their unrealized potential in the past and to the urgent needs of oceanography in the future. In so doing, the goals of the Soviet Union in this area are noted as only one important incentive towards drastically increasing our national efforts in the exploitation of inner space. But more importantly, the eventual transcending task of oceanography, in relation to the extraction of food, mineral and energy resources necessary for the perpetuation of mankind, will be assessed.

The resolution of this task is one fraught with many and varied difficulties, some of which stem from the traditional American philosophy of passive optimism and a concomitant inadequate sense of urgency. Other difficulties in devoting the necessary attention to oceanography will likely arise from budgetary competition with other research and development projects deemed necessary in the national interests. Finally, the necessary specialized manpower and facility requirements present problems of a nature that are imbedded in the overall realm of "technological war," to the extent that the future fate of oceanography will rest with the trends of our national purpose. To these considerations and to their resolution this paper is addressed.

Classified material relating to oceanographic projects, particularly in the realm of anti-submarine warfare, has not been utilized for this study. In this regard, certain important aspects of oceanography have been necessarily omitted but, in the main, the substance of the investigation has not been materially affected by these omissions.

THE EXPLOITATION OF INNER SPACE--
PRIME ELEMENT OF NATIONAL STRATEGY

CHAPTER I

OCEANOGRAPHY--MISSING LINK IN THE ELEMENTS OF SEA POWER

Mahan stated many years ago that the principal elements of sea power were: "I. Geographical Position. II. Physical conformation, including, as connected therewith, natural productions and climate. III. Extent of Territory. IV. Number of population. V. Character of the People. VI. Character of the Government, including therein the national institutions."[1] These elements are equally the essence of national power and obtain today as much--if not more so--as they did in Mahan's era.

To these fundamental elements of sea power and synonymously of national power must be added a separate entity--science and technology. To be sure, the processes leading to achievements in science and technology derive from most, if not all, of the stated fundamental elements but, like Dr. Frankenstein's monster, the force created has become one of such magnitude that it threatens the very existence of its creators--Man and his planet. Yet, the role that science and technology play is fortunately a dual one for it has led to a new age of prosperity for much of mankind and offers a great hope to the remaining millions still relatively untouched by this "revolution" of the twentieth century.

The science of oceanography, encompassing as it does the

---

[1]Alfred T. Mahan, The Influence of Sea Power Upon History, p. 28.

basic disciplines of mathematics, physics, chemistry, biology, geology, and related to a number of the geophysical sciences, constitutes a considerable portion of the entire spectrum of science and technology. Therefore, it needs to be considered as an integral element of sea power. Curiously, this science and that of its sister environmental science of meteorology, have been given relatively little attention until recently, when it is considered that man's dependence on and understanding of his atmospheric and oceanic environment transcend all other matters from the standpoint of academic survival. That Man has not been aware of their existence there is no question, for the history of environmental exploration is one essentially of the evolution of civilization. The Appendix to this paper charts some aspects of oceanographic exploration from ancient times down to the present day, and reflects this awareness in a paraphrase of the Benjamin Franklin adage that much was said of the oceans, but little done about them.

The emerging importance of environmental considerations became apparent during World War I with the advent of unrestricted submarine warfare, the use of chemical agents and aviation. United States participation, however, was too brief for this awareness to have any lasting effect, such that the period between the two great wars was characterized by a notable lack of progress achieved in the environmental sciences.[2] It was not until the "Battle of the Atlantic," the amphibious assaults in the Atlantic and Pacific, and the massive air raids of Europe and the Pacific theatre of World War II took place that environmental factors were

---

[2]_Infra_, ~~pp. 79-80~~. p. 88.

realized to be vital in successful prosecution of the war. This realization from the standpoint of the U. S. Navy, traditionally and functionally most concerned with the oceans, was scarcely precipitate, but rather one learned through the crucible of painful experience.

"The U. S. Navy was woefully unprepared, materially and mentally for the U-boat blitz on the Atlantic coast that began in January 1942 . . . this unpreparedness was largely the Navy's own fault."[3] There were a number of factors and events, some of which were beyond the Navy's control, that contributed to the foregoing analysis. To treat them in detail is beyond the scope of this paper, but it can be said that the lack of understanding of the effects of the oceanic environment upon prolonged and sustained naval operations at sea was a predominant contributing cause to this predicament.

For one thing, apart from the inadequate numbers of anti-submarine vessels available, those in existence were ill-designed to cope with the heavy seas and gales of the wintry North Atlantic. In contrast, the Canadian and British corvettes and frigates, although infamously uncomfortable, were among the most sea-worthy in the world.[4] The demands for convoy escort vessels far exceeded the supply and the need for anti-submarine escort vessels of moderate size and speed with excellent sea-keeping capabilities was a desperate one. This manifest need was finally met by the Destroyer Escort Program, the development of which in itself is an interesting study.[5]

---

[3]Samuel Eliot Morrison, History of United States Naval Operations in World War II, 15v., I, p. 200.

[4]Ibid, p. 13.

[5]Morrison, op. cit., II, pp. 32-36

Ship damage from heavy seas was incredibly high and only the equally incredible efforts of the American shipyards in effecting repairs and building new ships kept the balance of the Battle of the Atlantic in favor of the Allies. An example of the cumulative destructive force of sea waves is to note the following: "One of the worst winters on record was lashing the Western Ocean . . . heavy gales were almost continuous; . . . merchant ship losses, by marine casualty alone, for the five months, November 1942-March 1943, reached the enormous and unprecedented figure of 166 vessels totalling 337, 852 tons."[6] It was during this winter season in March 1943 that a gale of hurricane force accomplished what it prevented the Captain of the U-260 from doing--the sinking of the convoy Commodore's ship, which capsized with the loss of all hands.[7]

Indeed, the Battle of the Atlantic during the winter months was one pitted against the elements as much as a contest with the U-boats. For many men, that battle, so often a monotonous and frustrating one, was lost to the forces of the seas, sometimes sweeping a man overboard, other times engulfing an entire ship. The not-always-so-calm Pacific as well claimed its human bounty, primarily from typhoon-generated mountainous seas. The awesome and frightening spectacle of ships, regardless of size, in the grips of sixty foot waves in the eye of a typhoon can only be appreciated by those having experienced it. The fatal typhoon of 18 December 1944, in which some 800 men perished,

---

[6]Morrison, op. cit., I, p. 337.

[7]Admiral Karl Doenitz, Memoirs, p. 331.

three destroyers capsized and seven ships severely damaged,[8] etched a grisly tableau of an ocean's might. The only reassuring and even triumphant aspect emerging from this maritime tragedy was the success of the destroyer escorts in riding out the seas with only superficial damage. Their survival, in addition to their splendid rescue efforts in picking up survivors of the capsized destroyers under most difficult circumstances, provided ample proof of the value of taking environmental considerations into account in the design of these ships.

In a remarkable repetition of history, six months after this disaster the Third Fleet rendezvoused with another typhoon on June 4, 1945, in which similar circumstances of errors of judgement and inadequate meteorological advice, prevailed.[9] Fortunately, loss of lives were limited to a few but damage to ships and aircraft was most extensive. The worst and most dramatic incident occurred when the entire bow of the cruiser PITTSBURG was ripped off by a tremendous sea.

To a great extent, the hundreds of thousands of tons of ships lost and the hundreds of millions of dollars expended to repair ship damage caused by storm generated ocean waves were due to, for lack of a better description, "environmental indifference." This unfortunate lack of understanding of environmental effects--on the many types of naval operations required for the prosecution of both Atlantic and Pacific campaigns--was very much a part of an apathy in the Navy towards science in general, which appeared

---

[8]Morrison, <u>op</u>. <u>cit</u>., XIII, p. 59.

[9]Morrison, <u>op</u>. <u>cit</u>., XIV, p. 304.

to have stemmed in part from circumstances connected with Lieutenant Matthew Fontaine Maury's selection out of the Navy.[10] Thus, there were very few meteorological officers and oceanographers in the Navy at the outset of World War II, and even these few were handicapped by the overall inadequate development of the two environmental sciences. A partial remedy to this situation was brought about by the vast mobilization and training program for scientific personnel, but optimum results were greatly stymied by the necessary wartime security which reduced meteorological and oceanographic synoptic observations to a dangerously inadequate minimum.

There is no question that much of the marine casualty losses and damages was inevitable because of the demands of wartime schedules and other convoy routing requirements. However, if an environmental prediction system such as exists today for routing ships and convoys had been available, as well as an overall environmental awareness by the user and efficacy by the practitioner, marine casualties doubtless would have been considerably less.

In the same vein, design of ship hull forms did not take into account the irregular form and tremendous forces of the oceans. Therefore, it could scarcely be expected that ship motion and hull stresses would approximate those experienced by small scale models in test basins. But, only in recent years has there been developed mathematical equations treating the spectrum of ocean waves in relation to ship motion and stresses. The pioneering attempt of practical collaboration between oceanographer and the naval architect did not take place until 1953. It was the first major

---

[10] *Infra*, p. ~~74~~ 82.

step in discounting Lord Rayleigh's contention that "the basic law of the seaway is the apparent lack of any law,"[11] and led the way to continued collaboration which is now being exploited fully in the design of revolutionary hull types,[12] including hydrofoil craft.

Another area of Naval environmental interest or rather, apologetically, lack of it, centered on the behavior of deep water waves as they approached shallow water and were transformed into surf. Now well known of course, but little known in 1942, were the oceanographic effects on large scale amphibious operations. Moreover, little was known of the physical relationships between surface wind and the ocean waves caused by wind stresses.

Fortunately, attention was directed to this problem early in 1942 by the Directorate of Weather, Army Air Forces, which commissioned Dr. H. U. Sverdrup and Dr. W. A. Munk of Scripps Oceanographic Institute to prepare an ocean wave and surf forecasting manual. This project was accomplished successfully in time to be used for Operation Torch, the amphibious assault on North Africa in November 1942. These same forecast principles were used subsequently in the Mediterranean campaigns, in the Pacific theatre, and for the mammoth cross-Channel invasion of France.

It is not possible to over-emphasize the importance and vital nature of this particular environmental consideration in connection with the success or failure of amphibious assault. Of all the myriad and complex aspects of command and decision incident to the Atlantic-European theatre,

---

[11] M. St. Denis and W.S. Pierson, Jr., On the Motions of Ships in Confused Seas, p. 3.

[12] Edward V. Lewis and Edward Numata, "Ship Motions in Oblique Seas," Society of Naval Architects and Marine Engineers No. 5, November 1960.

General Eisenhower considered those relating to the environment as transcending all other elements of warfare. This was true to a great degree because as he stated, "the one thing that could give us this disastrous setback was entirely outside our control."[13]

The Navy's participation in this area of meteorological-oceanographic prediction was a limited one and subordinate to that provided by the U. S. Air Force and the Royal Air Force. Notwithstanding that the support responsibility of the ocean wave research program was transferred from the Air Force Weather Directorate to the Hydrographic Office in 1943,[14] comparatively few naval officers received training in this field. In fact, during the war years and for the decade following, Air Force training in physical oceanography far exceeded that of the Navy's. For this reason and others, it was not until 1956 that the Naval Weather Service was able to assume responsibility for providing requisite oceanographic forecasts of sea conditions for all Department of Defense activities. In collaboration with the Hydrographic Office, other oceanographic services are being performed, notable of which is the ship routing program, and while these efforts are successful and commendatory, they fall short of an optimum performance sorely needed now and even more so for the future.

The ship routing program for the Military Sea Transport Service, originally instituted by the Hydrographic Office about five years ago through the work of Dr. Richard James and now being conducted at Navy Weather Centrals on the East

---

[13] Dwight D. Eisenhower, Crusade in Europe, p. 239.

[14] Henry B. Bigelow and W. T. Edmondson, Wind Waves at Sea--Breakers and Surf, Foreword.

and West coasts, has in just a few years decreased trans-oceanic passage times up to 48 hours. The resultant savings of millions of dollars through conservation of fuel and avoidance of storm damage have been accomplished through a relatively small effort of environmental application. Much more synoptic information is required, however, of the ocean's surface before this routing system can be brought to its fruition of performance. For several years now, the British have had installed on their ocean station vessels (weather reporting and navigational aid ships) ship-borne wave recorders.[15] These instruments, relatively simple and inexpensive (the latter necessarily so from the standpoint of our thrifty cousins), are essential as a basis for the daily construction of an accurate relief map of the undulating and complex surface of the oceans. That U. S. weather vessels are not similarly instrumented only reflects residual symptoms of the lingering disease of "environmental indifference."

The airwater interface, proverbially, is "here to stay" and with respect to amphibious operations, is not at all outmoded by helicopter envelopment tactics. In terms of a future amphibious landing on a scale as large as Normandy, the numbers of personnel and tons of equipment airborne would be but a small fraction of that delivered by sea. Old-fashioned but, it is hoped considerably modernized, environmental forecasting in a future war, push button or no, will be required on a far greater scale than during World War II.

---

[15] Willard J. Pierson, Jr., "Wave Forecasting Methods and Heights of a Fully Developed Sea," Deutsche Hydrographische Zeitshrift. Band 12, Heft 6. 1959, p. 244.

A critical problem of perhaps greater dimensions than the foregoing is that of underwater communications.

> Perhaps the single most important obstacle to the widespread use of submarines for ASW work and as missile launchers is the difficulty of communicating across the airwater interface, as well as underwater. This applies to communications between a submerged submarine, on the one hand, and shore installations, aircraft, surface ships, and other submarines on the other. There is now no sure, reliable, and efficient way of effecting such communication.[16]

For different but just as important reasons, the bottom boundary of inner space, i.e., the ocean floor, needs to be mapped and understood just as much so as the top boundary of the air-water interface. While general features of the ocean floor in many areas are known, really accurate--sufficient for submarine missile-launching purposes--charts do not exist. Submarine inertial guidance navigation systems are phenomenally accurate but only for limited time periods and thus surfacing is required for celestial and/or electromagnetic navigation checks. A true map of the ocean floor or at least a grid of navigational check points, i.e., sea mounts, or unusually configurated canyons or crevices, would obviate the need for a nuclear submarine to surface just for navigational purposes. The oceanographic surveys required to map the ocean floors to this extent will require the same dedication to scientific exploration as that exhibited by the famed Challenger Expedition,[17] but on a scale far greater in scope.

The final area of oceanography to be discussed in this chapter--there are several others contributing to sea power

---

[16] U.S. Congress, Joint Committee on Atomic Energy, <u>Report of the Underseas Warfare Advisory Panel</u>, p. 9.

[17] *Infra*, p. ~~76~~ 84.

but are omitted for reasons of brevity limitations--is one directly associated with inner space. Specifically, it is concerned with the capability to see through the dark and immense expanse of the depths of the oceans. Any real success achieved so far has been through the medium of sound. While its speed of propagation in water and penetration thereof have rendered it effective as a visual device for several purposes, both military and commercial, its severe attenuation by several oceanographic parameters restricts its effectiveness, and simultaneously requires the utmost of oceanographic knowledge in order to optimize performance. Thus, the vital problem of vision necessary, among other requirements, to control and exploit inner space is an extraordinarily difficult one, involving technological and environmental knowledge of the highest order.

To understand some of the problems and implications involved is to recount briefly a bit of history illustrating again the imbalance between weapons development and environmental knowledge that existed in the Navy at the time of World War II. Certainly in the field of underwater acoustics, the Navy was unprepared in that the oceanographic parameters governing the behavior of sound propagation were not at all understood nor assessed. Although the active listening devices of Asdic and Sonar had been developed by the British and the United States respectively for the detection of submarines, the requisite operational characteristics under various conditions had not yet been determined and could only be so ascertained by scientific disciplines. To a significant extent, the necessary measures were effected by the scientific community established under the National Defense Research Committee.[18] For this particular instance,

---

[18]Morrison, op. cit., I, p. 222.

as in many other areas wherein the Navy was initially deficient, however, a remarkable ensuing facet of success characterized the scientific-operational combination that carried the Allies to ultimate victory. In no small measure, this achievement was in one sense negatively obtained by Hitler's disregard of operational scientists until too late in the war,[19] and as well as to his utter lack of appreciation of the significance of sea power.

There are few today who would question the outcome of the Battle of the Atlantic if the plans of the German Navy calling for 400 U-boats had materialized prior to joining battle with England.[20] Even so, with the pitifully few 43 U-boats ready for combat in September 1939, 25 of which were the small 250-tonners, the Germans launched an attack that came perilously close to destroying the vital sea life lines of the Allies. To be sure, literally hundreds of U-boats were constructed during the war years, but under difficult and severe handicaps of Allied bombing, competition with other war production priorities and training of crews. The Germans paid a severe price with 781 U-boats sunk while exacting a heavy toll of 5,700 Allied ships totalling 23,000,000 tons.[21] Of the many conclusions to be derived from this phase of warfare, the one of concern here is that while knowledge of the oceans in detecting the U-boat was employed to a considerable extent, it was minimal when compared to that required for detection of the high-speed

---

[19] Ibid, p. 316

[20] Daniel V. Gallery, Twenty Million Tons Under the Sea, p. 14.

[21] Gallery, op. cit. p. 15.

nuclear submarine of today and of even more sophisticated and deadly submarines and/or submersibles of tomorrow.

The immediate challenge posed is that of the large and modern Soviet submarine fleet which judged by any criteria is a real menace to the security of the intrinsically maritime alliance of the Free World. This threat has created the monumental task of devising ways and means to detect and identify Soviet submarines, keep them under surveillance, and attack once the gauntlet of interdiction has been cast across the oceans. Apart from this heavy and exacting responsibility is the related and vital requirement to prevent a surprise submarine-launched missile attack on the host of targets clustered along and near vulnerable coasts of the United States. In order to achieve or even approach this capability, a knowledge of the oceanic environment will be required on a scale exponentially greater than that existing at the present time.

It is no secret that the yet unsolved and paramount problem facing the U. S. Navy today is that of anti-submarine warfare. The fact that a minimum of $1.42 billion of the Navy's fiscal '61 budget has been allocated for anti-submarine projects[22] attests to the serious degree of this challenge. Unfortunately, however, the mere $17.7 million earmarked for oceanographic research reflects the continued imbalance between weaponry "hardware" and environmental investigations. Even the entire Federal budget for oceanographic research in Fiscal 1961 amounts to but six per cent

---

[22] Underwater Engineering, Staff Report, p. 18

of that to be devoted to non-military research in outer space.[23]

If oceanography is to fulfill its role as an integral element of sea power as it must so do for the security of the United States, a far greater effort and attention needs be devoted to this science than has been the case in the past. This need is at the present time being gradually recognized, but not at a pace commensurate with the urgency dictated by the international situation and the ultimate necessity for peaceful and orderly utilization of the oceans' vast resources.

Or, phrased differently but tersely and with authority, Vice Admiral John T. Hayward, USN, stated before Congress: "It goes without saying that a complete understanding of oceans and ocean bottoms and the atmosphere above must be obtained if the Navy is to wage modern war successfully."[24]

---

[23] U. S. Congress, House, Committee on Science and Astronautics, Ocean Sciences and National Security, p. 114.

[24] Congressional Record, Vol. 105, Part 15, September 11, 1959, p. 19094.

CHAPTER II

THE SOVIETS MEET THE CHALLENGE

"Peter (the Great) saw that the great nations of his day were strong on the sea, and he realized the importance of sea power."[1] Russia, traditionally seeking strategic outlets to the sea during periods of territorial expansion, had a considerable measure of success under the leadership of Peter and later the Tsarina, Catherine. A period of decline in Russian sea power set in which led to her defeat in the Crimean War and again by Japan. In a third, and from the standpoint of the Free World Alliance what must be the last, territorial expansion and concomitant resurgence of sea power, Stalin--"the real founder of Soviet sea power"[2]--instigated vigorous measures to establish the Soviet Navy second to none.

Within a period of only three decades, Stalin and his successors have all but accomplished this seemingly impossible feat. That the Soviets are now second to but one is particularly remarkable when one considers the centuries of time involved in the acquisition of the sceptre of sea power in turn by the great maritime nations of Portugal, Spain, Holland, England, Japan and the United States--not to mention Germany who twice in a generation barely missed grasping it.

Doubtless the two factors of technological revolution

---

[1] Jawaharlal Nehru, Nehru on World History, condensed by Saul K. Padover, p. 213.

[2] Commander M. G. Saunders, R. N., ed., et al., The Soviet Navy, p. 5.

and Soviet regimentation directed toward specific goals have brought about this revolutionary development in such a short time. Even as little as ten years ago the Soviet Navy was ranked only ninth.[3] Yet, her emergence as a leading naval power is no more startling than similarly unexpected achievements in nuclear weapons and outer space, occurring within the same time frame.

The unerring quest for sea power by the Soviet Union, particularly in the form of a modern and large submarine fleet (450 in operation, 50 abuilding, and six nuclear-powered),[4] should be obvious to even the casual observer. Events in history, however, have frequently proven that the obvious is heeded less than the obtuse, for which both the Allied and the German lack of preparation for submarine warfare in the Atlantic for World War II was the most notable example. There is little question at the present time, however, in the minds of Soviet and Western authorities that the oceanic coalition of the Free World is vitally dependent upon ocean transport. "To underscore this point, in 1957 the total bulk transportation by ship was 250 billion ton-miles, which represents 99.5 per cent of total tonnage moved by all means of transportation."[5] The preponderant bulk of this tonnage was carried across the Atlantic between the United States and the industrial powers of Western Europe.

In 1957, Rear Admiral Andreev of the Soviet Navy observed that it was imperative for the West to have the

---

[3] William O. Foss, "Russia's Assets in the 'Wet War,'" Underwater Engineering, September 15, 1960, p. 25.

[4] Jane's Fighting Ships, 1960-1961, p. 408.

[5] U.S. Congress, House, Committee on Science and Astronautics, Ocean Sciences and National Security, p. 12.

Assistant Chief of Naval Operations for Research and Development. This view has been paralleled by numerous observers in the military and scientific fields. There appears to be little doubt that the Soviets not only may equal the United States' efforts in this area, but are likely ahead in certain respects. The record of Soviet achievement in oceanography within the past few years has been well documented, indeed to the extent that the matter has become one of very serious concern to the Congress of the United States. Such men as Senator Jackson[11] and Senator Magnuson[12] have brought attention to what they consider a Soviet threat of an order of magnitude exceeding that of her intercontinental ballistic missiles.

To illustrate the real gravity of the situation is to quote but a few of the statements contained in the report, _Ocean Sciences and National Security_ already referred to, and one considered by Representative Overton Brooks (Louisiana), Chairman of the Committee on Science and Astronautics, to be a "real landmark for its scope and thoroughness in coverage of subject matter:"

> Soviet oceanography 10 years ago was provincial. Today it is worldwide in scope and progressing rapidly . . . Soviet Russia is winning the struggle for the oceans. . . without firing a missile, a rocket or a gun. Soviet Russia has the world's largest oceanographic fleet . . . four times as many ships capable of deep sea work as the United States . . . and 800 professional oceanographers compared to 520 in the United States. The Russians successfully completed, during the International Geophysical Year, the largest program of any of the 27 nations participating . . . their present research effort is oriented towards

---

11 U.S. Congress, Joint Committee on Atomic Energy, _Report of the Undersea Warfare Advisory Panel_.

12 _Congressional Record_, V. 105, Part 15, September 11, 1959, pp. 19094-19098.

applications. The Russians are in oceanography for obvious military and economic reasons and it appears to be their objective to stay in and excel. Should Russia be successful she would control commerce, weather, communications, much of the world's food supply and ultimately earth's resources, health and climate.

The foregoing views are scarcely those of the legendary sheepherder crying "wolf!" but rather reflect a considered scientific and military appraisal. Only meager comfort can be taken from the fact that in certain areas of oceanographic research the Soviets exhibit a quality inferior to that of the United States. Certainly, United States oceanographers supported by their very excellent research equipment, are amongst the best in the world. But their research operations have been supported by "shoe string" budgets in the past and the training and educational programs for young scientists to eventually take their place are grossly inadequate.[13]

In contrast, the Soviet educational system has been geared to render full and continuing support to their drive for technological supremacy in virtually all areas of endeavor. USSR graduates in science and engineering now total 130,000 annually compared to only 65,000 in the United States.[14] The scientific community has traditionally been accorded a privileged position and therefore has, on the whole, suffered less from "purges" than any other group of the Communist society. Oceanography is certainly no exception and, even though it is a relatively recent

---

[13] Ocean Sciences and National Security, op. cit., p. 70 and p. 111.

[14] C. P. Snow, as quoted in a book review, Commentary, February, 1960.

Soviet venture in the scientific-technological arena, its prestige is no less than other more established sciences. The annual salary of the average oceanographer of $12,000 is in itself rather striking evidence of Soviet support of this science.[15] Although comparisons of renumerations for services rendered can be meaningless, it is nevertheless significant that the average U. S. oceanographer receives only an $8,000 annual salary in a society where the standard of living is many times higher than that of the Soviet Union.

Apart from these considerations, the really serious note of the Soviet challenge is sounded with regard to their rapid rate of growth and improvement. During the Hearings before the House Committee on Science and Astronautics, April 28-29, 1960, Dr. Harrison Brown, Chairman of the Committee on Oceanography of the National Academy of Sciences summed up the situation succinctly: "Now, this /the Soviet rate of improvement in oceanography/ doesn't mean that they are ahead of us at the present time, but the curves of progress are likely to cross."[16]

Conclusions as to Soviet motives derived from the foregoing are inescapable and foreboding. Soviet maritime activity off the United States east and west coasts attests to their goals of mapping every facet of the oceans necessary for optimum deployment of their submarines for a potential submarine-launched missile attack. Scores of Russian trawlers are being observed in strategic areas of the North

---

[15] Mary Sears, "Moscow Visited," Oceanus, December 1960, p. 10

[16] Ocean Sciences and National Security, op. cit., p. 109.

Atlantic engaged in activities other than fishing. Parenthetically, even in this area they are excelling.[17] An increasing number of these vessels are being electronically armed for probing the oceans both for data acquisition purposes and surveillance of United States naval--particularly submarine--activity.[18]

From any viewpoint, the Soviet prying of international coastal waters of the United States by trawlers, oceanographic research ships and submarines in itself should be a matter of deep concern. That this unusual maritime activity so distant from the "Heartland" is a blatant one only reflects another of their now recognized aims--that of propaganda. During the past two years, their two finest oceanographic research ships in the Atlantic and Pacific respectively, the 5,960-ton MIKHAIL LOMONOSOV and the 5,546-ton VITYAZ, during the course of the International Geophysical Year, effected several visits to New York and San Francisco, extending "open-ship" visiting to the general public. Many Americans (amongst them qualified observers) who visited these two vessels were impressed with both marine and oceanographic equipment, and particularly so with the excellent laboratory and living spaces which provided for sixty to seventy scientific personnel. As one American oceanographer put it, "We'd be swamped with students of the marine sciences if we had a vessel like this one!"[19]

---

17 *Infra*, p. 35 39.

18 Hanson Baldwin, "Red Trawlers Fish for Secrets." *The Providence, R.I. Journal*, November 27, 1960.

19 William Hines, "Soviet Science Vessel Wins Praise in New York," *Washington Evening Star*, September 9, 1959.

News releases from these ships during their cruises were characterized by a prolificness and the achievement of another Russian "first"--a record sounding in the Marianas trench of 36,173 ft. Much was made also of discovery of radioactive waste in the Atlantic, a matter well recognized by the Russians as being fraught with international implications, with their propaganda designed to place the United States in the role as polluting the oceans of the world.

To be sure, the Soviet accomplishments in oceanography as in other scientific and technological fields have taken maximum advantage of the ready-made and superior technologies developed in the industrial nations of the West. As they approach the frontier of inner space, the going will undoubtedly be tougher and there will be required considerably greater efforts in resources, men and material to exploit the oceans for their own purposes. The evidence points, however, to their awareness of these demands, and the United States can ill afford to assume that the Soviets are incapable of meeting this challenge in the future.

CHAPTER III

WHAT OF THE FUTURE?

The hue and cry for increased programs in all phases of oceanography has been raised by literally a multitude of voices. It is not at all uncommon now to pick up almost any magazine or newspaper without noting an article relating to oceanography and the new frontier of inner space. Considerable effort in this regard has been devoted in translating this vocal and literary clamor into studied appraisals of the present status of oceanography at both naval and national levels, and into proposals and recommendations for the future. Whether these recommended programs will be implemented fully or only in part remains to be seen, but in the final analysis their implementation will depend ultimately on those military and national leaders who fully realize that knowledge of the oceans is truly a vital and integral element of national strategy.

It is pertinent here to scan briefly the nature of these proposals for future oceanographic programs, although their importance with respect to our national interests dictate that they be studied in their entirety. In this connection, reference is again made to the Ocean Sciences and National Security report and also to the completed eight chapters of the twelve chapter report by the committee on Oceanography, NAS-NRC, "Oceanography 1960-1970," for providing a lucid and comprehensive account of the present and future status of oceanography. In addition to the following brief review, attention will be focused on a few of the particularly demanding and difficult problems in oceanography that must be solved before substantial and early progress can be effected in this field.

> Since 1957, three significant studies have been undertaken to lay the groundwork for a systematic and coordinated long-range program in oceanography.
>
> The three studies embrace (a) a comprehensive analysis by a newly formed third Committee on Oceanography in the National Academy of Sciences, National Research Council (NASCO), undertaken at the request of several Government agencies; (b) a parallel study by the Office of Naval Research but only concerned with the Navy's contract program in Oceanography (TENOC); and (c) studies of the previous two programs by interdepartmental bodies, in particular the Interagency Committee on Oceanography (ICO). Additional studies, yet unreported, are being made by ONR to supplement item (b) with information regarding the Navy's own inhouse program of oceanographic research which has not been included in the original TENOC program.[1]

The first of these studies considered the problem from a national viewpoint and for this reason is the more comprehensive one, including, of course, the Navy's share of fiscal responsibility. Approximately half of the proposed $867 million to be expended during the period 1960-1970 would derive from the Navy's budget. TENOC, on the other hand, envisions a total expenditure during this period of about $265 million, some $100 million less than the sum proposed ($378 million) by NASCO. The resolution of these differences will presumably stem from the policy level ICO which, parenthetically, revised upward the admittedly conservative NASCO[2] ten year expenditures to $1 billion.

The major cost elements for this 10-year program as seen by ICO are: (a) oceanographic research and ship

---

[1] U. S. Congress, House, Committee on Science and Astronautics, Ocean Sciences and National Security, p. 116.

[2] NAS-NRC Report by the Committee on Oceanography, Oceanography 1960 to 1970, Chapter I., p. 2.

operations (including education and training), $490 million; (b) ocean surveys and ship operations, $144 million and, (c) construction of 78 new ships and facilities, 405 million.[3] These recommended programs and cost estimates thereof do not include costs for military oceanography or military surveying. For the most part, these expenditures are borne by the Hydrographic Office. The overall expenditure, then, of $1 billion during the 10-year period would be designed to double the present capability in oceanography. This factor is not one judged on an absolute basis, for the present rate of economic growth and the rate of Federal expenditures for research and development would ensure this growth rate. Rather, a relative factor of four is involved which is essentially double the rate at which science and technology are now growing as a whole.[4] Yet, even this goal is a modest one, for its 10-year cost is but one tenth that of the present annual efforts devoted to outer space.

Despite the extreme interest recently generated in oceanography--particularly exhibited at high levels of the legislative and executive branches of the Government--the NASCO, TENOC and ICO proposals have thus far only been fractionally implemented. The causes are likely many and varied, an important one being perennial budgetary limitations, but perhaps most important of all, an as yet insufficiently developed and coordinated sense of urgency necessary to implement the recommended programs with vigor and vision. Although Assistant Secretary of the Navy, James T. Wakelin,

---

[3] _Ocean Sciences and National Security_, _op. cit._, p. 130.

[4] _Ocean Sciences and National Security_, _op. cit._, p. 141.

Chairman of the ICO, has provided able and responsible leadership, his Committee has not achieved its initial goal of $120 million for fiscal year 1961. Only $56 million was allocated for that year and $37 million for 1960 instead of the $80 million recommended by NASCO, such that the ten year program has already been effectively delayed for two years.

Perhaps in view of a normal lag in governmental procedures relative to new ventures, this delay was to be expected; nevertheless, there remains the valid suspicion that other obstacles lie in the path of the acquisition of a bold and imaginative national policy for oceanography. One clue is provided by Admiral Burke's endorsement of the ONR TENOC program with the reservation that it would be supported "within budget limits in the Navy's research and development, shipbuilding and military construction programs."[5] Understandably, the Navy's dollars must be divided in a manner that best supports its mission, but the evidence is now clear and overwhelming that environmental studies for the Navy's Polaris deterrent mission and its ASW responsibilities are vital for their successful execution. Yet, it is entirely feasible, in spite of the clarion call for this knowledge, that the estimated $75 million required to effect repairs to the recently fire-gutted aircraft carrier CONSTELLATION, may well be at the expense of oceanographic laboratories or research vessels.

As in almost all areas of endeavor, the aspect of money and priority of expenditure will probably continue to be the

---

[5] Ibid., p. 128

primary determining force in the destiny of man and his creations. In the case of the missile and satellite program, the necessary funds needed only the magic of Sputnik I for them to be appropriated. The requisite men and materials to carry out this work were, for the most part, available. The intrinsic glamour of the space age, the almost unlimited opportunities for high-salaried scientific positions and excellent working facilities contributed to the initial and continuing success of the U.S. outer space effort. Its history, although more condensed, is markedly similar to that of the atomic energy programs of the last decade. One needs only to visit AEC installations at Los Alamos, New Mexico, or Livermore, California, to realize how the stimulus of purpose and money can create an efficient, hard-working and happy scientific community. The same process is evolving now for missile and space laboratory installations. The trek of the intellectual elite to these laboratories will not, for some time to come, be lacking for adequate numbers of scientists.

In rather stark contrast, oceanographic facilities, whether they be ships or laboratories or University Departments, are both antiquated and inadequate. Many of the buildings and ships date back to the thirties with floor space for office and laboratories extremely limited. One example and generally typical of the oceanographic community, is that of the Department of Oceanography and Meteorology of New York University. Its staff, though excellent, has always been a small one and can not expand because of space limitations and lack of financial support. The office, laboratory and storage areas as well as considerable equipment are thirty years or older. Professor Bernhard

Haurwitz, the esteemed Head of Department for many years, recently left the University after many unsuccessful attempts to enlarge the scope and provide adequate facilities for his Department. Even with its limited facilities, New York University has trained many oceanographers over the years and has done some outstanding research for governmental agencies, particularly in ocean wave and ship motion studies. But from the standpoint of growth and expansion of present efforts, there are no immediate prospects.

Before any substantial progress can be made, therefore, in bringing oceanography to the level envisioned by the various governmental proposals under consideration, direct Federal support to many of the Universities having oceanographic departments will be necessary for new buildings and equipment. Once tangible measures are effected towards enlarging and adding oceanographic facilities to the extent that oceanography and the exploitation of inner space is recognized as an element of national policy, there should be no great difficulty in attracting adequate and competent personnel. This is the view adhered to by Dr. Columbus Iselin[6] of the Woods Hole Oceanographic Institute, a member of the NASCO Committee and one who has been long associated with virtually all facets of oceanography.[7]

Even, however, assuming that the expansion and modernization of oceanographic facilities goes forward briskly--and this appears unlikely--the scientific manpower requirements still would probably not be met as easily, or

---

[6] Interview with Dr. Columbus Iselin (Woods Hole, Mass., December 28, 1960)

[7] _Infra_, p. ~~81~~ 90.

as readily, as were those associated with the nuclear weapons and missile-space projects. For one thing, the mysteries of inner space, albeit plentiful, have yet to achieve the aura of awesome attraction as have the "countdown" twins of nuclear weapons and missiles. Despite the element of danger, the instrumented concrete block house adjacent to the missile launching pad is a more comfortable and stable platform for scientific endeavor than that of a 2000-ton oceanographic research vessel on the high seas. The ingredients of salt water, diesel oil, and absence from home are not calculated to draw an overwhelming number of young scientists to the seafaring calling of oceanography.

It is thus the author's contention that the scientific manpower problem is the paramount one requiring immediate attention. For, although some scientists can be recruited from other scientific basic disciplines to man the initial input of new ships and laboratories, these men and women will constitute only a small portion needed to carry out the greatly expanded research programs contemplated five to ten years from now. For example, the operations and management of four or five bathyscaphs and several mid-depth submarines alone will require a considerable number of people. As these research vessels, along with the many new surface ships scheduled to be in active service several years from now, accumulate data in ever-increasing quantities, requirements will be generated for electronic computers and the men to operate them and analyse the data. Literally a crescendo of demands for more men and machines will ensue as the attack on inner space gains momentum, for the relative ignorance of the oceans' secrets makes them susceptible to a myriad of scientific "breakthroughs." The cracking of the ocean "safes" will release a vast array of resources that may prove to have a greater effect on mankind than any other development of the twentieth century.

The accomplishment of these feats will not be easy ones and will require a hardy and dedicated corps of scientists and engineers. Cruising along on abyssal plain at 18,000 ft beneath the surface or slowly bottom-crawling along a 36,000 ft trench is comparable in some aspects to orbiting the earth 200 miles out. Or, equally interesting but also demanding a little more than the usual, will be modern and functional "Kon-Tikis"--manned, drifting buoys, traveling with the wind and currents and at times cork-bobbing in spectacular roller-coaster style on giant sea waves. Truly, the new "Hydronaut" will require a similar measure of mental and physical stamina associated with that of the space age Astronaut.

At the present time the problem of recruiting graduate students in oceanography is a difficult one. Basically, the core of this problem rests in the American system of higher education which virtually commits its graduate students into a status of second class citizens for the duration of their study.[8] Oceanographers suffer from this system more than most other disciplines because their term of study tends to be of greater length. To some, but nevertheless inadequate extent, a portion of the top ten per cent of university students can win fellowships which will support them, but not a wife and/or family, both of which accrue in the majority of cases before the student has achieved his doctorate at an average age of twenty-eight. For those students in the next lower bracket, well above average

---

[8] Gordon A. Riley, "How to Train New Oceanographers," Underwater Engineering, September 15, 1960, p. 31.

and competent, but not in the top ten per cent, there is little university or governmental support. This group is very much needed in the science community, for the broad degree of levels of competence does not require doctorates in all cases.

The cost of college and postgraduate education is already high and has been predicted to double by 1970--to $3400 a year at a state university and to $4600 at a private college.[9] Leading educators as well as other officials, including Admiral Rickover, have voiced the need for drastic changes in the present educational system. That their proposals based on aptitude regimentation have not met with general public approval is largely due to their anti-democratic flavor. With, however, the forthcoming population surge of the younger generation materializing during the next decade, these measures or similar ones are inevitable if America is to grow and maintain its intellectual strength and vigor.

Therefore, there will be needed considerably more governmental and industrial support for higher education. The demands of oceanography in support of national security must be met in this area <u>without any further delay</u>. The rewards of financial security, optimum working conditions, and of respect and dignity will be most necessary to attract the rather specialized group of men whom Roger Revelle, Director of the Scripps Oceanographic Institute, has termed, "sailors who use big words." These oceanographers of the future will be explorers in the truest sense of the word--modern

---

[9] Robert O'Brien, "The U.S.A. in 1970," <u>Reader's Digest</u>, January 1961, p. 28.

Pathfinders of the Sea carrying on the traditions of environmental exploration so capably established by Matthew Fontaine Maury. They will, along with their brethern of other sciences, be in the front line of the "battle for technological supremacy that is now a battle for survival."[10]

[10] George C. Reinhardt and William R. Kintner, The Haphazard Years, p. 202.

CHAPTER IV

SURVIVAL BY SEA

The oceans of the planet Earth, in which life's earliest forms experienced its remote beginnings perhaps two billion years ago, have together with the sun and atmosphere fostered a human population whose numbers now approach three billion. Of the virtually infinite array of geological and astronomical facts that pertain to life and its evolution on earth and to the expanse and nature of the universe, the life-giving and life-sustaining oceans of the earth are likely the only ones in our solar system. That they exist on planets of other solar systems will only be determined when the latter themselves are established as realities in contrast to existent mathematical probabilities.

It is a curious and interesting thing that Man through the centuries has by observation, invention, ingenuity and scientific logic accumulated an extraordinarily vast wealth of information about the land areas of the earth and outer space, while in comparison acquiring so little of the hydrosphere and atmosphere--the two environments necessary for his very survival. Particularly in the case of the oceans, for in recent times the atmosphere has been gradually but surely receiving the attention it deserves, the reverse of an old adage is true in that the trees of the ocean have been overlooked in the examination of the forests of the universe. Now a cliché but yet worthy of repeating, "more is known of the back side of the moon than the bottom of the ocean."

> It is wonderful to look out and try to understand space; it will be exciting to go out; but . . . we should not forget the earth on which we stand and the great storehouse of living needs . . . ours

for the taking . . . held for us in the seas. Let us, in our effort to understand earth, sun and space, turn to the sea.[1]

Statistics and Geography. At the outset, the suggestion that the planet Earth is misnamed serves as an excuse to state that the term "planet Ocean" is valid only from the standpoint that the hydrosphere covers about 70 per cent of the surface of the planet. The definition of the hydrosphere--as the aqueous envelope of the earth--is a good one, for volume-wise the oceans constitute only .15 per cent of the total volume of the planet.[2] As deep as the oceans are, seven miles in a few spots and two and one-third miles as an overall average, our planet, from an astronomer's viewpoint, is about as wet as a soccer ball rolled through a puddle of water.[3] But, to carry the analogy further, the mud particles imbedded in the film of water on the soccer ball are of the same order of magnitude as that portion of the earth's lithosphere rising above the oceans' surface. For, if the mountains and even the continents themselves were all bull-dozed into the sea, there would still be a depth of water over the entire earth's surface of one and one-half miles.

While this view squeezes the range from the highest mountain top to the deepest ocean abyss into a thin egg shell, the perspective from man's vantage point presents a vast water laboratory 140 million square miles in area and some 330 million cubic miles of volume. The very greatness

---

[1] Athelstan Spilhaus, Turn to the Sea, p. 44.

[2] Isaac Asimov, The Intelligent Man's Guide to Science, 2 v., I, p. 103.

[3] Leonard Outhwaite, The Atlantic, p. 34.

of this expanse, however, requires that it be viewed in true relationship to its island continents through the medium of a geographical globe, rather than by means of distorted chart projections, the most infamous of which is the Mercator.

In terms of the land and water masses of the Earth, of natural resources and climate, of population distribution and of geo-political considerations, it is useful if not of utmost necessity to view the world as consisting of a Water Hemisphere and a Land Hemisphere. To do this is to turn any version of a classroom globe so that the southeast corner of New Zealand is at the top of the world. The hemisphere one sees from this point is almost entirely composed of the Pacific and Indian Oceans and the extreme southern end of the Atlantic.[4] All the land in this Water Hemisphere totals less than six per cent of that of the world and holds only four per cent of the population. In startling contrast, the Land Hemisphere viewed from the other end of the axis which intersects the earth's surface near London, England, contains nearly all the land areas and population of the world.

It is thus no surprise that the Atlantic Ocean, lying as a broad channel between the four continents of Europe, Africa, North and South America, and at the center of the earth's land mass, has become an increasingly important strategic area in both peace and war. The course of human history and the predestined geographical location of the Atlantic basin have dictated the necessity of controlling this oceanic "Heartland" as a prime requisite in dominance

---

[4] Outhwaite, _op. cit._, p. 59.

of the world.

<u>The Oceans--Friend or Foe</u>. Time was when a youthful and growing America was afforded considerable sanctity by the oceans' protective shield. During this period of isolation, together with an abundance of natural resources within its own borders sufficient to feed the machines of America's Industrial Revolution, there was little need for ocean transportation except to carry the tide of immigration to the New World. This was also the age of the railroad, and that the U. S. Merchant Marine suffered as a result is evidenced by the low ebb of tonnage in 1910 of only 782,517.[5]

Two world wars, an exponentially increasing rate of world energy production and a similar dwindling rate of natural resources have converted the oceans into a global network of international turnpikes. In less than half a century, the need for oceanic commerce and the threat of the submarine, the airplane and the missile, separately or together, have not only eliminated the oceans as a shield but have made them a potential foe. Fortunately, they can still be an ally, but only through efforts designed to understand the essential character of the oceans and to utilize their natural advantages and the resources contained within them.

The immediate and obvious need is to develop instruments to make the oceans transparent, so that submarines can be detected, classified and tracked, and at the same time, increase our knowledge of the oceans and the ocean

---

[5] U. S. Congress, House, Committee on Science and Astronautics, <u>Ocean Sciences and National Security</u>, p. 10.

floor so that our own submarines can use them to their advantage. Until there is developed a way to replace sound as a primary detection means, "sound receivers must be coupled together in a vast underwater spider web of millions of miles of cables, which, like our radar surveillance in the air space, can keep track continuously of normal comings and goings, yet single out any stranger in our midst."[6] Existent efforts in this regard are already sizeable but, in terms of the magnitude of the problem, they cannot be considered as sufficient.

The increasing Polaris submarine fleet, recent Soviet programs in oceanography, and evidence that their already formidable submarine fleet is being augmented by nuclear and missile firing submarines are compelling reasons to believe that the ocean may be the major battlefield of a future war. The age-old principle of warfare with regard to familiarity with the face of the country applies to the oceanic battlefield as well. Survival ultimately could depend on this knowledge.

Food and Water from the Sea. "In 1798, the Reverend Thomas Robert Malthus published the first edition of an essay which was destined to precipitate one of the longest and at times one of the most heated controversies in history."[7] The Malthusian principle that human populations, if not checked by various means, would increase much more rapidly than the means of subsistence and thus suffer disaster, has in the ensuing century and a half from its

---

[6] Spilhaus, op. cit., p. 11

[7] Harrison Brown, The Challenge of Man's Future, p. 5.

inception been ridiculed and scorned. Certainly from the standpoint of an almost threefold increase in population from the one billion of Malthus's time, his prediction of universal human starvation was grossly in error. In recent years, however, demographers and other students of the world scene have realized that Malthus's reasoning was sound and that his faulty predictions suffered not from false premises but from lack of knowledge relating to the potentialities of technological development.

The pendulum of thinking in light of the present surge of population growth and a lack of commensurate production of food has swung back to the Malthusian principle, at least to the extent that the burgeoning human population is recognized as a problem of concern to all mankind. There is now no question that some measure of population control and a considerable increase in food production will be necessary to provide adequate nourishment for all peoples of the world. The year 2050 may well be experienced by 10 billion humans, the support of which will require food, water and energy production on a scale far transcending that existing at the present time. Beyond this era lies the realm of conjecture which can envision a population of 50 billion or even (skeptically) 200 billion, garnering its energy requirements from the air, the sea and ordinary rock and its food about equally derived from the land and the sea.[8]

It is interesting to note that from the standpoint of sheer quantity the oceans still contain most of the earth's life but less than one per cent of the food consumed by

---

[8] Edward S. Deevey, Jr., "The Human Population," Scientific American, September 1960, p. 202.

human beings is obtained therefrom.[9] Recent annual production of sea fisheries amounted to about 25 million metric tons of fishes and invertebrates and about four million tons of whales, more than 90 per cent being derived from the Northern Hemisphere.[10] This represents an increase by one-half over that of a decade ago. India during this time has joined the fishing nations with catches exceeding one million tons annually and, significantly, Russia now ranking fourth, approached three million tons while increasing her powered fishing craft since World War II from 3,000 vessels to 13,000.[11]

While these increases are substantial, the ocean barrel has scarcely been scraped in terms of both animal and plant life available. The fishing industry is still in a stage comparable to that achieved by agriculture centuries ago. Farming of the sea, or aquaculture, will ultimately be required to augment the hard-pressed food resources taken from thin topsoils of the land. Only the requisite human effort and technology are needed to extract the literally billions of tons of plant and animal protein that reside in the upper strata of the oceans.

Equally necessary for the perpetuation of civilization are immense quantities of water which are used not only for drinking, hygienic purposes and irrigation but in support of the manufacturing of many products in industrial societies.

---

[9] Donovan Finn, "Fish: the Great Food Potential," The UNESCO Courier, July 1960, p. 59.

[10] National Academy of Sciences-National Research Council Report, The Effects of Atomic Radiation on Oceanography and Fisheries, p. 3.

[11] Finn, op. cit., p. 60.

From the oceans this water now comes through the processes of evaporation, producing over the United States alone an average daily rainfall of 4300 billion gallons. Of this seemingly phenomenal amount, 70 per cent that falls on the land returns to the atmosphere as the result of evaporation or transpiration of vegetation. The remaining 30 per cent, 1300 billion gallons, runs off the land and flows as streams and rivers into the ocean or filtrates through to the underground water table.[12]

This latter amount represents the maximum daily consumption rate unless some of it is re-used or additional fresh water is obtained from sea water. The existent rate of approximately 200 billion gallons daily[13] would appear well below the maximum available. But many conservation steps need be taken to reduce the run-off as well as to reduce the drain on the underground reserves of water before an imminent and serious water shortage can be averted in some of the Western areas of the United States. A predicted daily utilization of nearly 400 billion gallons by 1975 and of even greater increases beyond that time will inevitably dictate the conversion of sea water into useful water. The cost will be great compared to existent water costs but the water obtained in conjunction with the production of salt, magnesium, soda, fluorine, hydrogen, uranium, gold, to mention just a few, can be produced at acceptable costs. To this extent the oceans may ultimately become the major source of useable water, resulting in the conversion of millions of acres of arid lands for the production of food.

---

[12] Brown, op. cit., p. 212.

[13] Report, Presidential Advisory Committee on Water Resources Policy, p. 5.

Minerals from the Sea. Statistical facts frequently make for dry reading but there are some "wet" and simultaneously interesting statistics about the oceans that deserve at least cursory attention. A few of these have already been noted but were not really in a "Believe It or Not" category as are those relating to the mineral resources in the sea.

Recalling that the oceans consisted of some 330 million cubic miles of salt water, it has been calculated that just one cubic mile of this water contains, on the average, 166 million tons of dissolved salts and other elements.[14] If all the dissolved solids in the oceans could be precipitated out and deposited on the land areas of the earth, the "table salt" (78 per cent of the total) layer would be 500 feet thick.[15] Scattered very sparsely in this layer totalling 50 quadrillion tons would be about nine million tons of gold and 426 million tons of silver. The approximate total worth of these precious metals of $22 thousand billion would indeed solve all budgetary problems for some time but, unhappily, the existent technological processes for extracting these metals from the low-grade ore of the oceans are equal if not greater in cost than their worth. Interestingly enough, a rather grandiose attempt to mine the oceans' gold was made by the German chemist, Fritz Haber, after World War I in a scheme to pay off the German war debt.[16] The gold did not filtrate out in any great quantity but the

---

[14] Rachel Carson, The Sea Around Us, p. 188.

[15] Outhwaite, op. cit., p. 442.

[16] Carson, op. cit., p. 192

four-year South Atlantic Expedition of the "Meteor" resulted in considerable oceanographic data, which is still proving useful today.

Of the known chemical elements at least fifty have been recovered from the seas, the most important being iodine, bromine and magnesium. The latter especially is used for a variety of purposes, not the least of which is for aircraft and missile construction. Overall progress to date for extracting the mineral wealth from the oceans commercially has been somewhat slow (exceptions being sodium, potassium and magnesium salts), if only for the reason that necessary mineral resources from the land can be obtained more readily and economically. The depletion of these resources, however, is taking place rapidly which will in time (for some resources the time is near) dictate mining both the dissolved minerals in the ocean and various ones lying on the ocean floor. With respect to the former, basic research efforts are already in progress to determine how some of the invertebrates are able to extract relatively large quantities of such elements as cobalt, nickel, vanadium and copper when existent chemical processes can obtain only traces of these elements.

Of particular and timely interest has been the comparatively recent discovery of rich deposits of manganese nodules on the floor of the Pacific Ocean, some 300 to 500 miles off the coasts of North and South America and also in the central part of the southeastern Pacific.[17] The interesting aspect of these discoveries lies in the fact that the high-grade manganese nodules also contain substantial

---

[17] John L. Mero, "Minerals on the Ocean Floor," Scientific American, December 1960, p. 66.

quantities of nickel, cobalt and copper, all of which are now being imported by the United States in large quantities. Moreover, even these imported metals are being depleted to the extent that lower-grade ores are being mined which demand increasing production energy. Already for example, copper is being extracted from ore containing as little as 0.7 per cent copper,[18] its decrease from the 13 per cent ore of the eighteenth century vividly illustrating the voracious and insatiable appetite of industrial giants.

The comparative richness of the manganese, nickel, cobalt and copper is in itself an exciting prospect for exploitation, but the over-all estimated concentration of these submarine ores of 283 billion tons of nodules (30-50 per cent of manganese) is almost beyond belief. For, the estimated (President's Materials Policy Commission) total world's land supplies of manganese ore is no more than 400 million tons--approximately a 100-year supply at the present rate of consumption. The situation for copper is even worse, possibly requiring the processing of land ores containing as little as 0.1 per cent copper within 50 years. The approximate 1.6 per cent copper in the manganese nodules is by comparison, of course, a very rich ore.

Unlike the impractical means involved in extracting minerals from sea water, there now exists the technological "know-how" for retrieving ores from the ocean floor at costs comparable to those required for mining low-grade ores on land. To be sure, the engineering feats needed would be impressive ones and the operation of gigantic hydraulic dredges in stormy seas something to behold. Yet, the scope

---

[18] Brown, op. cit., p. 201

of the problem is no greater than that of construction of tunnels or mining ores 12,000 feet below the earth's surface.

In any event, industrial requirements will ultimately dictate the exploitation of these and other minerals as the eventual major source of supply, such that economic considerations, if any, will have been overtaken by those of necessity. In this connection, however, it is worthy of noting that the inexpensiveness of the sea transportation itself in hauling the ore to coastal refining and processing centers is a significant factor in the over-all reduction of costs.

Mention has not been made of the incalculable mineral wealth lying in the ocean floor sediments, but it is there in unmatched quantity and its composition of valuable materials considerably diversified. These ores also are recoverable and perhaps only await the exhaustion of their sister resources on land before man "turns to the sea" for them. There is absolutely no question that if existent industrial society is to continue in the generations to come and as well to envelop the impoverished and underdeveloped nations aspiring to some measure of prosperity, the oceans are truly the key to survival.

<u>Energy from the Sea</u>. The discovery of the fossil-fuels and their ensuing exploitation sparked the Industrial Revolution by providing the enormous energy necessary to convert the abundant natural resources into metals and chemicals, as well as providing the power to drive the very products created by industry. The history of the energy requirements of an industrial nation like the United States and estimates of requirements of the future are provocative and compelling stories, and have therefore been rendered

comprehensive treatment. Suffice it to recount here that the fossil-fuels, having taken several hundred million years to form are, like the mineral resources of the earth, being consumed in extraordinary quantities and at sobering rates.

Forecasts of ultimately complete consumption are admittedly tenuous ones, depending as they must do on projected energy requirements, industrialization of new nations, population growth, and estimated world reserves of fossil-fuels. These variables notwithstanding, several such forecasts have been made both by individuals and governmental committees, with a consensus envisioning a maximum of 800 years required to consume all the world's reserves, and feasibly only 200 years necessary to do the job. From the standpoint of the United States resources available and projected energy requirements, the range lies between 75 and 250 years.[19] Thus, the "black gold" that is now literally bursting its seams, particularly so in the Middle East, is in a somewhat similar status as the seemingly unlimited wood supplies were several centuries ago.

The increasing rates of expenditure of coal and oil from the land will necessitate, probably within the next half-century, the tapping of the estimated 400 billion barrels of oil--representing about a third of all that remaining on earth--[20] lying under the seas. Actually, this source is even now being utilized but, in terms of land production, is only fractional.

There are other energy sources contained in the oceans, perhaps the least of which but yet sizeable and practical,

---

19 Brown, op. cit., p. 164.

20 Spilhaus, op. cit., p. 40

are the tides. Massive projects are already underway in the United States (Fundy Bay), France (Mont St. Michel) and England (Seven Estuary), which will produce energy at an approximate rate of several billion horsepower-hours per year. When compared, however, with the 1950 over-all energy production of 13,000 billion horsepower-hours per year,[21] one can realize that tidal energy is literally and figuratively a "drop in the ocean's bucket!" Nevertheless, it should be remembered that energy from this source is virtually inexhaustible and will continue as long as there are tides.

The really spectacular sources of energy from the oceans come from the sun, 30 per cent of the total received which is converted into evaporating each year 400,000 billion tons of water.[22] The amount of this energy expressed in kilowatt hours is staggering to the imagination and, for example, is thousands of times greater than the release of energy from 20,000 megatons of thermonuclear weapons exploded simultaneously. Perhaps a better appreciation is gained by noting that just 10 days of oceanic evaporation expends energy equivalent to burning all the world's reserves of fossil-fuels and forests in one conflagration! While this source of energy cannot be garnered, its expenditure in giving the world its water supply is, of course, utilized vitally in an indirect way.

Two elements in the oceans may, in the last analysis, provide the world of 3000 AD and beyond its virtually infinite sources of energy. These are uranium, 20 billion tons

---

[21] Brown, op. cit., p. 161.

[22] Ibid., p. 168.

of it, and hydrogen--unlimited. The former, after the land resources are nearing depletion, will continue the provision of atomic power, and the latter will be the principal constituent in the harnessing of thermonuclear energy. Parenthetically, solar energy, requiring millions of acres of absorbing surfaces, would be impractical if the world population exceeded 50 billion, thereby needing all land areas for cultivation and occupation.

The widespread use of atomic power may well also become impractical in view of the disposition of atomic radioactive wastes. The oceans have already received some wastes but more than 99 per cent of radioactive wastes are now stored on land.[23] This practice doubtless will continue but in due time land storage would have to be supplemented by ocean storage. Extensive and fundamental oceanographic research will be required to determine to what extent the oceans can safely store atomic wastes. All things considered, it would appear that technological "breakthroughs" in harnessing the hydrogen bomb, extracting the inexhaustible hydrogen from the sea with little or no radioactive waste disposal problems, offer the optimum energy solution to the world of the future.

The Ocean and Weather Control. The subject of weather control in recent years has gained increased attention from various quarters. From the time that "artificial rain" was produced in a General Electric laboratory by Irving Langmuir and Vincent Schaefer in 1946, weather modification--in the form of dissolving certain types of cloud structures and

---

[23] George W. C. Tait, "Atoms Overboard," UNESCO Courier, July 1960, p. 64.

producing rainfall under certain atmospheric conditions-- has been slowly but surely progressing to the point of convincing even the severest skeptics that weather control is possible. That this control is not only probable but conceivably a potential and insidious weapon of incalculable power is reflected by the warnings of a particularly erudite segment of the scientific community and by a similar realization evoked by the military.

"The ability to control the weather and climate will become America's and the Free World's key to survival."[24] This opinion is shared and has also been voiced by the famed Dr. Edward Teller, father of the hydrogen bomb, and as well by Dr. Henry B. Houghton of Massachusetts Institute of Technology, one of the world's foremost meterologists.[25] Shortly before his death several years ago, the late Professor John Von Neumann, considered by many to be one of the most brilliant scientists America has ever produced, predicted that weather control on a vast scale would be possible in a few decades. Yet another prediction came from the late Captain Howard T. Orville, USN, Chairman of President Eisenhower's Advisory Committee on Weather Control for four years, who warned of the dangers inherent in an unfriendly nation obtaining the means of climate control.[26]

One might well ask then, what role will the oceans play on the stage of atmospheric warfare? An immediate,

---

[24] Captain William J. Kotsch, USN, "Weather Control and National Strategy," U.S. Naval Institute Proceedings, July 1960, p. 76.

[25] Everett S. Allen, "Oceanography: the Need and the Promise," U. S. Naval Institute Proceedings, January 1961, p. 78.

[26] Kotsch, op. cit., p. 80.

although not complete, answer is that at this very moment the oceans are controlling the weather, not only vitally from the standpoint of life on earth but indeed hold the key to the success of man's manipulation of the world's climate. Acknowledging for the moment that the atmosphere is after all a necessary ingredient and in fact the patient to be operated upon, it is the ocean that regulates and stabilizes the temperatures of the world. Without the oceans our planet would suffer unbearable temperature ranges, not greatly dissimilar to those occurring on the moon.

The interactions between the ocean and the atmosphere are simultaneously delicate and gargantuan. This interchange of energy between the two environments results in a chain of events that all add up to the daily weather of the world and, in its cumulative total, to world climate. The latter's influence on cultural development and national power is well recognized. Not so well known perhaps is that even favorable climates are precariously perched on the rim of the interacting forces of the sun, atmosphere and the oceans. "The fruitfulness of this country, the sterility of that"[27] can thus be brought about conceivably by leverage forces minute in comparison to the results achieved. However, considerably more knowledge than now amassed is needed of the oceans and, particularly of the energy exchange between the ocean's surface and the atmosphere, before controllable atmospheric manipulations can be effected.

To this task the Russians have already addressed themselves, and in the opinion of Dr. John Lyman, of the

---

[27] Matthew Fontaine Maury, Physical Geography of the Seas, p. 272.

Oceanography Section of the National Science Foundation, they are superior to us in energy interchange studies.[28] Their interest in this critical area is scarcely one without motive and we can be sure that their efforts in oceanography, like those of technology and military arms, are instruments for the seizure and expansion of political power. The Soviet proposal of several years ago to dam the Bering Strait and drive the relatively warm water of the Pacific Ocean into the Arctic Ocean likely would have proven to be of benefit to them at the expense of Canada and the United States. At the time of the proposal, American scientists had reservations as to possible adverse results. Now, in light of considerable credence given to the recent Ewing-Donn theory of a glaciation of much of North America as a result of an ice-free Arctic Ocean, extreme caution is dictated with regard to any large-scale tinkering of ocean currents.

Apart from overt and designed actions to work through the oceans in changing world climates as a means of warfare or as a benefit to all humanity, there is increasing evidence that man's exploitation and burning of the fossil-fuels is warming the earth by pouring about six billion tons of carbon dioxide a year into the atmosphere.[29] The average temperature of the world has already increased by one degree Fahrenheit since 1850 with the CO_2 content increased by about 13 per cent. At this rate of increase, in less than 200 years most of the polar ice cap and glaciers will have melted,

---

[28] Allen, op. cit., p. 79.

[29] Gilbert N. Plass, "Carbon Dioxide and Climate," Scientific American, July 1959, p. 46.

conceivably raising the ocean level up to 200 feet or more.

The oceans have once again proved their value to mankind for they have absorbed most of the carbon dioxide being discharged into the atmosphere. To the extent that they continue to do so and can be made to increase their absorptive power, through the normal cyclic mechanism of raising deep water layers to the surface successfully, may depend whether the coastal areas of the world are inundated or not. Other gigantic forces are involved, of course, in the existent oscillations of the Quaternary ice age, so that it remains a moot point whether New York and Paris will be inundated or glaciated first. In any event, for the first time in Earth's history, Man is wielding a force that possibly could alter adversely the equilibrium between the atmosphere and the oceans. Even within a century, Man's struggle may not be with himself but rather a desperate one with Nature, striving to maintain a balance between her "divisions" of infinite power and his own creations in an intricate mosaic for survival.

CHAPTER V

SUMMARY

The role that Man's environment has played on the world stage, although deserving of co-starring status, has until recently been a minor one. The atmosphere and the hydrosphere have always "been there" and presumably always will. Man's evolutionary activities whether in war or peace have proceeded in erstwhile fashion, disregarding wherever practicable the caprices of Nature and meeting her adverse challenges head-on whenever required. As the technological revolution came into being and as populations grew, greater dependence was necessarily placed on environmental considerations. This very dependence was, however, far greater in fact than Man realized it to be; so, it followed logically that there was relatively little need to assess the magnitude of these considerations, much less than to achieve a comprehensive understanding of the environment itself.

The operations of the U. S. Navy are unique in that they are conducted in both oceanic and atmospheric environments--from the bottom of the ocean to outer space. The Navy's need for environmental knowledge, therefore, is many times that of the other Services combined. Extraordinarily enough, the numbers of oceanographers and meteorologists in the Navy are considerably less than in the Air Force alone. This comparison in itself is only part of the story and not an answer to the Navy's inadequate recognition that knowledge of the oceans is a very real and vital element of sea power. Lieutenant Matthew Fontaine Maury, USN, recognized this fact a century ago and accomplished much to foster in the Navy an awareness of the importance of oceanography. His influence was, however, short-lived and not to be revived in comparable magnitude until 1958 by Rear Admiral (now VADM) John T. Hayward, USN.

As a matter of significance and worthy of considered appraisal, in but a few years the Soviet Union has directed attention and considerable resources to the needs of oceanography on a scale that already equals our own. Of greater concern than the existent level of support, is their projected growth in this area which likely cannot fail to surpass--perhaps greatly so--our future endeavors. From the standpoint of environmental knowledge required in submarine and anti-submarine warfare--representing a fulcrum in the balance of naval power--our national and military policy must be oriented to meet the Soviet challenge.

Surveying and analyzing this policy which has indeed been alerted, and to some extent has been carried out within the past two years, one is at first glance persuaded that all now will be well. Upon closer inspection, however, and delving more deeply into the heart of the matter, there is revealed a halting and somewhat confused implementation of oceanographic research and development, that at the very least has delayed recommended long-range programs by two years. In this regard, it is the author's view that, no less than the requirements and complexities of outer space projects, a sense of urgency and a commensurate provision of the requisite manpower and material resources are required in the vast realm of oceanography to ensure not only adequate military defense but national survival itself.

A look into the future--even only for a century of time, not much compared to the life's span of the Roman or British Empire--reveals a vital dependence on the oceans' food and mineral resources, its energy, its water and its continuing control as a global thermostat. The exponential dwindling of the earth's mineral and energy resources coupled with the ever-growing demands of food and energy by a multiplying world population, demands that a veritable crusade towards the exploitation of inner space be embarked upon at once. Only the merest beginnings can be seen at the present time. The marathon between Man and Nature is not unlike that of the race between the tortoise and the hare. Nature, in the form of the tortoise, may yet overtake Man if he does not meet the challenge of the future, and turn to the sea for a desperately needed "second wind."

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Throughout the course of this paper, conclusions and recommendations have to some degree already been noted, sometimes stated as referenced ones or the author's own, and other times by implication. For this final chapter, therefore, a list of specific actions deemed necessary to undertake with regard to the exploitation of inner space will not be enumerated. Rather, it will be essayed to focus the basic problems of oceanography into clear perspective and to evolve, from this analysis, solutions to these problems at the national and military policy level.

The fundamental problem of oceanography is one that besets to varying degree the entire educational-scientific community, i.e., national and military policies towards education and the "technological war." These policies, or more accurately, attitudes, are a curious mixture on the one hand of traditional suspicion of the intelligentsia and on the other, of disciplined driving of the scientific mind for technological advances applicable to the military field alone. Within these extremist attitudes are countless variations that in reality only reflect Man's struggle to cope with the impact of a dynamic and unceasing technological revolution.

It is understandable in view of radically changing world environment, but no longer excusable, that the United States is not now sowing the seeds of human enterprise and basic research sufficient to reap a harvest that can counter the forces of Communism, and lead the world to an enduring destiny. In one sense, the emergence of Communism has been a blessing for it has fostered a belated sense of urgency for action. But now the urge is for a quick harvest and the seeds are being strewn to the wind. Our desperate quest for the massive deterrent and the conquest of space, utilizing substantial resources of scientists and materials, has blinded us to the needs of the crises of the next generations, which are likely to surpass those of today in both quantity and severity. "The constant danger is that we have too much of yesterday's hardware, and too little of tomorrow's ideas."[1]

Let us not forget that the development of the atomic bomb could not have been started without the 40 years of basic science that went before.[2] Nor should we forget that the technological forging of scientific discoveries into instruments of wonder or peril were the results and not the origin of a pure and free science, "pursuing its independent way to unravel the mysteries of existence, carried on by free men whose guide is truth and whose faith is that it is good to know.[3]

The demands of technology and military arms have already created a shortage of scientists and engineers in some areas, of which oceanography is one. This shortage will become progressively worse if our present educational system is not modified to ensure a flow of the most competent and best suited into the many streams of science and engineering. The Soviets have recognized this need and count their scientific manpower base, with the regimented educational

---

[1]Warren Weaver, "A Great Age of Science," Goals for Americans (The Report of the President's Commission on National Goals), p. 113.

[2]Arthur Holly Compton, Atomic Quest, p. 340.

[3]Vannevar Bush, Modern Arms and Free Men, p. 248.

system that produced it, one of their most valued national assets. There is no need to emulate their system but rather simply to carry out to completion that proposed by Thomas Jefferson over a century and a half ago.

Our system today has haltingly but assuredly approached the ideal one he set forth but has fallen short of the most important element, i.e., state-supported education of university and graduate level, open without expense to those who qualify under terms of strict competition.

> Today there is a fresh and impelling necessity that we should do so. In a world where wars were crudely fought, with little relation to industry or the application of science, we could coast along fairly safely. In a world where the prosecution of war or the avoidance of war demands that we be in the forefront in the applications of science to public health, industry, and preparations for fighting effectively in a modern sense, we can no longer afford to drift with a slow current. It is essential that we provide equality of opportunity of higher education in the full sense, so that talent and intellectual ambition shall have no artifically imposed limitations, so that highly endowed youngsters, wherever located, may come forward with full educational equipment to attack the great problems of the future, in law, medicine, principles of government, social relationships, science, engineering, business theory and practice, and in the humanities that underlie all our thought on the problems of civilization.[4]

Of the host of challenges that America now faces, education of its most valuable of all resources--human beings--is in the long term perhaps the greatest of all. A vigorous and perspicacious response to this challenge can well set the stage for the resolution of other problems arising out of the technological revolution, the unprecedented growth of population, and the rising expectations of the emerging new nations. Fortunately, the Jeffersonian ideal of Federal-supported higher education is an avowed goal

---

[4] Bush, <u>op</u>. <u>cit</u>., p. 237.

of the new Administration, voiced by our President, John Fitzgerald Kennedy. In response to a questionnaire, he stated recently:

> We have failed to make a college education available to every young man or woman with the ability to pursue it. In 1959, 100,000 young men and women in the top ten per cent of their high-school classes could not go to college because their parents could not afford it. Therefore, I will propose enactment of a Student Loan Insurance Act. Under this program the Federal Government will--in return for a small premium--guarantee student loans made by colleges and universities. Basic responsibility for repayment will rest with the student.
>
> A gifted child is a national asset. It is the responsibility of the Federal Government to help him in every way to realize his full potential--for himself, and for his country.[5]

The execution of this plan, as well as other proposals in the field of education, will in time generate not only the manpower for science but the human resources for all endeavors that must be joined in Man's battle against extinction. From these seeds also will be reaped the national, military and scientific leadership that above all other considerations is necessary for survival.

To return specifically to the environment of the oceans and its relationship to naval operations, is to again focus on the problem of the manpower requirements to meet the demands of science and military technology. Apart from the acute needs of scientific manpower for oceanographic research and education in the universities and research institutes, a similar increase of oceanographers or, more aptly, "environmental applied physicists" is required within the Navy. These officer-scientists are needed not only to

---

[5] The Providence Sunday Journal, This Week Magazine, January 15, 1961.

provide environmental data and forecasts of changes for operational purposes, but to serve as a link between operation analyses and applications performed at sea and basic research conducted on the land. Sir Isaac Newton recognized this need long ago and directed attention to it in a letter to the Admiralty:

> If instead of sending the observations of Seamen to the able Mathematicians on Land, the Land would send able Mathematicians to Sea it would signify much more to the improvement of Navigation and the safety of Men's lives and Estates on that element.[6]

The lack of this coordination is particularly applicable to oceanography, in part due to insufficient sea-going military oceanographers and also due to the inherent problem of the vastness of the oceanographic laboratory. The Hydrographic Office is literally overwhelmed with tasks to carry out its mission and can make only temporary assignments to anti-submarine task groups. The Operational Test and Development Force in Norfolk, Virginia, charged with evaluating new weapon systems, many of which are affected by the hydrospheric and atmospheric environments, has neither an oceanographer nor a meteorologist on the Staff. The meteorologists aboard aircraft carriers and/or attached to CARDIV Staffs have had limited training in oceanography but their services are confined largely to operational meteorology and shipboard line duties, the latter responsibility deriving from the fact that most of these officers are unrestricted line.

The solution to this problem is not just in the realm of "more of," but lies rather in the philosophy of education

---

[6] T. F. Gaskell, Under the Deep Oceans, p. 54.

and organization of manpower that will most efficaciously carry out the Navy's mission. Obviously, this area of policy is a fundamental and complex one and cannot be dealt with in any detail here. But bearing on the specific need for additional officer (and enlisted as well) specialists, it must be stated that specialization, borne out of the technological revolution, has spread throughout every facet of human endeavor, and is destined to increase at an even greater rate in the future than in the past quarter century. Industry has recognized this need for specialization, and even the basic sciences have experienced considerable fragmentation.

The Navy's attitude towards specialization has been essentially a cautious one, backed by a traditional policy of emphasis on the command function. Recognition of the need of specialization came about slowly and reached its peak with the Officer Personnel Act of 1947, which allocated about 15 per cent of its total officer strength to technical areas of specialization. Since that time there has been no change in the basic line-technical balance despite the fact that since 1947 the growth of technology has been phenomenal.

The Committee on Organization for the Department of the Navy several years ago recognized this deficiency and recommended the establishment of a Technical Corps and an immediate and annual review of its structure to meet the changing needs of the Navy. The rejection of this concept by the Secretary of the Navy is not in consonance, in the author's view, with the demands of present and future military technology requirements. The Secretary's policy for increased postgraduate education leading to sub-specialization for line officers as the answer to the Navy's technological requirements is most questionable. The capabilities of the human mind with but few exceptions, cannot meet the cumulative, simultaneous and intricate demands of both line and technical functions.

As in industry where technological competition is the essence of progress, the separation of executive leadership and technical skill with respect to training and management must be instituted in the military services. "We need line officers who can be professional line officers, and specialists who can be professional specialists."[7] This view does not imply a decrease of education for the leadership elite--far from it. Indeed, this group in its evolutionary progress towards greater responsibility must not lose contact with the scientific and technological world. Through educational and other communication means, these officers must be trained to recognize and fully utilize the genie of science and technology. "A step in this direction would be to place more emphasis on technology in the curriculums of the major War Colleges which train the future Commanders of our military establishment."[8]

A final problem in oceanography (at least for consideration here) is again one that is inflicted upon most, if not all, of the scientific community. It has to do with military, political and bureaucratic entanglement of pure science to an extent that threatens to stifle and impede its progress.

---

[7] Lieutenant Commander Edgar K. Lofton, USN, "A Modern Navy for Modern Defense," U. S. Naval Institute Proceedings, November 1960, p. 61.

[8] George C. Reinhardt and William R. Kintner, The Haphazard Years, p. 224.

The imposition of secrecy upon the inquiries of science for military purposes, the imbalanced demands placed on science in the technological supremacy race with the Soviet Union, and the governmental superstructure of committees for science-administration are heavy burdens for science to bear. The nature of science is intrinsically one of the soaring spirit of Man's imagination. Science can flourish only if controls are kept at a bare minimum. Whether these controls are those of military secrecy, or of regimentation for specific technological achievements, or of inept administration, the effect in each case is to bind science by chains of restraint.

There is no pat solution to this fundamental problem, in part because of its controversial aspects. The science of oceanography is one of those particularly affected by a plethora of the aforementioned restrictions. Even now its interests are in the midst of a tug-of-war between legislative and executive factions, and the committees to resolve this conflict of interest are increasing. The obvious military applications of oceanography are creating international barriers to the exchange of scientific environmental knowledge. The demands of military secrecy notwithstanding, the exploitation of inner space will be one requiring international cooperation, of which there are already moderate beginnings. As in many other fields of human endeavor, the United States cannot undertake alone the great tasks facing mankind.

The Report of the President's Commission on National Goals together with Chapters Submitted for the Consideration of the Commission succinctly, yet comprehensively, outlined virtually the entire spectrum of the problems facing the

United States and the world itself. Solutions to these problems were offered which, regardless of eventual validity, are worthy of careful consideration. With respect to science and technology the Commission indicated:

> Today we must give high priority to those aspects of science and technology which will increase our military strength, but for the longer term we should recognize that our creative activities in science and all other fields will be more productive and meaningful if undertaken, not merely to be ahead of some other nation, but to be worthy of ourselves.[9]

Keynoted in the introduction to this study, reflected throughout the course of the investigation and repeated here, is that the fate of oceanography will rest with the trends of our national purpose. This science is but one of a galaxy of ultimate contributions to the perpetuation of mankind. Much has been said by national, military and scientific leaders as to the actions required for the exploitation of inner space. In view of the level and magnitude of attention directed to this clearly recognized problem, surprisingly little has been accomplished. There are presently several legislative bills before Congress dealing with oceanography as well as meaningful and sincere attempts by the Navy to bear its share of support. Thus, in spite of the truly dangerous delays already incurred, there remains justifiable hope that the requisite implementation will be forthcoming. Perhaps the catalytic force needed to commence the oceanic exploration of the future was brought into being by President Kennedy in his Inaugural Address when he said: ". . . let us tap the ocean depths," and, again in his State of the Union message to Congress on January 30, 1961: "We have neglected oceanography, saline water conversion, and the basic research

---

[9] Goals for Americans (The Report of the President's Commission on National Goals), p. 8.

that lies at the root of all technological progress."

BIBLIOGRAPHY

Allen, Everett S. "Oceanography: the Need and the Promise," U. S. Naval Institute Proceedings, January 1961.

Asimov, Isaac. The Intelligent Man's Guide to Science. New York: Basic Books, 1960. 2 vols.

Bagdikian, Ben H., ed. Man's Contracting World is an Expanding Universe. Providence: Brown University, 1960.

Baldwin, Hanson. "Red Trawlers Fish for Secrets," The Providence R. I. Journal, November 27, 1960.

Bascom, Willard. "The Mohole," Scientific American, April 1959.

Baxter, James Phinney 3rd. Scientists Against Time. Boston: Little, Brown, 1946.

Bigelow, Henry B. Oceanography. Boston: Houghton, Mifflin, 1931.

________. and W. T. Edmondson. Wind Waves at Sea--Breakers and Surf. H. O. 602. Government Printing Office, 1947.

Brown, Harrison. The Challenge of Man's Future. New York: The Viking Press, 1954.

Bush, Vannevar. Modern Arms and Free Men. New York: Simon and Schuster, 1949.

Carrison, Captain Daniel J. "The Soviet Drive for Sea Power," U. S. Naval Institute Proceedings, October 1959.

Carson, Rachel. The Sea Around Us. New York: Oxford University Press. 1951.

Compton, Arthur Holly. Atomic Quest. New York: Oxford University Press. 1956.

Congressional Record, Vol. 105, Part 15, September 11, 1959.

Cowen, Robert C. Frontiers of the Sea. New York: Doubleday, 1960.

Deevey, Edward S. Jr. "The Human Population," Scientific American, September, 1960.

Doenitz, Admiral Karl. Memoirs, Ten Years and Twenty Days. R. H. Stevens, trans. Cleveland: The World Publishing Co., 1958.

Eisenhower, General Dwight D. Crusade in Europe. New York: Garden City Books, 1948.

Elwes, Alfred. Ocean and Her Rulers. London: Griffith and Farran, 1878.

Emiliani, Cesare. "Ancient Temperatures," Scientific American, February, 1958.

Fairbridge, Rhodes W. "The Changing Level of the Sea," Scientific American, May, 1960.

Finn, Donovan. "Fish: the Great Food Potential," The UNESCO Courier, July 1960.

Foss, William O. "Russia's Assets in the 'Wet War'," Underwater Engineering, September 15, 1960.

Gallery, Admiral Daniel V. Twenty Million Tons Under the Sea. Chicago: Henry Regnery, 1956.

Gaskell, T. F. Under the Deep Oceans. New York: W. W. Norton, 1960.

Heezen, Bruce C. "The Rift in the Ocean Floor," Scientific American, October 1960.

Hines, William. "Soviet Science Vessel Wins Praise in New York." Washington Evening Star, September 9, 1959.

Holmquist, Captain Carl O. and R. S. Greenbaum. "The Development of Nuclear Propulsion in the Navy," U.S. Naval Institute Proceedings, September 1960.

Huxley, Aldous. "The Shape of Things in 1896," True, February, 1961.

Iselin, C. O. and W. S. Richardson. "Key to ASW Design: the Ocean's Thermal Structure," Space/Aeronautics, R&D Handbook, 1960-61.

____________. "Matthew Fontaine Maury." Introduction of Dr. Iselin by Raymond Stevens, The Newcomen Society in North America, 1957.

Johnson, Sir Nelson. "Milestones in a Century of Meteorology," Weather, March 1950.

Kotsch, Captain William J. "Weather Control and National Strategy," U. S. Naval Institute Proceedings, July 1960.

Lewis, Charles L. Matthew Fontaine Maury. Annapolis: United States Naval Institute, 1927.

Lewis, Edward V. and Edward Numata, "Ship Motions in Oblique Seas," Society of Naval Architects and Marine Engineers, November 1960.

Lewis, Winston B. "Prince Henry the Navigator," U. S. Naval Institute Proceedings," November, 1960.

Lloyd, David Demarest. Spend and Survive. Indianapolis: Bobbs-Merrill, 1960.

Lofton, Lieutenant Commander Edgar K. "A Modern Navy for Modern Defense, "U. S. Naval Institute Proceedings, November 1960.

Mahan, Captain Alfred T. The Influence of Sea Power on History, 1660-1783. Boston: Little, Brown, 1890.

Maury, Lieutenant Matthew Fontaine. The Physical Geography of the Sea. New York: Harper and Brothers, 1855.

Mero, John L. "Minerals on the Ocean Floor," Scientific American, December 1960.

Morrison, Samuel Eliot. "History of United States Naval Operations in World War II. Boston: Little, Brown, 1946-1960. 15 vols.

Murray, Sir John. The Ocean. New York: Henry Holt, 1913.

National Academy of Sciences, National Research Council. The Effects of Atomic Radiation on Oceanography and Fisheries A Committee Report. Washington: 1957.

____________. Oceanography 1960 to 1970. A report (12 chapters) by the Committee on Oceanography. Washington: 1959-1960.

National Defense Research Committee. Office of Scientific Research and Development. The Application of Oceanography to Subsurface Warfare. Summary Technical Report of Division 6, NDRC. Washington: 1946.

Nehru, Jawaharlal. Nehru on World History. Condensed from Glimpses of World History by Saul K. Padover. New York: J. Day, 1960.

"Ocean Frontier," Time, July 6, 1959.

O'Brien, Robert. "The U.S.A. in 1970," Reader's Digest, January, 1961.

Opitz, Lieutenant Commander Albert G. "From Science, Sea Power?" U. S. Naval Institute Proceedings, October 1960.

Outhwaite, Leonard. The Atlantic, a History of an Ocean. New York: Coward-McCann, 1957.

Pierson, Willard J., Jr. "Wave Forecasting Methods and Heights of a Fully Developed Sea," Deutsche Hydrographische Zeitshrift, Band 12, Heft 6, 1959.

Reinhardt, George C. and William R. Kintner. The Haphazard Years. New York: Doubleday, 1960.

Riley, Gordon A. "How to Train New Oceanographers," Under water Engineering, September 15, 1960.

Rotchi, Henri. "The Old Men (and the new ones) of the Sea," The UNESCO Courier, July 1960.

Saunders, Commander M. G., R.N., ed. The Soviet Navy. New York: F.A. Praeger, 1958.

Sears, Mary. "Moscow Visited," Oceanus. December 1960.

Shepard, Francis P. Submarine Geology. New York: Harper and Brothers, 1948.

Silk, Leonard S. The Research Revolution. New York: McGraw-Hill, 1960.

Snow, C. P. The Two Cultures and the Scientific Revolution. Book review by Steven Marcus, Commentary, February 1960.

St. Denis, M. and W. J. Pierson, Jr. "On the Motions of Ships in Confused Seas." Unpublished Report. New York: New York University, 1953.

Stommel, Henry. The Gulf Stream. Los Angeles: University of California Press, 1958.

Tait, George W. C. "Atoms Overboard," The UNESCO Courier, July 1960.

U. S. Congress. House. Committee on Science and Astronautics. Ocean Sciences and National Security. Report. Washington: U. S. Government Printing Office, 1960.

U. S. Congress. Joint Committee on Atomic Energy. Report of the Underseas Warfare Advisory Panel. Washington: U. S. Government Printing Office, 1958.

"USSR Submarine Fleet." Jane's Fighting Ships. 1960-1961 Edition. New York: McGraw-Hill, 1960.

Vallentin, Antonina. Leonardo da Vinci. E. W. Dickes, trans. New York. The Viking Press, 1938.

Van Doren, Carl. Benjamin Franklin. New York: The Viking Press, 1938.

Walsh, Don. "The Big Dive: Seven Miles Down to Sea's Deepest Pit." Life, February 15, 1960.

APPENDIX

THE PATHFINDERS OF THE SEA

The history of oceanography serves well to illustrate some of the basic concepts of the control of the seas. In its broadest context, oceanography is the study of the oceans in all their aspects. In ancient times, the emphasis was on the geographical aspect while in the past century attention has been directed more to the ocean's environmental characteristics and to its relationship with maritime strategy and national power.

Thus, the understanding of the nature of the oceans in their relationship to commerce and exploration led nations to grandeur and power. Ignorance and indifference to this ocean world led to their defeat and destruction. Therefore, it is most relevant to chronicle briefly the history of oceanography in order to gain an understanding of the vital rôle that the science of oceanography plays in the realm of sea power. In so doing, it is appropriate to designate but a few of many of those men--leaders, explorers, scientists, historians--who deserve some share of that honor bestowed upon Commodore Matthew Fontaine Maury, USN, as the "Pathfinder of the Seas."

For hundreds of centuries the seas and oceans have shaped the destinies of men and nations. Man's return to the sea, however, likely occurred in a comparatively recent era when one contemplates the aeonian millenniums that prehistoric man eked out a living on a hostile land. As fraught with dangers as this land was, the emerging nomadic peoples in time found themselves faced with a far greater one--the sea and the fear of the unknown. "But many men are gifted by Providence with a disposition which not only resists with persevering obstinacy the influences of danger, but actually finds pleasure in the struggle, and often times seeks it out for the delight of subduing it."[1] This attitude combined with, or substituted by, that of sheer necessity of survival or an innate human curiosity characterized the first and unknown Pathfinder of the Sea, and indeed as well those men who explored in one way or another the "great River of the Ocean beyond the Pillars of Hercules"[2] down to the present day.

Thus, early man's most important conquest, that of fear of the sea, led to using the ocean as the highway of the world and in turn fostered the foundations of civilization. Such, however, was not an easy nor a quick conquest. Its beginnings are found many centuries before the birth of Christ in the Mediterranean. This inland sea provided optimum conditions for Man's maritime exploits and prepared him for the greater and ultimate conquests of the surface of the oceans of the world.

Suffice it but briefly to sketch this early history of oceanography, although the study of that period from about 2000 BC to the time of the Roman Empire is an absorbing and a fascinating one. The ancient literature abounds in the recounting of this story and undoubtedly the poet Homer remains as the chief story teller of that time. While falling short of being an accurate historian and geographer, "his stories are full of the wonder and beauty of the

---

[1] Alfred Elwes, Ocean and Her Rulers, p. 3.

[2] Sir John Murray, The Ocean, p. 7.

'wine-dark sea' and of the feelings of seamen which are properly a mixture of fear and courage, of avoidance and desire."[3] He must therefore be designated as the first known Pathfinder of the Sea, albeit cloaked in the guise of his fabled heroic seafarer, Odysseus. But of even greater association with this title is that "the Trojan War of Homer is best interpreted as an episode in the long-drawn-out efforts of the Greeks to maintain control of the sea over trade and transport in the Aegean."[4]

The great fleets of the early Greeks were probably derived from contacts with the Minoan civilization of Crete. These truly ancient mariners sailed the eastern Mediterranean as early as 3000 BC. They in turn may have learned their trade in seafaring from the Egyptians where archeological evidence indicates that the Egyptians were cruising the Nile and Eastern Mediterranean 8000 years ago. But it was the Phoenicians, in the annals of man, who rightly deserve the title of the first maritime power.[5]

The Phoenicians epitomized the rise of colonial sea power. Their establishment of far-flung bases, the most notable of which was Carthage, their knowledge of navigation, exemplified by a fantastic voyage from east to west from the Indian Ocean into the Southern Hemisphere around the Cape of Good Hope, and their acquisition of wealth through extensive trade marked them rulers of the ocean world for more than 2000 years. Unlike the Egyptians, basically a

---

[3] Leonard Outhwaite, The Atlantic, A History of an Ocean, p. 73.

[4] Ibid, p. 74.

[5] Elwes, op. cit., p. 7.

land power and with little natural resources for the building of ships, the forests of Lebanon and the natural harbors of Tyre and Sidon provided the Phoenicians opportunities of which they took full advantage.

Their ultimate downfall came as a result of too great a devotion to the accumulation of wealth through the merchant marine force of their day and not enough attention to defense. Subdued first by the land power of Nebuchadnezzar of Babylon, then to lose their rejuvenated fleets a century later in support of the ill-fated march of Xerxes of Persia on Greece in 480 BC, the glory that belonged to Phoenicia came to an inglorious and brutal end with the destruction of Tyre by the famous General, Alexander the Great of Greece.

To Greece our attention must now be turned, perforce too briefly, for here was exemplified a vast spectrum of learning which penetrated to the very essence of the philosophy of life, of the beginnings of true science, of the nature of democracy and imperialism, and of the lessons to be learned from the concepts of oceanography in its relationship to sea power, scientific beginnings and geography.

The first of these was Thucydides, one of the great historians of all time--a Mahan of that age as it were--who illustrated among other classical philosophies of thought the relationship of sea power to national power. Aristotle equally deserves an honored position in the development of oceanography. His work was the first really genuine effort in scientific thought which brought together the elements of man's environment. The classic <u>Meteorologica</u> was the forerunner of scientific investigation on the interface between the ocean surface and the atmosphere, an area of which the understanding of forces at work is vital to the prosecution of naval warfare, and indeed to the very survival of mankind. Pytheas, a classic scholar and one of the greatest explorers of the ancient world, bent on increasing his knowledge of astronomy and geography, sailed from the Grecian colony of Massilia, the present French city of Marseille, about 325 BC on what was to be an historic voyage.[6] This undertaking, based largely on his knowledge of mathematics and astronomy, resulted in the accumulation of considerable scientific data, not the least of which was the observation of the tides of the Atlantic to which he correctly attributed their causation to the moon. Unfortunately, most of the reports of this voyage, which took him as far as Iceland, have been lost with one of them significantly entitled The Ocean, possibly the first treatise on oceanography as such ever written.

The evolution and ultimate decline of the Roman Empire witnessed a comparative end to further oceanic discoveries, scientific or geographical. Although primarily concerned with conquest of lands, Rome yet exercised sufficient control of the Mediterranean Sea to cause the defeat of Hannibal,[7] subsequently to destroy Carthage and through sea power to conquer all lands adjacent to the Mediterranean. It was left to these conquered countries such as Greece, Egypt and Morocco to venture on voyages outside the Mediterranean. The name of Hippalus, commander of a ship in the

[6] Outhwaite, op. cit., p. 98

[7] Alfred T. Mahan, The Influence of Seapower upon History, pp. 15-20.

Indian trade,[8] stands out as the discoverer of the "monsoon" route to India from the Arabian Gulf and also that of Juba, a king of Morocco, who effected the first European occupation of the Canaries.[9]

But with few exceptions "those who kept the sacred fire [of oceanography] alight were the Vikings and the Arabs."[10] The latter, utilizing their discoveries of the hinged rudder, the compass and the astrolabe, sailed beyond India to Sumatra and as far north as Canton in China. The fabulous Vikings, several centuries before the great "Age of Discovery," without benefit of navigational instruments but of necessity using the true seaman's knowledge of winds and currents, explored the North Atlantic time and time again, finally to land and establish short-lived settlements in North America.

In the fifteenth and sixteenth centuries, the renascent spirit of Pytheas came into being. Two small nations, Portugal and Spain, emerged to establish world-wide empires. It was from the ocean their power was founded and to one man goes the credit for fostering the initial voyages that led to the "Age of Discovery" and dispelled forever the medieval superstitious fear of the seas. Such a man was Prince Henry the Navigator of Portugal. Surrounding himself with mariners and experts in navigation, cosmography and cartography, he directed a series of long voyages to the

---

[8] Elwes, op. cit., p. 172.

[9] Outhwaite, op. cit., p. 96.

[10] Henri Rotchi, "The Old Men (and the new ones) of the Sea," The UNESCO Courier, July-August, 1960, p. 41.

Atlantic islands and down the west African coast. Had he lived on to the time of Columbus and Magellan, the historic voyages of these two men likely would have occurred under the flag of Portugal rather than Spain. Although Prince Henry voyaged no farther than Morocco, the stimulation and leadership he gave to the early voyages of the 15th century led to a significant increase of knowledge of the various oceans--their currents, tides, the winds upon them, depths, temperature and salinity. In August 1960, the 500th Anniversary of his death was marked by ceremonies in many parts of the world, in honor of the man who "opened the seas to navigation and began the discovery of the modern world."[11]

As far as is known, Magellan in crossing the Pacific in 1521 was the first to sound the open ocean.[12] His short line failed to reach the bottom and, while naively concluding that he had discovered the deepest part of the ocean, he had nevertheless commenced an important kind of oceanographic observation that yet goes on today. "Columbus should also be credited with a scientific and thoroughgoing attempt to explore the ocean itself."[13] For, of the eight crossings of the Atlantic he followed a different band of latitude in each instance such that it would appear he was attempting to gather oceanographic and navigational data.

These men in the era of discovery and represented here as Pathfinders of the Sea, as indicated earlier, are but a

---

[11] Winston B. Lewis, "Prince Henry the Navigator," U. S. Naval Institute of Proceedings, November 1960, p. 63

[12] Murray, op. cit., p. 9.

[13] Outhwaite, op. cit., p. 147.

few of the many responsible for making the length and breadth of the oceans known to Man. They were to be succeeded by another generation of Pathfinders, this time primarily in the realm of scientific exploration, both in the laboratory and on the oceans.

This new era of oceanographic development commenced with the Renaissance, the early stage of which is best characterized by the phenomenal works of Leonardo da Vinci. Apart from his fame as one of the great artists of all time, he was a mechanical genius and a visionary without peer. He investigated several aspects of oceanography which were definite contributions to the science but it was his prophetic vision of underseas warfare and the ominous role of the submarine that merits our attention.[14] One can only hope that the prophesy of this extraordinary individual relative to the end of all life in the form of a nuclear holocaust is not as accurate as were those of the airplane and the submarine.[15]

The Gulf Stream of the Atlantic Ocean which had figured importantly in navigation to the ever-increasing voyages to the New World provided a real impetus to scientific exploration of the oceans. Its importance then, as now and for the future with respect to navigation, to the fishing industry, and to the climates of North America and Europe, can only be measured in astronomical figures. Its effect on the colonization of America and the trade between the Old and New Worlds is a remarkable story in itself. During the

---

[14] Antonina Vallentin, Leonardo da Vinci, pp. 203-209, 274-275.

[15] Ibid, p. 40.

past century it has been the subject of intense exploration and study and only until recently has this massive circulation been substantially understood.[16]

Ponce de Leon was the first explorer on record as having experienced some problems with the Gulf Stream, or more specifically that portion now known as the Florida Current. For, in 1513, sailing south from Cape Canaveral to the Tortugas, the strong current was so swift his three ships had difficulty making headway.[17] His encounter with this massive oceanic circulation phenomenon was not unlike that of the B-29 bombers being unable to push westward to their targets in Japan against another swift but atmospheric river--the Jet Stream.

A host of explorers following Ponce de Leon enlarged upon his findings. However, for the most part the maritime knowledge gained by these seafarers was not widely known or published but rather pieces of information passed by word of mouth.[18] There is no doubt that the bulk of these findings, following the age-old trend of keeping secret for mercenary trade purposes navigational, meteorological, oceanographic and fishery information, was withheld. In view of the rapidly increasing communication between England and her American Colony, such secrecy was doomed to extinction.

To Benjamin Franklin goes a great measure of credit for not only initiating certain phases of oceanographic research but for making known considerable of this information

---

16 Henry Stommel, The Gulf Stream.

17 Ibid, p.10.

18 Rotchi, op. cit., p. 42.

to the public. His map of the Gulf Stream, which he had engraved and printed by the General Post Office at the time he was Postmaster General, is an archival classic.[19] His other "firsts," e.g., attempts to measure sub-surface temperatures at twenty fathoms[20] and meteorological experiments as well as a host of explorations into almost every field imaginable, rank this famous American a Pathfinder in every sense of the word.

The last half of the nineteenth century marks the beginnings and rapid evolution of the science of oceanography with all its ramifications into maritime and naval activities. One man emerges during this period to impart his genius to the laying of the foundations of two separate but related environmental sciences--oceanography and meteorology. This person was an American naval officer--Matthew Fontaine Maury--whose work was prodigious and versatile almost beyond belief. His contributions to the maritime world were colossal and the benefits to science, navigation and commerce are yet being derived to the present day.

The fame of Matthew Fontaine Maury rests primarily on the far-reaching effects of two great works, Wind and Current Charts of the North Atlantic Ocean, with later editions of charts for the Pacific and Indian Oceans, and Physical Geography of the Sea. Both of these maritime classics, published several years prior to the Civil War, resulted in revolutionary changes in the oceanic travel of both hemispheres. The great decrease in passage times for

---

[19] Stommel, op. cit., p. 5.

[20] Carl Van Doren, Benjamin Franklin, p. 727.

the major shipping lanes of the world, stemming from the utilization of Maury's charts, were realized practically in terms of economic results.

> It was estimated that the annual saving to British commerce in the Indian Ocean alone, from Maury's charts and sailing directions, amounted to $1,000,000 at least, and the amount saved to British Commerce in all seas reached the stupendous sum of $10,000,000 annually. As to the United States it has been conservatively estimated that the saving for the outward voyage alone from her Atlantic and California ports to those of South America, Australia, China, and the East Indies amounted to $2,250,000 per annum.[21]

It was, however, a dramatic element that brought about an immediate recognition of Maury--that of the gold rush to California in 1849 which engendered a great increase in shipping from the East Coast of the United States to its West Coast, and thereby provided a real test for verification of Maury's findings.

The world had not long to wait for the justification of his many years of painstaking and systematic study, for the important passage time to San Francisco was reduced from an average of 180 days to 133 days. With the building of the clipper ships, records were made only to be broken, climaxed by that of the FLYING CLOUD in 1851 of 89 days and 21 hours.[22] As Maury wrote:

> Some of the most glorious trials of speed and prowess that the world ever witnessed, among ships that 'walk the waters,' have taken place over it. Here the modern clipper ship--the noblest work that has ever come from the hands of man--has been sent, guided by the lights of science, to contend with the elements, to outstrip steam, and astonish the world.[23]

---

[21] Charles L. Lewis, Matthew Fontaine Maury, p. 63.

[22] Ibid., p. 60.

[23] Matthew Fontaine Maury, Physical Geography of the Sea, p. 263.

The obvious practical results stemming from Maury's investigations served to some extent to cloak the purely scientific merit of his work, which had a far more lasting effect in the development of the science of oceanography. That the extra-ordinary value of his work was not lost on the scientific community, however, there is no question, for honors from the United States and even more so from Universities all over the world were literally heaped upon him. This esteem with which he was held was also evidenced in the conferring of medals and decorations upon him by the rulers of Europe, to an extent for which there had been no precedent and in subsequent years matched only by the acclaim rendered Charles Lindbergh--a pioneering Pathfinder of the air.

There is supreme irony in the fact that amidst the glory justly deserved by and universally bestowed upon Matthew Fontaine Maury, he was to be "treated with the greatest cruelty by the Navy Department which placed him for a time in official disgrace."[24] This irony is all the more unbelievable when at one time he was considered by President Tyler for the cabinet post of Secretary of the Navy in 1841, fourteen years before the Navy Department's unjust action against him.

This earlier recognition of Maury had derived from his published writings concerned with the strengthening and reorganization of the Navy which at that time was at a low ebb. Most of his recommendations covering almost the entire spectrum of naval organization were adopted by Congress in those and in subsequent years. Of particular

---

[24] Lewis, C., op. cit., p. 64.

note was his interest in education, and while not the only individual to suggest the founding of an educational institution to train a corps of officers for the Navy, he contributed so greatly to the ultimate establishment of the U. S. Naval Academy that he justly deserves to be called the father of this famous institution.[25]

To return momentarily to the ungrateful, perhaps even spiteful, action taken by the Navy Department against Maury in 1855 is, in doing so, not for the purpose of criticism in itself nor even to compare such action with strikingly parallel measures taken with respect to Admiral Hyman Rickover. Rather it is to direct attention to an event in a way symbolic of the Navy's relative inattention and appreciation of the fundamental importance of the environmental sciences to sea power and naval warfare, which was to result in serious consequences in both World Wars and even today is receiving belated and questionably sufficient support.[26]

Interestingly enough, Maury himself was the victim of the first selection board of the Navy established by Congress to promote the efficiency of the Navy--a development ensuing from one of Maury's own recommendations relating the needs of the Navy with regard to personnel! Despite Maury's fame and popularity and his excellence of directing the Naval Observatory, bringing this institution to the high level of the oldest and best observatories in Europe, there was a singular group of individuals--his brother officers

---

[25] Ibid., pp. 38-40.

[26] Supra, p. 14 and p. ~~29~~ 31

in the Navy--who were most unfriendly to Maury and scarcely sympathetic with his work. Thus was Maury, then still a Lieutenant with some thirty years service, selected out of the Service and found "incapable of performing promptly and efficiently all their duty ashore and afloat."[27] He, and in turn the general public and the Congress, considering the action an humiliation, effected immediate steps to bring about a nullification of the Board's decision.

Two years were to pass, however, before Maury was vindicated but not without a rancor that stayed with the Navy for years thereafter. Maury had made it very plain in his writings during those years that science in the Navy had been condemned, an allegation which had, even after his restoration to duty, a peculiar after-effect of existing de facto for some time in the Navy. Significantly, the bill passed by Congress to amend the one establishing the Board contained a section providing for the organization of a scientific corps in the Navy. This section was not acted upon and Maury, who would have been the head of this corps, was satisfied as to the outcome, fearing that such a corps would only create dissident elements within the Navy.

In any event, on the 27th of January 1958, Lieutenant Maury was restored to duty and promoted to the rank of Commander, effective as of 14 September 1855, the same date he had been selected out of the Navy. The victory of Maury, having been sorely achieved was to be a short-lived one, for the Civil War was soon to engage the United States in a grim and devastating conflict. Maury's quiet

---

[27] Lewis, C., op. cit., p. 107.

pursuit of scientific truths and philosophical research were for the most part terminated when he, following the lead of another great American and Virginian, Robert E. Lee, tendered his resignation to President Lincoln on the 20th of April, 1961.

The scope of this paper unfortunately does not permit an adequate delineation of the greatness that belonged to Matthew Fontaine Maury and to the indelible marks of progress he made on the U. S. Navy and the world. But it must be noted he was a true prophet of American sea power, accurately predicting the stride of civilization into America's western frontier and the evolution of trade and commerce in the Pacific. In this regard, it is not to detract from the achievement of Mahan to say that Maury preceded the famed historian in the recognition of sea power as a vital force in the perpetuation of national power.

Moreover, mention must also be made of his contribution toward the establishment of the U. S. Weather Bureau and indeed to the concept of the vast communication networks and international cooperation necessary to bring about the complex, modern and efficient world meteorological organization of today. It is significant that one hundred years later, Sir Nelson Johnson, Director, Meteorological Office, London, stated:

> Coming now within our allotted century, the first important event was the calling of an international conference at Brussels in 1853. The instigator of this meeting was Lieutenant (later Admiral) Maury of the United States Navy. His object was to obtain the cooperation of other seafaring nations in making meteorological observations on ships all over the globe. The analysis of this material would then provide information about the prevailing winds and currents for navigating ships in every ocean. It was some 20 years before the value of international cooperation was appreciated by

meteorologists generally, and credit is due to Maury for initiating this aspect of meteorology.[28]

Maury's systematic investigations were not confined just to the surface of the oceans. It was under his direction that the first deep-sea soundings in the open ocean were carried out and the first samples of the ocean bottom were secured and analyzed. Much of this work had an early practical result in the final success by Cyrus Field in laying the first trans-Atlantic cable.[29] More importantly, however, Maury's initial investigations were to be an instigation of the great scientific expeditions, notably of the British, that were to lay bare many of the oceans' secrets.

In the year of Maury's death, 1873, Sir C. Wyville Thomson published the Depths of the Sea based on the cruises of the British ships, PORCUPINE and LIGHTNING. The classic cruise of oceanographic exploration and research was, however, that of the CHALLENGER from 1872 to 1876. The results of this famous nineteenth century voyage were contained in no less than 50 volumes, taking 15 years to be published. Sir John Murray, who edited the scientific results, stands out as the Pathfinder of this era and remained the leading oceanographer of the world until his death in 1914.

The scientific discovery pace quickened with many nations, among them Germany, adding to the knowledge of the oceans. The United States was not too far behind in this modern age of discovery. Alexander Agassiz, a wealthy

---

[28] Sir Nelson Johnson, "Milestones in a Century of Meteorology," Weather, March 1950, p. 88.

[29] Outhwaite, op. cit., p. 255.

Swiss-born American mining engineer and son of the famous naturalist, Professor Louis Agassiz, of Harvard, was primarily responsible for American interest in oceanographic exploration. He made many cruises on U. S. Coast Survey ships during the period 1877 to 1905. No less a scientist than Sir John Murray attributed to Agassiz significant and outstanding achievements in oceanography.[30] Also during this period, The Institute of Marine Biology was established in 1880 at Woods Hole, Mass., and other oceanographic institutions such as the Scripps Institution of Oceanography at La Jolla, Calif., the Bingham Foundation for Oceanography at Yale University and the Lamont Observatory of Geology at Columbia University came into being. From these institutions originated much of the U. S. scientific effort in oceanography after World War I.

Concomitant with the development of oceanographic institutions and scientific cruises came inventions resulting from the necessity for more and better instruments to sound the oceans. In 1900 Fridtjof Nansen, who was an ocean scientist as well as an explorer and humanitarian, invented the reversible water bottle which enabled accurate measurement of salinity and temperature at many depths. The science of submarine geology, commencing with the work of Sir John Murray and now extremely important to the economic welfare of mankind and to elements of undersea warfare, obtained its "breakthrough" from the invention of the submarine gun in 1936 by C. S. Piggott, an American scientist, which enabled bottom sampling to proceed on a greater scale.[31]

---

[30] Robert C. Cowen, _Frontiers of the Sea_, p. 41.

[31] Outhwaite, _op. cit._, p. 107.

A really significant advance in submarine geology came about shortly after World War I with the development of echo sounding devices, replacing the tedious lowering of weights to the bottom, involving countless hours of valuable time.[32] For example, the CHALLENGER'S deepest sounding in 4475 fathoms required about two and one-half hours.[33] As a result of the new technique involving only a few seconds, the soundings of the ocean increased from a few thousands to literally millions.

It seemed that in the early part of the 20th Century, the depths of the oceans remained the only frontier to be explored other than the more inhospitable polar areas. Therefore, it was a natural development for all types of oceanographic exploration to take place. "Now men were no longer concerned to find new routes or new continents . . . but only to extend their hold on a watery universe which they could not yet control and which only detailed knowledge, still completely lacking, would enable them to use for their own ends."[34] Perhaps this observation is considerably more applicable to the present time; for evidence is overwhelmingly mounting that a great land power--the Soviet Union--is vigorously gaining knowledge of the oceans for this very purpose of achieving mastery of the seas in peace or war.

Yet, over-all progress in the U. S. Navy in almost all aspects was slow during the peace time years after the

---

[32] Francis P. Shepard, Submarine Geology, p. 3.

[33] Murray, op. cit., p. 14

[34] Rotchi, op. cit., p. 43.

Spanish-American War. President Theodore Roosevelt did much to maintain the power and prestige of the Navy but his efforts were not sufficient to establish a first-rate Navy fully prepared to take up the sea battle of World War I. At the time of his administration, criticism was being voiced of the defects in the design of the Navy's ships, particularly with regard to placement of armor plate and too little freeboard.[35] There was no doubt that ship design and environmental effects had not been married as yet.

In fact, little had been done from an environmental effect standpoint since the days of the Clippers of Maury's time. The change from sail to steam and wooden ships to iron ones to a great degree failed to take account of the entirely new effects the oceanic environment would have on these "iron ships that float." Perhaps the classic example of ill-fated design was the loss of the MONITOR in a gale off Cape Hatteras. Her extremely low freeboard, one foot above the waterline, had a lasting influence on subsequent design of U. S. Naval vessels which was to ill-prepare some of them for the vital sea warfare against the German U-boats of both World Wars, and the wind and waves of the stormy North Atlantic and the typhoon-ridden Pacific.

This digression, as demanding and interesting as it is for further elaboration, is not, however, entirely germane to the historical development of oceanography. To continue that development is to refer now to the extraordinarily effective unrestricted submarine warfare waged by the Germans in World War I. Well known but curiously ignored by both the Germans and the Allies prior to World

---

[35] Outhwaite, op. cit., p. 420.

War II were the depredations wreaked on Allied shipping by the German U-boats, to the extent of more than 5,000 ships totalling 11 million tons. For the first time, the oceans dramatically revealed themselves as a gigantic hiding place for this serious menace--the opacity of the sea demanded an entirely new array of sensing elements to detect this instrument of destruction uniquely suited to an oceanic environment. Moreover, attention was directed to the vulnerability of the Atlantic Alliance which required millions of tons of transport of vital war materials and, therefore, demanded the utmost in the realm of anti-submarine warfare.

The challenge posed by this new kind of warfare was only fractionally met during the period between World War I and World War II. To the British and French go the credit for the major work of research in underwater detection systems although the Naval Research Laboratory in this country also made notable contributions in this field.[36] This earlier work, initiated at the close of World War I, with subsequent experimentation soon encountered environmental obstacles in the form of refraction of the sound beam, reverberation, false echoes and rough seas. Basically lacking was the detailed knowledge of oceanographic parameters, the effects of which were crucial on the behavior of underwater sound. Nor, significantly, were other oceanographic effects known upon still another new (at least for the nineteenth and twentieth centuries) type of naval warfare to make its appearance in 1942--the massive amphibious assault.[37]

---

[36] James Phinney Baxter, Scientists Against Time, p. 171.

[37] Supra, p. 7.

It can scarcely be questioned that the heritage left by Maury was for the most part lost by relative lack of scientific activity in the field of oceanography. "In 1927, a Committee on Oceanography, took note of the serious neglect of oceanic research in the United States."[38] This action marked an important renewal of interest in oceanography by the United States. The results of the Committee's work received well-merited attention, followed by substantial private sums for buildings and research vessels, and generous endowments to oceanographic institutions on both coasts. For example, the Woods Hole Oceanographic Institution, founded in 1930, was a direct result of recommendations of the Committee. A major portion of the Committee's report was contained in the book Oceanography by Henry B. Bigelow of Harvard University, the Dean of American Oceanographers and Secretary to the Committee. His book was the first major work on oceanography in the United States since Maury's Physical Geography of the Sea and, appropriately, he became the first Director of the Woods Hole Oceanographic Institute.

While this renewed effort did much in fostering the development of oceanography, really significant progress was not to be achieved until the desperate years following the commencement of World War II. In what turned out to be a brilliant strategic stroke in the annals of warfare, President Franklin Roosevelt, on 15 June 1940, established the National Defense Research Committee (NDRC). This organization massively mobilized science on a scale that

---

[38] U. S. Congress, House, Committee on Science and Astronautics, Ocean Sciences and National Security, p. 14.

proved to be of vital importance in winning the war.[39 & 40] The man primarily responsible for this unprecedented move was Dr. Vannevar Bush, who directed a scientific crusade against the Axis powers, covering the entire spectrum of science and reaching climatic proportions on a fateful day at Alamogordo, New Mexico.

Fortunately for the Allies, early attention was given to the problem of defense against submarines and related environmental factors. The work of Division Six of the NDRC, assigned to sub-surface warfare, deserves considerable credit for its contributions toward turning the tide in the Battle of the Atlantic. Standing out amongst a score of oceanographers during this period was Columbus O'Donnell Iselin, Director of the Woods Hole Oceanographic Institution. As Time Magazine put it, "the man who best exemplifies the growth of U. S. oceanography into a major science is Columbus O'Donnell Iselin II himself."[41] At Woods Hole under his direction and participation, were effected notable and valuable contributions--among them the development and operational use of the bathythermograph--of science in support of anti-submarine warfare during World War II. Honored by the United States in awarding him the Medal of Merit--"for his prudent foresight which saved a large number of ships during the war"[42] --Dr. Iselin continues

---

[39] Samuel Eliot Morrison, History of United States Naval Operations in World War II, 15 v., I, p. 29.

[40] Baxter, *op. cit.*, p. 27.

[41] "Ocean Frontier," Time, July 6, 1959.

[42] Raymond Steven, "Matthew Fontaine Maury," The Newcomen Society in North America, 1957, p. 5. Introduction of Dr. Columbus Iselin.

to this day the important and urgent endeavors of oceanography in support of U. S. national defense.

Even in 1946, however, Dr. Iselin wrote that "the fact remains that our knowledge concerning the ocean is still rather superficial,"[43] despite the gains in knowledge effected during the war years. The post-war period was not one to stimulate a healthy growth in a government-sponsored research for obvious reasons of budget limitations and the general prevailing psychology of "peace in our time."

The Committee on Oceanography of the National Academy of Sciences was well aware of the atrophy being experienced by oceanography and, as a consequence, initiated a second study in 1949 to review the needs of this science.[44] The results were published in 1951 with recommendations to establish a vigorous program in all aspects of oceanography. These proposals, markedly similar to the several present ones of today, unfortunately failed to develop adequate response. Thus the exploitation of inner space not unlike that of outer space had to await a series of momentous events occurring within the Soviet Union before a sense of urgency and reaction set in necessary to develop counter programs in both environments. With respect to outer space the launching of the first "sputnik" dramatically provided the catalyst needed to spur missile development in the United States. However, in the case of inner space, a gradually increasing recognition of the Soviet threat from the sea has recently brought about an

---

[43] U. S. Office of Scientific Research and Development. <u>The Application of Oceanography to Subsurface Warfare</u>, National Defense Research Committee, Div. 6, Vol. 6A, p. ix.

[44] <u>Ocean Sciences and National Security</u>, <u>op</u>. <u>cit</u>., p. 15.

almost sudden realization that only through optimum knowledge of the oceanic environment can the Soviet submarine menace be effectively challenged.

Although during the decade of the "fifties" progress in oceanography moved at an unhurried pace, developments in the field of nuclear propulsion were to bring to the United States a revolutionary element of seapower--the nuclear submarine and significantly, the consequent dire necessity for vastly increased knowledge of the oceans. Visualized in science-fiction almost a century before by the French novelist, Jules Verne, considerable credit for the ultimate materialization of the NAUTILUS deservedly goes to the scientific community at the U. S. Naval Research Laboratory.[45] Here at this research institution where several decades ago radar was first developed in the United States, Dr. Ross Gunn, the head physicist at the Naval Research Laboratory, in 1939 and during subsequent years provided the early concepts--originally stemming from Dr. Enrico Fermi--and impetus necessary for the complex evolution of this new and extraordinary weapon.

Through the maze of bureaucracy and the obstacles of conservatism and resistance to change, the embryonic development of the NAUTILUS propulsion plant was stubbornly carried forward by Captain (now Vice-Admiral) Hyman Rickover, USN. To such an extent was his persistent guidance a successful one that he has become widely known as the father of the nuclear submarine.

The cruises of the NAUTILUS were spectacularly successful, culminating in the historic voyage in August 1958 across the

---

[45] Carl O. Holmquist, et. al., "The Development of Nuclear Propulsion in the Navy," U. S. Naval Institute Proceedings, Sept. 1960, p. 66.

Arctic Ocean and the North Pole under the polar ice pack. In the finest tradition of those early seafarers who ventured into the "great unknown," Commander (now Captain) William R. Anderson, USN, and his intrepid crew had brought the twentieth century light of knowledge to the only remaining "Sea of Darkness."

This signal achievement was followed by a series of record-shattering feats by successors to the NAUTILUS, commencing a new era of underseas exploration. As eventful and important as these voyages were, however, their fame was eclipsed by yet another stirring event in the annals of oceanographic exploration.

The names of Dr. Jacques Piccard, son of the famous balloonist, and Lieutenant Don Walsh, USN, will be long remembered for their descent in the bathyscaph, TRIESTE, to the bottom of the seven-mile "Challenger Deep" in the Pacific Ocean. On January 23, 1960, at 1315 local time, these two Pathfinders were located on the floor of the Pacific Ocean at 35,800 feet below the surface.[46] This penetration by a manned "capsule" into an abyssal trench of inner space marked in one sense an end of era of oceanography inspired by Matthew Fontaine Maury a century ago. At the same time this conquest of a new dimension may well have augured a successful beginning of oceanographic exploration and exploitation that will lead to the full utilization of inner space for the ultimate benefit of all mankind.

---

[46] Don Walsh, "The Big Dive: Seven Miles Down to Sea's Deepest Pit," Life, February 15, 1960, p. 117.