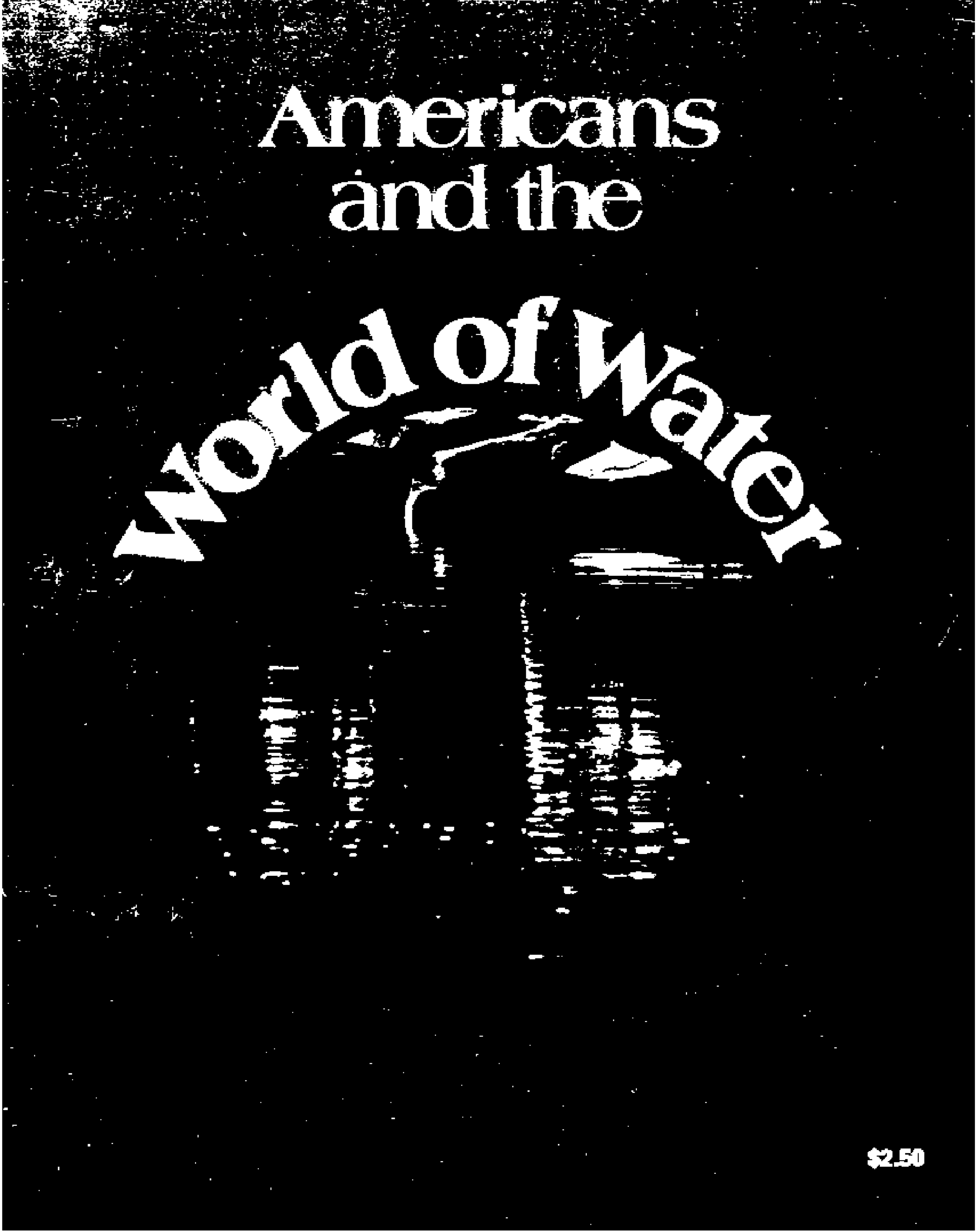
Americans and the World of Water



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Americans and the

WORLD OF WATER

Edited and Annotated by Harold L. Goodwin

With Chapters by E. R. Pariser
Joel W. Hedgpeth
John P. Craven
Peter W. Fong and Robert L. Stokes
Gerard J. Mangone

A Sea Grant Publication

University of Delaware Sea Grant College Program,
College of Marine Studies, University of Delaware,
Newark, DE 19711

NATIONAL SEA GRANT POLICY FOR MARINE EDUCATION PROJECT

Harold L. Goodwin, *Project Consultant*
James G. Schaadt, *Project Coordinator*
Lois M. Butler, *Graphic Design/Layout*
Pam Donnelly, *Composition*

Delaware Sea Grant College Program

Dr. W. S. Gaither, *Director*
Dr. C. A. Thoroughgood, *Associate Director; Director, Marine Advisory Service*
Dr. K. S. Price, *Associate Director*
Ms. Kathi Jensen, *Marine Information Coordinator*

Cover photograph: J. G. Schaadt

Produced under Grant No. 04-6-158-44120 by the Office of Sea Grant, National Oceanic and Atmospheric Administration, U. S. Department of Commerce to the Sea Grant College Program, College of Marine Studies, University of Delaware, Newark, DE 19711.

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Foreword

During 1976 and 1977 the University of Delaware Sea Grant Program undertook a project to develop a national statement on the importance of marine education. The draft statement, titled "An Introduction to Marine Education," was subjected to critical examination by educators and education administrators in 20 workshops around the nation. "Americans and the World of Water" was designed as a companion piece to the draft statement to help workshop participants recall the importance of the world of water to Americans everywhere.

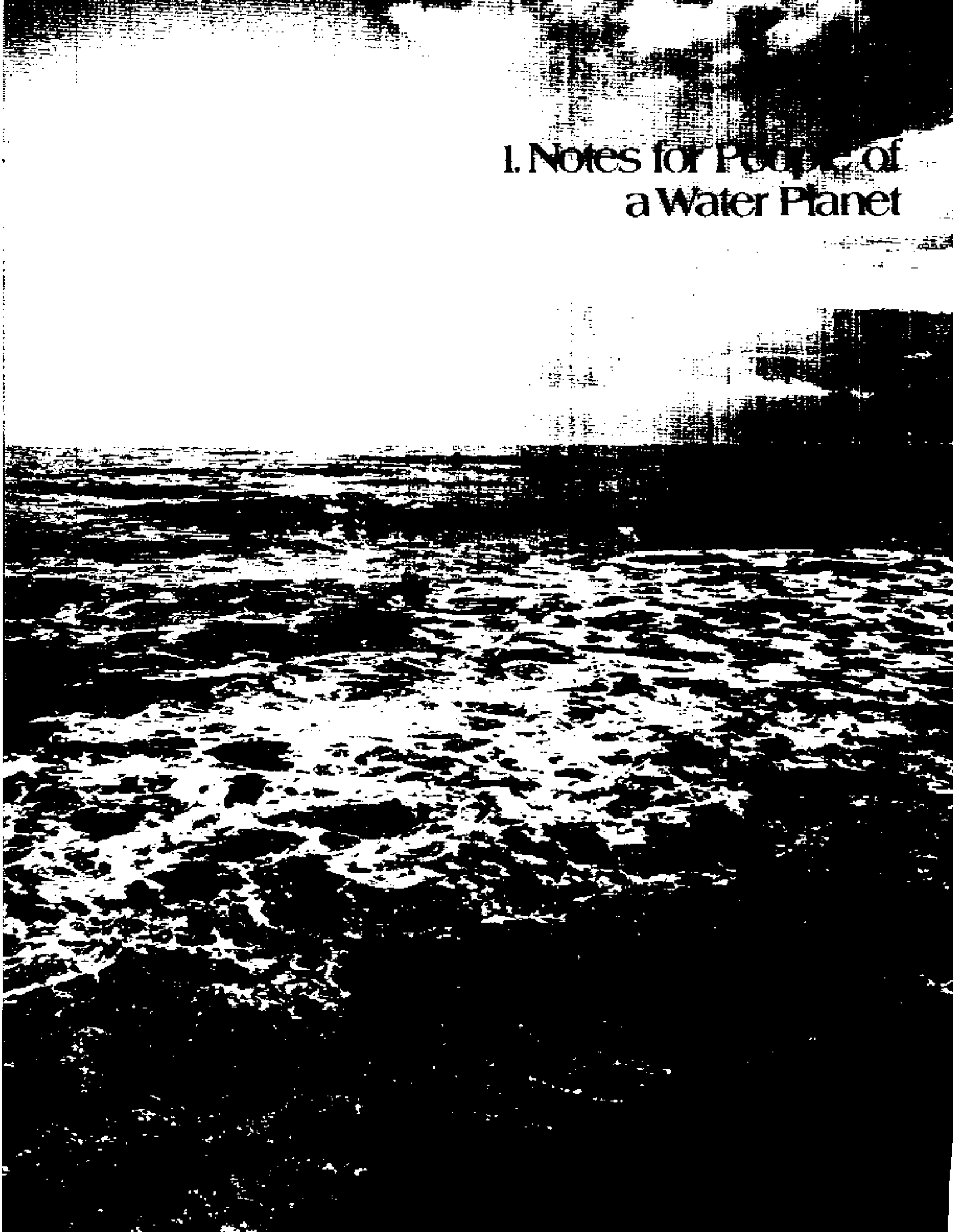
We were fortunate to persuade some of the nation's outstanding marine specialists to contribute chapters. By asking each to write in his field of special interest, we have assembled chapters on water itself and its meanings for Americans, on literature and the arts inspired by the sea, on the resources and uses of the sea, on the implications of those resources for America's economy, and the impact of marine resources and uses on the American society. Inevitably, some of the authors write about the same resources, the same uses; but each writes from his own perspective, so the redundancy is only in specific subjects and not in the treatment of those subjects.

Given an articulate and literate group of scientists to begin with, the editor's task was a very minor and enjoyable one made even more pleasant by the opportunity of writing introductory notes to the volume itself and to each chapter, with the added pleasure of introducing the authors.

The volume was produced by James G. Schaadt of the University of Delaware, College of Marine Studies. The editor and the Sea Grant staff at the University of Delaware acknowledge with thanks the help and cooperation of the Sea Grant Programs of the Massachusetts Institute of Technology, Oregon State University, The University of Hawaii, and the University of Washington for assistance in obtaining the talents of our distinguished authors.

Harold L. Goodwin
June 1977

1. Notes for People of a Water Planet



Notes for People of a Water Planet

Harold L. Goodwin

Earth, third planet from the sun, is a world unique in our solar system, and it is water that makes it so. Visions of a century ago, of a watery, swampy Venus and a Mars laced with water-filled canals, are gone forever, victims of space age technology that has revealed the truth about our neighbor planets.

The age of space also has given us beautiful, revealing photographs of earth from a far perspective. Ours is a lovely world of blue water, streaked with white vapor clouds, patterned with the brown and green of continents which lie like islands in the Global Sea.

Vast as the continents seem in human terms, they are a poor second to the dominant oceans as surface features of our planet: For every square mile of land there are about two and a half square miles of ocean. The elevation of the land ranges upward from sea level - from which all altitudes are measured — to the soaring heights of the Himalayas and the Andes; but, the mean elevation of earth's lands is only about a half mile while the mean ocean depths are five times as great, two and a third miles. If all land were dropped beneath the sea it would take only about 12 percent of the water to cover it completely. Imagine earth as a smooth sphere and it is also necessary to imagine it covered by a mile and a half of water.

We do not often recall that America began as a sea nation. While the colonies were still new and struggling, civil war in England cut off supplies and immigration and left the new world settlers in desperate condition. Governor Winthrop of Massachusetts wrote, *"All foreign commodities grow scarce, and our own of no price. These straits set our people to work to provide fish, clapboards, plank, etc., and to look out to the West Indies for a trade."*

Fish was the prime commodity, and as the colonists built ships to go into the sea trade, a new era began that opened the world to American merchants. Governor Winthrop later was moved to say, *"It was adversity that made New England great. That and codfish."*

No until the young nation expanded Westward and opened the great plains to agriculture did national dependence on the products and uses of the sea begin to take a lesser place. Gradually the sea origins and continuing sea necessities of the nation were relegated to the background. Even textbooks and school curricula gave cursory treatment to the importance of the seas. Our nation of seafarers became a nation of landlubbers.

* * * *

"Water, taken in moderation, never hurt anbody." So said Samuel Clemens, the incomparable Mark Twain.

If we switch Mr. Clemens' humorous context to mean the use of fresh water for all its purposes, and then look at the obverse, the humor is replaced by today's grim truth: *"Water, used in immoderation, hurts everybody."*

In Mark Twain's time the supplies of fresh, pure water were ample, although not always well distributed. There were droughts and floods, but little problem with pollution and even less with overuse. Many of the great underground aquifers that have made farms possible in some arid and semiarid regions were not even known or suspected in Twain's day; now, those apparently vast and endless underground water supplies are being depleted and, in some places, have been exhausted.

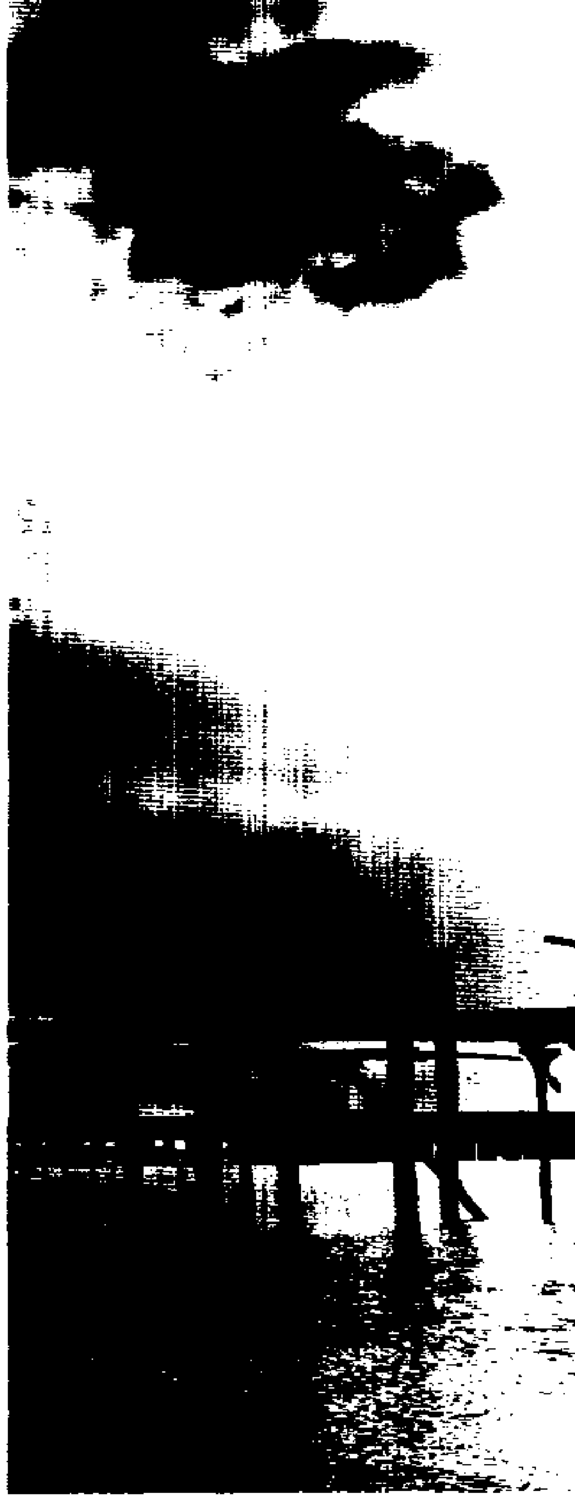
Twain's beloved Mississippi was muddy, changeable, and treacherous as it is today, but the wild life of the river faced no threat from industrial wastes or city sewage discharges. Times have changed. We are so bombarded with horror tales of what man is doing to the environment that, often, we simply tune out further messages. The incidents become remote. Yet, just one incident on Twain's great river illuminates the unhappy fact that pollution upstream equals pollution downstream in an equation as true as the river's flow. A load of pesticide was dumped into the Mississippi at St. Louis. It travelled to the Gulf, killing fish along the river's course. In the Mississippi Delta, the fish kill was very great, and eating the poisoned fish killed hundreds of porpoises, wiped out the Louisiana brown pelican population, and closed shellfisheries.

One wonders what Twain would have said. And we can imagine sulphurous language when he learned that one government agency, the U.S. Department of the Interior, sued the pesticide dumper, but another government agency, the U.S. Department of Agriculture, defended the dumper in court.

• • • •

An old weather saying goes something like this: *"A Chinaman sneezes in Shensi and sets men to shoveling snow in New York."* The saying emphasizes the oneness of world weather. The following ad-lib variation, inspired by recent history, similarly emphasizes the oneness of the world of water: *"A patch of warm sea lingers in the Pacific and buries Buffalo in snow."*

According to one analysis of the terrible winter of 1976-77, it was actually a patch of warm water that remained too long in the Northeastern Pacific which displaced the entire normal weather pattern. Drought in the West and Mid-West and floods in the East followed a winter of record high or low temperatures, depending on where one lived. Abnormally low temperatures in the Mid-West and East emphasized our dependence on movement of



essential supplies through the nation's inland waterways; the waterways froze, locking in ships and barges loaded with badly needed fuel and other critical supplies. So, in one of the worst winters on record, sea water in the Pacific and freshwater floods and precipitation across the continent interacted to epitomize the unity of salt and fresh waters. They are inextricably linked elements of the hydrologic cycle which determines the kind of world this is.

. . . .

As we speak of fresh or salt water, the reader's normal response very likely is: *"I knew that."* Of course. We know more about water than we realize, because it is a part of us in so many ways. It is less a matter of learning than of recalling. We have absorbed much lore and many impressions, but because water is taken for granted (unless we have a water problem) what we have absorbed or learned is relegated to deep storage in our mental retrieval systems.

Though facts and impressions may be stored deeply, water always is with us. Consider, for instance, what is pleasing: The ideal of lovely, natural serenity for many, perhaps most of us, is a woodland lake, pond, or brook. Landscape paintings and photographs are never out of style, and it would be interesting to know how many of those printed for wide distribution have water as a component or even as a focus. No census has been taken, but the impression is that the percentage is quite high, almost as though we need water as a visual component if a scene is to be truly satisfying and beautiful.

Water draws us, capturing our attention and our imagination. It is capable of enchanting us, as it enchanted Mole in Kenneth Grahame's beloved *Wind in the Willows:*[1]

"He thought his happiness was complete when, as he meandered aimlessly along, suddenly he stood by the edge of a full-fed river. Never in his life had he seen a river before — this sleek, sinuous, full-bodied animal, chasing and chuckling, gripping things with a gurgle and leaving them with a laugh, to fling itself upon fresh playmates that shook themselves free, and were caught and held again. All was a-shake and a-shiver — glints and gleams and sparkles, rustle and swirl, chatter and bubble. The Mole was bewitched, entranced, fascinated. By the side of the river he trotted as one trots, when very small, by the side of a man who holds one spellbound by exciting stores; and when tired at last, he sat on the bank, while the river still chattered on to him, a babbling procession of the best stories in the world, sent from the heart of the earth to be told at last to the insatiable sea."

It is one of our tragedies that so few of America's beautiful rivers remain clean and uncluttered enough to fit the image created by Mole's first experience with running water. There is a constant struggle to protect that few that remain.

. . . .

The sea, of course, is even more mysterious and enthralling than fresh water. Bringing its unseen seascapes and creatures to us via television and motion pictures has made Jacques Yves Cousteau the best known of the Sea People to a whole generation of Americans.

More than three decades have passed since Cousteau in 1943, with French engineer Emile Gagnon, invented the demand regulator which they called the Aqualung. It opened the undersea world to free divers unhampered by the massive helmet and air hoses of early diving costumes. There is no accurate census of United States sport divers, but a figure of several million commonly is used. Diving is an expensive sport, and that so many follow it is additional evidence of the strong lure of the water world.

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[1] *The Wind in the Willows by Kenneth Grahame, Charles Scribner and Sons. New York, Copyright 1933, 1953, and 1961.*

The time has come for a new awareness of water. It is time to renew our understanding of its importance. Those who must remember, and those who do not know must learn, that our personal, corporate, and national lives depend on the quality and supply of fresh water and the careful, planned uses of the sea and its resources. Simply, the resources of the land are dwindling.

Spring of 1977 brought a United Nations conference to discuss the problems of water, because the growing world population is fast approaching the limits of water supply.

Appropriately, as experts forecast the decline of world petroleum supplies, it was a representative of one of the oil-rich Arab states who made a telling prophecy. He said, in essence:

The time is approaching when a drop of water will cost more than a drop of oil.

"The oceans will offer us military, recreational, economic, artistic, and intellectual outlets of unlimited scope. Thus they'll offer us more space than space itself in which to remain human. The sea -- beautiful and dangerous, elegant and strong, bountiful and whimsical -- not only challenges us but offers to every 'man in the street' the exciting participation of being a 'man in the sea.'"

Athelstan Spilhaus, father of the Sea Grant concept.

2. The World of Water

In the long eons since our remote forebears emerged from the primordial sea, we have only occasionally been reminded of our sea origins and the close affinity with the sea that is still within us.

Perhaps our current awareness of the mammals of the sea is a reminder, in a way, because they are mammalian cousins that once came out of the water, then chose to go back and readapt.

Incidentally, today's efforts to save the great whales lends new meaning to an old bit of doggerel by Hilaire Belloc:

The Whale that wanders round the pole
Is not a table fish.
You can not bake or boil him whole
Nor serve him in a dish.

We think of whales, porpoises, seals, and other marine mammals as habitants of the oceans, but there are species of porpoise (which are really small, toothed whales) that live in fresh water, in the Ganges and Amazon Rivers, for example; and a freshwater seal is reported in Lake Baikal. This is by way of reminder that a distinction between fresh and salt water is sometimes misleading; the world of water is one world.

For many fish, the distinction between fresh and salt water is even less meaningful. Salmon and shad, for instance, spawn in fresh water, then go to sea; some of the shrimps, like the Malaysian prawn, spawn in salty water, then go upstream to spend their lives. Even to set arbitrary boundaries between air and water may not be wholly accurate; the human embryo is brought to term in the mother's internal sea of amniotic fluid, which has an affinity with seawater, and at one point the developing child even has vestigial gills.

When Public Health Service experts were planning for mass treatment of victims of nuclear attack during the days of the Cold War, need for a quickly available treatment for shock was a priority. The experts didn't really plan a close connection with seawater, but they came up with a saline solution for shock treatment remarkably close to sea salinity. Perhaps this was to be expected, for reasons E. R. Pariser points out in ensuing pages.

Nearly a century ago, Ambrose Bierce began publication of cynical definitions now compiled as *The Devil's Dictionary*. Among his definitions was this:

> *Ocean, n. A body of water occupying two-thirds of a world made for man—who has no gills.*

Gills, of course, are essential for extracting oxygen from water, aren't they? Certainly they are the most efficient means, but mammalian lungs can perform in water, too, when the oxygen level and pressure are high enough. At Duke University, Dr. Johannes Kylstra demonstrated in hyperbaric chambers that dogs can breathe water and survive. But what lungs like dogs' and ours cannot do well enough is to exhaust carbon dioxide and other waste gases back into the water. So, while we haven't lost entirely the capability to extract oxygen from liquid, a science-fiction future of man-turned-fishman to return to the sea seems pretty remote.

But such experiments and the role of sea-like liquids in the human experience reaffirm that we have not evolved all that far from our sea origins.

About E. R. Pariser

E. R. Pariser *is a senior research scientist in the Department of Nutrition and Food Science at Massachusetts Institute of Technology. Ray Pariser, as he is known to the Sea People, is an authority on proteins, with research emphasis on aquatic proteins. To characterize him as a food chemist specializing in proteins, however, does little to illustrate his enormous breadth of knowledge and interests. He is a member of several panels and committees of the august U. S. National Academy of Sciences/Research Council, head of Sea Grant Advisory Services at MIT, and an authority on the history and lore of foods, particularly aquatic foods. On completion of his education at Cambridge University in England he worked as an industrial food chemist, then became a researcher and private assistant to Dr. Chaim Weizmann. After coming to the United States he became program leader in the U.S. government's effort to develop fish protein concentrate, for which he received the U. S. Interior Department's Superior Performance Award. His interests in the world of water are wide-ranging, but have a common focus: he cares, about the food people eat, about the supply of aquatic proteins, about the future, and about the purity and supply of water.*

The World of Water

E. R. Pariser

To a farmer in Hibbing, Minnesota, a salesperson in Toledo, Ohio, or a teacher in Coeur d'Alene Idaho, the implications of the grounding of the oil tanker *Argo Merchant* off the island of Nantucket, Massachusetts in December 1976, might seem remote. Of course these people, like you and me, are aware of the high price of oil and of the generally harmful effects an oil spill can have on the economy and on sea creatures. But the awareness is only general, limited to the headline information that is given to us on the evening news. The farmer, salesperson, or teacher would think such a disaster should indeed concern the citizens of the coastal state whose livelihood depends on fishing in those waters, or on tourism in the coastal areas. It is the lives of those coastal people the oil might stain. But, in fact, our friends in Minnesota, Ohio or Idaho would be in error if they thought so; we need to convince them, instead, that there is but one sea, but one water, but one environment, and that ALL our lives are implicated in an event such as the grounding of the *Argo Merchant*.

We believe firmly that it is our ignorance of the nature of water and its tremendously creative and limiting effects on our lives that makes possible calamities such as that of the *Argo Merchant*. It is not only to avoid events like this in the future that we should know about water, but for constructive reasons.

For all the sophistication of contemporary science, our ignorance of the nature and behavior of water is almost as deep and widespread as water itself. In discussing the *Argo Merchant* oil spill, the Boston Globe reported that the oil was "not moving with the wind, but rather was being moved by ocean currents, about which little is known . . . oceanographers admit that they just don't know about oil's behavior at sea. They don't know whether the oil will keep floating or sink to depths where fish eggs are waiting to hatch. . . the one sure thing is that the spill couldn't be controlled."

The ignorance of oceanographers, quite apart from lack of knowledge by the general public, cannot simply be ascribed to lack of advanced knowledge in an advanced area. To understand the depths of ignorance we must go back to basic levels of education and realize how totally land-oriented and water-barren our education has been despite the fact that, with 65% of our body weight as water, we are truly water creatures ("bags of water") living on a unique water planet. There are about 330 million cubic miles of water on the planet, representing about 1/10 of 1 percent of the planet's mass. And yet, for the survival of living things, water is, besides air, the most important constituent on our planet. Consider that some forms of life can function without air, but none without water. It should also be reassuring and sobering to know that, according to the best evidence, the amount of water at present on our globe is roughly the same that existed three billion years ago.

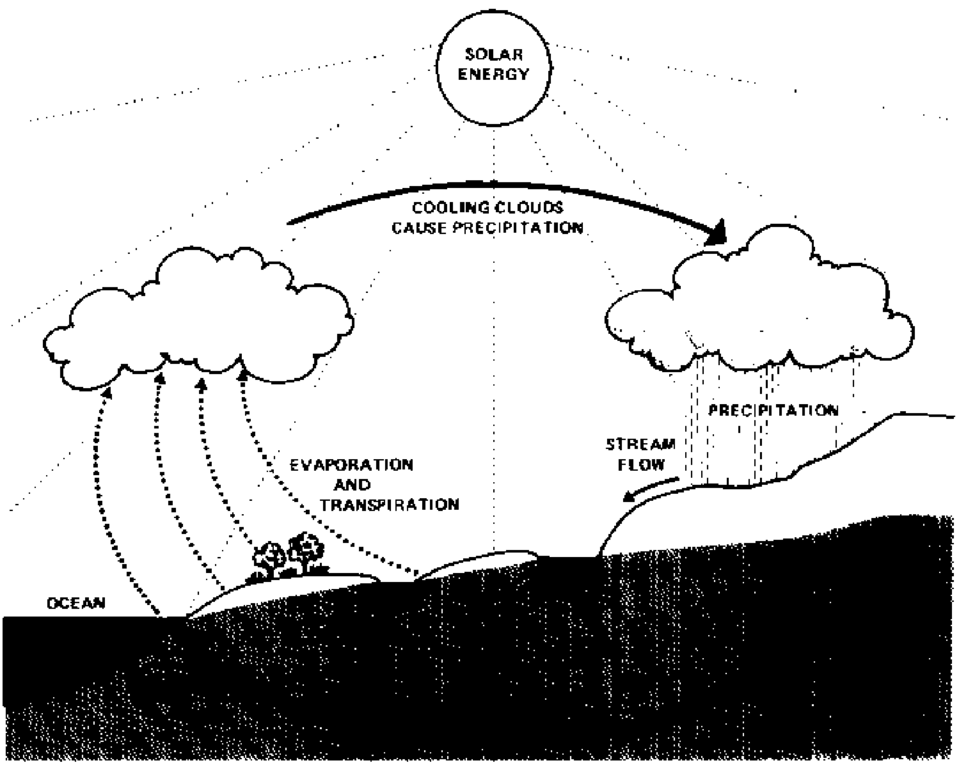
Water is the only common substance we know that exists simultaneously on our planet in its three states: gaseous, liquid and solid. The earth is able to maintain water in these fundamental forms because of the planet's middling size and mass, which permits it to have and keep an enveloping atmosphere, and because of the earth's special position in the solar system, not too far away from, and not too close to the sun.

The exact origins of our planet are still matters of debate, but it is likely that water was present here from the beginning. One theory maintains that the formative earth heated up to such an extent that it finally melted from within, causing some of its water to decompose and be lost as elements of hydrogen and oxygen. Eventually, the earth cooled; water vapor steamed up from fissures and craters and condensed as water drops and snow. As the cooling continued, water vapor approached the surface of the earth which finally became cool enough for water to strike the ground without evaporating again. So began a downpour which continued for centuries. It ended leaving on earth the earliest seas from which life was to emerge. Other theories of the origin of the earth and water exist, but the major ones agree that however the seas originated they filled great basins that already existed. These still exist, containing chasms deeper than the Grand Canyon and mountains higher than Mt. Everest.

Of the earth's water, the oceans, ice caps and glaciers constitute 99.35 percent. The relatively miniscule remainder accounts for *all* the earth's rivers, lakes, streams, inland seas and subsurface water. Yet it is this small fraction of the world's waters that occupies a very special place in our minds and our lives since this is the usable kind of water we are most familiar with, the water that we drink and use every day in myriad ways.

To understand the distribution of water over the earth, let us look at the hydrologic cycle, the global circle in which water moves.

HYDROLOGIC CYCLE

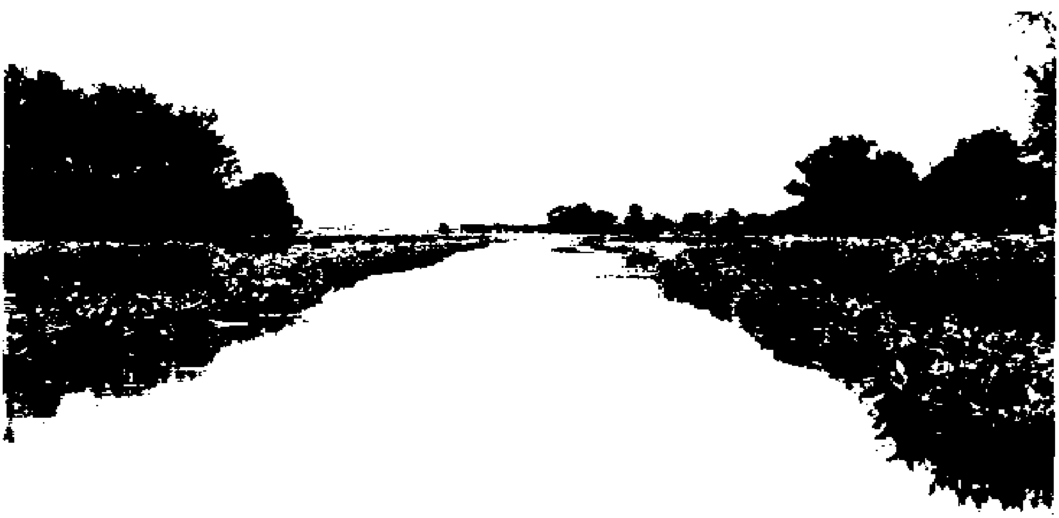


Water, evaporated from the oceans and from land, is drawn into the atmosphere, travels as invisible water vapor or visible clouds until it eventually falls back to earth as rain, hail, sleet or snow; it is absorbed back into the earth, reappears in rivers, streams and lakes, and eventually and constantly runs back to the sea. It has been estimated that close to 95,000 cubic miles of water go into the air annually. By far the largest part evaporates from the oceans, with the remainder coming from land and land waters and also from the leaf surfaces of plants. The water that goes out from the surface of the earth returns in equal amounts, creating a perpetual cycle. While this cycle is balanced for the whole planet overall, it is not so for individual areas; rates of evaporation and precipitation vary widely from area to area, all over the earth. The highest evaporation rates occur over the Red Sea and the Persian Gulf through the combined effects of sun and hot winds. Solar energy in the form of heat and resulting winds acts on water to produce a phenomenon that conditions the lives of us all: the weather.

Before considering the role of water and weather in our lives and before looking at the things we do to water, we should give some thought to the extraordinary properties of this very familiar and not so ordinary substance.

Let us, first of all, make quite sure it is understood that water is a chemical compound: it can be broken into smaller units, the elements oxygen and hydrogen which, on combining, will again form water. Second, water is water is water – that is: irrespective of where it is found, at the bottom of a fresh water pond, below thousands of fathoms of sea, on top of Mt. Everest, in the atmosphere, on Mars, wherever it is examined, water has proved to have one set of properties, and to be composed of two atoms of hydrogen and one of oxygen. So far as we can judge, water is the same no matter what its origin.

The basis for water's properties is its fine (molecular) structure. Detailed knowledge of the relationship between structure and function of water is recent and incomplete. What precise knowledge we have began to be accumulated only in the 1930's! It was then already known that the union of two atoms of hydrogen and one of oxygen forms a molecule of



unusual stability which offers great resistance to separation and which, conversely, joins with similar molecules at the smallest pressure. Just as tremendous energy is needed to break water molecules apart, the joining of hydrogen and oxygen releases huge amounts of energy.

It was further discovered that water has a uniquely high "dielectric constant," and that its capacity for forming hydrogen bonds is the basis for its many properties, such as its important role as a universal solvent. This solvent power is so great that truly 'pure' water occurs very rarely in nature. As rain falls, it dissolves, first of all, materials in the atmosphere; wherever it falls on the ground it dissolves still more substances, with every puddle, pond, lake, stream, river and sea becoming a chemical solution because of the dissolved materials. The seas and oceans, with all the dissolved substances brought to them from land, are the most concentrated of these solutions. As a consequence of the amounts of matter dissolved in water and carried to the sea, and also as a consequence of high rates of water evaporation in certain parts of the world, the concentration of dissolved materials sometime reaches such high levels that an entire sea solidifies and crystallizes. This has happened in the Sea of Galilee, in Israel.

Almost every substance we know of shrinks and grows more dense as it cools. Water follows that standard behavior as a gas and as a liquid, but as it nears the freezing point it reverses the process and begins to expand, becoming lighter till it freezes as ice on the surface of warmer water. This strange and most unusual property has meant that cold periods in our geologic and climatic history have not resulted in permanently frozen ice-lakes, ice-streams and ice-oceans. Because water freezes the way it does, ice rises to the surface of bodies of water, protecting the warmer liquid below and preserving living organisms. If water followed the more general temperature/density pattern typical of other substances, our arctic seas would not be seas but mammoth depressions of ice.

Another interesting and important property of water is its surface tension: The surface of a liquid, just like that of a stretched rubber skin, tends to reduce its area as far as possible. This tendency or driving force is called surface tension. Water is unique in that it has the highest surface tension of any liquid; this property permits water to rise very high in narrow capillary tubes, a critical factor in the supply of nutrients to plants and in the passage of blood through the capillaries of animals.

Finally, another property which affects our planet's climate as well as all living organisms is water's ability to absorb and store substantial amounts of heat. The term "heat capacity" simply refers to the amount of heat that is necessary to raise the temperature of a substance from one temperature to another. Water's heat capacity is very great compared with that of other substances. In other words, it takes a lot more fuel to raise the temperature of one pound of water by a certain number of degrees than similarly to raise the temperature of one pound of another substance with a smaller heat capacity, such as iron. The heat capacity of water is enormously important so far as our climate is concerned, because it is this property that allows our oceans to moderate the climate, keeping the earth's surface at a relatively constant temperature.

The concept of "latent heat" is another important thermal property of water and other substances which, however, does not involve temperature change. When ice melts to produce water at the same temperature, it absorbs a certain amount of heat, called its "latent heat of fusion." When water freezes to form ice at the same temperature, it gives up the amount of heat it has absorbed. Even the smallest amount of water vapor or the smallest ice crystal in a cloud therefore, is a heat/energy source. It is the movement of this energy laden substance in our atmosphere that profoundly affects our climate.

Another way of looking at climate is to consider a natural phenomenon that is always in evidence and always changing, that affects us before we are born and haunts us every day of our lives, unpredictably, ruthlessly, indifferently: the weather. The events we call collectively by this name and that we discuss, praise and curse endlessly, are brought about by these major interacting components: the sun, providing radiant energy; the earth's surface, with its landforms and oceans; and the earth's atmosphere, the envelope of gases that modulates the sun's radiation as it strikes the earth. The atmosphere is composed of oxygen and nitrogen and some carbon dioxide. Water vapor is quantitatively the most important constituent of the atmosphere, present as gaseous vapor, as liquid droplets and as solid ice crystals. At any one time, there is enough water in the atmosphere to cover the entire surface of the globe with one inch of rainfall.

Much of what we know as weather involves the transfer of heat, stored in water molecules around, in, and above the earth. The continuous movement and transfer of heat from one place to another modifies the extremes in global temperatures that would otherwise prevail and that would, in most parts of the globe's surface, make life extremely difficult, if not impossible.

Over a million years ago, the temperature of the earth fell slightly, causing enough of a thermal imbalance to upset the hydrologic cycle. As a result, great quantities of the earth's precipitation were stored as ice and the ice age began. Glaciers were formed which, over thousands of years, bulldozed and gouged out the land. At the time of their largest extension, glaciers covered almost half of the North American continent. They began to retreat over 10,000 years ago. Glaciers are the most powerful manifestation of water in its solid state. They have honed the faces of mountains around the world and ploughed and planed the lowlands. In smaller dimensions, water has frozen and expanded in rock crevices exploding giant boulders into smaller and smaller rocks, until finally vast sandy deserts were formed; the process continues today.

Because of its solvent power, liquid water flowing under the earth, has created caverns and valleys there dissolving the rock structure. The slow movement of water-filled soil has created the round contour of hill tops. Ocean waves, crashing against shorelines, wear down the coasts, create beaches and destroy them with equal effectiveness. But even more than glaciers, ice, rainfall and waves, rivers are the means by which water largely has formed the contours of the earth. To picture this, we have only to think of the Grand Canyon!

Water's energy comes into play in even the smallest raindrop. Rain acts like a million tiny hammers chipping miniscule fragments off mountains and rocks. Water collects and suspends these fragments and acts as an abrasive, scouring the ground as the rain runs off the soil into streams and rivers. Rivers act with the accumulated force of all the rain drops, moving to the sea and bringing with them the matter of mountains, the very mountains themselves. All the matter carried in rivers is not brought directly to the sea; due to shifting of courses, the natural flow of river currents and flooding, much of the transported material is deposited in valleys, flatlands and flood plains. The energy of a river is finally spent when, completing the water's circular journey from sea to sea, it reaches the ocean where the river deposits, in deltas and in the sea itself, the last of the soil it has carried from higher places.

Water, then, in its smallest as well as its largest and most awesome manifestations, is constantly shaping the earth, its climate and our daily lives. Its energy, its solvent power, its unusual thermal properties make it a multifaceted and wonderful substance. We would do well here, to remember the words of Lao Tsu, the Chinese philosopher: *"Under heaven nothing is more solid and strong, nothing is better; it has no equal."*

Long before the development of modern concepts of science, a Greek philosopher, living around 600 B.C. in Asia Minor, recognized the basic importance to water. What Thales of Miletus said made eminent, although startling, sense then and still makes eminent sense today: all things are made of water. With this statement, Thales not only anticipated by 2000 years the discovery of a finite number of chemical elements from which all matter is constructed, he also developed a concept which we have already mentioned and that is perhaps more profound: The fact that a substance such as water is the same everywhere in the universe and has identical properties, irrespective of where it is formed or found. Thales told long ago that there is only one water, one sea, one environment.

In antiquity, the sea was regarded as a god by many cultures. Today we have a love-hate relationship with the sea, a medium that we cannot live without, that we love, fear and hate, and that we know is hostile and dangerous at times. Listen to Swinburne: *"I will go back to the great sweet mother, mother and lover of men, the sea."* And to Shakespeare in *Romeo and Juliet: "The time and my intents are savage-wild, more fierce and more inexorable far, than empty tigers and the roaring seas."* And the experienced Conrad: *"I have known the sea too long to believe in its respect for decency."*

The intense relationship that so many of us have with the sea does not seem strange when we remember our watery origins, for all living things originated in the sea. Our affinity for the ocean is not imaginary: there is a lot of scientific evidence that very strongly supports this notion. Here is one bit of support: If we compare the relative proportions of the different salts present in the bloods of a number of animals, we find that there exists between them a very remarkable similarity. It has been shown in fact, that the bloods of widely different creatures are not only very much alike – as far as their salt composition is concerned – but that they are also closely similar to sea water. This resemblance was first noticed in the mid-nineteenth century and was emphasized in the early 1900's by a scientist named Quinton. Quinton believed, a little too naively perhaps, that blood was nothing but an elaborated form of dilute sea water; to prove this he bled dogs till they were nearly white and then made up the blood volume with dilute sea water without, apparently, any very untoward consequences.

Our origins in the sea may account to some extent also for the human body's total dependence on water. While some organisms can survive without air, none can survive without water. Human beings can exist for more than two months without food, but without water they will probably die in less than a week. Water runs throughout the body as it does throughout the earth, acting as a transport system, a detoxifier, a solvent and an irrigant. As it is on our planet, water is constantly circulated in the human body; however, in the human organism, a certain amount is taken in and removed daily. The average human has about 50 quarts of water in his or her body; daily about two and a half quarts are ingested and excreted in various ways. Tear glands, sweat glands, breathing, perspiration and urine excretion account for this removal. Water is ingested by drinking, through the water content of food, and by the metabolization of dry foods. Water, in the human body, is never stagnant, but moves constantly, just as it does in the hydrologic cycle.

The ways in which we have used the seas have had lasting and pervasive effects upon the destinies of nations. To judge from all available accounts, it seems likely that humans turned early in their history to the seas as a source of food and as a means of transportation, expansion and conquest. In his discourse on politics, the Greek philosopher, Aristotle, proclaims the fisheries to be the most important natural means of acquisition of property, comparable in significance, scale and ubiquity to war, hunting and pillage. The individual who dared to go to sea for the first time in a dug-out, perhaps to pursue fish off-shore, prepared the way for the development of the modern merchant and fighting navies, for the great explorations, and for the giant tankers of our time. All are direct, lineal descendants of the prehistoric fishing vessels.

Every indicator points to fish as food for humans since long before recorded history. Fish, and indeed many other aquatic organisms have been hunted, gathered and harvested wherever they have been found in every part of the globe. Fish, together with cereals, are the oldest of the basic food staples.

One example, randomly chosen from a wealth of globe circling stories, must suffice here to illustrate how profoundly our interaction with the seas has affected different aspects of our lives, and how marine concerns and concepts have jumped national and cultural barriers to become inextricably interwoven in the fabric of cultures. Among the coastal peoples who became expert seafarers, tradesmen, explorers and conquerors, are those living around the Mediterranean Sea. Arabic speaking people, like others, developed a far-reaching marketing network which they supplied with goods and services, shipped on merchant vessels that sailed to the furthest corners of the world. In the course of this vast trading and transportation, fragile ships sailed the treacherous and uncharted seas. Accidents were bound to occur, ships lost at sea, cargoes damaged. The arabic word "awariyah," meaning "goods damaged by sea water" became commonplace and entered world use. The word was adopted by the French and became 'avarie,' meaning damage to merchandise and ships. In English, the word 'average,' first designating an equitable division among all participants of loss incurred in a shipment at sea, finally lost its original narrow meaning, and today denotes, particularly, an arithmetic mean. The arabic term has become a mathematical expression of universal significance and use, based squarely and fairly on merchant marine origins.

The idea of equitably sharing losses gave rise, in the fifteenth century, to that of marine insurance. The first true marine insurance was written in Florence in 1501 and the idea was brought to England by the Lombards. In the late seventeenth century, Edward Lloyd, an enterprising businessman, kept a coffee house in Tower Street in London, which catered to merchants, bankers and seafarers who came there to drink coffee and conduct their business. In the course of the gatherings the idea established itself to have a number of financiers (underwriters) take upon themselves — singly or severally — the business of insuring a shipment of goods against damage or loss, for the payment of a premium. The premium was paid to the underwriters who eventually established Lloyds of London, an international insurance market and world center of shipping intelligence that is recognized and highly respected all over the world to this day.

Other terms and concepts from the world of the merchant marine have entered and been assimilated by the everyday language of the most varied cultures. In mentioning Lloyds, we must also note that in Lloyds Register, ships found to be in first class condition are referred to as A-1. This expression was picked up by Dickens in the early 19th century, and used by him in the Pickwick Papers ("he must be a first rater" said Sam, "'A-1' replied Mr. Roker."); the expression migrated to this country as "A No. 1," also meaning prime or first class. Today the expression has lost any association with Lloyds, ships or insurance matters.

Both on the planet and in our bodies, water is the element essential to life's basic survival. To go beyond that level, however, people have chosen to live near water, to search for more, to channel it where it existed, and in all possible ways to use its power to increase prosperity. History can be seen as the movement of peoples and nations in response to the presence or absence of water, and as struggle to gain control over water sources. The ancient civilizations of Egypt, Mesopotamia, and China all flourished beside and to a great extent because of mighty rivers: the Nile, the Tigris and Euphrates, the Yellow River. The duration of the Nile's regular flooding period was the basis for the Egyptian's 365 day calendar. The other rivers, subject to violent but less predictable flooding demanded flood control as did the Nile. Dams, dikes, reservoirs and canals were built; irrigation systems were designed. Centuries later, the Romans produced the imperial aquaducts which channeled into Rome alone over 200 million gallons of water each day. Whether for protection of agricultural lands, for transportation, or for expansion of existing frontiers, water has been a substance that has demanded of civilizations some of their most creative endeavors.

People everywhere work to use the power of water to sustain and enhance life. Today we use the same kinds of devices that the Babylonians and Romans used to harness and preserve water's energy. In the Netherlands and many other countries where dikes create an artificial coastline, seawater is pumped out and the drained land reclaimed for use. Dams have allowed the creation of powerful irrigation systems, thus making fruitful millions of formerly barren acres. In their massiveness dams also provide the hydroelectric power for entire regions as, for instance, the north of France, Switzerland, Norway, and here in the United States. Dams also create lakes for fishing and recreational uses.

One of the most critical junctures in the history of material progress occured in the late 18th century and was based on water: the invention and development of the steam engine. As early millwheels had used the energy of horizontally running and vertically falling waters to push a wheel attached to a millstone, the steam engine would use the energy of water that had been heated to a gaseous state. Because of water's heat capacity, a great amount of heat is required to raise its temperature. The converse is true in the cooling process: in changing water from its gaseous to its liquid form a great deal of heat, or energy, is released. The steam engine uses this energy to give power to wheels, cranks, pistons, looms and all the other machinery of modern industry. The quick progress from simple tube and piston experiments of Papin in 1690 to James Watt's critical elaboration of the vertical motion engine to a rotary engine in 1735, resulted in the machine that would create the industrial revolution in production and transportation. Today, the steam turbine engine has replaced the piston engine but its basic principle of operation is the same: the use of water's energy.

While water has demanded some of the most creative inventions of men and women for its use, these very inventions have had consequences far from purely positive. With the advent of the steam engine and its derivatives, industry became a western way of life whose goal was growth. This goal has become that of all nations, whether developed or developing. And every aspect of growth, whether in population or the consequent expansion of agriculture and industry, demands water.

In every aspect of industrial life, water is essential: in the manufacture of metal, glass and plastic (20,000 gallons to produce the steel for one car, 10,000 gallons for the car's assembly); in food production; and in the transportation and marketing of this multiplicity of products. As the population of the planet grows and nations develop, water is used by more and more people for more and more purposes. While it is initially comforting to know that the amount of water on earth has not decreased or increased, it is also true that the number of people using water increases staggeringly each year. Though water cannot diminish, it can be made unusable. While the steam engine gave us industrial progress, industry has taken a vast toll in the pollution of our rivers, streams, lakes and oceans. Not only industrial waste but human waste has filled our waters to such an extent that some rivers in industrialized areas have contained, at one time or another, nothing but used water — waste water effluents. Now the ingenuity that went into creating dams, irrigation systems and hydroelectric power plants, must be directed toward saving our water from the effects of human use.

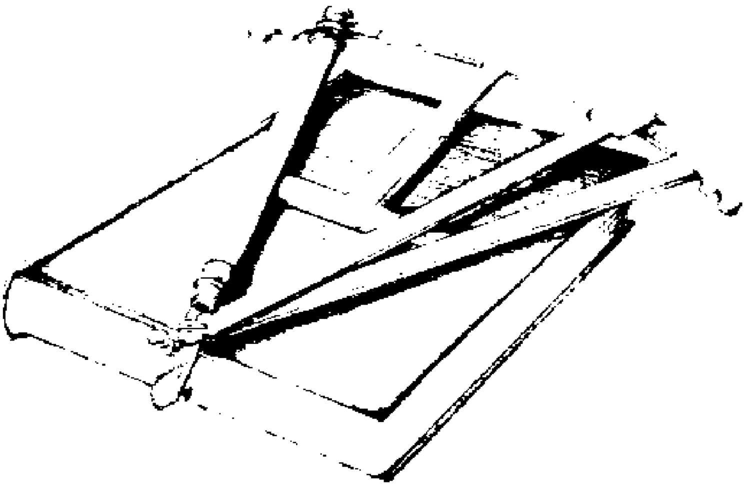
Undue faith in technology has created in water-rich countries a completely unrealistic sense of the limitlessness of the resource. Efforts to depollute fresh water or desalinate ocean water must be matched by attempts to educate ourselves about the preciousness of water *before* it has been polluted. If the North American continent had not been so blessed with oceans and waterways, perhaps the citizens of our continent would have the respect for water that has been given to it in countries or areas where the resource is scarce. In Israel, for example, rain does not fall in summer months and less than 1/5 of the land is humid enough for agriculture without irrigation. Since shortly after the founding of the country in 1948, a national agency has controlled the distribution and use of water for all purposes, domestic, industrial and agricultural. As in most of the mid-east, what rainfall there is, is carefully saved in tanks on rooftops. Water is pumped from underground and also is obtained from desalination plants. The factor which differentiates water use in Israel and similar arid countries from that in the United States is a pervasive public awareness of the need for water, of its scarcity, and of the dangers of pollution.

Even if our consciousness of water's essential role increases, we are still faced with the dilemma of uneven distribution. In the U.S. each one of us uses 1,800 gallons of water per day; in developing countries, the figure is about one hundredth of that amount, often because more is simply not available. To a certain extent water is like food in that it is usually the rich nations that possess most of

the resources; it is certainly the rich who have the advanced technology necessary for searching out water and de-polluting it. But the availability of water also depends on its wise use, and it is the richest nations that have squandered water most recklessly, using technology more to keep pace with wastefulness than to protect the resource. Even technology, however, is powerless against certain aspects of the water cycle: In 1977, many major rivers in the United States froze, preventing the transportation of fuel, food and merchandise. The cold closed countless schools. Recent droughts have taken thousands of lives in the Sahel, and flooding following earthquakes in China has caused massive damage. Technology cannot solve problems created by the kind of greed and error which play a great part in calamities such as the grounding of the *Argo Merchant* and other ships with subsequent large-scale pollution.

Increasing population, industrialization, and diminishing water availability (the world need for drinking and industrial-grade water will have doubled by the end of this century) have augmented political tension over who will bear the burden of scarcity and who will pay for pollution: industry, consumers, governments? Whatever group may pay at the moment, we must recognize that all of us as consumers will pay dearly at the outset. Legislation already exists in many countries to penalize polluters, but its existence is not enough to stop pollution. No legislation will be strong enough so long as individuals are unaware and careless about the extent to which water, as essential for life as air, is being made unavailable.

The tracing of oil slicks has shown that they tend to move and sometimes return to their place of origin by circumnavigating the globe, riding on currents and trade winds. Contrary to what some of us may have learned in a 5th grade geography lesson, there are not many oceans or seven seas, but only one, that encompasses our planet and runs through our nations, our bodies, and our lives. As citizens of a water planet, we must recognize this unity and continuity and realize that any mis-use of water *wherever it occurs* has effects that extend around the globe and into each of our lives.



3. Images for a Sea People

The World of Water breeds legends, conjures images, inspires art and poetry, and achieves mystical significance in religion.

We are reminded of the Gods of Greece and Rome through names given to military systems of the sea: the Greek Poseidon and the Roman Neptune are missiles and submarines. But we have another remnant of ancient worship of these sea gods, too.

In olden times Poseidon and Neptune were propitiated and asked for safe passage by sacrifices, which remain today in the ever-less-frequent "crossing the line" ceremonies when a ship crosses the Equator. It is a time when Neptune comes aboard, accompanied by beautiful maidens, the Nereids and Oceanids, and by a rough crew of helpers who grab the poor "polliwogs" – those who have never before crossed the Equator – and subject them to assorted indignities in order to turn them into acceptable travellers in King Neptune's domain.

The oceanic waters were and are fearsome, and divine help for those who "go down to the sea in ships" still is sought. Around the ports of the Christian world, the blessing of the fleet as fishing season opens is an annual event.

For lives lost at sea, the end was a choice between a sea-hell and a sailor's dream of heaven. The first was Davy Jones' Locker where bad men went to eternal torment of scraping foul ship bottoms, holystoning decks, chipping paint, cleaning bilges, and all the other chores hated by seamen. The name Davy Jones is a corruption of "Devil" and "Jonah."

Heaven for the good sailormen is a place below the sea called "Fiddler's Green," a haven of rest and delight filled with all those things for which sailors yearned -- and perhaps still yearn. No watches to stand, no storms, plenty of the best food and drink, lovely handmaidens, and a song to pass the time.

We can be sure one occupant of Fiddler's Green is Alfred B. Stormalong, greatest bosun who ever lived. This legendary American sea hero was bosun of the *Courser*, the perfect ship. *Courser* had masts of pure silver, the tops hinged to let the sun and moon pass. The tops and skysails were so high Stormy had to order the crew aloft a full week before a storm broke; that's how long it took them to climb *Courser's* rigging. Sometimes when the ship heeled and took water aboard, whales were found in the scuppers and had to be put back into the water, and the Horse Latitudes were really named for the horses aboard *Courser*, even though some folks believe they were named for Spanish horses that had to be sacrified when Spanish ships were becalmed for weeks. You see, *Courser* was such a huge ship that orders had to be carried from the quarterdeck to the forepeak on horseback.

How soon we forget! In these days of negotiations with Panama over the future of the Panama Canal, we forget that the waterway was accidently made by *Courser*. She was caught in a Caribbean hurricane, and running before it she smashed right through the Isthmus of Panama. The only witnesses were Army officers who took credit for digging the canal, but fortunately one recorded it in his diary so that we know the truth.

Stormy was the only person who could handle *Courser's* helm alone, being a rather large person. He stood a bit more than four fathoms high, a fathom being six feet. Stormy's gone to Fiddler's Green now, but he is still with us through his initials. You see, his full name was Alfred Bullpup Stormalong, his initials ABS, and to perpetuate his memory we have adopted those initials as the standard abbreviation for Able Bodied Seaman.

About Joel W. Hedgpeth

It may seem a bit odd to turn to a distinguished natural scientist for a chapter on the art and literature of the sea, but there is little that is usual about **Dr. Joel Hedgpeth.** *He is Emeritus Professor of Oceanography at Oregon State University and recognized internationally as a leading authority on the environment and ecology. What is less well known is that his credentials are equally impressive in the humanities of the sea. Not many scientists write as Hedgpeth does, illuminating the most scholarly scientific papers with quotations from the classics, or perhaps from Thoreau, Emerson, or his friend John Steinbeck.*

The humanities have been a neglected part of marine education and understanding, and it was Joel Hedgpeth who opened a new era for humanities scholars at Oregon State University as a principal mover in a conference on Steinbeck and the Sea. Steinbeck's close friend, and character in his Cannery Row stories was "Doc," Ed Ricketts. Ricketts was also co-author of a standard reference, Between Pacific Tides, by Calvin, Ricketts, and — now — Hedgpeth. This classic has gone through so many revisions and editions that little of Calivn and Ricketts remains; it is now nearly pure Hedgpeth.

A native Californian, Hedgpeth graduated and took his graduate degrees at the University of California, Berkeley. He has been associated with both state and Federal agencies, the University of Texas, University of the Pacific, and Scripps Institute of Oceanography. He has served as director of the Pacific Marine Science Station, California, and the Marine Science Laboratory, Newport, Oregon. His awards and publications are too numerous to mention except for the most recent, the Edward W. Browning Achievement Award for the person who has made an outstanding contribution in enhancing the quality of our physical environment. Persons are nominated for the award by the Smithsonian Institution, which noted: ". . .Dr. Hedgpeth has long been teaching, writing, and demonstrating through research that the natural systems of the earth and seas are exceedingly complex, exceedingly fragile, and exceedingly important. His work has led to the passage of significant environmental legislation, the addition of marine programs to school curricula, and the continued growth of what he calls, 'scientific beach-combing.'"

In addition, Joel Hedgpeth's advocacy of the arts and letters has aided the continued expansion of a new appreciation of the sea humanities.

Images for a Sea People: Arts, Letters and Science of the Sea

Joel W. Hedgpeth

The western world, the land of the two American continents, was colonized long after man emerged from the valleys of Africa or perhaps some idealized garden in Asia Minor. The first men who came to America found their way across the peninsulas or the ice floes of winter in the north, or perhaps sporadically by ships across the interminable reaches of the Pacific. Only in the north and along the northwest coast of America did these first immigrants, to what the latest to come here have called the New World, build a culture strongly dependent on the sea, a culture perhaps reflecting in some way their origin from a world beyond the great waters.

Today the Esquimaux, at least some of them, still live a life dependent on the seas, while the descendants of some of the Indians who built great houses and carved totem poles along the rain sodden shores of Alaska and British Columbia now bask in the glory of their departed ancestors and cultivate the almost forgotten culture of their historic past. Most of America, North and South, is now peopled by later arrivals, adventurers, entrepreneurs, fortune seekers and home seekers from Europe, not always willing to come to the New World, and others, always unwilling, captured for slaves. All of us, red, white or black, are descended from ancestors who crossed the seas to get to this land.

For those who came from the Old World of Europe across the Atlantic, the early days of settlement and colonization were still seafaring days. Much of the early impetus for exploration, especially in the northern waters was for whales and fish; the early settlements of Nova Scotia and New England were maritime, fishing communities.

Among the early explorers who praised the riches of the coastal waters as a potential resource, the most enthusiastic was Captain John Smith, who wrote in that original Chamber of Commerce document, *Arguments for Colonization*, 1614:

> *The main staple from hence to be extracted for the present, to produce the rest, is fish, which howbeit may seem a mean and a base commodity, yet who will truly take the pains to consider, I think, will allow it well worth the labor. It is strange to see, what great adventures the hopes of setting forth men of war to rob the industrious innocent would procure, though more are choked than well-fed with such hasty hopes. But who doth not know what the poor Hollanders chiefly by fishing at a great charge and labor in all weathers in the open sea, are made a people so hardy and industrious, and by the vending this poor commodity to the Easterlings for wood, flax, pitche, tar, rosin, cordage, and such like which they exchange again to the French, Spaniards, Portugals, and English, etc. for what they want, are made so mighty, strong, and rich, as no state but Venice of twice their magnitude is so well furnished with so many fair cities, goodly towns, strong fortresses, and that abundance of shipping, and all sorts of merchandise, as well of gold, silver, pearls, diamonds, percious stones, silks, velvets, and cloth of gold, and fish, pitch, wood or such gross commodities? What voyages and discoveries east and west, north and south, yea about the world, make they?*

Many of the New England colonists heeded Captain Smith's advice, while those of the south became planters, yet nevertheless dependent on the sea, for their market lay in the old world. It is small wonder that Boston became the land of the bean and the cod. Codfish are still important in Boston although it cannot be said that Boston is the predominantly maritime city it once was. No longer are young New Englanders painted with the vista of the sea and the commerce that is the promise of their future as seen through a window in the background, as was the custom of colonial portrait painters.

Yet it was an American artist, John Singleton Copley (1738-1815) who painted that strangely disturbing picture of the deadly menace of a shark against the backdrop of a peacefully unaware harbor. This painting, completed in 1778, brought painting out of its treatment of such themes in classic or antique garb, to depict them as contemporary events (which in fact this episode was), and its message of the ambiguity of nature and the peril of the sea anticipated Herman Melville's words. It also anticipated the less appealing aspects of photographic journalism that must show us the dripping stump of the amputated leg, if not the disjointed member protruding from the jaws of the shark. The painting, at

John Singleton Copley, *Watson and the Shark*, 1778
Courtesy of the National Gallery of Art, Washington, D.C. Ferdinand Lammot Belin Fund.

least, goes beyond the dimension of the camera lens as manipulated by a sensation seeker.

It was painting that first expressed America's development as a nation in the years after 1812, depicting naval successes, heroes and commerce in such scences as Thomas Sully's *Stephen Decatur*, John Wesley Jarvis' *Oliver Hazard Perry* and the various battle scences of the war of 1812 that are found in many school history texts.

Commerce and whaling prospered after our final settlement with England. Few but the wealthiest could afford paintings, but bowls from China, carved sperm whale teeth and other bits of scrimshaw, artifacts from distant islands and spectacular sea shells adorned even modest homes and kept the the sea in mind. In time some of these treasures would be found in parlors far from the sea.

More often than not when they got into difficulties the scions of well-to-do families were sent off to sea. One of these was James Fenimore Cooper (1789-1851) who was expelled from Yale at the age of 16 for tying a donkey in his tutor's chair. His father sent him off to sea, and after a couple of years in the merchant marine he served in the Navy, leaving with the rank of midshipman in 1811. Cooper did not start writing until he was thirty, and produced 50 books in 30 years. Cooper was our first great story teller, and we remember him as the author of novels about Indians and pioneers in the woods and prairies. But he was also a writer of the sea, and his first seagoing story, *The Pilot*, based on John Paul Jones and the cruise of the *Ranger*, published in 1823, was the first sea novel. He wrote several other sea stories, and Joseph Conrad acknowledged him as one of his masters. One of Cooper's last books was a sea story, *Afloat and Ashore*, published in 1844.

Another young man from a well-placed family who went off to sea, although he undertook the voyage to restore his eyesight, was Richard Henry Dana, Jr. (1815-1882). He shipped as a common sailor on a voyage around the Horn to gather hides for the boots and shoes of Boston and the story of his adventures has become one of the great classics of the sea, *Two Years Before the Mast* (1840). This book has never been out of print since it was published. In his later life, he became an eminent maritime lawyer.

During the two decades before the Civil War, from 1840 to 1860, the young United States was one of the great seafaring nations of the world. Our ships were everywhere. It was the last stand of the great sailing ships, and the Yankee clippers from Boston reached a perfection that has made them an unforgettable household word.. The ultimate in speed and beauty was *The Flying Cloud*, launched from Donald McKay's yard in 1851 and still holder of the record time from New York to San Francisco around the Horn in slightly more than 89 days.

In the same year that *Two Years Before the Mast* was published, Alfred Thayer Mahan (1840-1914) was born. He was intimately a part of America's great days on the seas, and was a combat officer in the Navy during the Civil War. His great book, *The Influence of Sea Power Upon History* (1890), had a profound influence upon naval policy all over the world. His was the age of the great battleships, now obsolete in our days of aircraft, missiles and atomic submarines. Although he died at the end of December 1914, he predicted the defeat of Germany at sea. In his lifetime he saw the transition from sail to steam, but the complete replacement of sail was only a bare whisper in 1840.

The great days of America's adventure with the sea did not begin auspiciously, for on January 13, 1840 the steamboat Lexington caught fire and burned on Long Island Sound with the loss of nearly 140 passengers and crew. It was, however, the occasion for the start of that most American of enterprises, the lithographic concern of Currier and Ives, for

N. Currier's lurid print of the event became an overnight best seller and established the company as the supplier of graphic art for thousands of homes across the land. One of the early advertising broadsides declared that the firm published "Colored engravings for the people." Much of its output was, of course, of scenes on land, of battles, hunting events and domestic felicity, but always there were sea views and maritime motifs, including views of the great clipper ships and a masterful scene of "The Whale Fishery."

More prosaically, the stubby, broad-bellied whalers from New Bedford wallowed about for years at a time in the Pacific, killing whales and boiling out their oil in a bloody, blubbery mess. From 1841-42, still another young man from a well-placed family, Herman Melville, sailed on one of those whaling ships. After two years at sea, including finally, a hitch on a man-of-war, Herman Melville returned home and by 1846 published *Typee,* followed by several other books and culminating in his masterpiece, *Moby Dick,* that appeared in 1851, the same year *The Flying Cloud* set her record. It took a long time for Americans to realize that *Moby Dick* was their great masterpiece of the sea, a leviathan of a book that made Copley's painting of Watson and the Shark seem like a quiet picnic scene. But it is a complex book. Few readers (and there were apparently very few) understood it or knew how to take it, although now we appreciate that it is a book, like the sea itself, of many levels. A story of a wild, strange adventure with a demented master obsessed with killing a particular albino whale, an allegory of good and evil in a world suspended in time and space, or a dull account of the details of the whaling industry with an extraneous story tossed in. It is all those things, some of them true. A whale actually did attack and sink a whaling ship, the *Essex,* in mid ocean west of the Galapagos in 1820.

Our new Republic had a lively interest in science as well as letters. Yankee sealers, exploring the Antarctic for seals, staged a scientific exploring expedition in 1829-31 under the approval of the Department of State after President Andrew Jackson vetoed the original plans for an official United States Exploring Expedition. Private interests in New England and New York financed this expedition, consisting of two small ships, captained by Nathaniel B. Palmer and Benjamin Pendleton, with James Eights as naturalist.

Finally, in 1838, the official United States Exploring Expedition set off to explore the Antarctic seas and the Pacific Ocean, a squadron of six ships, all under sail. They returned in 1842, the year that Matthew Fontaine Maury became Superintendent of the Navy's Depot of Charts and Instruments. While the expedition was supported by congress, publication of its results was not, although many of the collections and observations were of great importance.

In New England, the popular enthusiasm for this expedition was not shared by Henry David Thoreau, who wrote in *Walden* published in 1854:

> *What was the meaning of that South Sea Exploring Expedition, with all its parade and expense, but an indirect recognition of the fact, that there are continents and seas in the moral world, to which every man is an isthmus or an inlet, yet unexplored by him, but that it is easier to sail many thousand miles through cold and storm and cannibals, in a government ship, with five hundred men and boys to assist one, than it is to explore the private sea, the Atlantic and Pacific Ocean of one's being alone.*

Had Thoreau encountered *Moby Dick,* he could not have written so, for here is America's attempt to wrestle with the meaning of the seas and continents of the moral world, written by one who had endured the sea and "lived with cannibals." Thoreau did know Melville's first book *Typee,* but he disliked

Anonymous, *Meditation by the Sea,* c. 1855
Courtesy of The Museum of Fine Arts, Boston, M. and M. Karolik Collection

fiction and did not read Cooper, which may explain his failure to look into *Moby Dick*.

The Wilkes expedition (as it is often called) was indeed part of our experience of the sea. Thoreau had forgotten his Breton blood when he wrote so disdainfully of it in the conclusion of *Walden*. Yet, even before the publication of *Walden* he had begun his own experience of the sea. His first trip to Cape Cod was in 1849, his last in 1857, but he was not given time to bring his own book about the sea together. The book titled *Cape Cod* is a posthumous gathering of essays, published in 1865, three years after Thoreau's death; it is a quiet book, about his walks, the people, and flotsam and jetsam of Cape Cod. He bespeaks the spirit of beachcombers everywhere:

The seashore is a sort of neutral ground, a most advantageous point from which to contemplate this world. It is even a trivial place. The waves forever rolling to the land are too far-traveled and untamable to be familiar. Creeping along the endless beach amid the sun-squawl and the foam, it occurs to us that we, too, are the product of sea-slime.

It is a wild, rank place, and there is no flattery in it. Strewn with crabs, horse-shoes, and razor-clams, and whatever the sea casts up, — a vast morgue, where famished dogs may range in packs, and crows come daily to glean the pittance which the tide leaves *them. The carcasses of men and beasts together lie stately upon its shelf, rotting and bleaching in the sun and waves, and each tide turns them in their beds, and tucks fresh sand under them. There is naked Nature, — inhumanly sincere, wasting no thought on man, nibbling at the cliffy shore where gulls wheel amid the spray.*

A modern sequel to Cape Cod is *The Outermost House* (1949), Henry Beston's account of his year in a cabin on the Cape Cod beach, a quiet book about the moods of nature by the sea reminiscent of Thoreau yet obviously the statement of another individual, separate from Thoreau.

During those two decades before the Civil War the name of Matthew Fontaine Maury (1806-1873) became a household word, known to some as "Deep Sea" Maury, called by his more devoted admirers the "Pathfinder of the Seas," and regarded less enthusiastically by his scientific colleagues. Assigned to the Depot of Charts and Instruments after an injury to his leg made him unfit for active duty, Maury began to prepare charts of the winds and currents of the sea from the accumulation of log books in his charge. He was able to advise sailing ships captains how to take advantage of the patterns of winds and currents to shorten their voyages, and without his work *The Flying Cloud* could not have made her record voyage in 1851. The first of his famous wind and current charts appeared in 1847, and the first edition of the *Sailing Directions* appeared in 1851, that famous year of record voyages and the almost stillborn Moby Dick. Maury was an excellent interpreter of routine data, and a scientific organizer. He almost single-handedly organized the first International Maritime Meteorological Conference held in Brussels in 1853, the forerunner of international gatherings of all sorts that are now a standard part of our culture.

Maury's most famous work, however, was his book *The Physical Geography of the Seas,* published in 1855. It was tremendously popular and went into many editions in numerous languages. Copies of it may be found in secondhand bookstores far from the sea, even today. As science it is often erroneous and its style is contentious and somewhat pious. Yet it was the great book of the sea of its day in terms of circulation. It is often said that Maury was our first great oceanographer, but no great principle of science or advance in fundamental knowledge can be credited to him. Yet in popularizing knowledge of the sea he was a good influence. The American public in particular, it seems, likes to learn about the sea and in each generation some book takes hold and finds its way into thousands of homes. The book of our generation has been Rachel Carson's *The Sea Around Us* (1951), a far better book in its treatment of facts than Maury's *Physical Geography of the Seas.*

Our great decades of the sea, of Dana, Melville, Maury, and McKay ended with the Civil War, when we turned upon each other. Perhaps the last accomplishment of this great period was again, as with the clipper ships, a feat of design and engineering (albeit invented by a Scandanavian named Ericson), the steam-powered, revolving turret-armored battleship. Sail, and the leisurely life of long voyages, of scrimshaw and chanteys, was forever gone. No one realized this more poignantly than Herman Melville in his poem about the Monitor's fight:

Hail to victory without the gaud
Of glory; zeal that needs no fans
Of banners; plain mechanic power
Plied cogently in War now placed —
Where War belongs --
Among the trades and artisans.

We came to think of ourselves as a people of land battles, nonetheless, often forgetting that the most significant battle of all for the long run of history was that steel clad "black smith's fray" that "went by calculations caloric." Admiral Mahan did not forget it, and thanks to him in no small part the descendant of the clumsy, unseaworthy Monitor is the billion dollar Trident submarine. But we were turning westward across the land even before the Civil War, and our people across the Wide Missouri. Before the discovery of gold in California, they moved across seemingly interminable distances to Oregon, and after 1849 goldseekers with enough means demanded the more rapid transportation by sea rather than the long trip across the continent, and made the swift clipper ships financially as well as technically successful.

But there is more than nostalgia, a few chanteys and the handsome training ships that participated in the gathering of Tall Ships in New York in 1976 to remind us of our blue water days. The American language is rich in expressions from those times that we use almost every day. These include, to cite the selection given by H. L. Mencken in Supplement II of *The American Language:* aboveboard, three sheets in the wind, on the beach, bilge, to pipe down, to be taken aback, plain sailing, shipshape, half-seas over, to give a wide berth to, to run afoul of, to keel over, to stand by. The meaning of these words is understood everywhere, although there are few who realize they refer to the days of sail, and fewer who can explain exactly what they mean on board ship.

We turned to the land, but did not forget the sea. Just before the war, Winslow Homer (1826-1910) began his career drawing illustrations for the weekly magazines that illustrated the manners and mores of the time, including scenes of the growing movement of Americans, like their British cousins, toward the seashore holiday, of bucolic and more than discreetly clad bathers cavorting in shallow water, and of family groups simply standing on the beach. After service as a war artist, Winslow Homer turned to painting, first in oils and then in water color. He painted the American scene as no one else did, realistically, with a sense of still quietness that now seems almost unreal, yet this was the way it was

Winslow Homer, *The Life Line*, 1884
Courtesy of the Philadelphia Museum of Art, George W. Elkins Collection

done. When he turned to the sea, however, deeper more subtle meanings were worked in his scenes of people on the beach, of boating and New England fishermen. A master of composition and of the human form with the wind whipping dresses firmly about his figures, his women by the sea seem nevertheless anonymous and sexless because their faces are unreal. Homer's most overtly sexual painting is *The Life Line*, depicting the rescue (perhaps) of an unconscious, sensuously draped woman held by a sailor in a breeches buoy barely above an even more possessive sea. In all his pictures of the sea, we get the impression that, even when there is no land or shore visible, we are looking out from the land toward the sea. This expresses for the Americans of his time, those decades after the Civil War, how the sea was understood by a land-oriented nation.

Few other American paintings of the sea convey more than the often interesting and charming surface dimensions of a seascape. Albert Pinkham Ryder (1847-1917) born in the whaling town of New Bedford, but so obviously under the spell of Turner, could nevertheless haunt his marine canvas with ghosts, as in *The Flying Dutchman*, but aside from Homer's work, perhaps the most typically American painting of the sea is that strange painting by an unknown primitive artist, *Meditation by the Sea*, ascribed to the decade 1850-1860.

Science, as understood by the popular mind (then as now) as the sort of thing done, somewhat mysteriously, by certain flamboyant

Albert Pinkham Ryder, *The Flying Dutchman*, c. 1887
Courtesy of the National Collection of Fine Arts, Smithsonian Institution, Washington, Gift of John Gellatly

or well-publicized personalities, began to develop its quasiofficial organized structure during the Civil War. Among the great figures in the organization and development of science in the United States was the naturalist Louis Agassiz (1807-1873), a glamorous, enthusiastic import from Switzerland. Agassiz came to Harvard in 1846, and despite flattering inducements to return to positions of eminence in Europe, remained with his adopted country for the rest of his life. Originally a student of living and fossil fishes, echinoderms, glaciers and geological matters, he branched out into the study of marine life soon after his establishment in Cambridge. He was invited to participate in expeditions on U.S. Coast Survey vessels in New England and later in Florida, and in 1857 set up a laboratory for the study of marine invertebrates in a summer cottage at Nahant. A man of many schemes and ambitions, he became preoccupied with promoting official science in the United States and was one of the original members of the National Academy appointed by Abraham Lincoln in 1864. The Academy did not have an auspicious start; among its first actions were the establishment of a committee to look into the standardization of whiskey, and a resolution denouncing the scientific value of Maury's *Sailing Directions*, inspired by his old antagonist Alexander Dallas Bache of the Coast Survey.

Agassiz was too involved in schemes to enlarge and improve the museum at Harvard, and in public appearances everywhere to keep up with his study of the creatures of the Sea, but his son Alexander Agassiz (1835-1910) carried on the work and became one of the world's great oceanographers. He financed his studies from the proceeds of copper mines in Michigan that arose out of his skill as a professional mining engineer. An interesting commentary on the education of those days is that when young Alexander came to New England from Switzerland in 1849, the only language he had in common with his high school classmates was Latin.

Louis Agassiz' last work was the establishment of a summer teaching institute in seashore biology on Penikese Island in Buzzard's Bay in 1873. The famous summer event was the beginning of the teaching of marine biology on the shore that has become such a large part of maritime university activities all over the country, and of some universities far from shore who recognize the need to experience at first hand the sea and its life. While the effort at Penikese did not survive the death of Agassiz late in 1873, its descendant is the great complex of marine laboratories and research institutions at Woods Hole, Massachusetts. Agassiz had more in mind for Penikese than a place for the teaching of marine biology to teachers and promising professional students. He saw in it a part of a grand plan that, had it materialized, would have combined the Agricultural Experiment Station and the Sea Grant concept at the outset:

. . . We must now look to the founding of ten or twelve regular professorships covering the whole range of the natural sciences, with special reference to their practical application to Agriculture, the Industrial Arts, Medicine, as well as to the progress of science itself. I am now working at the plans for laboratories so that we may from the beginning make experiments upon every question bearing upon the breeding of stock, the raising of fish, bees, silkworms, oysters, lobsters. . . while our students shall be taught what they ought to know in order to teach successfully. . .

What Agassiz had in mind, as Edward Lurie reminds us in his centenary address at Woods Hole in 1973, was an "ideal form that comfortably merged European professionalism, American elitism, and social democracy" (*Nature and the American Mind;* Edward Lurie, Science History Publications, 1974).

Through all these years of war, of continental expansion across the sea of grass and the great mountains, Herman Melville, the product and apotheosis of our great age of sail, lived on, long after most had forgotten him. *Moby Dick* lapsed from print for 10 years, after a warehouse fire destroyed most of the original edition. Melville took up a position in the New York Customhouse and wrote as an avocation after 1865. He published poetry, at his own expense; his uncle financed his long and generally unread poem *Clarel* in 1876. In 1888 he published *John Marr and other Sailors*, a small volume of poetry, and finally, in the last year of his life, 1891, he published another small volume of poetry, *Timoleon*. Among the papers he left behind was a completed novel, *BillyBudd*, which was first published in 1924. Like *Moby Dick* and contemplation of the sea itself, *Billy Budd* leaves us not entirely resolved, adrift with the action of the surf. Almost no one knew who Melville was when he died.

Thirty years later, in the 1920's and 30's, Melville was revived. Everyone was told that the surging restless seas and dark corridors of Ahab's mind were indeed born of our own seafaring soul, of killing whales, tall fighting ships and, though no one mentions it, of

accepting slaves, and now, on almost every paperback rack in the land, one can find *Typee* and *Moby Dick.* Melville's stories now appear on our late, late shows; Captain Ahab is one of our conscious archetypes, possessed and insane yet leading all his men to destruction. Contrasted with this overwhelming phenomenon, Captain Queeg with his ball bearings seems almost a parody of this archetype of the sea although the Navy has always had its Captain Queegs, of whom Charles Wilkes of the Exploring Expedition is the best documented example. He was court-martialled twice for, among other charges, "conduct unbecoming an officer," and nearly got us into war with England.

When Melville died, in 1891, young Jack London (1876-1917) was stealing oysters and bumming around the waterfront of San Francisco. He attempted one great sea story, *The Sea Wolf* (1904) which invokes the master of the ship as a Nietzchean superman yet an archetype of the obsessed captain that has become a stereotype for our idea of madness at sea, identified in the popular mind by the faces of the various movie actors who have portrayed such characters.

The rawness of Jack London's prose (which apparently translates all too well into Russian, although I have never understood how Mark Twain could be successfully naturalized in that language) reminds us that America has never had, except for Herman Melville, a first-rate poet of the sea. We are too young a country for the great classic traditions that made the *Lusiads* of Camoens possible, or, evidently, even *The Ancient Mariner*. *Moby Dick* is, and perhaps will always be, our great poem of the sea. Yet many of our poets have written of the sea, and their idiom often reeks of spray and decaying seaweed. Walt Whitman, who got his inspiration from frequent walks on the beaches of Long Island, now and then evoked the sea. Perhaps the only writer of sustained narrative poems, and a few biting lyrics, about the sea in North America is the Canadian E. J. Pratt. Yet, the sea is often the essence of Robinson Jeffers' rock bound and fog softened lines. In these days Robert Lowell is our conscious poet of the sea, but he is not to everyone's taste and the verdict of time is yet to be returned.

During the years after the first world war, when we were cutting up our navies with acetylene torches and letting our merchant marine fall apart, the sea was never very far from the consciousness of readers. Among the great sellers of the 1930's were the books about the Bounty, Captain Bligh's voyage and the settlement of Pitcairn Island by Charles B. Nordhoff (1887-1947) and James Norman Hall (1887-1951). Charles B. Nordhoff was the grandson of Charles Nordhoff (1830-1901) who came to this country as a child and served in the Navy from 1844-47, and in merchant marine and fishing vessels until 1853, and wrote a number of books in the 1850s about the sailor's life and on whaling and fishing. The books of the Bounty trilogy, *Mutiny on the Bounty* (1932), *Men Against the Sea* (1934), and *Pitcairn's Island* (1934) were tremendously popular, inspired successful motion pictures and did much to remind American readers of their own seagoing past. The theme was universal for all seafaring nations and the sea, although the events were British.

At about the same time William Beebe (1877-1962) turned from his study of tropical birds to the sea, recounting first his expeditions in the Galapagos and studies in Bermuda, and, most famously, his experiences in a steel diving ball in *Half Mile Down* (1934). He also contributed frequently to the National Geographic Magazine and was as well known in his day as Captain Cousteau is in ours. In a sense he revived the popular awareness of the naturalist that Maury and Agassiz exemplified in their times, and he is now remembered more for his marine studies than for his work with birds although his greatest scientific achievements were as an ornithologist.

We have no great and acknowledged writer about the sea in our time. Two of our best known writers, John Steinbeck and Ernest Hemingway, have written short fables whose message at least in part is that to the sea belongs her own. In Steinbeck's *The Pearl* (1945) the humble fisherman Kino seeks and finds a pearl to provide money to save his son, but the pearl brings only death and evil and at last he returns it to the sea. In Hemingway's *The Old Man and the Sea* (1952), the fisherman Santiago seeks out and conquers the great fish, only to have it eaten by sharks as he tows it homeward after the struggle. Here the sea is the active agent in reclaiming its own. These are only vignettes that remind us of the inhumanity of man and the alien nature of the sea; interestingly enough they both involve Latin Americans. They are not tried out of the essence of "America" as we of the United States understand it; Moby Dick could only have been written from that America and no other.

John Steinbeck as a youth wanted to emulate Jack London and go off to sea, and he sought passage or employment in San

Francisco but no one would have him. What he did write about the sea was not altogether his own, but *The Sea of Cortez* (1941, or at least its essence, *The Log of the Sea of Cortez*) is still widely read and to many readers is an evocation of man interacting with the sea. It has aroused the interest of readers to become scientists or to take to the sea in their own boat and experience those languorous tropical nights and the blazing sun of the coast of Baja and to think, perhaps not too seriously, about the alternatives of letting the world be, taking it as it is, not returning to land to exist and compete in an industrialized world. On this level it might be called philosophical escape reading; the dual nature of the book, written as it was by two friends, gives it a dimension beyond most other factual or at least nonfictional books about the sea.

In *Cannery Row* (1945) John Steinbeck gave us a character, based in part on his friend Ed Ricketts, who was the antithesis of the organization, establishment scientist exemplified by Louis Agassiz. The Doc of *Cannery Row* was an appealing sort, aloof from many of the practical concerns of the world, who managed a life-style among incongruous surroundings, a person who lived as he wanted to live, with his books, recordings and girls, without pretensions or involvement with the anhydrous world of the professionals in the nearby university laboratory. True or not, this image of the Doc of *Cannery Row* has become to many the idea of what a marine biologist is really like. But like all such simplified portrayals, he has become one of the folk images of our time — the wise, all-knowing biologist of the sea, for whom the material world is only a nuisance. Unfortunately many students who have read *Cannery Row* find that there are other things they must know, besides the ability to recognize the intervals in Gregorian chants and to have a knack for seducing girls, to become a marine biologist and to understand the sea.

The most widely read book about the sea in our times has been Rachel Carson's (1907-1964) *The Sea Around Us* (1951), a work of popularization that stands in a long and honorable tradition of books about the sea. It has been translated into many languages and is available on most larger paperback racks in the country. It has also been reworked into several versions, for school use, "for children" with pretty illustrations, and excerpts quoted in coffee table books. She wrote two other books, *Under the Sea Wind* (1941) and *The Edge of the Sea* (1955). While we now know much more about many of the matters that Rachel Carson wrote about, her book *The Sea Around Us* has worn well and it still evokes for her readers man's continuous confrontation with the sea:

Eventually man, too, found his way back to the sea. Standing on its shores, he must have looked out upon it with wonder and curiosity, compounded with an unconscious recognition of his lineage. He could not physically re-enter the ocean as the seals and whales had done. But over the centuries, with all the skill and ingenuity and reasoning powers of his mind, he has sought to explore and investigate even its most remote parts, so that he might re-enter it mentally and imaginatively.

He built boats to venture out on its surface. Later he found ways to descend to the shallow parts of its floor, carrying with him the air that, as a land mammal long unaccustomed to aquatic life, he needed to breathe. Moving in fascination over the deep sea he could not enter, he found ways to probe its depths, he let down nets to capture its life, he invented mechanical eyes and ears that could re-create for his senses a world long lost, but a world that, in the deepest part of his subconscious mind, he had never wholly forgotten.

And yet he has returned to his mother sea only on her own terms. He cannot control or change the ocean as, in his brief tenancy of earth, he has subdued and plundered the continents. In the artificial world of his cities and towns, he often forgets the true nature of his planet and the long vistas of its history, in which the existence of the race of men has occupied a mere moment of time. The sense of all these things comes to him most clearly in the course of a long ocean voyage, when he watches day after day the receding rim of the horizon, ridged and furrowed by waves; when at night he becomes aware of the earth's rotation as the stars pass overhead; or when, alone in this world of water and sky, he feels the loneliness of his earth in space. An then, as never on land, he knows the truth that his world is a water world, a planet dominated by its covering mantle of ocean, in which the continents are but transient intrusions of land above the surface of the all-encircling sea.

REFERENCES

Agassiz, Elizabeth C., and Alexander Agassiz. *Seaside Studies in Natural History.* Houghton Mifflin, 1866. 2nd ed. 1871. Reprinted in facsimile by Arno & New York Times as one of American Environmental Studies, 1970. (This reprint is a tribute to the lasting influence of Louis Agassiz in our culture; the book itself is an effort to carry on some of the work that the husband and father was too busy to complete.)

Beebe, William. *Half Mile Down.* Harcourt, Brace, 1934. (This book went through several editions; its substance was also published in articles in the National Geographic magazine.)

Beston, Henry. **The Outermost House.* Holt, Rinehart & Winston, 1928, 1949. Paperback: Vicking Compass Edition C126, 1962.

Brooks, Van Wyck. *The World of Washington Irving.* E. P. Dutton, 1944. *The Flowering of New England, 1815-1865.* E. P. Dutton, 1937 *The Times of Melville and Whitman.* E. P. Dutton, 1947. *New England: Indian Summer, 1865-1915.* E. P. Dutton, 1940. (This listing is in order of the sequence the author intended them to be read. While they have not been reprinted in inexpensive editions, good copies are often to be found in secondhand bookstores. Our American classic of literary history.)

Carson, Rachel. **Under the Sea-Wind.* A naturalist's picture of ocean life. Simon and Shuster, 1941. **The Sea Around Us.* Oxford, 1951. (There are several paperback reprints; the best of these is the updated Mentor edition.) **The Edge of the Sea.* Houghton Mifflin, 1955. (Available in paperback in Signet editions.)

Cooper, James Fenimore, *The Pilot, 1823. Red Rover, 1828. Afloat and Ashore, 1844.* (Cooper's seafaring books are not available in inexpensive editions.)

Dana, Richard Henry, Jr. *Two Years Before the Mast.* A Personal Narrative of Life at Sea. Harpers, 1840. (The best recent edition is that of Ward Ritchie Press, 2 vols., 1974, ed. by John Haskell Kemble.)

Goodrich, Lloyd. **Winslow Homer*, A. & W. Visual Library, 1973. (The best inexpensive *Homer* edition, with samples of all periods and media.)

Hemingway, Ernest. *The Old Man and the Sea.* Scribner's, 1952. (*Available in paperback only as part of three short novels repr. by Scribner's.)

Howell, Sarah, *The Seaside.* Studio Vista (Cassell & Collier Macmillan, London) 1974. The development of the seashore as resort in both England and America.

London, Jack. *The Sea Wolf.* 1904.

Lurie, Edward. **Nature and the American Mind. Louis Agassiz and the Culture of Science.* Science History Publications, New York, 1974.

Maury, Matthew Fontaine. *The Physical Geography of the Sea and its Meteorology.* 1855. (The most recent edition, with critical introduction, is that of the Belknap Press of the Harvard University Press, 1963, edited by John Leighly.)

Melville, Herman. *Typee*, 1846; *Omoo*, 1847; *Mardi & Redburn*, 1849; *White Jacket*, 1850. *Moby Dick*, 1851; *Pierre*, 1852; *Battle Pieces*,

*Available in paperback.

1866; *John Marr*, 1888; *Timoleon*, 1891; *Billy Budd*, 1921. (*All of Melville's major works are available in paperback, especially *Moby Dick*, in various editions. However, the best paperback editions, with good introductions, are the Penguin Books editions, especially *Billy Budd*.)

Stanton, William. *The Great United States Exploring Edition of 1838-1842*. University of California Press, 1975.

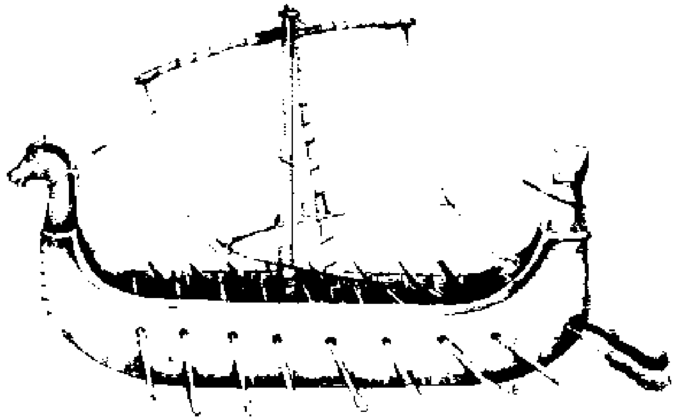
Stein, Roger B. *Seascape and the American Imagination*. Clarkson N. Potter, Inc. (Crown Publishers) 1975. (Excellent on American marine and maritime painting. However, it has been remaindered and may not be available.)

Steinbeck, John. *Sea of Cortez*. John Steinbeck and Edward F. Ricketts. Viking, 1941. **The Pearl*. Viking, 1947. (From magazine version, 1945. As paperback, paired with the *Red Pony*.) **Cannery Row*. Viking, 1945. **The Log of the Sea of Cortez*. Viking, 1951. (All of Steinbeck is available in paperbacks, mostly Bantam. However, the best edition of *The Log of the Sea of Cortez* is the Viking Compass Edition, when available.)

Thoreau, Henry David. *Cape Cod*. W. W. Norton, 1951. Reprinted Branhall House. (Of Thoreau's works, only *Walden* and *Civil Disobedience* are available in paperback.)

Viereck, Phillip. *The New Land*. Discovery, Exploration and Early Settlement of Northeastern United States, from earliest voyages to 1621, told in the words of the explorers themselves. John Day, 1967. (This has been on remainder tables.)

Wouk, Herman.* *The Caine Mutiny*. A Novel of World War II. Doubleday, 1951. Pocketbooks. (When published in 1951, this novel was awarded the Pulitzer Prize. In the following year, 1952, the same prize was awarded to Ernest Hemingway's *The Old Man and the Sea*.)



4. Resources of the Sea

In myriad ways, large and small, the resources of the sea touch our lives. As we examine the clouded crystal ball with which we predict the future, we see even more ways in which the sea will influence all our tomorrows.

A recent family of products that has come into the market place is the snap packs, both desserts and snacks. Pull the top as one opens a beverage can and spoon up the smooth chocolate or caramel. Resources of the sea? Indeed, and the beginning was long ago across the sea in Ireland.

History does not record the first brewing, but we know that centuries ago Irish housewives collected a crisp, fuzzy topped red seaweed from the intertidal zone and stewed it with milk. From some magic ingredient in the seaweed, a gel was produced. The Irish ate the silky-smooth white gelatin pudding; Irish maidens smeared it on their faces as an aid to clear, white complexions, and Irish babies were fed the stuff as a cure for croup. The French, who know a good sea thing when it is called to their attention, quickly adopted the milk-seaweed recipe and called it *blanc mange,* a name its descendent product bears to this day.

During the last century an English chemist became curious about the gelling property of the weed, and he found that it came from a colloid contained in the cell walls, a pre-sugar polymer called a polysaccharide. He named it Carrageenin after its Irish origin. The seaweed was called Irish Moss.

So much in demand was the milk-seaweed mixture that the colonists who came to the New World actually imported the seaweed on the sailing ships of the day — until someone realized that the red seaweed washed ashore in New England storms was the same, and that plenty of it grew in the shallows off the rocky coast. The seaweed, called *Chondrus crispus* by scientists and Irish Moss by everyone else, is still the basis for the marine colloid industry of which our authors speak in ensuing chapters, but other red weeds are collected worldwide, and one family, *Euceuma,* has become very important. To the carrageenins from the red seaweeds we have now added other colloids with gelling properties from the giant kelp of California, and these are called *alginates.*

But seaweeds have uses other than as gelling and smoothing agents. If one journeys to the coast of Brittany, hard by the great French tidal power station on the Rance River, the Bretons will be found in season at low tide harvesting seaweed to spread on their fields. The Bretons have long appreciated the magic properties of seaweeds and have used them to improve the soil and to produce better crops. We still are not sure why seaweeds are so beneficial in agriculture, and scientists are trying to find out. This is important, because modern agriculture is based on natural gas fertilizers and petroleum-based pesticides and herbicides, and when the supply runs low and the prices go up, a substitute must be found.

The other piece of the puzzle is fish. We have read of how the Indians helped the Pilgrims, and of how they taught the new settlers to put a small fish in their corn (maize) hills so that the crop might flourish and bear good ears.

Today, fertilizer made from a combination of seaweeds and trash fish (carp in the Midwest, for example) is proving to be remarkably effective, not only in stimulating crop growth but in keeping down weeds and insects through some natural process or component.

There is an aquatic counterpart to farming. We call it aquaculture, but it is really just animal husbandry or agronomy in a water environment. Statistically, it is not yet significant, but it will be. Aquaculture is very old. Dr. Shao-wen Ling has translated a treatise, on how to farm carp, that is more than 500 years old, and we know the Chinese were raising carp in ponds long before that.

Combinations of new and old aquatic technologies may be the answer to many of tomorrow's problems, combining the resources of the seas and fresh water with the resources of the land. Seaweeds grow well on the nutrients supplied by sewage, and sewage is an obvious problem at the moment. But, let the seaweeds grow on sewage to feed both our farm fields and certain kinds of fish and a problem becomes an asset. Sewage-grown fish in turn can feed the fields in fish-seaweed fertilizers, or perhaps feed other fish which can feed us, either directly or indirectly as food for poultry.

These, though, are less dramatic uses of aquatic resources than those we commonly think of, and which are the subject of our next chapter.

About John P. Craven

John Craven *is one of those people who so sparkle with ideas and new concepts that a few hours with him can supply enough food for thought and action to last more than a lifetime. He is currently Dean of Marine Programs and Director of the Law of the Sea Institute at the University of Hawaii, and also holds an appointment as Professor of Ocean Engineering. The combination of policy, law, and technology is quite legitimate, because he is an engineer, a lawyer, and an administrator. He took his BS in engineering from Cornell, his MS from California Institute of Technology, and his PhD from University of Iowa, and later earned his Juris doctor degree from George Washington University.*

Dr. Craven worked as senior hydrodynamicist at the famed David Taylor Model Basin, which is now the Naval Ship Research and Development Center, until 1959 when he became Chief Scientist of the U.S. Navy's Special Projects and Deep Submergence Project Office. The Office was responsible for development of the Poseidon-Polaris submarine-missile system, and for Navy man-in-the-sea projects and deep submersible developments. Craven's work earned him both the Department of Defense and Navy Distinguished Civilian Service Awards, and the U.S. Junior Chamber of Commerce gave him the Arthur S. Flemming Award as one of the "Outstanding Young Men in Federal Service." He was elected a member of the U.S. National Academy of Engineering.

On leave from the Navy, he was visiting professor of ocean engineering at Massachusetts Institute of Technology when he resigned to accept the position of Dean of Marine Affairs in Hawaii. He has taken a leading position in ocean policy and law of the sea negotiations, and in development of technology for improvement of and new uses of marine resources.

Resources of the Sea

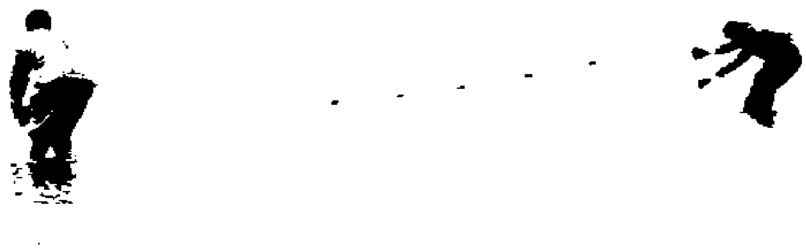
John P. Craven

To early civilization, the ocean was a feared and forbidding environment. From the dawn of civilization until about 1200 B.C., the primitive technology of ocean craft and navigation made every venture beyond the sight of land an uncertain and perilous voyage. From 1200 B.C. to nearly 1000 A.D., the useable salt water consisted of the Mediterranean, the Baltic, and the enclosed and semi-closed seas of the world. Nevertheless, regardless of peril and no matter how limited the venture, man wrested resources of great value from the ocean.

Initially, the major resource of the ocean was transportation, that characteristic of the seas which permits large quantities of materials, abundant in one place, to be moved with little expenditure of energy to places where they are scarce. This characteristic, so valuable to antiquity, is equally valuable today as witnessed, to mention just one cargo, by the supertankers carrying hundreds of thousands of tons of oil in each journey, from the oil-soaked Middle East to the oil-starved coasts of the North American continent.

The first maritime society to benefit from the transportation resource was the Phoenicians whose Mediterranean domination from 1022 B.C. to the fall of Carthage depended solely on their mastery of the sea. No better description of the nature and value of this resource has been given than that of the Biblical political geographer Ezekiel in his description of Tyre:

"Oh, Tyre, thou hast said, I am of perfect beauty. Thy borders are in the midst of the seas, thy builders have perfected thy beauty. They have made all thy ship boards of the fir trees of Mount Herman; they have taken cedars from Lebanon to make masts for thee. Of the oaks of Italy have they made thine oars; the company of the Ashurites have made thy benches of ivory, brought out of the isles of Cyprus. Fine linen with broidered work from Egypt was that which thou spreadest forth to be thy sail; blue and purple from the isles of Cyprus was that which covered thee. The inhabitants of the Levant were thy mariners: thy wise men that were in thee were thy pilots. The ancients of Iraq and the wise men thereof were in thee thy calkers: all the ships of the sea with their mariners were in thee to occupy thy merchandise. They of Iran and of North Africa were in thine army; thy men of war: they hanged their shield and helmet in thee; they set forth thy comeliness. The men of Syria with thine army were upon thy walls round about; they have made thy beauty perfect. Spain was thy merchant by reason of the multitude of all kind of riches: with silver, iron, tin and lead they traded in thy fairs. They of Greece were thy merchants: they traded the persons of men and vessels of brass in thy market. They of Southern Armenia traded in thy fairs with horses and horsemen and mules. The men of Arabia were thy merchants; many isles were the merchandise of thine hand; they brought thee for a present, horns of ivory and ebony. Syria was thy merchant by reasons of the multitude of the wares of thy making: they occupied in fairs with emeralds, purple and broidered work, and fine linen, and corals, and agate. Jordan and the land of Israel, they were thy merchants: they traded in thy market wheat, and honey, and oil, and balm. Damascus was thy merchant in the multitude of the wares of thy making, for the multitude of all riches; in wines and white wool. The Turks going to and fro occupied in thy fairs: bright iron, cinnamon, and calamus. The ships of Spain did sing of thee in thy market: and thou wast



Fishing has occupied mankind over many centuries

replenished, and made very glorious in the midst of the seas."[1]

It is quite clear that of this commerce and trade, relatively few items were products of the sea. Notable exceptions are the royal purple dye obtained from the shellfish, *Murex* and the corals employed for jewelry. The most obvious other ocean resource, fish, could not be a commodity in international trade at that time because there was no technique for preservation. The fish of the seas were thus an important, but very local, resource whose consumption was close to the place of catch.

It was a result of the development of the salt preservation process for herring that fish entered the world market as an international commodity, forming the economic base of what was perhaps the world's first multinational corporation — the Hanseatic League, a confederation that dominated oceanic commerce and trade in the fourteenth century. With its center on the Island of Visby, its dominance of the ports of Hamburg, Bremen, Lubeck and Bergen, it had a virtual monopoly over the total herring catch of the Baltic. This ocean resource was the basic commodity for trade with the Mediterranean ports of Venice and Genoa, Constantinople,

[1] *Modern place names are used to aid the reader. Most of the names have been obtained from Moscati, Sabatino, The World of Phoenicians, Frederick A. Praeger, Inc., 1968.*

Marseille; with the Iberian ports of Lisbon and Seville; with the French port of Calais; with the Cinque ports of Southern England, and with the merchants of London. Even as Ezekiel sang of Tyre, poets of the fourteenth century sang of the commerce of the Hanseatic League; of the oranges and figs of Seville, of the wines of Lisbon, of the tapestries of Venice, of the art of Florence, of the wool of Armenia, of the linens of Britain, and of the silver and gold of Spain. For the first time in the world's history, the driving commodity of international commerce and trade was an oceanic resource, fish.

The end of the Hanseatic League began with the disappearance of the herring. Whether this disappearance was due to overfishing or to a change in the ocean climate is a biological puzzle which bedevils the scientific community today in its assessment of fisheries stocks of the future. The outgrowth of the League was the Dutch East India Trading Company and the merchant fleets of the emerging British empire. Once again commerce and trade was "Phoenician" — the primary focus was on the movement of exotic land commodities from their source to the industrialized commercialized world. Coffee, teak, cloves, spices and other preservable tropical and far eastern products became the commodities exchanged for the trinkets and tools of an industrialized society. The Hanseatic experience in preservation of fish was translated to other nations, and quite independently of the growth of the international trading companies, a number of nations developed distant-water fishing fleets. The seventeenth, eighteenth, and nineteenth centuries saw the growth in Portugal, Japan, Korea, Iceland, Britain, Newfoundland, New England, Scandinavia, and Russia of distant-water fishing fleets of economic and cultural significance to the respective nations.

In the 19th century, the use of the ocean for transportation was complemented by the harvest of the whale. This remarkable marine mammal had and has a physiology so unique that its components have become useful to man. No one can match Melville's description in *Moby Dick* of these unique commercial properties. But those who have read the book are reminded of the many uses of whale bone as a preplastics lightweight elastic structural component of combs and corsets; of the purity of the oil and oil products having a wide variety of uses from lamp oil to machine and medicinal oil; of the haunting human-enhancing odor of the spermaceti perfumes, and of the artistic and jewelry use of the whales' teeth. We are all too aware today that the slow reproductive rate of the whale could not hope to compensate for the commercial value of harvesting these magnificent creatures, even to the point of extinction. Indeed, the development of petroleum as a source of oil, and the development of plastics and industrial chemistry, would have made this industry obsolete as a major resource, even if nature had kept pace with demand.

In the 19th and 20th centuries, the use of the ocean as a domain for the deployment of military power came to full flower. We shall not dwell long on this use and, indeed, many would not regard it as a resource. In the larger context, the physical properties of the sub-sea in hiding submarine fleets and the chaotic nature of the free surface which prevents the fencing in of the ocean or the establishment of fixed installations or other prerequisites of sovereignty, provide a unique opportunity for nations to extend their military power far beyond the limits of their own jurisdiction and as such provide a capability not obtainable on land except by extraordinary measures of conquest, domination, or alliance. Thus, the world came through its Second World War (which was in fact its first) with the awareness that the primary resources of the sea were transportation, military projection, and fish.

Since that time, dramatic changes in resource demand and utilization, and dramatic changes in the science and technology of the sea have opened up a host of ocean resources whose potential, when fully realized, may shift man's major resource dependence from land to sea.

The openers on the new uses of the sea were offshore oil and large scale "factory" fishing. The former was a new resource of the sea and the latter a new dimension in an old use of ocean resources. Initially, it was recognized that oil would exist on the continental shelves where oil bearing land masses dipped below the surface of the sea. The initial technology of extraction was to move land-based technology onto platforms on stilts in the shallow seas. These "old shakeys" proved vulnerable to storms, and it has been recognized recently that it is easier to drill in deep water where the subsurface waters are always calm than in shallow waters where storm turbulences are felt in a destructive manner on the sea bed itself. Geologists are now arriving at a fuller understanding of the areas of the world in which oceanic oil is to be found. With that understanding comes an awareness that the major oil fields of the future will be oceanic.

Geologists now realize that at one time in the history of the world, there was but one continent or island floating on the crust of the earth. This island has split and is splitting into the separate continents of the world. Whenever the pieces of the original continent have separated, continental valleys have been created into which the organic sediments of the land flowed and which provided nutrient-rich seas which generated more organic matter which in death deposited in the sediments of these rift valleys. Of this organic material, oil is made. The deposit, however, is not enough: nature must create traps in the form of geologic domes or folded structures, pinch-outs, tents of impervious clay, and shales to form natural reservoirs for entrapment of the oil and gas which would otherwise float to the surface of the sea.

The most prominent and most geologically recent zone of continental separation is of course the Mid-East, where the continent of Africa and the Arabian peninsula have been separating from the Eurasian continent. The Mid-East oil fields are by far the largest in the world, and it is highly doubtful that another area of comparable productivity will be found. Much of the Mid-East oil is underwater in the Persian Gulf and as such can be credited to the bounty of the sea.

Following this geologic trend, many petroleum experts believe that the East China, South China, and Yellow Seas of Asia are another area of the world where extensive petroleum reserves will be found.

Major proven areas are: the North Sea where the British Isles have separated from the East Asian continent; the North Slope of Alaska, Canada, Norway, and the Soviet Union where the "Hole in the Continental Doughnut" exists. The Alaskan oil necessitated the construction of the now famous Alaskan pipeline. This terminates in the Port of Valdez where the oil is then shipped by tanker to the consumer. Another obvious area is the Gulf of Mexico where shallow water oil wells have been producing for many years. As yet unexplored, but of great potential, are the deep waters of the Gulf. In this area, geologic dome structures have already been identified which would possibly be locales for oil.

Oceanic areas which have not yet been developed, but which have been identified as having great potential, include the continental shelf off the African coast of Angola and the mating coastline of South America off the coast of Brazil. Also included is the region between the tip of South America and Antarctica where these two continents have separated.

Of course oil is found on other continental margins such as the fields offshore of Santa Barbara, California, but those fields which are not identified with continental separation are, in general, relatively small.

We do not yet know the magnitude of the oil reserves, and in particular those which are in the deeper parts of the continental shelves and the inland seas. It is quite evident that an increasing percentage of the world's oil of the future will be drawn from under the sea, and that the end of the oil age whenever it occurs will take place with the exhaustion of reserves in the deeper parts of the continental sea.

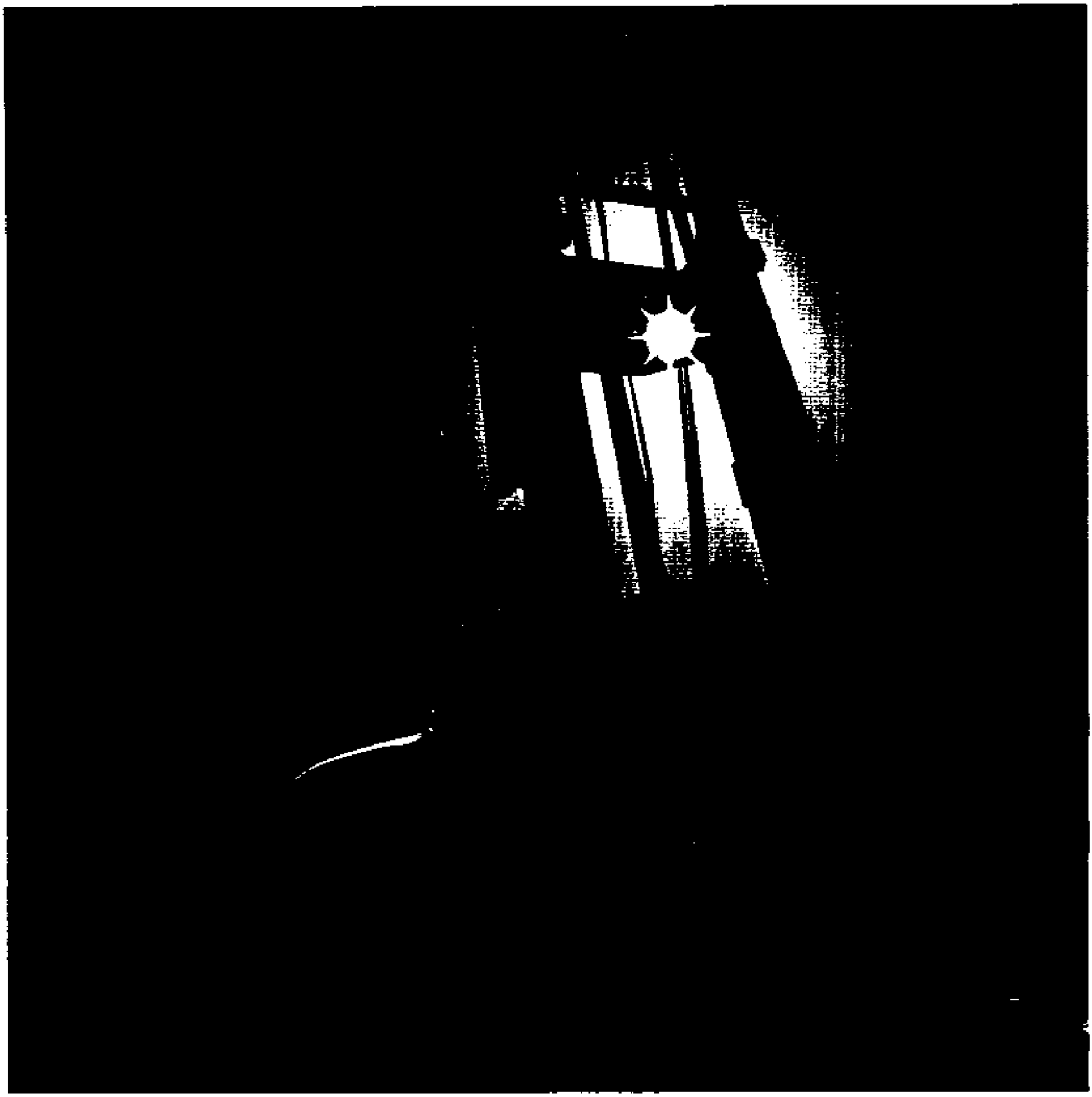
The availability of oil on the floor of the sea is not the whole story of oil and the ocean. The ocean is proving to be an environment suitable for the storage of oil, the processing and refinement thereof. In the North Sea and the Persian Gulf, huge structures of reinforced concrete have been installed which contain up to one half million tons of oil. These structures have been constructed in a shallow bay and floated to the site where the oil storage is desired. Initial steps have been taken to install refining facilities on these storage facilities or on the oil drilling platforms so that the tankers can carry products which require less additional refinement at the many points to which the oil is distributed. When oil production, processing, and transportation all take place on the sea, then this form of energy can be truly classified as oceanic.

Energy from the ocean has taken many forms and will take many more in the future. The ocean appears to be the primary environment from which man will extract solar energy. The total energy from the sun is our largest energy resource, and in principle, is large enough to supply mankind's needs even if the entire world population were to live at the level of affluent Americans. It is a diffuse form of energy providing, at best, 100 watts per square foot in full sunlight. Some means for collecting and integrating the energy must, therefore, be found. One of these mechanisms is in the generation of wind. The heating of the atmosphere by the sun coupled with the rotation of the earth results in wind patterns around the earth which in certain regions, such as the subtropical zones, are stable and predictable. A moment's reflection and we all

The search for every undersea resource is increasing

realize that wind power was the major energy for ocean transportation until the invention of the steam engine. If energy costs continue to rise, a hybrid form of sail and fossil fuel propulsion may once again be the most economic form of ocean transportation. Windmills have, of course, been the other well exploited form of wind power and their use for energy generation on fixed platforms in the ocean is now under investigation. Unfortunately, at the current state of the art, a steady state of velocity of about 40 knots is required for the economic generation of power.

The wind in turn generates waves. Many attempts have been made to convert wave energy into more useful forms. But wave energy, like the basic form of solar energy, is diffuse and except for small power sources, like those required for powering of lights on navigation buoys, this form of energy has not been successful.



Tides result from the interaction of the earth and moon. This gravitational attraction between the seas and the heavenly bodies sets up the periodic resonant wave motions of the ocean. In a few locales around the world, such as the Bay of Fundy, tides of very large amplitude are generated. These tides have been harnessed for hydroelectric power generation in power plants that have been quite successful. Although this ocean resource has not yet been fully exploited and many other successful plants have yet to be built, the total power generated by tidal power has been and will be minuscule in terms of world energy demands.

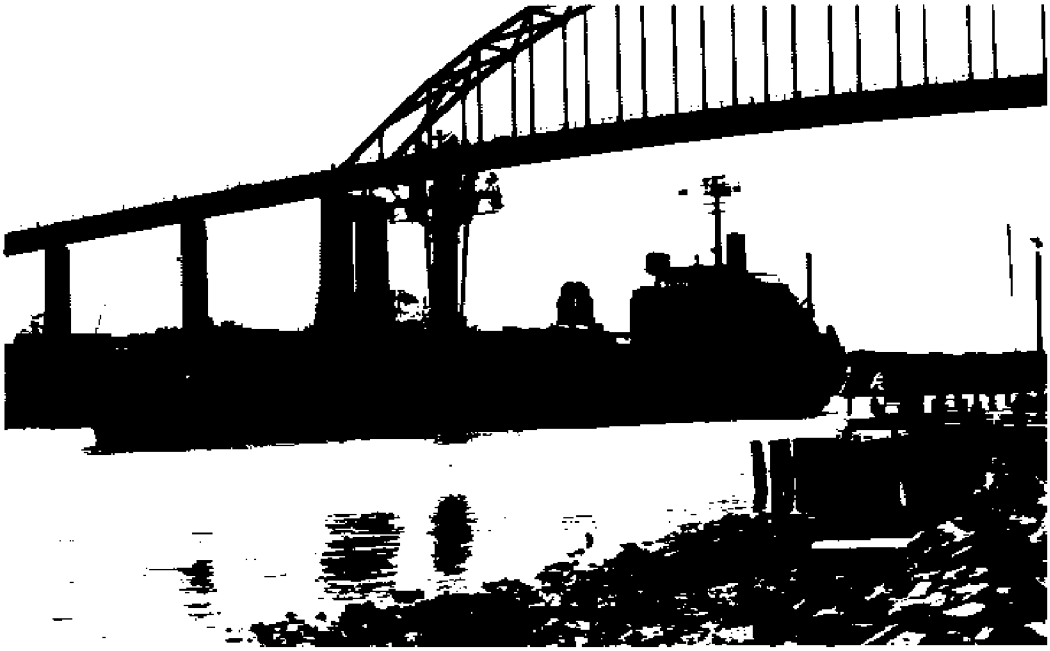
By far, the most promising form of oceanic solar energy is extraction of energy from the difference in temperature between the ocean surface water and the water of the ocean depths. It is the sun that creates the difference; its rays penetrate only the uppermost layer of water so that its effect is almost unmeasurable several thousand feet below the surface. Here, the cold waters of the Arctic have diffused throughout the ocean with an ocean temperature which is only slightly above that of freezing. This effect is, of course, greatest in the tropics. Here, the difference between surface and subsurface waters can be greater than 20° Celsius.

In principle, the extraction of energy from the ocean is the same as that employed in the conventional steampower plant. In a steam power plant, the heat from the fire or boiler is used to vaporize a "process fluid," which is almost invariably water that is converted to steam. In the ocean thermal plant, the warm surface water is the "fire" that vaporizes a process fluid, usually ammonia or butane (a fluid which boils at a low temperature). In both cases, the energy of the vaporized process fluid is extracted by expansion through a turbine which, in the process of rotation, generates electricity. In the steam power plant, the steam is condensed by cold water. Similarly, the ocean power plant, the ammonia or gas vapor is cooled by the deep ocean water. The efficiency of both steam and ocean thermal plants is determined by the nature of a thermodynamic cycle called the Carnot cycle. This efficiency is determined by the difference between the hot or vaporizing temperature and the cold or condensing temperature. Quite obviously, ocean thermal power plants will be inefficient, and large plants will be required to produce small amounts of power. Nevertheless, when and if such power plants are developed, large amounts of renewable energy will become available in the tropical belts of the ocean. These energy sources can then be employed to manufacture such energy-intensive products as ammonia or methanol, or to produce hydrogen from the electrolytic dissociation of sea water.

Prior to the development of ocean thermal energy itself, the ocean will serve as an effectively inexhaustible source of cold water for cooling. Since the efficiency of any thermal power plant, whether it be solar or nuclear or fossil fuel, depends upon the difference of temperature between the heat source and the cold sink, then the availability of cooling water is as important as the heat source. Land-based plants in general require expensive, unsightly cooling towers to meet requirements. Plants based at the edge of the ocean or on the ocean have this resource available in abundance.

In the distant future, at a time as yet unknown by scientists and engineers, it is expected that power generation by nuclear fusion will be both feasible and economic. The fuel for this form of power will be heavy water, i.e., water whose hydrogen atom contains an extra neutron. A small but significant percentage of sea water is heavy water. Thus, when this form of energy is developed, the ocean is not only the source for the cooling water, but the source for the fuel.

We can now clearly see that in the future, whether it be oil or coal, ocean thermal, wind, wave, tide, nuclear fission, or nuclear fusion, the substantial world production of



Increasing reliance is placed on water transport to carry supplies of energy and other materials

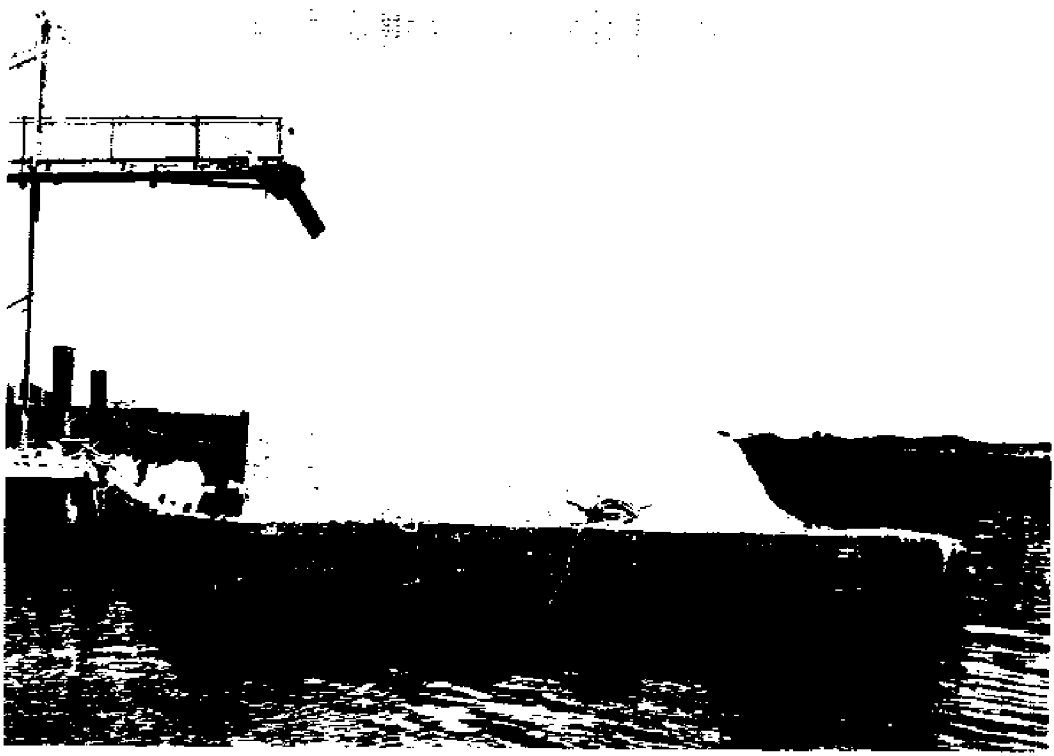
energy will be oceanic. We can also see that the most significant initial development will be that of offshore and oceanic oil.

Although oil is the mineral of greatest economic value to be obtained from the ocean, a great many other minerals have been and will be extracted from the sea and the seabed. Oceanic coal is as old as the Newcastle coal mines. Just as oil extends into the offshore continental shelf, so do deposits of coal and oil shale. However, the land reserves of this vital fuel are so great that they will dominate coal production as far in the future as we can see.

Under some circumstances the logistic convenience of coal on the seaboard could make oceanic coal the preferred resource whenever the trade-off in extraction costs are approximately equal. Large reserves of oceanic coal are available off the shores of Alaska and the eastern shores of Canada. Indeed, they are abundant throughout the world on the continental shelves. As coal develops as the predominant raw material for energy, fuels, and petrochemicals, we may expect to see oceanic coal assume a prominent and identifiable role.

Similar to the situation with respect to oceanic coal is that of sand and gravel. Although these resources are essentially inexhaustible on a world-wide basis, transportation costs by land are very high and the gradation and quality of land-based resources often require energy-intensive — and therefore expensive — crushing processes. The ocean through its beach erosion processes produces and sorts sand and gravel with gradations highly suitable for construction. Many readers are familiar with successions of coves along a beach shore which show a progressive gradation from rocks to stones, to pebbles, to coarse sands, to fine beach sands. Much of this graded material is carried out to sea and eventually deposited in areas where it is separated from the coastal erosion process. In such locales these deposits can be safely mined without damage to the environment of the coastal zone. Relatively little mining of offshore sand and gravel has been accomplished on the continental shelf of the United States. This is principally due to the cost and lead time of the many environmental and exploratory permits which are required before the recovery can commence. This time has been estimated as a minimum of five years if all the permit processes take place on schedule and without substantial objection. Nations such as Japan and the United Kingdom have already drawn heavily on this resource with more than ten percent of the total aggregates of the United Kingdom being derived from oceanic sources.

In addition to sand and gravel, many specialized mineral sands are derived from the ocean. Glauconite is mined for use as a fertilizer. Virtually all of the drilling muds which are used in the oil industry are derived from an offshore deposit in Alaska. Clam shells are mined extensively as a source of lime. Placer deposits of gold and silver have been found and more are expected to be found in the Bering Straits. It is equally true that geologic "pipes" or intrusions of minerals are as



Clam shells provide lime for landbased construction likely to be found in the ocean as they are on land. Commercial grade diamonds have been found in the waters off the coast of South Africa. They were exploited commercially for a period; but as most readers well know, the production of this resource is closely controlled and as a result, the operations have been suspended for the time being.

As techniques for undersea geophysical exploration are developed and refined, we may expect that more undersea deposits of metals and minerals will be located, but for the present, the means for identifying fruitful locales for exploration and techniques for discovery must be regarded as embryonic.

While conventional deposits of metals and minerals are waiting for discovery by future generations, the ocean has generated and is generating deposits of manganese, copper, cobalt, nickel, and titanium which are unique to the ocean environment. These are found in the unique potato-like rocks, called manganese nodules, which strew the ocean floor in the Atlantic and the Pacific. The origin of the nodules is not fully understood and is now the subject of major geochemical study. A suggested mechanism notes that creatures of the sea concentrate metals which are in solution in the ocean. At death, the creatures sink to the seabed, form part of the seabed, and in decay release metallic compounds which, migrating to the surface of the seabed, are electrolytically attached to a nodule seed. This process continues until a sizable nodule is developed for which the surface-to-volume ratio is such that growth is decelerated. The primary metallic constituent of the nodules is manganese, which accounts for their designation; if it were the only metal resource, the nodules would not be significant. Depending upon geographic location the nodules may also have substantial quantities of cobalt, copper, and nickel. In the subtropical latitudes of the mid-Pacific, concentrations of metals in the one- to two-percentile range can be found; the concentrations make the nodules rich ores when judged by land-mine standards.

Although no commercial mining has yet taken place, a substantial number of international combines have organized for the harvesting of these mineral resources. Some delay has been caused by the negotiations on the Law of the Sea. International recognition of the importance of the sea resources has resulted in protracted and conflicting negotiations to determine their legal status.

Regardless of the outcome of the international negotiations, we may expect that in the not-too-distant future the world's major supplies of copper, nickel, and cobalt will be derived from these nodules of the seabed.

While many minerals will be found in consolidated form on the continental shelf (such as coal, limestone, sulphur, tin, and hydrocarbons), many will be found as unconsolidated sands (such as semi-precious stones [agate, jade], industrial sands, phosphates, aragonite, and glauconite), and many more minerals are found in solution in sea water. Indeed, it is somewhat tempting to believe that some process will be found that will cheaply and easily remove these minerals from solution and reward the producer with a limitless store of wealth. Unfortunately, the energy costs of removing the dissolved minerals has made their extraction commercially unfeasible except for a few minerals in locales where nature has aided in brine concentration. Most prominent of the commercial seawater minerals are bromine, iodine, and magnesium. Currently, the oceanic extraction of these materials is on an economic par with land-based sources.

What may we say in summary on the mineral wealth of the oceans? We may say that all of the minerals of the land appear in the oceans and in concentrated quantities that are generally as large or larger than their land counterparts. We note that finding concentrated lodes and deposits of minerals in the ocean is more difficult than finding them on land, and as a result, many have yet to be discovered. We note that concentrated minerals on land have often been uncovered by erosive and segregating beach process which have concentrated the minerals in a form for recovery, and we note the geochemical processes of the sea which deposit minerals on the sea-floor in a manner not seen on land. We note the solution properties of a watery medium which disperses minerals uniformly throughout the water column where nature can employ other filtering and concentration mechanisms for their subsequent harvest. We may confidently predict that an ever increasing percentage of the world's minerals will be obtained from the sea and that the ocean will someday predominate as the storehouse of the world's mineral wealth.

Minerals are but half the story. The biological resources of the ocean are of equal diversity and may be of equal importance to man and his society. Biological production requires energy, generally to provide carbon, nitrogen, and a small but necessary source of phosphorus. Abundant productivity requires an abundance of nutrients and these are not found uniformly throughout the ocean. Indeed, the source of these nutrients, the dead products of previous productivity, migrate to the bottom of the sea below the depths which are reached by sunlight (600 to 1000 feet) and are not available unless some geophysical process creates an upwelling of the deep water into the shallow areas. This occurs in belts on either side of the equator where the rotation of the earth, coupled with the thermodynamic processes associated with a cold polar mass and warm equatorial mass, produces an upwelling in the subtropical latitudes.

Upwelling occurs where major ocean currents intersect continental land masses, as for example the Gulf Stream off the New England and Newfoundland coasts, or the Kuroshio current split in two by Taiwan, or the Japanese current as it sweeps past Alaska down the coast of North America. By and large, concentrated fishing resources are found in coastal and shallow water regions of the ocean in zones which are fairly well known. The major fisheries exist in the North Sea, in the Baltic, off Newfoundland and New England, off the coasts of Brazil, in North Pacific waters off Alaska and Canada, in the Ryukyus, and in semi-enclosed seas of Southeast Asia. Fish, like other biological creatures, have evolved to optimize on this food availability.

Fish are broadly categorized as: 1) pelagic — those who migrate across the ocean generally following the subtropical biogenic belts; 2) Arctic and Antarctic anadromous — fish, whose origins are in coastal streams, which migrate into the ocean and return to their place of origin to reproduce and die; these are principally the salmon; 3) coastal — fish which remain essentially in localized coastal regions; and 4) demersal — fish and crustaceans which live at or near the seabed.

Until recent decades, the quantity and availability of fish, as compared with world need and consumption, was such that there was little competition for the resource and little need for management. Estimates in the 1950s placed the maximum sustainable annual harvest from the sea at 55 million metric tons. In the past few years, world harvests have exceeded 70 million metric tons. Quite clearly there is and will be competition for the resource, and management is required.

Of the pelagic fish the most important from a world market standpoint are the tunas. A number of varieties — albacore, Big Eye, yellowfin — are harvested in the Northern Pacific, off the coasts of South America, and off the coast of Africa. Other species of less importance to commercial fishermen are the billfish, marlin, and mahimahi or dolphin fish. These latter species are, however, prime recreational fish and recreational or sport fishing must be included as an important resource of the sea.

Salmon are significant as animals that return to the fold. As such, they are capable of being bred and developed into a superior product just as poultry has been developed. Salmon have been successfully introduced into the streams of Japan and the Soviet Union, and an attempt is now being made to introduce them into the southern hemisphere. As a cold water fish, they are most prolific in the waters of the northern Pacific, but by selective breeding they may be developed for warmer waters.

Numerous coastal species of commercial importance are found in the major fishing zones of the world. Local culture and custom determine whether the fish is regarded as a delicacy, a staple, or as a trash fish. Haddock, hake, mackerel, pollock, mullet are species in this category. Among the coastal species are the schools of small fish such as the anchovy, sardine, anchoveta, and menhaden. These are used as a major source of fish meal. This valuable protein product forms a base for chicken feed and other animal foods. The chicken that you consume at the fast-food establishments is, most likely, twenty-five to thirty-five percent the result of fish meal consumption. This transformation of fish protein to meat protein before human consumption is regarded as wasteful by some and by others as a transition to mankind's greater consumption of the products of the sea.

Demersal species include the flounder and the cod as species of significance but also include the crustaceans — the king crab, lobster, shrimp, the shellfish abalone, clam, oyster, mussels, and in Hawaii, the exotic opihi, or limpet. Quite clearly as compared with animal protein alternatives (beef, lamb, pork, poultry) the ocean species present an almost limitless variety.

Consider the luxury and gourmet items: caviar, fish roe, sea urchin gonads, sashimi (raw fish), oyster, octopus, king crab, anchovy,

sardine, lobster, and shark fin. The gourmet chef would be at a complete loss were it not for the variety of the sea.

Consider again the staples: tuna, salmon, mullet, herring, pollock, haddock, and cod. The societies of Japan, Southeast Asia, Soviet Union, Scandinavia, and Iceland are as dependent upon the protein of the sea as we are dependent upon the protein of the land.

But, the protein bounty of the sea has yet to be fully developed. A first step was taken in the development of fish meal as a protein base. Derivatives of fish meal in the form of fish meal flour or in the highly concentrated white powder fish protein concentrate are independent of the species of fish or sea creatures which make up the initial constituents. Thus a wider spectrum of sea creatures is available, and the protein from the sea no longer limited to the 50-70 million metric tons of conventional harvest, could conceivably increase by an order of magnitude.

A leading candidate for this increase is the Antarctic krill. These tiny shrimp-like creatures are abundant in the waters once frequented by the baleen whales. The baleen whales, whose teeth are comb-like filters, harvested these creatures for direct conversion to mammal protein. With their disappearance, a window in the ecological system has been opened for other creatures to fill. Today, Soviet and Japanese trawlers are making initial harvesting of this vast resource estimated at one-hundred to one-hundred and fifty million metric tons a year. Such a yield would double or triple current world harvests, but would require great amounts of energy for both catching, and processing.

The biological harvest of the sea extends beyond living creatures for food to include the world of ocean botany. Seaweeds have long been a staple of Japan and form the wrapping of the delicious and popular "sushi" a roll of rice and raw fish.

Processed, certain seaweeds produce valuable colloids. In the future we may expect that developments now in progress will produce a wide variety of plants to grow in saltwater or brackish water. Success has already been achieved for brackish water growth of cloves, olives, tomatoes, figs, and other woody plants. Of longest range significance may be forms of algae. Experiments are suggesting that the highest production of biomass per acre can be achieved with sunlight, saltwater, mineral nutrients, and algae. Algae high in oil content have been developed and oil growth as high as a barrel per acre per day has been achieved. Clearly the growth potential for plants and algae has yet to be developed as one more resource of the ocean.

Our chapter on resources ought not to close without noting those adornments which are a gift from the sea. The pearl of the oyster has long been a prize jewel whose artificial production has never matched the deep lustre of nature. A growing competitor to this sea jewel are the precious corals. The black corals of Hawaii found at depths of 200 feet appear to grow as a tree. The tree-like structure is in fact the skeleton of many small coral polyps which live on the exterior and in dying, cement their skeleton to the branch on which they grew. At depths of approximately one thousand feet are found the pink corals. These corals range in color from a light pink (angel skin) to a deep bloodred. The corals are found on the reefs of Taiwan, in the Mediterranean, and in the Hawaiian Islands.

5. America's Future and the Sea

Unless there is reason in presentation, one is always in danger of closing down communication because the subject seems irrelevent. In one way or another, we all echo Lewis Carroll's whimsical query:

"And what mean all these mysteries to me,
Whose life is full of indices and surds?"

Or, in modern jargon, *"What's the bottom line?"*

For marine uses and resources, for the supply of pure, fresh water, the answer is: jobs, necessities, luxuries, maintenance of the U.S. standard of living, and even that important intangible called the quality of life.

One kind of use may illuminate the answer. In the previous chapter, John Craven spoke of transportation as a vital use of the sea, a point to be enlarged in ensuing chapters. But let us leave salt water and turn to fresh and study a map of the United States Inland Waterway System.

We see more than 25,000 miles of waterways, almost twice the length of our coastline. Those waterways penetrate deep into the heartland of the United States. Ocean-going ships travel for part of the distances, and one of the more startling sights to the uninitiated is to see a ship crossing a prairie, a sight visible in Oklahoma, for instance, as sea-going vessels travel to the port of Catoosa.

Barges, both self-propelled and towboat-propelled travel all the way, even to Sioux City, Iowa.

They carry fuel, raw materials, processed goods – all the articles of trade – at a cost per mile with which no other form of transport can compete. They load the agricultural produce of the great agricultural states, and either carry it direct to customers abroad, or to seaports for transshipment. They carry the manufactured goods we sell abroad, and the goods and raw materials we import. The inland waterways are truly the nation's arteries, and on the flow of goods through them our economic well-being depends.

A careful examination of the inland waterway map is revealing. There is history there; the famed Erie Canal, one of the great engineering feats of American history, is still operating, part of the New York system. It is also clear that a vessel of the right size could navigate completely around the Eastern half of the United States, through the Mississippi waterway system to Chicago and the Great Lakes, through the "Soo" Canal and the St. Lawrence Waterway out to the Atlantic, down the coast on the inland waterways and across the Gulf waterways to the Mississippi River again.

Because of the inland waterways, the Great Lakes and the salt water coastlines, 40 of the 50 United States have seaports. And that means that 40 states are coastal states, at least from the viewpoint of aquatic commercial transportation. Apart from the movement of goods, the economic impact is very great because of shipyards and boatyards and dredging to keep the channels cléar and the operation of locks and aids to navigation and the employment of about two million people afloat and ashore.

So even this one kind of use, transportation on the inland waterways, has profound effect on America's fortunes, taking goods and products to market, and bringing goods and products for our use, all of this at low cost. To finish, let us look at cost in fuel consumed, a more realistic appraisal than money. One gallon of fuel will take an airplane five ton-miles, a truck 50 ton-miles, a rail shipment 180 ton-miles. But a barge on the inland waterway system will travel 330 ton-miles on a gallon of fuel. The implications are apparent, not only for now, but for the fuel-short future.

About Peter Fong and Robert Stokes

Chapter V represents a collaboration of economists, but not the usual kind; these are economists who specialize in marine affairs. **Peter W. Fong** *is from Hawaii and is at this writing a pre-doctoral candidate at the University of Washington. He majored in mathematics at the University of Hawaii; then completed his Master of Arts in Economics at the University's Manoa Campus in Honolulu. He has served as a teaching assistant and instructor at both Hawaii and Washington, and as a research assistant for the University of Hawaii's Geothermal Energy Project.*

Robert L. Stokes, *a native of North Dakota, migrated to Washington state for his education at Eastern Washington State College and the University of Washington, completing a BA in political science and MA and PhD degrees in economics at Seattle. Bob Stokes' appointment is in the prestigious Institute for Marine Studies at the University of Washington.*

America's Future and the Sea

Peter W. Fong and Robert L. Stokes

Since the colonial times America has depended on the sea's resources, and been a world leader in devising ways to extract and use them. In the 18th and 19th centuries fishing, whaling and maritime commerce made the United States one of the world's principal seafaring nations.

In modern times United States industry has been a technological leader in developing ocean resources demanded by modern industrial society. Offshore oil technology was pioneered in the United States, making us the current leader worldwide and providing a growing resource to offset our declining onshore reserves. Although our coastal fisheries have lagged, the world tuna and shrimp fisheries were developed in large part by distant water fleets operating out of California and Gulf Coast ports.

The future promises further growth in America's dependence on the sea and technological leadership in expanding old uses and developing new ones. Recent legislation bringing fisheries within 200 miles of our coast under a unified system of conservation and management will insure that the biological productivity of these stocks is protected or restored to its full potential. These replenished stocks will become an increasingly important food resource and the basis for revitalization of the U.S. coastal fishery.

The technological capabilities for offshore oil production have been expanded from a few hundred feet of water depth in relatively mild climates to include operating on the edges of the continental shelf and under the harsh weather conditions of subpolar regions. Also, with U.S. leadership, the world has developed the capability to obtain several metals from manganese nodule "mines" on the deep seabed.

Marine resources are becoming increasingly important to all industries and regions. At the same time many of them are becoming less clearly identifiable as they move into normal commerce. Energy and metals are all-pervasive elements of modern life. Also much recent expansion in fisheries production has been "industrial fish," fish which, although not now acceptable for human use, can be reduced to animal feed contributing to the human diet indirectly and invisibly as chicken, pork and other meat products.

Living Marine Resources

Current United States consumption of edible fishery products is 11 to 12 pounds per person per year. Total quantity consumed will increase with population and income. By far the largest portion of edible fish is consumed in frozen breaded form. Frozen breaded fishery products consist of controlled amounts of fish or shellfish covered with a uniform coating of batter and breading material. These items are available in the raw state, or they may be pre-cooked for easier preparation by the consumer. Breaded fishery products have met with a high degree of consumer acceptance because of their convenience. To the housewife, they permit a varied menu with a minimum preparation. To the restaurant and institutional buyer, they provide uniform servings of consistent quality with exact cost control. In addition, these items provide year-round availability, greater speed of serving, lower labor costs and less storage space.

Many different breaded fishery products are on the market and new ones are being added constantly. The following are the more common breaded fishery products provided in the United States:

Fish sticks
Steaks, portions, fillets (e.g. cod, flounder, haddock, ocean perch, sea trout, yellow perch)
Shellfish: shrimp, clams, oysters, scallops
Others: smelt, marlin, fish cakes, fish dinners

The most important of these are breaded shrimp, breaded fish sticks, and fish portions. The use of these products has been increasing steadily. Growth in demand has been so great that processors are increasingly forced to rely on imported fish to meet their requirements. This is especially true in the fish stick portion industry, where nearly the entire U.S. production depends on imported fish blocks and slabs.

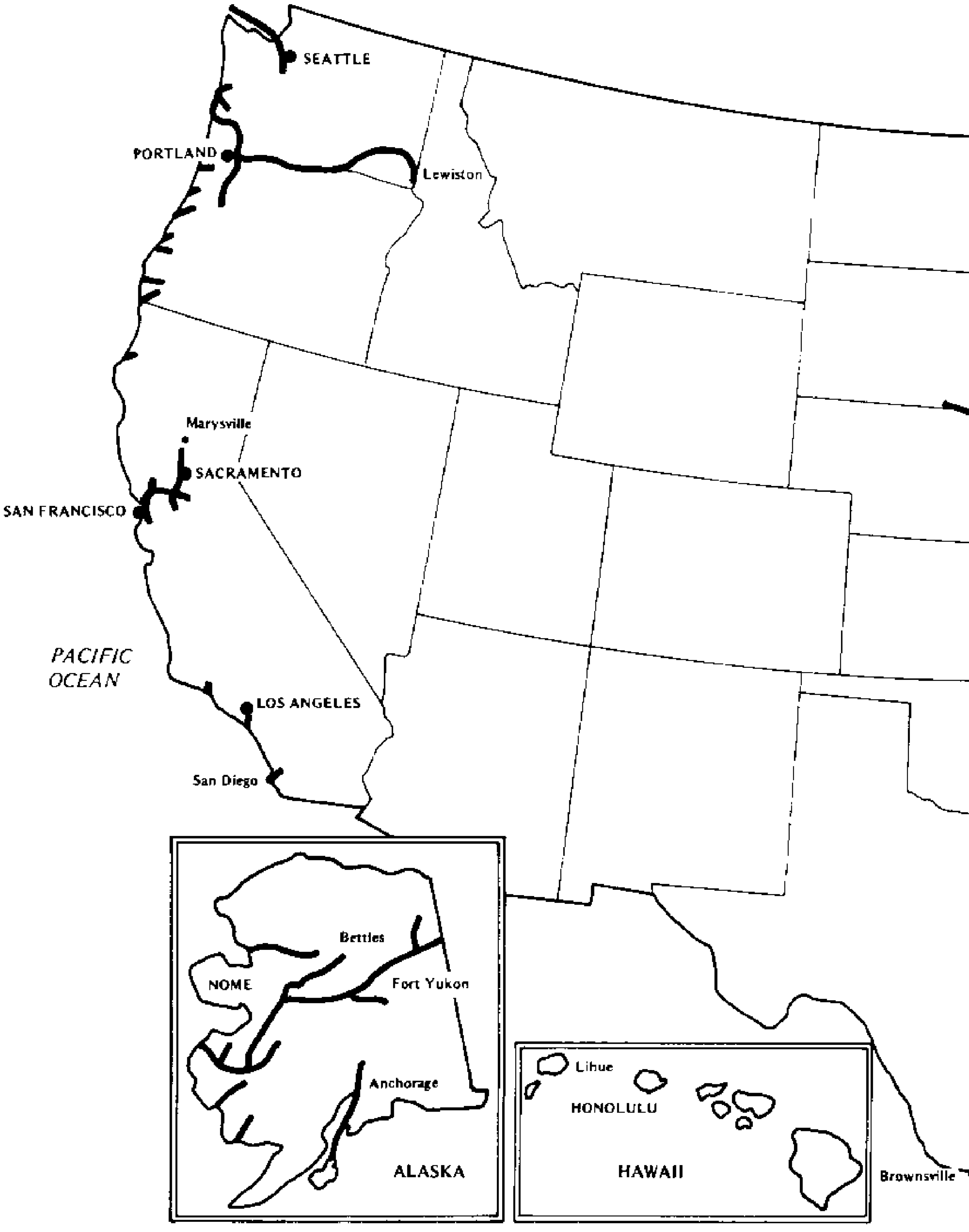
By far the largest volume of fish consumption in the United States occurs indirectly through the use of fishmeal in poultry and livestock feed. More than 55% of the fish caught off our coasts by U. S. fishermen is consumed by animals in a variety of forms.

Poultry producers have found that fish meals and solubles possess a high nutritive value that cannot be obtained from other foods, so fish meal is incorporated in starter, growing-finishing, and breeding diets of chicken and turkey poults. Chickens and turkeys use about 85% of all the fish meal available in the United States. Fish meal and solubles are especially valuable in pigs' starter diets (they are fed to 2-8-week-old pigs). The use of fish meals for pigs is about 5-10% of the total amount of fish meals available in the United States.

Fishery products are essential raw materials for the pet food industry. Canned cat foods may contain from 25%-100% fish. Pet birds are also fed fish-based feeds, usually manufactured from crab or shrimp waste.

Since fish have high protein and fat levels, they are practically indispensible ingredients in the diet of cultured fur-bearing animals, especially mink. Fish comprise 40-70% of the diet of these animals.

For humans, seafood has an amazingly high nutritional value. Seafood was one of man's earliest diets. Archaeological digs at the settlements of early man often reveal evidence of fish and shellfish consumption. Piles of mussel, clam and oyster shells frequently are found near riverside and seaside campsites of early American Indians. Today with the increasing knowledge of human nutrition and its relationship to cardiovascular diseases, seafoods are being recognized as a nutritionally desirable as well as flavorful source of protein. Protein from most fish species contains fewer calories and less fat and oil than the majority of meats. While the diet of most Americans includes both meat and fish, some Eskimos and northern Indians stay healthy and vigorous on a diet composed mainly of fish.

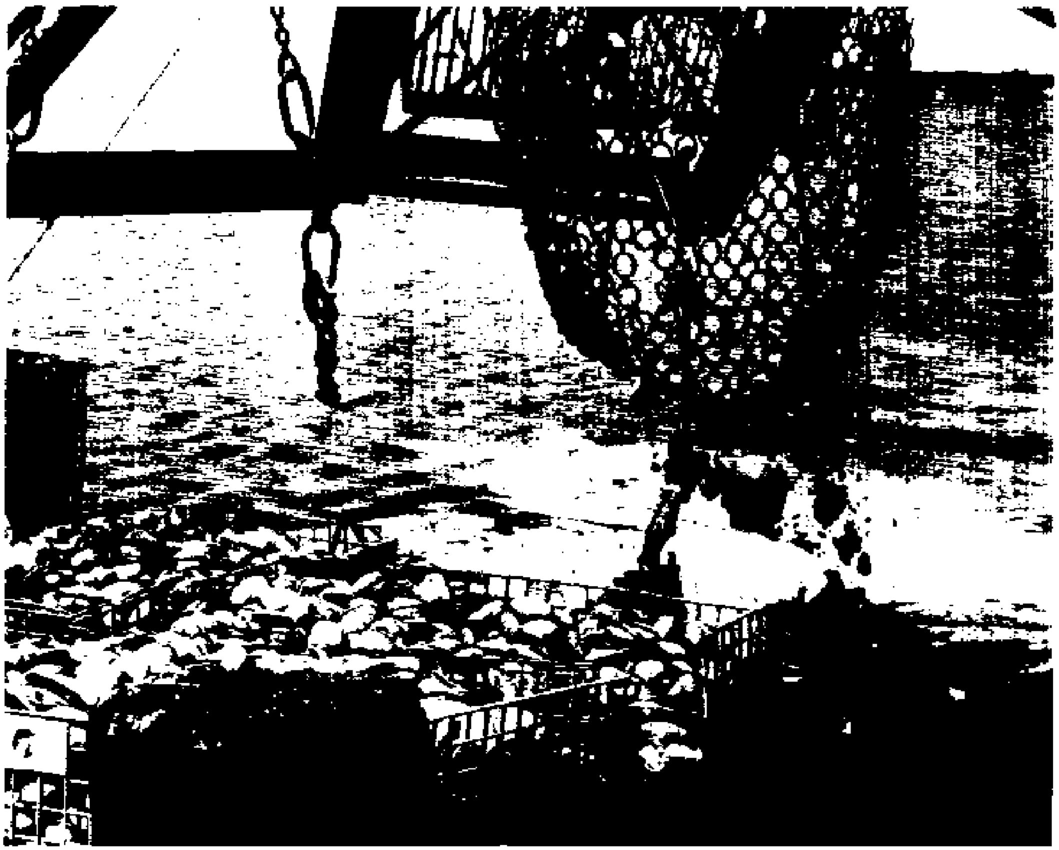

SEATTLE
PORTLAND
Lewiston
Marysville
SACRAMENTO
SAN FRANCISCO
PACIFIC
OCEAN
LOS ANGELES
San Diego
Bettles
NOME
Fort Yukon
Anchorage
ALASKA
Lihue
HONOLULU
HAWAII
Brownsville

WATERWAYS OF THE UNITED STATES

Eight amino acids are considered essential to human health: tryptohan, phenylalanine, lysine, threonine, valine, methionine, leucine and isoleucine. Seafoods contain adequate amounts of each and are especially good sources for lysine, threonine, valine, leucine and isoleucine. Amino acid availability varies with certain protein foods. Connective tissues may tie up the muscle fibers and prevent easy digestion. In general, marine organisms contain much less connective tissue and therefore are more easily digested. Typically 90-95% of fish protein is digested as compared with 87-90% of beef.

Fish oil contains more polyunsaturated oil than liquid vegetable oils. Polyunsaturated oils are important for avoiding arteriosclerosis. Studies have shown that a diet high in fish results in a lower rate of coronary attacks among middle-aged males, and significant reductions in obesity and high blood pressure have also been noted.

Seafoods have a high content of certain essential minerals. The ash content of fish



Commercial harvesting of clams

flesh includes sodium, potassium, calcium, phosphorous, zinc, sulfur, and chlorine and, in lesser abundance, iron, manganese, magnesium, iodine, copper, molybdenum, cobalt, selenium, fluorine, arsenic, and lead. Iodine and fluorine are essential to human health; lack of iodine in the diet produces a compensatory hypertrophy of the thyroid gland known as goiter, and oysters and other shellfish are recognized as a good source of available iodine. Fish are an excellent source of fluorine, important to prevent tooth decay.

Marine plants — seaweeds — are, for the most part, algae, whose principal use in the United States at present is in production of the marine colloids, or gelling compounds, carrageenin and alginate. They are complex polysaccharides whose fractions have different gelling or smoothing characteristics. By selecting the proper carrageenin fraction, for instance, the food chemist can produce any effect from a slight thickening and smoothing to a gel that has the consistency of rubber.

It is very difficult for an American to get through a day without coming into contact with a product made with the help of a seaweed colloid. At minimum, one may go to work or the store in a private car or on the bus, riding on rubber tires that were removed easily from their moulds with the help of an alginate. The number of uses of marine colloids is, in fact, limited by the world supply of the proper seaweeds. Even so, several hundred uses exist.

- **Bakery items**
  bread doughs, cake batters, fruit cakes, marshmallows, fruit and creme fillings, sugar glazes, icings, meringues, yeast-raised doughnuts

Seaweeds are studied and tested for their colloidal content

- **Packaged desserts**
  milk puddings (cooked and instant), pie fillings, water gels, dietetic products
- **Dairy products**
  ice cream, chocolate and other flavored milks (hot and cold processed to provide body and suspend the cocoa), variegating syrups, egg nog mixes (to stabilize the mixing compound), cottage cheese, cheese spread, sherbets, ices
- **Fountain confections**
  fruit toppings, syrups, flavoring emulsions, milk shakes, whipped cream
- **Meat, poultry, fish**
  jellied packed, e. g. canned ham, jellied coatings, batter mixes, antioxidant coatings, sausages of all kinds
- **Condiments**
  relishes, spaghetti sauces, mustards, salad dressings
- **Miscellaneous items**
  beer refining and other alcoholic drinks, infant feeding formulae, soup (canned), fruit juices, soft drinks, candy bars and candies, toothpaste, iodine, medicinal and lubricating jellies, tablet binders, emulsion and suspension in both medicinal and cosmetics, blood anticoagulants, culture media in medical labs, liquid shampoos, dental impression compounds, ulcer therapy, pharmaceutical suspensions
- **Industrial applications**
  alyinic acids, leather finishing, ceramics, water-based paints, wax emulsions, paper industry as a surface coating to control wax, oil and ink onto the paper stock, liquid fertilizers, vitamins in animal feeds, graphite abrasive or pigment suspensions, electroplatings, hectrograph compositions, rubber latexes, textile industry as a thickener for dyes and printing paste in fabric printing

Minerals

Annually, the rivers of the world dump hundreds of millions of tons of sediment into the sea. Most of this sediment settles in near-shore areas. In some cases this results in the formation of valuable mineral deposits, in marine beaches, on the surface of continental shelves, and in sea floor rocks. Some minerals also go into solution in the seawater itself. Marine beaches are mined for diamonds, gold, magnetite, columbite, ilmenite, zircon, scheelite, monazite, platinum and silica.

Magnetite is an important source of iron ore.

Columbite is a source of niobium; used in steel alloys, arc welding and superconductivity research, and tantalum; used to make electric-light-bulb filaments, electrolytic capacitors, lightning arresters, nuclear reactor parts, and some surgical instruments.

Ilmenite is a source of titanium used to alloy aircraft metals for low weight, strength, and high temperature stability.

Zircon is an important source of zirconium used in ceramics and refractory compounds, as an alloying agent, in nuclear reactors, and in medical prostheses.

Scheelite, a variously colored natural form of calcium tungstate, is used as a source of tungsten which has the highest melting point and lowest vapor pressure of any metal. Tungsten and its alloys are used in high temperature structural materials, electrical elements, most notably lamp filaments, and instruments requiring thermally compatible glass-to-metal seals.

Monazite is a reddish-brown mineral phosphate consisting of several rare-earth metals, chiefly cerium. Cerium is used in making lighter flints as well as various metallurgical and nuclear applications. It also contains lanthanum, used in glass manufacture and, with other rare-earths, in carbon lights for motion-picture and television studio lighting.

Silica, a white crystalline compound occurring abundantly as quartz, sand, flint, and agate, is used to manufacture a wide variety of materials, notably glass and concrete.

Platinum is used in electrical components, jewelry, dentistry, electroplating, and as an important catalyst in industrial uses.

Though onshore beaches have been mined for many years in some areas of the world, they provide limited opportunities in the United States because of recreational use and aesthetic value. In offshore areas, however, there are beaches that contain valuable minerals. During the Ice Ages, the sea level was appreciably lowered as ocean water was transferred to the continental glaciers. Because of the cyclic nature of the Ice Ages and the intervening warm periods, a series of beaches was formed which are now submerged. With sonic devices, it is possible to locate and delineate these submerged beaches. Because beach deposits tend to contain abnormally rich mineral paystreaks, they are very profitable to mine where accessible.

Seawater has all the natural elements in solution. Chlorine, produced principally by electrolysis of sodium chloride, is used widely to purify water and as a disinfectant, a bleaching agent and also in the manufacture of many important compounds including chloroform and carbon tetrachloride.

Magnesium is used in structural alloys, pyrotechnics, flash photography, incendiary bombs, and the manufacture of steel.

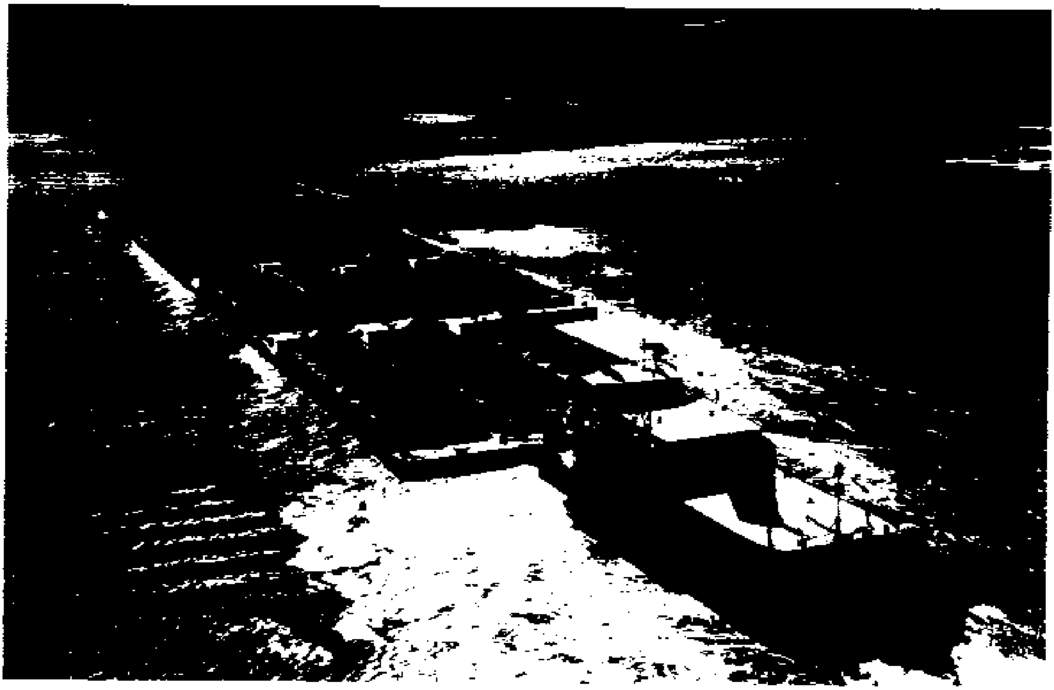
Bromine is used in producing gasoline antiknock mixtures, fumigants, dyes and photographic chemicals.

The distribution of trace metals in seawater is quite uneven. Once found, high concentrations of trace metals may be economically extractable by presently available technology. The cost of locating such "high-grade" bodies of water within the ocean has, however, precluded exploitation.

The continental shelves of the world cover an area equal to 20% of the land area of the earth. Because the rocks of the continental shelves are similar to those on land, they can be expected to have similar mineral potential. Because of their cover of water, however, the continental shelves hold other types of mineral deposits formed from thousands of years of precipitation from seawater. Some of these are exploitable with present day techniques. For example, calcareous shell deposits are a source of calcium and calcium carbonate used in a variety of manufactured products including commercial chalk, medicines and dentifrices. These shells are mined from offshore deposits in the Gulf of Mexico and off the coast of Hawaii. The shell bearing animals are crushed by the waves leaving shell deposits on the continental shelves. The accumulation of shell material far exceeds current extraction. Thus, they are a renewable resource, unlike land based minerals, which are non-renewable.

Tin is used to coat other metals to prevent corrosion, and forms part of numerous alloys, such as soft solder, pewter, type metal and bronze. It is mined in many areas of the world from river placers extending to the present sealevel. These deposits often extend into offshore areas. Such offshore placer deposits, like offshore beach deposits, are now being located through use of seismic techniques. Offshore drilling is then used to delineate the ore locations. Drowned river valleys may also hold substantial placer deposits of gold and platinum off Alaska, of diamonds off the mouth of the Orange River in Southwest Africa, and of tin and titanium minerals off the coasts of Australia. In fact, any area of the world in which placer deposits are mined in river channels near the present coast may also contain placer deposits of like minerals in the offshore area.

Sand and gravel are the most prosaic of mineral commodities. However, from a ton-



Distant construction sites are serviced with materials transported through the inland waterways

nage standpoint, they are the most important hard mineral commodities mined in the world. All industrial societies need large quantities of these materials for the manufacture of concrete, for fill, and for many other purposes. Until recently, these materials were extracted from pits near the market. Opening new gravel pits near population centers is becoming increasingly difficult, due to environmental and other objections. Offshore areas generally have abundant sand and gravel deposits. Because much of the world's population is concentrated in the sea-coast areas, offshore gravel deposits will become an ever increasingly important source of this material.

Glauconite is another interesting mineral precipitated from the seawater. It is found in considerable quantity in various offshore locations. Containing from 4 to 9% potassium oxide, it is used as a source of potassium for agricultural fertilizers and as a water softener.

Phosphorite deposits are formed as the skeletons of marine organisms and precipitation from seawater settle to the sea floor. Thus, it is another renewable ocean mineral. Phosphorite contains calcium phosphate used in baking powder, as plant food, plastic stabilizer, in glass, ceramics and in rubber. It also contains phosphorous used in safety matches, pyrotechnics, incendiary shells, fertilizers, glass and steel. Thus far, phosphorite deposits have been found off Peru, Chile, Mexico, the West and East Coasts of the United States, off Argentina, South Africa, Japan and on the submerged parts of several islands around the Indian Ocean. Off California, the sea floor

Gravel is unloaded from barges into building contractor's trucks phosphorite occurs as nodules, which vary in shape from flat slabs, several feet across, to minute spheres.

Mining the deep seabed for manganese nodules promises to increase the ocean's mineral production, as Craven has noted. It is estimated that there are 1.5 trillion tons of manganese nodules on the Pacific Ocean floor alone, and that they are forming in the Pacific at an annual rate of about 10 million tons. Lying loose at the surface of the sea floor their concentration could be as high as 100,000 tons per square mile.

Various commercial groups in the U.S., Japan, and Europe have completed the exploration or prospecting phase and are now evaluating potential nodule mine sites. There is great interest in the Central Pacific region, which contains extensive concentrations of higher value nodules. Within this region some evidence suggests that nodules with the highest potential value are concentrated in a belt a few hundred miles off the coast of Hawaii.

Several national governments (but not the United States) are involved in nodule mining through subsidization of mining activities. They have funded research on exploration, offered tax relief, and made government facilities available for research. In some cases governments are contemplating direct participation in mining ventures. By most estimates, it appears that nodule mining will prove commercially profitable. The decision to begin production will depend on whether: (a) the firms are on safe legal grounds with security of investment and assurance of exclusive access to their chosen mine sites; and (b) that they have adequate financing for their ventures. Once the decision is made, it is assumed that commercial operations can commence within three to five years. Six groups are expected to be in operation by 1987.

Nickel production from nodules might amount to about one-fifth of our total demand by 1987. The most important uses of nickel are in the manufacture of stainless steel, alloys, and for electroplating. Nickel imparts certain properties to alloys, such as an increase in strength and resistance to corrosion, that cannot be economically obtained by other means. New steels and alloys are constantly being developed. Over 40% of nickel consumption is used in the manufacture of stainless steel, a market which has very good growth prospects. Nickel also has many other minor uses and its application is constantly increasing.

World copper output is currently about 14 times greater than nickel output so ocean mining is unlikely to be a significant element in copper production. Production of copper from manganese nodules may displace only 5.5% of our net import requirements by 1987.

Electrical conductivity and resistance to corrosion make copper invaluable in the manufacture of electrical equipment, cables and wires for communication and electrical transmission lines, electrical appliances, tubing and sheeting for the construction and chemical industries, alloys and in a number of other uses.

Manganese may or may not be recovered from nodules depending on technical and economic factors. If extracted it may be recovered from nodules in two forms, pure metal or ferromanganese. More than 90% of the manganese produced is consumed as ferromanganese in the manufacture of steel. Production from nodules may supply up to one-third of our total import requirements by 1987.

Cobalt is an expensive metal with a relatively small market. It is used in a variety of industrial products, both metallic and nonmetallic. The principal characteristic of the metal is its resistance to high temperatures, but it also possesses important magnetic and chemical properties, which make it particularly suited to a number of rapidly expanding advanced-technology industries. The motor vehicle industry uses cobalt in heat-resisting alloys for the manufacture of gas turbines, and as a catalyst in exhaust gas after-burners. As automobile pollution restrictions become more stringent the demands for cobalt will grow.

All in all, the nodule industry is expected to become an important source of minerals by 1987, with its long term prospects tied closely to nickel and copper. By that time, nodules will be a significant source of nickel, cobalt and, if extracted, manganese. On a percentage basis the contribution to copper production will be small.

Petroleum and Natural Gas

The world-wide energy crisis, brought to a critical point by the 1973-74 cutback in Middle East oil production, is a long-term problem that has been building for years and that will be with us for many years to come. Offshore oil is already a major factor in today's energy supply.

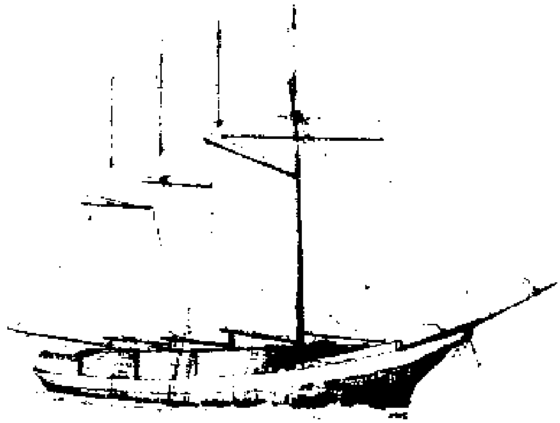
Limited world petroleum resources mean that oil and gas production cannot rise indefinitely to meet growing demand. Major steps must be taken to conserve energy and develop other fuels. Nevertheless, development of remaining oil and gas reserves where they do exist will contribute to the solution of short- and long-term energy problems.

Reserves on the United States Outer Continental Shelf (OCS) are estimated to be 186 billion barrels of oil and 844 trillion cubic feet of gas recoverable under present technology. These reserves are found along the Atlantic, Gulf, Pacific and Alaskan coastlines. Only the Gulf Coast and California have been extensively developed. The East Coast Outer Continental Shelf alone is estimated to hold 58 billion barrels of oil and 222 trillion cubic feet of gas. Another highly productive area is the Gulf of Alaska. According to one estimate the eastern portion of the Gulf "could contain from 7-20 billion barrels of oil."

Perhaps the largest U.S. offshore reserve is the shallow water off the North Slope of Alaska in the Arctic Ocean. The Arctic Institute of North America estimates that North Slope Reserves, including offshore to a depth of 30 feet, hold 43 billion barrels of oil and 200 trillion cubic feet of gas. Reserves beyond 30 feet of water are estimated to contain an additional 33 billion barrels of oil and 150 trillion cubic feet of gas. The Arctic Ice Pack and hostile arctic environment are very real constraints to petroleum development. Arctic petroleum engineers have concluded, however, that while costly, technology is available to deal with the arctic environment.

Only two percent of the available offshore lands have been leased for drilling, almost all in the Gulf Coast and off California. It is not likely that offshore oil development will ever make the United States self-sufficient. Once its extraction is proved to be environmentally as well as economically sound, however, it could significantly reduce reliance on foreign imports. Expanded federal offshore leasing and Arctic offshore development combined could supply 15-30% of projected requirements by the early 1980's and decrease imports by that amount. Because a period of 5-7 years is required to develop and bring new fields on stream, they will not begin to have an impact on petroleum supply until the end of this decade.

In summary, the ocean provides an enormous variety of products necessary for modern life. The success with which the United States uses its technological leadership to improve these products and make them more readily and inexpensively available involves the well-being of all Americans.



6. American Society and the Uses of the Sea

Pessimists, viewing traffic congestion, have predicted dourly that some day a monumental highway jam will take place covering hundreds of miles of superhighway, and that it will be so bad that people will just get out and abandon their cars forever. Should that happen before the petroleum crunch drives many cars from the roads, it will undoubtedly be on a Sunday as people all try to go home at once from the sea and lake shores.

One of the great phenomena of our time is the increase in aquatic recreation which has taken place so gradually that it is most noticeable by the clogged highways and waterways during weekends and vacation times. There are many causes: more leisure time, more disposable income, the fact that aquatic recreation can be as simple and inexpensive as swimming or fishing from a pier or as expensive as anyone cares to make it. Above all, there is the attraction of water.

We mention aquatic recreation because it is a highly visible and useful manifestation of the social value of the world of water. To be sure, there are economic values, too; next to offshore petroleum and gas in economic impact is the recreation business, according to some estimates, with fisheries third. The phenomenon of water recreation has created such oddities as Arizona, a state with severe water problems but also with one of the highest rates of pleasure boat ownership in the land; and beaches crowded past belief with scarcely a square yard of sand unoccupied and the salt smell of the seashore completely lost in a miasmic haze of sun-tan lotion effluvia. Of course crowded beaches in some places are not new. Some years ago John Steinbeck characterized Coney Island as a place *"where the surf is one-third water and two-thirds people."* The difference today is that once-remote beaches are now becoming equally crowded. The estimate is that more than 150 million Americans will seek aquatic recreation by century's end, and this figure may be conservative.

About Gerard J. Mangone

There are many more social implications to the uses and resources of the sea than recreation, and among the small handful of scholars who have studied the implications, **Dr. Gerard J. Mangone** *is a recognized leader. He is the H. Rodney Sharp Professor of International Law and Organization, and Director of the Center for the Study of Marine Policy in the College of Marine Studies at the University of Delaware. Gerard Mangone's studies and writings have provided a significant amount of the background against which marine policy is developed. He is author, co-author, or editor of some 20 books on international relations, including The Idea and Practice of World Government, A Short History of International Organization, The Elements of International Law, and Energy Policies of the World. His latest, now in press, is: The United States At Sea: Ocean Policy For America.*

American Society and the Uses of the Sea

*Gerard J. Mangone**

When the United States of America was proclaimed in 1776 as free and independent of Great Britain, the largest city of the thirteen states was Philadelphia – with a population of 34,000. New York came second with 22,000 and bold Boston had a mere 16,000 inhabitants. All the cities of America were busy seaports, like Charleston and Baltimore, for the struggling young nation clung fiercely to the coast, looking eagerly out upon the broad Atlantic that had first borne its founders to the New World and now provided sustenance in fish, prosperity in trade, and protection from the powerful nations of Europe.

The American people have always been a maritime nation. In the nineteenth century the sailing vessels of the United States were the finest in the world, beautifully designed and more swift than any other merchant marine. Yankee vessels made record trips to Europe and south around Cape Horn to the expanses of the Pacific. Fish and lumber, cotton and tobacco went by sea to purchase the manufactures of Europe; furs went to China for tea, textiles, and pottery; the whalers scoured the Antarctic and the South Seas to bring home the bone and meat and especially the oil, which lighted almost all the lamps in the United States until the middle of the century.

In 1818, for example, Gloucester, the leading fishing center of New England, inspected about 2,000 barrels of mackerel a year; by 1864 that figure had soared to more than 154,000 barrels. Before the Civil War, the cod and mackerel industry alone in Massachusetts and Maine were worth more than three and one-half million dollars, engaging more than 200,000 tons of shipping. The whaling trade, moreover, involved more than 650 ships along the Atlantic seaboard. The New Bedford of Herman Melville had a fleet of 329 ships for whaling in 1854, employing some 10,000 seamen. Over a million and a-half pounds of whalebone and some 700 thousand gallons of sperm oil were being exported annually in addition to the much larger domestic consumption of whale products in America.

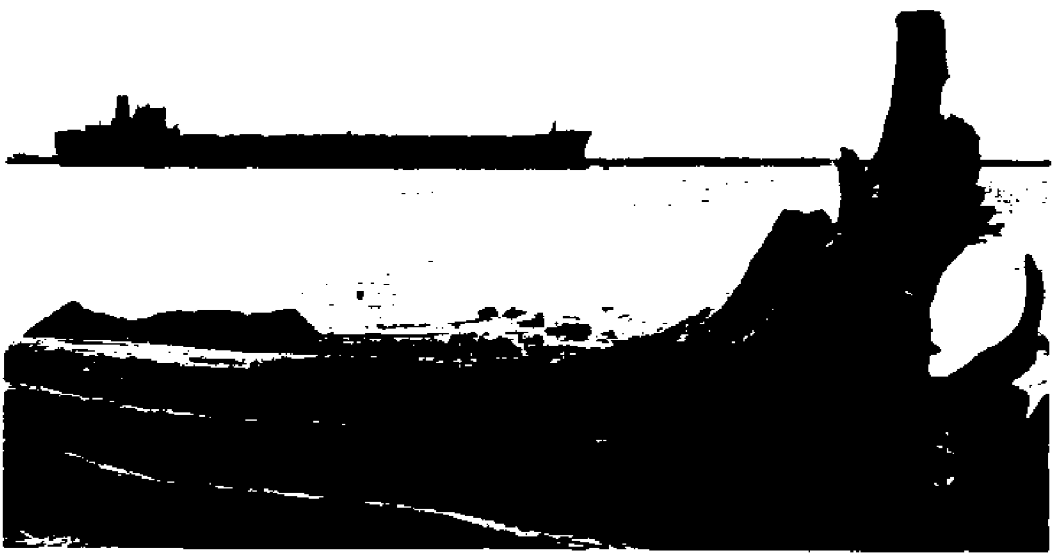
By the 1850's, moreover, the United States led the world in marine architecture, in shipyards, and in seamanship. The total tonnage of Great Britain's merchant fleet was slightly larger, but there was little comparison with the speed, management, and profitability of the American vessels. Just before the outbreak of the Civil War, more than two and one-quarter million tons of cargo were carried by vessels flying the American flag. This was equal to about two-thirds of all the ocean commerce of the United States and worth about $700 million, a phenomenal figure at that time. And the United States was first in scheduling passage for travellers by sea, for in 1817 five American businessmen first offered trans-Atlantic crossings to the public between New York and Liverpool at regular departure dates. By 1855 there were 56 American ocean liners, with no foreign country even close to competition.

The Civil War, among other things, crushed the South's agricultural economy and slave-based social hierarchy, stimulated invention and technology, and moved millions of young people about America. The cruel conflict, worst of all wars between Napoleon in 1814 and the German Kaiser in 1914, shattered home manufactures and village habits, and encouraged large-scale industry. Above all it brought forth a large and united country under a single government with a vast western frontier waiting to be explored and exploited in an era of peace. The United States turned inward, never abandoning the sea, but directing its resources to master the mighty rivers and plains and mountains that stretched between the Atlantic and Pacific oceans.

From the end of the Civil War to the last decade of the nineteenth century, the U.S. Navy declined to a minor coastal defense force. Year by year, the bold farm boys from the rocky farms of New England and other coastal states who found adventure and reward in going to sea, either moved into the new infant industries of the towns or pushed westward where mining, herding, or cheap farm land attracted their robust energies. While the importance of fishing to the Atlantic communities declined, the Gulf and the Pacific regions rapidly increased their catch, with oysters and salmon accounting for about half of all the money value of fish by the beginning of the twentieth century. And the great merchant marine of the United States, so dependent upon profitable ocean trade, slowly withered in the face of scarce labor technological innovation, and the competition from other maritime nations whose governments encouraged and supported ocean shipping. Because its sailing ships had been so marvelous, the United States was slow in accepting steam-powered navigation and as late as 1899 almost half of the vessels in the merchant marine still depended upon sails for propulsion.

The turning of America to the exploitation of its rich agricultural mid-west and its unlimited treasure in the mountains of coal for industry was a time of fabulous growth. Immigrants streamed across the seas from Europe to land in New York and fanned out to the multitude of farms or were absorbed into the labor-hungry cities. Overland bv wagon and train, or by seas around South America or across the steamy isthmus of Panama before the Canal was built, Americans found their way to California, Oregon, and Washington. From 1860 to 1890

Land resources go to sea . . . an ore carrier heads out



the population of the United States doubled from 31 million to 62 million; from 1860 to 1910 it almost tripled to 92 million, making it one of the great states of the world. By the end of the nineteenth century America was already leading the world in the production of many agricultural commodities and some minerals.

The expansive economy of America within its frontiers, consolidated by peace and industry, once again turned the United States toward the sea. By the administration of Theodore Roosevelt the United States was self-conscious of its power, eager to sell its product to foreign markets and protect not only its own shores but outlying regions. The opening of China to European and American trade early in the nineteenth century, followed by the dispatch of Commodore Matthew Perry with four warships to the Pacific in 1852 and his subsequent "opening" of Japan, as well as his securing of some distant islands and a coaling station on Okinawa, had first involved the naval interest in areas far beyond American shores and traditional sea lanes. With its further interest in Samoa later in the century as well as its determination not to let Hawaii fall into the hands of Great Britain or Germany, the United States was compelled to increase its sea-going fleet.

Beginning in 1885 under new naval construction the warships of the United States quickly increased in number, size, and firepower, so that by the time of the Spanish-American War the Navy, though not in the same class as the mighty British fleet, was modern and formidable among the world naval powers. And it was the sea that saved the victory of the Allied Powers in World War I, for the chief mission of the U. S. Navy was to convoy men and supplies to Europe. More than two million American soldiers were transported to Europe and more than six million tons of supplies were shipped to France alone, enough to make the difference between victory and defeat.

During World War I the United States also embarked on a great ship-building program. As late as 1917 there had only been 61 shipyards, of which 24 were used for the construction of wooden ships. But by 1918 there were 341 shipyards with 1,284 launching ways – and in that fiscal year the production of vessels quadrupled the production of 1915. By mid-1918, after seizing a half-million tons of German shipping and some neutral Dutch merchant tonnage, the United States had almost ten million tons of merchant shipping under its flag. Nevertheless, in the post-war years the merchant marine again began to decline as the high costs of American labor and the attractions of capital to more profitable investments in industry discouraged the continuous building of a modern fleet. In the 1930s the Great World Depression collapsed international trade and few incentives existed to rehabilitate the American merchant marine.

Similarly, in the area of fishing, the United States turned more and more to the processing of fish rather than the capture of fish from the open seas. While cod, mackerel, or flounder continued to be harvested, the tastes of an increasingly rich and urbanized nation were changing. From primitive salting the fishing industry had moved into canning. This gave a tremendous impetus, first to the consumption of salmon and then to tuna, which only became a valuable species in the 1920s. Oysters remained a much wanted delicacy, followed by shrimp, clams, lobsters, and other shell fish, with good regional catches, but hardly requiring the fish fleets of the past. Again as the costs of labor increased and as most fishermen remained fixed in their family trade, unwilling or unable to make large investments for technological improvements to improve efficiency, the competition in the harvesting of fish by the British, Scandinavians, Germans, Spanish, or Portuguese in the Atlantic and the Japanese in the Pacific increased. By the twentieth century the United States had virtually abandoned whaling, the last searches for Leviathan sailing out of San Francisco Bay, and a final effort to get Americans to eat whale meat during the stringencies of World War I ended in complete failure.

The 1930s were the years of American isolation from the dread that stalked Europe and Asia. Huddled behind enormous moats of the Atlantic and Pacific oceans, worn and worried by economic depression with mass unemployment at home, the United States watched the rise of Germany under the Nazis and the faltering resistance of the democracies to the expansion of the Third Reich in Europe. Simultaneously, Mussolini's Italy brutally annexed Ethiopia while, on the other side of the world, Japan in 1931 raped Manchuria and embarked upon the conquest of China. At sea the United States had neither the forces nor the will to intervene in any way with the malevolent ambitions of the dictators. Indeed, from 1935 to 1937 the neutrality legislation of the United States forbade Americans from sending any arms, ammunitions, or implements of war to any belligerent; prohibited Americans from sailing under a belligerent's flag; and made illegal the arming of American merchant vessels that traded with a belligerent.

In this sweeping legislation the United States abandoned with the pen all the rights for which it had fought so passionately in 1812 and in 1917 under the doctrine of "freedom of the seas." And the net result, if the legislation had finally not been abrogated, was to cut off the resistance of the friends of America to the aggressive dictatorships whose war machines were fully oiled and prepared to attack.

President Franklin D. Roosevelt finally brought the nation to perceive its danger — and its utter unpreparedness at sea. Some new cruiser construction had been authorized in 1933 and 1934, but the forces of the Navy never came close to the limits permitted under international disarmament conferences. The manpower of the Navy averaged about 100,000 during these grim years. And the plight of the merchant marine had become desperate. Slowly naval appropriations climbed and in 1938 Congress responded at last to the President's warning by authorizing a 20% increase in naval tonnage. Two years before, the Merchant Marine Act had boldly faced the need for government subsidies to revive American shipbuilding and carriage of cargo. Yet the United States could not become a mighty seapower overnight.

When France crumbled and Britain shuddered under the impact of German war might in 1940, the United States was ill-prepared to implement a strategy of dominating two oceans, the Atlantic and the Pacific, for its own protection and for the supply of its Allies. Frenzied shipbuilding and airplane construction, safely mobilized behind the frontiers of the two great seas that protected America, finally enable Washington to overcome the surprise destruction of five battleships in Hawaii and the debilitating attacks by German submarines upon vital oil tankers in the western Atlantic.

Month by month the United States grew stronger at sea, welding a lifeline of ships to Europe that enabled the transport of men and supplies, which eventually overwhelmed Italy and Germany. And it was seapower, with naval aircraft, the greatest seapower ever marshalled by one country, that finally swept the Japanese back across the vast regions of the Pacific that they had occupied, back to utter defeat — with or without the detonation of the first atomic bomb.

With the European powers exhausted by World War II and Japan both crushed and occupied by Americans, the United States emerged as the most powerful country in the world with a superb naval force of more than three million men. Immediately the American people began to question whether they needed a navy at all! The dramatic raids of land-based bombing planes and their frightful devastation of the enemy cities in the closing years of the conflict had impelled short-sighted planners to rely upon the terror of "strategic bombing" as the cheap and irresistible defense for America. But Korea ended that fantasy, for the bitter war was beginning in 1950, and costing the United States 150,000 casualties, demonstrated that atomic bombs and massive air raids were not the answer to strife in a distant, underdeveloped country receiving aid from a potent ally; that it was still necessary to transport armies and supplies by sea; that both shells and planes could be hurled with effect from the safety of strong carriers hovering off a coast; and that interdiction of an enemy's ocean trade could break resistance. Just twenty years later the same lessons were taught in Vietnam.

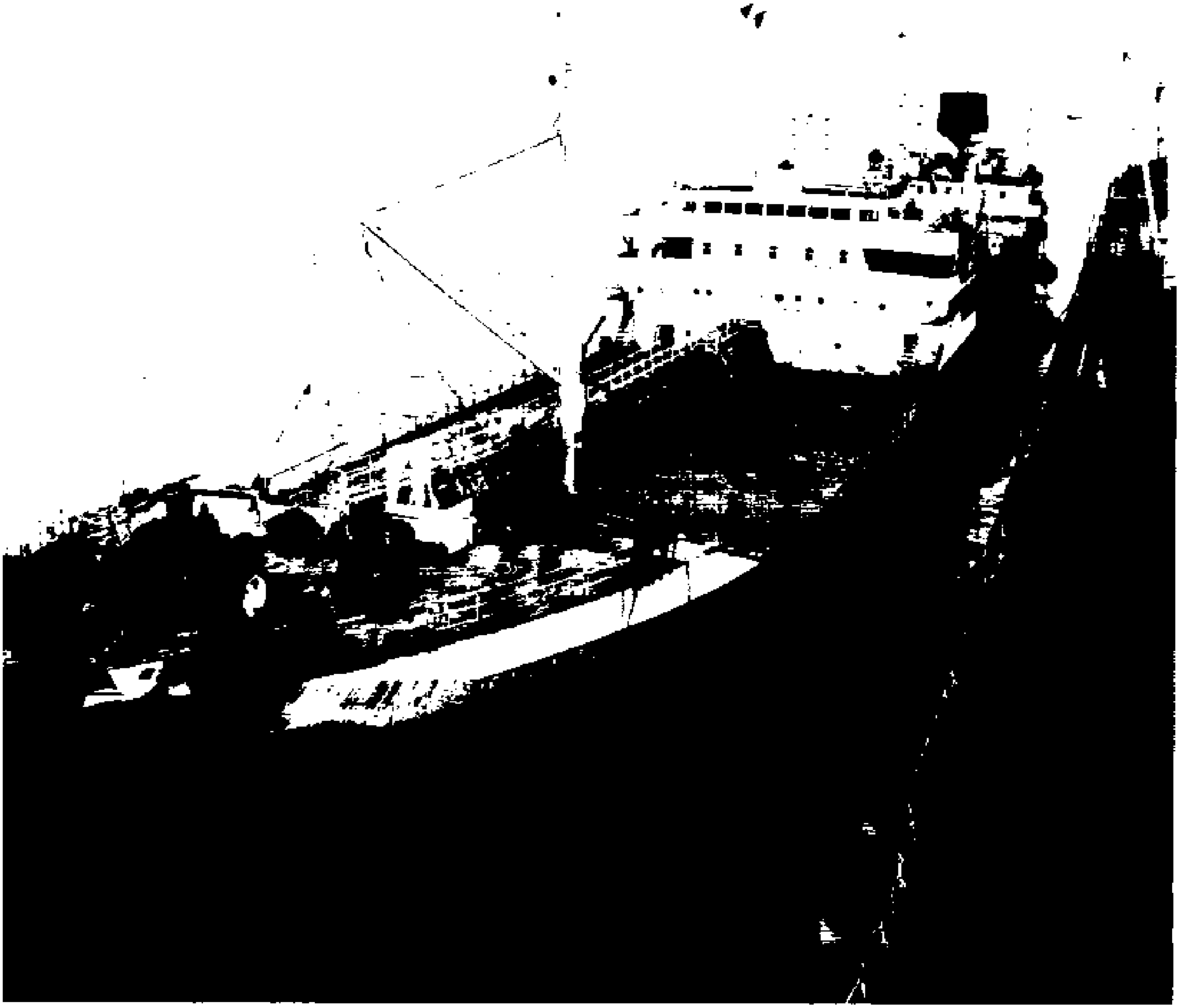
The most dramatic change of the twentieth century for warfare was the invention of the atomic bomb coupled with incredible powers of propulsion to send missiles across thousands of miles of space. With such weapons the task for the United States has been to ensure the "hardness" of their launching sites so that under all conditions some missiles would survive an initial attack. While land-based missiles and missiles placed in airplanes first seemed to guarantee security against the ever-mounting military capability of the Soviet Union in the 1950s and 1960s, it was — and is — the sea that mainly affords the world and the American people a balance of terror and therefore military restraint between the world's two superpowers.

The first nuclear powered submarine of the United States was launched on 21 January 1954, opening an entirely new era of naval warfare. Two years later the first guided missile cruiser joined the fleet. Surface to air, air to air, and air to surface missiles became part of the Navy arsenal. At the time the Navy was given responsibility for developing a submarine ballistic missile system. In 1960 two POLARIS missiles were successfully launched by the submerged *George Washington*. Henceforth the United States was able to depend upon a fleet of submarines, silently ranging through the deep, dense, waters girded and alert to a signal from Washington to launch its deadly missiles in the event of an attack upon America. And because detection of these submarines in the vast reaches of the ocean is so difficult, their invincibility to any first strike by the enemy seemed assured.

The Soviet Union, of course, was not far behind in its armada of submarines capable of launching ballistic missiles. In fact, by the early 1970s the Soviet Union had the largest fleet in the world of surface and submarine vessels as well as a merchant marine that quadrupled its numbers between 1945 and 1968. Thus, the ultimate security of the American people and world peace rested upon a mutual recognition by Moscow and Washington that both would retain retaliatory nuclear forces hidden in the seas even if their major cities should be devastated by a first nuclear strike by the other. Again it is the oceans, by their depth and space and medium for obscure, submerged vessels that provide protection for the heartland of the United States.

The struggle for strategic supremacy is unending. From POLARIS/POSEIDON missiles with ranges up to 2,500 miles, the Navy has planned TRIDENT missiles with ranges up to 4,000, enabling the submarines to cruise far from the shores of their targets in even greater security from attack. Moreover, surface combat ships have not been neglected by either of the two superpowers.

At the beginning of 1977, the U.S. Navy had more than 100 new ships either under construction or authorized by Congress. Since 1975, moreover, all new major combatant ships must be nuclear-powered. The costs of new submarines, aircraft carriers, and task-force escorts, therefore, has risen enormously, raising doubts about the national strategies that call for certain types of vessels, such as aircraft carriers and nuclear strike cruisers, and sending qualms of conscience through legislators who must be concerned



Preparation for oil transfer from giant tanker

with domestic issues like unemployment, health, education, and rising tax burdens. In three years from 1974 to 1976 Congress authorized more than eight billion dollars for new ship construction alone, and for 1977 the President asked for a total of 41 billion of new money for the Navy in the Defense Department budget of $110 billion. The United States has never before made such a peacetime commitment to the sea for defense, although the country has always relied upon the oceans to separate itself from aggressors.

While nuclear power, with its exorbitant costs, may be required for the life or death issues of national defense, oil and gas, as every American knows, are still the key energy fuels for industry, commerce, transport, and household amenities. The connection between petroleum and the oceans noted in previous chapters is a recent phenomenon, linking the American people to the seas. In 1930 a leading American business magazine heralded the wealth of the seas and the opportunities for business in exploiting marine resources. The article mentioned sand, gravel, phosphates, magnesium, bromium, algae, and, of course, both finfish and shellfish. But there was not a single word about petroleum. Yet petroleum – liquid and gaseous – located under the seabed have been the greatest bonanza for the American economy to come through the oceans.

During the four years of World War II the United States consumed as much petroleum as it had consumed during all the years from the first drilling for oil in 1859 to 1941. And the economy of the American people had been totally transformed by the steady shift from coal to oil and gas for fuel, not only for power, heat, and light, but for transportation too. In fact, the automobile, key to American prosperity and culture, was totally dependent upon oil. At the rate of consumption reached in 1945 only fifteen years of proven reserves were indicated for the gross appetite of the American people for petroleum products, so that the United States had to seek new reservoirs lying beyond its shores, yet under its control. For that reason President Harry S. Truman in 1945 proclaimed that the resources of the continental shelf, that is, the seabed adjacent to the coast that has the same geological attributes as the continent itself, but it lies underwater, belonged to the United States.

Anxious to free itself from any great reliance on the exporting nations, particularly in Latin America and the Middle East where volatile politics might be added to ever-higher prices, American leaders in government have sought to expand offshore production, so much so that by the mid-1970s about 13% of United States crude oil and about 17% of domestic natural gas production was streaming from wells drilled into the ocean's bottom. Not all Americans were or are enthusiastic about this development. Some fear that new drilling into Alaska or off the Atlantic seaboard would have dire environmental consequences for the sea, its marine life, and the land-side communities affected by a noxious industry. Thus a political dilemma is posed, offering a difficult choice between abundant energy for a demanding economy upon which many jobs and much comfort depend, or an environmentally-restricted development, more costly in economic terms, at least in the short run, yet more satisfying in its humane and esthetic goals.

In any event, offshore petroleum exploitation offers splendid opportunities for the investment of American capital around the world and the sharing of advanced American technology in recovering oil and gas from the difficult environment of the seas. American companies with their drillers are found on the hot sea of the Persian Gulf and on the inhospitable wintry waters of the North Sea, in Venezuela, Indonesia, or Nigeria. About 80% of all the offshore mobile rigs in the world are owned by U.S. companies and no less than 80% of the crews exploring by seismic means the possible location of oil and gas in foreign areas are Americans.

The importance of ocean-related energy and minerals to the United States since World War II has not diminished the continuing American interest in the seas as a source of food. Although American harvesting of fish has remained stable in comparison to the growth of the catch of other countries, the United States still ranks fifth in the world in its total capture of fish. Moreover, the value of the American catch in the mid-1970s was exceeded by only three other nations. But most of the fish eaten by Americans was and is imported from foreign fishermen; and the value of fish imports from abroad worth about $1.7 billion, far exceeds the value of the commercial landings by Americans. This increasing dependence upon the importation of fish was brought about by a number of changes in the technology of harvesting, marketing, and distribution of both finfish and shellfish.

As already indicated, many of the enterprising and energetic youth of the United States had found an easier and more rewarding life in the industry, commerce, and professions of an expanding American economy. Moreover, with rising wages, generally part of increased security for unionized workers; long and conservative family traditionsin the fishing industry, particularly along the Atlantic seaboard; and small capital investment, the productivity of American fishermen declined. Small boats and laggard catching, storing, and handling facilities could not compete with new foreign fleets that began to appear off American shores in the 1960s. These ships, many from Japan and Russia, were completely modern, trawlers working in tandem with large factory ships fully equipped for sorting, cutting, and freezing the catch of the fishing vessels.

Illustrating the trend of the American economy is Gloucester, Massachusetts, a town that for more than three centuries has symbolized the rugged New England fisherman sailing out to sea to make his catch. From 1955 to 1975 the catch of the fleet from Gloucester declined nearly 50%. No more than 100 vessels and perhaps some 800 men were still engaged in the actual harvesting of fish in 1976. Yet Gloucester remains a booming fish town, with its experience and energies diverted to the processing of fish, almost all of it purchased from foreign firms. Close to four thousand people have been engaged by one of the oldest and largest fishing firms entirely in the processing of fish such as cod, haddock, and flounder, that has been brought from about a dozen countries around the world, including Korea, Japan, Denmark, and Poland. One of the reasons for this transformation of one large firm from a harvester to a processor has been the use of the fish block, a method of freezing large numbers of fish into a solid block of ice for preservation and then using saws to cut separate filets into a convenience food for the American restaurant, hospital, school, or home. No longer dependent upon the vagaries of the fish catch, subject to weather, wandering or depleted fish schools, and other hazards of the hunt, Gloucester, among other towns, has found processing to be more stable for employment and more profitable for investment, with sales of frozen fish increasing at a phenomenal rate during the 1960s and 1970s.

Still, many American fishermen are not about to give up their ancient trade. With some species, like tuna, salmon, and shrimp, three big money fish, fleets from the United States have competed quite well. Their main concerns lie in distant-water fishing close to the coasts of foreign states or, in the case of salmon, conservation for a species that spawns in fresh water then swims very far out to sea where little or no regulation of the catch has been the rule. Indeed, beginning in 1977 some profound changes in law may greatly affect the American fishing industry and all the people connected to it.

Under the Fisheries Management and Conservation Act no foreign vessel will be able to fish in the seas adjacent to the United States and extending up to two hundred miles from its shores unless authorized by permit by the United States. And such permits will only be allowed after calculating and allowing to American fishermen the amount of each species they are capable of harvesting. Only the future will tell the full effect of this Act upon the American fishing economy and United States uses of the sea. The expectation is that there will be a rational management of a living resource which, if overfished, can lead to depletion and even extinction of renewable wealth. Moreover, the proponents of the law, strongly urged by a small, but vociferous group of American coastal fishermen whose image of rugged individualism has the nostalgic support of a wide public, expect that Americans will be able to take larger and larger

shares of the coastal fish, without the competition of the foreign fleets, and revitalize harvesting. For the distant-water American fishermen the prospect is different inasmuch as foreign countries will have a legitimate claim to license, restrict, or restrain fishing within 200 miles of their shores, most likely requiring rents for the catch and thereby either reducing profits to the American fleet or ensuring higher prices for the American consumer, or both.

The fishing industry has been an important part of the American economy and may, under extended fisheries jurisdiction of the United States, again be transformed. In 1974 there were about 240,000 people employed in the American fishing industry, of which some 170,000 were actual fishermen. But of these only about half gained their livelihood from the sea, with the other half engaged in fishing as a supplement to their regular jobs. The largest number of employees in the fishing industry in the mid-1970s were found in Alaska, Maine, and California, as well as Maryland and Louisiana with their shellfish industries, followed by Florida and Washington. Americans are not great fish eaters, but fish do form a modest part of their diet, especially in the delicacies of salmon, tuna, shrimp, oysters, and lobsters. Plainly the value of the sea for its living resources will continue to be important to the United States.

The dimensions and the attachment of Americans to the sea are extraordinary. Including Alaska, Hawaii, four island groups in the Atlantic ocean and nine island groups in the Pacific, the United States has a general coastline of more than 12,000 miles. If all the shorelines of all the coasts in sounds, bays, rivers, and creeks washed by tidal waters were counted, the shoreline would amount to 88,000 miles – more than three times around the Equator of the earth. Alaska alone has a coastline of more than 6,000 miles, and the Pacific rolls for more than 1,300 miles along the shores of Washington, Oregon, and California. The coastline of the Gulf of Mexico, about 1,600 miles, is almost as long as the Atlantic seaboard. Although they are called "lakes," the Superior, Huron, Michigan, Ontario, and Erie are vast bodies of water with all the activities of navigation, fishing, and coastal recreation associated with the seas.

The cities of the original thirteen states hugging the Atlantic Coast in 1776 were attached to water. Three hundred years later the population centers of America are still linked to bodies of water. Of the thirteen largest cities in the United States, twelve are either located on estuaries of the sea or on the Great Lakes.

To attempt to calculate the number of Americans whose jobs depend directly or indirectly upon the use of the oceans would be futile, leading to intractable problems of definition. But a quick scan of the public agencies would reveal millions of people and billions of dollars invested in the Maritime Administration, the Coast Guard, the Fish and Wildlife Service, the Bureau of Land Management, the Geological Survey, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and other Washington agencies. The Navy alone had a budget of close to $40 billion for 1977. Without counting military expenditures, well over two billion dollars are spent by the public in eleven Federal agencies for marine science activities and ocean related affairs. In addition, all of the coastal states have directors, boards, and commissions to deal with problems of their coastal areas and fisheries. They are not only responsible for industrial and commercial development, but also seek a rational use of the coastal zone through planning, zoning, tax incentives, or other devices to protect the natural resources and provide attractive marine facilities.

As indicated earlier, some 240,000 Americans are directly employed in the fishing industry. Moreover, in recent years the United States has had about 550 ships in its merchant marine with a carrying capacity of more than 14 million tons. In addition to the crews of these private ships, there must be added all the Americans engaged in the port activities of reception and handling fueling and repairs, traffic management and insurance, and litigation, as well as in the intricate network of buying and selling the products that move internationally by ship, the overwhelming part of the $200 billion of imports and exports in America. In 1977 alone the United States authorized over $400 million to be paid to American operators of merchant ships as subsidies to keep them competitive in foreign trade with certain lines and cargoes. Another $22 million went into research and development of the merchant marine, while more than $13 million was authorized for the Merchant Marine Academy at Kings Point, which graduates about 200 seamen a year with a Bachelor of Science and eligibility for a Third Mate or Third Assistant Engineer's license. The ship construction industry, finally, which involves the employment of more than 100,000 people, has been heavily subsidized by Congress in the past to keep the U.S. merchant marine afloat and available both for peacetime commerce and auxiliary war use.

Yet the ordinary American is most aware of the value of the sea and the great lakes through his recreational habits. By the millions the people of the United States go down to the sea from beaches, from small boats, and off piers. Up to 20 million people a year fish the streams, lakes, bays, and coastal waters of the United States for fun and a personal catch of food. As family farms have declined and as people have sought the amenities of being close to a large body of water, more and more Americans have moved to lakesides and seasides for their employment and enjoyment.

In fact, more than three-quarters of the population of the United States can be found in those states which bound the Great Lakes and the oceans. *Almost half the urban counties of America touch the seas.* And the rates of increase in the population of the United States have been greatest in areas with coastal lands, with about 90% of the increase over the last twenty years or so occurring in coastal states.

This heightened awareness of the seashore and its marginal waters both as a place for work and leisure, has alerted the people to the importance of maintaining control over the uses of the sea in order to reach a balance between necessary economic development and the necessary conservation of the environment. Compatibility between marine transportation or marine energy exploitation with social enjoyment of the beaches or the conservation of the living resources in tidal marshes and deeper waters must be ensured.

A whole series of acts, both by the Federal government and the states, has attempted to guarantee that American waters will not be polluted to the point of endangering human and marine organic life while allowing a continuous social enjoyment of American lakes and ocean beaches for bathing and recreation. Important steps have been taken to reduce point source pollution from the factories that pour their wastes into streams and estuaries, to eliminate vessel source pollution from ships with oil engines or carrying oil cargoes, to minimize the dumping of wastes into the oceans, and to prevent accidents by ships or oil drilling rigs in the ocean. Less effective have been controls over the run offs of various pollutants that wash from the roads, streets, and countrysides into marginal waters. These reforms, of course, have been accompanied by extensive litigation, problems of conflicting jurisdiction, and a genuine concern that the costs of implementation must fall back upon the taxpayer or consumer of these products that require use of the marine environment.

The American society seems destined to be closely attached to its marine environment for the long run of its history. With foresight and tolerance it can surely manage its needs for a Navy, a merchant marine, offshore mineral resources, fish, and even coastal islands for nuclear power in concert with its spirited desire to provide the United States with a healthy marine environment. Zealots on either side of a debate over the uses of the sea will need to be curbed and reasonable accommodations can surely conserve nature, provide joy at the seaside, and not destroy the important American economy that must have access to the oceans.

About the Editor

Harold L. Goodwin *operates his own marine affairs consulting service specializing in marine education, ocean energy, and aquaculture. He is a consultant to the University of Delaware College of Marine Studies, the Oceanic Institute of Hawaii, the University of Hawaii, and the Office of Technology Assessment of the U.S. Congress.*

For eight years, until 1974, Harold Goodwin was Associate Director of the National Sea Grant Program, first in the National Science Foundation, and later in the National Oceanic and Atmospheric Administration. Before joining Sea Grant and assisting in its organization and program development, he spent six years in various capacities with NASA, three years as scientific advisor to the United States Information Agency, and eight years in nuclear test operations.

Goodwin is the author of 38 published books, many of them youth fiction under a pseudonym. Under his own name are books on astronomy, space, general science, and "Challenge of the Seven Seas," which he co-authored with Senator Claiborne Pell of Rhode Island.

As a committed menber of the marine community, Goodwin has held directorships or offices in most of the ocean-oriented professional societies, and was a member of the founding committee of the National Marine Education Association. His honors include the U.S. Junior Chamber of Commerce Flemming Award as "Outstanding Young Man in Federal Service," The James Dugan Award for contributions to aquatic science from the American Littoral Society, The Department of Commerce Silver Medal, and several awards for meritorious achievement from other agencies.