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THE ECONOMIC VALUE OF REMOTE SENSING OF EARTH RESOURCES FROM SPACE: AN ERTS OVERVIEW AND THE VALUE OF CONTINUITY OF SERVICE

VOLUME IX

OCEANS

Prepared for the
Office of the Administrator
National Aeronautics and Space Administration
Under Contract NASW-2580

October 31, 1974
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NOTE OF TRANSMITTAL

This resource management area report is prepared for the Office of the Administrator, National Aeronautics and Space Administration, under Article I.C.1 of Contract NASW-2580. It provides backup material to the Summary, Volume I, and the Source Document, Volume II, of this report. The interested reader is referred to these documents for a summary of data presented herein and in the other resource management areas.

The data presented in this volume are based upon the best information available at the time of preparation and within the resource of this study. This includes a survey of existing studies plus Federal budgets and statutes. Throughout the analysis, a conservative viewpoint has been maintained. Nonetheless, there are, of course, uncertainties associated with any projection of future economic benefits, and these data should be used only with this understanding.

ECON acknowledges the contributions of Keith Lietzke who authored this volume.

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ABSTRACT

This report deals with the impact of remote sensing upon marine activities and oceanography. The present capabilities of the current Earth Resources Technology Satellite (ERTS-1), as demonstrated by the principal investigators, as well as desirable capabilities from this and other satellite systems are discussed. A survey of past studies of ocean applications of remote sensing has been made and some benefits have been calculated using these studies and original material.

Cost-savings benefits have been quantified, particularly in the area of nautical and hygrographic mapping and charting. Considerable benefits have been found in aiding coastal zone management. Unquantified benefits are noted as being highly significant; these exist in the fields of weather (marine) prediction, fishery harvesting and management, and potential uses for ocean vegetation. Difficulties in quantification are explained, the primary factor being that remotely sensed information will be of greatest benefit as input to forecasting models which have not yet been constructed.

Hard benefits range from $6.78M (lower bound) to $17.04M (upper bound).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION AND OVERVIEW: OCEANS

The study of Oceans can provide a vast source of information important to applications as broad as weather prediction, recreation, mineral resources and food production. Yet the vastness of its area makes the sea a particularly difficult phenomenon to study adequately. Nowhere else in the known universe is there a large body of water drifting freely about on a spinning sphere. It is impossible to model such a physical system in the laboratory; the only way to study it is to observe it. Surface ships and subsurface vessels have vertically sampled the ocean, but the horizontal dimension, 5,000 times greater than the mean depth of the ocean, has never adequately been sensed. The vastness of the surface is beyond the logistic abilities of aircraft. The satellite is the only feasible vehicle from which the whole surface of the sea can be viewed.

However, satellite imagery can only be employed in sampling the upper layers of the sea, the part that is stirred by the wind and lit by the sun. No matter how far within the range of foreseeable technological progress, it is very unlikely that any information below these upper layers will be obtained by satellite. Under ideal conditions, blue band imaging detects light which has penetrated 60 meters; but considering that the mean ocean depth is over 3500 meters, such remote detection does not tell us much about the entire volume of the ocean.

Fortunately, the layer of the ocean exposed to the over-view is far more significant than the sum of the other layers. It is the part of the ocean that overwhelmingly concerns the everyday affairs of mankind. It is the site of waves, storm surges, the rise of tide, and other changes of sea level. It covers the continental shelves where oil and minerals are being recovered. It is the part of the sea that most concerns sailors, because of currents, destructive waves, dangerous shoals, or drifting ice. It impinges on the beaches, harbors, and estuaries that are important for industry, recreation, and human habitat. It includes the zone that supports the photosynthesis upon which the whole biological resource of the sea depends.

And not only is this the part of the sea by which mankind is most affected, but it is also that part of the sea which he most affects. Dredging for harbors, the building of erosion-preventive structures, marine life harvesting, and pollution all occur in these layers.

This layer also includes the air/water interface. Virtually all energy that controls the inner workings of the sea flows across this interface; all the water types that constitute the ocean's anatomy have their genesis at the surface in the region of exposure to the sun and wind. Like the sediments of the earth's crust, the sea is composed of tilted strata that outcrop somewhere at the surface. Thus, a complete map of the surface must contain much information about the water masses in the deeper, darker regions.

The relationship between the ocean and the overlying atmosphere is so intimate that neither can be described without consideration of the other. The meteorologist is interested in the upper ocean because it stores and transports a significant portion of the world budget of heat, and modifies air masses during their long dwelltime over the ocean. Conversely, the oceanographer realizes that nearly all the energy found in the ocean is derived either from the sun or from the overlying air. Sluggish events in the ocean tend to be the summation of much more dramatic events that are first apparent in the large scale weather patterns.

Satellites will prove to be particularly useful ocean observers in the future because nearly all important ocean parameters can or will be able to be sensed from satellite or commumicated via satellite using DCP's (Data Collection Platforms). Coastal water circulation can be determined from turbidity patterns. Estuarine water mixing can also be seen. Water depth and hazards to navigation can be spotted using processing techniques, depending upon turbidity conditions which can also be measured. Sea ice can be detected and current speed and direction are found through its movement. Major ocean currents can be located and their movements monitored. Chlorophyll-a can be measured; its existence is a sign of vegetation or algae upon which fish feed and the presence or absence of which is felt to be a good indicator of the "health" of an estuary. Water contamination can be detected to a limited degree now and probably to a higher degree in the near future. Satellites with thermal infrared bands will be able to measure ocean surface temperatures and active microwave sensors will be able to measure sea state. Fixed and freely floating data buoys (DCP's) will measure water content and current speed and direction.

Although the potential advantages are great, oceanographic remote sensing is in a very juvenile stage. Compared with forestry, agriculture, terrestrial geography, and meteorology, air sensing techniques have been little applied to ocean observation. This is largely because both the scale and the distance from base has inhibited the effectiveness of aircraft. Thus, oceanographers do not have a transitional base from which to move to the application of satellite imagery. Acquiring "ground truth" presents unusual difficulty when remote sensing is applied to oceans. But the biggest problem in using remotely sensed information is the entire historic orientation of oceanography. Although the idea that the sea derives its constitution and motive force at the air/sea boundary is well-established in oceanographic theory, in practice the data of oceanic observation have usually been obtained and analyzed in vertical sections. As a result the presently existing instruments, data-handling routines, analytic methods and the oceanographers themselves have all been oriented toward vertical rather than horizontal aggregates of information. How quickly and how well this prevailing orientation can be redirected is, of course, a function of how much society and science is willing to invest in research and technology to make the transition. Thus, oceanography has a wholly new capability in its data gathering and one which will yield valuable information. But due to the uniqueness of this data source, direct user application is not in the immediate future.

It is easy to identify the beneficiaries of improved understanding of the ocean, particularly in the United States. We are a maritime people, 80 percent of whom live and work in coastal areas conditioned by the sea. Even our heartland cornbelt owes its productivity to the maritime air from the Carribbean, without which it would be a relatively unproductive plain. Over 90,000 miles of coast afford the varied environment for recreation, welfare, livelihood and commerce for some 100 million of our citizens. Conversely, the coastal seas on occasion present hazards to life and property that sometimes overwhelm whole regions in calamity.

In looking toward benefit determination, one important point must be made. None of the ultimate consumers of information about the ocean can use raw data effectively. In many applications information of the current situation is sufficient. In ocean applications, the data almost invariably must be put into models which forecast future conditions. For example, the fisherman is not particularly well served by the day-to-day report of where the fishing was good. Rather he needs to know, when he leaves port, where the fish will be when he arrives on the grounds; thus, he saves search time. Or, on a longer time scale, he needs to know how bountiful a given fishery may be in the season ahead so that he can make a wise decision as to his investment in costly ship and gear. On a longer time scale still, the entrepreneur who must provide a cannery or other marketing facilities must evaluate the the future of the fishery over the expected life of his investment. This need for future, and not present, information application holds for fishermen, vacationers, ship operators and marine engineers. Thus, the immediate applicability of remotely sensed oceanographic information is lessened because the complex mathematical models necessary for prediction are generally not in existence. It is fair to say that heretofore the unavailability of data on a global synoptic basis has prevented the construction of adequate models that could be used for these predictive purposes. For this reason, the vast majority of benefits from satellite sensing applied to oceans will accrue in research and is unquantifiable at present.

Turning to quantifiable benefits, considerable cost-savings and increased capability exist in the area of ocean mapping. Island charting can be done easily and very cheaply by satellite, particularly considering the cost of sending a ship or a plane 4000-6000 miles to do the same job; and frequently the synoptic eye can improve maps which are dangerously misleading (see Figure 2 and explanation in RMF 7.1.1.) Hydrographic mapping, primarily involving water depth charting to find navigable areas, can also be done inexpensively by satellite where possible. Clear water and highly reflective bottoms provide the best areas for satellite water depth mapping; depths of 60 meters have been charted. Turbid waters provide greater problems because light does not penetrate well. Here there is room for statistical methods for estimating bottom depth; it will take time to develop these methods.

Pollution detection will prove to be a significant function of remote sensing. Ocean dumping in the New York Bight is clearly shown in the ERTS image of Figure 1. Coastal circulation analysis will give information about what will happen to wastes which are dumped five or 30 miles offshore. Sediment plumes and turbidity patterns provide much information about tidal, river and estuarine currents (see Figure 6). Benefits from remote detection of oil spills have been quantified. The New Jersey Department of Environmental Protection has indicated considerable benefit in determining optimum ocean outfall placements.

The N.J.D.E.P. has also estimated benefits from synoptic observation of how coastal zone land use is changing.

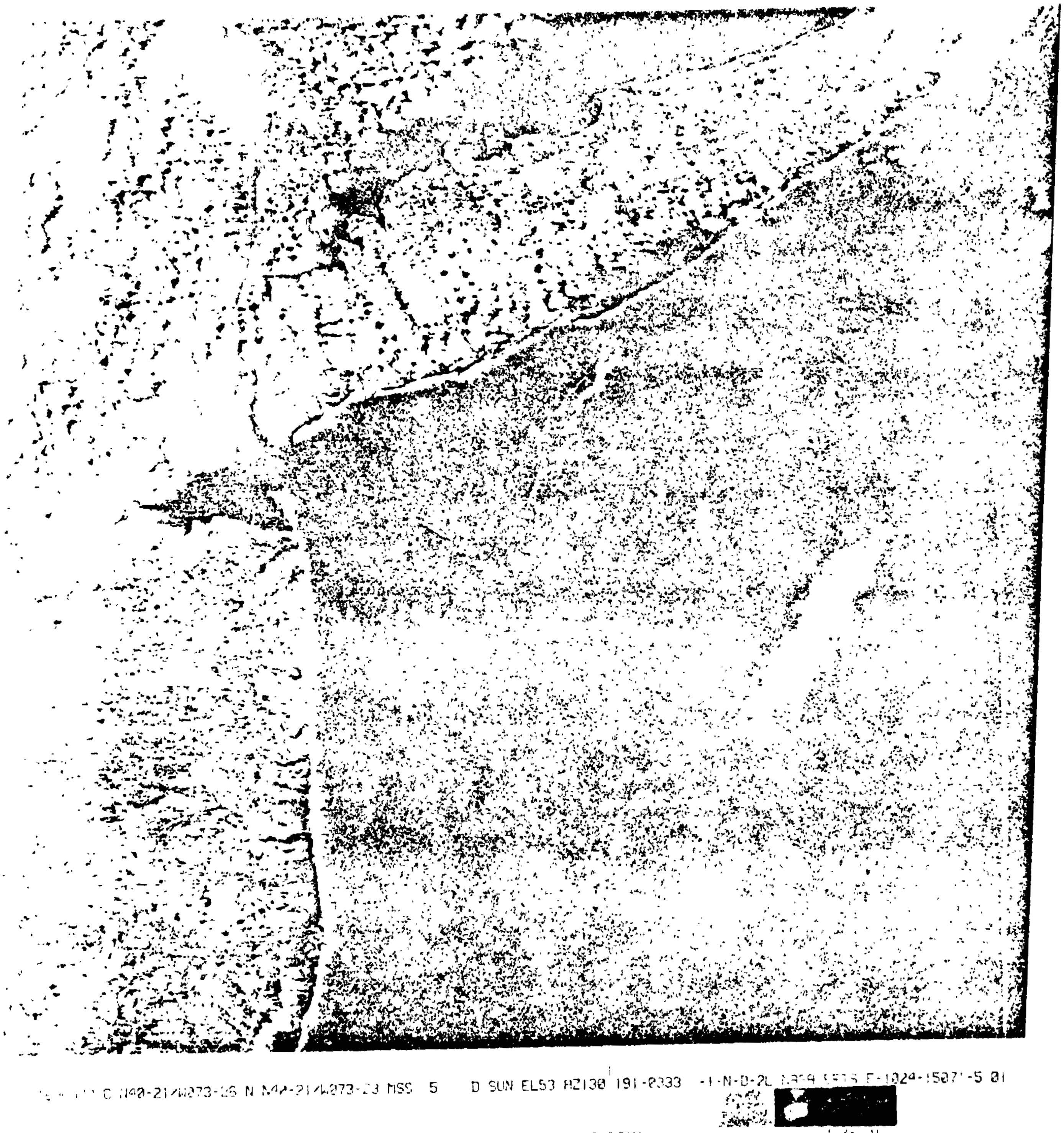

Figure 1 Ocean-Dumped Pollution in
New York Bight

They have detected land use changes as small as two or three acres using limited enhancement techniques. Further benefits have been demonstrated by N.J.D.E.P. in shoreline protection and new legislation.

Unquantified benefits are abundant in weather prediction, fishery management, and assessing the effects of pollution. The supply of food in the oceans is enormous. Presently little-used sea vegetation offers a food supply with dimensions and growth sufficient to stem many of the fears of devastating world food shortages.

Satellites will also show great application with the use of DCP's or data buoys. These platforms will provide continuous and important information which could only be gathered at prohibitively high costs. Satellites will provide the means for communicating this information to the processors and users.

Benefits by Resource Management Function are summarized in Table 1; in depth explanation and quantification of these benefits can be found in Appendix A. Additionally, relevant Federal budgets and statutes are located in Appendices B and C, respectively. Desired sensing capabilities from future satellite imaging devices are shown in Table 2.

1.1 Cartography, Thematic Maps and Visual Displays

Satellite imaging provides activities not feasible by other means. Islands and reefs never before mapped can be detected and charted. Water depths over large areas can be measured at minimal costs. The movements of shoals, reefs and islands can be monitored. For navigation purposes, satellite sensing will be particularly useful; the draft of the bigger tankers, except for the super-tankers, do not exceed 15 meters. Although ocean bottom cannot be detected in many areas, it would be possible to ascertain that there are no barriers to navigation at 20 meters. Turbidity presents the biggest problem to light penetration, but methods are being developed to determine water depth even in turbid waters. The Environmental Research Institute of Michigan is socn to publish a report on this subject.

1.2 Statistical Services

Various indicators are useful in determining the "health" of an ocean area, the most important of which is the presence of chlorophyll-a. Monitoring the existence of chlorophyll enables one to infer the availability of food for fish; it is a good barometer for determining how man's

Table 1 Magnitude and Types of Net Annual Benefits by Resource Management Activity - Oceans

Resource Management Function	Benefits, $ millions (1973)		
	Equal Capability	Increased Capability	New Capability
7.1 Cartography, Thematic Maps and Visual Displays			
7.1.1 Oceanographic mapping	(5.0-12.7)**		
7.1.2 Thermal mapping of the oceans	*	*	
7.1.3 Mapping ocean ice and polar caps		*	
7.2 Statistical Services			
7.2.1 Monitor ocean food supply	*	*	
7.3 Calendars			
7.3.1 Monitor tides and currents in coastal waters	*	*	
7.3.2 Monitor the movement of the major oceanic currents	*	*	
7.4 Allocation			
7.4.1 Optimize ocean fisheries management		**	
7.4.3 Improve coastal zone management		.19-.78	
7.4.4 Optimize ocean shipping routes		*	
7.5 Conservation			
7.5.1 Improve shoreline protection programs		.07-.15	
7.5.2 Control ocean pollution		.62-2.5	
7.5.3 Monitor oil slicks	.55	.28	
7.6 Damage Prevention and Assessment			
7.6.1 Reduce ocean resources losses due to man-made changes		*	
7.8 Research			
7.8.1 Research on ocean parameters		**	*
7.8.2 Research on estuarine ecology		**	*
7.9 Administrative, Judicial and Legislative			
7.9.1 Aid in enforcing national and international regulations and agreements		*	
7.9.2 Aid in designing legislative controls and administrative procedures			
Total:			
Hard benefits documented in ECON Case St·dies....................	.55	1.2-3.7	
Soft Benefits..................	(5.0-12.7)		

Source: ECON

* Approximately $73.4 - 220.8M total benefits are possible via a satellite with a thermal infrared band for mapping of the North Pacific. However, it is likely that satellites other than ERTS e.g., SEASAT and NIMBUS G, will obt·in this benefit.

** Parenthesis indicate "soft" benefits.

\+ Indicates unquantified benefits.

\++ Indicates significant benefits.

Table 3 Desired ERTS-1 Modification for Oceans

Subdiscipline	Increased sensitivity	Addition of blue band	Increased spatial resolution	Increased observation frequency
Coastal	++	++	+	+
Bathymetry	++	++	+	-
Sea ice	+	-	+	+
Oceanic circulation	++	+	-	-
Living marine resources	++	+	+	++

Source: Merchanti, "ERTS-1 Teaching us a New Way to See," Astronautics and Aeronautics (September 1973)

Key: ++ = Most Desired, + = Desired, - = Little Impact

activities are affecting the biology of an estuary. Chorophyll-a can also point out ocean vegetation fcr harvesting purposes.

1.3 Calendars

Currents can be mapped and monitored by satellite imagery. Coastal circulation information important for marine engineering and planning optimum waste disposal can be ascertained from turbidity patterns. Ocean current movements important for shipping and heat transfer information can be observed through changes in ocean color and chlorophyll content.

1.4 Allocation

Fish availability prediction models are under development. Fish catch/ocean parameter correlation studies have already been made and the results are significant. Not only should remote sensed data be able to help the fisherman find the fish at less cost, but the data can help avoid overfishing. Land use changes can be detected which aid in coastal zone management. Better water depth and ocean current informtion will facilitate ocean shipping.

1.5 Conservation

Circulation analyses will aid in constructing erosion-preventive structures and in planning for waste disposal. Satellite imagery can detect illegal sources of pollution and evaluate the effects of waste disposal on estuarine ecology.

1.6 Damage Preventio~ and Assessment

A system with sufficient resolution would be able to detect beach erosion and indicate where preventive structures would help. Estuarine "health" can also be measured to assess the effect of man's coastal activities.

1.7 Unique Event Reconition and Early Warning

Considerable benefits exist in this area for a geo-stationary satellite system. However an ERTS-like system would not provide coverage with sufficient continuity to be of benefit here.

1.8 Research

This is the primary benefit area in remote sensing application to oceans at this time. Benefits exist in weather forecast improvement, fish harvesting and assessing, and operationally using the ocean food supply.

1.9 Administrative, Judicial and Legislative

Remote sensed data is helpful in constructing and enforcing international shipping, fishing and mining agreements. These data can also contribute to the resolution of jurisdictional disputes between local, state, federal and international interests. These data have also been used to form new laws which aid in coastal zone management.

APPENDIX A:

DETAILED EXAMINATION OF BENEFITS BY RMF

This section contains documentation of benefits obtained from an ERTS-like ERS Satellite system applied to oceans, as presented in Volumes I and II and in the introduction to this volume. In this appendix, benefits are quantified and user demand for information in this resource area is identified.

RMF No. 7.1.1

OCEANOGRAPHIC MAPPING

Rationale for Benefits

Accurate ocean maps are essential for safe and efficient oceanic travel. The International Hydrographic Office has expressed concern over the status of shipping charts around the world, many of which cannot be updated due to a lack of technical resources in some countries. Meanwhile, some maps contain certain data based on survey records from the early 19th century. Chart makers are forced to use labels such as "Position Approximate" and "Existence Doubtful" in reference to many reported sightings. Depths measured by lead lines tend to give too large a depth because of bending of the line. Echo sounders can give errors from suspended materials, that cause depths to be recorded as too shallow. Storms bring rapid change so that even recent maps may be in error due to shifting sand bars and changes in coastlines. Benefits from improved ocean mapping will come to the public in the form of lower shipping costs.

Federal Government Activities and Responsibilities

The Department of the Navy, the Coast Guard, and Nation Oceanic and Atmospheric Administration have the responsibility for keeping oceanographic maps accurate and current. Types of maps are shown in Table 3. Expenditures are found in Tables 4 and 5.

Non-Federal Activities

Other national governments update shipping charts on a regular but limited basis. Great Britain used to be the foremost explorer and charter in the field but has recently undergone severe cutbacks in this activity. Reports from private ships are continuously recorded, but these sightings do not contain a high degree of accuracy and occur in the limited regions of the major shipping routes.

Functions of Remote Sensing

Satellites provide the opportunity for obtaining reliable ocean maps around the world. Our knowledge of the topography of the oceans will no longer be limited to major shipping routes and the limited areas where research explorations take place. Although water penetration ability is an important limitation in determining water depth, the areas where such knowledge is most important are shallow areas where ships may run aground. Remote sensing will be particularly useful in pointing out these dangerous areas. Satellite imagery will be most useful in areas of clear water and highly reflective bottoms, like the Carribbean.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Nautical Charts: From other budget figures, it is shown that data acquisition/data processing costs run around five to one. Assuming this ratio holds true for nautical chart production also, with a total budget for nautical charts of $22.6M (Table 4) about $18.0M would go toward data acquisition. With reference to Table 3, it can be seen that the vast majority of maps are of the scale of 1:50,000 or smaller. If we assume that 80% of the surveying is for maps of 1:50,000 scale and smaller, then about $14.4M go toward data acquisition for maps of this type.

Table 3 The NOAA/NOS Nautical Charting Program — Map Types and Their Use

Type	Scale	Federal	Maritime	General Public
Sailing	1:600,000 and smaller	62%	13%	25%
General	1:100,000 to 1:600,000	50%	17%	33%
Coastal	1:50,000 to 1:100,000	40%	20%	40%
Harbor	1:50,000 and larger	60%	13%	27%
Small Craft	1:80,000 to 1:15,000	12%	6%	82%

Table 4 1972 Expenditures on Nautical Charting

Agency	Expenditures on Nautical Charting $ thousands (1973)	Expenditures on Nautical Charting man years
DEPARTMENT OF DEFENSE		
Defense Mapping Agency	-.342	-
Office of Naval Research	-	-
Navy Operations	-	-
Corps of Engineers, U.S. Army	37	1
Mississippi River Commission, U.S. Army	15	1
TOTAL - DEFENSE	52.342	2
DEPARTMENT OF THE INTERIOR		
Geologic Division, Geological Survey (GS)	-	-
Conservation Divison, GS	-	-
Bureau of Reclamation	-	-
TOTAL - INTERIOR		
DEPARTMENT OF COMMERCE		
National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA)	20,635	1,012
Environmental Data Service, NOAA	-	-
Environmental Research Laboratories, NOAA	-	-
National Marine Fisheries Services, NOAA	-	-
TOTAL - COMMERCE	20,635	1,012
DEPARTMENT OF TRANSPORTATION		
U.S. Coast Guard	1,856	181
INDEPENDENT AGENCIES		
Atomic Energy Commission	-	-
National Science Foundation	-	-
Tennessee Valley Authority	26	1
TOTAL - INDEPENDENT AGENCIES	26	1
TOTAL	22,569.342	1,196

RMF No. 7.1.1

Now, the problem of ascertaining how much of this information can be gathered by remote sensing. In clear water, depths up to 60 feet can be measured by a sensor with a blue band.* In turbid waters shoals and hazards to navigation can be spotted when in shallow water,** and, once spotted by ship, other shoals can be monitored in deeper water. Shoreline delineations can be mapped to a very high degree of accuracy and resolution due to the high contrast between water and land. Very much current information can be gotten from satellite. *** Clearly what cannot be detected from remote sensing are shoals beyond the range of penetration of remote images, and placement of navigational markers. From the above, it can be estimated that at least 25-50% of that which is presently being mapped by ship and aircraft for navigation could be done by remote sensing. Using the lower figure, .25 x \$14.4M = \$3.6M of this activity could be done by satellite; using the upper figure, .5 x \$14.4M = \$7.2M of the activity could be done by satellite.

Almost all of this mapping is done by NOAA and the Coast Guard, whose jurisdiction extend to twelve miles off-shore. Thus, a figures of 12 x 11,300 = 136,000 square miles is the estimate of mapping coverage. These maps are updated at intervals running from six months to four years.

If we assume that, on the average, they are updated annually, we arrive at an average cost per square mile of data acquisition which remote sensing could replace of

$$\frac{\$3.5M}{136,000} = \$25 \text{ per square mile (lower bound)}$$

$$\frac{\$7.2M}{136,000} = \$50 \text{ per square mile (upper bound)}$$

---

* Using the blue band on Skylab, water depths up to 60 feet have been calculated. Source: Personal conversation, F.C. Polcyn, Environmental Research Institute of Michigan.

** Williams, R.S., "Coastal and Submarime Features on MSS Imagery of Southeastern Massachusetts: Comparison with Conventional Maps," Symposium on Significant Results Obtained from ERTS-1, Volume I, March 1973, NASA, p. 1417.

*** Hunter, E.R., "Distribution and Movement of Suspended Sediment in the Gulf of Mexico off the Texas Coast," Ibid, p. 1345.

RMF No. 7.1.1

Thus, we get a cost savings equal-capability figure of ($25 -.194*) x 136,000 - $3.3M (lower bound) and ($50 - .194) x 136,000 - $6.7M (upper bound) accruing from remote sensed data applied to nautical charting.

Hydrographic Surveys: The primary function of this type of charting is to ascertain hazards to navigation as well as land figures, islands, deemed to be of value to the mariners in determining ship position by visual observations and verification of the shoreline feature of the land area. While some of this mapping is done in harbors, much is done in the oceans to aid ship navigation.

There are no available figures to determine how much area is mapped. In order to arrive at an estimate for this figure we turn back to the budget for navigational surveying, estimated to be $16.9M and divide by the estimated number of square miles covered, $\frac{\$16.9M}{136,000} = \$124$ per square mile of ocean survey. Total budget for hydrographic survey data acquisitions is $17.9M (Table 5).

Depth sounding can be done accurately at a speed of 15 knots,** significantly faster than the speed of charting ships in coastal waters. Assuming the cost per square mile for sounding is about half the cost for nautical chart surveying, we arrive at a figure of $\frac{17.9M}{60} = 300,000$ square miles of hydrographic surveying yearly.

Again, we are faced with the question of how much of this activity could a remote sensor replace and again there is probably a range of water area where remote sensing can provide water depth penetration deep enough to show all barriers to navigation in that area. Not a great deal of information is available on this subject, although there is a report coming from Environmental Research Institute of Michigan (ERIM) to be published soon. It is felt that 10% is a reasonable lower bound to the area covered by hydrographic surveys which will allow enough water penetration to show

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* Cost per square mile of mapping from ERTS-1. Source: "The Role of ERTS in the Establishment and Updating of a National Land Cover Information System," (Draft) ECON report prepared for NASA, 5 August 1974, III-19.

** "Report of the Federal Mapping Task Force on Mapping, Charting, Geodesy and Surveying, July 1973," Office of Management and Budget.

Table 5 Budget Figures for Hydrographic Surveys (FY 1972)

Agency	Data Acquisition $ thousands (1972)	Data Processing $ thousands (1972)	Totals $ thousands (1972)
NOAA/NOS	8,898	1,767	10,665
NAVOCEANO	2,838	434	3,272
CE	6,238	607	6,845
Totals	17,974	2,808	20,782

navigational hazards at least 20 feet deep. 30% will be considered the upper bound here. Using the lower bound, 30,000 miles of surveying would be replaced by remote sensing. This yields an equal-capability, cost savings benefit of (60-.194) x 30,000 = $1.7M. Using the upper bound, 100,000 miles, would yield an equal-capability benefit of (60-.194) x 100,000 = $6.0M.

Current ERTS Activities

ERTS-1 has demonstrated limited, but significant ability at water depth estimation. Shallow waters less than 17 meters, the most dangerous from the point of view of ship safety, are measurable from ERTS-1.* Imagery capable of recording shorter wave lengths will permit superior water penetration.

* Polcyn, F.C. and Lyzenga, D.R. "Calculations of Water Depth from ERTS Data," Ibid, p. 1434.

RMF 7.1.1

Referring to Figure 2, one can see the improved mapping possible from ERTS-1. A small ship looking for rough weather shelter near Montgomery Island (upper center) would be forwarned of the danger not shown in current nautical charts.

Resolution from ERTS-1 imagery has been shown sufficient to meet U.S. National Map Accuracy Standards at the 1:250,000 scale.*

Principal Investigators in this field are:

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Environmental Research Institute of Michigan
Mountain View, California

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Estimate of ERTS Economic Capabilities

From the above information, we feel that ERTS imagery is sufficient to replace many mapping and charting activities. Thus, there is an equal capability benefit within the range of $3.3M - $6.7M for nautical charting and $1.7M - $6.0M for hydrographic surveys.

Annual Benefit:

Equal Capability: ($5.0 - 12.7 million)

* Colvocoresses, A.P., "Mapping with ERTS," unpublished U.S. Geological Survey, Reston, VA.

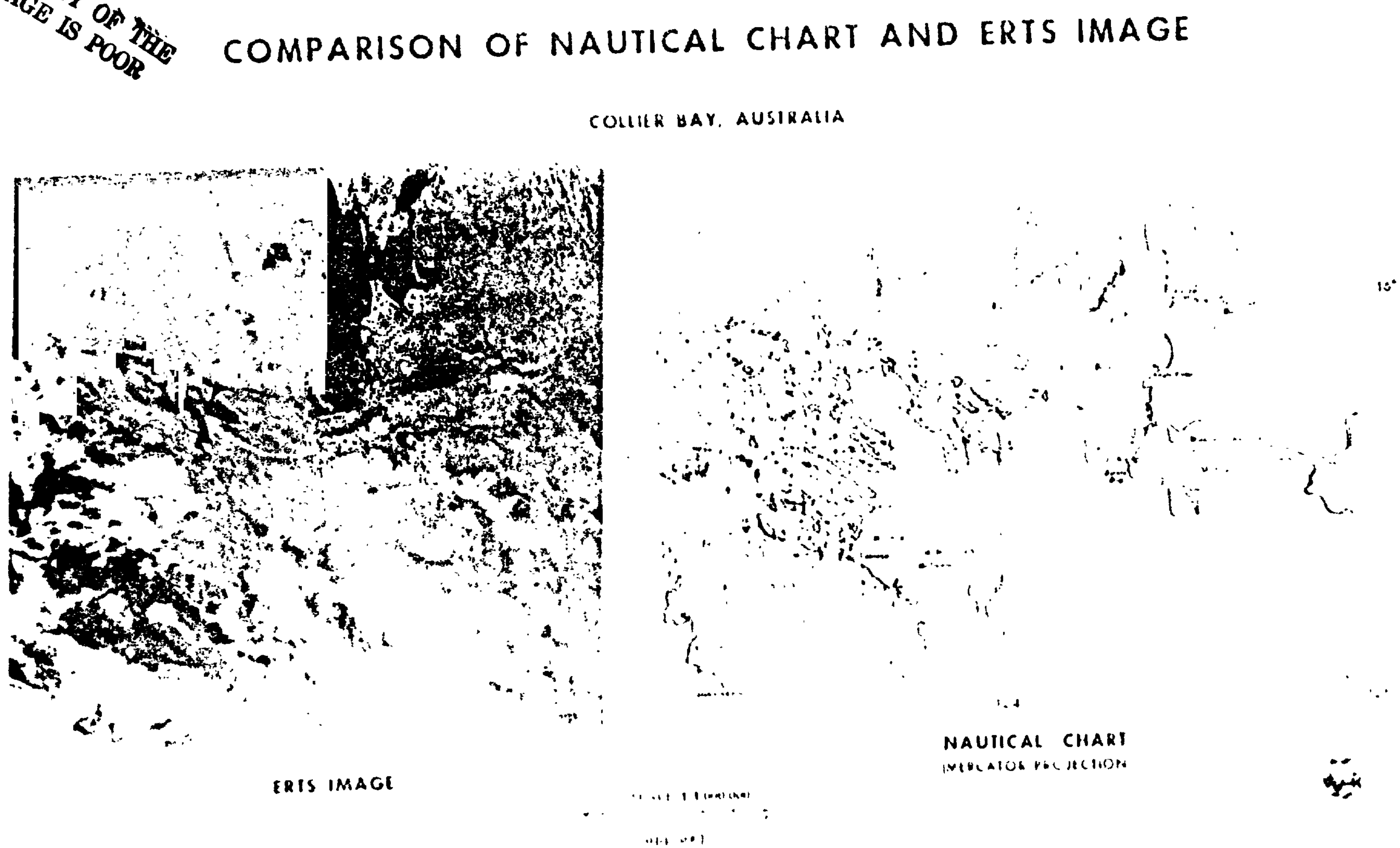

Figure 2 Comparison of ERTS Image of Collier Bay, Australia with Existing Nautical Chart

RMF No. 7.1.2

THERMAL MAPPING OF THE OCEANS

Rationale for Benefits

Charts of sea-surface temperature are widely used for a number of purposes, including studies of energy exchange at the sea surface, studies of surface circulation (location of current boundaries), studies of biological productivity (location of upwelling areas), and studies of biological environment. Such studies can be beneficial in making fish prediction models which reduce fishery search time, in making long-range weather forecasting by studying the air-sea interface, and in detecting major currents.

Benefits accrue to fisheries, shippers, and the public in the form of lower costs of goods and services.

Federal Government Activities and Responsibilities

Generally the same statutes that applied to 7.1.1, apply here as well. Sea surface temperature charts based on ship observations are routinely prepared and published by the Naval Oceanographic Office and the Fleet Numerical Facility. The National Oceanic and Atmospheric Administration also supports a data buoy system which continuously measures ocean parameters. Recently, airborne infrared radiation detectors have been used by the Bureau of Sport Fisheries and Wildlife to prepare temperature charts along the Atlantic and Pacific coasts.

NOAA has plans to soon include thermal sensing in its ITOS satellite series.

Non-Federal Activities

Temperature charting is also undertaken by foreign governments, primarily the Japanese, as an aid to their fisheries management. Several thousand ship observations of sea-surface temperature are available each day from the Northern Hemisphere. Distribution of observations is not homogeneous, most observations being made along major shipping lanes. Accuracy of the data is not high. Further, individual fisheries occasionally do their own infra-red airborne mapping, but this is not common and the area of coverage is very limited.

RMF No. 7.1.2

Functions of Remote Sensing

Remote sensing through IR imagery will provide continuous thermal contour maps not available through ship sampling. Area coverage and frequency will greatly increase to an extent presently impossible by any other means. Greater accuracy will be available than is presently attainable.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Benefits from knowledge of the thermal contours of the surface will add greatly to our weather prediction capabilities. The temperature of winds travelling over the ocean surface is greatly influenced by the temperature of that surface. Almost all of our weather originates over the ocean surface. (See RMF 6.2.3). Ocean environmental information, temperature being a main factor here, leading to improved and longer-range marine environmental prediction has had estimated annual values of $600M* to $2 billion.**

Benefits will also accrue in the fishing industry sector. Thermal mapping will give information as to fish availability, greatly cutting down search time and costs. Although there are some fisheries that could use this information now, the main one being the tuna industry, many fisheries are so intensively fished that this added information will not be of significant benefit. Thermal information will come into play in the near future. As demand for food increases, the demand for fish will also increase, bringing into use more marginal fisheries. These fisheries have little known about them and thermal contour mapping will contribute greatly to the speed with which they become productive.

As illustrated in Figure 3, extensive thermal mapping will not greatly affect the supply curve at the

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* Cost Benefits for a National Data Buoy System, an essay, Travellers Research Center, October 1967, Prepared under Coast Guard contract TCG - 16790-A

** Economic Benefits from Oceanographic Research, National Academy of Sciences - National Research Council, Publication 1228, 1964.

existing demand levels. But, given a growing world population and growing world need for food, as demand for fish increases, such mapping will be an important tool in locating new areas where the probability of finding fish is highest. Such mapping is an increased capability which yields no returns now (at least, as applied to this RMF), but will help in reducing costs in future fisheries. The benefits in the form of reduced costs are represented by the shaded region in Figure 3. DD is current demand; D^1D^1 represents projected future demand. SS is the industry supply with such maps. Due to the increased capabilities, the public will receive greater quantity (Q_1 to Q_2) at lower prices (P_1 to P_2).*

In order to reach a quantitative estimate of the value of this information one could do an equal-capability analysis assuming the demand were sufficient to have to oceans mapped at present by aircraft. Some of what was said above was an attempt to illustrate that sufficient demand for such activity is present. Were the oceans to be mapped, a reasonable demand level would be at least once every two months or six times a year. The area of coverage should be an area of the Pacific of at least three times the size of the United States. Mapping some of the Atlantic and the Gulf of Mexico would also prove valuable, but we will limit our area to three times the area of the U.S. or 10,000,000 square miles. At a demand level of coverage of once every two months this is 60,000,000 square miles per year. Average cost of U-2 coverage is $1.27 per square mile.** Thus high altitude aircraft coverage of the proposed area would cost $76.2M. Using the marginal cost of processing of $.048 per square mile*** for satellite imagery, this area could be covered at a cost of $2.8M, giving a cost savings of $73.4M. Different benefits at different demand levels are summarized in Table 6. It should be pointed out that the estimates for high altitude aircraft costs were for land-cover. Going over the oceans would mean being further from home bases and, in all probability, higher costs. Therefore

* Benefits come from increased producer rent and increased consumer surplus. Refer to Section 2.1 of the Source Document.

** This is based on figures from "The Role of ERTS in the Establishment and Updating of a Nationwide Land Cover Information System" (DRAFT), ECON report prepared for NASA, 5 August 1974, III-19.

*** Ibid.

the estimate of $1.27 per square mile is biased low and the derived benefits are conservative.

Current ERTS Activities

The present ERTS satellites are not equipped with thermal infra-red sensors but experiments from high-altitude aircraft indicate that such imagery will be both useful and accurate in measuring sea-surface temperature. Research has shown that the remote sensing of thermal emissions sensitive to temperature gradients of 0.5 degrees centigrade is possible by infra-red sensors.*

Estimate of ERTS Economic Capabilities

ERTS-1 does not contain a thermal infra-red imager, nor will ERTS-B; however, an operational future ERS satellite system could have this capability. Benefits outlined here will be captured by the NOAA ITOS satellites until such an operational ERS system is flown. Such a system is expected to have about three times the resolution capability of the ITOS satellites and will yield significant benefit, ($73.4M to $220.8M) as outlined above.

* Lopik, J.R., Pressman, A.E., Ludlum, R.L., "Mapping Pollution with Infrared", Photogrammetric Engineering, Vol. XXXIV, No.5 (May 1968), pp. 561-564.

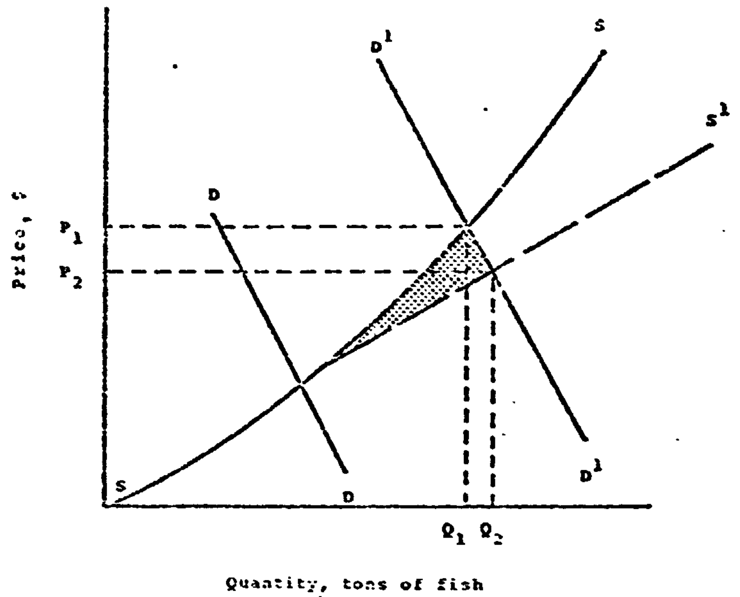

Figure 3 Benefits from Remotely Sensed Thermal Mapping with Projected Increased Demand for Fish

Table 6 Benefits from Thermal Remote Sensing of the Oceans

Cost-Benefit ($M)	Demand Level (coverages per year)				
	6	9	12	15	18
Cost of high altitude A/C	76.2	114.3	152.4	190.5	228.6
Cost of remote sensed data	2.8	4.3	5.8	7.2	8.6
Benefit (cost savings)	73.4	110.0	146.6	183.3	220.8

RMF No. 7.1.3

MAPPING OCEAN ICE AND POLAR CAPS

Rationale for Benefits

Detecting sea ice in shipping zones presents possibilities for avoiding loss of ships, freight, and lives. Mapping clear channels within ice fields can save many shipping hours and decrease shipping costs. Economic exploitation of Alaska will require increased shipping in Arctic waters, demanding increasingly accurate ice-condition forecasts. The safety of offshore structures and pipelines depends on the depth and distribution of ice grounding. Shipping will be guided by the presence or absence of barriers to onshore movements of ice. (See RMF 8.1.1 in Vol X for navigation benefits.)

Several scientists have pointed out that because of the critical effect of sea ice on the heat balance of the Arctic, the amount of ice may be an important factor in the climate of the Northern Hemisphere.* Fletcher states that the seasonal patterns of surface heat exchange over oceanic regions, which are directly related to ice distribution, are the most important factors to monitor in both the Arctic and Antarctic.** Such heat exchange is greatly affected by the dynamic movement of the Arctic polar cap, which can move as much as 75 km in one day.*** Further, tracking of sea ice can also give insight into ocean currents.

Naval defense operations and search and rescue are also benefited by accurate knowledge of sea ice.

Studies are also underway which show the cost-effectiveness of towing icebergs north from Antarctica as an alternative source of fresh water.

Federal Government Activities and Responsibilities

Sea ice reconnaissance now conducted by NAVOCEANO provides information for ship routing forecasts and for scientific investigations which require a knowledge of the areal and seasonal

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* Committee on Polar Research, 1970: Polar Research: A Survey, National Research Council, National Academy of Sciences, Washington, D.C.

** Fletcher, J. O., 1968: "The Polar Oceans and World Climate", Proceedings of the Long-Range Polar Objectives Conference, U.S. Department of Transportation, Washington, D.C.

*** Sherman, S. W., 1971: "Remote Sensing Oceanography", International Workshop on Earth Resources Survey Systems, National Aeronautics and Space Administration, Washington, D.C., p. 101.

distribution of sea ice. Information on iceberg location is also received by Nimbus and ITOS. The U. S. Coast Guard also makes ice surveys. In addition, there have been several polar expeditions, partially funded by the government.

Non-Federal Activities

Ice detection and monitoring is done by governments of many northern countries, including Canada and the Scandinavian countries. Canada in particular has made several studies about ice in connection with ship routing. Commercial ships report sea iceberg sightings and many are equipped with sonar and radar for sea ice detection.

Functions of Remote Sensing

Any past quantification of this information has required the use of slow and costly methods. As early as 1966, Fletcher stated that the "observational barrier" in the Arctic was crumbling primarily under the impact of satellite observation systems.* Information previously unobtainable is now available from remote sensing. Satellites can reach over areas prohibitive to even aircraft sensing. In addition, the high degree of overlap of successive orbits makes satellites particularly appropriate for high latitude studies. However, sensing is prohibited by the high probability of cloud cover and the long period of darkness in these areas.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

The primary quantifiable benefit which accrues from remote sensing is that of improved ocean routing through sea ice fields. See RMF 8.1.1, Vol X.

Current ERTS Activities

Principal investigators in this field are:

James C. Barnes
Environmental Research and Technology
429 Marrett Road
Lexington, Massachusetts 02173
617-861-1490

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* Fletcher, J. O., 1966: "Forward", Proceedings of the Symposium on the Arctic Heat Budget and Atmospheric Circulation, Memorandum RM-5233-NSF, the RAND Corporation.

RMF No. 7.1.3

Dr. John L. Hult
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1700 Main Street
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Topographic Division, U. S. G. S.
National Center, RM 2A 420
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Tahitorninkatu 2
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635-092

G. D. Sharma
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701
907-279-8528

Albert Don Super, Com.
International Ice Patrol
Bldg. 110, U.S. Coast Guard Base
Governors Island, New York 10004
212-264-4799

Analysis of ERTS-1 data indicates that sea ice can be identified in all spectral bands because of its high reflectance. Considerable information on ice type and ice surface characteristics can be obtained. Although sea ice and clouds have similar reflectances, methods have been developed for easy differentiation between them. ERTS-1 provides superior iceberg citing to Nimbus or ITOS because of its higher resolution.

The following information has been extracted from MSS images in conjunction with field data:*

(a) surface distribution of suspended matter, temperature and salinity along the coast

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* Barnes, P. W. and Reimnitz, E., "New Insights into the Influence of Ice on the Coastal Marine Environment of the Beaufort Sea, Alaska", Symposium on Significant Results Obtained from ERTS-1. NASA, March, 1973, p. 1309

(b) coastal current directions from grounded ice and ice-distribution patterns

(c) determination of ice-movement patterns from successive overlapped images

(d) correlation of grounded ice with topographic highs

Estimate of ERTS Economic Capabilities

Although we realize that information received from ERTS will help in eventually determining optimum locations for offshore structures in the Arctic and will lend much information about heat transfer, these benefits cannot be quantified at present.

RMF No. 7.2.1

MONITOR OCEAN FOOD SUPPLY

Rationale for Benefits

Good estimates of fish supply are essential for fisheries management to avoid harvesting beyond maximal sustainable yield levels. Monitoring plankton and sea vegetation areas are important from the aspects of determining environmental effects from man and nature in these areas and determining future fields for food harvesting. Beyond the use of sea vegetation for food, it is also being used as an energy source by burning it.

Federal Government Activities and Responsibilities

The MARMAP (Marine Resource Monitoring, Assessment, and Prediction) program of the National Oceanic and Atmospheric Administration is the principle source of information on fishery stocks. Data from MARMAP and related biological and ecological studies are utilized to predict changes in abundance and distribution of fish and shellfish stocks, and to identify and predict man-made effects on the marine ecology and fishery stocks. State and federal officials require this resource information for decisions affecting domestic and international allocation, conservation and management. Commercial and sport fishing interests also use the information to determine where to fish and how to invest funds in new equipment. Funds allocated for this program in FY 1974 are $6,619,000.

Under 15 USC 313 and 16 USC 742, the Secretary of Commerce and the Secretary of the Interior, respectively, are to conduct investigations on the availability and abundance of fish resources. In addition, the Secretary of the Interior is required to make investigations of whether any and what diminution in the number of the food fishes has taken place (16 USC 744).

In addition, there is the Marine Mammal Protection Act of 1972 (16 USC 1361-1407) which requires NOAA to regulate activities for the protection and management of marine mammals as resources of great esthetic and recreational value as well as resources of economic significance. For this activity NOAA has been appropriated $1,990,000. The Bureau of Sport Fisheries and Wildlife also participates in this activity.

Non-Federal Activities

Other national governments, particularly Japan, are involved in activities to determine the size of their fisheries. Private fisheries management also obtain accounts of their fish supplies.

RMF No. 7.2.1

Functions of Remote Sensing

The detection of fish and the given environmental conditions in which a particular species of fish is most likely to be found have been shown to be amenable to remote sensing applications in several studies.* Studies of the direct detection of fish include spectrometer measurement of fish oils, photography of schooling fish for behavioral analysis, spectral and fluorescent properties of fish, and bioluminescence displays resulting from excitation of light producing plankton by the mechanical motion of swimming fish. Remote sensing allows for coverage of more area than by ship at comparable costs.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data.

Were satellite sensing systems able to spot schools of pelagic fish, it would reduce the amount of activity undertaken in the MARMAP program. Spotting of seaweed and kelp might be beneficial in the future if harvesting of ocean vegetation becomes a profitable venture. At present, there is enough quantity at known near-shore locations to make this spotting economically insignificant.

Current ERTS Capabilities

At present, ERTS-1 has not demonstrated sufficient resolution to achieve any of the previously mentioned functions with the exception of a limited amount of fish oil detection. Functions previously mentioned are presently possible from aircraft. ERTS-1 has shown abilities at locating potential fish areas through inferred thermal mapping and plankton detection, but these activities would not contribute toward assessing ocean food stocks.

Estimate of ERTS Economic Capabilities

From the above considerations, we estimate zero economic benefit from an ERTS-like ERS system in this RMF.

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* "Oceanography from Space", Woods Hole Oceanographic Institution Ref. No. 65-10 (1965).
"Oceanography and Meteorology", Report No. DAC-58121, Control No. NASA-21064, Douglas Aircraft Co., Missile and Space Systems Division, Huntingdon Beach, California, (1968).
"Final Report on the Space/Oceanographic Study". General Electric Co., Missile and Space Division, Phila., Pa., (1967).

RMF No. 7.3.1

MONITOR TIDES AND CURRENTS IN COASTAL WATERS

Rationale for Benefits

The single most useful body of data that one could assemble concerning an estuary system would be information from which a realistic model of water movement could be developed for the system.* Almost all else that occurs in the system is controlled by circulation or is strongly related to it. The causes of water movement, such as tides and currents, have been delineated. The integration and correlation of the causes of water movement in an estuarine system are complex problems which have been adequately solved for only a very few simple situations.

The major circulation feature of the Gulf of Mexico is the Loop Current. This flow enters the basin as a well-formed western-boundary current through the Yucatan Straits. It penetrates into the gulf to a varying latitude before it exits through the Straits of Florida. Transporting vast amounts of heat, salt and momentum, the current significantly affects circulation on the shelf, local fisheries, marine transportation, and is thought to be associated with hurricane intensification.

Federal Government Activities and Responsibilities

The National Oceanic and Atmospheric Administration regularly makes marine boundary surveys which consist of the demarcation, delineation, and graphic portrayal of the high and low water tidal basins. All NOAA vessels assigned to hydrographic surveys are equipped with portable tide gages. NOAA's data buoy system provides regular information about currents. NOAA was allocated $2,258,000 in FY 1974 for coastal mapping and marine boundary surveys. Additionally $356,000 is spent on estuarine circulatory observations and predictions. Under 33 USC 883a and b, the Secretary of Commerce is authorized to conduct tide and current observations.

Further, the Army Corps of Engineers engages in extensive port-improvement activities (see Table 7).

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* Bowker, D.E., et al, "Correlation of ERTS Multispectral Imagery with Suspended Matter and Chlorophyll-a in Lower Chesapeake Bay," Symposium of Significant Results Obtained from ERTS-I, March 1973, NASA, p. 1291.

For this purpose, they must have detailed information on harbor tides and currents.

Non-Federal Activities

Individual coastal states have programs for monitoring coastal processes for the purpose of upkeep of local recreational and commercial activities.

Functions of Remote Sensing

Satellite systems with sufficient resolution would be able to study coastal currents and tides on a global basis. Such studies are possible only on local basis at present.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Were a satellite system to have sufficient resolution and sufficient frequency of coverage, predictive models for

Table 7 Army Corps of Engineers Projects for Navigation Improvement

Status of Navigation Improvement Projects	Number of Projects	Total Estimated Federal Cost, $ thousands (1973)
Pre-Construction Planning Required Planning Complete	13	342,471
No Pre-Construction Planning Required	4	28,288
Pre-Construction Planning Underway	26	573,749
Pre-Construction Planning Not Started	40	1,106,345
Planning New Starts	3	50,220
Total	86	2,101,07_

movement of coastal and nearshore structures might be possible. With such models, most efficient preventions against erosion would be more likely and materials and time would be saved.

Harbor Circulation information from remote sensing could reduce the study activities done by the CE significantly. An analysis of this cost-savings has not been pursued in this report.

Current ERTS Activities

Coastal circulation analyses have been used in planning sites for ocean outfalls. A "wealth" of information has been derived on current direction and relative velocities from variations in turbidity patterns.* An illustration of how ERTS imagery can show river/estuarine mixing is shown in Figure 6, page A-48.

Estimate of ERTS Economic Capabilities

From the above considerations, we estimate zero benefits from an ERTS-like ERS system in this area.

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* Hunter, R.E., "Distribution and Movement of Suspended Sediment in the Gulf of Mexico off the Texas Coast," Symposium of Significant Results Obtained from ERTS-1, March 1973, NASA, p. 1345.

RMF No. 7.3.2

MONITOR THE MOVEMENT OF THE MAJOR OCEANIC CURRENTS

Rationale for Benefits

Large masses of warm and cold water are carried into and through sea areas of different temperatures by ocean currents, thus greatly affecting heat transfer and weather over the oceans. The water/air interface is particularly dynamic over these current areas. Knowledge of currents and their seasonal changes will add greatly to long-range weather prediction models. Marine life is carried along by these water movements, sometimes an essential part in the life cycle of sea organisms, sometimes destructive to whole marine communities. Long distance ocean shipping employs information on currents in routing. While there exists general knowledge on current locations, not much is known about speed and seasonal variations.

Federal Government Activities and Responsibilities

The Naval Oceanographic Office undertakes ocean surveys by which they determine several ocean parameters, including current direction and speed. The National Oceanic and Atmospheric Administration has similar operations.

Functions of Remote Sensing

Again, remote sensing is particularly valuable for covering areas where there is little activity, such as shipping, taking place. Another important function of satellites involves the use of IRLS (Interrogation, Recording, and Location Systems) or DCP's (Data Collection Platforms). These buoys can accomplish many of the activities which previously required ocean vessels. The IRLS offers continuous monitoring of sea conditions and their information can be transmitted line-of-sight to satellites.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

It is difficult to find any direct benefits from remote-sensed current information. As the development and cost-efficiency of IRLS improves, satellites will be important features for relaying data.

RMF No. 7.3.2

Current ERTS Activities

Presently ERTS has been shown effective in measuring the boundaries of major currents*:

1. The cyclonic edge of the Loop Current tends to concentrate surface marine algae which appears as a bright lineation marking the edge of the current in ERTS MSS Band 6.

2. The boundary area also concentrates chlorophyll-bearing organisms which can be observed as a shift towards the green recognizable in MSS Band 4.

3. A third observation is the usual change in the sea state across the boundary. It is not uncommon for the sea state to increase from one to two meters when crossing into the current. This increased sea state can be detected because of the higher reflectance when white-caps are present. The total reflectance of water with white-caps is estimated to be 270% higher than without white-caps.

4. With the introduction of thermal infrared, currents will be easily detected due to the changes in temperature across current boundaries. However, temperature differences correlate highly with chlorophyll concentration, so much of the temperature changes can be inferred from chlorophyll measurement. (See Figure 4)

Estimate of ERTS Economic Capabilities

We assign a value of zero to benefits for an ERTS-like ERS system in this area.

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* Maul, G.A., "Remote Sensing of Ocean Currents Using ERTS Imagery," Symposium of Significant Results Obtained from ERTS-1, Vol. I, March 1973, NASA, p. 1367.

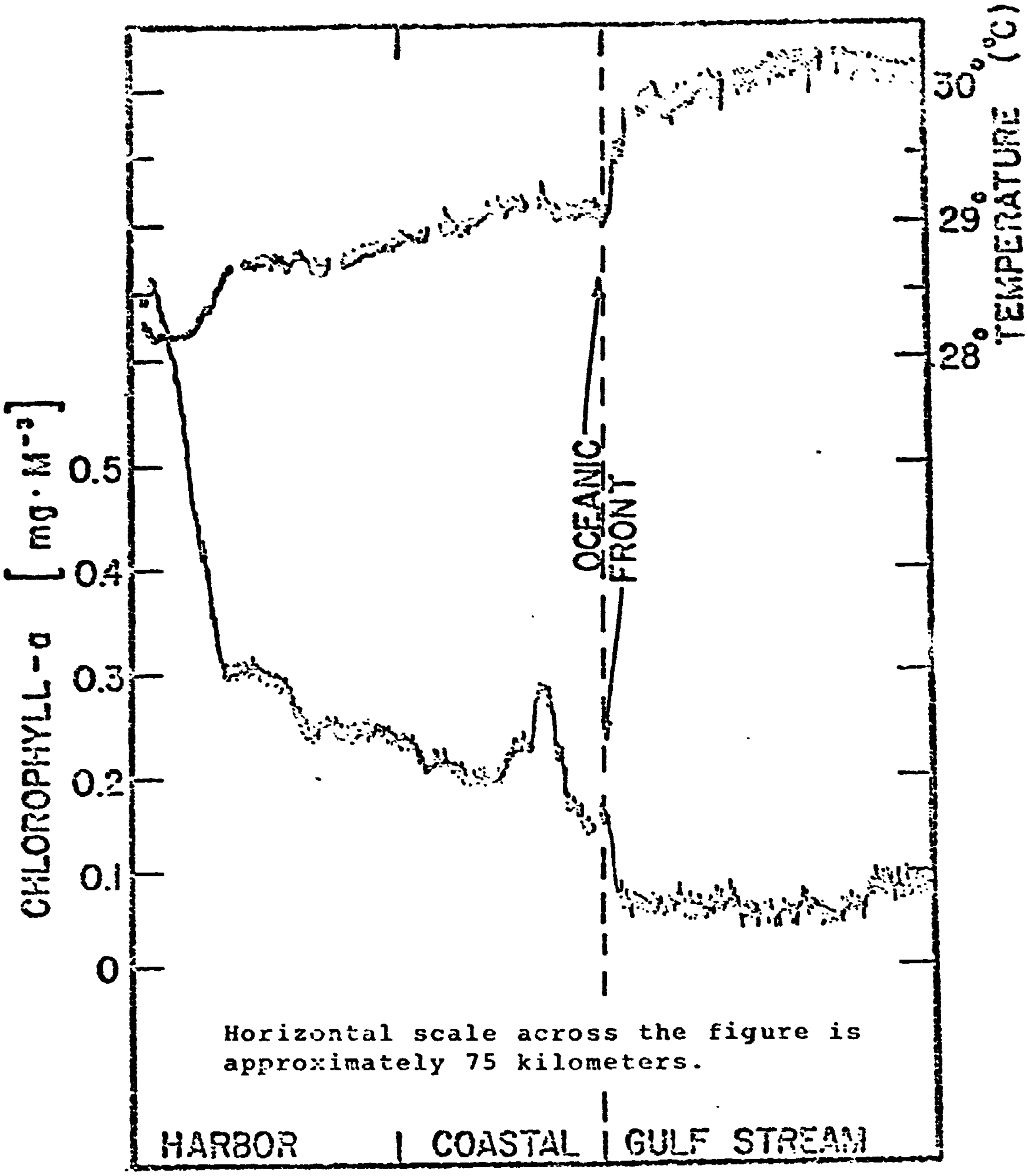

Figure 4 Surface Temperature Trace (upper) and Surface Chlorophyll-A Profile (lower) Across the Loop Current Front and into Key West Harbor.

RMF No. 7.4.1

OPTIMIZE OCEAN FISHERIES MANAGEMENT

Rationale for Benefits

Fishing has always been an economically marginal enterprise. Fishing in many parts of the world is not much different today than it was hundreds of years ago and, although yield per man-year has increased over the years, fishermen are still hunting---and not farming---fish.

Most of the capital in a modern fishery is in vessels, and it must be steadily employed to earn its rent. As vessel investment is the large end of the business, the trick of successful modern fishing is to cut down on fish locating and running time as much as possible and keep the capital (the vessel) on top of the fish every hour and day that can be arranged.

The fishing industry is a volatile one, easily and significantly affected by changes in ocean parameters such as temperature, turbidity, salinity, currents. For ocean fish such as tuna, a change in ocean circulation may, and frequently does, shift the center of fish availability by 2,000 miles.* It depends on where the fishermen are as to whether this results in a "boom" or a "bust". And, if they are caught in the center of population with only two vessels, they still have a "bust".

Thus, what is important about new information is the extent to which it can contribute to predictive models of ocean parameters. Fishing people are primarily interested not in the condition of the sea, but in the deviation of the ocean from a mean state. It is known how fishing will be under certain conditions. What needs to be known is how those conditions will be tomorrow, next day, next month, and, for capital investment purposes, in years to come.

Yet, not only is the increasing efficiency of fish harvesting important, but so is the serious consideration of what is the maximum sustainable yield attainable in fishery areas. Boosting productivity of fishing vessels jeopardizes

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* Stevenson, R.E., "The 200-Mile Fishline", Oceans from Space, 1969, Gulf Publishing Company, Houston, p.29.

the continued profitable life of a fishery through the threat of overfishing, unless a strong management authority exists. The potential for overfishing is stimulated by an economics which offers incentive to overfish to the fisherman who has little responsibility for management. "It is not the husbandman who would kill the goose that lays the golden egg, but the hunter."* We need information on present and future productivity of our important fisheries. So we are faced with not only an efficiency problem, but also an institutional and political problem.

Further difficulties exist. Fish protein will have an increasingly important role as a nutritional source in the world. Fish protein concentrate (FPC), the cheapest source of protein available (see Table 8) in 1972, was sent to foreign countries in order to combat malnutrition, but its use was inhibited in the U.S. due to Food and Drug Administration regulations that it not be sold in quantities greater than one pound. Thus, the efficiency of production and marketing is hurt, driving up the cost. Tastes in consumers make a pound of protein, derived from prime blue fish tuna, three hundred times more expensive than that derived from anchovies.**

Table 8 Amounts of Food and Costs to Provide the Recommended Daily Supply of 70g of Protein

Food Substance	Weight	Cost, $ (1973)
Fish protein concentrate	2-1/4 oz	0.005
Gelatin dessert	10-1/3 oz	0.41
Haddock fillet	12-4/5 oz	0.45
Eggs	17-1/2 oz	0.45
Chuck beef	12-4/5 oz	0.50
Cheddar cheese	10 oz	0.55
Bread	40 oz	0.63
Pork	12-4/5 oz	1.00
Milk	4-3/4 pt	1.02
Fowl (boneless, in jar)	12-4/5 oz	1.20

* "A Report To: The President and the Congress", The National Advisory Committee on Oceans and Atmosphere, First Annual Report, June 30, 1972.

** Peruvian anchovies bring the fisherman $10/ton. Japanese fishermen earn $3,000/ton of tuna. The protein content per pound for the two fish is about the same.

RMF No. 7.4.1

Fish will become an increasingly more important source of food in the future. Animal protein necessary for efficient meat and egg production can be provided most cheaply by fish meal. The yield of ocean fisheries has increased in the past 20 years at a rate considerably greater than the rate of increase of the human population or the rate of increase of other food production. Demand is expected to grow. Resources are available in the ocean to meet it. But competent management is essential and it needs accurate and improved information to make it competent.

Federal Government Activities and Responsibilities

The National Oceanic and Atmospheric Administration and The Bureau of Sport Fisheries and Wildlife engage in comprehensive activities in this function. NOAA's MARMAP program contributes greatly in this area (see RMF 7.7.1). In addition, NOAA has been allocated

- $8,435,000 for State-Federal fisheries management,
- $5,156,000 for Anadromous fisheries restoration and enhancement,
- $2,741,000 for fishery product technology and gear development.

The BSFW has been allocated $18,663,345 for management and improvement of fishery resources.

Legislation for these activities exist under the Commercial Fisheries Research and Development Act of 1964 (16 USC 779a) and the Fish and Wildlife Acts of 1947 (16 USC 758a), 1949 (16 USC 759), 1950 (16 USC 760a), and 1956 (16 USC 742). In addition, there are the Central, Western, and South Pacific Ocean Fisheries Resources Development Act (P.L. 92-444) and the High Seas Fisheries Conservation Bill (HR-4760 and S-1069).

Due to the increasing complexity of fishery negotiations brought about by the rapid advance of technology, the expansion of foreign deep water fishing fleets and the increase in world-wide demand for fishery products, the United States is required to maintain continued attention and expertise in this area. During FY 1975, special attention will be given to maintaining maximum protection for American fisheries interests under existing international mechanism, pending results of the

Law of the Sea (LOS) Conference from which possible modifications from international law and fisheries jurisdiction may emerge.

There are eight commissions established by international conventions with various management authorities. Table 9 is a listing of commissions currently active and their principal areas of concern.

Finally, the terms of 16 USC 1191-1194, October 14, 1966, established the contiguous fisheries zone and support activities within the zone in return for certain preferential rights for American fishing interests on the high seas adjacent to our coastal areas and for foreign abstention from fishing for some species in certain areas. Table 10 is a list of 11 current bilateral agreements.

Table 9 International Commissions for Use of the Sea

Commission	Parties	Area of Concern
International Pacific Halibut Commission	Canada, United States	Halibut Fishery of North Pacific and Bering Sea
International North Pacific Fisheries Commission	Canada, Japan, United States	Fishery Stocks of the North Pacific and Bering Sea
International Pacific Salmon Fisheries Commission	Canada, United States	Sockeye and Pink Salmon of the Fraser River System
North Pacific Fur Seal Commission	USSR, Japan, Canada, United States	North Pacific Fur Seals
International Commission for the Northwest Atlantic Fisheries	Sixteen countries, including United States	Fishery Resources of Northwest Atlantic Ocean
Inter-American Tropical Commission	Seven countries, including United States	Yellowfin Tuna of the Eastern Pacific
International Commission for the Conservation of Atlantic Tunas	Thirteen countries, including United States	Tuna and Tuna-like Fisheries of the Atlantic Ocean
International Whaling Commission	48 countries, including United States	Whale Stocks of the World

Table 10 : Current American Bilateral Fishing Agreements

Principal	Area of Concern	Expiration Date
Canada	Reciprocal Fishing Agreement	April 1974
Japan	Fisheries Agreement	December 1974
Japan	Eastern Bering Sea and Tanner Crab Agreement	December 1974
Poland	Middle Atlantic Agreement	June 1975
Romania	Fisheries in western region of middle Atlantic	December 1975
South Korea	Cooperation in fisheries	December 1977
U.S.S.R.	Fisheries Agreement relating to gear conflicts in fishing operation in North Pacific and Bering Sea	February 1975
U.S.S.R.	Middle Atlantic Agreement	December 1974
U.S.S.R.	Eastern Bering Sea King and Tanner Crab Agreement	February 1975
U.S.S.R.	Contiguous fishing zone	February 1975
U.S.S.R.	Claims resulting from damage to fishing vessels or gear	February 1975

Non-Federal Activities

Various educational institutions are studying fisheries management. In addition, several states provide limited management functions and research and development studies for the improvement of their fisheries.

RMF No. 7.4.1

Functions of Remote Sensing

Remote sensing provides the possibility for improving fish harvesting through two steps: (1) by providing correlation data between fish catch and ocean parameters such as depth, color, temperature, and turbidity, and (2) by providing input for models used to predict these parameters.

If fishery catches and locations can be determined on days of satellite overflights, we can correlate this information with data received from space and we can find, for example, that tuna might be found within a temperature range of 22-25°C with a probability of "a" and within a temperature range of 11-22°C with a probability of "b". Further correlation coefficients can be derived for all measurable parameters and areas of high catch probability can be determined.

In conjunction with weather data, satellite oceanographic data can be utilized in forming and improving predictive models of ocean parameters. It is these models which will be of greatest value to fishermen, but such models will be complex and currently are quite a way from attaining sufficient accuracy for operational use.

However, such information will not be of significant value for existing high-efficiency fisheries, such as the menhaden fishing in the Gulf of Mexico. Remote sensing also has very limited application to fishery management, where the important variables are what is the existing stock and how it is changing.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Estimating economic benefits accruing from satellite data to fisheries is very difficult. There are almost no studies which have tried to improve catch efficiency using such data. Estimates have been made that accurate chlorophyll and temperature mapping have the capability to reduce search costs by 30 percent.*

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* Useful Applications of Earth-Oriented Satellites: Oceanography, 1969, National Academy of Sciences, National Research Council, p.50.

RMF No. 7.4.1

However, due to the highly competitive nature of fisheries and the inaccessibility of their figures, no close estimate of their search costs are available. Guesses at search costs range anywhere from several dollars per ton of fish caught to one-half of the price received for the fish.

The tuna industry appears to be one where remotely-sensed information can be well-used. It has been estimated that a 50% reduction in search time, combined with a 25% increase in catch due to better information, would yield annual cost reductions of about $12 million and a decrease in fleet investment of $6.4 million.*

Current ERTS Activities

Several studies correlating ocean parameters obtained from ERTS data with fish catch have proven successful. Significant correlation has been found between menhaden fish and salinity, water color, and depth shown on ERTS imagery.

Principal investigators in this area are

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Bay St. Louis, MI 39520
601-688-3650

Estimate of ERTS Economic Capabilities

Although it seems evident that significant benefits will accrue to the fishing industry from ERS data, we are unable to assign a firm figure to these benefits. This is because operational use of ERS data has not yet been demonstrated and probably will not be demonstrated until reliable ocean parameter prediction models have been formulated.

* Norton, U.J., "Some Potential Benefits to Commercial Fishing Through Increased Search Efficiency, A Case Study - The Tuna Industry", prepared for the Geological Survey of the U.S. Department of the Interior, January 1969.

RMF No. 7.4.2

OPTIMIZE OCEAN PLANT FOOD HARVESTING

Rationale for Benefits

The oceans represent the largest source of protein known to man. As compared to land yield statistics for grains ---1000 pounds per acre wheat, 3000 pounds per acre hay---the comparable non-farmed annual yield of zooplankton in the Long Island Sound is estimated to be 7800 pounds per acre.* This does not even include vegetation, whose value is potentially enormous. Seaweed is presently being harvested offshore Japan and Australia, and to a small extent in the United States. The harvest of algae such as kelp, agar, and Irish Moss reduces the organic wasteload in coastal areas which contribute to oxygen consumption and the recycle of excess phosphorus and nitrogen. Algae harvesting would help clean polluted waters and provide a valuable food product containing 45 to 50% protein. Alfalfa, containing only 21% protein, sells today for $40 per ton. The observed regeneration of the harvested areas is extremely rapid. Some seaweeds are reported to grow at rates of 6 inches per day. Large thickly matted areas regrew within two weeks of cutting. Further, the increased nitrogen and phosphate pollution of rivers may increase some seaweed production many fold.**

However, consumer tastes seem to be the major drawback in capitalizing in this area. Ocean vegetation is available and relatively inexpensive, but the demand is small so far.

Federal Government Activities and Responsibilities

At present, there are no Federal activities specifically involving this activity.

Functions of Remote Sensing

Remote sensing could be used to monitor the health and growth of seaweed fields and identify new areas for harvest.

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* McHugh, J.L., "Estuarine Nekton", Estuaries, Washington, DC: Publication No.83, American Association for the Advancement of Science, 1967, p.597.

** Ketchum, B.H., "The Flushing of Tidal Estuaries", Estuaries, op.cit.

RMF No. 7.4.2

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

At present, location of ocean vegetation presents no difficulty as such plants are so plentiful; nor does it seem likely that over-harvesting could pose a threat to the continuance of the fields.

Current ERTS Activities

ERTS has demonstrated the ability to detect chlorophyll-a which infers the existence of ocean vegetation.

Estimate of ERTS Economic Capabilities

Due to limited demand and great supply, there are no likely benefits from an ERS satellite system for this function in the near future.

RMF No. 7.4.3

IMPROVE COASTAL ZONE MANAGEMENT

Rationale for Benefit

The coastal United States has always been a very desirable zone. Its aesthetic and economic value make it an area of intensely high, and frequently conflicting, demand. Simply because its bounds are limited, it is a pressure cooker. Over 70% of the population of the United States lives within counties bordering the coast, and the major portion of the industrial capacity of the Nation is located along these same coastlines.* The ocean provides recreation, efficient transportation, water for coolants, and a source of waste dispersal. Every act done in this area involves a serious decision with difficult tradeoffs.

There is the problem of balancing conservation and recreational uses with the equally legitimate needs for increased power and port facilities. Decisions such as this require an appreciation of the state and national interests involved, yet they are typically being made at the local level without due regard for the total implications of the action.

Nearshore waters are highly susceptible to pollutants, whether direct and intentional or the result of surface and subsurface drainage, and most of the species on which our fisheries depend are dependent on waters of the coastal area. A further problem is the significant erosion that affects much of our coast (see RMF No. 7.5.1). The decisions to be made are difficult ones and important ones, and better information can go a long way toward improving these decisions.

Federal Government Activities and Responsibilities

The Coastal Zone Management Act (33 USC 1101), passed in 1972, establishes a basis for a rational program of management and conservation of land and water resources of the nation's coastal areas in cooperation with the coastal states. Twelve million dollars has been appropriated for fiscal year 1974 for the express purpose of encouraging and assisting

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* United States Congress, House, Subcommittee on Oceanography of the Committee on Merchant Marines and Fisheries, National Oceanic and Atmospheric Administration Oversight, Hearings, 29 November 1972, p.99.

states in the exercise of their responsibilities in the coastal zone through the development and implementation of management programs. The responsibilities in this area fall to the National Oceanic and Atmospheric Administration (NOAA). Additionally, NOAA has given $1,400,000 in sea grants for marine socio-economic and legal research to help states in their coastal zone management. The Army Corps of Engineers also has responsibility for upkeep of the shoreline, mostly through beach erosion programs.

Non-Federal Activities

State and local governments have their own laws governing use of coastal areas. Comprehensive state laws and agencies in this area have not existed very long and many states still do not have adequate management functions. However, recent improvements have been made, largely through the support and funding provided by the Coastal Zone Management Act.

Functions of Remote Sensing

Remote sensing provides activities which have great use to coastal zone managers. Monitoring currents and tides yield information useful for planning waste disposal systems and predicting and planning for shore erosion. Significantly, satellites provide the possibility of continuous monitoring of land usage changes and waste disposal, and surveillance for enforcing legislation.

Economic and Technical Models for Estimating Benefits

The New Jersey Department of Environmental Protection has estimated benefits accruing from ERTS-1 to aiding in their management functions. These benefits have come in improved surveillance and cost reduction. The New Jersey DEP estimates $195,000 annually in these areas.* In trying to arrive at potential *national* benefits in this area, we wish to find other regions similar in population and shoreline. With reference to Figure 5, we identify three such similar areas:

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* "Application of ERTS Data to the Regulation, Protection, and Management of New Jersey's Coastal Environment---An Extension of SR-304 ERTS-1 Investigation", New Jersey Department of Environmental Protection and Earth Satellite Corporation, June 1974.

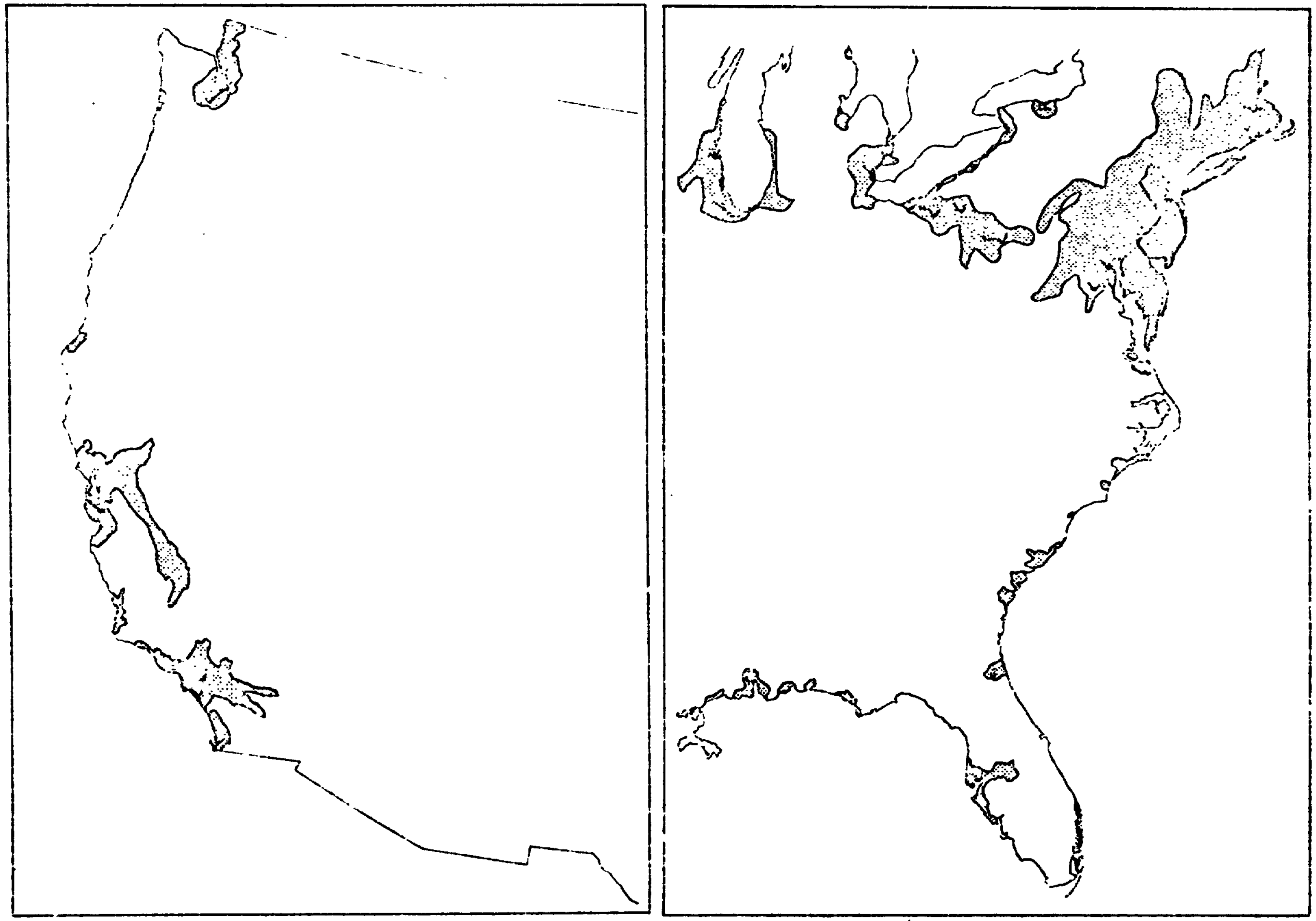

Figure 5 Major Coastal Population Areas

Massachusetts---Rhode Island
New York
Los Angeles---San Diego*

Obviously, there are many other smaller areas than those used here with similar situations to that of New Jersey. In order to keep estimates consistent, and on the conservative side, we limit our extrapolation to these three areas. Agencies with equal jurisdiction and authority to New Jersey DEP may not yet exist in these other regions, but it is likely that they are soon to arise, given the increasing need for coastal zone regulation, and given the stimulus provided nationally through the Coastal Zone Management Act.

Current ERTS Activities

The New Jersey Department of Environmental Protection has authority to control major development within the coastal area of New Jersey. Enforcement of their regulations must deal with two basic situations:

1. Monitoring authorized development projects to insure compliance with permit conditions.

2. Detecting clandestine or unauthorized major land use modifications.

The New Jersey DEP has previously used aircraft photography and ground inspectors, however, this was not a satisfactory method for broad coastal coverage. "Comparison of ERTS images

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* Coastal counties of New Jersey: population, 4,041,000; shoreline, 1792 miles;
Coastal counties of New York: population, 11,574,000; shoreline, 1850 miles;
Coastal counties of Massachusetts---Rhode Island: population, 4,326,000; shoreline, 1903 miles;
Coastal counties of Los Angeles---San Diego: population, 10,439,000; shoreline, 1,100 miles;
Source: World Atlas and Gazeteer, C.S.Hammond & Co., 1966, and U.S.Bureau of the Census, U.S.Census of Population, 1970, Part A.

for the period 10 October 1972 through 7 July 1973 have detected 276 changes. These changes are plotted on 1:24,000 scale photo maps, which are used to guide field inspectors. We have successfully detected changes as small as 2-3 acres."*

Estimate of ERTS Economic Capabilities

Extrapolating from information submitted by New Jersey DEP to the three before-mentioned areas, we arrive at an estimate of 4 X $195,000 = $780,000 annually for this RMF area. It should be pointed out that this extrapolation is a very "loose" procedure; however, we have tried to keep it conservative enough to insure reasonable accuracy. We will use benefits cited by N.J.D.E.P. as a lower bound for our estimation.

Annual Benefits: $780,000

Increased Capability: ($.19 - .78 million)

* Mairs, et al, "Application of ERTS-1 Data to the Protection and Management of New Jersey's Coastal Environment", Earth Satellite Corporation and New Jersey Department of Environmental Protection, Ninth International Symposium on Remote Sensing of Environment, April 1974, Environmental Research Institute of Michigan.

RMF No. 7.4.4

OPTIMIZE OCEAN SHIPPING ROUTES

Rationale for Benefits

Improved shipping routes could yield a higher return on investment for ship owners due to decreased crossing times and hence an increased amount of shipping destinations over time (increased utilization/time). To the purchaser of this service improved routing could mean lower costs and reduced transport time. Superior routes could also lead to a reduction of ocean accidents, saving raw materials and lives.

Federal Government Activities and Responsibilities

The Department of Navy and the National Oceanic and Atmospheric Administration are responsible for maintaining and updating information which are of use in navigation.

Non-Federal Activities

Other national governments and private shipping firms support activities which aid in ship routing.

Functions of Remote Sensing

Remote sensing has impact here in two areas: improved mapping and current detection. Ships frequently have to avoid uncertain areas, thus increasing costs. Satellite imagery offers an inexpensive way to map these areas and keep updated on areas whose conditions are in constant flux, in a way that would not otherwise be possible for shipping purposes. Satellite imagery would be quite useful because knowledge of the entire ocean topography is not necessary; only shallow areas (accessible from satellite) need be mapped. Current detection is another area where remote sensing would be of use. Although the major currents are generally known, changes in them have not been recorded; satellite imagery affords a means for recording these changes.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Benefits from satellite data can be determined by finding how much shipping time has been saved from improved maps, multiplying by the variable cost per shipping hour and subtracting user cost. However, this calculation is very difficult at present for several reasons. One, there are few areas of major shipping routes where ships detour large distances because of uncertain conditions. There are, however, many short detours made for this reason. But, summing up all these detours would be a formidable task. Second, it is not known how many of these areas would prove accessible to satellite mapping due to poor water penetration. Only in some seas, such as the Carribbean, is the water clear and the bottom highly reflective. Further, in only some of the waters chartable by satellite will there be sufficient depth for ships to avoid detours. Estimates of benefit in this area are, therefore, impossible to predetermine.*

Current ERTS Activities

Presently, ERTS has been shown to be able to measure bottom depth up to 17 meters (see RMF No. 7.1.1). Current location detection has also been demonstrated with ERTS imagery (see RMF No. 7.3.2).

Estimate of ERTS Economic Capabilities

Although an ERTS-like ERS system will provide benefits in this area, they are presently unquantifiable. This is due to the fact that one cannot predict what areas such a system will show to be navigable. Also, an ERTS-like satellite system will be significant in ocean routing as new, presently little-traveled, waters come into use.

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* Considerable benefits accrue in ocean shipping from monitoring other parameters, such as sea state. Such sensing requires advanced equipment, particularly active microwave sensors found in the proposed SEASAT satellite system. For an in-depth analysis of benefits in this area, refer to "SEASAT Economic Assessment," a report prepared for NASA by ECON, Inc. under Contract NASW-2558, October 1974.

RMF No. 7.5.1

IMPROVE SHORELINE PROTECTION PROGRAMS

Rationale for Benefits

Shorelines provide unique areas for recreation and habitation in the United States. Ocean marshlands are complex ecozones, supporting a wealth of species frequently not found in any other area. Almost one-half of our population utilizes beaches for recreation annually. The shorelines also provide homes for individuals and businesses.

However, the existence of these important areas is threatened. "Critical" erosion exists on 2,700 of our 37,000 miles of shoreline; two-thirds of this area is privately owned and all of it is under extensive development. "Significant" erosion affects over 40% of our total shoreline. Ironically, much of this erosion is traceable to man-made developments.*

Federal Government Activities and Responsibilities

The United States Army Corps of Engineers is the primary agency active in this area (see Table 14). They are called in, usually by state agencies, to study and design features to impede erosion. Comprehensive legislation for this activity is contained in the Coastal Zone Management Act, 33 USC 1101.

Non-Federal Activities

States request the assistance of the Corps of Engineers and frequently they partially fund work done by the Corps. Local authorities also engage in limited protection activities.

Functions of Remote Sensing

Remote sensing provides the possibility for frequent study of coastal currents, nearshore features and littoral

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* "Critical" erosion is that where action to stop it is felt justified in the light of economic, safety, demographic, or ecological factors. "Significant" erosion is undesirable but efforts to arrest it may not be justified in these terms. "Report on the National Shoreline Study", Department of Army, Corps of Engineers, August 1971.

changes, such as beach erosion. Such information can guide the placement, or lack of it, and design of structures used to impede erosion and can determine the effectiveness of such structures.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

The New Jersey Department of Environmental Protection has determined that ERTS-1 information has provided annual benefits of $75,000 to New Jersey's shore protection program in the areas of "processes/analyses" and "funds allocations".* Because of similar shoreline type, we feel that similar benefits can be extrapolated to the Boston---Cape Cod area.** Clearly, other areas of the entire United States Atlantic coast, whose shore is also sandy, could also benefit from ERTS information to about the same degree as New Jersey. But, because similar studies have not been made for other areas, we conservatively limit our extrapolation to the Massachusetts area. We will not extrapolate to the West Coast, where the shore is largely rocky.

Current ERTS Activities

Very much information about nearshore current patterns has been derived from ERTS-1 imagery.*** To a limited extent, detection of changes in shorelines due to littoral processes has also been demonstrated from ERTS-1.**** And, although the New Jersey Department of Environmental Protection has

*"Application of ERTS Data to the Regulation, Protection, and Management of New Jersey's Coastal Environment---An Extension of SR-304 ERTS-1 Investigation", New Jersey Department of Environmental Protection and Earth Satellite Corporation, June 1974.

**Massachusetts and New Jersey have shorelines of about equal length, 1,519 miles and 1,792 miles, respectively.

***Hunter, R.E., "Distribution and Movement of Suspended Sediment in the Gulf of Mexico off the Texas Coast", Symposium of Significant Results Obtained from ERTS-1, March 1973, NASA, p.1345.

****Slaughter, T.H., "Seasonal Changes of Littoral Transport and Beach Width and Resulting Effect on Protective Structures", ibid.

found ERTS-1 data to be quite useful, the Army Corps of Engineers has not demonstrated ERTS imagery to be of great value for their purposes. They cite a need for higher resolution (up to 50 meters) and greater water penetration, which could be accomplished with the addition of a blue wavelength band to the MSS imager.*

Principal investigators in this area are:

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Estimate of ERTS Economic Capabilities

From information supplied by the New Jersey Department of Environmental Protection and from using a very conservative extrapolation, we estimate benefits of $150,000 annually in this area. The N.J.D.E.P. estimate for New Jersey is the lower bound.

Annual Benefit:

Increased Capability: $.07 - .15 million

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* Miller, G.H. and Berg, D.W., "An ERTS-1 Study of Coastal features on the North Carolina Coast", United States Army Corps of Engineers, Coastal Engineering Research Center, October 1973.

RMF No. 7.5.2

CONTROL OCEAN POLLUTION

Rationale for Benefits

Ocean water contamination has effects with which we are all familiar, the most obvious of which is unusable beaches. Yet, besides the loss of recreation area, pollution hurts marine life production. For example, in 1969, one-fifth of the Nation's ten million acres of shellfish beds were closed due to contamination---a loss of 63 million dollars.* Organic waste pollution increases the growth of certain algae. Such expanded growth dramatically inhibits the productivity of phytoplankton, on which fish populations feed. The same inverse relation also holds true for thermal pollution. The United States Environmental Protection Agency estimates that 13,055,000 fish were killed in 1972 due to water pollution.** Most of the species on which commercial or recreational fishing industries depend are dependent on the waters, wetlands, and bottoms of the coastal margin---those areas most susceptible to pollution. On the other hand, according to some, suspended sediment currently is the most serious and detrimental pollutant in all water bodies. It is estimated that newly developing areas may produce as much as 20,000-30,000 times more sediment than natural undisturbed areas.***

Federal Government Activities and Responsibilities

The Environmental Protection Agency and the Coast Guard through the Federal Water Pollution Control Act (33 USC 1151), and the Department of Commerce, through the Marine Protection, Research, and Sanctuaries Act (P.L. 93-254), are mandated to monitor and survey the quality of United States coastal waters. Under 33 USC 1151, the EPA is to utilize the resources of NASA, NOAA, USGS, and USCG. In this surveillance, NOAA is to spend $4,455,000 in FY 1974 for the purpose of studying "Marine Ecosystems".

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* Council on Environmental Quality, 1970. Ocean Dumping---A National Policy. Washington, DC.

** United States Environmental Protection Agency, Water Quality Office, Pollution-Caused Fish Kills, Annual 1972.

*** "Environmental Currents, 1972, Environmental Science and Technology, Vol.6, No.12, p.965.

RMF No. 7.5.2

Non-Federal Activities

State and local governments also have laws and engage in activities trying to inhibit ocean contamination.

Functions of Remote Sensing

Satellite imagery provides the opportunity for finding sources of pollution. Regular overflights can keep track of both the pollution source and also the movement of pollutants, thus enabling better enforcement of laws prohibiting illegal pollution and better planning of waste disposal areas, so that the waste can be optimally dispersed.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

The New Jersey Department of Environmental Protection has identified several areas, falling within this RMF, in which ERTS imagery has been of benefit. For waste disposal monitoring, they have assigned an annual benefit of \$50,000; for waste disposal site recommendations, annual benefit of \$300,000; for circulation analysis, one-time benefit of \$200,000; and for ocean outfall placement, one-time benefit of \$2,500,000.

Using the same procedure outlined in RMF No. 7.4.3, we extrapolate these state benefits to national benefits by identifying similar areas in which the same benefits could potentially exist. In 7.4.3, we found three areas sufficiently similar in size and population to warrant extrapolation.

Current ERTS Activities

ERTS-1 imagery clearly shows approved dumps of waste in the New York Bight (see Figure 1) and illustrates the routine operational use of similar imagery to monitor the location of barge dumps to assure compliance with regulations and aid in selecting new dump sites. Turbidity patterns shown in ERTS-1 imagery of the Delaware Bay (see Figure 6) indicate specific areas where confluence of currents could result in concentration or dispersal of dumped waste. In the Osaka Bay, Japan, ERTS-1 imagery has shown that dumped wastes do not disperse rapidly, but remain as a stationary or moving mass of water, which is ideal for monitoring, even at only eighteen-day intervals. ERTS has demonstrated the ability to detect acid-wastes, sewage sludge, suspended sediment and surface oils.

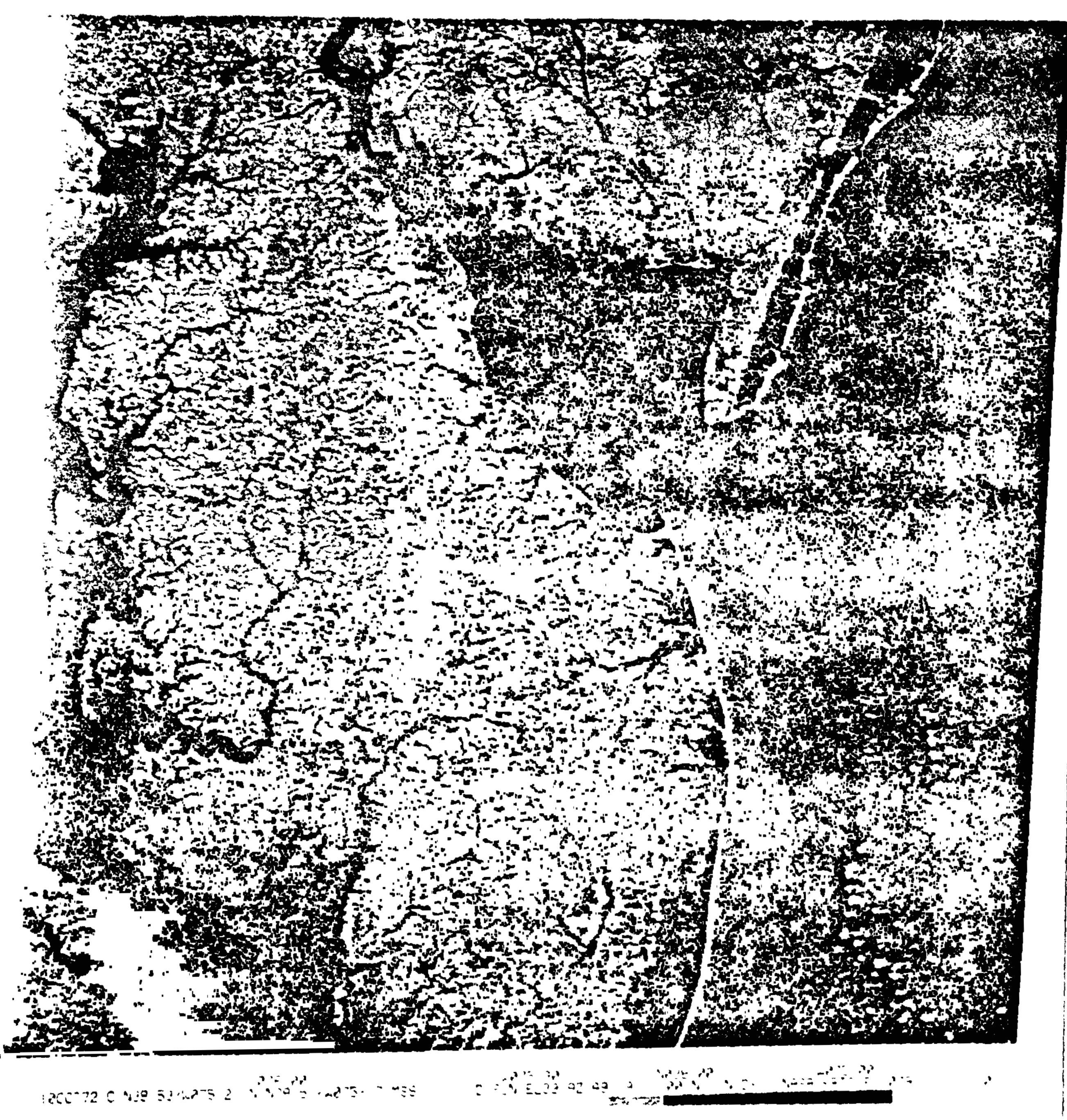

Figure 6 Turbidity Patterns in Delaware Bay

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

RMF No. 7.5.2

Principal investigators in this area are:

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Estimate of ERTS Economic Capabilities

From the above analysis, we estimate economic benefits of an ERTS-like ERS satellite system in this RMF to be 4 X \$350,000 = \$1,400,000 annually, plus 4 X \$2,700,000 = \$10,800,000 one-time, "annualized" to \$1,080,000. The N.J.D.E.P. estimate for New Jersey will be used as a lower bound estimate.

Annual Benefits:

Increased Capability: .62 - 2.5 million

RMF No. 7.5.3

MONITOR OIL SLICKS

Rationale for Benefits

Approximately 60% of the world crude oil production is transported over the oceans; over 2 million tons are spilled annually. Despite spill cleanup costs from representative incidents like Santa Barbara and San Francisco of $4.5 million or $4.0 million, only a small percentage was recovered and prevented from inflicting damage to beaches and the marine ecology. Detection of the spills before they reach shore is the only way to reduce enormous environmental losses because oil can only be recovered while it is still on top of the water. The sooner a slick is detected, the more damage can be avoided; also, the more likely that the offender(s) can be prosecuted.

Federal Government Activities and Responsibilities

Under the Federal Water Pollution Control Act (33 USC 1151), the Environmental Protection Agency and the Coast Guard have responsibility for monitoring coastal and near-coastal water for oil spills. The Coast Guard began an oil spill surveillance program in the summer of 1973. Surveillance is performed by six HU-16 aircraft which provide bi-weekly coverage of part of the United States coastal waterways and weekly coverage of the Great Lakes.

Non-Federal Activities

State and local governments keep up general ocean pollution surveillance programs.

Functions of Remote Sensing

Remote sensing could provide frequent coverage of coastal areas and a satellite equipped with an adequate imaging system could survey waters and detect oil spills with great accuracy. The range of the satellite is greater than that available through ships and aircraft.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

The Coast Guard covers areas of the ocean coast twice weekly and most of the Great Lakes coast once weekly. Areas of coverage on the ocean coast include from Portland, Maine, to North Carolina for about 1,000 miles; Southern Florida, about 300 miles; and California from San Francisco south, about 500 miles.* Total ocean coast coverage is about 1,800 miles. Total Great Lakes coast coverage is about 1,500 miles. Area of coverage is to 12 miles offshore, with areas to 50 miles offshore surveyed about every 3 weeks. The ocean coast (12 miles offshore) is covered 100 times a year (twice weekly). This yields a figure of 1,800 x 12 x 100 = 2,160,000 square miles ocean coastal coverage per year. The Great Lakes coast is covered 50 times a year. This yields a figure of 1,500 x 12 x 50 = 900,000 square miles Great Lakes coastal coverage per year. In addition, an added 38 miles offshore is covered about once every 3 weeks or 16 times a year for a total additional figure of 3,300 (total coastal miles) x 38 x 16 = 2,006,000 for a total coastal coverage of 5,066,000 square miles per year.

This figure bears up reasonably well with dividing the Coast Guard's total budget for this activity; $2.68 million, by their rental cost per hour, $404.31** charged to those who wish to have them survey specified areas, yielding 6,700 flight hours per year. Their aircraft (HU-16 Albatross) fly at a speed of 125 knots or about 140 miles per hour. It takes two passes to cover the 12-mile offshore zone, so each pass covers a 6-mile swath 6 miles x 140 miles per hour = 840 square miles per hour. Eight-hundred forty x 6,700 flight hours per year = 5,628,000 square miles. This figure compares closely with 5,066,000 estimated above, particularly considering that the $2.68 million probably includes some overhead. We divide this 5,628,000 square miles into the yearly budget to arrive at an estimate of average cost per square mile of $.476.

Of this 5,066,000,*** a satellite such as ERTS, in an 18-day cycle, can cover the 3,300 total coastal miles 20 times,

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* Personal conversation, Lt. Bailey, United States Coast Guard Marine Environmental Protection, 16 August 1974.

** Personal conversation, Ibid.

*** We will use this figure as our estimate of total square miles covered. We divided the budget by 5,628,000 square miles in order to stay on the conservative side and to average out the overhead cost.

or 3,300 x 12 x 20 = 792,000 square miles, in one year. This is all the weekly and bi-weekly coverage that an ERTS-like system can accomplish with equal capability. A satellite with an 18-day cycle can also achieve all of the 38-mile zone additionally which is covered every three weeks; this is an added 2,006,000 square miles which Coast Guard aircraft is freed from. Thus, we arrive at a total satellite potential, equal-capability coverage of 2,798,000 square miles.

At aircraft costs previously estimated to be $.476 per square mile, this coverage would cost $1,332,000. At average ERTS image processing costs of $.194 per square mile,* marginal expenditure using an ERTS-like satellite would be $543,000. We, thus, arrive at an equal-capability net benefit of $788,000 to an ERTS-like system. However, if we assume a loss of 30% due to cloud cover, our net benefit figure drops to $552,000 with a coverage of 1,959,000 square miles annually. The shaded region A in Figure 6 represents this equal-capabilities benefit. We will conservatively assume no loss of aircraft coverage due to cloud cover because of the flexibility of aircraft.

Turning to equal-budget analysis, which is particularly applicable in this case, the equal budget partially being used to "necessarily" fill in holes in satellite imagery due to cloud cover, we have as benefit from remote sensing not only Area A (=Area B), but also Area C. Using the formula for an equal-budget (unitary elasticity) demand curve PQ = k - 932,000 PQ = k = 932,000

$$\text{Area B} + \text{Area C} = \int_a^b P\,dQ = k \int_a^b \frac{dQ}{Q} = k \ln \frac{4.31}{1.96}$$

$$= 932{,}000 \times \ln 2.45 = 932{,}000 \times .90$$

$$= 839{,}000$$

$$C = 839{,}000 - B = 839{,}000 - 553{,}000 = 287{,}000$$

We thus have a total net benefit of $552,000 (equal capability) + $287,000 (increased capabilities) = $839,000 annually.

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* "The Role of ERTS in the Establishment and Updating of a Nationwide Land Cover Information System" (Draft), ECON Report prepared for NASA, 5 August 1974, III-19.

RMF No. 7.5.3

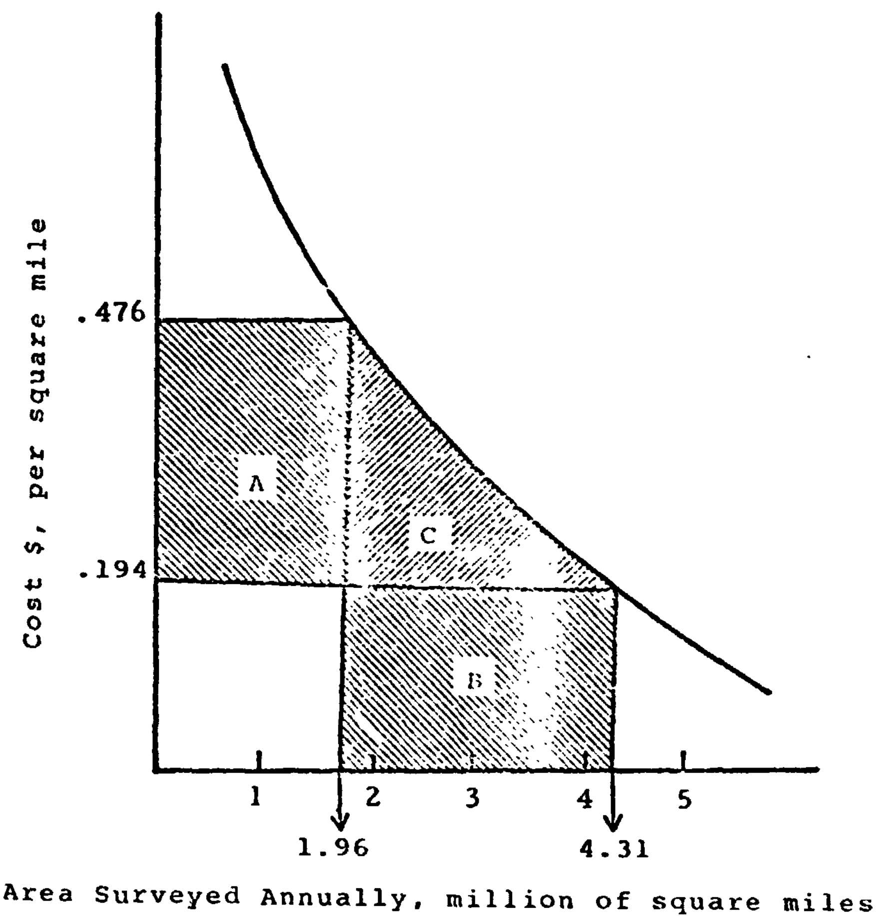

Figure 7 Benefits from Remote Sensing of Oil Spills by 18-day Cycle Sensor (with loss to cloud cover)

RMF No. 7.5.3

Current ERTS Activities

There have been some studies of oil detection, both fish and mineral, but for the purpose of this RMF, it seems that higher resolution and a thermal infrared image would be necessary for accurate oil spill detection.

Estimate of ERTS Economic Capabilities

From the above analyses, we feel that a potential annual benefit of $839,000 is attainable through an ERTS-like system with improved resolution and a thermal IR band added.

Annual Benefit:

Equal Capability: .55 million

Increased Capability: .28 million

RMF No. 7.6.1

REDUCE OCEAN RESOURCES LOSSES DUE TO MAN-MADE CHANGES

Rationale for Benefits

Changes in shoreline structure and composition significantly influence the marine life and other coastal processes. Vital estuarine areas have been destroyed or degraded in the past at a rate of about 1% annually (250,000 acres).* Ocean pollution from construction and waste disposal also pose great threats to marine ecosystems (see RMF No. 7.5.2).

Federal Government Activities and Responsibilities

The National Atmospheric and Oceanic Administration has been allocated funds for this function in two areas: $5,556,000 has been allocated in FY-1974 for ecological investigations to understand man-induced changes in environment and to develop actions to reduce or eliminate losses of marine animals due to these changes; $1,801,000 has been allocated to NOAA for environmental impact analysis to ascertain the environmental and economic effects of proposed projects, to develop recommendations to conserve and protect fishery resources, and to follow up with investigations of the effectiveness of their recommendations. NOAA's responsibility in this area is contained in the Fish and Wildlife Coordination Act of 1958, the National Environmental Policy Act of 1969, the Marine Protection and Sanctuaries Act of 1972, and the Federal Water Pollution Control Act of 1972, as amended.

Functions of Remote Sensing

Satellite sensing offers an opportunity for frequent coverage of areas whose structure needs to be monitored. The most common example would be beach erosion-preventive structures. It is necessary to assess the effects such structures have in order to determine their effectiveness and also to be advised as to possible adverse environmental effects. Actual marine resource losses could only be inferred, but preventive measures could be taken when the situation appears potentially destructive to marine life.

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* United States Congress, House Committee on Appropriations. Hearings of Departments of State, Justice, and Commerce, The Judiciary and Related Agencies Appropriation for 1975, 93rd Congress, p.670.

RMF No. 7.6.1

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

It is not likely that remote sensed data would be useful in forewarning as to ecosystem damage, except in areas in which there is little economic activity. In sucn areas, it would be very difficult to assign monetary benefit to prevented losses.

Current ERTS Activities

Beach erosion studies are being undertaken using ERTS-1 imagery. However, the Army Corps of Engineers has found that ERTS-1 does not provide sufficient resolution to be of significant value in this area.

Estimate of ERTS Economic Capabilities

From the above, we estimate that an ERTS-like ERS system will offer zero quantifiable benefits in this area.

RMF No. 7.7.1

EARLY WARNING OF OCEANIC AND COASTAL AREA DISASTERS

Rationale for Benefits

Hurricanes, tsunami (tidal waves), and large coastal storms are weather phenomena of unusual severity. They pose a significant threat to life and property, often with a short lead time for predictions, warnings, and public response. Timely accurate forecasts and advance warnings of these potential natural disasters allow the public to take actions to protect life and property.

Federal Government Activities and Responsibilities

The National Oceanic and Atmospheric Administration has a public forecast and warning services program to which there has been allocated $37.4 million in FY 1974. Of this, $5.2 million goes specifically for hurricane and tornado warning services.

Non-Federal Activities

Most non-federal activity involves public preparedness programs, under the support and guidance of NOAA.

Functions of Remote Sensing

Satellite sensing provides unique, synoptic ability for forewarning of ocean storms. Satellites used by NOAA are used to detect and chart hurricanes hundreds of miles from the United States, allowing maximum time for disaster-preparation activities on land.

Economic and Technocal Models for Estimating Benefits of Remote Sensed Data

Due to its 18-day cycle, ERTS does not provide the continuous monitoring necessary for this RMF. Therefore, we will not go into constructing models to measure benefits. Instead, we refer the reader to reports on SEASAT, SEOS, NIMBUS, GOES, and NOAA satellites.

Current ERTS Activities

To date, ERTS-1 has not been used in this area.

RMF No. 7.7.1

Estimate of ERTS Economic Capabilities

From the above considerations, we attribute zero benefits from an ERTS-like ERS System in this area.

RMF No. 7.8.1

RESEARCH ON OCEAN PARAMETERS

Rationale for Benefits

As most everyone knows, the oceans cover three-quarters of the surface of the earth. They have a tremendous impact on our weather. Storms come and go at sea sometimes having no effect, and sometimes severe effects, on land. Only tornadoes and earthquakes match the destructive capabilities of hurricanes and severe coastal storms. As has been mentioned earlier (RMF No. 7.1.3), the heat exchange occurring at the water/ice interface in the Arctic may be one of the most important effects in the climate of the Northern Hemisphere.* The dynamic moisture and heat exchange at the water/air interface affects humidity, clouds, air temperature, and pressure zones. Currents, tides, waves, and winds can all feed off each other.

Changes in thermal, salinity, and turbidity contours govern the distribution and availability of fish and other living marine resources. There is room for vast cost reductions to the fishing industries if these parameters can be predicted. Chlorophyll measurement is a prime indicator of plankton. According to Yokto,** satellite monitoring of plankton production "could be considered equivalent to a gauge providing information on life-support systems aboard spacecraft."

Measurement and monitoring of these parameters will lead to the development of predictive models which can have tremendous impact on weather prediction improvement, ocean shipping, and ocean food harvesting.

Federal Government Activities and Responsibilities

Both the Naval Oceanographic Office and National Oceanic and Atmospheric Administration have fleets patrolling and surveying ocean parameters. The National Marine Fisheries Service also does a limited amount of fishery-significant ocean parametric measurement and prediction (see RMF No. 7.8.2).

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* Committee on Polar Research, 1970: Polar Research, A Survey, National Research Council, National Academy of Science, Washington, DC.

** Yokto, H.J., 1972. "The Case for Ocean Color", Fourth Annual Earth Resources Program Review, Houston, Texas.

RMF No. 7.8.1

Functions of Remote Sensing

Remote sensing has three important functions which cannot be provided via other means:

1. Measurement from ships provides discreet sampling from which the condition or surrounding water can be inferred. Satellite imagery offers continuous contours which are essential to complete predictive models.

2. Satellite sensing offers the possibility for gathering information far beyond the range of present ship and aircraft survey programs. This includes not only the middle of the oceans, about which little is known and about which much must be known for long-range forecasts, but also ice areas whose environmental importance has already been mentioned.

3. Satellites allow for the use of ocean-monitoring buoys for continuous monitoring of these parameters. These buoys such as IRLS (Interrogation, Recording, and Location System) and DCPs (Data Collection Platforms) use line-of-sight transmission and must involve the use of satellites or aircraft.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

As is usually the case with research, the benefits are frequently enormous, and yet, because application is so distant, they are very difficult to quantify. Estimates of dollar benefits to be derived from improved and longer-range marine environmental prediction services range from $600 million* to $2 billion** annually.

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* Cost-Benefits for a National Data Buoy System, an essay, Travelers Research Center, October 1967, Prepared under Coast Guard Contract TCG-16790-A.

** Economic Benefits from Oceanographic Research, National Academy of Sciences - National Research Council, Publication 1228, 1964.

RMF No. 7.8.1

Current ERTS Activities

ERTS has demonstrated ability at current location detection, limited current speed measurement using icebergs, water turbidity measurement, relative temperature and salinity measurement, chlorophyll content measurement, and some water depth measurement.

Estimate of ERTS Economic Capabilities

Although considerable potential benefit exists from an ERTS-like ERS system, we feel this benefit is presently unquantifiable.

RMF No. 7.8.2

RESEARCH ON ESTUARINE ECOLOGY

Rationale for Benefits

Estuaries are complex and delicate ecozones whose balance can easily be destroyed. Estuarine areas are a necessary link in the life cycle of about 66% of our fish and shellfish and these vital areas have been destroyed or degraded in the past at a rate of 1% annually (250,000 acres).* Temperature and salinity, whose quantities change in estuaries as a result of tides, land water runoff, and river mouth discharge, are critical environmental factors, especially to spatially fixed species. The danger and possible control of thermal pollution, generally resulting from injection of water used for industrial cooling purposes, are now being studied. Oxygen content, therefore, is a major parameter and is considered to be an index of the "health of the estuary". Extensive losses of bottom dwelling life have been recorded when, due to the injection of organic materials from heavy water runoff following storms, the dissolved oxygen content on the bottom has approached zero. The same result can be produced by bottom flora and fauna which can deprive economically more desirable species of the available oxygen.

Because estuaries provide close access to inexpensive ocean shipping, close access to fish areas, and water for cooling and waste disposal purpose, they are economically attractive locations for industry centers. Seven of the 10 largest metropolitan areas in the world border on estuaries. In this country, about one-third of the population lives and works near an estuarine habitat (see Figure 7).

However, because estuarine areas are so desirable and because they are nearly-closed biological communities, their future living marine resource and aesthetic values are threatened. The recreational value of some areas have become zero. There is evidence, albeit inconclusive, that man has seriously impaired major fishing values, at least in certain estuaries. It is reported that, for example, in the Delaware River estuary,

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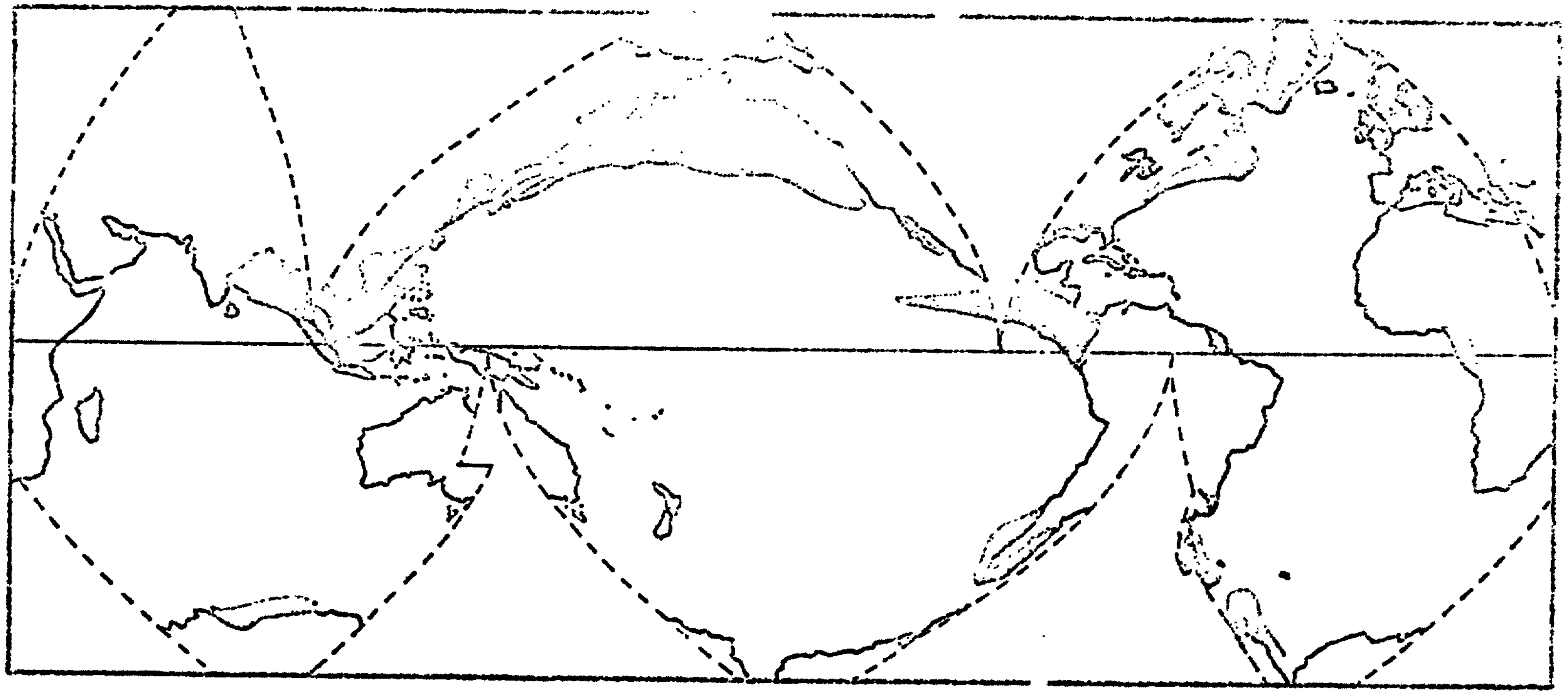
* United States Congress, House Committee on Appropriations Hearings on 1975 Appropriations for the Departments of State, Justice, and Commerce, the Judiciary, and Related Agencies, 93rd Congress, p.670.



Source: J. L. McHugh, "Estuarine Necton", Estuaries, G. H. Lauff (ed.), Washington, D.C.: Publication No. 83, American Association for the Advancement of Science 1967, p. 582.

Figure 8 Offshore Estuarine Zones of the World Ocean Bounded by the 3.35% Isohaline the total fin fish catch is currently less than 10% of its level in 1900.*

Because of their threatened value, we need more information about the structure, content, and dynamic processes of estuaries, in order to evaluate the effect of present and future estuarine activities. This information is also important for possible regeneration of degraded estuarine areas.

Federal Government Activities and Responsibilities

The National Oceanic and Atmospheric Administration partakes in much research which aids in our ability to understand and use our ocean environment. In FY 1974, $6,495,000 was allocated for biological investigations. Under this activity, research is directed toward understanding the basic requirements for life of commercial and recreational fish and shellfish. Fisheries biological investigations are aimed at the following: (1) to determine the population dynamics and life histories of marine and anadromous species of sport and commercial importance; (2) to identify the physiological processes of these animals and to ascertain their environmental requirements for reproduction, growth, and survival; (3) to describe behavior of commercial and recreational species in relation to each other, to their environment, and to the fishing gear used to catch them; and (4) to identify and enumerate the animal and plant histories of marine and anadromous species of sport and commercial importance.

Also, $1,360,000 has been allocated for aquaculture research and technology. $3,800,000 of Sea Grants has been allocated for marine environmental research and $4,600,000 for marine resources development.

Functions of Remote Sensing

Remote sensing provides a means for monitoring estuarine water circulation to aid in assessing waste disposal methods. Water circulation study can point toward areas where protective shoreline structures might be beneficial. Satellite imagery with sufficient resolution may even be able to monitor

* Estimates provided in: Federal Water Pollution Control Administration, Delaware Estuary Comprehensive Study, 1966.

the coastal erosion itself. Measuring chlorophyll will be an indicator of the biological "health" of the estuaries. Temperature of the waters can also be monitored.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Once again, benefits accruing from research are not sufficiently operational to permit quantification.

Current ERTS Activities

ERTS-1 imagery has shown significant capability in this area. Turbidity patterns provide much information as to circulations in the estuaries. Wastes can be detected and followed as they disperse, move inshore or offshore. There have been studies showing the success and accuracy of chlorophyll measurement. Addition of a thermal IR wavelength sensor would provide the necessary temperature information.

Estimate of ERTS Economic Capabilities

From the above considerations, we estimate zero quantifiable benefits from an ERTS-like ERS system, although we recognize many benefits which are not yet operational.

RMF No. 7.9.1

AID IN ENFORCING NATIONAL AND INTERNATIONAL REGULATIONS AND AGREEMENTS

Rationale for Benefits

Foreign fishing vessels pose the threat of overfishing some of our own fisheries. They cannot be managed and restrained by agreements among the fishing vessel owners. Foreign fishing is even subsidized, a luxury not afforded to our own fishermen. As continental shelf drilling and mining become more important, such enforcement will come increasingly into play. We also need to enforce waste disposal regulations for the protection of our coastal waters and beaches.

Federal Government Activities and Responsibilities

The United States Coast Guard is the major coastal water enforcement agency. The Department of Navy and the National Oceanic and Atmospheric Administration ships also aid in this enforcement.

Functions of Remote Sensing

Satellite sensors would be capable of monitoring for detection of oil spills, illegal ocean dumping and other waste disposal, and detecting illegal fishing vessels.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Benefits from an ERS system for enforcement can be estimated by summing the fines and damage awards coming directly from remote sensing of illegal activity. Further benefit is derived from decreased incidence of total violations which result from increased probability of apprehension.

Current ERTS Activities

ERTS imagery has identified dumped wastes and has detected some oil spills. ERTS has not demonstrated sufficient resolution to spot illegal fishing vessels.

Estimate of ERTS Economic Capabilities

Benefits in this area have not yet been demonstrated, although it seems likely that some will be shown in the near future.

RMF No. 7.9.2

AID IN DESIGNING LEGISLATIVE CONTROLS AND ADMINISTRATIVE PROCEDURES

Rationale for Benefits

Pointing out areas where regulation is needed to preserve the aesthetic or economic value of an area is a highly useful activity. Surely some of our waters and beaches have been protected from ruination by needed legislation and enforcement. Yet, there is the possibility that "environmental zealots" can force through legislation which is too restrictive in areas where there is not need for such regulation. Adequate information is necessary to assess the values of arguments proposed by partisan sides.

Federal Government Activities and Responsibilities

The whole purpose of government is to see that the rights of all people are not jeopardized by the activities of some, or many, people. It is the purpose of legislation to see that these rights be preserved in the best manner possible.

Functions of Remote Sensing

Remote sensing can point out areas where continued, unconstrained activity may be unduly harmful. Construction which is damaging to the shoreline can be spotted. Waste disposal which is threatening either marine life or the aesthetic value of the land and water can also be detected. Remote sensing provides a view of the situation which cannot otherwise be realized.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Benefits from remote sensed information in this area can be estimated from the cost of destruction which has been avoided directly from this information.

Current ERTS Activities

ERTS-1 imagery is presently being used in coastal zone management and in deciding on regulations governing waste disposal. ERTS-1 imagery is being used to assess present designated EPA dumping areas. The imagery will help support a case by the New Jersey Department of Environmental Protection with

EPA for possible alternate disposal sites, if the data demonstrate this need.*

Estimate of ERTS Economic Capabilities

The New Jersey Department of Environmental Protection has assessed a one-time value of 100,000 dollars to ERTS-1 information leading to new legislation.**

One-Time Benefit:

Increased Capability: $.1 million

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* Mairs, R.C. et al., "Application of ERTS-1 Data to the Protection and Management of New Jersey's Coastal Environment", Ninth International Symposium on Remote Sensing of Environment, April 1974, Environmental Research Institute of Michigan, Ann Arbor.

** "Application of ERTS Data to the Regulation, Protection and Management of New Jersey's Coastal Environment - An Extension of SR-304-ERTS-1 Investigations", New Jersey Department of Environmental Protection and Earth Satellite Corporation, June 1974.

APPENDIX B:

SUMMARY OF APPLICABLE FEDERAL BUDGETS

Included in this appendix are relevant Federal budgets for U.S. agencies important to this resource area. Table 11 lists applicable budget figures for the National Oceanic and Atmospheric Administration, and Table 12 for the Bureau of Sport Fisheries and Wildlife. Table 13 lists all federal marine mapping and charting costs for several agencies. Table 14 gives ocean-related engineering construction costs for the U.S. Army Corps of Engineers.

Table 11: Applicable Federal Budgets: National Oceanic and Atmospheric Administration

Activity: Mapping, charting, and surveying services
Subactivity: Aeronautical chart services

(Dollar amounts in thousands)

	1974 Adjusted		1975 Estimate		Inc.(+) or Dec.(-)	
	Perm. Pos.	Amount	Perm. Pos.	Amount	Perm. Pos.	Amount
Visual charting	72	$1,731	72	$1,731	...	...
Instrument charting	61	1,583	61	1,583	...	...
Aero charting research	7	116	7	115	...	...
Total requirements	140	3,430	140	3,430	...	...

Activity: Mapping, charting, and surveying services
Subactivity: Nautical chart services

	Perm. Pos.	Amount	Perm. Pos.	Amount	Perm. Pos.	Amount
Hydrographic surveys:						
Analysis and processing	83	$1,566	83	$1,556	...	...
Hydrographic field parties	29	1,469	29	1,469	...	...
Vessels:						
FAIRWEATHER	78	1,833	78	1,918	...	+580
MT. MITCHELL	79	1,904	79	1,934	...	+30
RAINIER	74	1,838	74	1,918	...	+80
DAVIDSON	41	1,003	41	1,003	...	...
McARTHUR	37	1,001	37	1,001	...	...
PEIRCE	35	932	36	1,081	...	+99
WHITING	37	931	37	1,026	...	+45
RUDE/HECK	24	612	24	657	...	+45
Total Vessels	405	10,159	405	10,588	...	+429
Total hydrographic surveys	519	13,194	518	13,623	...	+429
Charts and publications	230	6,864	230	8,449	...	+1,585
Nautical chart research	6	142	6	142	...	...
Total requirements	754	20,200	754	22,214	...	+2,014
Capital outlay: (Amounts shown are included in amounts above)						
Hydrographic surveys	...	...	...	(429)	...	(+429)
Charts and publications	...	...	...	(1,585)	...	(+1,585)
Total, capital outlay	...	...	...	(2,014)	...	(+2,014)

Activity: Mapping, charting, and surveying services
Subactivity: Ocean mapping, investigations, and services

	Perm. Pos.	Amount	Perm. Pos.	Amount	Perm. Pos.	Amount
Ocean investigations:						
OCEANOGRAPHER	88	$2,447	85	$2,447	...	...
RESEARCHER	74	2,272	74	2,272	...	...
Structure and motion of the oceans research	97	2,143	97	2,143	...	...
Total requirements	259	6,862	256	6,862	...	...

Activity: Mapping, charting, and surveying services
Subactivity: Coastal mapping and services

	Perm. Pos.	Amount	Perm. Pos.	Amount	Perm. Pos.	Amount
Coastal mapping and marine boundary surveys	114	$2,258	114	$2,258	...	...
Estuarine and lake investigations:						
FERREL	21	502	21	502	...	...
Great Lakes engineering studies and measurements	11	374	11	374	...	...
Tide observations and predictions	42	1,019	42	1,019	...	...
Circulatory observations and predictions	11	356	11	771	...	+415
Subtotal	85	2,251	85	2,666	...	+415
Great Lakes research	35	910	35	910	...	...
Total requirements	233	5,419	233	5,834	...	+415

Table 11: Applicable Federal Budgets:
National Oceanic and Atmospheric Administration
(con't)

Activity: Mapping, charting, and surveying services Subactivity: Geodetic surveys and services	1974 Adjusted Perm. Pos.	1974 Adjusted Amount	1975 Estimate Perm. Pos.	1975 Estimate Amount	Inc.(+) or Dec.(-) Perm. Pos.	Inc.(+) or Dec.(-) Amount
	(Dollar amounts in thousands)					
National geodetic control network	267	$5,214	271	$6,714	+4	+$1,500
Network maintenance	23	502	23	502	...	...
Crustal movement investigations	12	316	12	315	...	...
Marine and satellite applications	19	526	19	525	...	...
Geodetic research	21	696	21	696	...	...
Total requirements	342	7,254	3[illegible]	8,75[illegible]	+4	+1,500
Activity: Mapping, charting, and surveying services Subactivity: Ship bases and program support						
Atlantic Marine Center	46	$1,117	46	$1,117	...	...
Pacific Marine Center	37	1,004	37	1,004	...	...
[illegible] program support	39	1,133	39	2,451	...	+$1,318
Total requirements	122	3,254	122	4,572	...	+1,318
Activity: Ocean fisheries and living marine resources Subactivity: Resource research and assessment						
Resource surveys	243	$5,519	248	$5,619	...	...
Survey data processing, analysis, and dissemination	76	2,193	76	2,193	...	...
Biological investigations:						
Analysis and processing	122	3,265	122	3,263	...	...
Ship Support						
ALBATROSS IV	19	799	19	[illegible]	...	...
DELAWARE II	17	503	17	503	...	...
GEORGE M. BOWERS	2	58	2	93	...	...
OREGON II	17	593	17	593	...	...
DAVID STARR JORDAN	15	609	15	709	...	+$100
JOHN N. COBB	8	281	8	281	...	...
TOWNSEND CROMWELL	...	...	15	400	+15	+400
MURRE II	2	65	2	65	...	...
[illegible]ECON	8	274	8	274	...	...
Subtotal, vessels	89	3,227	104	3,807	+15	+550
Subtotal, biological investigations	211	6,495	226	7,075	+15	+550
Biological investigations	209	$5,555	209	$5,556	...	...
Marine mammal conservation	63	1,990	75	2,940	+12	+$950
Total requirements	807	22,853	834	24,383	+27	+1,530
Capital outlays: (Amounts shown are included in amounts above) Biological investigations: DAVID STARR JORDAN	...	...	...	(100)	...	(+100)
Activity: Ocean fisheries and living marine resources Subactivity: Resource management and development						
State-Federal fisheries management	76	$3,435	81	$8,935	+5	+$500
Enforcement and surveillance	63	1,878	76	2,378	+13	+500
Environmental impact analysis	67	1,801	74	2,301	+7	+500
Anadromous fisheries restoration and enhancement	69	5,156	69	5,156	...	...
Statistical and economic services	139	3,343	139	3,343	...	...
Aquaculture research and technology	43	1,360	43	1,360	...	...
Fishery product technology and gear development	43	2,741	43	2,741	...	...
Total requirements	500	24,714	525	26,214	+25	+1,500

Table 11: Applicable Federal Budgets: National Oceanic and Atmospheric Administration (con't)

(dollar amounts in thousands)

	1974 Adjusted		1975 Estimate		Inc.(+) or Dec.(-)	
	Perm. Pos.	Amount	Perm. Pos.	Amount	Perm. Pos.	Amount
Activity: Ocean fisheries and living marine resources Subactivity: Fisheries financial support services						
Federal ship financing fund	18	$349	18	$349	...	...
Fisheries loan fund	8	203	8	203	...	...
Vessel construction subsidy	...	24	...	24	...	...
Capital construction fund	9	258	9	258	...	...
Total requirements	35	834	35	834	...	...
Activity: Marine ecosystem analysis and ocean dumping Subactivity: Marine ecosystems investigations						
Regional projects and ocean dumping research	29	$2,431	39	$3,931	+10	+$1,500
Effects of marine environmental alterations	19	1,015	19	1,015	...	...
Manned underwater support	18	1,009	18	1,409	...	+400
Total requirements	66	4,455	76	6,355	+10	+1,900
Activity: Sea grant Subactivity: Sea grant						
Marine environmental research	...	$3,300	...	$5,200	...	+$2,400
Marine technology development	...	3,300	...	5,300	...	+2,000
Marine resources development	...	4,600	...	4,600	...	...
Marine socio-economic and legal research	...	1,400	...	1,400	...	...
Marine advisory service	...	4,500	...	4,500	...	...
Marine education and training	...	1,400	...	1,400	...	...
Program management	23	879	23	879	...	...
Total requirements	23	15,579	23	23,279	...	+4,400

Table 12: Applicable Federal Budgets: Bureau of Sport Fisheries and Wildlife

Activity	FY 1973 Amount Available	FY 1974 Amount Available	FY 1975 Estimate	Increase(+) or Decrease(-) 1975 Compared with 1974
1. Habitat preservation	$11,120,114	$12,405,000	$16,801,000	$+4,393,000
2. Wildlife resources	33,555,658	33,237,609	45,642,000	+7,354,391
3. Fishery resources	18,663,345	21,340,000	23,123,000	+1,783,000
4. Endangered species	4,095,233	4,660,000	5,527,000	+857,000
5. Interpretation and recreation...	5,705,252	5,670,000	6,039,000	+419,000
6. Administration	3,227,115	3,623,000	3,913,000	+290,000
Unobligated balance lapsing	85,034			
Totals	76,452,761	85,935,609	101,095,000	+15,106,391

Table 13 Applicable Federal Budgets: Federal Marine Mapping

Agency	Systematic Mapping and Charting (FY 1972 Expenditures)			
	Nautical Charting		Bathymetric Mapping	
	$ thousands (1972)	Man Years	$ thousands (1972)	Man Years
DEPARTMENT OF DEFENSE				
Defense Mapping Agency	- (342)	-	-	-
Office of Naval Research	-	-	-	-
Navy Operations	-	-	12,799	197
Corps of Engineers, U. S. Army	37	1	-	-
Mississippi River Commission, U. S. Army	15	1	-	-
TOTAL - DEFENSE	52 (342)	2	12,799	197
DEPARTMENT OF THE INTERIOR				
Geologic Division, Geological Survey (GS)	-	-	-	-
Conservation Division, GS	-	-	-	-
Bureau of Reclamation	-	-	-	-
TOTAL - INTERIOR				
DEPARTMENT OF COMMERCE				
National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA)	20,635	1,012	906	46
Environmental Data Service, NOAA	-	-	-	-
Environmental Research Laboratories, NOAA	-	-	-	-
National Marine Fisheries Service, NOAA	-	-	-	-
TOTAL - COMMERCE	20,635	1,012	906	46
DEPARTMENT OF TRANSPORTATION				
U. S. Coast Guard	1,856	181	2,350	241
INDEPENDENT AGENCIES				
Atomic Energy Commission	-	-	-	-
National Science Foundation	-	-	-	-
Tennessee Valley Authority	26	1	-	-
TOTAL - INDEPENDENT AGENCIES	26	1		
TOTAL	22,569 (342)	1,196	16,055	484

Table 13 Applicable Federal Budgets: Federal Marine Mapping (cont'd)

Agency	Systematic Mapping and Charting (FY 1972 Expenditures)			
	Geophysical Mapping		Subtotal	
	$ thousands (1972)	Man Years	$ thousands (1972)	Man Years
DEPARTMENT OF DEFENSE				
Defense Mapping Agency	-	-	- (342)	-
Office of Naval Research	-	-	-	-
Navy Operations	1,888	18	14,687	215
Corps of Engineers, U. S. Army	-	-	37	1
Mississippi River Commission, U. S. Army	-	-	15	1
TOTAL - DEFENSE	1,888	18	14,739 (342)	217
DEPARTMENT OF THE INTERIOR				
Geologic Division, Geological Survey (GS)	-	-	-	-
Conservation Division, GS	-	-	-	-
Bureau of Reclamation	-	-	-	-
TOTAL - INTERIOR				
DEPARTMENT OF COMMERCE				
National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA)	1,950	90	23,491	1,148
Environmental Data Service, NOAA	125	5	125	5
Environmental Research Laboratories, NOAA	-	-	-	-
National Marine Fisheries Service, NOAA	-	-	-	-
TOTAL - COMMERCE	2,075	95	23,616	1,153
DEPARTMENT OF TRANSPORTATION				
U. S. Coast Guard	-	-	4,206	422
INDEPENDENT AGENCIES				
Atomic Energy Commission	-	-	-	-
National Science Foundation	7,800	-	7,800	-
Tennessee Valley Authority	-	-	26	1
TOTAL - INDEPENDENT AGENCIES	7,800		7,826	1
TOTAL	11,763	113	50,387 (342)	1,793

Table 13 Applicable Federal Budgets: Federal Marine Mapping (cont'd)

Agency	Scientific and Engineering Surveys (FY 1972 Expenditures)			
	Hydrographic		Bathymetric	
	$ thousands (1972)	Man Years	$ thousands (1972)	Man Years
DEPARTMENT OF DEFENSE				
Defense Mapping Agency	-	-	-	-
Office of Naval Research	-	-	-	-
Navy Operations	-	-	11,865	84
Corps of Engineers, U. S. Army	6,662	395	-	-
Mississippi River Commission, U. S. Army	560	34	-	-
TOTAL - DEFENSE	7,222	429	11,865	84
DEPARTMENT OF THE INTERIOR				
Geologic Division, Geological Survey (GS)	-	-	-	-
Conservation Division, GS	-	-	-	-
Bureau of Reclamation	162	12	-	-
TOTAL - INTERIOR	162	12		
DEPARTMENT OF COMMERCE				
National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA)	-	-	-	-
Environmental Data Service, NOAA	-	-	-	-
Environmental Research Laboratories, NOAA	-	-	-	-
National Marine Fisheries Service, NOAA	-	-	-	-
TOTAL - COMMERCE				
DEPARTMENT OF TRANSPORTATION				
U. S. Coast Guard	-	-	-	-
INDEPENDENT AGENCIES				
Atomic Energy Commission	-	-	-	-
National Science Foundation	-	-	-	-
Tennessee Valley Authority	83	5	-	-
TOTAL - INDEPENDENT AGENCIES	83	5		
TOTAL	7,467	446	11,865	84

Table 13 Applicable Federal Budgets: Federal Marine Mapping (cont'd)

Agency	Scientific and Engineering Surveys (FY 1972 Expenditures)			
	Geophysical		Oceanographic	
	$ thousands (1972)	Man Years	$ thousands (1972)	Man Years
DEPARTMENT OF DEFENSE				
Defense Mapping Agency	-	-	-	-
Office of Naval Research	21,700	50	32,300	380
Navy Operations	2,500	20	8,549	88
Corps of Engineers, U. S. Army	-	-	-	-
Mississippi River Commission, U. S. Army	-	-	-	-
TOTAL - DEFENSE	24,200	70	40,849	468
DEPARTMENT OF THE INTERIOR				
Geologic Division, Geological Survey (GS)	3,290	59	-	-
Conservation Division, GS	3,243	150	-	-
Bureau of Reclamation	-	-	-	-
TOTAL - INTERIOR	6,533	209		
DEPARTMENT OF COMMERCE				
National Ocean Survey, National Oceanic and Atmospheric Administration (NOAA)	-	-	-	-
Environmental Data Service, NOAA	-	-	-	-
Environmental Research Laboratories, NOAA	3,377	166	3,434	137
National Marine Fisheries Service, NOAA	-	-	21,285	1,091
TOTAL - COMMERCE	3,377	166	24,719	1,228
DEPARTMENT OF TRANSPORTATION				
U. S. Coast Guard	550	53	7,223	853
INDEPENDENT AGENCIES				
Atomic Energy Commission	90	1	-	-
National Science Foundation	12,500	-	29,800	-
Tennessee Valley Authority	-	-	-	-
TOTAL - INDEPENDENT AGENCIES	12,590	1	29,800	
TOTAL	47,250	499	102,591	2,549

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers

PRE-CONSTRUCTION PLANNING IS COMPLETE
$ thousands (1973)

Div	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete
	NAVIGATION			
NPD	Kake Harbor, Alaska (1958)	3,150	180	2,970
SPD	Port San Luis Obispo, Calif. (1965)	5,130	393	4,737
SAD	Panama City Harbor, Fla. (1972)	2,850	110	2,740
POD	Ala Wai Harbor, Hawaii (1968)	363	54	309
POD	Barbers Point Harbor, Hawaii (1965)	18,080	268	17,812
POD	Honolulu Harbor, Hawaii (1965)	3,920	82	3,838
POD	Nawiliwili Small Boat Harbor, Hawaii (1965)	758	75	683
POD	Lahaina Small Boat Harbor, Hawaii (1965)	1,440	75	1,365
ORD	Mound City Lock & Dam, Ill. (1909)	211,000	1,539	209,461
NCD	Cedar River Harbor, Mich. (1965)	1,020	58	962
NAD	Moriches Inlet, N.Y. (1960)	9,760	470	9,290
SAD	Cooper River, Charleston Harbor, S.C. (1968)	74,000	1,500	72,500
SWD	Brazos Island Harbor, Texas (1960)	11,000	31	10,969
	TOTAL - NAVIGATION - Planning Complete (13 Projects)	342,471	4,835	337,635
	BEACH EROSION CONTROL			
SWD	Corpus Christi Beach, Texas (1970)	1,060	64	996
	TOTAL - BEACH EROSION CONTROL (1 project)	1,060	64	995

Table 14: Applicable Federal Budgets:
U.S. Army Corps of Engineers
(con't)

NO PRE-CONSTRUCTION PLANNING REQUIRED PRIOR TO CONSTRUCTION
$ thousands (1973)

Div	Project and State	Estimated Federal Cost
	NAVIGATION	
SAD	Tampa Harbor (Branch), Fla.	18,700
LMV	Mississippi River, Baton Rouge to Gulf of Mexico, La. (1945)	8,990
NAD	St. Georges Creek, Md. (1970)	475
NCD	Two Rivers Harbor, Wis.	123
	TOTAL - NAVIGATION (4)	28,288
	BEACH EROSION CONTROL	
NED	Silver Beach to Cedar Beach, Conn. (1954)	156
NED	Brant Rock, Mass. (1960)	237
NED	Clark Point, Mass. (1962)	235
NED	Lynn-Nahant Beach, Mass. (1954)	835
NED	North Scituate, Mass. (1960)	170
NED	Plymouth Town Beach, Mass. (1960)	168
NED	Thumpertown Beach, Mass. (1960)	135
NED	Town Neck Beach, Mass. (1960)	388
NED	Winthrop Beach, Mass. (1960)	407
NCD	St. Joseph Shore, Mich. (1958)	1,310
NED	Hampton Beach, N.H. (1962)	911
NAD	Perth Amboy, New Jersey (1965)	82
NAD	Stone Harbor, New Jersey (1960)	403
NCD	Crane Creek State Park, Ohio (1962)	3,780
SAD	San Juan & Vic., Puerto Rico (1962)	380
	TOTAL BEACH EROSION CONTROL (15)	9,597

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

PRE-CONSTRUCTION PLANNING UNDERWAY
$ thousands (1973)

Div.	Project and State	Estimated Federal Cost FY 1974	Allocations thru FY 1974	Balance to Complete After FY 1974	Approved Budget Allowance FY 1975	Balance to Complete After FY 1975
	NAVIGATION					
SAD	Mobile Harbor, Ala. (1970)	10,780	110	10,670	125	10,545
NPD	Hoonah Harbor, Alaska (1972)	5,410	75	5,335	100*	5,235
NPD	Metlakatla Harbor, Alaska (1972)	3,170	60	3,110	80*	3,030
SPD	Bodega Bay, Calif. (1965)	1,570	100	1,470	80*	1,390
SPD	Humboldt Harbor, Calif. (1968)	4,050	50	4,000	48	3,952
NAD	Delaware Bay to Chesapeake Bay WW, Del., Md. & Va. (1970)	11,225	290	10,935	75*	10,860
POD	Waianae Harbor, Hawaii (1965)	2,030	120	1,910	125*	1,735
NCD	Ill. WW, Duplicate Locks, Ill. & Ind.	417,000	1,904	415,096	210	414,886
LMVD	Vermilion Lock, La. (1909)	9,930	442	9,533	100	9,438
NCD	Ludington Harbor, Mich. (1970)	2,770	155	2,615	80	2,535
NCD	Tawas Bay Harbor, Mich. (1965)	955	60	895	130*	765
NCD	Beaver Bay Harbor, Minn. (1945)	1,320	50	1,270	40	1,230
NCD	Lutsen Harbor, Minn. (1945)	1,560	50	1,510	60	1,450
NAD	Corsons Inlet & Ludlam Beach, N.J. (1970)	6,190	65	6,125	100	6,025
NAD	Great Egg Harbor Inlet and Peck Beach, N.J. (1970	7,268	125	7,143	75	7,068
NCD	Cattaraugus Harbor, N.Y. (1963)	2,600	160	2,440	120	2,320
SAD	Manteo (Shallowbag) Bay, N.C. (1970	18,200	60	18,140	65	18,075
NCD	Huron Harbor, Ohio (1962)	5,740	75	5,665	100	5,565
NPD	Coos Bay, Oregon (1970)	13,600	161	13,439	139*	13,300
SAD	Little River Inlet, S.C. & N.C. (1972)	8,500	75	8,425	250	8,175
SAD	Murrells Inlet, S.C. (1972)	6,200	150	6,050	250	5,800
SWD	Freeport Harbor, Texas (1970)	18,300	100	18,200	150	18,050
SWD	Mouth of Colorado River, Texas (1963)	11,400	410	10,990	[illegible]*	10,840
SWD	Texas City Channel (Industrial Canal), Texas (1972)	3,120	40	3,080	90*	2,990
	TOTAL - NAVIGATION (24 Projects)	572,938	4,83[illegible]	568,101	2,742	565,359
	BEACH EROSION CONTROL					
SAD	Duval County, Florida (1965)	7,630	120	7,510	130*	7,380
NED	Revere Beach, Mass. (1970)	1,850	110	1,740	150*	1,590
	TOTAL - BEACH EROSION (2 Projects)	9,480	230	9,250	280	8,970

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

PRE-CONSTRUCTION PLANNING IS UNDERWAY
$ thousands (1973)

Div.	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete
	NAVIGATION			
POD	[illegible] Kahai Light Draft Harbor, Hawaii (1965)	685	35	650
NCD	Clinton Small Boat Harbor, Iowa (1952)	76	10	65
	TOTAL - NAVIGATION (2 projects)	762	45	716
	BEACH EROSION CONTROL			
NCD	Lakeview Park, Ohio (1954)	1,260	100	1,150
	TOTAL - BEACH EROSION CONTROL (1 project)	1,260	100	1,160

PRE-CONSTRUCTION PLANNING HAS NOT BEEN STARTED
$ thousands (1973)

Div	Project and State	Estimated Federal Cost
	NAVIGATION	
SAD	Montgomery to Gadsden, Ala. (1965)	253,000
SAD	GIWW, St. Marks to Tampa, Fla. (1968) (Ecological Study)	137,000
POD	Hanalei Small Boat Harbor, Hawaii (1965)	732
POD	Hana Small Boat Harbor, Hawaii (1965)	3,450
POD	Kailua Small Boat Harbor, Hawaii (1965)	500
POD	Kaunakakai Deep Draft Harbor, Hawaii (1962)	15,025
POD	Kikiaola Small Boat Harbor, Hawaii (1968)	374
POD	Maalaea Harbor, Hawaii (1968)	755
POD	Nawiliwili Harbor, Hawaii (1970)	2,270
POD	Reeds Bay Small Boat Harbor, Hawaii (1965)	505
NCD & LMV	Mississippi River between Missouri River and Minneapolis, 9-ft Channel (3 Districts), Ill., Iowa, Minn, Mo. & Wisc. (1930 & 35)	24,058
NCD	Keokuk Small Boat Harbor, Iowa (1962)	371
LMV	GIWW, New Orleans-Houston (Louisiana Section) (1970)	43,700

C-2

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

PLANNING NEW STARTS IN F.Y. 1975 BUDGET
$ thousands (1973)

Div.	Project & State	Estimated Federal Cost	Allocations FY 1974	Approved Budget Amount FY 75	Balance to Complete After FY 75
	NAVIGATION				
NED	Edgartown Harbor, Mass. (1970)	2,270	0	40	2,230
ORD	Grays Landing Lock & Dam, Pa. (1969)	45,800	0	100	45,700
NCD	Northport Harbor, Wisc. (1972)	2,150	0	40	2,110
	TOTAL - NAVIGATION (3)	50,220	0	180	50,040

CONSTRUCTION NEW STARTS IN F.Y. 1975 BUDGET
$ thousands (1973)

Div.	Project and State	Total Estimated Federal Cost	Allocations thru FY 74	Balance to Complete After FY 74	Budget Allowance FY 75	Balance to Complete After FY 75
	NAVIGATION					
SAD	Tampa Harbor-(Main Channel), Fla. (1970)	97,500	1,083	96,417	900	95,517
LMV	Calcasieu River at Devils Elbow, La. (1970)	4,930	150	4,780	200	4,580
NED	Frenchboro Harbor, Maine (1970)	[illegible]	85	765	200	565
SAD	Morehead City Harbor, N.C. (1970)	4,140	160	3,980	200	3,780
	TOTAL - NAVIGATION (4)	107,420	1,478	105,942	1,500	104,442

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

CONTINUING CONSTRUCTION PROJECTS IN F.Y. 1975
$ thousands (1973)

Div	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete	Approved Budget Allowance	Balance to Complete After FY 1975
	NAVIGATION					
SAD	Tennessee-Tombigbee Waterway, Ala. & Miss.	623,000	56,852	566,148	30,000	536,148
SPD	Humboldt Harbor, Alaska	3,350	520	2,830	200	2,630
	McClellan-Kerr Arkansas River Navigation System, Ark. and Okla:					
SWD	a. Bank Stabilization and Channel Rectification	130,000	128,026	1,974	610	1,364
SWD	b. Locks and Dams	497,200	488,684	8,516	4,000	4,516
LMV	Ouachita and Black Rivers, Ark. & La.	144,000	66,937	77,063	7,000	70,063
SPD	Oakland Harbor, Calif.	4,953	3,453	1,500	1,500 *	-
SPD	San Diego Harbor, Calif.	8,642	1,093	7,542	500	7,042
SPD	San Francisco Bay to Stockton (John F. Baldwin and Stockton Ship Channels), Calif.	76,200	4,348	71,852	725	71,127
NAD	Inland Waterway, Delaware River to Chesapeake Bay (C&D Canal) Part II, Del. & Md.	109,730	96,411	13,319	3,715	9,604
SAD	Jacksonville Harbor, Fla.	34,500	17,494	17,006	7,000	10,006

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

Div	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete	Approved Budget Allowance	Balance to Complete After FY 1975
		$ thousands (1973)				
	NAVIGATION (Cont'd)					
SAD	Savannah Harbor, 4 ft (Widening and Deepening), Ga.	9,710	8,607	1,103	1,103 *	-
SAD	Miami Harbor, Fla.	14,400	9,640	4,760	4,760 *	-
SAD	Savannah Harbor (Sediment Basin), Ga.	10,500	8,200	2,300	2,300 *	-
NCD	Calumet River & Harbor (1962 Mod.) Ill. & Ind.	16,500	6,997	9,503	170	9,333
NCD	Illinois Waterway, Calumet-Sag. Mod. (Part I), Ill. & Ind.	91,100	87,898	3,202	1,500	1,702
LMV	Kaskaskia River, Ill.	112,000	86,470	25,530	4,700	20,830
LMV	Lock & Dam 26, Alton, Ill. & Mo.	382,000	7,258	374,742	27,500	345,842
ORD	Lock & Dam 53 (Temp. Lock), Ill. & Ky.	19,400	1,600	17,800	7,000	10,800
	Mississippi River between Ohio and Missouri Rivers:					
LMV	a. Chain of Rocks, Ill.	57,700	53,160	4,540	4,540 *	-
LMV	b. Regulating Works, Ill. & Mo.	81,000	69,361	11,639	3,200	8,439
ORD	Smithland Locks & Dam, Ill, Ind. & Ky.	192,000	78,188	113,812	22,300	91,512
ORD	Newburgh Locks & Dam, Ind. & Ky.	94,700	87,137	7,563	6,000	1,563
ORD	Cannelton Locks & Dam, Ind. & Ky.	98,900	95,465	3,435	2,650	785

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

Div	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete	Approved Budget Allowance	Balance to Complete After FY 1975
		$ thousands (1973)				
	NAVIGATION (Cont'd)					
ORD	Uniontown Locks & Dam, Ind. & Ky.	95,700	81,210	14,490	7,850	6,640
MRD	Missouri River, Sioux City to Mouth, Iowa, Kans. Mo. & Nebr.	450,000	399,874	50,126	4,700	45,426
LMV	Atchafalaya River and Bayous Chene, Boeuf and Black, La.	14,700	4,323	10,377	500	9,877
LMV	Bayou Lafourche and Lafourche-Jump Waterway, La.	9,500	1,066	8,434	1,400	7,034
LMV	Mermentau River (Chan. Imprv.), La.	2,640	1,106	1,534	1,534*	-
LMV	Michoud Canal, La.	3,670	1,510	2,160	2,160*	-
LMV	Mississippi River-Gulf Outlet, La.	275,000	67,790	203,210	1,300	206,910
LMV	Mississippi River Outlets-Venice, La.	7,650	499	7,151	510	+ 6,651
LMV	Overton-Red River Waterway (Lower 31 Miles Only), La.	18,300	5,250	13,050	1,100	11,950
LMV	Red River Emergency Bank Protection, La. Ark., Okla. and Tex.	22,700	11,523	11,177	3,900	7,277
LMV	Red River Waterway (Mississippi River to Shreveport,) La.	473,000	8,013	464,987	12,000	452,987

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

Div	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete	Approved Budget Allowance	Balance to Complete After FY 1975
		$ thousands (1973)				
	NAVIGATION (Cont'd)					
NED	Weymouth-Fore and Town Rivers, Mass.	25,000	17,730	7,270	1,800	5,470
NCD	Great Lakes Connecting Channels, Mich.	145,000	126,784	18,216	1,200	17,016
NCD	Lexington Harbor, Mich.	1,280	375	905	400	505
NAD	Newark Bay Hackensack and Passaic Rivers, N.J.	18,210	14,210	4,000	525	3,475
NAD	East River Spur Channel, N.Y.	3,010	160	2,850	1,500	1,350
NAD	New York Harbor (Anchorages), N.Y.	34,900	17,329	17,571	4,000	13,571
SAD	Atlantic Intracoastal Waterway, Bridges, N.C.	16,200	350	15,850	100	15,750
ORD	Hannibal Locks & Dam, Ohio & W. Va.	86,000	74,184	11,816	10,110	1,706
ORD	Willow Island Locks & Dam, Ohio & W. Va.	73,300	58,739	14,561	10,100	4,461
NPD	Columbia & Lower Willamette Rivers (40-ft Channel), Ore. & Wash.	26,600	20,097	6,503	600	5,903
NPD	Tillamook Bay & Bar (South Jetty), Ore.	12,700	11,190	1,510	1,510 *	-
SWD	Corpus Christi Ship Channel (1968 Act), Texas	26,600	9,082	17,518	3,500	14,018
SWD	Galveston Channel (1971 Auth.), Texas	2,210	640	1,570	1,570 *	-
	TOTAL - NAVIGATION (47 Projects)	4,656,358	2,376,833	2,279,525	217,242	2,062,283
	BEACH EROSION CONTROL					
SAD	Brevard County, Fla.	3,110	520	2,590	400	2,190
SAD	Pinellas County, Fla.	3,140	615	2,525	100	2,425
SAD	Tybee Island, Ga.	2,250	686	1,564	900	664
NAD	Fire Island Inlet to Jones Inlet, N.Y.	22,300	1,807	20,493	1,500	18,993
	TOTAL - BEACH EROSION CONTROL (4 Projects)	30,800	3,628	27,172	2,900	24,272

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

CONTINUING CONSTRUCTION PROJECTS
$ thousands (1973)

DIV.	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete
	NAVIGATION			
SPD	Crescent City Harbor, Calif.	3,650	1,108	2,542
SPD	Monterey Harbor, Calif.	10,200	530	9,670
SPD	Port Hueneme Harbor, Calif.	1,710	820	890
SPD	San Diego River & Mission Bay, Calif.	13,500	10,593	2,907
SAD	Canaveral Harbor, Fla.	13,600	6,025	7,575
SAD	Cross Florida Barge Canal, Fla.	179,000	61,759	117,241
NCD	Davenport Small Boat Harbor, Iowa	122	14	108
NAD	Baltimore Harbor & Channels, Md. (1958)	23,750	19,652	4,098
NAD	Delaware River, Philadelphia to Sea, Anchorages, N.J.	39,300	8,806	30,494
NCD	Irondequoit Bay, N.Y.	3,530	142	3,388
SAD	AIWW - Masonboro Inlet, N.C.	5,410	1,690	3,720
NED	Fall River Harbor, Mass. & R.I.	21,800	2,360	19,440
NCD	Cleveland Harbor, 1958 Act, Ohio	16,300	3,282	13,018
NCD	Lorain Harbor, Ohio	21,800	17,341	4,459
SWD	GIWW - Chocolate Bayou, Texas	2,510	658	1,852
SWD	Wallisville Lake, Texas	28,800	22,079	6,721

Table 14: Applicable Federal Budgets: U.S. Army Corps of Engineers (con't)

Div.	Project and State	Estimated Federal Cost	Allocations thru FY 1974	Balance to Complete
		$ thousands (1973)		
	NAVIGATION (Cont'd)			
SWD	Trinity River & Trib Bridges, Texas	10,400	8,833	1,567
NAD	Hampton Roads, Virginia	31,800	26,870	4,930
	TOTAL - NAVIGATION (18 projects)	427,182	192,562	234,620
	BEACH EROSION CONTROL			
SPD	Imperial Beach, Calif.	548	190	358
SPD	Surfside-Sunset and Newport Beach, Calif.	7,410	3,689	3,721
SAD	Key West Beach, Fla.	950	96	854
SAD	Mullet Key, Fla.	896	474	422
SAD	Virginia Key and Key Biscayne, Fla.	2,580	1,332	1,248
POD	Waikiki Beach, Hawaii	1,810	1,269	541
SAD	Hunting Island Beach, N.C.	2,140	1,416	724
	TOTAL - BEACH EROSION CONTROL (7 projects)	16,334	8,466	7,868

APPENDIX C:

SUMMARY OF APPLICABLE LAWS AND STATUTES

Table 15 lists laws and statutes applicable to remote sensing of oceans. Experts from these are provided on the pages shown in Table 15.

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Table 15: List of Laws and Statutes Applicable to Remote Sensing of Oceans

Title	Code	Page
Military Surveys and Maps	10 USC 4537	C-3
Military Surveys and Maps	10 USC 9537	C-4
Fish and Wildlife Act	16 USC 744	C-5
Fish and Wildlife Act of 1947	16 USC 758a	C-6
Wildlife Protection from Pollution	16 USC 665	C-7
Fish and Wildlife Act of 1956	16 USC 742	C-8
Fish and Wildlife Act of 1947	16 USC 749	C-9
Fish and Wildlife Act of 1950	16 USC 760a	C-10
Coastal Zone Management Act of 1972	33 USC 1101 et seq.	C-11
National Environmental Policy Act of 1969	P.L. 91-190	C-12
Marine Protection, Research, and Sanctuaries Act of 1972	P.L. 92-532	C-13
Endangered Species Act of 1973	P.L. 93-205	C-14
Intervention on the High Seas Act	P.L. 93-248	C-15
Marine Protection, Research, and Sanctuaries Act of 1974	P.L. 93-254	C-16
Prevention, Control, and Abatement of Environmental Pollution at Federal Facilities	Executive Order 11752	C-17
Hazardous Waste Management Act of 1973 Proposed Legislation	S. 1086 H.R. 4873	C-18
Toxic Substance Control Act of 1973 Proposed Legislation	S. 888 H.R. 5087	C-19

Military Surveys and Maps
10 USC 4537

Agency Affected: Department of the Army, Department of the Interior (Geological Survey)

Date Passed: 14 May 1928

Data Collection
Statutory Requirement: The Secretary of the Army may obtain the assistance of the Geological Survey and other mapping agencies of the United States in making surveys and maps and in obtaining topographic data.

Comments: Remote sensing could have a role in assistance to the Army. No specific level of activity is mandated.

Military Surveys and Maps
10 USC 9537

Agency Affected: Department of the Air Force, Department of the Interior (Geological Survey)

Date Passed: 2 November 1966

Data Collection
Statutory Requirement: The Secretary of the Air Force may obtain the assistance of the Geological Survey and other mapping agencies of the United States in making surveys and maps and in obtaining topographic data.

Comments: Remote sensing could have a role in assistance to the Air Force. No specific level of activity is mandated.

Fish and Wildlife Act
16 USC 744

<u>Agency Affected</u>: Department of the Interior, Fish and Wildlife Service

<u>Date Passed</u>: 3 March 1887; 24 May 1950

<u>Data Collection Statutory Requirement</u>: The Director of Fish and Wildlife Services shall make investigations of whether any and what diminution in the number of the food fishes of the coast and lakes of the United States has taken place; and, if so, to what causes the same is due, and also whether any and what protective, prohibitory, or precautionary, measures should be adopted in the premises.

<u>Comments</u>: Application to remote sensing dependent upon its ability to detect fish populations and sources of fish stresses.

Fish and Wildlife Act of 1947
16 USC 758a

Agency Affected: Department of the Interior, Fish and Wildlife Service

Date Passed: 4 August 1947

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized to conduct studies to insure maximum development and utilization of the high seas fishery resources of the territories and island possessions of the United States in the tropical and sub-tropical Pacific Ocean and intervening areas.

Comments: Very general data collection mandate. Remote sensing may be relevant.

Wildlife Protection from Pollution
16 USC 665

<u>Agency Affected</u>: **Department of the Interior, Fish and Wildlife Service, Bureau of Mines**

<u>Date Passed</u>: **10 March 1934**

<u>Data Collection</u>
<u>Statutory Requirement</u>: **The Secretary is authorized to make such investigations as he deems necessary to determine the effects of domestic sewage, mine, petroleum, and industrial wastes, erosion silt, and other polluting substances on wildlife.**

<u>Comments</u>: **Very general non-mandatory data requirements.**

Fish and Wildlife Act of 1956
16 USC 742

Agency Affected: Department of the Interior, Fish and Wildlife Service

Date Passed: 8 August 1956

Data Collection
Statutory Requirement: The Secretary shall conduct continuing investigations, prepare and disseminate information, and make periodical reports to the public, to the President, and to Congress, with respect to the following matters:

⋮

(2) The availability and abundance and the biological requirements of fish and wildlife resources.

⋮

(4) The collection and dissemination of statistics on commercial and sport fishing.

⋮

(5) The collection and dissemination of statistics on the nature and availability of wildlife, progress in acquisition of additional refuges and measures being taken to foster a coordinated program to encourage and develop wildlife values.

⋮

(7) Any other matters which in the judgment of the Secretary are of public interest in connection with any phases of fish and wildlife operations.

⋮

(f) The Secretary shall also

⋮

(4) take such steps as may be required for the development, advancement, management, conservation, and protection of the fisheries resources, and

⋮

(5) take such steps as may be required for the development, management, advancement, conservation, and protection of wildlife resources through research, acquisition of refuge lands, development of existing facilities, and other means.

Comments: This law presents a broad mandate for the collection of a wide variety of natural resources information.

Fish and Wildlife Act of 1949
16 USC 759

Agency Affected: Department of the Interior, Fish and Wildlife Service

Date Passed: 18 August 1949

Date Collection
Statutory Requirement: The Secretary of the Interior is authorized to undertake a comprehensive and continuing study of the shad of the Atlantic Coast, to arrest the decline, increase the abundance, and promote the wisest utilization of shad resources.

Comments: Remote sensing may be applicable here.

Fish and Wildlife Act of 1950
16 USC 760a

<u>Agency Affected</u>: Department of the Interior, Fish and Wildlife Service

<u>Date Passed</u>: 25 August 1950

<u>Data Collection</u>
<u>Statutory Requirement</u>: The Secretary of the Interior is directed to undertake a comprehensive continuing study of species of fish of the Atlantic coast, including bays, sounds, and tributaries, in order to recommend to the coastal states appropriate measures for the development and protection of such resources and their wisest utilization.

<u>Comments</u>: Remote sensing may be applicable.

Coastal Zone Management Act of 1972
33 USC 1101 *et seq*.

Agency Affected: Department of Commerce

Date Passed: 27 October 1972

Data Collection
Statutory Requirement: The Secretary of Commerce is authorized to make annual grants to any coastal state for the purpose of assisting in the development of a management program for the land and water resources of its coastal zone. Such a management program shall include, among others,

- an identification of the boundaries of the coastal zone subject to the management program
- an inventory and designation of areas of particular concern within the coastal zone

Comments: Remote sensing has been found useful in New Jersey and elsewhere in the identification of coastal zone areas. It should also be useful for land use inventory purposes and management in coastal zone areas of particular concern.

National Environmental Policy Act of 1969
P.L. 91-190

Agency Affected: All

Date Passed: 1 January 1970

Data Collection
Statutory Requirement: All federal agencies shall assess the environmental impact of their actions when the action is deemed to have the potential to significantly affect the quality of the human environment. Alternatives to the proposed action and their environmental impact must also be considered.

Comments: Remote sensing may be helpful in assessing environmental impact of federal actions and alternatives, particularly power plant siting and land use.

Marine Protection, Research,
and Sanctuaries Act of 1972
P.L. 92-532

Agency Affected: Environmental Protection Agency, Department of Transportation (Coast Guard)

Date Passed: 23 October 1972

Data Collection
Statutory Requirement: The Administrator of EPA may issue ocean dumping permits when he has considered the effects of such dumping on marine ecosystems, fishery resources, and human welfare.

The Secretary of Transportation, through the Coast Guard, shall initiate a comprehensive and continuing program of monitoring and research regarding the effects of the dumping of materials into ocean and coastal waters.

Comments: Satellite remote sensing information should assist EPA in estimating the effects of particular dumping actions on marine ecosystems, as ERTS experiments have shown. Satellite remote sensing should also be a useful monitoring tool, particularly for a synchronous satellite.

Endangered Species Act of 1973
P.L. 93-205

Agency Affected: Department of the Interior

Date Passed: 28 December 1973

Data Collection
Statutory Requirement: The Secretary of Interior may enter into agreements with any state for the administration and management of any area established for the conservation of endangered species or threatened species.

The Secretary is authorized to enter into cooperative agreements, including funding agreements, with any state which establishes and maintains an adequate and active program for endangered and threatened species conservation. To be deemed adequate and active, the program must, among other requirements, authorize the appropriate state agency to conduct investigations to determine the requirements for survival and the status of resident species of fish and wildlife.

Comments: The management of endangered species areas would likely be enhanced by timely ERS data. This could create a demand for ERTS-type data at the state level. Species status determination may possibly be assisted by ERS data through indirect methods, such as the monitoring of grazing progress through changes in range vegetation vigor, etc.

Intervention on the High Seas Act
P.L. 93-248

Agency Affected: Department in which the Coast Guard is operating (currently the Department of Transportation)

Date Passed: 5 February 1974

Data Collection
Statutory Requirement: When the Secretary of the department in which the Coast Guard is operating determines that a ship collision, stranding, or the maritime incident resulting in material damage or the imminent threat of material damage to the ship or her cargo creates a grave and imminent danger to the United States from oil pollution, the Secretary may take measures on the high seas to prevent, mitigate, or eliminate that danger.

Comments: An ERS capability may be an effective surveillance and monitoring approach.

Marine Protection, Research,
and Sanctuaries Act of 1974
P.L. 93-254

Agency Affected: Environmental Protection Agency,
Department of Transportation (Coast Guard)

Date Passed: 22 March 1974

Data Collection
Statutory Requirement: The United States and each other signatory country shall designate an appropriate authority or authorities to monitor individually or in collaboration with other countries and international organizations the condition of the seas for the purposes of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

Comments: Remote sensing probably applicable - no other method provides comparable synopticity.

Prevention, Control, and Abatement of Environmental Pollution at Federal Facilities Executive Order 11752

Agency Affected: All

Date Signed: 17 December 1973

Data Collection Requirement: The heads of all federal agencies shall cooperate with the EPA Administrator and state, interstate, and local agencies in the prevention, control, and abatement of environmental pollution and, in accordance with guidelines issued by the Administrator, provide to the Administrator and to those agencies such information as is necessary to determine compliance with applicable standards.

Comments: Remote sensing would be useful for monitoring potential pollution sources.

Hazardous Wasta Management Act of 1973
Proposed Legislation: S.1086
H.R. 4873

Agency Affected: Environmental Protection Agency

Date Passed: Still Pending

Data Collection
Statutory Requirement: The Administrator is authorized to conduct and encourage research, surveys, and other investigations of adverse effects from the release of hazardous wastes into the environment.

Comments: Ability of remote sensing to detect hazardous wastes is very uncertain.

Toxic Substances Control Act of 1973
Proposed Legislation: S.888
H.R. 5087

Agency Affected: Environmental Protection Agency

Date Passed: Still Pending

Data Collection
Statutory Requirement: The Administrator of EPA is authorized to conduct such research and monitoring as is necessary to determine the extent of substances deemed toxic for the enforcement of this law.

Comments: No data collection is mandated, authority granted is primarily in the realm of enforcement.

Pertinence of this data depends on the ability of remote sensing to monitor trace substances. Application is also possible for remote readout.

UNITED STATES CODE
TITLE 15

15 USC 272---Functions of Secretary

"The Secretary of Commerce...is authorized to undertake the following function:

(b) The determination of physical constants...when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

In carrying out the functions enumerated in this section, the Secretary is authorized to undertake the following activities and similar ones for which need may arise in the operations of Government agencies, scientific institutions, and industrial enterprises:

(12) the investigation of the conditions which affect the transmission of radio waves from their source to a receiver;

(19) the compilation and publication of general scientific and technical data resulting from the performance of the functions specified herein or from other sources when such data are of importance to scientific or manufacturing interests or to the general public, and are not available elsewhere, including demonstration of the results...by exhibits or otherwise as may be deemed most effective."

15 USC 313---Duties of Secretary of Commerce

"The Secretary of Commerce...shall have charge of the forecasting of weather,...issue of storm warnings,...weather and flood signals,...gauging and reporting of rivers,...collection and transmission of marine intelligence...,...reporting of temperature and rainfall conditions..., the display of frost and cold-wave signals, the distribution of meteorological information..., and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties."

15 USC 313 nt---Study of Thunderstorms and Atmospheric Disturbances; Report; Expenditures; Cooperation of Other Departments

"...the Secretary of Commerce is authorized and directed to study fully and thorou ly the internal structure of thunderstorms, hurricanes, cyclones, and other severe atmospheric disturbances,...with a view to establishing methods by which the characteristics of particular thunderstorms may be forecast and methods by which the characteristics of such storms may be determined on visual observation from outside of the immediate thunderstorm area."

15 USC 313a---Establishment of Meteorological Observation Stations in the Arctic Region

"...the Secretary of Commerce, shall, in addition to his other functions and duties, take such action as may be necessary in the development of an international basic meteorological reporting network in the Arctic region of the Western Hemisphere, including the establishment, operation, and maintenance of such reporting stations..., with the meteorological services of foreign countries and with persons engaged in air commerce."

15 USC 330b---Duties of Secretary---Records, Maintanance, Summaries, Publication

"(a) The Secretary shall maintain a record of weather modification activities, including attempts, which take place in the United States and shall publish summaries thereof from time to time as he determines."

UNITED STATES CODE
TITLE 33

33 USC 462---Investigations Concerning Erosion of Shores of Coastal and Lake Waters

"The National Oceanic and Atmospheric Administration, under the direction of the Secretary of Commerce, is authorized and directed to cause investigations and studies to be made in cooperation with the appropriate agencies of the various states on the Atlantic, Pacific, and gulf coasts and on the Great Lakes, and of the States of Alaska and Hawaii, the Commonwealth of Puerto Rico, and the possessions of the United States, with a view to devising effective means of preventing erosion of the shores of coastal and lake waters by waves and currents;..."

33 USC 426a---Additional Investigations Concerning Erosion of Shores of Coastal and Lake Waters; Payment of Costs; Definition of Shores

"...it shall be the duty of the National Oceanic and Atmospheric Administration to make general investigations with a view to preventing erosion of the shores of the United States by waves and currents and determining the most suitable methods for the protection, restoration, and development of beaches; and to publish...such useful data...as...may...be of value to the people of the United States."

33 USC 540---Investigations and Improvements; Control by Department of Commerce; Wildlife Conservation

"Federal investigations and improvements of rivers, harbors, and other waterways shall be under the jurisdiction of and shall be prosecuted by the Department of Commerce under the direction of the Secretary of Commerce and the supervision of the National Oceanic and Atmospheric Administration..."

33 USC 883a---Surveys and Other Activities

"...the Secretary...is authorized to conduct the following activities:

(1) Hydrographic and topographic surveys;
(2) Tide and current observations;
(3) Geodetic-control surveys;
(4) Field surveys for aeronautical charts;

(5) Geomagnetic, seismological, gravity, and related geophysical measurements and investigations."

33 USC 883b---Dissemination of Data; Further Activities

"...the Secretary is authorized to conduct the following activities:

(1) Analysis and prediction of tide and current data;
(2) Processing and publication of data...;
(3) Compilation and printing of aeronautical charts...;
(4) Compilation and printing of nautical charts...;
(5) Distribution of aeronautical charts...;
(6) Distribution of nautical charts..."

33 USC 883d---Improvement of Methods, Instruments, and Equipments; Investigations and Research

"...the Secretary is authorized to conduct developmental work for the improvement of surveying and cartographic methods, instruments, and equipments; and to conduct investigations and research in geophysical sciences..."

33 USC 883h---Employment of Public Vessels

"The President is authorized to cause to be employed such of the public vessels as he deems it expedient to employ, and to give such instructions for regulating their conduct as he deems proper in order to carry out the provisions of sections 883a to 883i of this title."

33 USC 1123---Marine Resource Development Programs

(a) Cooperation of Agencies with Secretary of Commerce.

"In carrying out the provisions of this subchapter, the Secretary shall (1) consult with...experts...and all departments and agencies of the Federal Government...interested in, or affected by, activities in any such fields, and (2) seek advise and counsel from the National Council on Marine Resources and Engineering Development..."

(b) Development Programs; Research; Publication of Useful Information.

"The Secretary shall exercise his authority under this subchapter by--

(1) initiating and supporting programs...for the education of participants...;
(2) initiating and supporting necessary research programs...; and
(3) encouraging and developing programs...with the object of imparting useful information to persons...in the various fields of marine resources, (including) the scientific community, and the general public."

(c) Grants and Contracts to Carry Out Programs

"Programs to carry out the purposes of this subchapter shall be accomplished through contracts with, or grants to, suitable public or private institutions..."

UNITED STATES CODE
TITLE 42

42 USC 1891---Authorization to Make Grants

"The head of each agency of the Federal Government, authorized to enter into contracts for basic scientific research at non-profit institutions of higher education, or at non-profit organizations whose primary purpose is the conduct of scientific research, is authorized, where it is deemed to be in furtherance of the objectives of the agency, to make grants to such institutions or organizations for the support of such basic scientific research."

MISCELLANEOUS AUTHORITIES

Reorganization Plan No.2 of 1965---Transfer to Secretary of Commerce

The plan consolidates:
(1) The Weather Bureau...
(2) The Coast and Geodetic Survey.

Reorganization Plan No.4 of 1970---Transfers to Secretary of Commerce

The plan consolidates:
(1) The Environmental Science Services Administration...
(2) The Bureau of Commercial Fisheries...
(3) certain functions of the Bureau of Sport Fisheries and Wildlife...
(4) The Marine Minerals Technology Center...
(5) The Office of Sea Grant.

EO-11564, October 8, 1970; 35 FR-15801---Transfer of Certain Programs and Activities to the Secretary of Commerce

"Section 1 (a) The following programs and activities are...transferred to the Secretary of Commerce:
(1) The National Oceanographic Instrumentation Center...
(2) The National Oceanographic Data Center...
(3) The Ocean Station Vessel Meteorological Program...
(4) The Trust Territories Upper Air Observation Program...
(5) The Hydroclimatic Network Program...
(6) The National Data Buoy Development Project...

(b) Such personnel and...property...used... with the operation of the (se) programs...as the Director of the Office of Management and Budget shall determine shall be transferred...to the Department of Commerce..."

In addition to the above, there are the following acts:

The Anadromous Fish Conservation Act of 1965 (10 USC 757a)---authorizes NOAA with the states to conserve, develop, and enhance the anadromous fishery resources of our nation.

The Commercial Fisheries Research and Development Act of 1964 (16 USC 779a)---authorizes NOAA to cooperate with the fifty states in carrying on research and development of commercial fishery resources and to relieve resource disasters affecting commercial fisheries production and utilization.

The Central, Western, and Southern Pacific Ocean Fisheries Resources Development Act (P.L. 92-444)---provides for a joint industry/government program to develop a shipjack tuna fishery.

The Marine Mammal Protection Act of 1972 (16 USC 1361-K107)---requires NOAA to regulate activities for the protection and management of marine mammals as resources of great aesthetic and recreational value as well as resources of economic significance.

The High Seas Fishery Conservation Bill (HR-4760 and S-1069)---provide the Secretary of Commerce with the authority to regulate marine fisheries as they pertain to American fishermen on the high seas.

There are eight commissions established by international conventions with various management authorities. The following is a listing of commissions currently active and their principal areas of concern:

Table I-6 : The Eight International Commissions and Their Areas of Concern

Commission	Parties	Area of Concern
International Pacific Halibut Commission	Canada, United States	Halibut fishery of North Pacific and Bering Sea
International North Pacific Fisheries Commission	Canada, Japan, United States	Fishery stocks of the North Pacific and Bering Sea
International Pacific Salmon Fisheries Commission	Canada, United States	Sockeye and pink salmon of the Fraser River system
North Pacific Fur Seal Commission	U.S.S.R., Japan, Canada, United States	North Pacific fur seals
International Commission for the Northwest Atlantic Fisheries	16 countries, including United States	Fishery resources of northwest Atlantic Ocean
Inter-American Tropical Tuna Commission	Seven countries, including United States	Yellowfin tuna of the eastern Pacific
International Commission for the Conservation of Atlantic Tunas	13 countries, including United States	Tuna and tuna-like fisheries of the Atlantic Ocean
International Whaling Commission	48 countries, including United States	Whale stocks of the world

The terms of 16 USC 1191-1194, October 14, 1966, established the contiguous fisheries zone and support activities within the zone in return for certain preferential rights for American fishing interests on the high seas adjacent to our coastal areas and for foreign abstention from fishing for some species in certain areas. The following is a list of 11 current bilateral agreements:

Table 17: Current American Bilateral Fishing Agreements

Principal	Area of Concern	Expiration Date
Canada	Reciprocal Fishing Agreement	April 1974
Japan	Fisheries Agreement	December 1974
Japan	Eastern Bering Sea and Tanner Crab Agreement	December 1974
Poland	Middle Atlantic Agreement	June 1975
Romania	Fisheries in western region of middle Atlantic	December 1975
South Korea	Cooperation in fisheries	December 1977
U.S.S.R.	Fisheries Agreement relating to gear conflicts in fishing operation in North Pacific and Bering Sea	Februeary 1975
U.S.S.R.	Middle Atlantic Agreement	December 1974
U.S.S.R.	Eastern Bering Sea King and Tanner Crab Agreement	February 1975
U.S.S.R.	Contiguous fishing zone	February 1975
U.S.S.R.	Claims resulting from damage to fishing vessels or gear	February 1975