EARTH RESOURCES PROGRAMS AT THE LANGLEY RESEARCH CENTER

PART II. COASTAL ZONE OCEANOGRAPHY PROGRAM

by

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INTRODUCTION

One area of emphasis within the Application Program at Langley is on the coastal zone. Forty-five percent of the population of the United States lives in coastal counties, and this population is growing at twice the rate of the population of the country as a whole. As a result, there are serious pollution and other ecological problems in the coastal zones, and these problems are destined to get worse.

Most of Langley's experimental work will be carried out along the East Coast because, with both Langley and Wallops located there, the logistics will be minimized, and because most of the important coastal zone problems can be worked in this region.

Discussion

Figure 1 shows the activity in Langley's coastal zone oceanography program as a function of time separated into two groups; studies and experiments. The development of this program began with a Small Applications Technology Satellite Phase A study along with an Earth Resources Technology Satellite E&F, later to be called the Earth Observation Satellite A&B study.

The second activity was a coastal zone study to identify the environmental problems, establish the data needs, and recommend the spacecraft instrumentation to satisfy these needs.

Each summer for the past four years, we have had in cooperation with the American Society for Engineering Education, a summer study. Last summer, 23 participants, representing 13 academic disciplines, from 19 different universities, investigated problems in water quality management using the James River as a case study. The title of their report is "Clean Water: Affluence, Influence, Effluents - A Design for Water Quality Management." A similar study on the subject of Earth Resources Satellites was performed in 1969. Also, last year a NASA-sponsored conference on Remote Measurements of Pollution was held in

Norfolk, Virginia with Langley people heavily involved. The conference addressed the question of remote measurement of air, water, and land pollution. It is expected that the Remote Measurements of Pollution (RMOP) report will be published in January 1972.

The final two study items are internal NASA efforts where we had three working members on the Earth Observation Satellite Mission Review Group, and we are continuing to develop a coastal zone oceanographic experiment in the framework of the SATS concept.

In the experiments area, we did some early work with the then named Bureau of Commercial Fisheries and some balloon photography out of Wallops, but it was not until we had completed these above studies that we were able to develop and get underway some experiments in coastal zone oceanography. These experiments, which I will detail for you later, in every case were developed and are being undertaken by teams composed of both Langley personnel and people from neighboring institutions and agencies who have interest or responsibility in solving environmental problems in the coastal zone. Figure 2 lists these partners.

Wallops, who has been a long time partner of Langley in the areas of instrumentation and experimental performance, has been working in the coastal zone for some time. The Virginia Institute of Marine Science (VIMS) and Old Dominion University (ODU) are extremely important because they have people who are experts as marine scientists. VIMS is a unique institution because, besides being an educational and research institution, it has responsibilities for advising the Governor and State Legislature on marine matters. The Army Corps of Engineers with major responsibilities in marine matters is presently discussing plans for a joint program with us.

With the help of figure 3, I would like to trace our approach to the development of the program. Beginning with the following areas of concern: Pollution, Fisheries, Hazards, and Cartography, we performed contractor, in-house, and the previously described conference studies to identify the problems in various areas and established the data requirements.

For the contractor studies, we let four contracts to assure that many segments of the coastal zone would be represented. VIMS is a state institution with managerial responsibility; ODU has a research interest in the coastal zone; TRW is a large aerospace corporation; while Ocean Data System, Inc. represented the commercial interests. Although the approach was different in each study, the results were very much in agreement.

The type of problems that were identified in the area of pollution, for example, are shown in figure 4. These are as follows:
Is there pollution?
What kind is it?

What are its effects?
Will the environment accept it?
Where should industry locate?
How can pollution laws be enforced?
What can be done?

With these kinds of problems in mind, the study teams then established various data needs. In the center of figure 5 are shown the ten most relevant data needs that were established. It was from these data needs that our program in Satellite Applications, Estuaries, Continental Shelf, and Environmental Modeling evolved.

In the Satellite Applications area, we first identified the remote sensing requirements that would be needed to satisfy the data needs. Figure 6 is a chart taken from the Remote Measurements of Pollution Conference that lists the ten (10) major water pollutant types and the remote sensing requirements. For each instrumentation parameter, an optimum value and an acceptable value (in parentheses) is given. The acceptable spatial resolution value for chemical and toxic wastes, for instance, allows one to detect the pollutant and perhaps classify it. But in order to locate the source of the pollutant, 10-meter resolution will be required. With respect to temporal resolution, a 10-day viewing interval will yield gross data on thermal effluents; but to assess the dynamics of the dispersion process, a 2-hour viewing interval is desired. For oil pollution, a large field of view is desired in order to cover the entire phenomenon. However, for viewing the source of the spill and during the immediate period following the spill, a narrow (20 x 20 Km) field of view is acceptable.

A multispectral imaging concept that we believe could meet these varying requirements is shown in figure 7. The basic idea of this concept is to provide a high resolution - narrow field of view and a low resolution - wide field of view system on the same spacecraft, both of which have off-nadir pointing capability.

In our next program activity area, as shown in figure 8, that of Environmental Quality of Estuaries, a number of efforts are underway and a couple under discussion. The first of these, suspended sediment and chlorophyll activities in the lower Chesapeake Bay, is an approved ERTS-A experiment with Old Dominion University as a partner.

Figure 9 is an aerial view of one of the eight planned test sites where surface and sub-surface measurements will be made and analyzed by ODU, and correlated with aircraft and satellite imagery using Langley computers. The site will be located along the James River Bridge where the river span of nearly 5 miles will result in approximately 80 resolution elements from ERTS data.

The second activity in figure 8, volatile organics in the environment, is concerned with the exchange rates of volatile, synthetic, organic compounds, as depicted in figure 10, from the atmosphere to the water, to the organisms, the quantity of which are all unknown. Quantitatively, they are measured in fractions of a part per billion. Langley has developed a computerized, microwave spectrometer, currently being used to establish standard spectra of some of these compounds. Working together with VIMS, the most promising method of sample collection from both the atmosphere and the water will be established. Some quantitative results are expected within a year.

The effects of oil compounds on plant and animal life in the coastal estuaries, item 3, figure 8, are not understood. VIMS received a request for a proposal from the Environmental Protection Agency to determine the effects of spilled Bunker C in the marine environment, and VIMS and Langley scientists developed a joint program. Using the expertise of both institutions, major components of Bunker C will be traced through the ecosystem to measure residence times, modes of transport, concentrating mechanisms, and toxicity on plant and animal life. Mini-ecosystems, constructed in a local marsh, will be employed in this research. The proposed site for the mini-ecosystems is outlined on the map in figure 11. The populated area on the left is Williamsburg, Virginia, and the body of water at the top right is the York River.

Activity number 4, figure 8, Wetland survey for boundaries and remote sensing key for vegetation, concerns itself with the ownership and boundaries of the wetlands which in many areas of Virginia are unclear. The Governor's Council for Environmental Quality has directed VIMS to survey Virginia wetlands and to establish a legal definition of wetland boundaries for pending legislation. VIMS has been working with Langley to map wetlands from recent aerial photographs. The boundaries of the wetlands may be more adequately described by the boundaries of specific vegetation species, rather than the interface between open water and marsh, or even a prescribed mean water level. It is our belief that all four of the discrimination signatures shown in figure 12 must be employed to identify wetland vegetation remotely. To identify the shape and texture of various species will require higher resolution than usually obtained from aircraft and spacecraft photography. A goal of our investigation is to define the minimum spatial resolution required in terms of the variables listed in figure 12. Figure 13 is an aerial photo with a spatial resolution of about 1/2 meter. The texture, and some shapes, are evident. The area inside the red block is shown in figure 14. Now the resolution is down to about 1/2 centimeter and may be sufficient to determine shapes of different vegetation. Photographs like these last two will be used to relate shape and texture to various species. The relative tone and color of lower resolution pictures will then be used to relate the vegetation in this small area to other areas of like vegetation.

For the last two items in figure 8, the Coastal Engineering Research Center of the United States Army Corps of Engineers has submitted an ERTS-A proposal to study the changes in the Barrier Islands of the North Carolina coast using space imagery. Recently Goddard asked the Corps to monitor a CARETS (Central Atlantic Region Ecological Test Site - USGS) package of eight ERTS-A experiments in the vicinity of the Chesapeake Bay. The Corps has asked Langley for cooperative scientific support in both of these areas, as well as some help in instrumentation problems. Further discussions are planned.

The final activity is a cooperative effort with VIMS in the Continental shelf area. The objective of this activity is to understand the shelf waters sufficiently well so that forecasts or predictions can be made of conditions on the shelf. Let me explain with the help of figure 15 some of the reasons for such a predictive capability.

VIMS has identified the seven problems depicted in figure 15 as major ones that will require some kind of state action, including additional legislation, in the next ten years. As an example, if ocean dumping into the shelf waters is required, are there preferred locations for such activities which will minimize any unwanted effects? The area of the Continental Shelf under consideration for this program is shown in figure 16. It extends from Cape May, New Jersey, to Cape Hatteras, North Carolina, and seaward to beyond the 100-fathom line, an accepted definition of the edge of the shelf. Also shown in figure 16 is the general surface circulation that one expects in this area. The circulation pattern is complex and has both large scale and small scale features. The area is not strictly Virginia coastal waters. However, the concern is that major inputs to this system not be overlooked. For example, the concern is with the input of the Delaware Bay as well as the Chesapeake Bay, and of course, the input of the Gulf Stream. Although these boundaries are not viewed as fixed, it is emphasized that the area under consideration is roughly 20,000 square miles and, as such, requires remote sensing if synoptic inputs are to be available for inputs to predictive models. The predictive capability of the objective is approached by breaking the problem into manageable parts. These specific areas of investigation are listed in the first five items of figure 17.

The last item listed in figure 17 is really a part of each of the first five in that mathematical models are required in each. The key word is "circulation." This dynamic process is the basic phenomenon to be modeled in detail. Plans for investigations in each of these areas are now being developed.

A single surface drogue shown in figure 18 to track circulation has been designed and built at LRC. The drogue is located by an aircraft using a beacon signal and visual sighting. Tracking of the aircraft from Wallops and radio communications will provide precise position location of the drogue. Periodic location thus allows surface current determination.

Summary

In this paper, I have presented the NASA, Langley Research Center's Coastal Zone Oceanography Program, outlined the approach used to develop the program, briefly described the activities which are in the areas of Satellite Applications, Estuaries, Continental Shelf, and Environmental Modeling, and identified the organizations who are expected to be working with us to accomplish the program mission.

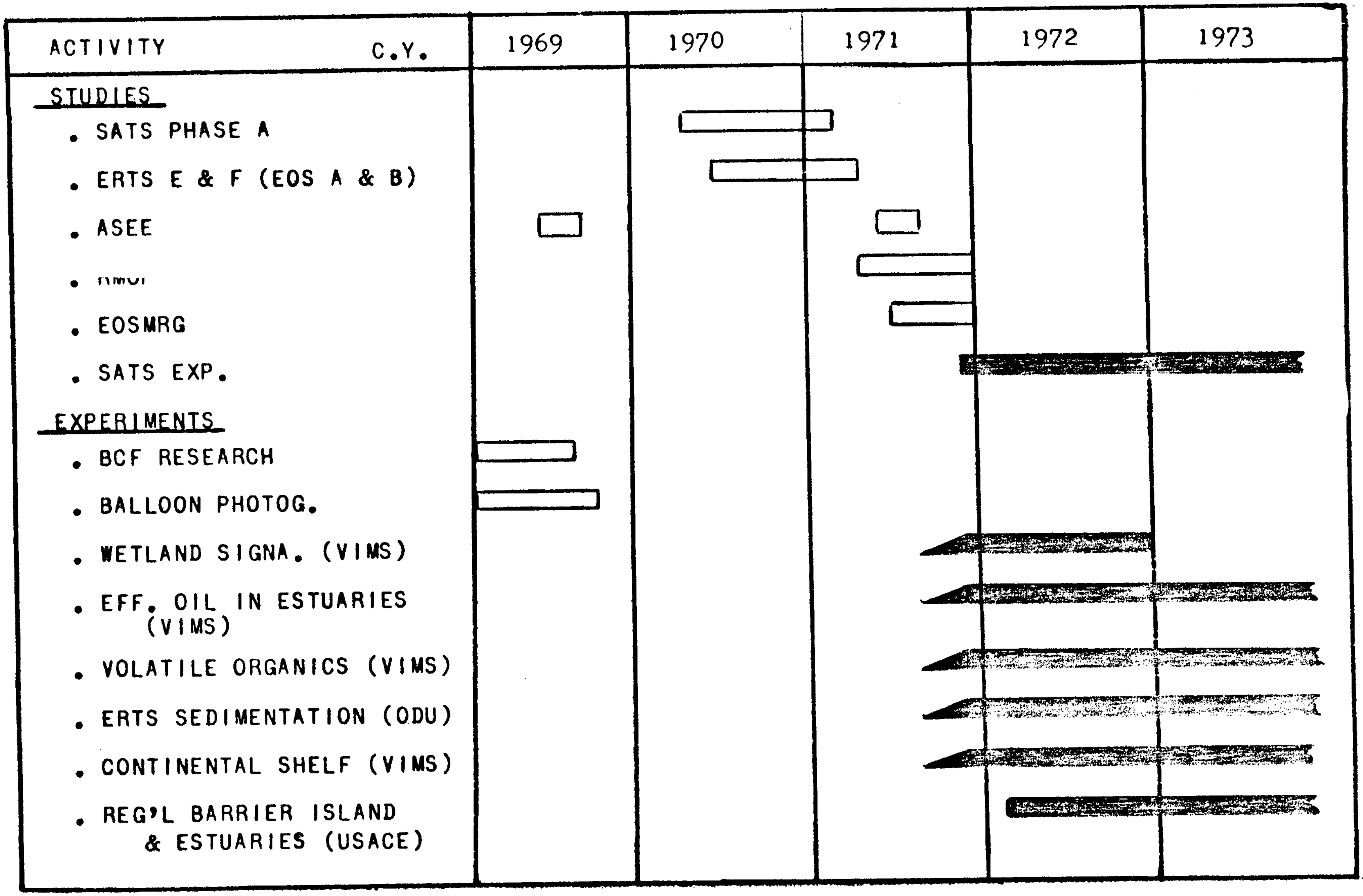

Figure 1.- The activities in the Langley Research Center's Coastal Zone Oceanography Program as a function of time.

- NASA WALLOPS
- VIRGINIA INSTITUTE OF MARINE SCIENCE (VIMS)
- U.S. ARMY CORPS OF ENGINEERS (USACE)
- OLD DOMINION UNIVERSITY (ODU)

Figure 2.- The Langley Research Center's Coastal Zone Oceanography Partners.

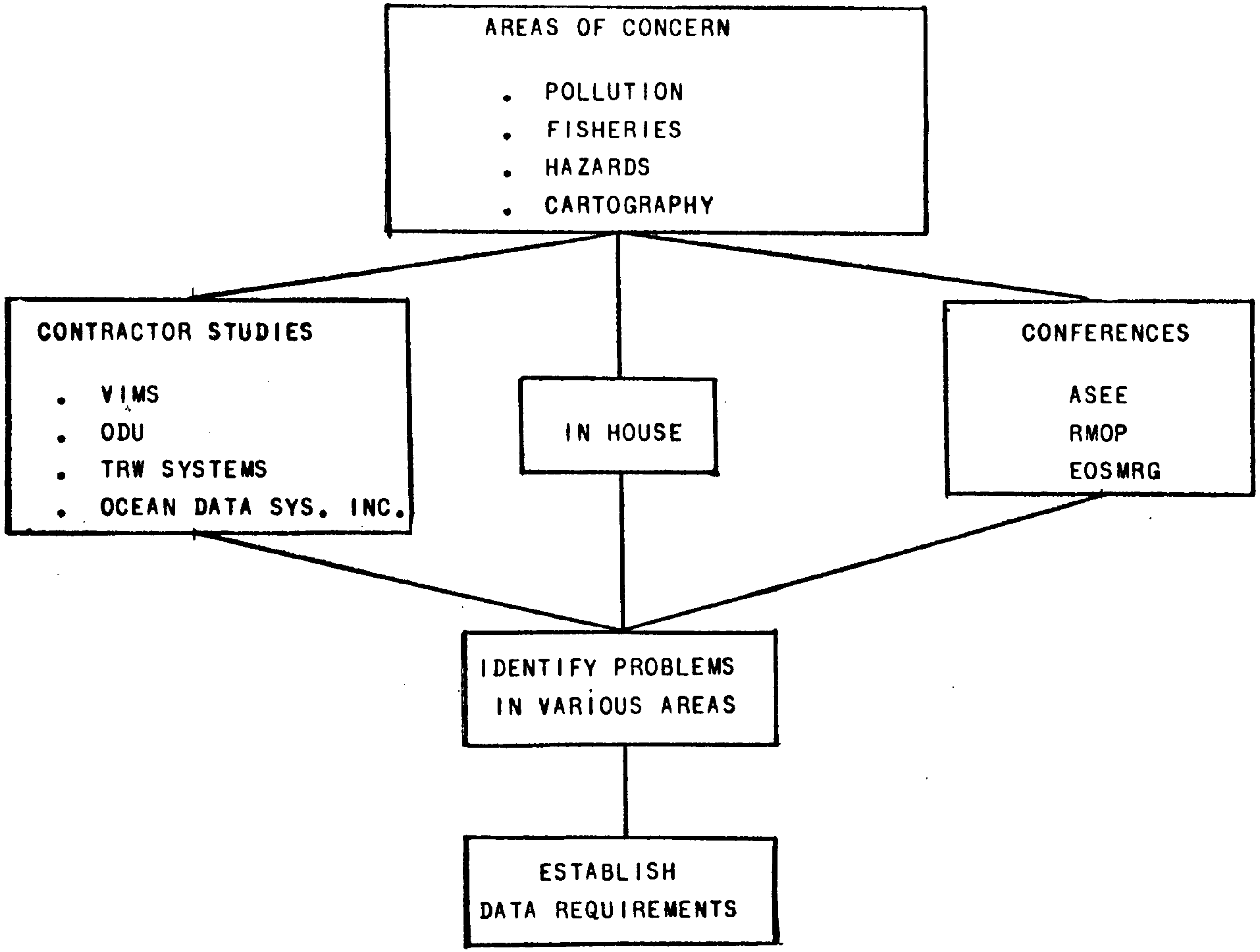

Figure 3.- The Langley Research Center's Coastal Zone Oceanography studies to identify the problems and establish the data requirements in the areas of pollution, fisheries, hazards, and cartography.

- IS THERE POLLUTION?
- DETERMINE TYPES OF DISCHARGE
- DETERMINE EXTENT OF POLLUTION EFFECTS
- DETERMINE ASSIMILATIVE CAPACITY
- OPTIMAL LOCATION FOR INDUSTRY
- EFFECT ENFORCEMENT
- ASSIST RAPID CLEAN-UP

Figure 4.- The type of problem identified in the pollution area.

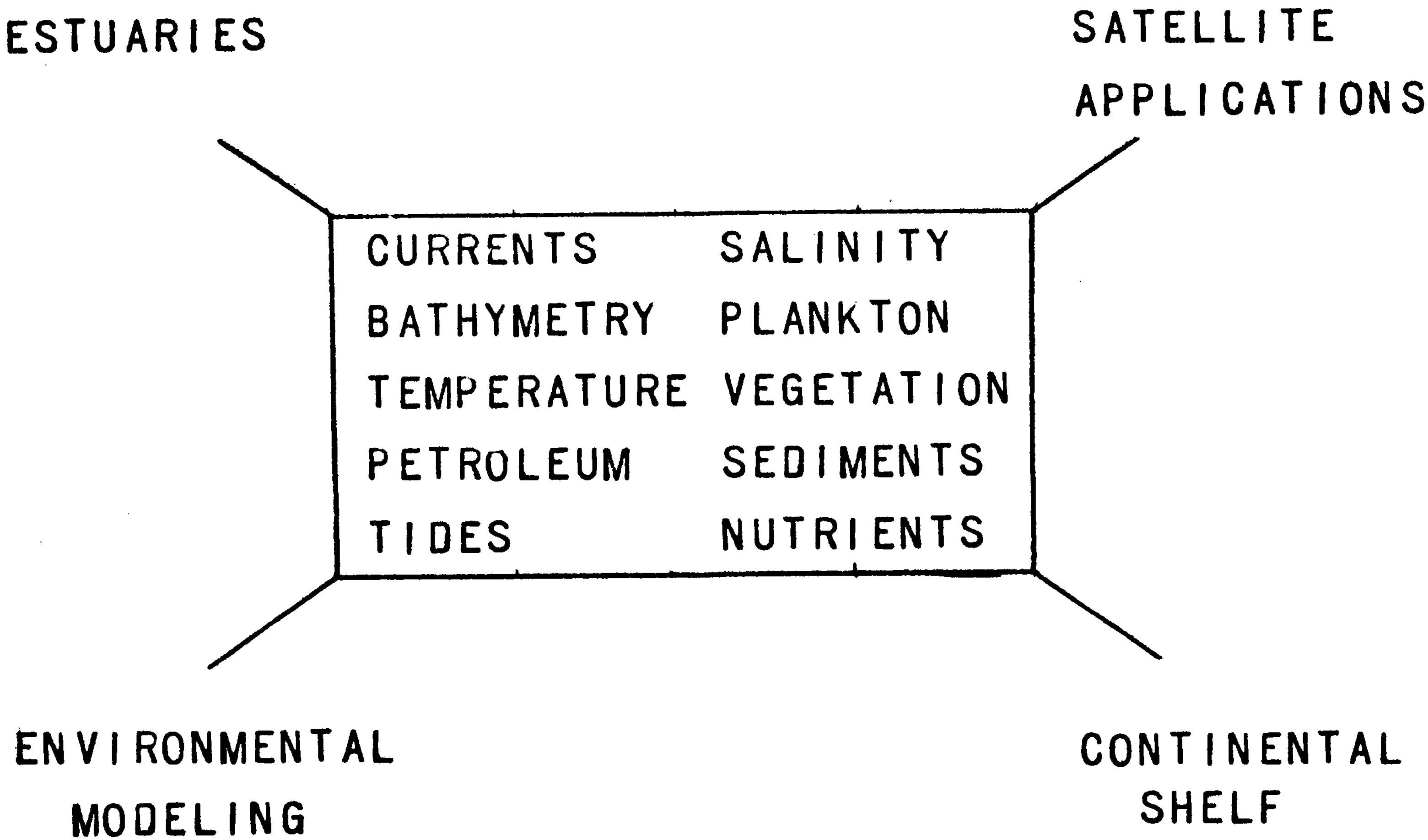

Figure 5.- The ten formost data requirements established from the coastal zone studies and the Langley Research Center's research areas for satisfying some of these data needs.

REMOTE SENSING REQUIREMENTS

POLLUTANT TYPE	SPATIAL RESOLUTION	SPECTRAL RESOLUTION	SPECTRAL RANGE	TEMPORAL RESOLUTION	SOLAR ELEVATION	LOW ANGLE (FROM NADIR)	AREA COVERAGE
OIL	10-30m (300m)	Broad-band	UV, Vis. μ wave	2-4 hrs. (1 day)	only import. with glitter	only import. with glitter	200x200km (20x20km)
SUSPENDED SED.	20m (500m)	.15μm (.15μm)	350-800mm (400-700mm)	2 hrs. (1 day)	45° (30°-60°)	0 to+15° (-5°to+30°)	350x100km (10x10km)
CHEM. & TOX. WASTES	10m (200m)	.015μm (.015μm)	350-700nm (400-700nm)	5 hrs. (10 days)	45° (30°-60°)	0 to+15° (-5°to+30°)	35x35km (10x10km)
SOLID WASTES	10m (200m)	.015μm (.015μm)	350-800nm (400-700nm)	5 hrs. (10 days)	45° (30°-60°)	0 to+15° (-5°to+30°)	35x35km (10x10km)
THERMAL EFFLUENTS	30m (500m)	±0.2°C (±1°C)	10-12μm (10-14μm)	2 hrs. (10 days)	N/A	to be determined	35x35km (10x10km)
RADIOACTIVE WASTES	30m (500m)	N/A	gamma (gamma)	5 hrs. (15 days)	N/A	0° (0°)	35x35km (10x10km)
NUTRIENT WASTES	100m (2km)	.005μm (.015μm)	400-700nm (400-700nm)	2 days (14 days)	45° (30°-60°)	0to+15° (0to+30°)	350x350km (35x35km)
INTRO. OF SPECIES	to be determined	.1μm (.1μm)	Vis. (Vis.)	3 mos. (1 yr.)	N/A	N/A	350x350km (10x10km)
RED TIDE	30m (2km)	.015μm (.015μm)	400-700nm (400-700nm)	5 hrs. (2 days)	45° (30°-60°)	0to15° (-5°to+30°)	350x35km (20x100km)
HUMAN & CUL. EFFECTS	10m (100m)	Variable	UV, Vis., IR, μ wave	1 yr. (5 yrs.)	N/A	N/A	350x350km (35x35km)

Figure 6.- The ten formost water pollutant types and their remote sensing requirements identified by the remote measurements of pollution conference in Norfolk, Virginia 1972.

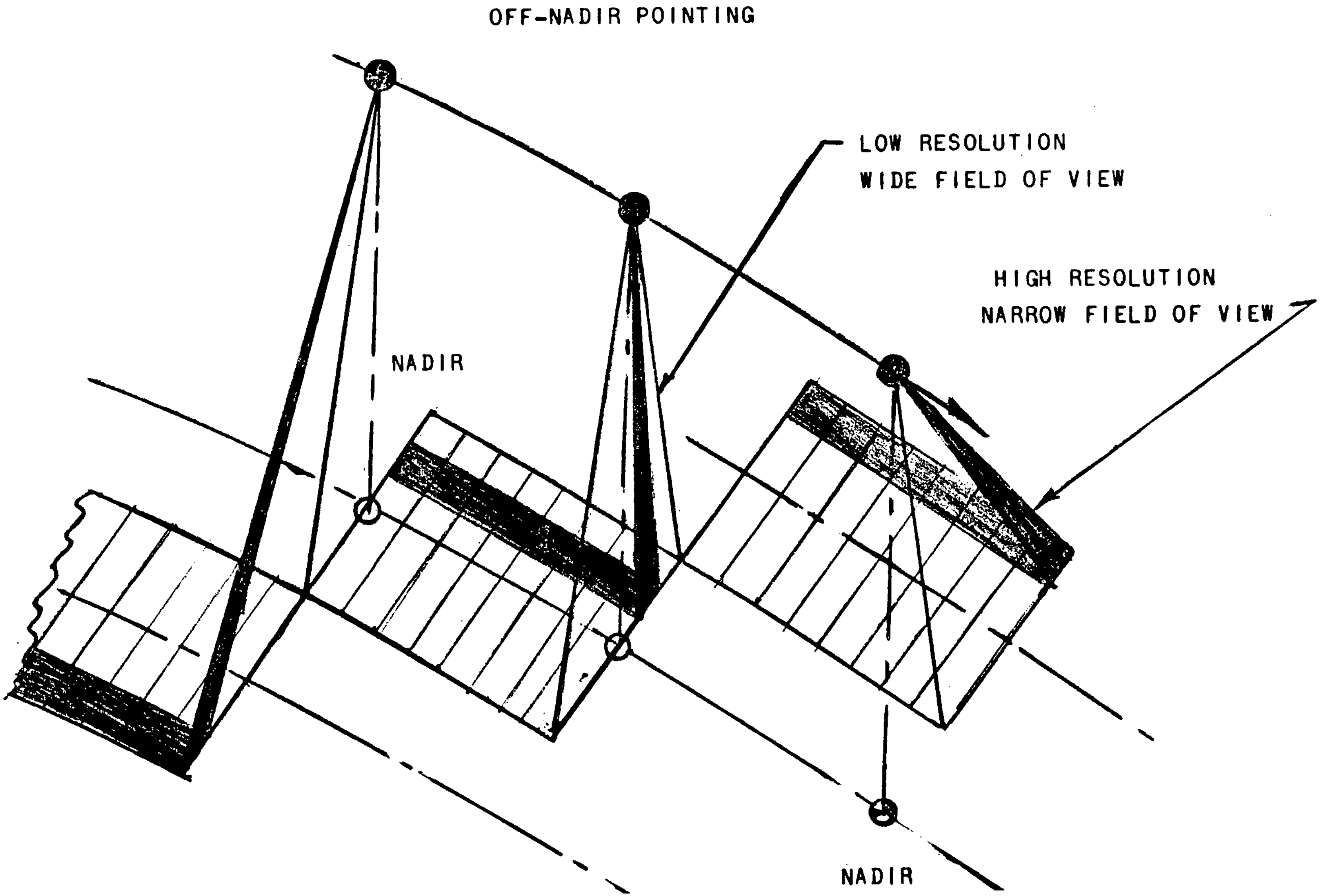

Figure 7.- A multispectral imaging system concept that could satisfy the varying data needs for the coastal zones.

- SUSPENDED SEDIMENT AND CHLOROPHYLL IN LOWER CHESAPEAKE BAY (ERTS-A & SKYLAB PROGRAMS)(ODU)

- VOLATILE ORGANICS IN THE ENVIRONMENT (VIMS)
- EFFECTS OF OIL IN COASTAL ESTUARIES (VIMS)
- WETLAND SURVEY FOR BOUNDARIES AND REMOTE SENSING KEY FOR VEGETATION (VIMS)

UNDER DISCUSSION

- NORTH CAROLINA BARRIER ISLAND & ESTUARY STUDIES WITH COASTAL ENGINEERING RESEARCH CENTER (USACE)
- SCIENTIFIC MONITORS FOR 8 ERTS-A EXPERIMENTS IN CHESAPEAKE BAY AND CENTRAL ATLANTIC REGIONS (USACE)

Figure 8.- The Langley Research Center's activities in the area of environmental quality of estuaries.

Figure 9.- An aerial photograph of the James River Bridge System. One of eight sites for the Old Dominion University-LRC, ERTS A, sediment and chlorophyll experiment.

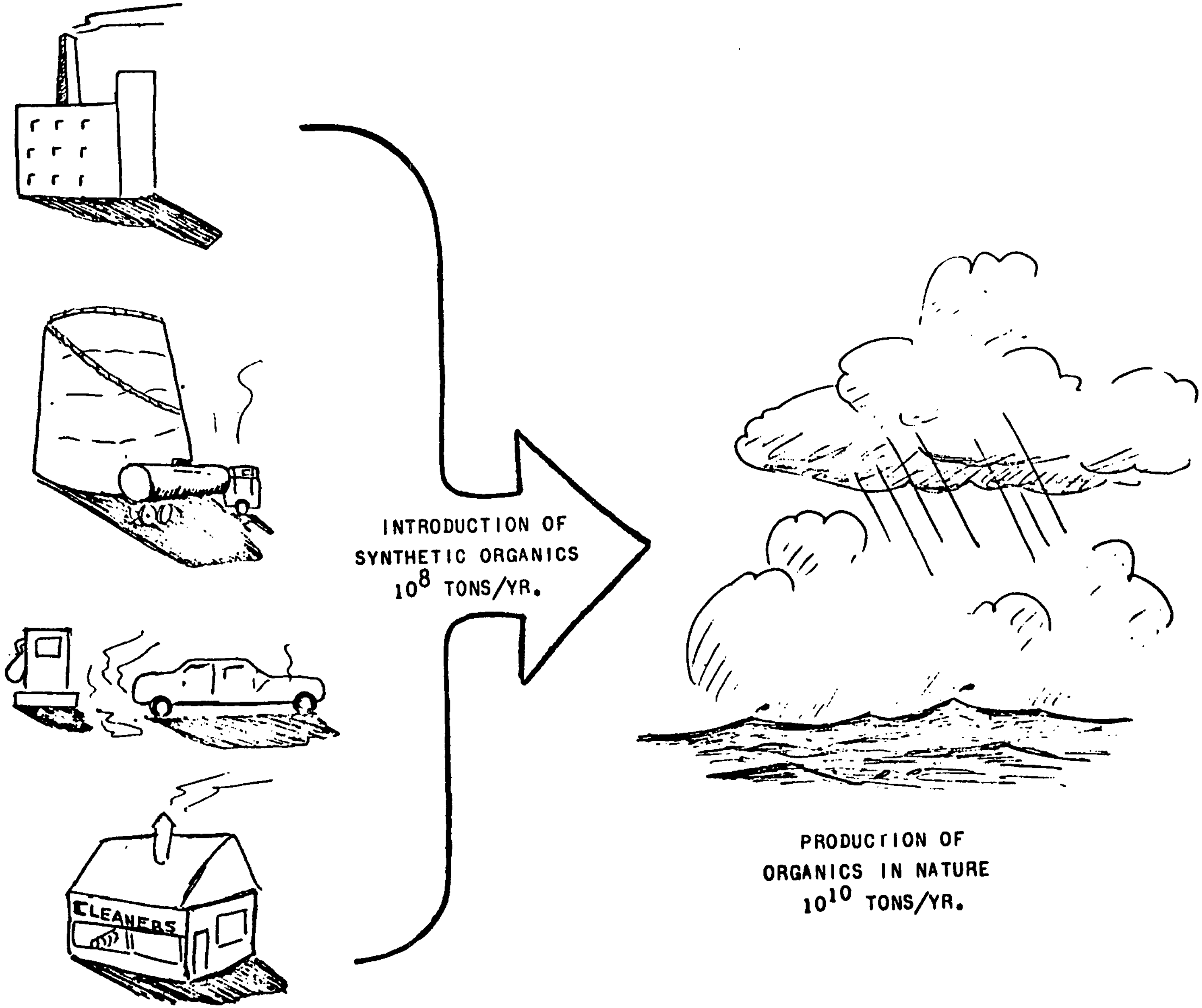

Figure 10.- Synthetic organics in the environment.

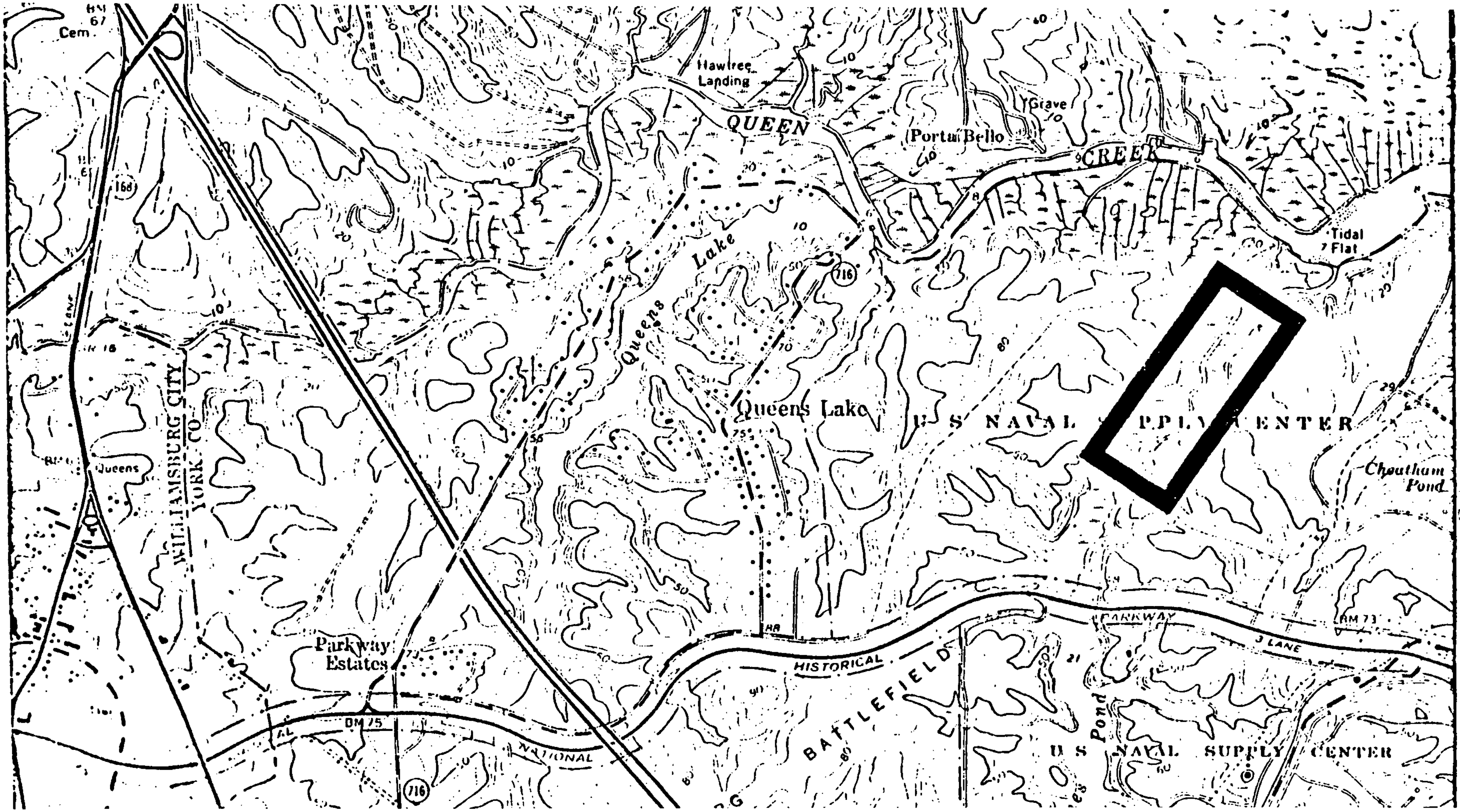

Figure 11.- The location of the Virginia Institute of Marine Sciences -LRC mini-ecosystem for the study of oil pollution on marine plant and animal life.

DISCRIMINATION SIGNATURES

- SHAPE
- TEXTURE
- COLOR
- TONE

VARIABLES

- SPECIES
- SEASON
- FILM/LIGHTING
- TIDE CYCLE
- PLANT CONDITION

Figure 12.- Remote sensing descriminatory signatures and wetland variables.

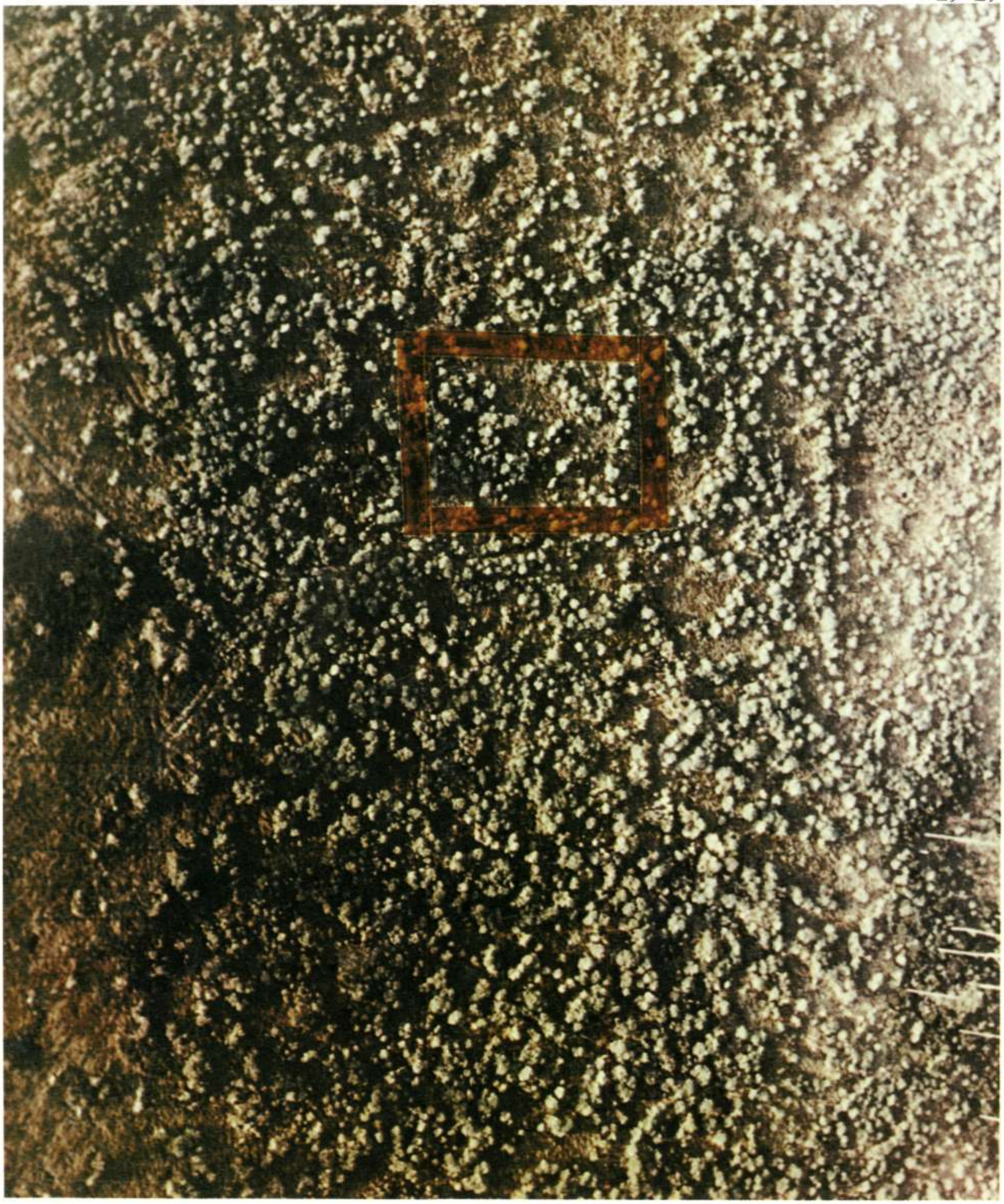

Figure 13.- Aerial photograph of wetlands with a spatial resolution of one-half meter.

Figure 14.- Aerial photograph of wetland with a spatial resolution of one-half centimeter.

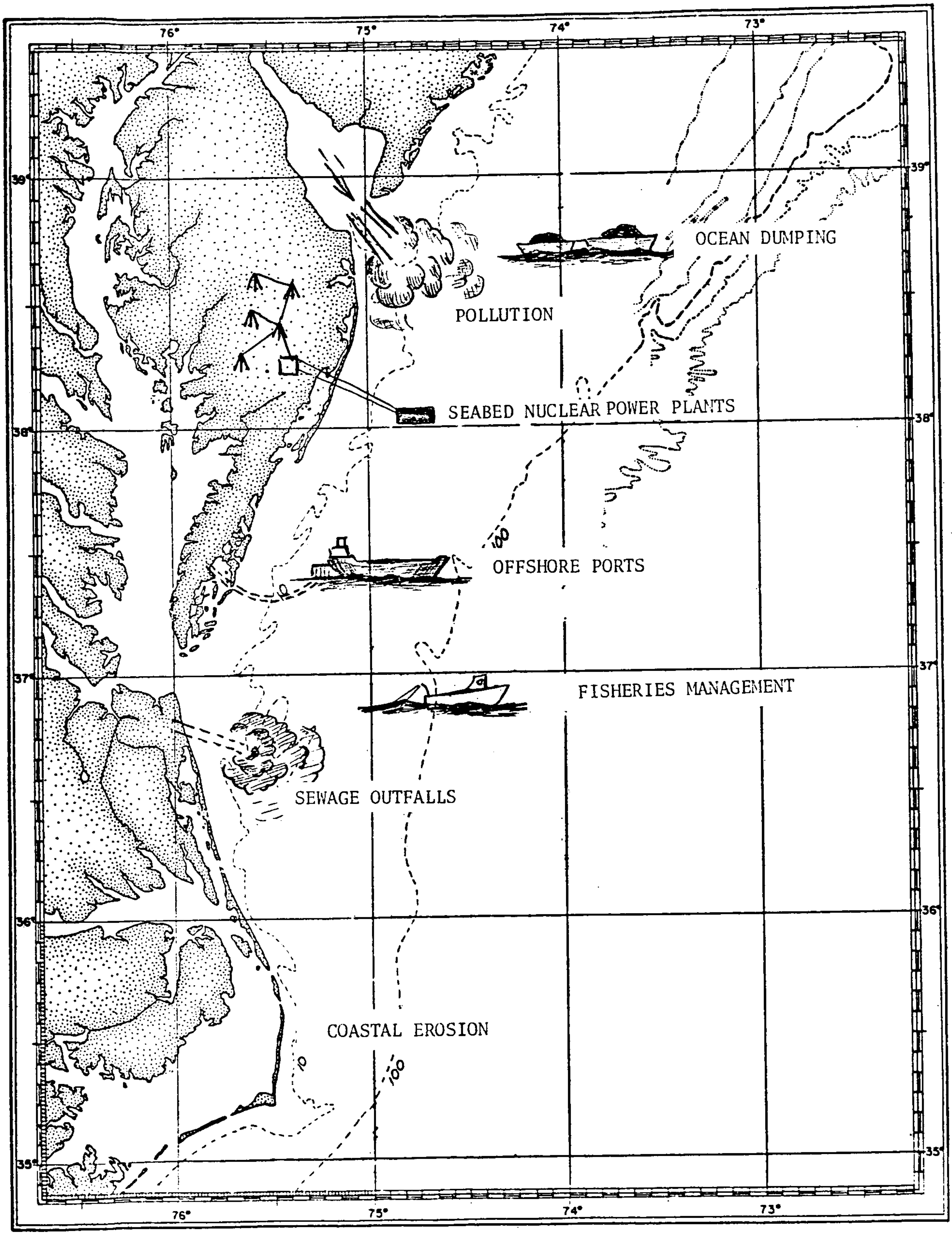

Figure 15.- Seven environmental problems on the Continental Shelf.

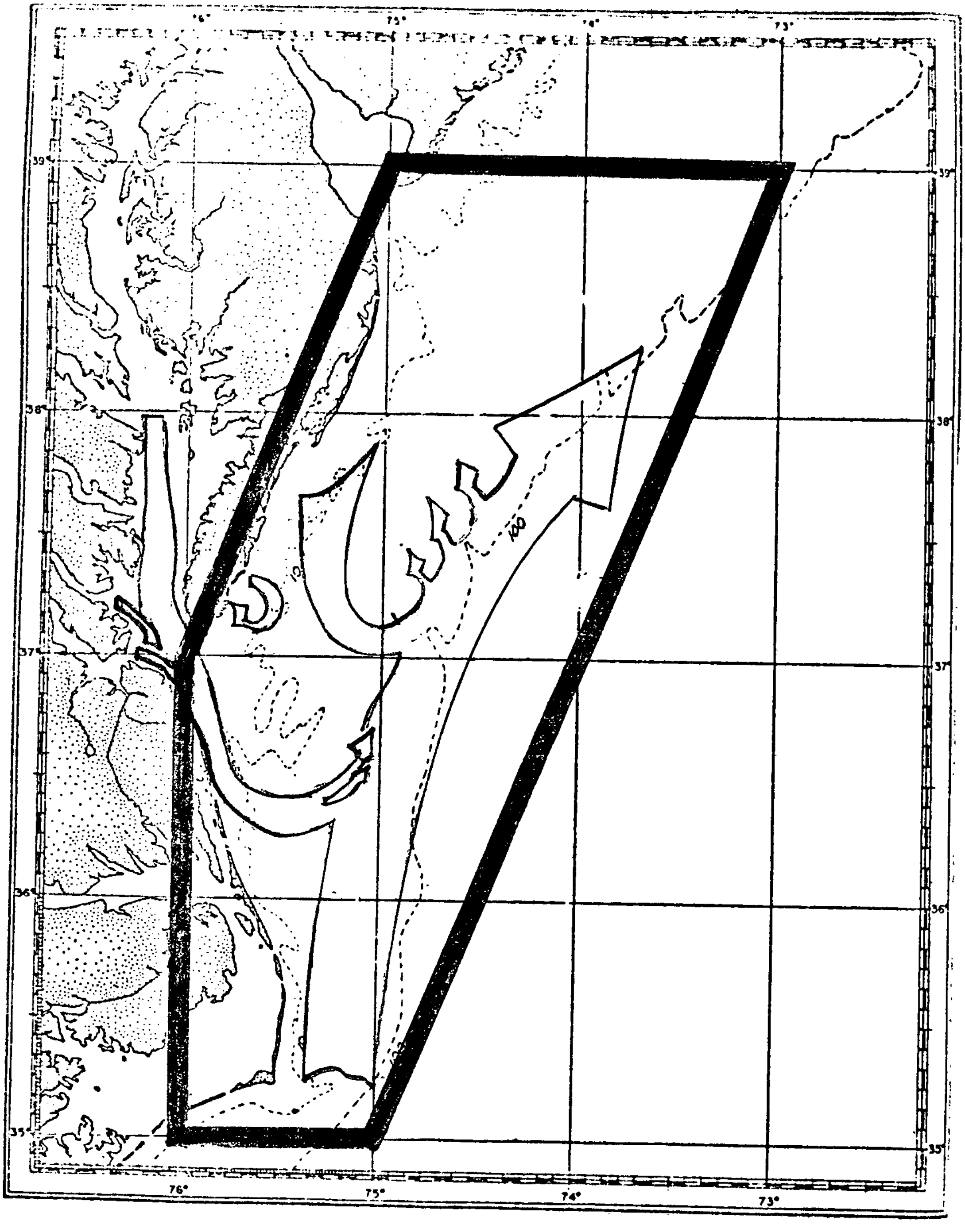

Figure 16.- The boundaries of the Virginia Institute of Marine Science-LRC Continental Shelf research area showing the normal surface flow pattern.

- CIRCULATION ON THE BROAD SHELF
- NEARSHORE CIRCULATION
- WIND DRIVEN CIRCULATION
- WAVE REFRACTION AND COASTAL EFFECTS
- SEDIMENT TRANSPORT
- MODELS

Figure 17.- The Virginia Institute of Marine Science-LRC specific areas of investigation on the Continental Shelf.

Figure 18.- A picture of the LRC drogue for detection of surface current.