

## Finding Fish With Satellites

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**ABSTRACT**—The LANDSAT (Land Satellite) Investigation began in April 1975 to determine if satellites can be used to help fishermen find fish. The cooperative government, industry, and academic study uses multispectral scanners in LANDSAT satellites to measure certain ocean features for locating fishing areas for menhaden and thread herring. Two study areas were selected for field operations during the 1975 menhaden fishing season; the eastern portion of Mississippi Sound and a 5,200 km<sup>2</sup> area off the Louisiana coast. Aircraft sensors, fishing vessels, spotter pilots, research vessels, and offshore oil platforms were used to collect supplementary and corroborative data on chlorophyll, surface water temperature, salinity, color, turbidity, and fish school location and size. Data analyses so far indicate that water color and turbidity significantly correlate with the distribution of menhaden. Surface temperature and salinity do not appear to be significant factors. The effect of chlorophyll is unclear. Classification algorithms were developed for satellite data which divide the study areas into high and low probability fishing zones. Tests performed on these algorithms with fish catch location information indicate classification accuracies in excess of 80 percent.

### INTRODUCTION

A cooperative U.S. Federal Government, private industry, and academic study is being conducted in the northern Gulf of Mexico. It is called the LANDSAT (Land Satellite) Menhaden



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and Thread Herring Resources Investigation. Its purpose is to demonstrate the potential of satellite remote sensing as an aid in locating commercially harvestable stocks of menhaden and thread herring. The study uses the talents and capabilities of fishermen, oceanographers, engineers, fishery biologists, data managers, and remote sensing specialists, all with different objectives, but when taken together satisfying the same purpose.

In a study of this type, especially one involving participants from many different occupations, there are many questions to be answered. These questions are difficult to answer because they deal with subjects not directly related to any single discipline. Answers to 20 of the more commonly asked questions are given in the following section.

### QUESTIONS AND ANSWERS

1. Q. What is LANDSAT?

A. LANDSAT consists of two identical satellites, LANDSAT I, and LANDSAT II, launched in 1972 and 1975, respectively. The two satellites are platforms for remote sensors, the one

used in this study is a multi-special scanner. It measures color as light intensity in four regions of the light spectrum. Both are experimental satellites that are being used by scientists to find out if satellites can help them in areas such as forestry, agriculture, water resources, oceanography, etc. These satellites orbit the earth at 917 km and provide repeat coverage of specific points every 18 days. Their orbits are synchronized so that a specific area is covered every 9 days.

2. Q. What is the purpose of the LANDSAT Menhaden and Thread Herring Investigation?

A. It is an attempt to find out if satellites can help fishermen find fish. Our assumption is that if satellites can help fishermen find fish then the same capability can help fishery managers better manage fish resources. We are also using the study to develop better techniques for analyzing remotely sensed data (from aircraft and satellites) and to determine how selected parameters in the ocean environment affect fish movements.

3. Q. How can a satellite that looks at the Gulf Coast area only every 18 days help fishermen? Information is needed several times a day!

A. We agree that LANDSAT satellites probably will not presently aid fishermen directly. However, before an operational satellite system, to benefit fishermen, can be designed and deployed, we must know if such a system is feasible. The LANDSAT satellites should

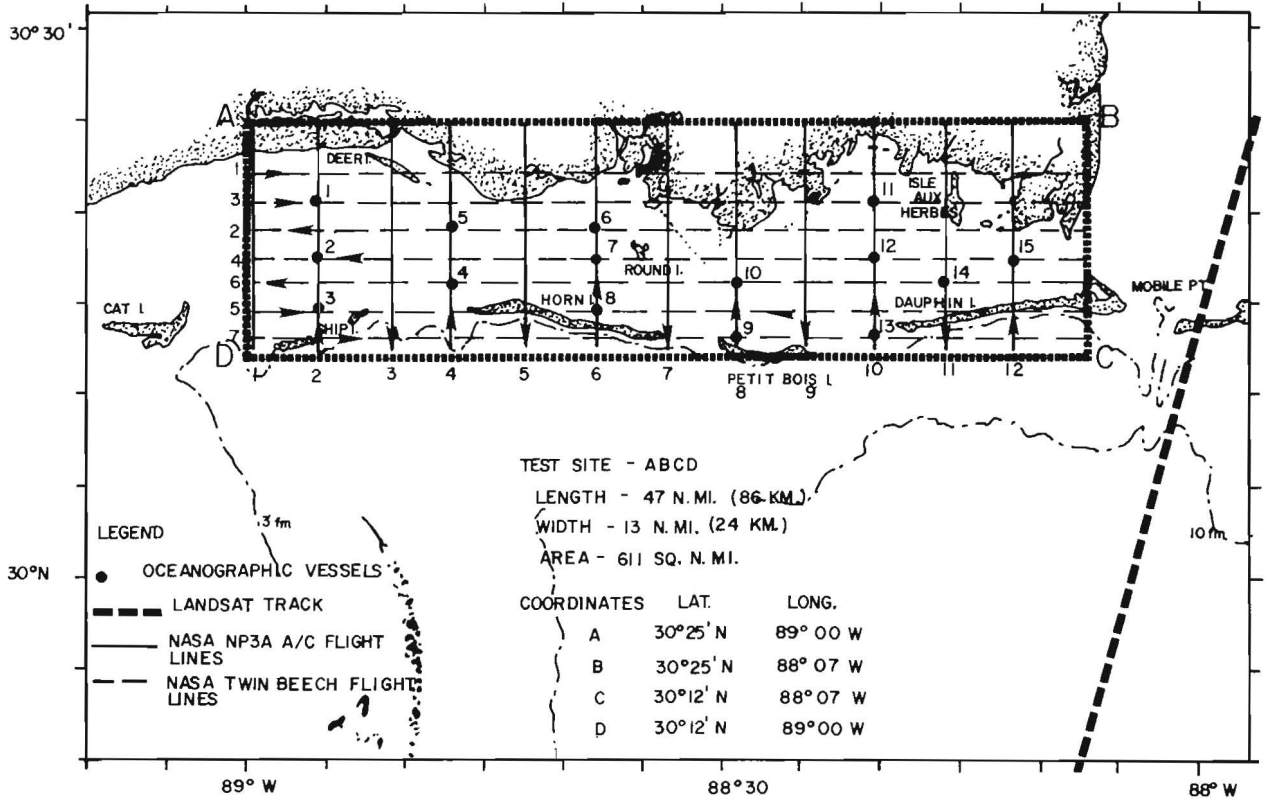


Figure 1.—Mississippi Sound study area.

provide this information. Probably the class of satellites needed for fishery applications is what is known as "geostationary." This means the satellite orbits at the same speed as the earth turns so that its position never varies with respect to a given location on earth. The GOES (Geostationary Operational Environmental Satellite) satellite, already in orbit over the Gulf, does exactly that. It transmits data to earth regarding cloud patterns and movements every 30 minutes.

4. Q. Does LANDSAT see fish?

A. No, its resolution (ability to detect objects like fish schools) is inadequate. There are no civilian satellites available with adequate resolution to detect most fish schools (e.g., menhaden and thread herring). An object has to be about 80 m in diameter and very contrasting in color before LANDSAT can detect it.

5. Q. If LANDSAT cannot detect fish schools, what good is it?

A. Even though it cannot detect fish schools directly, it can measure certain ocean features which may affect the distribution of fish. One of the basic assumptions in ecological theory is that all living organisms are influenced by their environment. Fish are no exception. For example, our data suggest that the distribution of menhaden is strongly related to the turbidity of the water. If this is true, it should be possible to predict where menhaden are by monitoring water turbidity. The LANDSAT sensors may be able to do this.

6. Q. Who is involved in the LANDSAT Investigation?

A. Primary participants are from the menhaden fishing companies (member companies of the National Fish Meal and Oil Association), NASA's Earth Resources Laboratory, and the Fisheries Engineering Labora-

tory (Southeast Fisheries Center, National Marine Fisheries Service). Throughout the investigation, and especially during the 1975 fishing season, we worked closely with fleet managers, vessel captains, and spotter pilots from the five menhaden companies in the northern Gulf of Mexico. In addition, each company appointed one or more people called "cooperators" to review, advise, and coordinate plans, procedures, and results. Other participants include NASA's Goddard Space Flight Center (they funded most of the investigation), the Johnson Space Center, and the National Space Technology Laboratories; NOAA's National Environmental Satellite Service, the National Weather Service, and the Atlantic Oceanographic and Meteorological Laboratory; the U.S. Geological Survey; the U.S. Coast Guard; Nicholls State

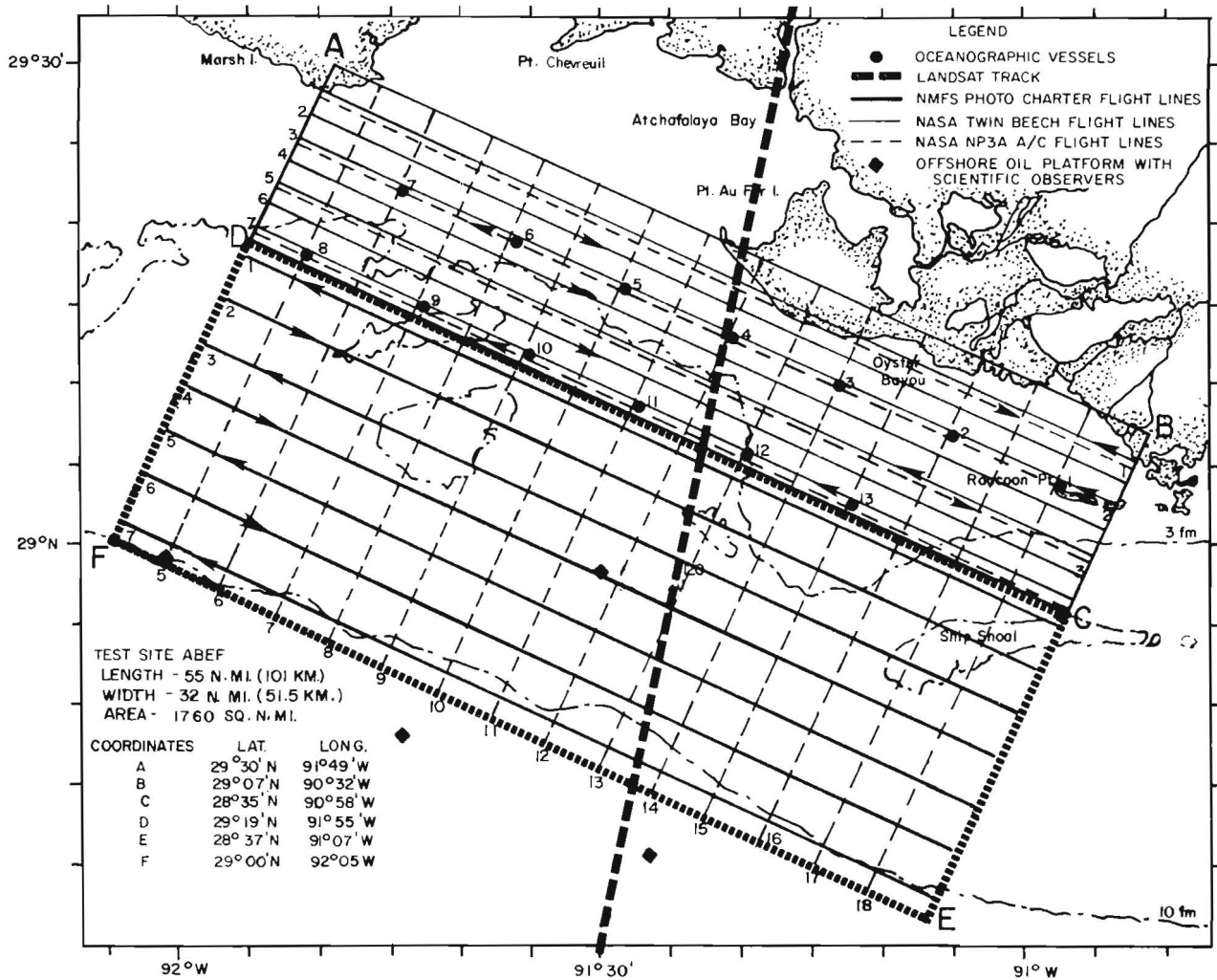


Figure 2.—Louisiana study area.

University; and four offshore oil companies.

7. Q. When did the LANDSAT Investigation begin, and when will it be completed?

A. Officially, the investigation did not begin until 29 April 1975. Unofficially, however, we began developing plans for it in the fall of 1974. The field phase, i.e., the phase where information was collected, was conducted during the 1975 menhaden fishing season (April-September). We are now in the analysis phase which will continue until the final report is prepared in February 1977.

8. Q. Why will it take so long to finish the investigation?

A. Primarily because the remotely sensed data will take many

computer hours to process and analyze. The LANDSAT Investigation is an experiment in the truest sense of the word. A tremendous amount of data was collected and all of these data have to be processed and analyzed. Frequently, an analytical strategy selected for a particular set of data does not work well and something else has to be used. There are many analytical "blind alleys" that have to be explored. Some lead to something of value, others do not.

9. Q. Where was the LANDSAT Investigation conducted and why?

A. Two study areas were used: the eastern portion of the Mississippi Sound and a 5,300

km<sup>2</sup> area off the Louisiana Coast (Figs. 1 and 2). These study areas were selected because both support sizable populations of menhaden, and thread herring are known to occur off Louisiana at about the 10-fathom curve. Two study areas were used instead of just one because we wanted to be able to test the results from one against the other so that ultimately the results might be applied to the entire northern Gulf of Mexico.

10. Q. Why were menhaden and thread herring chosen as target fish species?

A. Both are generally found near the surface of the water and thus are likely to be affected by ocean features which can be

measured with aerospace remote sensors. In addition, because of the active menhaden fishery, we felt that we could get good information on fish distribution and abundance. Without these fishing data, the investigation would have been worthless. We hope by showing that satellite remote sensing will work for menhaden that enough interest will be stimulated in federal, state, and private industry groups to apply this technology to other species. Thread herring are a secondary target species in the investigation and we hope information obtained for menhaden can be applied to them. This might aid in expanding the thread herring fishery.

11. Q. What kind of information was collected during the 1975 menhaden fishing season?
- A. We collected data on ocean features measurable from aerospace platforms, from fishermen, and from aircraft spotter pilots. These were: chlorophyll (measure of the amount of algae in the water); surface water temperature; salinity (amount of salt in the water); water color; turbidity (amount of silt and other material in the water); and location and size of fish schools.

12. Q. How was information collected?
- A. We relied on vessel captains and spotter pilots for the fishing data. Scientific observers, on board selected fishing vessels, collected water samples at the site of menhaden and thread herring catches. Two NASA remote sensing aircraft were used to measure water temperature and salinity, two features LANDSAT does not measure. One NASA aircraft was also equipped with a similar remote sensor employed by LANDSAT. This provided coverage when cloud cover or other reasons prevented coverage by LANDSAT. Also, three oceanographic research vessels were used in both study areas and scientific

PLATFORM	MISSION	MAIN	MAIN	SUPPLE-	ABORTED	SUPPLE-	MAIN <sup>2</sup>	SUPPLE-
	DATE	MAY 2	MAY 20	MAY 25	MAY 31	AUG 18	SEP 5	SEP 23
FISHING VESSELS		X	X	X	X	X	X	X
SPOTTER AIRCRAFT		X	X	X	X	X	X	X
FISHING VESSEL OBSERVERS		X	X		X		X	
RESEARCH VESSELS		X	X				X	
ERL AIRCRAFT		X	X					
NP3A AIRCRAFT		X	X				X	
LANDSAT II		X	X	X	X	X	X	X

- 1 Mission aborted due to inclement weather and unavailability of NP3A.  
 2 ERL Aircraft unable to complete mission due to inclement weather and mechanical failure.

Figure 3.—Summary of Mississippi Sound missions, 1975.

PLATFORM	MISSION	MAIN	MAIN	SUPPLE-	ABORTED	SUPPLE-	RESCHED-	SUPPLE-	SUPPLE-
	DATE	APR 25	MAY 13	MAY 18	MAY 24	AUG 11	AUG 20	AUG 29	SEP 16
FISHING VESSELS		X	X	X	X	X	X	X	X
SPOTTER AIRCRAFT		X	X	X	X	X	X	X	X
FISHING VESSEL OBSERVERS		X	X		X		X		
RESEARCH VESSELS		X	X				X		
OIL PLATFORMS		X	X				X		
ERL AIRCRAFT		X	X				X		
NP3A AIRCRAFT		X	X				X		
PHOTOGRAPHIC AIRCRAFT		X	X				X		
LANDSAT I		X	X	X	X	X	X <sup>2</sup>	X	X

- 1 Mission aborted due to mechanical failure reported aboard LANDSAT I.  
 2 LANDSAT II.

Figure 4.—Summary of Louisiana missions, 1975.

- observers collected water samples from four offshore oil platforms in the Louisiana study area. Figures 1 and 2 show flight lines of the remote sensing aircraft, locations of water sample stations for the research vessels, the flight track of LANDSAT, and the oil platform locations in the Louisiana area. All sampling from surface vessels and oil platforms followed identical collection procedures so that the data could be integrated.
13. Q. Was this information collected continually throughout the fishing season?
- A. No. Three major and four minor field operations were conducted in each study area (Figs. 3 and 4). These opera-

tions took place the day before, the day of, and the day after LANDSAT coverage. Major field operations are referred to as "Main Missions" and the minor ones as "Supplementary Missions." The main missions were designed to provide all data necessary for developing and analyzing computer models; data from the supplementary missions are used to serve as checks on main mission data analysis.

14. Q. What does LANDSAT measure?
- A. It measures water color, i.e., the amount of light energy radiated from the water. The multispectral scanner aboard LANDSAT measures light intensity in four spectral bands

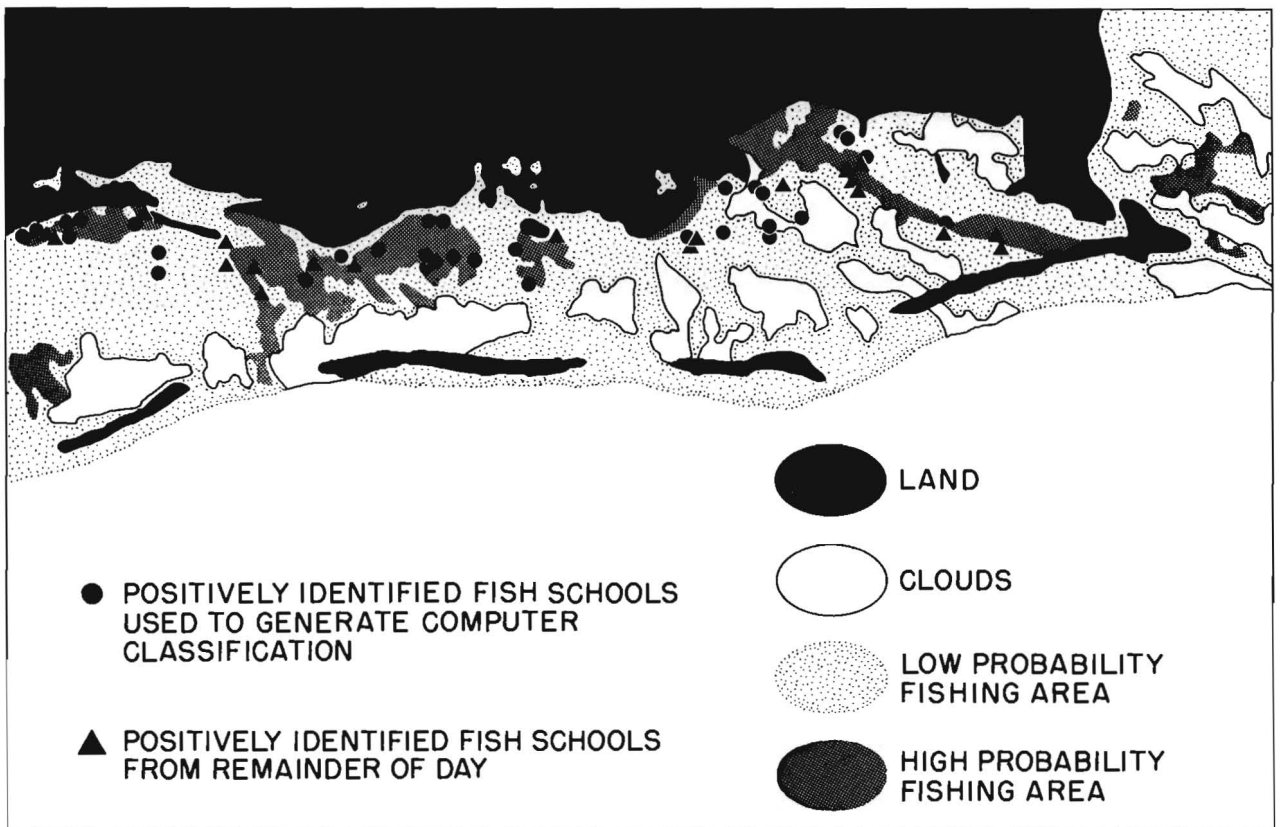


Figure 5.—Computer classification of LANDSAT data into high and low probability fishing areas (data from 20 May 1975).

(green, red, infrared-1, and infrared-2). It views the earth as a series of small squares, 79 m on a side, and records the amount of light radiated from each square in the four spectral bands. From these color measurements, we hope to be able to infer water chlorophyll, turbidity, and possibly fish distribution. Four images (photographs) are produced from LANDSAT corresponding to the four spectral bands. Images are formed by putting the 79 m squares together and representing the quantity of radiant energy in each square as a shade of gray. The lighter the square the greater the radiated energy.

15. Q. What ocean features affect the distribution of menhaden and thread herring?  
 A. Although the analyses are still not complete, it appears that water color and turbidity cor-

relate strongly with menhaden distribution (menhaden seem to prefer turbid waters). For example, 1.1 m was the average secchi disc visibility depth (measurement of turbidity) where menhaden were caught in both the Mississippi Sound and the Louisiana test sites. The same was found to be true for a 1972 menhaden experiment conducted in the Mississippi Sound where similar measurements were made. Water temperature and salinity do not appear to have much of an effect on menhaden distribution within the range of values measured during the study. The influence of chlorophyll is still unclear. Our analysis of the thread herring data is too incomplete for conclusions.

16. Q. Does LANDSAT measure anything that can be used to find fish?  
 A. Yes. We compared locations of

fish catches and spotter pilot observations to LANDSAT data and there appears to be a relationship between these locations and water color as viewed from space. Figure 5 shows how LANDSAT data were used to develop a chart of good and bad fishing areas in the eastern portion of the Mississippi Sound. The data were computer classified into four areas: land, clouds, high probability fishing, and low probability fishing. The black dots are locations of menhaden catches and spotter pilot observations within 2 hours of satellite passage; the black triangles represent similar observations throughout the remainder of the day. Except for the cloudy area near the center of the figure, the results of the classification technique appear to be reasonably accurate. The misclassifications in the center

portion were probably due to cloud contamination of the satellite data. The computer algorithm used to process the data does not distinguish between wispy clouds and turbid water.

17. Q. Will the LANDSAT classification procedure work every time?

A. We do not know with any degree of assurance. That is why we are still analyzing data. We want to know if this classification procedure will work most if not all of the time. We have, however, successfully classified data from two other missions into high and low probability fishing areas.

18. Q. What about the geostationary satellite GOES? Does it have any potential for finding fish?

A. No one knows. We hope to be able to answer this question as part of the LANDSAT Investigation. We do know, however, that its predictions of fish distribution will not be as good as those computed from LANDSAT data, primarily because of its limited sensor capa-

bility. The sensor aboard GOES is similar to LANDSAT except that it measures radiated energy in two channels instead of four and with much less spatial resolution. The two channels include one in the visible portion of the spectrum and one in the infrared, or temperature region. Spatial resolution for the first is about 0.8 km (compared to 79 m for LANDSAT) and about 6.4 km for temperature. The ability of the sensor to measure subtle differences in water color is also probably less than for LANDSAT.

19. Q. Are there any other proposed satellites that might be used for fisheries?

A. Yes, a satellite named Nimbus-G is scheduled for launch in 1978. It will have a color sensor with better color resolution than LANDSAT. This satellite will provide repeat coverage for most areas every 3 days. The Coastal Zone Color Scanner (CZCS) scheduled for launch aboard Nimbus-G is the first visible region imaging sys-

tem designed specially for oceanographic purposes. It will have six radiance channels ranging from 433 to 12,500 nm add a sun synchronous orbit at an altitude of 955 km. Exact repeat coverage will be provided every 6 days. Swath-width will be about 1,200 km with a spatial resolution of about 800 m.

20. Q. How can I get more information about the LANDSAT Investigation?

A. Write or call either of the following people:

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