ABSTRACT
Although U.S. satellites have been gathering environmental data from space since the early 1960's, prior to the launch of SEASAT in July 1978, whatever satellite data that was used by oceanographic or other marine-oriented scientists and engineers had to be obtained from systems primarily designed for meteorology, land-use or other non-marine disciplines. This paper will briefly describe the types of satellite data that are on archive at NOAA and of interest and use to oceanographic researchers.

1. INTRODUCTION
The Satellite Data Services Division (SDSD) of the National Climatic Center (NCC), part of NOAA's Environmental Data and Information Service (EDIS), maintains the U.S. archive of satellite data from all the NOAA operational satellites and from several non-operational NASA satellites. These data are available from as early as April 1960 up to the present, and include data and products from both the polar orbiting satellite series and the geostationary satellite series. The polar orbiting series circled the earth on the average every 100 minutes, and completed approximately 14 orbits per day. NOAA-6, the most recent operational polar orbiter, had a period of 98 minutes, an average altitude of 811km and an inclination of 98.7°. The geostationary satellites were placed into an orbit about 36,000km above the equator such that they appear to stand still. The two operational geostationary satellites are located at 75° West longitude (GOES-EAST) and 135° West longitude (GOES-WEST). The data on archive from all of these satellites include photographic imagery, computer compatible tapes, and derived products such as charts and other analysis products.

2. PAST SATELLITES
The data on archive at SDSD dates back to April 1960 with imagery from the TIROS-1 polar orbiting satellites. Data from this series of satellites (TIROS-1 through TIROS-X) and the ESSA series (ESSA-1, 3, 5, 7 and 9) from 1960 through 1972, are only available as film products. The resolution and scale of this imagery is such that it is of little use to the oceanographic research community. Beginning with ITOS-1, in April 1970, and the NOAA-1 through 5 series, a new, higher resolution sensor, the Very High Resolution Radiometer (VHRR) was flown in space. This instrument allowed data to be recovered in both the visible and infrared region of the spectrum with nearly 1km resolution. While limited to less than global coverage, the VHRR proved to be of use to the marine community by allowing major currents and sea surface temperature gradations to be observed. This sensor was upgraded in 1978, with TIROS-N, to the Advanced Very High Resolution Radiometer (AVHRR) with 1km resolution in all four channels. Figure 1 shows a 10.5 to 12.5μm Thermal Infrared Channel image from TIROS-N taken over the Gulf Stream on May 7, 1979. From a series of these images, the Gulf Stream Analysis Chart (Figure 2) is produced weekly. Starting in 1980 this Chart was converted to a North Section (produced three times a week) and a South Section (produced twice weekly). In addition to this, a computer derived sea surface temperature chart called GOSSTCGW (Figure 3) is produced globally once every week.

Data from NASA's Geodynamics Experimental Ocean Satellite (GEOS-3) are also archived at SDSD. The data from GEOS-3 consists of digital tapes containing 3½ years of global radar altimeter measurements of the earth's oceans including smoothed sea surface heights, surface wind speed, current and sea-ice boundaries, etc.

One other very important satellite that is no longer operational is SEASAT, the first dedicated oceanographic satellite. SEASAT, launched in July 1978, only lasted about 100 days but provided the scientific community with enough data to last for several years. All but one of the five sensors on SEASAT were microwave sensors, which afforded all weather, day-night observations of the ocean surface. The Scatterometer (SASS) and Microwave Radiometer (SMR) provided global data on ocean surface roughness, wind speed, etc., while the Altimeter (ALT) provided detailed global coverage of sea surface heights. Probably the most spectacular instrument on SEASAT was the Synthetic Aperture Radar (SAR), which obtained radar imagery of the ocean and land surfaces with 25 meter resolution. Figure 4 is a digitally processed SAR image of the Nantucket Shoals region.
Data from the Geostationary Satellites first started to be archived at SDSD in 1969 with the ATS series. In 1974 up to the present, while the resolution and scale of the imagery from these satellites made it difficult for oceanographers to use, once again they managed. In addition to the photographic imagery routinely available, digital tapes of reduced resolution and full resolution data are available from August 1976 to the present and December 1978 to the present respectively. GOES data are very valuable due to their availability every ½ hour, 24 hours a day from both satellites. One example of the type of observations of interest to oceanographers is shown in Figure 5, which shows the oil spill in the Bay of Campeche. The major portion of the spill around the well-head was observable for several months due to the opportunity angle of the sun and the sun-glint pattern on the water surface.

3. PRESENT SATELLITES

Currently, NOAA only has one operational polar orbiting satellite in space - NOAA-6. This satellite has sensors similar to those of TIROS-N and is presently providing data and derived products on a regular basis. In June of this year, NOAA plans to launch NOAA-7 which, while nearly identical to NOAA-6, will provide coverage at similar times as TIROS-N.

The GEOSTATIONARY series of satellites are still functioning. New satellites (GOES-4 and GOES-5) will soon replace the older satellites in the east and west positions.

The one present operating satellite that is of most interest to oceanographers is NIMBUS-7, which was launched in October 1978. The Coastal Zone Color Scanner (CZCS) instrument is the only sensor from NIMBUS-7 whose data are archived at SDSD. This sensor consists of 6 narrow band channels specifically designed to sense water temperature, chlorophyll, and suspended sediment. It has a resolution of 825 meters and data are available as both film products (Figure 6) and digital tapes. Over 3000, two-minute scenes from CZCS are available currently from SDSD, and this archive is growing rapidly weekly.

4. FUTURE SATELLITES

The NOAA polar orbiting series will continue into the future with launches planned every other year to replace degrading satellites already in orbit. As the present GOES satellites likewise degrade, they will be replaced with new ones.

The National Ocean Satellite System (NOSS), a tri-agency system, was planned for launch in the 1985 time frame. This satellite was to be the first operational oceanographic satellite. Due to recent budget cut-backs, this system has been postponed.

NOAA has been tasked with taking over the operation of the LANDSAT series of satellites. Progress is being made for this changeover, however, it is currently planned for the EROS Data Center to continue to process and provide the LANDSAT data to users.

NASA is planning a series of experimental satellites and spaceborne sensors well into the future. The role of NOAA and SDSD in these future systems is not known at this time. NASA is planning to fly a Shuttle Imaging Radar (SIR-A) on several future Space Shuttle Missions. SIR-A will be similar to the SAR flown on SEASAT.

In addition to these, several foreign countries and organizations plan to orbit sensor packages in the future which may be of use to oceanographers. These include: (1) The Canadian Synthetic Aperture Radar Satellite Program (late 1980's); (2) The Japanese MOS and LOS programs (mid 1980's); (3) The French SPOT System (mid 1984); and (4) The European Space Agency's ESA Remote Sensing Satellite (ERS-1) (mid 1980's).

5. SUMMARY

Limited space does not allow the inclusion of detailed listings or samples of all the data and products available through SDSD. Additional information on past, present and future satellites and products are available to all interested users by contacting SDSD directly. A wide variety of articles, brochures, users guides and documentation are maintained and available through SDSD. Several data catalogs are routinely updated and mailed to users, in addition to our Satellite Data Users Bulletin which is published several times each year. The Bulletin is published over 2500 data users throughout the world, helps keep everyone up to date on the status of the satellites and data available from them.

SDSD maintains a staff of Oceanographers, and Meteorologists as well as computer specialists to assist users in the selection or interpretation of data. In addition, we maintain close contact with the operational organizations at NOAA and NASA, who produce the satellite data and other organizations throughout the world who perform similar archival and reproduction services as SDSD. All data on archive at SDSD can be reproduced in various formats for users at a relatively low cost. For example, a 10" x 10" print of satellite imagery costs approximately $4.00 (U.S.), a 9-track, 1600 bpi digital tape approximately $72.00 (U.S.)

Potential users are encouraged to contact SDSD directly at the address below or at 301-763-8111 (FTS 763-8111) to inquire about specific data availability, potential applications, or for a price estimate.

Direct all inquiries to:

Satellite Data Services Division (SDSD)
NOAA/EDIS/NCC
World Weather Building, Room 100
Washington, D.C. 20233

302
FIGURE 1

TIROS-N AVHRR Infrared image of northeast U.S. and Gulf Stream. This image was acquired at 19:22:11 GMT on May 7, 1979. Resolution is 1km, covering an area approximately 1500km x 1500km. The main core of the Gulf Stream appears as the darkest, sinuous feature across the central portion of the image, with lighter cooler shelf water to the North. Other eddies and meanders are also detectable. Clouds appear as bright white features in lower left corner.

FIGURE 2

Gulf Stream Analysis Chart of May 4-9, 1979, based on the analysis of six days of satellite imagery similar to that shown in Figure 1. Analysis include the Gulf Streams' main core, eddies, shelfwater and slope water.
FIGURE 3
Global Ocean Sea Surface Temperature Computation (GOSSTCOMP) chart produced for the week of May 8, 1979, based on satellite imagery. This 50° x 50° chart is produced globally. Temperature contours are 1°C. Dotted lines indicate regions where cloud cover conditions restricted the analysis.

FIGURE 4
Digitally processed SEASAT Synthetic Aperture Radar (SAR) image of Atlantic Ocean near Nantucket Island, Massachusetts. This image, from revolution 880, was obtained at 12:34:14 GMT on August 27, 1978. Various degrees of ocean roughness are shown (the darker the surface, the smoother the water). This 100 x 100km scene of the Nantucket Shoals provides a dramatic example of bathymetric expressions occasionally evident over large areas. The actual depths are mostly in the 20-40 meter region.
FIGURE 5
GOES-EAST full resolution (1 nautical mile) visible sector of the Bay of Campeche, Mexico taken at 2033 GMT on June 18, 1979. The Ixtoc-1 Oil Spill is clearly visible just west of the Yucatan peninsula.

FIGURE 6
NIMBUS-7 Coastal Zone Color Scanner (CZCS) image of the Cape Hatteras, North Carolina, and Gulf Stream area. This image was acquired at 16:07:16 GMT on April 21, 1979.