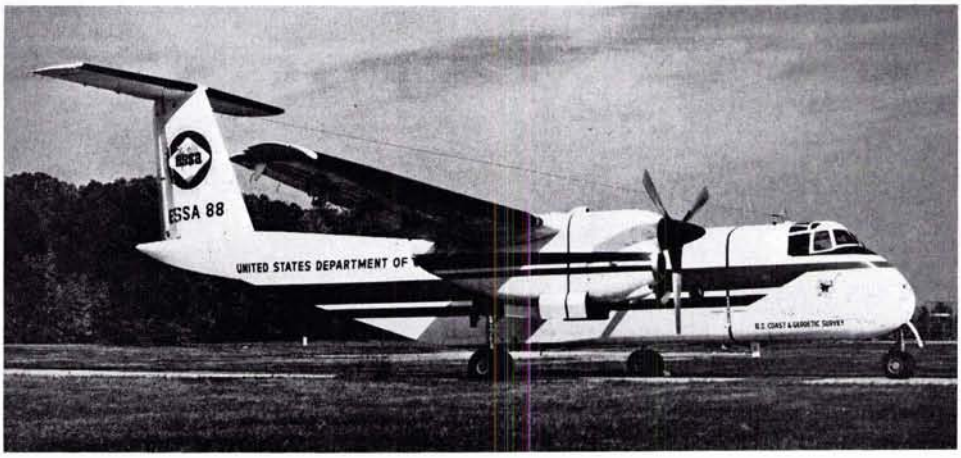

FIG. 1. NOAA-NOS Buffalo aircraft is normally equipped with three aerial cameras for simultaneous operation, or two aerial cameras and one thermal infrared mapper.

JOHN T. SMITH, JR.
NOAA National Ocean Survey
Rockville, Maryland 20852

Oil Slick Remote Sensing

A spill is hunted and photographed for environmental protection.

(*Abstract on next page*)

THE NATIONAL OCEAN SURVEY of the National Oceanic and Atmospheric Administration was contacted by the Environmental Protection Agency on the morning of April 1, 1971, and asked to locate and photograph an oil slick which was sighted in the Atlantic Ocean about 100 miles east of Cape Hatteras. The slick apparently resulted from the sinking of the tanker S.S. *TEXACO-OKLAHOMA* on March 27 when the 661 ft. vessel broke in two. The stern section sank rapidly approximately 60 miles north-northeast of Cape Hatteras, North Carolina. No information was available as to when or where the bow sank. Survivors picked up by S.S. *SASSTOWN* were all from the stern section and they reported the bow section appeared to be sinking when last seen; the bridgehouse was at sea level and the stem high above the water.

The ill-fated tanker was carrying 220,000 barrels (10,240,000 gallons) of fuel oil which represented a pollution problem of considerable proportion. Would the ocean currents direct the slick to our Atlantic Coast beaches or to the North Atlantic Ocean and what was its magnitude? National Ocean Survey has a unique competency for answering these questions by pooling the expertise of its Oceanography and Photogrammetry Divisions; the most difficult task was to find the slick. Oil thins down to an incredibly thin film on the surface of the ocean and if viewed from the air may appear as a slight sheen differing little from surrounding waters. But once sighted, aerial photography and subsequent photogrammetric measurements would be more or less routine.

National Ocean Survey Buffalo aircraft (Figure 1) had returned to Washington, D. C., the evening before, (March 31, 1971) from photographic assignments at Charleston, South Carolina, and vicinity. A leased infrared scanner was aboard, and the crew were under instructions to unload the scanner and prepare the aircraft for aerial photography which was scheduled to commence the following week in Oregon and Washington.

The timing of the Environmental Protection Agency's request could not have been

ABSTRACT: *The National Ocean Survey (formerly the Coast & Geodetic Survey) of the National Oceanic and Atmospheric Administration responded in April 1971 to a request from the Environmental Protection Agency to locate and photograph an oil spill off Cape Hatteras, North Carolina. Using its Buffalo photographic aircraft, which was then equipped with two aerial cameras and a thermal-IR scanner, the NOS photo crew was able to find the spill about 80 miles from the reported position of the sinking of the stern section. Imagery was obtained, processed and delivered for inspection the next day. It was speculated that the bow of the ship had been carried by ocean currents to its eventual location where it sank and released its cargo of oil.*

better. National Ocean Survey's scheduled operations permitted assignment of the Buffalo aircraft for one day to obtain remote imagery of the oil slick. The Mission set out from Washington, D. C., at 1800Z on April 1 in search of the slick. The aircraft was equipped with one Wild RC-8 camera (Figure 2), one RC-9 camera, and the leased Bendix infrared thermal mapper (Figure 3). The Mission was informed that the oil slick was east of Cape Hatteras, and the Mission followed the flight path shown in Figure 4.

At approximately 1950Z an oil slick was sighted. Photography and thermal recording commenced at 2004Z. The RC-8 camera, using positive color MS film, and the infrared scanner, recording on both 70 mm film and magnetic tape, were used. Seven flight lines were flown over the area of the slick, which was approximately two miles wide and eight miles long, the last photography being taken at 2114Z. The photography was taken at approximately 1:6,000 and 1:12,000 scales. The color film and the IR scanner film was returned to Washington and processed by the National Ocean Survey Aerial Photographic Laboratory.

On April 2 the first of a series of evaluations was begun. First, information gathered from the Coast Guard regarding dates and locations of recovered debris were plotted (Figure 5). The track of the plot and the pattern of the surface currents developed speculation as to why the oil slick was located at latitude 35°35′, longitude 73°08′, approximately 80 nautical miles east-southeast of where the

FIG. 2. Wild RC-8 camera installation on Buffalo aircraft being checked prior to commencement of photography.

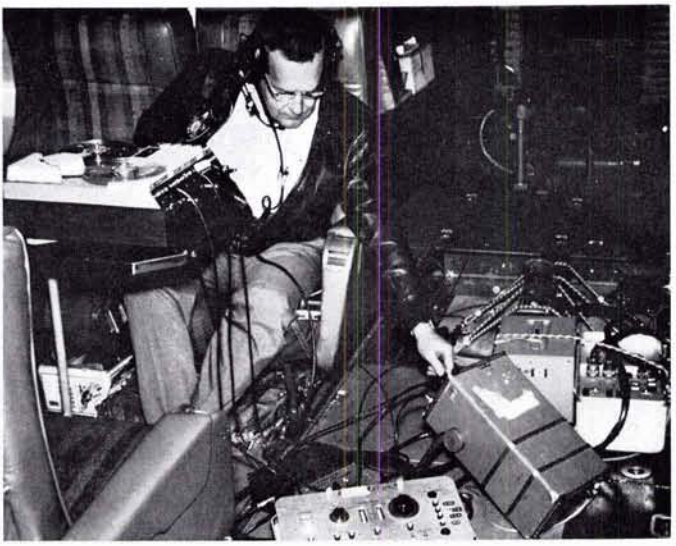

FIG. 3. Thermal infrared scanning equipment installed in Buffalo aircraft.

stern sank. Photogrammetric and photographic interpretation techniques were employed to determine that the slick was moving somewhere between 1.5 and 2.5 knots, on a true heading of 025°. The movement of the oil in an offshore direction alleviated the fear of pollution occurring along the coastline.

After examining the IR thermal photographs (Figure 6), it was speculated that the denser portion of the oil indicated bubbling or upwelling. Separation negatives were made in the NOAA-NOS Aerial Photographic Laboratory from the original color film of the suspected area in order to analyze better the dense portion and to try to determine if upwelling was occurring. Special photographic techniques were used to enhance further the dense portions of the slick (Figures 7, and 8).

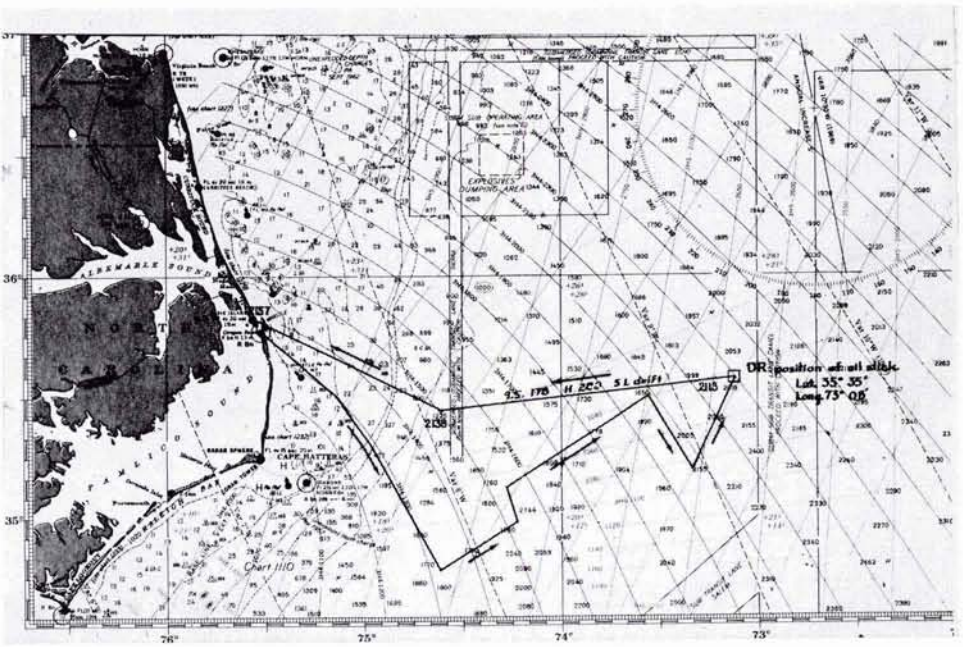

FIG. 4. Flight path of NOS aircraft in search of oil slick resulting from the sinking of S.S. *Texaco-Oklahoma*.

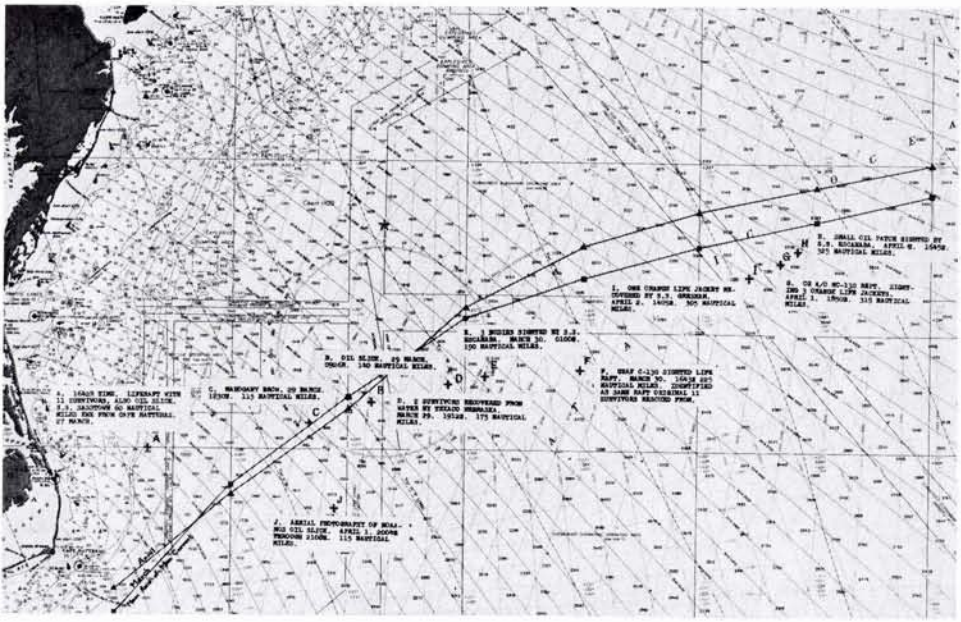

FIG. 5. Plot of debris and oil slick.

The enhancement of the area did indicate heavy concentrations of oil, but it could not be determined if upwelling was occurring. The need for ground truth was obvious. Neither the water temperature in the vicinity of the oil slick nor the temperature of the oil were known. The average thickness of the oil slick was unknown as was the density of the thick concentration areas. It was also considered that if actual upwelling was occurring, cooler water from the depth would be mixed with the oil and this, displacing the warmer water on the surface, would have been indicated on the thermal imagery. At the present time there has been only a small amount of research in this area. To make this assumption, therefore, could lead to an erroneous analysis.

The major question was the reliability of the position of the oil slick in view of oceanographic conditions which existed at the time of photography. Therefore, a number of potential causes for the slick being located near latitude 35°35′N, longitude 73°08′W, were investigated.

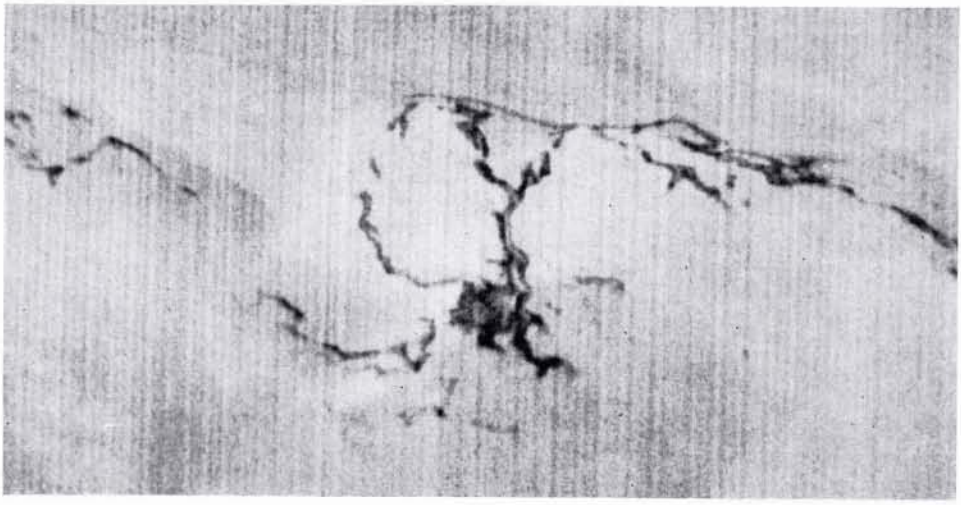

FIG. 6. Thermal infrared imagery of oil slick pattern showing dense area in center.

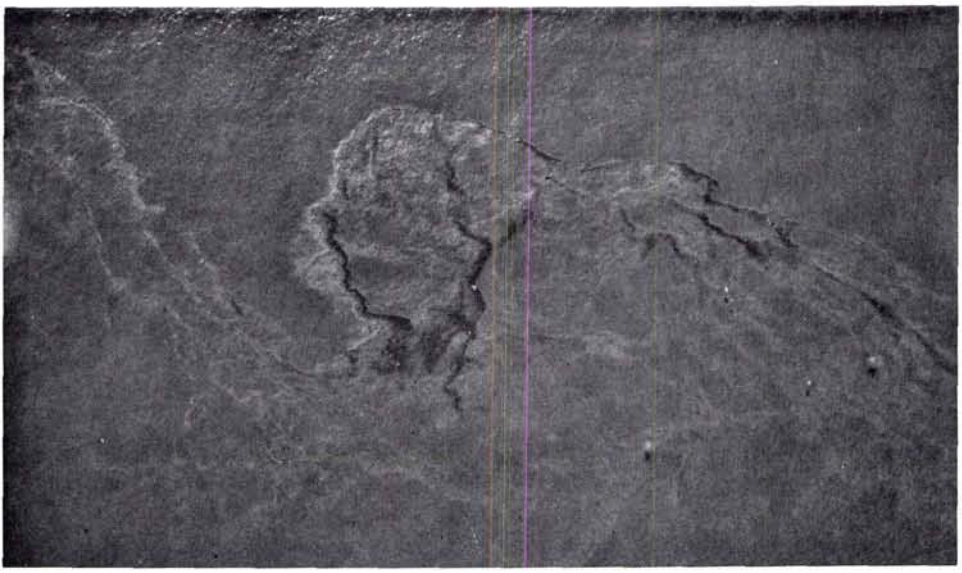

FIG. 7. Black-and-white reproduction of original color film showing the dense area of the oil slick.

The location of the slick could not be dismissed as a navigational error. After reconfirming the position with the navigator and pilot of the NOS aircraft, the dead-reckoning position of the aircraft was verified to within plus or minus 10 miles; the at-sea position of the center of the slick was used to navigate the aircraft back to a known position on land by using a reverse course.

The actual position of the Gulf Stream during the period in question is unknown at this time (when the information is published, it will be examined again). The mean position of the axis of the Gulf Stream during the months of March and April was plotted (Figure 5) and debris, such as life rafts, life jackets, etc., resulting from the sinking closely followed the mean position of the

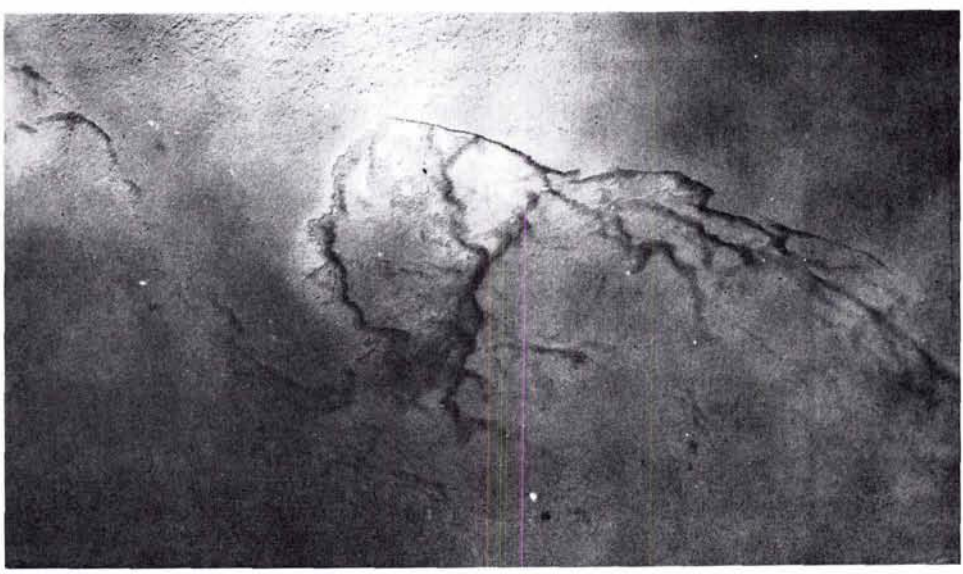

FIG. 8. Enhanced photograph from the original color transparency showing thin areas of oil.

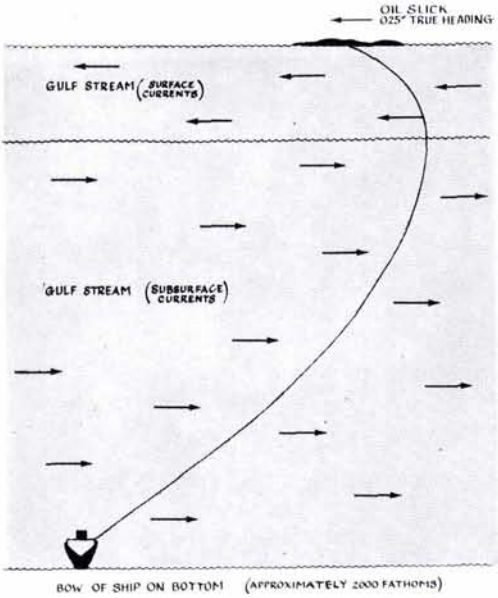

FIG. 9. Artist's rendition illustrating portions of gulf Stream flow of surface and subsurface directions.

Gulf Stream at an average velocity of 2.3 knots. This velocity fits well with the historical data for the velocity and location of the Gulf Stream at this time of year.

Another possibility investigated was the reversal of subsurface currents, as the Gulf Stream is known at some positions to follow a northeasterly direction on the surface, but flows southwesterly at greater depths (Figure 9). On researching this point, it was found that the Gulf Stream at the location of the oil slick extends from the direction, although there are counter-currents on the surface at the southern edge of the Gulf Stream on the order of 0.5 knots.

A third possibility investigated to determine whether the oil slick had indeed resulted from the sinking of the *TEXACO-OKLAHOMA* was a determination of the winds on the days in question. The winds on the days from March 27 through April 1 were out of the northwest with an average speed of 20 knots. This would cause an object to be blown to the south across the Gulf Stream and it is conceivable that the bow section, acting as a large sail, was moved across the main axis of the Stream before sinking. The concentration of the oil shown in the photograph suggests that the bow section may have sunk somewhere near the location of the oil slick that was photographed.