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Determining Synoptic Surface Current Patterns Using Aerial Photography

Surface current probes, dropped from a helicopter, were then photographed from the helicopter in order to determine current velocity and direction.

Abstract: *Acquisition of detailed temporal and spatial surface current patterns has been a difficult task for oceanographers for many years. The use of in-situ current meters can be an extremely costly endeavor. A technique which solves this problem uses a combination of a developed expendable air deployable current probe and aerial photographic techniques. To obtain synoptic surface current data, the probes were deployed from helicopters at 35 locations. At each location the helicopter would hover and a photograph of the released floats from the probe were taken. Analysis of these photographs allows calculation of the surface current speed. Thus, this technique can be used to obtain detailed surface current patterns over a large area in a short period of time.*

Introduction

The special requirements of Very Large Crude Carriers (vlcc's), namely deep draft and extensive maneuvering room, cannot be met by existing United States Ports. Deepwater ports (dwp) located at offshore sites in the Gulf of Mexico are planned to provide these needs (Figure 1). The Deepwater Port Act of 1974 directed the Department of Transportation and the U.S. Coast Guard to establish licensing procedures and operating instructions. Among other things, the Deepwater Port Act requires that careful provisions be made to protect the onshore and offshore environments.

To provide this protection and to determine the adequacy of protective or preventative measures adopted by the port operators, a computer model capable of predicting the movement of oil spills was developed. This model was adapted for deepwater ports from a model developed by Kollmeyer and Thompson (1974). The model requires the input of surface current values on a grid system covering a large ocean area about the deepwater port site. In situ current meters are impractical for large numbers of observations; therefore, a different technique for obtaining surface current values had to be used. The selected technique utilizes an air-deployable surface current probe and aerial photography.

Synoptic Current Measurements

A field experiment was conducted to determine the current regimes in the vicinity of the dwp sites. In order to obtain a synoptic pattern, expendable surface current probes (Richardson *et al.*, 1972) were deployed from helicopters. Figure 2 depicts the use of these

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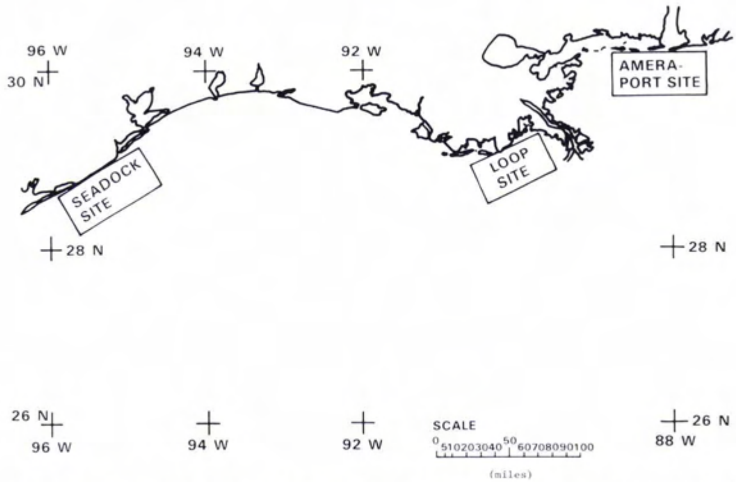

FIG. 1. Proposed locations of the three deepwater port sites in the Gulf of Mexico.

probes. The helicopter hovers over a selected station and the probe is dropped. Upon hitting the water, a surface marker (SM) is released as a reference point. This marker serves as a station locator for the helicopter until the first float, F1, rises to the surface. The remainder of the probe sinks to the bottom. Upon striking the bottom, a float (F1) is released which rises to the surface. After a predetermined time, which is set on a special release mechanism, a second float is released (F2). This float rises and, when it reaches the surface, the distance between F1 and F2 allows calculation of the surface current speed. At each of the three sites 35 surface current probes were dropped. Aerial photographs were taken of the floats to determine probe separation. Two surveys were conducted at each site in order to obtain surface current patterns for two different wind regimes. An example of the pattern of probe site drops for one of the Deepwater Port Sites is shown in Figure 3. These sites were selected using an x and y distance chosen randomly from a given point to avoid bias error. Each experiment commenced from a known point on shore. The helicopter then flew magnetic headings for specific periods of time to move from site to site.

DATA REQUIREMENTS

The data needed to compute the surface current are divided into categories of constants and variables. The constants are the camera focal length, a foot to centimetre conversion factor, float release time interval, and the magnetic to true heading conversion factor. The variables consist of helicopter altitude, the distance between floats 1 and 2, the heading of the aircraft, and the depth of the water.

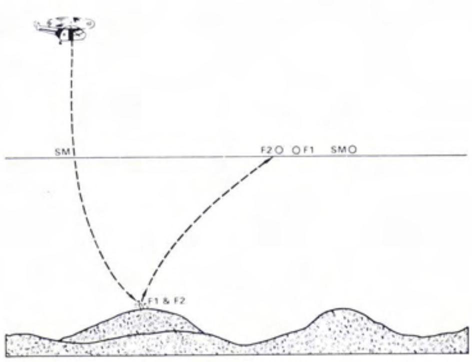

FIG. 2. Diagram of the operation of a surface current probe.

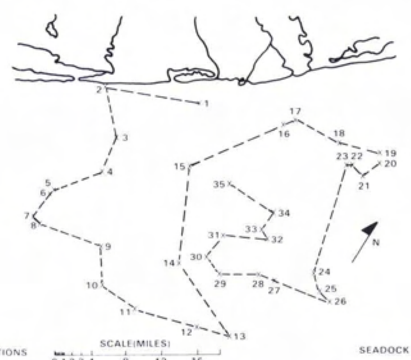

FIG. 3. Location of the 35 drop sites for surface current probes at the proposed site for Seadock deepwater port site.

All photography was obtained with Hasselblad 500 EL/M cameras using a 100 mm focal length lens. Measurement was made from the negatives using a projected scale micrometer, read in decimal feet. All calculations were in feet and converted to centimetres by multiplying by 30.48. All of our surface current probes were set for a release time of 144 seconds between floats 1 and 2. The helicopters were equipped with magnetic compasses, and all headings were converted to true headings by applying the appropriate correction factor for the test area.

Aircraft altitude, from the helicopter's altimeter, and magnetic heading were recorded for each photograph, and the distance between probes 1 and 2 were measured on the negatives. Photographs were taken at an altitude of 1000 feet to prevent small fluctuations in altitude from causing large errors in computing the distance between floats 1 and 2. These floats release dye which acts as a marker for visual assistance in locating the position of the float. Color film has a very narrow range of tolerances and allows for little or no error in proper exposure; therefore, black-and-white film was used throughout. An enhancement filter was used to increase the contrast between the dye plumes released by the floats and the water surface. This created the problem of distinguishing the actual floats because they varied in color and are quite small, measuring about six inches long. In order to alleviate this problem, photographic runs were made down current, F2 to F1. In a few instances, we were forced to fly a reciprocal heading, i.e., F1 to F2, due to sun glint from the sea surface. When this was done, it was noted prominently on the photo data card to facilitate determination of the correct current direction.

Computing Surface Currents

In order to compute the surface current velocity the following formula is used:

Velocity = (Alt/Focal Length) (Dist F2−F1) (Ft−Cm Conversion/ Time Interval)

where

Velocity = surface current velocity in cm/sec,
Alt = altitude of the aircraft (ft),
Focal Length = focal length of the camera (ft),
Dist F2−F1 = measured distance between floats F2 and F1 (ft),
Ft−Cm Conversion = conversion factor from feet to centimetres, and
Time Interval = time interval set on probe (sec),

The only quantity that must be measured on the negative is the distance F2−F1. This is done by the following procedure. The negative is oriented so that the helicopter heading is from left to right, thereby becoming the x-axis on the negative. When the photographs were taken, the camera mount was set up so that, when frame numbers along the edge of the negative were readable along the bottom of the negative, the helicopter heading became the x-axis. Once this is accomplished, the x and y dis-

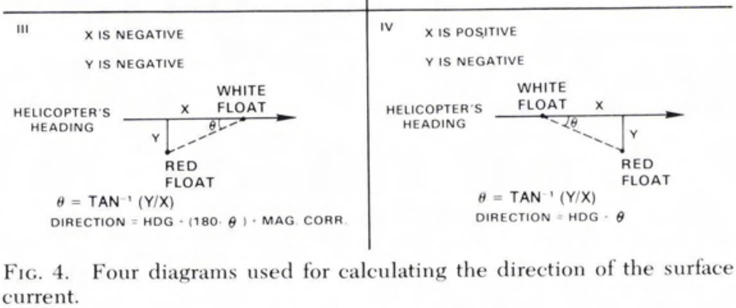

Fig. 4. Four diagrams used for calculating the direction of the surface current.

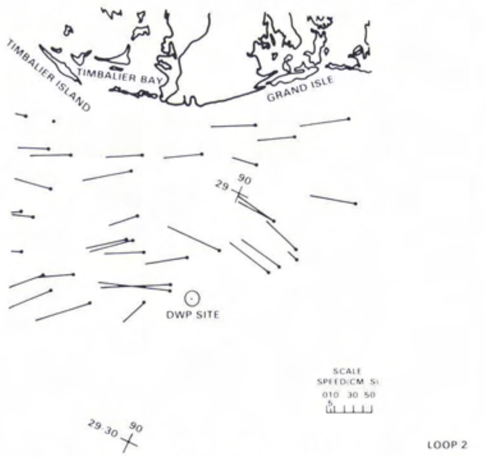

FIG. 5. An example of the surface current patterns obtained using photographic techniques with the surface current probe. The dots represent the stations. Direction of current is away from the dots.

tance from float F2 and F1 can be obtained using the stereoscopic viewer. The signs of x and y determine the formula for finding the direction of the current. Figure 4 shows the four possible combinations of signs and the appropriate formulas for each one. Mag. is the helicopter's magnetic heading at the time the picture was taken and Mag. Corr. is the correction from magnetic to true.

Once the F2−F1 distance is calculated, the surface current velocity can be computed. For calculating velocities, a program has been developed which inputs the station number, the magnetic to true correction, and the variables and constants mentioned. It outputs the surface current velocity in cm/sec and the true direction of the current.

An example of the results of this experiment is shown in Figure 5. This figure shows the surface current pattern in the vicinity of the LOOP deepwater port site off the Louisiana coastline. The dots represent the stations and the lines represent the direction and magnitude of the surface current. This survey was completed in less than six hours.

SUMMARY

The need to acquire surface current values over large ocean areas necessitated marrying several established techniques into one encompassing method. The measurement of surface currents at numerous locations over a short time frame allows for the identification of localized affects and conditions, which can be taken into account for the purposes of modeling the synoptic patterns of a given region. Aerial photography and rapid data reduction have expanded the overall capability of oceanographers in understanding the surface current dynamics of large ocean areas, both temporally and spatially.

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