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# Results From Some Parachute Drogue Measurements in the Central North Pacific Ocean, 1961-1962

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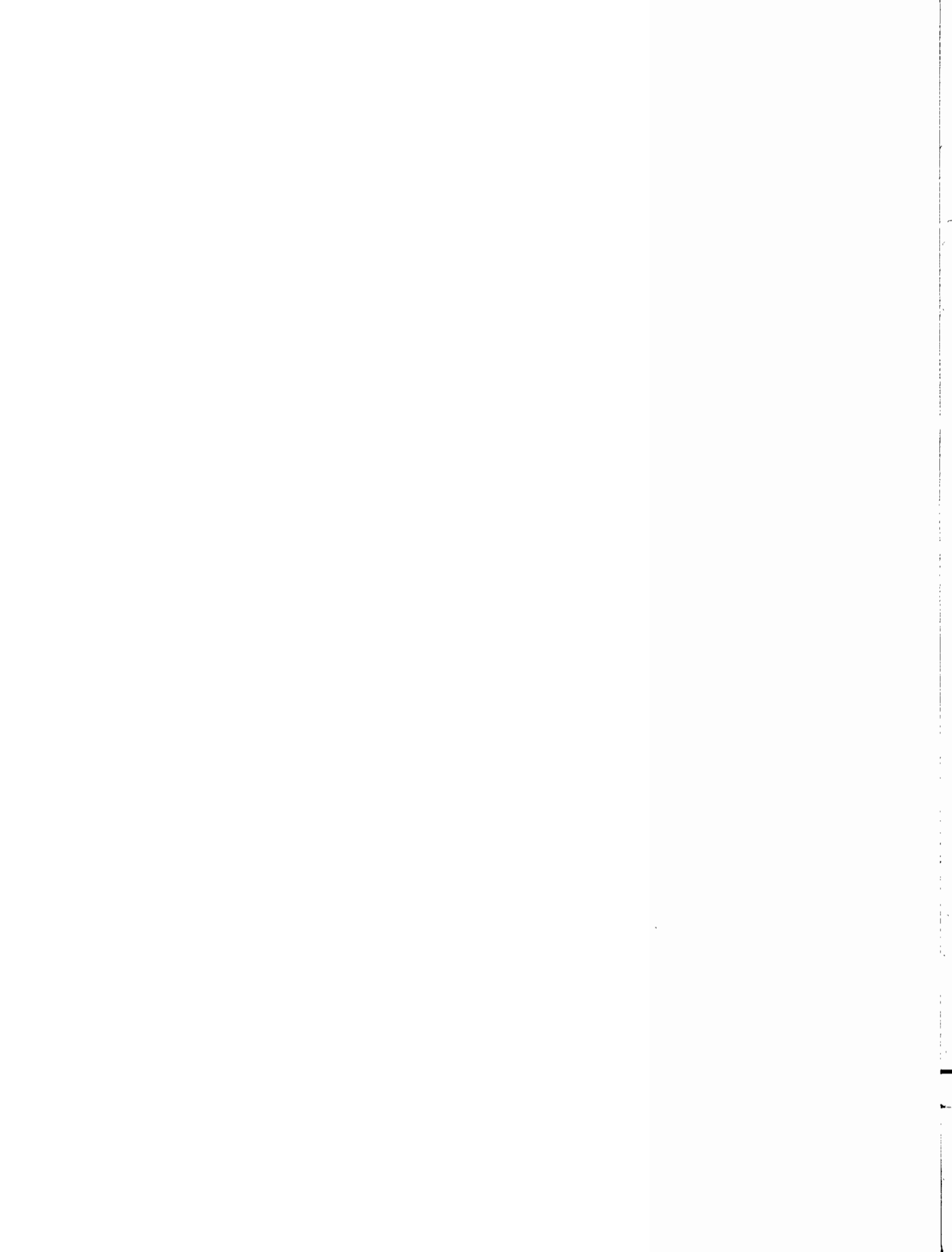
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RESULTS FROM SOME PARACHUTE DROGUE MEASUREMENTS IN THE  
CENTRAL NORTH PACIFIC OCEAN, 1961 - 1962

R. K. Reed

This report presents the paths of seven parachute drogues tracked in the North Pacific Ocean during 1961 and 1962. In the Alaskan Stream near  $161^{\circ}\text{W}$ , four drogues moved in a clockwise gyre in agreement with meanders in the Stream suggested by other data. A drogue farther east in the Stream moved at 36 cm/sec,  $240^{\circ}\text{t}$ . A semidiurnal flow of about 10 cm/sec was superimposed on the net flow. Two drogues near  $27^{\circ}\text{N}$ ,  $160^{\circ}\text{W}$  drifted southwest at speeds in excess of 25 cm/sec, and there is some suggestion of periodic motion in the paths.

1. INTRODUCTION

Acting upon recommendations of the National Academy of Sciences, in 1961 the Coast and Geodetic Survey initiated a geophysical mapping program (SEAMAP) in the North Pacific Ocean which to date has been completed in most of the area between the Hawaiian and Aleutian islands from  $155^{\circ}\text{W}$  to  $180^{\circ}$ . In conjunction with this program, limited oceanographic measurements were made to help describe water properties and flow. Several devices were employed to measure currents directly, but by far the most successful were parachute drogues. Their method of construction was essentially as described by Volkmann et al. (1956), and navigational control was by Loran-C. Only those drogue paths with sufficient duration to reliably determine net flow and which were not unduly affected by strong winds are presented here. One of the SEAMAP drogue

paths has already been described by Reed (1966).

## 2. DROGUE PATHS IN THE ALASKAN STREAM

In summer 1961 drogues were tracked at two stations in the Alaskan Stream, the swift boundary flow which moves westward along the south side of the Alaska Peninsula and Aleutian Islands. Previous measurements in the Stream near 175°W had revealed peak speeds in excess of 75 cm/sec (Reed and Taylor, 1965).

### 2.1 Measurements of 19-21 July 1961

Drogues placed at 6, 91, 183, and 300 m were tracked in deep water over the Aleutian Trench. All of the drogues at this site moved in clockwise orbits at average speeds of 20-30 cm/sec (fig. 1). The latter part of the paths are somewhat more linear, but they still appear to have an orbital tendency.

During the first part of the series, the 6-m drogue moved in the smallest orbit. The average wind during this period was from the southwest at 6 m/sec; consequently, the 6-m drogue (but not the others) may have experienced wind drift which affected its orbit. The 91-m drogue, which was released near the same place as the 6 and 300-m drogues, moved much farther south and east than the others. Although there are differences in flow at the different levels, all paths exhibit the motion of a clockwise eddy.

In order to further examine this motion, other data obtained in summer 1961 were utilized. In this region during summer, vertical

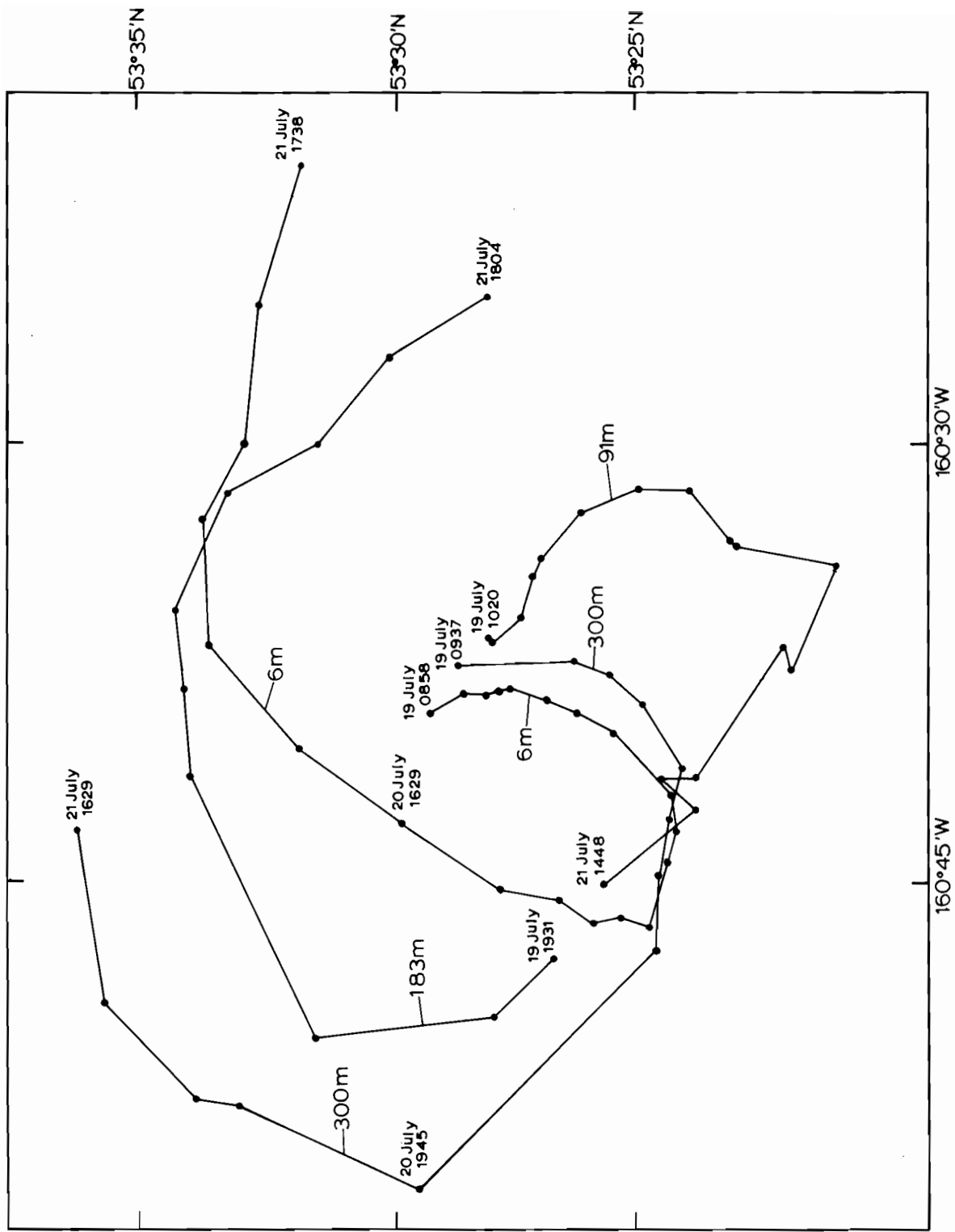


Figure 1. Paths of parachute drogues at depths of 6, 91, 183, and 300 m, 19-21 July 1961.

temperature structure is characterized by a relatively warm surface layer, a rapid decrease to a temperature minimum just below, and an increase to a temperature maximum at a depth usually between 100 and 200 m. Favorite (1967) used the distribution of maximum temperature below the minimum stratum to trace the Alaskan Stream, which advects the warmest water. The location of the  $5^{\circ}$  isotherm in figure 2 suggests that the Stream is just offshore of the Alaskan shelf and that near  $160^{\circ}$ W it has a complex structure with some southerly flow. A system of cyclonic and anticyclonic bends in the Stream is implied, which could produce detached eddies as suggested by the drogue paths. Unfortunately, closely spaced hydrocasts were not made across this eddy-like feature, and its degree of geostrophy cannot be assessed.

## 2.2 Measurements of 4-6 August 1961

The path of the drogue tracked during this period is presented in figure 3. The net flow (from first to last drogue position) was 36 cm/sec,  $240^{\circ}$ t. Water depth was approximately 2000 m at the start and 4500 m at the end of drogue tracking, and the average wind was from the west at 6 m/sec.

The drogue path reveals departures from the net motion; consequently, the net velocity vector was subtracted from the velocity vector of each segment of the path, and north-south and east-west component velocities were computed from the resultant vectors (fig. 4). Motion with a period of about 12 hr and an amplitude of approximately 10 cm/sec is apparent, and maximum component velocities are out of phase by about



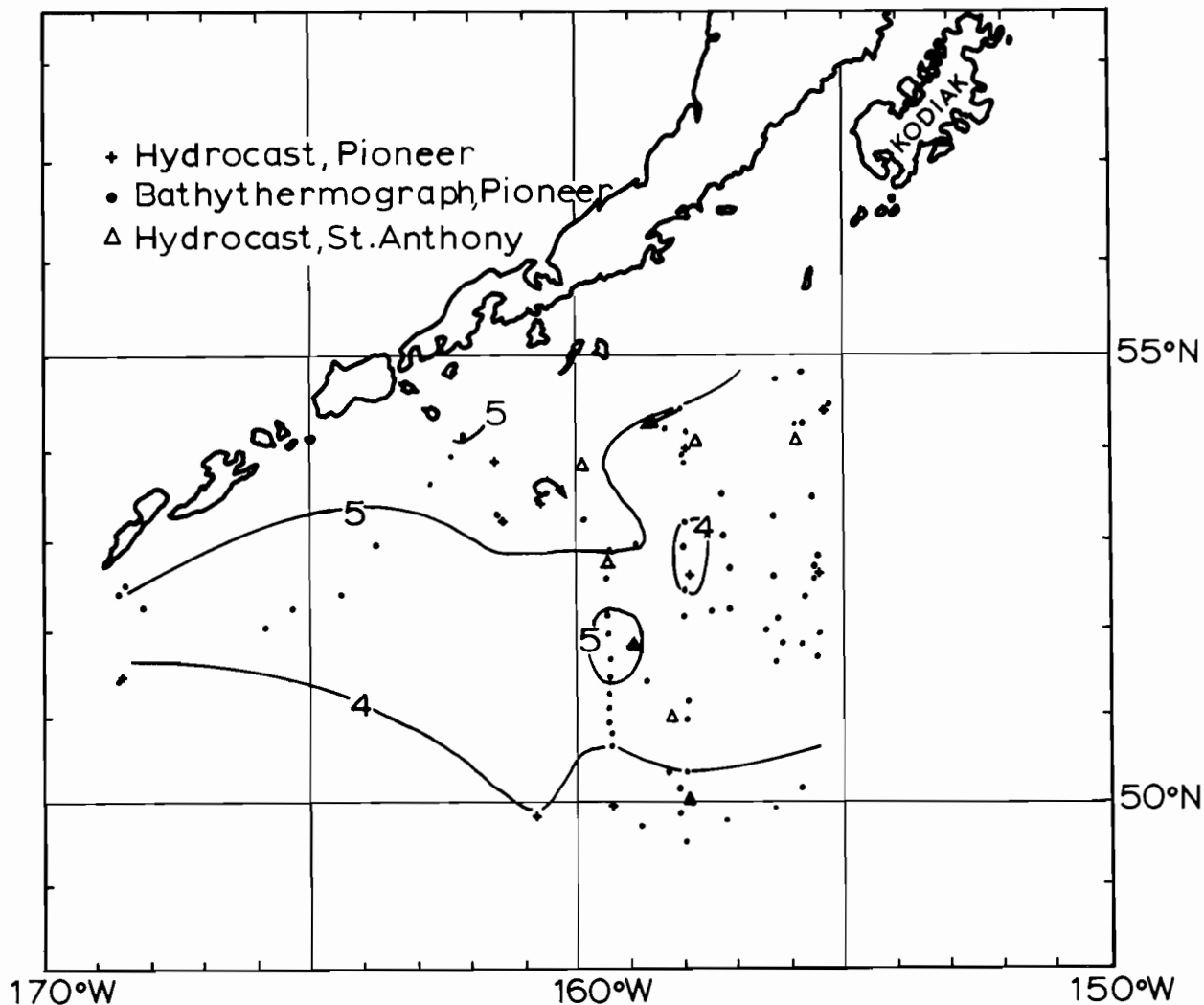


Figure 2. The distribution of maximum temperature ( $^{\circ}\text{C}$ ) below the temperature minimum stratum. (From Nansen bottle cast and bathythermograph data taken by the USC&GS Ship *Pioneer*, 24 May - 12 August 1961, and the CNAV *St. Anthony*, Canada, 20-22 June 1961.) Generalized paths of the drogues tracked during 19-21 July and 4-6 August 1961 are shown by the arrows.

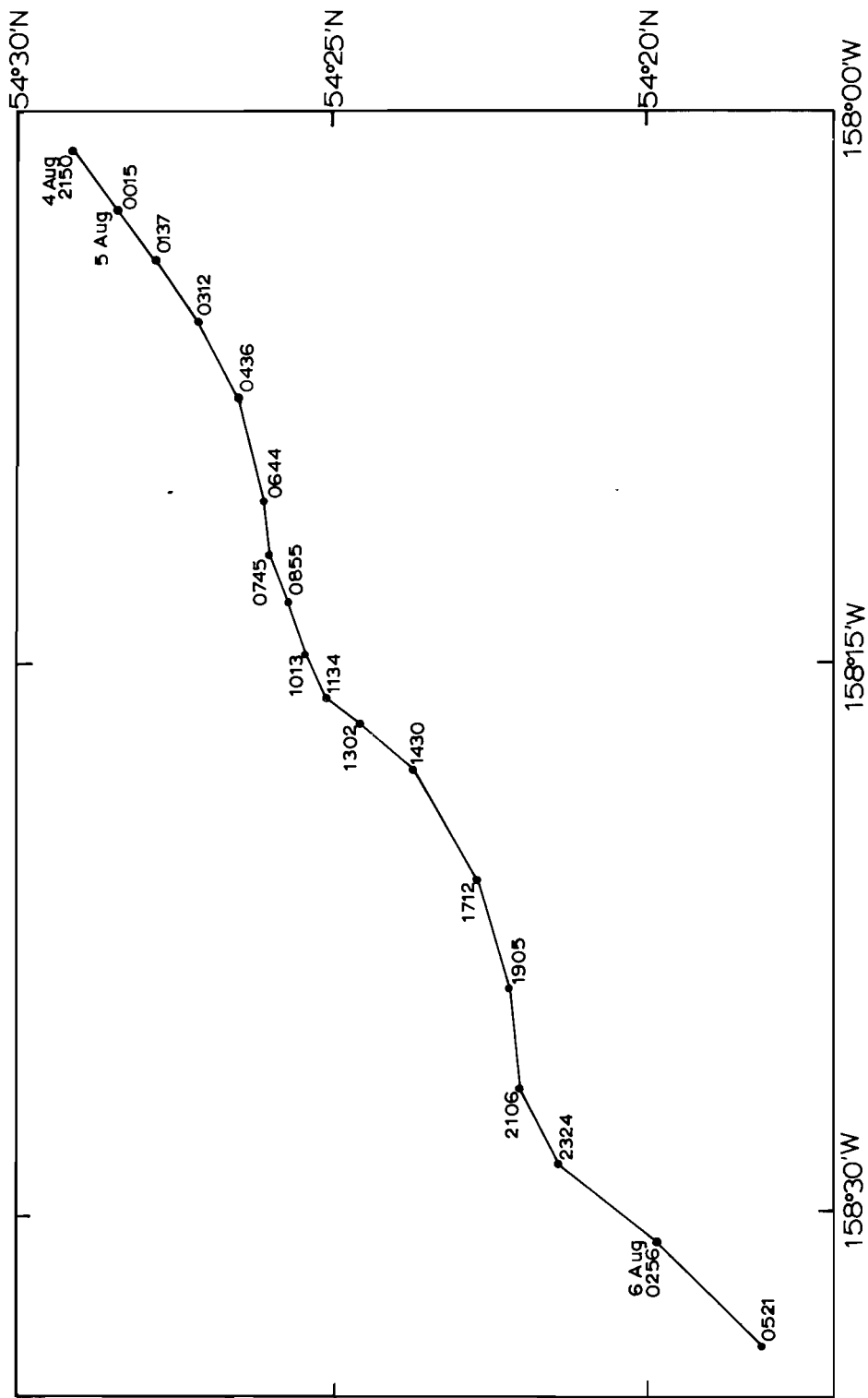


Figure 3. Path of parachute drogue at a depth of 122 m, 4-6 August 1961.

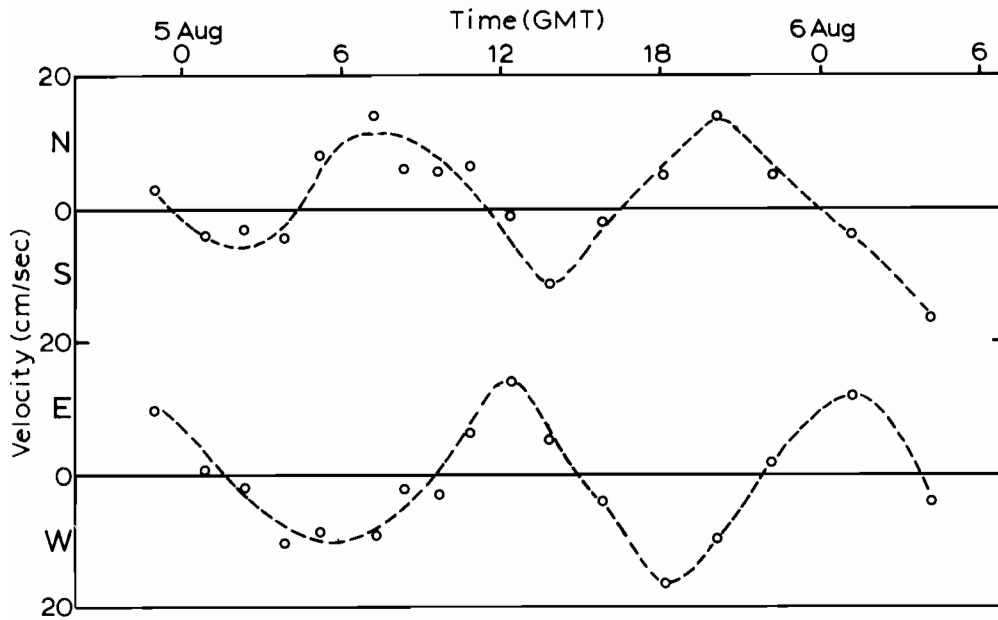


Figure 4. North-south and east-west component velocities (after removal of the net motion) at 122 m, 4-6 August 1961.

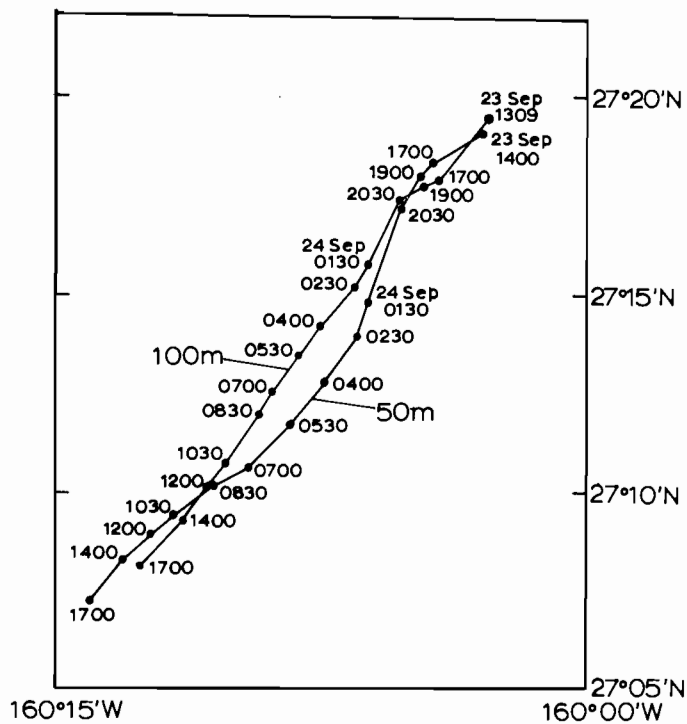


Figure 5. Paths of parachute drogues at depths of 50 and 100 m, 23-24 September 1962.

90°. Thus a clockwise, rotary flow, with perhaps some elongation and possibly of tidal origin, is present.

### 3. DROGUE PATHS NORTH OF HAWAII

The region from south of the West Wind Drift to the Hawaiian Islands has long been considered an area of very weak flow within the clockwise gyre of the central North Pacific. Yoshida and Kidokoro (1967), however, predicted the existence of relatively intense flows within the subtropical regions of all oceans, and Reed (1968) presented observational evidence of such flows north of Hawaii.

The paths of two drogues (at 50 and 100-m depths) north of Hawaii tracked during September 1962 are shown in figure 5. At 50 m the net flow was 29 cm/sec, 220°t; at 100 m it was 26 cm/sec, 218°t. Water depth was over 5000 m, and winds were from the northeast at 1 to 4 m/sec. Other data obtained at the time support a westward component of flow, but they do not suggest flows as intense as those measured.

It is difficult to ascertain the nature of any motion superimposed on the net flow. One problem is that velocities over the second half of the paths seem to be appreciably higher than during the first. (This situation does not appear to result from periodic components, which suggests that a real change in the basic current occurred.) After removal of the net flows considerable 'scatter' is present, but there is the suggestion of a rotary (clockwise) component with an amplitude of 5-10 cm/sec and a period of 18-24 hr.

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