An Observation of an Oceanic Front

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(Manuscript received September 9, 1956)

Abstract

A detailed temperature section across an oceanic front in the Eastern Equatorial Pacific is described. The frontal zone was moving at about one knot from the colder water toward the warmer water. The temperature difference across the front was 5° F. In the temperature section it is possible to see the cold water overrunning the warm water and creating an unstable zone approximately 100 yards wide.

On the Scripps Institution Eastropic Expedition we were able to observe an oceanic front in somewhat more detail than had been described previously (CROMWELL and REID, 1956). The measurements were made 12 October 1955 in the vicinity of 3° N and 120° W. The nearest land, Clipperton Island, was 1,000 miles to the north-northeast.

Observations

Movement and orientation of the front: The Scripps research vessel, HORIZON, was traveling south, completing a long north-south series of stations along 120° W, when the front was first registered by the recording surface thermograph at 0415 PST, 12 October. The surface temperature suddenly dropped 4.8° F. The ship's position at this first crossing was 2° 46′ N, 120° 39′ W. The front's orientation was not observed by anyone aboard the ship. The HORIZON continued to steam south to her last station and returned to the front late the same afternoon. At evening star sights at 1820 the ship's position at the front was 3° 08′ N, 120° 36′ W. The front was observed to be oriented on a line running about 225°—45°. If we assume the front was moving on a line normal to itself, the average velocity for this fourteen-hour period was about one knot.

The Scripps research vessel SPENCER F. BAIRD, which was working a similar north-south series of stations 300 miles to the east, did not observe the front on her north-south traverse.

Appearance of the front: The frontal zone was easy to observe with the eye. The cold water (which was to the south) was darker, the waves were shorter crested, and the sea state value was lower than on the warm side. The wind was from 170° T and was blowing between 18—20 knots during the time of observations.

High biological activity was associated with the front; however, there was no floating debris. The cold water was relatively sterile; most of the life appeared to be concentrated in the relatively narrow frontal zone. A dip-net collection made while drifting across the front yielded squid, colonial tunicates (*Pyro-*

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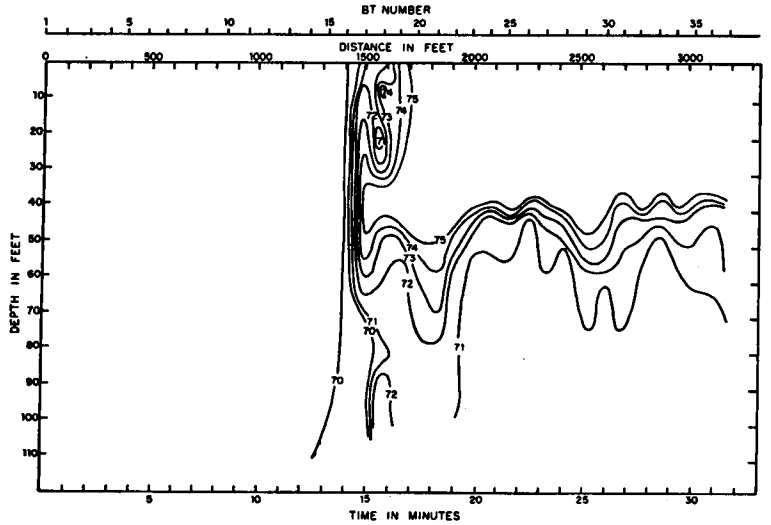

Fig. 1. Temperature (°F) profile based on BT's which were made while ship drifted across front. BT's are plotted against time.

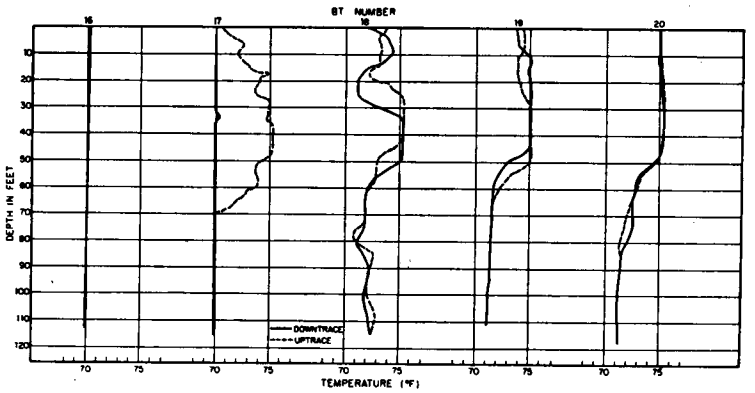

Fig. 2. Copies of individual BT's taken across frontal edge. "Down trace" is assumed to be that which indicated colder surface temperature.

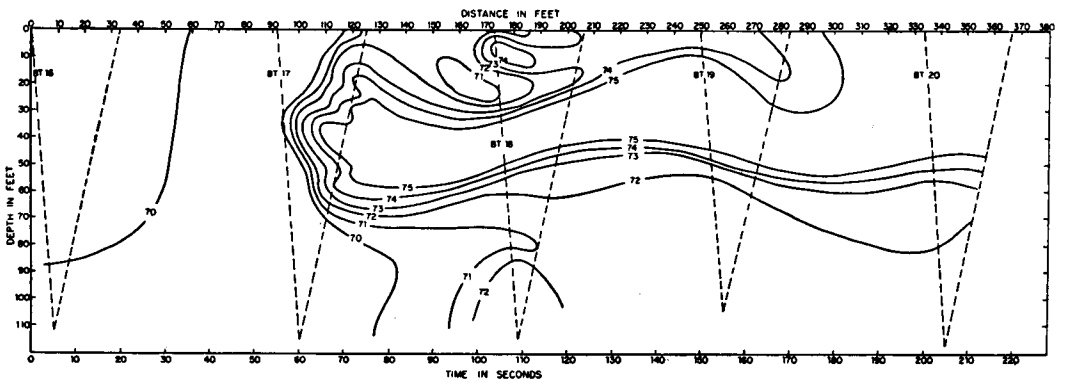

Fig. 3. Frontal edge of Fig. 1 plotted with no vertical exaggeration. The assumed position of BT's shown by dashed lines.

soma atlantica), flying fish (*Cypselurus xenopterus*, and *Exocoetus* sp.), sauries (*Cololabis adocetus*), and lantern fish (*Hygophum reinhardi*, and *Myctophum affine*).

Temperature measurements: Because of the strong wind at almost right angles to the front, it was possible to drift the R/V HORIZON through the frontal zone. As the ship drifted, shallow bathythermographs (BT's) were taken as rapidly as possible (about one every 50 seconds). The drift of the ship relative to the front was estimated at one knot.

Fig. 1 is a temperature profile based on the BT's taken from the drifting ship. The positions of the BT's are plotted as a function of time; the distance scale is based on the assumed one-knot rate of drift. In Fig. 2 are plotted the five BT's (16—20) taken as the ship drifted across the edge of the front. Note that 16 was completely in the cold water as were 1—15; 17 was lowered in cold water and raised in warm water; 18 shows a confused unstable trace, as does 19 to a somewhat lesser extent. By the time 20 was taken, some two minutes later, and approximately 80 yards from the frontal edge, the BT trace showed a stable configuration, similar in most respects to the remaining 17 BT's in the series.

In Fig. 3 these five BT's have been plotted without vertical exaggeration. For this plot both the up and down trace were used; the assumed position of the BT is indicated by the dashed lines. It was assumed that the BT took five seconds to reach depth and 15 seconds to return to the surface, and it was further assumed the "down trace" was that trace which registered the lower surface temperature, an assumption substantiated by the surface recording thermograph which registered a steadily increasing temperature as the ship drifted across the front.

Salinity: Surface salinity was measured in conjunction with seven of the BT's as the ship drifted across the front. Their values, along with the surface temperatures and calculated density values are listed in Table I.

Velocity measurements: The surface velocities measured by the BAIRD and the HORIZON in this area are shown in Fig. 4 along with the surface temperatures recorded in the area. Measurements were made by the geomagnetic electrokinetograph (GEK), using "neutrally buoyant" cables.

The highest velocities were those recorded by the BAIRD in the vicinity of the equator

Table 1

BT	Temp. (°F)	Salinity	Density
1	70.2	34.54	1.0241
3	70.2	34.52	1.0241
9	70.2	34.51	1.0241
16	70.5	34.49	1.0240
19	74.7	34.46*	1.0233
23	75.4	34.46	1.0232
37	75.4	34.46	1.0232

* salinity sample taken during BT's "uptrace"

Surface temperature and salinity measurements and calculated surface density values from samples collected as the HORIZON drifted across front. Positions of samples with respect to frontal zone are indicated by BT number and can be located in Fig. 1.

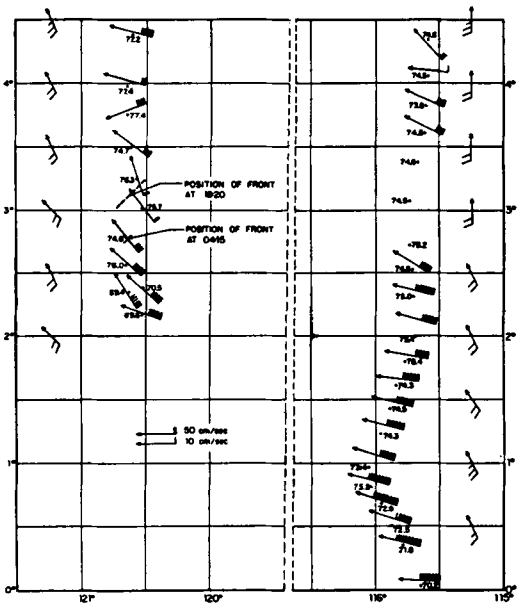

Fig. 4. Surface currents, surface temperatures and average winds as recorded by HORIZON and BAIRD on their north-south traverses. Temperature and current data are plotted at position of observation. Then the average wind data are plotted alongside in the Beaufort scale. The front was first observed at 0415, 12 October, while the HORIZON was traveling south. On returning from southernmost station, the front was observed at 1820 the same day. The two current and temperature observations shown between the 0415 and 1820 positions of the front were made while the HORIZON was traveling south. Hence these observations were made north of the front.

where the current was flowing 3—5 knots west to west-northwest (1 knot = 51 cm/sec). These high velocities recorded by the GEK are in general agreement with as yet unpublished measurements made at the equator at the same time by free-floating parachute drogues. In the vicinity of the front the water had a strong north component and was moving almost at right angles to the front.

A series of four GEK measurements was made a few hundred yards on either side of the front. The two measurements in the cold water to the south were 94 cm/sec-335° and 105 cm/sec-324°, respectively. The two measurements north of the front were less consistant: 84 cm/sec-307° and 62 cm/sec-268°.

Discussion

It is believed that the temperature measurements shown in Fig. 1—3 are the most detailed yet made in an oceanic front (or in any open-ocean convergence zone). Although the details in Fig. 3 are subject to personal interpretation, the picture of cold water overrunning the less dense warm water and then plunging downward is inescapable. On this particular crossing the unstable area was no more than 100 yards wide.

The concept of the frontal wall being continuously destroyed by cold water overrunning the warm water and then mixing with the warm water is not inconsistent with the observations of: (1) the front moving as a "cold front" at a speed of about one knot and (2) the cold water to the south moving at right angles to the front at speeds in excess of two knots. The cold water is probably part of the South Equatorial Current.

It should be pointed out that this is an observation of a single front. Fronts have been reported in this area which move as warm fronts (Cromwell, personal communication). It is unlikely in these cases that mixing at the frontal wall of the type suggested here could occur.

Acknowledgement

The observations of biological activity were contributed by A. E. EBELING.

REFERENCE

CROMWELL, T., and J. L. REID, JR., 1956: A Study of Oceanic Fronts. *Tellus*, 8, pp. 94—101.