SUMMARY, 1955-57 OCEAN TEMPERATURES, CENTRAL EQUATORIAL PACIFIC

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PACIFIC OCEANIC FISHERY INVESTIGATIONS

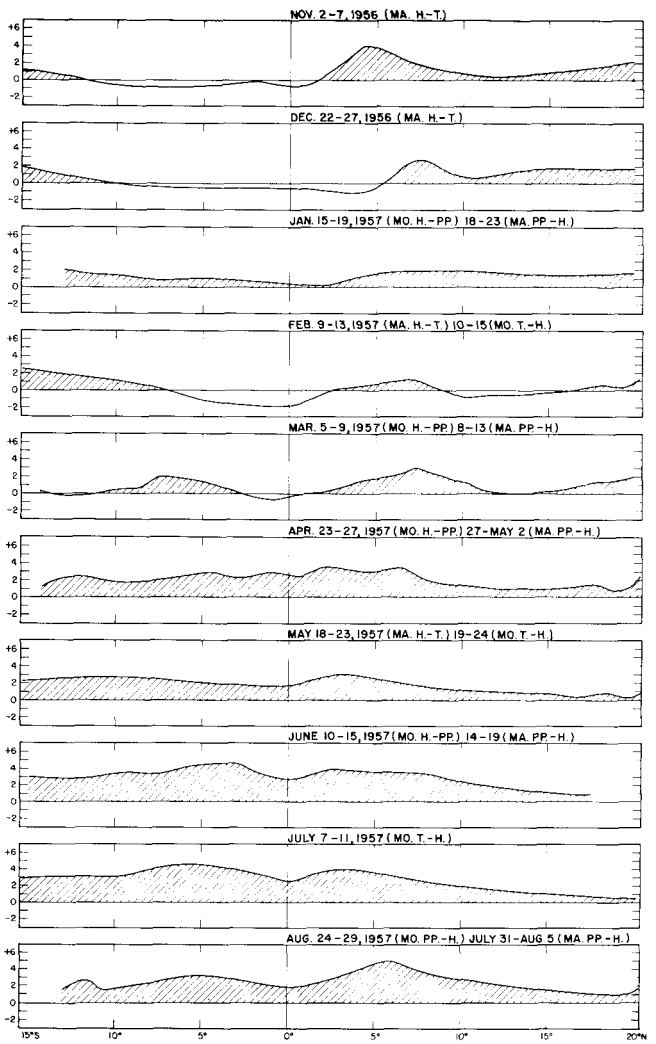
MONTEREY AND MARIPOSA DATA

Late in 1956, POFI made arrangements whereby two passenger liners, the SS *Mariposa* and the SS *Monterey,* were to collect surface temperature data and salinity samples once each watch (four-hour intervals) during their passage, Honolulu to Tahiti and/or Pago Pago and return. As a result of these arrangements, at least one surface temperature and one salinity section, along the courses traversed by these vessels, are available for each month, November 1956 to present.

In figure 36, the temperature data have been expressed as anomalies from the mean; positive anomalies have been shaded. Along the top of the panel for each month, the inclusive dates for the section, the vessel(s) (MO-*Monterey,* MA-*Mariposa*), and the ports of call (H-Hawaii, T-Tahiti, and PP-Pago Pago) are given. When both vessels made the run during any one month, their observations have been averaged and a single curve drawn. Mean temperatures, to which the observed temperatures were algebraically compared, were taken from the Monthly Meteorological Charts of the Western Pacific Ocean.[1]

When departing Honolulu (right end of each panel) (Fig. 36) and proceeding south, the vessels crossed the

[1] British Air Ministry, Monthly Meteorological Charts of the Western Pacific, MO-484, 120 p.



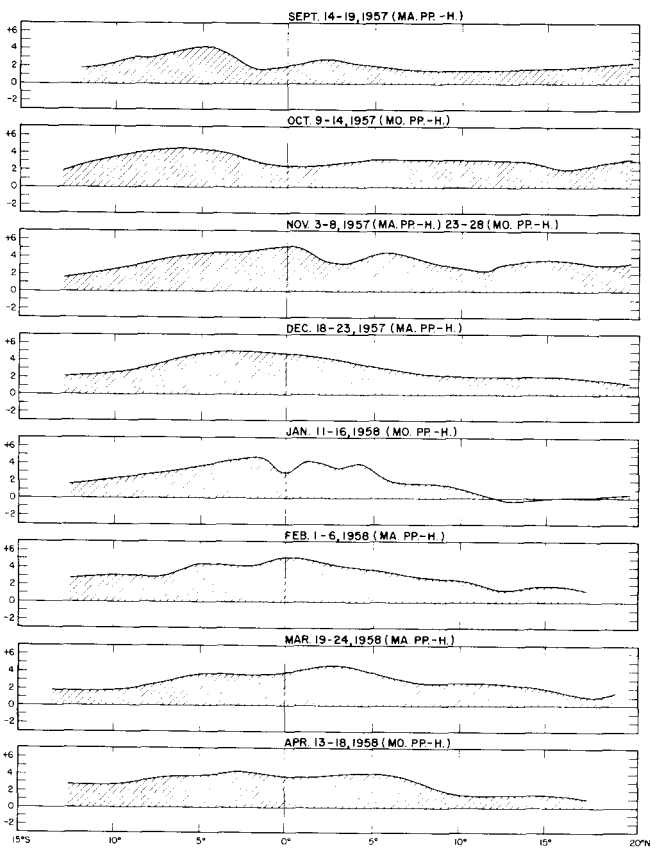


FIGURE 36. Sea surface temperature anomalies calculated from observations taken aboard the SS *Monterey* (MO) and the SS *Mariposa* (MA) during passage between Honolulu (H) and Pago Pago (PP) and Tahiti (T) and return. Inclusive dates for each voyage are given at the top of each panel. Positive anomalies are shaded.

westerly flowing North Equatorial Current to about 10°N. latitude, the easterly Equatorial Countercurrent, 10°N. to 5°N., and then the westerly South Equatorial Current, 5°N. to Tahiti or Pago Pago. At or near the Equator, they passed through the surface waters which are normally cooled by the upwelling from subsurface layers.

Referring to figure 36, April 1957 was the first month during which the anomalies were positive for the entire passage. With the exception of the northern portion of the leg for January 1958, the anomalies remained positive for each month of the year, April 1957 through April 1958. It would appear that, in general, the equatorial surface waters in the Southern Hemisphere warmed somewhat more slowly, but once warmed, maintained the positive anomaly at a consistently higher level than for the surface waters north of the Equator.

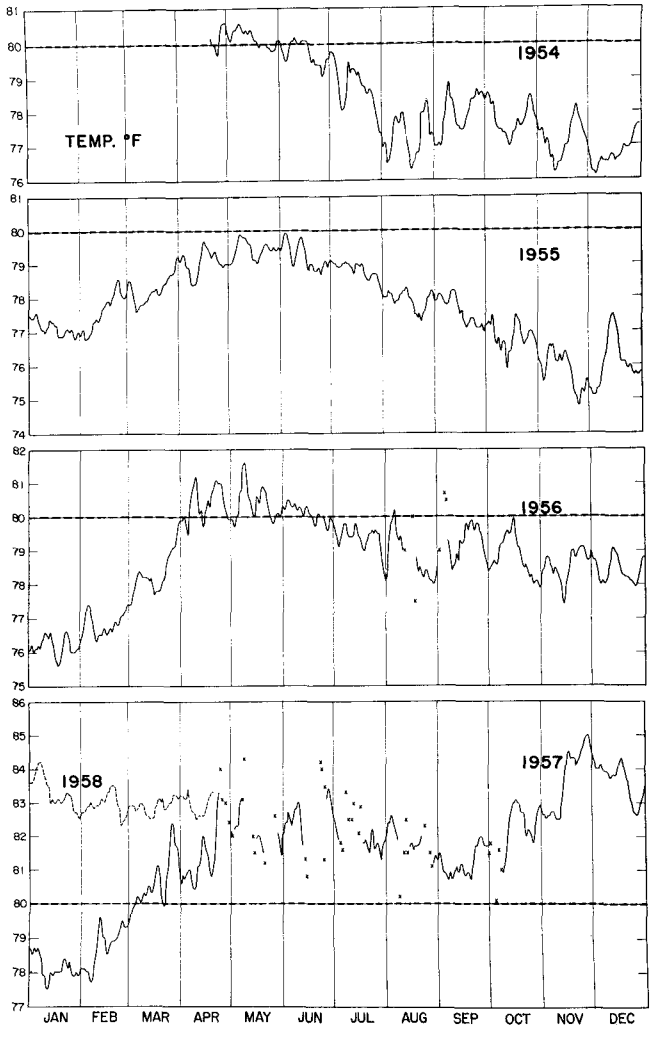


FIGURE 37. Five-day moving averages for daily sea surface temperatures recorded at Christmas Island (2°N., 157°W.), one of the Line Islands group. Observations are taken along the lee shore near the seaward edge of the reef. An "x" denotes observed temperature for days within periods during which the five-day moving average could not be calculated.

CHRISTMAS ISLAND DATA

In early 1954, POFI, in cooperation with the U. S. Weather Bureau, established a weather station on Christmas Island--an atoll of the Line Islands group centered near 2°N., 157°W. At the same time, arrangements were made for daily sea-surface temperature observations and weekly salinity samples to be taken at a position near the seaward edge of the reef, lee (western) side of the island.

The results of the daily temperature observations have been depicted as a five-day moving average in figure 37; as monthly means in figure 38. In figure 37

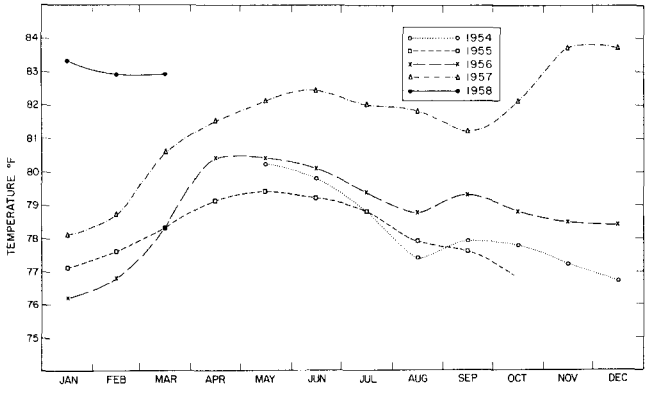


FIGURE 38. Thirty-day mean sea surface temperatures, Christmas Island station.

the small "x's" denote the observed temperature for days within periods during which a break in the record did not permit calculation of the five-day moving average.

The comparatively warmer surface temperatures observed at the Christmas Island station during late 1956, all of 1957, and early 1958 are quite evident on both figures 37 and 38. If we start with November-December 1955, we note that the temperatures were the coolest during the period of the observations. This situation, according to Rodewald (1956) was characteristic for the winter of 1955, Alaskan waters south to the coast of Peru. The surface temperatures then increased in a rather normal fashion, reaching the 1956 maximum during April and May. Subsequently there was cooling, but the 1956-57 winter minimum (78.5°F.) never did reach the same low as in 1954 (76.5°F.) or 1955 (75.0°F.). The 1957 spring warming continued until the surface temperatures reached 82° to 83°F., 2°F. warmer than for the same period during the years 1954-1956. Although the anticipated summer cooling was evident, June through September 1957, the normal trend was marked by reversal towards further warming (October), and the midwinter minimum was absent during 1957-58 (Figs. 37 and 38). Comparison of the dashed curve (1958), lower panel, figure 37, with the solid curve (1957) for the months January through April, shows that the January 1958 temperatures were approximately 6°F. warmer than those for January 1957.

Referring to figure 38 which shows the mean monthly temperatures, the curves for 1954, 1955, and 1956 show a reasonable degree of similarity. During the latter half of 1956 and all of 1957, however, the surface temperatures at the station were consistently higher than for the previous years of the series. The question arises: how indicative of subsurface conditions are these surface temperatures? Frequent meridional temperature-depth sections, at no more than monthly intervals, would be required to adequately answer such a question.

Some data for consideration of variations in temperature-depth distribution, 1957-1958 compared with previous years, are available from BT sections, Honolulu south to the Equator or to the Marquesas. 140°-150°W. longitude. Two sets of such sections have been compared in figures 39 and 40. The 60°, 70°, and 80°F. isotherms for each BT section are included; those for the particular month in 1957 as a solid curve, those for the chosen previous year (1955) as a dashed curve.

The September 1955 and October 1957 sections are very similar; the December sections comparatively dissimilar. On the December 1955 section, the only surface and subsurface waters observed to be 80°F. or above were those of the Equatorial Countercurrent.

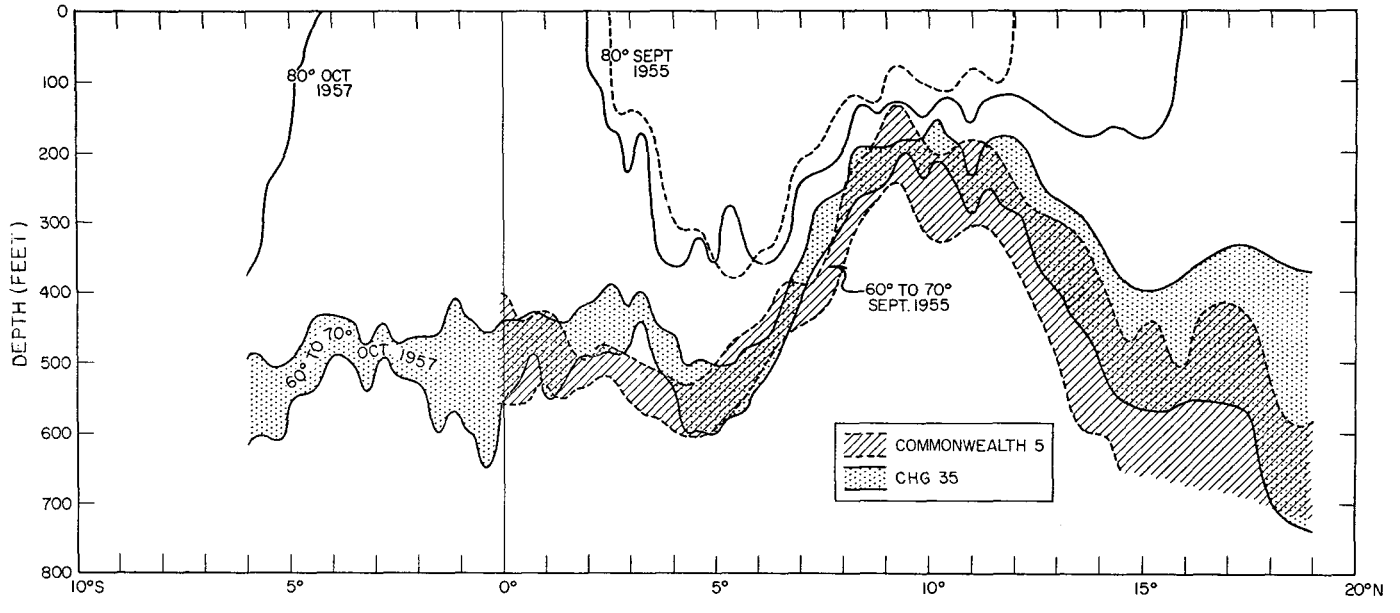


FIGURE 39. Vertical temperature distribution (80°, 70°, and 60°(F) isotherms) from BT sections made during *Commonwealth* Cruise 5, September 1955 (dashed contours) and C. *H. Gilbert* Cruise 35, October 2-7, 1957 (solid contours), 140°W.-150°W. longitude.

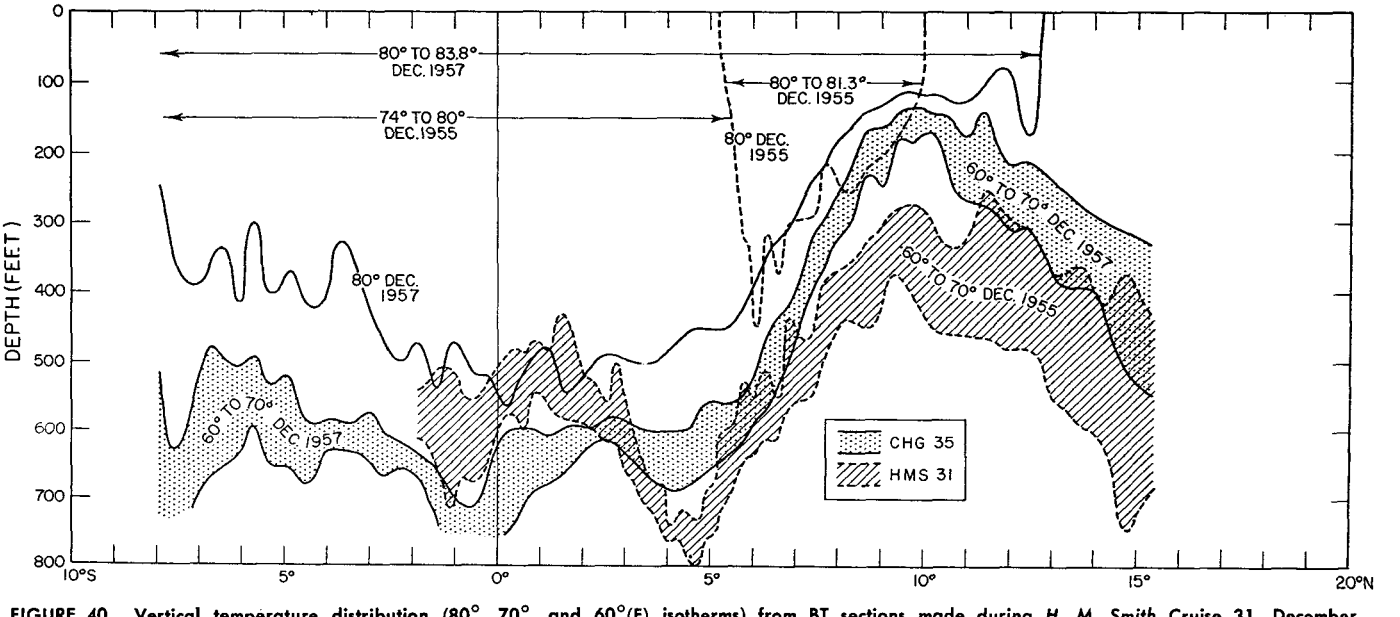


FIGURE 40. Vertical temperature distribution (80°, 70°, and 60°(F) isotherms) from BT sections made during *H. M. Smith* Cruise 31, December 1955 (dashed contours) and C. *H. Gilbert* Cruise 35, December 1957 (solid contours), 140°W.-150°W. longitude.

South of the countercurrent, the temperature of the waters above the thermocline were generally 74° to 80°F. In contrast, along the December 1957 section, temperatures in the surface layer, from 12°N. to at least 8°S. latitude were 80°F. or above, reaching a maximum value of 83.8°F. in the countercurrent. The 80°F. isotherm reached depths of 500 feet or more near the Equator. From consideration of surface temperatures at Christmas Island, figure 38, the means for early October and for December 1957 were 3°F. and 6°F. warmer, respectively, than the same months, 1955. From consideration of the subsurface distribution (Fig. 39) the subsurface temperature conditions were very similar during September 1955 and early October 1957, not clearly reflecting the apparent warming, while in a similar consideration of the two sections for December 1955 and 1957, figure 40, the surface and subsurface differences are strikingly evident.

If we compare the October and December 1957 sections (shaded areas and solid curves, figures 39 and 40, at least two interesting points may be seen. First, within approximately 90 days, a large quantity of warm water had apparently moved into the area, too large a quantity to be attributable to local effects such as that of insolation. In general, with persistent southeast trades, advection through 150°W. by the westerly South Equatorial Current would transport cooler waters normally found to the east of 150°W. Upwelling would cool the surface waters near the Equator. This situation, as inferred from variations in depth of the 60°F. and 70°F. isotherms, is illustrated on both the December 1955 and the October 1955 sections. These isotherms reach a maximal depth near 5°N., decreasing in depth toward the Equator, then increasing again in the Southern Hemisphere. The resulting ridge centered near the Equator reflects both westerly transport and upwelling. However, in the December 1957 section (Fig. 40), the same isotherms deepen continuously, 5°N. to the Equator, then slope upwards in the Southern Hemisphere. The trough thus formed near the Equator suggests, in contrast to the situation for December 1955 and October 1957, easterly transport through 150°W. of the warmer surface waters from the west and little or no upwelling. That such transport may have been the case is supported by an observation of a 5-knot easterly set, 00°30′N. to 02°30′N.; 160°W. reported by the SS *Monterey* on November 25, 1957.

Available data are too few to permit any more than speculation as to what processes may have been involved in causing these variations between the October and the December meridional, temperature-depth distributions. In general terms, there is a progressive east-west warming of the surface waters in the Equatorial Pacific, with the most pronounced east-west gradient to be found east of the 180th meridian. The sea surface in the Western Pacific is 0.8 to 1.0 dynamic meters higher than in the east; the thermocline progressively shallows, west to east. The existence of and variations in these situations are related to the presence of and variations in the trade wind system.

We mentioned above that vertical distribution of temperature for the October BT section suggested westerly flow of the surface waters, 5°N. to the southern limit of the section and upwelling centered about the Equator. This is the "normal" situation with the easterly component of the trades. With a relaxation of the trades, and particularly with a comparatively high frequency of westerlies, one could postulate a reversal in flow of the surface waters (and the undercurrent reaching the surface), with the warmer waters from the west becoming evident through the 150°W. section. A second factor leading to warmer waters in the surface layers—westerly winds are *convergent* in terms of surface flow at the Equator, thus there would be no divergence of the surface waters and no upwelling of the deeper, cooler waters. From advance indications of the available data, this may have been the situation during the December 1957 section.

LITERATURE CITED

Rodewald, Martin. 1956. Die Nordatlantische Temperaturanomalie in den Jahren 1954 und 1955. Sonderdruck aus der Deutschen Hydrographischen Zeitschrift, Band 9, Heft 3, p. 137-142.