Atmospheric Response to SST Anomalies

For the past year a spectral General Circulation Model of the Climate Dynamics Group of NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) (Manabe, *et al.*, 1978) has been used in numerical experiments to improve our understanding of the physical mechanisms operating in the Walker Circulation and the Southern Oscillation.

The model is global and has spectral truncation at 15 waves using the "rhomboidal" truncation. It has 9 σ levels in the vertical. Nonlinear terms are calculated in the grid domain after transformation of the variables from the spectral domain. For the computation of radiation the seasonally varying isolation is prescribed at the top of the atmosphere, and a zonally uniform cloud cover is assumed.

Equatorial Anomalies

The model has a hydrologic cycle. Surface temperature over land is determined by the routes discussed in the earlier article were covered.

Temperature maps at standard depths are produced using objective analysis techniques (Gandin, 1963) to interpolate the data to a

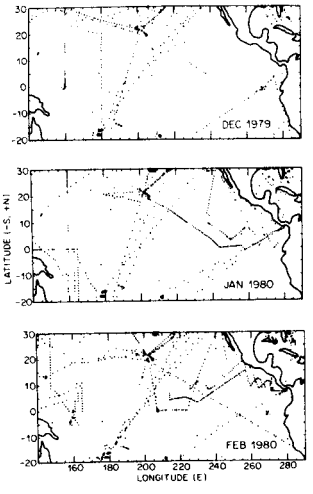

FIGURE 1 *(Meyers & Guberek)*

XBT observations in the tropical Pacific from top to bottom, December 1979, January 1980 and February 1980; observations from the Hawaii-Tahiti Shuttle Experiment were not plotted.

the condition of no heat storage in the soil. Seasonally varying sea surface temperatures are prescribed. For these experiments warm sea surface temperature anomalies over different parts of the equatorial Pacific were used (Figure 1). The anomaly was introduced in the middle of March; integrations were carried out until the end of August, and the anomalous response was studied June-August. The statistical significance of the response was assessed.

Walker Circulation

Precipitation increased near the anomalies and decreased slightly to the west. The induced heat sources (precipitation anomalies) produced global-scale anomalies in the equatorial zonal winds, especially in the upper troposphere and in the sea level pressure. Figure 2(a,b,c) shows the east-west anomaly circulations induced in the equatorial atmosphere by the sea surface temperature anomalies over the eastern subtropical and central Pacific for the equatorial Pacific is a prototype. The statistical structure used for objective analysis reflects the fact that energetic interannual fluctuations in sea level and baroclinic structure have a spatial scale on the order of 1000 km (Wyrtki, 1979). The grid in this area was 2°-latitude by 10°-longitude. A network analysis to improve the mapping procedure is being developed. Specification of the necessary autocorrelation functions and signal-to-noise ratios will be made as accurately as historical data permits.

the equatorial Pacific a Walker Circulation occurs with easterlies in the lower levels and westerlies in the upper levels, with ascent over the vicinity of Indonesia and descent over the eastern Pacific. Thus, warm anomalies over the eastern Pacific tend to weaken the Walker Circulation and similar ones over the western Pacific tend to strengthen it. These circulation anomalies were found to be statistically significant. Besides these equatorial and tropical anomalies a significant strengthening of the subtropical westerlies occurs principally in the winter hemisphere in the general longitude of the anomalies.

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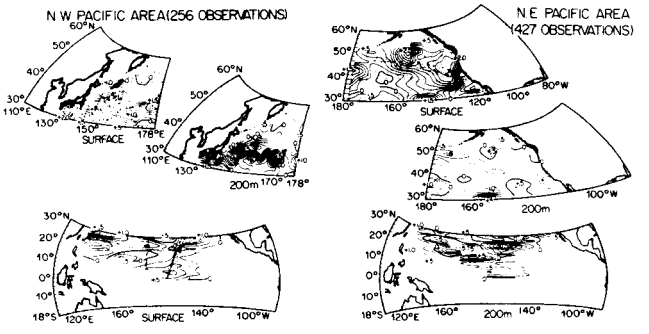

FIGURE 2 *(Meyers & Guberek)*

Objective analysis of temperature anomalies in August 1979.

Cetaceans and Equatorial Oceanography

More evidence of the distinctiveness of the equatorial cetacean community was obtained during the 21 March-19 April 1980 trans-Pacific voyage of the NOAA ship *Oceanographer*. Two biologists from the Southwest Fisheries Center (SWFC) in La Jolla were aboard during the San Diego-Kwajalein EPOCS voyage that transited the equator between 110°W and 175°E longitude. Using 25 × 150 mm binoculars, they searched both for seabirds and cetaceans along the cruise track and logged 162 separate sightings of cetacean schools. Their sighting rate, up to 34 sightings/100 track miles searched, indicates that equatorial waters at times support a major cetacean community. The *Oceanographer* voyage provided a rare opportunity to collect detailed data on the distribution of cetaceans in the poorly known eastern and central equatorial Pacific.

The concentration of cetaceans is related to oceanographic conditions.

Large baleen whales and pilot whales were the animals most frequently sighted, followed by the beaked whales. Among the latter, Cuvier's beaked whale (*Ziphius cavirostris*), a species not generally considered equatorial, was abundant between 110°W and 115°W. Very few spotted and spinner dolphins (*Stenella attenuata* and *Stenella longirostris*), the characteristic species of eastern tropical Pacific waters, were seen. They were replaced along the equator by another species pair that also forms large schools, Fraser's dolphin (*Lagenodelphis hosei*) and the melon-headed "whale" (*Peponocephala electra*). Both of these dolphins have been described only recently in the eastern Pacific (Perrin *et al.*, 1973; Perrin, 1976), where continuing studies have suggested that they are primarily equatorial in distribution. This now appears confirmed as 13 (possibly 21) schools of Fraser's dolphins and/or melon-headed whales were seen from the *Oceanographer*, more than on any other research cruise. Another interesting species, also abundant between 110°W and 115°W, was the "rare" dwarf sperm whale (*Kogia simus*) which was sighted 10 times during the cruise.

The concentration of cetaceans along the equator appears related to distinct oceanographic conditions there (Figure 1). A conspicuous feature is the relatively weak thermocline gradient and often the absence of a mixed layer. East of 145°W surface divergence and the effects of the undercurrent had virtually

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eliminated the mixed layer. Eighty-two percent of the cetaceans were seen there, and the predominant birds were the plankton-feeding storm petrels. As the surface mixed layer developed and deepened west of 145°W, these birds were rapidly replaced by great numbers (2,000-4,000/day) of sooty terns (*Sterna fuscata*), which feed commensally with surface fish. In tropical waters north of the equator, where the thermocline is strong and shallow, birds and fish are most frequently found associated with aggregations of dolphins. But along the equator the numerous sooty terns were conspicuous in their general lack of association with cetaceans. These changes in species communities relative to oceanography support the conclusions of Au, *et al.*, (1979) but have never before been so clearly demonstrated.

A major deficiency in present knowledge of eastern Pacific cetaceans is the understanding of seasonal effects. More observations from a wider band about the equator are needed, *e.g.* to study the school-aggregating effects of the seasonally intensified Equatorial Front (Au *et al.*, 1979). Further participation by SWFC cetacean biologists on EPOCS cruises are being planned.

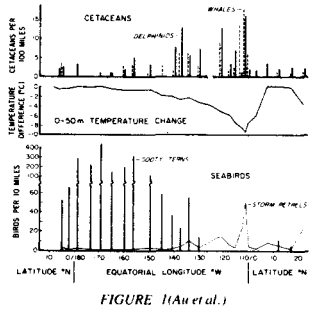

FIGURE 1(Au et al.)

Cetaceans, birds, and environment along the track of the R/V Oceanographer *21 March - 19 April 1980. The 0-50 m vertical temperature change is an index of the depth of the mixed layer.*

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