ic habitat." But Karl *et al.* cite no evidence that station ALOHA is "representative" of the oligotrophic North Pacific subtropical gyre, and there is strong evidence against this notion.

For more than 20 years, persistent, large-scale, coherent sea-surface temperature anomaly patterns have been reported in the North Pacific[2]. These are associated with long-lasting atmospheric anomaly patterns. Large sectors of positive anomaly exist concurrently with other large sectors of negative anomaly. Most of the central anticyclonic gyre is out of phase with eastern boundary currents and the ocean south of about 20° N (ref. 3). The HOT ALOHA station lies in the steep gradient between these two regimes (see figure). Monthly sea-surface temperature anomalies averaged over the 5°×5° surrounding station ALOHA are not correlated, either positively or negatively, with 5°×5° temperature anomalies over most of the central, oligotrophic gyre. These large-scale temperature anomalies at the sea surface are known to extend to at least the upper pycnocline and are accompanied by changes in upper water column physical and biological structure[4–7].

If ecosystem properties such as productivity, nutrient cycling and biomass vary in response to climatic and water column changes of the magnitude indexed by the sea-surface temperature anomaly patterns, then it is evident that studies at station ALOHA are not representative of the anticyclonic central gyre.

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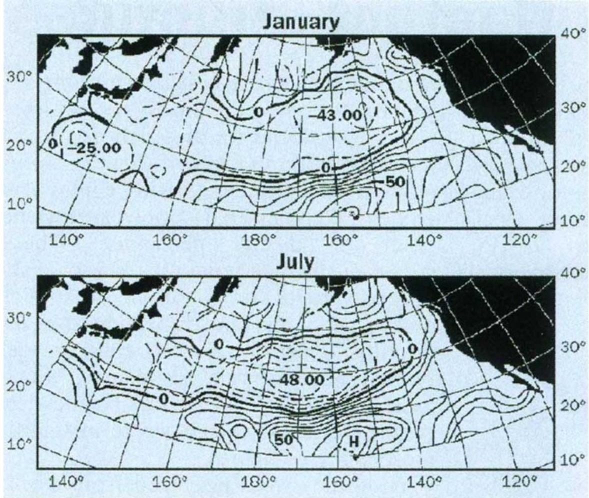

Contours of seasonal cross-correlations of sea-surface temperature anomaly of the 5°×5° surrounding the HOT ALOHA station (22°45′ N; 158° W) with all other 5°×5° anomalies in the North Pacific during 1947–94. Solid lines are positive, broken lines negative. H indicates the 5°×5° that includes station ALOHA (data provided by D. R. Cayan).

KARL REPLIES — The ocean is variable on nearly all time and space scales that have been examined to date[8]. Consequently, the design of oceanographic field studies must accommodate this anticipated variability to avoid introducing a sampling or data interpretation bias. Ideally, a sufficient number of 'representative' stations in a given habitat must be revisited frequently over at least a decade, or longer. Unfortunately, this ideal sampling strategy is not practical, so intelligent compromises must be made. One approach is to establish time-series sampling stations at strategic sites that are characteristic of key oceanic habitats. This strategy was adopted by the US Joint Global Ocean Flux Study (JGOFS) programme and led to the establishment of oligotrophic ocean benchmarks near Bermuda[9] and Hawaii[10].

To date, this combined JGOFS time-series research effort of >150 research cruises on approximately monthly intervals has provided an unprecedented view of the complexity of physical and biogeochemical processes in these distinct subtropical habitats. Of general importance are the discoveries of relatively high annual rates of primary production (around 14 mols C m^{-2} yr^{-1}), the importance of N_2 fixation as a source of 'new' nitrogen and the temporal decoupling of organic matter production, export and decomposition. A hallmark of these oligotrophic habitats is variability, a remarkable departure from the previous view of a 'monotonous self-regulating climax ecosystem'[5] based on research conducted near 28° N, 155° W. Of the 18 cruises during 1971–85 (ref. 11), approximately 70% were in summer (June–September) and 5% in August alone. No cruises were conducted in 1970, 1975, 1978–79, 1981 or 1984, further time-biasing this data set.

Station ALOHA, the HOT programme site, is located at 22° 45′ N, 158° W in deep water (4,750 m), one Rossby radius (50 km) upwind of steep topography associated with the Hawaiian Ridge, but close enough to Honolulu to provide feasible logistical support. Based on an analysis of sea-surface temperature anomaly patterns over the North Pacific Ocean, McGowan disputes that our results from station ALOHA are truly representative of the anticyclonic central gyre. While this opinion may be valid, without the presentation of an equivalent, synoptic oceanographic data set on biological rates and processes from a 'representative' station, it cannot be proved definitively.

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Evolution of deuterium on Venus

SIR — Venus has a large deuterium-to-hydrogen (D/H) ratio, almost 160 times that of Earth[1]. Current models assume that Venus initially had an Earth-like D/H ratio which has risen due to atmospheric evolution. Two models have been advanced: the primordial-ocean model, which interprets the high D/H ratio as the result of the fractionation loss from a large initial reservoir of water (perhaps even an 'ocean'), and the steady-state model, where the ratio results from a balance between sources of water (probably volcanic) and fractionation losses, with the total abundance of water remaining constant over time[2]. The primordial-ocean model allows extrapolation back to the initial water abundance, whereas the steady-state model implies that this information has been lost.

Grinspoon[2,3] has argued that the steady-state model provides a good description of the current water budget, as the timescale for D/H evolution is more favourable to a steady-state solution. The steady-state model predicts a limiting D/H ratio of α/f, where α is the source D/H ratio (from, for example, outgassing) and f is the fractionation factor (describing the efficiency of D relative to H escape; f is currently 0.13; ref. 4). This creates a paradox of sorts, if the source D/H ratio is terrestrial-like, then the Venus D/H ratio should be only a factor of eight times that on Earth.

Grinspoon has proposed two solutions: either the source D/H is high, enriched by

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