ability that the observed coherences between the global air temperature and the month to month change in CO_2 in the frequency range 0.0 cycles per year $< \nu <$ 0.55 per year occurred by chance is less than 5%. The rise in the coherency at frequencies < 0.15 per year is due to long-term increasing trends in both series[1]. As the non-equatorial northern and southern regions show much weaker coherency for $\nu > 0.1$ cycles per year, we conclude that most of the short-term correlations present in the global temperature record originate in the equatorial region. Indeed, equatorial air temperatures from 23.6° S to 23.6° N are coherent with CO_2 over a broader range of frequencies than temperatures averaged over the entire globe (*b* in the figure). Coherences in the equatorial record at frequencies higher than roughly 0.5 cycles per year are apparently washed out in the global average. Sea surface temperatures averaged over the equatorial Pacific region (20° S to 20° N and 80° W to 180°) show coherences comparable to those in the equatorial air temperature record at frequencies greater than about 0.25 per year. Both the equatorial air and the sea surface temperature show three peaks in the coherency at frequencies of approximately 0.3, 0.5 and 0.8 cycles per year, but we do not know if they represent physically distinct processes.

Phase analysis shows that the SST fluctuations lead the CO_2 anomalies by about 4 months but equatorial air temperature leads CO_2 by only 1 month. This difference is not surprising as the air temperature is strongly correlated with the SST but lags behind by about 3 months. The relative time lags are consistent with the hypothesis that fluctuations in SST set off changes in the equatorial air temperature and the CO_2 concentration. If SST variations directly affect equatorial sources and sinks then the lag is consistent with the atmospheric transport time for a parcel of CO_2-enriched or CO_2-depleted air to reach Mauna Loa.

The flux of CO_2 between the atmosphere and the equatorial regions can be affected by fluctuations in the temperature through changes in CO_2 solubility, upwelling of CO_2-enriched deep water and availability of nutrients for the organic carbon pump. Associated changes in wind and precipitation also affect terrestrial biota. The coherence between temperature and CO_2 is significant over a range of frequencies in addition to those that characterize ENSO[2]. It is important to consider whether these mechanisms could lead to a significant positive temperature–CO_2 feedback on the longer timescales for which global warming is projected to occur.

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Whale carcasses

SIR—Communities of benthic marine invertebrates, including clams and other animals supported by chemosynthetic processes, are associated with whale skeletons on the deep-sea floor[1]. Such animals, apparently dependent upon sulphide-rich reducing microenvironments created by the decomposing carcasses, are closely related to taxa found at hydrothermal vents, cold seeps and on sunken wood[1]. We have found clams associated with three early Tertiary fossil whales from northwestern Washington State, and our results indicate that molluscs may have been utilizing this trophic resource for approximately the past 35 million years.

The fossil whales, in the collections of the Natural History Museum of Los Angeles County, are probably previously unknown taxa. They were collected at three separate localities along the north shore of the Olympic Peninsula, from concretions within hemipelagic siltstones of the Makah Formation, deposited at lower to middle-bathyal depths[2] and are early Oligocene (about 35 million years) in age[3]. These basin-plain and outer-fan fringe deposits[2] are otherwise nearly barren of macrofossils, and only a few widely scattered deep-water gastropods (such as *Aforia* spp. and *Bathybembix* spp.) and large isopods[4] have been found in them.

Two of the fossil whales are small (less than 4 m body length) primitive mysticetes (baleen whales). Small clams (*Modiolus* sp.) are found in the immediately surrounding matrix. There are external moulds of clams (*Thyasira*) in the matrix on the outside of one skull and within the cranial cavity. The third whale is a smaller (less than 2 m), primitive odontocete (toothed whale). A single clam (*Lucinoma hannibali*) was found nestled among its ribs and vertebrae.

Both valves of all these clams are still articulated in the living position, and the *Thyasira* inside the skull seems to be too large to have entered accidentally through the foramen magnum, so it probably matured within the cranium. The clams, therefore, seem to have been preserved where they lived and grew rather than having been transported. Fossils of *Lucinoma hannibali* and *Modiolus* sp. were also found associated with a single 15-cm-long piece of fossil wood from the same stratigraphic horizon of the Makah Formation where the whales were found.

The association of fossil whales and clams in the Makah Formation is, in our opinion, not coincidental. Extant species of clams in the same genera (*Modiolus*, *Thyasira* and *Lucinoma*) have been reported from modern[5] and ancient reducing environments[6]. Their *in situ* relationship with the Oligocene whales in otherwise essentially fossil-barren deposits strongly suggests that they were part of a chemosynthetic community supported by whale bone-oil seepage.

Smith *et al.*[1] suggested that whale carcasses could be 'stepping stones' for dispersal of such benthic invertebrates, especially vent faunas, that depend on chemosynthesis. But, as pointed out by Tunnicliffe and Juniper[7], whale carcasses are not good vent analogues. Another problem for dispersal of vent faunas via whale carcasses is the timing. There is no record of whales in the Pacific Basin before the latest Eocene (about 39 million years ago)[8,9]; however, cold methane-seep communities[6] and (probably) hydrothermal-vent communities existed in deep-ocean basins in the northeast Pacific as early as the middle Eocene. The carcasses of Oligocene whales that lived in the North Pacific, as exemplified by those from the Makah Formation, were apparently not large enough to sustain many organisms. Because whales of sizes comparable to some of the larger (15 m body length) recent mysticetes are unknown in the Pacific Basin before the late Miocene[9], carcasses large enough to sustain many chemosynthetic animals were unavailable until about 11 million years ago. It is, therefore, very unlikely that whales were significant in the early dispersal of vent faunas.

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