above. Experiments conducted in pressurized culture vessels or in situ growth rate studies will have to be conducted to confirm this result.

The uptake of $^{14}CO_2$ as a result of the assumed chemosynthetic oxidation of H_2S was measured in situ. It was planned that an array of 200-ml syringes, precharged with the radiolabeled material and filled by *Alvin* in situ, be deposited for a 4- to 6-day incubation period approximately a meter away from the vents. Because of a mechanical problem, the scheduled recovery dive was canceled and the samples were retrieved after a 10-day delay. Since the recycling of the CO_2 in a closed system will lower the values of carbon incorporation with time, the obtained data must be considered conservative. In spite of this, they are considerably higher than in similar experiments conducted at the interfaces of H_2S to O_2 of the Black Sea and the Cariaco Trench (*13*). Of the 200 isolates obtained, those tested thus far show a considerable variability in CO_2 fixation.

Our preliminary results indicate a high production of metabolically active bacterial biomass in the water emitted from the investigated Galápagos hydrothermal vents. Although complementary data on the stoichiometric transformation of reduced sulfur, and iron and manganese as well, to a more oxidized form cannot be obtained in the presence of a substantial spontaneous (chemical) oxidation, we feel confident that the striking quantity of CO_2 fixation observed is, in fact, bacterial chemosynthesis. This form of primary production represents the basis of the food chain sustaining the dense populations of higher organisms discovered around the vents. In view of the complexity of the entire vent system and the limited amount of sampling possible, a useful quantification of deep-sea primary production is quite out of reach at this time.

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Mass Measurement at the National Bureau of Standards: A Revision

Abstract. *In 1975, the results of a series of mass measurements undertaken by the National Bureau of Standards were published in* Science. *The inconsistencies reported seemed to depend on barometric pressure. An inference to be drawn from the report is that buoyant forces on objects weighed in air are somehow incorrectly accounted for by the usual appeal to Archimedes' principle in which the density of air, ρ, is computed from an equation of state. The magnitude of the unexpected effect was estimated as approaching 1 milligram in 1 kilogram over a pressure range from 0.5 to 2.0 atmospheres for objects having a volume difference of 200 cubic centimeters. In a new experiment at the National Bureau of Standards, in which more elaborate and precise equipment was used, the calculation of air density from the atmospheric variables is confirmed to within 0.05 percent, hence within the uncertainty usually claimed for the air density and buoyancy calculations.*

Several years ago a monitory paper from the National Bureau of Standards (NBS) (*1*) reported the discovery of what was termed an "anomaly" in the weighing at various altitudes of objects nominally equal in mass but differing in density (D). The reported effect emerged as a finding of a set of measurements carried out in several laboratories. Kilograms of low density ($D \sim 2.7$ g cm^{-3}) appeared to lose mass at high-elevation sites and kilograms of high density ($D \sim 16$ g cm^{-3}) seemed to gain, when compared to standard kilograms ($D \sim 8$ g cm^{-3}). The greatest departure, an apparent loss of 1 mg kg^{-1}, was recorded at an elevation of 1600 m above mean sea level. Because the observed anomalies appeared only in weighings which required a substantial correction for buoyancy in air and because the magnitude of the anomalies was a function of air density ρ, the source of the peculiar results has been sought in some aspect of the buoyancy correction. The reported effect, if confirmed, would be of consequence in the determination of the fundamental constants and in precise force measurements.

The warning appearing in *Science* was the result of the analysis of three exploratory experiments. In these experiments the correction for the buoyancy of the air was made through the use of hydrostatically determined volumes of the artifacts and through use of an algorithm, or equation of state, for calculating ρ. The algorithm used the pressure, temperature, relative humidity, and CO_2 fraction of the air (*2*). The algorithm consists of the ideal gas law with small corrections for the nonideality of the constituents of the air. Such calculations are usually assigned an uncertainty of about 0.04 percent, or less, of ρ.

In these experiments, a failure of the algorithm to calculate ρ accurately under the various conditions would manifest itself as apparent differences in mass. The data on weighings made at the different sites and under various conditions did indeed yield an apparent variation in mass, about five times the maximum expected uncertainty arising from the calculation of ρ (*1*). The losses in mass, if interpreted as resulting from errors in the calculation of ρ, show the calculation to be in error by 1 percent per atmosphere of pressure change.

Subsequent to the publication in *Science*, a careful recalculation of the equation for the density of moist air was car-

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ried out at NBS (*3*). The recalculation differs from the previously extant equations (*4*) at a level far too small to explain the anomalous results. In addition, a recent experiment which measured in vacuum the mass difference between objects of differing *D* (*5*) has made it possible to determine ρ directly through Archimedes' principle. No anomalous behavior was observed.

In an effort to reconcile the various results, the Center for Absolute Quantities (CAPQ) undertook a reexamination of the matter. (The CAPQ is responsible for the maintenance of the kilogram mass unit and of the high-accuracy mass measurement capabilities at NBS.) The original data that were used to develop the *Science* report (*1*) were reviewed, and a new experiment was undertaken.

In an analysis of his results after the publication of (*1*), Pontius became aware of a number of defects in the original work not initially obvious, the main one being a break in the chain of certification of the pressure-measuring devices at the high-elevation stations and another being a questionable pressure sensor in the altitude and decompression chambers. Forewarned of these difficulties, we endeavored to avoid whatever systematic errors might have been present in the original study by measuring the experimental parameters as accurately as possible and by maintaining calibrations rigorously traceable to NBS.

Since the effect seemed to occur entirely between normal atmospheric pressure and 80,000 Pa, the findings should be confirmed if the experiments are repeated in a well-equipped laboratory at an elevation of about 1600 m. Such a laboratory exists at Sandia Corporation, Albuquerque, New Mexico. With the cooperation of Sandia staff, CAPQ personnel repeated the experiment with all of the objects listed above and several other stainless steel kilograms with four times the surface-to-volume ratio of the standards. State-of-the-art measurement systems were used wherever possible (*6*).

The comparisons conducted at NBS and Sandia show mass discrepancies between weights with large volume differences which, if attributable to errors in the applied buoyancy corrections, would place an uncertainty on the ρ algorithm of less than 0.04 percent of ρ. This figure, if dependent on barometric pressure, would imply an error in the calculation of ρ of less than 0.2 percent per atmosphere of pressure change and thus within the maximum uncertainty originally expected by Pontius (*1*).

We have not been able to establish in detail the exact point at which the large, unexpected systematic error crept into the initial experiments. The difficulties with pressure measurement mentioned above, the less than ideal thermal conditions at the high-elevation laboratories, and the apparent effect of vibration in the deep-sea decompression chamber all seem possible sources for the introduction of systematic error.

Even though the initial alarm concerning difficulties in comparing masses of different *D* now seems overstated, significant problems still exist. There remains, for instance, an uncertainty in the mass unit in materials other than platinum (for example, stainless steel) which exceeds the precision of the best kilogram comparators and which is a direct result of presently accepted uncertainties in state-of-the-art buoyancy corrections. At 293.15 K, 101,325 Pa (1 atmosphere), and 50 percent relative humidity, estimated uncertainties in ρ based on our most recent measurements correspond to uncertainties in mass in the transfer between platinum-iridium and stainless steel artifacts (volume difference, ~ 80 cm^3) of approximately 40 μg. This uncertainty may be compared to the precision of the best kilogram comparators, about 1 μg. It is also true that, in order to achieve even this accuracy, a substantial effort is necessary both to measure accurately the properties of air in the balance enclosure and to create stable conditions within the balance case during weighings.

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Organic Carbon: Oxidation and Transport in the Amazon River

Abstract. *Spatial and temporal patterns in the organic carbon load (< 1 millimeter) of the Amazon River indicate that oxidation was constant throughout the river at any one time but was much greater at rising water than at high water, whereas transport was constant. The total effective efflux, as the sum of oxidation plus transport in the river, was about 10^{14} grams of carbon per year. Estimates for other river systems suggest that global riverine carbon fluxes exceed 10^{15} grams per year.*

The transport and oxidation of organic carbon in the Amazon River reflect, over long distances, upstream flooding events and the geologic and vegetative structure of the drainage basin (*1*). The sum of the transport and processing fluxes yields the amount of organic carbon effectively exported from Amazonia. The sum for all large rivers constitutes the riverine role in the global carbon cycle. This role is not yet defined. As far as we know, there are no published data for the transport of organic carbon in any major river that encompass the hydrologic year (*2*). Existing data on organic carbon from the Amazon are either from restricted reaches or were taken at only one stage of the hydrologic cycle.

We report results from two cruises of the R.V. *Alpha Helix* which assess for the first time spatial and temporal patterns in the organic carbon load of the Amazon River. Using these data as a model, we then estimate global riverine carbon fluxes. We test three hypotheses, based on the work of earlier investigators (*3*), concerning the sources, utilization rate, and downstream export of organic matter. They hypothesized that changes in the input and utilization of dissolved and particulate organic matter should be predictable on the basis of river size. For very large rivers (order 9 through 12), the hypotheses are as follows:

(i) Swamp hardwood forests and floodplains decompose fine particulate matter during periods of low water; this material is subsequently returned to the rivers by flooding water and surface runoff.

(ii) The relative rates at which organic matter is utilized tend to be constant from the headwaters to the sea in an unperturbed river system.

(iii) The seasonally pulsed nature of organic inputs is damped by biological processes and retention, such that the total exports of organic matter do not increase downstream.

Transect 1 extended 2000 km, from