off compounds containing the phosphorus-methyl linkage, it is necessary to compare a downstream sample with an upstream sample. The size of both samples must be such that a specified difference in terms of standard deviation will be found statistically significant according to the t-test with a chosen level of significance in a specified percentage of cases. With a level of significance of .05, a difference of 2 standard deviations will be found with a probability of .95 if both sample sizes are chosen to be seven or more (*22*). In our measurements we found that the standard deviation was about 12 percent of the determined value. This means that with a background value of 1.2 μg (the highest value found up to now) a downstream concentration of 0.29 μg will be detected under the above specified conditions; with a background of 0.5 μg, this concentration is 0.12 μg.

The commercially available pesticide Mecarphon (*7*)

$$[(CH_3O)CH_3P(S)SCH_2C(O)N(CH_3)COOCH_3]$$

will give rise to dimethyl methylphosphonate and will thus interfere in the verification procedure. In the case of the insecticide Dyfonate

$$[(C_2H_5O)C_2H_5P(S)SC_6H_5]$$

dimethyl ethylphosphonate will result. This compound (retention index, 1495 ± 1) is easily distinguished from dimethyl methylphosphonate (retention index, 1451 ± 3) during gas chromatographic analysis. The potential nerve gas Tabun

$$[(C_2H_5O)(CH_3)_2NP(O)CN]$$

and related compounds will not be detected upon application of this verification procedure because these compounds are derivatives of phosphoric acid and consequently yield trimethyl phosphate after hydrolysis and methylation.

Binary nerve gases are made by mixing two compounds during the delivery of the projectile to its target. For the nerve gases Sarin and Soman

$$[(CH_3)_3C(CH_3)CHOP(O)(CH_3)F]$$

methylphosphonic difluoride will probably be one of the binary components (*23*). This substance as well as Sarin and Soman can be detected with the proposed verification procedure. However, preliminary experiments indicated that the phosphorus-containing component QL

$$[(C_2H_5O)CH_3POCH_2CH_2N(C_3H_7)_2]$$

a possible precursor for binary VX (*23*), is not readily detected with the verification procedure described here.

The reported procedure for the verification of the presence of nerve gases, their decomposition products, or their starting materials in waste water gives a simple yes or no answer to the question of whether compounds related to these agents containing the phosphorus-methyl linkage are present or not. The method is sufficiently sensitive to give a positive indication even after extensive waste water purification and can be used even in heavily polluted water. In cases of strong dilution of the waste stream flowing into a river, the production of nerve gases may be masked.

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15. The gas chromatographic peak was scanned at three characteristic mass-to-charge values, 79, 94, and 109, which correspond to

$$(CH_3O)P(O)H^{\oplus},\ (CH_3O)P(O)H(CH_3)^{\oplus\cdot},\ \text{and}\ (CH_3O)_2P(O)^{\oplus}.$$

The peak intensity ratio was 6:4.4:1, which equals the result obtained with a reference sample of dimethyl methylphosphonate. Owing to the small amount, the intensity of the molecular ion was insufficient to permit scanning.
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18. Assuming a 24-hour production day.
19. The sensitivity of the method (1 nmole liter^{-1}) is equivalent to a detection of 140 ng of Sarin per liter.
20. The Meuse River at Liege, Belgium (1975) had a mean flow rate of 189 m^3 sec^{-1} (range, 42 to 726 m^3 sec^{-1}). The mean flow rate of the Rhine River at Lobith, Netherlands (1975), was 2170 m^3 sec^{-1} (range, 980 to 5341 m^3 sec^{-1}).
21. The formula $C_x = C_0Q_0/H\ (\pi DUx)^{1/2}$ was used, where C_x is the maximum concentration at a distance x from the waste outlet point, C_0 is the outlet concentration, Q_0 is the outlet flow, H is the depth, D is the diffusion coefficient $= 0.013\,HU$, and U is linear flow. For both rivers it was assumed that $H = 2$ to 3 m and $U = 0.5$ to 1 m sec^{-1}.
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Late Wisconsinan Sea Levels on the Southeast U.S. Atlantic Shelf Based on In-Place Shoreline Indicators

Abstract. *A new interpretation of late Pleistocene sea levels on the U.S. Atlantic continental shelf is based on in-place lagoonal and salt-marsh sediments obtained from vibra-cores. These data show sea levels during the last Wisconsinan transgression were about 30 meters shallower than is indicated by existing sea-level curves.*

Shoreline indicators obtained in vibracores permit new observations concerning Wisconsinan sea levels. Establishment of sea-level curves has generally been hampered by the difficulties involved in obtaining in-place shoreline indicators. The information reported here, obtained through vibra-coring, allows an evaluation of sea-level curves.

Pleistocene-Holocene sea-level curves commonly used for the U.S. Atlantic Coast are those of Milliman and Emery (*1*) and Curray (*2*), which differ significantly. A comparison of the two curves can be seen in Fig. 1. Milliman and Emery (*1*) have a much lower sea level from 16,000 to 11,000 years before present (B.P.) than Curray (*2*). There is up to 50 m difference in the depths between the two curves over portions of this time interval. From 25,000 to 18,000 years B.P. Milliman and Emery have a higher sea level than Curray. All curves are water depth–location curves because they are attempts to locate past sea levels on the shelf or slope.

Macintyre *et al.* (*3*) presented new information for sea-level curves based on shelf-edge sandstones. Minimum reconstructed depths for these sandstones indicate a curve at least as shallow as Curray's for 15,000 to 10,000 B.P. Macintyre *et al.* (*3*, *4*) also made the important distinction between "mobile" dates, in which the material dated was subject to sediment transport, and "fixed" dates, obtained from in-place material. They noted the large number of mobile dates that have been used in curves as well as dates for shells that originally could have existed over broad depth ranges. Macintyre *et al.* showed that the depth scatter of mobile dates in the Milliman and Emery curve demonstrates extensive sea-floor transport.

It is difficult to ascertain how mobile or fixed many materials dated by other workers should be considered, especially dredged loose material. Even peat taken in a scallop dredge (*5*) may be transported. Additional cores would determine whether deposits of peat actually exist at some locations mentioned in the literature.

It is recognized that sea-level curves do not represent eustatic sea-level changes and that isostatic corrections must be made. On the basis of glacial tilting of a portion of the shelf off Delaware and Long Island, Dillon and Oldale (*6*) indicated that Milliman and Emery's sea-level curve may be erroneously deep at glacial maximum. A new curve [figure 5 in (*6*)] was proposed based on dates for oolites and minimum depth estimates for these subtidal sandstones. The data used in this report, including Kraft's (*7*), are south of the inflection zone recognized by Dillon and Oldale.

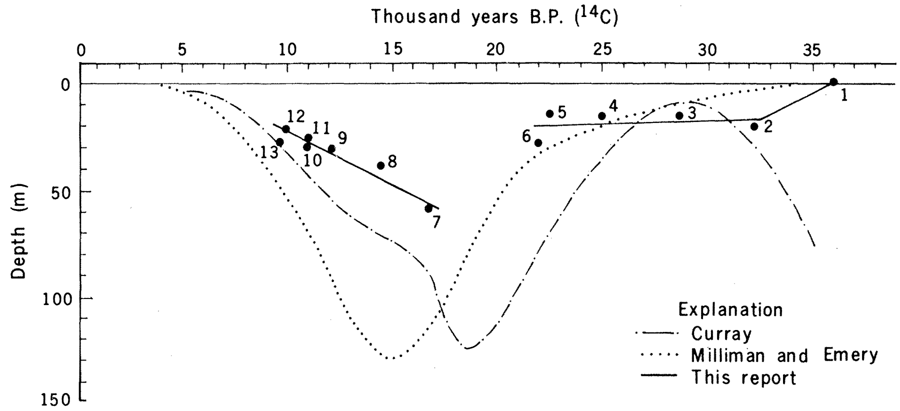

Fig. 1. Sea-level curves established by Milliman and Emery (*1*) and by Curray (*2*) contrasted with proposed sea levels based only on in-place material.

In 1975 a series of vibra-cores was obtained on two cross-shelf transects, a 10-core transect across the southern North Carolina shelf and an 11-core transect across the shelf at Charleston, South Carolina. From the cores, seven fixed shoreline dates were obtained for materials that were deposited at sea level and were not subsequently transported. Table 1 indicates our interpretation of the materials used to date sea levels. Fixed shoreline indicators from the vibra-cores of this study include in-place salt-marsh peat as well as shallow lagoon assemblages dominated by articulated oysters (*Crassostrea*) of intertidal-type, thin-elongate morphology. The salt-marsh peat and the oysters having this morphology are restricted to the intertidal zone. The present tidal range on the Georgia coast is approximately 2.2 m. It is somewhat less on the South Carolina coast. Therefore these intertidal materials would indicate zero mean sea level with a maximum error of approximately 1.1 m. Other data (Table 1) thought to be reliable were also used, including Kraft's (*7*) dates for buried salt-marsh peat and lagoonal material from Delaware. Ooid dates were not used because of problems with older nuclei. Field's (*8*) vibra-core dates from the southeastern U.S. Atlantic shelf were not used because it is not certain that the deposits dated represent sea level. Although dates before 22,000 years B.P. have a rather large counting

Table 1. Ages and locations of samples used in Fig. 1.

Number of point in Fig. 1	Location	Age (years B.P.)	Sample depth (meters below mean sea level)	Material dated	Area	Source
1	33°55′, 78°09′	$36,000 {}^{+\ 3,700}_{-\ 2,600}$	0	Salt-marsh peat	North Carolina	(*11*)
2	31°59.66′, 80°24.95′	$32,000 {}^{+\ 910}_{-\ 1,025}$	−21.5	*Crassostrea* in lagoonal sediment	Off South Carolina	This report (core 4536, 145 to 155 cm)
3	38°40′, 75°5′	28,400 ± 1,800	−14	Lagoonal silt	Delaware	(*7*)
4	33°29.27′, 78°50.27′	25,065 ± 310	−14.7	*Crassostrea* in lagoonal sediment	Off South Carolina	This report (core 4525, 20 cm)
5	33°29.27′, 78°50.27′	22,585 ± 530	−13.2	*Crassostrea* in lagoonal sediment	Off South Carolina	This report (core 4525, 172 cm)
6	30°14′, 86°30′	22,042 ± ?	−28	Beach coquina	Off Northwest Florida	(*12*)
7	31°44.94′, 79°38.96′	16,450 ± 155 17,265 ± 235	−58.6	*Crassostrea* (two specimens) in lagoonal sediment	Off South Carolina	This report, (core 4525, 460 cm)
8	31°48.42′, 79°44.85′	14,540 ± 180	−38, −38.3	Salt-marsh peat	Off South Carolina	This report (core 4544, 505 to 535 cm)
9	31°51.30′, 79°57.06′	11,865 ± 140	−31	*Crassostrea* in lagoonal sediment	Off South Carolina	This report (core 4541, 100 to 110 cm)
10	33°03.40′, 78°22.99′	10,785 ± 130	−28 to −28.5	*Crassostrea* in lagoonal sediment	Off South Carolina	This report (core 4532, 100 to 150 cm)
11	38°40′, 75°04′	10,800 ± 300	−26	Peat under lagoon	Delaware	(*7*)
12	29°43.7′, 84°57.4′	9,950 ± 180	−22	*Rangia cuneata* articulated in growth position in pro-deltaic sediments	Off northwest Florida	(*13*)
13	33°08.37′, 78°28.66′	9,520 ± 95	−26.8	*Crassostrea* in lagoonal sediment	Off South Carolina	This report (core 4530, 170 to 190 cm)

error (Table 1), the corrections for any error would make only minor shifts in the position of our sea-level line (Fig. 1). After 22,000 years B.P. the counting error is rather small.

Figure 1 contrasts our proposed sea levels with previous curves. Our data indicate that at approximately 36,000 years B.P. sea level stood at the present-day shoreline (0 m). From 36,000 until 22,500 years B.P. there was a lowering of the sea to between −10 and −20 m. We lack data on the maximum low stand, which presumably occurred at 18,000 to 19,000 years B.P.

From 17,000 to 10,000 years B.P. sea level climbed from about −60 to −22 m in relation to present sea level. This transgression is much shallower than that indicated by other curves. Some of Curray's dates (*9*, pp. 254–255) support our interpretation (Table 1). Other data in the literature suggest a sea level as shallow as the one proposed. A salt-marsh sediment off Texas falls on our transgression line (*5*) and a curve used by Richards (*10*, p. 8) for North America coincides with the younger end of our line around 10,000 years B.P.

The proposed sea levels apply specifically to the South Carolina continental shelf area. Shelves in other areas may have had different histories, particularly shelves adjacent to glaciated areas. Our data do agree well, however, with fixed dates for materials obtained off Delaware, the west coast of Florida, and the Gulf of Mexico. The South Carolina shelf area has apparently been tectonically stable over the last 30,000 years, and the proposed sea levels should be applicable to the entire southeastern United States. Compared to other sea-level curves, our data indicate that substantially less ice was present from 17,000 to 10,000 years B.P. Our data strongly suggest that the late Wisconsinan maximum regression was not as profound as has been indicated in the literature. Within the time span represented by our sea-level data, a low stand as great as 100 m or more would require catastrophic rates of regression and transgression.

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Nitrogen-Fixing *Anabaena*: Physiological Adaptations Instrumental in Maintaining Surface Blooms

Abstract. *Both laboratory and in situ studies indicate that the nitrogen-fixing blue-green nuisance algae* Anabaena *spp. have developed adaptive means of dominating surface lake waters. During the dramatic diurnal shifts in surface light intensity and oxygen saturation accompanying blooms,* Anabaena *can overcome oxygen toxicity by sequential optimization of carbon dioxide and nitrogen fixation and by pigment alteration. These mechanisms allow optimal utilization of the radiant energy while minimizing competition for photoreductant between two main energy-demanding processes.*

Various hypotheses have been proposed to explain the dominance of blue-green algae in the surface waters of nutrient-rich lakes (*1*). The ability of some species to fix elemental N_2 while occupying surface waters that are rich in radiant energy, nitrogen-poor, and highly oxygenated is a distinct advantage over eucaryotic organisms. Occupying such a region, however, is not without its constraints: the processes of carbon (CO_2) and nitrogen (N_2) fixation are sensitive to O_2; high light intensity and O_2 concentrations can lead to photooxidative inactivation of photosynthetic pigments (*1*). We report here on a number of mechanisms, including temporal separation of CO_2 and N_2 fixation and pigment alteration, that various species of *Anabaena* use to cope with such constraints.

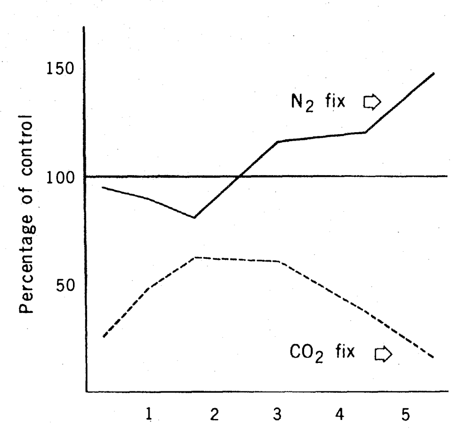

Fig. 1. Responses of N_2 fixation (acetylene reduction (——) and CO_2 fixation (-----) under O_2-supersaturated (pO_2 = 0.4 atm) conditions as percentages of the control (pO_2 = 0.2 atm) values. All O_2-supersaturated samples were prepared at the start of the experiment. At hourly intervals duplicate 30-minute acetylene reduction (nitrogenase activity) and $^{14}CO_2$ fixation assays were conducted on samples taken from the total pool of O_2-supersaturated and control samples.

In examining blue-green algal growth in eutrophic lakes, few studies have incorporated the vast amount of physiological information now available from laboratory studies. A majority of such studies have been carried out on axenic cultures of nonbloom-forming *Anabaena cylindrica* (*2*), rendering ecological interpretations of physiological mechanisms difficult. Nevertheless, among various species of *Anabaena*, the biochemical uniformity of N_2 and CO_2 fixation processes has become apparent (*3*).

In our studies we examined and compared several physiological responses of natural populations and axenic batch cultures of *Anabaena* to elevated O_2 concentrations and light levels. Our main objective was to ascertain how N_2 and CO_2 fixation in *Anabaena* respond to O_2-supersaturated conditions and if these responses promote the dominance of *Anabaena* in surface waters.

Results from studies in two small eutrophic lakes, Lake Rotongaio on the North Island of New Zealand and Thompson Lake near Toronto, Ontario,

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