

**U.S. Geological Survey
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**Gulf of Mexico Hypoxia Working Group
National Atmospheric and Oceanic Administration
National Centers for Coastal Ocean Science
Room 9127, East West Highway
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Colleagues:

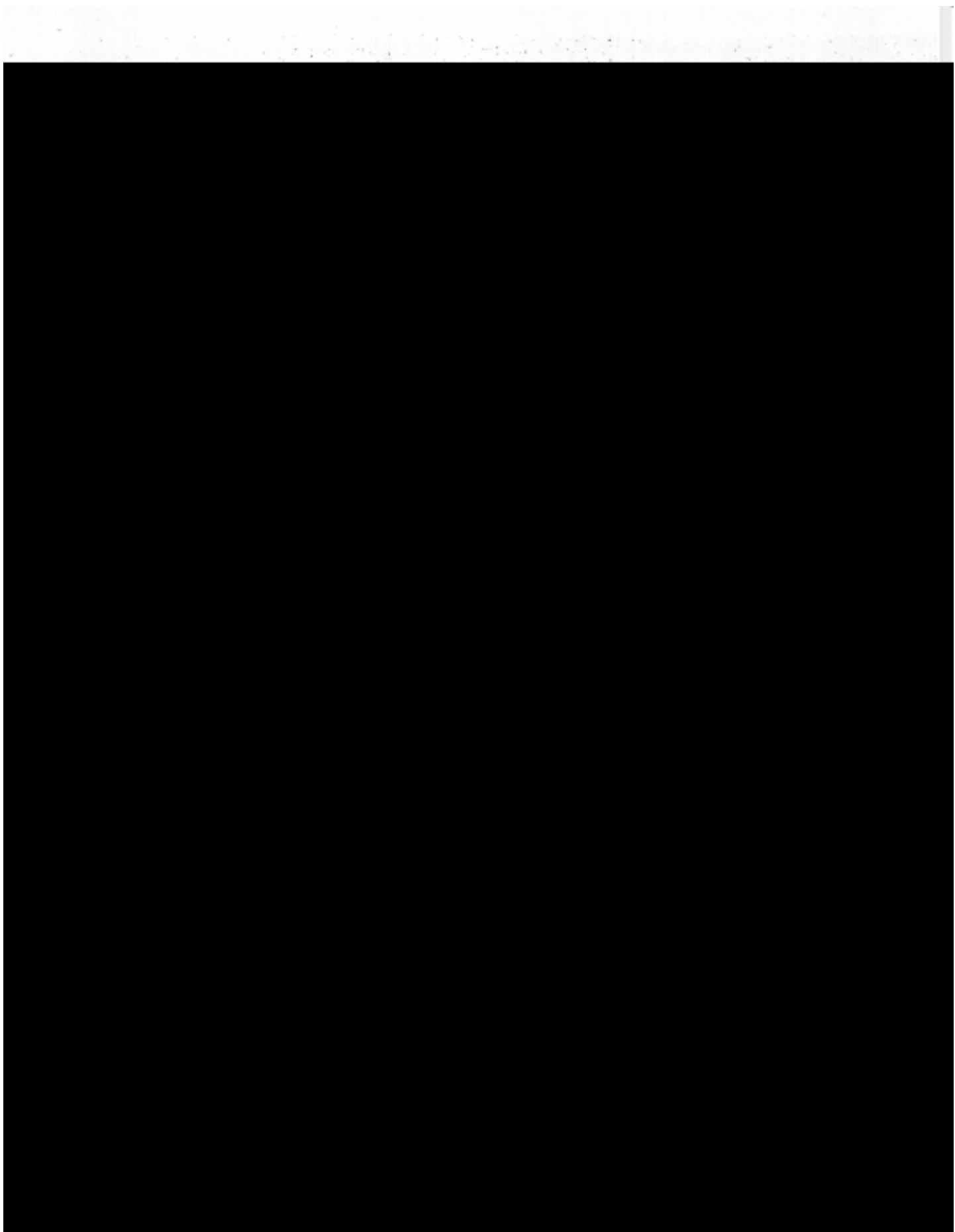
The following material is being submitted in response to public comments suggesting that total nitrogen concentrations in the lower Mississippi River were higher at the beginning of this century than they are today. This response is based largely on published data presented in reports by Palmer (ca. 1903), Leighton (1907), Dole et al. (1909), Goolsby et al (1999), Howarth et al. (1996, 1998), and Maybeck (1982).

To provide a basis for determining long-term changes in nitrogen concentrations in the Mississippi Basin, an estimate of mean nitrogen concentrations in the basin before European settlement ("pristine" conditions) was developed for all major nitrogen species. This estimate is given in table 1 at the end of this document. The mean dissolved inorganic nitrogen (DIN) concentration, nitrate + nitrite + ammonium, was estimated to be about 0.115 mg/L, and the mean total dissolved nitrogen (organic + DIN) was estimated to be 0.375 mg/L (Maybeck, 1982). From these estimates the mean dissolved organic nitrogen (DON) was calculated to be about 0.26 mg/L. Particulate organic nitrogen (PON) concentration was calculated from the pre-development annual sediment flux from the Mississippi-Atchafalaya Basin to the Gulf (400 million metric tons per year; Meade, 1995), the estimated N content of the sediment (0.15%), and a mean annual streamflow of 21,990 cubic meters per second (table 2.2 in Goolsby et al., 1999). From this calculation, the PON concentration was estimated to be 0.86 mg/L. The pre-development total nitrogen (TN) concentration was then calculated from the sum of the DIN + DON + PON to be 1.24 mg/L. Other TN estimates from the literature range from 0.79 to 1.15 mg/L (see table 1). Thus, our TN estimate of 1.24 mg/l may be a little high.

Published data were used to develop estimates of mean annual concentrations of all major nitrogen species during the period 1897-1906 for 4 locations in the Mississippi Basin. The locations are 1) the Lower Illinois River, 2) Mississippi River near Grafton, IL (below Illinois River and above Missouri River), 3) Lower Missouri River, and 4) Lower Mississippi River. These estimates, based on data published in Palmer (ca. 1903), Leighton (1907), and Dole, (1909), are shown in table 2. Mean nitrogen concentrations at these 4 sites for 1980-98 (Goolsby, et al., 1999) are also shown in table 2 for comparison.

The concentrations of DIN, DON, and PON are shown in graphic form in figures 1-4 for the four locations. Estimates are shown for three periods in the history of the basin—pristine, 1897-1906, and the present (1980-98).

Results presented in tables 1-2 and figures 1-4 show that concentrations of total nitrogen

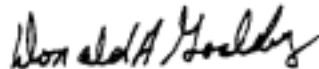


Lewis, W.M., 1986, Nitrogen and phosphorus runoff losses from nutrient-poor tropical forest. Ecology v67, p1275-1282.

Maybeck, Michael, 1982, Carbon, Nitrogen, and Phosphorus Transport by World Rivers. American Journal of Science, v282, April, 1982, p 401-500.

Meade, R.H. 1995. Contaminants in the Mississippi River. U.S. Geological Survey Circular 1133. 140 p.

Palmer, Arthur W., ca. 1903, Chemical Survey of the Waters of Illinois: Report for the years 1897-1902, University of Illinois, 254 p.



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Table 1. – Estimates of Nitrogen Concentrations in the Mississippi River Basin prior to European Settlement (Pristine conditions).

Nitrogen species	mg/L	Reference of source
Nitrate	0.10	Maybeck (1982). Ave. for unpolluted major world rivers
	0.09	Clark, et al., (in press) median for 82 relatively undeveloped U.S. watersheds
Ammonium	0.015	Maybeck (1982)
Dissolved inorganic N	0.115	Calculated from Maybeck (1982)
Total dissolved N	0.375	Maybeck (1982)
Dissolved organic N	0.26	Calculated (from Maybeck, 1982)
Particulate organic N	0.86	Calculated from estimated pre-development sediment flux of 400×10^6 t/y (Meade, 1995); N content of sediment of 0.15%; 1980-96 mean annual streamflow of $21,990 \text{ m}^3/\text{s}$.
Total organic N	1.12	Calculated from dissolved and particulate organic N
Total N	1.24	Calculated from total dissolved N and particulate organic N
Other estimates of total N	0.93	Howarth et al., 1996 (from Maybeck 1982)
	0.08-1.15	Howarth et al., 1996 (from Lewis, 1986)
	0.79	Howarth et al., (1998) for mean discharge= $17,313 \text{ m}^3/\text{s}$; basin area= $3.23 \times 10^6 \text{ km}^2$
	0.26	Clark, et al. (in press); small watersheds throughout the United States

Table 2. - Historical and Recent Data on Nitrogen Concentrations in the Mississippi River Basin (Results in milligrams per liter as N).

Location	Number of Samples	Organic N			Inorganic N			Total N ²
		Total	DON ¹	PON ¹	Nitrate-N	NH ₄ -N	DIN	
Lower Illinois River								
1897-1902	weekly	1.01	0.59	0.42	1.25	0.38	1.63	2.64
1980-98	189	1.22	0.45	0.60	4.09	0.14	4.23	5.46
Upper Mississippi River near Grafton (below Illinois R. & above Missouri R.)								
1899-1900	70	1.10	0.48	0.62	0.59	0.13	0.72	1.82
1980-98	120	1.27	0.81	0.63	2.63	0.11	2.74	4.01
Lower Missouri River								
1899-1900	63	1.83	0.30	1.53	0.51	0.06	0.57	2.40
1980-98	186	1.03	0.51	0.69	1.23	0.05	1.28	2.24
Lower Mississippi								
1905-06	52	1.16 ^a	0.40 ^b	0.76 ^c	0.56	0.1 ^d	0.66	1.82
1980-98	104	0.92	0.52	0.38	1.45	0.06	1.51	2.40

¹DON and PON not analyzed on all samples in 1980-98, thus DON + PON does not equal total organic N for this time period.

²Total N calculated as the sum of total organic N + DIN.

^aCalculated as the sum of DON + PON.

^bEstimated from DON concentrations in upper Mississippi River and Lower Missouri River.

^cEstimated as 2 times the average 1980-98 PON concentration.

^dEstimated from NH₄ concentrations in the upper Mississippi and Lower Missouri River.

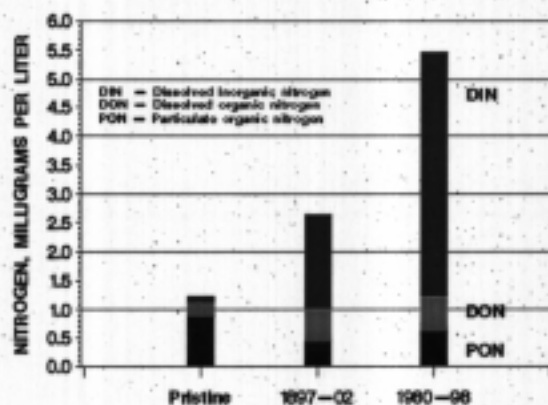


Figure 1. Nitrogen Concentrations in Lower Illinois River

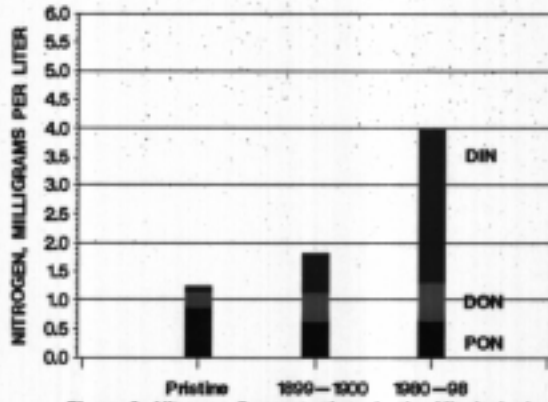


Figure 2. Nitrogen Concentrations in the Mississippi River near Grafton Illinois

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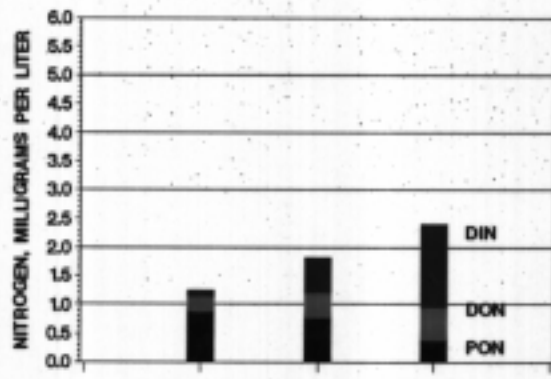


Figure 4. Nitrogen Concentrations the Lower Mississippi River