

Supplementary Material

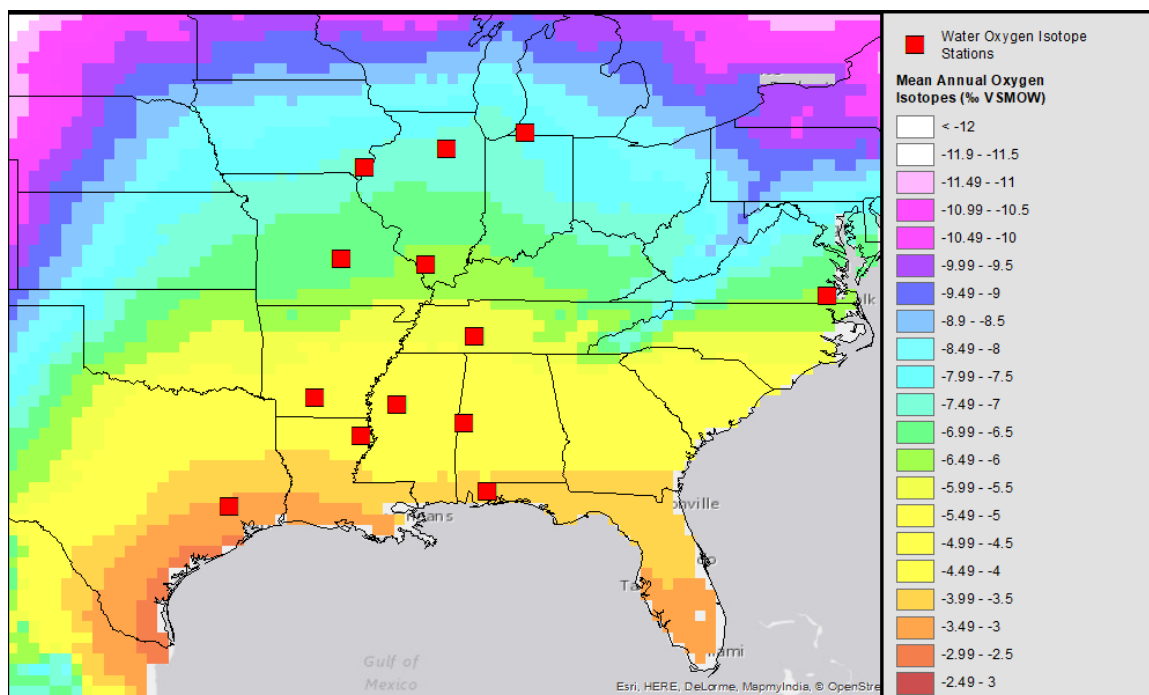


Figure S1. Map of water station localities (IAEA/WMO, 2018) superimposed on a map of mean annual oxygen isotopes $\delta^{18}\text{O}_{\text{water}}$ for the continental United States (Bowen and Revenaugh, 2003; Bowen et al., 2005).

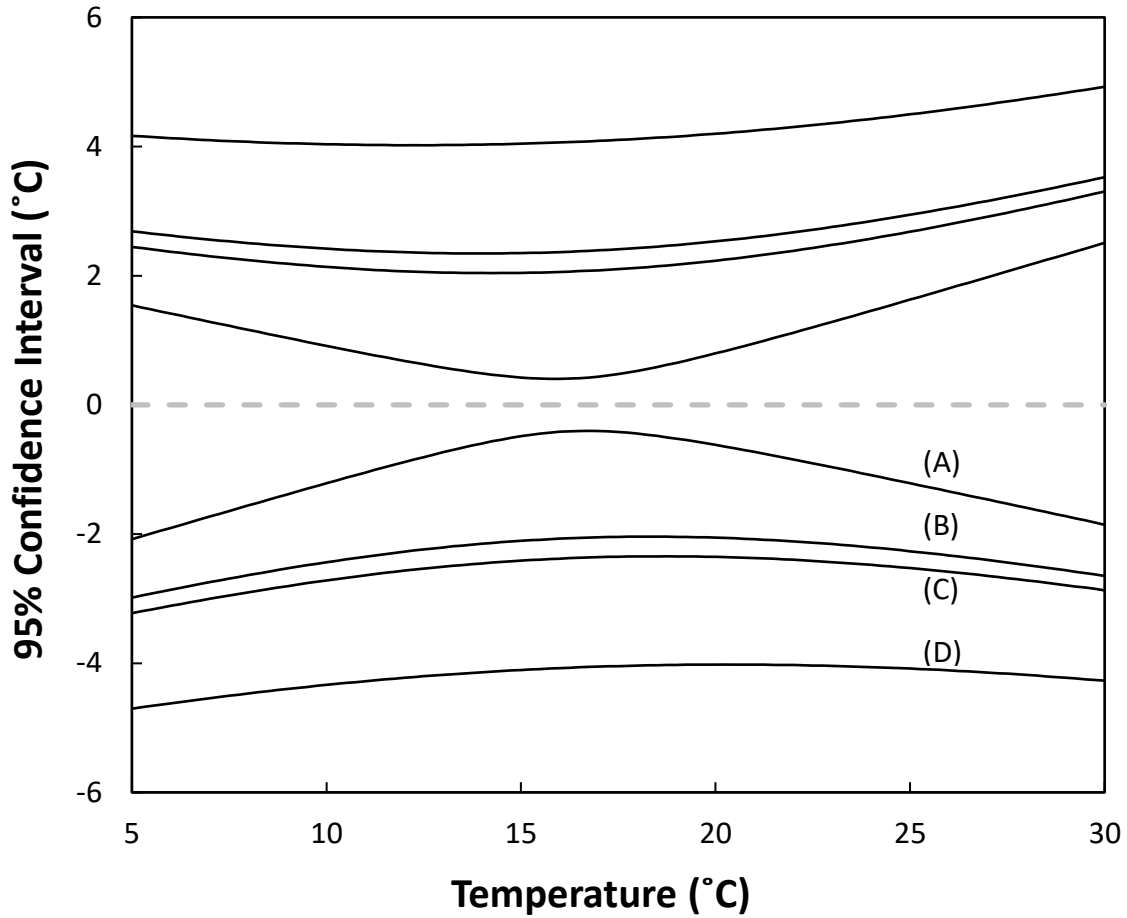


Figure S2. Graphic summary of 95% uncertainty for a temperature estimated using the gar scale bioapatite calibration. Uncertainty is a function of temperature and standard error contours. Maximizing numbers of unique sites (n_s) with multiple fish specimens (n_r) with multiple replicates of $\delta^{18}\text{O}_p$ reduces $\text{SE}(\Delta_{p-w})$. (A) Uncertainty comes from the calibration error alone, with $\text{SE}(\Delta_{p-w}) = 0\text{‰}$. (B) $\text{SE} = 0.371\text{‰}$, $n_s = n_r = 4$. This is closest to the average number of sites and number of fish specimens in this study. (C) $\text{SE} = 0.428\text{‰}$, $n_s = n_r = 3$. (D) $\text{SE} = 0.742\text{‰}$, $n_s = n_r = 1$.

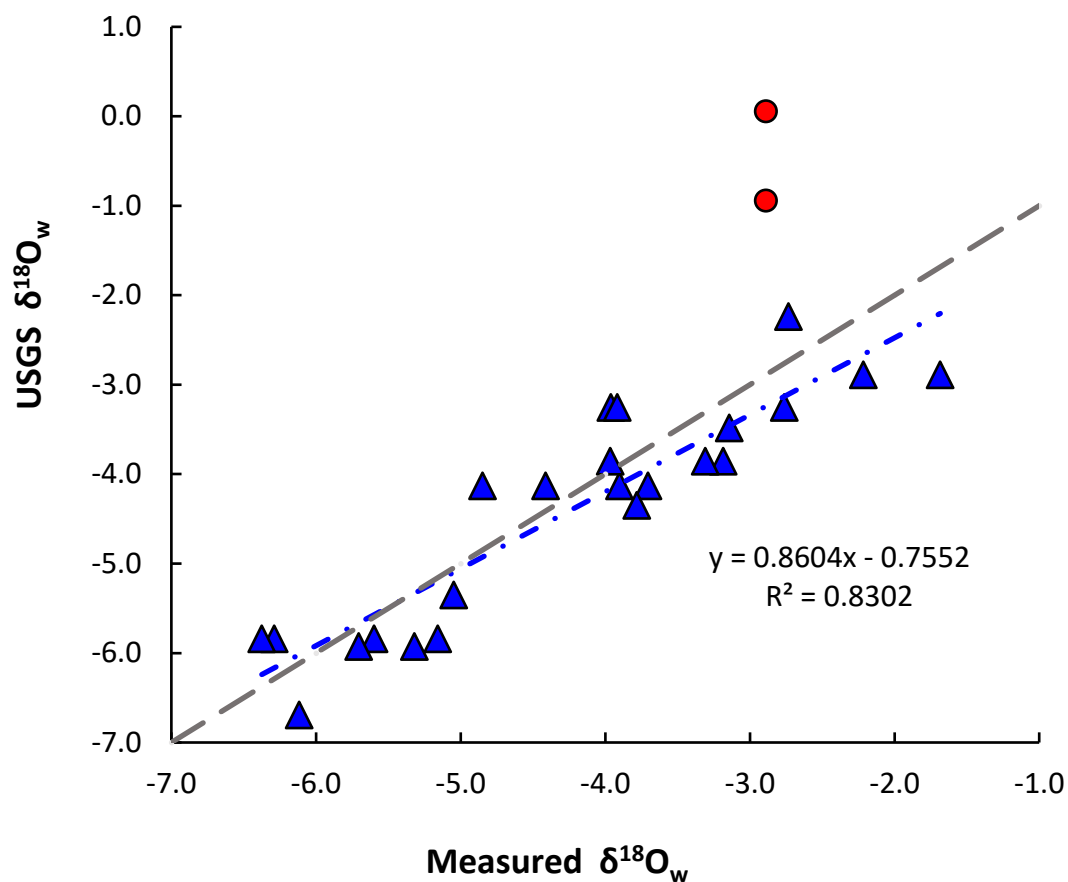


Figure S3. $\delta^{18}\text{O}_{\text{water}}$ values from waters collected in July 2014 compared to summer (July and August) values from those collected by the USGS from 1984 to 1987 (Kendall and Coplen, 2001). Two outliers (red circles) were collected on 19 July 2014 from east Texas after heavy rainfall (~50 mm) following mild drought conditions. Gray dashed line is 1:1 relationship. These values and their constituent samples were ultimately not included in this phosphate-oxygen isotope dataset.

Table S1. Specimen localities and annual water oxygen isotope compositions. $\delta^{18}\text{O}_{\text{water}}$ measurements are from USGS measurements (Kendall and Coplen, 2001). Annual air temperature are average temperatures taken from NOAA's National Centers for Environmental Information. Abbreviations: Yale Peabody Museum (YPM); Florida Museum of Natural History (UF); Texas Natural Science Center (TNSC); Chicago Field Museum (FMNH).

Specimen Name	Coordinates	Location	Annual Air Temp (°C)	Annual $\delta^{18}\text{O}_{\text{water}}$ (‰SMOW)	$\delta^{18}\text{O}_w$ Measurement Location
YPM 12016	42.399700°N, 85.411400°W	Gull Lake, MI	9.15 ± 0.45	-7.94	St. Joseph River, Niles, MI
YPM 8878					
FMNH 85897	41.530978°N, 88.032708°W	Joliet, IL	9.94 ± 0.82	-6.92	Illinois River, Marseilles, IL
YPM 27220	40.445169°N, 89.948581°W	Canton, IL	11.35 ± 0.74	-7.55	Skunk River, Augusta, IA
YPM 27221					
YPM 27222					
YPM 27211	38.037086°N, 88.956222°W	Rend Lake Dam, IL	13.77 ± 0.77	-4.13	Big Muddy River, Murphys-boro, IL
YPM 27212					
YPM 27216					
UF 129480	37.967501°N, 89.351882°W	Du Quoin, IL	13.57 ± 0.72	-4.13	Big Muddy River, Murphys-boro, IL
IC-05-01	37.368500°N, 89.360119°W	McLure, IL	14.17 ± 0.74	-6.10	Gasconade River, Jerome, MO
IC-05-02					
IC-05-03					
ADY-01-01	37.306750°N, 88.984069°W	Karnak, IL	14.13 ± 0.76	-6.10	Gasconade River, Jerome, MO
ADY-01-02					
IX-03-01	37.273281°N, 89.183789°W	McLure, IL	14.18 ± 0.86	-6.10	Gasconade River, Jerome, MO
IX-03-05					
IX-03-06					
IX-03-09					
IX-03-10					
IX-03-11					
YPM 11983	36.546089°N, 76.931078°W	Holland, VA	14.71 ± 0.44	-4.89	Blackwater River, Franklin, VA
YPM 12006					
YPM 12007					
YPM 027686	35.255697°N, 86.133170°W	Estill Springs, TN	14.88 ± 0.60	-5.68	Buffalo River, Flat Woods, TN
YPM 027687					
YPM 027688					
YPM 027689					

YPM 027690					
YPM 027691					
YPM 027692					
YPM 027693					
MMNS 59029	33.936869°N, 88.531789°W	Aberdeen, MS	16.90 ± 0.53	-3.91	Yazoo River, Shell Bluff, MS
YPM 27218	33.808794°N, 89.774011°W	Grenada, MS	16.82 ± 0.62	-3.91	Yazoo River, Shell Bluff, MS
YPM 27223					
YPM 27224					
MMNS 51497	33.705806°N, 88.343700°W	Hamilton, MS	16.98 ± 0.55	-3.91	Yazoo River, Shell Bluff, MS
MMNS 58721	33.662754°N, 88.501777°W	West Point, MS	16.90 ± 0.53	-3.91	Yazoo River, Shell Bluff, MS
MMNS 58880	33.636978°N, 88.501311°W	West Point, MS	16.90 ± 0.53	-3.91	Yazoo River, Shell Bluff, MS
FMNH 109203	33.398444°N, 90.700560°W	Indianola, MS	17.80 ± 0.54	-3.91	Yazoo River, Shell Bluff, MS
MMNS 54500	33.189222°N, 88.708694°W	Brooksville, MS	17.46 ± 0.74	-3.91	Yazoo River, Shell Bluff, MS
MDF 3	32.897717°N, 90.537892°W	Yazoo City, MS	18.40 ± 0.84	-3.64	Wolf River, Landon, MS
MDF 4					
MDF 1	32.896631°N, 90.541906°W	Yazoo City, MS	18.40 ± 0.84	-3.64	Wolf River, Landon, MS
MDF 2					
BARNRES	32.395362°N, 90.066850°W	Jackson, MS	18.45 ± 0.45	-2.77	Tensas River, Tendam, LA
UF 120183	30.947522°N, 87.263955°W	Jay, FL	19.44 ± 0.55	-3.90	Perdido River, Barrineau, AL
UF 119897	30.775972°N, 87.309028°W	Molino, FL	20.20 ± 0.42	-3.90	Perdido River, Barrineau, AL
UF 119908	30.679889°N, 87.268861°W	Molino, FL	20.20 ± 0.42	-3.90	Perdido River, Barrineau, AL
UF 150169	30.775833°N, 87.339167°W	Molino, FL	20.20 ± 0.42	-3.90	Perdido River, Barrineau, AL
TNSC 31670	30.555314°N, 95.185664°W	Coldspring, TX	19.39 ± 0.75	-3.81	San Jacinto, Conroe, TX

Table S2. Summer only $\delta^{18}\text{O}_{\text{water}}$ average values (July and August) of the water isotope stations monitored by the USGS from 1984 to 1987 (Kendall and Coplen, 2001) compared to $\delta^{18}\text{O}_{\text{water}}$ values from waters collected in July 2014. FMNH = Chicago Field Museum, TNSC = Texas Natural Science Center, UF = Florida Museum of Natural History, YPM = Yale Peabody Museum.

Location or Catalog Number	City, State	Coordinates	Date Sampled	Sampled $\delta^{18}\text{O}_{\text{water}}$	Station $\delta^{18}\text{O}_{\text{water}}$	River Station Name
Presque Isle	Erie, PA	42.160010°N, 80.094269°W	04-Jul-14	-6.12	-6.69	Grand, Painesville, OH
FMNH 85897	Joliet, IL	41.530978°N, 88.032708°W	07-Jul-14	-5.60	-5.84	Illinois, Marseilles, IL
FMNH 124364	Channahon, IL	41.401133°N, 88.280402°W	07-Jul-14	-6.29	-5.84	Illinois, Marseilles, IL
FMNH 11168	Dayton, IL	41.386380°N, 88.789155°W	07-Jul-14	-6.37	-5.84	Illinois, Marseilles, IL
Rice Lake	Banner, IL	40.480604°N, 89.939408°W	08-Jul-18	-5.16	-5.84	Illinois, Marseilles, IL
Pere Marquette State Park	Grafton, IL	38.971261°N, 90.545534°W	09-Jul-18	-5.32	-5.93	Salt, New London, MO
FMNH 83724	Grafton, IL	38.968445°N, 90.438492°W	09-Jul-18	-5.70	-5.93	Salt, New London, MO
Rend Lake Dam	Benton, IL	38.037437°N, 88.956454°W	10-Jul-18	-4.41	-4.13	Big Muddy River, Murphysboro, IL
Clear Creek	McLure, IL	37.368500°N, 89.360119°W	21-Jul-14	-3.90	-4.13	Big Muddy River, Murphysboro, IL
Old Cache River	Karnak, IL	37.306750°N, 88.984069°W	21-Jul-14	-3.71	-4.13	Big Muddy River, Murphysboro, IL
Cache River	Ullin, IL	37.273281°N, 89.183789°W	17-Jul-14	-4.85	-4.13	Big Muddy River, Murphysboro, IL
Nottoway River	Holland, VA	36.546089°N, 76.931078°W	28-Jul-14	-3.78	-4.35	Blackwater, Franklin, VA
Henry Horton State Park	Wilhoite Mills, TN	35.590478°N, 86.700220°W	14-Jul-14	-5.05	-5.35	Buffalo, Flat Hills, TN
YPM 27218	Grenada Dam, MS	33.808794°N, 89.774011°W	15-Jul-14	-3.96	-3.25	Yazoo, Shell Bluff, MS
MMNS 58721	Barton Ferry, MS	33.664683°N, 88.501955°W	15-Jul-14	-3.92	-3.25	Yazoo, Shell Bluff, MS
Sunflower River, MS	Indianola, MS	33.398444°N, 90.700560°W	16-Jul-14	-2.76	-3.25	Yazoo, Shell Bluff, MS
Barnet Reservoir	Jackson, MS	32.395362°N, 90.066850°W	17-Jul-14	-2.73	-2.24	Tensas, Tendal, LA
UF 120183	Jay, FL	30.947522°N, 87.263955°W	26-Jul-14	-3.18	-3.86	Perdido, Barrineau Park, AL

UF 119897	Molino, FL	30.775972°N, 87.309028°W	26-Jul-14	-3.97	-3.86	Perdido, Barrineau Park, AL
UF 119908	Pensacola, FL	30.679889°N, 87.268861°W	26-Jul-14	-3.31	-3.86	Perdido, Barrineau Park, AL
Lake Livingston, TX	West Livingston, TX	30.631787°N, 95.010855°W	25-Jul-14	-1.68	-2.89	West Fork San Jacinto, Conroe, TX
TNHC 48690	Bryan, TX	30.559488°N, 96.423447°W	19-Jul-14	-2.22	-2.89	West Fork San Jacinto, Conroe, TX
TNHC 46355	Hutto, TX	30.526316°N, 97.566827°W	19-Jul-14	-3.14	-3.48	South Fork Rocky Creek, Briggs, TX
TNHC 58066	Clay, TX	30.368110°N, 96.343175°W	19-Jul-14	0.06	-2.89	West Fork San Jacinto, Conroe, TX
TNHC 15583	Hempsted, TX	30.097696°N, 96.158949°W	19-Jul-14	-0.94	-2.89	West Fork San Jacinto, Conroe, TX

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