Supporting Information

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SI Text

1 Construction of δ^{15}N Time Series. The recent (AD 1926–2001) bulk δ^{15}N stable isotope record (Fig. S1) was derived from six specimens of *P. resedaeformis*. Use of multiple colonies from the same location allows for quantification of inter-colony reproducibility and contributes to greater confidence in our interpretations. Where multiple sections per colony were analyzed, the time-series records were averaged. Annual means (±95% confidence intervals) were calculated with a mixed effects linear model with year as the fixed effect and colony as the random effect using the ProcMixed program in the statistical software SAS.

2 Cross-Correlation Analysis. Climate and stable isotope time-series records were strongly autocorrelated, even after detrending. Autocorrelation is a problem in cross-correlation analysis because it violates the assumption of sample independence among observations and increases the likelihood of identifying significant correlations where none exist (1). The traditional practice of removing autocorrelation by first-differencing or prewhitening data to control for this effect inflates the rate of Type II error, and thus decreases statistical power (2). We used an alternative, robust method of adjusting the degrees of freedom to account for autocorrelation that has the advantage of conserving both Type I and Type II error rates ("modified Chelton" method) (2). Correlations and probability levels (90 and 95%) were calculated over N/5 lags on the detrended time series (Fig. S2). Monte Carlo estimates of Type I error were checked by randomizing one time series with respect to another and counting the number of significant ($p < 0.05$) correlations in 1000 simulations. In all cases, the number of significant correlations was <5%.

3 Northeast Channel Nitrate Data. Phytoplankton preferentially assimilate ^{14}N over ^{15}N during growth on NO_3^- (3, 4). As a result, they initially have lower δ^{15}N than NO_3^-. As nutrients are consumed, the δ^{15}N of both the phytoplankton and residual NO_3^- increase following Rayleigh fractionation kinetics (5, 6). In continental shelf and slope settings spring and autumn blooms often lead to complete drawdown of euphotic zone NO_3^-. Because all of the nitrate is converted to biomass in the study area, the δ^{15}N of newly exported particulate organic matter (POM) converges on that of the initial NO_3^-.

To verify nutrient drawdown in the study region, temperature and nitrate data were obtained for the 2×2 degree grid centered over the coral collection area over the years 1997–1999 (Fig. S1). The years 1997 and 1999 represent warm, WSW-influenced states with the 150–250 m deep layer exhibiting a temperature of 9 °C and [NO_3^-] of 20 μM (Fig. S3). The year 1998 represents a cold, LSW-influenced state with a temperature of 6 °C and [NO_3^-] of 15 μM. Despite differences in initial slopewater concentrations, [NO_3^-] in the productive upper 25 m of the water column was depleted to <1 μM by late spring of all years.

4 Age Models of Fossil Specimens. In addition to the six recent specimens of *P. resedaeformis*, four fossil specimens were analyzed for δ^{15}N. Age models for two of these specimens, "Fossil-95" (7) and "COHPS-2001-1" (8), were described earlier. The remaining two specimens were dated by conventional ^{14}C dating. Raw ^{14}C ages were calibrated with the CALIB program (9) using the Marine04 dataset (10) and corrected for local variation in the marine reservoir age using a ΔR (11) value of 128 ± 35 (8).

Specimen "COHPS-2001-2": 44 growth rings were sampled across the axial radius of the specimen at approximately annual resolution. Sample (growth ring) #43 from the inner region of the skeleton was dated at 640 ± 35 (1σ) ^{14}C years (Lab code LLNL 111134); calibrated 1σ age range of sample = 1716–1874 AD. The maximum age of the oldest sample (#44) = 1716 yrs AD – 1 = 1715 yrs AD. The minimum age of youngest sample (#1) = 1874 yrs AD + 42 yrs = 1916 yrs AD.

Specimen "R6400016-1": 61 growth rings were sampled across the axial radius at approximately annual resolution. Sample #55 was dated at 625 ± 35 (1σ) ^{14}C years (Lab code LLNL 111630); calibrated 1σ age range of sample = 1727–1951* AD (*Samples calibrated to 1951 yrs AD are suspect because they impinge on end of calibration dataset). The maximum age of oldest sample (#61) = 1727 yrs AD – 6 = 1721 yrs AD. The minimum age of youngest sample (#1) = 1951 yrs AD + 54 yrs = 2005 yrs AD. The minimum age was truncated to year of collection (2002).

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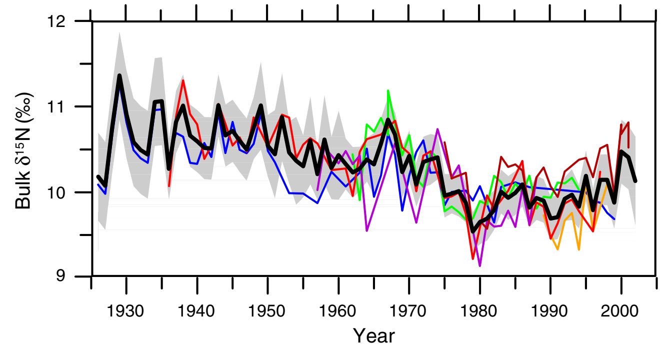

Fig. S1. Time series of bulk $\delta^{15}N$ from individual specimens of *P. resedaeformis* (represented by different colored lines). Bold black line is the mixed effect mean with 95% confidence envelope (shaded gray area).

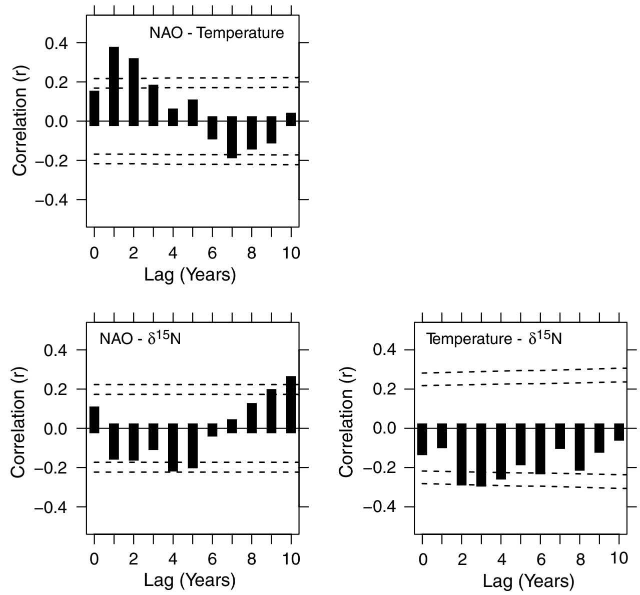

Fig. S2. Cross-correlation matrix of detrended NAO, temperature, and bulk $\delta^{15}N$ time-series. First variable leads the second. Inner and outer dashed envelopes represent 90% and 95% significance levels, respectively.

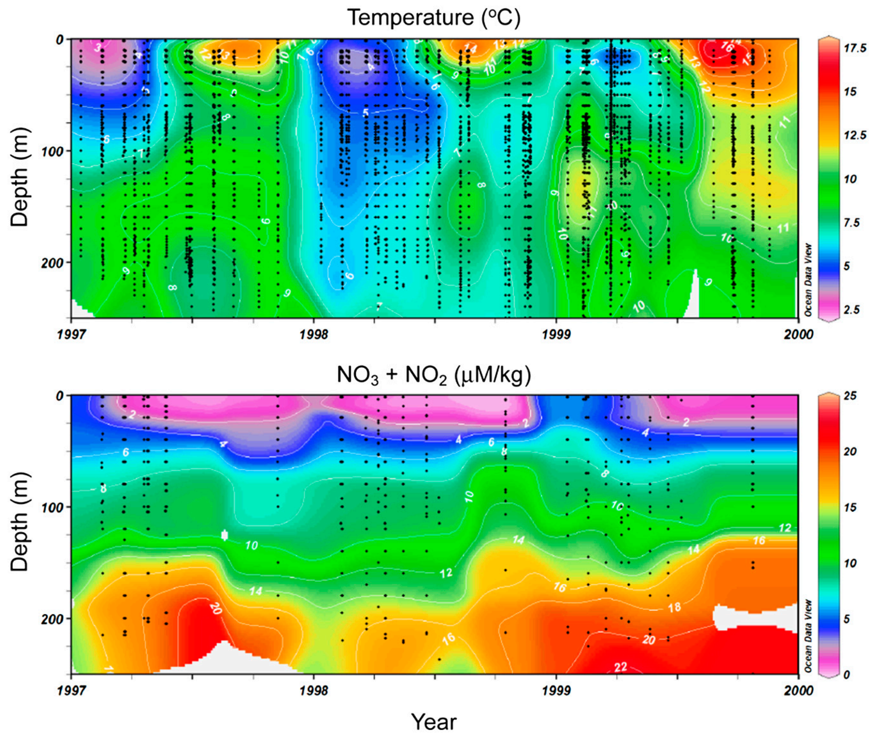

Fig. S3. Depth vs. time plots of temperature (*Upper*) and NO_3^- ($NO_3 + NO_2$) concentration (*Lower*) for stations in the Northeast Channel. Nutrient data were compiled from the Bedford Institute of Oceanography Biochem database (http://www.meds-sdmm.dfo-mpo.gc.ca/biochem/Biochem_e.htm) and results of the US GLOBEC program (http://grampus.umeoce.maine.edu/jg/serv/globec/nut_phyto.html). Graph created with Ocean Data View software (1).

1 Schlitzer R (2010) Ocean Data View, http://odv.awi.de.