Biogeographic responses of the copepod *Calanus glacialis* to a changing Arctic marine environment

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Supplemental Materials

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Table.S1 Linear trend regression of annual success rate (ASR), annual mean growth season length (GSL), critical development time (CDT), temperature (T) and food (F) of all transition-zone individuals against year and in each of the 9 sectors within the transition zone. Bold numbers denote statistically significant linear trends ($p < 0.01$).

Sector (# individuals)	ASR		GSL		CDT		T		F	
	Trend (%/yr)	R^2	Trend (d/yr)	R^2	Trend (d/yr)	R^2	Trend	R^2	Trend	R^2
All (n = 2933)	**+1.9**	0.87	**+0.61**	0.78	**-0.59**	0.89	**+0.027**	0.88	**+0.012**	0.88
Beaufort (n = 295)	**+2.5**	0.60	**+0.92**	0.57	**-0.58**	0.32	**+0.021**	0.28	**+0.015**	0.60
Chukchi (n = 315)	**+2.9**	0.74	**+1.13**	0.69	**-0.75**	0.54	**+0.021**	0.50	**+0.021**	0.70
Siberian (n = 271)	**+2.7**	0.62	**+0.99**	0.54	**-0.79**	0.57	**+0.032**	0.57	**+0.019**	0.54
Laptev (n = 191)	**+2.1**	0.56	**+0.84**	0.52	**-0.49**	0.40	**+0.031**	0.53	**+0.015**	0.51
Kara (n = 307)	**+2.3**	0.78	**+0.62**	0.61	**-0.65**	0.70	**+0.034**	0.53	**+0.014**	0.74
Barents (n = 544)	+0.8	0.17	+0.16	0.05	**-0.35**	0.27	**+0.018**	0.37	+0.003	0.17
GIN (n = 263)	+0.6	0.11	+0.25	0.13	**-0.37**	0.30	**+0.019**	0.25	+0.002	0.11
Baffin (n = 539)	**+1.8**	0.60	**+0.33**	0.30	**-0.71**	0.63	**+0.032**	0.61	**+0.009**	0.58
CAA (n = 208)	**+2.7**	0.76	**+0.96**	0.64	**-0.97**	0.78	**+0.050**	0.73	**+0.021**	0.70

Table.S2 Spearman's rank correlation coefficients between each two of the following metrics: annual success rate (ASR), annual mean growth season length (GSL), critical development time (CDT), temperature (T) and food (F) of all transition-zone individuals and in each of the 9 sectors within the transition zone. Bold numbers denote statistically significant correlations ($p < 0.01$).

Sector (# individuals)	ASR & GSL	ASR & CDT	ASR & T	ASR & F	GSL & CDT	GSL & T	GSL & F	CDT & T	CDT & F	T & F
All (*n* = 2933)	**0.97**	**-0.95**	**0.92**	**0.97**	**-0.90**	**0.85**	**0.93**	**-0.95**	**-0.96**	**0.93**
Beaufort (*n* = 295)	**0.92**	**-0.90**	**0.84**	**0.97**	**-0.71**	**0.65**	**0.91**	**-0.87**	**-0.88**	**0.75**
Chukchi (*n* = 315)	**0.94**	**-0.90**	**0.83**	**0.97**	**-0.77**	**0.76**	**0.90**	**-0.90**	**-0.91**	**0.88**
Siberian (*n* = 271)	**0.95**	**-0.92**	**0.90**	**0.97**	**-0.84**	**0.83**	**0.94**	**-0.96**	**-0.92**	**0.89**
Laptev (*n* = 191)	**0.96**	**-0.73**	**0.88**	**0.94**	**-0.63**	**0.84**	**0.90**	**-0.80**	**-0.77**	**0.89**
Kara (*n* = 307)	**0.93**	**-0.87**	**0.79**	**0.94**	**-0.66**	**0.60**	**0.86**	**-0.86**	**-0.88**	**0.80**
Barents (*n* = 544)	**0.89**	**-0.90**	**0.44**	**0.89**	**-0.72**	0.11	**0.86**	**-0.59**	**-0.88**	0.35
GIN (*n* = 263)	**0.78**	**-0.91**	**0.55**	**0.90**	**-0.65**	0.24	**0.81**	**-0.72**	**-0.78**	0.32
Baffin (*n* = 539)	**0.84**	**-0.92**	**0.81**	**0.93**	**-0.64**	**0.48**	**0.75**	**-0.90**	**-0.91**	**0.83**
CAA (*n* = 208)	**0.96**	**-0.96**	**0.84**	**0.96**	**-0.92**	**0.78**	**0.93**	**-0.89**	**-0.87**	**0.74**

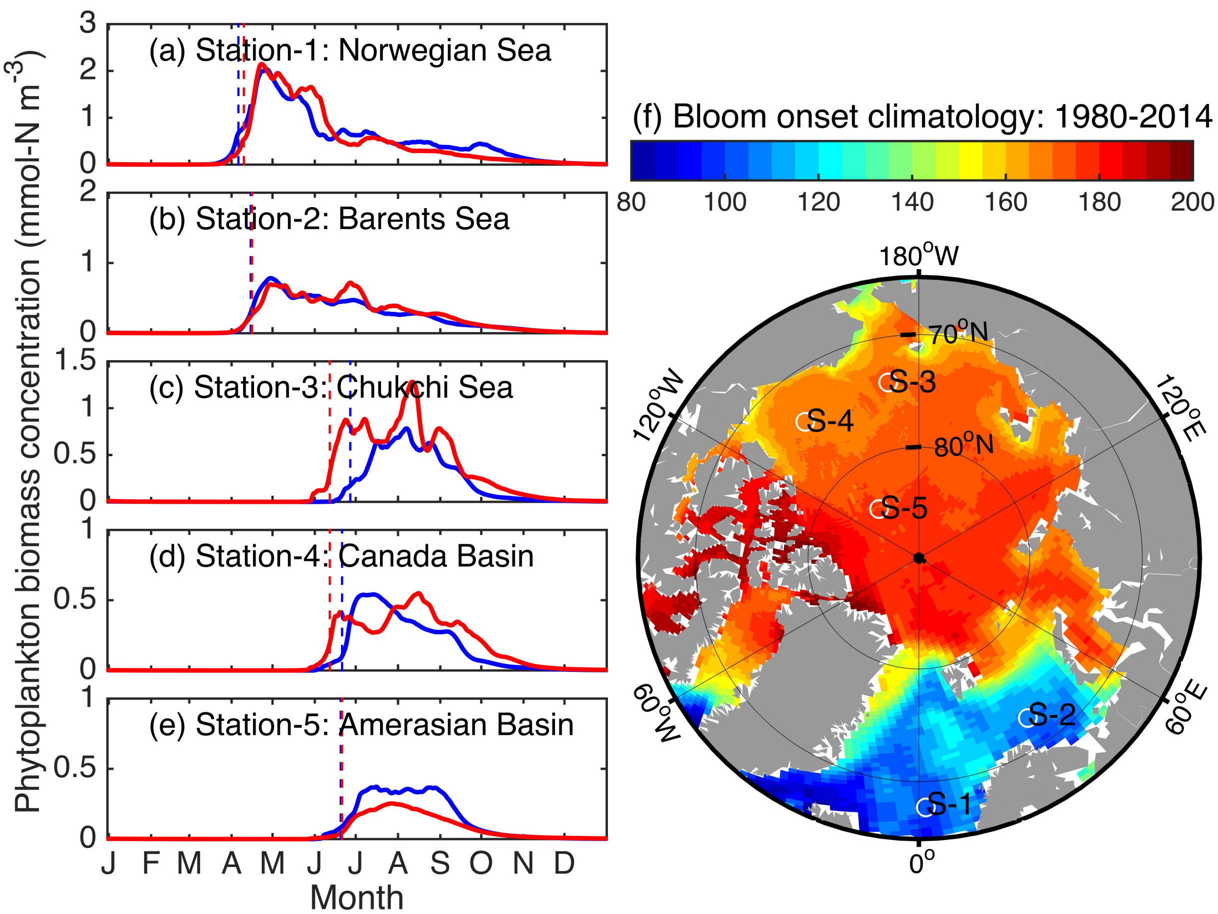

Fig.S1 (a)-(e) BIOMAS-simulated upper ocean (0-60 m) depth-average phytoplankton biomass concentrations at 5 stations (locations are indicated in Panel-f). (f) Phytoplankton bloom onset climatology in 1980-2014. In Panels (a)-(e), blue and red lines show annual time series in 1982 and 2012, respectively. The vertical dash lines indicate the phytoplankton bloom onset timing (year-day when cumulative sum phytoplankton biomass exceeds 2.5% of annual total biomass). In Panel (f), the climatology is calculated by averaging the bloom onset dates of the 35 years.

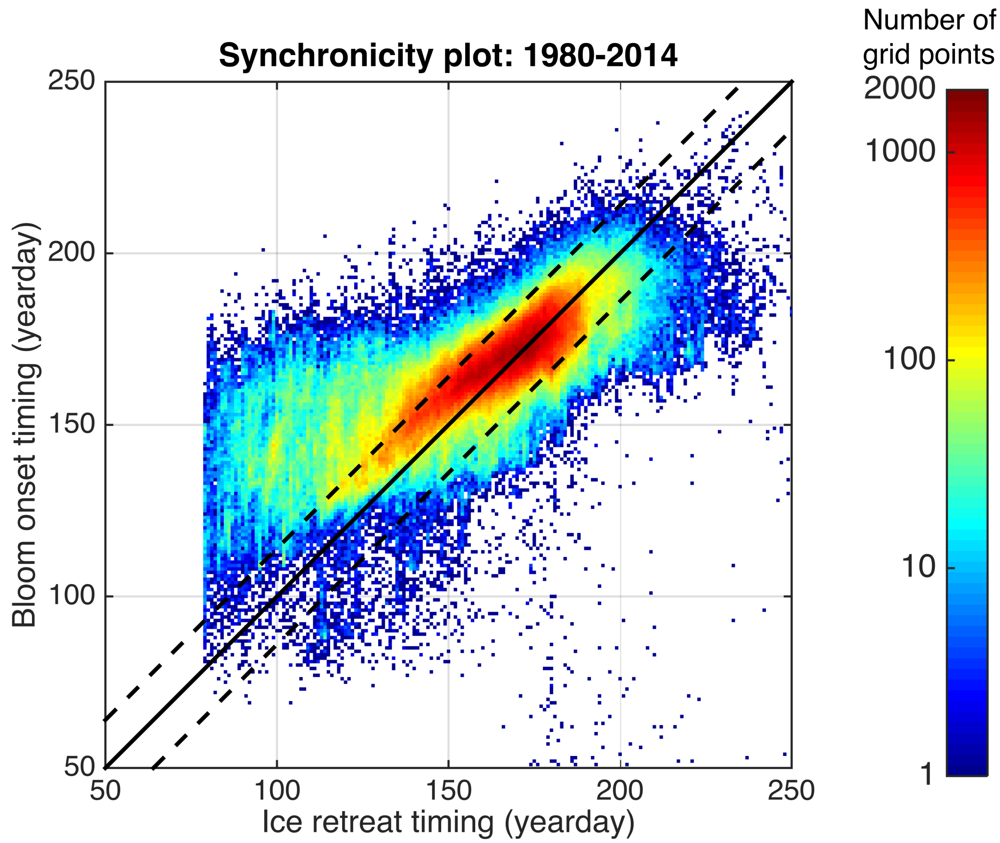

Fig.S2 Synchronicity between ice retreat and phytoplankton bloom onset timing based on the BIOMAS simulations in 1980-2014. The ice retreat timing is defined as the year-day when sea ice concentration reduces to below 0.85. The phytoplankton bloom onset is defined as the year-day when cumulative biomass concentration exceeds 2.5% of the annual total biomass. The solid diagonal line indicates a perfect match between two timings and the dash lines indicate offset of ±14 days.

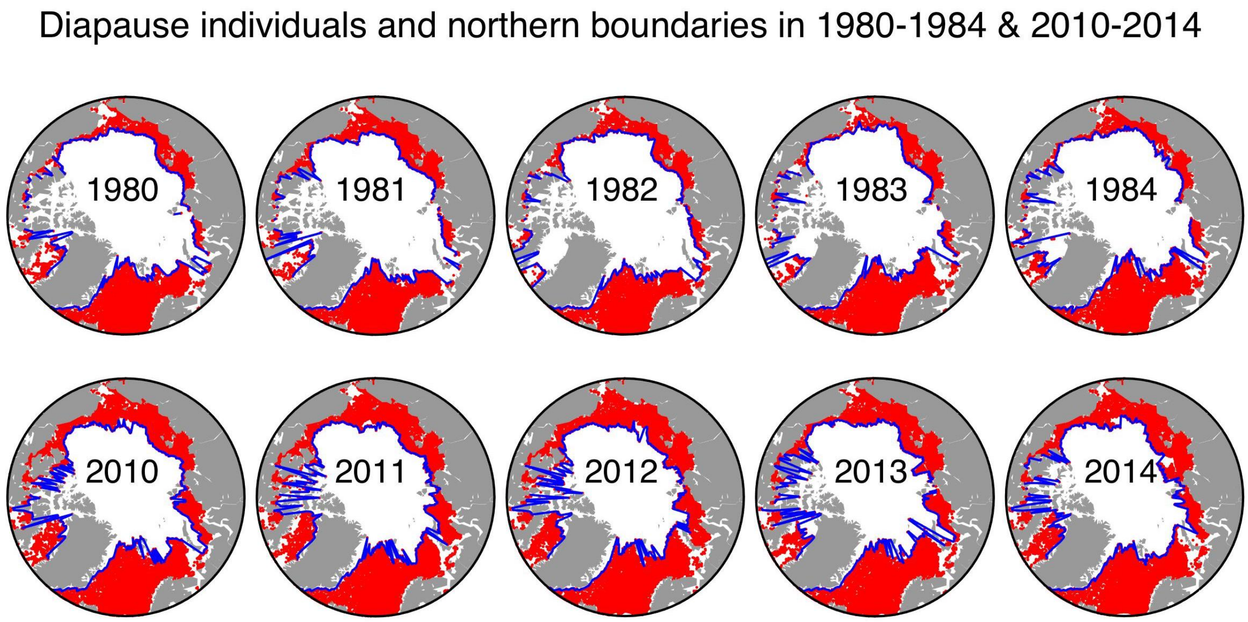

Fig.S3 Modeled annual distributions and northern boundaries of *C. glacialis* diapausers for periods of 1980-1984 and 2010-2014. The red dots represent *C. glacialis* individuals that reach *C4* diapausing stage before growth season ends. Those individuals not reaching diapause are not shown. The blue curves represent modeled northern boundaries in corresponding years.

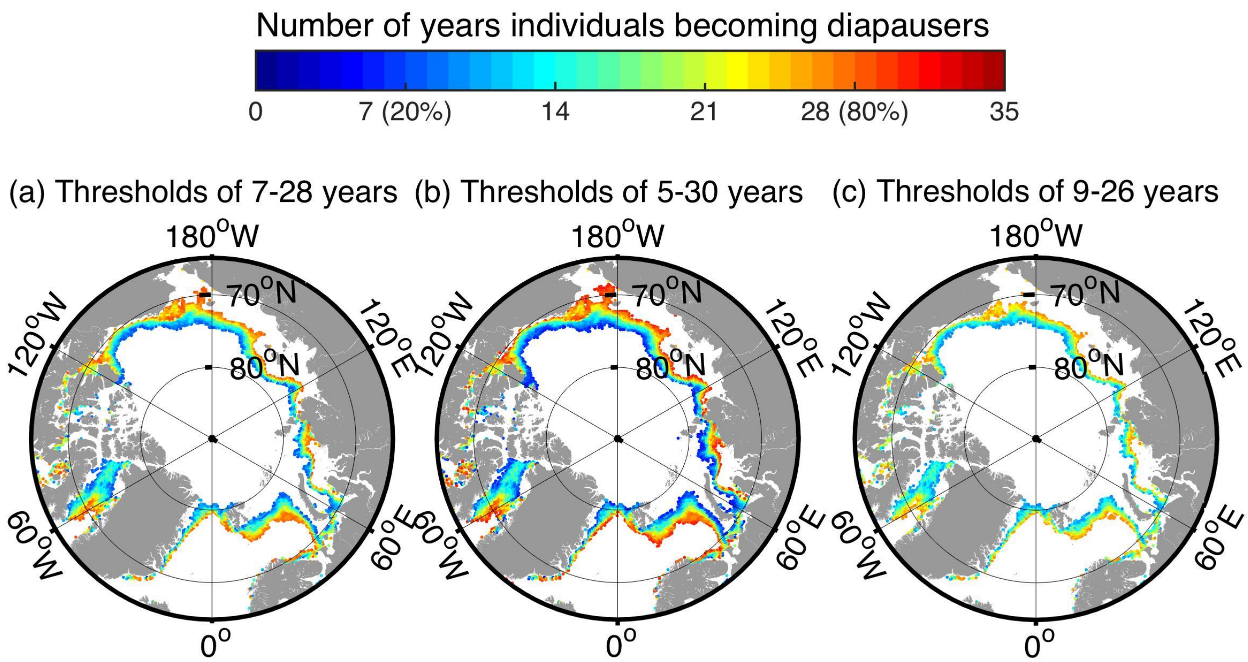

Fig.S4 Sensitivity of *C. glacialis* transition zones to different threshold years: (a) 7-28 years (definition adopted in the paper), (b) 5-30 years, and (c) 9-26 years.

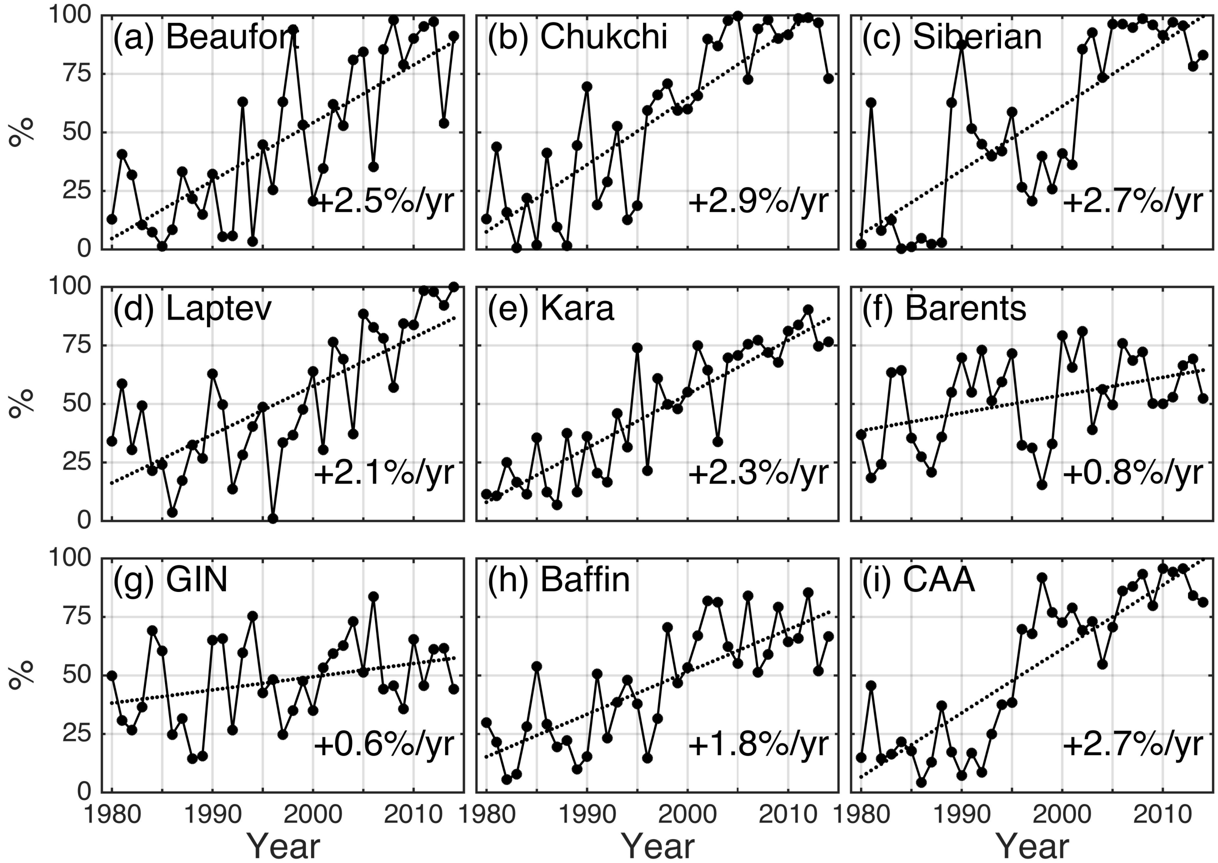

Fig.S5 Annual successful rates of transition-zone *C. glacialis* individuals in 9 circumpolar sectors. The dashed lines show fitted linear trends.

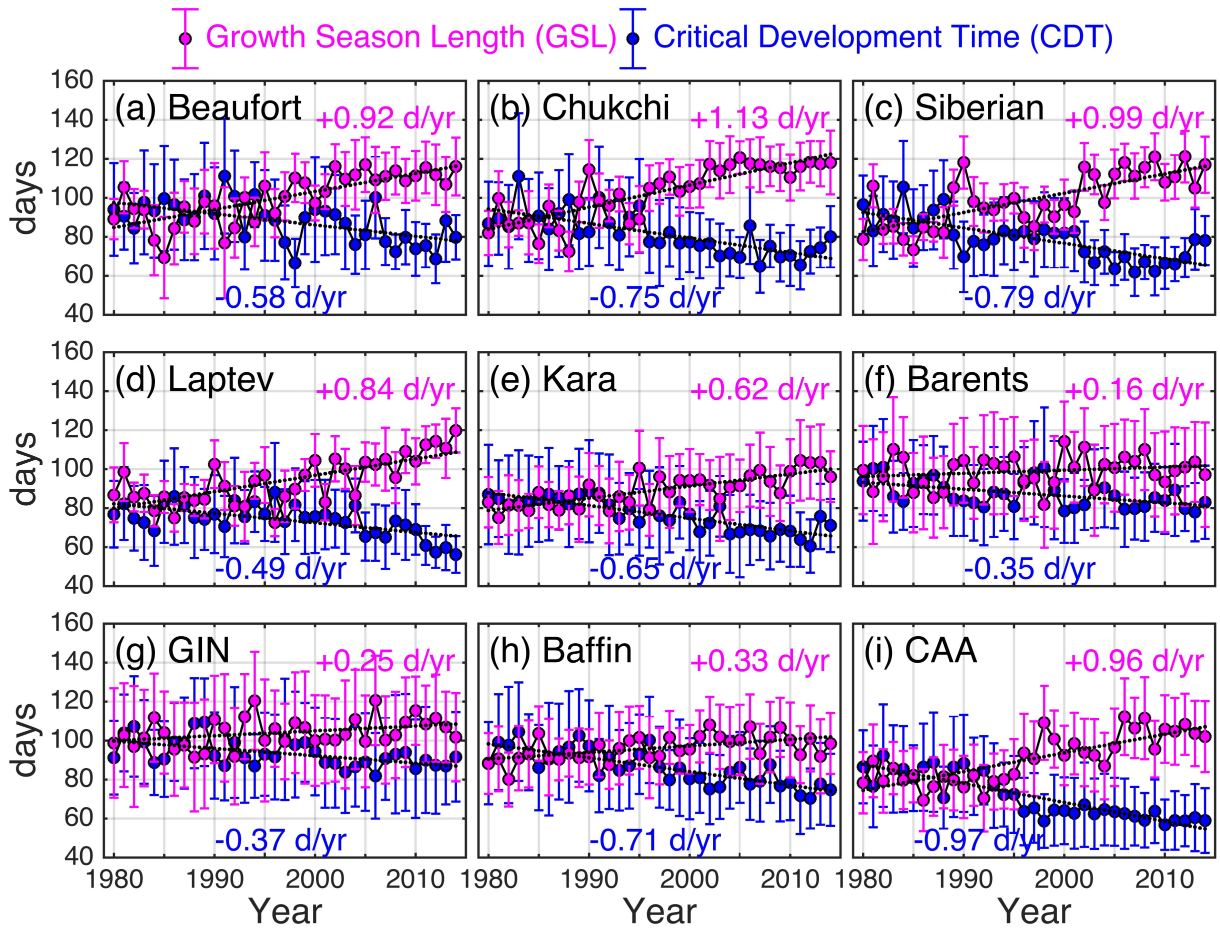

Fig.S6 Annual mean (and standard deviation) growth season length and critical development time of transition-zone *C. glacialis* individuals in 9 circumpolar sectors. The dashed lines show fitted linear trends.

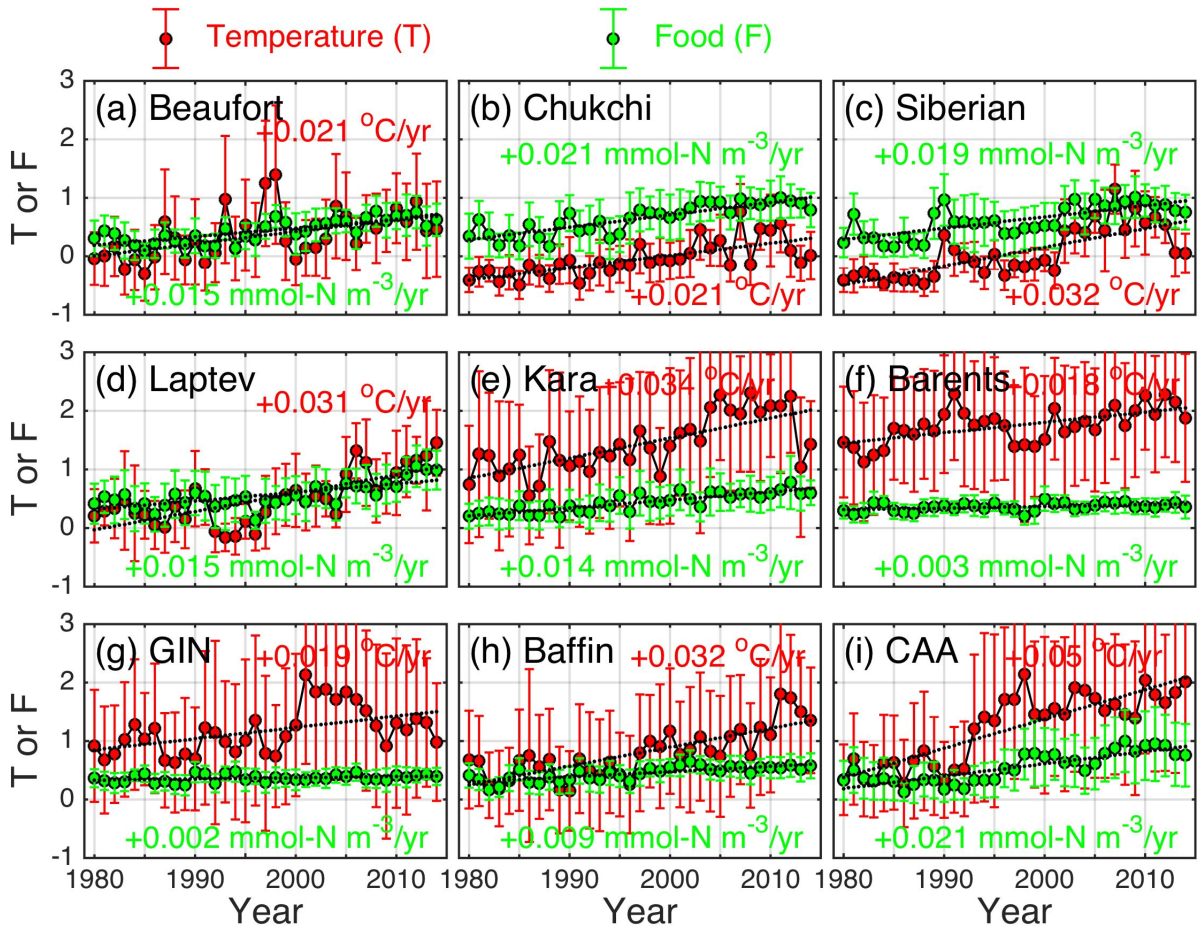

Fig.S7 Annual mean (and standard deviation) temperature and food of transition-zone *C. glacialis* individuals in 9 circumpolar sectors. The dashed lines show fitted linear trends.