Supplementary Information

Supplementary Methods

Data

We used catch-per-unit-effort (CUE) data from the Ontario Ministry of Natural Resources and Forestry (OMNRF) Broad-scale Fisheries Monitoring (BSM) Program (complete details can be found in Sandstrom et al.[1]). In summary, each lake was netted between May and September from 2008 to 2012 using standardized multipaneled mesh gillnets to randomly sample the fish community in up to eight depth strata, depending on the maximum depth of each lake (strata were 1-3m, 3-6m, 6-12m, 12-20m, 20-35m, 35-50m, 50-75m, and >75m).

Lake Attributes

We used the average recent air temperature (hourly air temperature in °C for the 30 days prior to field sampling) based on data available from Microsoft's FetchClimate, www.fetchclimate.org, for the latitude and longitude of each lake. In addition to temperature, we used 5 additional lake attributes: surface area in hectares, mean depth in metres, Secchi depth in metres, total phosphorus in ug per L, and lake shape (the shoreline development index or SDI, see Dolson *et al.* [2]). These 5 variables have been previously identified as drivers of feeding and/or behavioural responses in boreal shield lake ecosystems.

Species

We examined all coldwater fish species that had at least 5 individuals caught in at least 8 lakes with a maximum depth more than 6m (to ensure that both nearshore and offshore habitats were present). We used the thermal guild classifications from Hasnain *et al.* [3], who define coldwater fishes as those that prefer waters colder than 19°C.

Mean Depth of Capture

For each species and for all species combined (i.e., the whole coldwater guild), we calculated the mean depth of capture for each species in each lake using a weighted average based on CUE per depth stratum as

$$\mathrm{MD} = \frac{\sum_{i=1}^{4} d_i \times CUE_i \times p_i}{\sum_{i=1}^{4} CUE_i}$$

where MD is the mean depth of capture of a fish species or guild, CUE_i is the CUE of that species or guild for depth stratum i, p_i is the proportion of the lake in depth stratum i, and d_i is the natural log transformed middle depth of the depth range for stratum i: log(2) for stratum 1(1m - 3 m), log(4.5) for stratum 2 (3 - 6 m), log(9) for stratum 3 (6 – 12 m), and log(16) for stratum 4 (12 – 20 m). We only use data from depth strata 1 through 4 to calculate mean depth of capture because these are the only depth strata that were sampled using both gear types.

Statistical Analyses

We used multiple linear regression models to examine whether the mean log depth of capture of these coldwater fishes increased with increasing average recent air temperature while accounting for the effects of five non-temperature variables (lake size in hectares, lake shape (SDI), Secchi depth in m, mean lake depth in m, and total phosphorous in μg per L). We used $\log_{10}$ transformed lake surface area and natural log transformed shoreline development factor, mean lake depth, total phosphorous. All regression analyses were performed in the R statistical language (v3.2.3).

Supplementary Results

We found strong evidence for aggregate guild-level response of coldwater fishes driven by the unified responses of many species. The whole coldwater guild and 6 of the 13 species showed a significant increase in log-transformed mean depth of capture with increasing temperature, and the direction of all slope coefficient estimates was towards deeper capture with increased temperature. Our results indicate that many species move into deeper, colder water with warming (see Figure 3 and the *Aggregate Rewiring* section of the main text).

Table S1. Taxonomic information about the 13 species of coldwater boreal shield lake fishes we examined (as classified by Hasnain et al.[3]), as well as the number of lakes, average number of individuals, and the average mean log depth of capture for each species.

Common Name	Scientific Name	Family Name	Number of Lakes	Average Number Caught	Mean Log Depth of Capture
whole coldwater guild	-	-	356	112	2.14
brook stickleback	*Culaea inconstans*	Gasterosteidae	8	20	1.31
brook trout	*Salvelinus fontinalis*	Salmonidae	27	36	1.51
burbot	*Lota lota*	Gadidae	80	16	2.49
cisco	*Coregonus artedi*	Salmonidae	239	101	2.41
lake chub	*Couesius plumbeus*	Cyprinidae	47	91	1.27
lake trout	*Salvelinus namaycush*	Salmonidae	199	26	2.51
lake whitefish	*Coregonus clupeaformis*	Salmonidae	209	62	2.29
longnose sucker	*Catostomus catostomus*	Catostomidae	40	58	2.13
ninespine stickleback	*Pungitius pungitius*	Gasterosteidae	17	24	2.10
pearl dace	*Margariscus margarita*	Cyprinidae	15	55	0.97
rainbow smelt	*Osmerus mordax*	Osmeridae	52	133	2.36
spottail shiner	*Notropis hudsonius*	Cyprinidae	151	86	1.20
trout-perch	*Percopsis omiscomaycus*	Percopsidae	129	31	1.83

Table S2. Summaries for multiple regression models to test the effects average recent air temperature (T) on mean log depth of capture (y) for 13 species of coldwater boreal shield lake fishes. Each model also included 5 additional variables: $\log_{10}$ transformed lake surface area in ha (LSA), natural log transformed shoreline development factor (LSDF, a measure of lake shape), natural log transformed Secchi depth in m (LSD, a measure of water clarity), natural log transformed mean lake depth in m (LMD), natural log transformed total phosphorous in $\mu g \bullet L^{-1}$ (LTP, a measure of productivity).

species	slope coefficient	standard error	t-statistic	degrees of freedom	p-value
whole coldwater guild	0.0359	0.0066	5.451	349	<0.0001
brook stickleback	0.1040	0.0274	3.801	1	0.164
brook trout	0.0460	0.0219	2.102	20	0.0484
burbot	0.0026	0.0124	0.212	73	0.833
cisco	0.0340	0.0053	6.437	232	<0.0001
lake chub	0.0039	0.0217	0.178	40	0.860
lake trout	0.0168	0.0044	3.838	192	0.000168
lake whitefish	0.0409	0.0073	5.586	202	<0.0001
longnose sucker	0.0285	0.0163	1.756	33	0.0884
ninespine stickleback	0.0923	0.0420	2.197	10	0.0527
pearl dace	0.0564	0.0572	0.986	8	0.3529
rainbow smelt	0.0430	0.0121	3.552	45	0.000911
spottail shiner	0.0135	0.0102	1.327	144	0.1865
trout-perch	0.0379	0.0094	4.050	122	<0.0001

Supplementary References

1. Sandstrom, S., Rawson, M. & Lester, N. Manual of instructions for broad-scale fish community monitoring using North American (NA1) and Ontario small mesh (ON2) gillnets. 35 p. + appendices (2013).

2. Dolson, R., McCann, K., Rooney, N. & Ridgway, M. Lake morphometry predicts the degree of habitat coupling by a mobile predator. *Oikos* **118,** 1230–1238 (2009).

3. Hasnain, S. S., Shuter, B. J. & Minns, C. K. Phylogeny influences the relationships linking key ecological thermal metrics for North American freshwater fish species. *Can. J. …* **972,** 964–972 (2013).