## Winter and summer bathymetric distribution and diet of benthic fishes in Grand Traverse Bay, Mich.

We set micro-mesh gill nets from December 2015 to August 2016 in Grand Traverse Bay and used a remotely operated vehicle to document distributions and diets of benthic fishes. Gill nets captured 1,952 fish of 19 species, with alewife *(Alosa pseudohargenus)* (29%), rainbow smelt *(Osmerus mordax)* (24%), and round gobies *(Neogobius melanstomous)* (17%) most abundant. Alewives migrated to depths of greater than 100 meters during winter and 20 meters during summer. Round gobies migrated to deep water by December, then to less than 20 meters during summer. The largest individuals led the migration.

Video showed round gobies composed 88 percent, alewife 6 percent, and deepwater sculpin *(Myoxocephalus thompsoni)* 7 percent of observations in 70–125 meters and 15, 73, and 12 percent, respectively in 166–191 meters. The proportion of round gobies increased with increasing quagga mussel densities, but maximum densities were observed around objects, such as trees. Many round gobies were found near dead fish, presumably for food and shelter (see photo). One deepwater sculpin guarding a nest was found on March 16, 2021, marking the first time this behavior was observed.




Presumed lake whitefish *(Coregonus clupeformis)* carcass surrounded by many round gobies, December 22, 2015, in 122 meters of water in the west arm of Grand Traverse Bay, Lake Michigan. Photo courtesy of Marine Technology/ Northwestern Michigan College.

Round goby winter diet was insects, fish, quagga mussels *(Dreissenia bugensis)*, and *Mysis*. Round gobies did not eat fish eggs or larvae. Predator winter diets included alewives, round gobies, and *Coregonus* spp. *Mysis* were most abundant on sand and occurred in schools. Quagga mussel densities were inversely related to depth, and they formed large, dense colonies (druses) in March not seen in December. Through this research, we elucidated a better understanding of the winter distribution and diet of benthic fishes and predators that may be used to monitor fish abundance and year-class strength.

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## Earlier winter-spring runoff leads to lower summer primary production in temperate lakes

Winter conditions are changing rapidly, and such changes have the potential to impact lake ecosystems across seasons. However, how these changes may play out on a global scale is difficult to quantify. Hydrologists have documented earlier runoff occurring in watersheds worldwide, but we do not fully understand the ecological impacts of earlier runoff on receiving bodies, such as lakes. A group of researchers from the Global Lakes Ecological Observatory Network (GLEON) explored how changes in spring runoff timing affected summer chlorophyll-a (a proxy for phytoplankton biomass). The study was published in the October issue of Global Change Biology.

We compiled long-term monitoring data sets from 41 temperate lakes across North America and Europe that included stream runoff measurements, summer chlorophyll-a, and several covariates. We found that years with earlier runoff had lower summer chlorophyll-a. Years with early runoff also tended to have more protracted runoff and lower runoff volume. Although early runoff correlated with early ice-out, ice-out timing was not related to summer chlorophyll-a. The result that lower summer productivity occurs with earlier runoff is likely linked to changes in nutrient input timing and availability. For example, lower-volume winter melting events that happen in early runoff years may contain nutrients that are quickly flushed out of a lake, taken up by heterotrophic bacteria, or taken up by sinking diatoms. In contrast, years with later runoff that occurs in a concentrated "spring flood" may be more available for entrainment in the upper water column, where they are available to summer phytoplankton. Our results suggest that winter conditions set the stage for open-water phytoplankton growth in lakes.



Early spring ice loss on Otsego Lake, New York. Photo by Kiyoko Yokota.

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