in the winter when ice and snow cover prevent photosynthesis. In Lake Erie, hypoxic conditions are common during the summer when stratification prevents adequate mixing in the hypolimnion. Summertime hypoxia in the central basin of Lake Erie is a well-documented and, likely, natural phenomenon. However, there is increasing evidence that the duration and severity of hypoxic conditions are exacerbated, at least in part, by anthropogenic factors such as the loading of nutrients from tributaries. In order to fully account for such anthropogenic contributions, baseline estimates of the spatial extent and severity of hypoxia are required. Here, we present preliminary results from a monitoring program designed to provide a high-resolution estimate of the spatial extent of hypoxia in central Lake Erie. During the summers of 2014 and 2015, we deployed an array of 25 dissolved oxygen loggers throughout the central basin of Lake Erie, with an emphasis on near shore areas. The logger network is spread out over an area greater than 7000 km^2 and collects data at 10 minute intervals. Our initial results indicate that the hypoxic zone is dynamic, particularly along its edge and that rapid intrusions of hypoxic water into near shore areas are common. The development of hypoxic conditions follows a consistent spatial pattern, forming first in nearshore areas in the highly populated southwest shoreline of the lake and extending offshore and along the north eastern shoreline throughout the summer. We conclude our analyses with a comparison of our estimates of the size of the hypoxic zone to previously published estimates based on measurements taken from EPA historical data and discuss the implications of dynamic hypoxia for Lake Erie's food webs.

41-O The off-shore shunt – the influence of top predators on nutrient and energy availability.

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Quantifying *in situ* nutrient and energy flows in spatially and temporally complex aquatic ecosystems represents a major ecological challenge. Food web structure, energy and nutrient budgets are difficult to measure, and it is becoming more important to quantify both energy and nutrient flow as food web processes and structure are modified by multiple stressors. We propose that polychlorinated biphenyl (PCB) congeners represent an ideal tracer to quantify *in situ* energy and nutrient flow between trophic levels. Here, we demonstrate how an understanding of PCB congener bioaccumulation dynamics provides multiple direct measurements of energy and nutrient flow in aquatic food webs. To demonstrate this novel approach, we quantified nitrogen (N), phosphorus (P) and caloric turnover rates for Lake Huron lake trout, and reveal how these processes are regulated by both growth rate and fish life history. Although minimal nutrient recycling was observed in young growing fish, slow growing, older lake trout (> 5 yr) recycled an average of 482 Tonnes·yr^{-1} of N, 45 Tonnes·yr^{-1} of P and assimilated 22 TJ yr^{-1} of energy. Compared to total P loading rates of 590 Tonnes·yr^{-1}, the recycling of primarily bioavailable nutrients by fish plays an important role regulating the nutrient states of oligotrophic lakes. We then further this concept using a non-steady state PCB bioaccumulation model to quantify nutrient and energy flows in both Pacific Salmon and Lake Trout under various warming scenarios to contrast the influence of life history traits and growth rates on nutrient and energy dynamics in Lake Huron and highlight how climate change might affect nutrient and energy availability within this system.
The results of this study demonstrate that Lake Trout are more effective at recycling nutrients and are critical for food web stability in these highly oligotrophic ecosystems, whereas Pacific salmon tend to act mostly as nutrient sinks. As fish reach their asymptotic length of the von Bertalanffy growth curve, the mass of nutrients they recycle increases. For Lake Trout, at approximately 5 years of age, their individual growth rates fall below 50% yr^{-1}, causing these upper age cohorts to become nutrient sources rather than sinks. Pacific Salmon, on the other hand, migrate to tributaries to spawn when individual growth rates decline below 50% yr^{-1} exporting significant masses of nutrients out of the lake. Given the differing life-spans, growth rates and reproductive strategies of Lake Trout relative to stocked Pacific salmonids in the Great Lakes, the results of this study demonstrate that Lake Trout provide a critical ecosystem service by effectively recycling nutrients to enhance food web stability in highly oligotrophic ecosystems.

41-O Fish and fisheries impacts on large lake ecosystems.

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From the early 2000s, two rather similar concepts - Ecosystem-Based Fisheries Management (EBFM) and Ecosystem Approach to Fisheries (EAF) have attracted increasing attention that is reflected in expanding publication/citation records. EBFM is a new direction for fishery management, essentially reversing the order of management priorities to start with the ecosystem rather than the target species with the overall objective to sustain healthy ecosystems and the fisheries they support. EAF strives to balance societal objectives by taking account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries. Despite the distinctions between ecosystem management and fisheries management, the two concepts are in large extent overlapping. Most examples of EFBM and EAF are still coming from marine fisheries as long-term data from freshwater fisheries are rare. Moreover, even in most recent papers only fish communities are typically considered under the term of the 'ecosystem' and indirect or cascading fisheries impacts on other food web components remain largely or completely unstudied.
Fisheries are ecosystem-scale ecological experiments providing opportunities to test ecological theory through large-scale, repeated, and well-documented perturbations of natural systems. While freshwater fisheries undoubtedly provide valuable ecosystem services which have been the subjects of extensive scientific investigations, in some situations they may also result in sustained negative impacts on other components of the aquatic environment and thus on the ecosystem services that they provide. EBFM aims at better incorporation of ecological theory into decision making as fisheries management can be improved through better understanding of the ecology of exploited ecosystems. The so-called 'fishing down' of predators may have cascading top down effects and can even shift entire ecosystems into alternate stable states.
In the present study we analyse 4 large lake case studies (Võrtsjärv, Geneva, Maggiore and Windermere) with available long-term data on lake ecosystem properties and services, including fish and fisheries information. The aim of our analysis is to assess the extent and strength of top-down cascading effects of fish and fisheries at the whole ecosystem level in these case study lakes.
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41-O Algal biomass is proportional to phosphorus in nitrogen limited lakes.

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Algal biomass in lakes and rivers is often limited by nutrient concentrations especially at biomass maxima; and high nutrient concentrations can lead to undesirable levels of algal growth. Therefore, the reduction of nutrient loads in freshwaters is advocated to reduce algal abundance. The occurrence of waters with low nitrogen to phosphorus ratios, compared with freshwater in other OECD countries, has encouraged the promotion of nitrogen reduction as a tool to reduce algal biomass in New Zealand lakes. However, long term observations in several large lakes considered to be nitrogen deficient have shown that algal biomass is more responsive to phosphorus than to nitrogen loading. Some of the largest lakes in New Zealand that were considered to be nitrogen limited, based on bioassay results, have had their nitrogen and phosphorus concentrations modified by changes in nitrogen and phosphorus loading over recent decades. The effect of nitrogen on algal biomass was less than the effect of phosphorus in these lakes. Our results question the efficacy of nutrient enrichment bioassay results to predict how lakes will respond to changes in nutrient loading and suggest that managing P loading should be the primary management strategy to control algal biomass in lakes.