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Variation in the essential fatty acids EPA and DHA in fillets of fish from the Great Lakes region

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ABSTRACT

This dataset represents the largest collection of fatty acid data from the Great Lakes region to date, summarizing concentrations of omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in fish sampled from the U.S. waters of all 5 Great Lakes and 92 U.S. lakes and rivers. Determining how freshwater fishes' fatty acid content varies across environmental gradients is important in understanding aquatic trophic interactions and to providing comprehensive fish consumption advice. However, there is currently a lack of information on variation in freshwater fish fatty acid content that may hinder human health and fisheries professionals tasked with establishing fish monitoring and analysis programs which capture this variability. To that end, fillet EPA + DHA concentrations were modeled over several biotic and abiotic gradients in order to constrain variability. Recommendations based on model results are then used to suggest starting points for planning future fish sampling efforts (e.g. inland walleye [EPA + DHA] varied with both length and waterbody eutrophication; these gradients should be incorporated into sampling efforts to capture walleye [EPA + DHA] variability). In terms of nutrition, Great Lakes species (all taxonomic families) and inland salmonid fillets contained a daily adequate intake (AI) level of ≥ 250 mg of EPA + DHA per 8-oz. (227 g) fillet, but other taxonomic families from inland waters generally did not. Very few species' fillets, regardless of sampling location or taxonomic family, contained the equivalent weekly AI level of 1750 mg EPA + DHA per 8-oz. fillet. The data presented here can inform both fish sampling efforts and fish consumption risk-benefit analyses.

Introduction

In recent years, the fatty acid content of freshwater fish has become an important topic among both human health professionals tasked with providing comprehensive fish consumption advice (Ginsberg et al., 2015; Neff et al., 2014; Oken et al., 2012) and fisheries professionals attempting to understand aquatic trophic interactions and fish physiology (Czesny et al., 2011; Daly et al., 2010; Makhutova et al., 2011). It is now understood that fatty acids, omega-3 fatty acids in particular, are essential components of animal cell membranes and contribute to ocular, neural, and cardiovascular health (Chowdhury et al., 2012; Innis, 2000; Joensen et al., 2010; Simopoulos, 2008). As such, deficits of essential fatty acids can cause adverse health outcomes in humans and fish alike (Henderson and Tocher, 1987; Kris-Etherton et al., 2009).

As more is understood about the functions of fatty acid nutrients, it is apparent that there are significant gaps in information on how the fatty acid content in freshwater fish may vary with environmental gradients. These may include, but are certainly not limited to, gradients in: geography, season, fish physiology, and waterbodies' physical or chemical attributes. Although some previous research has begun to document fatty acid variability, studies covering a large geographic range have generally surveyed fatty acid content in a small number of fish species (Blanchet et al., 2005; Pantazopoulos et al., 2013), while those covering a large number of fish species have focused on a limited geographic area (Cakmak et al., 2012; Chan et al., 1999; Neff et al., 2014; Williams et al., 2014). This lack of information on fatty acid variability often represents a significant obstacle to establishing well-planned fish monitoring and analysis programs, as current knowledge does not provide adequate

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information on how many samples, of what sizes of fish, from waterbodies with which characteristics, at what times of year, should be collected in order to create comprehensive datasets that sufficiently capture the variation in the fatty acid content of fish populations.

To that end, we present here a dataset containing the largest collection of fatty acid data from the Great Lakes to date, summarizing fatty acids in fillets from freshwater fish sampled from the U.S. waters of all 5 Great Lakes and 92 U.S. inland lakes and rivers in the Great Lakes region. These data were collected through Great Lakes Restoration Initiative funding to the States of Wisconsin and Minnesota, via the Great Lakes Consortium for Fish Consumption Advisories, and through the USEPA's 2010 Great Lakes Human Health Fish Tissue Study (GLHHFTS). Datasets were combined and analyzed to determine how freshwater fish species' fatty acid content varies across spatial, biological, physical, and chemical gradients. Model results are then used to recommend over which environmental gradients different fish species should be sampled. These recommendations will allow fisheries and human health professionals to efficiently plan future fish sampling efforts so that variability in fatty acid content is constrained. The model results may also provide a crucial building block for researchers investigating the complex role of fish consumption in humans' exposure to both omega-3 fatty acid nutrients and toxic chemicals by complimenting research into patterns in contaminant variability. Finally, fish fatty acid data collected as part of future sampling efforts following the recommendations presented here will help to further fill this important research gap.

Methods

The work presented here focuses on variability in concentrations of two long-chain polyunsaturated omega-3 fatty acids: eicosapentaenoic acid (EPA, C20:5 ω-3) and docosahexaenoic acid (DHA, C22:6 ω-3). Although samples were analyzed for more fatty acids than EPA and DHA, we focused on these two for several reasons, including the fact that EPA and DHA are widely acknowledged to be vital to human cardiac health, are relevant to studies of aquatic food chain length and fish physiology, and were measured in every sample by the laboratories whose data were combined for this report. Summary data (mean ± SE) on concentrations of analytes that were measured in fish samples but not discussed in this paper can be found in Electronic Supplementary material (ESM) Tables S1 and S2, while the full datasets can be accessed via program websites (details provided in ESM Tables S1 and S2).

Sample collection

This dataset represents 900 fillet samples from wild fish collected between 2010 and 2013. Approximately one third of the fish were collected from the Great Lakes, while the remaining two-thirds were collected from inland waterbodies within the Great Lakes states (Fig. 1). Samples were collected from 34 Minnesota lakes, 17 lakes and 1 river in Wisconsin, 2 Michigan lakes, 10 Ohio lakes, 9 Pennsylvania lakes, and 15 lakes and 2 rivers in New York (Fig. 1).

Fish were collected over many sampling events by state agencies and through the USEPA's 2010 GLHHFTS. Collections by state agencies were accomplished by fisheries surveys that focused on fish of consumable sizes caught using a variety of methods (i.e. electrofishing, netting, hook and line, etc.; Bonar et al., 2009). Whole fish were wrapped in foil and labeled, then stored at −20 °C. After storage, thawed fish were weighed and filleted in a manner representing the way people most often prepare them (i.e. scaled skin-on for most species, skin-on for salmonids, skin-off for catfish), according to the methods specified in the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (Anderson et al., 1993). Prepared fillets were then homogenized using a meat grinder, and tissue was re-frozen in sample jars until analysis.

For the GLHHFTS, field teams used both active (i.e., hook and line) and passive (i.e., gillnetting) methods at 157 sampling sites, targeting a composite of 5 adult fish of the same species and similar size at each location. Composites containing fewer than 5 fish were accepted in an effort to retain a sample from each site. Whole fish were shipped on dry ice to a designated sample preparation laboratory for storage and preparation prior to analysis for a wide range of contaminants, as well as fatty acids. Fish were scaled and filleted in the laboratory where

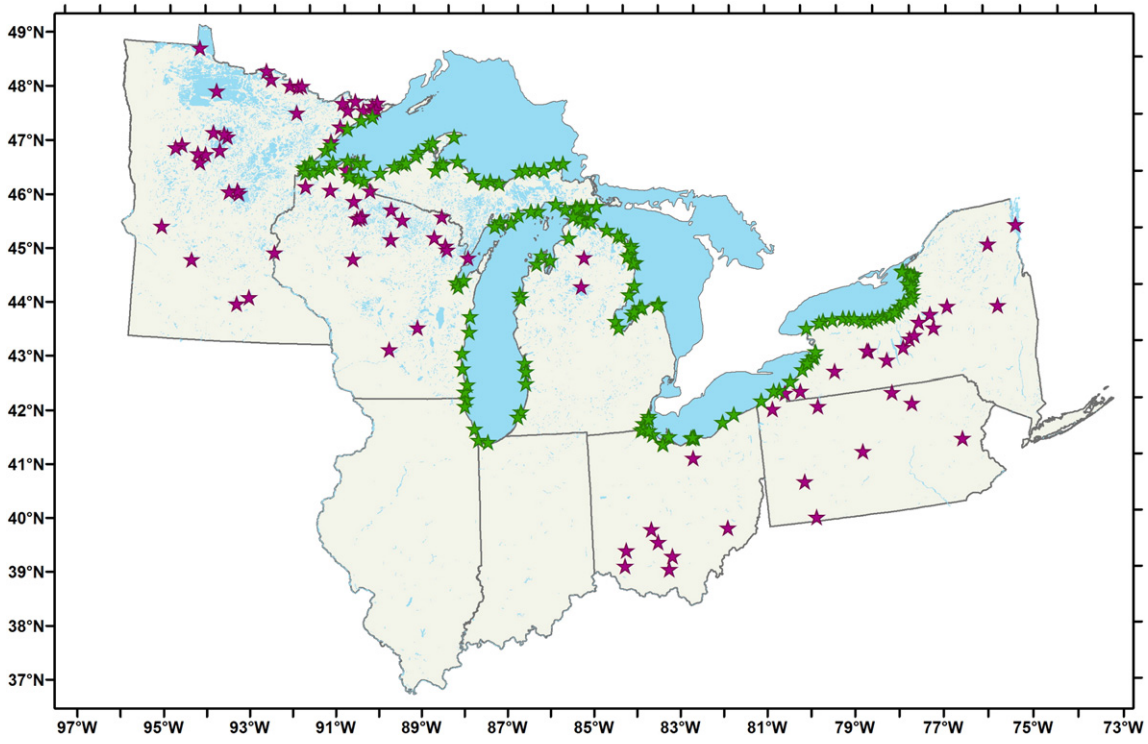

Fig. 1. Locations from which fish were sampled for fatty acid analysis. Green stars indicate Great Lakes sampling locations; purple stars indicate inland sampling locations.