****ABSTRACT NOT FOR CITATION WITHOUT AUTHOR PERMISSION.** The title, authors, and abstract for this completion report are provided below. For a copy of the full completion report, please contact the author via e-mail at marten.koops@dfo-mpo.gc.ca. Questions? Contact the GLFC via email at frp@glfc.org.

Implications of Phosphorus Reduction for Sustainable Great Lakes Fisheries

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ABSTRACT:

The *Great Lakes Water Quality Agreement* (GLWQA) has been successful in reducing total phosphorus (TP) loadings and concentrations, thereby initiating an oligotrophication process across the Great Lakes. Emerging evidence suggests that the Great Lakes have experienced both an 'offshore desertification', whereby low ambient TP concentrations undermine pelagic ecosystem integrity, while some nearshore areas experience blooms of toxic blue-green algae from excess nutrients. TP is a determinant of ecosystem productivity related to observed biomass at all trophic levels and has been recognized as a predictor of fish biomass and production for decades. However, TP reductions have not occurred in isolation; a number of anthropogenic stressors may have affected the energy dynamics that determine how TP is converted into fish biomass. One important stressor is the invasion of dreissenid mussels that have engineered changes in nutrient cycling and lake productivity and have affected many components of the food web including the production of fish. We described the phosphorus to fishes (P2F) relationship across multiple habitats in the Great Lakes basin to examine the form of the P2F relationships, how it is affected by the addition of stressors, and resulting predictions of fish biomass responses to TP reductions. We compiled data on TP concentrations from water quality monitoring programs, fish biomass from fish community monitoring surveys, and food web components from ecosystem monitoring programs. We applied two modelling approaches: a statistical approach to empirically describe the P2F relationship, and a food web modelling approach to mechanistically predict the P2F relationship. Both modelling approaches described curvilinear P2F relationships, with the strongest effects of TP on fish biomass in more oligotrophic habitats. The presence of dreissenid mussels had the greatest effect on the P2F relationship in oligotrophic habitats, reducing the efficiency of food webs to convert TP into biomass. The addition of fish harvest did not change the P2F relationship in lakes Michigan or Ontario, but increased harvest did result in reduced biomass of harvested species and changes to the P2F relationship in Lake Erie. Reducing TP is predicted to reduce the biomass of most food web groups, with predicted total fish biomass reductions of 16-36% in

Lake Erie from a 40% TP reduction, though individual fish functional groups or species may exhibit greater reductions. Given current TP concentrations in many Great Lakes habitats, these models predict stronger reductions in fish biomass from additional TP reductions now than were experienced in the past when TP concentrations were higher.