Annotated Bibliography:
The Great Lakes Fisheries and Ecosystem Services Valuation Virtual Workshop

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Great Lakes Recreational Fisheries: Non-market Valuation Studies

In this section, we provide a bibliography of non-market valuation studies of recreational fishing in the Great Lakes. Methodologies employed are the travel-cost method, stated preference methodologies (such as contingent valuation), and benefits-transfer methodologies. We do not include papers from the vast literature on methodology but see Johnston (2017) for overviews of stated preference methodology and Parsons (2017) for travel cost methodology. There are undoubtedly relevant papers that we have missed; however, the objective is to provide a good, reasonably complete, overview of literature to get a sense of the direction research has taken in recent decades.

In addition to an annotated bibliography, we provide a very brief overview of the literature. A good way to do this is to start with the review paper by Poe et al (2013). We have not duplicated in our bibliography most of the papers covered in that review but do include a small number that stand out.

Poe et al (2013), hereafter Poe, is the most comprehensive review paper on non-market valuation of recreational fisheries in the Great Lakes. Note, however, that Melstrom and Lupi (2013) also provide a brief review of the literature and only a subset of the papers reviewed are common to both papers. Poe state that their main purpose is to (1) assess whether there is sufficient knowledge to estimate the current value of recreational fishing in the Great Lakes basin and (2) how that value might change with the introduction of aquatic nuisance species. They conclude that the evidence is sufficient to achieve the first but not the second objective.

With respect to the first objective, we reproduce the table from Poe that summarizes estimates from the literature on estimated non-market valuation of recreational fishing trips. It is important to keep in mind that whenever one speaks of the value of a fishing day in the Great Lakes, any point estimate will mask an enormous amount of underlying variability due to the well-known finding that values vary by target species and location especially, but are also affected by other characteristics such as catch rates, proximity to urban centres, the presence of amenities, aesthetic values, availability of subsititute sites and so on. Nevertheless, Poe concludes that there is sufficient evidence to indicate that estimates generally range from $20 to $75 per day ($2012 dollars)[1]. (about $22.8 - $85.5 in $2021 using US CPI index for the midwest). Poe combines these estimates with an estimate of the total participation in recreational fishing to generate an estimated aggregate value from recreational fishing in the Great Lakes of $393 million to $1.47 billion per year ($2012). (about $448M - $1.68 billion in $2021). To relate this to the often-cited figure of $7 billion (from the American Sport Fishery Association), see the section on Economic Impact Studies.

[1] The authors drop 3 estimates that were above $75 but which they regarded as outliers

Several studies have attempted to estimate the impact that changes in fishing quality (eg catch rates) would have on estimated recreational values. For example, Lupi et al (2000) link estimated values in Lake Michigan to fishing characteristics, especially catch rates. This type of model has been the basis for a number of other papers that estimate the impacts of management actions on the value of recreational fishing. For example, Kotchen et al (2006) estimate the potential benefits of the increased catch rates in Lake Michigan that would result from changing two hydroelectric dams on a feeder river from peaking to run-of-river flows. Lupi et al (2003) estimate the benefits that accrue to recreational anglers as a result of sea lamprey control. Nevertheless, Poe conclude that the available studies do not provide a broad enough basis for calculating economic losses associated with potential declines in catch rates as may be caused by an aquatic nuisance species. They therefore identify a gap in knowledge with respect to achieving their second objective.

Many authors have emphasized that estimated values such as those reproduced in Table 1 represent "all-or-nothing" values, which are rarely relevant for policy or management purposes. More relevant is an understanding of how the value of recreational fishing would change as a result of a management action that had an impact on fishing characteristics such as catch rate, subsitute site availability, amentities and aesthetic qualities and so on.

Since the publication of the Poe et al (2013) review paper, we have been able to find only four papers directly related to the non-market valuation of recreational fisheries in the Great Lakes specifically: Melstrom and Lupi (2013), (good updates to the literature summarized in Poe), Wolf et al (2017), Zhang et al (2018), (these two attempt to estimate anglers' willingness-to-pay for reduction of harmful algal blooms (HABs) at fishing sites), and Hunt et al (2021), (estimating how transitioning to different sport fish availability affects anglers' valuations).

It is worth noting that there is also an extensive literature on the question of what characteristics influence the demand for fishing: specifically, what characteristics affect recreational fishers' choices of where, when and for what to fish. See Hunt (2019) for a review. We include a couple of these papers in this section because estimating the "demand" for recreational fishing is the foundation of value estimation. As such, this literature is closely related to the valuation literature.

Table Reproduced from Poe (2013)

Valuation Method	Estimated Net Value/Day ($2012)	Fish Category	Location	Reference
Average Benefits Transfer	45	Cold water fish	GL & Northeast	Loomis and Richardson (2008)
Average Benefits Transfer	48	Warm water fish	GL & Northeast	Loomis and Richardson (2008)
Average Benefits Transfer	44	Anadromous runs	GL & Northeast	Loomis and Richardson (2008)
Average Benefits Transfer	23	Mixed species	GL & Northeast	Loomis and Richardson (2008)
Average Benefits Transfer	56	Not specified	GL & Northeast	Loomis and Richardson (2008)
Transfer/Meta Analysis	45-54	General	GL & Northeast	Rosenberger and Loomis (2001)
Travel Cost	41	Trout	Michigan GL	Lupi & Hoehn (1997)
Travel Cost	51	Salmon	Michigan GL	Lupi & Hoehn (1997)
Travel Cost	42	Salmon &/or trout	Wisconsin, Southern L. Michigan	Phaneuf et al (1998)
Travel Cost	42-55	Anadromous runs	L. Erie tributaries	Kelch et al (2006)
Travel Cost	33-34	General	New York inland & GL	Spink (2014)
Contingent Valuation	54	Yellow perch	Green Bay	Bishop et al (1990)
Contingent Valuation	25	General	New York GL	Connelly & Brown (1991)
Contingent Valuation	28	General	New York Inland	Connelly & Brown (1991)
Contingent Valuation	41	Salmon & trout	Wisconsin GL	Lyke (1993)
Contingent Valuation	22	General	New York GL	Connelly et al (1997a)
Contingent Valuation	22	General	New York inland	Connelly et al (1997a)
Contingent Valuation	50 (IA), 50 (IL), 69 (IN)	Bass	Selected GL states	Aiken (2009)
Contingent Valuation	48 (PA), 53 (NY)	Trout	Selected GL states	Aiken (2009); Harris (2010)
Contingent Valuation	49 (MI), 68 (MN), 74 (OH)	Walleye	Selected GL states	Aiken (2009)

Note: * denotes reference is included in Poe survey. Also note that we have not reproduced the majority of papers reviewed in the Poe survey.

Bishop, R., et al. (1987). "**Toward Total Economic Valuation of Great Lakes Fishery Resources**." Transactions of the American Fisheries Society.

Instead of estimating the use-value of sport and commercial fishing (which is what all other valuation papers do in this bibliography), they estimate the indirect (existence) value of striped shiners (an endangered species resident in a tributary of Lake Michigan) to Wisconsin taxpayers ($12M per year).

Glass, R. and R. Muth (1987). "**Pitfalls and Limitations in the Use of Fishery Valuation Techniques**." Transactions of the American Fisheries Society **116**: 381-389.

This paper provides a bit of a primer on basic economic concepts and a warning about some of the pitfalls of trying to measure consumers' surplus and apply it to decision making.

Hunt, L., et al. (2007). "**Predicting Fishing Participation and Site Choice While Accounting for Spatial Substitution, Trip Timing, and Trip Context**." North American Journal of Fisheries Management: 832-847.

Developed choice models to understand and predict the amount, timing, and locations of recreational fishing trips in northwestern Ontario. As an example of how fishery managers could use this information, they simulated the restoration of walleyes in a large water body. The forecasts suggested that the effect of this on fishing effort at other waters was influcenced by spatial proximity and temporal use at the fishing sites.

Hunt, L. M., et al. (2019). "**Catch and Non-catch-related Determinants of Where Anglers Fish: A Review of Three Decades of Site Choice Research in Recreational Fisheries**." Reviews in Fisheries Science & Aquaculture **27**(3): 261-286.

This is a literature related to the valuation literature in the sense that it attempts to estimate the factors influencing the demand for recreational fisheries. This paper provides a review of 30 years of papers in site choice by anglers.

Hunt, L., et al. (2021). "**Per trip changes to the economic value of Ontario, Canada anglers fishing the Laurentian Great Lakes under target species transitions**." Human Dimensions of Wildlife **26**(2).

Changing fish communities in the Laurentian Great Lakes could substantially affect how anglers value fishing trips. Using responses from licensed Ontario, Canada anglers to potential fishing trip options, we estimated changes to per-trip values for transitioning from a walleye (Sander vitreus) to a bass (Micropterus spp.) fishery, and from a Chinook Salmon (Oncorynchus tshawytscha) to a lake trout (Salvelinus namaycush) fishery. These walleye and salmon transitions, respectively, were estimated to produce large per-trip losses for active ($64 and $35 CAD 2017) and potentially large losses for non-active but interested Great Lakes anglers ($29 and $34). These aggregate estimates masked significant differences among anglers. For example, a class of more-specialized, active

anglers would lose more from walleye ($102) and from salmon ($46) transitions than would less specialized anglers ($19 and $2, respectively). These results confirm that fish community changes can strongly affect economic values among active and potential Great Lakes anglers.

*Hushak, L., et al. (1988). "**Economic Value of Great Lakes Sportfishing: The Case of Private-Boat Fishing in Ohio's Lake Erie**." Transactions of the American Fisheries Society **117**: 363-373.

Note: an earlier unpublished version is included in the Poe et al (2013) review. This is an early travel cost demand study of the valuation by private boater fishers of walleye, yellow perch, and bass in Lake Erie. Illustrates the sensitivity of travel-cost estimates to assumptions about the opportunity cost of time.

Kotchen, M. J., et al. (2006). " **Environmental Constraints on Hydropower: An Ex Post benefit-Cost Analysis of Dam Relicensing in Michigan**." Land Economics **82**(3): 384-403.

As part of the benefit cost analysis, measure the benefits of improved recreational fishing. Switching from peaking to run-of-river modes on river dam is estimated to increase river-based reproduction and therefore catch rates in Lake Michigan. Use Lupi et al (2000) angler demand model to estimate the welfare effect.

*Lupi, F. and J. P. Hoehn (1997). **Recreational fishing use-values for Michigan's Great Lake trout and salmon fisheries**. Unpublished Manuscript.

Although this paper is included in Poe et al (2013) survey, we include it separately in our bibliography because it is has an excellent discussion of the usefulness of valuation/demand studies: for example, they suggest that resource managers may want to know if investments in the fisheries are targeted at the best angling activities, sites, and species. Coastal development agencies and businesses may be interested in how changes in site facilities will affect the number of anglers who visit. Environmental managers may want to know the economic losses associated with contamination at a given site. These types of questions cannot be addressed by economic impact studies. They require insight into the economic demands of anglers. But the authors also point out that even having a good measure of non-market value does not help answer these questions. What is needed is an understanding of how the economic value of the resource changes with and without some management action or policy decision (and how value may be affected by ecosystem improvements or impairments). By linking demand (via travel cost) to the quality of fishing sites, these models can then be used to estimate changes in economic value associated with changes in quality.

As is common, the authors emply a random utility model with various site choices but also describe sites by catch rates, and differentiate trips by duration, water body and target species.

Among the many results, they found that salmonids were about 2 to 3 times (or more) as valuable as lake trout, and that there is substitution between species and sites when

site- or species-specific catch rates change. For example, trips targeting the Great Lakes warm fishery decrease by 5% when the catch rate of Great Lakes cold fishery rises by 50%.

*Lupi, F., et al. (2003). "**Using an economic model of recreational fishing to evaluate the benefits of sea lamprey (petromyzon marinus) control on the St Marys River**." Journal of Great Lakes Research **29**: 742-754.

Covered in the Poe et al (2013) survey but included separately here as a good example of how to link an economic model of recreational fishing to fish population size in the Great Lakes, in this case to illustrate how to estimate the benefits that accrue to anglers from sea lamprey control.

*Lupi, F., et al. (2000). **The Michigan Recreational Angling Demand Model**. Proceedings of the International Institute of Fisheries Economics and Trade, Corvalis, Ore.

This paper reports on a large-scale demand model for recreational fishing in Michigan. The model distinguishes among a broad range of fishing trip types including trips of different lengths, for different species, to Great Lakes, inland lakes, and inland streams. For Great Lakes fishing, anglers' site choices are related to catch rates which vary spatially and temporally.

Melstrom, R. T. and F. Lupi (2013). " **Valuing Recreational Fishing in the Great Lakes**." North American Journal of Fisheries Management **33**: 1184-1193.

A recreational fishing demand model for recreational fishing in lake Michigan. Results indicate that anglers tend to substitute more readily between sites within a lake than between lakes, and that catch rate is the most important determinant of site choice. They find that willingness to pay is highest for Chinook Salmon, Coho Salmon, steelhead and walleye (in that order). Day trips to a typical site in a lake worth about $30 per trip in 2009$. They also estimate willingness to pay to avoid loss of access to an entire lake and this of course is much higher (than to an individual site within a lake); eg $144 per trip for Lake Michigan but only $37 for Lake Erie.

Overall, the advantage of this type of demand model is that the results can be used to simulate the welfare effects of reduced catch rates at any particular location or for any particular species included in the study.

The paper also reminded us that as the population of anglers continues to age and generally decline in number, studies that utilize older data may diminish in relevance, so important to have periodic studies (something we have not seen).

*Milliman, S. R., et al. (1992). "**The Bioeconomics of Resource Rehabilitation: A Commercial-Sport Analysis for a Great Lakes fishery**." Land Economics **68**(2).

This is a bioeconomic model that has a fairly complex biological growth model for perch in Green Bay linked to an economic model of the value to commercial fishing vs the valuation by recreational anglers (based on contingent valuation estimates). The objective is to find optimal harvest strategies for the two types of anglers (so not a valuation paper *per se*).

Poe, G. L., et al. (2013). **Net Benefits of Recreational Fishing in the Great Lakes Basin: A Review of the Literature**. HDRU Series No 13-10. Cornell University.

Ready, R., et al. (2012). Net benefits of recreational fishing in the Great Lakes, Upper Mississippi River, and Ohio River Basins.

The average net value per angler day, estimated from Cornell University's recreational fishing travel-cost model, was $19.52. The aggregate net value of recreational fishing in those portions of the Great Lakes basin below barriers impassable to fish is estimated to be $1.228 billion for calendar year 2011. The corresponding aggregate net value of recreational fishing in those portions of the Upper Mississippi and Ohio River basins below barriers impassable to fish is estimated to be $1.124 billion. Although CU was originally tasked with estimating the impacts of ANS on the net value of recreational fishing, USACE was not able to obtain sufficient information to quantify the timing or magnitude of impacts of ANS on sportfish populations in the Great Lakes, Upper Mississippi River, and Ohio River Basins. Consequently, this report serves as an indicator of the net value of recreational fishing that could be impacted in the future without-project (FWOP) condition – the case where no Federal action is taken to prevent the transfer of ANS between the Great Lakes and Mississippi River Basins.

Samples, K. C. and R. Bishop (1982). "**An Economic Analysis of Integrated Fisheries Management: The Case of the Lake Michigan Alewife and Salmonid Fisheries**." Journal of Great Lakes Research **8**(4).

A bioeconomic model about finding the determinants of optimal harvesting strategies when two species are inter-related; i.e one is the prey of the other and both can be harvested. (Not a valuation paper *per se*)

*Talhelm, D. R. (1988). **Economics of Great Lakes fisheries: A 1985 assessment**, Technical Report No 54. Ann Arbor, MI, Great Lakes Fisheries Commission.

This is one of the earliest and best papers in this literature that provided good guidance for the literature that followed. In addition to a discussion of valuation methods, the author argues that, in principle, each management instance must be evaluated individually because each achieves different outcomes that have different values. However, he acknowledges that this will not always be practical so suggests some rules of thumb that might be useful. He says, for example, studies suggest that values of angling for Great Lakes salmonids per increment in angler day are in the $20 to $40 range (in $1985); for non-salmonids, $12 to $15; these values depend on proximity to population centers and are site specific (and are based on pre-1985 literature).

Wolf, D., et al. (2017). **Reeling in the Damages: Harmful Algal Blooms' Impact on Lake Erie's Recreational Fishing Industry**. 2017 Agricultural and Applied Economics Association Annual Meeting. Chicago, IL.

Used a variation of the hedonic valuation approach by using data on variation in fishing permit sales over time and space as HABs severity varied, for Ohio anglers, to infer willingness to pay for HABs reduction.

Zhang, W. and B. Sohngen (2018). "**Do U.S. Anglers Care about Harmful Algal Blooms? A Discrete Choice Experiment on Lake Erie Recreational Anglers**." American Journal of Agricultural Economics **100**(3).

Provide estimates of willingness to pay for HABs reduction by Lake Erie anglers who live in Ohio. The authors used a stated preference methodology (dichotomous choice survey) and found that anglers are willing to pay in the range of an additional $40 to $60 per trip for a policy that reduces HABs by cutting upstream phosphorous loadings by 40%.

Great Lakes Recreational Fisheries: Economic Impact Studies

We include a selection of economic impact studies of recreational fisheries in the Great Lakes. Methodologies vary somewhat but generally involve taking stock of total expenditures by anglers, which lead to local income and employment (direct effects), and then applying multipliers (usually calculated using an input-output model) to estimate the income and employment effects in related industries (indirect effects) and the resulting impacts of the spending within the region of the income generated from the direct and indirect effects (induced effects).

American Sportfishing Association (2020). "**Economic impacts of recreational fishing**." from https://asafishing.org/economic-impacts-of-recreational-fishing/.

High-level data on employment, expenditure etc by region throughout US.

Brown, T. L. and N. Connelly (2009). **Lake Ontario Sportfishing: Trends, Analysis, and Outlook**. HDRU Series No 09-3. Cornell University.

Based on a survey of over 20,000 respondents to understand the economic importance of recreational fishing to U.S. Lake Ontario communities. In 2007, it was estimated that "tourist" anglers (those living outside the county bordering Lake Ontario where they fished) fished 811,416 days and spent $43 million in local communities. This translated into an economic impact of $60 million and 1,032 jobs.

In addition, a regression analysis of the determinants of participation forecasts a decline in the number of fishing trips to Lake Ontario in the short-term (next five years). This

was attributed primarily to the novelty of Great Lakes salmonid fishing continuing to wear off and the declining interest in fishing and outdoor recreation seen nationally.

Graefe, A. R., et al. (2018). **Assessing the Economic Impact and Significance of Recreational Angling on Lake Erie Waters: Final Report**, Dept of Recreation, Park and Tourism Managemen, The Pennsylvania State University.

The study consisted of both on-line surveys and in-person interviews of recreational anglers fishing in the Pennsylvania section of Lake Erie. Contains rich data about expenditures and reasons for fishing. Estimates economic impact in terms of activity and jobs supported.

Martin, L. (1987). "**Economic Impact Analysis of a Sport Fishery on Lake Ontario: An Appraisal of Method**." Transactions of the American Fisheries Society **116**: 461-468.

This is an economic impact study of sportfishing in the Bay of Quinte. Martin argues that a good economic impact analysis can assist local policy makers to formulate appropriate regional development strategies. Could tell you where your visitors are coming from, so where to advertise, what they like to spend their money on so what parts of your region to develop further and so on.

NOAA. "**Socioeconomics**." from https://www.fisheries.noaa.gov/topic/socioeconomics#recreational-fisheries-economics.

This reference does not contain information about the Great Lakes *per se* but it serves as a model for what could be a useful exercise for the Great Lakes. The stated mandate of this branch of NOAA is to interpret the economic impacts of recreational fisheries and estimate the benefits of those fisheries. They collect economic data, develop economic models, and conduct analyses. This research also helps us understand and predict the behavior of those that participate in recreational fisheries and the possible effects different management actions might have on recreational fisheries.

Poe, G. L., et al. (2013). **Net Benefits of Recreational Fishing in the Great Lakes Basin: A Review of the Literature**. HDRU Series No 13-10. Cornell University.

This review paper (summarized in greater detail in the previous section) does not include economic impact studies but it does offer a comment on the often-cited reference that the Great Lakes recreational fishery is worth $7 billion in economic activity. The authors say that the figure comes from an American Sport Fisheries Association study in 2008 that uses a fairly large mulitplier (2.4). Multipliers in the range of 1.5 to 2.5 are common, depending on the size of the region.

The authors point out that is important not to misinterpret estimates of economic impact as benefits. They cite a Congressional Research Service report: "… Measures of economic activity such as the $7 billion … cannot be used to estimate changes in social

welfare, to assess trade-offs among public policy alternatives, or to conduct benefit-cost analysis…"

Propst, D. and D. Gavrilis (1987). "**Role of Economic Impact Assessment Procedures in Recreational Fisheries Management**." Transactions of the American Fisheries Society **116**: 450-460.

Offers an explanation of the difererence and relationship between economic impact analysis and benefit cost analysis

Southwick Associates (2019). **Economic Contributions of Recreational Fishing Within U.S. States and Congressional Districts**.

Recreational angling constitutes one of the largest components of outdoor recreation in the U.S., having generated over $49 billion in retail sales in 2016 (USFWS, 2016), and contributed $125 billion to the national economy (ASA, 2018). At the state level, anglers spent $41.8 billion within the states where they live and $7.9 billion beyond the borders of their home state. The spending by residents supported 802 thousand jobs worth $38 billion in wages and income. These economic effects are also important at smaller scales. In this study we estimate the contributions that anglers make to their respective state economies based on their residence in each of the 435 U.S. congressional districts.

Great Lakes Recreational Fisheries: Other Socioeconomic Studies

Berkes, F. and D. Pocock (1987). "**Quota Management and "People Problems": A Case History of Canadian Lake Erie Fisheries**." Transactions of the American Fisheries Society **16**: 492-502.

Analyzes the introduction of a quota system in Lake Erie by DFO in 1984. Points out the equity/conflict problems that arose. Points out that when introducing new policies like this, important to have good baseline biological and statistical data, and suitable socioeconomic and cultural information on fishermen; also need to take into account any existing self-regulation

Brown, T. (1987). "**Typology of Human Dimensions Information Needed for Great Lakes Sport-Fisheries Management**." Transactions of the American Fisheries Society **116**: 320-324.

Discusses the origins of the "human dimensions" concept. Argues that historically, this was not regarded as an important input in fisheries management. Instead, fisheries managers clung to the notion that biological assessments should dictate resource decision making, even though they are managing the resource for people. (Keep in mind this is a 1987 paper). The authors say that economics as a discipline was kept separate from human dimensions research, which was meant to incorporate research from the other social sciences.

These authors also comment on economic impact versus economic valuation. They argue that fisheries administrators have been inclined to use data in a persuasive mode (to argue for more resoures) - and expenditure or impact data are readily available for this purpose - whereas economists tend to use data in a decision-making mode, and valuation estimates - which are not readily available but must be esimated - are appropriate for this purpose.

Brown, T. L., et al. (1991). "**Lake Ontario's Sport Fisheries: Socioeconomic Research Progress and Needs**." Canadian J of Fisheries Aquatics and science 48.

This paper provides a good historical discussion of expenditures and fishing effort and a good description of survey sources. It argues that not enough attention has been devoted to estimating the economic value of Lake Ontario fishing to anglers themselves and that such studies are important to understanding both the overall magnitude of value and the value of particular types of fishing experience (such as particular species, tributary vs open-lake boat fishing). Knowledge of these values is important for evaluating policies and projects affecting alternative uses of fisheries resources.

The paper adds that we have a good base of economic impact data for Lake Ontario fishing, but little information to assess the true impacts of environmental changes or changes in fisheries policies. For example, what impact would contaminants have on fishing effort, the reduction in values to anglers, and the resulting loss of revenues and employment. There is also little known about non-use values (existences and option value) of fresh water ecosystems.

Burkett, E. and R. L. Winkler (2017). **Recreational Fishing in Wisconsin: Demographic Analysis Using an Age-Period-Cohort Approach to Understand Angler Participation**. Houghton, MI.

In order to understand change in Wisconsin's anglers over time, researchers at Michigan Technological University partnered with the Great Lakes Fishery Commission and the Wisconsin Department of Nat- ural Resources to analyze demographic patterns in the fishing population and to use those results to project future numbers of anglers in Wisconsin. We used an Age-Period-Cohort regression model to analyze 15 years of Wisconsin resident fishing license sales data from 2000 to 2014. We specifical- ly looked at differences by gender, age, and birth cohort among both total anglers and more specifi- cally at Great Lakes salmon/trout anglers. The results show that age, time period, and cohort effects all impact general fishing participation among males and females, with age and cohort effects having the greatest impact

Burkett, E. M. and R. L. Winkler (2018). **Recreational fishing in Illinois: demographic analysis: using an age-period cohort approach to understand fishing participation**. Michigan Technological University. Houghton, MI.

Contains good demographic information and projections into the future.

Canada (2015). " **Survey of Recreational Fishing in Canada**." Retrieved February 25, 2021, from https://www.dfo-mpo.gc.ca/stats/rec/can/2015/index-eng.html.

Contains detailed demographic and catch data on the Canadian side. Shows the declining number of anglers.

Connelly, N. and T. Brown (2010). "**Sportfishing Participation on Lake Ontario: Modeling the Past, Predicting the Future**." North American Journal of Fisheries Management **30**: 821-830.

Contains an informative history of stocking, sea lamprey eel control and other management actions and shows the declining participation in recreational fishing over a couple of decades. Used a regression model to evaluate the extent to which biological factors, socioeconomic factors, and management actions have influenced recreational fishing participation rates New York's Lake Ontario between 1967 and 2006. Among other things, found that number of Pacific salmon stocked is positively correlated with number of trips; black bass caught is positively correlated but not significant. Overall, time seems to be the most important explanatory variable.

Connelly, N. and T. Brown (2010). "**Assessing the Economic Importance of Recreational Fishing for Communities Along Lake Ontario**." Tourism in Marine Science **6**(2-3).

This appears to be the published version of Brown and Connelly (2009)

Eschenroder, R. (1987). "**Socioeconomic Aspects of Lake Trout Rehabilitation in the Great Lakes**." Transactions of the American Fisheries Society

This short paper describes how the Lake Trout commercial fishery was productive in the early part of 20th C prior to the introduction of the sea lamprey, and how the species was nearly eradicated by a combination of overfishing and sea lamprey. Sea lamprey control followed by stocking of Lake Trout was meant to bring back the populations but, as of the publication date of this article, was not broadly successful. However it was successful enough In some of the Great Lakes that conflict arose between the commercial and sport fishers for this species; managers allocated most of the catch to sport, believing it to be of the higher economic value. The paper advocates for greater consultation and greater input of socioeconomics into decision-making. It concludes that a major problem will be how to determine public values and interests and how to translate such information into management practice that is ecologically and economically rational.

Gregory, R. (1987). "**Nonmonetary Measures of Nonmarket Fishery Resource Benefits**." Transactions of the American Fisheries Society **116**: 374-380.

This paper's objective is to present a framework to facilitate the comparison of four different nonmonetary valuation approaches: measures of social well-being; psychophysical measures; attitude measures; and multiattribute choice measures

Heck, N., et al. (2016). "**Human dimensions information needs of fishery managers in the Laurentian Great Lakes**." Journal of Great Lakes Research.

The authors argue that information on the human dimensions (HD) of fisheries is essential to manage fisheries. Managers now need to consider not only the fish resource but also the people using it and must confront the inherent unpredictability of

human behaviour in addition to the unpredictability of the fishery resource itself. Management success or failure will be determined as much by social and institutional factors as by ecological factors. Understanding stakeholder perceptions, beliefs and attitudes can help managers develop relevant managment practices, identify and reduce conflicts among user groups and understand attitudes and reactions of management actions and regulations.

Conducted a survey of fishery managers that reveals what they are most concerned about. The top three concerns are: 1) declining agency funding. 2) declining users and license sales, 3) user conflicts. The survey also revealed that managers want to understand what are the factors that influence anglers' decisions to use the resource. For example, managers would like to know more about angler behaviour in terms of when, how many hours, where, targeted species, about the demographic make up and so on so they can allocate their management resources to address these needs. We add that many of these questions can be answered by the approaches covered in many of the papers listed in the bibliography on non-market valuation.

In conclusion, the authors argue that fishery managers want information on the economic value of the fisheries to demonstrate the importance of the sector to policy makers. They also correctly point out that economic impact studies contribute to this objective by demonstrating how the fishery affects local communities that provide supplies and accommodation to anglers. Moreover, they add that it is time that fisheries management move beyond the resource and the fishing community; it must also recognize ecosystem services such as improved water quality, biodiversity, and aesthetic values of the fisheries; such information would indicate the contribution of fishery management to society beyond the fishing community and produce a broader accounting of the value of fisheries.

Hunt, L. M., et al. (2013). "**Illustrating the critical role of human dimensions research for understanding and managing recreational fisheries within a social-ecological system framework**." Fisheries Management & Ecology **20**(2/3): 111-124.

"Effective management of recreational fishing requires understanding fishers and their actions. These actions constitute critical links between social and ecological systems that result in outcomes that feedback and influence recreational fishers' actions and the management of these actions. Although much research exists on recreational fishers and their actions, this research is often disconnected from management issues. One way to help to overcome this disconnect is to illustrate how past research on the social component of recreational fishing fits within an emerging coupled social-ecological system (SES) framework. Herein, a conceptual SES is first developed with specific attention to recreational fisheries. This SES is then used to illustrate the importance of considering human dimensions research for articulating, studying and ultimately managing key outcomes of recreational fisheries (e.g. fish population conservation, fisher well-being) using the example of harvest regulations and a brief review of past

interdisciplinary research on recreational fishing. The article ends by identifying key research needs including understanding: how factors such as management rules affect the diversity of actions by recreational fishers; how governance and management approaches adapt to changing social and resource conditions; and how recreational fishers learn and share information."

Knuth, B. A., et al. (1995). "**Fishery and environmental managers' attitudes about and support for lake trout rehabilitation**." Journal of Great Lakes Research **21**(1).

The authors surveyed fisheries and environmental managers about their attitudes towards a lake trout rehabilitation program. They organized responses according to type of manager (eg local vs federal) and got some interesting results; eg, local managers care more about anglers and economic benefits than federal managers; environmental managers placed higher priority on re-establishing native species and less priority on anglers values.

Lower, E., et al. (2020). 2019 update to "**Update To An Impact Assessment of Great Lakes Aquatic Nonindigenous Species**". Ann Arbor, MI.

Based on extensive literature reviews, this paper attempts to categorize both the environmental and socioeconomic impacts of invasive species using a simple, intuitive scale.

Margaret Ross Dochoda and C. Fetterolf Jr (1987). "**Public Purpose of Great Lakes Fishery Management: Lessons from the Management Experience**." Transactions of the American Fisheries Society **116**: 302-308.

Interviewed a small number of fisheries managers to get their perspective on their priorities as part of the 1985 Symposium on Social Assessment of Fisheries Resources; purpose was to be able to inform academic social scientists about the fisheries management problems faced in practice. Two major responsibilities were emphasized: 1) to protect, maintain, and improve the Great Lakes fishery resources in order to perpetuate benefits to society, and 2) to optimize benefits for the use and enjoyment of the resource by society.

Muth, R., et al. (1987). "**Subsistence Use of Fisheries Resources in Alaska: Implications for Great Lakes Fisheries Management**." Transactions of the American Fisheries Society **116**: 510-518.

"Use of fisheries resources for subsistence by rural populations is becoming an increasingly controversial issue in industrialized societies. Alaska is the only state which has enacted a law to provide for subsistence uses of renewable natural resources by both natives and nonnatives. The legal context of subsistence allocation and management is governed by both state and federal laws that currently ascribe subsistence rights only to rural Alaskan residents. These laws also provide priority allocation of fish and wildlife to subsistence users over other uses if harvest reductions

are necessary to maintain viable fish and wildlife populations. Subsistence serves a variety of social, economic, and cultural functions in the lifestyles of Alaskan residents, including kinship cohesion, in-kind supplements to income, and maintenance of important ceremonial activities. Great Lakes fisheries managers are intimately familiar with the values and meanings associated with commercial and recreational uses of Great Lakes fisheries resources. They have relied on this knowledge successfully to design programs responsive to the needs of commercial and recreational users. Subsistence use of Great Lakes fisheries resources, however, constitutes a separate set of values that needs to be acknowledged and actively managed. Implications of the Alaskan experience for Great Lakes fisheries management include the need to identify the nature and extent of subsistence use of fisheries resources in the Great Lakes region and the importance of an impact assessment framework for evaluating the effects of specific policies and management actions on subsistence uses."

O'Keefe et al. (2015). "**Factors influencing charter fishing effort trends in Lake Huron**." Fisheries **40**(5): 214-221.

Use a regression model to predict variability and decline of charter fishing effort in the Michigan waters of Lake Huron using data from 1999 to 2012, including explanatory variables such as Chinook Salmon catch per unit effort, gasoline prices.

Pope, K. L., et al. (2016). "**Fishing for ecosystem services**." Journal of Environmental Management.

The authors argue that fisheries management tends to focus on socially valuable fish rather than ecologically important species and functional groups. This paper discusses policy decisions in fisheries management and the tradeoffs involved between fisheries and ecosystem services for three case studies of inland fisheries management (1) dam construction (2) river rehabilitation (3) fish stock enhancement. They have three main conclusions: (1) management always involves tradeoffs; (2) explicit management for ecosystem services could facilitate a transition from reactive to proactive management; (3) adaptive cooperative-managment is a process that could enhance management for ecosystem services (as an example, water-quality data are collected and analyzed separately from fish community data which, likewise, are collected and analyzed separately from river-flow data resulting in silos for chemical limnologists, fisheries biologists, and river-regulation engineers)

Stewart, T. J., et al. (2003). "**Recommendations for Assessing Sea Lamprey Damages: Toward Optimizing the Control Program in the Great Lakes**." J Great Lakes Res **29**.

Interesting paper about how best to allocate resources for sea lamprey control.

Talhelm, D. (1987). " **Recommendations from the SAFR Symposium**." Transactions of the American Fisheries Society **116**: 537-540.

Summarizes the recommendations that came out of the symposium about how fisheries managers and social scientists could work together and how the former could learn more about the latter.

Talhelm, D., et al. (1987). "**Introduction to the Social Assessment of Fisheries Resources Proceedings**." Transactions of the American Fisheries Society **116**: 289-292.

Introduces the special issue on this symposium.

Taylor, W. W., et al. (2019). "**The changing face of Great Lakes fisheries**." Aquatic Ecosystem Health and Management **22**(3).

This paper provides a good overview of the evolution of Great Lakes fisheries and makes an appeal to (1) have better valuation of the fisheries that include not just users values (although the authors are just using expenditures by anglers as a measure of value) but the non-use values (though they don't use this terminology) in order to make angling more appealing so as to increase participation and the priority for funding to manage the resource and (2) to treat the fishery resource as a CHAN (coupled human and natural system) in both research and management.

York, N. (2019). "**New York's 2019 Lake Ontario fisheries program highlights** ". from https://www.dec.ny.gov/docs/fish_marine_pdf/lou2019highlights.pdf.

Catch data, angling days etc., summarized by year.

Great Lakes Ecosystem Services: Non-market Valuation Studies

In this section, we provide a bibliography of the literature on non-market valuation of ecosystem services in the Great Lakes. Methodologies employed are the travel-cost method, stated preference methodologies (such as contingent valuation), and benefits-transfer methodologies. We do not include papers from the vast literature on methodology but see Johnston (2017) for overviews of stated preference methodology and Parsons (2017) for travel cost methodology.

The fairly limited literature on non-market valuation of Great Lakes ecosystems focuses primarily, but not exclusively, on remediating designated areas of concern (AOCs) and reducing harmful algal blooms (HABs).

Bingham, M., et al. (2015). **Economic Benefits of Reducing Harmful Algal Blooms in Lake Erie**, Environmental Consulting and Technology Inc.

The IJC commissioned this report on the economic benefit of reducing HABs in Lake Erie. The report used a combination of benefits transfers and assumptions to provide estimates of the increases in property values and recreational activities that could result if HABs were reduced on Lake Erie.

Braden, J., et al. (2008a). "**Economic benefits of remediating the Buffalo River, New York Area of Concern**." J. Great Lakes Res **34**: 649-660.

This paper used hedonic valuation analysis (on property values) to estimate the value of ecosystem service impairment in two areas of concern (AOC) in the Great Lakes basin: Buffalo River and Sheboygan River. They found that the loss of ecosystem services due to proximity to AOCs in the Buffalo River and Sheboygan River are valued at $118M and $158M respectively.

Braden, J., et al. (2008b). "**Economic benefits of remediating the Sheboygan River, Wisconsin Area of Concern**." J. Great Lakes Res **34**: 649-660.

Similar methodology to the Braden et al (2008a) paper. Used hedonic valuation analysis (on property values) to estimate the value of ecosystem service impairment in Sheboygan River AOC.

Cangelosi, A. and et al (2001). **Revealing the Economic Value of protecting the Great Lakes**, Northeast-Midwest Institute and NOAA.

This is essentially an instructional manuscript about how economic valuation could inform decision making. In that regard, it has some very good overviews of methodology. It also has a number of good case studies; for example, estimating the benefits of soil remediation, wetlands restoration in Saginaw Bay, angling demand model, soil erosion in Maumee River, designing a benefits assessment: sediment remediation at Fox River, analytical challenges of valuation, aquatic nuisance species control, and health improvement benefits.

Hayder, S. (2019). **Socio-Economic Risk Assessment of the Presence of Grass Carp in the Great Lakes Basin**. Winnipeg, Manitoba, Fisheries and Oceans, Canada, Policy and Economics.

This report estimates the possible economic impacts of grass carp on commercial fishing, recreational fishing, and ecosystem services in the Great Lakes. Describes nicely many of the ecosystem services and their extent such as the acreage of wetlands in the Great Lakes; goes on to survey the literature on valuation including an IJC report that puts the annual value for wetlands habitat services at $5830 per hectare or $548M total. Continues in this vein for other ecosystem services to establish baseline values that could be at risk if grass carp were to invade. Includes expert scientific opinion from a group of scientists involved in the companion report on risk assessment (not included in this bibliography) in order to establish a defensible foundation for determining what activities/sectors might be at risk as well as the degree of risk over the short (10 years) and long (40 years) terms.

Isely, P., et al. (2011). **Muskegon Lake area of concern habitat restoration project: socio-economic assessment**. Final Project Report, Grand Valley State University.

Used three approaches (travel cost, contingent valuation, hedonic valuation) to estimate the net value of restoring wetland habitat along the Muskegon Lake AOC. They found that the $10M restoration investment resulted in a $66M return in terms of valuation over a ten-year period.

Isely, P., et al. (2018). "**A socioeconomic analysis of habitat restoration in the Muskegon Lake area of concern**." Journal of Great Lakes Research **44**(2).

This is likely a revised and extended published version of the Isely et al (2011) paper. This AOC was one of 3 sites to be awarded funds ($10M) for restoration in the Great Lakess: The authors surveyed visitors to the area to ask, hypothetically, how many additional visits they would make if restoration were undertaken - so the methodology is a combination of travel cost and contingent valuation. See Adamowicz et al (1994) on combining revealed and stated preference methods.

Isely, P., et al. (2017). "**Phragmites Removal Increases Property Values in Michigan's Lower Grand River Watershed**." Journal of Ocean and Coastal Economics **4**(1).

This paper uses hedonic property valuation to show the positive impact on property prices of removing phragmites in Michigan's lower Grand River watershed. It is a good example of the use of hedonic valuation to get at ecosystem service values.

Krantzberg, G. and C. De Boer (2006). **A Valuation of Ecological Services In The Great Lakes Basin Ecosystem to Sustain Healthy Communities and a Dynamic Economy**. Prepared for the Ontario Minstry of Natural Resources. McMaster Univerisyt.

This analysis of the value of the Great Lakes to the health of people, communities and the economy in Ontario has been designed to provide the Ontario Ministry of Natural Resources (MNR) with a credible assessment of the contributions made by the Great Lakes and to the local, provincial, regional, and national economies. For non-traditional benefits assessment, we provide methods for valuation of natural resources and options for MNR to more thoroughly quantify benefits that we can only estimate by extrapolation from existing literature. This document first characterizes the major uses of the Great Lakes for which economic value can be calculated either directly or indirectly. It then portrays a subset of the major stressors many of which have not historically been addressed through COA and/or the Great Lakes Water Quality Agreement (GLWQA). After a brief review of valuation methods, the document describes different categories of benefits ascribable to different aspects of the Great Lakes economy. A short number of case histories are then provided for studies that have calculated values of some Great Lakes attributes that go beyond direct market values. The document concludes with recommendations as to what methods and studies could be undertaken to more fully valuate particularly difficult attributes that have inherent, but not market value.

Midsummer Analytics (2015). Algal blooms: estimating costs to the Lake Erie Basin economy. Environment Canada, Great Lakes Issue Management and Reporting Section. Ottawa.

This commissioned report attempts to estimate the cost of algal blooms on Lake Erie. The report includes both use values (recreational activities) and non-use values using a benefits-transfer approach.

Ontario (2010). "**Assessing the economic value of protecting the Great Lakes ecosystems: a cost-benefit analysis of habitat protection and restoration**." Retrieved February 25, 2021, from https://www.ontario.ca/page/assessing-economic-value-protecting-great-lakes-ecosystems

This report uses the benefit-transfer method as input to a benefit-cost analysis of two hypothetical ecosystem interventions in southern Ontario: protection of an existing habitat (via land securement) and restoring a degraded habitiat. The authors were not able to include non-use values for wetlands; doing so would substantially increase the benefits of the interventions. Nevertheless, the net present value of benefits minus costs was estimated to be substantially positive.

Palm-Forster, L. et al, (2016) **Valuing Lake Erie beaches using value and function transfers**, Agricultural and Resource Economics Review, 45 (2)

Simple benefit-transfer and the benefits-function transfer approaches are used and compared to estimate welfare losses from closure of Lake Erie beaches due to HABs.

Rabinovici, S., et al. (2003). "**Economic and Health Risk Trade-Offs of Swim Closures at a Lake Michigan Beach**." Environmental Science and Technology **38**(10).

Thsi paper uses a benefits-transfer approach to estimate the losses due to beach closings at a Lake Michigan beach.

Smith, R. et al. (2019). "**Estimating the Economic Cost of Algal Blooms in the Canadian Lake Erie Basin**", Harmful Algae, 87.

This is based on the Midsummer Analytics/Environment Canada report cited above.

Steinman, A. D. and et al (2017). "**Ecosystem services in the Great Lakes**." Journal of Great Lakes Reseach **43**: 161-168.

This paper presents a comprehensive review of ecosystem service research in the Great Lakes basin. The review points out that the vast array of ecosystem services in the Great Lakes have not been inventoried in a comprehensive fashion. And no study has systematically examined ecosystem services at the geographic scale of the entire Great Lakes; the few efforts that exist have been performed at a basin scale and only for a select subset of ecosystem services. Knowledge gaps are especially large with respect to non-use values.

Not surprisingly, ecosystem service research in the Great Lakes to date has focused on areas where data currently exist – mostly measures of use values (navigation, fishing) in and around habitats that are heavily used (AOCs, beaches), which leaves signicant gaps in knowledge; as a result, management decisions are based on partial information. The authors recommend a comprehensive analysis of ecosystem services in the Great Lakes be undertaken - even though they recognize this is an ambitious task - with special attention paid to non-use values and less-assessed use values.

Wang, S., et al. (2019). **Lake Erie Ecosystem Services Assessment: Economic Benefits from Phosphorous Reductions**, Key-Log Economics, keylogeconomics.com.

This analysis estimates that achieving the GLWQA 40% phosphorus reduction goal would result in gains of $1 million (2018$ USD) and $31.3 to $123.4 million (2018$ USD) for Lake Erie's beach-goers and recreational anglers, respectively. These are the first estimates that directly quantify economic benefits that all (Canadian and U.S.) beach-goers and recreational anglers visiting Lake Erie would receive if the GLWQA 40% reduction target is achieved.

Methodology:

1) Evaluating Means-Ends Using the National Ecosystem Service Partnership Guidebook

a) The first element develops a means-end diagram that lays out the most important pathways by which our predefined stressor connects to biophysical and economic quantities. Once an action and pathways between the action and ecosystem services are established, we then can measure how changes in ecosystem service provision in the Lake Erie subregion translates into economic benefits.

b) An important step in this process is gaining a better understanding of what ecosystem services are important for people living in, or visiting, the Lake Erie subregion. To further refine and prioritize the baseline ecosystem services, we incorporated 11

Lake Erie Ecosystem Services Assessment Economic Benefits from Phosphorus Reductions

stakeholder input, in the form of an online survey and two online webinars, to get a better account of how people in the subregion value and use the lake.

2) Spatial Analysis Connecting Sources, Sinks, and Benefit Areas

a) After identifying key ecosystem services and societal benefits or outputs in the Lake Erie subregion using means-ends diagramming, we connect actions and ecosystem processes to geographically specific areas where ecological and/or economic outcomes could occur.

3) Estimating Key-Ecological and Economic Outcomes

a) Our last step employs the production function method to estimate the value of key individual ecosystem services produced and enjoyed in the region using the results from the survey and webinars, relevant data, and previous studies of ecosystem service provision in other areas reasonably similar to the Lake Erie subregion.

Wolf, D., et al. (2017). **Reeling in the Damages: Harmful Algal Blooms' Impact on Lake Erie's Recreational Fishing Industry**. 2017 Agricultural and Applied Economics Association Annual Meeting. Chicago, IL.

Used a variation of the hedonic valuation approach by using data on variation in fishing permit sales over time and space as HABs severity varied, for Ohio anglers, to infer willingness to pay for HABs reduction.

Zhang, W. and B. Sohngen (2018). "**Do U.S. Anglers Care about Harmful Algal Blooms? A Discrete Choice Experiment on Lake Erie Recreational Anglers**." American Journal of Agricultural Economics **100**(3).

Provide estimates of willingness to pay for HABs reduction by Lake Erie anglers who live in Ohio. The authors used a stated preference methodology (dichotomous choice survey) and found that anglers are willing to pay in the range of an additional $40 to $60 per trip for a policy that reduces HABs by cutting upstream phosphorous loadings by 40%.

Great Lakes Ecosystem Services: Economic Impact Studies

This bibliography includes a sample of economic impact studies that are primarily, but not exclusively, related to measuring the economic impacts of expenditures on the restoration of areas of concern (AOCs) in the Great Lakes.

Krantzberg, G. and C. De Boer (2008). "**A valuation of ecological services in the Laurentian Great Lakes Basin with an emphasis on Canada**." Climate Change/Environmental Issues Journal AWWA **100**(6).

A very comprehensive literature survey of what is known about economic impacts and valuation of the Great Lakes ecosystem services.

Samonte, G., et al. (2017). **Socioeconomic Benefits of Habitat Restoration**, US Dept of Commerce, NOAA.

This paper studies the economic impact of the 125 NOAA-funded restoration projects, one of which is the Muskegon AOC restoration. See the paper by Isely et al (2018) on the non-market valuation of this restoration project as a contrast to an economic impact assessment.

University of Michigan (2018). **The Socioeconomic effects of the Great Lakes Restoration Initiative**. University of Michigan Research Seminar in Quantitative Economics.

This report analyzes the economic impacts of the funding provided by the US Great Lakes Restoration Initiative from 2010 to 2016. The study found that US$1.7 billion was spent on restoration initiatives over this period and projected that this will create an additional 3.35 times as much in additional economic spending in the Great Lakes region through 2036. As is typical of economic impact studies, the study also estimated the increase in tax revenue and jobs that would result from the spending.

Great Lakes Ecosystem Services: Other Socioeconomic Studies

This section includes a bibliography of studies related to socioeconomic aspects of ecosystem services in the Great Lakes that do not fall into the economic valuation or economic impact categories.

Allan, J. D. and et al (2015). "**Using cultural ecosystem services to inform restoration priorities in the Laurentian Great Lakes**." Front. Ecol. Environ **13**: 418-424.

Uses the phrase "cultural ecosystem services" (CES) to mean those benefts of ecosystem services received by humans, such as recreation, health, aesthetic appreciation,and so on. The authors point out that concern over ecosystem impairment has led to investment of more than US$1.5 billion in restoration projects in the expectation that improved ecosystem health will result in high economic returns. But to maximize returns requires systematic analysis of the spatial distribution and local intensity of both stressors and services. So this paper quantifies the spatial variation in 5 recreational ecosystem services (sport fishing, recreational boating, birding, beach use, park visitation) that underpin economic activity in the Great Lakes region, and assesses the spatial coincidence of these services and identifies locations of high total service delivery. Using quite ingenious methods, are able to get measures of usage intensity at differeent locations throughout the Great Lakes and find the areas that are used most intensively. Also find positive correlation among 4 of the 5 CES suggesting there would be complementary benefits from restoration. Also find high degree of correlation between usage intensity and local GDP.

Allan, J. D. and et al (2017). "**Ecosystem services of Lake Erie: spatial distribution and concordance of multiple services**." Journal of Great Lakes Research **43**: 678-688.

Quantified the spatial distribution of ecosystem services in the Great Lakes Basin that are associated with specific recreational activities. While not a valuation study per se, the study does show that these types of ecosystem services are greatest in some of the most populated and heavily degraded ecosystems in the Great Lakes.

Breffle, W., et al. (2013). "**Socioeconomic evaluation of the impact of natural resource stressors on human-use services in the Great Lakes environment: A Lake Michigan case study**." Resources Policy **38**(2).

This paper reports the results of a focus group held in the Grand Rapids area to elicit peoples' perceptions of what are the relative importance of 9 stressors to the Great Lakes. Concern about pollution was the highest. Also found some inconsistences in results and suggest education is vital. Also suggest that this type of study is an important pre-cursor to a valuation study because it identifies what people view as the most critical stressors.

Chan, K. M. A. and e. al (2012). "**Where are cultural and social in ecosystem services? a framework for constructive engagement**." BioScience **62**(8).

The paper acknowledges the usefulness of monetary valuation of ecosystem services but says that, at the same time, doing this can cause decision-makers to ignore or overlook the many intangible benefts/values of ecosystem services that cannot easily be

monetized, such as cultural benefits, way-of-life benefits. In brief, the problem is that ecosystem services decision-making tools are being used in many places, but the intangible dimensions of ecosystem values are little considered, despite widespread recognition of their importance. Moreover, they are not adequately reflected in monetary valuations. This article tries to fill this gap by proposing a framework for ecosystem research. The approach iteratively involves local experts and stakeholders to identify key relationships, perceptions of impacts of the decision, getting permission from the stakeholders to conduct the research, and identifying stakeholders' views as to the important values. The authors argue that conceptual models and qualitative and quantitative methodologies do exist that can characterize the sociocultural values associated with ecosystems and that can be used in real decision contexts.

Graziano, M., et al. (2019). "**Understanding an emerging economic discourse through regional analysis: Blue economy clusters in the U.S. Great Lakes basin**." Applied Geography **105**: 111-123.

Uses the Great Lakes basin as a case study to explore the concept of regional Blue Economy.

Levine, K. J., et al. (2020). "**What do our lakes mean to us? An understanding of Michigan coastline communities' perceptions of the Great Lakes**." Journal of Great Lakes Reseach **46**: 1716-1725.

Focus groups were held for 100 Michigan residents to learn how they feel about general issues facing Michigan's coastline. Two major themes emarged: (1) rising lake waters and (2) need for education on coastline awareness and stewardship.

Rosaen, A. L., et al. (2012). **The Costs of Aquatic Invasive Species to Great Lakes States**. East Lansing, MI, Anderson Consulting Group LLC.

This report attempts to estimate the economic impact of aquatic invasive species (AIS). It tries to capture the cost to both individuals and industries of having to combat an AIS and/or repair damage caused by AIS. The report takes the adddional step of trying to estimate the indirect costs of AIS such as lost productivity and higher prices in industries affected by AIS.

Sterner et al. (2020). "Ecosystem services of Earth's largest freshwater lakes." Ecosystem Services **41.**

Assembled data to quantify five ecosystem services (transportation, fish production, energy production, recreation and tourism, water supply) that benefit humans in the world's 20 largest freshwater lakes, including the Laurentian Great Lakes. Found that the way in which humans benefit from ecosystems depends very much on the ecological and social context in which they are found.

Studies Outside the Great Lakes

We include a small sample of the many studies that have been done on ecosystem services or recreational fisheries outside of the Great Lakes. Some of these could provide insights and guidance for future research within the Great Lakes region.

Bergstrom, J. C. and J. B. Loomis (2016). "**Economic valuation of river restoration: An analysis of the valuation literature and its uses in decision-making**." Water Resources and Economics **17**: 9-19.

Surveyed 32 studies of ecosystem valuation of river restoration in the US.

Criddle et al. (2003). "**Participation decisions, angler welfare, and the regional economic impact of sportfishing**." Marine Resource Economics **18**(4): 291-312.

A behaviorally-based model for predicting changes in angler welfare and regional economic activity in Cook Inlet, Alaska occasioned by changes in the demand for sportfishing that arise from changes in trip costs or the expected number, size, or mix of species caught.

Dorr, B., et al. (2002). "**A socioeconomic and biological evaluation of current and hypothetical crappie regulations in Sardis Lake, Mississippi: an integrated approach**." North American Journal of Fisheries Management **22**: 1376-1384.

The authors argue that fisheries managers need to take account of not only management actions' impacts on the fish population but also the effects on the socioeconomic environment in which the fishery exists. The paper's objectives:
1. assess anglers' acceptance of current and hypothetical harvest restrictions
2. determine the recreational value of the fishery to anglers (using the travel-cost method)
3. estimate possible changes in recreational value based on angler responses to hypothetical regulations (by altering the estimated demand function based on answers to hypotheticals)
4. integrate results of the socioeconomic surveys with existing biological information

Eiswerth et al. (2008) "**Examining angler behavior using contingent behavior modeling: A case study of water quality change at a Wisconsin lake**." Water Resources Research **44**(11)

Use contingent behavior analysis, as opposed to contingent valuation analysis, to estimate how angling behavior would respond to hypothetical water quality changes in a small lake in southeastern Wisconsin. Study estimates the value (consumers surplus) of an angling day is $104, for a total annual value of $1.4M. The loss in value associated with a loss in water clarity from 10 to 3 feet is estimated to be about $0.53M annually (a 38% decrease).

Fletcher et al. (2015). "**The Value of Nature's Benefits in the St. Louis River Watershed**." Earth Economics, Tacoma, WA.

Using the benefit transfer method, estimated the value of ecosystem services provided by the thirteen ecosystems in the St. Louis River watershed.

Golet, G., et al. (2006). "**Assessing societal impacts when planning restoration of large alluvial rivers: a case study of the Sacramento River project, California**." Environmental Management **37**(6).

This is an example of a paper that argues for the importance of developing appropriate tools for addressing stakeholder concerns before undertaking restoration activities.

Knoche, S. and T. Ihde (2018). **Estimating ecological benefits and socio-economic impacts from oyster reef restoration in the Choptank River complex Chesapeake Bay**, Morgan State University Report #11-05.

The paper reports on research in which simulations are used to estimate the increased harvest that would result from oyster-bed restoration and then uses an input-output model to estimate the resulting economic impacts on employment, labor income, and value added activity.

Lee-Hsueh, L. (2016). "**The Relationship between Visual Satisfaction and Water Clarity and Quality Management in Tourism Fishing Ports**." Journal of Water Resource and Protection **8**(8):797-796.

Used questionnaires on tourists to investigate perceptions of water clarity and quality at five tourism fishing ports.

Loomis, J. B., et al. (2000). " **Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey**." Ecological Economics **33**: 103-117.

The authors conducted a dichotomous choice study to estimate the net value of restoring 5 specific ecosystem services on a section of the Platte River in the US.

Melstrom, R. T. and F. Lupi (2015). "**Valuing recreational fishing quality at rivers and streams**." Water Resources Research **51**(1).

In this paper, the authors link the demand for recreational stream fishing to fish biomass (as opposed to self-reported catch rates) as a measure of fishing quality in Michigan for several game species (bass, trout, walleye). They use a travel-cost model that includes as site options nearly all fishable streams in the state. They are able to estimate the impacts on economic value of several quality-change and site-loss scenarios.

Mitchell et al. (2020). "**Identifying key ecosystem service providing areas to inform national-scale conservation planning**." Environmental Research Letters **16.**

Developed new methods that integrate measures of the capacity of ecosystems to provide services with indicators of human demand and ability to access these services. Among other interesting results, the analysis indicates that one-half to two-thirds of current ecosystem service hotspots in Canada (54–66%) overlap with current and planned resource extraction activities. The analysis demonstrates how to identify areas where conservation and ecosystem service management actions should be focused to more effectively target ecosystem services to ensure that critical areas for ecosystem services that directly benefit people are conserved.

Richardson, L., et al. (2014). "**Assessing the value of the Central Everglades Planning Project (CEPP) in Everglades restoration: an ecosystem service approach**." Ecological Economics **107**: 366-377.

This paper identifies the ecosystem services in the CEPP that could be improved as a result of a restoration project (eg, better salinity moderation leading to an increase in shrimp harvest) and explains how simulation models predict the changes in various ecosystem services that could occur as a result of restoratioin. It identifies the subset of those changes for which benefits data exist and then applies those benefit transfer data in a valuation exercise.

Talhelm, D., et al. (1987). "**Product Travel Cost Approach: Estimating Acid Rain Damage to Sportfishing in Ontario**." Transactions of the American Fisheries Society **116**: 420-431.

The authors use a travel-cost model previously developed by Talhelm to estimate a fishery demand model in the lakes of Eastern Ontario. They then use an acid rain model to predict the impact of projected levels of acid rain on lake acidification, translate this into catch rates over the next 50 years, and then use the economic model to estimate the lost net values.

Vesterinen et al. (2009). "**Impacts of changes in water quality on recreation behavior and benefits in Finland.**" Journal of Environmental Management **91**(4): 984-994.

Estimates the benefits (consumers surplus) of improving water quality in Finland using travel cost methodology.

Wang, Y., et al. (2016). "**An integrated model for marine fishery management in the pearl River estuary: linking socio-economic systems and ecosystems**." Marine Policy **64**: 135-147.

This paper links an input-output model to an ecosystem model of this particular fishery. The ecosystem model generates results showing the effect on landings of management policies such as reducing fishing effort, closing seasons, and changing gear. The I/O model then generates results showing the effect of the change in landings on local economic sectors.

Great Lakes Commercial Fisheries

Because market data are available for prices, costs, landings, employment and so on, economic valuation of commercial fisheries, unlike recreational fisheries, is fairly straightforward. As a result, there isn't much in the way of literature on economic valuation of commercial fisheries. Instead, studies tend to focus more on policy and local economic impacts. We include a small sample of studies here.

Berkes, F. and D. Pocock (1987). "**Quota Management and "People Problems": A Case History of Canadian Lake Erie Fisheries**." Transactions of the American Fisheries Society **16**: 492-502.

Analyzes the introduction of a quota system in Lake Erie by DFO in 1984. Points out the equity/conflict problems that arose. Points out that when introducing new policies like this, important to have good baseline biological and statistical data, and suitable socioeconomic and cultural information on fishermen; also need to take into account any existing self-regulation

Brenden, T. O. and et al (2013). **Great Lakes commercial fisheries: historical overview and prognoses for the future**. Great Lakes Fisheries Policy and Management. A.J. Lynch and N. J. Leonard. East Lansing, MI, Michigan State University Press.

Ebener et al. (2008). "**Management of commercial fisheries for lake whitefish in the Laurentian Great Lakes of North America**." International Governance of Fisheries Ecosystems: 99-143.

Objective is to describe the status of the commercial fishery for lake whitefish in the Great lakes in relation to the fish's population dynamics, ecological change, market demands, and the global economy, and document evolution of management policies for regulating the fishery.

Hudson, J. C. and S. S. Ziegler (2014). "**Environment, Culture, and the Great Lakes Fisheries**." Geographcial Review **104**(4).

Kinnunen, R. **Great Lakes Commercial Fisheries**, Michigan Sea Grant.

Unpublished powerpoint presentation of data on commercial fisheries in the Great Lakes. Looks to have data up to year 2000.

NOAA (2016). **Fisheries of the United States 2015**. Current Fisheries Statistics No 2015. A. Lowther and M. Liddel.

US Army Corps of Engineers (2012). **Commercial fisheries baseline economics assessment: US waters of the Great Lakes, Upper Mississippi, and Ohio River Basins**. Great Lakes and Mississippi River Interbasin Study.

Other References

Methodology

Adamowicz, W., et al. (1994). "**Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities**." Journal of Environmental Economics and Management **26**(3): 271-292.

Hunt et al. (2005). **Recreational fishing site choice models: insights and future opportunities, human dimensions of wildlife**." Human Dimensions of Wildlife **10**(3).

An excellent survey and overview of the methodology and the literature on recreational fishing site choice modeling. Explains how fisheries managers could use the probabilistic models to forecast how changes in the factors affecting site choice (such as fishing quality, cost, environmental quality, facilities, regulations and so on) may affect both the spatial distribution of angling effort and the valuation of recreational fishing.

Johnston, R. J., et al. (2017). "**Contemporary Guidance for Stated Preference Studies**." Journal of the Association of Environmental and Resource Economists **4**(2).

Keeler et al. (2012). "**Linking water quality and well-being for improved assessment and valuation of ecosystem services.**" Proceedings of the National Academy of Sciences **109**(45)

Water quality is often misrepresented as a final ecosystem service. In fact, it is a contributor to many different ecosystem services such as recreation and health. Paper addresses a gap in the literature: properly assessing and valuing ecosystem services related to water quality. Suggest a framework for doing this: at the risk of oversimplification, it works as follows: management actions or changes on the landscape lead to changes in water quality (predicted via biophysical models), which in turn leads to changes in the provision of ecosystem goods and services (via biophysical models ideally, but not so much in practice), which in turn leads to changes in values (via non-market valuation models). If properly done, the framework provides a linkage between actions to a change in water quality and then to the value of ecosystem goods and services.

Parsons, G. (2017). **Travel Cost Models**. A primer on nonmarket valuation. P. Champ, K. Boyle and T. Brown, Springer Science and Business Media**:** 187-233.

Data

Boyle, K. J., et al. (1998). A database on sportfishing values. Report to the U.S. Fish and Wildlife Service.

This report surveys literature and records economic valuations by location and species. Most of these occur outside the Great Lakes. This study is referenced in the Poe et al (2013) survey so is not included in the literature review

Other Great Lakes Studies

Hodges, A., et al. (2012). **Economic Analysis of Working Waterfronts in the United States**. The University of Maine, DigitalCommons@UMaine, Maine Sea Grant Publications.

Included here as it is a very comprehensive economic impact study of coastal-related industries. The study compiles data on economic activity - including multiplier effects - on waterfront communities for employment, GDP, and wages for all coastal areas of US including the Great Lakes region at the county, state and regional levels for 1990 - 2010. Includes a literature review of other economic impact studies.

US Army Corps of Engineers (2008). **Great Lakes Recreational Boating**. In response to Public Law 106-53, Water Resources Development Act of 1999, Section 455(c), John Glenn Great Lakes Basin Program, Great Lakes Recreational Boating, Main Report - Final.

This study was required within 18 months of enactment of the Water Resources Development Act of 1999 which require the Corps to submit to Congress a report detailing the economic benefits of recreational boating in the Great Lakes Basin, particularly at harbours benefiting from operation and maintenance projects of the Corps. Instead, it looks like they did an economic impact study. The study covers the entire 8-state area and identifies total regional impact generated by Great akes boaters and the industry that supports them.