Methodology to Quantify the Economic Impact of the Double-Crested Cormorant (*Phalacrocorax auritus*) to the Oneida Lake Region, New York

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ABSTRACT: The economic impact of wildlife-caused damage and associated management is one of the many factors that arguably play a role in the decision-making process of wildlife managers. Often the role of an economist is to value the damage created by wildlife, or to assess programmatic efficiency to determine if changes can be made to increase return per dollar invested in management efforts. Frequently, the results of economic analyses of wildlife-caused damage are used to justify program efforts in the pursuit or maintenance of funding. The complexity of determining the economic impact of wildlife-caused damage requires that there is a clear understanding of the methodological approach used to determine impacts. Examining specific methodological approaches used in actual case studies provides a systematic replicable approach to valuing damage. This study outlines the methodology for determining the economic impact of cormorant damage to natural resources in a local economy: the Oneida Lake Region of central New York.

KEY WORDS: benefit-cost analysis, damage by wildlife, double-crested cormorant, economics, *Phalacrocorax auritus*, socioeconomic study, wildlife management

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INTRODUCTION

Double-crested cormorants (*Phalacrocorax auritus*; hereafter, cormorants) are large, fish-eating, colonial waterbirds that have undergone dramatic population fluctuations in North America over the past 100 years (Weseloh and Ewins 1994, Hatch 1995, Weseloh et al. 1995). Despite having suffered severe population declines in the U.S., largely due to widespread persecution and pesticide contamination, the estimate of the total Great Lakes region population of cormorants at the time of this publication was 350,000 (Hanisch et al. *In Review*). Cormorants almost exclusively eat fish, and they are keystone predators in systems where they are abundant (Hatch and Weseloh 1999). As populations of cormorants have increased, so has their potential negative impact on fish populations, and this has put cormorants in conflict with recreational anglers concerned about competition. This conflict has been evident in many Great Lakes area fisheries, sometimes resulting in decreased angler bag limits to protect sport fish populations, which has the potential to decrease the attractiveness of fisheries, lead to fewer anglers, and ultimately decrease angler-associated economic activity.

A methodological approach was chosen that could value the direct and indirect economic impact created by the cormorants in the region and assess the benefits and costs associated with the U.S. Department of Agriculture's Wildlife Services (WS) management of cormorants at Oneida Lake, located in New York. This paper provides some background information and details the selection of economic methodology to assess the cormorant management program.

Recreational fishing is an important socio-economic activity in upstate New York, including Oneida Lake, which consistently ranks among the top 5 most important fisheries in the state (Connelly and Brown 1991). Oneida Lake has been commonly referred to as the "The Walleye Lake of New York State". The lake supports healthy populations of popular sportfish, including walleye (*Sander vitreus*), yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieui*) (VanDeValk et al. 2008). Although other recreational fishing areas in New York have also undoubtedly been impacted by the presence of the cormorant, Oneida Lake presents an ideal economic study location for several reasons. First, biologists at the Cornell Biological Field Station located on the south shore of Oneida Lake have been maintaining long-term records of lake conditions, and have been studying fish populations in the lake since 1956 and colonial waterbird populations since 1979. These records provide excellent baseline data that predate the arrival, and document the growth of, the cormorant colony. Second, WS began monitoring, recording, and managing the cormorant populations in 1998. Lastly, a significant body of evidence exists supporting the detrimental effects of the cormorant on the Lake's sport fish populations, and anecdotal evidence has been collected concerning potential impacts of cormorants on the local economy, which includes a significant fishing tourism component. These factors make Oneida Lake a unique study site with robust data for economic analysis.

Study Area

Oneida Lake is the largest lake entirely within New York State, measuring about 21 miles (33 km) long by about 5 miles (8.7 km) wide, with an average depth of 22 feet (6.4 m) (Mills et al. 1978). The lake is located northeast of the city of Syracuse and is in the Lake Ontario watershed (Figure 1). The four counties surrounding Oneida Lake, Oswego, Oneida, Madison and Onondaga, will henceforth be referred to as the Oneida Lake Region (OLR).

Although many intrinsic and extrinsic factors have influenced fish populations, and by extension, angler effort, at Oneida Lake over the years, perhaps the most highly publicized has been the colonization of the lake by cormorants in the 1980s (Rudstam et al. 2004). Although cormorants are native to the U.S. and Canada, there is no evidence that cormorants nested in the OLR historically. The first documented breeding attempt by cormorants at Oneida Lake occurred in 1984 (Claypoole 1988). By 1997, the population had grown to over 250 pairs (Coleman 2008). The population has been monitored via the maximum number of migrating cormorants each year, which was the maximum number counted on a single day in the fall at Oneida Lake (Coleman 2008, USDA WS 2008).

At Oneida Lake, the cormorant diet consisted primarily of yellow perch and walleye (Rudstam et al. 2004), which are also the most abundant fish in the lake and historically the most important species supporting the lake's recreational fisheries (VanDeValk et al. 2008). Extensive research on fish populations at Oneida Lake and cormorant diet and movement patterns indicate that cormorants negatively affect adult walleye and yellow perch populations through the consumption of subadults, thereby reducing recruitment into adult age classes that support the fishery (VanDeValk et al. 2002, Rudstam et al. 2004).

Other potential causes for sport fish population changes must be considered in an economic analysis of this type. Oneida Lake has undergone other significant biological changes over the past two decades. A major contributor to such alterations was the recent invasion by the zebra mussel (*Dreissena polymorpha*) (Zhu et al. 2006), a small bivalve mollusk native to the Black, Caspian, and Aral Sea basins of Eastern Europe and Western Asia. Zebra mussels increase water clarity and therefore cause an increase in submerged vegetation. Although direct impacts of zebra mussel on adult walleye and yellow perch may be subtle, potential impacts on early life history dynamics are poorly understood and therefore were not considered as a factor in reducing the sport fish populations for the purpose of an economic study (Rudstam et al. 2004).

Cormorant Management

To decrease cormorant impacts on fish at Oneida Lake, the New York State Department of Environmental Conservation initiated a management program in 1998 (Miller 1998, Chipman et al. 2000, Coleman 2008, DeVault et al. 2008). The objectives of the adaptive management plan were to reduce the predation impact on fish by reducing the number of resident and migrant cormorants on the lake in the fall, and to limit the impacts of resident cormorants through nest control procedures. From 1998 through 2003, WS was contracted to harass cormorants during the fall migration period of August and September. Since 2004, when the management plan was expanded, WS has been responsible for managing cormorants at Oneida Lake from ice-out in April until the end of September (NYSDEC 2004). WS employees use boat chases, pyrotechnics, nest control, and limited lethal removal to reduce cormorant numbers on the lake. As such, cormorant management at Oneida Lake was primarily a non-lethal program. From 2004 through 2007, the average number of cormorants on Oneida Lake from ice-out in April until 30 September (based on weekly boat surveys of the entire lake) was 225, 154, 129, and 103, respectively. These weekly observations were reduced from average counts of more than 1,500 in 1996 and 1997. Thus, cormorant impacts to fish on the lake have been minimized.

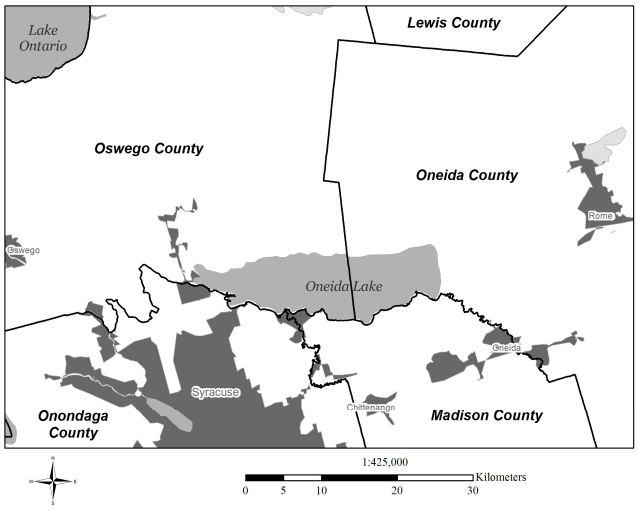

Figure 1. Oneida Lake and the surrounding four counties.

METHODOLOGY

Two methodologies, one main and one supporting, were determined to be appropriate for this study. A benefit-cost analysis (BCA) methodology was chosen as the overall main methodology for the economic analysis, and in order to value benefits, the damage avoided methodology was also selected. Several factors led to the selection of the BCA as the appropriate methodology to determine overall cormorant impacts in the OLR. First, the cormorant impact on sport fish was viewed as a loss of an amenity to the lake, which reduced its attractiveness to anglers. Therefore it was appropriate to choose a methodology that could incorporate the impact of reduced angler spending. BCA allows for the incorporation of angler spending into the model as a resource "saved" as a result of fewer cormorants in the region. Secondly, BCA is a common tool used by economists to evaluate government programs and to determine the efficiency of management efforts (Zerbe 1994). It requires a monetary comparison of benefits and costs of cormorant management in the OLR. This prospect may be challenging, as evaluating these types of programs generally

involves valuing non-marketed goods and services, such as environmental goods (Zerbe and Dively 1994). One accepted methodology to value non-market services is the damage-avoided method, which utilizes the value of resources protected, in this case angler spending in the region (King and Mazzotta 2007).

When performing a BCA, the benefits and costs can be compared using the total expenditures of the program and the total estimated benefits derived from the program during the study period. An alternative method is to compare the benefits and costs on a year-by-year basis. In many cases, the best method for evaluating wildlife management programs is to compare the benefits and costs for the entire program time period.

The economic approach of evaluating this particular cormorant management program involves mainly ex post data to describe the activities, costs, and potential savings associated with WS operations. As is common with BCA of government programs, the valuation of cost was more easily accomplished than the valuation of benefit. In this case, the cost of the program equals the expenditures for employee salaries as well as equipment and materials directly used for cormorant management at Oneida Lake.

Benefits

Identification of the benefits of the cormorant management program was the first critical step in the BCA methodology. In the case of cormorants, the actual dollar value of damage must first be assessed, and then the benefits of the management program can be determined by estimating how much of that damage was potentially prevented by the initiation of the management program. Two main impacts of the cormorants to the OLR were initially considered, including the value of fish lost and the value of angler spending lost. The initial impact of the cormorants was obviously to sport fish populations; however, because Oneida Lake was stocked regularly with fingerlings for "pennies" per fish, value of individual fish lost was determined to be negligible and dropped from the analysis. Secondarily, a less conspicuous yet much more important area of damage from the cormorant's predation on sport fish was the drop in angler tourism to the OLR.

The choice of "type" of angler impacted by the cormorant was important for this analysis. For this purpose, anglers were broken down into two general categories; residents and non-residents. Consistent with the BCA methodology, the benefits were measured using the estimated number of anglers "lost" due to cormorant impacts and additionally the estimated number "saved" due to cormorant management. Potentially, both resident and non-resident anglers were impacted by the cormorants; however, it was argued that resident anglers would still continue to spend money in the OLR, while non-residents would not. It was the loss of non-resident anglers that would have a measurable impact on the economy of the OLR and that would be important to quantify using this methodology. Non-residents anglers typically purchase lodging, food, gas, supplies, etc. at the fishing site with income that would normally be spent in the state in which they reside. Therefore, the most appropriate data available to measure economic damage was the variation in non-resident license sales in the OLR. Mitigation of the decline in non-resident fishing license sales was viewed as a benefit of the cormorant hazing program.

The BCA methodology requires that other potential causal factors for variations in the data be explored. Therefore, while the cormorants seemed to provide a potential main factor influencing the drop in non-resident fishing license sales in the OLR, other possible explanatory factors that could explain the change in the attractiveness of Oneida Lake to anglers were examined. Other potential factors include decreasing non-resident fishing license sales nationally, and increases in fishing license prices in New York. Ruling out the influence of other explanatory factors creates a clear link between management actions and the resulting benefits.

Finally, to determine the benefits of WS management of cormorants, multiple sources of information were used to create reasonable assumptions and determine a probable range of benefits associated with the number of non-resident anglers (and their spending) "saved" by WS operations. Determination of the number of non-resident anglers saved by the management of cormorants requires the hypothetical estimation of the number of anglers at Oneida Lake in the absence of the cormorant management program (i.e., if cormorant damage continued unabated). Multiple techniques exist to forecast the potential future number of non-resident anglers present in the absence of the cormorant management program.

Costs

From federal fiscal years 1998 through 2002, the WS cormorant management program employed a small staff and operated on a limited budget. Due to program success, documented by a reduction in fall migrating cormorant populations on Oneida Lake from 1998-2002, Congress provided additional funding to implement the hazing program for the 2003 fiscal year. This allowed for increased cooperative research and management of cormorants in 2003 and the following years (USDA WS 2003). The cumulative expenditures from 1998 to 2005 were considered the cost of the cormorant management program in the BCA.

Benefit-cost ratios could then be estimated by comparing the value of anglers saved versus the costs of the program over the entire study period. Final results of this analysis could be used to estimate the dollar amount of angler expenditures saved for every dollar expended on the WS cormorant management program.

DISCUSSION

Performing an economic analysis of wildlife damage mitigation activities in cases of natural resource protection can demonstrate the multiple returns on invested dollars. A uniform systematic approach to determining the benefits and costs associated with wildlife damage can aide in the explanation and quantification of management efforts. Due to the challenge of valuing these types of non-market goods, assumptions must be made using the best available data, or in some situations using information from similar cases. This study outlines economic methodology to estimate the change in angler-generated

economic activity potentially caused by cormorants, and to assess the benefits and costs associated with WS cormorant management in the OLR.

Anglers are sensitive to myriad factors when choosing fishing destinations. Accessibility, aesthetics, weather, local amenities, fish species composition and numbers, and other factors determine the attractiveness of any location. In addition to cormorants impacting the availability of sporting fish to anglers, the publicity surrounding the cormorants' activity at the lake could have potentially influenced the attractiveness of Oneida Lake to non-resident anglers. Residents and non-residents consider similar but not identical factors when deciding where to fish. Non-resident anglers may be less able to quickly or easily verify positive or negative media reports regarding their proposed fishing locations, and therefore they may be more responsive to such media reports. Strong positive or negative media attention to a location may therefore be given greater weight by non-residents. Separate quantification of these factors, although not explored here, represent both direct and indirect impacts of the cormorants to the OLR.

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