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IMPACTS OF A POTENTIAL ZEBRA MUSSEL INFESTATION IN FLORIDA

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Abstract

Zebra mussel (*Dreissena polymorpha*) colonization of the eastern United States has resulted in expenditures of tens of millions of dollars spent by consumptive surface water users, in order to mitigate infrastructure impairment caused by this invasive species. Analogous to benefit-transfer analysis, a "cost-transfer" approach will be used to obtain general estimates of potential mitigation costs of zebra mussels in an area (Florida) that this invasive species has yet to establish itself. The goal of this research is to provide initial information about this issue to parties interested in, and/or charged with, invasive species management in the state of Florida.

Key Words

Bio-fouling, cost-transfer, economic impacts, Florida surface water users, monitoring and control, zebra mussels

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Introduction

A freshwater species native to the Black Sea, the zebra mussel (*Dreissena polymorpha*) was introduced to the Great Lakes in the late 1980's through the ballast water of ships coming from Europe. This non-indigenous mollusk poses a threat to the surface waters of the United States because it exhibits many biological characteristics that an "ideal" invasive species would possess. According to the USGS (2000): "Zebra mussels are very successful invaders because they live and feed in many different aquatic habitats, breed prolifically…and have both a planktonic larval stage and an attached adult stage." Some of the adverse effects of zebra mussels include: the disruption of native eco-systems, the impairment of recreational activities, and the obstruction of water conveyance systems owned/operated by consumptive surface water users. For these reasons, and because of their subsequent widespread dispersal into the Ohio River Valley and down the Mississippi River, Florida (along with many other states) faces a high probability of becoming infested in the future.

Zebra mussels are not presently found in the waters of Florida. However, researchers from the Mote Marine Laboratory [Sarasota] report that hydrologic conditions suitable for their colonization exist in several areas of the state. The identification of such areas by Hayward and Estevez (1997) indicate that municipal and industrial users of freshwater in several economically important regions of Florida stand to be impacted should zebra mussels become established there. In particular, they

mention the St. Johns River system, peninsular Florida north of Lake Okeechobee, and the tributaries of Tampa Bay and Charlotte Harbor. Much of this area is conspicuous for having relatively high population densities, and thus obviously has significant economic importance – both in terms of recreational activities and potential impacts to infrastructure.

In contrast to many of the ecological damages resulting from zebra mussel colonization, the impacts to municipal public utilities, private citizens and businesses are rather direct and tangible. This facilitates an assessment of economic costs associated with colonization. For example, such entities that possess intake and discharge structures for surface water could incur higher maintenance costs, in order to mitigate the so-called "bio-fouling" caused by colonization of zebra mussels. In affected areas, such as the Great Lakes, increased maintenance and prevention costs, along with the costs of retrofitting equipment, are necessary investments to ensure the unobstructed flow of water. Thus, the potential for significant economic damages exists should zebra mussels become established in Florida. Based upon their rapid spread southward from the Great Lakes, and the enormous economic impacts to that region – *an estimated $5 billion over the next ten years*, according to the U.S. Fish and Wildlife Service (USGS, 2000) – the zebra mussel is an economic threat to Florida that must be seriously considered.

The overall objective of this paper is to provide general estimates of the potential costs that would result from zebra mussels colonizing Florida waters using a "cost-transfer" analysis. Analogous to benefit-transfer analysis, this cost-transfer technique will provide estimates of the mitigation costs of zebra mussels in an area (Florida) that this invasive species has yet to establish itself. The goal of this research is to initiate,

however limited in scope, an investigation that informs parties interested in, and/or charged with, invasive species management in the state of Florida.

Cost-Transfer Analysis

The term benefit-transfer is an evaluative technique that has become an accepted tool used by resource and environmental economists for assigning values to various non-market goods and services in the absence of primary data. As the name implies, the basic premise of this valuation technique is to transfer previously generated economic information (environmental values) to another location. Such values are generated by using different non-market valuation methods usually requiring significant data collection efforts, and in many cases, the administration of surveys (e.g., contingent valuation method). Thus, benefit-transfer is generally employed when existing data for the target location is poor, time is limited, or sufficient resources to conduct a full-scale evaluation are not available (Rosenberger and Loomis, 2001). Benefit-transfer analysis is also advantageous for exploratory investigation of a previously unstudied topic.

A similar approach can be employed on the cost side of an economic evaluation lacking the appropriate data. Like the benefit-transfer technique, the concept of "cost-transfer analysis" implies that existing cost data can be used to estimate potential economic costs (or damages) in a different location. Such an approach is appropriate for the same reasons described previously for benefit-transfer; and is appealing for cases such as the present evaluation, where economic costs of an invasive species on an un-colonized location are completely hypothetical. While encouraging in its possibilities, cost-transfer analysis also shares similar limitations that are observed with the benefit-

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transfer approach. Because secondary data is used to transfer values to a different location, two aspects of these applications are salient: 1) the original study was conducted without consideration of the particular objectives and parameters of the current study, and 2) important differences in the characteristics of source and target locations are likely to occur. The relative magnitude of these effects will determine the overall accuracy and relevance of the transfer estimates that are subsequently generated. In addition, the quality and validity of the original study and associated values will directly influence the quality and validity of estimates generated through the transfer process. It is very important to keep this in mind when reviewing and interpreting benefit or cost values obtained through transfer analysis.

Description of Data

Although much research has been conducted on the biology and ecosystem effects of zebra mussels, comparatively little investigation of their economic impacts have been undertaken. Two main sources of information regarding the economic damages caused by zebra mussels constitute most of the empirical data on the subject, and form the basis of the cost-transfer analysis in this paper.

A study conducted by New York Sea Grant and the National Zebra Mussel Information Clearinghouse (NZMIC) indicates that over $69,000,000 was spent during the period 1989 to 1995 for monitoring, impacts, research and control of zebra mussels (O'Neill, 1996). This figure was obtained from a survey of industrial, drinking water treatment, electric power generation, and other facilities located mainly in New England, the Mid-West, and the South. The number of respondents reporting expenditures

incurred for zebra mussel monitoring, control, prevention, training, and planning totaled 339 facilities (O'Neill, 1996). The data are generally presented as bar charts, histograms, and simple statistical means. The comprehensive nature of this study is extensive in both the spatial coverage of the survey and the types of facilities sampled, and despite the presentation of average cost figures, the basic value of the information provided is best characterized as being qualitative.

This is due to the diversity of facilities responding, the quality of the data elicited, and the range of expenditures reported; and O'Neill cautions against transferring the values generated by the survey to un-infested locales (1996). Nevertheless, selected values from the NZMIC report are necessarily utilized in this investigation to provide ballpark estimates of expected economic costs arising from the potential for zebra mussel introduction and proliferation in Florida surface waters - for the simple fact that no estimates currently exist.

Research conducted by Deng (1996) also relies on survey data to, among other things, assess the economic effectiveness of zebra mussel control technologies employed by facilities located on, or near, one of the Great Lakes. These data face similar issues of suitability of use for cost-transfer analysis, mainly because there is little indication of the size characteristics (in terms of withdrawal capacities) of responding facilities. The types of surface water users identified do not correspond very well with the application target dataset, either. These issues are discussed later in this section.

The categories of surface water users identified are private utility, public utility, municipal water, and other industry.[1] Over the period 1989 to 1994, 141 facilities reported expenditures of \$60.7 million incurred for zebra mussel monitoring and control

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[1] These designated surface water use categories are also referred to as "sectors."

(Deng, 1996). Deng defines control costs as being inclusive of variable chemical costs, labor costs, equipment investment costs, contractual service costs, etc. (1996). Also provided are various summary tables of calculated average costs by surface water user category, year, and source of water (Great Lake, tributary, in-land lake). Of particular interest to this investigation is a table detailing zebra mussel control cost data, which provides both variable and total cost figures for five types of control technologies based on volume of water treated ($ per MG[2]). The five control technologies are thermal treatment and cleaning, chlorination (Cl_2), bromination (Br), use of potassium permanganate ($KMnO_4$), and use of a biocide. These "volume-based" cost values are used to generate cost estimates for Florida surface water users.

Ideally, the target universe to which cost-transfer values are assigned should contain all consumptive surface water users in Florida that are permitted by one of the five water management districts in the state. However, as a practical matter of data availability, this evaluation is restricted to consumptive surface water permit holders within the Southwest Florida Water Management District (SWFWMD). Review of these records suggests that the cross-section of permit holders in this water management district generally represent the main types of consumptive surface water users in Florida. The parameters relevant to this study are water use designation (sector), and annual average daily water withdrawal. The five sectors defined in the SWFWMD data are: public supply (also referred to as water treatment facilities), industrial/commercial, agricultural, recreational/aesthetic, and mining/dewatering.

The difficulty encountered in this evaluation stems from the fact these sectors only partially overlap with the designations found in the source datasets of both O'Neill

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[2] MG = million gallons.

and Deng. Another problem is that, while the SWFWMD data contain withdrawal amounts for each facility, the source datasets contain little to no information on the size ranges (in terms of w/d amounts) of the facilities that report expenditures incurred. Only the water treatment plants surveyed by O'Neill have average values calculated from reported facilities that are correlated with size designations. Even this fact is of limited value to the present study because of the relatively small number and size of the representative Florida public supply facilities.

Analysis and Results

Two economic impact estimates based on cost-transfer analysis were derived from each of the two sources of cost data available from the cited literature. The first set of estimates utilizes NZMIC average zebra mussel control costs calculated from total expenditures reported by water treatment plants and industrial facilities. These estimates are found in Table 1. The second set of estimates is obtained by using Deng's variable and total cost figures that are based upon the volume of water treated; these estimates are exhibited in Table 2.

The NZMIC data from water treatment plants are subdivided by withdrawal amounts, with two categories applicable to the dataset of Florida public supply facilities.[3] NZMIC average cost values for each of the two size categories are multiplied by the number of Florida public supply facilities corresponding to the respective category, and summed to obtain one value for this sector. The estimated value of $310,908 represents the expected costs to be incurred by public water supply facilities in the study area. This figure is found in both estimate columns of the first row in Table 1.

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[3] The two categories are: less than 10 MGD, and 10 to 100 MGD. (MGD = million gallons per day)

Expenditure estimates for the remaining sectors are derived from two different NZMIC average cost figures calculated from costs reported by industrial facilities. This is done to provide both low and high estimates, as there is much uncertainty regarding which values are the most appropriate to transfer.[4] The low estimate, denoted MRIU, is based upon an average control cost calculated using data from 18 Industrial Users with facilities on the Mississippi River. Similarly, the high estimate (ARIU) is based on an average control cost figure calculated for All Reporting Industrial Users (N = 35) in the survey, based upon their reported expenditures.

In addition to listing the "source" values used to derive cost estimates, Table 1 also displays the number of facilities in each sector, with the total cost per year for each sector obtained through simple multiplication. Each cost estimate column is summed to arrive at the respective total cost per year figure. Thus, the low estimate results in expected total zebra mussel control expenditures of $6,234,036 per year for consumptive surface water users in the SWFWMD. The high estimate obtained is $23,961,684 per year for expected zebra mussel mitigation costs.

Use of Deng's volume-based cost data provides a limited way of using facility size in cost estimation, by utilizing the withdrawal amounts for each facility contained in the SWFWMD data. In addition to presenting the total costs/sector/year for each of two different cost treatment options (TO1, TO2), Table 2 lists the unit cost of treatment ($/MG), and the number of facilities in each sector. The total cost per year estimates for each sector are obtained by multiplying the treatment cost ($/MG) assigned to each sector by the cumulative yearly withdrawal amount (MG/year) of each facility within that

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[4] As noted previously, the uncertainty arises due to the lack of information regarding size ranges (in terms of w/d amounts) of facilities reporting expenditures incurred.

sector. Summing over all sectors results in the estimated total economic impact of zebra mussel control for each hypothetical treatment scenario.

TO1 represents a least-cost scenario. In this scenario, water treatment plants are assumed to currently use of chlorine as part of their operations, and adopt this chemical treatment method for dealing with zebra mussels. Chlorine is the most commonly used molluscicide used to combat zebra mussels, and can have an effectiveness of up to 95% kill (USACE, 1994). At a variable cost of $1.13 per MG of water treated, chlorine represents the least cost alternative to such facilities currently capable of employing this strategy, because additional capital outlays are likely to be minimal (Deng, 1996).[5] Furthermore, the least cost option for the other sectors is chemical treatment with Bromine, which has a total cost of $3.57 per MG. In addition to the variable chemical cost, this figure reflects the capital costs necessary to employ this technique. As a result, the estimated total cost of zebra mussel control for this treatment option is $249,157 per year.

The environmental effects of zebra mussel control strategies (e.g., chemical treatments) are likely to be monitored, either directly or indirectly, by regulatory agencies; and the minimization of such adverse effects may be weighted higher than other zebra mussel control goals (USACE, 2001). Therefore, the second scenario (TO2) represents a hypothetical "environmental" scenario in which the use of chlorine for zebra mussel control is prohibited, as well as any chemical treatment for the agricultural, recreational/aesthetic, and mining/dewatering sectors. Facing such restrictions, public supply facilities are assumed to convert their zebra mussels control strategy from chlorine to treatment with potassium permanganate ($KMnO_4$) at a total cost of $6.50 per MG.

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[5] All unit costs in Deng (1996) are based on a three-year average (1992-94), as reported by respondents.

According to Deng (1996), this is the likely strategy for the water treatment sector, as $KMnO_4$ treatment is already employed by nearly 20% of all survey respondents.[6] Facilities in the agricultural, recreational/aesthetic, and mining/dewatering sectors, restricted to non-chemical treatments, would have to employ thermal treatments and/or physical removal strategies at a cost of $4.90 per MG. Industrial facilities would still select Bromine treatment ($3.57/MG) as the least cost alternative. Thus, the estimated total cost of zebra mussel control for the environmental scenario is $791,216 per year.

Conclusion

Concern for both the ecologic and economic impacts of invasive species in the United States is becoming widespread. As a result, increased governmental attention and budgetary expenditures will be focused on this issue in the near future. When considering the well-documented invasion of the Great Lakes by the zebra mussel, it is clear that the potential adverse ecological and economic consequences of zebra mussel introduction/establishment in Florida are alarming. However, information on the threat of zebra mussels to Florida is very limited, and any appropriate response to this threat will first require an economic assessment estimating potential damages should zebra mussels colonize Florida surface waters.

Even though there are valid concerns with the use of cost-transfer analysis, and this study is clearly no exception, it is exceedingly useful in helping to initially assess a problem that lacks available data. Such a situation is addressed in this paper: the hypothetical case of zebra mussel monitoring, prevention, treatment and control costs

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[6] Potassium permanganate and Bromine are both considered to have less adverse environmental impacts than chlorine (Deng, 1996).

incurred by surface water users in Florida. Despite the problems inherent in conducting a cost-transfer analysis with data compatibility issues between source and target, this technique is the only available means to establish initial estimates of damages to Florida from zebra mussels. As mentioned previously, the estimated costs arrived at herein are to be considered more qualitatively than quantitatively because of the gross uncertainties that surround the numbers. These estimates are intended for use as ballpark figures that can help frame the issue, especially in terms of a policy response to the zebra mussel threat.

In addition to consumptive surface water users, there are important implications for other economic actors affected by any policy formation dealing with invasive species control. These include recreational boaters, fishermen, and firms engaged in international trade that own ocean vessels. As global trade and the domestic vacation/recreational migration of people to Florida continue to increase, it is reasonable to assume such transmission pathways will keep alive the threat of zebra mussel introduction. Quantification of economic damages, even if limited to consumptive surface water users, will provide valuable information to lawmakers and government agencies charged with invasive species control. Spending on education, monitoring and prevention campaigns to control zebra mussels can then be better evaluated against the economic costs resulting from their introduction, allowing the necessary trade-offs to be made objectively.

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Appendix

Table 1. Estimated Costs of Zebra Mussel Control in SWFWMD (1995 dollars)

Sector *	N facility	Mean Cost $/facility/yr.	MRIU $/year	Mean Cost $/facility/yr.	ARIU $/year
Public Supply **	6, 13	12.9k, 23.9k	$310,908	12.9k, 23.9k	$310,908
Industrial/Commercial	25	$8,366	$209,150	$33,405	$835,125
Agricultural	342	$8,366	$2,861,172	$33,405	$11,424,510
Recreational/Aesthetic	278	$8,366	$2,325,748	$33,405	$9,286,590
Mining/Dewatering	63	$8,366	$527,058	$33,405	$2,104,515
Total Cost/Year	727	n/a	$6,234,036	n/a	$23,961,648

* Cost values shown for each sector are sum of costs for all firms in that sector with
 water withdrawals > 1,000 MGD.
** Mean cost estimates for two size categories based on withdrawal capacity.

Table 2. Cost Estimates as a Function of Withdrawal Amounts (Nominal **)

Sector *	N facilities	Unit Cost ** $/MG	Cost TO1 $/year	Unit Cost ** $/MG	Cost TO2 $/year
Public Supply	23	$1.13	$104,784	$6.50	$602,741
Industrial/Commercial	26	$3.57	$25,993	$3.57	$25,993
Agricultural	347	$3.57	$41,874	$4.90	$57,474
Recreational/Aesthetic	283	$3.57	$44,979	$4.90	$61,735
Mining/Dewatering	63	$3.57	$31,527	$4.90	$43,273
Total Cost/Year	742	n/a	$249,157	n/a	$791,216

* Cost values shown for each sector are sum of costs for all firms in that sector.
** Unit costs are based on a three-year average (1992-94), as reported by respondents.