



Analysis

Controlling an Invasive Species through Consumption: The Case of Lionfish as an Impure Public Good

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1. Introduction

The traditional approach to analyzing the voluntary provision of public goods is to assume individuals choose between consuming private goods and making contributions to pure public goods (Samuelson, 1954; Bergstrom et al., 1986). This characterization of the choice set is becoming increasingly incomplete as consumers are inundated with products that have both private and public attributes (Kotchen, 2006). These composite goods, often called “impure public goods” are ubiquitous. Some examples include green electricity, hybrid vehicles, fair trade chocolate, shade grown coffee, environmentally friendly soaps and detergents, eco-labeled food products (such as dolphin-safe tuna), and organic produce. Moreover, in many cases individuals consume products in part because the producer/supplier donates a percentage of profits to charity (e.g., Newman's Own product line). Recent studies show that consumers may respond positively to public good attributes when making private consumption decisions, and in some cases may be willing to purchase them at a premium (Menges et al., 2005; Kotchen and Moore, 2007; Longo et al., 2008). In this study we use experimental methods to examine individuals' values for consuming lionfish and how those values change in response to more information about how consumption can help mitigate a public bad. Lionfish – an invasive species along the Southeast Atlantic coast, in the Gulf of Mexico, and throughout the Caribbean Sea - is a particularly unique type of impure public good in the sense that consuming lionfish has direct private benefits but also indirectly contributes to the broader public good of controlling rapid population growth. Our study is the first to solicit willingness to pay estimates to consume lionfish with the goal of isolating the premium consumers are willing to pay to consume lionfish when informed about the destructive nature of the species and the use of consumption as a management strategy.

Lionfish (*Pterois*) are an invasive species in United States and Caribbean waters. First detected along the Florida coasts in the mid-1980s, their populations have increased dramatically in the past two decades as a result of having no known predators outside of their native habitat (Indo-Pacific). Lionfish were likely introduced into Florida waters after being released from aquariums, either intentionally as

owners tired of maintaining them as pets or unintentionally from the destruction caused by hurricanes (Goddard, 2008). The rapidly growing population of lionfish is stressing the already fragile natural reefs in the Gulf of Mexico and is threatening commercial and recreational fisheries (such as the grouper and snapper fisheries). Local, state and federal regulatory agencies are actively looking for ways to reduce the population of lionfish, either to a stock size small enough to be commercially sustainable without disrupting native species or driving the stock down toward eradication.

One potentially promising management strategy is through private consumption (Nunez et al., 2012). The National Oceanic and Atmospheric Association (NOAA) recently launched an “Eat Lionfish” campaign aimed at promoting consumption of lionfish as a viable seafood choice. NOAA states that human consumption of lionfish is practical, feasible and should be promoted. Although lionfish possess 18 venomous spines that make catching, handling, and preparing them risky, the fish itself is completely safe to eat and prepared lionfish is comparable in taste to other whitefish like grouper or flounder. Our study contributes to the broader economics literature on invasive species management by considering consumption as a management strategy for controlling population growth. Previous research has estimated the economic damages associated with invasive species and the cost-effectiveness of regulatory control strategies (e.g., Eiswaerth and Cornelius van Kooten, 2002; Horan et al., 2002). A more limited contribution to this literature involves measuring individuals' values for regulatory management options directed at controlling invasive species (Nunes and van den Bergh, 2004; Olden and Tamayo, 2014) as well as the social factors that influence these individual valuations (Garcia-Llorente et al., 2011). These studies develop either revealed or stated preference techniques (such as hedonic property price models or contingent valuation methods) to estimate respondents' willingness to pay to control invasive species through regulation. Our application differs as it examines consumption as a management strategy to control the population growth of an invasive species.

As the existing market for lionfish is extremely thin, we solicit individuals' values for consuming lionfish via a series of controlled economic experiments. The experiments were conducted at the annual

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Pensacola, Florida Seafood Festival over two days in September of 2015, during which interested participants voluntarily self-selected into our study. This form of experimentation is typically categorized as a *framed-field experiment* in which the subject pool consists of experienced seafood consumers and takes place in a familiar market context (Harrison and List, 2004). Participants were given the opportunity to purchase a single three-ounce fillet of cooked lionfish through an auction mechanism. The auction used the Becker-DeGroot-Marschak (BDM) method as an incentive compatible approach to solicit willingness to pay measures. The experimental treatments differ in the type of information provided to participants. In all treatments, participants were provided some basic information about lionfish, such as how its taste has been likened to other white fish, such as snapper or grouper. In the baseline treatment participants were not provided with any other information.

In a second treatment, participants were informed about the invasive nature of lionfish in Florida Gulf of Mexico waters and the “Eat Lionfish” management strategy for controlling the invasive population through consumption. A comparison of willingness to pay measures between the baseline and this second treatment yields the premium the average consumer is willing to pay to eat lionfish when they are informed that consuming lionfish provides a public benefit. A third treatment is designed to estimate the change in willingness to pay when the description of the threat imposed by lionfish is intensified. In the social psychology literature, Protection Motivation Theory (PMT) describes adaptive and maladaptive coping behaviors of individuals to threat information (Rogers, 1975). Studies within this body of literature have shown that behavior of individuals can be altered by the severity of a threat (Maddux and Rogers, 1983). Consumers in this treatment are exposed to an increased severity of threat by being informed that there is a real possibility of localized extinction of important commercial and recreational fisheries (snapper and grouper) due to rapidly expanding lionfish populations. The impact of the threat severity can be examined by analyzing how the new information alters consumers' willingness to pay for lionfish relative to the other treatments.

While our study is the first to solicit willingness to pay estimates to consume lionfish and, in particular, isolate the premium consumers will pay when informed about consumption as a strategy to mitigate the environmental problem, the approach and methodology of using experimental auctions to value non-market goods have deep roots in the economics literature. Experimental auctions have been used to estimate consumer demand for safer food products (Hayes et al., 1995; Shogren et al., 1999; Fox et al., 2002; Rousu and Shogren, 2006; Bruner et al., 2014), hormone-free and organic milk (Bernard and Bernard, 2009), insecticide-free apples (Roosen et al., 1998), non-genetically modified foods (Huffman et al., 2003; Lusk et al., 2005), animal-friendly products (Gracia et al., 2011), remanufactured products (Michaud and Llerena, 2011) and many other examples. Economic experiments are becoming increasingly popular methods for estimating consumer values for non-market goods. As opposed to hypothetical studies (e.g., stated preference surveys), experimental auctions involve the purchase of real products in exchange for real money and therefore there is a strong incentive for people to reveal their true values.

Our sample consists of participants from the 2015 Pensacola Seafood Festival that voluntarily opted into our study. Although the subject pool consists of experienced seafood consumers, our sample may not provide an accurate representation of the broader population of potential lionfish consumers. Acknowledging the potential bias of our willingness to pay point estimates, our analysis focuses primarily on the changes in willingness to pay for lionfish over the different information treatments (i.e., treatment effects).¹ This approach follows

the established experimental literature (referenced in the previous paragraph) on valuing food products in which convenience samples (self-selected participants) are used to estimate changes in willingness to pay for different consumption attributes.

In our baseline treatment we find that consumers in our sample, on average, are willing to pay \$6.28 for a three-ounce prepared lionfish fillet. When informed about the invasive nature of the species and consumption as a potential management strategy, willingness to pay for the same fillet increased by \$0.71 (11.3%) on average. When the severity of the threat is increased – individuals are informed about both the consumption management strategy and the possibility of local extinction of valuable species if lionfish populations continue to flourish – the average willingness to pay jumps \$1.66 (26.4%) above the baseline. The results show that people are willing to pay a premium to consume lionfish when there is a perceived public-good component, and this premium increases significantly when the threat posed by lionfish is escalated.

These findings also have strong policy implications. The Magnuson-Stevens Act and the 1996 Sustainable Fisheries Act (SFA) have combined to create a fishery management process implemented through eight geographic councils. Three of the councils; Gulf of Mexico, Caribbean, and South Atlantic, are located within the boundaries of the lionfish invasion. The SFA included a provision to protect essential fish habitat and promote conservation through management. Although much more research is needed, our study contributes to a broader research agenda trying to understand whether there is potential for a viable commercial lionfish fishery.

2. Experimental Design and Protocol

The research team harvested the lionfish for this study off the Pensacola, Florida Gulf Coast in September 2015. Catching lionfish is labor intensive, as it requires scuba divers to spear them by hand while using PVC tube containers for underwater storage to protect them from the venomous spines. In total, roughly 300 lb of lionfish were harvested by the researchers at an average cost of \$6.50 per pound of whole fish. One pound of whole lionfish yields roughly 1/5 lb of fillet. The entire harvest was cleaned, filleted and prepared by the researchers. At the time of the study, it was also possible to special order lionfish from a Publix supermarket at \$30 per pound of filleted fish, but the researchers were able to harvest a sufficient quantity.

The experiments were conducted at the Pensacola Seafood Festival during 25–27 of September in 2015. The experiment was run over the first two days of the festival. The University of West Florida reserved the festival space (100 ft²) and a research station was set up near the central area at the festival. The researchers, along with two graduate assistants, were responsible for all aspects of the experiments. The lionfish for auction was individually packaged in three-ounce portions and cooked using the sous-vide method of hot water emersion. The filets were cooked to a uniform 135 °F (57 °C).

Participants for the study were recruited at random from the large number of attendees at the seafood festival. Potential subjects were approached, briefly informed that the research team was conducting a study on lionfish and asked if they would like to participate. At this point potential subjects were also informed that they would be given money to participate and they could use a portion of that money to try and purchase a fillet of cooked lionfish. The only requirements for participation were that subjects were at least 18 years of age, of good health (self-evaluation) and that they could speak English. Once a person indicated that they were interested in participating they were

(footnote continued)

external validity of controlled experiments has been discussed in detail in the literature and many studies show comparable results between experimental and non-experimental decision makers (e.g., Plott, 1987; Dyer et al., 1989; Shogren et al., 1999; Alm et al., 2015).

¹ As with all controlled experiments that use convenience samples, the differences observed between treatments could be biased if our particular sample responds to the intervention (information) differently than the general population of interest. The

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