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Mechanisms matter for evaluating the economic impacts of marine reserves☆

Matthew N. Reimer [a,*], Alan C. Haynie [b]

[a] Institute of Social and Economic Research, Department of Economics and Public Policy, University of Alaska Anchorage, 3211 Providence Drive, Anchorage, AK 99508, USA

[b] Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, Bldg. 4, Seattle, WA 98115, USA

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ABSTRACT

Large areas of marine and coastal environments have been protected to satisfy diverse policy goals, but there has been limited work understanding the economic impacts of such closures. While methods for establishing causal impacts are prevalent, less attention has been paid to explaining the mechanisms through which the causal relationship came to be. Understanding mechanisms is crucial for designing policies that foster the mechanisms that achieve the intended objectives of marine reserves and mitigate the mechanisms that do not. We estimate the treatment effect of a large marine reserve on the net earnings of a commercial fishery using difference-in-differences and synthetic-control designs, and decompose the treatment effect into its constituent mechanisms through structural equation modeling. We find minimal evidence that closing the marine reserve to fishing had a significant economic cost for the industry; however, several counteracting mechanisms are critical for explaining the effect and for generalizing to other settings.

1. Introduction

Program evaluation is a critical element of evidence-based policy making for natural resource and environmental management (Ferraro, 2009). When conducted properly, program evaluations assess the degree to which changes in an outcome

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* Corresponding author.
E-mail addresses: mreimer2@alaska.edu (M.N. Reimer), alan.haynie@noaa.gov (A.C. Haynie).

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variable can be attributed solely to a particular policy, and are therefore essential for eliminating any plausible explanations of the outcomes that are unrelated to the policy. Most of the program evaluation literature is devoted to establishing whether a program causally affected an outcome variable; in contrast, relatively few evaluations explain how or why such a causal relationship came to be (Imai et al., 2011). Understanding the mechanisms through which a program influences an outcome variable is important for both testing economic theory and for generalizing results beyond the setting at hand (Heckman and Smith, 1995). Moreover, understanding mechanisms can aid policy makers in designing policies that foster the mechanisms that achieve the intended policy objectives and mitigate the mechanisms that do not (Ferraro and Hanauer, 2014).

We estimate the causal short-run economic impacts and the underlying mechanisms associated with a large marine reserve for the protection of the endangered western stock of Steller sea lions (SSL) in U. S. waters off the coast of Alaska. Marine reserves, or spatial closures more generally, prohibit some or all fishing in a defined geographic area for a specific period of time, and are among the primary tools of marine resource managers in the world. Indeed, the United Nations, national and state governments, and other management agencies having formal goals of placing 10–30 percent of the oceans in marine reserves (Wabnitz et al., 2010). The potential long-term benefits of marine reserves, such as the protection of vulnerable species (Hooker and Gerber, 2004) and/or the spillover effects of rebuilt stocks (e.g., Abesamis and Russ, 2005), are well known and have been discussed thoroughly (e.g., Gaines et al., 2010). However, empirical estimates of the short-run costs incurred by the commercial fishing industry are relatively scarce. Marine reserves can change the opportunities available to fishers—for instance, by forcing them out of productive fishing areas and/or constraining their ability to balance multispecies catch compositions in accordance with annual species-specific harvest quotas (Abbott et al., 2015). A marine reserve may therefore increase short-run costs or reduce revenues, possibly outweighing the benefits of the reserve. Thus, evaluating the short-run costs incurred by the fishing industry relative to any benefits of marine reserves is a critical element for evidence-based policy making for ecosystem-based fisheries management (Smith et al., 2010; Sanchirico et al., 2013).

Previous evaluations of the short-run cost of marine reserves are predominantly *ex ante* analyses, which rely on predictive models of how fishers adjust their behavior in response to a potential spatial closure (e.g., Holland and Brazee, 1996; Hannesson, 1998; Sanchirico and Wilen, 2001; Smith and Wilen, 2003; Berman, 2006; Haynie and Layton, 2010). Unfortunately, evaluating the impact of a marine reserve *ex post* is complicated by the fact that reserves are not implemented in a manner that facilitates the measurement of their causal impact (Smith et al., 2006). For instance, the implementation of a marine reserve rarely generates clear “treated” and “control” groups in which one group of fishermen is not permitted to fish in an area while others are, thereby impeding estimation of the counterfactual outcomes that would have occurred without the closure. In addition, marine reserves typically do not occur in isolation; other factors that influence fishing-related outcomes inevitably change simultaneously, such as total allowable catches (TACs), prices, abundances, etc. Thus, simply using outcomes from before and after implementation of a marine reserve may not isolate the effect of the closure from other simultaneous changes.

Our evaluation of the short-run economic impacts of a spatial closure for SSL protection addresses several important issues that have impeded *ex post* evaluations of marine reserves in the past, and makes several contributions to both the resource economics and program evaluation literature. First, the policy intervention directly affected the annual fishing operations for only a subset of comparable fishing vessels, creating a natural group of control vessels that we can use to estimate the counterfactual evolution of relevant outcome variables (e.g., net revenue) for the affected vessels. To this end, we conduct a comparative case study which estimates the evolution of an outcome of interest for units (here vessels) affected by a particular intervention and compare it to the evolution of the same outcome estimated for some control group of unaffected vessels (Abadie et al., 2010). Comparative case studies for evaluating policy interventions are relatively rare in the fisheries economics literature due to the frequent lack of unaffected and comparable units for constructing a counterfactual.[1]

Second, we are able to estimate the economic impacts of the spatial closure using a unique confidential dataset of annual fishing revenues and costs. Extensive cost data are rarely collected from the fishing industry. Indeed, most *ex post* policy evaluations resort to using proxies for net impacts, such as gross revenues, harvests, or welfare estimates from random utility models. Our unique dataset allows us to estimate net impacts using a measure of net revenues—a combination of fishing revenues and variable costs associated with fishing operations.

Third, we employ empirical methods that allow us to relax some of the limiting features of traditional methods for conducting comparative case studies, such as the standard difference-in-differences (DnD) estimator. In particular, we estimate the average treatment effect on the treated (ATT) of the spatial closure using propensity-score-weighted (PSW) difference-in-differences (Heckman et al., 1997; Hirano et al., 2003), which more closely balances the treated and control groups based on pre-intervention characteristics and initial conditions, and the synthetic control method (SCM) (Abadie and Gardeazabal, 2003; Abadie et al., 2010), which allows for vessel-specific comparison (or synthetic) units and the effects of unobserved vessel-specific factors to vary with time. Importantly, both the PSW and the SCM are transparent and data-driven processes for constructing a comparison group and easily allow the researcher to explore whether the comparison group is sufficiently similar to the treated group for causal inference, a feature that is obscured in the difference-in-differences model (Abadie et al., 2014).

[1] Some notable exceptions of comparative case studies for evaluating fishery policy interventions include Scheld et al. (2012) and Kroetz et al. (2015). Other comparative case study examples in fisheries for evaluating non-policy shocks include Abbott and Wilen (2010) and Jardine et al. (2014).