frontiers in Marine Science

PERSPECTIVE
published: 03 May 2016
doi: 10.3389/fmars.2016.00061

Measuring Management Success for Protected Species: Looking beyond Biological Outcomes

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The complexity of the ocean ecosystem, including the human component, is such that a single fishery may require multiple policy instruments to support recovery and conservation of protected species, in addition to those for fisheries management. As regulations multiply, the need for retrospective analysis and evaluation grows in order to inform future policy. To accurately evaluate policy instruments, clear objectives and their link to outcomes are necessary, as well as identifying criteria to evaluate outcomes. The Northeast United States sink gillnet groundfish fishery provides a case study of the complexity of regulations and policy instruments implemented under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) to address bycatch of marine mammals. The case study illustrates a range of possible objectives for the policy instruments including *biological, economic, social-normative,* and *longevity* factors. We highlight links between possible objectives, outcomes and criteria for the four factors, as well as areas for consideration when undertaking ex-post analyses. To support learning from past actions, we call for a coordinated effort involving multiple disciplines and jurisdictions to undertake retrospective analyses and evaluations of key groups of policy instruments used for protected species.

Keywords: policy instruments, marine mammals, bycatch, social norms, compliance, retrospective analysis, ex-post analysis

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Marine Affairs and Policy, a section of the journal Frontiers in Marine Science

Received: *05 January 2016*
Accepted: *15 April 2016*
Published: *03 May 2016*

Citation:
Bisack KD and Magnusson GM (2016) Measuring Management Success for Protected Species: Looking beyond Biological Outcomes. Front. Mar. Sci. 3:61. doi: 10.3389/fmars.2016.00061

The complexity of the ocean ecosystem, including the human component, is such that a single fishery may require multiple policy instruments to support recovery and conservation of protected species. Many policy instruments are assessed prior to implementation (i.e., prospective or ex-ante analysis) when we have limited information; however, we seldom go back to undertake evaluation after implementation (i.e., retrospective or ex-post) when we have more information (Greenstone, 2009). As regulations multiply, the need for ex-post analysis grows, as it allows us to identify what works and what does not. After 20 years of regulating under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) in the United States (US), regional Protected Resources (PR) leaders for National Oceanic and Atmospheric Administration (NOAA) have voiced their desire to learn how well the policy instruments in place are working, as well as how accurate our estimates of impacts made prior to implementation (ex-ante) are compared to actual economic and biological outcomes (ex-post) (Bisack et al., 2015). In order to undertake such instrument evaluation, evaluation criteria based on measurable outcomes must be identified (Rossi et al., 2004), which in turn are defined by the objectives of the instrument.

Traditionally the performance of protected species management has been measured using biological criteria as proxies for the larger policy objectives and outcomes. For example, under the MMPA the biological objective is to conserve marine mammals as significant functional elements of marine ecosystems, which is primarily undertaken with moratoriums on their direct take. The 1994 potential biological removal (PBR) control rule under the MMPA sets the criteria for how much bycatch is allowed. Yet policy instruments for protected species recovery generally have multiple objectives, suggesting the need for multiple criteria or measures of performance outcomes. Proposed regulations for policy instruments must meet economic and social objectives; evaluation criteria are necessary for these objectives as well. For example, a regulation must ensure that national benefits exceed costs [i.e., under Executive Order (EO) 12866 in the US or the Cabinet Directive on Regulatory Management (CDRM) in Canada] and consider distributional impacts [e.g., among small businesses, minority groups and/or low-income populations under EO 12898, the Regulatory Flexibility Act (RFA) and CDRM]. A regulation may also be required to illustrate that future compliance, monitoring, and enforcement costs have been considered (e.g., under the CDRM), although even when this occurs motivation and incentives to comply are seldom addressed.

We advocate for a coordinated effort involving multiple disciplines and jurisdictions to develop an evaluation strategy for protected species policy instruments. Further, we advocate for the use of multiple evaluation criteria based on *biological, economic, social-normative,* and *longevity* objectives and outcomes, to name a few. The biological and economic efficiency objectives may be more recognizable, and potentially easier to attain, than the distributional concerns of participants in a fishery, which may be captured in social-normative objectives. Instruments that explicitly consider social-normative factors may be better situated to address the distributional issues (e.g., access/exclusion from fishing opportunities), issues which can delay or impede implementation. Since the design and implementation of policy instruments is costly, it may be desirable to include design features that extend the useful life of an instrument by allowing it to adapt to a changing environment (i.e., longevity). With this group of factors in mind, we use the Northeast United States (NE US) sink gillnet groundfish fishery as a case study to illustrate considerations when identifying evaluation criteria. While we recognize that the success of a policy instrument in achieving its objectives may be, in part, unique to the setting, we believe that assessing the strengths and weaknesses of a range of policy instruments is essential to developing successful plans for protection of species in the future.

The NE US sink gillnet groundfish fishery has been regulated under multiple legislative authorities for over 20 years. The MMPA provides the authority to address bycatch of marine mammals such as harbor porpoise in commercial fisheries, while the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) provides the authority to manage commercially fished species in US waters. During the early 1990's, high harbor porpoise mortalities motivated innovative cooperation between industry, scientists and government which resulted in the development of acoustical devices (pingers) that attach to gillnets to deter porpoise interactions (Kraus et al., 1997). The first Take Reduction Plan (TRP) under the MMPA combined pinger requirements and gillnet gear closures to protect harbor porpoise (National Marine Fisheries Service (NMFS), 1998), with monthly rolling closures under the Northeast Multispecies Fishery Management Plan (FMP) (63 Federal Register 66464, December 2, 1998). By 2000, harbor porpoise mortalities/takes were below the PBR level (Waring et al., 2002). However, the reduction in takes under the plan was temporary (Waring et al., 2006), even though restrictions on effort in the commercial groundfish fishery were ongoing to achieve stock rebuilding goals.

By 2004, Days-At-Sea (DAS), initially established in 1994 to limit the number of days a vessel owner could fish, had dropped between 67 and 100% for any given vessel and catch trip limits had tightened (New England Fisheries Management Council (NEFMC), 2006). In addition, a sector allocation program (similar to a harvest cooperative) was introduced, which allocated a share of a groundfish stock to a group of vessel owners that voluntarily joined a sector group. Only one sector formed, the Cape Cod Hook Sector, which was allocated a share of Georges Bank cod. In response to overfishing of several stocks, including Gulf of Maine cod, a 2006 emergency rule implemented differential DAS counting (National Marine Fisheries Service (NMFS), 2006), and NMFS approved a second voluntary sector which was a gillnet gear sector (71 Federal Register 48903, August 22, 2006). In 2010, a revised voluntary sector allocation program was implemented for the entire groundfish fishery. Vessels that did not join a sector fished under the effort controls (DAS) and an Annual Catch Limit (ACL) for all the vessels in the "common pool" (75 Federal Register 18356, April 9, 2010). About 55% of the northeast gillnet vessels joined one of seventeen initial sectors. At about the same time pinger non-compliance was identified as a major source of high bycatch of harbor porpoise, and a revised TRP was implemented. The TRP increased, spatially and temporally, the areas that required pingers to fish, and created an incentive for pinger compliance in the form of a threat—indefinite closures over a large area if compliance remained below defined levels (National Marine Fisheries Service (NMFS), 2009). Industry agreed to the plan that would largely rest on individual responsibility for compliance (i.e., self-policing).

The choice of a policy instrument may influence the objectives that can be considered during design, and consequently during evaluation. As illustrated with the harbor porpoise example, most policy instruments NOAA has implemented for marine protected species under its authorities have used a "command and control" (C&C) approach directed toward fishermen (also see National Marine Fisheries Service (NMFS), 1998; National Oceanic Atmospheric Administration (NOAA), 2006, 2009, 2012). Policy instruments under the C&C approach include controls on inputs (fishing effort, DAS) and outputs (catch, ACLs), as well as technical standards (gear modifications, pingers). Under the C&C approach, the governing agency requires individuals to undertake specific activities to meet specific standards to achieve a specific objective; this approach can limit the ability of individuals to achieve economically efficient outcomes.

In general, the more specific is the requirement, the fewer opportunities exist for individuals to modify their behavior or processes for economic efficiency. The specificity of C&C instruments may encourage the use of sunset clauses, to address concerns of cost and effectiveness. The objectives of a C&C policy instrument for protected species tends to be narrowly focused on a biological outcome, with economic considerations focused on a least-cost or cost-effective objective. While other factors may be considered during policy development, they are seldom explicit.

Economists have long supported policy instruments where market signals create incentives for desired behavioral changes; this may require consideration of additional objectives such as social-normative objectives. Incentives can be classified as positive ("carrots"), such as property rights, or negative ("sticks"), such as taxes, fines or sanctions. In the harbor porpoise case study, the threat of an indefinite closure if pinger compliance did not meet a target was a "stick." Generally positive rewards are preferred to negative punishments, given political and user difficulties with imposing and enforcing sanctions (Polasky and Segerson, 2009). Market-based instruments allow individuals to voluntarily choose how to meet an objective, with prices and other economic variables providing signals to reduce or eliminate negative externalities (e.g., harbor porpoise bycatch). This flexibility may allow the instrument to adapt to changes in economic or biological environments. Market-based instruments, explicitly or implicitly, establish some degree of property right characteristics (exclusivity, divisibility, transferability, duration, and enforcement), that allow for better planning by users, owners and managers. There is a growing literature on the implications of various market-based instruments in fisheries management (e.g., Pascoe et al., 2010; Squires et al., 2013; Innes et al., 2015). Yet, even with these approaches, some forms of technical standards or controls are typically retained to support or complement market measures, further supporting the need for evaluation of C&C instruments.

Theoretical and empirical analyses of policy instruments for protected species have largely focused on biological and economic outcomes. However, objectives based on social norms (e.g., fairness) may also be implicit in an instrument, and an understanding of those norms is important to successful implementation of either C&C or market-based instruments. Social norms include the unwritten, yet mutually understood rules that govern acceptable behaviors and coordinate interactions with others within a society. Human societies use norms of acceptable behavior among their members with the threat of punishment encouraging compliance. There is generally a range within which acceptable behaviors fall, but also a consensus as to when behavior falls within and outside the range of "acceptable skirting" of the rules (e.g., Toner et al., 2014). Misperceptions in group norms, as well as perceptions of a lack of adherence to norms such as fairness, can result in the creation of a new social norm that may run counter to the intensions of the policy instrument; non-compliance may be a potential outcome. Investing in stakeholder meetings during development of a new policy instrument is an approach to understand customary rules of behavior and factors of importance, as well as provide a baseline of existing norms. At times, minor changes in regulations can eliminate small incentives for non-compliance, nudging the average fisherman toward compliance. While details on methods to identify norms go beyond the scope of this paper, non-compliance may be a signal that the norms implicitly assumed by the designers of the policy instrument do not align well with those of the community the instrument impacts.

Few evaluations of protected species policy instruments have been undertaken. A coordinated approach to analysis may create synergies, although such an approach will require agreement on a number of factors such as identification of baselines and evaluation criteria. A few considerations for such an approach are examined below; in particular, we suggest four general criteria as the initial focus. **Table 1** uses examples from the case study to illustrate potential means to identify and measure the proposed criteria. For retrospective analyses and evaluations to be useful the objectives of a policy instrument must be clearly linked to its outcomes or results. As well there needs to be a way to determine if the change in outcome was due to the instrument or other forces. This is done using a baseline which describes what would have happened if the policy instrument had not been implemented. Simulation is frequently used to develop a baseline for retrospective biological and economic analyses. Alternatively, experimental or quasi-experimental design may be used to identify the outcomes of similar situations where the policy instrument was not implemented; these may be called counterfactuals (Greenstone, 2009). Experimental-based counterfactuals for protected species may be difficult to identify due to their imperiled state or legislated requirements; however, alternative locations or jurisdictions and species may provide relevant examples.

The *biological* objective of most actions directed toward protected species is conservation; however, the criteria to evaluate biological objectives may vary depending on the population status and condition of the species such as endangered, threatened (ESA, Species at Risk Act of 2002) or depleted (MMPA). That is, criteria to measure the success in meeting the biological objective may relate to bycatch (incidental take), abundance, distribution, or the probability of extinction of a species. Often determining the biological objective does not automatically translate into measurable criteria to evaluate the outcome. Fisheries observer data have provided fertile ground for ex-ante analysis, prior to implementation of the instrument. There are enough direct interactions observed for species such as harbor porpoise (**Table 1**), loggerhead sea turtles and bottlenose dolphins for ex-ante analyses to attain predictive statistical power (National Marine Fisheries Service (NMFS), 2009), suggesting sufficient data may also exist for ex-post analyses. In contrast, species with limited observed interactions such as the North Atlantic Right Whales (NARW) require non-standard approaches. There are no direct interactions recorded by observers of NARW bycatch in the gillnet fishery; rather, mortality, along with a cause determination, is typically determined post-mortem after carcass recovery. Thus, for a species such as the NARW, performing ex-ante analysis on the implications for a regulation to achieve a conservation objective

TABLE 1 | Examples of evaluation objectives and criteria based on harbor porpoise case study of command and control instruments of pingers and closures.

Objective class	Policy instruments evaluated	Act	Evaluation criteria	Identified during instrument design?	Evaluation criteria used	Implementation strengths/shortfalls
Biological	Pingers and Closures	MMPA	PBR	Yes	Reduce bycatch below PBR	Northeast Fisheries Observer Program data primary and fertile source for ex-ante and ex-post analysis.
Economic	Pingers and Closures	E.O.12866	Net National Benefits (NNB)	Yes	Cost-effectiveness-Analysis (CEA): vessel profit losses per harbor porpoise saved[a]	Benefits not assessed—CEA second best to NNB[b]. Difficult to untangle impacts of non-MMPA and MMPA policy instruments.
Social-Normative	Pingers	RFA, MSFCMA National Standards (NS)	RFA - SBA impacts on small businesses; NS 4[c], 8, 10 - No discrimination among states, consider community impacts, vessel safety	Yes	RFA and NSs: Profit loss and percent impacted by SBA	Stakeholder buy-in not assessed[d]. Self-policing impractical—instrument fails to meet PBR due to non-compliance. NEFOP data—observer effect could bias compliance assessments in ex-post analysis.
Longevity	Pingers	MMPA	New TRP when bycatch exceeds PBR	Somewhat	Frequency of change in TRP (1998 and 2010)	*Ad-hoc* review for MMPA policy instruments vs. periodic appraisal.

While the TRT consists of a team of stakeholders that work collectively to develop conservation measures, it is the fishermen who are asked to comply; focus group participants were unaware of who their TRT representatives are suggesting communication and buy in to comply is unknown.

[a]*The cost of saving one harbor porpoise using closures exclusively vs. pingers exclusively was \$3398 vs. \$583, respectively (National Marine Fisheries Service (NMFS), 2009).*

[b]*See Bisack et al. (2015) for discussion by NMFS economists on pros and cons of CBA and CEA.*

[c]*Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) requires U.S. fisheries to adhere to 10 National Standards (NSs) (16 U.S.C. 1851 §301), including many directly related to social and economic outcomes: NS4, do not discriminate between residents of different states; NS5, consider economic efficiency; NS7, minimize costs; NS8, take into account the importance of fishery resources to fishing communities; and NS10, promote safety at sea.*

[d]*Stakeholder meetings are a strategic way to derive usability objectives from business objectives, and to gain commitment to usability. They also collects information about the purpose of the system and its overall context of use. In contrast, scoping meetings are held to give the public an opportunity to get involved in the development of conservation measures (e.g., proposed policy instruments such as closures or pingers).*

may be challenging. The data however, may be sufficient for the development of ex-post evaluation criteria. For example, to assess the effectiveness of regulations, Pace et al. (2014) developed a novel method that relied on opportunistic entanglement data from 1999 through 2009. The study determined gear modifications as outlined in the Large Whale TRP did not result in a detectable decrease in waiting time (the number of days) between entanglement events. Thus, they concluded management measures implemented during the study period to reduce large whale mortalities were generally ineffective in abating whale deaths from fishing gear entanglements; hence, more action was required. It is worth noting, human behavior was not included in this model. Perhaps a multi-disciplinary approach would have identified the source of the failure and potential solutions.

The *economic* objectives used to inform the selection of a policy instrument for protected species, unlike the biological objectives, are seldom articulated during the development phase of the instrument. However, most developed nations require some sort of ex-ante cost-benefit analysis to support regulatory proposals, although allowance for cost-effective analysis may exist in some guidance documents (e.g., Treasury Board of Canada Secretariat (TBS), 2007). For example, in the US, Executive Order 12866 requires an evaluation of costs and benefits of regulatory proposals to US society and a determination of net benefits to the Nation (net national benefits). In Canada, the CDRM requires an evaluation of social and economic impacts, and directs authors of a regulation to identify the "instrument that maximizes net benefits for [Canadian] society." Most economic analyses for protected species are ex-ante analyses, and economic measures of benefits are often not available. In such cases, net benefits analysis may be replaced with cost-effectiveness analysis, such as the cost of saving a porpoise estimated in the 2010 TRT plan (**Table 1**; National Marine Fisheries Service (NMFS), 2009). Instruments, however, may not always require regulation; instrument actions may be voluntary or negotiated between parties (Segerson, 2010). In such cases ex-ante analysis may not be undertaken and retrospective analysis may be more challenging. Examples of ex-post economic analyses are relatively rare and focus on regulatory change. While not specific to protected species, Lee and Thunberg (2013) showed the benefit of moving to catch shares by evaluating the additional cost if the US Northeast groundfish fishery had instead remained under DAS. In that scenario, the US society would have been $33 million worse off ($25 million in consumer surplus and $7.5 million in producer surplus). Squires showed a $75 million loss in US consumer surplus as a result of increased sea turtle bycatch in foreign waters following driftnet fishery area closures to protect sea turtles in the US (Bisack et al., 2015).

Explicit incorporation of *social-normative* objectives in policy instrument development is rare, and yet these factors may have a significant impact on the implementation and outcomes of policy instruments (Revesz and Stavins, 2007). Both norms surrounding compliance and level of participation in the creation of regulations are important determinants of eventual compliance behavior (e.g., Dalton, 2005a,b; Pomeroy and Douvere, 2008). Not considering these factors can reduce compliance and result in unmet goals and objectives. Social pressure (community), perceived legitimacy, fairness, and morals (stewardship) are all examples of normative factors. The case study of the gillnet fleet and high non-compliance with pinger regulations illustrates the importance of social-normative factors (**Table 1**).

The fundamental premises of consequential closures in the 2007 TRP were: (1) as a result of the threat, non-compliance with pinger requirements would decrease and ensure bycatch rates would not exceed benchmark limits; and, (2) the threat of indefinite seasonal closures would encourage fishermen to enforce compliance with pinger requirements among their communities (i.e., self-police). However, successful "self-policing" requires a small group or community that conducts activities in a confined setting with members that have face-to-face contact (Dietz et al., 2003). Northeast sink gillnet vessels reside in ∼22 different ports on the long New England coastline from Maine to Connecticut, making face-to-face contact problematic. During focus groups, sink gillnet fishermen who are members of groundfish sector groups self-report that they have a high level of compliance with pinger requirements (Bisack and Clay, 2012). Sectors are typically limited to a small number of members and for gillnet, the negotiated contract identifies pinger violations as one cause for expulsion. Focus group participants provided insights into pinger non-compliance including: they knew who the "violators" were in their (local) communities, saw punishment as non-existent (lack of fairness), and, while they believed pingers deter porpoise (legitimacy of the solution), they also believed the stock was healthy and therefore management was unnecessary (legitimacy of problem). Work such as this may provide a framework for future stakeholder meetings to gather information on social norms when developing new policy instruments. This information may improve understanding of potential outcomes and assist with retrospective analyses, as well as support the development of methods and systems to gather baseline information on norms or identifying counterfactuals for retrospective analysis.

Lastly, one objective of instrument design seldom discussed is *longevity*, which considers whether the instrument is able to continue to achieve the intended outcomes over time, given changes in human behavior and environmental conditions. That is, given the biological, economic, and social-normative factors associated with the instrument, how long should we expect that instrument to continue to meet the purpose and need for the policy? The RFA requires a periodic review of some regulations to consider this question, while one of the benefits of market-based policy instruments is their ability to allow participants to respond to changing conditions. Diametrically opposed to longevity are sunset clauses, which are often added simply as a means to get disparate groups to agree to a policy. While such clauses may purport to be concerned with outcomes and effectiveness, their actual timing may occur before results are anticipated and may not include measures to evaluate effectiveness, an issue for data-poor and long-lived species such as NARW (78 FR 73726, December 9, 2013). Synergistic and cumulative impacts with other management actions are likely to have an impact on the longevity of a policy instrument, and need to be considered as well. For instance, under the MMPA closures may coincide with changes in effort on commercial stocks targeted by sink gillnet vessels. Achieving the MMPA biological PBR criteria is feasible when there is no change in the fish management actions that suppress effort. However, if fishing effort increases as fish allocations increase, the objectives of the closure may be defeated as takes of PR increase in the open areas. Instrument effectiveness may also decline due to biological factors. For example, concerns have been raised regarding the potential for harbor porpoise to habituate to pingers. While one field experiment found porpoises in the Bay of Fundy habituated to a specific pinger and were not alerted to echolocate by pingers (Cox et al., 2001), alternative analysis using interaction data from the NEFOP concluded there did not appear to be habituation (Palka et al., 2008). In general, concerns about changes in biological or environmental conditions are addressed by reactively adding additional instruments onto existing measures. While sunset clauses and retirement plans should be considered during design, possible evaluation criteria include measures of the frequency of modifications or additions to the instrument (**Table 1**).

The need for retrospective analysis of individual policy instruments and evaluation across instruments and settings, for marine protected species is clear, but the way forward is less so. The management of marine fisheries with protected species interactions is set within a complex system. Ecosystem based management (EBM) can provide a natural bridge between single species assessments and management. However, current EBM models are frequently missing the economic and social components, which would consider interactions between ecological and human systems. Retrospective analysis and evaluation can guide us. We need to identify a common language for a multi-disciplinary approach and select a small number of data rich examples for an initial analysis and evaluation. We encourage looking beyond national borders for potential counterfactuals, increasing data collection on non-biological factors for baseline development and suggest further consideration for quasi-experimental design opportunities. The information gleaned from retrospective analysis and evaluations can help identify the key factors to consider when choosing an instrument (e.g., biological, economic, social-normative, and longevity). The goal is more effective use of policy instruments from all perspectives.

AUTHOR CONTRIBUTIONS

All authors listed, have made substantial, direct and intellectual contribution to the work, and approved it for publication.

ACKNOWLEDGMENTS

We thank Drs Patricia Clay, Eric Thunberg and Michael Simpkins and two anonymous reviewers for their comments. The views expressed in this manuscript do not reflect those of the National Marine Fisheries Service or those of Fisheries and Oceans Canada.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.