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Understanding Non-compliance With Protected Species Regulations in the Northeast USA Gillnet Fishery

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Marine mammals and sea turtles in the United States are protected from commercial fishery interactions under the Marine Mammal Protection Act and the Endangered Species Act. To reduce harbor porpoise bycatch in the northeast sink gillnet fishery, fishermen are mandated to attach pingers to their nets in regulated areas. Although, pinger regulations have been in place for over a decade, in practice, enforcement is weak and the penalty for a violation is almost non-existent. In this scenario, the presence of normative factors may motivate a fisherman to comply with the pinger regulation. This study considers both economic and normative factors within a probit framework to explain a fisherman's compliance decision. Model results indicate fishermen who previously violated pinger regulations, who are not completely dependent on gillnet gear and face a lower chance of being detected by an observer, are more likely to violate. Understanding the influence of normative factors on compliance decisions is a key component for higher compliance. That is, incorporation of these factors in the design of policy instruments may achieve higher compliance rates and thus more success in protecting these species. Our model findings were ground-truthed by conducting focus group research with fishermen using pingers; some preliminary findings are shared in the discussion in support of our model results. Finally, these results also suggest observer data can be used to support compliance and enforcement mechanisms in this fishery and possibly other fisheries as well.

Keywords: non-compliance, fisheries, normative factors, law enforcement, observer effect, U.S. endangered species, marine mammals

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INTRODUCTION

Non-compliance with regulatory requirements can derail resource management objectives. Biological assessments used to monitor the health of a stock can trigger management responses and regulatory actions when stocks are in danger of over-fishing. In most cases, fisheries and marine mammal management rely on regulatory instruments such as a command-and-control approach, in the form of fishing effort reductions and gear standards to protect the stock. Regulatory instruments *direct* individuals how to behave; while economic instruments, market based, can be designed with incentives to *influence* an individual's behavior, to achieve the same desired goal. Therefore, choosing a policy instrument is a strategic choice. Resource managers can use any combination of instruments, however, if goals are not met, non-compliance may be the source of failure and not the policy instrument itself; additional policy instruments may not rectify the problem and cause further economic harm. Hence understanding the underlying motivation of behavioral responses to regulations is crucial and may allow us to design more successful policy instruments. In this paper, we examine economic and normative factors that may motivate compliance behavior in the sink gillnet fishery in relation to required gear standards in order to protect porpoise under the United States (U.S.) Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. 1361 et seq.).

The MMPA established a long-term regime for governing interactions between marine mammals and commercial fishing operations; the potential biological removal (PBR) control rule enacted under the MMPA Amendments of 1994, specifies the allowable level of human-induced mortality for a marine mammal stock (MMPA 1972, section 1386). In the northeastern United States (US), the National Marine Fisheries Service (NMFS) is primarily responsible for protecting populations of harbor porpoise (*Phocoena phocoena)*, northern right whales (*Eubalaena glacialis)*, coastal bottlenose dolphins (*Tursiops truncates),* and loggerhead sea turtles (*Caretta caretta)* via the MMPA and Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531) (Resolve, 1996; NMFS, 2002, 2005; NOAA, 2006a,b,c). One of the major threats to their survival is lethal injuries from interactions with commercial fishing gear, including sink gillnet gear.

Most policy instruments the National Oceanic and Atmospheric Administration (NOAA) has implemented to protect marine mammals under its authorities have been a "command and control" approach. In general, time and/or area closures reduce or shift fishing effort out of a high bycatch area by prohibiting fishing completely; gear standards reduce the bycatch rate and allow vessels to continue fishing. While closures can be monitored remotely (e.g., electronic vessel monitoring systems) or by patrolling the area, monitoring gear compliance involves hauling gear at-sea for inspection; it can be more labor intensive and thus costly.[1] Consequently, in terms of compliance detection (e.g., monitoring) and cost, a closure may be the preferred policy instrument for the regulator while the individual being regulated may prefer gear modifications since they can continue fishing in the proposed closed area.

In 2007, harbor porpoise bycatch exceeded PBR (U.S. Department of Commerce, 2010) and based on the statutory requirements contained in Section 118 of the MMPA, NMFS was required to take action. Closures and acoustical devices (pingers), a gear standard, were the two primary policy instruments chosen to reduce the harbor porpoise bycatch in the northeast sink gillnet fishery to levels below PBR under the 1999 Harbor Porpoise Take Reduction Plan (HPTRP). Non-compliance with pinger regulations was as high as 65%, from 1999 to 2007, in some regulated areas in the northeast, based on data collected in the Northeast Fisheries Observer Program (NEFOP) (Palka et al., 2009).

Regulators often rely on strict enforcement and penalties to achieve high levels of compliance. An individual will violate a regulation if the expected illegal gain exceeds the penalty, which is a function of the size of the fine for non-compliant behavior and the detection rate of a violation (Becker, 1968). Sutinen and Anderson's (1985) seminal conceptual work on law enforcement was followed with empirical papers confirming Becker's original hypothesis (Sutinen and Gauvin, 1989; Bean, 1990; Sutinen et al., 1990; Furlong, 1991; Kuperan and Sutinen, 1998; Hatcher and Gordon, 2005; Shaw, 2005), demonstrating the economic gain often outweighs the penalty. King and Sutinen's (2010) survey of the northeast United States groundfish fleet indicate the deterrence effect of the existing enforcement system is weak; violations had a 32.5% probability of being detected, and if detected, a 33.1% chance of being prosecuted and resulting in a penalty. Economic gains from violating fishing regulations are nearly five times the economic value of expected penalties. The incentive to not comply is high.

Sink gillnet vessels, members of the northeast groundfish fleet may find it more practical to take the risk of receiving an unintentional first offense of $200 (NOAA, 2014) vs. purchasing pingers; what's more, the maximum statutory penalty for a MMPA violation is equivalent to the initial cost of pingers, $8000 (NMFS, 2009). Thus, the likelihood of a pinger violation leading to an arrest, prosecution and a *fine* is extremely low. However, evidence in various fisheries indicates the majority of fishermen seemed to comply even when the expected illegal gain did exceed the penalty (Kuperan and Sutinen, 1998; Sutinen and Kuperan, 1999). Normative influences may motivate an individual to comply. That is, social norms (obligatory, shared or forbidden behaviors) mediate the way in which people in society behave (Ostrom, 1990, 2000; Wiber et al., 2004). Moral, ethical, legitimacy, and social influences can induce an individual to comply even when the economic incentives for non-compliance are high.

Sutinen and Kuperan (1999) extended Becker's crime model; they developed a theoretical framework which adopts work by Adam Smith (1759) that explicitly portrays human economic motivation as being multidimensional, arguing the psychic well-being is based on acting morally and receiving the approval of others, as well as enhancing wealth. Kuperan and Sutinen's empirical work (1998) found that compliance in a Malaysian fishery depended on the tangible gains and losses, as well as the moral development, legitimacy, and behavior of others in the fishery (Sutinen et al., 1990). Hatcher et al. (2000) made a similar conclusion in regard to fishermen's compliance with quota in the United Kingdom fisheries; a significant positive relationship between perceptions of fairness and levels of compliance was reported though a follow up study confirmed the deterrence effect but found less evidence of normative factors influencing compliance (Hatcher and Gordon, 2005). Similarly, Keane et al. (2008), Nielsen (2003), and Nielsen and Mathiesen (2003), communicated how normative factors (e.g., legitimacy of the imposed regulations) influences individual's compliance decisions while Eggert and Lokina (2008) showed the importance

[1] A dock-side gear inspection program is a lower cost alternative, however, the effectiveness of monitoring compliance may be species dependent; while a vessel may pass a dock-inspection for Turtle Excluder Devices or pingers, that does not enforce proper use at sea. http://www.greateratlantic.fisheries.noaa.gov/protected/porptrp/ptci.html

of normative variables in addition to deterrence variables in explaining compliance behavior of the Tanzanian Lake Victoria fishers. A deterrent, which in practice usually means greater enforcement, is not the only way to improve compliance. Sutinen (2010) argues policy makers should pay more attention to the institutional design to strengthen perceived fairness and legitimacy of the management process.

Normative influences may motivate a fishermen to comply with protected species regulations. The existence of laws and policies such as the MMPA and ESA, imply society values these animals. According to Lavigne et al. (1999), North American attitudes toward marine mammals have in many respects paralleled the evolution of attitudes toward the environment, endangered species and wilderness (Richardson and Loomis, 2009; Wallmo and Lew, 2012). Marine mammals are part of a healthy marine ecosystem and may factor into a fishermen's livelihood. There is an inherent incentive for fishermen to protect their income; fisheries regulations directly impact their day to day earning decision. In a 2012 meeting of fishermen discussing pinger compliance, similar values were echoed: "All I know is in this room there is not a guy in here that wants to hurt a porpoise or whale" (Appendix in Supplementary Material, comment 1). Hence, normative factors may explain compliance decisions with harbor porpoise pinger regulations in the presence of economic incentives to not comply.

We develop a behavioral model which incorporates deterrent (e.g., perception of detection), economic and normative factors (e.g., moral, legitimacy, and social influences) to investigate compliance decisions. Specifically, the compliance behavior of fishermen in the northeast sink gillnet fishery under the 1999 TRP with regard to pinger compliance is examined from 2007 to 2010. Proxy variables are developed from NMFS observer data, NEFOP, to model normative factors. Potential biases with observer data were identified as a concern because forewarned captains may fix problems before the observed trip; however, we are not measuring compliance rates but instead attempting to understand compliance behavior. Our model findings were ground-truthed by conducting focus group research with fishermen using pingers; some preliminary findings are shared in the discussion in support of our model results. The percentage of outcomes correctly predicted is 92% based on model estimates. Our results also suggest observer data such as the NEFOP can be used to support compliance and enforcement mechanisms in this fishery, though this is likely applicable to other fishery compliance problems as well. The intent of this study is to identify the importance of understanding and including normative and economic factors that may influence fishermen's compliance decisions, in order to design effective regulations to protect harbor porpoise.

BACKGROUND

Gillnet Fishery

Sink gillnet gears are used by vessels targeting commercially sought species such as, cod (*Gauds morgue*), spiny dogfish (*Squalls acanthi as*), pollock (*Pollachius virens*), goosefish (*Lophius americanus*), and flounder (*Pleuronectiform*). These vessels operate from Maine to North Carolina. The mix of species landed varies by season and area. In season-areas where groundfish landings, such as cod, pollock, flounder and goosefish are prevalent, dogfish landings are generally absent. Typically, gillnet vessels leave their ports in the early hours of the morning, haul their catches, reset their gears, and return to port the same day. A vessel usually hauls four to eight strings of gear per trip, where one string is around 3000 feet in length. Gear is set in the water to soak for 24–72 h, after which it is hauled and reset. During the long soaking period of gillnets, harbor porpoise (*Phocoena phocoena*) become entangled in the gear and suffocate.

Harbor Porpoise Management

During the last 25 years there have been cycles with harbor porpoise bycatch above or below PBR (Waring et al., 2012). The MMPA indicates that when the 5-year average annual bycatch estimate is greater than PBR (Wade and Angliss, 1997), the following process is initiated to reduce bycatch. First, the stock is designated "Strategic," which requires convening a *Take Reduction Team* (TRT). The TRT has 6 months to develop a plan that will reduce bycatch below PBR within 6 months of implementation of the plan, with a long-term goal of reducing bycatch to an insignificant level approaching zero. The HPTRP implemented the pinger requirement on 1st January 1999 (63 Federal Register 66464, 2 December 1998) after the 1994-1998 average bycatch rate exceeded PBR.

In December 2007, NMFS reconvened the team to consider additional modifications to the HPTRP to reduce harbor porpoise bycatch in New England and Mid-Atlantic gillnet fisheries to levels below the stock's PBR and approaching ZMRG. High non-compliance rates with pinger regulations was one of the reasons bycatch levels exceeded PBR. Enforcement presence was lacking. Since 2012, two pinger violation cases have been prosecuted by NOAA's Office of General Council in the northeast. A $4000 fine was issued in 2014 to a vessel found in "contravention of applicable regulations designed to prevent harbor porpoise from interacting with fishing gear" (NOAA, 2015); and in 2012, a written warning was issued to another vessel for "fishing in the closed offshore area without pingers" (NOAA, 2013).

The focus of this study is the 2010 fishing year (June 2009–May 2010), when gillnet vessels were operating under that 1998 HPTRP plan (NMFS, 1998). According to this plan, vessels could continue fishing if they attach pingers to their gear in the following areas: the Mid-Coast, Mass Bay, Offshore and Cape Cod South Area, north of 40°N (**Figure 1**).

METHODOLOGY

Conceptual Framework

Although pingers regulations are in effect for over a decade, a systematic way to monitor compliance does not exist. Under the current institutional structure, researchers detect and assess pinger violations via NMFS's NEFOP. In general, violations are recorded by NEFOP observers; however, observers do not report

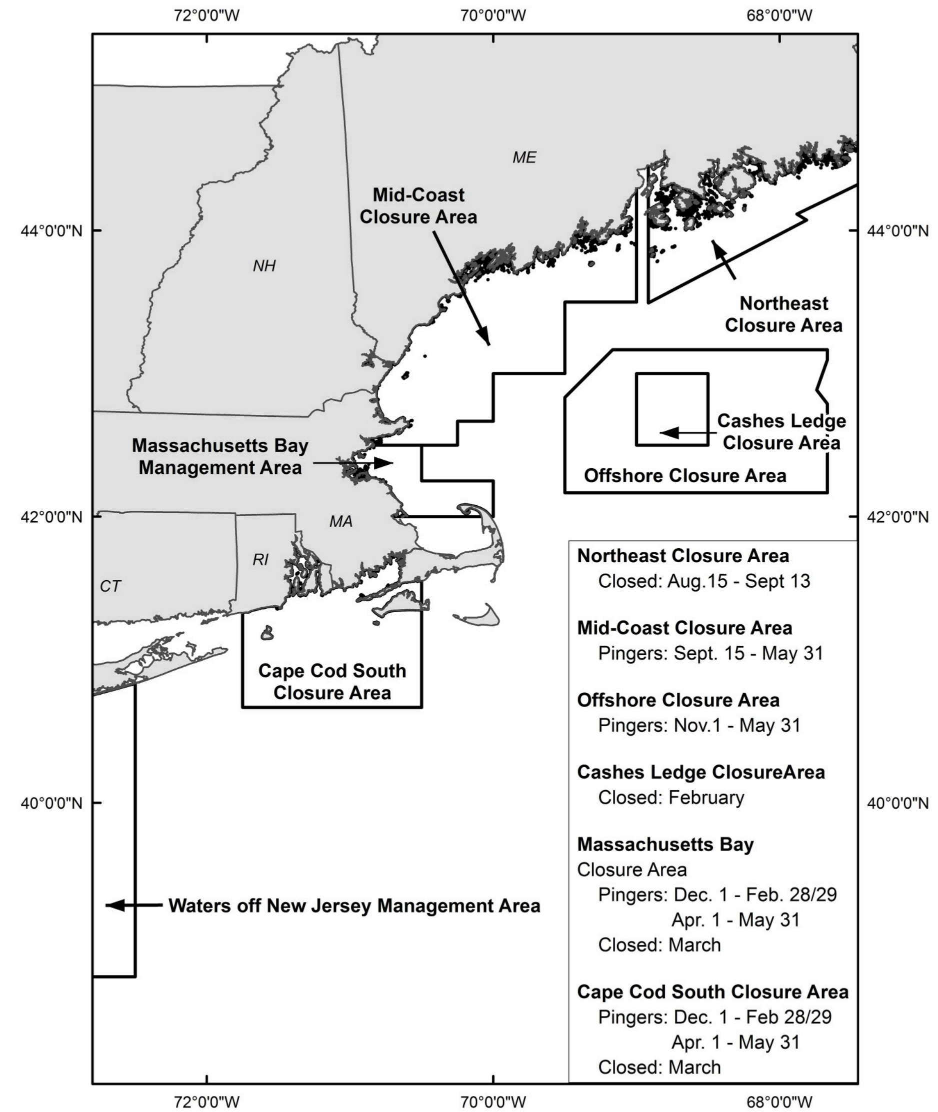

FIGURE 1 | 1998 Harbor porpoise TRT management areas in the northeast (NMFS, 2009).

to enforcement[2]. As a consequence, the likelihood of an observed violation leading to punishment is rare. Moreover, a common belief among fishermen is pingers adversely impact catch and thus revenue; pingers are known to act as dinner bells for harbor seals that eat the warm bellies of cod caught in the gear (Bisack and Clay, 2012). Although there has been no experiment to study the impact of pingers on catch since 1997 (Kraus et al., 1997), the 2007–2010 NMFS observer data show significant differences in cod and pollock catch rates between strings with 100% and zero pingers present [$p = 0.0040$ (equal variance) or $p = 0.0159$ (unequal variance)][3]. An average gillnet trip (8 strings with 10 nets per string soaking for 24 h) fishing with pingers could incur a revenue loss on average of $1535 per trip (= 1190 pounds less cod and Pollock *$ 1.29 per pound). With the potential perception that the economic benefit of compliance is lower than non-compliance and a low likelihood of a fine being issued, the economic incentive for non-compliance is assumed to be high. Under this environment, a fisherman's compliance behavior may be explained by normative influences.

We consider three broad types of normative variables: individuals' moral values, social influences and their perceived legitimacy of the regulations. We hypothesize that a fishermen's attitude toward compliance can differ due to differences in their moral standards. An individual's behaviors are often motivated by their personal moral values (Frank, 1996; Nielsen, 2003; Nielsen and Mathiesen, 2003). That is, an individual concerned

[2]NOAA's Office of Law Enforcement (OLE) has requested this information from NMFS, yet only two cases have been prosecuted between 2012 and 2014.

[3]NMFS observed hauls targeting cod (Gadus morhua) and pollock (Pollachius virens) had a mean catch rate of 2.38 pounds of fish per net soak hour ($n = 749$, $std = 0.098$) while hauls with zero pingers had a mean catch rate of 3.00 pounds of fish per net soak hour ($n = 316$, $std = 0.238$).

with the principles of right and wrong behavior, may feel obligated to obey the law, and thus gain a greater sense of satisfaction by behaving an honorable way.

Social interactions can also influence an individual's attitude toward compliance. A person is likely to be more non-compliant the more his community and peer groups are non-compliant (Vogel, 1974; Geerken and Gove, 1975; Witte and Woodbury, 1985; Robinson and O'Leary-Kelly, 1998; Beams et al., 2003). O'Fallon and Butterfield (2012) explain the occurrence of unethical behavior through three different theories: social learning (i.e., "I behaved unethically because I observed my peers doing it and being rewarded for it"), social identity (i.e., "I behaved unethically because unethical behavior is the social norm"), and social comparison theory ("If I do not engage in unethical behavior, I will fall behind my peers"). There are many reasons a person may be persuaded to make a decision in a particular direction; formal unions are a peer pressure mechanism for example. However, peer pressure may or may not make a difference since it is just one of several factors to consider.

The legitimacy of regulations can also impact an individual's decision to comply. Their perception of the problem and solution can impact their compliance decision; they may question the need for protection and whether the solution works (e.g., whether pingers repel porpoise). The literature on local management or co-management approach to fisheries governance suggests that a greater involvement of fishermen in the management process will lead to increased levels of compliance because regulations will then be accorded greater legitimacy. To be precise, participation by fishers in the management process is considered by many as "essential" for achieving more sustainable, equitable, and efficient management outcomes (Ostrom, 1990; McCay and Jentoft, 1995; Pinto da Silva and Kitts, 2006; Rountree et al., 2008; Yochum et al., 2011). We tend to support solutions with greater satisfaction if we participate in the development of the solution.

Many factors contribute to an individual's personal decision on an issue. The objective of this study is to analyze the influence of these economic and normative factors, in addition to deterrents and a set of vessel characteristics, on an individual's compliance behavior. A formal model of the decision process is given below.

Model Specification

A binary choice modeling framework is used to explain a fisherman's compliance behavior. We assume a fisherman will decide to violate the pinger regulation if their expected utility from non-compliance exceeds the expected utility from compliance. In this scenario, the difference in the expected utilities of the individual is modeled as follows:

$$y_i^* = \beta' x_i + \varepsilon_i$$

Where, x represents a vector of variables that effect a fisherman's compliance decision, β is the vector of unknown parameters and ε_i is the error term. In practice, we do not observe utilities, or y_i^*. What we observe instead is the binary choice variable V_i, which indicates whether a violation has occurred or not. The relationship between y_i^* and V_i can then be defined as follows:

$$\begin{aligned} V_i &= 1 \quad \textit{if } y_i{}^* > 0 \\ V_i &= 0 \quad \textit{otherwise.} \end{aligned}$$

The probability of violation is written as:

$$\begin{aligned} Prob\,(V_i = 1) &= Prob\left(\varepsilon_i > -\beta' x_i\right) \\ &= F(\beta' x_i) \end{aligned}$$

Where F is the cumulative distribution function of ε. If we assume ε is independent and an identically distributed standard normal, we obtain a probit model which can be expressed as:

$$Prob\,(V_i = 1) = \Phi(\beta' x_i)$$

Where, Φ(.) is a standard normal distribution function. The parameters of this binary probit model are estimated via a maximum likelihood method. In a probit model, the estimated coefficients cannot be interpreted as marginal effects; rather they are calculated as follows (Greene, 2000):

$$\frac{\partial E[\nu|x_i]}{\partial x_i} = \varphi(\beta' x_i)\beta$$

The dependent variable, violation V_i is equal to 1 if vessel i violated the pinger regulations under the 1998 HPTRP plan at least once in the 2010 fishing year (May 2009–April 2010). A gillnet haul was considered in violation of the pinger regulation if the vessel did not have the correct number of pingers attached to the gillnet gear (Palka et al., 2009).

Our independent variable vector x, includes a set of vessel characteristics, deterrence and normative variables. Characteristic variables consisted of a vessel's registered gross tons (*GT*), the ratio between the engine horsepower to vessel length representing the vessel's capital stock (*HPLEN*), the number of years the captain has been fishing with gillnet gear (*CYRS*) and gross revenues (*GREV*) the vessel earned within the last year. We assume the expected fine is less of a deterrent to high earning vessels and test whether the probability of violating pinger regulations is related to high earning revenue vessels. We also examine whether vessels fished gillnet gear exclusively within the last year; vessels may have *less* flexibility to adjust their behavior in response to changes in regulations specific to gillnets if they fish the gear exclusively (GGE = 1), and therefore more likely to comply.

Fishermen that perceive low detection probabilities may consider this factor in their compliance decision. NMFS observer data are used to identify pinger violations in order to assess compliance rates for management. We consider the idea that NMFS observers can be a substitute or complement to enforcement. That is, does the presence of an observer deter non-compliant behavior similar to an enforcement agent? We include a detection variable that captures the vessel's history of being observed over several years to test whether being observed in previous year's influences their compliance in the current year. A person may be compliant whether an observer has been on board or not. Specifically, the detection variable is positive (*DETECT = 1*) if a NMFS observer was aboard the vessel while fishing in pinger areas, at least once in *each* of the previous two fishing years (May 2007–April 2009). Vessels can be observed more than once within a year. However, by adding the additional requirement of sampling two consecutive years for our deterrent variable (DETECT), we test whether consistent annual observer sampling of a vessel influences their compliance behavior.

The normative variables considered take account of both intrinsic and extrinsic values that may influence behavioral outcomes, such as a compliance decision. Our assumption regarding these factors is lower moral values for example, are associated with lower compliance rates while higher values with higher compliance. We construct proxy variables using existing data due to a lack of direct observable data (e.g., interview survey data) for these factors. We assume a vessel's previous violation history captures the decision maker's moral behavior. That is, persons with a history of repeat violations are associated with lower moral values compared to persons with no violations; some individuals follow the law no matter what. The variable recording the vessel's violation history is positive (V_OLD=1), if the vessel has two (2) or more observed pinger violations in the previous 2 years; a violation did not have to occur in consecutive years. We therefore examine whether vessels that have a violation in the current year are more likely to have violated in previous years. Individuals with two or more violations (V_OLD=1) observed in two consecutive years (DETECT=1), may be lackadaisical or casual about regulations, may have low moral standards, but are classified as repeat violators.

Social influences can affect compliance decisions. An individual may feel compelled to not comply with regulations if others are not complying. There were no apparent groupings of sink gillnet vessels fishing with pingers at the time of this study in any particular area. Nonetheless, vessels fishing from the same port of landing are likely to have more opportunities to communicate about prices, regulations etc., compared to vessels fishing in different ports. As a consequence we attempt to understand this factor by including a proxy social variable; we include a "port behavior" variable which indicates whether another vessel in an individual's landing port also had a pinger violation (*PBEHAV = 1*). Specifically, our model tests whether port effects are present; are vessels more likely to not comply if other vessels in their port do not comply as well? Vessels landing in multiple ports were assigned to their highest revenue port.

Our proxy legitimacy variable tests whether a fishermen's involvement in the management process influences compliance with regulations. Specifically, we determine the decision maker's affiliation with a HPTRP team member within their port; members include gillnet fishermen from Maine to Rhode Island, though members are not in every port. A fisherman having direct access to a TRT member may allow information sharing, cooperation, and potential collaboration with the development of the HPTRP. We test whether a fishermen is more likely to comply if they have an active TRT member in their port ($TRT = 1$) *or not* ($TRT = 0$).

Many factors can enter an individual's decision process. We develop proxy normative factors in the absence of a formal compliance survey. Our intent is to investigate alternative normative factors in addition to the expected economic factors that influence a person's decision. This may lead us to consider developing a more formal compliance survey in the future.

DATA

Model Data

Pinger violations, non-compliance, are observed and calculated by using data from the NEFOP, the only available data source to estimate compliance rates. Several data bases are used to build our compliance model data set. The Northeast Commercial Fisheries database and the Northeast Vessel Tracking and Reporting database were used to estimate a vessel's gross revenue (*GREV*) and number of different gears types used within a fishing year (*GGE*). The NMFS Northeast Regional Office's (NERO) Vessel Permit database identifies a vessel's characteristics such as horse power, length and gross tons.

The first step involves identifying all *observed* gillnet vessels fishing in pinger regulated season-areas during our current fishing year, June 2009 through May 2010. The NEFOP observed 52% of the gillnet vessels fishing in areas that require pingers during the current year. Using this unique observed vessel list, we track each vessel from June 2007 to May 2009, two previous fishing years, to calculate a vessel's violation and detection history. Several different databases are accessed over the study period to construct our set of independent variables (**Table 1**) to identify statistically a set of factors that may explain a vessel's compliance behavior in the current year (dependent variable).

During the current fishing year (2009-2010), 248 gillnet vessels took 15,022 trips north of the 40 degree latitude line, earning revenues of $45.6 million dollars. Of these, 107 vessels (43%) fished in areas that required pingers and earned revenues of $8.3 million in pinger managed areas (18% of the total revenue earned by all 248 active gillnet vessels). The NEFOP observed 56 gillnet vessels that had the same operator during the entire study period (2007–2010); this is important because our independent variables include fishing history. We assume the individual making the

TABLE 1 | Description of independent variables.

Variable	Description
CYRS	Number of captain years fishing
HPLEN	Ratio of engine horsepower to vessel length
GREV	Gross revenues of vessel in the previous year (in $1000)
GTONS	Gross tons
DETECT	Perceived probability of detection (observed in each previous 2 years at least once = 1; else = 0)
GGE	Fish gillnet gear exclusively yes = 1; no = 0
V_OLD	Previous violations (at least 2 observed violations in the previous 2 years =1; else = 0)
PBEHAV	Port Behavior of other vessels (yes, others violated = 1; no = 0)
TRT	TRT member belonged to this port? (yes = 1; no = 0)

compliance decision is the vessel operator; therefore our sample consists of vessels that have the same decision maker (operator or captain) over the entire study period. Our data and model results therefore represents 52% (=56/107 vessels) of the fleet fishing with pingers during our study period.

Focus Group Data

Following the completion of this model, researchers held several focus group meetings with the objective of ground-truthing the compliance model results reported in this paper. NOAA Fisheries (NMFS) frequently uses qualitative research such as focus groups and cognitive interviews to facilitate the development of survey instruments. This qualitative research was conducted in facilities that allow observations of the discussion or interview and provide a professional atmosphere for the research. Four focus group sessions with 15 invited gillnet fishermen from Rhode Island to Maine participated (Bisack and Clay, 2012) during the week of 4–8 March 2012. Focus group sessions were facilitated by the researchers. We share some preliminary findings regarding fishermen's perceptions in our discussion section to interpret some of our statistical model findings that follow. Invited fishermen were asked to express their opinions on several normative factors considered here and about regulations in general. Some selected comments by the participants are presented in the appendix. Our model results are based on 2007 to 2010 data and though the focus group meetings were held 2 years after these period, selected comments are robust and independent of the time delay.

RESULTS

During the 2009–2010 fishing year there was at least 1 observed violation on 66% of the vessels (=39/56 vessels) and on 51% of the observed trips in our sample. On average, observed vessels fishing in pinger management areas weighed 21 tons, had a measure of 8 horse power units per vessel foot, earned $228,325 in annual revenues and had captains with 24 years of experience in gillnetting (**Table 2**). Data indicate 79% of the vessels used gillnet gear exclusively. Based on their 2 year history, 48% had an observer on-board their vessel for 2 consecutive years while fishing in pinger areas. Previous violations were present for 55% of the vessels, our moral proxy variable. Our proxy legitimacy and social influence variables indicate 38% of the vessel operators were affiliated with a local TRT member in their port, and 54% resided in a landing port where other vessels had a violation.

Table 3 reports the estimated probit coefficients (estimated with SEs) for the incidence of non-compliance, violations, with pinger regulations among vessels. The log-likelihood test rejects the zero-coefficient hypothesis implying that the model fits the data well ($p < 0.0001$). The percentage of outcomes correctly predicted is 92% based on the model estimates. This suggests an overall good fit of the model. All variables, except the port behavior (*PBEHAVE)* and *TRT*, were significant at 95% level or higher (**Table 3**). Marginal effects were calculated at the individual observation and then averaged over the sample. The marginal effects show a particularly strong influence on VIOL in the estimated model for some variables such as DETECT and GGE.

TABLE 2 | Summary statistics and frequency distribution of the independent variables.

Continuous variables	Mean	Standard deviation	Min	Max
CYRS	24	10	3	45
HPLEN	7.98	2.14	4.6	13.81
GREV ($1000)	228.33	124.23	17.57	644.69
GTONS	20.89	10.15	4.00	65.00
Dummy variables	**Frequency**		**Percent**	
VIOL	39		66.10	
DETECT	27		48.21	
GGE	44		78.57	
V_OLD	31		55.36	
PBEHAV	30		53.57	
TRT	21		37.50	

No. Observations:56.

TABLE 3 | Factors of a vessel's decision to violate pinger regulations.

Variable	Coefficient estimates	Marginal effects*100
INTERCEPT	8.62 (2.46)***	–
CYRS	0.08 (2.36)**	1.22
HPLEN	−1.31 (3.00)***	−18.74
GTONS	0.09 (2.44)**	1.30
DETECT	−2.55 (−2.39)**	−36.43
GREV	0.01 (2.03)**	0.14
GGE	−5.14 (2.02)***	−73.55
V_OLD	3.11 (2.87)***	44.45
PBEHAV	1.42 (1.31)	20.32
TRT	−0.61 (−0.60)	−8.72
Log Likelihood	−14.59	
Zero-slope chi-square (9 df)	42.59 ($p < 0.0001$)	
Percent correctly predicted	92.3%	
No. Observations	56	

*The t-statistics based on SEs are in parentheses. Marginal effects, predicted probabilities, are evaluated at the individual observation and then averaged over the sample. *** and ** indicate significance at 1% and 5% level, respectively. Variance inflation indices and correlation checks indicate multi-collinearity was not present.*

The deterrent factor *DETECT* was inversely related with the probability of a violation, suggesting a higher expectation of being observed will lead to fewer violations. Individuals observed in previous years were on average 36% less likely to violate the pinger regulation. The sign of *GGE* indicates vessels that fish multiple gears, or vessels that do not fish gillnet exclusively, are more likely to violate. The marginal effect for this variable is 74%.

Among the vessel characteristics, those with lower horse power per feet (HPLEN), or under powered vessels, are more likely to violate; this variable has the largest marginal effects among the set of vessel characteristic variables Results also indicate vessels that had more experienced captains (CYRS), were heavier (GTONS) and earned higher revenues (GREV) are more likely to violate. However, the magnitudes of these impacts are low; the marginal effects are close to 1%.

Among the normative variables, vessels with a history of violations, our moral variable (*V_OLD),* have a positive significant relation. Individuals who violated previously are, on average, 45% more likely to violate in the current year. This implies a large number of vessels are, in fact, repeat violators. Vessels are more likely to violate if they did not have a NMFS observer on board in the previous 2 years and they have a history of violations. While the social and legitimacy variables, port behavior (*PBEHAV*) and *TRT*, both have expected signs for their parameter estimates, they are statistically insignificant. The sign for the port behavior (*PBEHAV)* coefficient may suggest the compliance decision of the vessel operator tends to be positively related to the compliance decision of the other port members. The negative sign for the *TRT* coefficient proposes that fishermen's involvement in the development of the TRT plan may lead to lower violations.

In summary, our model estimates suggests, vessels more likely to violate the 1998 TRT harbor porpoise pinger regulations are characterized by lower horse power per foot, higher gross tons, multiple gear use, a positive violation history, and were not carrying a NMFS observer in the previous 2 years while fishing in pinger management areas.

DISCUSSION

Policy planning requires a sound understanding of compliance behavior to achieve successful regulatory goals. Commercial fishing gear standards along with closures are the typical regulatory instruments chosen to reduce the take of protected species such as marine mammals to PBR goals; however, pinger regulations, for example, are successful *only if* there is a high level of compliance. In 2007, non-compliance was one of the primary reasons the TRT reconvened when the porpoise bycatch levels exceeded PBR; compliance was not addressed in the 1999 HPTRP development. NMFS works with various partners, including NOAA's OLE, the U.S. Coast Guard, and individual states to monitor compliance and enforce regulatory components of the HPTRP; this includes coordinating special operations patrols to conduct more focused at-sea monitoring and enforcement of HPTRP requirements (NMFS, 2010). Becker's (1968) basic deterrence framework assumes detection probabilities and fines can be set to improve compliance with regulations; however, requests for more enforcement and higher penalties may not be cost-effective for monitoring pinger gear compliance and though observers record violations in NEFOP, they are not enforcement agents. Subsequently low detection rates can lead to an extremely low probability of being caught and prosecuted; hence, the economic incentive for pinger non-compliance is high. We need to strengthen and expand our compliance framework; HPTRP compliance measures continue to rely primarily on NMFS observer data. Enforcement may not be the only remedy to curb the compliance problem; the observer program may be a substitute or a complement for enforcement. However, our intent in this paper is to understand what factors may influence a fisherman to comply in the absence of incentives.

We follow Sutinen's seminal work along with others and consider normative, economic and perceived detection variables to explain compliance behavior with pinger regulations in the northeast sink gillnet fishery to shed light on other approaches we can pursue to improve compliance with gear standards. Using a probit framework we incorporate economic and normative factors to examine compliance behavior of fishermen with regard to pinger regulations. Results indicate a fisherman who had a history of violations, a low detection rate the previous year, and were characterized as high revenue earners fishing multiple gears were more likely to be non-compliant with pinger regulations. High revenue earners fishing multiple gears may be associated with more capital and hence willing to take more risks with violation consequences.

To ground-truth these model results focus group discussions were held with fishermen using pingers who reside in Connecticut to Maine ports. We weave some preliminary focus group findings about fishermen's perceptions of the normative factors considered in this paper. Participant's views support our model hypothesis and findings. In general, fishermen believed pingers deter harbor porpoise; however, they agreed the economic incentive to comply is absent (Appendix in Supplementary Material, comment 2).

Compliance model results suggest vessels more likely to violate pinger regulations had lower detection rates by NMFS observers. Our deterrent variable DETECT, may indicate the presence of NMFS observers have an influence on compliance decisions. Some focus group participants stated 40% of their 2012 trips were being observed and therefore "non-compliance was not an option." However, they also discussed among themselves who the "bad apples" are and stated the coast guard knows them as well (Appendix in Supplementary Material, comment 3). They went on to share their perception of how these "bad apples" make their decisions; "you can land flounder revenues of "$4000 and your MMPA fine is $500, you break the law every day" (Appendix in Supplementary Material, comment 4). Participant's sense or believe the chance of getting caught is low, and if you do get caught, the fines are acceptable.

Violators may often be repeat offenders. We assume a vessel's violation history captures their moral behavior. Our model results show vessels more likely to violate pinger regulations had a history of violations. Fishermen's statements during the focus group meeting echoed King and Sutinen's (2010) findings that most fishermen comply, and within a typical population, there is a small core subgroup that tends to violate routinely (Appendix in Supplementary Material, comment 7–8). Participants talked about "Smart Compliance" in general which recommends different types of enforcement strategies and penalties for different groups of fishermen based on their compliance history (King and Sutinen, 2010); specifically, more aggressive targeting of frequent violators and for certain types of violations, criminal penalties and the forfeiture of all fishing privileges should be considered. Participants recognize the need to increase the penalties.

The presence of a TRT member in a vessel's residing port was not statistically related to their recorded pinger violations. The social science literature asserts we should see improved levels of compliance when individuals have more opportunity to participate in the design and discussion of regulations. We suggested a fishermen's involvement in the development of the HPTRP via a TRT member residing in their port, may lead to lower violations. However, the statistically insignificant finding is consistent with focus group participants' comments. Frankly, only a third of the participants knew who their TRT representative was and some of these participants had that knowledge because they in fact, were members of the 2007 harbor porpoise TRT and participated at TRT meetings. Meetings are infrequent; the TRT met in 1998 and then nine (9) years later in 2007 when bycatch levels exceeded PBR. An increase in face-to-face communication could improve compliance behavior.

The proxy social (*PBEHAV*) variable was not statistically significant; we tested whether other vessels in the same port had violations or not. Focus group participants stated fairly strongly, that their decision to comply is not influenced by other's behavior (*PBEHAV*) (Appendix in Supplementary Material, comment 6). Why would we be expected to know other people's behavior? It was clear fishermen may have an impractical assessment of their peer's behavior. A participant made the following comment when asked whether they know who is and is not complying with the pinger regulations: "So I mean our gillnet fleet *I think* is, (long pause), I know he's a complier (pointing to another participant)" (Appendix in Supplementary Material, comment 5). The response was not surprising. Gillnet vessels reside in approximately 22 different ports along a large New England coastline from Maine to Connecticut; they describe their day-to-day fishing operations as a somewhat solitary existence. Given that fishermen are in short supply of face-to-face TRT meetings to discuss MMPA regulations and have a limited awareness of their peer's compliance; these environmental conditions may possibly provide an explanation of the insignificant finding for our legitimacy and social proxy variables.

Models and data in general are not flawless; we do not have perfect information and consequently, shortcomings and potential biases exist. We followed Hatcher's et al. (2000) compliance model with some adaptations. First, though a penalty structure was present in the sense that MMPA fines exist, only one recorded pinger violation has been prosecuted with a resulting fine. For that reason we could not investigate Becker's original crime model relationships; that is, empirically estimate whether the expected illegal gain exceeds the penalty. Second, while Hatcher et al. (2000) relied on face-to-face interview survey data to investigate normative factors, our model relies on historical data recorded by NMFS observers. Our model data are based on recorded observations vs. an individual's perception of their history. Using both data types, interview surveys and NMFS observed data, may improve our ability to understand compliance behavior. For example, comparing differences between an individual's "actual" vs. "perceived" history of violations may uncover whether an individual's awareness of their own compliance behavior is accurate. Third, while the non-significance of the social and legitimacy proxy variables to some extent was expected, including these variables sheds light on the importance these factors can have on compliance decisions. In contrast, our *moral* variable was significant. While anecdotal, the hot topic with focus groups participants was "repeat violators"; everyone knows who the repeat violators are including enforcement.

Responses from focus group participant seem to authenticate our normative variable findings and these variables remain in our study with a long term goal of improving these data in future research. Finally, the appropriateness of using observer data was raised; there is a perception that vessels may be forewarned and repair broken pingers prior to a NMFS observer boarding a vessel for official data recording. If this were the case, the observed violation rate would be negatively biased; however, we are researching factors that may influence compliance decision and not the compliance rate itself.

Our research findings will hopefully provide resource managers some valuable knowledge and insights to include while developing regulations. Observers could simply inform vessel owners that OLE does access their records. Thus, NMFS's observer program can complement or supplement enforcement. With that mind, increasing or balancing observer coverage in low sampling areas could result in high compliance returns; under sampling can induce non-compliant behavior. Alternatively, only vessels fishing gillnets exclusively be allowed to fish in pinger areas, was suggested by an anonymous reviewer. In addition, increasing observer presence which collects multi-disciplined research data simultaneously is likely more cost-effective than increasing enforcement levels in-order to conduct at-sea gear compliance checks for a single species. Second, profile and target repeat violators for compliance inspections. This may induce a sense of fairness among fishermen which may also lead to improved compliance. While these findings are not a surprise, the validation thru a formal model may provide enough scientific support to turn these recommendations into management actions.

Consequential closures, entire fishing areas would be closed for several months and years, threatening a vessel's livelihood if non-compliance exceeded a benchmark porpoise bycatch rate for two consecutive years in pinger management areas (75 Federal Register 7383, 19 February 2010). This incentive in the form of a "threat" was not implemented during this study (2007–2010) but immediately after in May 2010. Approximately half of the gillnet fleet started operating under sector management in the northeast groundfish fishery in May 2010 simultaneously. Future research will investigate pinger compliance under a new incentive structure, consequential closures and sector management. We anticipate these new data, along with additional focus group socio-economic research data, will enrich our model. Our results are not conclusive but deserve more attention. We anticipate this research can help us understand the internal motivation embedded in the compliance decision of the individual being regulated, ultimately leading to more successful regulations.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: http://journal.frontiersin.org/article/10.3389/fmars.2015.00091

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