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# Measuring Regulatory and Noncompliance Prevalence Among Maryland Commercial Blue Crab Fishers

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This is to certify that the doctoral dissertation by

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Abstract

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by

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MA, Salisbury University, Maryland, 2003

BA, University of Maryland's Eastern Shore, 2001

Dissertation Submitted in Partial Fulfillment

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Abstract

Few empirical studies exist that compare regulation (R) and fishing crime (VL). The lack of information about R and VL effects stakeholder decision-making. Crime weakens conservation efforts and creates false baseline data. This furthers R and the cycle repeats. The purpose of this correlational study was to determine the statistical association between the number and type of annual commercial blue crab R and VL of the same. The Pearson's R correlation was used to analyze the data because it demonstrated the strength of each relationship. This quantitative study was grounded in enforcement theory. The data was public record and consisted of the number of R and VL issued yearly from the General Assembly of a Mid Atlantic's State Department of Natural Resources (MD-DNR). The intent was to correlate multiple decades, but the earliest available VL data began in 2009. The analysis uncovered divergent patterns. The correlation coefficient of 0.79644 confirmed laws from 2009 correlated positively with 2010 violations. Further analysis revealed a negative correlation for 2010 and 2011 that was indicated by a negative correlation coefficient of -0.3588 and -0.166. The mean average of VL was 12.5%. As restrictions keep increasing, the economic impact on local communities is substantial. This research has the potential to effect positive changes in restrictive harvest practices, record keeping of VL by Natural Resources of this Mid Atlantic State, and harvest reporting practices by crabbers. Sharing the findings with industry stakeholders may stimulate dialogue among stakeholders that answers why one type of regulation was violated more than another, encourage compliance by industry users, and improve conservation efforts to proliferate blue crab. This research contributes to future investigation of often-neglected variables that compromise conservation of blue crab.

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# Chapter 1: Introduction to the Study

## Introduction

Despite having a police force in place since the late 1800s, there continues to be noncompliance in the harvesting of fishery resources from the Chesapeake Bay. Although regulations and a police force are avenues to manage marine natural resources, it is unknown how the passage of commercial blue crab fisheries regulations effects the compliance behavior of commercial crabbers in Maryland's Chesapeake Bay. Drawing on enforcement theory, which suggests optimal enforcement is zero crime and willing compliance, this quantitative, correlational study filled the gap in the research regarding the relationship between the number and type of commercial blue crab fisheries laws passed each year and the level of noncompliance by the number of commercial fishers crabbing in the State of Maryland.

The core of crime and policing theory resulted from a 1960s study performed by a Stanford University psychologist whereby two vehicles were abandoned uptown and downtown, respectively. Criminologists, George L. Kelling and James Q. Wilson, were intrigued by this study and how the psychologist demonstrated that visible neglect of an item can influence time until vandalism. They suggested that cleaning-up the visible signs of neglect in a neighborhood would influence the overall behavior of citizens living in that community and would ultimately lower the crime rate. They coined the theory broken windows (Vedantam et al., 2016). Like that experiment, in this research, I reviewed crime over time. Although my research may not have shown why and where crime occurred, it provided knowledge that may contribute to identifying trends in policy and enforcement. The results of this study can assist in making regulatory actions meaningful for all vested parties. Outcomes of compliance include a reduction in citations issued (less actual direct and indirect costs) and proliferation of Maryland's seafood industry (increase in harvest potential).

User groups throughout the world of commercial fisheries argue the harvesting of marine resources as a conditional right, not an allotted privilege (Lam & Pauly, 2010). As these perceived rights pertain to the use of marine resources, distinguishing right from wrong proved difficult, even in the face of overfishing. Numerous scholars have described overfishing in various areas in the world (Ali & Abdullah, 2010; Carrier, 2002; Guenther, López-Carr, & Lenihan, 2015; Hall, 2008; Maryland Department of Natural Resources (MD-DNR), 2011; McGrath, 2001; Nasser, 2013).

It could be argued that rights lean towards other implications such as ethics, stewardship, and other business-related fiduciary responsibilities (Lam & Pauly, 2010; Lord, 2011), while privileges resonate something earned. However, there is no guarantee of ethical behavior and stewardship from the fishing community, which leads to legislative and agency laws and regulations to protect each fishery. In this research, I discussed violations of commercial blue crab (*Callinectes sapidus*) regulations in Maryland's Chesapeake Bay. The purpose of my research is to share the findings with industry stakeholders to affect a positive social change between policy makers and commercial crabbers.

In this chapter, I provided background of the problem and detailed the purpose of the study. I introduced the theoretical foundation and methods. Even though correlation does not require testing hypotheses, I chose to present research questions and the hypotheses for explicative purposes. I defined the key terms and highlighted the assumptions and limitations. In Chapter 2, I reviewed the popular theories guiding fisheries management and introduced the theory of enforcement, which grounded this study. In Chapter 3, I elaborated upon the study's design, data collection, and analysis procedures to establish the validity and reliability of the results, which I explained in Chapter 4. Finally, I provided conclusions and recommendations for future related research in Chapter 5.

## Background of the Study

Those who flock to the Lower Eastern Shore of Maryland to enjoy the quintessential spicy "Old Bay" steamed blue crab and salty sea air instead meet with an unpredictable crab market because of unpredictable regulatory actions faced by the industry. There is a long contentious history in Maryland concerning regulating the harvests of the Chesapeake Bay. In general, management dates to Royal orders enacted in the 17$^{th}$ century by Charles the 1$^{st}$ of England guaranteeing Lord Baltimore "fishing of every kind" via The Maryland Charter of 1632 (Casey, 2002; Hall, Casey, & Wells, 2004). Ongoing disagreement concerning regulations appropriate for the preservation of the blue crab and other marine delicacies characterizes this rich history (Carrier, 2002; McGrath, 2001).

For my research, the word *fishing* means the act of removing commercially harvested living, marine natural resources from the Chesapeake Bay and its tributaries. The words *waterman, watermen,* and *crabber* designate the commercial people deriving a living by fishing on the Chesapeake Bay. People held dip nets and scooped up blue crabs one at a time (Kennedy, Oesterling, & Van Engel, 2007) prior to the mid-1900s making regulations unnecessary, and oysters and fish were numerous as evidenced by harvest reports (MD-DNR, 2015). The first commercial crabbing regulations were enacted at the turn of the 20$^{th}$ century (MD-DNR, 2013) with the introduction of the crab pot into Maryland in 1939. Crab pot use tended to be reported widely as the gear that most threatened the blue crab population. In 2018, crab pot limits continued to range between 50 to 900 pots per commercially licensed fishing person (MD-DNR, 2018) and caught 62% of the total crab harvest in Maryland (Carrier, 2002; MD-DNR, 2015). Thus, the debate about regulating this gear in Maryland is extreme as it relates to arguable species quantity or maximum sustainable yield (MSY) and individual transferable quota (ITQ) in the Chesapeake Bay.

Currently, numerous types of commercial blue crab regulations and difficult enforcement hurdles facing the Maryland Natural Resource Police (MD-NRP) continue to threaten the Chesapeake Bay resources, particularly blue crab. What consumers enjoy, and commercial fishers depend upon may not survive into the next decade without willing compliance to a limited number of succinctly worded enforceable regulations. Willing compliance by commercial crabbers could be the foundation to provide accurate baseline harvest data from which to create valid policy. While noncompliance continues, commercial marine resources remain at risk, threatening a $52 million blue crab harvest (Maryland State Archives [MSA], 2015) and a $600 million contribution to the state’s economy (MSA, 2018), as well as a 300-year-old way-of-life carried on by commercial fishing communities throughout Maryland.

## Problem Statement

In Maryland, commercial blue crab fishers continue to reject regulations enacted or proposed individually or in combination before, during, and after commercial fishing seasons (Chisolm, II, 1940; MD-DNR, 2015; *Maryland Register*, 2017), which results in noncompliance. The legislative practice of constant, cumulative implementation of commercial fishing regulations without empirical evidence lends itself to noncompliance by user groups. Rejecting regulations threatens baseline data, which furthers regulatory action that then effects stakeholder decision-making, and conservation plans fail. Whether unidentified or identified, undesirable outcomes of regulatory action effect the analysis and interpretation of harvest data.

The blue crab is migratory, and the Bay traverses six states, which include Virginia, Maryland, Delaware, Pennsylvania, New York, and West Virginia, as well as the District of Columbia (Chesapeake Bay Program [CBP], 2015). This makes management and the following enforcement difficult at best. Federal and state laws limit harvest pressure on the blue crab, but individual states are charged with managing this natural resource independently; although, some efforts have been made to act cooperatively. Despite Maryland's regulations, noncompliance continues to occur, and "chronic overexploitation" (Lord, 2011, p. 60) is common in coastal states. In this research, I explored MD-NRP citations alongside blue crab regulations to identify patterns.

An unknown percentage of commercial blue crab fishers exceed their licensed commercial gear limits. The MD-DNR estimates regarding the illegal use of crab pots are inaccurate, and monitoring is near impossible. This leads commercial blue crab fishers to under-report harvest to avoid scrutiny. This type of noncompliance results from economic considerations (Arias, Cinner, Jones, & Pressey, 2015). Such skewing of blue crab harvests distress population data, and blue crab harvest reports are the catalyst for regulation, particularly when harvests appear low. In short, blue crab regulations are difficult to enforce that leads to noncompliance by user groups, creating discrepancies in harvest reports that further regulation. These factors contribute to a misrepresentation of the economic analysis of the blue crab industry and the population estimates in Maryland. As such, it becomes difficult to identify the many individual variables and their relationship with the resource, as they embed in one another.

There is a limited check and balance system in place for monitoring commercial crab harvests from catch to retail market. The harvest process begins when the crabber purchases the commercial gear, sets the pot, empties the catch, and reports the number of blue crab harvested on an honor system. The market process for the commercial blue crab fisher includes direct retail (off the boat) or wholesale (to the dealer) dockside sales. Specifically, commercial blue crab fishers are to report daily harvests by the month on a chart template supplied by the MD-DNR. These data are compared to the dockside buyer reports to try to balance blue crab harvests in Maryland. Although MD-DNR (2012) requires 40% of a participant's income to be derived from natural resources to be considered a commercial fisher, blue crab reports do not reflect specific Internal Revenue

Service (IRS) data. Reporting does not include comparisons between the number of gear licensed for use in a season and the supplies listed on IRS form Schedule C, Profit and Loss from Business, of any one commercial licensed blue crab fishing person. Instead, MD-DNR compares active license limits and their quotas to buyers' reported dockside purchases to determine the accuracy of commercial crab reports (MD-DNR, 2017).

Crab pots attract blue crabs continuously while submerged, which contradicts the MD-DNR's regulation requiring commercial blue crab fishers take one day off per week (2015). Emptying crab pots daily avoids mortality, but crab pots left unattended or stranded on the bottom of the Bay leads to carnivorous activity and hypoxia (lack of oxygen) (National Oceanic and Atmospheric Administration [NOAA], 2015) as the crab pot fills with crabs and by-catch such as turtles, fish, eel, and other marine animals, which goes underreported. In addition, crab pots that are in use, but not reported on, may be termed *black-market*, as well as the harvest these pots produce.

In 2008, the MD-DNR discovered that Maryland commercial blue crab fishers claimed 30% more blue crabs harvested than dockside buyers reported on purchases. MD-DNR conjectured that this behavior was commercial fishers' response to upcoming regulatory action in the form of additional blue crab limits (MD-DNR, 2008). This indicates that regulation may have a negative corollary effect on compliance behavior, at the very least in the form of inaccurate harvest reports, suggesting an unexpected negative relationship between regulation and its intended outcome  conservation.

If it is feasible for commercial blue crab fishers to set an inflated number of gear, then underreport for personal or business financial reasons, there is a negative influence on blue crab conservation efforts. Economics further control this situation because only those who can afford the extra gear will benefit, while those who cannot will suffer with unequal harvest available to them. This type of noncompliance behavior is feasible because MD-NRP lacks enforcement ability of crab pots. As the Chesapeake Bay Stock Assessment Committee (CBSAC, 2012) noted, "based on continued evidence of inflated harvest reports, Maryland's estimated the 2011 commercial harvest from fishery-independent data sources" (p. 4). Commercial blue crab fishers are the direct data source. Relying on outside stakeholders for data removes an important key ingredient for successful conservation of the blue crab.

In 2019, fisheries management regulates the resource, the worker, and the gear. MD-NRP are limited in number (MD-DNR, 2015) but are responsible for 4,480 square miles (Chesapeake Bay Foundation [CBF], 2015) and upwards of 5,000 commercial fishing licenses in the Chesapeake Bay management area. Regulations are a form of limits used to manage fisheries; I focused on the commercial fisheries management of Maryland's Chesapeake Bay blue crab, and "fisheries management depends upon the possibility of prediction" (Apollonio, 2010, p. 184; see also Liermann, Sharma, & Parken, 2010). Limits are what make prediction possible. I explored the history of commercial blue crab fisheries regulations in Maryland alongside the citations and warnings written for commercial noncompliance. I found trends that can be explored for future policy making and policing practices. A correlational study of regulatory action and enforcement data aids not only in identifying trends of regulatory actions and enforcement data, but also, in identifying possible embedded responses. This makes future predictions reliable and valid and develops a base for future qualitative studies (Osbourne, 2010).

## Variables

Existing articles of law in the *Maryland Registry* as well as rejected and repealed laws provided the independent variables. The dependent variable consisted of the available number of commercial blue crab enforcement data reported for each year that included the harvest of hard, peeler, and female crabs as defined by the MD-DNR. Additionally, I used enforcement data that MD-NRP reported for the “0” factor, times when no laws were passed, for comparison. To show patterns relating to enforcement data, I generated a model that presented blue crab enforcement data in chronological order simultaneous with the passing of blue crab regulations, whether the regulation became enacted or repealed. I examined any patterns that emerged.

## Literature Gap

Fisheries population estimates, a multitude of management strategies, projected outcomes, economic projections, and conservation necessities to advance ecological success usurped the literature. Countries practice pet theories with little empirical evidence to support their reasoning. Even with the best of intention, strategists in the MD-DNR who plan for blue crab management fail to control the use of crab pots, which continue as the largest contributor to blue crab catch effort (MD-DNR, 2015; NOAA, 2015).

News articles and government reports have quoted decision makers’ references to the success of specific regulatory actions, but few have published empirical results related directly to such actions. No models exist that allow for comparing outcomes such as citations and warnings, judiciary outcomes, population fluctuations, population estimates, active crab pot licenses, or harvest reports to gear operated. I found little cross-reference between MD-NRP and MD-DNR blue crab related records (MD-NRP, 2015). Further, I did not find a means to compare gear (assets) to crab harvest and income reported. The cumulative literature and media dating to the early 19$^{th}$ century demonstrated that contention over the crabbing industry has evolved into a tangled web of one's translation of events.

In this research, I sought to fill the literature gap by

- Identifying patterns concerning regulatory activity and enforcement of the harvest of blue crabs in Maryland's Chesapeake Bay;
- Contributing to an increased understanding about the importance of enforceable regulations;
- Increasing decision makers' understanding about the significance of accurate Maryland blue crab baseline data (Kerlinger, 1986; Lord, 2011) that comes directly from the frontline; and
- Discussing the impact that harvest discrepancies continue to have on Maryland's commercial blue crab fishery.

## Purpose of the Study

The purpose for this quantitative, correlational study was to determine whether there was a statistically meaningful relationship between commercial blue crab enforcement and regulatory action and types of regulation on years with none, one, or multiple regulatory actions. I considered regulation spanning 2009-2017, while comparing enforcement spanning 2010-2017. The comprehensive purpose is to share the findings with industry stakeholders to affect a positive social change between policy makers and commercial fishers. I identified crime trends in this research, and those interested in more detail must delve further to ascertain and confirm what drives these trends. The results of this study can assist in making regulatory actions meaningful for all vested parties.

I appraised commercial blue crab fisheries related regulatory activity alongside enforcement data. The results of this correlational study aided in making regulatory considerations pertinent to blue crab management strategies (see Osbourne, 2010). This research contributes to future investigation of often-neglected variables that may halt a regulation's ability to meet its intended purpose. Specifically, I addressed Maryland's commercial blue crab fisheries regulatory action within its boundaries of the Chesapeake Bay. I focused on non-positive law titles that represent all commercial blue crab related regulations dating 2009-2017.

My research is distinct from previous research in that I created a model designed specifically for blue crab enforcement data in relationship to blue crab regulatory action. Identifying patterns may support assumptions concerning discrepancies in blue crab harvest reports. Neither science nor Maryland reports discussed the state or federal monetary losses (costs) related to the above-mentioned variables, but they discussed the conservation implications of this type of noncompliance. It is plausible that commercial blue crab fishers' compliance behavior produced unexpected outcomes because of the number or type of regulatory actions enacted annually, thereby suggesting the existence of an unintended relationship between regulatory action and compliance behavior.

This led to the following research question: What is the relationship between the number and type of annual commercial blue crab regulations enacted as measured by individual count and type and noncompliance by commercial blue crab fishers as measured by the number of tickets written annually? I expanded on compliance and enforcement theory by applying a historical view to the relationship between regulatory action and compliance behavior for Maryland's blue crab.

## Nature of the Study

I chose a quantitative study because it precluded the human perception and experience and focused on existing data. The primary concern in quantitative research is how the truth relates to external reality. In this study, I systematically compared secondary data, profiling a specific group and specific commercial regulations related to blue crab. By doing so, it made it possible to generalize about regulation and responses by stakeholders to such. This research provides a volume estimate of enforcement data relative to commercial crabbing in Maryland's Chesapeake Bay. The sample spanned nearly a decade, and I employed blue crab regulatory actions that provided for reliable statistical analysis. A model using enforcement and regulation presented how a group might respond to expected or what might be considered overregulation and the unexpected consequences that may result.

The legislative practice of constant, cumulative implementation of commercial fishing regulations without empirical evidence lends itself to noncompliance by user groups. Rejecting regulations threatens baseline data, which furthers regulatory action that then effects stakeholder decision-making. This data, expressed in numbers, provided a base for statistical testing using descriptive statistics. Further, I employed inferential statistics. I attempted to identify trends on a specific demographic. In the interest of the best use of secondary data, a quantitative study best represented the variables that uncovered phenomena relating to regulatory action and compliance behavior of commercial blue crab fishers.

I have a professional and personal interest in the topic of Maryland blue crab and its sustainability as an economic and affordable grocery and income resource for Maryland citizens. Several decades of intimate community-connection have created a sense of loyalty to the cultural practices of the fishing community. I viewed the most important task as providing clear and accurate data in a model that compared regulatory compliance behavior to regulatory activity. As an educator and facilitator of stakeholder pro-activity, wanted to encourage cooperation between the vast and diversified stakeholders to solve a problem. Currently, a cross-reference database between enforcement data and current regulations does not exist. I determined that statistical methodology best suited this research. Thus, I chose to engage in a quantitative study.

The independent variable represented the presence, type, and number of commercial blue crab regulatory actions brought to Maryland's General Assembly. In this study, *blue crab regulations* included all related regulations, acts, laws, public notices, management practices, and or proposals. This included sunset and repealed laws. The selection process included those regulations that have a direct enforcement relationship to blue crab as defined by the MD-DNR. The independent variables were analyzed and presented in historical format.

The dependent variable under investigation included blue crab commercial enforcement data. The enforcement data comprised citations reported or recorded by MD-NRP between 2010 and 2017. Missing data were considered in the hypothetical model developed. I analyzed the above-mentioned variables over time and drew conclusions regarding regulation changes that created time to event slots for discussion. Data analysis provided knowledge that represented both negative and positive correlations that represented noncompliance by commercial blue crab fishers. Noncompliance contributes to overregulation that leads to enforcement barriers that negatively effects conservation efforts and economic opportunities.

## Research Design

Enforcement data and regulatory activity provided the variables for the correlation. I made comparisons year-to-year that provided a timeline to present patterns that developed in compliance behavior. I retrieved data from annotated codes of Maryland via the Maryland Department of Legislative Services, active and proposed regulations via the MD-DNR, and enforcement data via the MD-NRP to investigate correlations between the years 2009 and 2017. By employing a priori analyses, I avoided Type I and Type II errors (see Booth & Quinn, 2015; Gerrodette & Brandon, 2014). I reduced correlations reported to reduce Type I error rates. I presented tables and a graphic representation of the development of relationships between the variables because these are pertinent to stimulating further investigation.

To demonstrate positive, negative, or no correlations among the variables, I used correlational design. Through descriptive methods, I provided basic information about the variables I discuss in the research. I made no causal inferences from this quantitative study. Based on my review of commercial fisheries regulations, I determined that nested data should be a consideration because laws are subdivided into title, subtitle, chapter, regulation, section, subsection, paragraph, and subparagraph. Nested data provided greater detail for testing. This leads to protection against error of inference or over or under estimating effects (see Libertia & Mian, 2008; Scheuerell et al., 2015). I had to delete many data because a multitude of cell data were not filled out preventing collection of the nested data.

For tests, I employed nominal scales because count data includes number of enforcement incidents; ordinal scales because correlation sought medians; interval scales because the differences between values had merit; and ratio scales because both the differences and ratios of values held meaning. The scales determined the strength of the research correlations.

The work by way of correlational designs in fisheries and time series studies in Ali and Abdullah (2010), Dichmont, Pascoe, Lompas, Punt, and Deng (2010), Guenther et al. (2015), Hankin, Hackett, and Dewees (2005), Mazany, Charles, and Cross (2005), and Wilen (1985) provided examples of how to collect, test, and present the data empirically. Secondary data provided the intended variable correlation (MD-DNR, 2015; MD-NRP, 2015; Maryland Register, 2017; Pauly & Zeller, 2003). I examined independent variables (commercial blue crab regulations) and dependent variables (commercial blue crab enforcement data) month-to-month and year-to-year to determine if associations existed. I studied the years with and without regulatory activity. This research represented blue crab in Maryland, and the results may not be applicable to other fisheries; however, some coastal fishing fleets that use similar commercial fishing gear to Maryland may benefit from the general knowledge this research uncovered.

**Main Research Question: Hypotheses and Subsidiary Questions**

The primary research question: What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial fishers as measured by the number of tickets written annually? Regulations and enforcement data provided the variables for the intended correlation. The data set encompassed years that included regulatory actions as well as reported enforcement data for years with zero regulatory activity. This research question led me to develop the following hypotheses that are stated for holistic review purposes in null and alternative form:

$H_0$1: The number of commercial regulatory actions enacted does increase the number of blue crab citations and warnings reported annually.

$H_1$1: The number of commercial regulation action enacted does not increase the number of blue crab citations and warnings reported annually.

$H_0$2: The type of commercial regulatory actions enacted does increase the number of blue crab citations and warnings reported annually.

$H_1$2: The type of commercial regulation action enacted does not increase the number of blue crab citations and warnings reported annually.

Equally important questions are: How many times has fishing illegal gear occurred during the study years? Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit? Do years with no regulatory activity have less enforcement (crime) compared to years with regulatory activity? What percentage is noncompliance behavior of total licenses reporting activity?

To comprehend the evolution of the blue crab industry and its effects on Marylanders and U.S. citizens in general, I reviewed literature starting with the earliest record of the trade. As with all economic ventures that flourish, fisheries needed regulating for a host of reasons including but not limited to economic, conservation, and ecological impact. Thus, what became the number one export for Maryland – blue crab – also became a public policy issue and has remained such since its discovery by Maryland's earliest Native American tribes.

## Theoretical Base

### Influences

The evolution of blue crab as an important Maryland commodity represented the base concept for this research. On point, since King Charles I (1632) bestowed the Province of Maryland upon Lord Baltimore (Virginia Marine Resource Commission [VMRC], 2010), the debate reigned on about fishery rights and what that means to different stakeholders. Further, findings by the Supreme Court Justices (540 U.S., 2003) illuminated the broader implications surrounding fisheries debates and riparian rights. My initial research concerning blue crab led to ecosystems theory. This theory attempts to view a variable without fully understanding key interactions from other variables including different species in its habitat (Emery, Green, Gardner, & Tisdell, 2012). Alternatively, several themes emerged as dominant in the literature, presented here, most to least reported: conservation, environmental, informational, common-property and rights-based, economics, and enforcement. Standing alone, none of these theories represented the research problem concisely.

Specifically, common-property and rights-based theories represent the current management standard in fisheries. Although both theories address open access or the division of fisheries, equal access to the harvest does not represent the real world accurately. These theorists believe that participation in the decision process on the use of a fishery acts as an incentive for fishing persons to “take the appropriate management actions” (Deacon, 2012, p. 261). These theories of management resulted in a percent of the overall allowable harvest per fishing person in hopes of developing an efficient, sustainable fishery (Stewart & Callagher, 2011) often referred to as MSY. The premise is that these theories support a sustainable fishery; however, skewed baseline data has the potential to impact MSY drastically, making it a poor model for fisheries management, particularly blue crab, which is unpredictable and misreported. As such, the division of opportunity to harvest is not equal among the frontline stakeholders, creating economic and harvest conflict that may lead to noncompliance behavior. Economic theories aim to create an equilibrium between effort and catch and analyze this in terms of present value (Diekert, Eikeset, & Stenseth, 2010; Nasser, 2013). Compliance and enforcement have received little attention in the literature but are  intricate ingredients in sustaining and proliferating fishery resources (Ali & Abdullah, 2010). As such, the trends that became apparent between compliance behaviors relative to regulatory action are significant to future decision-making concerning blue crab management.

**Theories**

Fisheries managers reported enforcement of regulation commonly as the greatest expense in fisheries management (Kuperan & Sutinen, 1998). Enforcing the law of fisheries often leads to litigation between commercial fishers and the government agency creating the policy. Nie (2008) purported a "co-evolution" (p. 140) occurring between regulation and litigation. O'Connor Shelley and Crow (2009) argued that resource police receive little attention in the literature because the types of crimes that characterize their work may be considered "folksy" and do not fall under the "construct of crime" as studied in leading research (p. 11). Ali and Abdullah (2010) contended previous compliance studies followed either positive or normative theories. They suggested that fishing people make a conscious choice to break the law and accidental oversight of a violation is a rare event (see also Kuperan & Sutinen, 1998).

Economic theory as it relates to fisheries has been considered by Ali and Abdullah (2010), Bressan and Shen (2008), Lord (2011), and Upadhyaya, Larson, and Mixon (2002). Because regulation controls the industry, it dominates economic sustainability. Ali and Abdullah (2010) pointed out that economists should be concerned with fisheries management. In their research conducted on Malaysian fisheries, the researchers showed a significant contribution from fisheries that equates to a 1.6% gross domestic product (GDP) employing 82,000 fishers. The GDP and employed fishing people represented the sum of both small and large-scale commercial operators. Maryland's blue crab industry contributes to a $33 trillion global value of ecosystem services (Roberson, 2003).

In recent literature, rights-based fisheries centered in common property theory dominated the literature (Blankenship, 2010; Deacon, 2012; Lam & Pauly, 2010; Stewart & Callagher, 2011; Turris, 2010). Griffin and Woodward (2011) suggested biologists lean towards regulating effort or inputs and harvest potential or outputs, while economists are concerned with maximizing present value (PV). Turris (2010) argued that principal-agent issues have a significant impact on behaviors, as owner-operators would view fishing as a long-term stake as opposed to a leaseholder of licenses or fishing quotas. Lam and Pauly (2010) asserted that the issue of publicly owned resources leads to the perceived right to fish with an ethical dilemma of gaining financial rewards from such. Common property theory has led to management systems such as ITQ, MSY, and even cooperatives (Deacon, 2012; Stewart & Callagher, 2011). I further discuss the evolution of dominant theories in fisheries research and management in Chapter 2.

I methodically examined the literature that revealed limited studies in compliance and enforcement theory. Literature grounded in the common property/rights-based and economic theory premises appeared as most prominent. The present main research question, subsidiary questions, and hypotheses benefited best from compliance grounded in enforcement theory. A study conducted by Guenther et al. (2015) analyzed commercial lobster fishers whose traps are stationary like blue crab pots. Like lobster fishers, commercial blue crab fishers are known to be territorial when using space in the Chesapeake Bay. The authors reviewed secondary data before and after a major management change that created moratoriums on specific fishing locations. The study represented a time to event design similar to this blue crab regulatory and enforcement data study.

Even though compliance and enforcement theory literature in fisheries appeared limited, it is essential to conservation and management; therefore, I discuss the apparent trends in noncompliance in the blue crab fishery. I assumed the secondary data as factual. The data included citations written for any law relative to commercial blue crab in Maryland's Chesapeake Bay and its tributaries. Since the underlying standard for fisheries management is common property and rights-based theories, I discussed it thoroughly; however, economics drive the industry, so the costs associated with the possibility of skewed data is essential to the overall impact on the state by noncompliant commercial blue crab fishers.

As I reviewed the vast literature, documentation suggested a specific theory to incorporate conservation and economics into a method that can be empirically documented has yet to come to fruition concerning ecosystem theories, in this case, the blue crab of the Chesapeake Bay (Fisher et al., 2009). Dichmont et al. (2010) stated that the newest paradigm attempts to manage the user group of natural resources rather than the resource itself. I used quantitative design to generate patterns between regulation and enforcement data in a state that manages both the resource and the user group. The results may contribute to future management strategies for blue crab.

The plausibility existed that regulation had a negative corollary effect (Guenther et al., 2015) on commercial fishers' compliance, which could skew harvest reports, thereby suggesting the existence of an unintended relationship. Although Guenther et al. (2015) reviewed before and after data in fishing effort concerning regulatory changes on spatial demographics. Their research provided reference for my study. Most important, enforcement related to cumulative commercial blue crab regulatory actions was difficult to decipher. These noncompliance issues skew harvest data, which leads to additional regulatory action. Regulation inhibits economic opportunity. The documented history of blue crab management demonstrated sporadic decision making with little direct empirical evidence. This created enforcement management issues and leaves room for multiple judicial interpretations. I reviewed several theories for this study that included compliance and enforcement theory and common property and rights-based theories because each plays a vital role in the commercial fishing industry. Many of the researchers grounded their studies in economic theory, and they made up the majority of literature available.

## Operational Definitions

The independent variables, indicated by $R_{1, 2, 3 \ldots}$ are Maryland laws and statutes and are housed in the *Maryland Registry.* Congress categorized and named the articles Natural Resources. Each independent variable represented was titled: *Title 4. Fish and Fisheries*. Subtitles and sections define the independent variables into subject matter. To limit the independent variables into a workable data set, I grouped the articles into 6 categories from existing Maryland Statutes:

- Regulation 1 ($R_1$) Tidal Fish License, License for Catching Crabs for Commercial, Penalties, Natural Resources – Authorization to Catch Crabs – Revocation;
- Regulation 2 ($R_2$) Removing Fish, Nets, or Gear of Another Prohibited;
- Regulation 3 ($R_3$) Rules and Regulations Generally, Use of Crab Pots in Chesapeake Bay, Limitation on Number of Crab Pots, Crabbing – Crab Pots – Requirements;
- Regulation 4 ($R_4$) Rules and Regulations Generally, Closed Season for Hard Crabs;
- Regulation 5 ($R_5$) Limitations and Prohibitions on Catching and Possessing Certain Kinds and Sizes of Crabs Purposes; and
- Regulation 6 ($R_6$) Rules and Regulations Pertaining to Female Crabs

Enforcement data that related to commercial blue crab regulations as reported by MD-NRP represented the dependent variables. Furthermore, I reported the “0” factor, those times during which there were no regulations enacted, but enforcement occurred, as zero regulation in this correlational study.

## Key Terms

### Legal Terms

For the purpose of this research, the following source supported definitions relative to laws are interchangeable and referred to as a regulation(s) or law(s)throughout my research.

*Actions:* Emergency legislation brought to the Administrative Executive

Legislative Review (AELR) Committee by the MD-DNR. Their authority includes making emergency decisions on fishing activities, including but not limited to moratoriums, early season closings, shorter day endings, and harvest limitations. However, the Governor has the authority to override an AELR decision (Maryland General Assembly, 2016).

*Annotated code:* A compilation of laws that reference other relevant regulations or statutes and summarize cases that discuss or interpret the code section (Harvard Law School, 2018).

*Code of Maryland (CoM):* These are statutes referenced from the annual editions of the Laws of Maryland by year and chapter. These are further subdivided by article, title, subtitle, section, subsection, paragraph, subparagraph, and so on (University of Maryland, 2018).

*Code of Maryland Regulations (COMAR):* These are cited from the Maryland Registry by volume, number, and page. Individual regulations are further subdivided by title, subtitle, chapter, subchapter, section, subsection, and so on (University of Maryland, 2018).

*Maryland Agency Rules and Regulations (MARR):* These represent regulations created between 1972 and 1975 prior to the adoption of COMAR. MARR is cited by number and or date of a regulation's adoption (Office of the Secretary of State, 1992).

*Positive law and non-positive law:* A positive law (legislative act) title represents one law, conforms to Code, and is named and enacted by Congress. Congress specifically organizes the text, and it appears exactly as proposed by Congress. Even though both types of titles may be temporarily modified with emergency regulations, Congressional laws always supersede departmental regulations (uscode.house.gov, 2015). A non-positive law (agency regulation) title represents a regulation and is assigned by the agency in charge, such as the MD-DNR. When necessary, the agency creates a new title. Each regulation has been specifically arranged in the text. “The organization, structure, and designations necessarily differ from those of the incorporated statutes (legislative acts), and there are certain technical, although non-substantive, changes made to the text for purposes of inclusion in the Code” (uscode.house.gov, 2015).

*Regulation:* Rules that *“*administrative agencies adopt, amend and repeal. …under the authority granted to them by statutes. Unless the Legislature has created an exemption, agencies must follow the procedures in the Administrative Procedure Act when adopting, amending, or repealing regulations” (Maryland Secretary of State, 2015).

*Statutes/Laws:* Legislative enactments developed in Congress (Maryland Secretary of State, 2013).

*Uncodified regulations:* These are regulations created prior to the adoption of MARR. They are cited by number and or date of a regulation’s adoption (Maryland Department of Legislative Services, 2007).

**Crab Definitions**

For the purpose of defining the blue crab, the following details will be specific to the research discussion.

*Blue crab: Callinectes sapidus* is found in the Western Atlantic within its tidal tributaries and estuaries (Chesapeake Bay Program, 2015). Predominantly, it is a bottom feeder. Legal harvest size varies from state to state. The blue crab evolves through six cycles: hard, peeler (white, pink, rank sign), buster, soft, buckrum, green (male), or sook (mature female). Visual identification of the male is defined by the “Washington Monument” apron on its bottom, while the mature female sports the “Capital” building on her bottom (J. Rachor-Hornsby, personal communication, 2018).

*Hard crab:* It is not a female, soft, peeler, buster, buckrum, or green crab as defined by the MD-DNR. It is a male crab whose shell is hard, and it is harvested by regulated size; at specific times; on specific days; with specific apparatus. It is referred to as a #1 Crab, a #2 Crab, or a Jimmy Crab (J. Rachor-Hornsby, personal communication, 2018).

*Peeler crab:* Authenticated by the distinct sign in the shape of a half-moon on the last paddle of the rear swimming fins. Three phases in this sign include a white sign, a pink sign, and the blood red sign (rank) that signifies it will shed its outer shell within several hours. The female can be identified visually by the rainbow-colored triangular apron on her bottom (J. Rachor-Hornsby, personal communication, 2018).

*Soft crab:* Authenticated by its soft, spongy structure and inability to use its pinchers. It lacks physical control and floats with the tide until it gains some strength. This crab shed its outer shell within the previous two to four hours (J. Rachor-Hornsby, personal communication, 2018).

*Sook crab:* Authenticated by a hard shell and rounded apron on the bottom side. A mature female close to the end of its life cycle that may or may not shed its shell, or it may have been fertilized during its soft-shell duration. Once fertilized, it will grow a spongy, egg bottom, which is protected by the apron (J. Rachor-Hornsby, personal communication, 2018) and develops through distinct cycles (Virginia Places, 2018).

**Fisheries Terms**

For the purpose of this research, the following source supported definitions will be applicable to this study.

*Crab pot:* A cube-shaped or rectangular device with openings toward the inside for the entrance of crabs (COMAR 08.02.03.01.A.(4)). The structure and its compartments are made from wire mesh in a cube shape, and it has not changed much since its introduction in 1939. An iron square is attached to the bottom perimeter to help it maintain its structural integrity. Wire mesh separates it into two levels: an upper chamber and a lower chamber. The bottom chamber has two to four concave funnels that allow a crab to enter but unable to escape because of the crab's pointy shell and legs. Often, the crabs crawl up to the top chamber through another funnel in the center of the pot where they stay until dumped from the pot by a commercial blue crab fishing person. The top of the pot at the upper chamber opens to release the crabs. The commercial blue crab fisher holds the pot upside down, and the crabs naturally release their grip falling into a waist high box where specific stages of their life sort them. Although design is consistent, crab pots used to harvest hard crabs utilize a heavier gauge wire and iron to weight the pot to the bottom.

The crab pot is a stationary device and is placed in rows of about 50 pots with each pot placed 20 feet apart. A floating device (buoy) is attached to a rope to identify which pots belong to whom and their location; then, the rope is attached to one corner of the bottom iron square. Commercial blue crab fishers hook the buoy with a hand-held boat hook, pull it on board the vessel, and turn the pot over, which allows the crabs to drop, bait the pot in a special chamber on the bottom, dump the pot, close the pot, and then throw it back over board. As the boat travels from buoy to buoy, the boat mate culls the harvest into specific baskets or aerated, water-filled boxes. This process from daybreak to closing time is referred to as "fishing pots" (J. Rachor-Hornsby, personal communication, 2018).

*License type:* The MD-DNR allocates licenses by gear used and quota of crab pots allowed per person per boat. Tidal Fishing License (TFL) up to 900 crab pots; Crab Harvester (CB6) up to 600 crab pots; Crab Harvester (CB3) up to 300 crab pots; and Limited Crab Catcher (LCC) up to 50 crab pots (COMAR 08.02.01.05.A.).

*Maximum sustainable yield (MSY):* The largest long-term average catch that can be taken from a population under prevailing ecological, environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets (NOAA, 2011).

*Overharvesting:* A loosely used term to discuss the nature of fishing persons removing more than the species can sustain or one's license allows and that can cause a fishery to collapse (PNAS, 2018).

*Overreporting:* The falsification of crab reports by inflating actual harvests (MD-DNR, 2008).

*Overregulation:* A loosely used term used to discuss the cumulative regulating of the Maryland blue crab and Maryland commercial fishing person (J. Rachor-Hornsby, personal correspondence, 2018).

*Stock abundance:* Numerical data used to represent the blue crab population for any given year or season (NOAA, 2009).

*Underreporting:* The falsification of crab reports by deflating actual harvests (MD-DNR, 2008).

*Winter dredge survey:* The only bay-wide fishery independent effort to estimate the number of blue crabs living in Maryland's Chesapeake Bay (MD-DNR, 2013).

**Maryland Statutes**

The following is a list of the defined Maryland Statutes I examined in this research. Maryland's Congress specifically named the article, title, subtitle, and section.

*§4-701 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 7 Licensing, Regulation, and Supervision of Fishing and Fisheries in Tidal Waters, Section 701 Tidal Fish License.

*§4-703 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 7 Licensing, Regulation, and Supervision of Fishing and Fisheries in Tidal Waters, Section 703 Issuance of new tidal fish licenses after September 1, 1988.

*§4-803 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 803 Rules and Regulations Generally; Public Hearings Before Rules and Regulations Become Effective.

*§4-804 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 804 License for Catching Crabs for Commercial or Noncommercial Purposes.

*§4-809 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crab, Section 809 Limitations and Prohibitions on Catching and Possessing Certain Kinds and Sizes of Crabs.

*§4-810 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 810 Rules and Regulations Pertaining to Female Crabs.

*§4-812 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 812 Use of Crab Pots in Chesapeake Bay Waters in Dorchester and Somerset Counties.

*§4-813 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 813 Harvesting Crab with Crab Pots in Somerset County.

*§4-814 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 814 Limitation on Number of Crab Pots.

*§4-1201 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 12 Penalties and Fines, Searches, Seizures and Forfeitures, Section 1201 Penalties.

*§4-1205 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 12 Penalties and Fines, Searches, Seizures and Forfeitures, Section 1205 Seizure and Disposition of Fish Unlawfully Caught, Sold, Offered for Sale, Transported, or Possessed.

*§4-1206 Natural Resources:* Title 4 Fish and Fisheries, Subtitle 12 Penalties and Fines, Searches, Seizures and Forfeitures, Section 1206 Seizure, Forfeiture, and Disposition of Devices, Equipment, or Property.

## Assumptions

Based upon MD-DNR complaints (2008), it must be assumed that commercial blue crab fishers can over-report harvest, and commercial blue crab fishers have the means to exceed their crab pot limits. MD-NRP cannot enforce crab pot limits effectively. Secondary data provided by MD-DNR represented the independent and dependent variables for this research. Because this agency collected, compiled, and disseminated this information, it must be assumed to be evaluated and based upon fact.

Certainty in fisheries does not exist. Several assumptions about this research must be considered. First, skewed harvest data acts as a catalyst to further regulation. Inconsistent blue crab data and a migratory species makes MSY a poor control for population stock abundance since MSY is dependent upon consistency. Blue crab populations and fluctuations are inconsistent. The effect of overharvesting, overregulation, and black market crab pots is unknown. Crab pots trap blue crab and by-catch continuously while submerged.

For this research to have merit, I assumed that overreporting and exceeding crab pot limits occurred. Moreover, governmental secondary data provided the necessary depth and breadth for this time series model. Maryland provided reliable sources for a compilation of variables. I presented a bias free model of positive and negative trends found in regulatory action. The results of this will further positive outcomes in the fishery through open communication. I used  an existing time model because I had limited time available to complete my study. Using a quantitative study, I presented trends that may lead to future qualitative studies in this area of research.

Because Maryland uses individual crab harvest quotas for hard crab, understanding how MSY works is essential for understanding MD-DNR's viewpoint on blue crab management. The MD-DNR is charged with sustaining the resource, not with guaranteeing a livelihood to commercial fishers. The MD-DNR regulates the resource for this purpose. Multiple variables influencing population data exist such as unhealthy habitat, climate changes, and unknown black market crab pots. Certainty is not an accurate representation of any fishery. It must be assumed that blue crab float or swim both in and out of the Bay dependent upon natural phenomena, effecting blue crab population to the minute. I tested the data to identify patterns and relationships. Future researchers can delve deeper to ascertain the meaning and influence of trends discovered. In any fishery, MSY is dependent upon consistency, and blue crab are not consistent, making MSY a poor measurement and management strategy for the blue crab population in the Bay.

## Scope

I conducted this study  in Somerset County, Maryland. I determined if an unexpected relationship existed between blue crab enforcement data (2010 – 2017) and regulation (2009 – 2017) represented by secondary data. For this research, I included commercial blue crab related enforcement data and blue crab related regulation data. I used the commercial crabbing community as defined by MD-DNR active licenses as the basis for this research. This community reflected a culmination of commercial blue crab harvesters, whether they were Maryland residents or other, but they had to work in Maryland's portion of the Chesapeake Bay or its tributaries. In the results section, I discussed key differences between crabbing communities and how that may have influenced the results of this research.

The populations I investigated included the commercial blue crab fisher, commercial blue crab citations and enacted, rejected, and repealed commercial crabbing regulations, and the Maryland blue crab. I investigated multiple theories for grounding the research and analyzing the variables. I developed an empirical study to represent the correlational research question. I reviewed articles from all aspects of the marine sciences, social sciences, and economic theories to determine the appropriate variables to test. To gain a concise representation of the research, I had to dissect and group the variables to a manageable size. Thus, time, money, and availability of data became the final determination of variables to be used in this research. Many researchers attempted to identify causes for existing obvious problems in the industry such as overharvesting, disease, or conservation. I sought to identify possible unexpected outcomes to regulatory action. Secondary data and time analysis became the obvious choice in variable and design selection. This made compliance and enforcement theory most relative to this research.

This study cannot be generalized to other marine resources since the information reported about the subjects and populations under study was specific to Chesapeake Bay. However, this design may be applicable to similar gear used in fisheries. This model allowed for the analysis of any regulation and its corresponding enforcement data. However, cultural conditioning and specific state regulations from fishing community to fishing community would change the outcomes of any similar research. For this study, I compiled public data on enforcement and legislative activity, and I viewed the commercial crabbing community as a single unit, simplifying ethical confidentiality.

## Delimitations

I did not investigate the commercial blue crab community as a group or as individuals because I attempted to identify trends rather than causes of such. Generalized secondary data reflected the citations and warnings without the necessity of identifying the accused offender. Repeat offenders were not considered in the variable set. I did not consider the number of NRP as compared to the number of citations and warnings written in the research. I reviewed judicial outcomes for informational purposes, but the outcomes of warnings and citations were not included in the data set. I found limited empirical research that supported management decisions for the Maryland blue crab, particularly, research that considered multiple theories as a lens to view a single problem, and ecosystems theory dominated blue crab literature.

## Limitations

Maryland's DNR only concerns itself with the Maryland portion of the Bay. The situational conflict is that blue crabs participate in northerly and southerly migrations influencing the geographic data of blue crab and affecting multistate regulations. Limited historical enforcement data and activity and general blue crab data hindered my research. How, when, where, types, and to what degree data was collected by scientists and reported by commercial fishers since the 1940s varied throughout the 1900s and twenty-first centuries and can be described as sporadic. I based this research solely on Maryland's portion of the Chesapeake Bay. However, much of the literature considered the entire Bay in its studies. The patterns discovered in this research from the selected variables can be addressed immediately and directly, but the results are not pertinent outside of Maryland's boundaries.

Maryland collected data throughout the history of commercial crabbing in Maryland can be described as inconsistent at best. Regulations are formed and repealed most legislative sessions. This creates problems for monitoring outcomes of regulation and additional enforcement costs. Noncompliance behavior data was limited. There existed no cross-referencing of data between the administrative, enforcement, and scientific agencies of the MD-DNR. Further, the Maryland Department of Agricultural and the United States Department of Agriculture have some regulatory influence concerning the Chesapeake Bay and its tributaries. License holders may not be active from season-to-season. Cultural practices may influence noncompliance behavior as opposed to regulatory action.

My past professional experience had given me the opportunity to work as a commercial blue crab fisher within Maryland on the Chesapeake Bay where I performed the necessary duties of a boat mate, which included but was not limited to cutting bait, flipping pots, baiting pots, culling crabs, loading/unloading bushel baskets full of crabs, fueling, and assisting in maintaining and operating the rig. Further experience included the operation of a soft crab-shedding shanty. I worked laborious, 4-hour intervals during blue crab shedding, which continued around the clock, from June through late summer. I have a stake in supporting the sustainability of the Chesapeake Bay fishing community by testing current practices using secondary data. Because I worked as a commercial blue crab fisher and was involved politically in the industry, I have several preconceived philosophies. To eliminate personal bias, I chose a quantitative study, which represented the compared data empirically. Representing data accurately best serves the commercial crabbing community as well as the resource – blue crab. I accomplished this using secondary government data. By employing a quantitative study, I presented the data free from emotion and any misinterpretation of human responses that can occur in qualitative studies.

I identified trends between noncompliance and regulatory action, but I did not seek to discover why patterns emerged. Patterns that emerged can be analyzed using qualitative design to answer the question "why" these patterns emerged. Further, time and money constraints prevented me from investigating similar variables related to other fisheries in Maryland to make possible general predictions about the nature of compliance related to regulatory action. An enforcement database that is accessible for strategic planning is nonexistent. Voluntary harvest reporting occurred until the mid-twenty-first century. Geographical conflict arose between the southern, central, and northern Bay fishers because blue crab life cycles differ in time and place that influence harvest type, effort, and season. The cost to acquire detailed data from MD-DNR limited my research, so a preexisting data base supplied by MD-NRP provided the enforcement variable set.

## Significance of the Study

This study is crucial because as restrictions keep increasing, the economic impact on local communities is substantial, and compliance and monitoring issues escalate with the problem. One importance of the study to past and current research is that it empirically connects commercial blue crab regulations to enforcement over time. Because patterns emerged between regulation and noncompliance, I suggest skewed baseline data exists that may then drive policy, which furthers regulation unnecessarily. This research may lead to changes and repeals in legislative policies relating to both blue crab regulation and enforcement policies. This research may lead to changes in MD-NRP budgets needed to perform enforcement. Legislative bills that have the potential to make enforcement of crab pot limits possible may be a result. In turn, enforcement of crab pot use will improve base line crab data, which will improve conservation of the blue crab and even the playing field for stakeholders through economic opportunities within Maryland’s commercial crabbing community.

The scale of the fishery is of no consequence when deciphering the relationship between baseline data and regulation (Lord, 2011). In this study, I touched on important social issues relative to the perception of rights, the cultural significance of crabbing communities, and the direct and indirect costs of enforcement, including the inability to enforce. Compliance issues interfere with the ability to collect accurate baseline data from the frontline (Lord, 2011) - commercial fishers. Because regulation controls the industry, it dominates economic sustainability.

I extended the body of knowledge by expanding upon the chronological order of events that include the development of the blue crab commercial fishing industry, the MD-DNR, its counterpart, the MD-NRP and how it relates to historical regulatory action. Reviewing the life span of these events and their relationship to each another was significant for understanding the unpredictable relationship between stakeholders. The identification of correlations between regulations and enforcement and how it translates into harvest discrepancies is essential to public policy making. This empirical study discovered patterns between blue crab regulations and commercial fishers' compliance behavior.

## Summary and Transition

Chapter 1 provided background information relating to the commercial blue crab industry in Maryland. The research problem of regular implementation of commercial blue crab regulations and the impossible task of monitoring and enforcing blue crab regulations represented the essence of this research. A historic review of blue crab management and enforcement data illuminated important, influential trends that exist but were unexpected. This data has the potential to impact legislative decision making and support or negate previously held beliefs about over-harvesting the Maryland blue crab.

The purpose of this quantitative, correlational study was to determine whether there was a statistically meaningful relationship between commercial blue crab enforcement and regulatory action on years with none, one, or multiple regulatory actions spanning 2009 – 2017, respectively. A comprehensive purpose for this quantitative, correlational design is to share the findings with industry stakeholders to affect a positive social change between policy makers and commercial fishers. I grounded the study in enforcement theory. I collected data from the MD-DNR, MD-NRP, and the *Maryland Register* regarding blue crab related enforcement and regulatory action. I analyzed data using time series and linear regression.

I provided a detailed explanation of the importance of reviewing the key theories considered for this research in Chapter 2. The concept of time analysis provided an environment from which to study the variables of enforcement data and regulation. The relevant literature consisted of rights-based and common property theories, economic theories, and compliance (enforcement) theories. Individually, these theories were routine in fisheries research, but in combination, innovative ideas were revealed for future research. In Chapter 3, I further discussed the choice of method and provided additional information about validity within the research. I analyzed secondary sources and measurement tools in detail.

# Chapter 2: Review of the Literature

## Introduction

In Maryland, commercial blue crab fishers continue to reject regulations enacted or proposed individually or in combination before, during, and after commercial fishing seasons (Chisolm, II, 1940; MD-DNR, 2015; *Maryland Register*, 2017), which results in noncompliance. The legislative practice of constant, cumulative implementation of commercial fishing regulations without empirical evidence lends itself to noncompliance by user groups. Rejecting regulations threatens baseline data, which furthers regulatory action that then affects stakeholder decision-making, and conservation plans fail. Whether unidentified or identified, undesirable outcomes of regulatory action affect the analysis and interpretation of harvest data. This baseline data furthers regulatory action, which effects industry stakeholders' decision-making regarding marine resources, and the cycle continues.

MD-NRP is limited in number (MD-DNR, 2013) but is responsible for 4,480 square miles (CBF, 2015) of Chesapeake Bay management area. I appraised commercial blue crab fisheries related regulatory activity beside enforcement data as my primary objective for this research. Enforcement data included warnings and citations written to commercial blue crab fishers within the boundaries of Maryland's portion of the Chesapeake Bay. I did not include the outcomes of warnings and citations. Specifically, I addressed Maryland's historic regulatory action within its boundaries of the Chesapeake Bay and whether it had influenced compliance and enforcement data in unexpected ways.

## Summary Content

I conversed with active and retired MD-DNR administrators, MD-NRP, and commercial fishing people to identify reoccurring keywords to research for my study. I used television, radio news broadcasts, newspaper articles, online blogs, and chat rooms to identify keywords in fisheries research. I participated in the commercial fishing industry from 1992 to 2000 where I learned key vocabulary in its colloquial form and searched said words. From 1992 to 1998, as a fulltime, grassroots lobbyist and president of a newly formed watermen's association for the reform of Maryland commercial fishing licenses, I learned administrative and legislative terms that became keywords in my search for materials. I used this collection of key words to search Google Scholar and electronic databases accessed via Walden Library for scholarly, peer-reviewed literature. The findings led to in-depth searches into American state and federal agency search engines and websites regarding the management of marine resources, while scholarly work provided international data.

One contribution this study made to past and current research is that it empirically connects commercial blue crab regulations to enforcement over time. The social change implications of this research include affecting a positive social change between policy makers and commercial fishers by identifying unexpected relationships between regulations and noncompliance. Further, the historic value of this study is that it demonstrates how cultural gear practices as well as the interpretation of a fisher's perceived rights can act as an enforcement barrier, which changed little for centuries.

## Preview and Organization of Major Sections

In this chapter I highlighted the strategies I employed to access appropriate literature. In the first section, I discussed the major theoretical themes found in the literature and their direct relationship to this study. I presented the review of the thematic literature in order of the study variables from most relevant to least relevant as they relate to the current study: compliance and enforcement in fisheries, common property and rights-based fishing, and economics and fisheries. However, as reoccurring themes in the literature review, each supported this study by presenting the persistent problem of enforcement. Thus, I discussed thoroughly the problems, as identified by the authors, within each theme.

Following the thematic review, I have organized a section on methods relevant to this study by theme and presented materials in chronological publication order. The first theme presented is basis for all fisheries, which is conservation of the natural resource. I followed this with compliance and enforcement literature, common property and rights-based literature, and economic theories relative to fisheries. Finally, following the current literature that supported the research design, I detailed my choice of the study's quantitative, correlation time analysis that identified trends.

## Literature Search Strategy

Searching for materials began with a "to do" list that I wrote while brainstorming ideas for this study. First, I completed an online search named "list of quantitative theories" using Google, Google Scholar, and the Walden University Library. Databases I accessed via the Walden Library included Academic Search Premier, Academic Search

Complete, EBSCOhost, Business Source Premier, and Galegroup. I performed this task to familiarize myself with as many quantitative theories as possible. For those theories unfamiliar to me, I performed a defining search.

Further, I searched Amazon where I purchased and then read a variety of books, including those I had on hand. This list of books included:

- *Fixed Effects Regression Models* by Paul D. Allison,
- *Analyzing Quantitative Data* by Norman Blaikie,
- *Asking the Right Questions: A Guide to Critical Thinking* by M. Neil Browne and Stuart Keeley,
- *Statistical Power Analysis for the Behavioral Sciences, Second Edition* by Jacob Cohen,
- *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Third Edition* by John W. Creswell,
- *Discovering Statistics Using SPSS, Third Edition* by Andy Field,
- *Modelling and Quantitative Methods in Fisheries* by Malcolm Haddon,
- *The Reviewer's Guide to Quantitative Methods in the Social Sciences, Revise, Accept, Reject* by Gregory R. Hancock and Ralph O. Mueller,
- *How to Measure Anything: Finding the Value of Intangibles in Business* by Douglass W. Hubbard,
- *Secondary Analysis of Survey Data* by K. Jill Kiecolt and Laura E. Nathan,

- *Statistics for Social Data Analysis, Fourth Edition* by David Knoke, George W. Bohrnstedt, and Alisa Potter Mee,
- *Interviews: An Introduction to Qualitative Research Interviewing* by Steinar Kvale,
- *The Fisherman's Problem: Ecology and Law in the California Fisheries (1850 -1980)* by Arthur F. McEvoy,
- *PASW Statistics 18 Guide to Data Analysis* by Marija J. Norušis,
- *Social Science Research Design and Statistics: A Practitioner's Guide to Research Methods and IBM SPSS Analysis* by Alfred P. Rovai, Jason D. Baker, and Michael K. Ponton, and
- *Statistics II for Dummies* by Deborah Rumsey.

Initially, I organized the hard copy materials alphabetically by author's name to prevent duplication of printing. I assessed over 1000 sources for inclusion in this review. Two hundred and ninety-nine scholarly and professional articles were catalogued in an Excel spreadsheet. I purchased and read 10 books to gain a stronger understanding of theory and data measurement. For future convenience, I developed headings such as year, author, title, design, theme, and results to sort and filter the multitude of documents collected and reviewed. After entering the information for each resource, I organized the hard copy materials by year from oldest to newest to review historic changes in academic thought. I sorted and organized the data by multiple headings depending on the information I sought. I created a separate Excel database to organize the materials representing the evolution of Maryland commercial blue crab fishing regulations. I named headings like year, regulation type, license type, and description to allow sorting of the materials.

**Key Search Terms**

After I defined the collected theories, I cross-referenced these with the words: *fisheries, fish*, and *commercial fishing* utilizing the same websites. When a theory failed to present materials with the keywords, I eliminated it from the list of usable theories under consideration. The keyword list included words that came to mind at any time and in any place related to fisheries, crabs, harvest reports, and citations. I started with scraps of paper and notebook entries that included elements of conversation with active and retired MD-NRP, active and retired commercial fishing people, and MD-DNR staff. Further, I listed key words from television and radio news broadcasts, and I cut articles from newspapers. Additionally, I collected keywords from online blogs and chat rooms, as well as from *Maryland Public Television* broadcasts. I searched for keywords in three stages.

Stage one keyword search. *Quantitative theory, quantitative and economics and theory, quantitative and conservation and theory, quantitative and fisheries and theory, quantitative and economics and conservation, economics and conservation and fisheries*.

Stage two keyword search. *Time series analysis design, correlational design, causal-comparative research, survey research, evaluation research, ex-post facto designs, logic model, longitudinal study, prospect theory, supply-side economics, differential association theory, causal determinism, action research, systematic evaluation, process theory, game theory, theory of compliance, deterrent model, common property theory,* *normative theory, causal model, command and control approach, manifest and latent analysis, content analysis, creative destruction, dynamic inconsistency, principle-agent theory, fish, fishery, fisheries, crab(s), economics, conservation, policy, quantitative, Chesapeake,* and *bay*.

Stage three keyword search. *blue crab, economics, fisheries, fish, fishery, regulation, regulatory, action, policy, discrepancies, crab pot, Chesapeake, bay, regulations, blue crab fishers, commercial, fishing, management, strategy, theory, theories, quantitative, harvest, reports, Maryland, brood, stock, harvest, overharvest, enforcement, compliance, hierarchy, model(s), legislation, theory, correlational, time-to-event, license, ITQ, limits, conservation, law, reporting, illegal, sustainability, monitoring, compliance, data, watermen, waterman, annual, title, COMAR, article, outcome(s), industry, dockside, value, DNR,* and *NRP*.

I used this list of keywords related to the commercial fishing industry to perform the initial search. Next, I divided the list into specific categories related to the Chesapeake Bay, and then I segmented them further into the Maryland section of the Chesapeake Bay. The list shows how I continually segmented each group of words in an effort to narrow the research to the subject under study.

**Scope of the Literature Review**

While initially investigating the literature, I placed few limits other than keywords and combinations of such. The use of fish dates to the beginning of human survival. For this research, my focus on regulation concerning fisheries in Maryland created parameters by which to focus. Specifically, the research dates Chesapeake Bay material to the late 15th century and concludes with the year 2017.

The complexities involved in managing the blue crab require social change agents to speculate on broader implications such as noncompliance, enforcement, the right to fish and common property, the multifaceted economic variables, and discrepancies in harvest reporting. This requires gaining a working understanding of the diverse stakeholders, the crabbing culture as it has developed over time, and the gear called crab pots. Because crab pots are reported as the gear that catches the majority of blue crabs in Chesapeake Bay, knowledge gathered about its uses provided further understanding to the evolution of this industry.

After I completed the initial searches, I limited database searches to “full text and peer reviewed,” and I searched again. I searched in the MD-DNR, MD-NRP, Maryland Legislative Services, Maryland Division of State Documents, and The United States Supreme Court to find relative historical information. I limited searches to publication from 2011 to 2015 in order to analyze current trends in fisheries research. This search echoed concerns for the need of quantitative empirical research.

**Limited Research**

Locating empirical studies for this subject in excess of economic theory and measuring variables related to a particular species such as stock numbers, mortality rates, growth rates, birth rates, sustainability, harvest pressures, and the like for a particular time in a particular place usurped most of the research. I found few quantitative studies that measured and analyzed specific outcomes related to specific regulations other than for ITQs or empirical studies related to discrepancies in fisheries harvest data.

Additionally, research regarding enforcement/compliance analyzed the "why and where" behind fisheries criminal activity as opposed to the "who, what, when, and how often" a trend occurred.

Limited quantitative research available forced me to expand my limiters to include qualitative studies that offered further resources. This literature varied a great deal, and like the quantitative studies, researchers produced qualitative work from all over the world. Nonetheless, European and American resources produced the majority of all the work collected. A great deal of information concerning game and compliance theory appeared cross culturally in qualitative studies but did not necessarily address the current research. The question as to "why people break the law" attracted a great deal of interest from social scientists using qualitative design.

**Summary**

In summary, I narrowed the topic of study to common theories related to the commercial fishing industry. Once I completed this, I moved to the population of interest - the commercial blue crabbers. I cross-referenced this with the theories that became apparent during my second search. To conclude, I explored the research with the final limits: Maryland, Chesapeake Bay, full-text, and peer-reviewed because I intended on including only compliance, regulation, and specific gear harvest data for blue crab that may have influenced fisheries decision making processes in an unexpected manner in Maryland.

**Theoretical Foundation**

An immense span of literature relative to fisheries exists, and my attempt at conciseness forced me to review several theories for consideration in this study. The problem is intertwined tightly within the selected theories, and these theories are interwoven further. Noncompliance and enforcement theory - to a degree – are neglected in the commercial blue crab literature, falling short to economic theories. I explored compliance alongside regulatory actions. Maryland treats its natural resources as common property; likewise, commercial blue crab fishers lean towards rights-based fishing. Therefore, these two theories were essential to review. Ultimately, the regulations that manage the industry control the economic sustainability of the practice of commercial crabbing in Maryland's Chesapeake Bay; thus, economic theory became critical. I sought patterns using existing enforcement data, so I reviewed compliance grounded in enforcement theory. I measured enforcement data alongside regulatory activity to see if patterns appeared over time.

Empirical fisheries literature on noncompliance and enforcement was scarce. In the beginning of this diverse fishery, in 1632, King Charles I made a Charter for Lord Baltimore to establish the Province of Maryland that led to Jefferson, Madison, Washington, and Randolph negotiating secure access for Virginians to have equal harvest potential in the Potomac River fisheries. Tensions over this continued until 1785 when the Maryland and Virginia Compact established state boundaries on the Potomac River because of deadly battles between Virginia and Maryland commercial fishers (VMRC, 2010, para. 8). Another 100 years lapsed before Maryland enacted a commission to manage fisheries decision-making in 1874 (Kennedy et al., 2007; MD-DNR, 2007), but in the meantime, Maryland created the first marine police force in 1868 (MD-DNR, 2007). In contrast to active legislative and community interest, enforcement and noncompliance concern by academics did not seem to take route until the late 1990s. Since then, Ali and Abdullah (2010) and Kuperan and Sutinen (1998) reflected upon the limited empirical studies available and added to the limited body of evidence concerning blue water crime and compliance.

Material on criminal activity can be dated to Beccaria (1764) in his paper, *Essay on Crimes and Punishment*; however, I did not read about theory leading to the capture of the criminal and his or her punishment. This came much later in Ehrlich's *The Market for Offenses and the Public Enforcement of Laws* (1996). All through the centuries, crime has drawn a great deal of interest in research and academia, but the enforcement facet, that which is assigned to protect and impose, the police, seem to be taken for granted as a perfect determinant variable. Certainly, the perceived response of police by a particular group of criminals influences the actions of those same criminals.

Nielsen and Mathiesen (2003) on compliance theory particularly influenced this study by discussing in the literature an often-ignored widespread problem, which is "management bodies [often respond to concerns with] restrictive control measures or ignore problems [altogether]" (p. 409). Second, the researcher conducted the study over time using secondary and primary data. My study, modeled for time analysis, highlights crucial changes in regulation that impacted blue crab harvests in Maryland's Chesapeake Bay. Finally, Arias et al. (2015) used time analysis to analyze compliance before and after the implementation of MPAs. Arias and I tested, in our perspective studies, for correlations between regulation and enforcement data. I decided enforcement/compliance theory using time analysis best suited my research.

**Major Propositions and Hypotheses**

The plausibility existed that regulation had a negative corollary effect on commercial blue crab fishers' compliance, which influenced harvest reports, thereby suggesting the existence of an unintended relationship. Noncompliance and regulations that are difficult to enforce skew population and harvest data, which leads to additional regulatory action. Regulation inhibits economic opportunity. The history of blue crab management demonstrates sporadic decision-making with little empirical evidence to support those decisions. The hypotheses and null hypotheses are stated for the purpose of discussion but not called for in correlation design.

$H_0$1: The number of commercial regulatory actions enacted does increase the number of blue crab citations and warnings reported annually.

$H_1$1: The number of commercial regulation action enacted does not increase the number of blue crab citations and warnings reported annually.

$H_0$2: The type of commercial regulatory actions enacted does increase the number of blue crab citations and warnings reported annually.

$H_1$2: The type of commercial regulation action enacted does not increase the number of blue crab citations and warnings reported annually.

Based upon MD-DNR complaints, I assumed that commercial blue crab fishers can over-report harvest, and commercial blue crab fishers had the means to exceed their gear limits. Inconsistency in blue crab harvest was common. In contrast, MSY depends upon consistency for application and is used by the MD-DNR to create blue crab harvest quotas and license caps. I considered several assumptions such as skewed harvest data acts as a catalyst to further regulation; MSY is a poor control for population stock abundance since blue crab populations fluctuate regularly. ITQs create inequality in a small-scale fishery, such as blue crab in Maryland's Chesapeake Bay. The effect of overharvesting, overregulation, and black market crab pots related to illegal activity in the blue crab industry remains unidentified. One fact is certain, crab pots trap blue crab and by-catch continuously while submerged until oxidation eventually breaks down the metal.

**Theory Rationale**

The three theories guiding the literature review included compliance/enforcement theory, common property/rights-based, and economic theory. I implemented a strict selection process to narrow down the theory pool. By continually asking myself what I wanted to test assisted in keeping the objective in focus. I appraised commercial blue crab fisheries related regulatory activity beside enforcement data as my primary objective in this research. Does the regulatory process lead to an unexpected relationship between compliance behavior and this activity? As a rule, regulation had been grounded in common property and rights-based management strategies, and economic theory had not ventured further than costs associated with the practice of crabbing, renting the licenses, or illegal, risky activity. My study considered the ramifications of unexpected relationships, specifically for blue crab harvest that effects commercial blue crab regulations using enforcement/compliance theory to lead and ground the study. I used a descriptive study to capture the essence and prevalence of particular compliance phenomena that may lead to further research to determine the underlying causes of such a phenomenon.

**Relative to the Study**

The existing gap in the literature concerned possible unexpected relationships between enforcement data and blue crab regulations. By me expounding upon the development of the MD-NRP, blue crab enforcement tactics and outcomes, blue crab interest, and regulatory action, a person might grasp the volatile relationship between stakeholders. As restrictions continue to increase, the economic impact on local communities is substantial, and compliance and monitoring issues escalate with the problem. In this study, I connected regulatory action to commercial crabbing noncompliance data. Patterns developed, and this may suggest the use of skewed baseline data as an issue, and this further drives policy. The MD-DNR is charged with protecting the natural resources of Maryland despite economic concerns held by the commercial blue crab fishers. Compliance and enforcement theory in fisheries were limited, but it is essential to management. Common property and rights-based theories remain and continue as the foundation in fisheries policy. Economics drive the industry, but in the current literature, researchers viewed it narrowly.

## Conceptual Framework

### Key Phenomenon

According to enforcement/compliance theory, people choose to break the law. The literature supported this with reasons as to why a person breaks the law. Specifically, in fisheries, moral development, income potential, and perceived legitimacy, as well as prisoner's dilemma were often quoted as contributors to making the decision to break the law or not. Types of crimes characterized by this specialized group of individuals included illegal, unreported, and unregulated harvest of fish, as well as fishing in private and or protected areas (Ali & Abdullah, 2010; ; Arias et al., 2015; Daw & Gray, 2005; Dresdner, Chávez, & Barriga, 2015; Eliasen, Papdopoulou, Vassilopoulou, & Catchpole, 2014; Hentati-Sundberg, Hjelm, & Österblom, 2014; Kuperan & Sutinen, 1998; Mazany et al., 2005; Nielsen & Mathiesen, 2003).

The continued lack of empirical studies in fisheries enforcement was mysterious in light of the constant call for improved enforcement. Testing and proving the necessary role of enforcement in fisheries is obligatory. Authors had stressed the importance of the need for enforcement to encourage compliance in fisheries regulations, but credible data that supported specific regulatory action continued neglected in the field. This study discovered enforcement/compliance trends developed in response to regulatory activity. Thus, enforcement/compliance theory best represented the current problem and the results of this study in an often-neglected area in academia.

**Key Theorists**

Guenther et al. (2015) analyzed fishing effort of commercial lobster fishers whose traps were stationary like blue crab pots. Their interest involved Marine Protected Areas (MPAs) possible spillover effects. The authors proposed it was common knowledge that MPAs increase "…species abundance, biomass, and productivity within their borders" (p. 78). One assumption presented in this study suggested as an adaptive strategy to recover possible losses, fishers would "fish the line" to capture target species as they "spill-out" (p. 79) from the MPA. The authors viewed secondary harvest data prior to and after an MPA was established to determine how fishing efforts may have changed.

Their study represented a time to event design. It provided a guideline for my study on blue crab compliance and the number and type of regulations enacted whereby enforcement data was identified in relationship to these regulatory actions. The authors asserted few studies had compared "methodological outputs or examined discontinuities in environments" (p. 80). Further, the authors contended that human behavior may be unwittingly effecting models whereby they may no longer fit the actual data. In 2008, the MD-DNR suggested commercial blue crab fishers over-reported harvest in response to upcoming regulatory action. The commercial crabbing industry in Maryland had little research that spanned beyond conservation and ecosystem services. My study suggested that if commercial blue crab fishers can set crab pots that exceed the limit, the probability of over or underreporting blue crab harvest was likely, and they were unwittingly, negatively effecting current MSY models.

## Related Methods

### Enforcement Theories

Termed "conservation," the mid-1920s saw the first plea for enforcement. In January 1926, *the Baltimore Sun,* in bold, stated, "Big Depletion in Crab Supply Found by U.S." urging the drawing of drastic laws to conserve the Chesapeake Bay blue crab. The paper continued to report that over the previous 15 years, the average blue crab harvest per trotline (baited rope stretching 1000') had decreased by 70%. In contrast, the gear called scrape (metal frame with fishing net attached) and dip net (small net on a stick) had harvests that remained uniform and average throughout the season. Hoover made the following recommendations:

- The taking of sponge crabs be outlawed.
- The taking of buckram crabs be outlawed.
- The peeler crab be defined by the new soft shell fully formed under the outer hard shell and easily detected by the backfin's coloration.
- A thirty percent reduction takes place in all forms of crab fishing.
- Continuous collection of statistics and biological data occur to analyze the effect of any new regulations.
- By approval of the Governor, state fishing commissions may change regulations.

Limited literature provided empirical studies pertaining to compliance and enforcement issues in fisheries. On July 24, 1941, the height of the blue crab season, *The Baltimore Sun* heralds, "Judge Melvin Upholds Ban against Crab Pots." An angry commercial blue crab fisher “attacked the validity of the law” (para. 2). He asserted that a multitude of men had been employing the use of crab pots prior to this new law. Indeed, this law bounced between passed and over-turned for several years, but the crab pot won out and continues as the gear most used to harvest blue crab in Maryland in 2019.

By November 1942, The Board of Natural Resources ordered a study completed by Charles C. Davis of the Chesapeake Biological Laboratory named, “A Study of the Crab Pot as a Fishing Gear.” He conducted a quantitative study that introduced the general principles of the industry and gear types employed in the blue crab industry. He compared the harvest of crab pots to the traditional trotline. He counted individual harvests that included total number of crabs, legal and illegal in three locations and displayed these in a table. The summary reported that the crab pot as good for conservation and efficient if employed in deep waters as opposed to marshy inlets and rivers where it could be destructive biologically. Further, he asserted that if crab pots are legalized in Maryland it should be with location restriction and a limited number of pots per license.

This era in the United States did not call for research in this area. The industry was changing and growing so quickly that compliance behavior and enforcement abilities were given little thought. However, this author published this report through a government agency, at the request of the government, and presented an overall picture of the commercial crabbing industry. The title denoted the content, and the report presented all common gear and its use in the crabbing industry as well as recreational gear. He founded the content first-hand during interviews with all the watermen in crabbing regions throughout the State. He reported the results professionally and written with common vocabulary. Industry stakeholders or academics would benefit from reading this report. At the age of its publication, the author remained objective and provided new literature not considered at the time. Much of the industry has remained unchanged.

In the 1990s, limited literature continued to evade compliance and enforcement theories. K. Kuperan and Jon G. Sutinen (1998) published in T*he Law and Society Review*, "Bluewater Crime: Deterrence, Legitimacy, and Compliance in Fisheries." The authors tested the roles of deterrence and legitimacy in the compliance behavior of Malaysian fishers. They asserted that empirical evidence continued to evade the scholarly work related to this industry and these variables. Kuperan and Sutinen, used a qualitative study to collect their data. The survey included several facets including probability statements, potential for illegal gains, and why a fishing person complies or not considering instrumental and normative compliance theory.

Financial gains drive instrumental while normative is driven by moral obligation. Process variables were considered from efficiency and effectiveness ratings and how these equate to the result of compliance to a regulation. Further, the authors utilized cognitive and social learning theory to understand the forces that influenced compliance behavior. The authors tested hypothesized relationships among variables. They extended the model of compliance to include moral decision-making. Their work uncovered stock abundance and income potential play a leading role in compliance choices. They discussed a need for fine tuning instrument use and proper assessing of subjective probability responses. Their research supported the deterrence model that asserts the value of expected penalties compared against the benefits of illegal fishing determines the outcome of compliance behavior. Their model provided support for increased enforcement that would increase the probability of being caught in illegal activity.

Kuperan's international exposure and research conducted in many countries has led him to teach courses in global economic theories, as well as courses in international business and management economics. He chairs for MBA and DBA students at the Othman Yeop Abdullah Graduate School of Business. Dr. Kuperan has been cited more than 1,300 times with a third of them occurring since 2011. Sutinen's expertise lies in fisheries economics. The past 30 years has led him to conduct research in fisheries management, specifically the compliance and enforcement of regulation. His research has been adopted by a multitude of government agencies and shaped regulation in several countries, including the United States. He began to take an interest in recreational fisheries management, an area often neglected for the variables under study.

The title specifically introduced the content of the article, which was written for the academic. The authors do an excellent job of creating background for the research hypothesis by introducing a variety of theories by which to view the problem. This research highlighted the occurrence of illegal activity and the extent of requested data that fishers were not willing to share. For instance, they would not discuss the associated costs of conducting illegal fishing. The dated article underscores the need for empirical evidence and research pertaining to enforcement and compliance. Because limited literature exists, the authors were limited in resources. This primary work acted as an update to existing materials and substantiated the need for further studies in fisheries compliance behavior and enforcement ability.

Fabienne Lord (2011), author of “Understanding Social Impacts by Using New Variables and a Causal Model Diagram in New England Fisheries,” addressed regulatory response through a qualitative causal model that focused on identifying a new list of variables indicative of social impact and social change processes. The Magnuson-Stevens Act provides for social impact analysis caused by regulation change. A Social Impact Assessment (SIA) identifies, predicts, and manages or mitigates for these possible impacts. This provision was equally true for environmental processes referred to as EIS, Environmental Impact Statements. The New England groundfishing industry continued to fail in spite of these changes and continual regulations. The regulations increased conflict with fishers. The Northeast Multispecies Fisheries Management Plan was adopted in 1987 and changed 41 times, with 11 amendments, and 30 framework adjustments by the year 2000. The author contended that the list of indicators to be considered in SIAs and EISs does not adequately consider the indirect, cumulative, and interactive effects from multiple stressors in the industry; thus, it misrepresents the range of impacts experienced by fishers.

Lord (2011) categorized the fishermen’s response to regulations into the following: reduced perceived quality of life, reduced job satisfaction, distrust in government, adopting risky behavior, reduced psychological and physical health, and reduced standard of living. He contended that processes lead to impacts, and the ability to identify these processes in advance can assist management in providing interventions in advance of a regulation. He asserted that a more thorough assessment tool can improve baseline data through 'lessons learned' for a particular management actions' impact on context-dependent causal pathways that lead to social response. This new knowledge could be transferred to new regulatory actions.

This article was informative. The title reflected the content accurately. The author's message supported the importance of understanding the mind-set of the commercial fishing community. Currently, Lord (2011) is a Consultant and Project Coordinator for Environment and Sustainability in Montreal, Canada. He graduated from the University of New Hampshire. This research has been cited eight times since its publication. This was a thorough read for the academic or scientist. Lord provided much background information to support his views. He employed qualitative methods to collect data, which I believed to be subjective. The work does update the available materials in that it discussed regulation and effects of such without an economic basis. The material reads on the emotional side, and it lends itself towards the possibility of bias work.

**Common Property and Rights-Based Theories**

Current research is grounded in common property and rights-based theories because that is the status quo for fisheries management. Although the terms as vernacular were not mentioned in the early research, the ideals date back several centuries. However, in 1954, H. Scott Gordon, a forerunner in economic and common property theories in fisheries, set a new bar by examining economics extensively alongside common property. He implied fisheries hold "no economic rent," and a sea harvest equaled any other common-property natural resource harvested individually. He further argued that for all those who used the term 'economics' no one had extensively examined it. "Fisheries management" surfaced, but Gordon suggested this focus on maximization of resource fails to consider other costs that go uncounted. He applied economic theory to "demonstrate that the 'overfishing problem' has its roots in the economic organization of the industry" (p. 128).

The title, *The Economic Theory of a Common-Property Resource: The Fishery,* clearly delineates the nature of the study. H. Scott Gordon, an economist who taught college in the United States and Canada, founded an economics department, chaired and multi-chaired several academic departments, at times, simultaneously. Most notably, he peer-reviewed for the *Journal of Law and Economics*. This particular work became a "citation classic" (2016, Indiana University, Archives, Bibliographic Note, para. 3). Although the article was dated, the material remains current to fisheries and this blue crab related study. The author addresses multiple groups that may be influenced by this application of economic theory. Although the author described technical content, it remained digestible for a general population. The work was based upon facts and available research materials. Many of the concerns put forth by the author continue into present day. Certainly, this primary source advanced and highlighted the complex relationships that exist in fisheries, even today.

In 2012, economists continued to evaluate the influence common property had upon fishing effort. The article named *Are Input Controls Required in Individual Transferable Quota Fisheries to Address Ecosystem Based Fisheries Management Objectives,* pointed to common property as the issue behind the 'open access / right-to-fish' competitiveness. Emery et al. research suggested allotting value to the right-to-fish would "eliminate the competitive 'race to fish'" (p. 123). Their research focused upon the use of ITQs, a system by which the fisher owns the right to a percentage of the overall harvest but holds no property rights to the actual resource. Traditional approaches manage the fishery through effort restrictions, the top-down approach. The failing fisheries led management towards a bottom-up approach or ITQs. Only 2.7% of the world's fishing harvest utilizes this system. The advent of ecosystem-based management forced ITQ systems to consider more than economic rent, but also, environmental and biological factors. These authors reviewed 18 ITQ fisheries across six countries limiting the research to five fishing methods in an attempt to present the success or not of input controls in light of the onset of ecosystem-based fisheries management. The results demonstrated that ITQ systems are inherently inflexible requiring the continued use of management controls. This control undermines the value of perceived ownership in the harvest "security" and affects human behavior. The authors' review encouraged future studies were warranted to promote the security of fishing people and the test of incorporating ecosystem-based management.

Two schools of thought at the University of Tasmania meshed for this research and publication: Institute for Marine and Antarctic Studies and School of Finance. The precision of referencing the literature within the article assisted in analyzing the content. The title and sub-headings made this difficult read easier to follow. This article was intended for a fisheries-related informed audience. It was advanced, but, well synthesized. The study covered a reasonable amount of data for its purpose. The authors reviewed prominent literature, but that which supported the authors' view. Many works were in line with the authors' views, representing the gap in the literature. Assumptions that were made about fishermen's' behavior related to regulation and enforcement first must be proven to exist. The tone seemed an attempt at convincing the reader about ITQ appropriateness, rather than educating the reader on his or her choices as to his or her thoughts about ITQs and its relationship to the ecosystem at large. This paper would hold legislative influence in support of ITQ management. A rebuttal article could be written using some of the same literature found in the Reference section. Specifically, the Reference section adds to the wealth of this article.

**Economic Theories**

Limited empirical literature exists that grounded regulations, compliance behavior, and enforcement in economic theory. However, in 1905, the Department of Commerce and Labor, Bureau of Fisheries captured blue crab interest in a paper titled, "The Crab Industry of Maryland" by Winthrop A. Roberts, Agent. The data provided in this paper stemmed from a general study conducted on the Maryland fisheries in 1902. Simultaneously, Professor W. P. Hay (1904) of Howard University researched the natural history of the blue crab, and his notes were applied liberally to this paper. Roberts' stated specifically in his report that the point of view would not be from science but that of blue crabs' economic value.

The author visited, physically, the entire Tidewater area in Maryland that produced the newest edible natural resource. With the advent of ice and gas, Maryland became the top producer in the Union. Mr. Roberts' covered a multitude of happenings and apparatus and how each individually related to the economics of the industry.

Further, he discussed some theory on biological aspects, such as feeding stale meat to crabs in captivity, which led to high mortality. He discussed demand, supply, and market prices. He reviewed the “seasons” of the industry biologically, not as a rule of the industry, but as an industry practice. The report provided a table of blue crab harvest in 1901, which was an asset as little empirical evidence was available from the establishment of commercial crabbing as an entrepreneurial practice.

Although the report was dated, much of the data interestingly remains unchanged. The author held a government based relationship to the study, and it could be considered factual in its entirety. He presented the information in an easy to read format for any person who showed interest. This was a scholarly work for its time. The report provided background industry information, walked the reader through the gear, and discussed the practice of crabbing for two life stages: hard crab and soft crab. Each community produced harvests regionally within the Chesapeake Bay. This report provided another example of the importance of the industry to Maryland both economically and culturally.

However, in 1985, James E. Wilen of the Department of Agricultural Economics of the University of California delved into fisheries and economics, only to discover that this paradigm did not yet exist. He contended this contrasted with microeconomic studies in most industries. Wilen suggested real-world views of the working environment captured problems that could be resolved with realistic theory and empirical research. He asserted that nothing further than the wastefulness of open access (common property theory) with formulas for “optimally managing” (p. 370) (MSY) fisheries had emerged.

His study, *Towards a Theory of the Regulated Fishery*, highlighted that the common-property model was no longer relevant because fisheries first are managed at species survival and second at economical returns. He called for a look between the "regulators and the regulatees" (p. 372). Wilen insisted that fishing behavior was "itself the outcome of gaming situations between the individual units at the microeconomic level" (p. 372). He presented the first approximation of a theory, which demonstrated "behavior is aggregated from a microeconomic-level theory of the individual unit's behavior" (p. 386).

Dr. Wilen is a distinguished professor who has authored 126 publications and 2,442 citations. Regardless of its 1987 publishing, the source continues to be legitimate to current fisheries issues. The author speaks to the need of developing behavior related fisheries theories. The title conveys the intent of the publication, which was to introduce such a theory. This article read with ease but was intended for a scientific or academic audience. Wilen covers the general facts concisely and merges the idea of the need for a relationship between those who regulate and those who are supposed to follow the commands. He contended that the disequilibrium decision making that was encountered in Prisoners' Dilemma was in effect the same response of fishing people. He or she does not consider the long-term effects of his or her actions, only how it relates to what other people are perceived as "doing" in the here-and-now. This article supported literature as an important update to other sources and extensively covered the current topic.

In 2013, Abdullah Nasser addressed concerns about overfishing in a paper called, "Overfishing: Economic Policies in Finite Resource Biological Pools." The paper addressed the state of innovative technologies and the impact of the Industrial Revolution on the fishing industry. The idea of resource-depletion was a new idea, but the improvements in gear created the capacity to fish beyond sustainability or to complete destruction if allowed. Although the 1949 International Convention for the Northwest Atlantic Fisheries (ICNAF) addressed this through new command and control regulations, it did little to address the inability to monitor and enforce the regulations. In contrast, this same monument was dissolved in 1979, and fishing advocates faced less pressure. The author expressed some fisheries became bankrupt, several fish were pushed to near extinction, and revenues declined by some 50% for the commercial fisher. The author used a mathematical model to "establish payoffs in a time-dependent dynamic system." Three stages were employed: Biological, Individual fishers, and Supply-demand economics. Several factors were considered in the model, which consisted of deficiencies related inter-species interactions, factors assumed constant were not, and prices at the market, which changed with the wind or because of natural global supply/demand chains. Again, the prisoner's dilemma was exposed. The general conclusions of this paper can act towards policy recommendations.

The author can be found at Harvard's Schulich School of Medicine and Dentistry Medicine. He has been cited a dozen times, with nine of those occurring since 2011. The publication is current and published in the *Undergraduate Economic Review*. The title demonstrates the content accurately; the author addresses the audience with concise and simple language. Most readers would understand this article, including the interpretation of the math formulas used in the model. The article read objective and impartial, but it does make some glaring assumptions that would impact the outcome of the model significantly if completed in a time-series analysis. Regardless, this article not only updates gaps in the literature, it identifies the importance of the need for accurate base line data and the dangers of a lack of monitoring and enforcement of regulations.

## Approaching the Problem

### Enforcement Theories

I discovered little on compliance and enforcement literature until publications dating the late 1990s. In the first quarter of the twentieth century, conservation ideals ruled fisheries. As reported by *the Baltimore Sun*, January 11, 1926, after the Fisheries Bureau, Maryland, and Virginia cooperated in collecting the data, Herbert Hoover urged a 1/3 reduction in the harvest of blue crab. The cooperative, quantitative study surveyed harvests over multiple years to determine the condition of the fishery. The author's immediate focus summarized the rise and fall of the population through documented harvests. The government hypothesized that 75% of the adult population faced removal each season.

The idea of a "study" made this research leading edge. It was the first serious gauge of the blue crab population. The study was limited using unquantifiable data. The Chesapeake Bay blue crab was fast becoming a delectable resource by demand because of the industrial revolution: gasoline engines, refrigerated railway cars, and delivery service by ship. Historical gear faced new gear in the form of a crab pot in 1939. This was outlawed in Maryland in 1941, but Virginians 20 miles south employed some 40 thousand pots for blue crab harvest (Davis, 1942). Maryland confiscated crab pots as enforcement, but ownership of the crab pot was not identifiable (*The Sun, 1941*).

In 1942, Charles C. Davis of the Board of Natural Resources completed a study of the crab pot. Mortality, injured, legal, illegal, and by-catch data was collected from crab pots placed at three separate locations. This data was compared to harvest from a traditional gear – trotline. This was an economic analysis as well as a mechanical, biological, and environmental review of the use of the crab pot. The analysis touted the crab pot as efficient in its harvest, as well as superior in conservation to its counter, the trotline, when used in deep water. It suggested the crab pot would be destructive in marshy areas and sounds. This research was leading edge for its time and made several excellent considerations for future research. The study was weak in that it was performed once. In addition, the data collected, unless commercial blue crab fishers' verbal responses were guaranteed by honesty or anonymity lacked validity.

By 1998, Kuperan and Sutinen highlighted crime in fisheries focusing on deterrence and legitimacy in behavior choices. This qualitative study occurred because the authors' recognized the lack of empirical evidence in the fisheries literature concerning behavior of fishing people. They discussed the expense of enforcement, an often-ignored issue in the literature. The report relied on the answer to questionnaires provided to 318 Peninsular Malaysian fishers. Limited available data in the field hindered the study. Further, the data could not be quantified. There may have been motivation on the part of the fishers not to report honestly. Many questions remained unanswered by fishers, so the impact of no response had to be considered in the formulas. Regardless, the literature brought forth important considerations about the human aspect of the fishing industry.

In another decade, social impacts were reviewed in a causal model of New England fisheries (Lord, 2011). This author used qualitative research to review how new processes under the Magnuson-Steven Act were prohibited from reaching their goal, which was to consider social impacts of a regulation. Ground theory guided the research; it allowed the data to lead to hypotheses of relationships between variables without research bias. The author adapted a causal model, which allowed indirect and direct effects of any stressor to be analyzed. This was valid when the model was applied to "all" aspects of the research. This validity would be hard achieved in view of time constraints to publish research results. The research employed direct quotes from fishing people. The literature did not provide the steps applied to collecting data from the fishing community. The considerations in this research were important, but the study lacked procedural vernacular important to validity of the content and analysis.

**Common Property and Rights-Based Theories**

In reviewing the literature for common property and rights-based fishing, it seemed we as a people had not made much progress. Throughout time, particularly in international seas and bodies of water within the United States, the ideal of common property rights had existed as a survival belief first and as an ideal of equality among men, in this case – fishers of all sea life, second. In contrast to some phenomena uncovered by previous research, the United States, in particular, Maryland continued to employ status – quo, common property theory, while attempting to maintain sustainable quotas (MSY), an oxymoron. There were two forces at work. The ideal of common property and rights-based fishing immediately depicted an entrepreneur working towards profit (Arnason, 2009). In contrast, one view attempted to create a sustainable fishery without cooperation and another view attempted to profit under limits.

The research on common property and rights-based fishing was leading edge in its roots. These authors provided an array of overviews. The authors presented documented background information; they offered solutions to the problem or ideas for further research. However, the theories had not made much progress even in the use of economic theories. This author used quantitative research grounded in economic models that sought value in the efficiency and work of the industry. The qualitative methods were limited, and they were geared toward cultural significances. Limited available data hindered the research content. As cited by H. Scott Gordon in the mid-50s, the literature lacked empirical economic research that supported common property/rights-based fishing. Furthermore, he contended fisheries management was not for protecting fish through management, but for the exploits of man; thus, how was this beneficial *per se*? The ideals of common property continued into the 1990s. MSY came into existence as science attempted to identify and maintain a specific harvest that would sustain a fishery biologically and economically. In 2012 (Emery et al.), scientists continued to ask questions about the practicality of quota systems in a common property resource.

**Economic Theories**

In 1905, Winthrop A. Roberts of the Bureau of Fisheries visited all blue crab regions in Maryland to investigate the industry. The author used descriptive reports and relied upon personal observations, extensive notes collected by Dr. Hay (1904), interviews with industry participants, and harvest reports from the 1901 season. Roberts provided standard industry terminology for gear and descriptive terms for the life cycles of the blue crab in the report. He discussed the day-to-day practices of the industry and the market prices for specific life stages – hard crab or soft crab. Historical, cultural practices persist today in mindsets as beneficial to the submerged world of blue crab. This descriptive, qualitative report presented as a factual representation of the blue crab industry in Maryland. The sheer volume of information that had to be compiled and entered by hand for this research indicated a weakness in the research. Numerous transpositions could have occurred. Regulations did not exist for blue crab, so verbal responses were presented as fact from the perspective of the watermen community. Maryland reported its first economic gauge for the blue crab industry, documenting its economic importance for the state.

In 1985, James E. Wilen questioned the lack of studies developing microeconomic theories meant to capture the decision-making environment fishers face. Wilen asserted the assumption that "fishermen are assumed to make decisions regarding potential fishing and capacity in light of how they anticipate fellow fishermen and regulators to act" (legitimacy in compliance) (p. 369). He asserted that fisheries require a shift to predictive modeling and away from normative modeling. Wilen suggested a regulator-regulatee model is essential to avoid disequilibrium decisions or Prisoner's Dilemma. With potential-effort limited by constant regulation, fishers continue to compete for a share of the catch. The author presented several formulas by which to discuss fishing effort, resources, and economic impacts such as taxes and fees as a way to regulate the fishery. In the paper, the author discussed real world decision-making (compliance behavior) and how that related to macroeconomics and microeconomics. This study represented the continuation of the interest in economic behavior in fisheries. The author introduced innovative ideas, but the ideas would need to be tested for practicality. Even when a theory may appear valid on paper, it may not fit real world applications. The paper oversimplified the problem.

Abdullah Nasser (2013) addressed the equilibrium solution using mixed methods grounded in game theory. The model was intended to estimate the effects different variables had on the fishing market. It would assist in predicting fishers' responses, thus, controlling overfishing. Their modeling demonstrated that fishers were caught in a Prisoner's Dilemma-type problem. The quantitative model was created using several qualitatively described regulatory proposals. The author suggested several economic strategies to control overfishing: quotas, moratoriums, licenses, taxes, and price stabilization through price controls. The authors address concerns that have continued since the commercialization of crabbing. This work does not add to the literature, but rather, it rehashes concerns about common property, economic decision-making, compliance behavior, and overfishing.

## Variable Selection Rationale

Throughout the literature, the variables selection appeared across time and theory, fisheries - economics. The focus was upon individual decision making as it related to risk and economics. This evolved into a comparison to prisoner dilemma theory. Compliance and enforcement although mentioned were not reviewed until the late twentieth century. The research failed to produce actual outcome data. Each article or report provided historical data to introduce the variable set and continued with a specific interest in economics along-side common property and rights-based theories. The selection of compliance – enforcement data (v1) and the regulations (v2) from which it stemmed as it related to the gains made by a person's right to fish remain familiar themes. This study maintained this familiar theme in variables, but it employed simultaneously the use of all the variables to produce empirical data that may reveal timed non-compliant phenomenon as opposed to day-to-day compliance issues.

## Thematic-Chronological Review of Related Studies

### Conservation Theory Review

In 1927, Maryland took measures to define the "peeler crab" using clearer language. In addition, it increased the minimum harvest size for soft crabs to 3½ inches (Kennedy et al., 2007). However, Maryland did not take charge until 1928 when it started an annual collection of data on commercial harvests (Kennedy et al., 2007). *The Sun* reported in its headline on June 1, 1930 (Brooke) - "Household – A Crab Season of Plenitude and Cheapness." The blue crab season peaked at 36,938,783 pounds (Kennedy et al., 2007) quadruple the 1925 harvest (Maryland State Planning (MDP), 1938).

The ebb and flow of the fishery triggered continuous interest, and Maryland's Chesapeake Biological Laboratory began a long-term study of the blue crab (Kennedy et al., 2007). However, in contrast to conservation and proliferation, in 1932 Virginia repealed its protective legislation banning the taking of the sponge crab (impregnated blue crab) during spawning season (*The Sun*, 1932). Maryland's conservation commissioner proclaimed that the increase in crab harvests from 30 million pounds in

1926 to 63 million pounds in 1932 in Maryland and Virginia was a direct result of the previous outlawing of the harvest of sponge crabs (Griffin, 1932). No empirical evidence exists to support this claim. Again, commercial blue crab fishers were pitted against one another through unequal regulation in Virginia and Maryland's Chesapeake Bay.

As posted by *The Sun* on January 19, 1932:

> The uninitiated wonder at times why so much interest surrounds the famous blue crab of the Chesapeake, why so much legislation has been passed regarding it, so many scientific studies made of the creature. Chief reason is the fact that the annual crab catch affects well nigh every fiber of the business structure in the tidewater counties of Maryland and Virginia (para. 2).

In 1934, the National Recovery Association in Washington, D.C. announced that the Crab Packers' Association group would administer the blue crab code for Maryland and Virginia. This group comprised of commercial blue crab fishers and industry participants from both Virginia and Maryland. Their responsibilities included improving marketing, other conditions, and pricing in the industry (*The Sun*, 1934). Eighty-seven percent of the entire blue crab production in the United States stemmed from Maryland, followed by Virginia (*The Sun*, 1934). In 1937 in response to an unstable blue crab harvest, Maryland's General Assembly closed the blue crab season early in November, one month prior to the spawning season (Kennedy et al., 2007). It was suggested that the blue crab was on the verge of extinction (West, 1938).

By 1938, the male dominated industry felt stricter measures were necessary, and this was the first year a Maryland senator, Tydings, attempted to involve the Federal government in regulating the blue crab, specifically the spawning female blue crab. Although he was heavily criticized, he had introduced a similar bill just three years earlier (West, 1938). In December, Maryland's Planning Commission published a report, "Five Years of State Planning" (MDP, 1938). The report detailed the seafood industry in Maryland. It discussed the breakdown between Virginia and Maryland. It asserted that instead of Virginia lifting the ban on sponge crabs, she should have attempted to adjust in the market to absorb the vast supply of blue crabs harvested that season. Both the report and Senator's Tydings' bill created activity that resulted in Virginia's Fisheries Commissioner outlawing the taking of female crabs during the spawning season. Equally important, Maryland closed the female crab season during November and outlawed the use of sloughing boxes for hard crabs (4 out of 5 die), which are submerged or stationary dry-docked wooden boxes (colloquial term is crab float) where peeler crabs are held in Bay water until they shed into soft crabs (West, 1938).

The past decade demonstrated, although experiencing some minor industry changes, the fight over blue crab harvest had not waned even a little since the late 15$^{th}$ century. However, the fight led to some proactive conservation efforts that continue to be debated in 2017. Specifically, data collection and regulation took root, commissions were developed to assist in creating an extended market for the delicacy, and inhumane practices were put to rest. Most important to the blue crab during these years was the use of traditional, non-threatening gear such as dip nets and trotlines.

Conservation as a word is interpreted often in a multitude of ways that can contradict the interpretation of others' views, especially when applied as a systematic means to control the use of natural resources. The proof to implement these intentions is often lacking, and the defined meaning behind the act is often rejected in the fishers' community vernacular, or it is missing altogether. The word "conservation" has been thrown around loosely for many decades, but its general premise is understood, and fishers hold strong religious and cultural beliefs that influence their thinking. Thereby, research that supports a conservation theory or attitude is regarded as guarding and proliferating the existing resource, and many industry participants are threatened by the attitude of "at the blue crab fishers' expense" when many variables contribute to the destruction of the Bay's habitat daily.

Innovative thinking by Eldridge, Burrell, Jr., and Steele (1979) led their research towards reshaping the gear in order to originate a self-culling blue crab pot. This research addressed actual response of blue crab to gear, which effected enforcement of undersize crabs caught in legal pots and might lessen illegal catches in illegal pots, which influenced commercial blue crab fishers' compliance. The article, *Development of a Self-Culling Blue Crab Pot* discussed a conservation effort that would require an industry change but lessen the physical effort for the blue crab fisher; however, it never reached fruition until the late 1990s (DNR, 2015). The study estimated that the number of sublegal crabs made up 60 percent of the catch during May and June, and a great deal of time would have been spent *culling* (removing) these crabs from the legal ones, which often led to injury and sometimes death of the crab. The authors tested escape ports using rectangles and circles with different measurements. A chi-square confirmed that pots with three escape ports as opposed to two reduced the catch of sublegal crabs by 82%. Circles were determined as best suited for escape without reducing legal catch, while rectangles allowed legal crabs to escape. The authors determined that the test was valid and produced the expected results of reduction in sublegal catch without reducing legal catch, which significantly reduced damages to the blue crab. This experiment was relative to over and underreporting commercial blue crab harvest in the twenty-first century. If more crab pots than Maryland's legal limit were set, additional uncounted mortality, injury, and ghost pots were likely. The authors used chi-square to measure catch and release differences using different style escape routes for sublegal crabs; the current study can employ chi-square in order to measure differences in enforcement data, as well as the potential black-market blue crab harvest. This article adds to the literature that demonstrated the perpetual, cyclical nature of the limited available empirical research concerning blue crab and crab pots.

Two decades later, Guillory and Prejean (1997) conducted similar experiments in their study of trap selectivity with various mesh sizes and shapes. The article, B*lue Crab, Callinectes sapidus, Trap Selectivity Studies: Mesh Size,* asserts that sublegal crabs continue to be retained by more than the 10 percent allowable tolerance in Louisiana. They tested three shapes with assorted sizes and collected crabs 2 weeks in March, April, and from June through July. Pots were set in shallow waters adjacent to emergent vegetation. Pots were baited with cut fish. They performed statistical tests using SAS. They tracked average catch rate by weight. Hex mesh pot rates by number and by catch were significantly higher than rectangle traps. Although the historical Hex mesh pots remained the most efficient in maximizing legal harvest while minimizing sublegal catch, the sublegal catch still exceeds the 10 percent tolerance. Guillory and Prejean asserted that changes in structure would lead to trap saturation effects, decrease handling, and increase catches of legal-sized crabs when escape vents are provided for sublegal crabs. Abandoned pots (Ghost) on the bottom would allow escape of crabs and smaller by-catch, as well as fishing efficiency would occur with less culling required. The authors demonstrated how self-culling pots could assist in conservation by minimizing mortality and creating economic efficiency by lessening time constraints. My research addressed non-compliance concerning undersized crab retention and other violations of regulations.

Guillory (1998) revisited mesh and retention rates in his article, *blue crab, Callinectes sapidus, Retention Rates in Different Trap Meshes.* The author hand measured each crab using a dial caliper for carapace and body width. Next, he manually passed each crab through the 5-experimental square meshes and the hexagonal commercial mesh observing the capability of passage without aid. Because blue crab communities vary in season and salinity, male and female crabs were assumed equal to calculate the overall retention curve. The results indicated that the 44.4 mm square allowed maximum escapement of sublegal crabs to escape while retaining the highest rate of legal blue crabs. The author contended that this study offers evidence and justification for gear management strategies to reduce sublegal catch at the onset as opposed to the time of harvest. This article addresses noncompliance of crab pot use as a means to manage fishing effort through gear standards. Enforcement data concerning illegal harvest of crabs would make it possible to recognize the skew that exists in fisheries stock data. My study reviewed the influence of regulation on blue crab fishers' noncompliance using enforcement data. The current study included the time that Maryland required commercial blue crab fishers place escape rings in each commercial crab pot.

J. F. Caddy (1999) discussed the role of paradigms on fisheries management in chronological theme in his article titled *Fisheries Management in the Twenty-First Century: Will New Paradigms Apply?* Caddy sought to predict future changes in methodologies by reviewing historical science and management. He asserted that current paradigms have a “marked geographical context, [a limited view of analysis], and are driven by technological changes” (p. 3). He discussed the academic context of fisheries, stock assessment tools, limits reference points, dominant paradigms, management cycles, and common property issues in this in-depth review. Caddy provided the Mediterranean demersal fishery as an example to exploitation using ITQs and elaborates upon ecosystems theory for multispecies management. He discussed the newest requirements that include economic and social impacts. The author contended that management would have to move towards technical advances. For instance, he suggested the use of telemetry and black-box systems, as well as global positioning technology to track fleets in open seas, while he believes inshore fisheries would be best suited to community management using catch limits and access rights. He expressed the importance of improved management infrastructure that leans towards innovative designs in experimentation for improved conservation.

The advanced arguments of this author relate to noncompliance in fisheries. In particular, his suggestions for technological advances in enforcement would assist in identifying unreported crab pots via video recorders or other devices. His historical review of paradigms demonstrated the changes in management cycles much like the overuse of regulation to address problems. In this way, this article provided my study trends in styles of regulation and the “why” behind a particular strategy. Further, the author discussed skews on harvest reports similar to that of blue crab in Maryland. This article addressed the need for improved infrastructure, which equated to enforcement agencies having the ability and the means to influence commercial blue crab fishers’ noncompliance, particularly for crab pot.

Dr. Anthony Hart (2002) for the Australian Centre for Tropical Freshwater Research produced, *Fisheries Monitoring Programs in the Southern Gulf of Carpentaria – a Review*. The author reviewed existing monitoring programs from the government, participant stakeholders, and community groups. Five criteria for assessments included: scientific credibility, ability to protect environmental value, cost-effectiveness, level of duplication across regions, and helpfulness of reporting style. Four types of monitoring were reviewed: commercial fisheries, fisheries independent monitoring, recreational fisheries, and fish habitat. Commercial fisheries have included on-board observer programs. Observations were used to consider risk analysis and sustainability indicators along with catch and effort using daily logbooks provided by fishers. Independent monitoring is accomplished when observers hire out commercial vessels to collect samples for factors such as length, weight, sex, and maturity. Limited data on recreational harvest exists although 90% of tourists expressed fishing as a main reason for visiting. Hart contends that the 1990s resulted in the recognition of the importance of maintaining marine ecosystems that begin with fish habitat. The Queensland Fisheries Act of 1994 led to creating Fish Habitat Areas (FHA also called MPA). In some areas, habitat characteristics and water quality were analyzed.

The author discussed CHRIS (Coastal Habitat Resource Information System), which is an interactive mapping resource for coastal fisheries habitat, environmental datasets, and fisheries harvest data. It has the ability to integrate a multitude of agency data from coastal vegetation to topographic and bathymetric data. However, Hart stated after multiple attempts to utilize the program, it was “difficult to operate” (p. 16). Monitoring programs for the blue crab have been completed commercially and independently because of accusations of falsifying crab harvest reports. This occurrence skewed baseline data that acted as a catalyst to regulation. He suggested there are many gaps in the data such as “ghost” fishing and by-catch surveys. These issues mirrored the effect of ghost pots on blue crab and unreported losses of mortality and by-catch found in crab pots. This author addressed the impact of ghost pots, and commercial blue crab fishers’ noncompliance on number of pots allowed. He contended ghost pots cannot accurately be estimated creating a cause for concern. Thus, the damages and costs associated with a black-market crab pot that then gets lost at sea remains uncounted.

Ju, Secor, and Harvey (2003) produced a *Demographic Assessment of the blue crab (Callinectes sapidus) in Chesapeake Bay Using Extractable Lipofuscins as Age Markers*. Common methods to determine population to regulate fishing dynamics include age-structured models. Hard parts cannot be analyzed because blue crab sheds its outer shell with growth. Length-frequency as a second approach was limited because of interannual and seasonability variables and protracted spawning season that led to multimodal distribution of sizes per age class. Instead, the authors investigated lipofuscins that accumulates in the eyeball and can be measured for age as opposed to size-based measurements. It was a biochemical option that eliminated "overlap of sizes in age classes that can reduce accuracy in age determination" (para. 3). Sciences disputed natural longevity because empirical evidence does not exist. The authors compared measurements of lipofuscin to traditional size-based methods to assess the differences in identifying accurate age of blue crab, a critical factor to determining future harvest potential, and to build in safeguards against overfishing.

The winter dredge surveys provide stratified random sampling. Juvenile crabs were underestimated in abundance because they escaped the gear. Likewise, lipofuscin index in small crabs cannot be determined because of analytical limitations. At least three ages appeared (ages 0, 1, and 2) in both sampling years. Classifications using lipofuscin were drastically different from those using carapace width (CW) indicating this modal could "lead to substantial errors in determination of growth, mortality and fishery yield estimates" (Discussion, para 2). Population data drives policy. This article addressed the importance of compliance concerning the number of crab pots allowed and the mean size crab each pot catches. If the juvenile population is underestimated, then the importance of crab size to black market estimates is essential to determine loss of future potential harvest.

Bjǿrndal, Lane, and Weintraub (2004) presented a limited review in *Operational Research [OR] Models and the Management of Fisheries and Aquaculture: A Review*. This article addressed the under investigated skew on harvest data and its relationship to management of fisheries. The authors evaluated the use of OR models in fisheries management and aquaculture. They suggest the difficulties in fisheries are in response to required sustainability. The authors identified what they perceived as the prominent issues and presented successful cases of OR models. Population modeling was the focus of most fisheries' management. Biological modeling may consider fish stock and recruitment behavior or apply age structure and class growth while recording mortality and forecasting potential yields. These models have led to quota assignments of available stocks. Likewise, economic modeling has persisted since Gordon (1954), simultaneous to population discussions. Mathematical programming and analysis have been incorporated by OR, which uses a systematic approach to five major areas: descriptive mathematical modeling, mathematical programming and optimization, statistical analysis and estimation procedures, computer simulations, and decision theory. This included minimizing costs for monitoring, surveying, and enforcement.

Unreliable catch and effort continued to be a concern and the inability to view the fishery as a whole support the uncertainties in capture fisheries. Computer simulation of ecosystems theory became popular and was meant to simulate actual and potential outcomes. The authors contended that, OR models would continue to flourish as a source to fisheries management but that they would face new challenges as environmental issues change and expand. The review presents an important timeline in modeling attitudes for fisheries. It provided an avenue to make comparisons of finfish to blue crab science and what analysis designs were dominant in specific fisheries. As regulations evolved for blue crab, they may reveal shifts in modeling.

*Assessing the Potential for Stock Enhancement in the Case of the Chesapeake Bay blue crab (Callinectes sapidus)* compiled by Davis, Young-Williams, Hines, and Zohar (2005) was a leading-edge study pertaining to blue crab. The authors described the ideal model as one that rears juveniles with aquaculture and releases them after surpassing “early-life-history mortality” (p. 109) whereby they exponentially improve population to add to future resources. The authors reported that no empirical studies had previously been performed to discern opponents’ concerns. For example, farmed to wild fish may not survive, may have negative interbreeding results, may overtake wildlife, or may lead to exasperated fishing pressure. They touted the blue crab as ecologically important but the most “economically important fishery in the Chesapeake Bay, Maryland, USA” (p. 110). The authors suggested a highly exploited fishery must be managed properly, and this was not the case with blue crab. In this regard, they insisted responsible stock enhancement aimed at restoring breeding stock was necessary in addition to traditional methods.

Their experiment required only four mature females that were carrying wild blue crab sperm. After hatching and growing the crabs, crabs from each batch were tagged and released. Groups of crabs ranged from 3,800 to 9,600 per release. They conducted sampling of the wild and hatchery crab population in each site. The authors sampled for wild blue crab 1-3 times before the release of hatchery raised crabs. Regardless of gear used to catch crabs, gender and CW was recorded for all blue crabs. The experiment lasted 4-12 months as measurements were taken until no more hatchery crabs were located in any of the three coves. The experiment resulted in an equal ratio of females to males hatching, but a lower female ratio to males found in the wild equal in size. It can be assumed that the hatchery crabs contributed to overall spawning stock of the Bay. The growth for hatchery crabs was 50% greater in a shorter time than wild crabs. Late summer releases did not favor the same. Because limited empirical evidence was available, the researchers had difficulty measuring the success of the experiment. Nonetheless, the potential to effect blue crab populations at a local level was a viable option if it can meet economic efficiency. In this article, the author demonstrated alternative management strategies that could be incorporated with traditional methods. Although the objective would be to supplement new breeding stock, financial feasibility would determine the outcome. The authors addressed the number of illegal and legal crabs fished from the Bay. Likely, the use of black market crab pots would be responsible for a number of this new stock being removed and uncounted.

Rudershausen and Turano (2006) conducted an experiment for the conservation and protection of pregnant blue crabs (sponge crabs) in North Carolina, its most economically important fishery. The authors addressed how sponge crabs are injured by crab pots, which would prevent them from hatching their egg mass; these same damages can be assumed to be occurring in illegal crab pots as well. This influenced estimates of damages. The authors discussed the results in an article titled, *Testing a Device to Exclude Ovigerous Blue Crab, Callinectes sapidus, from Commercial Pots*. North Carolina had practiced restrictive sanctuaries for brooding females since 1865, but the harvest of sponge crabs was legal. This had offered minimal protection, and NC was considering other means to protect the sponge crab. The authors contend that rather than the prohibition of capture, the gear crab pot can be manipulated to exclude the capture of the sponge crab.

The criteria considered for assessing practicality of an excluder was that of Eldridge et al. (1979): reduced levels of harvest, reduced stress, and eliminated a barrier to migration for brood release. They collected data over three years from 1,061 control pots and 1,027 excluder pots. The results demonstrated that the pots with excluders barred legal male crabs and or deterred them from narrow entrances. Further, stress of capture caused brood scrubbing and delayed migration to brood release areas. This article linked brood scrubbing directly to crab pots. The gear crab pot continued under scrutiny anywhere blue crab was surviving. The study took place in NC, but it was relative to the current study in Maryland.

In 2008, Zohar, Hines, Zmora, Johnson, Lipcius, Seitz, Eggleston, Place, Schott, Stubblefield, and Chung asserted that over the previous 15 years the blue crab population declined by 70 percent. The article, *The Chesapeake Bay Blue Crab (Callinectes sapidus): a Multidisciplinary Approach to Responsible Stock Replenishment* highlights the authors' concerns about the decline in spawning stock as opposed to the decline in pounds landed by proffering a replenishment program. Seven years previously, the Blue Crab Advanced Research Consortium (BCARC) made up of scientists and stakeholders was formed to advance biological understanding, develop a hatchery program, assess the feasibility of such, and transfer the program to the fishing industry, if successful. The authors declared previous stringent regulations created a stabilization of blue crab, but the resulting population records did not indicate a rebound. They supported restocking must take place.

Specifically, research must include a consideration for migration patterns and specific seasonal and geographical behaviors of breeding and spawning blue crab. The authors completed research in nursery settings where they hatched 570,000 blue crabs between 2002 and 2006. Near 300 thousand were tagged and released into Chesapeake Bay. The plan involved beginning in small habitats in the upper and lower Bay and then expanding to the larger system. However, to reach optimum cost effectiveness, gaining control of juvenile production through ovulation, brood production, and hatching was necessary, but required a complete understanding of a complex reproductive process including gene and hormonal levels. An integral result of hatchery blue crab included a survival rate in the wild equal to that of the wild blue crab suggesting survival to sexual maturity. The authors recognized that with additional success a genetic marker would be necessary to eliminate the labor of tagging. Identifying release areas included considering density of wild plus hatchery crabs and available food sources. blue crabs were released between April and October, which was optimum growth and spawning time.

Hatchery crabs were able to migrate and spawn the second year of life, while the majority of wild blue crab would not grow large enough to make the migration and would overwinter in its current habitat. Diagnostic tools were used to manage disease and health. Quality assurance measures prevent incoming diseases, release into disease potential areas, and disease-free releases from hatchery blue crab. The program was cost prohibitive until hatchery costs can be reduced, as biological processes were better understood by science. This required solid science. Restoration had the potential to provide “substantial and long-term ecological and financial benefits” (p. 32). This article addressed rebound measures that were relative to compliance behavior by commercial blue crab fishers in Chesapeake Bay. Successful replenishment programs had the potential to reduce harvest pressures if the problem of crab pot enforcement was solved; otherwise, noncompliance would effect restocking programs negatively.

Havens, Bilkovic, Stanhope, Angstadt, and Hershner (2008) discussed the negative effects of crab pots in their article titled, *The Effects of Derelict blue crab Traps on Marine Organisms in the Lower York River, Virginia*. Limited literature existed regarding crab pots environmental impact on the Chesapeake Bay. During trawl surveys taking place between 2002-2005, 91 crab pots were captured in trawling equipment and brought on board to document their contents. The authors chose to survey both active and derelict crab pots. Areas were selected based upon known fishing pressure. GPS recorded active pots and potential derelict pots were viewed using benthic mapping during non-fishing periods using side-scan sonar to collect real-time georeferenced data. The sonar produced 676 potential derelict crab pots. Experimental designs included measuring encrustation and condition of the pots and baited and nonbaited pots. The results of the crab pot density comparison showed a ratio of 16:40 (40%) derelict to buoyed in 2005 and 12:54 (22.2%) in 2006. Encrusted pots continued to collect blue crab throughout the 13-month study. Pots fouled up with organisms that increased crab pot weight, then lost weight in the summer as diebacks occurred. The authors suggested vinyl-coated pots have an average life of 2 years or more. However, after time the crab pot acts as habitat to some creatures and continues to do so after it degrades beyond catching. The results suggested that crab pots stop catching in at least 1 year in high salinity and much longer in lower salinities. This article addressed issues pertaining to the use of crab pots. It confirmed that there is limited literature on crab pot use beyond economic relevancy. The skew created by ghost pots referred to as derelict in this article suggests a 30% loss of gear yearly had the potential to be exasperated using black-market pots.

In *An Evaluation of the Effects of Blue Crab (Callinectes sapidus) Behavior on the Efficacy of Crab Pots as a Tool for Estimating Population Abundance*, authors Sturdivant and Clark (2011) discussed the use of independent assessments produced by the individual blue crab fisher and how that assisted in estimating catch per unit of effort and population dynamics. The authors developed the ability to observe blue crab in and around crab pots. The study took place during July and August of 2003 and attempted to determine if intraspecific interactions affect catch and escape rates due to size or abundance, to determine if these factors were affected by abiotic factors like depth, and to assess the effects of behavior on crab pot efficacy. The authors used commercial crab pots to test catch rates. Field tests included seeding a pot with crabs to determine if the presence or size of a crab affected catch or escape rates. One meter to a maximum of 5 m depths was chosen along with a previously studied site that was free of vegetation and habitat. The minimum size crab was the legal minimum catch allowed in Maryland (2003) at 127 mm CW.

The population of interest was legal crabs. Video was modeled after lobster trap video presented in 2001. The contraption allowed an aerial view of the pot, and a red light, unseen by crabs was used for night vision. Crabs observed entering level 1 had an

85% escape rate, but for those that then entered the second level escape decreased to a 2% escape rate. The authors suggested that this skews population data, and population estimates should be measured from the second level counts only. The crabs exhibited limited quantifiable aggressive behavior, which leaves the authors to believe that this does not influence catch and escapes in a crab pot. They suggested patterns identified in this study may have been different using crabs in different molt cycles or gender. Enforcement tactics benefit from a self-culling crab pot. My research addressed identifying misconceptions about crab pot harvest numbers and mortality concerns that were exasperated. Crab pots act as the main gear for the harvest of blue crab, and research that discovers new behaviors in blue crab may assist in designing enforcement regulations.

The article, *Marine Extinctions and Conservation*, written by Briggs (2011) discussed the collapse of populations that were once a major seafood source. The author suggested future demise can be controlled by an aggressive use of MPAs. Briggs asserted that a thousand plus small populations of fish and invertebrate are remnants of species that collapsed from overfishing, and some stem from 30-50 years ago. These populations were typical of coastal and estuary populations that had further been reduced by habitat destruction, yet they continue to survive. The author stressed a shift towards ecological based fisheries management to save the struggling smaller populations. He contended that with global warming many of these species face sure extinction unless this philosophy was adopted. This author addressed overfishing as the heart of this article, which was an accusation that has continued in the blue crab industry. Noncompliance that may lead to extinction must be investigated. Determining when and why compliance issues arise is essential to any fisheries management plan, in particular, crab pot.

*Analyzing Large-Scale Conservation Interventions with Bayesian Hierarchical Models: a Case Study of Supplementing Threatened Pacific Salmon* by Scheuerell et al. (2015) addressed the constant threat of extinction of multiple species. Interventions have included habitat restoration, hatchery restoration, and protected areas. The authors analyzed 43 years of data from 22 populations. Using a time-series model, the authors discovered that environmental variables had a profound influence on interannual variability in adult density. Hatchery supplementation over varying time spans appeared to have negligible effect on increasing density in naturally spawning adult salmon. Hatchery supplementation was expensive and "the effectiveness of these programs in achieving conservation goals remains poorly understood" (Introduction, para. 4). Scheuerell et al. proposes that correlations across time and space can cause problems for traditional approaches, but they demonstrated how a Bayesian hierarchical model could tackle some of these limitations. This can answer questions about ecological responses to drastic conservation efforts. This study provided a guide for the current crab pot study. It provided a means to address the response of commercial blue crab fishers to regulatory action. It can incorporate time series and event influence for a given regulation, in this case, crab pot compliance.

**Enforcement Theory Review**

Maryland took some drastic measures when it outlawed the use of crab pots during the 1941 legislative session, but it allowed the use of motor power on crab scrape boats. Many blue crab fishers had invested heavily in crab pots, and beginning in June of 1941, illegal crab pots were being confiscated. In July, a Dorchester county blue crab fisher filed a suit attacking the validity of the law; however, Judge Melvin of the Circuit Court of Annapolis upheld the constitutionality of the 1941 law (*The Sun*, 1941). Between June and October of 1941, the Tidewater Fisheries Department of Maryland confiscated 1,900 crab pots valued in excess of $2,000 (*The Sun*, 1941). Again, in November, a Dorchester county blue crab fisher filed a lawsuit against the Tidewater Fisheries Department requesting an injunction prohibiting enforcement of the crab pot law. Then, in an appeal, he made the same request to Maryland's Court of Appeals who denied his request and upheld the law as it was written. In contrast to Maryland's activity, Virginia issued 20,000 commercial crab pot licenses (*The Sun*, 1941) and fished "some 40,000 pots" (Davis, 1942, p. 3). *The Sun*, December 11, 1941 printed a response from *the Crisfield Times* to the Watermen's Association who supported lifting the ban on crab pots. It reads:

> The Times emphatically declares—in answer to [Emerson's] appeal for the use of pots on the ground that they catch the 'better grades of crab'—that "If there are better grades of crabs, Emerson, the crab pot certainly gets 'em. For the crab pot works twenty-four hours a day and not only gets the better grades, but gets the intermediate grades and the commonest grades. The crab pot gets 'em all. And, next to the destruction of sponge crabs, is the greatest and most formidable enemy the crabbing industry has (the Sun, 1941).

In March of 1942, Maryland's Governor O'Conor requested the Maryland Bureau of Fisheries and Wildlife to complete a survey of conditions contributing to the blue crab decline for the past several years (*The Sun*, 1942). Governor O'Conor proposed a meeting between Maryland, Virginia, and conservation officials of both states, as well as the Secretary of the Interior to discuss possible "methods of rehabilitating" (para. 1) the blue crab population (*The Sun*, 1942). In April of 1942, Virginia called on Maryland to tighten their conservation efforts. *The Old Dominion* asserted the problem was an old one – blame placing. Further, ignorance, jealousy, and suspicion as well as indiscriminate laws regulating the Chesapeake Bay have led to a lack of cooperation among commercial blue crab fishers in both states. However, Virginia claimed that there were "ample laws" (para. 5) but that "a determination on the part of every enforcement agent to see that compliance with the law is strict and complete" (para. 5) was necessary, as well as a better understanding of the need for conservation (Bentley, 1942).

The Board of Natural Resource, State of Maryland, Department of Research and Education produced Publication No. 53 – "A Study of the Crab Pot as a Fishing Gear" in November of 1942. Davis (1942) wrote that the dispute over the use of crab pots had been littered with a wide range of pet theory based largely on the economic interests of those making the statements without the benefit of facts. The purpose of this study was to provide facts to assist in writing management policy for the blue crab fishery. The time study ran from June 1942 to October 1942 using the same pots as Maryland blue crab fishers. Pots were set in various locations, but data collection lacked clear purpose; thus, different variables were collected at different sites.

The focus of the study made comparisons between the use of a trotline and a crab pot to harvest blue crabs. Pounds of crab harvested were the consistent variable throughout the data collected over the five-month study. Davis (1942) concluded that the crab pot was clean-cut and efficient, requiring less time and labor, as compared to historical methods such as the trotline or dip nets and catches roughly equal weight in crabs, pound for pound. If the pot was used in the open Bay and deeper rivers it was constructive gear, but in shallow water, becomes “distinctly destructive” (Davis, 1942, p. 20).

In April of 1943, Maryland gave the Department of Tidewater Fisheries power to regulate the blue crab fishery without waiting for the legislature to pass laws (Kennedy et al., 2007). Opponents were fearful of an inundation of new regulation, but the commissioners promised they would “contemplate action only when its advisability is clearly shown by scientific research” (*The Sun*, 1943, para. 4); nonetheless, the first action the commission took was to outlaw the use of crab pots in Bay tributaries. Maryland further demonstrated its commitment to conserving fisheries when it provided for a department of research in the conservation field (*The Sun*, 1943). Additionally, Maryland and Virginia announced a conservation program with three points pertaining to the blue crab (*The Sun*, 1943).

- That both states should prohibit the use of crab pots in areas where undersized crabs predominate.
- That both states study advantages and disadvantages of crab pounds.

- That Dr. R. V. Truitt of Maryland and Captain Selden Taylor of Virginia join officials of the United States Fish and Wildlife Service in their studies of the blue crab.

A legal notice was posted in *The Sun* on June 25, 1943 (Warfield, Jr.) describing The Commission of Tidewater Fisheries' four-section regulation to take effect on July 2, 1943. Specifics of the regulation included crab pot construction specifications, territorial limits, license handling requirements, crab pot limit requirements, specific fees, and how license funds collected would be allocated within the Department of Natural Resources. At this time, the crab pot limit per licensed blue crab fisher was 35 pots. By October, *The Sun* suggested the cooperative effort between Maryland and Virginia resulted in a rehabilitation of the blue crab industry (1943) although there was no empirical evidence to support this claim. The following year, 1944, federal biologists supported Virginia's claim that there was no effect of sponge crab harvesting on subsequent crab abundance (Kennedy et al., 2007). In contradiction to Maryland's ban on the harvest of sponge crabs, it allowed the possession and transport of sponge crabs caught elsewhere (Kennedy et al., 2007).

The Chesapeake Bay Interagency Planning Committee was founded (MSA, 2010). By 1971, enforcement of policy became urgent, and the Natural Resource Police was created, which combined the Marine Police and the Wildlife Law Enforcement Division (MD-DNR, 2015) giving both parties the ability to enforce on sea and land. The Bruce Decision, a court ruling, allowed a Maryland citizen to fish in any county in the state, potentially increasing harvest pressure on local crab resources (Kennedy et al.,

2007) where previously, crabbing was a localized activity. However, these changes came with new regulations that required Maryland crab potters to maintain daily harvest reports and submit them monthly to the Department of Natural Resources (Kennedy et al., 2007). At last, in 1972, the necessity for population data becomes apparent, and a routine trawl and seine survey was begun for the blue crab by Maryland's DNR Fisheries Service (Hall et al., 2004). At the same time, the Federal Clean Water Act was passed (Hall et al., 2004).

Interested parties would expect a plethora of compliance/enforcement behavior literature considering the angry, frustrated debates that continued into 2019 among the Chesapeake Bay blue crab stakeholders. However, it continues to elude the academics. The following literature describes an evolution of views relating to compliance/enforcement theory in the 21st century.

M. Paolisso (2002) expressed his study in an article titled, B*lue Crabs and Controversy on the Chesapeake Bay: A Cultural Model for Understanding Watermen's Reasoning about Blue Crab Management.* The perspective was from a cognitive anthropological window that attempts to employ the cultural and biological knowledge of the commercial blue crab community to build a cultural model of blue crab fishers' views on managing the fishery. The author repeated that management agencies and science concluded that blue crab was at a level where a natural disaster could decrease the population to unrecoverable numbers. The causes were numerous, and the science was limited, but the managers and science believed the best action was immediately to reduce the commercial harvest. Blue crab fishers proposed looking to water quality and predation instead of cutting the commercial blue crab fishers' share of the resource. The author suggested anthropology can address "causes, consequences and possible resolution" (p. 227) for conflicts arising among stakeholders in the fishery. Paolisso used ethnographic data to identify the cultural model for understanding views regarding regulation and resistance to science. He suggested blue crab fishers would "resist any regulation, and the science that seeks to prohibit the harvest of crabs provided by God, yet they would be supportive of regulations that increase sustainability of the crabs provided by God" (p. 227).

He reported 4,800 licensed watermen harvest blue crab with an average dockside value of $50 million a year. Resource managers argued that regulation was the most effective policy response to protect the spawning stock of blue crab because commercial fishing was a major source of mortality for blue crab. The author used semi structured interviews, in-depth and extensive conservations, and participant observation to collect data. The data revealed that the blue crab fishers' propositions include nature manages crabs, which are for human use. Second, pollution destroys crab habitat and science studies effects of pollution – and they can agree that regulations promote sustainable harvests and greed threatens future populations. They contended nature controls them, but humans control pollution; thus, commercial harvest was not the enemy.

However, blue crab fishers acknowledged that excessive harvest of small crabs and the use of significantly more crab pots than allowed was a problem. Their responses ultimately agreed that some regulations are necessary to sustain the fishery. The study addressed several variables for the current research. It discussed crab pots, compliance attitudes, and revealed the thought process of commercial blue crab fishers as it relates to the ideal of regulating the fishery. Thus, the enforcement variable in the current study demonstrates patterns in blue crab fishers' responses to upcoming regulation and or the aftereffects of. This literature showed that managements' response to fisheries declines had been restrictive control measures or to ignore the problem.

Nielsen and Mathiesen (2003) discussed that few measures had been taken to understand noncompliance behavior. The research from *Important Factors Influencing Rule Compliance in Fisheries Lessons from Denmark*, depicts the choices of three Danish fisheries; all were gill fish. One fishery's focus was quota management, while the other two focused on mesh size and by-catch regulations. The research employed both quantitative and qualitative. Questionnaires were mailed, 1 to 1-1/2-hour interviews were conducted and included dominant figures in each fishery. It lasted for three years from 1997-2000 and was analyzed around a 5-point framework. The first consideration was the industry structure, then control and enforcement, content of regulation, norms within, and morals of fishers, and last was the decision-making process. Five major themes developed with the possibility of a sixth determine factor influencing rule compliance.

The first was the economic gain to be obtained, then deterrence factors, fit of regulation with practice, common-sense of regulation, and norms and morals associated with the regulation. The sixth was the perception of having influence over regulatory action. Fishers recognized that at a large scale of noncompliance, paper trails would tell, but on a smaller scale, opportunistic behaviors, and risk assessment play vital rules. The research demonstrated that "the implementation of output-based regulations like quotas/catch rations was often in conflict with the mentality and prestige of fishers and undermines the socio-cultural norms in the community" (p. 414).

Nielsen and Mathiesen asserted that the problem would not be solved with improved monitoring and controlled activities, but that these measures tended to build mistrust among stakeholders. This article addressed why regulations were not working and suggested improved voluntary compliance can occur when regulations adapt to practical fishing situations. In my research, I asked to what degree noncompliance occurred by comparing enforcement and compliance behavior against regulation. A new quota system was a regulation that was tested against enforcement data. Current enforcement technology included offshore cameras to scan for poachers. However, as Nielsen and Mathiesen's study suggested, norms and mores or economic gain may determine the risk of noncompliance.

In Project PR 26109 titled, *Policy Research – Implications of Liberalization of Fish Trade for Developing Countries*, Macfadyen (2004) discussed fisheries and aquaculture schemes. Certification schemes came in a variety of standards and labeling of such may or may not be helpful to any particular fishery. The costs for such a scheme may be prohibitive for fishers to comply and create inequity among small and large-scale fisheries. He identified 9 non-organic groups related to fisheries management and guidelines. The common theme in these groups was each lacked social and poverty emphasis, each focused on environmental concerns or social issues, lacked any social element, or favored social and economic relationships focusing on sustainability of the resource. Seven organic groups were identified, and none of these included a social or poverty element in its guidelines of management or focus on terrestrial agriculture that related to aquaculture operations. Many schemes focused on the environment and lacked concern for the social issues that compromise fisheries management. The author suggested there was a lack of participation from the small-scale fishery and this effected legitimacy of management. He suggested that "open access and overlapping multi-species fisheries" (p. 10) using assorted gear with a multitude of landing sites was characteristic of the small-scale fishery.

Macfadyen contended this lent itself to noncompliance issues that occurred from poorly monitored or reported harvests. As the demand for labeling increased so would the need for policy recommendation for developing countries; however, little research existed about the impact this may have on developing countries. Certifying products regarding their source and style of catch could be a costly measure. The author addressed misreporting of harvests in small-scale fisheries, which appeared as a frequent problem in the Maryland blue crab fishery. My research considered how often this occurred. Further it addressed legitimacy of regulations as perceived by the small-scale fisher who often lacked participation in the decision-making process. These variables relate to the skews identified in blue crab dockside landings as compared to actual harvest reports, which threatens compliance efforts.

In 2004, Fogarty and Miller studied the effects on reporting harvests after Maryland changed from a self-reporting system to a randomized selection of blue crab fisher program. They reported the findings in a 3-page paper titled, *Impact of a Change in Reporting Systems in the Maryland Blue Crab Fishery*. The authors employed time series models to demonstrate changes in abundance of blue crab. They included an intervention model to demonstrate changes in the regulation on reporting harvest. Secondary data of recorded harvests and population data provided before and after the event were employed as variables. This cut and dry quantitative study revealed a substantial impact in numbers of blue crab reported; however, the differences in total abundance showed minor change in fluctuations. The authors addressed a change in regulation for reporting harvest. It provided an example to follow to discover discrepancies in reporting based on historical populations, crab pots allowed, and harvests reported, which would answer the questions regarding skew on harvest data. The time series model and intervention model provided the current research a means to demonstrate enforcement against regulation. Further, the current research  overlaps with this study in that time slots for comparison of enforcement events coincided with the 1981 change in reporting requirements.

Hankin et al., (2005) introduced *California's Dungeness Crab: Conserving the Resource and Increasing the Net Economic Value of the Fishery*. The authors discussed the indirect effects of regulation that turn into direct effects in another fishery. Effort changes to other stocks when regulations limit harvest potential of the crab. Three points were discussed. The economics of processing the fishery, industry participants' perceptions of management, and biological components of the species were reviewed for data. Primary and secondary sources were used and interviews from six processing firms. The authors stressed because of the natural fluctuations in crab landings, data collection over substantial time worked best. They hit a barrier for the last sequential year as regulation changes prevented the acquisition of ticket landings indicating quantity and price received for the value-added analysis. Estimates were applied based on the previous year.

The findings suggested a variety of benefits could be experienced with management that considered individual quotas. The highest yield-adjusted market prices and value added represents picked and frozen crab. Phase two involved mailing 616 surveys after two pretests resulting from multiple revisions discussing regulatory tools used in the crustacean fishery. Forty percent respondents completed the survey representing the total crab fleet. The fleet consisted of small, medium, and large vessels, but 75% of those fished less than 400 traps. Seventy-three percent of respondents stated that at least 40% of their income was derived from the crab fishery. The authors stated fishers of small vessels believed their license held a value of $10,303, while medium vessels were $18,187, and larger vessels considered their worth $31,111. This seems to equate to the number of traps a boat can transport.

The survey uncovered three major themes in attitudes of blue crab fishers and management. The first apparent opinion suggested maintaining status quo. The next opinion suggested a majority approved of the 1-trap limit for all vessels regardless of size. The last theme suggested emptying traps during daylight hours only. The authors state that the Pacific Coast Federation of Fishermen’s Associations was currently creating legislation to create trap limits per vessel at least as an experiment. Nonetheless, all discussion relating to additional regulation as opposed to seasonal management tools was received negatively by fishers. Finally, phase three considered biological crab processes. The authors wanted to estimate natural and fishing mortality rates of sublegal and legal sized male crabs. Further, they worked to determine the validity of the mating marks used to determine mating activity that can act as a marker for future stock potential.

They implemented a tag recovery project over three successive years on approximately 2000 crabs. Two timeslots for testing included just before the season open and after the harvest were reduced drastically at the end of the season. Their assumption contended that all-natural death should occur between April and November. Flyers and posters were placed offering a $10 reward for the return of legal and $5 reward for the return of sublegal crabs. The last year of the research, the rewards were increased by $5 each. Of 10,735 tagged male crabs released, 1,446 were returned by commercial or sport fishing people. The study did not produce any evidence that mating markers are a significant source of activity. The authors suggested that mating success following a season results in 100% mating. No empirical evidence existed to support the idea that primarily harvesting the male crab effected the pregnancy rate of the female crab in this species in California.

This article addressed the influence of regulations and management of the California commercial blue crab fishers. The current study tested the enforcement environment against changes in regulation. This article contradicted the management strategies employed in the Maryland blue crab fishery. Population markers were measured by females and males at specific ages, and the general belief by science was that restricting both the female and male harvest was necessary for sustainability. This included number of pots per person, number of pots per boat, and number of crabs per season. Measurements of enforcement in the current study against regulations that change limits for male and female crabs may show definite patterns. The skew on population as it relates to crab pots allowed and gender specific regulations could be significant.

In *Fisheries Science and Sustainability in International Policy: a Study of Failure in the European Union's Common Fisheries Policy*, Daw and Gray (2005) attempted to explain why fisheries management had failed to create a sustainable fishery. Examining political systems and fisheries science caused the authors to determine scientific data often inhibits effective fisheries management. Their study presented the chronological order of the science that has guided policy in the European Union (EU) Common Fisheries Policy. They followed the routes that scientific advice takes, if it was acted upon, and the factors that act as barriers in translation from idea to policy. The authors examined the breakdown in translations from the point of view of decision makers and fishers as well as the scientists who make the recommendations. The first barrier was that policy rarely adopts in full the advice of science. The second breakdown was that changes in gear such as technical or structural are often stalled for many years. Finally, poor enforcement was a major contributor to sustainability management. Fishing mortality occurring above the recommendations of science, poor catch records, and illegal landings influenced the EU failure. Ideally, science must be separate and thought of as independent from state regulatory agencies. Science was for science sake, yet the state needs this science to convince the public that these policies were necessary. They suggested the tragedy of the commons, and fisheries were known to be difficult to enforce, short of privatization and regulation.

The authors asserted that economic discount rate theory, which was to exploit it while the opportunity presents itself and reinvest the profits. Popularity in politics acts as another barrier to sustainability; most politicians lean towards the people's choice as opposed to sciences' advice. Fisheries science was limited in scope and offers zero certainty. Fishers cautiously view the act and results of science. Single species assessment limits most science. This makes MSY a poor management tool where many fishes interact via predation or as by-catch. The authors asserted that the political and scientific framework in EU states create barriers to fisheries sustainability. This research addressed the need for a realignment of research objectives towards usable management goals. This related to answering the number of times blue crab fishers had fished more than their license allows. This study correlates with the current research in that identifying barriers in advance of regulation solves indirect problems associated with regulating. The authors specifically addressed poor enforcement, illegal landings (black market fish) and poor record keeping as key issues. My study demonstrated a skew on harvest was possible and associated with the use of illegal gear.

The author, Betsi Beem (2006) reviewed the course of blue crab management in her paper *Planning to Learn: blue crab Policymaking in the Chesapeake Bay*. She discussed the traditional Fisheries Management Plan and the development of the Bi-State Blue Crab Advisory Committee (BBCAC). Beem argued that the value the blue crab fishers assigned to the group, how conflict was managed between science and practice, and the degree that participants were involved in the planning process were key factors to its success. It was common knowledge the people are managed -- not fish. The author asserted that accurate representation of recreational and commercial crabbing was a necessity to assure proper management strategies. She further contended that when economic modeling data was not available, policy makers must depend upon self-reporting from blue crab fishers to analyze the economic health of the industry. Additionally, social impact assessments were necessary to address the effects of regulatory action on fishing community.

To determine if learning had occurred in the process, empirical evidence relating to the evaluation of objectives and instruments was required. Beem used semi structured and focused interviews, personal observation, and content analysis to perform her study. The analysis tracked conflicts over time and changes in understanding of factors effecting the blue crab. Size limited this study. Some participants were unsure of dates, times, and places making isolation of variables difficult. Last, the participation of key decision makers from the legislature and natural resource department lent credibility to the BBCAC. This study addressed the learning process and what may inhibit it. This was essential to accepting and complying with regulations - compliance. This research addressed several barriers that could lead to noncompliance that management attempted to remedy with further regulation. The current research reviews compliance behavior of commercial blue crab fishers as it relates to crab pots. Many changes occurred in regulations for blue crab that effect commercial blue crab fishers who use the gear, crab pot. Science and blue crab fishers have remained in conflict over recommendations and methodology for studies of population.

Hastings (2007) presented *The Chesapeake Bay Blue Crab Conflict* in her Honors Thesis supervised by Dr. Shunlin Liang, University of Maryland. The author reviewed how social, economic, and political factors have effected blue crab spatial distribution and population size. Harvest prior to 1950 was used to determine “boom and bust” (p. 6) natural periods to discover if natural patterns do occur. She suggested that before solutions can be created for the “crisis” in the Bay, the most important causes must be isolated. Maryland and Virginia waters were considered in data collection and interpreted into broad generalizations. The decline in blue crab can be contributed to nutrient overload in the Bay, habitat destruction, and over-fishing.

Two common byproducts of sewage treatment, urban areas, and agriculture are phosphorous and nitrogen. Another controversial threat was that of overfishing. Disagreement between science and commercial blue crab fishers was blue crab fishers believe the blue crab is extremely prolific; however, during a BBCAC meeting, 76% of blue crab fishers expressed concern over their futures. Enforcement concerns include agriculture noncompliance as well. This article addressed overfishing as one main contributor to the decline in the blue crab fishery, which was an enforcement/compliance issue. This supported my research, which sought to determine if a pattern emerged between noncompliance and regulation and if so, did patterns present, and to what degree did they occur?

Fahy (2008) discussed what occurs with passive enforcement in his research titled *Performance of in Inshore Fishery in the Absence of Regulatory Enforcement*. According to the author, inshore fishing fleets have smaller rigs with a maximum vessel size of 12 m. Crews were teams that split profits equally. They operated passive and static gear as opposed to mobile fishing gear. The author’s study addresses relaxed regulatory enforcement of an inshore whelk fishery. Until 1990, the fishery was hand operated, but with new demands, it had turned to mechanical gear for harvesting resources. This fishery was like the blue crab fishery in a variety of ways, which made it an interesting comparison for comparison sake. Lack of risk perpetrates noncompliance like blue crab pots. The whelk fishery harvests approximately 350 pots per day akin to crab pots.

Further, regulation was geared toward quota-regulated and minimizing TAC per fisher like blue crab pots. Fahy stated that until 1996, census codes did not include the commercial fishery, and crew members were considered as co-operators responsible for their portion of taxes and other business-related responsibilities. Some demographics were collected through the two main commercial buyers of the product and from interviews. Larger vessels had a greater fishing potential as the ability to carry more pots existed. In the southwest Irish Sea, the status of the stock determines the performance because it was a single species fishery. The new demand from the orient had added to noncompliance through undersize harvest that contributes to catch, but it has no true value by weight. Vessels have left and returned to the fishery based on these catch reports. Accordingly, in this open access fishery, there was no incentive to conserve because a casual competitor was able to harvest illegal sized whelk.

Nie (2008) presented, *The Underappreciated Role of Regulatory Enforcement in Natural Resource Conservation*. He explained how regulatory enforcement can lead to new ways of addressing conservation. He suggested a “co-evolution” of regulation and litigation was occurring. Likewise, he asserted that when regulatory enforcement was weakened simultaneous strategies also were weakened. He contended that the “command

and control" style was poorly suited to some resources and that "analysis paralysis" occurred because of burdensome procedures.

In contrast, some groups had called governmental regulation a barrier to less adversarial approaches to management. Further, the courts had been used as a first line of defense as opposed to collaborative problem solving. He suggested the development of environmentalism was a result of the chronological order of lawsuits filed in its name. However, the judiciary response was to ensure legislation becomes reality. This became a problem when resource law was too "open-ended, vague, contradictory," or problematic in its vernacular. The result was that agencies filled in the blanks using "best available science" that undoubtedly supported its view for management. On some occasions, litigation was essential to "check on unresponsive and/or captured agencies" (p. 143). Often, it seemed the literature undermined regulatory enforcement. Some theorists suggested command and control, or top-down methods of management were not designed to address current complex problems such as non-point sources of pollution. The judiciary as opposed to the agency does not have to contend with trade-offs and compromises destined for the political arena of decision-making. Many problems go unexamined as a result.

In collaborative efforts, which often were preferred as less adversarial, were not a comparable replacement and could undermine the usefulness of regulation. Regardless, population advisory committees had become a part of the establishment. These groups had success in that they had been able to achieve some regulatory goals and objectives, but the ability to quantify this was difficult. Similarly, agencies that place undue practice on acquisition of resources often do this to avoid unpopular processes like rule enforcement; however, “this is a grave error” (p. 152). The author suggested that the mere threat of active enforcement causes some people to take the money, rather than face the penalties for noncompliance later. However, this does not build long-lasting effective social behavior for compliance issues. Last, the eco-system strategy continued to evolve, but Nie contended this was a tool rather than the one size fits all model that was often projected. As cited by Nie from 40 C.F.R. §1508.7,

> the impact on the environment which results from the incremental impact of the action [regulation] when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other action…[and]…can result from individually minor but collectively significant actions taking place over a period of time.

Adaptive management styles had a renewed emphasis on monitoring, but this raised suspicion, which was counterproductive to the idea of collaboration with stakeholders. However, agencies and interest groups could agree in advance of the steps to be taken when video apparatus identified any violation. This would provide a means for agencies to share accountability. Nevertheless, task forces or groups ran the risk of appearing as a public relations ploy to further agency agendas without risk. However, if these champions of collaboration shout loud enough to get all interests to the table, the movement would likely continue to gain strength in influence. This author discussed regulations as a cooperative effort to manage natural resources. This article caught and addressed the true essence and conflict of over-regulating. It described some unintended consequences of breakdowns in belief systems. Nie's study sought patterns in enforcement in response to regulation much like my study. I applied several ideals from this research to my study in the blue crab problematic areas in the recommendations section. Regulation and enforcement were reviewed in my study, and the results of my study may in fact effect future enforcement ability and interpretation by the judiciary.

Nøstbakken (2008) presented *Fisheries Law Enforcement – a Survey of the Economic Literature*. The author advised that commercial fishers would harvest more than a socially optimal harvest under the common property scheme. He suggested that fishers and the industry do not self-enforce regulations regardless of what people witness. Likewise, he contended that not all regulations required full compliance. He viewed the idea of crime from an economic view and suggested fishers measure the risks and expect to take risks as a facet of the business. The author reviewed the literature of Burke, Polinsky and Shavell, Malik, Mullin, and Snyder, and more as to the measurement of illegal activity as it pertained to personal profit for the fishers. He asserted that penalties in the form of fines were the preferable deterrence because they were the least costly - socially. Further, he emphasized the structure of the compensation might encourage employees to commit crimes on behalf of employers.

Thus, I considered principle-agent theory. Nøstbakken's article addressed the development of the fisheries law enforcement model and presented manipulations of the model to fit assorted scenarios in fisheries. The author's article complimented my study in that the idea of adding law enforcement to the economic equation created a new variable to consider. Managers had to determine priority of budget placement. Some enforcement was indirect such as the cull ring in the crab pot to allow the escapement of undersize crabs, while other enforcement required site on scene or the use of technological advances to catch illegal behavior. my study adds to the literature concerning the illegal activity that surrounds crab pots. The extent of discovery in patterns necessitates additional enforcement research.

In 2009, O'Connor Shelley and Crow in *The Nature and Extent of Conservation Policing: Law Enforcement Generalists or Conservation* Specialists, asserted that little information was known regarding fisheries law enforcement agencies. Accordingly, they asserted the need to add to the academic literature in order "to understand the nature and extent of modern conservation policing" (p. 10). They asked questions about the Florida fish and wildlife resource police. Specifically, they wanted to discover what the actual activities of the officers included and if these were different from previous literature. Law enforcement in rural areas was understudied, even though more than 45 percent of American law enforcement agencies employ nine or less employees. MD-NRP activities lacked studies in general. The authors contended that the literature that does exist focused upon personal interests such as job satisfaction and stress. However, several studies suggested that natural resource police lack time for conservation crimes as city type crimes were increasing that included traffic and drug arrests. Regardless, the content analysis discovered in the literature supported the fact that criminal enforcement tended to be a secondary response to fishing, boating, and hunting regulation enforcement.

The authors' findings indicated that in Florida 72.9 percent of their total work activities were allocated to non-fish or wildlife enforcement. The authors utilized Berg's

(2001) model for content analysis that included latent and manifest analyses of the data. Initially, counts of incidents were sorted to predetermined categories for comparison. Latent coding was required to interpret the meaning of wording in reports. The variables were drafted reports and secondary data collected about enforcement crimes. The mixed method analysis provided a rare view of law enforcement data. The study addressed and decidedly described the traditional criminal law model as ineffective for understanding the dynamics of natural resource policing as a generalist opposed to a specialist agency. Their study sought to review types of enforcement occurring like my study. My study provided an entire overview of regulations that directly affect crab pot use in Maryland, and then I narrowed each to a type to create a comprehensive working list of data for enforcement comparison. I did not ascertain, wholly, that illegal gear enforcement and regulations demonstrated patterns.

*Reassessing the Value of U.S. Coast Guard At-Sea Fishery Enforcement* addressed misleading data in the literature. King, Porter, and Price (2009) presented evidence that asserted many actual violations go undetected, and compliance rates used to demonstrate success of enforcement created a veil that keeps managers from recognizing this problem. The Magnuson-Stevens Fishery conservation and Management Act (MSA) issued by the Federal government had failed in its mandate to end overfishing. Amendments occurred in 1996 and 2007 that added legal vernacular to require stock rebuilding targets and timetables. As of 2008, a report to Congress identified that of approximately 230 economically significant U.S. fish stock, 45 continued to be overfished. Accordingly, a great deal of literature attempted to explain how regulation had failed these fisheries.

Much of the literature blamed a lack of political will, the institutional structures, mix of council members, scientific uncertainty, and disagreement about estimates, past regulations that were implemented without empirical evidence, and short sightedness of fishing interests.

The authors asserted that noncompliance of regulation was understudied in the United States. Most of the science was based on the theory of compliance and the economic incentives to commit crime. However, in fishing, it seemed that crimes fall into 3 distinct categories, which include chronic or frequent violators motivated by economic gain, occasional violators who normally obey the law, but may cheat when the benefits of noncompliance significantly outweigh the likely costs, and accidental violators who unintentionally fail to comply to a misunderstanding of the law, faulty electronics, or other reasons. Several U.S. studies suggested 70-90 percent of fishers occasionally violate regulations, while 5 to 15% are chronic lawbreakers. The authors argued that the performance standard for the USCG was an inaccurate representation of enforcement data because they did not know how many violations go undetected, therefore, they cannot assign a percentage to those that they know occur.

King et al. analyzed enforcement and prosecution data for USCG using NOAA's Enforcement Management Information System (EMIS) database. In general, if violations did not carry some economic loss, permit sanction, or the like, they did little to encourage compliance. The authors concluded that the "USCG-observed compliance rate APM was seriously flawed and should not be used as an indicator of the success of the USCH fishery enforcement program" (p. 365). They recommended an initiative that would target chronic illegal activity by fishers. Like my study regarding blue crab, the authors addressed and concluded that the number assigned to criminal and or noncompliance activity not reported or measured in the fin fishery was likely substantially under par. Many of the regulatory restrictions on fishers discussed in this article were identical to that of the Maryland Chesapeake Bay fisher.

Ali and Abdullah (2010) examined influences on compliance behavior in a fishing industry in Malaysia in their paper titled *Impact of Enforcement and Co-Management on Compliance Behavior of Fishermen*. As violations escalate so do the expenditures of law enforcement. This paper addressed the enforcement question as to what types of crimes are occurring. My research addressed how often these crimes were occurring. Malaysia expected a decline in harvest since it had reached its MSY. As fishing gear had become more efficient, the need for better management had become essential. Industry participators have open access and are in a race to harvest more than the next guy. Malaysia used management zones to create equality between small and large-scale fishers. Determinations for zoning depended upon gear type and vessel size. Major complaints included large-scale fishers ignoring the ban, creating a smaller catch for small-scale fishers.

Pilot studies of questionnaires borrowed from Kuperan & Sutinen (1998) and Hatcher, Jaffry, Thebaud & Bennet (2000) were conducted on a group of 40 fishers. After changes were made in the wording or other areas of concern, the actual survey took place between November 2001 and April 2002. The authors retrieved secondary data from several fishery sources and statistical offices. Using disproportionate stratified random sampling sum 284 fishers were interviewed. Three groups arose because of the category "type" of fishing gear. The authors analyzed primary data using Statistical Package for Social Sciences. A comparative analysis represented four main characteristics of the fishers.

The author discovered that those involved in co-management were more likely to follow the rules. The mean income of fishers was higher with violators than for those who followed the rules. Their study discovered that the higher the probability of getting caught performing illegal fishing activity, the more people would be discouraged from doing so. In addition, considerable monetary gains would likely lead to noncompliance if there was less chance of detection. Third, the authors ascertained that trawl fishers were likely to violate zoning regulations more than any other harvester types. Last, compliance decisions seem to be influenced by the involvement of fishers in co-management activities. The empirical study provided evidence in support of co-management strategies and that more time should be spent strengthening these relationships.

This study was pertinent to my study if co-management teams in Maryland's blue crab fishery were actual participants for the particular gear crab pot. If this was the case, compliance by these members would be assured based on the result of Ali & Abdullah's study. However, zoning management in Maryland is not determined by vessel size; although, this idea could easily be argued for the blue crab fishery based on a great deal of previous research in the uses of the crab pot within and outside of shoal areas.

In *The Unintended Consequences of Formal Fisheries Policies: Social Disparities and Resource Overuse in a Major Fishing Community in the Gulf of California, Mexico*, Cinti, Shaw, Cudney-Bueno, and Rojo (2010) investigated the local, social and fisheries impact of formal policy. The authors argued that the licensing system used to manage this fishing resource provides the wrong incentives for compliance. This article addressed the non-verbalized rules of fishers and how this may or may not represent actual regulations used to manage resources. Likewise, my study suggested that the timing of regulations effect these non-verbalized rules. The authors reviewed the Northern Gulf of California, Mexico where this fishery provided thousands with food and employment. The Institutional Analysis and Development Framework (IAD) framed this research and helped identify variables for analysis. Three categories addressed in this research are the local rules in use, characteristics of the resource, and characteristics of the community. Structured interviews were conducted with 45 divers that were active in 2007. Other interviews included local authority and local leaders of the permit holders' sector. The authors collected secondary data including statistics on catch, bylaws of cooperatives, and logbooks from a voluntary program. These study respondents included 82% of independent fishers who were not legal permit holders and only 18% were members of a cooperative holding fishing permits.

Existing requirements for permit application and economic status of the diving communities created disparities. Most of the direct fishers were uneducated and poor like many scenarios around the world. The formal Mexican system only allowed ownership of fishing equipment, including vessels, by permit holders; however, the study identified that 24% of fishers without permits owned their own equipment, while 47% were owned by permit holders, and the remaining were in the process of buying equipment from permit holders. This allowed permit holders to push the burden of maintenance onto the actual fishers. A common criminal activity included sheltering illegal harvest under another permit number. The community called them buyers because they can legitimize the illegal catch. Communities fear the intrusion of institutional management because they believe it would open their small fishery to other communities who would invade for specific seasons. The authors suggested that because the area was vast and shared with numerous fishers, permit holders, and cooperatives, little incentive exists to be responsible, work together, or comply with institutionalized rules. Further, they contended that the federal government needs to take steps to formalize the informal labor system hiding behind the existing permit holders. This can provide them a secure right and encourage them to follow the rules to a sustainable fishery.

My study reviewed regulations in the blue crab fishery that may or may not create incentives to harvest blue crab illegally. Commercial license holders were the only fishers allowed to harvest and sell crabs, but it had been a concern that recreational blue crab fishers sell their catch for profit. Although the current research did not identify recreational regulations or violations, any practice of illegal crabbing skews the data that was analyzed to create future management decisions.

In his study, Arnason (2013) asserted that compliance was generally “a function of the state of the fish stock” (p. 361) at any given time. He titled the article, *An Optimal Dynamic Fisheries Enforcement*. He defined management into two components that were a management system and an enforcement system. The management system was a set of rules, and the enforcement system was supposed to make certain the rules were followed.

He contended, enforcement changes behavior, not a set of words. The author added to Becker's (1968) theory of law enforcement and Nøstbakken's (2008) review of the literature to create a specific dynamic framework. He discovered that an optimal dynamic policy might be impossible to express. To counter this, the author created a numerical fisheries enforcement model and then optimal enforcement paths were derived and discussed. In contrast, management measures were easy to characterize. Regardless, the model was misrepresentative because the assumption was that enforcement was costless. After analyzing the path that became apparent to the model, assuming costless enforcement, the results were illustrated in a numerical model. Then the author utilized the model to derive optimum penalty levels for specific management measures with the assumption of some enforcement taking place. The results of the study led Arnason to affirm, "fisheries advice on the basis of the conventional fisheries models ignoring enforcement costs may be seriously misleading" (p. 375). The article addressed my study's question as to whether regulation and enforcement demonstrated a pattern because of blue crab related noncompliance.

Lack of enforcement and attempting to separate it from management was a serious mistake towards reaching management targets and or changing compliance behavior. Although collecting the necessary data may be a daunting task for enforcement agencies, and the practice may not align with traditional agency practices, the outcome was the ability to create optimal dynamic fisheries management that was enforceable. The results of the study suggested that optimal level of enforcement declines with the rise of fish stock biomass. Regardless, the expense of enforcement might be uneconomical, but without it, the practice would lead to low quality fisheries management. It may be that for a particular species the costs were so high, management was not worthwhile. The results of this study would only apply to those management systems that can maximize benefits from the existing fishery.

I presented a similar assumption in my study that enforcement was the ultimate management strategy for fisheries noncompliance. It identified noncompliance behavior using regulation as a barometer. It identified types of noncompliance rather than times. Enforcement may benefit from this analysis to determine optimal enforcement times based upon types of regulations enacted and even locations.

*Modelling Enforcement and Compliance in Fisheries: a Survey*, presented by Coelho, Filipe, and Ferreira (2013), employed theoretical analyses grounded in Becker's theory of crime and tested the data using a bio-economic model (Gordon/Schaefer). The study focused upon the available literature on monitoring and enforcement, which were lacking in the research. Costs were often neglected in analysis of fisheries management. The authors presented a model for illegal behavior and enforcement costs assuming that any catch above the permitted quota was illegal, but that not all violators would be caught. Then, the authors analyzed how expensive and imperfect enforcement might influence optimal management policies. However, enforcement costs would be zero if quotas were large enough to reach free access equilibrium, but there had been a shift away from this because of overfishing that was increasing net benefits and enforcement costs. This article addressed noncompliance behavior in response to regulation such as ITQ management that was also prevalent in commercial female crabbing.

The complexities involved in enforcement and compliance demonstrated advantages to private property rights-based management because they self-enforce. Where the cost of enforcement becomes uneconomical, command and control measures work best. Studies demonstrated that ITQ systems face illegal behavior. Current studies demonstrated the need for empirical research relative to compliance in an attempt to ensure it. The economic studies had proven that fishermen’s perception of detection heavily influence whether they would break the law. My study identified how many violations were written in a given time and addressed when blue crab fishers might be breaking the law. This would allow enforcement agencies to plan in advance of responses to new and or upcoming regulations. In this case, specific time slots might be cost effective enforcement as opposed to visual monitoring at no particular time.

DaRocha, Villasante, and González (2013) presented, *Credible Enforcement Policies Under Illegal Fishing: Does Individual Transferable Quotas Induce to Reduce the Gap Between Approved and Proposed Allowable Catches*. Their model had two components. The first was that illegal fishing does exist because of imperfect enforcement technology, and “the enforcement agency cannot commit on announced penalties” (p. 1047). It had become common knowledge that excessive fishing effort leads to exploitation that causes economic waste of common property resources. Further, science had proven the potential of ITQs to curb the problems of overcapacity in fishing industry systems. However, there were few studies highlighting ITQ systems when 100% compliance cannot be guaranteed. The authors examined enforcement agency behavior using game theory under total harvest numbers and ITQs within those limits using the assumption that scientific recommendations were ignored. This article addressed how regulation may or may not influence compliance behavior.

Regardless of the scientifically approved total catch number, fishing fleet numbers had not changed with the setting of sanctions. Enforcement agencies had an incentive to lower sanctions and legalize some of the harvest. Economic efficiency had been proven to improve with ITQ, but this did not address the issue of equity and social justice as perceived by fishing communities forced to accept ITQs. The authors asserted that overfishing was a result of overcapacity and that without compliance ITQs would not prevent a "tragedy of the commons." The authors employed a case study approach to their research. In short, it appeared that government approved Total Allowable Harvests were higher than science recommended, and the actual reported landings were higher than what government approved. The study demonstrated that enforcement agencies were in conflict over science, landings, and illegal harvests. The authors questioned the advisability of widespread ITQs. In Maryland, ITQs are employed for the hard crab industry. The concerns demonstrated in this article were pertinent to my research in that noncompliance continues to occur as demonstrated by the majority of natural resource research.

Scheld and Anderson (2014) discussed *Market Effects of Catch Share management: the Case of New England Multispecies Groundfish*. They share that in 2010, the NE fishery transitioned to a collective rights-based management strategy. Studies produced by NOAA led to a swarm of catch share program for underperforming US fisheries. Evaluation needed to occur to refine these programs during the growth of new ideas. The NE had two options that included receiving group allocations for individual multispecies stocks or to continue with the common pool TAC but receive drastic cuts in days allowed to harvest. Following the introduction of catch share programs to the multispecies stocks, price increases were observed. This article addressed the costs that commercial fishers might consider when choosing noncompliance.

In the US, management has been in a reactive state as opposed to a proactive position, developing regulations in a disjointed manner. Price response to quantity changes would influence how fishers' respond. If market patterns could be identified, it might be possible to control for exogenous price determinants, whereas prediction reaches validity and revenue effects may be estimated. The NE Fishery Management Council FMP had experienced 18 amendments and 50 framework adjustments. As restrictions piled up, harvesters solely dependent on groundfish were forced to diversify. As new exports and domestic markets grew, collapses of many multispecies stocks occurred. Annual harvest strategies remained unchanged after the introduction of the catch share program. Although there were not major differences in landings after its induction, there were specific changes in when a species was harvested and landed. Between 2007 and 2010, observations of 375,000 individual species were observed and used to assess the effects of catch share management. The individual dealer determined prices at landing based on the entire region's harvest of varied species quantities. Complex context often leads to statistical methods that use existing data before and after a "treatment" (p. 1839).

The author contended that earlier model of rights-based management did not control for exogenous factors, and this led to results influenced by spurious correlations and weakened data through aggregation. In contrast to the positive aspects of the catch share program, they may lead to increased mortality of other differently managed stock. Multispecies catch share programs may drastically alter the working waterfront community and may impose unintended cultural and societal costs. I reviewed secondary data that reflected a relationship between regulations and enforcement. I presented time by year and through count data. Enforcement as a variable in management continues to be discussed and remains undetermined as to its rightful place in a working model.

In 2014, Hentati-Sundberg, Hjelm, and Österblom presented a study on the misrepresentation of reported harvests in a paper titled, *Does Fisheries Management Incentivize Non-compliance? Estimated Misreporting in the Swedish Baltic Sea Pelagic Fishery Based on Commercial Fishing Effort*. The authors asserted that accurate baseline data was essential to stock assessment. In cases where little or no official catch was reported, development of a new method to recalculate historical reporting was constructed. The studies demonstrated that estimates range between 30 to 75 percent higher than what was reported. This article addressed the skew on reported historical harvests that had influenced regulation and compliance. Reasons such as discard catch, recreational catch, economics, and misreporting from over capacity of fishing stocks led to misrepresented statistics. The Baltic Sea was not limited until the late 1990s.

The author explored capacity of the fleet relative to the fishing quotas available for harvest. The data collected for statistical analysis came from logbook data and changes in regulations that led to ITQs in this fishery in 2009. The pelagic fishery harvest had continued under scrutiny since 2004 when fishing patterns seemed to change statistically. The authors asserted that estimating with effort was more accurate than depending on the frontline stakeholders. They employed the use of two General Linear Models (GLMs) and developed 2 models. The first model presented species composition, and the second model estimated total catch quantities. The variables included, "total effort, trip length, engine power, depth, latitude and longitude, month, gear, and abundance" (p. 1847) of the two species. Total capacity was represented by the capacity as sum of the entire fleet. All the variables were applied to both models in order to select the best fit.

The authors identified quota skews and overcapacity parameters throughout the entire study period. The results indicated that different types of over-reporting occurred at different times and cycles in the fishery. Their study was validated in that several fishers faced sanctions during the same period for misreporting and misrepresenting their logbooks. The authors stress that non-compliance and species misrepresentation has occurred because of overcapacity in the field, unreasonable TACs in light of biological realities, and lack of sensible management. The authors argued that the major challenge involved changing policies and management that led to unexpected outcomes in management policy. This article provided resources for a time to event analysis that covered historical data that may or may not be accurate. It provided a means to count for inaccurate data or misrepresented data, which was one phase of my research. Further, it demonstrated the divide between fishers and management much like the situation in the Maryland Chesapeake Bay region.

Dresdner et al. (2015) declared Sutinen and Andersen (1985) hold claim to a seminal conceptual work on fisheries law enforcement. The authors reviewed the consequences of weak enforcement and how this plays into noncompliance behavior. Enforcement programs that had been empirically analyzed had led to two distinct regularities in compliance. First, in line with Becker’s (1968) study, the expectation of penalties or sanctions acted as a deterrent to noncompliance, and second, more compliance than was expected had been taking place. Comparing results from assorted studies was difficult because different measurements were used as well as an assortment of variables. The authors utilized a set of questions meant to test the role of mortality on compliance as well as the ability to measure individual morality. The results suggested that moral considerations, peer effects, and legitimacy are the three most key factors to one’s willingness to comply with any one regulation. In fact, rarely had mortality been operationalized beyond a one-point approach.

This article addressed the response of noncompliance to regulation. The authors used the Morally Debatable Behaviors Scales (Harding and Phillips 1986). They suggested evidence appeared that warned against the endogenous nature of the variables that measure social response based upon peer effects. The evidence supported that one’s perception of the groups’ compliance defines the individual’s compliance behavior; this can create spurious correlations in the analysis. In the authors’ analysis, noncompliance was based upon self-reporting and the collection of 301 observations. Information was collected for 10 different regulations. The results of the study indicated that policy that considers the moral considerations and perceptions of the fishers, but these must be context accurate to communities. The authors reviewed noncompliance from the view of human nature and perception. Whatever the reason for noncompliance, the noncompliance must first be identified. In my research, the types of noncompliance were analyzed from 6 categories. Measurements were made to determine the degree of noncompliance occurring before and after a regulation took effect that changed the rules for blue crab in any manner.

Arias et al. (2015) discussed noncompliance in *Levels and Drivers of Fishers' Compliance with Marine Protected Areas*. They asserted that the 20% estimate for illegal catch in the world fisheries was a conservative figure, and their interest lies in what influences noncompliance behavior. More importantly, it demonstrated that more than one-half of the deaths of nature rangers were the result of poachers. This paper enhanced the literature by providing empirical research where academia lacked studies concerning the importance of compliance and the negative effects of a lack of such. This article addressed skewed harvest reporting and shared the degree of noncompliance as self-reported by commercial fishers.

MPAs were context dependent and illegal fishing was a broad topic. This dictated no simple solution to the problem. The authors asserted that localized, well-designed intervention was how compliance would be achieved. Between February to April 2014, data was collected using questionnaires and interviews. Participants included commercial and sports fishers that provided vessels and gear. Both these groups spend a majority of their time at sea. Response and nonresponse bias created inaccurate data. The authors hoped to decrease this bias by using nonthreatening approaches. Interviewers identified themselves as students, interviewees were assured anonymity, the questionnaire began simply and advanced towards more personal requests, and last, indirect questioning was employed in the survey that masked personal action but highlighted the actions of others as perceived by the interviewee. Ninety-nine questionnaires and 41 key interviews were conducted. The authors used a linear mixed-effect model to quantify perceived compliance in specific areas. The results demonstrated that enforcement was not the entire answer, but it added positive influence in areas that were solely dependent on fishing, while in areas where livelihood alternatives existed, such as sport fishing vessels, compliance was perceived as occurring more. I investigated the type and number of noncompliance occurring in the blue crab fishery in Maryland.

**Common Property and Rights Based Theories Review**

The U.S. Fish and Wildlife Service (FWS) passed a Federal resource law referred to as the Fish and Wildlife Act of 1956. The emphasis was on the commercial fishing industry, but the Act was to be administered in such a way as to promote common-property theory "with regard to the inherent right of every citizen" to enjoy the activity of fishing (FWS, 2015). The Act puts into writing the intention to "develop measures for 'maximum sustainable production of fish'" (FWS, para. 3) and to "make economic studies of the industry and recommend measures to insure stability of the domestic fisheries" (FWS, para. 3). The importance of data collection continued to develop, but the current theories caused some relaxation in regulation. Maryland packing houses record keeping requirements changed from daily to weekly reporting in 1956 (Kennedy et al., 2007), easing some pressure on those stakeholders.

In Maryland, John P. Tawes, commission chair, reports that sport blue crab fishers leave their pots in the water a week at a time without checking them. Eels, which get into the pots, are feeding on the crabs, which was not good for conservation or for commercial reasons. He suggested setting up more stringent requirements for crab pot licenses (*The Sun*, 1958). For instance, one such idea involved requiring commercial blue crab fishers to have 2 years crabbing experience before receiving a license (*The Sun*, 1958) similar to the 1998 Apprenticeship Program established for commercial fishers. In 2013, the General Assembly repealed the 1998 Apprenticeship Program and replaced it with the earlier version (1994) of a prepayment of license fees for candidates to be placed on a waitlist with no guarantee of receiving a license (MD-DNR, 2013).

Once again, in 1958, Virginia and Maryland joined forces. They cooperated to administer, regulate, and manage the Potomac River fisheries (VMRC, 2010). In Kent county Maryland, several blue crab fishers appealed for marker changes effecting how the gear, crab pot, was utilized. Some blue crab fishers wanted to be allowed to string together 25 crab pots with 2-3 buoy markers on the line. Single pot blue crab fishers complained that a line of strung pots would interfere with vessel maneuverability. The consensus was that the problems could be solved with strict crab pot license regulations. Moreover, they agreed that sport blue crab fishers (recreational blue crab fishers) could be restricted to gear besides crab pots (*The Sun*, 1958). The annual crab pot license fee was $10.00, which permits fishing up to 50 crab pots (*The Sun*, 1958). Approximately 800 crab pot licenses were issued during the crabbing season (*The Sun*, 1958).

The early 1960s brought about concern for “possible effects of the thermal discharge from the Calvert Cliffs Nuclear Power Plant on the blue crab population in the Chesapeake Bay waters adjacent to the plant" (Abbe, 2010, para. 1). A biologist, Rachel Carson, for the U.S. Fish and Wildlife Service published a book in 1962 that brought attention to the use of pesticides and their effect on the environment (NOAA, 2011). Resource consumption came to be considered gluttonous and a mistrust of science and government took root (NOAA, 2011). The concern at Calvert Cliffs led to a series of studies between 1968 to 1983, which was only 1 of 4 major fishery independent surveys conducted using crab pots to study the crab population (Abbe, 2010, para. 1). The conservation movement took root, and value judgments concerning the environment became dominant in public policy (NOAA, 2011). Once again, Virginia and Maryland united in 1963 to manage the Potomac River's fisheries and created the Bi-State Potomac River Fisheries Commission, (Kennedy et al., 2007) a commission that continued into 2015.

By 1964, the Bi-State Potomac River Fisheries Commission creates blue crab licensing and harvest statistic procedures superseding those of Maryland and Virginia state laws (Kennedy et al., 2007). Maryland created The Department of Chesapeake Bay Affairs Commission. New regulations were enacted that included a reporting system that categorized crab harvests by gear type. They categorized the crab pot as commercial gear. Since there was no reporting system for recreational blue crab fishers, crab pot use by this group was outlawed (Stagg & Whilden, 1997). The conservation movement led to the 1967 formation of the CBF, one of the largest regional environmental groups in the United States (Horton, 2005) and continues to exist in 2019. It is common to witness

CBF license plates anywhere in Maryland. However, their conservation policies impacted the economics of the commercial fishing industry. By 1968, Maryland experienced a record low for blue crab, from which they recovered, and used this data to set benchmarks for present day calculations of the stock (Cascorbi, 2004; MD-DNR, 2015).

Nineteen sixty-nine ushered in the National Environmental Policy Act (NEPA). This Act required that all policies

- utilize a systematic, interdisciplinary approach which would insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment, and
- identify and develop methods and procedures…which would insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical consideration…. (NOAA, 2011, para. 6-7).

Common property and rights-based theories faced new demands that altered the ability to test and measure valuables using previous means. However, division of stakeholders continue to effect positive group cooperation. Current theory attempted to explain the pros and cons of the common property theory and the variables that influenced its success or failure.

George D. Santopietro (economics) and Leonard A. Shabman (agricultural economics) presented *Common Property Rights in Fish and Water Quality: the Oyster Fishery of the Chesapeake Bay* (1990). The authors introduced the concepts of property rights in fisheries. The New Resource Economics (NRE) perspective from the 80s suggest that change occurs when business proprietors formulate new property rights arrangements that would improve economic potential of resources, while the neoclassical economic decision model based individual decision makers choices upon benefits and costs.

This analysis presented the continuous change from open access to private ownership of natural resources. Another group of economists suggested that consideration must be given to social values, environmental conditions, and non-economic sources of political power. Varieties of social values that changed from community to community had heavily influenced this fishery. Scientists, who were less favorable of the NRE ideology, were specific in distinguishing the difference between open access where the resource had zero restrictions and common property, which was group-owned, and rules of access existed. Private property was a resource held by an individual who made his or her own rules. The research was meant to explain why the oyster grounds in the Chesapeake Bay had developed into a mixed property model. This article addressed how regulations evolved and effected community models and attitudes that effect noncompliance.

In both Virginia and Maryland, the public oyster beds can be described as “state oyster farms.” However, VA and MD manage their resource differently. While both states hire watermen to plant oyster seed on natural beds, MD’s annual oyster seed plant (spat) was around 6 million and VA’s was between 500,000 and 1.5 million bushels per year. The structure in the Chesapeake was fully developed by 1910 and has persisted. In MD, watermen have fought vehemently since the 1880s to maintain public beds, while in VA private beds hold majority. Maryland's governance of oystering was premised by the idea that watermen were underclass, and privatizing oyster beds would lead to social economic stress; those who would have the money to plant seed were considered outsiders, and only those near the Bay became involved in the political battle over oyster beds. The concerns of the Maryland watermen must be factored into understanding the evolution of the oyster fishery.

Shortly after rights were established, water quality concerns became active. Germ theory evolved and became the catalyst to water treatment disposal. In 1897, the first recommendation of a sewage commission recommended the discharge of raw sewage into the Bay. Industry participators came together and halted this through the Maryland General Assembly. However, after compromises were made, this project became the largest undertaking in the country to purify sewage. Water quality protection for oyster harvesters private and public came to court in 1932. For over 100 years, biologist and economists have asserted the privatization of oyster grounds as the only efficient way to harvest oyster. The Chesapeake Bay as the single supplier of oysters in the country soon dwindled to second place in 1976. Regardless of the revitalization needed in the oyster fishery and the call for privatization of oyster beds, history had proven that this change was not likely but that only regulation management of the common grounds would evolve.

My research discussed the evolution of regulations. Common property and or rights-based models had dominated the commercial crabbing fishery. Natural resources in

Maryland are considered common property to be enjoyed by all. The evolution of regulation in Maryland was a means to control and manage both the resource and the human. However, regulation without enforcement lacks results. Enforcement data compared over time in commercial crabbing presented and predicted unexpected patterns as watermen feared the economic results of these changes.

Elinor Ostrom (2000) presented *Private and Common Property Rights* in relation to natural resources. She suggested there are common misconceptions relating to the differences between common property and open access, common pool, and common property, as well as resource systems and the flow of resource units. Further, she asserted that the argument over the supremacy of one versus the other continues to reign. She suggested many economists considered common property as an inefficient means to management because of rent dissipation, high transaction and enforcement costs, and low productivity.

During the 1960s, the rise in concern for natural resources prompted the nationalization of all land and water resources that had not been recorded as private property. This caused a shift in enforcement. Local governance and participants once controlled management, but after this shift, bigger government became responsible who lacked the resources to guard and protect the fisheries. The ability to gain accurate measurements of the variables that are involved in the management of resources was essential to establishing a common property pool that was equal. However, when resources were mobile such as fish, it was more difficult to develop effective systems. The author suggested that most important was the involvement of industry participants in planning these rules and creating quotas which might alleviate common issues in the day-to-day administrative costs. This article addressed how the rules can effect day-to-day decisions made by the user group.

My research addressed noncompliance as a response to regulatory action that may increase the fear of watermens' perceived economic losses. The newest blue crab regulations involved assigning transferable quotas for the hard crab fishery, which sparked a discrepancy in reporting harvests. This suggested that new regulation might trigger noncompliance behavior, and I tested for this in my study.

Robert T. Deacon (2012) presented *Fishery Management by Harvester Cooperatives*. Until recently, cooperative like organizations have been largely ignored by academia. The author argued that assigning user rights to a group can generate efficiency gains. However, no support has been concluded that suggests cooperative management adds value. Further, his research does not account for rent seekers in transferable quotas. This article addresses how rules within and without groups can effect compliance.

No empirical evidence supported the operation of fishery cooperatives, but theory could predict performance in practice. The author asserted that when individual harvesters were separate entities, the common good might not be realized in management. In other words, coordination leading to profit depended critically on the condition of a key input, the stock of fish, and the stock's condition because of the individual actions of all the participants. Catch quality could be enhanced through collective action. However, this required all fishers to participate to reap the benefits.

Success and failure of fishery management depended upon the ability of government to perform its function. ITQs were susceptible to weak government enforcement. Cooperatives had the means to combat this situation through self-governing. One way to improve compliance behavior was through sharing catch or catch revenue. However, empirical evidence was mostly anecdotal. Assigning harvest rights to individuals would not address stewardship or policing problems. Distribution among individual users was plagued with problems. Evidence demonstrated that that group rights rather than individual rights made the group responsible to each another. Fishery cooperatives present an under researched management strategy. Evidence exists that suggests cooperatives can solve many issues that other strategies fail to resolve.

One regulation change during my research included assigning ITQs to individual hard blue crab fishers. This led to a discrepancy in harvest reporting for the blue crab. This discrepancy acted as a catalyst for this research as I measured enforcement after this and other blue crab regulations that effected the use of the crab pot.

*Wealth, Rights, and Resilience: an Agenda for Governance Reform in Small-scale Fisheries* (Ratner & Allison, 2012) reminded the reader to recognize the opportunities to improve growth and reduce poverty in developing countries' fishing communities as a byproduct of responding to the fishing crisis. The authors stated that more than 90% of the world's fisher people operate in small-scale fisheries. Earlier debates diagnosed these as inefficient, poorly developed, misguided, and ineffective. Correcting this included privatizing state support services like ice, boat yards, and fisheries training colleges, as well as financial investments in boats, gear, and industrial technology. Several projects emerged in the 1990s and 2000s exploring avenues to increase fishing livelihoods and the associated industries in which they were embroiled. Recent debates continue to assert economic inefficiency but focus upon the “inadequate rights of property over common-pool or open-access resources” (p. 373). These debates suggested over-capacity adds to overharvesting the theoretical maximum economic yields. This article addressed the methods used to create rules and how commercial fishers’ response may be influenced by this. The authors contended that despite positive examples of progress in fisheries management, few examples can be found of economic, ecological, or socially sustainable well-managed fisheries. Many countries’ fisheries policies still managed resources using production targets. The authors contended the process of determining goals for the fishery mattered not the appropriate balance of goals. This provided them legitimacy.

The authors presented their perception of a balanced approach to fisheries management, which included three perspectives: rights-based, wealth-based, and social-ecological resilience. Practical guidance on analyzing the governance context of fisheries management plans remained deficient making strategies such as the ecosystem approach underdeveloped. As such, the authors suggested a critical rather than normative framework that was quick to identify practical flexibility. They further suggested that economic characteristics as to suitability of reform in a specific fishery need to be taken into consideration in the face of reform suggestions. Their literature reviewed identified eight principles to assess reform options. The authors supported, through these principles, the small-scale fisheries as it faced governance reform. However, they asserted success would depend on the cooperation of science, politicians, and development practitioners beyond the traditional scope of the fishing industry.

This article provided evidence that could be generalized to the Maryland crabbing industry as part of the 90% small-scale world fishery. This article lent credence to the finding in my study that show  increased enforcement that equates to noncompliance after changes in regulation. Maryland failed to consider the unexpected consequences of ITQs in a common pool fishery. Patterns found in my study presented new data for management and enforcement guidance.

Brewer (2012) presented *Don't Fence Me In: Boundaries, Policy and Deliberation in Maine's Lobster Commons*. The author asserted that common property theory requires the "need for clear boundaries" (p. 383); this includes material and social boundaries that define and describe a specific community. Federal pressures in the fishing industry generated a formalization of a "more statist comanagement regime" (p. 383). Captains worked to take control of decision-making leaving crew and locals to deal with the results. Some experts proposed that regardless of positive benefits found in common property ideals, there had been applications that fell short of following general democratic processes within the community. The authors contended successful common property ideals in practice can be found in numerous cases.

The authors offered the Main lobster fishery as a case where social norm contributed to the conservation of resource outside the government and market control. Current investigation depicted commons theory via the human-environment geography lens, which considered dynamic relationships as a component of small and larger socioecological systems. Some examples included historical and formal legal institutions, local to national control, as well as the relationship between the individual fisher person and the collective interests of the industry. The “tragedy of the commons” dates to early economic works. It contends that without government intervention, the commons would use the resource to decimation, while common property scholars contend that groups do work together to prevent exploitation of common pool resources using informal rules and that this can be more effective than government interaction.

Commons ideals and practice were often found in rural areas where government did not assign budgets or effort. The authors argued that comanagement had become a catchall term to describe relationships between government and resource user groups. The authors referenced Ostrom’s (1990, 2005) claim that governments must support local common property rights for these systems to succeed. She further argued for clarity in defining the boundaries of who can use the resource otherwise for whom was the resource being managed? Many coastal towns lack any employment options outside of the fishing industry. This was a generational industry and few women have entered it until the late 1990s as crew. The literature showed that the lobster population was growing for the past 20 years without clear rhyme or reason that could be supported by empirical data. By the 1990s, NOAA institutionalized moratoria as a management strategy. However, the lobster industry fought against this and relied upon regulation formalizing entry through apprentice programs that dated back to the 70s. A commissioner who did not support this management style repealed this later, and new legislation exempted young lobstermen who could prove three years of trapping before the age of eighteen.

The vision of comanagement waned from face-to-face discussions to mail in ballots, and this lead to the removal of local context to weakened communication. The authors argued the necessary measure for conservation was defining clear user group boundaries as urged by Ostrom and other “commons” theorists. A balance must be struck between communitarian and individual interests about day-to-day fishing practices. Resource managers were more comfortable with statistical models than with sociological discoveries, depending on fixed and rigid lines that can appear to be supported by mathematical formulas that look to create sustainable harvest levels that in theory look good on paper.

However, this may move decisions beyond the necessity of equity and sustainability that can be reviewed by public scrutiny. The authors purported that the common literature needed to move towards new empirical and theoretical arenas to master the common resource pools. Blue crabs are a common resource pool that government has attempted to manage for 60 years. I reviewed regulation and enforcement data for the current research that was the result of management strategies grounded in common property theory, which was demonstrated through the newest regulation - ITQs. These were analyzed using enforcement data to determine if unexpected outcomes occurred because of new regulation.

Allison, Ratner, Åsgård, Willmann, Pomeroy, and Kurien (2012) presented the article *Rights-based Fisheries Governance: from Fishing Rights to Human Rights*. The authors reported that 24,000 fisheries related deaths occur throughout the world annually because of unsafe conditions. They suggested that many pirate vessels enslaving crew fly flags of convenience to avoid monitoring of their illegal activity. The past several years had focused upon governance in fisheries; however, the assumption on formalized regulation was that the fishing industry would go along with reform because their livelihoods depended upon it. The authors contended it was unwise to ignore the economic motives of fishing people and what this means to resource conservation. They argued that the more secure a fishing community was, the more likely they would overfish, and the less vulnerable they perceived themselves, the more likely they would support fisheries reform. This article addressed the fear of fishers and how this may have led to noncompliance by the user group.

In developing their argument for the rights-based approach, they contended that government must uphold the basic economic, social, and cultural rights held within a small-scale fishery. They suggested this appearance of protecting the basic human rights of these communities would strengthen their cooperation in fisheries management. Policies had been focusing on sharing a defined total allowable catch using group-based quotas. The authors stated that naming these property rights was a play on words as the rights pertained to the harvest as opposed to controlling the resource, which they did not do. Further, they asserted that this division generally occurred with the large fishing operators. The authors contended that fishing people want to claim and defend their rights; however, their conception was broader than their theorists' counterparts were, and fishers' ideals aligned more with right-based approaches. The authors believed that a rights-based approach was equitable for resource access. Local systems management fishing rights could deal with threats that effected the group such as damming of rivers or coastal development and pollution. The problem was that many small-scale fisheries were made from those who lacked the incentive or capacity to claim and defend their fishing rights.

The human rights-based approach to rights-based fishing aims to target the constraints that bind sustainable small-scale fisheries and attempt to address these first. Removing any perceived threats to their livelihood could secure governance support by fishers. The authors suggested that failure in fisheries management stemmed in part from disregarding the complexities of perceived human rights in fisheries within the social and ecological dimension of fishing communities. My study variables included enforcement and regulations that effected blue crab fishing. This article touched on the fear aspect of present and future earnings for fishing people. One theory presented by MD-DNR in the current work was that blue crab fishers reported false harvests as a response to the fear of losing future earnings because of an ITQ regulation in discussion in 2008.

In 2013, Luc van Hoof published *Design or Pragmatic Evolution: Applying ITQs in EU Fisheries Management*. He opened with the thread that binds many researchers who preach the "Tragedy of the Common." He suggested the people would make decisions that benefit their personal interests. He suggested the core question in fisheries should be to answer how management can bridge the gap between personal interests and those of the larger group as it effects the natural resources and society in general. The theory was that the implementation of individual fishing rights would work towards closing this gap. This article addressed noncompliance responses by fishers using the ITQ system to new regulation.

A variety of transferable and nontransferable rights exists, but some negative impacts of ITQs include discards, underreporting, and a dwindling of individual fishing rights within communities. This results in a reduction of fishing industry employment in general. If quotas fail to reach individuals, the costs of lease rates then outnumber these fisher folks. The European Commission expected five basic principles to guide decision making about ITQs. These principles included resources must remain public good, the transferring of quotas must be guided by strictness, relative stability was a necessity, and members' states must reserve some of total harvest for future industry participants. A case study of the Dutch demonstrated that regardless of these principles, illegal fishing and underreporting continued. One variable mentioned was a lack of policing and enforcement in the Dutch state. Regardless of several setbacks over a period of years, the Dutch system evolved into a system of transferable rights based on ITQs. This brought about a system of improved enforcement controls.

Several problems remaining were the over grading of harvest and the discard of others. This was difficult to monitor in terms of landings as opposed to actual catch. The author pointed to an important concern because of the contrast in theory and practical application, which was that the design of ITQs was to reduce overcapacity in the industry by moving the rights to the most efficient operation, which disregarded the distribution of rights and income within the fishing community. He contended that for success the legal vernacular regarding "entitlements, privileges, and responsibilities are defined in detail" (p. 469).

In my study, the correlation concerned the response of commercial blue crab fishers to the implementation of regulations that directly effected blue crab harvesting.

Measuring enforcement against the regulations in this study emphasized the patterns that became apparent. The implementation of ITQs as regulation in Maryland were a single measurement of enforcement and regulation analyzed in this study. Many of the author's contentions were related to the blue crab industry within coastal communities on the Bay.

Brigham Daniels (2015) wrote *The Tragicomedy of the Commons* highlighting three significant scholars that included Garrett Hardin (ecologist), Carol Rose (legal academic), and Elinor Ostrom (Nobel Laureate). Hardin labeled the concept of the "Tragedy of the Commons;" Rose suggested the commons can lead to positive ends, and Ostrom argued that such tragedies can and have been avoided. While many authors sought the causes of fishery tragedies, Hardin sought the consequences. He contended individuals benefit from the use of a resource, but all users share the cost of that consumption. Rose's research uncovered cases where the crowd benefited from additional users of the resource. This was the opposite of what to expect based upon Hardin's studies. The comedy was in that social settings were representative of the commons; thus, to some degree "the more the merrier." For instance, the game of chess requires two, and many forms of recreation benefit from groups, i.e.: volleyball, baseball, frisbee. Intellectual and cultural resources such as libraries and internet forums further supported this concept. Ostrom's seminal work, *Governing the Commons*, presented a common thread, which she referred to as "design principles of long-enduring institutions." She cited Spain's *huertas* as an example. This long-standing water allocation system had existed and worked since before the days of Columbus, and it was as old as the time when the Moors ruled Spain. This article addressed the group at large and how those who do not follow the rules influence regulation that effects those who do follow the rules.

Daniels connected these three diverse depictions of the commons and suggested that positive and negative effects would continue to coexist. He asserted that the commons were consistently exceeding the limits of sustainable resources. He cited outer space as an example. Companies now race to embed satellites in a limited orbit in space. Space appears a continuum, but access was limited. Thus, the perception of crowding depends upon the perception of robustness. He suggested, “rapid shifts” (p. 1358) in numbers of users for a resource could establish an end to a tragedy when it did not appear immediately evident. Additionally, invention can effect consumption rates of users. There are complex connections in resource management, and a demand that outweighs the resource was the central problem facing managers. Further, solving evident problems might lead to creating unexpected problems. He illustrated this using smog. A regulation reduced fog tolerance within a county; producers corrected the problem by heightening the dispersement towers, which solved the immediate problem, but led to regional problems. He asserted that pure public-goods do not exist because rivalry often plays a role.

The author purported Ostrom’s principles entwine three main principles for long standing institutional common systems success that included:

1. credible commitments from the government for the sacrifice of the immediate benefits and a trust that the effort would reap rewards

2. credible threats to those who did not follow the rules, which would protect the interests of those who were making the sacrifices was necessary
3. the costs associated with these new transactions must be affordable. Reducing costs was essential, which could be accomplished with assignment of management responsibilities to resource users, providing a local means to halt free riders.

Regardless, these principles do not prevent the conflict over use of resources as perceived by diverse groups. It was common to regard current historical structures in law as the source of conflict for problems in the here and now. This attitude creates an “us-against-them” fever that makes changes more difficult but possible. The author presented three perspectives for the underlying principles of the commons and how they might influence the results of the current study. Thus, the credible threats in this study would be the actual enforcement that took place against commercial blue crab fishers, but this data would not be compared to the number of actual NRP active.

Emily Self (2015) presented *Who Speaks for the Fish? The Tragedy of Europe’s Common Fisheries Policy*. As of 2014, more than 75 percent of EU fisheries were overfished because lawmakers have failed to conserve the resources they believed to be plentiful. Contributors to the failing fishery included a more mobile fleet, overcapacity, and technological advances. These problems in combination threaten financial devastation of the fishing industry. Ignoring sustainability enhanced negative trends in an open access industry. Agreement of fishing people as well as enforcement was essential to conservation measures. If industry participants believed their competitors could cheat, they in turn would cheat. This article addressed how overharvesting impacted rule making and compliance by the total group.

The author believed that in contrast to the goals purported by the Common Fisheries Policy, overfishing continued to occur. She contended that a successful management scheme required eliminating the open access regime that played out between fishing people within and without a region. She asserted that poor enforcement was a catalyst for fishers to disregard blatantly the rules of compliance. Although the changes made in the new policy were a better version, it did nothing to prevent cheating through overharvesting. Originally, the Common Fisheries Policy was enacted to protect fishing open access in response to several international laws that thwarted this practice. Some North Atlantic state announced the extension of their coastline, which would exclude some EU members from fishing areas that had been considered common. In response, EU member states did the same. This would upset the open access ideals favored by the EU fishing industry.

At the 2002 World Summit on Sustainable Development, the European community vowed to take steps towards diminishing overfishing and rebuilding stock to sustainable levels by 2015. The author contended that standing up to the fishing industry came with great political costs. The policy had no clear hierarchy, which often led to income pressures outweighing the concerns for conservation. Over 2007 to 2008, the EU fishery passed the Integrated Maritime Policy and the Marine Strategy Framework Directive, which decentralized authority-deciding challenges in the fishery would be better handled at the regional level. The new directive had a multitude of environmental objectives that should be achieved by 2021. The Treaty of Lisbon created a reform measure to involve European Parliament in the decision-making, which created representation for European citizens as opposed to the fishing industry and their member states. They became champions of conservation. Lawmakers adopted measures to produce the MSY for a given population. However, quotas would still be allocated to ensure the livelihoods of small fishing communities.

In 2013, the Common Fisheries Policy stressed the importance of data collection to provide empirical studies that supported or negated rules. The author asserted that all must be bound by the same rules for conservation measure to meet success. Although the new policy might not correct the problem of overcapacity, the guidelines supported a new, conservative direction towards a sustainable fishery. Within a fishery system, it was necessary that all violators were equally deterred by enforcement; thus, regional enforcement as opposed to localized enforcement was best suited to achieve legitimacy. The author contended that an ideal system would create fines that would be comparable to the value to be gained by cheating. She further asserted that more binding authority be given to regional councils to overcome member states' or fishermen's behavior regarding overfishing.

Maryland instituted MSY several years ago, but enforcement of current regulations seemed to be relaxed. Variables of enforcement and regulatory action in detail present a picture that identified several trends. If nearly every fishery in the world that has been studied was cheating conservation measures through overharvesting, it was not a stretch to assume the same was occurring in Maryland's commercial crabbing industry.

**Economic Theory Review**

In 1944, A. G. Huntsman defined the problem of fisheries depletion in economic terms. He suggested the “take in proportion to the effort fails to yield a satisfactory living to the fisherman” (Gordon, 1954). Although some research mentioned the term economics, no research or models had been developed. In 1976, the U.S. Army Corps of Engineers built a computer-generated model of the Chesapeake Bay at a cost of $14 million. By 1983, it was abandoned as a massive, expensive flop (Powledge, 2005). The EPA spent $27 million over a five-year study of the bay’s environment (Powledge, 2005). What was once a local, cultural tradition changed by 1982 when the Federal Court ruled in favor of Maryland and Virginia commercial blue crab fishers, allowing them to fish in each other’s state (Kennedy et al., 2007). Arguments about equality and types of crabbing took root again, and in 1983, the harvesting of sponge crabs was allowed in Maryland (Kennedy et al., 2007). However, Maryland restructures the crab license causing a drop of 57% in the number of commercial licenses issued from 14,348 in 1983 to 6,166 in 1984 (Davis & Speir, 1997). A Junior and Senior crab license was introduced allowing children 14 and younger as well as folks 64 and older to crab license free (Davis & Speir, 1997).

Maryland introduced the Tidal Fish License (TFL) in 1984 to Maryland citizens allowing the harvest of all commercial species and the use of up to 300 crab pots under one license type (Davis & Speir, 1997; Lawrence, Clark, van Montfrans, & Musick, 2013). Complaints from the 1950s and 60s continue to resonate in 1985. Wilen (1985) recounts the lack of attention paid to fishery economics. Still, no theories or models exist that consider microeconomic behavior concerning the decision-making nature of commercial fishing people, yet other industries such as utilities were benefiting from microeconomic theory attempting to decipher real world work environments (Wilen, 1985). He suggested a valid need exists to shift away from normative towards predictive modeling for fishery economics. By 1989, it became illegal to possess, transport, or pack a sponge crab in Maryland (US EPA, 1990; Kennedy et al., 2007); however, Maryland continued to allow Virginia blue crab fishers to sell sponge crabs in Maryland. Maryland developed a long-range conservation strategy called The Fishery Management Plan (Kennedy et al., 2007). The Nation recognized that "the blue crab supports the largest crab fishery in the United States, representing about 50 percent of the total weight of all species of crabs harvested [National Marine Fisheries Service (NMFS), 1986]" (Mercer, 1989).

Thirteen thousand twenty-seven recreational blue crab fishers harvested 6 million pounds of blue crab in 1989 (US EPA, 1990). The MD-NRP conducted a recreational crab survey that reported recreational blue crab fishers spent an average of 4.8 hours of crabbing per visit and landed 41 crabs per trip (US EPA, 1990). The Chesapeake Bay region comprising of Maryland and Virginia represents 90% of the commercial blue crabs harvested in the Mid-Atlantic Region (Mercer, 1989).

In 1990, blue crabs were reported as the most valuable commercial harvest in the Chesapeake Bay (US EPA, 1990). Between 1990 and 1994, blue crab harvests had a dockside value of more than $200 million (Stagg & Whilden, 1997). Concern existed that "biases relating to landings of out-of-state blue crab fishers and shoreline property owners were not adequately dealt with in the [dredge] survey" (Stagg & Whilden, 1997, p. 7). Blue crab fishers were utilizing cull rings on a voluntary basis allowing small crabs to escape the crab pot (US EPA, 1990). The EPA asserted Maryland's evaluation of the economic and social impacts of containing blue crab harvests were too broadly stated in its Fisheries Management Plan (US EPA, 1990). The MD-NRP conducted a survey of crab shedding operations (US EPA, 1990). Maryland's crab catch report was modified to include a separate total for dozens of soft crabs and numbers of peeler crabs (US EPA, 1990).

Current literature continues to attempt to explain the relationship between economics and the fishery. However, collecting quantifiable harvest data will continue to thwart the accuracy of its value and validity. In 2019, blue crabs in the Chesapeake Bay provide for a large group of stakeholders that equates to billions of dollars generated by this fishing industry.

Van Iseghem, Quillérou, Brigaudeau, Macher, Guyader, and Daurès (2011) presented, *Ensuring Representative Economic Data: Survey Data-collection Methods in France for Implementing the Common Fisheries Policy*. Economic theories had become embedded in many international institutions, particularly fisheries because of ecosystem approaches. However, accurate and reliable data was a necessity for a good economic depiction of fishery assessments, but this variable had been neglected in the literature. Even less analysis had been placed upon the quality of data. In France, 59% of the fleet was of small scale but demonstrated great underestimates of landings. Two stages defined this work. The first employed sampling from the entire fleet for a given year throughout a multitude of districts assigned by the Common Fisheries Policy. The second sought to improve response rates on questionnaires using assorted grouping of interviewees within the districts. The authors provided evidence of underreporting harvests using official statistics, which was rarely reviewed. The authors collected data derived from the French Ministry of Fisheries and a survey conducted by Ifremer. Segments were groups by vessel types and sizes, with small scale fishers grouped into a single category. Probability random sampling provided representative data. However, the budget limited the survey to 600 fishing boats. This article addressed noncompliance by fishers concerning under-reporting their harvests.

Ifremer's observers covered the French MRDs between February and June each year for the previous year's information, and they carried out thirty economic surveys. Five categories of gear were chosen from a fleet of 34 to represent the diversity of the fishery. Although the overall fleet of the NSCA decreased by 18%, the small-scale fishers declined by only 13%. Economic assessments employed samples as opposed to census, so identifying bias was essential to the design. Of 533 interviews conducted, 75 were classed as non-responders. Of the original panel from 2007, nine fishers refused the second interview in 2008. Economic performance was evaluated from gross revenue, fuel costs, operational costs, and opportunity as full-time equivalent calculated as the average monthly crew size for any given year. The authors examined productivity from days at sea and engine hours clocked. They examined capacity by the horsepower of the average vessel. The study revealed that small-scale fishers' landings demonstrated discrepancies as high as 46% meaning official statistics are underestimated. Small vessels have alternative outlets for their catch, which provides opportunity to cheat. Three popular types of data collection included a census of the entire population, a probability-sample that uses random sampling of the population, and a non-probability sample that was not random. My study answered the question whether enforcement changes after a regulation takes effect. The patterns that developed provided new details concerning compliance behavior.

Holzer, Lipton, and François (2012) analyzed unrestricted access to fisheries in their article *Rent-Seeking and Incentives for Compliance in the Commons*. Over the last 30 years, managers had employed the use of limited entry to control overcapacity in the fisheries. This did not sustain fish stocks because effort could be produced differently via engine power or gear use. Managers used input controls to regulate effort, but outputs were difficult to control. TAC was another means to control harvest, which was often tradable. This article examined and addressed the behavior of fishers whose rent seeking interests might lead to noncompliance. They further examined if the vulnerability of the resource to these actions depended on whether input or output controls manage the stock. This article added to the empirical literature on fleet composition and attrition and how these contributed to the landings or profits realized in the fishery. Further, they analyzed how managers failed to meet biological goals for a fish because they did not account for fishermen's behaviors. This article added to the previous research on tradable fishing rights. They used secondary data in the form of Maryland license transfers for blue crab and striped bass. Their evaluation provided evidence that fishing people were practicing informal leasing of licenses.

The law states no revenue can be exchanged for the transfer, which was intended for family, crew, or others within his close network during times of poor health or other unforeseen circumstances. Each season the license holder faces three options. The first option was to harvest his own license; the second option was to remain out of the common pool, and the last option was to temporarily transfer his license and receive payment. Leasing licenses encourages the least skilled to leave the fishery, while the most efficient remain.

In Maryland, MSY controls the annual harvest. Two popular types of crab gear include the crab pot and the trotline. MD-DNR has relied heavily on input controls to manage the harvest within its target harvest. In September 2008, bushel limits were enacted for the female crab. In the striped bass fishery, fishers use a variety of gear. Allocation of quotas was based upon gear selected. Quotas can be controlled daily, weekly, or seasonally. In Maryland's case, payment for transfer is forbidden; regardless, fishers negotiate a lease rate in advance of the season, as actual harvest has no bearing on this negotiated amount. The license owner is responsible for reporting harvests. In striped bass, fishers may hold numerous permits while owners do not have to transfer their actual license.

The authors asserted that the lower the enforcement budget was for blue crab, the more likely this illegal leasing would continue in Maryland. Leasing occurred more often in the striped bass fishery as opposed to the blue crab fishery. The latter only provided more pots to fish per day, while the striped bass provided catch limits and or quotas. Although leasing in general added to an efficient fishery, bypassing the regulation through rent seeking created a barrier to assessing the fleet's true fishing power. Specifically, blue crab was sensitive to environmental variation, and this situation added one more confounding variable to an already complex fishery. The occurrence of illegal license transferring was relative to enforcement data collected for crab pot use. If blue crab fishers set more pots than a license allowed, it decreased conservation effort.

Schnier and Felthoven (2013) reported that economists have argued that secure property rights and markets can solve the problems of open access fisheries in their article *Production Efficiency and Exit in Rights-Based Fisheries*. Although consolidation of vessels would occur, little research was available to assist in predicting which vessels were likely to remain or leave the fishery after enactment of ITQs. Pre-ITQ reform efficiency of vessels might influence owners' decisions to remain in the fishery. The author contended day-to-day operations might change under the two different regimes and what was efficient prior to ITQ may no longer be efficient. Without identifying this first, using measures of efficiency before a regulation change to predict fleet changes was flawed. The authors used an empirical model to estimate a vessel's measure of technical inefficiency and the owner's decision to exist or remain in an ITQ fishery. This article addressed how commercial fishers respond to a new regulation, ITQ.

The research demonstrated the cost savings and efficiency gains resulting from rights-based management. Although the assumption was that the technically efficient captains would remain, there was little research to support this. However, it was economic theory that predicted the most efficient vessels would remain. Limited data prevented the authors from performing a dual model, so a primal model best reflected the periods presented. The authors focus on the 5 years prior to the regulation change to ITQs. The results of their analysis demonstrated that the more inefficient a vessel was prior to the change in regulation, the more likely it would exit the fishing industry. Although the authors employed the single stage estimation process, the results were like those studies that utilized a dual stage estimation process. The authors stated these results are specific to this fishery but are in line with economic theory.

Enforcement is a cost to Maryland, and risk-taking via noncompliance carries costs for the fishing people. The implementation of ITQs was a time slot considered in the current study. Enforcement data for 2008 was reviewed after the ITQ regulation took effect in Maryland. Since the study did not consider the sanctions imposed, the study would not identify if ITQ was effected by the offense.

Chávez and Stranlund (2013) discussed the costs of implementing and managing the ITQ system in fisheries in their study titled *Who Should Pay the Administrative Costs of an ITQ Fishery?* Administrative costs included formulating and implementing rules to guide the regulation, monitoring, and enforcement tactics, as well as research in marine science and economics. The authors developed a theoretical model of harvests under an ITQ regime. They explored how administrative costs and their distribution can affect the equilibrium of an ITQ program. Some research asserted the fishers should bear the costs since they are the direct beneficiaries of the policy. Conversely, fishers rarely bulk at regulations for which they would benefit but not have to pay. This article addressed how group fiscal responsibility might lend itself to self and group regulating, which would curb compliance issues in response to new regulations.

Three factors were identified that can influence distribution of costs. The first was quota price effect, which asserted noncompliance increases with quota price; the next was individual harvest effect, whereby costs might increase directly with individual harvests, and the last factor was fleet size effect, where the public bear a larger part of the costs but can lead to additional entry in the fishery creating aggregate administrative costs. Existing literature made valid arguments for fishers to bear 100% of the costs; however, this conceptual analysis suggested that this end was difficult at best. Equity consideration might have influence over these decisions, and distribution factors might influence the design and other factors of an ITQ policy. This analysis could be applied to other regulations that might contribute to the design of a more efficient management system for ITQ fisheries.

General funds were a greater part of the M-DNR budget, and fees were paid into this fund from resource users, which in turn were used to create and implement new conservation/regulation rules. Factors relating to the discussion and implementation of ITQs in Maryland's crab industry might have led to noncompliance on the part of blue crab fishers. ITQ were based upon historical record keeping, and commercial blue crab fishers attempted to manipulate those numbers in 2008 by what was reported as over-reporting of harvests. However, no studies demonstrated whether this over-reporting was an intentional community effort or an individual response out of fear because of the new quota rule. In other words, how can a person determine if the effect had been under-reporting all along? Since patterns occurred by comparing regulations and enforcement data, this peaks future questions to address.

Felthoven (2014) presented *Cooperative Formation and Peer Effects in Fisheries*. The author contends that fisheries management was famous for command-and-control tactics even though research had shown that fisheries might be more efficiently prosecuted if rights-based fishing was utilized. The literature referred to this as *rationalization*. Changes could be expected in the extensive margin when inefficient vessels leave the fleet or in intensive margins when changes in behavior and economic performance occurred rather than fleet changes. Economics literature focused on achievable gains before and after a change to ITQ systems. This article addressed how fishers responded to regulation changes as a group via information sharing about harvest locations.

The authors discussed the effect of information sharing, which they referred to as "peer effects," and this had gained little attention in the literature. The authors hypothesize that fishers would share information within the same cooperative to harvest total quota at a minimum cost. The authors employed an empirical model to discover if information sharing was present across different cooperatives. They contended that fishers would continue to exert too much search effort to maximize their competitive edge through information. The authors would assess the extent to which cooperatives effectively shared information and capitalized on those opportunities. Likewise, peer input could lead to congestion externalities that lower one's harvest.

The author's focused on two crab species, and they allocated harvest through catch quotas. The authors collected data from eLandings - electronic reporting system. The authors employed a stochastic production frontier model for the years leading up to

ITQ in the crab fishery. They studied two interactional variables that included vessel's horsepower and the number of days spent on a single trip as well as a vessel's horsepower and the number of pots fished. The research provided support that fishers do share information to make greater gains. However, the researchers were unable to assert whether this was a construct of regulatory changes or a response to the rights-based regime itself. Traditionally, rights-based fishing continued to promote the independent fishing people. These marginal effects and differences were an important aspect to rule planning in the ITQ fishery.

My study concerned a similar stationary gear called crab pot. Like this research, Maryland's industry utilizes TAC and ITQ to manage the hard crab fishery. Enforcement data generated information to consider. I measured group noncompliance year by year.

*Socio-economic and Institutional Incentives Influencing Fishers' Behavior in Relation to Fishing Practices and Discard* prepared by Eliasen et al. (2015) discussed the issues of by catch and the discard of unwanted catch in the fishing industry. It was impossible to avoid by catch in nets, pots, trawls, or almost any fishing gear. Several perspectives provided a view to this problem. For instance, assessment perspective reviewed harvest data, economic perspective reviews the waste of income, an ethical perspective reviewed the waste of nutrition in a world of starving people, and the environmental perspective concerned itself with the natural resource system. There were three facets influencing fishing practices, which were the community, the state, and the market. Unfortunately, early business decisions might lock a fishing person into a certain species because of investments in species-specific gear. This article addressed the continuous implementation of new regulation and how this led to compliance and then how fishers perceived it.

The authors conducted a desk study using the list of factors influencing discard behavior in the Greek and Danish fisheries. English studies were conducted for the fisheries department and utilized in this study. Interviews were conducted at the end of 2011 and the spring of 2012. The study was nationally defined but was specific to the bottom trawl fishery. Experience in the fishery was a limiter for interviewee selection, and grounded theory was applied to analyze these interviews. The cross-case findings demonstrated that discard rates have a profound influence over stock recovery, and a scientific or management definition of discard has yet to be accepted across stakeholders. The Danish and English had taken steps towards decreasing discards as a problem, but the Greeks only viewed this as an economic hardship.

The authors suggested the differences in attitudes can be explained by political and managerial historical practices. In community, most fishers did not see themselves as discarders nor was social pressure mentioned as an enforcement means. Many fishers considered themselves in agreement with some measures but were upset at the substantial number of new measures occurring in short periods. The fishers identified the state as a formal institution that initiates input or output type regulations to control the industry. The perceived rightness of any given regulation was linked to the efficacy of the formal and informal communication structures. Enforcement exerted improved actual discard levels and behavior in the Danish and Greek cases. However, it proved difficult to get an overview on noncompliance registration; thus, this became irrelevant in the list of factors.

The market seemed a major player in the discard rate and illegal behavior. Indirect costs, black-market, and risk costs are difficult to measure, but fisheries that faced constant fluctuating prices and costs considered risks. Fishers never mentioned the market pressure for fish from certified minimal discard vessels as an influence in either case study. Although the list of factors that influence behavior has been tested only on three cases, it proves to be a tool to help identify things that influence discard behavior. Performing additional case studies could assist in refining this list to perpetuate its usefulness.

In my study, regulations that pertain to by-catch were reviewed in the literature. Crab pots required an open ring for undersize crabs to escape, and dumping the pot should have eliminated the rest of unwanted catch. However, discards had not been defined in Maryland and are categorized under illegal harvest whether because of size, season, species, or other.

Reimer, Abbott, and Wilen (2014) discussed the transferability of fishing quotas in their paper titled *Unraveling the Multiple Margins of Rent Generation from Individual Transferable Quotas*. The authors asserted that the ability to transfer eliminates excess capita thereby creating an efficient fishery. The literature purported both extensive and intensive marginal changes with an ITQ regime. The authors contended that identifying the types of rent generated was important to policy, and to analyze this required an experiment like setting where scenarios could be tested. This paper used the 2005 ITQ data for the Bering Sea red king crab fishery to separate the types of rent generated after ITQ implementation. They based the simulation upon a limited entry fishery and an individual non-tradable quota. They introduced a detailed description of the production process to focus the context-specific intensive margin decision made immediately following a new ITQ regime. A simple input-output model would not capture the subtle strategic use of gear choice over time and space. The authors found that the interaction of economic, technological, and biological parameters determine the degree and components of rent generation. This article addressed both timing and response to regulatory action.

Production decisions met by blue crab fishers are not typical of conventional economic models of production processes, but these were the major decisions - although short run - that blue crab fishers made daily concerning their income. This study identified a 64% reduction in the average variable cost to operate in the fishery and a 16% increase in fishery rents after ITQ was implemented. However, the magnitude of the effects, whether consolidation of the fleet or incentive to rent the license, was determined by the timing of the introduction of the ITQ regime. They discovered that consolidation of the fleet did not always lead to less intensive fishing. The authors asserted that to access accurately the impact of regulation changes, a person must include a description of the production process in depth to be invariant to regulatory changes.

ITQ in Maryland continues to be debated but has been evolving since 2008. Each specific change that has occurred in the ITQ fishery impacts crab pot use; thus, I measured each addendum or new regulation pertaining to ITQ for noncompliance using enforcement data.

Huang (2015) presented *An Inverse Demand System for the Differentiated Blue*

*Crab Market in Chesapeake Bay*. The author asserted the financial importance of the blue crab industry produced from the Chesapeake ranges from $46 to $103 million annually. Huang studied the demand for the blue crab from its various life cycles. He suggested it was inaccurate to treat fish species of varied sizes as a single group, and further asserted that policy makers need to consider these differentiated values in advance of regulatory changes. This article addressed policy making for the harvest of blue crab, which includes the gear – crab pot.

The Inverse Almost Ideal Demand System (IAIDS) was a common model for agricultural markets and the inverse demand systems were representative of wholesale markets where trade was limited asserting that this model was the right choice. However, this model required treating quantities of fish as exogenous, but in fish studies endogeneity was the standard, and fishers do not make decisions based on expected price at the market. In this study, the author used stock estimates to correct for this potential problem. It was an objective measure that was correlated with harvests but exogenous to the market in the year following the assessment. The author examined season demand by including binary variables for shifting the demand equations.

The author reviewed five market categories that included the #1 Male, #2 Male, Female, and grouped the Soft and Peeler (SP) crab. He stressed that the SP was the most valuable market crab. The author contended that separating economic studies from species' characteristics could cause potential problems. He suggested the development of a structural form of the quantity equation would deal with endogeneity. Without its consideration, incorrect estimates would be generated.

Considering endogeneity, it was essential to consider how a regulation for specific category effects other categories; likewise, my study measured noncompliance in the blue crab industry. Maryland categorized the crab pot industry by two gear types, one was for SP, and the other was for male or female hard crabs. This fact had been neglected in the literature, and costs were associated with it. Therefore, regulatory changes to the pots in general were evaluated for enforcement response.

## Current Literature Research

In the twenty-first century, several themes have become known in the fisheries research. After decades of neglect, compliance and enforcement variables were getting some investigation. Items of interest included illegal, unreported, and unregulated fishing harvest and activity. Several authors call to a shared information / enforcement model (Kaye, 2014; Witbooi, 2014). They suggested that cross-referencing vital information about vessels could aid enforcement at port states and on the high seas. Important data entry would include historic compliance behavior, harvest limits, harvest rights, catch data, inspection data, and the like. However, small-scale fisheries would be too numerous to record. Hentati-Sundberg et al. (2014) suggested some management strategies may incentivize non-compliance in the form of misreporting harvests. Other research attempted to identify any triggers that may lead to noncompliance behavior. For example, several important influences recorded in their study include many fishermen's decisions stem from personal and community morality, legitimacy of the regulations, the perceived behaviors of others (Felthoven, 2014), community, and individual poverty, and the efforts of enforcement agencies (Arias et al., 2015; Dresdner, 2015).

Although there were several researchers who had taken an interest in enforcement and compliance studies, many of them lean towards the conflict of common property or rights-based fishing activities (Brewer, 2012; Deacon, 2012; Ratner & Allison, 2012). Since the introduction of ITQs in the fisheries in the late twentieth century, many authors continued to study ITQs and the effects of this regulation on small and large-scale fisheries; however, the main interest seemed to be in the economic sphere concerning production efficiency and rent creation (Holzer et al., 2012; Iseghem et al., 2011; Reimer et al., 2014; Schnier & Felthoven, 2013). Huang (2015) created an analysis to evaluate polices in terms of socio-economic outcomes and the impact of regulations on each another. However, the literature did not seem to address specific compliance issues in time or place or in a specific response to setting. My study compared enforcement data to regulatory action in time and place for blue crab gear. Blue crab regulations were the independent variable. The dependent variables consisted of available enforcement data that was compared to regulations to determine if compliance was influenced by regulatory action in unexpected ways.

**Synthesizing the Current Research**

*The Maryland Register* and COMAR hold all the fisheries regulations. From these documents, six key independent variables were categorized for simplification in the study. What was known was that the Maryland crabbing industry had continued to evolve since the use of crab pots in 1940. Multiple changes had been made to licensing, the number of crab pot allowed, the use of crab pots, times of year and day, size requirements for harvest, and changes in harvests of male and female hard crabs. The dependent variable of enforcement data had been sporadic throughout the history of the industry. DNR and NRP including news releases, would provide the necessary enforcement data. Kuperan and Sutinen (1998) suggested empirical evidence was limited in making connections between fisheries crime and compliance. Studies had continued since Nielsen and Mathiesen (2003) concerning factors influencing compliance in fisheries. Beem (2006) asserted planning policy for the Chesapeake Bay blue crab caused decision-makers to come to the realization that they were managing people not resources. However, a constant conflict remained between science and commercial blue crab fishers because they rarely agreed (Hastings, 2007). Variety of task forces and planning committees had surfaced to deal with these conflicts. Since 2008, ITQ had created a variety of responses, the most important was the discrepancies in harvest reports discovered by MD-DNR. Compliance and enforcement were lacking in the Maryland literature involving blue crab. Since this is the number one fish export for the State, gaining a handle on the timing and frequency of blue crab noncompliance is essential to policy.

Lord (2011) addressed the social changes fishing communities must face and conquer in response to continuous regulations. Science has reported time-and-again the misreporting and under-reporting of harvests (De Roacha et al., 2013; Hentati-Sundberg et al., 2014; Witbooi, 2014). Although common property and rights-based fishing had existed since humankind discovered fish as a natural resource, the division of this resource continued to be debated by scholars who intimately studied the fishing industry (Allison et al., 2012; Brewer, 2012; Guyader & Thébaud, 2000; Lam & Pauly, 2010;

Ostrom, 2000; Ratner & Allison, 2012; Santopietro & Shabman, 1990; Stewart & Callagher, 2011; van Hoof, 2013). Economic theory had played a vital role in the development on views of the fishery as a sustainable resource (CapLog, 2011; Mazany et al., 2005; Nasser, 2013; Roberts, 1905; Wilen, 1985).

**Current Research Methodologies**

Ali and Abdullah (2010) examined factors believed to affect compliance in fisheries pertaining to zoning regulations in their study titled *Impact of Enforcement and Co-Management on Compliance Behavior of Fishermen.* The Malaysian fishing crew experienced new zoning regulations that were meant to act as an equity lines between small and large-scale fishers. However, large-scale fishers continuously ignore the regulation. The rate of non-compliance can be significant, and deterrence means higher enforcement costs. The authors asserted that a great deal of research has been completed on criminal behavior as formulated by Becker (1968), and Sutinen, Rieser & Gauvin (1990) studied regulatory enforcement and compliance using deterrent theory in an econometric study. The authors used primary and secondary sources. They collected secondary data from The Department of Fisheries and the Fisherman's Association. They used the individual commercial fisher as the unit of analysis. They analyzed the primary data using SPSS (Statistical Package for Social Sciences) and STATA. The report began with a descriptive analysis followed by the result of the hypothesis testing.

Hentati-Sundberg et al. (2014) discussed the lack of data or misreporting may lead to unreliable stock assessment data, which in turn results in bad advice. They asserted stock assessment methodology was dependent on accurate data. Commercial data can be biased particularly in highly regulated commercial fisheries. Overcapacity can promote economic incentives for non-compliance. The authors built a statistical analysis using logbook data from fishing operations. The time was selected because it marked an important change in management systems. In fisheries, it is important to distinguish between catch and landings. The authors used two General Linear Models to estimate total catch. Explanatory variables included depth, latitude, longitude, month, gear, total effort and were spatially explicit. The sensitivity of the model was tested by parameterizing the model to individual years in the beginning and end of the time-series.

Arias et al. (2015) discussed management by marine protected areas and fishers' compliance response. The authors suggested that the 20% catch estimated to be illegal was conservative. This was becoming a serious topic in the conservation and rebuilding of fish stocks. They contended that the ecological success of MPAs has been linked directly to compliance. However, little empirical evidence existed to support these assumptions. Illegal fishing was a broad topic and comes in many forms. There would be no simple solutions. The authors studied 12 sites. MPAs were chosen purposefully to prove a varied sample. Data collection involved quantitative questionnaires. Since this was a sensitive subject, the questionnaires were prone to no response and response bias. Levels of compliance were measured for each MPA.

Guenther et al. (2015) investigated what happens to displaced fishers when MPAs were implemented in historical fishing areas. As an adaptive strategy, fishers were accused of fishing the border of the MPA. In recent years, researchers have applied the use of spatial methods in their studies. Few of these studies have mixed various spatial methods. Units of analysis come from secondary sources. The authors tested for reallocation of effort after the implementation of MPAs. The authors reviewed captains' daily fishing logs over a span of 10 seasons that included five before and five after the implementation of the MPA. The authors used a Chi analysis to test whether fishing effort aggregated along the border of the MPA. Comparisons of catch were analyzed using a paired Student's *t* test of the mean difference of the fisherman's daily CPUE in and out of the MPA border.

Scheuerell et al. (2015) discussed the effects of a large-scale supplementation program on the density of the fishing population. They asserted when designed accurately, a priori, large-scale interventions could be treated as large-scale experiments with effect sizes estimated through carefully constructed analysis of variance (ANOVA) applied to data from before and after control-impact (BACI) studies. Time series models could overcome when no true "control" existed and could overcome some of these problems. It could address the data sequentially. A lack of explicit experimental design was supported in a hierarchical model. It could support missing data, different error distributions, and data from varying sources. A multivariate, hierarchical time-series model could describe year-by-year changes.

Ronald E. Wilson, Program Manager for Mapping and Analysis for the Public Safety Program at the National Institute of Justice in Washington, D.C. (2010) discussed developing a theory for the use of the DDACTS (Data-Driven Approaches to Crime and Traffic Safety) model, which was a time and space-to-event means to track repetitive – high crime areas. This model tracked incidents that had occurred over time in specific geographic locations. This model might uncover a pattern that demonstrates certain areas attract crime. The new theory under development was referred to as Place-Based Theory. The author suggested that B.F. Skinner's theory on learning strengthens the conditions for crime in certain locations. Wilson suggested that consistent enforcement in these same areas would simultaneously send a message of less opportunity. He asserted that geographic type theories of crime that demonstrated the ebbs and tides of crime patterns would effect policing and lead to creating preventive policy to stop patterns from developing.

## Variable and Methodology Rational

The common methodology in fisheries has been quantitative. The common theory was economics, so the combination had been an interest in income and costs as they relate to fishing effort. The introduction of MPAs and ITQs has had an impact on the literature about income efficiency before and after the implementation of such regimes. Compliance concerning the theory of open access or rights-based fishing was another studied variable. However, the interest in compliance was not to what degree it was occurring, or how often it was occurring, but what was the costs associated with this risk-taking activity. Much of the data was collected from primary sources such as the fishers themselves or from secondary sources which were marine fisheries agencies. Enforcement studies were nearly zero in the literature except in the form of related costs. To view compliance from a different lens, my study tested for direct responses to regulatory action. This included all major changes to fishing commercial blue crab. Recognizing if noncompliance was occurring in patterns was an important policy implication.

## Summary and Conclusions

The race for fish in a common property fishery and non-compliance in the ITQ fishery were common themes throughout the literature. Common property concerns date back to the 1950s and continued through the present research. Social sciences were attempting to uncover why commercial fishers practice illegal activity. The theory of prisoner's dilemma was a common theme, and it was used to explain the responses of fishers to regulation. If a fishing person was concerned about the other's behavior, he or she would continue in self-interest for immediate gains that might be had by the competition. For all the literature representing common property, enforcement, and economic theories, they were seldom found simultaneously. In my research, I focused on actual true enforcement and analyzed this effect over time against a specified set of regulations filling a continued gap in the literature.

It was well documented that illegal activity was occurring in the fishing industry. This included but was not limited to harvesting illegal catch, under-reporting catch, utilizing illegal gear, and or misrepresenting geographical locations of harvest. Enforcement was lacking in many of the worlds' fisheries; allotted budgets are often cited as a reason for weak enforcement. Equitable distribution of TACs and ITQs continues to be a problem in large and small-scale fisheries. What science has yet to discover was to what degree this illegal activity was occurring. Without long-term data, noncompliance patterns cannot be accurately analyzed. Often, regulations are not enforcement friendly, making it impossible to monitor certain fishing activities.

In Chapter 3, I presented specific details for data collection and testing. Identifying and sharing unexpected responses as a problem in policy making with academia might stimulate research in specific coastal areas in the enforcement/compliance field within the social sciences. It is American coastal states' frontlines where the problem exists, and states can take direct action against criminal behavior related to its fishery resources – setting a precedence of zero tolerance. Larger patterns along coasts could develop over years of data collection and systems development. Identifying patterns of enforcement would assist in identifying underlying behaviors that might be addressed in future policy or corrected in current policy. I collected this crucial secondary data and presented it as a model for present and future data collection using continued time and space analysis procedures.

# Chapter 3: Methods

## Introduction

The purpose of this quantitative, correlational study was to find whether there was a statistically meaningful relationship between commercial blue crab enforcement and regulatory action and type on years with none, one, or multiple regulatory actions spanning 2009-2017. My goal for this quantitative, correlational study was to share the findings with industry stakeholders to affect a positive social change between policy makers and commercial fishers. Since I identified trends in the research, interested people must delve further to learn what drives these trends. The results of this study can aid in making regulatory actions meaningful for all vested parties.

The primary objective of this research was to appraise commercial blue crab fisheries related regulatory activity beside enforcement data. The results of this correlational study may aid in making regulatory considerations pertinent to blue crab management strategies (see Osbourne, 2010). The research contributes to future investigation of often-neglected variables that may halt a regulation's ability to meet its intended purpose. Specifically, this research addressed Maryland's commercial blue crab fisheries regulatory action within its boundaries of the Chesapeake Bay. I focused on non-positive law titles that represented all commercial fisheries related regulations dating 2009-2017.

Enforcement data and blue crab regulations served as variables for comparison. Logically, by comparing data, this quantitative design incorporating a correlational, time series study uncovered any direct relationships between the numbers of recorded blue crab citations, warnings, and commercial Maryland blue crab regulatory action. These relationships may skew harvest data that then drives policy. This research was not meant to answer why this phenomenon occurred but simply to assess whether it was occurring. I analyzed the data using descriptive statistical analysis.

In my role as researcher, I made valid assumptions based upon the results of the research. I collected data methodically, then grouped and categorized the data in relationship to the variables under study. I resisted all bias and presented data as they were uncovered. This scientific study was a means to produce empirical results about enforcement and regulations. I collected enough data to ensure detection of even the least meaningful relationship between variables. I found and collected secondary data. I entered the data into a statistical software program, surveyed and summarized the results, and presented the results in a clear, concise manner using empirical evidence as support for future research.

The population under study was the licensed Maryland Chesapeake Bay commercial blue crab fishers. Most significant, enforcement data related to the commercial blue crab fisher and the gear used to harvest blue crab was investigated. The research took place in Princess Anne, Somerset County, Maryland – a mere 13 miles from the Bay and several working commercial fishing communities. This stretch of peninsula in Maryland is referred to as the Lower Eastern Shore, and the Bay is divided into two more sections – Middle and Upper Bay. The sample included a collection of commercial blue crab enforcement data and regulatory actions in Maryland's Chesapeake Bay. Harvest data from institutions and historical print media dating to 1939 provided background for discussion. Further, regulatory action and harvest data provided a timeline to discuss the economic growth and status blue crab has earned in Maryland.

Data collection procedures included searching agency websites and relying on educational and scientifically based websites related to the Chesapeake Bay blue crab. Public notices posted by MD-DNR announcing commercial crabbing related proposed regulations provided a timeline. Secondary data collection included retrieving annotated codes of Maryland via the Maryland Department of Legislative Services and the *Maryland Register*, which comprises regulations passed each congressional session. I collected active and proposed regulations via the MD-DNR and enforcement data via the MD-NRP, as available.

Data collected throughout the history of commercial crabbing in Maryland was inconsistent at best. For this research, I grouped regulatory action into six specific blue crab strategies dating from 2010. The MD-DNR provided archival blue crab population and regulatory data. The retrieval of this data was pertinent to the research in that the sample size must represent blue crab related enforcement and regulatory action at a number large enough to make valid assumptions from the results of the research. I reported on 96 time events that represented 2010 – 2017 enforcement data, viewed monthly and analyzed by year.

I acted as the main data collection instrument. Instrumentation involved the coding of archival and print media data for grouping. I coded the data in order to group types of blue crab regulations, crime, and number of licenses and crab gear allowed during a given time slot into useable sets. I entered all the data into a statistical analysis program to be sorted and measured. The population, comprising commercial blue crab fishers, is licensed by the State of Maryland to harvest blue crab commercially from the Chesapeake Bay. Blue crab is a popular species of crab harvested in three out of seven of its lifecycles. This includes the hard crab, the peeler crab, and the soft crab. The blue crab regulations included all gear with a focus on both hard crab pots and peeler crab pots. Crime collection included enforcement data related to blue crab harvested by a licensed, commercial blue crab fisher, regardless of license type or the legal outcome. Legitimate agencies or print media from reliable sources provided historical and or missing data. Timing or slots of time included the year after a regulation, the time after an emergency regulation, and the time after zero regulatory action, that is, in-season and out-of-season spans of time for correlation.

Quantitative, correlation in time series research demonstrates the importance of the continued problem. In Maryland, commercial blue crab fishers continue to reject regulations enacted or proposed individually or in combination before, during, and after commercial fishing seasons (Chisolm, II, 1940; MD-DNR, 2015; *Maryland Register*, 2017), which results in noncompliance. The legislative practice of constant, cumulative implementation of commercial fishing regulations without empirical evidence lends itself to noncompliance by user groups. Rejecting regulations threatens baseline data, which furthers regulatory action that then effects stakeholder decision-making, and conservation plans fail. I expressed the data in numbers that provided a base for descriptive statistical testing including the mean, median, and standard deviation. Descriptive methods provided the foundation for the variables discussed in the research. I tested the least amount of reduction in variables to reduce Type 1 error rates. Both tables and figures I developed have created a reader friendly environment to present such tightly woven data. This research provides a volume estimate of enforcement data relative to commercial blue crab regulations in Maryland's Chesapeake Bay. The sample was large, spanning 8 years, and included six specific regulatory categories that provided for reliable statistical analysis. Enforcement and regulation may present how a group responds to new regulation and the unexpected consequences that may result. In this research, I attempted to identify trends on a specific demographic.

Several threats to validity stemmed from archival data. Data collection systems for tracking commercial blue crab fishers and harvests have dramatically evolved since 1939. Typos and transposed numbers are obvious factors with dated material. Further, sampling and collection of data was sporadic at best. Grouping and sorting this data into crime and regulation variables that accurately worked to answer the research question was essential. Sporadic, archival data influenced my ability to make fine distinctions in the representative data. Accuracy would be impacted if the measurement did not capture the differences and similarities of the variables in the analysis. The measurement showed through the available data that a phenomenon occurred. Last, measurements of crime against regulations have covariates that change from crab season to crab season, influencing outcomes.

Ethical issues related to research included the fabrication or falsifying of the archival data. This data may originate from previous quantitative and qualitative studies. Previous miscoding of data through negligence or bias was another consideration. My goal was to promote accuracy of data in this research to discover unexpected relationships. Transparency of key informants was essential to attaining honest, voluntary cooperation for providing sample documents and historical matter. Further, cultural sensitivities must be respected to avoid conflict of interest. Decision makers would benefit from a full-circle review of how their intentions are unfolding.

## Research Design and Rationale

I investigated whether blue crab enforcement data correlates with regulatory action by number or type. I based the study upon one primary research question: What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial fishers as measured by the number of tickets written annually? Regulations and enforcement data provided the variables for the intended correlation. The data set encompassed years that included regulatory actions as well as reported enforcement data for years with zero regulatory activity.

Equally important questions were: How many times has fishing illegal gear occurred during the study years? Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit? Do years with no regulatory activity have less enforcement (crime) compared to years with regulatory activity? What percent is noncompliance behavior of total licenses reporting activity?

### Independent Variable

The independent variables under investigation included a selection of blue crab regulations. I determined the regulation selected by the commercial blue crab enforcement data available; therefore, I reviewed regulatory actions dating 2009-2017. Regulations are nominal variables. I included blue crab regulations, acts, laws, public notices, management practices, and proposals. My selection process included those regulations that had a direct enforcement relationship to the commercial harvest of blue crab as defined by the MD-DNR.

**Dependent Variable**

The dependent variable under investigation was blue crab commercial enforcement data. The enforcement data comprised citations and warnings reported or recorded by MD-NRP since a specific regulation's inception. I reviewed material to the earliest recorded enforcement of commercial blue crab as reported by Maryland. However, the variables tested included enforcement data spanning the years 2010-2017.

**Covariate Variable–Continuous and Control**

Time was one covariate variable I used in this research. Time selection mirrored enforcement data relative to regulatory action. Thus, sampling was sporadic in that some samples were continuous, while other dates had zero regulatory action and enforcement. Samples were drawn for each action or inaction starting in 2009 and ending 2017, while samples for enforcement were limited to 2010-2017 and further divided into months. This model did not allow random sampling.

**Mediator Variable**

The number of licensed commercial blue crab fishers in Maryland for a given season was one mediator variable I used in this research. Several other mediator variables

I considered included weather conditions and emergency regulatory actions.

**Moderator Variable**

The harvest of blue crab by commercial blue crab fishers was one moderator variable I considered in this research. This number, if accurate, should not skew from total crab pots allowed in Maryland's Chesapeake Bay during a given season. A second moderator variable to consider was the harvest of blue crab as reported by NOAA. This number, if accurate, should not skew from Maryland's harvest reports.

**Connection to the Questions**

I used a correlational design to demonstrate positive and negative correlations among the variables. I examined the independent variables (commercial blue crab regulations) and dependent variables (enforcement data) during specific time slots to determine if associations existed. The time I studied consisted of the season that occurs, pre - through implementation or rejection of a regulation, in or out of regulatory season. I eliminated missing data as a variable.

The right or licensing - or historical lack of - to participate in commercial blue crab harvesting has evolved since the invention of the crab pot. I considered this information in order to hypothesize its influence on any patterns that became apparent, but the resulting data was not measured for the purpose of this research.

**Constraints**

The most vital time constraint I faced was a completion deadline required by Walden University. Time was of the essence. Second, I was constrained to conduct data collection individually because keen accuracy concerning typos and or transposition error would dramatically influence the results. Further, much of the data lexicon and or jargon was legal vernacular, which can be difficult to interpret. The sample size was gigantic in terms of chronological availability, but the resources had content accuracy challenges. I was progressive in reading and writing law, as well as hands-on experience with cultural jargon. Missing data may skew time comparison of variables over time, so I eliminated them. Cooperation from state agencies and scientific organizations was expected, but it became a constraint when legislative documents had to be printed individually for accuracy and organization.

**Advancing Knowledge**

A great deal of literature presented the fishing industry using qualitative studies with a concentration in conservation management. In and of itself this appeared as a validity problem; conservation management was perceived by the fishing industry as a direct threat -- in general. Guaranteeing truthful responses from human participants in an already threatened industry lacked acceptable validity. Prior to expansive marine destruction, common sense cited historical harvest data as valid since there were limited threats to the crabber's livelihood. Skews in modern data were expected, since perceived threats had increased with the increase of regulatory action for commercial crabbing in Maryland's Chesapeake Bay these past 15 years. I presented a quantitative, correlational, time series study using descriptive statistics. My study provides an empirical review of important variables related to blue crab management. Particularly in enforcement of crab pot regulations, many blue crab management decisions lacked empirical evidence. I discovered negative and positive correlations by comparing the variables. I provided secondary questions for additional data discussion and consideration. Objective, bias-free, hard numbers should be necessary for decision makers to support or reject pet theories promulgated by special interest groups.

## Methodology

### Introduction

The crux of my research was correlation and comparison. I aimed to discover if an unexpected relationship existed between regulation and enforcement. The independent variable used for comparison was commercial blue crab related regulations. I created six sets of regulations that involved the policing of blue crabs. The variables I provided for measurement were enforcement data on specific regulations selected from a broad group of laws enforced under Maryland's direction. My main research question aimed to discover if any patterns became clear over time between regulatory action and law enforcement – specifically for blue crab related laws in Maryland's Chesapeake Bay.

Those who use this research will benefit from the regression analysis because it will assist in deciding if future similar events will occur. However, even with a before view of events, without a control group, no true assumptions can be made as to whether commercial blue crab fishers rejected a specific regulation. Regardless, future crimes may have the potential to be curtailed in advance of regulatory action based upon the outcomes of this research.

### Quantitative Justification

Time was the standard by which this research began and ended. However, it became apparent after I performed a thorough literature review that the terms Time Series and Time to Event models had been used interchangeably. For this research, I collected data in and out of season for each independent variable. This may be described as before a regulation occurred or zero time when no regulation was enacted in a specific year. Enforcement data available and regulation activity predetermined data collection. This research benefited more from sample size than from equal dispersion. Because data collection times were sporadic and dependent upon actual enforcement and regulatory activity, a Time to Event Model using Paired *t* tests to measure events seemed logical.

Parametric tests were possible for this research, as meeting the size guideline was possible over the spread of years representing this combination of nonnormal, continuous and discrete data. Twenty samples in a parametric test with 6 research variables provided substantial data. Each of 6 variables stood for a set of specific regulatory actions that effected blue crab harvesting in Maryland's Chesapeake Bay. Nonparametric tests were useful in that the median best represented the center of distribution, so they were utilized for comparison sake. A time to event model based in descriptive statistics guided my research.

Trochim & Donnelly (2007) discussed the time series model, but it offered several major problems. It was difficult to identify other influential factors, and the researcher must consider the sample objective, remain bias free and ethical while giving a representative sample of the population. The independent variable requires attention in that considerations must be made for all things that can affect the dependent variable. Then, these items are measured creating longer "real-time" issues. However, I was unable to provide equal time slots because each measurement was random in that enforcement and regulation are random.

Predictive analysis could measure possible explanatory variables. However, the more effects sought the more chance of Type 0 error rates. As such, the effects on the dependent variable as covariates, weather and crab availability, could effect the participation of commercial blue crab fishers, which ultimately effects the outcome of enforcement. These covariates could make the study cumbersome and stray from the purpose of discovering unforeseen patterns in the historical data. Therefore, I chose descriptive analysis because it cannot be confirmed that a regulation met its intended purpose, nor can all the covariates be considered in the research.

I considered qualitative, quantitative, and mixed methods for this study. The study became quantitative when I decided to analyze the use of existing enforcement data and review license and harvest data. Exhausted finances and time for my education reduced my ability to conduct a thorough mixed methods research. I chose a comprehensive quantitative study because it provided a large data set from which to view enforcement and regulation from a historical perspective with descriptive analysis. Most important, I achieved this research with my limitations.

**Role of the Researcher**

I observed outcomes in my role as researcher. My role began with deciding where data would be collected, what would be collected, how much would be collected, how it would be recorded, and how it would be grouped or categorized best to answer the research questions. Then, I made valid assumptions based upon the results of the research. I identified and collected data, as well as entered it into a statistical software program, surveyed and summarized the results, and presented the results in a clear, concise presentation using empirical evidence as support for future research. To protect the validity and reliability of the results, I employed structured and systematic data collection and employed concise measurement tools. I collected data methodically then grouped and categorized the data in relationship to the variables under study. I collected enough data to ensure the detection of even the least meaningful relationship between variables. I resisted all bias and used scientific studies to produce empirical results. I took precaution against numerical typos and or transposition, as this would void all study results.

I chose to use secondary data because it reduced effects of earlier personal and professional relationships with participants. However, I was intimately involved in the commercial crabbing industry since 1992. I am well known as a grassroots lobbyist in support of Maryland’s commercial watermen and community interests. Once heading a 120+ membership of commercial watermen, I worked to introduce bias free data in support of an apprenticeship program for licensing as opposed to a moratorium. I followed the data to its end. I used statistic software to present the patterns that developed. I used hard numbers for citations to find possible patterns. I included 96 time slots using data from MD-DNR. My design managed my bias. I continue to own a home in a commercial crabbing community. Unguarded information was shared with me in community settings. This information had the power to influence or bias me for or against any matter discussed at local gathering places within the crabbing community.

Previous participation in the commercial crabbing industry as a boat mate subjected me to both ethical and unethical behavior of several licensed blue crab fishers. Grassroots lobbying for license changes in the commercial blue crab fishing industry encompassed 12 years of my time. These intimate experiences demanded a strict protocol for data collection, assembly, and presentation.

To address possible ethical concerns, I remained bias free, and I provided a representative sample of the population. I reviewed regulation and enforcement data to the turn of the 18$^{th}$ century; however, enforcement data was limited and organized by the number of occurrences per regulation as opposed to occurrences per person. Personal knowledge of the offenders or their criminal history was unnecessary to answer the main research question.

**Target Population**

The main research question I had to answer was whether criminal activity related to Chesapeake Bay blue crab increased with the number or type of additional blue crab management strategies - regulation. To answer this question, I reviewed criminal activity during years that regulatory activity occurred and did not occur. The population under study were folks who held the legal right to harvest Chesapeake Bay blue crab for commercial purposes in the State of Maryland. This included those who held a valid commercial crabbing license. The number of license holders changed throughout the data collection period because of outside influences such as the gasoline engine, war, and opportunity. In my study, the commercial blue crab fisher must have currently held an Unlimited Tidal Fish License (TFL), a Crab Harvester License (CB-3, 6, or 9), or a

Limited Crab Catcher License (LCC) or the equivalent of any combination of these licenses. Regardless of the license type, according to current COMAR, a commercial blue crab fisher may not have more than 900 crab pots utilized on or by a boat at any given time regardless of the number of licensed blue crab fishers aboard the vessel. I did not consider any other characteristics for this population for the intent of this study.

A second population and most significant to this study was the independent variable, which included a selection of blue crab regulations. Regulations were nominal variables with neither one nor the other being more important than the last. For the purpose of this study, blue crab regulations were not limited to those that were signed into law. It included all past and current regulations, acts, laws, public notices, management practices, and proposals submitted to the General Assembly dating between the years 2009-2017. This included direct and indirect impacts on the use of crab pot in the Chesapeake Bay in Maryland. The selection process I used included regulations that had a direct enforcement relationship to harvest blue crab commercially as defined by the MD-DNR.

A third population under study was enforcement data for the commercial blue crab industry. Specifically, I limited this data to Maryland and the Chesapeake Bay. I did not include any enforcement for any other types of fishes. Further, I included geographical waterways that at a minimum begin in Maryland or that ultimately empty into Maryland's Chesapeake Bay, otherwise known as tributaries. I included enforcement for all regulations effecting the commercial harvest of blue crab. This data included citations and warnings reported or recorded by MD-NRP. I recorded this variable as count data and by type of criminal activity when available.

Finally, the Chesapeake Bay blue crab was the population of interest for me. Providing opportunities for blue crab to proliferate is meaningful to all vested parties. For the purpose of correlation, I did not review crab harvest as a variable. I limited the study to commercial blue crab violations perpetrated by commercial fishing persons as reported by MD-DNR.

**Summary**

Maryland licensed commercial blue crab fishers inclusive of each type of crab license was 5,500 approximate licenses issued as of 2017. In earlier years, size of the crabbing fleet would impact the number, harvest available, regulation, and outside influences such as war. Since 1939, Maryland has put forward and carried out an exorbitant amount of commercial crabbing regulations in one form or another. This could be as many as 500 or more individual passages or rejections of potential commercial crabbing regulations. Enforcement has not been measured in the State of Maryland. There were no hard numbers by which to make an estimate of citations and warnings issued. I collected this count data from the MD-NRP.

**Sampling and Procedures**

I used purposive, non-probability sampling to complete this study. This sampling strategy allowed me to place the research in one or more specific predefined groups without using random collection methods (Trochim & Donnelly, 2007). I included 96 time points and held valuable nonnormal, continuous and discrete records that were used to investigate regulatory action and its cohort - enforcement. Regulations that directly control for blue crab harvest predetermined my sampling strategy. I ensured sampling validity by the range of topics selected for this subject (see Trochim & Donnelly, 2007). Each variable represented a set of specific regulatory action based upon a COMAR title and number. Twenty samples are a minimum for using parametric tests (see Allison, 2009). This research provided more than 20 points over 8 years. I noted each of the 6 variables as $R_1 – R_6$ respectively, and I used specific criteria to limit the representative sample.

In the early years, I found regulatory and enforcement activity were reported via newsprint. Further, I found that the legislature maintained copies of enacted regulations for blue crab, while enforcement records lacked systematic storage by agencies. In later centuries, television, public hearings, radio, and now internet had provided a means to collect regulatory data concerning Maryland's Chesapeake Bay blue crab and enforcement. The data set for regulatory action was cumbersome to review. Specifically, for this research, blue crab harvest in Maryland's Chesapeake Bay drove the collection of data. Therefore, I considered only enforcement data related directly to blue crab harvest for this research. The above-mentioned resources: legislature, agency, news media, public hearings, and internet provided me access to the data set. I collected this information by hand in hard copy, via U.S. mail, by telephone via experts, by personal correspondence, and by downloading internet resources. I reviewed these items for limiters, accepted, or rejected as pertinent, and recorded on a spreadsheet for coding categorically. Recorded information included the incident, summary, source, author if appropriate, and other applicable information.

The sampling frame included Maryland statutes specifically named by Maryland's Congress. Congress named and categorized COMAR - Natural Resources. Maryland titled each independent variable as *Title 4. Fish and Fisheries*. Subtitles and sections define the independent variables into subject matter. Each of these statutes had the potential to be identified on a citation or warning concerning blue crab harvest. Only statutes that effected commercial blue crab pot harvest were selected for this research from among all Maryland's natural resource statutes. The following is a list of selected Maryland Statutes.

- §4-701 Natural Resources, Title 4 Fish and Fisheries, Subtitle 7 Licensing, Regulation, and Supervision of Fishing and Fisheries in Tidal Waters, Section 701 Tidal Fish License.
- §4-703 Natural Resources, Title 4 Fish and Fisheries, Subtitle 7 Licensing, Regulation, and Supervision of Fishing and Fisheries in Tidal Waters, Section 703 Issuance of new tidal fish licenses after September 1, 1988.
- §4-803 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 803 Rules and Regulations Generally; Public Hearings Before Rules and Regulations Become Effective.
- §4-804 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 804 License for Catching Crabs for Commercial or Noncommercial Purposes.
- §4-809 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crab, Section 809 Limitations and Prohibitions on Catching and Possessing Certain

Kinds and Sizes of Crabs; Regulations: …

- §4-810 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 810 Rules and Regulations Pertaining to Female Crabs.
- §4-812 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 812 Use of Crab Pots in Chesapeake Bay Waters in Dorchester and Somerset Counties.
- §4-813 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 813 Harvesting Crab with Crab Pots in Somerset County.
- §4-814 Natural Resources, Title 4 Fish and Fisheries, Subtitle 8 Crabs, Section 814 Limitation on Number of Crab Pots.
- §4-1201 Natural Resources, Title 4 Fish and Fisheries, Subtitle 12 Penalties and Fines, Searches, Seizures and Forfeitures, Section 1201 Penalties
- §4-1205 Natural Resources, Title 4 Fish and Fisheries, Subtitle 12 Penalties and Fines, Searches, Seizures and Forfeitures, Section 1205 Seizure and Disposition of Fish Unlawfully Caught, Sold, Offered for Sale, Transported, or Possessed.
- §4-1206 Natural Resources, Title 4 Fish and Fisheries, Subtitle 12 Penalties and Fines, Searches, Seizures and Forfeitures, Section 1206 Seizure, Forfeiture, and Disposition of Devices, Equipment, or Property.

The statutes were reduced to six key categories from existing Maryland Statues to limit the independent variables into a workable data set. The independent variables, indicated by $R_{1, 2, 3 \ldots}$ in the research exist as Maryland laws and statutes and are housed in the *Maryland Registry*. Each set corresponds directly to a title and sub-title.

- Regulation 1 ($R_1$) Tidal Fish License, License for Catching Crabs for Commercial, Penalties, Natural Resources – Authorization to Catch Crabs – Revocation;
- Regulation 2 ($R_2$) Removing Fish, Nets, or Gear of Another Prohibited;
- Regulation 3 ($R_3$) Rules and Regulations Generally, Use of Crab Pots in Chesapeake Bay, Limitation on Number of Crab Pots, Crabbing – Crab Pots – Requirements;
- Regulation 4 ($R_4$) Rules and Regulations Generally, Closed Season for Hard Crabs;
- Regulation 5 ($R_5$) Limitations and Prohibitions on Catching and Possessing Certain Kinds and Sizes of Crabs Purposes; and
- Regulation 6 ($R_6$) Rules and Regulations Pertaining to Female Crabs

I limited enforcement data collection to the selected Maryland Statutes categorized into the above 6 categories. Enforcement data included all citations and warnings issued by the MD-NRP. G*Power 3.1.9.2 (2017) downloaded free from the internet provided a calculator to perform a power analysis. I computed a priori power analysis for the required sample size and actual power, given α, power, and an estimated effect size. The one-tail t test using a point biserial model provided the required information. According to Cohen (1988), so long as three of the four parameters were fixed, the fourth was predetermined. This research had a preset sample size (n) because data for the years 2010-2017 was available from the MD-NRP. Sample size (n) was present at 96, which reflects each month for eight years. Because I was measuring effects between regulatory action and number of recorded enforcement warnings and citations, effects that become apparent in either direction were important to the study. This provided a data pool of 96 enforcement samples. Therefore, n=96. Alpha level was set at .10, and effect size was estimated at the social sciences common use of .10, which indicates a significant difference. Identifying the degree to which the phenomenon was present was called the effect size (ES). The literature did not provide a common effect size. Therefore, the ES was set using the above assigned values to the mentioned parameters, Power ($1 - \beta$) was set at .90 and required a minimum total sample size of 34.

**Archival Data Use**

Procedures for recruitment included using public records access. Maryland's Public Information Act (PIA) allowed me to access regulatory action and enforcement data without bias or an ethical threat to the anonymity of the accused. Further, I requested documentation that was unavailable from government bodies via the internet databases through Gmail using typewritten correspondence. MD-DNR provided this data in downloadable form. I collected other data from credible websites that included .org, .edu, and .gov in its URL. Last, I learned background knowledge by thoroughly reviewing historical *Baltimore Sun* newspapers that consistently reported on the politics of the legendary blue crab since the turn of the 18th century.

Procedures for participation were not necessary as this research employed the use of archival data. Secondary resources were available through government and public access websites. Procedures for data collection included the use of Microsoft Excel to log, track, and sort data. This included entering count data that represented enforcement data, active commercial crabbing licenses, blue crab harvests, commercial crabbing seasons, and years of activity. Further data entry included statutes listed by number and title. After logging incoming data, I reviewed it for accuracy and completeness. To deal with missing data, I determined to delete that data. Status quo has been to remove these samples from the research or to replace missing data with estimates (see Trochim & Donnelly, 2007). Both options were considered for the most valid conclusion.

Public record materials made up much of the data that I collected for this research. I collected data from websites of legitimate organizations and government agencies. For example, NOAA, VIMS, MD-DNR, MD-NRP, and professional journals provided a great deal of information. To produce a valid study and create a solid database of information, all possible data collection points were contacted by one or more of the following: Gmail, U.S. mail, telephone, and in person where physical distance was not an issue. I gained permission to access the data easily. Archival, primary, and secondary data stem from public records for this research. Request letters were necessary to fill in any missing data. A departmental hierarchy exists in the MD-DNR and the MD-NRP. This hierarchy saved me time and provided me the contacts relevant for specific variable data.

In the early years of commercial crabbing, few regulations existed. There is a limited number of Maritime police charged with enforcement of regulations. Most detrimental to this study was that record keeping of enforcement and harvests was not required by natural resource agencies. Most information was delivered via the *Sun*, a historical Maryland newspaper. However, as time progressed, and the government became active in natural resource development, data began to be collected by scientists who visited the Chesapeake Bay crabbing regions. Sadly, this data was not organized by method of collection, tested, or cross-referenced with any existing records to measure for accuracy.

With these limitations, early newspaper, judicial, and legislative reports along with scientific research were the most reputable and accurate points of background knowledge for the start of the 1900s. As the decades progressed, the research depended upon agency reporting requirements and its scientific estimates. As the century turned, the research provided multiple points of collection from interactive agencies and marine science institutions. In combination, these data collection points are both reputable and represent the best sources of the required data. These changes in data archiving further limited the study to a financially acceptable investment of eight years dating 2017 backwards to and including 2010.

**Instrumentation and Operationalization**

I acted as the main instrument for data collection. Instrumentation involved grouping archival and print media data for transformation of regulatory discussion and crime reported into a statistics software program. I coded regulation into groups and types of crab pot regulations and types of crime into useable sets and based upon specific criteria. For instance, I grouped Regulation 1 ($R_1$) as all regulations pertaining to license changes effecting commercial blue crab fishers.

I collected each regulation defined for this research that effects commercial blue crab and grouped it accordingly. Blue crab pot use included rules for hard crab pots and peeler crab pots. The *Maryland Register* and COMAR are published by Maryland's Division of State Documents (DSD) that collects and publishes regulatory activity (DSD, 2017). I collected additional information from professionals working at both agencies – MD-DNR and MD-NRP. I contacted these scholars via landline to assist in reducing missing data to the minimal amount.

I contacted and collected from MD-NRP data on crime and occurrences. I reviewed codes to identify by Title number and subsection the regulation's noncompliance history (2017). The Maryland State Archives collects and disseminates government reports and publications (2017). I accessed this database via the internet. I calculated crime as a rate of occurrence and counted it. MD-NRP shared much of this data using public crime blotters. The data describes the offender as recreational or commercial and the crime he or she has committed. Crime collection included warnings and citations related to blue crab harvested by a licensed, commercial blue crab fisher, regardless of license type and the legal outcome.

Historical and or missing data for regulatory and enforcement discussion are housed within other legitimate agencies and reliable print sources. I contacted these agencies and sources as this data adds to the time model. It demonstrated slots of time, that is, in-season and out-of-season spans of time for correlation. I entered this data into MS Excel, a common statistics software program to analyze.

In contrast to the mixed methods research conducted by Hentati-Sundberg et al. (2014) on mobile Swedish Baltic Sea fin fish fishermen heavily dependent on the population sharing the truth of their individual noncompliance over time, this approach amassed a statistical analysis of regulatory activity and enforcement data for commercial blue crab fishers working in Maryland's Chesapeake Bay from 2010 - 2017 using secondary data. I studied the population crab pot as a fixed gear. For the background and literature review, the 1939 - 2009 period was selected because it represented the intense growth of the gear known as crab pot in the fishing industry in Maryland, which culminated in the use of MSY and ITQs for blue crab in 2018. I selected this research period because MD-DNR's historical data collection practices limited the data pool.

I consider regulatory activity an incentive for commercial blue crab fishers' noncompliance such as under or overreporting harvests. It was likely that effort, defined as crab pots allowed for a given season, was an accurate representation of actual catch. As noted by Hentati-Sundberg et al. (2014), it is essential to distinguish between actual catch and landings reported. Actual catch includes culled blue crab or possible black-market harvest, while landings represents the harvest of blue crab reported to Maryland. This research used General Linear Models (GLMs) as published by Hentati-Sundberg et al. (2014) to compare regulatory activity to enforcement data. While Hentati-Sundberg et al. (2014) utilized trips to sea for time reference, this research reviewed eight years making *n* months = 96. Guenther et al. (2015) used $Chi^2$ analysis to compare before and aftereffects of regulation using a spatial model.

I used a *t* test to demonstrate any significant differences in the proposed time model. Descriptive statistics employed by Ali and Abdullah (2010) and grounded in criminal behavior theory were beneficial to this research. Their main assumption "is that the individual was a rational decision-maker who considers the costs and benefits of participation in illegal activities" (p. 115). Their model extended Kuperan and Sutinen's (1998) research in fisheries. They asserted that time spent on non-compliance by fishers was a result of income generated from the activity, and this contributes to their overall ability to invest in their operation. Specifically, they use a logit model to test binary variables. Correlation coefficient can quantify the direction and strength of any correlation that becomes apparent. However, I believed discovering median as equally important because I used it to determine percentages. Over time, cumulative regulation may increase the potential for law breaking, which may have skewed the means.

I sent a letter to the MD-DNR requesting permission for the use of its instruments. I grounded this study in enforcement theory and used secondary data to analyze enforcement and regulatory activity side by side. I built upon existing fisheries research relative compliance behavior in the commercial industry by making multiple comparisons over decades in search of correlation.

The operationalized variables were selected from research that spanned decades and continues to be a crucial factor in today's commercial fishing industries all over the world. Time models and descriptive statistics have been the backbone of fisheries research. However, much of the research has been grounded in economic theories or the decision-making process of non-compliers. My study builds upon these ideas and models but chooses to reflect upon the unexpected patterns that may emerge. The published tools have held reliable and valid results for this industry and its relative variables – marine resources. Although much of the previous work focused upon finfish, this research expands on that by testing a commercial crabbing community fishing blue crab in Maryland's Chesapeake Bay and pattern development of noncompliance.

The following authors employed the use of common instruments employed in fisheries research. They built upon previous research and sought to uncover phenomenon. All three studies provided primary and secondary data as each sought to understand why the phenomenon occurred. I sought to determine if a phenomenon in noncompliance occurred as an unexpected outcome of regulatory activity. The variable selection, design, and methods cross decades of fisheries research and can be considered both valid and reliable for this type of study.

The selected instruments were used to determine the differences in lobster fishing effort before and after the State of California established MPAs for the industry. It was a spatial model that analyzed the stationary gear – lobster trap –, and reviewed compliance behavior using spillover theory. Specifically, Guenther et al. (2015) wanted to identify how close to "the line" commercial lobstermen would chance to fish and how this effected fishing effort and direction over 5 seasons and the mapping of 10 seasons of logbook data. The authors derived their work from primary and secondary sources. The authors determined the participants had no reason to lie as the study was concerning where a person fishes as opposed to whether he or she breaks a fishing law.

The selected instruments were used to determine if management incentivizes noncompliance among fishers in Hentati-Sundberg et al. (2014). They asserted that harvests are misreported by as much as “30% to 75 times higher than officially reported” (p. 1846). The authors filled two separate models with all combination of the independent variables and selected the model using AIC, as did Burnham et al. (2010). They fitted their model with overcapacity and technological creep for consideration on catch quantities. This approach proposed possibilities for “reconstructing historical catches based on commercial effort data” (p. 1847). They used the uncertainties from both models to calculate the confidence intervals for conservative catch numbers.

The selected instruments were used to determine what factors affect compliance behavior among Malaysian fishers. The authors used the basic deterrent theory model, which integrated economic theory and theories related to human psychology. They used SPSS to analyze the primary data. The authors used logit regression which uses the maximum likelihood method. Descriptive analysis was followed by hypothesis testing using the logit model. Their model expressed what types of licenses are committing more crimes through probability testing. They used 5% as the significance level for this occurrence. Five percent was the standard used in this research. They considered the results as an informational benefit to public policy making bodies.

**Operationalization of Variables**

Commercial blue crab fishers (licensees). A discrete independent variable that represented the number of Maryland licensed commercial blue crab fishers whose workday begins and ends in the Maryland region of the Chesapeake Bay and or its tributaries. Each season a number of licensees actively harvests blue crab. Commercial blue crab licenses are categorical variables that can be grouped by limitations set for each license type. For this research and correlation, the digit will express the total number of licenses issued for each type of commercial crab license. This variable was ratio data. It would supply base data for each month and year totals. The number stood for the number of allowable licenses. I meant to use this number for comparison of harvest reports to license violations to investigate discrepancies; however, the data did not provide sufficient detail. Comparing enforcement totals to license totals provided percent of crime occurring over time.

Compliance behavior (crime incidents). A discrete dependent variable that represented enforcement by the number of warnings and citations issued to Maryland licensed commercial blue crab fishers during any season and year for a specific Title and Subtitled law. I limited the study to 6 specific categories of regulation pertaining to commercial blue crab activity. The total number of enforcement incidences in Maryland's Chesapeake Bay and its tributaries pertaining to commercial blue crab fishers licensed for crabbing expressed this digit. For this research and correlation, I expressed in digits the total number of incidents and percent recorded for each categorized regulation. This variable was ratio data. It provided the number of incidents related to regulatory action. I counted incidences after each regulatory action. This number supplied a total of crime incidents by which to measure against regulatory action to seek patterns. Crime compared to licensees were expressed in percent for each year. This measure of compliance behavior provided base line data to view criminal activity.

Regulatory action (in-session, emergency, out-of-session). A discrete independent variable that represented public or agency discussion and or introduction of a legal action altering commercial crabbing activity in Maryland's Chesapeake Bay and its tributaries. When action occurred, I assigned a score of 1 and a value of 0 if action did not occur. This variable was nominal data. This variable expressed whether regulatory activity took place or not. It provided the total number of actions taken to alter commercial crabbing via agency or Congress. I listed actions by type to provide detail to regulatory activity compared to specific changes in management. I counted actions, and this number supplied a total of regulatory actions by which to measure against enforcement data to determine if patterns emerge.

Season (in-season and out-of-season). A continuous independent variable that stands for time by month and year that the commercial blue crab season begins and ends in Maryland's Chesapeake Bay and its tributaries. I listed these digits by month and year for correlation tables. This variable was interval data. Although this data was abstract, it was measured by the life cycle of the blue crab living in the Chesapeake Bay. The blue crab harvest cycle runs from early spring to early winter. Each year the "legal" season may vary. For this research, a season will be divided into individual months and years. This variable represented the in or out of season time compared to regulatory action. The variables were expressed month to month and year to year.

Harvest (blue crab). A discrete independent variable that represented the number of blue crab harvested by Maryland commercial blue crab fishers. This variable was intended for comparison. This number was meant to be measured against the number of crab pots allowed or seized to uncover reporting discrepancies. However, the available data did not provide enough detail to measure for this.

I measured effects between regulatory action and number of recorded enforcement warnings and citations. Effects that became clear in either direction are important to this study. Thus, a=.10 was the scientific rate of rejecting the True Null hypothesis. I sought to measure enforcement over 8 years beginning in the year 2010. This provided a data pool of 96 samples. Therefore, n=96. The ES was set at .10 effect. Power equals .90. Once I collected the secondary data, I measured for means and standard deviation. However, in correlation design, hypothesis testing was unnecessary to identify patterns.

**Data Analysis Plan**

Microsoft Excel 2016 analysis software allowed me to arrange and sort data in ascending or descending order. It allowed me to filter data in and out of the worksheet for a variety of tests. Once I entered the data, filters and formulas were embedded to group items and perform mathematical algorithms. Excel provided a variety of charts for visual representation. It provided both validation and consolidation tools. Correlational, descriptive statistics and the secondary, quantitative data were used to compare regulatory activity to enforcement of regulation for the natural resource, blue crab, in Maryland's Chesapeake Bay. Microsoft Excel 2016 was the latest version available for statistical analysis. I have had the opportunity to learn and perform Excel commands in previous professional positions. This experience prepared me for the requirement to enter data, perform calculations, and analyze the data collected. Correlational analyses provided a venue to examine relationships between regulation and enforcement. Parametric and nonparametric testing provided distribution norms by examining data year to year.

This quantitative, correlational study required a mass amount of data entry. As such, duplicate entries could be a concern. MS Excel can identify and eliminate or deal with these cells, as necessary. Missing data was one other concern. I eliminated missing data cells from the study. Data collection procedures limited entry in the software using limiters in the selection process. I coded this data into specific categories. To illustrate, 6 categories exist for regulatory activity. I categorized enforcement activity using Title and subtitles of regulations. The software allowed me to perform data screening. Outliers and other significant problems were deleted or retested, as necessary.

I based the current study upon one predominant question: What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial blue crab fishers as measured by the number of tickets written annually? Regulations and enforcement data will provide the variables for the intended correlation. The data set encompassed years that included regulatory actions as well as reported enforcement data for years with zero regulatory activity. This research question would have led to the following hypotheses that are stated in null and alternative form; however, correlation design did not require testing for hypotheses.

$H_0 1$: The number of commercial regulatory actions enacted does increase the number of blue crab citations and warnings reported annually.

$H_1$1: The number of commercial regulation action enacted does not increase the number of blue crab citations and warnings reported annually.

$H_0$2: The type of commercial regulatory actions enacted does increase the number of blue crab citations and warnings reported annually.

$H_1$2: The type of commercial regulation action enacted does not increase the number of blue crab citations and warnings reported annually.

Equally important questions were: How many times has fishing illegal gear occurred during the study years? Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit? Do years with no regulatory activity have less enforcement (crime) compared to years with regulatory activity? What percent is noncompliance behavior of total licenses reporting activity?

This data, expressed in numbers, provided a base for statistical testing. Descriptive statistics underlined the mean, median, and standard deviation. A large sample, spanning 8 years and employing 6 regulatory categories provided reliable statistical analysis. Using a correlational design demonstrated positive and negative correlations among the variables. Employing a priori analyses avoided Type I and Type II errors (Booth & Quinn, 2015; Gerrodette & Brandon, 2014). To reduce Type I error rates, I reduced the number of correlations reported.

Aligning enforcement and regulation, and license data and compliance revealed unknown phenomenon concerning regulation. Independent variables (blue crab regulations) and dependent variables (enforcement data) examined during specific time slots determined associations exist. The time studied represented the years 2010 – 2017. This demonstrated post-regulation and activity with no regulation. Tests employed nominal ordinal scales to determine the strength of those correlations.

The Pearson correlation coefficient can range in value from −1 to +1. The larger the absolute value of the coefficient, the stronger the relationship between the variables. An absolute value of 1 indicates a perfect linear relationship. A correlation close to 0 indicates no linear relationship between the variables. If variables increased and or decreased together, the correlation was positive with an upward slope of the line. A downward slope of the line indicated the correlation was negative because as one variable was on the rise, the other was on the decrease. However, causality cannot be proven with this study. Any extreme values can throw the correlation coefficient; therefore, identifying the cause of any extreme value and correcting data or measurement errors was essential. Pearson works best when values are removed that are associated with unique circumstances and or events. I repeated the analysis after each change in data.

To examine nonlinear relationships simple regression allowed for table representation. To determine the significance of the correlation, I compared the p-value to the significance level. I set alpha at 0.10. An $\alpha$ of 0.10 indicates a risk level of 10% as to whether a correlation “actually” exists or not. The p-value describes the significance level from 0, while a 0 specifies no linear relationship. Thus, if the p-value was less than or equal to the significance level, then the correlation was different from 0. Likewise, if the p-value was greater than the significance level, then you cannot conclude that the correlation was different from 0.

## Threats to Validity

One threat to external validity included selection treatment interaction. I derived the sample for the study from archival data, and it was specific to the research. Nonrandom sampling reduced the ability to generalize the results to the greater world. Additionally, the specificity of variables controlled the study through the incorporation of specific regulations, and the differences in regulations from state-to-state or region-to-region would never align. Further, enforcement strategies and gear specifications are different from state-to-state or region-to-region. However, the act of the study can be duplicated in similar fisheries that may produce similar or drastically different results, mainly because of specificity of variables. Data collection systems continue to evolve within fisheries development; regardless, human error produces typos and transposed numbers challenging the use of secondary and archival data. Sporadic and missing data created representative issues. Last, unethical reporting practices on the part of the commercial blue crab fisher cause discrepancies in data.

Historical events do effect outcomes in studies that employ the use of secondary data. Because I focused on maritime activity, environmental factors played a role in all study outcomes and may have acted as interference. Weather influences all maritime participants whether directly or indirectly. One must factor in a measurement to ascertain *to what degree* this may occur. The accuracy or not, of this measure, will effect the outcome of the study. Reviewing enforcement against commercial crabbing license activity may discover hidden patterns. Weather not only effects the ability to participate in a workday for both the commercial blue crab fisher and the natural resource police officer, but it effects the harvest potential and the overall crab catch for the season. Long droughts create hypoxia (low oxygen) in the Bay, which leads to mortality. War as a historical event can effect outcomes in studies. War temporarily or permanently shrinks the population under study. Three wars took place since the development of the blue crab commercial fishing industry: WWII, Korean, and Vietnam Wars.

Using secondary data saved time and reduced threats to internal validity, such as ethical bias. As the data collection process matured within MD-DNR, changes in measures occurred, which acted as a threat to the coding and grouping of like data for this study. Utilizing external data sets lean towards the ability to generalize the results of a study. In this study, descriptive statistics using a correlation design do not seek to discover cause and effect making internal threats to validity less key.

Essential to this study was the convergence of data from reliable sources, which provided strong support for construct validity. A poorly worded operational definition applied to data can cause an inaccurate measure. I quelled threats to data collection by providing a clear, concise detailed definition. When data was intended to support or negate an issue, it was essential that the data measured that which was intended to be measured. For example, data collected from assorted secondary sources may use different measurements to measure identical situations or concrete items. If this data was not converted accurately, it would produce erroneous results, which become meaningless.

## Ethical Procedures

Since the use of the secondary, archival data used for this study was public record, an ethical agreement was not necessary to gain access to it or protect participants and or data. I categorized data by license type, and the study did not require names, ages, or other characteristics to perform its tests. The data included regulatory actions and enforcement data. Regulatory actions included public notices, public hearings, congressional sessions, emergency regulations, and the like – all of which were heard by Committee and enacted into law. The enforcement data is public record. I sourced this data from MD-NRP in numerical form. Names or identification numbers were not be necessary. In most cases, warnings and citations identified the law that a fisher violated and whether it was a commercial citation. IRB approved the proposal on July 31, 2018 - 07-31-18-0128716.

Systematic error concerned me as an ethical concern when presenting the findings of this research. For instance, if an incident occurred whereby MD-NRP were directed to actively seek out noncompliers of anyone specific or group of regulations, this information was unavailable to me, and this would place question upon the accuracy of measures concerning enforcement and or compliance behavior phenomenon. It must be assumed that participants would avoid criminal behavior during a time of heavier than usual enforcement. Consequently, normal and heavier enforcement would need to be operationally defined, and by whose definition, the commercial blue crab fisher or the MD-NRP? However, I chose to include these enforcement incidences within the data as it demonstrates actual noncompliance of laws pertaining to commercial blue crab in the Chesapeake Bay, the basis of this research.

Some people may claim I am biased by my current occupation, chicken farmer on the Lower Eastern Shore of Maryland where the population under study resides.

Although the State Seal depicts both a farmer and a fisherman, it is common knowledge that they are singularly concerned rather than cohort active. I remedied this bias easily by the fact that I have been employed in both occupations for at least 10 years each, giving me ample time to experience both livelihoods during feasts and famines, with constant legislative review controlling my income potential. I chose to study a field that intimately impacts my love of the Bay, my state, and its citizens, Maryland. It is a multimillion-dollar industry and touches most people who reside in Maryland. Secondary data provided a means for me to present findings based upon the professional, ethical, and critical review of field scientists and fisheries institutions at my disposal on a subject constantly regulated and, on a subject, neglected in Maryland's blue crab research – enforcement and noncompliance behavior.

## Summary

I conducted a quantitative, correlational, time series study that sought to discover if any patterns emerged between Maryland Chesapeake Bay blue crab enforcement data and regulatory action that directly impacts commercial blue crab harvest in the Bay and its tributaries. I reviewed literature dating each year since the inception of the crab pot in 1939 for a variety of variables. However, MD-DNR provided limited valid data dating 2010 – 2017. Enforcement data and regulatory action revealed correlations and unexpected outcomes of regulation. I housed the model in MS Excel for easy sorting and categorizing, and descriptive statistics provided evidence for correlation but not for causation. Synchronizing the diverse data into a primary workbook created a friendly working environment for converting numbers, as necessary. Microsoft Excel performed a variety of statistical tests. Results of this study provided evidence in support for future compliance behavior studies to uncover unexpected phenomenon by the Maryland commercial blue crab fisher.

In Chapter 3, I provided an explanation and description of the research design and its methodology. I used a quantitative, historical time series design to identify correlations between blue crab enforcement data and regulatory action in the Maryland Chesapeake Bay and its tributaries. The review covered the years 1939 to 2017 with specific tests related to 2010 - 2017. Time intervals became necessary to cover the in-depth material. Historical and archival data from MD-DNR, MD-NRP, and legislative and judicial websites, as well as the leading media in the early decades of the 19$^{th}$ century provided data and background knowledge. Threats to validity and ethical bias were presented and discussed to support the results.

After I received IRB approval, #07-31-18-0128716, I began my research, and I collected the data, entered the data into MS Excel, and analyzed the data to record measurements that demonstrated correlations between the variables. I discussed the results of this research and the tests in Chapter 4.

# Chapter 4: Results

## Introduction

The purpose of this quantitative, correlational study was to determine whether there was a verifiable relationship between the number of commercial blue crab statutes and regulatory actions (laws) and the resultant violations occurring from such laws. Although the above objective constituted the main question that drove this research, I explored other subsidiary questions related to the commercial blue crab industry if the testable data available from MD-DNR provided a sufficient information base to make answering these questions possible.

My primary objective for this research was to share the findings with industry stakeholders with the hope of effecting a positive social change and fostering improved relationships between policy makers and commercial crabbers in the research area. Results of this study may augment efforts in making regulatory actions meaningful and coordinated with evolving trends in the commercial blue crab industry. If any unique trend not captured in the main research question or subsidiary questions was unearthed in the course of examining the baseline data for this research, I made efforts to explain such trends and ascertain potential factors or conditions driving such a trend.

Apart from the primary objective, I sought to influence how commercial blue crab fisheries related regulatory activities are formulated and implemented with more emphasis on their practicability, enforcement potential, and potential reactions from commercial crabbers (violations). Although this study predominantly was informed by the need to ascertain the extent to which various laws governing commercial blue crab fishing correlate with violations of such laws, I projected that the underlying data and supportive literature for the study might help answer or shed more light on the following subsidiary questions:

- How many times has fishing illegal gear occurred during the research period?
- Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit?
- Do years with no regulatory activity have less enforcement (crime) compared to years with regulatory activity?
- What percentage is noncompliance behavior of total licenses reporting activity?

Since hypothesis testing is not the goal when conducting correlational studies and verifying associations, I developed these subsidiary questions to highlight other important issues confronting the commercial blue crab industry and how answers to these questions might go a long way to bridge the information gap between state regulators and fishers in the commercial blue crab industry.

## Process

My research method evolved from the main research question. In order to ascertain the correlation between the various laws or regulations and the violations of such laws, I set out to collect the available data from which I hoped to find empirical evidence to answer my main research question. My intial activity involved preparing letters to send to appropriate agencies to collect secondary data. I followed-up with a “thank you and just checking-in” note. I conducted correspondence and received replys via email. I made telephone calls to MD-DNR, and upon completing the final spreadsheet of inclusive data, I sought assistance from a statitician at University of Maryland, Eastern Shore. He assisted me in framing my goals, preparing the data for testing, reviewing the results, anlayzing the results, and preparing a graph to present the findings.

Unexpected hurdles in data collection forced me to revisit how I coded my raw data. MD-DNR data collection and storage was inconsistent at best, and this required making adjustments in the coding. For instance, an estimated 6% of the remaining violations after the first wash came without subtitles or sections that assisted in identifying the exact type of violation that occurred. Besides adjustments in coding, I added a new variable because it showed itself multiple times in the raw data, making it a point of interest. When laws regulating female crabs were separated from those regulating male crabs, I had to make a second adjustment to avoid overlap of the results. I made a decision to revisit the variables a second time for coding in this specific effect. Further, violations specific to life stage became apparent such as violations concerning blue crabs in their soft stage and their peeler stage of life.

Coding culminated into 6 variable sets viewed between 2009 and 2017 for correlation tests of regulatory activity from the previous year with enforcement data for the following year. MD-DNR did not provide me secondary data that would provide the necessary information to answer each of my questions due to its inconsistent record keeping systems. In contrast to 8 points of measurement, the study period, I viewed some of the data at individual years and at individual (R) to determine the appropriate steps to answer critically the subsidiary questions. I relied on critical statistical assumptions for answering these additional questions.

## Preview

Because the study called for the testing of a specific time and set of secondary data, I did not use a pilot study; however, adjustments had to be made as the research method unfolded. Additional time and money were required to complete the study. Specifically, time was dependent on the response from agencies and the unexpected time and money that was spent researching law and printing materials for reference. I spent additional money on statisticians because the first gentleman was fraudulent in his advertising (an expensive lesson), while the second statistician acted as mentor, tutor, and editor on my final calculations and tables.

I made written requests to the agencies that house the data as the predominant data collection method. Specifically, MD-DNR's administrative department provided me the necessary data for enforcement of regulations. Initially, the study period had to be adjusted because MD-DNR does not house enforcement data in digital format predating 2009. This limited the study to the years 2010 – 2017. More importantly, although the data was housed digitally, it came in multiple formats that later had to be merged and screened for accuracy. While MD-DNR provided enforcement data directly, they referred me to the General Assembly online source for regulations that were introduced, rejected, accepted, rescinded, or amended for the correlation years. Like MD-DNR, the method by which the General Assembly house the digital data changed every few years. Documenting the information became burdensome, and to maintain organization of the data, I printed each law effected for the study years.

I followed the fundamental protocols in data collection, data management, coding, and key statistical basics in performing its main test. Key strategies that enhanced accuracy and consistency were also adhered to in data handling and testing, and I have presented the results in two formats. My goal was to find out if significant interaction effects existed among the various variables examined in the study and the extent to which it might influence the outcome. The first format had three groups reflecting three different year structures. The second format showed the entire scope of the period captured in the study and was designed to take a holistic overview of the entire data (see Table 8). Results from the two formats presented in Tables 5, 6, 7, and 8 clearly indicated a divergent correlation outcome. Empirical correlation coefficient evidence associated with some periods examined seemed to show that more statutes or laws were associated with more violations of the same; however, this could not be said for other years captured in this study. Consequently, it would not be factual to suggest that more laws breed more violations of such laws, as some may espouse.

A visual presentation of the data for the main research question and the additional subsidiary questions were provided in several tables for ease of analysis and interpretation. A written explanation introduces each visual presentation. Table 1 shows the coding for the various statutes and laws collected for this study. I defined each variable type by R1-R6, described by statute, and defined by explanation. Table 2 represents the number of laws effected and the resulting violations in the following year. Again, because of size, Table 3 consists of 2009-2013, while Table 4 consists of 2014-2017 and is segmented to highlight the descriptive statistics. Tables 5-7 present the correlation analysis in 3 groupings of years, and Table 8 is a final presentation of the correlation analysis. The relationship between the types of statutes and number of violations can be viewed in Figure 1.

To answer the subsidiary questions, Table 9 presents the percent of violations of the individual coded variables over the study period. Table 10 is a culmination in percentiles of the average violations of the coded variables over the study period. Table 11 is a reference to the types and number of licenses issued for each year during the study period, and Table 12 provides an overview of noncompliance originating from a failure to report 100% of one's harvest, but this noncompliance factor is not reflected in the raw data. Table 13 is the culmination in percentiles of licenses failing to report commercial harvest 100% of the time.

This study showed that, all things being equal, existing data does not fully support the notion that more laws or statutes in the blue crab fishing industry breed more violations of the same laws. A holistic overview of the data sets indicates a divergent correlation outcome. Although the study captured both positive and negative correlation, it cannot be said that one is more significant than the other; thus, the number of regulations introduced each year does not necessarily lead to more violations of the same or other statutes or regulations.

Correlation coefficient estimates presented in the various tables indicate that in some periods over the research period, some of the statutes or laws enacted tended to correlate positively with violations of such laws a year after its enactment; some other periods over the same study period failed to exhibit similar positive correlation. These divergent relational outcomes indicate that the growing number of statutes or laws in the blue crab fishing industry does not necessarily fully correlate with resulting or observed violations of such statutes or laws. In other words, the notion that an increasing number of violations of statutes or laws in the blue crab fishing industry are a result of the growing numbers of such statutes cannot be supported fully by existing data. However, the data uncovered a specific (R) that towered above the rest in most years of the study period.

## Data Collection

Data collection began in August 2017 after IRB approval, and I finalized a spreadsheet on November 25, 2018. The first merge of data presented 10,179 violations spanning 2010-2017. The initial wash of data ended with 6,828. This elimination included violations concerning recreational crabbing in the Chesapeake Bay. The final violation count after a great deal of sorting and eliminating ended with 6,358 commercial blue crab violations. This step eliminated further recreational crabbing violations as well as other fisheries unrelated to blue crab specifically in Chesapeake Bay and its tributaries. This task took much longer than I anticipated because regulations were amended, which changed identifiers for specific crimes committed.

I expected to go to a single location on the website and access each item identically. This was not the case, and the collection process of regulations was burdensome and expensive. I printed each item point individually by statutue, printed by year, printed by type, and so on. It appeared that with the changing of the guard, the style of digital bookkeeping changed as well. Once I collected these items, I keyed the information into a spreadsheet for easy sorting and comparing.

I organized, sorted, and washed the enforcement data 3 times for validity and accuracy, while I organized, sorted, and washed the straightforward articles of law and COMAR two times. By me doing this repeatedly, reliability increased in that duplicates and unwanted data that would skew the results were removed.

Data collection unfolded as expected except for the lack of detail I assumed to be available as a consequence of missing information on the original citation/warning or from failing to include the detail of subtitle and section at the point of entry into the original database. Sorting required a multitude of headings not limited to date, statute number, title, subtitle, section, and the related COMAR to eliminate duplicate and missing entries from the raw data. My previous spreadsheet experience and grassroots lobbying prepared me well for this unexpected overwhelming task.

Additionally, to eliminate jumping back and forth from multiple computer screens, websites, and hardcopy, I created a single data spreadsheet of the items I sought that included the articles and regulations of interest for this project, and I printed it for instant reference as I read and sorted each violation in order to code it correctly. Also, some of the items I eliminated included violations that I could not assign to any specific title or COMAR, so the variable was most likely keyed-in incorrectly at the source. Finally, I discovered that a key ingredient in the raw data was inconsistent; at the point of data entry into the MD-DNR system, either the clerk failed to enter the subtitle and section on many entries or the officer failed to report it on the original citation/warning, while other entries included these key elements. As such, I was limited to sorting data by

Title and Comar as opposed to specific sections (detail) in the law.

I conducted this study in Somerset County, Maryland. In the study, each year of data encompassed the legal commercial blue crab season for this small-scale fishery. I conducted this study to determine if an unexpected relationship existed between blue crab enforcement data (2010-2017) and regulation (2009-2017) represented by secondary data representing the commercial crabbing industry in Maryland. The commercial crabbing community as defined by MD-DNR active license use on a year-by-year basis provided the foundation for the above-named content. This community reflected a culmination of commercial blue crab harvesters, whether they were Maryland residents or other, but they had to work in Maryland’s portion of the Chesapeake Bay or its tributaries. The populations I investigated included the commercial blue crab fisher (commercial crabber), commercial blue crab citations, and enacted, rejected, and repealed commercial crabbing regulations, and the Maryland blue crab. To gain a concise representation of the research, I dissected, grouped, and specified the variables into a manageable size. I compiled enforcement and legislative activity for this study, which was public record, and I viewed the commercial crabbing community as a single unit.

I did not conduct this study on a living population, but I used secondary numerical hard data to review type and number of violations over a specific period; thus, a representative sample did not apply to this study. Univariates analysis is often employed as pre-estimation tests conducted to examine the nature of the data in one’s research. In this instance, because my goal was to verify potential correlations between variables of interest, such univariates analysis was not required.

## Results

The results emanating from this empirical investigation are presented below in various tables and one figure. In Tables 1 through 8 and Figure 1, I provided information on the core data I employed in the various tests. Additionally, I reported statistical results from which various analysis and research conclusions were derived in Tables 9-13.

I explained in Table 1 how the various statutes were coded for the correlation analysis. I represented the summation of the individual details for each variable to be tested in Table 1. My coded items, R1–R6, represented a variety of laws that could potentially be violated. I described by definition the general category for each variable. I described the statute and the associated rule title number and COMAR for the individual categories. I used this number to sort the data. Finally, I provided an explanation describing all the possible violations that could potentially occur within each variable set.

Table 1

*Coding for Various Statutes & Laws*

| CODE | R1 | R2 | R3 | R4 | R5 | R6 |
|---|---|---|---|---|---|---|
| DEFINITION | Single or Grouped Licenses; Times - Crab Pot Specific | Theft of Catch | Crab Pots - Specific | Blue Crab Gear - Not Specific; Times; Locations; Male Crabs; Policy | Peelers; Soft Crabs; other Blue Crabs | Mature Female Blue Crabs |
| STATUTE | §4-701, §4-804, §4-1201, §4-1210 (SB635) | §4-505 | §4-803, §4-812, §4-813 (HB1561), §4-814, §4-817 (SB994) | §4-803, §4-808 | §4-809 | §4-810 |
| EXPLANATION | Tidal Fish License, License for Catching Crabs for Commercial, Penalties, Natural Resources - Authorization to Catch Striped Bass and Crabs - Revocation | Removing Fish, Nets, or Gear of Another Prohibited | Rules and Regulations Generally, Use of Crab Pots in CB, Limitation on Number of Crab Pots, Crabbing - Crab Pots - Requirements | Rules and Regulations Generally, Closed Season for Hard Crabs | Limitations and Prohibitions on Catching and Possessing Certain Kinds and Sizes of Crabs - Purposes | Rules and Regulations Pertaining to Female Crabs |

In Table 2, I presented the raw data from which various research tests were performed. I presented the variables in two charts, splitting the years for easier review. R1–R6 represented the NL and VL for each year tested in this study.

Table 2

*Number of Laws Passed and the Resultant Violation in the Following Year*

| | NL (09) | VL (10) | NL (10) | VL (11) | NL (11) | VL (12) | NL (12) | VL (13) | NL (13) |
|---|---|---|---|---|---|---|---|---|---|
| R1 | 5 | 62 | 9 | 15 | 21 | 13 | 19 | 14 | 7 |
| R2 | 1 | 14 | 0 | 12 | 0 | 3 | 0 | 0 | 0 |
| R3 | 4 | 86 | 1 | 34 | 1 | 47 | 1 | 31 | 0 |
| R4 | 8 | 761 | 0 | 715 | 3 | 704 | 2 | 436 | 0 |
| R5 | 1 | 117 | 1 | 76 | 0 | 120 | 0 | 21 | 1 |
| R6 | 2 | 109 | 3 | 5 | 4 | 4 | 4 | 5 | 2 |

| | VL (14) | NL (14) | VL (15) | NL (15) | VL (16) | NL (16) | VL (17) | NL (17) | VL |
|---|---|---|---|---|---|---|---|---|---|
| R1 | 13 | 8 | 10 | 6 | 10 | 18 | 21 | 4 | |
| R2 | 5 | 1 | 1 | 0 | 6 | 0 | 0 | 1 | |
| R3 | 36 | 2 | 73 | 1 | 48 | 1 | 35 | 0 | |
| R4 | 532 | 3 | 691 | 3 | 813 | 8 | 409 | 8 | |
| R5 | 51 | 1 | 49 | 0 | 53 | 0 | 50 | 0 | |
| R6 | 2 | 2 | 1 | 2 | 5 | 2 | 23 | 4 | |

In Tables 3 and 4, I presented descriptive statistics outlining key features of the base data for this research. I examined fundamental characteristics using descriptive statistics for the sample data employed in this research, and I presented it in Tables 3 and 4. I presented key sample data information such as the mean, the standard deviation, median, mode, standard deviation, sample variance, kurtosis, skewness, and range.

I provided the minimum and maximum number by which to make comparisons of laws and violations that occurred each year. I presented the sum total for each year. I used the mean to calculate the percentage of violations that occurred over the life of the study. I had to divide the table into 2 sets because of the sheer quantity of data required; in particular,  I reviewed the years 2009-2013 in Table 3, and I reviewed the years 2014-2017 in Table 4. I captured descriptive statistics for this research in the following tables.

Table 3

*Descriptive Statistics (2009-2013)*

| | NL (09) | VL (10) | NL (10) | VL (11) | NL (11) | VL (12) | NL (12) | VL (13) | NL (13) |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 3.5 | 191.5 | 2.333 | 142.833 | 4.833 | 148.5 | 4.333 | 84.5 | 1.667 |
| SE | 1.118 | 114.905 | 1.406 | 114.912 | 3.301 | 112.562 | 2.996 | 70.4456 | 1.116 |
| Median | 3 | 97.5 | 1 | 24.5 | 2 | 30 | 1.5 | 17.5 | 0.5 |
| Mode | 1 | #N/A | 0 | #N/A | 0 | #N/A | 0 | #N/A | 0 |
| SD | 2.739 | 281.458 | 3.445 | 281.476 | 8.085 | 275.719 | 7.339 | 172.556 | 2.733 |
| $S^2$ | 7.5 | 79218.7 | 11.867 | 79228.567 | 65.367 | 76021.1 | 53.867 | 29775.5 | 7.467 |
| Kurtosis | -0.048 | 5.648 | 3.896 | 5.822 | 5.157 | 5.444 | 5.120 | 5.913 | 4.202 |
| Skewness | 0.876 | 2.352 | 1.955 | 2.405 | 2.235 | 2.31525 | 2.233 | 2.427 | 2.023 |
| Range | 7 | 747 | 9 | 710 | 21 | 701 | 19 | 436 | 7 |
| Minimum | 1 | 14 | 0 | 5 | 0 | 3 | 0 | 0 | 0 |
| Maximum | 8 | 761 | 9 | 715 | 21 | 704 | 19 | 436 | 7 |
| Sum | 21 | 1149 | 14 | 857 | 29 | 891 | 26 | 507 | 10 |
| Count | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |

Table 4

*Descriptive Statistics (2014-2017)*

| | VL (14) | NL (14) | VL (15) | NL (15) | VL (16) | NL (16) | VL (17) | NL (17) |
|---|---|---|---|---|---|---|---|---|
| Mean | 106.5 | 2.833 | 137.5 | 2 | 155.833 | 4.833 | 89.667 | 2.833 |
| SE | 85.453 | 1.078 | 111.337 | 0.9309 | 131.724 | 2.903 | 64.222 | 1.276 |
| Median | 24.5 | 2 | 29.5 | 1.5 | 29 | 1.5 | 29 | 2.5 |
| Mode | #N/A | 1 | 1 | 0 | #N/A | 0 | #N/A | 4 |
| SD | 209.316 | 2.639 | 272.7180 | 2.280 | 322.657 | 7.111 | 157.312 | 3.125 |
| $S^2$ | 43813.1 | 6.967 | 74375.1 | 5.2 | 104107.767 | 50.567 | 24747.07 | 9.767 |
| Kurtosis | 5.826 | 4.367 | 5.758 | 1.257 | 5.907 | 2.381 | 5.771 | 0.035 |
| Skewness | 2.405 | 2.030 | 2.388 | 1.214 | 2.425 | 1.676 | 2.389 | 0.879 |
| Range | 530 | 7 | 690 | 6 | 808 | 18 | 409 | 8 |
| Minimum | 2 | 1 | 1 | 0 | 5 | 0 | 0 | 0 |
| Maximum | 532 | 8 | 691 | 6 | 813 | 18 | 409 | 8 |
| Sum | 639 | 17 | 825 | 12 | 935 | 29 | 538 | 17 |
| Count | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |

Lastly, in Tables 5-8, I presented two formats of correlation analysis examining the relationship between the number of statutes or laws on the blue crab fishing industry and the number of violations of the laws following that year. In Tables 5 and 6, I presented the correlation for the years 2009-2012 and 2012-2015, which shows positive and negative trends occurred. Table 7 depicts positive trends and Table 8 is the culmination of all years.

Table 5

*Correlation Analysis (2009-2012)*

| | *NL(09)* | *VL(10)* | *NL(10)* | *VL(11)* | *NL(11)* | *VL(12)* |
|---|---|---|---|---|---|---|
| *NL(09)* | 1 | | | | | |
| *VL(10)* | 0.79644 | 1 | | | | |
| *NL(10)* | 0.1484 | -0.3286 | 1 | | | |
| *VL(11)* | 0.786012 | 0.993286 | -0.3588 | 1 | | |
| *NL(11)* | 0.356795 | -0.12713 | 0.964653 | -0.14309 | 1 | |
| *VL(12)* | 0.76746 | 0.990893 | -0.37545 | 0.997483 | -0.1667 | 1 |

Table 6

*Correlation Analysis (2012-2015)*

| | *NL(12)* | *VL(13)* | *NL(13)* | *VL(14)* | *NL(14)* | *VL(15)* |
|---|---|---|---|---|---|---|
| *NL(12)* | 1 | | | | | |
| *VL(13)* | -0.1592 | 1 | | | | |
| *NL(13)* | 0.973986 | -0.3037 | 1 | | | |
| *VL(14)* | -0.18408 | 0.998573 | -0.3214 | 1 | | |
| *NL(14)* | 0.973918 | 0.033593 | 0.905855 | 0.007783 | 1 | |
| *VL(15)* | -0.19245 | 0.998747 | -0.33655 | 0.998573 | 0.00375 | 1 |

Table 7

*Correlation Analysis (2015-2017)*

| | *NL(15)* | *VL(16)* | *NL(16)* | *VL(17)* | *NL(17)* | *VL* |
|---|---|---|---|---|---|---|
| *NL(15)* | 1 | | | | | |
| *VL(16)* | 0.18674 | 1 | | | | |
| *NL(16)* | 0.974369 | 0.19376 | 1 | | | |
| *VL(17)* | 0.199595 | 0.998204 | 0.20215 | 1 | | |
| *NL(17)* | 0.617416 | 0.777667 | 0.556477 | 0.782573 | 1 | |
| *VL* | | | | | | |

Table 8

*Correlation Analysis – All Variables*

| | **NL (09)** | **NL (10)** | **NL (11)** | **NL (12)** | **NL (13)** | **NL (14)** | **NL (15)** | **NL (16)** | **NL (17)** |
|---|---|---|---|---|---|---|---|---|---|
| **NL (09)** | 1.00000 | | | | | | | | |
| **VL (10)** | 0.79644 | | | | | | | | |
| **NL (10)** | 0.14840 | 1.00000 | | | | | | | |
| **VL (11)** | 0.78601 | -0.35883 | | | | | | | |
| **NL (11)** | 0.35679 | 0.96465 | 1.00000 | | | | | | |
| **VL (12)** | 0.76746 | -0.37545 | -0.16674 | | | | | | |
| **NL (12)** | 0.31841 | 0.97563 | 0.99879 | 1.00000 | | | | | |
| **VL (13)** | 0.82042 | -0.33310 | -0.11433 | -0.15918 | | | | | |
| **NL (13)** | 0.13363 | 0.99154 | 0.96564 | 0.97399 | 1.00000 | | | | |
| **VL (14)** | 0.79845 | -0.35531 | -0.13892 | -0.18408 | -0.32135 | | | | |
| **NL (14)** | 0.51187 | 0.90919 | 0.98251 | 0.97392 | 0.90586 | 1.00000 | | | |
| **VL (15)** | 0.81259 | -0.36404 | -0.14762 | -0.19245 | -0.33655 | 0.00375 | | | |
| **NL (15)** | 0.64051 | 0.84019 | 0.93293 | 0.92015 | 0.83452 | 0.96364 | 1.00000 | | |
| **VL (16)** | 0.80180 | -0.35550 | -0.13817 | -0.18307 | -0.32333 | 0.00818 | 0.18674 | | |
| **NL (16)** | 0.62133 | 0.82734 | 0.94215 | 0.92482 | 0.84058 | 0.97856 | 0.97437 | 1.00000 | |
| **VL (17)** | 0.80313 | -0.33671 | -0.12664 | -0.17103 | -0.30413 | 0.01766 | 0.19959 | 0.20215 | |
| **NL (17)** | 0.78284 | 0.15481 | 0.33113 | 0.29937 | 0.17956 | 0.40814 | 0.61742 | 0.55648 | 1.00000 |
| **VL (18)** | | | | | | | | | |

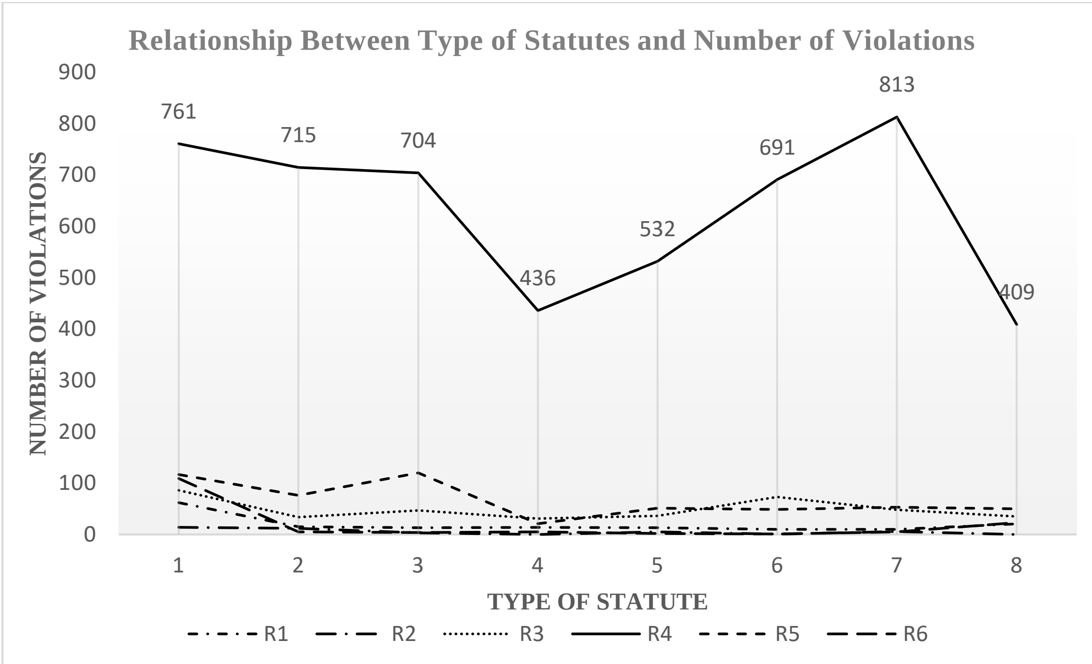


*Figure 1. Types of statutes and number of violations*

In Tables 9 and 10, I provided the average violations that occurred over the study period.

Table 9

*Average Violations of (R) Over Study Period*

| Code ( R ) | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | TOTALS | Mean VL Yr ( R ) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 62 | 15 | 13 | 14 | 13 | 10 | 10 | 21 | 158 | 19.75 |
| R2 | 14 | 12 | 3 | 0 | 5 | 1 | 6 | 0 | 41 | 5.125 |
| R3 | 86 | 34 | 47 | 31 | 36 | 73 | 48 | 35 | 390 | 48.75 |
| R4 | 761 | 715 | 704 | 436 | 532 | 691 | 813 | 409 | 5061 | 632.625 |
| R5 | 117 | 76 | 120 | 21 | 51 | 49 | 53 | 50 | 537 | 67.125 |
| R6 | 109 | 5 | 4 | 5 | 2 | 1 | 5 | 23 | 154 | 19.25 |
| Per YR | 1149 | 857 | 891 | 507 | 639 | 825 | 935 | 538 | 6341 | |

Table 10

*Average Percent of Violations (VL) Over Study Period*

| Coded Statutes/Laws | R1 | R2 | R3 | R4 | R5 | R6 |
|---|---|---|---|---|---|---|
| | 62 | 14 | 86 | 761 | 117 | 109 |
| | 15 | 12 | 34 | 715 | 76 | 5 |
| | 13 | 3 | 47 | 704 | 120 | 4 |
| | 14 | 0 | 31 | 436 | 21 | 5 |
| | 13 | 5 | 36 | 532 | 51 | 2 |
| | 10 | 1 | 73 | 691 | 49 | 1 |
| | 10 | 6 | 48 | 813 | 53 | 5 |
| | 21 | 0 | 35 | 409 | 50 | 23 |
| Total VL per Statute | 158 | 41 | 390 | 5061 | 537 | 154 |
| Mean of VL per Statute | 19.75 | 5.125 | 48.75 | 632.625 | 67.125 | 19.25 |
| | | | | | | |
| Grand Mean (mean of the means) | | | 132.104 | | | |
| Mean VL of Total VL per Statute | | | 1056.83 | | | |
| | | | 0.125 | | | |
| Mean Percentage Violations over the Study Period 12.5% | | | | | | |

In Tables 11 and 12, I presented the number and type of licenses issued and noncompliance specific to failure to report one's harvest for the study years, and this culminates in percentages in Table 13.

Table 11

*Number of Commercial Crab Licenses*

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| LCC | 3,599 | 2,362 | 2,356 | 2,437 | 2,434 | 2,607 | 2,357 | 2,580 | 2,583 |
| LCM | | 481 | 452 | 448 | 445 | 398 | 392 | 451 | 458 |
| TFL | | | | | | | | | |
| NO Add On | 1,490 | 1,496 | 1,528 | 1,501 | 1,529 | 1,567 | 1,509 | 1,24 | 1,528 |
| TFL- CB3 | 232 | 236 | 237 | 233 | 236 | 251 | 232 | 259 | 270 |
| TFL-CB6 | 195 | 194 | 195 | 192 | 195 | 191 | 187 | 192 | 193 |
| TFL-CB9 | 371 | 372 | 372 | 362 | 360 | 362 | 357 | 365 | 362 |
| Total Licenses | | 5,141 | 5,140 | 5,173 | 5,199 | 5,376 | 5,034 | 5,371 | 5,394 |

Table 12

*Types and Number of Licenses Not Reporting 100% Harvest*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| LCC | 66 | 130 | 131 | 217 | 392 | 500 | 426 | 416 |
| LCM | 20 | 42 | 39 | 49 | 96 | 133 | 111 | 109 |
| TFL NO Add On | 41 | 125 | 123 | 208 | 311 | 428 | 388 | 362 |
| TFL- CB3 | 14 | 23 | 17 | 27 | 56 | 63 | 52 | 51 |
| TFL-CB6 | 10 | 22 | 11 | 17 | 29 | 39 | 33 | 30 |
| TFL-CB9 | 11 | 36 | 34 | 51 | 89 | 115 | 109 | 106 |
| Total Licenses | 162 | 378 | 355 | 569 | 973 | 1278 | 1119 | 1074 |

*2009 Data are not available for this request. Record-keeping changed in 2010 that allows us to provide this information for 2010 forward.

In Table 13, I present the number of commercial crabbers not reporting.

Table 13

*Percent of Crabbers Not Reporting 100% of the Time*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| LCC | 2.79 | 5.52 | 5.38 | 8.92 | 15.04 | 21.21 | 16.51 | 16.11 |
| LCM | 4.16 | 9.29 | 8.71 | 11.01 | 24.12 | 33.93 | 24.61 | 23.80 |
| TFL NO add on | 2.74 | 8.18 | 8.19 | 13.60 | 19.85 | 28.36 | 25.46 | 23.69 |
| TFL-CB3 | 5.93 | 9.70 | 7.30 | 11.44 | 22.31 | 27.16 | 20.08 | 18.89 |
| TFL-CB6 | 5.15 | 11.28 | 5.73 | 8.72 | 15.18 | 20.86 | 17.19 | 15.54 |
| TFL-CB9 | 2.96 | 9.68 | 9.39 | 14.17 | 24.59 | 32.21 | 29.86 | 29.28 |

Like most statistical tests, the main assumptions associated with correlation analysis adopted in this research were as follows:

1. Test variables were assumed to have related pairs; this assumption is not much of a problem in the data being examined in this study because of the focus on absolute numbers of statutes and number of violations within the same industry.
2. Correlation analysis further assumed the absence of outliers in the data; this assumption was meant to ensure that there were no extremes in the data sets being examined, and often this is captured by the standard deviation from the mean. In reported descriptive

statistics, the standard deviations and the various means suggested potential outliers, but this was not projected to significantly skew the goal only of verifying a relationship between key research variables.

3. Normality of variables was another assumption in correlation analysis, which verifies if the variables were sampled from a fairly distributed population. Data collecting procedures adopted in this research were designed to ensure that the samples were from a normally distributed population.

## Main Research Question

Question 1: *What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial fishers as measured by the number of tickets written annually?*

To answer the main research question, I presented the results in Tables 5, 6, 7, and 8. My critical analysis of the results is presented in Table 5, and it suggested that there was a positive correlation between the various laws introduced in 2009 and the number of violations of the same in the period of the introduction of the law in 2010; this was indicated by a correlation coefficient of 0.79644. Correlation results presented in Table 5, however, further suggested a negative correlation between the number of laws introduced in 2010 and 2011 and the number of violations which occurred a year after those laws were introduced. This was indicated by a negative correlation coefficient of -0.3588 and -0.1667 respectively.

I followed a similar format in Table 6 to what I presented in Table 5; in this instance, however, the number of laws introduced between the years 2012 and 2015 and the number of violations of such laws, which occurred afterwards, were examined. The results I presented in Table 6 suggested that there was a negative correlation between the number of laws introduced in 2012 and 2013 and the number of violations that occurred a year after those laws were introduced: 2013 and 2014, respectively. Correlation coefficient results presented in Table 6, in contrast, suggested that the number of statutes or laws introduced in 2014, correlated positively with the number of violations of the law in 2015.

Table 7 followed correlation tests similar to those presented in Tables 5 and 6. Coefficient estimates reported in Table 7, however, indicated that the number of statutes or laws introduced in 2015 and 2016 respectively correlated positively with the number of violations of the law which occurred in the year after its introduction that is in 2016 and 2017. I tested for associations in this study, which does not require the element of hypothesis testing.

## Subsidiary Questions

Question 2: *How many times has fishing illegal gear occurred during the study years?*

In Table 1, I showed specifically, R4 is defined as Blue Crab Gear – Not Specific; Times; Locations, Male Crabs; Policy and Rules and Regulations Generally, Closed Season for Hard Crabs. To answer this question, the raw data would have had to record this specific violation as an individual incident. In most cases, the raw data did not provide the subtitles or sections or any necessary detailed descriptions to identify the specific rule that was violated. The actual statutes and regulations were written as groupings of management strategies. Each section and subsection of a title had vernacular specific to a crucial element that was not recorded necessarily by the MD-DNR during the writing of warnings and citations. Further, R1 and R3 defined Crab Pots, but neither was limited to number of crab pots allowed, and each described other requirements not pertinent to question 2. Therefore, the data available from MD-DNR did not provide enough detailed information to answer this question reliably. However, the data in Table 2 dis reveal that R4 had a statistically significant number of VL as compared to the remaining (R) codes, which supported a claim that the type of regulation enforced may have some effect on compliance behavior.

Question 3: *Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit?*

Data made available by MD-DNR for this study did not specifically provide enough information or capture the extent to which the use of illegal gear and commercial crabbers exceeding crab pot limits ultimately skews harvest data. In particular, the data could not be organized in a manner that provided a number for this skew because subtitles and chapters were missing from the keyed data. Without these significant details, data had to be grouped by general rules rather than dissected as individual violation types, preventing a detailed look at illegal gear use - specifically. However, what we do know is that significant literature exists, and Table 2 illuminated how such illegal acts could ultimately skew harvest data. According to reviewed literature from the MD-DNR on surveys conducted and other related materials on the health of the blue crab population in the Chesapeake Bay, effects of the use of illegal gear and commercial crabbers exceeding the crab pot limit skew on harvest data depends on a series of factors. Available literature suggested that if illegal gear was used in harvesting mandated crab types (male, female, soft, or peeler), the condition would in the short run have a positive upward skew on harvest numbers, but such positive increase in harvest on the market may not reflect in the data for the season since such illegal acts most likely were not reported. Thus, the general output in the marketplace might increase, but official data might not capture such increases all things being equal because such catch emanated from illegal activity.

However, if the illegal catch targets prohibited crab type such as egg bearing female crabs or spawning-age female crabs, then although such activity might increase the market count during the harvest season, the activity would ultimately negatively influence the volume of blue crab harvest in the next crabbing season since the initial illegal crabbing activities would have the potential of impacting development of young crabs, possibly creating a downward skew. Accordingly, commercial crabbers exceeding the crab pot limit has the potential to increase blue crab population in the marketplace in the short run; however, such illegal activity can negatively impact commercial crabbing harvest in the future if unchecked.

Question 4: *Do years with no regulatory activity have less enforcement (violations) compared to years with regulatory activity?*

I conducted a critical examination of the data made available for this research, and it suggested that years with no regulatory activities do not have less crime or violations compared to years with regulatory activities. To appreciate this conclusion, it is important for the reader to understand the structure of the data supporting this research. I coded and categorized the primary data into years in which statutes or laws had activity and or new laws and the number of violations of such statutes that occurred a year after the introduction of such laws.

This coding structure adopted was a reasonable assumption in data management and consistent with the lag time between when statutes had activity and when violations become enforced. In this study, the lag time was one year. Ordinarily, when such laws were enacted, there was a period before such laws take effect; this period was often used for sensitization of the intended population before it finally took effect.

The data I presented in Table 2 provides the necessary information needed to answer question 2. Information presented in Table 2 suggested that all things being equal, years with no regulatory activities did not necessarily have less crime or violations compared to years with regulatory activities. For instance, in Table 2 under NL(10), NL(11), NL(12), NL(13), NL(15), and NL(16), which captured the number of laws or regulations introduced in 2010, 2011, 2012, 2013, 2014, and 2015 respectively, it was evident that although in most instances no laws coded under R2, R3, R4, and R5 were enacted in those years, a significant number of violations of similar laws coded under the same (R) code from the previous year still occurred even though no similar law or statutes under the broad categorization as coded in this study was enacted. For instance in 2013, that is NL(13), available data suggested that no statutes or laws coded in this study under R2, R3, and R5 were enacted; however, under VL(14) where violations of these statutes or laws were captured, it was evident that a significant number of violations of these three coded laws or statutes occurred. Consequently, available data did not necessarily support the notion that years with no regulatory activities tend to have less crime or violations of existing laws or statutes.

Question 5: *What percent is noncompliance behavior of total licenses reporting activity?*

The data collection system utilized by MD-DNR, the data collection process, and the coding of variables technique I adopted in this research made it difficult to answer this question; in that, the data from which various correlation estimates were derived had no systematic category for the number of compliance instances versus the number of noncompliance instances for the proportion of noncompliance behavior to be estimated. For instance, zero percent noncompliance would suggest zero violations over the period of the research.

Nonetheless, there were several violations of the various statutes over the period captured in the research. Therefore, by viewing noncompliance as a sum, several basic assumptions could be made. In this study, the percentage of noncompliance was based on the coding of the violations produced in Table 1 and repeated in the descriptive statistics found in Table 2. In this study I chose to estimate the percent based on the various laws coded in R1 – R6.

I adopted the following calculation to determine percent

- the sum of violations per (R) code divided by the number of (R) code equal mean VL then,

- the sum of mean VL per (R) code divided by the number of (R) code equal mean of the means then,
- divide the grand mean by the mean VL of total VL per (R) code by the mean of VL per (R) code equal,
- mean percent VL over the study period.

The individual sums of VL are recorded in Table 9. A holistic view of this data is presented in Table 10. The average is 12.5% and is based on the data captured during the study period and is based upon the number of statutes and the number of violations occurring thereafter. It is evident from the 6 calculations that the number of noncompliance incidences differs significantly between R1–R6 based on the differences in the laws themselves over the study period. However, in Table 11 and Table 12, MD-DNR provided hard numbers for all licenses issued and the number of noncompliant licensees failing to report his or her commercial blue crab harvest employing those licenses. Percent of noncompliance for not meeting 100% harvest reporting culminates in Table 13.

## Summary

As I indicated in the introduction, I sought to answer the main research question of finding any correlation between two variables in one industry. In this study, I conducted correlation analysis, which does not require estimation of confidence intervals, necessarily. Therefore, the testing did not provide for any confidence interval. I conducted only correlation analysis as indicated in the introduction; the correlation analysis does not necessarily require conducting hypothesis testing. No initial or additional tests of hypothesis was conducted in this research; as stated in the introduction, I focused primarily on correlation analysis between key variables of interest.

Question 1: *What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial fishers as measured by the number of tickets written annually?*

Correlation coefficient estimates presented in grouped format from Tables 5 through 7 and the holistic test results reported in Table 8 are all consistent in suggesting that a narrative that an increasing number of laws and statutes introduced into the blue crab fishing industry might correlate with the growing number of violations of such laws and statutes cannot be fully or wholly supported. Reported correlation results from various years over the study period diverge significantly. Whereas correlation coefficient from some years suggest that the number of statutes and laws introduced in some years correlates positively with the number of violations which occurred afterwards; negative correlation coefficient results were found also in other years.

Question 2: *How many times has fishing illegal gear occurred during the study years?*

It is not possible for me to answer this question reliably with this study because the actual statutes and regulations are written as groupings of management strategies rather than each line of vernacular having its own corresponding identifying number or letter. Further, R1 and R3 defines some aspect of crab pot use, but neither is limited to number of crab pots, locations, time, season, and each (R) describes data beyond the scope of this question. In other words, one enforcement officer may have chosen statutes listed under R1 which vernacular groups a variety of types of violations pertinent to blue crab commercial harvest, while another officer may have chosen statutes under R3 which groups a variety of types of violations pertinent only to crab pots to identify the violation on his or her citation – in this case, the study is seeking illegal gear only. Therefore, the data available from MD-DNR does not house enough detailed information to answer this question reliably.

Question 3: *Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit?*

According to reviewed literature from the MD-DNR on surveys conducted and other related materials on the health of the blue crab population in the Chesapeake Bay, effects of the use of illegal gear and commercial crabbers exceeding the crab pot limit skew on harvest data depends on a series of factors. Available literature suggests that if illegal gear is used in harvesting mandated crab types, the condition would in the short run have a positive upward skew on the harvest. However, this is short lived because what is reported in the market may not reflect on the data for the season because illegal acts go unreported. Likewise, if the illegal catch targets prohibited crab type such as egg bearing female crabs or spawning-age female crabs, then although such activity might increase the market count during the harvest season, the activity would negatively influence the volume of blue crab harvest in the next crabbing season. Commercial crabbers exceeding gear limits has the potential to increase blue crab population in the short run; however, such illegal activity can negatively impact commercial crabbing harvest in the future if continued unchecked.

Question 4: *Do years with no regulatory activity have less enforcement (violations)* *compared to years with regulatory activity?*

Enforcement data available from MD-DNR for this research study suggest that years with no regulatory activities do not have less crime or violations compared to years with regulatory activities. The coding structure adopted is consistent with statistical data management and lag time between the variables analyzed. Information presented in Table 2 suggests that all things being equal, years with no regulatory activities do not necessarily have less crime or violations compared to years with regulatory activities. It is evident that although in most instances no laws coded under R2, R3, R4, and R5 were enacted in some years, a significant number of violations of similar laws coded under the same (R) code from the previous year occurred, nonetheless. Available data does not necessarily support the notion that years with no regulatory activities tend to have less crime or violations of existing laws or statutes.

Question 5: *What percent is noncompliance behavior of total licenses reporting activity?*

There are several violations of the various statutes over the period captured in the research. The individual sums of VL are recorded in Table 9. A holistic view of this data is presented in Table 10. The average percent is 12.5 and is based on the data captured during the study period and is based upon the number of statutes and the number of violations occurring thereafter. Table 11 and Table 12 provide hard numbers for all licenses issued and the number of noncompliant licensees failing to report his or her commercial blue crab harvest 100% of the time. Percent of noncompliance for not meeting this requirement culminates in Table 13. Reporting harvest is an assumed responsibility, and its necessity is interpreted and required by agency rule as opposed to statute; thus, it is not reflected in the raw data for noncompliance.

In this research, I sought to verify the extent to which growing numbers of statutes or laws in the commercial blue crab industry correlates with the number of violations of such statues. Two forms of correlation analysis were conducted, and the results were consistent in both approaches. Correlation coefficient estimates reported in both scenarios failed to support fully, a narrative surmising a link between the number of statutes or laws introduced in the commercial blue crab fishing industry and the resultant violation of such laws.

Critical analysis of various correlation coefficient estimates reported in Tables 5, 6, 7, and 8 suggest that it is not accurate, to infer a consistent relationship between the number of laws or statutes enacted in the commercial blue crab industry and subsequent violations occurring after such enactment. In some of the post statutes or laws period, the number of such statutes or laws tend to correlate positively with subsequent violations of the statutes; however, in other year periods, similar numbers of statutes tended to correlate negatively with the number of violations that occurred thereafter.

These divergent outcomes over the period of the research, to some extent, suggest that available data does not or is inconsistent with a notion that more statutes or laws in the commercial blue crab industry tend to coincide with an increasing violation of such laws. One of the key features of consistency identified in this research has to do with the fact that the number of violations of statutes or laws tend to reflect more on the type or nature of a statute or law. Some of the statutes or laws tend to be associated with relatively more violations than others regardless of the number of such statutes or laws according to the data. For instance, in Table 2, it is evident that statutes or laws coded as R4 is associated with many more violations than the rest of the coded statutes; although in some of the year periods, other coded statutes such as R1 in 2011 had more statutes or laws introduced.

It is evident from Table 2 that R4 was violated markedly more than any other statute or law presently on the books for the commercial blue crab industry in Maryland's Chesapeake Bay area. This variable is a culmination of gear, time, location, seasons, and general blue crab rules and policy – not mature females, peelers, or soft blue crabs. These particular blue crab life cycles are found in R5 and R6, respectively. Table 3 demonstrates that violations begin 2010 and include up to 2017. Violations for R4 are no less than 409 violations in 2017 to as many as 813 in 2016. The next largest violations for a data set is R3 with as few as 31 violations in 2013 and as many as 86 violations in 2010.

Finally, grouped correlation estimates to a greater extent suggest that the number of statutes or laws introduced does not always correlate positively with the number of violations of such laws as has been presumed by some in the industry. Even in instances where the number of laws or statutes introduced were found to correlate positively with the number of violations of such laws afterwards, it is important to point out that presented results only suggest a mere significant association between the variables. The results do not infer any causal interactions between the variables since correlation analysis only focuses on identifying relationships and not causal association.

The findings from this research have considerable policy implication for key policy makers responsible for managing activities in the commercial blue crab industry which is worth exploring further. Presented results, for instance, could help shape the nature and type of policies introduced to management activities in the commercial blue crab industry. Apart from the main research question, ensuing empirical analysis found evidence suggesting that rather than the number of statutes or laws having meaningful relationship with the number of violations of such statutes after its implementation, a growing number of violations recorded tend to relate to the type and nature of statutes introduced. For instance, from Table 2, it is evident that R4, which is a coded variable for some statutes seems to be associated with significantly more violations that other coded statutes or laws. Finally, Table 13 demonstrates that commercial crabbers fail to report their harvest 100% of the time, and without this core, frontline data, harvests would remain a poor estimate of the blue crab population.

In Chapter 4, I provided the results of the study and answer each of the research questions. I provided graphs that depict the identified correlations and percentages of noncompliance for reporting harvests. The data uncovered interesting phenomenon for future studies. The prescriptive material for further exploration in the next chapter then, is to further investigate why specific statues or laws tend to attract significantly more violations than others. In Chapter 5, I presented the discussion, summary findings, and recommendations for future research.

# Chapter 5: Discussion, Conclusions, and Recommendations

## Introduction

The purpose of this quantitative, correlational study was to determine whether there was a statistical or empirically verifiable relationship between the number of commercial blue crab statutes (laws) introduced, and the resultant violations of such laws. In the study, I systematically compared secondary data, profiling a specific group and specific commercial regulations related to blue crab. The data collection process provided a volume estimate of enforcement data relative to commercial crabbing in Maryland's Chesapeake Bay. The sample spanned nearly a decade. The selection process included those regulations that have a direct enforcement relationship to commercial blue crab as defined by the MD-DNR.

Noncompliance contributes to overregulation that leads to enforcement barriers, which negatively effect conservation efforts and economic opportunities. In this study, I sought to influence how commercial blue crab fisheries related regulatory activities are formulated and implemented with emphasis on equality of harvest, enforcement potential, and potential reactions from commercial blue crabbers (violations). I attempted to answer the following questions with the available data: What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial fishers as measured by the number of tickets written annually? How many times has fishing illegal gear occurred during the study years? Based on enforcement data related to illegal gear, what is the skew on harvest data because of commercial blue crab fishers exceeding the crab pot limit? Do years with no regulatory activity have less enforcement (crime) compared to years with regulatory activity? What percent is noncompliance behavior of total licenses reporting activity?

As a facilitator of resource management pro-activity, I sought to provide clear and accurate findings based upon the available data in order to encourage cooperation between the vast and diversified stakeholders to solve a problem. Within the Chesapeake Bay, the stakes are personal at the community level. For instance, lower shore crabbers depend a great deal on the soft and peeler crab market, while the middle Bay crabbers depend on peelers, hard, and sook crabs, and the upper Bay crabber's focus is hard crabs. These differences play a vital role in enforcement data, making location equally important to coding violation activity. Secondary data provided both variables. The independent variable was the presence, type, and number of commercial blue crab regulatory actions brought to Maryland's General Assembly. Blue crab regulations included all that which encompassed the words: regulation, act, law, public notice, management practice, and or proposal including sunset and repealed laws. The dependent variable under investigation was blue crab commercial enforcement data. The enforcement data comprised citations, warnings, and public hearing announcements reported or recorded by MD-NRP between 2010 and 2017.

The foremost purpose for this study was to find out if significant interaction effects exist among the various variables examined in the study and the extent to which it might influence the outcome of enforcement, harvest, and regulatory activity. A large data set required that I present the results in multiple formats. The first format I utilized had three groups reflecting three different year structures. The second format involved the entire scope of the period captured in the study and was designed to take a holistic overview of the entire data sets for this research. The results clearly indicated a divergent correlation outcome. Empirical correlation coefficient evidence associated with some periods examined seem to support, while other periods examined negated the narrative that more statutes or laws were associated with more violations of the same. As such, it would be erroneous to suggest that more laws produced more violations of such laws.

## Discussion

I based this study on enforcement/compliance theory, which assumes that compliance equals zero violations, but free will leads to behavior that suggests humans choose to break the law based upon a variety of factors. Researchers have identified a multitude of factors that affect compliance behavior such as moral development, income potential, perceived legitimacy, expected penalties compared against benefits, reduced perceived quality of life, reduced job satisfaction, distrust in government, adopting risk behavior, reduced psychological and physical health, and a reduced standard of living (Kuperan & Sutinen, 1998; Lord, 2011; Nasser, 2013).

In commercial fisheries, this might lead to crimes such as illegal, unreported, and unregulated harvest, fishing over the line, and other gear violations (Ali & Abdullah, 2010; Aries et al., 2015; Daw & Gray, 2005; Dresdner, Chavez, & Barriga, 2015; Eliasen, Papdopoulou, Vassilopoulou, & Catchpole, 2014; Hentati-Sundberg, Hjelm, & Osterblom, 2014; Kuperan & Sutinen, 1998; Mazany et al., 2015; Nielsen & Mathiesen, 2003). Applying enforcement/compliance theory to my study topic yielded data that demonstrated violations as a response to regulatory activity in the commercial blue crab management arena, but the data did not wholly show that cumulative regulations lead to additional violations of such regulations.

However, the data clearly showed that based on the data provided and the time captured that R4 had significantly more violations each year as compared to other coded variables, regardless of zero regulatory activity in any prior year. R4 captured violations regarding blue crab gear – not specific, which consists of crab pots and other harvest gear; times and locations to fish commercially; governing rules of male blue crabs; policy that included rules and regulations generally; and closed seasons for hard crabs except females. The runner up for the most violations each year captured R5, except in the years 2013 and 2015. R5 violations concerned peelers and soft crabs and sizes of such and other crabs, lawful gears, and commercial rules, limitations, and prohibitions generally. Finally, R3, crab pots, had the most violations per year regardless of regulatory activity in the previous year except in the years 2013 and 2015 when R3 held second place for total violations committed.

Unfortunately, the lack of detail available in the violations' raw data prevented me from coding the variables with the desired statute detail. Statute detail would have provided depth to the specific activity violated as opposed to the lumping of statutes and relative violations to identify trends. Empirical studies that support or negate rules are essential to championing compliance as stressed by the Common Fisheries Policy in 2013. The results make it clear that MD-DNR and MD-NRP need to work together to implement detailed violation data entry to detect other trends present in specific statute subtitles, chapters, and paragraphs. Identifying and addressing trends can assist stakeholders in working towards cooperative management and compliant behavior. This study showed that fisheries enforcement and management needed empirical studies and must consider enforcement and compliance theory as it relates to regulatory activity and responses of the end-users – in this case, the Maryland Eastern Shore commercial crabber.

## Interpretation of the Findings

Credible data that supports specific decision-making regarding management of the Maryland Chesapeake Bay blue crab continues to be absent in the study of fisheries. Most researchers rely on conservation, eco-systems, economics, and common-property/rights-based theories to ground their studies. This neglects the most important aspects of implementing laws to manage natural resources because it fails to answer questions about the who, what, where, how, and when enforcement is occurring. Identifying these factors can lead to asking not only the why behind compliance behavior, but also offering recommendations on how to work towards a solution of the problem using autonomous, qualitative design to reach stakeholders. This study demonstrated that patterns emerge between regulatory activity and enforcement data, and those patterns can be analyzed further through future research.

Quantitative, empirical studies on compliance behavior and enforcement that identify patterns are scarce in the literature. This lack of interest spans 300 years, and it remains an untackled, obligatory necessity. Current practices in blue crab management in Maryland's Chesapeake Bay is an example of Nielsen and Mathiesen's (2003) observation that "management bodies [employ] restrictive control measures or ignore problems [altogether]" (p. 409). Those researchers who have ventured into this arena have discovered compliance behaviors do exist. In 2004, Fogarty and Miller discovered substantial impact in the number of blue crabs reported when reporting requirements were changed even though the overall population showed minimal fluctuation in population. This response to reporting changes is one more example of how regulatory activity can influence end-user response, and these types of responses provide evidence in support of the need for continued empirical studies grounded in enforcement and compliance theory. A second example includes "fishing the line and spill-out" effects, which simply means that commercial fishing people drift on the edge of sanctuaries then harvest the resources as they swim out of their hideaway (Guenther et al., 2015). What is seen in R5 is another form of fishing the line. A fraction of an inch or blatant disregard lead to violations of undersize, out-of-season, or illegal catch of peelers, soft crabs, and other crabs not sook, and in this study, this violation saw a great deal of enforcement activity.

## Conclusions

My study's primary research question asked: What is the relationship between annual commercial blue crab related regulations enacted as measured by individual count and type and noncompliance by commercial fishers as measured by the number of tickets written annually? The results clearly showed a divergent correlation outcome. Empirical, correlation coefficient evidence associated with some periods examined seems to support the narrative that more regulations breed more violations of such; however, this cannot be said for other years captured in this study. A critical analysis of results presented in Table

5 showed that a positive correlation between the various laws introduced in 2009 and the number of violations of the same in the period of the introduction of the law in 2010 existed; this is indicated by a correlation coefficient of 0.79644. Correlation results presented in Table 5, however, further suggest a negative correlation between the number of laws introduced in 2010 and 2011 and the number of violations which occurred a year after those laws were introduced. This is indicated by a negative correlation coefficient of -0.3588 and -0.1667 respectively.

Through the literature review, I described the strife leading up to the above dates of interest. In 2008, MD-DNR identified overreporting of harvest as a response to upcoming hard crab laws whereby new individual quotas were to be set to historical harvests from each license holder. During the same year, hatchery crabs were being released into the wild (Zohar et al., 2008). Those that underreported initially were feeling the sting of this new law. Then again in 2010, the female and male hard crab harvest was separated by license type. This skewed numbers mirror Lord's (2011) characterization of fishers as willing to break the law based upon their individual perspective if they feel a threat to their standard of living. Indeed, in 2012, Emery et al. questioned the practicality of quota systems in common property resources. The diverse literature certainly gave the commercial fishing community a reason to resist change as they perceive their historical practices as no more or less credible than those proposed by the science they resist. Certainly, identifying R4 as a prominent area of violation helps fill the gap in the literature as to types of laws that are violated more than others.

Although a correlation design does not identify causes of such a phenomenon, I would argue that changes in hard crab laws that specifically separated male from female harvests by ITQs was the source of the positive correlation in 2009 to 2010. This time in Maryland's blue crab industry was wrought with unrest among its participants. Not only were license types changed, but also boat harvest limits, individual harvest limits, and new formulas for identifying brood stock numbers were under discussion by MD-DNR. The current study adds to the enforcement/compliance knowledge base and supports the age-old problem that fisheries is lacking empirical studies in enforcement theory.

**Limitations of the Study**

I limited this study to the Maryland Chesapeake Bay: commercial blue crab regulations and violations of such by commercial crabbers. For this study, I sought to collect data that included regulatory activity and the following enforcement. However, I discovered early on in data sorting that the details of the violation were limited and the entry of such was disjointed. I aimed for greater detail such as: specific # of individual illegal male or female hard, peeler, or soft crabs caught and # of illegal crab pots overused and or confiscated. The results cannot be generalized to other states or to other types of commercial fisheries, but the study is worth repeating for other resources in the Chesapeake Bay region. I based this study on a correlation design, and I presented commercial blue crab regulations and the violations of such by commercial crabbers between the years 2009 and 2017. Because the raw data was inconsistent in its original entry, it cannot be assumed that the data on which this study was based was inclusive and whole. Moreover, although I had access to hard numbers for yearly harvest and the number of and license type of commercial crabbers working, I did not perform discrepancy calculations because the raw data did not provide enough detail describing the violation. The details required to perform a reliable calculation were not identified in the raw data to determine discrepancies between individual harvest reports, pots allowed, and type of license demonstrating violations. Regardless, the study discovered several trends worth noting.

## Recommendations for Action

"Bluewater Crime" as coined by Kuperan and Sutinen (1998) is not "folksy" as pointed out by O'Connor Shelley and Crow (2009), and it requires monitoring like any other legislative action that leads to enforcement and results in violations. Traffic lights are put in place because a specific number of accidents occurred, and the State wants to protect its citizens; likewise, protections are required for the commercial blue crab industry and its participants. The frontline stakeholders are the primary eyes and experience of the state of the fishery, and nothing can replace this baseline data (Kerlinger, 1986; Lord, 2011). Eliminate harvest discrepancies and vie for enforceable, reasonable, and practical regulations to proliferate the industry not simply stabilize it at maximum capacity, such as MSY attempts to do. I recommend the following actions be taken:

1. The federal government should play an active role in advising how to improve the water quality of the Chesapeake Bay. The Chesapeake Bay is the largest natural estuary in the United States and continues to be a productive resource. Water sources begin in New York state and rush through the tributaries until they spill into the tidal basin bringing with it, garbage of every kind as well as

unimaginable mineral and chemical runoff that contributes to the demise of the Bay. Disjointed regulation for a migratory species such as blue crab demands oversight that provide checks and balances for individual states' management theories and practices - evening the playing field for commercial crabbers in both states - and requires that all states share in the stewardship of this natural wonder in America.

2. Individual states should encourage stewardship of the Bay through media avenues of all kinds (social media, billboards, commercials) that visually depicts the negative effects on the Bay from everyday practices like: litter such as butts, soda cans, and plastics, fertilizer use at home, overuse of exterior water sources, illegal harvest of natural resources, gear left unkempt, illegal gear, illegal sale of illegal harvest, and the like.
3. MD-DNR and MD-NRP should rethink how they will record violations from point of incident to data base entry that includes specific titles, subtitles, chapters, location and the like for future reference and studies. This data is the key to future success in compliance behavior. It will uncover unexpected trends that can be identified and addressed directly without using the top-down or control and command approach, which has proven unsuccessful in most fisheries throughout the world as the literature represents. Compliance behavior can and should be encouraged through communication between stakeholders.

4. Individual commercial crabbers should take responsibility for themselves at an individual and group level. Based on the results of the data, it is evident that some commercial crabbers continue to break the law and are unsatisfied with regulatory actions. The literature states most violations occur as a direct choice. If this is the case, then it is prudent to discuss why they continue to break certain laws as opposed to others, or to discuss what it would take to gain compliance in that specific regulation. This being the case, they need to provide honest, hard-core dialogue in an environment where they feel safe and free from reproach or punishment later.

## Recommendations for Further Research

This topic is significant because despite having a marine police force in place since the late 1800s, noncompliance continues to threaten the fishery resources of the Chesapeake Bay. Compliance results in a reduction in citations which means less actual direct and indirect costs and proliferation of Maryland's seafood industry increases with legal harvest potential. Therefore, I recommend that further studies be led in the following areas:

1. Supplementary research could include sourcing original, hardcopy data that includes the physical ticket that may or may not provide additional violation details. Repeating the study steps and making comparisons for an extended time series study spanning multiple decades would provide a great deal of detail in the types of crimes occurring consistently over time and may reveal further trends.

2. This study was quantitative, and a qualitative or mixed-methods study could provide important perspective on the issue of enforcement and compliance in the Chesapeake Bay region as opposed to Maryland's Bay area only.
3. This study was based on a single commercial harvest: Maryland blue crab, and a similar study could be performed for other natural marine resources utilized as a commodity in Maryland's fishing industry to seek trends in compliance behavior.

## Implications for Social Change

There is a long contentious history in Maryland concerning regulatory action for the Chesapeake Bay blue crab (*Callinectes sapidus*). Over 300 years, industrial revolutions occurred that made it possible to exploit this natural resource and send it to the farthest reaches of the world creating a multimillion-dollar blue crab delicacy. In 1939, the crab pot invention changed the playing field for evermore. Today, crab pots continue to catch more than 62% of the total blue crab harvest and are managed by MSY, a poor design for a migratory species. As supported by the data, noncompliance continues onward and has even demonstrated trends in response to some types of regulations. Now is the time for change through communication and empirical evidence that supports or negates previous management systems. As restrictions keep increasing, the economic impact on local communities is substantial, and compliance monitoring issues escalate with the problem. This study has the potential to bring stakeholders together to lead discussions in policy making and the unspoken costs of enforcement and compliance behavior.

My original argument that more laws breed more violations has been debunked in that it may be true some of the time, but it is not wholly true all of the time. The analysis further demonstrated that types of laws may breed more violations of such a law. This is a starting ground to discuss potential policy changes in record keeping strategies. The enforcement variable has often been taken as a constant and not included in the literature. In contrast to that perception, the day-to-day officers on the ground are an important key ingredient equal to that of the commercial crabbers themselves. The methods by which they record activities and violations is the secondary data employed by the use of empirical studies in enforcement.

Additionally, future data collection needs to include the location of violations as it pertains to longitude and latitude in an effort to create a complete picture of violation occurrences within the Chesapeake Bay. This study helps to fill that continued gap in empirical studies in enforcement. In 2004, Fogarty and Miller analyzed the changes in the Maryland blue crab harvest reporting system and discovered that substantial changes in the blue crab reported individually did not flow into differences in total stock abundance of the blue crab population. The study was timely for its necessity to demonstrate empirical studies in regulatory requirements of how harvests were reported. Now, MD-DNR needs to revisit their reporting systems from harvest to violation of regulations in detail in order to provide accurate, factual data regarding new phenomena discovered by this regulatory enforcement analysis.

## Contribution of the Study to Social Change

Even though the data captured in this study did not demonstrate statistically significant results for each research question, the main question demonstrated divergence, suggesting responses from commercial crabbers are sometimes effected but not all the time for similar regulatory activity in the blue crab industry. This proves that commercial crabbers do not always respond negatively towards regulatory activity. Indeed, the empirical evidence suggests that certain types of regulations seem to be violated more than others, and this is worth further discussion in a workgroup setting. The results of the current study confirm the conclusion of earlier research that included types of crimes committed (Ali & Abdullah, 2010; Arias et al., 2015; Daw & Gray, 2005;Dresdner, Chávez, & Barriga, 2015; Eliasen, Papdopoulou, Vassilopoulou, & Catchpole, 2014; Guenther et al., 2015; Hentat-Sundberg, Hjelm, & Österblom, 2014; Kuperan & Sutinen, 1998; Mazany et al., 2005; Nielsen & Mathiesen, 2003).

Seeking dialogue concerning these results with the frontline is prudent for MD-DNR and MD-NRP. This may lessen the volatile relationship between immediate stakeholders (commercial crabbers, NRP, DNR, and legislators), improve on data collection and storing practices, create meaningful management practices, and build lasting relationships among the players allowing a multimillion-dollar industry to flourish without constant duress from groups seeking independent agendas.

## Summary

The study provided data spanning nearly an entire decade relative to commercial crabbing in Maryland’s Chesapeake Bay. The selection process included those regulations that have a direct enforcement relationship to commercial blue crab as defined by the MD-DNR. I sought to discover if significant interaction effects existed among the various variables examined in the study and the extent to which it might influence the outcome of such. Unfortunately, the lack of detail available in the violations' raw data limited my coding of these statutes and the detailed results desired.

The results make it clear that MD-DNR and MD-NRP need to work together to implement detailed violation data entry to detect other possible trends present in specific statute subtitles, chapters, and paragraphs. Quantitative studies remain scarce in the literature. This lack of action in empirical research has continued for more than 300 years and continues to threaten conservation of the Maryland blue crab. Although the results cannot be generalized to other states or to other types of commercial fisheries, the study is worth repeating for other resources in the Chesapeake Bay region. I based this study on a correlation design that presented commercial blue crab regulations and the violations of such by commercial crabbers between the years 2009 and 2017.

Noncompliance contributes to overregulation that leads to enforcement barriers that negatively effects conservation efforts and economic opportunities. In this study, I sought to influence how commercial blue crab fisheries related regulatory activities are formulated and implemented with emphasis on practicability, enforcement potential, and potential reactions from commercial blue crabbers (violations). Noncompliance represents an ongoing problem in commercial fisheries. Results of this quantitative study indicate that certain types of regulations are violated more than others, and in some years, regulations triggered violations, while in other years, regulations appeared to have no bearing on the number of violations that occurred following the regulatory activity. Results of the study can be used by Maryland agencies, legislators, educators, and a variety of stakeholders interested in the success of the Maryland commercial blue crab industry, which will serve the entire State of Maryland.

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Appendix: Request to Conduct the Study

Dear Maryland Natural Resource Police:

My name is Jacquelyn, previously – President of Watermen's Allegiance for Regulatory Fairness - WARF, and I had the fortune to work with the Department of Natural Resources after submitting legislation – The Apprenticeship Program, (1998). Specifically, I worked with Mr. Pete Jensen who introduced me to your many departments. Today, I am working to complete my PhD in Public Administration. My strong interest in the blue crab industry in Maryland continues as my title asserts, "Measuring Regulatory and Noncompliance Prevalence Among Maryland Commercial Blue Crab Fishers." I am writing this letter to request, officially, the use of departmental secondary data in order to complete my research requirements. I humbly request the assistance of the Department to acquire such data. I recognize time and budget constraints necessitates prioritizing resources, but I believe this research is essential to filling the gap that exists between enforcement data and regulatory action. Often, enforcement issues and related budgets are barriers to successful conservation. The purpose of this quantitative, correlational study is to discover if a relationship between types and number of regulatory action and recorded blue crab citations and warnings exists.

Certainly, should my document be published, credit would be given to the Department for its appreciated and valued assistance. Therefore, I am seeking commercial citation and warning data related to blue crab that you can offer via your public access availability. At the very least, I hope to retrieve enforcement data for a minimum of the 10 previous years to create solid validity. I look forward to hearing from you, and I thank you in advance for your valuable time and knowledge. Please feel free to reach out to me by any media above provided. I anxiously await your questions, concerns, and direction.

With sincere respect,

Jacquelyn Lee Rachor-Hornsby