Income and Harvest Effects of Alternative Management Policies
on Commercial Crab Potters in Virginia

by

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Thesis submitted to the faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirement for the degree of
Master's of Science
in
Agricultural and Applied Economics

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July, 1993
Blacksburg, VA
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(ABSTRACT)

In recent years, the blue crab fishery has become the main source of income for Virginia's watermen. This fact, along with growing concerns of overharvesting and uncertainty about the amount of effort in the fishery, has led to calls for more complete data on the fishery. This study examined the characteristics of Virginia's blue crab fishery, through an extensive survey of crab pot license holders conducted on a monthly basis from March to November of 1992.

Along with a description of the people in the fishery, this study also modeled prices, harvest levels, and income levels for the blue crab industry. Because the models were interactive in nature, the effects of various fishery management strategies were also analyzed. The main emphasis of the policy simulations was to discover what impacts the different strategies had on harvest and income levels. The results of the simulations showed that many of the policies currently under
consideration will have only a small impact on overall harvest and income levels, but there are some larger distributional effects among different firm classes. The findings of this study suggest that in order to gather accurate and useful data on the fishery, the random surveying techniques of this study should be continued over a period of years.
Acknowledgements

I am grateful for the opportunity I received to work with Leonard Shabman on this project. He has been the guiding force throughout this study and he has given me much that I will carry with me throughout my life. He was always there with a helpful hint, a new direction, a calming word. He is a good blend of theorist and practicalist, facing every problem with a focused mind and a valuable solution. I would also like to thank the other members of my committee, Paul Driscoll and Charley Coale for their comments and suggestions. This work was sponsored by the Office of Sea Grant.

I would like to warmly thank all those graduate students who made the experience of working on my master’s degree much more than simply an exercise in time and patience. Instead, they made it an adventure, full of strange realities and sanity-saving escapades. The common bond we shared was strengthened by long conversations, even longer happy hours, and great disco music.

I would like to express my gratitude to my parents, to whom I owe a debt that can never be repaid, only acknowledged by my love and respect. I would especially like to thank my mother, who has encouraged me in every endeavor.

My most important thanks go to my husband, Ben who provided not only lots of support, but also many dinners. He somehow managed to marry me while I was in the process of finishing this work and for that, I am most appreciative.
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CHAPTER 1 - INTRODUCTION

1.1 Background

Historically Maryland and Virginia have provided between 45 and 55 percent of the U.S. hard blue crab harvest and over 60 percent of the soft crab catch. In recent years, the blue crab has become the main source of income for Virginia’s watermen, as harvests of oysters and finfish have declined. Over the last two decades, total harvest of blue crabs has fluctuated, but shows no systematic trend. During the same period, however, the dockside value of blue crabs as a proportion of total Chesapeake Bay landings has risen. In 1970, the blue crab harvest was about 49 percent of the total food fish and shellfish harvest value in the Bay. In contrast by 1989, the hard blue crab harvest was about 70 percent of the total value.

Despite the apparent stability in harvest levels, the decline in other fisheries has focused attention on the status of the blue crab fishery. The increased reliance on the blue crab as a revenue source has caused watermen who harvest the crabs to complain of low incomes. Watermen have often attributed this low income to price fixing by the large blue crab processing firms in Virginia. Price trends reveal that the real exvessel prices of blue crabs (prices received by harvesters for fish and shellfish landed at the dock) has not declined in recent years (see Figure 1), although the wide fluctuations in price in the early seventies are no longer apparent (US Department of Commerce). Also, processing firms are only one of many available marketing channels for blue crabs, so there may be other marketing channels where
higher prices are received. Also, while watermen often lay the blame for low prices at the feet of the processing industry, there are more players in the marketing chain, including retailers and wholesalers who have the ability to influence exvessel price. A survey done as part of this study asked Virginia crab potters what percent of their catch was sold to picking houses in 1990. Only 30 percent of the respondents indicated that they sold 75 percent or more of their catch to these houses, while close to 60 percent sold 0 to 24 percent of their catch to the picking houses.

Overharvesting, which may reduce future population levels, is another concern expressed by some watermen and state officials. As catch levels fluctuate from year to year, showing no trend in total harvest, the catch per crab gear license issued jumped sharply in the early 1980s and exhibits a slight downward trend since (see Figure 2). The decline in this crude measure of catch per unit of fishing effort is cited as evidence of falling population levels. Also, with increased recreational use of the Bay, the recreational harvest for direct home consumption may be rising. However, there is little recreational harvest data (See Section 1.6) so the extent of this harvest pressure is a matter of some speculation.
Figure 1 - Exvessel Price - Hard Blue Crabs

Source: National Marine Fisheries Service
Figure 2 - Catch per license - Virginia Blue Crabs

Source: Virginia Marine Resources Commission
In 1989, in response to these concerns, a Blue Crab Subcommittee of the Virginia Marine Resources Commission (VMRC) was formed. This committee consists of Virginia watermen, crab processors, and VMRC personnel. The main purpose of the committee is to discuss policy related issues and to decide how to implement measures mandated by the Chesapeake Bay Blue Crab Management Plan. Those on the committee are concerned with both improving watermen's income and maintaining viable population levels of blue crabs (minutes, Committee meeting, 1990-91). The subcommittee efforts, along with mandates from the Chesapeake Bay Plan, have helped to define recent Virginia General Assembly bills on fisheries policy.

The 1992 General Assembly session passed laws allowing VMRC to require mandatory reporting from all commercial fishermen and to charge a marketing fee to all commercial fishermen. Both of these measures took effect in January of 1993. Mandatory reporting requires commercial fishermen to provide daily catch data. The $150 marketing fee is a prerequisite to obtaining a license to use any gear for harvesting blue crabs. Only those who pay this fee will be allowed to sell their catch to seafood buyers. This fee is aimed at,

Providing estimates of the level of fishing in advance of the fishing year. Management programs can then be structured pro-actively in response to the anticipated levels of fishing. The proposal also prevents the sale of seafood by 'recreational' fishermen. (Chesapeake Bay Commission)

While the end result of both of these regulations is still unclear, they are both aimed
at estimating and managing harvest levels within the fishery.

The General Assembly also passed laws giving VMRC the authority to implement delayed or limited entry in any fishery which appears to be in danger of overharvest or economic depression. In a delayed entry system, watermen must wait two years before they can purchase a gear license, if they did not have one the previous year. In a limited entry system, only a certain number of gear licenses are sold each year. Both of these measures are designed to indirectly control fishing effort (as defined by number of gear licenses) within the fishery and hence reduce total harvest. This control of effort and harvest is mainly to keep prices from falling in the winter and late fall, as VMRC officials contend that there is currently not a problem with stock depletion in the fishery (Smoller, conversation). Delayed entry was implemented in all Virginia fisheries beginning in 1993. Currently, the VMRC is considering implementing a limited entry system in the winter crab dredge fishery (Gear types are discussed in section 1.3).

Other possible policies that have been discussed by the Blue Crab Subcommittee include a limit on the amount of crabs a person can catch each day or a limit on the number of crab pots a person can fish. In 1991, a 51 bushel a day limit for the hard crab pot fishery was proposed at a meeting of the Blue Crab Subcommittee. Most watermen, however, felt that this limit was unnecessary and would put Virginia crabbers at a disadvantage with other states (minutes, 8/29/91). Limiting the number of pots would have high enforcement costs to be effective,
because it is difficult to know how many pots a crabber has in the water.

In order to understand the intent of these strategies, it is important to understand the structure of the blue crab fishery in Virginia. The next sections outline biological characteristics, the harvesting and processing sectors, the recreational sector, and current regulations in the fishery.

1.2 Biological Characteristics

The blue crab is known as *Callinectes sapidus*, which translates as "savory, beautiful swimmer". It inhabits near-shore waters along the Atlantic coast from New Jersey to Florida and along the Gulf Coast to Texas. It is also found in small quantities in Europe and in larger quantities on the coast of Israel and in the Nile River Delta.

Mating of the blue crab occurs in brackish water between early May and October, but mainly in late summer, in the Chesapeake Bay. Females mate only once, while in the soft shell state, but males may mate several times. Females can have anywhere from 700,000 to 2 million eggs in one spawning. Crabs go through eight larval stages before they become a "first crab". During these larval stages, the crabs serve as food for various fish in the Bay.

Crabs grow by shedding their hard, outer shells. Small crabs shed frequently, but the time interval between sheddings increases as the crabs grow. Young crabs moult every 3 to 5 days, while older crabs may shed every 20 to 50 days. There are
25 to 27 sheddings between the first larval stage and the adult (Van Engle, 1973).

In the Chesapeake Bay, crabs become 5 inches or larger in width in 14 to 18 months, between August and November of the second summer of life. Crabs may live for more than 3 years, but few live for more than 2 years. In the Bay, crabs undergo semi-hibernation when the water temperature falls to 40 degrees F or less.

The short life span of the blue crab, coupled with its large reproductive capacity, makes it unlikely that a Schaefer stock-recruitment curve, where harvest in the period is a direct function of the previous year's stock, is appropriate for the blue crab. Instead environmental factors, such as temperature and salinity, are the main determinants of stock size in any year (Chartier, 1988). Differences in population levels will be discussed further in Chapter 3.

1.3 Harvesting Gear

The blue crab is harvested in two forms. Hard crabs are taken when their exoskeleton has hardened between moultings, and are sold live, steamed, or as picked meat. Soft crabs have recently shed their exoskeleton. The marketed soft crab is often harvested as a peeler crab, a crab which is preparing to moult. Peeler crabs are kept in pounds or floats until they shed their exoskeleton, and are sold live or frozen or, if they die during moultng, are sold as fishing bait.

A variety of gears are used in harvesting. Hard crabs are generally caught with pots, trotlines, and dredges. Pots and trotlines are used mainly in the spring, summer, and fall, while dredges are used only in the winter. Pots are the most used
gear, accounting for over 70 percent of the annual catch in Virginia. A crab pot is a mesh wire, nearly cubical cage with two to four openings on each side, through which crabs enter, attracted by bait placed in a central compartment. The crab pot is placed on the bottom of bays and rivers. It can be pulled up manually or with an hydraulic lift (Chowning, 1990). Pots are usually left in the water for the entire season and pulled every one or two days in order to empty out the crabs and rebait the pot. The most common type of bait used is menhaden. Pots are buoyed in the water so that crabbers can identify and locate them.

Prior to the introduction of the crab pot in 1928, the trotline had been the main method of harvesting blue crabs for centuries. Trotlines are long lines, baited with salted eel, buoyed at each end, and set each morning by a boat. They catch crabs as they actively feed on the bait. Trotline crabbing is done throughout the Bay, but is especially important in creeks, sounds, and protected waters where crab pots are prohibited.

Crab dredges are used in Virginia to harvest crabs from December to March. Dredging consists of raking semi-dormant crabs off the bottom of the water with a metal toothed bar, connected to a mesh bag (Van Engel, 1962).

Soft or peeler crabs are harvested by peeler pots, peeler pound nets, or crab scrapes. Peeler pots are similar to hard crab pots, but they are baited with a male crab, called a Jimmy to attract female peeler crabs who are ready to moult. Scrapes are toothless dredges that collect soft and peeler crabs from the eelgrass in the
bottom of the Bay. Peeler pound nets stretch out on the water and lead crabs to a trap from which they cannot escape. They are placed near the shoreline to attract peeler crabs who are seeking shelter to moult.

1.4 Marketing Channels

After the crabs are harvested, they can be sold through many channels. Crabbers may sell all or part of their hard crab catch to picking houses, where the crabs are processed into meat (See Section 1.5). They may sell their peeler crabs to shedders. They may also choose to sell all or part of their catch to the "basket trade", which consists of wholesalers or retailers who buy crabs at the dock. As part of the "basket trade" crabbers may also perform value-added activities, including shedding their own crabs, steaming their hard crabs, or retailing their live crabs directly. Some crabbers even choose to fly their soft crabs directly to Northern markets (Wesson, conversation). Large crabs are usually sold as whole crabs in the basket trade, but the smaller crabs (with less meat) usually go to the picking houses to be processed.

In 1982, Vance noted that there was a growing basket trade in Virginia. This growth has continued, as evidenced by a recent survey in which Virginia crabbers indicated that they sold only 37.8 percent of their hard crab catch, on average, to traditional picking houses in 1990.
1.5 Hard Crab Processing Sector

While many marketing channels exist for large hard crabs, processors take most of the smaller hard crabs, which are not usually sold live or steamed. Instead the small ("picking") crabs go to picking houses where they are steamed and the meat is picked from the shells. Processed products include: fresh and pasteurized crab meat, frozen and canned specialty products, and hermetically sealed canned crab meat (Dressel and Whitaker, 1982).

The average meat yield of hard blue crabs in the Chesapeake Bay region is between 8 and 12 percent, meaning that 100 pounds of live crabs yield 8 to 12 pounds of crab meat, in various grades. Although it varies depending on regional customs and state laws, the technology used in processing blue crabs has changed little since fresh crabmeat was first marketed in the late 1800s. Hand-picked crabmeat still constitutes the major product from the crab plants (Hong, 1990).

There is some mechanization within the industry, mostly in the larger plants. The Harris process is used to remove claw meat. In this process, claws are put through a hammer mill type machine that breaks the claws into many small pieces. The meat is separated from the shells by a brine floatation process with the meat floating to the top and the shells sinking to the bottom. The meat is sprayed with fresh water and the water is removed by a metal squeezer. A second picking machine is the Quik-Pik, which removes meat from the main body of the crab by high speed vibration (Hong, 1990). These mechanization techniques are not widely
used in the processing industry, not only because of their high startup costs, but also because the meat produced by these machines is of lower value than hand-picked meat.

1.6 Recreational Sector

The size of the blue crab recreational fishery in Virginia is unknown, but it is thought to be quite large. In addition to those who fish recreationally with only 1 or 2 pots per person or by hand lines with dip nets (which does not require a license), a fairly substantial portion of the license-holding population could be considered non-commercial, in that they do not derive any part of their income from potting. Because this catch does not move through any marketing channels, it goes unreported. Concerns about this sector have come from both commercial fishermen and Chesapeake Bay planners. The watermen are concerned that recreational fishers are claiming too large a share of the harvest and that some of them may be selling part of their catch, which gluts the market and holds down exvessel prices (Survey, 1992). Chesapeake Bay planners are concerned about the lack of information on the recreational sector and therefore the inability to establish whether or not it has an impact on blue crab population levels. A further exploration of the impact and characteristics of the noncommercial sector will be done in Chapter 2, as the survey results are analyzed.
1.7 Current Regulations

While new regulations are being considered in the industry, there already exist some laws in Virginia that govern the fishery. Each person wishing to catch crabs commercially (more than 2 pots per person) must purchase a gear license. There is currently no limit on the number of gear licenses that can be sold, or on the number of gear units that can be employed once a license is purchased. In 1990, 2550 crab pot licenses were sold.

Hard crabbing is prohibited on Sundays, and potting is not allowed from December 15 to January 31. Crab dredging is only permitted from December 1 to March 31 and is prohibited on Saturdays and Sundays and between sunset and sunrise on all days.

The minimum size limit for male hard crabs and sexually immature female hard crabs is 5 inches. There are no minimum size limits for peelers, soft crabs, or adult female hard crabs (sooks). Some watermen believe that enforcement of these size limits is not effective because fishery inspector checks are sporadic and because culling rings, which release small crabs from pots, are not mandatory in Virginia (Survey, 1992).

The crab dredge fishery has a 75 bushel limit of crabs per day per vessel. In the pot fishery, catch is restricted to 51 bushels or 17 barrels per vessel per day from March 15 to May 31.

There are also area restrictions. Dredges are not allowed in rivers, estuaries,
inlets, or creeks. There is a Crab Sanctuary Area in the lower Bay, where crabs cannot be taken from June 1 to September 15. Hard crabs may not be taken at any time from the Tangier Island Crab Scrape Sanctuary (VMRC circular, 1992).

1.8 Current Situation

The recent passage of the General Assembly laws signals an increased interest in effective management of the blue crab fishery. In order for the most effective policies to be implemented to achieve income and population goal levels, data on fishery effort, prices, costs, and catch must be carefully analyzed. The need for such analysis was recognized in 1989 when, as part of the Chesapeake Bay agreement, crab fishery management plans (FMPs) were developed. The current bi-state blue crab FMP states the following:

The goal of this plan is to manage blue crabs in a way which conserves and protects the ecological value of the stock, and at the same time generates the greatest long term economic and social benefits from the resource [Chesapeake Bay Executive Council, 1989]

The bi-state FMP also calls for an effort to, "investigate and promote harvesting practices which minimize waste and maximize economic return from the resource". And then, in a statement especially germane to this study, the FMP seeks to "promote studies to collect the kinds of economic, social, and fisheries data required to effectively monitor the status of the blue crab fishery" (Chesapeake Bay Executive Council, 1989).
These excerpts from the bi-state crab FMP recognize that people harvest crabs for income and for pleasure, and a plan to manage the fishery is ultimately a plan to manage people's harvest to achieve some social purpose related to these income and recreational values. The goals and motivations of these people, often income driven, must be analyzed and understood if the purposes of management are to be socially optimal and if regulatory strategies are to be cost-effective and effectively influence behavior of harvesters. Management questions needing attention include, but are not limited to:

- What are the current income levels for watermen from the crab fishery?
- How do income levels differ among watermen?
- How will income be affected by alternative policies?

To answer questions such as these requires that catch per unit effort, costs of harvest, market distribution channels, and the exvessel price formation process be understood.

Lack of accurate data and careful economic analysis of such data is a serious problem within the industry. Landings reported to the National Marine Fisheries Service (NMFS) appear to have been underestimated in the past (Vance, 1982), and exvessel prices are gathered from large picking houses which may currently be taking less and less of the market share of blue crabs. There are little available data on costs currently faced by the watermen. The main purpose of this study is to examine the effects of fishery management strategies on the income of crab potters in Virginia. This study will gather data that will be used to examine the effects of
alternative policies on the income of potters in Virginia. In 1991, crab pots accounted for over 70 percent of the hard and soft crab commercial catch in Virginia. Because of this, the primary focus for this study is the hard and soft crab harvest by pots. While hard crab catch far exceeds that of soft crabs, the soft crab industry in Virginia is important, as it provides close to 60 percent of the annual U.S. soft crab harvest. For this reason and because there are some harvesters who fish both hard crab and peeler crab pots, consideration will be given to the economics of the hard and soft crab industries, and comparisons between the two will be developed.

1.9 Objectives

1. To profile Virginia's commercial blue crab pot harvest sector for 1992. Specifically,

a) to develop a classification of firm size, with firm size defined by firm characteristics such as crabbing region, type of operation, and percent of income derived from crab potting.

b) to determine what marketing channels exist for blue crabs and how crab potters use these channels.

2. To predict harvest and net income levels for the 1992 Virginia blue crab pot fishery as a whole and for firm classes.

3. To evaluate the effects of alternative management policies on harvest and income levels for the industry and for each firm class.
1.10 Procedures

One of the most important steps in analyzing the industry is outlining the economic and physical flows into and out of the fishery, recognizing types and amounts of inputs (or fishing effort), the harvest result and the marketing system. The combination of inputs defines fishing effort, although the primary indicator of effort for this study will be pots days fished. Chapter 2 describes these input and output flows for the 1992 season. In order to quantify these flows for the 1992 season, a primary data collection survey was undertaken. Because inputs and harvest vary between months, the survey was done on a monthly basis, from March to November. Chapter 3 develops the theoretical basis for the empirical models to be estimated and develops the expected implications of alternative management policies on harvest levels and income.

The model used to estimate harvest and income for 1992 and under different policy regimes is described in Chapter 4. Chapter 5 analyzes the effects of the General Assembly laws and other policies on the net income of the watermen. A discussion of the implications of the study, additional issues to be considered, and recommendations for gathering more complete data over a longer period are included in Chapter 6.
CHAPTER TWO - A PROFILE OF THE BLUE CRAB POT FISHERY IN VIRGINIA

This chapter profiles the blue crab pot fishery in Virginia using the results from a 1992 survey of crab pot license holders. Also included are the results of a 1991 survey of crab potters which examined the differences between people who came into or left the fishery over a period of 2 years and those who stayed in the fishery for the two year period. The evidence for and against monopsony in the Virginia blue crab processing sector is also examined, in part using data from the surveys.

Figure 3 is a representation of the flows of inputs and outputs for the blue crab pot harvesting sector. At the bottom are the variable and fixed inputs used in harvesting for both hard and soft crab operations. These inputs contribute to harvest which, in turn, move through a series of available marketing channels. The hard crab firm may sell all or part of its catch to a processing plant (where crabs are processed for picked meat), to the basket trade (people in trucks who take crabs at the dock and may sell them either to processing plants or retail them directly), retail them steamed and/or as picked meat. If the hard crab harvester chooses a marketing channel other than the processing plants or basket trade buyers who come to the dock, there are additional costs including transportation, cooking and/or picking. Also, these alternative channels are not available everywhere. While the prices the crabber receives may be higher in marketing channels other than the traditional
Figure 3 - Input and Output Flows for the Blue Crab Fishery
picking houses, there must be an available sales outlet for the live crabs.

For soft crabs, a harvester may choose to shed his own peeler crabs which requires more inputs including a shedding system (which can be either floating in the water or a recirculating system) and labor. Peeler crabs are held in the shedding system for anywhere from a few hours to 5 or 6 days, until they shed their hard outer shell. After this, the crabs are usually frozen and shipped to a retailer. Peeler crab harvesters may also choose to sell their crabs to a shredder who then retails them. Again, if a harvester retails his own soft crabs, there must be an available sales outlet.

This chapter will quantify and characterize these flows. The next section presents the procedures used in building the survey instrument and sampling procedures. The third section examines the Virginia commercial blue crab potting sector for 1992, developing characteristics of representative firms classified by region, firm type, and percent of income from crabbing. The fourth section of the chapter describes the characteristics of the non-commercial license-holding population and how it compares to the commercial sector. The fifth section describes the characteristics of Maryland watermen who crab pot in Virginia waters. The sixth section examines the differences between transient and permanent crabbers in the fishery. The final section examines the evidence for and against monopsony in the Virginia blue crab processing sector.
2.1 Survey Design and Sampling Procedures

2.11 Entry/Exit Survey

Before the extensive profile of the fishery began in 1992, a shorter survey was done in the summer of 1991. This survey was designed to determine the characteristics of those who enter and exit the blue crab pot fishery and if these characteristics differ from those who remain in the fishery.

Three sets of crab pot license holders were surveyed. These were:

1) All those who held a crab pot license in 1989 but not in 1990
2) All those who held a crab pot license in 1990 but not in 1989
3) A random sample of those who held a crab pot license in both 1989 and 1990.

The Dillman method, explained later in this section, was used for mailing the surveys and 61 percent of the surveys were returned. The survey instrument was three pages long and a copy is shown in Appendix A. The sample was found to be representative of the crab pot license-holding population by age and county of residence. The results of this survey are discussed in section 2.5.

2.12 Profile of the 1992 Crab Pot Fishery

In order to characterize the fishery, a series of steps were taken to profile the Virginia blue crab pot fishery for 1992. The main source of data for this profile was to be a series of monthly surveys, conducted from March to November. In order to make the survey as efficient and useful as possible, a series of interviews were
conducted with people involved in the fishery. A rough draft of the survey instrument was sent to three watermen in Virginia, who included a peeler crabber and two hard crab potters. All of these watermen were members of the VMRC Blue Crab Subcommittee. These watermen were personally interviewed and gave their comments on both the merits and problems of the survey instrument and on characteristics of the industry. The survey was also sent to personnel at VMRC and the Virginia Institute of Marine Science (VIMS) who, because they had both previously conducted surveys of watermen, provided valuable insights on survey design and implementation.

To obtain a better idea of the flows at the harvesting level, this observer accompanied two watermen on the daily crabbing runs - a peeler crab run on the York River and a hard crab run in the Rappahanock River and Chesapeake Bay. These trips provided insights on the everyday workings of watermen - from how the boats are loaded in the morning to how the catch is marketed in the afternoon.

On the processing side, an interview was conducted with a large picking house company in Virginia. This interview provided information on how processors operate, the competition they face, and how the prices they offer to watermen are formed. Another interview was conducted with a soft crab harvester and wholesaler in Virginia, which gave some insights into soft crab price determination.

The basic objective of the survey instrument in this study was to provide primary data on inputs and outputs from the crab pot sector of Virginia. The survey
was designed to gather data to be used in estimating production, cost, and net return functions for the 1992 season. Because both input and harvest levels vary throughout the year, the survey was conducted on a monthly basis from March to November. The potting season generally begins in mid-March and ends in mid-November, but surveys for March and November were combined with those for April and October, respectively, totaling 7 separate survey instruments for the season.

A monthly survey was also chosen to avoid recall problems that might result from one mailing at the end of a season and also because watermen were required to provide catch data for only one month. Few questions on costs were asked, except for the fixed costs that the crabber pays annually. This helped to prevent non-responses as the questions did not require the watermen to provide all the financial details of their operation. Costs for variable inputs were obtained in a telephone survey of selected crabbers (those who, through their comments on the survey, expressed concern for the fishery and a willingness to provide additional information).

The survey was divided into two parts. (See Appendix A). Part I contained questions for all of the respondents to answer. These included attitude questions about fisheries policy, general characteristics of the crabber, and fixed costs and inputs. Part II was to be answered by those who crab potted during the month they received a survey. This section included a monthly calendar, on which respondents were asked to fill in the number of bushels of peeler and/or hard crabs that they
caught each day. The rest of the section asked questions about variable inputs (bait, pots, labor, etc.) and marketing channels. The survey ended with a section for additional comments by the crabber.

A cover letter emphasizing the importance of the survey to fisheries policy was sent, and those on the first list (see below) were also sent the results of the fall 1991 survey.

The response results of the 1991 entry/exit survey were used to determine the sampling procedure for the 1992 survey. Only those who held crab pot licenses in 1990 were considered for sampling, a total of 2550 people.\(^1\) 583 people who fit this criteria responded to the 1991 survey. These people, because they had responded to one survey were removed from the complete census and marked as the first list. These 583 people were tested for representativeness of the population of license holders using Chi-Square tests. The only population characteristics available for all crab potters are age and county of residence. The sample taken in the 1991 survey was found not to be significantly different from the overall population in either characteristic. Therefore there was no age or location bias in this sample. If any other bias existed, it could not be detected. Those who did not respond to the 1991 survey were removed from the list, as they would probably not respond to a second survey. After removing those from the list who were know to be deceased or had

\(^1\) The 1990 list was used as the 1991 list of license holders was not available from the VMRC at the time of sampling.
moved out of state, there were approximately 1250 people on the list who had not been previously surveyed. This 1250 comprised the second list.

A total of 1204 people were surveyed over the season. Because there were seven periods to be surveyed, 172 people were surveyed each period. These 172 people were drawn from two lists. The first list was the 583 people who had responded in 1991. Each period, 83 or 84 of these people were surveyed. These people were not drawn randomly, however. One of the questions on the 1991 survey asked the respondents in which months they usually crab potted. The list was divided over the months so that each person received a survey in a month in which they normally crab potted. This procedure assured a higher response rate for Part II of the survey than might otherwise occur. The remaining 87 or 88 people were drawn randomly from the previously unsurveyed license holders, using a random number generator.

The Dillman (1978) method was used in mailing the surveys. This method has three steps. First a questionnaire and cover letter were sent. Then in two weeks a reminder postcard was sent to those who had not responded. Two weeks later a second letter is sent as well as another copy of the survey form. In this survey, two different cover letters were sent with the first mailing. One letter was sent to those who had responded to the 1991 survey, thanking them for their response. The other letter, sent to those who had not received a survey in 1991, did not include the first paragraph of the other letter. For the October/November survey, no postcards were
sent. All of the cover letters, the postcard, and the survey instrument are shown in Appendix A. The survey instrument is shown for the month of August.

The response rates for each period are shown in Table 1. 1204 surveys were mailed, 36 of which were undeliverable. The overall response rate for the survey was 62 percent. A total of 720 surveys were returned. Of this number, 490 were usable surveys, as a number of surveys were returned by those who did not crab pot in 1992 and some surveys contained incomplete information.²

The survey data was tested for representativeness of the crab pot license-holding population by performing Chi-square tests on the two statistics that were known for the population - age and county of residence. The results of these tests are shown in Table 1. The Chi-Square statistics indicated no difference between the sample and the population, and therefore the sample will be considered representative of the population and the following sections which characterize the fishery will refer to percentages of the population rather than the survey responses. Appendix B presents the breakdown of the license holders into various categories which will be profiled in the remaining sections of this chapter.

² Many people who filled out Part II of the survey (monthly data) filled out everything except the monthly calendar. These surveys were not considered incomplete because they provided much other useful information. Incomplete surveys included only those who did not fully complete Part I (general data).
TABLE 1 Response rates for 1992 Survey of Crab Potters

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>NUMBER OF RESPONSES</th>
<th>RESPONSE RATE (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March/April</td>
<td>97</td>
<td>58</td>
</tr>
<tr>
<td>May</td>
<td>95</td>
<td>57</td>
</tr>
<tr>
<td>June</td>
<td>103</td>
<td>62</td>
</tr>
<tr>
<td>July</td>
<td>113</td>
<td>68</td>
</tr>
<tr>
<td>August</td>
<td>110</td>
<td>66</td>
</tr>
<tr>
<td>September</td>
<td>115</td>
<td>69</td>
</tr>
<tr>
<td>October/November</td>
<td>87</td>
<td>52</td>
</tr>
</tbody>
</table>

Representativeness of Survey Responses

Chi-Square Statistic

<table>
<thead>
<tr>
<th>Factor</th>
<th>Chi-Square Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.708</td>
</tr>
<tr>
<td>County of residence</td>
<td>.545</td>
</tr>
</tbody>
</table>
2.2 Characteristics of the Commercial Fishery

Approximately 64 percent of the license holders were classified as Virginia commercial, potters from Virginia who derived all or part of their income from crab potting. These potters were further divided into those who both peeler and hard crab potted, those who only hard crab potted, and those who only peeler potted. Within these three categories, the survey responses were divided into part-time crabbers and full-timers. A final subdivision of the commercial sector was done using three regions. A definition of the terms used in separating the surveys is shown in Table 2. The next three sections examine the differences among commercial firms by income class, region, and type of operation.
<table>
<thead>
<tr>
<th>Terms used for Classifying Crab Pot License Holders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-Time Crab Potter - derives 50 percent or more of their income from crab potting</td>
</tr>
<tr>
<td>Part-Time Crab Potter - derives less than 50 percent of their income from crab potting</td>
</tr>
<tr>
<td>Region 1 - Eastern Shore of Virginia - counties of Accomac and Northampton</td>
</tr>
<tr>
<td>Region 2 - Counties of Eastern Virginia north of York River - counties of Westmoreland, Northumberland, Richmond, King George, Stafford, Prince William, Loudon, Spotsylvania, Orange, Caroline, Essex, Lancaster, King and Queen, King William, New Kent, Hanover, Louisa, Goochland, Henrico, Gloucester, Middlesex, Mathews, Fairfax, and city of Arlington</td>
</tr>
<tr>
<td>Region 3 - Counties of Eastern Virginia south of York River - counties of York, Isle of Wight, Southampton, Dinwiddie, Prince George, Surry, James City, Charles City, Chesterfield, and the cities of Chesapeake, Virginia Beach, Norfolk, Hampton, Newport News, Richmond, Suffolk, and Portsmouth</td>
</tr>
</tbody>
</table>
2.21 Part and Full-Time Crabbers

38.6 percent of the license-holding population were full-time crab harvesting firms and 25.4 percent were part-time firms. Table 3 shows some of the characteristics of full versus part-time firms. Full-time crabbers tend to fish more pots (both hard and peeler), fish more pot days per season, be younger, and have more crabbing experience than part-timers. Full-timers also tend to fish in more months than part-timers, especially in the months of March, October, and November. Full-timers tend to market a larger percentage of their harvest to picking houses, (over 50 percent), while only 30 percent of part-timers catch goes to the picking houses. Part-timers keep more of their catch for home use, indicating that part of their crabbing motivation is pleasure rather than income-driven. Full-timers also derive slightly more of their income from other fishing than part-timers.

Overall, full-timers have a larger size of operations, as would be expected from those who depend on crab potting for the majority of their income. The fact that full-timers tend to be younger than part-timers may reflect 1) older crabbers have more alternative forms of income and/or 2) potting on a large scale is done mostly by young crabbers. Conversations with and comments in the survey from crab potters around Virginia indicate that many younger crabbers do not feel they can make a sufficient income from potting unless it is done on a large-scale, i.e. 300 pots or more.
<table>
<thead>
<tr>
<th>Table 3: Part and Full-Time Commercial Crab Potters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Averages</strong></td>
</tr>
<tr>
<td>Part-Time</td>
</tr>
<tr>
<td>Average hard crab pots fished</td>
</tr>
<tr>
<td>Average peeler pots fished</td>
</tr>
<tr>
<td>Hard pot days fished per season</td>
</tr>
<tr>
<td>Peeler pot days fished per season</td>
</tr>
<tr>
<td>Average length of vessel</td>
</tr>
<tr>
<td>Average age of crabber</td>
</tr>
<tr>
<td>Years of crabbing experience</td>
</tr>
<tr>
<td>% income from other fishing</td>
</tr>
<tr>
<td><strong>Market channels:(percent)</strong></td>
</tr>
<tr>
<td>Hard crabs sold to picking house</td>
</tr>
<tr>
<td>Peeler catch sold to shedder</td>
</tr>
<tr>
<td>Hard crab catch for personal use</td>
</tr>
<tr>
<td>Peeler crabs for personal use</td>
</tr>
<tr>
<td><strong>Months Fished:(percent)</strong></td>
</tr>
<tr>
<td>March</td>
</tr>
<tr>
<td>April</td>
</tr>
<tr>
<td>May</td>
</tr>
<tr>
<td>June</td>
</tr>
<tr>
<td>July</td>
</tr>
<tr>
<td>August</td>
</tr>
<tr>
<td>September</td>
</tr>
<tr>
<td>October</td>
</tr>
<tr>
<td>November</td>
</tr>
</tbody>
</table>
2.22 Regional Variations

The population was divided into three regions based on their county of residence. 17.7 percent of the population was from region 1, 33 percent from region 2 and 11.7 percent from region 3. Table 4 summarizes some of the key characteristics of crabbers in each region. Crabbers in region 1 (Eastern Shore of Virginia) tend to have larger operations i.e., fish more pots and have larger vessels. They also tend to be younger than crabbers in regions 2 and 3. However, crabbers in region 3 (Southern Bay) tend to fish more in the early months, with almost 50 percent fishing in March, compared with 36 percent in region 1 and 26 percent in region 2. People in regions 2 and 3 tend to keep more of their catch for home use, than those in region 1. People in region 1 also derive more of their income from other fishing than those in regions 2 and 3, indicating that they tend to make most of their living from the water.

The difference among the three regions reflects 1) people on the Eastern Shore crab pot on a large scale, but also rely on other fisheries to provide income, 2) large peeler potters tend to be on the Eastern Shore and 3) potting in the early spring and late fall months appears to be influenced by region, with more potting done in the Southern Bay area mainly because of crab migration patterns and water temperature. The water in the South is warmer and crab potting can begin earlier in region 3 and last later into the fall than in regions 1 and 2.
<table>
<thead>
<tr>
<th></th>
<th>Region 1</th>
<th>Region 2</th>
<th>Region 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average hard crab pots fished</td>
<td>237.6</td>
<td>154.7</td>
<td>144.5</td>
</tr>
<tr>
<td>Average peeler pots fished</td>
<td>215.6</td>
<td>79.9</td>
<td>59.1</td>
</tr>
<tr>
<td>Hard pot days fished per season</td>
<td>22915</td>
<td>23013</td>
<td>21695</td>
</tr>
<tr>
<td>Peeler days fished per season</td>
<td>11847</td>
<td>1123</td>
<td>885.9</td>
</tr>
<tr>
<td>Average length of vessel</td>
<td>27.8</td>
<td>26.1</td>
<td>26.4</td>
</tr>
<tr>
<td>Average age of crabber</td>
<td>46.7</td>
<td>50.1</td>
<td>50.9</td>
</tr>
<tr>
<td>Years of crabbing experience</td>
<td>22.8</td>
<td>23.1</td>
<td>19.9</td>
</tr>
<tr>
<td>Percent of income from potting</td>
<td>55.8</td>
<td>54.8</td>
<td>46.4</td>
</tr>
<tr>
<td>Percent income from other fish.</td>
<td>22.3</td>
<td>14.5</td>
<td>13.8</td>
</tr>
</tbody>
</table>

**Market Channels:(percent)**

<table>
<thead>
<tr>
<th></th>
<th>Region 1</th>
<th>Region 2</th>
<th>Region 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard crabs to picking house</td>
<td>49.6</td>
<td>46.9</td>
<td>37.9</td>
</tr>
<tr>
<td>Peeler crabs to shedder</td>
<td>52.1</td>
<td>65.3</td>
<td>6.7</td>
</tr>
<tr>
<td>Hard crabs for personal use</td>
<td>0.9</td>
<td>3.5</td>
<td>14.9</td>
</tr>
<tr>
<td>Peeler crabs for personal use</td>
<td>4.7</td>
<td>12.9</td>
<td>23.3</td>
</tr>
</tbody>
</table>

**Months fished:(percent)**

<table>
<thead>
<tr>
<th></th>
<th>Region 1</th>
<th>Region 2</th>
<th>Region 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>36.1</td>
<td>25.8</td>
<td>49.1</td>
</tr>
<tr>
<td>April</td>
<td>69.9</td>
<td>61.3</td>
<td>75.5</td>
</tr>
<tr>
<td>May</td>
<td>90.4</td>
<td>87.7</td>
<td>92.4</td>
</tr>
<tr>
<td>June</td>
<td>85.5</td>
<td>94.8</td>
<td>90.6</td>
</tr>
<tr>
<td>July</td>
<td>68.7</td>
<td>91.6</td>
<td>92.4</td>
</tr>
<tr>
<td>August</td>
<td>62.6</td>
<td>89.0</td>
<td>92.4</td>
</tr>
<tr>
<td>September</td>
<td>60.2</td>
<td>84.5</td>
<td>84.9</td>
</tr>
<tr>
<td>October</td>
<td>53.0</td>
<td>70.3</td>
<td>69.8</td>
</tr>
<tr>
<td>November</td>
<td>40.9</td>
<td>42.6</td>
<td>54.7</td>
</tr>
</tbody>
</table>
2.23 Differences by Type of Firm

There are three types of firms - firms which both hard crab and peeler crab pot, firms which only hard crab pot, and firms which only peeler pot. The majority of commercial crabbers were hard potters only, making up 44 percent of the license holding population. Hard and peeler potting operations made up 13.4 percent of the population, while peeler potters made up only 6.6 percent of the population. Table 5 summarizes characteristics of each firm type.

On the average, those who only fished hard crab pots or peeler pots tended to fish these pots on more days than those who did both. Those who did both tended to be younger and have fewer years of experience than those who only did one type of potting. People who only peeler pot tended to fish in the months of May through August, while hard potters and those who did both tended to fish throughout the year. For hard crabs, those who both peeler and hard crab pot tend to keep more of their catch for home use, while those who only hard crab pot sell more of their catch to the picking houses. For peeler crabs, the opposite is true with those who both hard and peeler crab pot selling more of their catch to a shedder, while those who peeler pot only keep more of their catch for home use. Those who both hard and peeler crab pots also derive more of their income from other fishing than those who only hard crab or only peeler crab pot.
### TABLE 5 Characteristics of Crabbers by Firm Type

<table>
<thead>
<tr>
<th></th>
<th>Hard &amp; Peeler</th>
<th>Hard Only</th>
<th>Peeler Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average hard crab pots fished</td>
<td>159.2</td>
<td>176.4</td>
<td>n/a</td>
</tr>
<tr>
<td>Average peeler pots fished</td>
<td>134.4</td>
<td>n/a</td>
<td>178.7</td>
</tr>
<tr>
<td>Average length of boat</td>
<td>24.7</td>
<td>28.2</td>
<td>20.8</td>
</tr>
<tr>
<td>Hard pot days fished per season</td>
<td>18657</td>
<td>28297</td>
<td>n/a</td>
</tr>
<tr>
<td>Peeler days fished per season</td>
<td>11330</td>
<td>n/a</td>
<td>17621</td>
</tr>
<tr>
<td>Average age of crabber</td>
<td>45.3</td>
<td>49.9</td>
<td>52.4</td>
</tr>
<tr>
<td>Years of crabbing experience</td>
<td>19.1</td>
<td>22.9</td>
<td>24.9</td>
</tr>
<tr>
<td>Percent of income from potting</td>
<td>51.7</td>
<td>54.8</td>
<td>48.2</td>
</tr>
<tr>
<td>Percent income from other fish.</td>
<td>20.3</td>
<td>15.4</td>
<td>16.6</td>
</tr>
</tbody>
</table>

**Market channels:** (percent)

<table>
<thead>
<tr>
<th></th>
<th>Hard &amp; Peeler</th>
<th>Hard Only</th>
<th>Peeler Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard crabs to picking house</td>
<td>41.1</td>
<td>46.4</td>
<td>n/a</td>
</tr>
<tr>
<td>Peeler crabs sold to shader</td>
<td>56.3</td>
<td>n/a</td>
<td>46.4</td>
</tr>
<tr>
<td>Hard crabs for personal use</td>
<td>8.9</td>
<td>4.6</td>
<td>n/a</td>
</tr>
<tr>
<td>Peeler crabs for personal use</td>
<td>6.1</td>
<td>n/a</td>
<td>9.3</td>
</tr>
</tbody>
</table>

**Months fished:** (percent)

<table>
<thead>
<tr>
<th></th>
<th>Hard &amp; Peeler</th>
<th>Hard Only</th>
<th>Peeler Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>40.3</td>
<td>35.0</td>
<td>6.9</td>
</tr>
<tr>
<td>April</td>
<td>75.8</td>
<td>70.1</td>
<td>24.1</td>
</tr>
<tr>
<td>May</td>
<td>96.8</td>
<td>86.8</td>
<td>89.6</td>
</tr>
<tr>
<td>June</td>
<td>90.3</td>
<td>92.9</td>
<td>82.8</td>
</tr>
<tr>
<td>July</td>
<td>75.8</td>
<td>91.9</td>
<td>62.1</td>
</tr>
<tr>
<td>August</td>
<td>70.8</td>
<td>89.3</td>
<td>58.6</td>
</tr>
<tr>
<td>September</td>
<td>67.7</td>
<td>86.3</td>
<td>44.8</td>
</tr>
<tr>
<td>October</td>
<td>61.3</td>
<td>75.1</td>
<td>13.8</td>
</tr>
<tr>
<td>November</td>
<td>45.2</td>
<td>50.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>

35
2.3 Non-Commercial License Holders

The non-commercial crab pot sector consists of those who derive no income from potting. These people made up 32.6 percent of license-holders. The majority of these people do not sell any of their catch, but instead keep it for home consumption. A few non-commercial potters sell part of their catch to cover the expenses of potting.

Table 6 summarizes the characteristics of the non-commercial sector. Eighty-five percent of the non-commercial crabbers were people who hard crab potted only, with 7.5 percent hard and peeler crab potting, and 7.5 percent peeler crabbing only. Seventy-one percent of non-commercial crabbers came from region 2, with 21 percent from region 3, and 8 percent from region 1. Table 6 summarizes the characteristics of this large sector of the crab potting population. The average age of these crabbers is almost 60, indicating that many of these people may be retired. They fish only a couple days a week, and their years of crabbing experience range from 2 to 75 years. They also tend to crab in the summer months, with very few fishing in March and November.

On average, non-commercial crabbers kept 95 percent of their hard crab catch and 96 percent of their peeler crab catch for their own personal use. On average, they sold 3 percent of their of hard crab catch to picking houses and 2 percent of their peeler crab catch to a shedder.
<table>
<thead>
<tr>
<th>Characteristics of the Non-Commercial Sector</th>
<th>Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard crab pots fished</td>
<td>16</td>
</tr>
<tr>
<td>Peeler crab pots fished</td>
<td>10</td>
</tr>
<tr>
<td>Hard pot days fished per season</td>
<td>63</td>
</tr>
<tr>
<td>Peeler pot days fished per season</td>
<td>64</td>
</tr>
<tr>
<td>Age of crabber</td>
<td>59.5</td>
</tr>
<tr>
<td>Years of crabbing experience</td>
<td>19.7</td>
</tr>
</tbody>
</table>

Months fished:(percent)

<table>
<thead>
<tr>
<th>Month</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>2.8</td>
</tr>
<tr>
<td>April</td>
<td>19.4</td>
</tr>
<tr>
<td>May</td>
<td>54.9</td>
</tr>
<tr>
<td>June</td>
<td>87.5</td>
</tr>
<tr>
<td>July</td>
<td>93.8</td>
</tr>
<tr>
<td>August</td>
<td>88.2</td>
</tr>
<tr>
<td>September</td>
<td>76.4</td>
</tr>
<tr>
<td>October</td>
<td>35.4</td>
</tr>
<tr>
<td>November</td>
<td>6.3</td>
</tr>
</tbody>
</table>
2.4 Maryland Crab Potters

Three percent of the population were Maryland crabbers who crab potted in Virginia waters in 1992. Of these all were considered commercial. Table 7 shows a comparison between the Maryland and Virginia commercial crab pot sectors. The Maryland crabbers have larger scales of operation in both hard and peeler pot firm types. Maryland crabbers have larger vessels, more experience, and are younger than their Virginia counterparts. They also fish more months of the year. Maryland crabbers tend to keep less of their peeler and hard crab catch for home use than Virginia crabbers, but sell less of their hard crabs to picking houses, indicating that Maryland crabbers tend to use more alternative marketing channels for hard crabs. Maryland crabbers derive less of their income from other fishing than commercial potters in Virginia, indicating that they rely on crab potting for most of their income. These statistics reveal that while Maryland crabbers make up only a small percentage of Virginia crab pot license holders, they may be taking a significant portion of the commercial harvest.
<table>
<thead>
<tr>
<th></th>
<th>Maryland</th>
<th>Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average hard crab pots fished</td>
<td>360.4</td>
<td>168.8</td>
</tr>
<tr>
<td>Average peeler pots fished</td>
<td>206.0</td>
<td>146.4</td>
</tr>
<tr>
<td>Total hard pot days fished</td>
<td>45647.0</td>
<td>22731.7</td>
</tr>
<tr>
<td>Total peeler pot days fished</td>
<td>8242.0</td>
<td>4070.6</td>
</tr>
<tr>
<td>Length of crabbing vessel</td>
<td>37.9</td>
<td>26.5</td>
</tr>
<tr>
<td>Age of crabber</td>
<td>45.7</td>
<td>49.7</td>
</tr>
<tr>
<td>Years of crabbing experience</td>
<td>28.9</td>
<td>22.4</td>
</tr>
<tr>
<td>% income from other fishing</td>
<td>10.3</td>
<td>17.4</td>
</tr>
</tbody>
</table>

**Market Channels:(percent)**

<table>
<thead>
<tr>
<th></th>
<th>Maryland</th>
<th>Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard crabs sold to picking house</td>
<td>31.1</td>
<td>45.5</td>
</tr>
<tr>
<td>Peeler crabs sold to a shedder</td>
<td>89.7</td>
<td>51.7</td>
</tr>
<tr>
<td>Hard crabs for personal use</td>
<td>0.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Peeler crabs for personal use</td>
<td>0.7</td>
<td>7.6</td>
</tr>
</tbody>
</table>

**Months fished:(percent)**

<table>
<thead>
<tr>
<th></th>
<th>Maryland</th>
<th>Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>40.0</td>
<td>32.2</td>
</tr>
<tr>
<td>April</td>
<td>80.0</td>
<td>66.1</td>
</tr>
<tr>
<td>May</td>
<td>100.0</td>
<td>89.7</td>
</tr>
<tr>
<td>June</td>
<td>86.7</td>
<td>91.7</td>
</tr>
<tr>
<td>July</td>
<td>86.7</td>
<td>85.7</td>
</tr>
<tr>
<td>August</td>
<td>80.0</td>
<td>82.1</td>
</tr>
<tr>
<td>September</td>
<td>73.3</td>
<td>77.7</td>
</tr>
<tr>
<td>October</td>
<td>66.7</td>
<td>65.1</td>
</tr>
<tr>
<td>November</td>
<td>53.3</td>
<td>43.5</td>
</tr>
</tbody>
</table>
2.5 Transient and Permanent Watermen

The main objective of the 1991 entry/exit survey was to determine if there were significant differences between those who crabbed on a transient basis (only one year) and those who crabbed on a more permanent basis (two years). Preliminary analyses showed no major differences between those who only crabbed in 1989 and those who only crabbed in 1990. Therefore further analysis was done, combining the crabbers who held a license in only one of the two years into one group (labelled transients) and those who crabbed in both years into another group (labelled permanent). Table 8 presents comparisons between the two groups.

The people who stayed in the fishery through 1989 and 1990 earned more of their income from fishing than the others. They were also more likely to have fishing as their only employment. They had larger boats and tended to fish in more months than the transients, especially in the months of March, October, and November. They fished a significant amount more of hard crab pots and peeler pots, and also fished these pots more days per season. They sold more of their catch to picking houses, indicating that they were less apt to be recreational crabbers. More of the those who stayed in the fishery planned to continue fishing in 1991, and more also planned to fish in 1992.
<table>
<thead>
<tr>
<th></th>
<th>Transient</th>
<th>Permanent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average hard crab pots fished</td>
<td>88.0</td>
<td>125.1</td>
</tr>
<tr>
<td>Average peeler pots fished</td>
<td>108.6</td>
<td>139.1</td>
</tr>
<tr>
<td>Total hard pot days fished</td>
<td>5375.4</td>
<td>12246.8</td>
</tr>
<tr>
<td>Total peeler pot days fished</td>
<td>2734.4</td>
<td>4953.6</td>
</tr>
<tr>
<td>Length of crabbing vessel</td>
<td>21.1</td>
<td>23.4</td>
</tr>
<tr>
<td>Average age of crabber</td>
<td>46.9</td>
<td>51.7</td>
</tr>
<tr>
<td>Years of crabbing experience</td>
<td>14.8</td>
<td>22.3</td>
</tr>
<tr>
<td>No non-fishing employment</td>
<td>19.8</td>
<td>35.0</td>
</tr>
<tr>
<td>Catch sold to picking houses</td>
<td>27.5</td>
<td>37.8</td>
</tr>
</tbody>
</table>

Months fished:(percent)

<table>
<thead>
<tr>
<th></th>
<th>Transient</th>
<th>Permanent</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>13.2</td>
<td>25.4</td>
</tr>
<tr>
<td>April</td>
<td>33.0</td>
<td>49.7</td>
</tr>
<tr>
<td>May</td>
<td>59.5</td>
<td>70.3</td>
</tr>
<tr>
<td>June</td>
<td>73.3</td>
<td>81.1</td>
</tr>
<tr>
<td>July</td>
<td>71.7</td>
<td>76.5</td>
</tr>
<tr>
<td>August</td>
<td>69.0</td>
<td>74.3</td>
</tr>
<tr>
<td>September</td>
<td>52.1</td>
<td>65.2</td>
</tr>
<tr>
<td>October</td>
<td>24.2</td>
<td>40.4</td>
</tr>
<tr>
<td>November</td>
<td>10.6</td>
<td>23.5</td>
</tr>
</tbody>
</table>
A total of 576 people left the fishery in 1989 out of a total population of 2550. This translates into 22.6 percent of the population leaving. In order to determine exactly who these people were, they were characterized in the same manner as the commercial fishermen from the 1992 survey (see Appendix B). The only difference in this classification was that part, full-time, and noncommercial crabbers were defined by number of pot days fished rather than percent of income from fishing. The following distribution of pot days fished was used:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noncommercial</td>
<td>less than 11,700 pot days fished per season</td>
</tr>
<tr>
<td>Part-time</td>
<td>between 11700 and 23500 pot days fished</td>
</tr>
<tr>
<td>Full-time</td>
<td>23500 or more pot days fished</td>
</tr>
</tbody>
</table>

The classification of the transient crab potters is given in Appendix B-2.

2.6 Concentration in Blue Crab Processing Industry

Chapter 1 pointed out that many watermen fear there is price fixing in the processing sector because the large picking houses may have a monopsony on the buying of small crabs, i.e., they are the only buyers. The economic theory of monopsony demonstrates that this type of system will lead to depressed quantities bought and prices paid. Many watermen are convinced that large picking houses confer each day to set the prices for buying crabs. They cite as evidence that prices rarely vary from one picking house to another on a given day. Also, it is true, that since the late 70s, the number of picking houses has declined steadily and the
possibility of collusion for price setting may be enhanced. Data on blue crab processing plants in Virginia were obtained from the Shellfish Sanitation Division of the Virginia Department of Health. These records provided the number of licensed pickers in each processing plant from 1987 to 1992. Table 9 shows the concentration of firms in 1987 and 1992, measuring market concentration as the number of licensed pickers in each firm. In 1992, 12 firms out of 42 had 60 percent of the pickers. This is in contrast to 1987 when 12 firms out of 69 had 51.6 percent of the pickers.
TABLE 9 Concentration of Virginia Blue Crab Processing Firms

<table>
<thead>
<tr>
<th>Number of firms</th>
<th>1987 (percent of pickers)</th>
<th>1992 (percent of pickers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>23.1</td>
<td>26.1</td>
</tr>
<tr>
<td>8</td>
<td>38.5</td>
<td>45.5</td>
</tr>
<tr>
<td>12</td>
<td>51.6</td>
<td>60.0</td>
</tr>
<tr>
<td>Total Firms</td>
<td>69</td>
<td>42</td>
</tr>
</tbody>
</table>

Source: Virginia Department of Health, Shellfish Sanitation Division
There is also some concern that there may be monopsonies by location. To consider this possibility of increasing market concentration, the processing firms were divided into four regions. Region 1 comprised the counties of Westmoreland, Northumberland, Richmond and Lancaster. Region 2 was the counties of Middlesex, Mathews, Gloucester, King and Queen, and Essex. Region 3 was the counties of York, James City, and the cities of Poquoson, Hampton, Newport News, Norfolk, Portsmouth, and Virginia Beach. Region 4 was the Eastern Shore of Virginia, the counties of Accomac and Northampton. The main concern voiced by crabbers is that Region 3, especially in the area of Newport News and Hampton, has gained more market power. Figure 4 shows the concentration of picking houses by region for 1987 and 1992. The numbers shown are the percent of total licensed pickers in Virginia which each region had in 1987 and in 1992. While Region 3 has gained some concentration, along with Region 4, there has not been that substantial of a loss of concentration from Region 1, but Region 2 has lost a little over 5 percent of the market share.
Figure 4 - Concentration of Processing Firms by Region

Source: Virginia Department of Health, Shellfish Sanitation Division
Processors, however, argue that the prices they offer the watermen are dictated by retail demand, and that they face increasing competition from blue crabs processed in Mexico and Louisiana (Casey, 1992). Exvessel prices appear to be a function of wholesale prices less a processing margin.

Price trends reveal that wholesale and exvessel prices tend to follow each other closely. There is no evidence, over the last ten years, that the processor's gross marketing margin has increased, in real dollars. Figure 5 shows the trend in the gross monthly processing margin (the difference between real wholesale and exvessel prices) over the last 10 years. While there is a seasonal nature to the processing margin, there has been no upward trend in it. Therefore, although there may be more concentration within the processing industry than there has been in the past, these trends suggest that this concentration has not been used to increase the wholesale-exvessel price margin.

One possible explanation for the stability of the processing margin is that picking houses are only one of many markets for live crabs. Therefore, even with higher concentration levels, the picking houses still have to compete with other market channels. Chapter 1 pointed out that while most of the smaller crabs must go through the picking houses, there are more marketing options for the larger crabs. Watermen may retail their crabs live or steamed. Figure 6 shows that over the last decade, the number of seafood buyers operating from a boat or truck has increased, while the number of those operating from a specific location has declined.
Figure 5 - Wholesale-Exvessel Price Margin for Hard Blue Crabs

Source: National Marine Fisheries Service
Figure 6 - Virginia Seafood Buyer Licenses

Source: Virginia Marine Resources Commission
In the survey done for this study, questions were asked about what percent of the crabber's catch went to alternative marketing channels. The results of these questions are shown in Table 10. This table gives the average percent of catch that went to each marketing channel by full-time and part-time firms. While the majority of the full-timers hard crabbers' catch still goes to picking houses, a substantial portion of the catch is being sold to outlets other than the picking houses. Over 40 percent of full-timers' peeler crab catch is going directly to retail or wholesale markets.

The data in Table 10 also suggest that exvessel prices, which are currently reported as averages from the large picking houses, may not accurately represent the price that the waterman receives. Anecdotal data suggests that while picking house prices may correctly represent the prices crabbers receive for their smaller (#2) crabs, the prices for the larger (#1) crabs appears to be two to three higher than the prices of the #2 crabs. #1 crabs comprise approximately one-third of a crab potter's daily catch. However, there are no data on prices in alternative marketing channels nor any time series on the percent of catch going to each marketing channel.
### TABLE 10 Marketing Channel Results - 1992 Survey

<table>
<thead>
<tr>
<th>MARKETING CHANNEL</th>
<th>PERCENT OF CATCH SOLD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Part-Time</td>
</tr>
<tr>
<td>Hard crabs:</td>
<td></td>
</tr>
<tr>
<td>Picking house</td>
<td>29.8</td>
</tr>
<tr>
<td>Live, not picking house</td>
<td>43.1</td>
</tr>
<tr>
<td>Steamed</td>
<td>4.5</td>
</tr>
<tr>
<td>Picked meat</td>
<td>.83</td>
</tr>
<tr>
<td>Personal Use</td>
<td>13.4</td>
</tr>
<tr>
<td>Retail/Wholesale Market</td>
<td>8.37</td>
</tr>
<tr>
<td>Soft crabs:</td>
<td></td>
</tr>
<tr>
<td>Shedder</td>
<td>44.6</td>
</tr>
<tr>
<td>Fishing Bait</td>
<td>15.4</td>
</tr>
<tr>
<td>Personal Use</td>
<td>19.7</td>
</tr>
<tr>
<td>Retail/Wholesale Market</td>
<td>20.3</td>
</tr>
</tbody>
</table>
2.7 Summary

This chapter examined some of the differences among various sectors of the crab pot license-holding population. Some important conclusions to emerge from this analysis are:

1) Non-commercial crabbers comprise over 30 percent of the license-holding population.
2) Larger commercial crab potting operations seem to be prevalent among younger crabbers.
3) Watermen who come from Maryland to crab pot in Virginia waters may be taking a significant portion of the Virginia blue crab commercial harvest.
4) People who buy their crab pot licenses every year tend to be larger operators than those who get in and out of the fishery.
5) There is evidence of increasing concentration in the blue crab processing sector, but no evidence that this concentration has led to a higher processing margin. This may be due to the presence of alternative marketing channels for blue crabs.

The next chapter examines the economic theory used to build the simulation models of Chapter 4.
CHAPTER THREE - AN INDUSTRY MODEL FOR POLICY ANALYSIS

This chapter describes the economic theory used to model costs and revenues for the fishery in Chapter 4. The factors which contribute both to harvest and net revenue in the fishery are examined and a general outline of alternative policy scenarios is discussed.

3.1 Revenue Flows

Figure 7 shows the flows of costs and revenues that contribute to net income for the individual crab potting firm and the crab potting industry as a whole. Exvessel price is exogenously determined for the individual firm, but at the industry level, total harvest will affect price determination (See Chapter 4). Total revenue is equal to exvessel price multiplied by the amount of crabs harvested, which will be a function of fishing effort for the individual firm, but at the industry level will also be affected by the blue crab population size.

Total costs are made up of both fixed and variable costs. Fixed costs are those which the firm faces whether or not it crabs on a given day. Variable costs are the costs of fishing inputs such as pots, bait, fuel, and labor. An important consideration in this fishery is that these variable inputs are not highly substitutable within an individual firm, but can be substituted (to a certain degree) within the industry. This implies that some of the inputs must be used in a fixed proportion, i.e., if a person decides to fish one more pot then they must use some amount of additional labor to fish the pot, a fixed amount of additional bait to put in the pot,
and some amount of additional fuel to get their boat to the pot.

Fishing a pot more than once a day will not generally produce more crabs than fishing it only once a day. The use of more bait per pot will also not significantly increase returns to effort. There is some possibility for substitution between labor and pots in that a person may choose to fish less pots and extend the number of days on which he pots. This possibility is limited, however, not only by the closed season on potting, but also by the seasonal nature of crab landings. Therefore an individual waterman cannot usually substitute inputs on a large scale, but must either contract or expand the size of his operation, which is best represented by pot days fished.

The substitution of pots for labor is more possible within the industry as a whole. For example, if the labor supply is limited in the fishery by regulation, the people who remain may fish more pots (ie, expand the size of their operation). This same effect will occur if the number of pots per person is limited. More people will enter the fishery if they find the opportunity cost of fishing to be acceptable. This idea will be explored further as the dynamic implications of the simulation model are discussed in Chapter 6.
Figure 7 - Net Revenue Flows for the Individual Firm and the Industry
3.2 Net Returns

The main purpose of this study is to examine the effects of alternative management policies on the net revenues of watermen. In order to accomplish this objective, net revenue to the watermen will be modeled so that it is possible to trace through all the possible impacts of a specific policy. Policies may affect supply, demand, prices, cost structure of the firm, and/or size of the firm.

Net revenue to the individual fishing firm, is defined by,

\[
\text{Net Revenue} = Pq - C \quad (1)
\]

where \( P \) is the price of the output, \( q \) is the quantity of output, and \( C \) is total costs. The net revenue that is estimated will be only for the crab potting enterprise of an individual fishing firm. If a firm derives revenue from a source outside of crab potting, this revenue will not be included, but some share of fixed costs will be allocated to other fishing enterprises.

A firm may peeler pot, hard crab pot or both. Equation (1) then becomes,

\[
\text{Net Revenue} = \{ P_{hc}q_{hc} - C_{hc} \} + \{ P_{pc}q_{pc} - C_{pc} \} \quad (2)
\]

where \( hc = \) hard crabs and \( pc = \) peeler crabs\(^3\).

\(^3\) The terms peeler and soft crabbing will be used throughout this study. Peelers are the crabs that are actually caught by the waterman, while soft crabs are the product sold on the retail and wholesale markets.

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Peeler and hard crab operations will have different price formation processes, different catch patterns, and varying cost structures.

3.3 Price Determination

The prices to be estimated in this study are the exvessel prices the waterman receives for his crabs at the dock. The crab fishery is fairly unique in that its product is highly perishable - i.e., the crabs must be sold within hours of harvesting or, if they die, they are no longer a processable good. This leads to a short-run supply curve that is vertical, as shown in Figure 8. In the long run, however, supply can adjust to changes in prices offered, opportunity costs of harvest labor, and the costs of fishing.

Demand at the processor level is influenced by retail prices, wholesale prices, supply of hard crabs, seasonal factors, and input prices. Other input prices may include labor and capital costs in the processing plant. Exvessel price formation is the key question in this study, and is represented by the following equation:

\[ P_{ex} = g(\text{quantity crabs}_{harvested}, \text{wholesale prices, retail prices, season}) \]  \hspace{1cm} (3)

Quantity is assumed to have inverse effect on price, while wholesale prices will have a positive effect. The seasonal effect will vary (see Chapter 4), while costs will have an inverse effect.
Figure 8 - Short-Run Supply Curve
3.4 Bio-Economic Relationships

Effort is defined in two ways. Nominal fishing effort refers to the volume of resources devoted to fishing, quantified either as monetary or physical units. Effective fishing effort is used by biologists to refer to fishing mortality, usually measured as the biomass of fish extracted by fishing, expressed as a proportion of the mean population (Cunningham, 1985). In this study, all references to effort will be to nominal fishing effort, which will mainly be defined as pot days fished, but may also include other variables such as bait and labor. Pot days fished is the number of pots fished each day multiplied by the number of days fished. Again, there will be limited possibilities of substitution among inputs for the individual firm, but these possibilities will increase for the fishery as a whole.

Production, in fisheries, is a combination of biological and economic factors. Fisheries are renewable resources, meaning that the stock size may be increased as well as decreased by general environmental factors and harvest levels (Pearce and Turner, 1991). In particular, harvest in time period \( t \) influences harvest in time period \( t+1 \). Design of management policies, therefore, requires a basic understanding of the population dynamics of the fishery.

Many economic analyses of fisheries begin with the assumption that the population dynamics of a fish species are characterized by a Schaefer stock-recruitment curve. This biological theory assumes that the growth of the fish stock measured in weight is a function of its size in weight. In the long run, this
relationship allows for a constant maximum sustainable yield (MSY), which is the highest level of harvest that can be taken each period without negatively affecting the size of the population.

One of the major assumptions of the model is that harvest in one period affects harvest in the next period. This model may be appropriate in a fishery where environmental changes do not have a large influence on the fish population. The blue crab fishery, however, is highly influenced by its marine environment. The population is usually dependent upon certain ecological conditions during critical phases of its life cycle and bears little relation to the population size of the previous generation.

In 1985, Willard Van Engel, professor Emeritus at VIMS, summed up the current thought on blue crab dynamics:

There is no evidence of any long-term change in the number of blue crabs in the Bay. Although the commercial catch varies from season to season and year to year, these variations result from short-term changes in the quality of the environment. Water, temperature, salinity, dissolved oxygen, the quality and quantity of food affect reproduction, growth, and the rate of survival of every stage in the crab's development. [VIMS bulletin, 1985]

A 1992 publication from the Chesapeake Bay Program reported that the only attempt made to directly assess the size of the female spawning stock of blue crabs demonstrated a year-to-year variability of nearly 80 percent (Rickhus et al., 1992). This emphasizes the importance of accurately modeling the population dynamics of
the blue crab. Attempts at this have been made. Some authors have found a
spawner/recruit model (like the Schaefer model) to be inappropriate because of the
overwhelming importance of the physical environment in determining recruitment

Some models based on the Schaefer analysis have suggested the MSY for blue
crabs in the Chesapeake Bay to be between 69 and 77 million pounds. Landings in
the Bay in the 1980s were consistently larger than these numbers, indicating either
that the stock is ready to collapse or that these MSY estimates are inappropriate for
the fishery. Rickhus et al. conclude that more work is needed to obtain more
accurate stock assessments of the blue crab population (Rickhus et al., 1992).

The early 1992 season was characterized by low rates of harvest and small
crabs (minutes, Blue Crab Subcommittee, 1/93). Some concerns were raised by
watermen and Chesapeake Bay managers about harvest pressures on the population.
VIMS scientists have cited a drop in the natural cycle of the crab larvae, along with
weather patterns and currents at the mouth of the Bay, as the key factors in the low
catches. There is still some concern, however, that increased harvesting pressures in
recent years is responsible for the decreased catch.

For this study, the blue crab fishery will be assumed to be a density
independent stock, meaning that growth levels are not affected by harvest levels in
previous time periods. This assumption is consistent with most of the scientific
literature, which stresses environmental factors over human factors in blue crab
population determination. It also is an acceptable assumption for the single year focus of this study. Harvest, therefore, will become a direct function of effort and the population level in any given year.

In *The Economics of Fishery Management* (1986), Anderson points out that the "independence of population size from the level of effort precludes any long-run equilibrium position." This occurs because the optimal effort for any period is the place where the difference between the annual revenue and annual harvesting costs is maximized, and this point will shift from period to period with changes in the population size (Anderson, 1986). Population size, however, is not a constant. It is a function of various environmental factors. The population size will fluctuate from year to year, but will not depend on the harvest level. It is, therefore, treated as an exogenous variable in the model. As effort increases on a fixed stock, returns to effort may tend to diminish.

Graphically, Figure 9 shows production functions for different stock sizes, where CC represents the maximum carrying capacity of the environment and 3 is the largest possible stock size (Cunningham, 1985). The idea of diminishing returns is represented by the concave shape of the productions function.
Figure 9 - Effort-Yield Functions
3.5 Property Rights, Common Property, and Economic Returns

Another important aspect of the fishery is the issue of property rights. The blue crab fishery, like many others, is a common property resource, one that is not exclusively controlled by a single agent or source (Tietenberg, 1992). The blue crab fishery is not completely an open access system, where no one owns the resource and access is open to all. While no one owns the blue crab resource, access is limited by the laws that govern the fishery (see 1.6) and by the skills of the watermen. Crabbers must also be licensed by the state, there is a closed season on crab potting, and there are catch limits at certain times of the year to limit effort.

Total costs of effort, for the blue crab fishery, will be increasing due to the differences in skills of the watermen. Since there are various degrees of skill, as less skilled labor enters the fishery, the cost of supplying extra effort increases because more non-labor inputs must be used with each unit of labor (Anderson, 1986). Also costs can be increasing because the opportunity cost of crabbing labor is rising.

Figure 10 is a general representation of industry harvest equilibrium for Virginia's blue crab fishery. In Panel A, ES is the supply response for effort function, which is upward sloping, indicating that effort enters the fishery in response to expectations that the return to effort will equal or exceed the cost of effort. \( MRP_e \) and \( ARP_e \) are, respectively, the marginal and average revenue products of effort, which are the marginal and average products of effort times the dockside price of
Figure 10 - Sole Owner and Open Access Equilibriums
blue crabs. These curves are negatively sloped, suggesting that the marginal and average products of effort decline with increasing levels of effort.

In a sole owner fishery, equilibrium effort occurs where $\text{MRP}_e = \text{ES}$, point $E_{sol}$. At this point the owner is deriving rent to the ownership of the rights to fish (resource rent) of ABFH. He is paying out rent of FGHE$_{sol}$ to those who work in the fishery.

In an open access fishery the crab stocks are unowned and there is unrestricted entry of fishing effort. Harvest costs will vary across fishermen using identical levels of effort and all of the resource rent will be dissipated to the point where $\text{ARP}_e = \text{ES}$, point $E_{oa}$. At this point factor rent is GCE and this rent accrues to the more highly skilled fishermen who have low cost curves. The rent derived under an open access system (GCE) is less than the rent derived under the sole owner regime (ABFH + GFH), which indicates that financial returns to the industry are lower in an open access system.

In Panel B of Figure 10 the total product of effort ($\text{TRP}_e$) is shown. Harvest increases at a decreasing rate with effort. The sole owner effort level results in a harvest level of $H_{sol}$, while the open access effort level results in a higher harvest level of $H_{oa}$. Panel C is an inverse demand function, suggesting that increases in harvest levels will reduce exvessel prices. The sole owner harvest level results in price $P_{sol}$ which is higher than $P_{oa}$, the price resulting from the open access harvest level. The main reason prices are lower in an open access system is the higher
harvest levels caused by the additional effort of the marginal firms who come into the fishery when access is not limited. These marginal firms, with higher cost curves than others in the fishery, bring in additional harvest which depresses prices, and therefore income, for the entire fishery. The average firm, therefore, is worse off under open access than under a sole owner regime.

Open access systems, therefore, tend to result in higher effort and harvest levels and lower price levels than sole owner regimes. The objectives of many fishery management policies are to keep effort and/or harvest levels from being too high and endangering the fish stock. As a consequence, restricting effort may raise industry and firm level incomes. These types of policies will also affect the incomes of the people in the fishery. The next section examines the possible income effects of alternative policy actions. These effects will be estimated in Chapter 5.

3.6 Theorized Income Effects

Chapter 1 pointed out that most of the concerns about the Virginia blue crab fishery center on overharvesting and low incomes. Many fishery management policies must make a tradeoff between these two goals, because lower harvest levels often imply lower incomes for at least some of the people in the fishery. Higher incomes often imply higher harvest levels. It is possible to lower harvest levels and raise incomes by limiting access to the fishery, which brings the fishery closer to the effort, harvest, and price levels of a sole owner regime.
The models shown in Figure 7 illustrate how certain factors influence net revenue both for the individual crab potting firm and for the industry as a whole. If the fishery management objective is to raise net revenue to watermen, then policies must be targeted to increasing the price paid to harvesters or to lowering harvest costs per unit of catch. There may be other management objectives, such as maintaining a certain population, redistributing factor rents, or increasing recreational opportunities.

There are three basic policy approaches to increasing industry net revenue. One is to increase the marginal and/or average product of labor. The second is to lower the relative costs of inputs, and the third is to increase the prices paid to the watermen. Each policy action will have effects on one or more of these areas, either directly or through second-round effects.

Generally policies can restrict either inputs or the output of a firm. Restrictions on inputs include decreased labor, gear limits, and closed seasons. Output restrictions are generally quotas, which can be implemented in many different ways. A quota which restricts how much a firm can catch allows the firm to choose how it will change its input combination to achieve a lower output level.

An important distinction must be made between policy effects on the individual firm and effects on the industry as a whole. Section 3.1 suggested the limited possibilities for input substitution within the individual firm, but that these possibilities will expand for the industry. The consequence of these characteristics
is that while one waterman may be unable to compensate (by input substitution) for restrictions placed on his effort, the industry can compensate for this effect. The importance of this will become apparent as the dynamic effects of alternative policy actions are assessed in Chapter 6.
CHAPTER 4 - THE SIMULATION MODEL

4.1 Introduction

In order to predict the net income effects of alternative policy actions, a series of interactive models must be built. These include price prediction models, physical equations of the production processes, and cost equations. The integrated simulation model may be viewed as a large spreadsheet with many cells, each of which contribute in some way to the overall calculation of net revenue levels for the individual firm. Figure 11 is a schematic representation of the model, showing all the individual calculations that go into a firm's net revenue.

Annual net revenue for the firm is equal to total annual revenue less total annual costs. Total annual revenue for the crab potting enterprise is equal to the sum of monthly revenues, which are the product of monthly exvessel prices and monthly firm harvest. The individual firm is a price taker, with exvessel prices determined by industry harvest levels and other exogenous factors. Harvest levels are determined by a combination of inputs, chief of which are the number of pot days fished by the firm. Total annual costs are the sum of monthly variable costs and annual fixed costs. Variable cost levels are also dependent on the number of pot days fished per month, as fuel, bait, and labor costs increase as pot days fished increases. Fixed costs are not dependent on input levels, but must be paid annually by the firm. The numbers in Figure 11 correspond to the sections of the Chapter which discuss the data and procedures used to build that part of the integrated model.
Figure 11 - Net Revenue Flows for the Blue Crab Industry
4.2 Total Revenue

4.2.1 Price Formation

4.2.1.1 Hard Crab Prices

Historically studies of blue crab prices have used a standard demand function, modelling quantity consumed as a function of prices and income. Two of these studies include one done by the National Marine Fisheries Service (NMFS) in 1973 for all crabs and one done by Dressel and Whitaker in 1982 for blue crabs. The NMFS study has an exvessel price elasticity of demand for all types of crabs equal to -.3, which implies that there is a significant inverse relationship between quantity consumed of all crabs (which is generally equal to quantity harvested) and exvessel prices. The Dressel and Whitaker study had a retail price elasticity for blue crabs equal to -.6. This finding demonstrates that there is a significant inverse relationship between retail blue crab prices and blue crab consumption. While these studies are important as indicators of possible relationships between prices and quantity, neither one gives any measure of the specific correlation between blue crab exvessel prices and quantity harvested. These studies also suggest that retail price may have a larger effect on consumption than exvessel price.

One missing element of the above studies is the analysis of seasonal variations. Those studies were based on annual rather than monthly data. There are seasonal fluctuations in both landings and prices in the blue crab industry. This is most important for hard crabs which have a limited shelf life. Stock supply, therefore, is
dependent on landings. Prices for hard crabs tend to be lower in the late summer and early fall, when the harvest of crabs is at its highest. Figure 12 shows the seasonal variation in prices and landings for hard blue crabs in 1990. Soft crab prices are less variable as they are usually frozen and have a longer shelf life.

One study which did address the question of seasonality was done by Hudson and Capps in 1984. They estimated a monthly exvessel price formation equation for Chesapeake Bay hard crabs for the period January 1973 to July 1979. Their equation forecasted monthly exvessel price as a function of monthly landings, monthly retail and wholesale prices, and season of the year. Their results indicate that harvest levels do not have a significant impact on exvessel price. Their results also confirm that prices tend to be higher in the winter and spring and lower in the fall. Wholesale and retail prices were significant estimators of exvessel prices, suggesting that the three sets of prices tend to follow each other.

The main purpose of the estimated price equation is to establish the nature of the relationship between harvest levels and exvessel price at the processing level, i.e., will decreases in harvest levels have a significant effect on price? Consequently the model be an inverse demand function, estimating hard crab exvessel price as a function of landings and other variables. Because of the seasonal nature of crab landings and of hard crab prices, the equation will be evaluated on a monthly basis.
Figure 12 - Seasonal Index of Hard Blue Crab Exvessel Prices

Source: National Marine Fisheries Service
An econometric model will be used despite the fact that Hudson and Capps concluded "generally speaking, it would appear that exvessel prices for hard crabs possess strong time dependencies, and consequently, better forecasts occur with time-series models than with econometric models." The time series models they recommend are not suited for testing the effects of alternative management policies and the harvest effect on price, which are the foci of this study.

The empirical model for hard crab price formation has the following form:

\[
\text{PHC}_{\text{ex(t)}} = \text{B}_0 + \text{B}_1(\text{CBL}_{(t)}) + \text{B}_2(\text{WPHC}_{(t)}) + \text{B}_3(\text{JAN}) + \text{B}_4(\text{FEB}) + \text{B}_5(\text{MAR}) + \text{B}_6(\text{APR}) + \text{B}_7(\text{MAY}) + \text{B}_8(\text{JUN}) + \text{B}_9(\text{AUG}) + \text{B}_{10}(\text{SEP}) + \text{B}_{11}(\text{OCT}) + \text{B}_{12}(\text{NOV}) + \text{B}_{13}(\text{DEC})
\]

Where \( \text{PHC}_{\text{ex(t)}} \) = exvessel price of hard blue crabs in month \( t \)
(dollars per pound of meat)

\( \text{CBL}_{(t)} \) = Chesapeake landings of hard blue crabs in month \( t \)
(Maryland and Virginia landings, 10 pound units)

\( \text{WPHC}_{(t)} \) = Wholesale price of blue crab meat in month \( t \)
(special grade, dollars per pound of meat, New York)

\( \text{JAN} = \)  
\( \text{FEB} = \)  
\( \text{MAR} = \)  
\( \text{APR} = \)  
\( \text{MAY} = \)  monthly dummy variables  
\( \text{JUN} = \)  variable = 1 for month = \( t \), else variable = 0  
\( \text{AUG} = \)  
\( \text{SEP} = \)  
\( \text{OCT} = \)  
\( \text{NOV} = \)  
\( \text{DEC} = \)
The model was estimated over the period January 1981 to December 1991. Based on demand theory and previous studies, the price offered to the watermen is hypothesized to vary inversely with landings and the sign on B1 is hypothesized to be negative. The wholesale price, which represents demand by retailers, is hypothesized to have a positive effect on exvessel price, and the sign on B2 is hypothesized to be positive. Because exvessel prices are assumed to be reflections of the demand for hard crabs at the processor level, it is hypothesized that this demand is seasonal. Demand for crabs will be highest in the summer. Therefore, the signs on B3 to B7 and B10 to B13 are hypothesized to be negative, as the demand will be lower in the winter, spring, and fall as compared with the base summer month of July. The signs on B8 and B9, which represent the summer months of June and August will be indeterminate, as they will not vary much from July demand.

The model was estimated as a log-log function. The results of the regression are shown in Table 11. These results generally conform with theoretical expectations. The only months that were not significantly different from July were May, June, and August. All of the other parameters on the monthly indicators were negative, indicating that processor demand peaks in the summer months. There is also a significant inverse relationship between exvessel price and quantity of crabs harvested. The Durbin-Watson statistic is 1.3, indicating the presence of some serial autocorrelation, but it is not a significant problem.
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>PARAMETER ESTIMATE</th>
<th>P-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.48547</td>
<td>.0001</td>
</tr>
<tr>
<td>Log(WPHC)</td>
<td>.709460</td>
<td>.0001</td>
</tr>
<tr>
<td>Log(CBL)</td>
<td>-.245482</td>
<td>.0001</td>
</tr>
<tr>
<td>JAN</td>
<td>-.666554</td>
<td>.0001</td>
</tr>
<tr>
<td>FEB</td>
<td>-.716764</td>
<td>.0001</td>
</tr>
<tr>
<td>MAR</td>
<td>-.832313</td>
<td>.0001</td>
</tr>
<tr>
<td>APR</td>
<td>-.283713</td>
<td>.0031</td>
</tr>
<tr>
<td>MAY</td>
<td>-.020727</td>
<td>.7919</td>
</tr>
<tr>
<td>JUN</td>
<td>.095942</td>
<td>.1597</td>
</tr>
<tr>
<td>AUG</td>
<td>-.082890</td>
<td>.2148</td>
</tr>
<tr>
<td>SEP</td>
<td>-.362773</td>
<td>.0001</td>
</tr>
<tr>
<td>OCT</td>
<td>-.574558</td>
<td>.0001</td>
</tr>
<tr>
<td>NOV</td>
<td>-.674288</td>
<td>.0001</td>
</tr>
<tr>
<td>DEC</td>
<td>-.895759</td>
<td>.0001</td>
</tr>
</tbody>
</table>

r-Squared = .8360  
Adjusted r-Squared = .8142 
D-W statistic = 1.3
The flexibility of exvessel price in this model is equal to .245, indicating that a ten percent decrease in quantity will cause a 2.45 percent increase in exvessel price. The wholesale price elasticity of exvessel price is equal to .709, indicating that a ten percent increase in wholesale price will cause a 7.1 increase in exvessel price.

Table 12 reports the intercept variables for each month. These were obtained by adding the parameter estimates on the monthly variables to the intercept term. From these results, it appears that, all other factors equal, the prices offered for hard blue crabs is lowest in December, followed by March and February. Processor price offers are highest in the months of May through August, followed by April and September.
### TABLE 12 Intercept Variables for Each Month

<table>
<thead>
<tr>
<th>Month</th>
<th>Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2.82</td>
</tr>
<tr>
<td>February</td>
<td>2.77</td>
</tr>
<tr>
<td>March</td>
<td>2.65</td>
</tr>
<tr>
<td>April</td>
<td>3.20</td>
</tr>
<tr>
<td>May</td>
<td>3.48</td>
</tr>
<tr>
<td>June</td>
<td>3.48</td>
</tr>
<tr>
<td>July</td>
<td>3.48</td>
</tr>
<tr>
<td>August</td>
<td>3.48</td>
</tr>
<tr>
<td>September</td>
<td>3.12</td>
</tr>
<tr>
<td>October</td>
<td>2.91</td>
</tr>
<tr>
<td>November</td>
<td>2.81</td>
</tr>
<tr>
<td>December</td>
<td>2.59</td>
</tr>
</tbody>
</table>
The above price model only predicts the price the watermen will receive at the picking house for his crabs. Chapter 2 pointed out the many alternative marketing channels available for hard crabs, which demonstrates that the picking house price is not always the price the crabber receives. A telephone survey of crabbers in early 1993 revealed that, on average, crabbers sell one-third of their catch to a retail or wholesale market where the price they receive is 2 to 3 times higher than the picking house price. Therefore, a two-price model was used to predict the average price the crabber receives for his catch based on the following formula:

$$\text{Exvessel price}_t = [1/3 \times 2.5 \text{ (picking house price}_t)] + [2/3 \times \text{ (picking house price}_t)]$$

where the picking house price in month $t$ was determined by the econometric equation in Table 12. The landings data used in the model are the total of hard crab landings each month for all hard crab harvesters in the survey, multiplied by the aggregation factor of 5.2. Hard crab landings are explained in section 4.221.

4.212 Soft Crab Prices

In 1985, Shabman and Capps estimated an exvessel price equation for soft crabs based on annual time series data, in which exvessel price was an inverse function of soft crab harvest and a positive function of consumer disposable personal income. Their equation had an $r$-squared equal to .94, indicating that most of the
variation in price can be explained by variations in harvest and income. These results imply that the forces which drive soft crab price formation may be less seasonally driven than those which drive price formation for hard crabs.

Soft crab exvessel price and landings data were obtained from the National Marine Fisheries Service. Soft crab wholesale prices were obtained from Umer-Barry, a private marketing company in New Jersey. Initial attempts at modeling Virginia soft crab exvessel prices as a function of Virginia landings, wholesale soft crab prices, and season of the year demonstrated no significant relationship among these variables. Talks with soft crab harvesters, processors, and wholesalers revealed that because soft crabs are often shipped to Northern markets for wholesaling and can often be kept frozen for months, price discovery is often difficult. Another important factor in exvessel price formation is that Virginia has a much lower share of the national soft crab market today than it did fifteen years ago. Currently Virginia provides about 60 percent of the national soft crab harvest, compared with almost 90 percent fifteen years ago (Whittaker, conversation). This means that Virginia soft crab exvessel prices are dictated more by national landings than by Virginia landings.

Because national monthly landings of soft crabs were not available over a long time period, monthly soft crab exvessel prices were not modelled, but rather were taken from VMRC estimates for 1992. To account for higher prices in alternative marketing channels, the published price series was multiplied by 1.5. Table 13
summarizes the monthly exvessel prices used for peeler crabs in the spreadsheet model.

4.22 Production Processes

Chapter 3 pointed out that blue crab production processes have both a biological and economic component. The level of the blue crab population is one factor which will influence the amount of crabs caught by the individual firm. Section 2.4 presented some of the current thinking on the blue crab population dynamics. However, this study is for a single year, when effort is applied to a fixed population level, which need not be known. Therefore, in the production functions, there will be no variable for stock size, although seasonal shifters will account for variations in stock size over a season. In addition, the intercept term in the statistical models will also account for 1992 population levels.

Production processes were modeled using monthly data from the surveys, with the number of pot days fished in the month hypothesized to be the main factor influencing harvest levels for a firm in that month. Other variables which were hypothesized to have influence included vessel length, years of crabbing experience, crabbing region, and season of the year.
<table>
<thead>
<tr>
<th>Month</th>
<th>Price per Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>1.78</td>
</tr>
<tr>
<td>May</td>
<td>2.91</td>
</tr>
<tr>
<td>June</td>
<td>2.76</td>
</tr>
<tr>
<td>July</td>
<td>2.76</td>
</tr>
<tr>
<td>August</td>
<td>2.79</td>
</tr>
<tr>
<td>September</td>
<td>2.70</td>
</tr>
</tbody>
</table>

Source: Virginia Marine Resources Commission
4.221 Hard Crab Production Function

A monthly log-log production function was estimated using data obtained in the 1992 monthly survey of crab potters for the months of March through November. A log-log function was used because, as Figure 9 showed, there are diminishing returns to effort in the fishery. The number of bushels of hard crabs caught in a month was a function of hard crab pot days fished in the month, vessel length, crabbing region, years of crabbing experience, and season of the year. Initial runs of the model showed crabbing region and years of crabbing experience to be insignificant, and consequently these variables were not used in the final model. The results are summarized in Table 14. Fall was the only significant seasonal indicator, with catch levels higher in September, October, and November than in the rest of the months. In a sense, this variable captures some of the biology of the fishery, as blue crab stocks are thought to be highest in the fall months. Pot days fished was a significant estimator of monthly harvest, with a ten percent increase in pot days fished causing an 8.16 percent increase in harvest levels. Vessel length was also significant, with larger vessels catching more crabs. The adjusted R-squared was .74, indicating that harvest variation is well explained by the model variables.

In the spreadsheet model, the following equation was added to predict each firm's monthly harvest levels for each month in which the firm hard crab potted:

\[
\text{Log(bushels of crabs)}_t = -3.640389 + .816460 \times \text{log(pot days fished)}_t + .505752 \times \text{log(vessel length)} + .434556 \times \text{for fall months}
\]
**TABLE 14 Log-Log Monthly Hard Crab Production Function**

Dependent variable: Log (bushels of hard crabs)\(_t\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-3.640389</td>
<td>.0001</td>
</tr>
<tr>
<td>Log(pot days fished)(_t)</td>
<td>.816460</td>
<td>.0001</td>
</tr>
<tr>
<td>Log(vessel length)</td>
<td>.505752</td>
<td>.0059</td>
</tr>
<tr>
<td>Fall*</td>
<td>.434556</td>
<td>.0279</td>
</tr>
</tbody>
</table>

*Fall = 1 for September, October, and November = 0 for all other months

R-squared = .7608
Adjusted R-squared = .7554
4.222 Soft Crab Production Function

A monthly production function for peeler crabs was estimated for the months of April through September\(^4\). Again, the model was a log-log function, with monthly peeler crab harvest a function of peeler pot days fished in the month, vessel length, years of crabbing experience, crabbing region, and season of the year. Vessel length and season of the year were not insignificant in initial runs of the model, and consequently were dropped from the final form of the model.

The results of the model are shown in Table 15. The signs on the parameters of the region dummy variables indicate that people in Region 2 and Region 3 tend to catch more than those on the Eastern Shore. This may be because of biological factors, with warmer waters in Region 3 and the bottom part of Region 2 and also the fact that soft crabs tend to migrate southward, with large runs in May and August. Crabbing experience was also significant, with those having more experience having higher harvest levels. A 10 percent increase in peeler pot days fished will cause a 4.3 percent increase in monthly peeler crab catch. The adjusted R-squared was .4534, indicating that about half of the variation in harvest is explained by the model variables.

---

\(^4\) Production functions were not estimated for the months of March, October, and November because no surveys reported any peeler crab catches in these months.
TABLE 15 Log-Log Peeler Crab Production Function

Dependent variable = $\log(\text{bushels peeler crabs})_t$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.093887</td>
<td>.3395</td>
</tr>
<tr>
<td>Log(pot days fished)</td>
<td>.432389</td>
<td>.0014</td>
</tr>
<tr>
<td>log(experience)</td>
<td>.229239</td>
<td>.0969</td>
</tr>
<tr>
<td>Region 2</td>
<td>.883893</td>
<td>.0001</td>
</tr>
<tr>
<td>Region 3</td>
<td>1.266357</td>
<td>.0023</td>
</tr>
</tbody>
</table>

R-squared = .5239
Adjusted R-squared = .4534
The following equation was added to the spreadsheet model to predict the firm's soft crab harvest levels for each month in which the firm peeler potted:

\[
\log(\text{bushels of crabs}_t) = -1.093887 + .432389 \log(\text{pot days fished})_t + .229239 \log(\text{years of crabbing experience}) + .883893 (\text{if crabber is in Region 2}) + 1.266357 (\text{if crabber is in Region 3})
\]

4.3 Total Costs

Table 16 presents all of the costs faced by a crab potting operation, along with either a section where the cost calculations are explained, or a reason why these costs were not calculated. Most variable costs were calculated on a monthly basis, dependent on whether or not a firm potted in that month. Fixed costs were calculated on an annual basis, as these costs are faced by the firm whether or not it crab pots at all.
TABLE 16 Costs for the Crab Potting Firm

<table>
<thead>
<tr>
<th>Variable:</th>
<th>Explanation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pot costs</td>
<td>Section 4.411</td>
</tr>
<tr>
<td>Bait costs</td>
<td>Sections 4.412 and 4.413</td>
</tr>
<tr>
<td>Fuel costs</td>
<td>Section 4.414</td>
</tr>
<tr>
<td>Labor costs</td>
<td>Section 4.415</td>
</tr>
<tr>
<td>Ice, Baskets/Bushels, Gloves, and Transportation</td>
<td>Section 4.416</td>
</tr>
<tr>
<td><strong>Fixed:</strong></td>
<td></td>
</tr>
<tr>
<td>Docking Fees</td>
<td>Section 4.42</td>
</tr>
<tr>
<td>Boat and Engine Maintenance</td>
<td>Section 4.42</td>
</tr>
<tr>
<td>Boat Insurance</td>
<td>Section 4.42</td>
</tr>
<tr>
<td>License Fees</td>
<td>Section 4.42</td>
</tr>
<tr>
<td>Depreciation (Boat, Engine)</td>
<td>Depreciation was not included in the budgets because the age of crabbing vessels ranged so greatly that it was impossible to assign mean value and useful life numbers</td>
</tr>
</tbody>
</table>
4.31 Variable Costs

4.311 Pot Costs

To calculate annual pot costs for both hard crab pots and peeler pots, it was determined that pots are replaced approximately every 18 months and that 10 percent of pots must be replaced during the season, due to being lost, cut, or stolen. Therefore, for each pot bought, an additional one-tenth of a pot must also be paid for. The cost of getting a pot into the water (adding rope, buoys, and zinc anodes) was estimated at $18.50. The following equation was added to the spreadsheet model to calculate a firm's annual pot costs:

\[
\text{Pot costs} = [(\text{number of pots fished}) \times (\$18.50 + \$1.85)] / 18 \times \text{months fished}
\]

4.312 Hard Crab Bait Costs

The survey responses indicated very little variation in the use of bait per pot over all months. Bait costs were estimated for frozen menhaden, which is the most commonly used form of hard crab bait used in Virginia. An average price of $10 a bushel was used, obtained in a telephone survey of selected watermen. Therefore, the average of cost of bait per pot was used to calculate each respondent's bait use for each month. The following equation was added to the spreadsheet model to calculate the firm's bait costs for each month in which it hard crab potted:

\[
\text{Bait costs}_t = 0.0185737 \times (\text{Hard pot days fished})_t \times \$10
\]
4.313 Peeler Crab Bait Costs

Peeler pots are usually baited only during the large peeler runs in May and August. They are baited with a large male crab to attract females who are preparing to moult. The average weight of a hard crab was estimated at .75 pounds and forty pounds in a bushel of crabs. The price the peeler crab pays for a bushel of hard crabs was estimated at $10, which was the average reported in a telephone survey of crabbers. In the spreadsheet, the following formula was used to predict bait costs for firms which peeler potted in May and August:

\[
\text{Baitcost}_t = \frac{[\text{(Peeler pot days fished)}_t \times .75]}{40} \times 10
\]

4.314 Fuel Costs

The first step in estimating fuel costs was to determine the time of each respondent’s daily run to fish his pots. Because this information was reported only for those respondents who filled out Part II of the survey, a function was estimated so that hours for crabbing run could be simulated for each survey. The main estimator of hours of crabbing run was hypothesized to be number of pots fished, with other possible estimators being crew hired and month of the year.

Separate functions were estimated for hard crab and peeler crab runs. These functions are summarized in Table 17. The equations were estimated as linear functions. Hours for a hard crabbing run were a positive function of number of hard crab pots fished and an inverse function of number of crew hired. The number of
crew hired for each firm is explained in Section 4.34. The adjusted R-squared for this function was .54. For peeler crab operations, run time was a function of number of peeler pots fished. The adjusted R-squared was .3052.

The average price of fuel for 1992 in Eastern Virginia was $.99, an average obtained in a telephone survey of crabbers. The following equations were added to the spreadsheet model to calculate a firm’s monthly fuel costs:

**Hard crab run hours** = 2.820677 + .016336*hard pots fished per day
- .593276*number of crew hired

where crew hired is explained in section 4.415

**Peeler crab run hours** = 2.908216 + .011077*peeler pots fished per day

**Fuel costs** = Run hours * gph * (pot days fished)_t * .99

where gph = gallons of fuel used per hour, answered by all survey respondents
### TABLE 17 Crabbing Run Hours for Peeler and Hard Crabs

**Hard crab run:**

Dependent variable = hours of hard crabbing run

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.820677</td>
<td>.0001</td>
</tr>
<tr>
<td>Hard pots fished</td>
<td>.016336</td>
<td>.0001</td>
</tr>
<tr>
<td>Crew hired</td>
<td>-.593276</td>
<td>.0887</td>
</tr>
</tbody>
</table>

R-squared = .5498
Adjusted R-squared = .5416

**Peeler crab run:**

Dependent variable = hours of peeler crabbing run

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.908216</td>
<td>.0001</td>
</tr>
<tr>
<td>Peeler pots fished</td>
<td>.011077</td>
<td>.0001</td>
</tr>
</tbody>
</table>

R-squared = .3391
Adjusted R-squared = .3052
4.315 Labor Costs

The amount of labor hired by each respondent was determined by the number of pots they fished. For hard crab operators, the following distribution was used:

- < 250 pots fished per day - no labor hired
- 250 to 349 pots - 1/2 person
- 350 or more - 1 person

For peeler crab operators the distribution was:

- over 300 pots fished per day - 1 person

An average wage rate of $4.35 an hour was used as the cost of labor. The following formula was added to the spreadsheet model to calculate total labor hours used in a given month:

\[ \text{Total hours}_t = \text{Amount of labor} \times \text{run hours} \times (\text{pot days fished})_t \]

4.316 Miscellaneous Costs

Additional variable costs faced by the crab potter, which were not asked for in the survey, include costs for ice for both bait and the crabs, costs of barrels and baskets to keep the harvested crabs in, and equipment costs such as gloves and boots. These costs were assumed to be higher for those who fish large numbers of pots per day. The following costs were added to the spreadsheet to cover miscellaneous expenses:
$450 for those with less than 250 pots
$900 for those with 250 pots or more

4.32 Fixed Costs

All of the fixed costs calculated in the budgets, with the exception of license fees which were already known, were directly reported by all survey respondents. Each respondent provided their annual outlays on maintenance and repairs on their boat and engine, on boat insurance, and on docking fees. Each respondent also provided what percent of their income was derived from other fishing. The following formulas were added to the spreadsheet model to calculate each firm’s annual fixed costs:

Docking fees = Total annual docking fees * (1 - INCFISH)
Boat insurance = Total annual boat insurance * (1 - INCFISH)
Engine Maintenance = Total annual engine main. * (1 - INCFISH)
Boat Maintenance = Total annual boat main. * (1 - INCFISH)

where INCFISH = percent of income derived from fishing activities other than crab potting

The cost of a crab pot license in 1992 was $48.00.
4.4 Net Revenue

Net revenue for each survey respondent was found by adding variable and fixed costs and subtracting this amount from their total revenue. Revenue, cost, and harvest variables for the Virginia blue crab pot industry were found by summing over all survey observations and aggregating from the sample to the industry, given the already known information that the sample was representative of the population. There were 299 commercial crab potters in the whole sample of 490, which represented 61 percent of the sample, and hence 61 percent of the license-holding population of 2550. Therefore an aggregation factor of 5.2 was used. Non-commercial crabbers, which represented 32 percent of the population, were assumed to not sell any of their catch, and therefore, their harvest levels were not included in the harvest levels which fed into the price equations. Their impact on the fishery will be further discussed in Chapter 6.

The next step, using the simulation model developed in this chapter, is to test the effects of alternative policy actions. Effects on total harvest, total revenue, total costs, and net revenue will be examined in the next chapter.
CHAPTER 5 - POLICY SIMULATIONS: THE COMMERCIAL SECTOR

This chapter presents the results obtained from alternative simulations, using the models developed in Chapter 4. First will be the base case, which is the 1992 crab pot fishery in Virginia without any new policies in effect. Then, policies which affect harvest, price, and/or cost levels, resulting in changes in overall net revenue for the industry and the individual firm, are described and their effects estimated. Changes from the base case are reported by percentages in Appendix C. Effects on prices and net revenue will be based on rates of commercial harvest, because non-commercial crab potters do not market their catch and have no influence over marketable harvest levels and consequently, prices. The presence of the non-commercial crabbers, however, will be considered in policy simulations of limited entry techniques.

5.1 Base Case Scenario

Table 18 presents the results for the base case. Total industry harvest levels, revenue levels, and cost levels are shown along with the numbers for the average crab potting firm. Some important factors to consider when viewing these numbers are: 1) These numbers do not include depreciation costs on the crabber's boat, engine and truck or transportation costs to a marketing channel, and 2) the harvest numbers do include Maryland crabbers who pot in Virginia, but the assumption was made that these people will sell their catch in Maryland and have no effect on price, and hence net revenue, in Virginia. The average annual net revenue for a Virginia
crab potter is $13,658. This number includes a large number of part-time crabbers who may have other sources of income. In the second part of Table 18 are the base case statistics for firms by operation type. The highest net revenues went to those who both hard and peeler crab potted, crabbers in Region 1 and full-time crabbers. The third part of the table presents the monthly hard crab prices (per pound) for the base case. The peeler crab prices are the same as in Table 13.

5.2 Published Data

One of the main objectives of this study was to gather accurate data on the fishery. This included both data which were currently unavailable, such as characteristics of the license holders and the marketing channels used for hard and peeler crabs, and data which are currently collected, such as harvest and price levels, which may not be accurately reported.
TABLE 18 Base Case Statistics

1. Total Industry and Average Potting Firm

<table>
<thead>
<tr>
<th></th>
<th>Total Industry</th>
<th>Average Virginia Firm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peeler Harvest</td>
<td>2,034,055 lbs.</td>
<td>4012 lbs.</td>
</tr>
<tr>
<td>Hard Crab Harvest</td>
<td>58,665,974 lbs.</td>
<td>38,034 lbs.</td>
</tr>
<tr>
<td>Total Harvest</td>
<td>60,700,029 lbs.</td>
<td>35,452 lbs.</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>$37,360,112</td>
<td>$24,272</td>
</tr>
<tr>
<td>Total Costs</td>
<td>$16,337,053</td>
<td>$10,614</td>
</tr>
<tr>
<td>Net Revenue</td>
<td>$21,023,059</td>
<td>$13,658</td>
</tr>
</tbody>
</table>

2. Firm Averages by Types of Operations

<table>
<thead>
<tr>
<th></th>
<th>H &amp; P</th>
<th>H only</th>
<th>P only</th>
<th>Reg 1</th>
<th>Reg 2</th>
<th>Reg 3</th>
<th>P-T</th>
<th>F-T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
<td>30823</td>
<td>41297</td>
<td>4693</td>
<td>37637</td>
<td>35124</td>
<td>33261</td>
<td>13754</td>
<td>48635</td>
</tr>
<tr>
<td>TR</td>
<td>26058</td>
<td>25287</td>
<td>13255</td>
<td>27501</td>
<td>23192</td>
<td>22678</td>
<td>10766</td>
<td>32260</td>
</tr>
<tr>
<td>TC</td>
<td>9942</td>
<td>11738</td>
<td>4167</td>
<td>12586</td>
<td>9799</td>
<td>10071</td>
<td>4322</td>
<td>14335</td>
</tr>
<tr>
<td>NR</td>
<td>16116</td>
<td>13549</td>
<td>9088</td>
<td>14915</td>
<td>13393</td>
<td>12607</td>
<td>6444</td>
<td>17925</td>
</tr>
</tbody>
</table>

3. Monthly Hard Crab Prices

- March  .51
- April   .62
- May     .77
- June    .74
- July    .71
- August  .71
- September .48
- October .42
- November .55
The 1992 method for gathering published harvest and price data for Virginia's blue crab fishery was a voluntary reporting system, whereby the Virginia Marine Resources Commission collected data from those watermen and crab buyers who were willing to report on harvest and prices. One official at VMRC conceded that, through this system, only about 60 to 65 percent of the harvest was being captured (Ner, 1993). In 1982, Vance concluded, through evidence of other surveys and calculations of net returns in the fishery, that harvest levels for Virginia's blue crab fishery were underreported by one-half (Vance, 1982).

Table 19 presents the data on harvest and prices estimated from this study and the data collected by VMRC. The harvest from this study does not include the harvest by Maryland crabbers in Virginia, as these numbers are not counted by VMRC. The published data's hard crab catch is about 40 percent of the catch estimated in this study, while the peeler crab catch is only about 30 percent of the catch estimated in this study. Hard crab and peeler crab prices are significantly higher in this study, mainly due to the use of the two-price model which accounts for alternative marketing channel prices.

5.3 Policy Alternatives

Management policies can either attempt to change fishing behavior from the input or the output side. The marketing fee, limited and delayed entry schemes, and restrictions on pot use are all policies which regulate the use of inputs, be it labor
or gear. Quotas, transferable or not, limit the output of a firm. Table 20 summarizes the expected first-round effects of some representative management policies. These are the short-run effects and are the effects which will be simulated over the 1992 season. Both input and output restrictions will reduce total harvest levels, increasing prices.

Input restrictions will raise the average product of effort, by reducing the level of effort (either labor or gear inputs). Limited entry scenarios reduce the number of people in the fishery, with price and harvest effects that raise incomes for those left in the fishery.
<table>
<thead>
<tr>
<th></th>
<th>This Study</th>
<th>Published Data*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Crab Commercial Harvest</td>
<td>53,201,713</td>
<td>19,712,233</td>
</tr>
<tr>
<td>Peeler Crab Commercial Harvest</td>
<td>1,919,446</td>
<td>518,770</td>
</tr>
<tr>
<td>Hard Crab Exvessel Price per pound</td>
<td>.61</td>
<td>.41</td>
</tr>
<tr>
<td>Peeler Crab Exvessel Price per pound</td>
<td>2.62</td>
<td>1.73</td>
</tr>
</tbody>
</table>

* Source: Virginia Marine Resources Commission
Pot limits reduce harvest levels for some firms, increasing prices, thus increasing revenues for the smaller firms. Limited entry can be combined with pot limits in order to reduce both gear and labor inputs. Another means of limiting inputs is to shorten the length of the potting season.

Output restrictions tend to reduce input costs for firms, as they are forced to contract the scale of their operations. Only individual quotas with an overall harvest quota policies will be simulated in this chapter. Quotas allow firms to choose how they will reduce their inputs, either through fishing less pots or by shortening the length of their potting season (either fishing fewer months of the year or less days per week).

A third way to raise industry incomes is by price increases caused by factors outside of the harvesting sector, such as wholesale price increases or declines in the processing margin. These policies raise everyone's incomes, without decreasing harvest levels or forcing people out of the fishery.

Appendix B presents the results of the simulations for the overall average firm and for average firms within classes. For exposition's sake, the base case statistics will be indexed to 100, with all other policies shown as a difference from this index of 100. The next sections present the procedures used to run policy simulations and some general results.
<table>
<thead>
<tr>
<th>POLICY</th>
<th>RAISE AP OR MP OF EFFORT</th>
<th>CHANGE IN INPUT COSTS</th>
<th>INCREASE IN PRICES PAID</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2 Limited number of gear licenses</td>
<td>policy limits labor and for those left in the fishery, average product of effort rises</td>
<td>as long as there is no input substitution, costs will not change for individual firms</td>
<td>drop in labor will decrease total harvest, increasing prices</td>
</tr>
<tr>
<td>5.3 Limited number of gear units per person</td>
<td>policy limits gear inputs and so AP of effort increases, assuming the limit on pots is set so that some operations are forced to use less effort</td>
<td>Variable costs for some firms will decrease as they are forced to scale down their operations</td>
<td>drop in number of pots used will decrease total harvest, increasing prices</td>
</tr>
<tr>
<td>5.5 Limit length of potting season</td>
<td>policy bans effort in certain months, and so AP of effort increases</td>
<td>Variable costs for some firms will decrease as they are forced to scale down their operations</td>
<td>drop in effort will decrease total harvest, but because prices are monthly, they will not increase</td>
</tr>
<tr>
<td>5.6 Daily individual quota (without overall quota)</td>
<td>no direct effect, but secondary effects will depend on the amount of the limit</td>
<td>Variable costs for some firms will decrease as they are forced to scale down their operations</td>
<td>drop in harvest levels will increase prices (assuming quota levels are below current levels)</td>
</tr>
<tr>
<td>5.6 Individual non-transferable quota (with overall quota)</td>
<td>no direct effect, but secondary effects will depend on allocation of quotas and size of overall quota</td>
<td>Variable costs for some firms will decrease as they are forced to scale down their operations</td>
<td>drop in harvest levels will increase prices (assuming quota is below current levels)</td>
</tr>
<tr>
<td>5.7 Product promotion and/or technological change in the processing sector</td>
<td>no direct effects</td>
<td>no change</td>
<td>prices will increase, either due to lower processing costs or to higher wholesale and retail prices being paid</td>
</tr>
</tbody>
</table>
5.4 Limited Entry Scenarios

For the purposes of this simulation a reduction in the number of crab pot licenses issued will be considered an entry limitation. It is assumed that a limited entry scheme would be implemented by not allowing any new people in the fishery, so that all those who had not renewed their licenses would be dropped. Section 3.5 reported that 22.6 percent of the license-holding population left the fishery after 1989. This section also reported the distribution of these transient watermen by firm type. 15.1 percent of the transients were noncommercial watermen, while the remaining 7.5 percent were commercial crabbers. The percentages reported in Appendix B were used to delete the corresponding percentages from each firm class, by a random process.

The results of this simulation show that a 22.6 percent drop in the number of people who held crab pot licenses causes an 11.3 percent drop in total industry harvest levels. Harvest does not drop as drastically as number of people because almost three-fourths of those removed were noncommercial crabbers who have no effect on marketable harvest levels. Net income for the industry declines, but increases for the average firm, because there are less people in the fishery.

5.5 Pot Limits

One concern of many crabbers is the presence of large potters in the Bay who fish as many as 500 pots a day. There have been complaints that these large operators are glutting the market with crabs and keeping exvessel prices down.
Another concern is that these large potters are making it difficult for smaller operators to make a living, by taking such a large share of the harvest.

Three simulations were run with pot limits set at different levels - 250 pots, 300 pots, and 350 pots. These simulations were implemented by reducing any firms who fished over the limit down to the maximum allowable number of pots. These policies, therefore, had impacts on the cost and harvest levels of some individual firms, and because total harvest levels in the fishery decreased, prices increased.

None of the pot limits managed to raise net revenues for the average firm, but the 300 pot limit reduced industry harvest levels by 6.3 percent and kept net revenue at the same level. However, as reported below, the median net revenue values increased from the base case, indicating a more even distribution of net incomes.

Median net income base case - 10,652
Median net income 250 pot limit - 10,972
Median net income 300 pot limit - 10,849
Median net income 350 pot limit - 10,732

Those who benefit most from pot limits are those who only peeler pot, crabbers in region 2, and part-time crabbers. These are the people who probably did not have to reduce their pot numbers, and hence the only effects of this policy on their incomes was an increases in prices paid.

Another important result to emerge from the pot limits simulations was that Maryland crabbers, because they tend to fish a large number of pots (up to 600 a day) lost a significant portion of their harvest. The numbers for Maryland harvest
levels are reported below:

<table>
<thead>
<tr>
<th></th>
<th>Average Harvest</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>71,523.97</td>
<td>0</td>
</tr>
<tr>
<td>250 pot limit</td>
<td>50,435.95</td>
<td>-29.5 %</td>
</tr>
<tr>
<td>300 pot limit</td>
<td>58,254.20</td>
<td>-18.5 %</td>
</tr>
<tr>
<td>350 pot limit</td>
<td>62,365.21</td>
<td>-12.8 %</td>
</tr>
</tbody>
</table>

5.6 Limited Entry Combined with a Pot Limit

A policy which addresses both concerns of low income levels and inequity of distribution could be combining a limited entry scheme with a set pot limit. This policy was simulated by first reducing all crab pot licenses according to the limited entry scenario outlined in section 5.4 and then limiting the remaining people in the fishery to 300 pots.

The results of this simulation were that average net revenue for the individual firm increased, but industry net revenue levels declined along with a significant decrease in harvest levels. Income increased most for those who both hard and peeler crab potted and part-time crabbers, although incomes increased in all firm classes. The median income level was also higher than the base case at $ 11,155, which was also higher than under the pot limit scenarios.

5.7 Limited Potting Season

This scenario was implemented by assuming that potting was banned in the months of March and November. This ban affected only hard crab harvests, because,
in this study, no soft crabs were harvested in these months. One important difference of this policy is that there are no price effects to compensate for decreases in harvest levels, since the monthly hard crab exvessel price is only a function of landings in that same month.

This policy decreased net revenue for all firm classes, except for those who peeler pot only, because they were not affected by this policy. This policy did manage to achieve a reduction of 7 percent in harvest levels, however. Incomes declined more for those who hard crab potted only, crabbers in region 1, and full-timers.

5.8 Quotas

Quotas, in contrast to the other policies considered so far, place direct restrictions on the output (rather than the inputs) of a firm. If an imposed quota is lower than a firm's current output level, the firm has alternative ways to reduce its inputs. The waterman may choose to fish less pots or shorten the length of his potting season (either fishing fewer months of the year or less days per week).

A individual daily quota was simulated, as this is the most likely way a quota would be implemented in the fishery. A 10 bushel a day quota for hard crabs was set, which translates into a 9600 pound quota for a month. This policy was simulated by reducing the number of pot days fished in a given month for all firms which caught over 9600 pounds of hard crabs.
With this simulation, industry harvest levels decline by almost 20 percent, with individual net revenue declining only 10 percent on average. Net revenue for part-timers goes up slightly, while those in region 1 are affected the most, with a drop in income of over 20 percent. There were no effects on peeler potting only firms.

5.9 Exogenous Exvessel Price Increase

An exogenous increase in exvessel prices can be caused either by an increase in wholesale prices or a decrease in processing costs. An increase in wholesale prices will be caused by increased retailer and/or consumer demand for blue crab meat. This is a policy which directly increases net revenue for the waterman since it will increase the price he receives for his crabs (recalling from Chapter 4 that exvessel price is a function of wholesale price). This policy was simulated assuming a 10 percent increase in hard crab wholesale price, using the price equations of Chapter 4. This translates into a 7.9 percent increase in hard crab exvessel prices. Peeler crab prices were not effected.

The effects of this simulation were increased net revenues for all firm classes, except peeler potters only, without any decreases in harvest levels. On average, net revenue increased by 10 percent, with the largest increase in incomes going to those who hard crab pot only, full-timers, and those on the Eastern Shore.
CHAPTER 6 - SUMMARY

This chapter summarizes the findings of the policy simulations of Chapter 5, and combines these findings with other information about the fishery and long-term economic effects. Conclusions are drawn about the usefulness of this study, the need for future studies, and the important characteristics of the blue crab fishery in Virginia.

6.1 Conclusions of the Simulation Model

The policy simulations of Chapter 5 looked at the effects of alternative policy actions on both harvest and income levels in the fishery. A decline in total industry harvest levels often causes a decline in income for the average crab potting firm. Figure 13 shows the tradeoffs between harvest and income that occurred under 6 different policy scenarios. The policies considered were the base case, the 10 percent reduction in all crab pot licenses, the 300 pot limit, limited entry combined with a pot limit, the closed season on potting, the 10 percent quota reduction, and the 10 percent increase in wholesale prices. Limited entry reduces harvest by 10.2 percent and raises average net revenues by 4.2 percent, while the pot limit reduces harvest by 6.3 percent and keeps income at the same level. Both the quota and the closed season on potting reduce both harvest levels and average net revenues in the fishery. The price increase has no harvest effect, but raises net revenues by 13 percent.

Another important consideration of the simulation results are the distributional effects among firm classes. Policies such as quotas and pot limits tend
to decrease incomes for those with larger operations, who tend to be in Region 1, tend to be full-time potters, and also tend to hard crab pot only. A pot limit also tends to reduce the variance of income levels within the industry, addressing concerns of equity as well as those of overharvesting. A closed season policy tends to hurt only hard crabbers, as the peeler crabbing season is shorter and more dictated by biological and environmental factors. Quotas also have a negative income effect on only hard crab potters, as peeler crab harvest levels are only less than one-fiftieth of total blue crab harvest levels.

Another important conclusion to be drawn from the simulations is that the fishery is a highly variable cost industry. Reductions in pot days fished tend to cause larger decreases in cost levels than in harvest levels. This is because as pot days fished decreases, so do fuel, bait, and labor costs, which constitute a high portion of the waterman’s total costs.

The effects of Maryland watermen who crab pot in Virginia waters are also significant. Maryland crabbers take approximately 5 percent of total Virginia blue crab harvest and average 360 hard crab pots fished per day. Since it was assumed that Maryland crabbers do not sell their catch in Virginia, a 300 pot limit manages to reduce Maryland harvest levels by 18 percent while actually slightly increasing the net revenues of crab potters in Virginia.
Figure 13 - Harvest and Income Tradeoffs of Policy Simulations
Two sectors of Virginia crabbers who were not included in the simulations include the non-commercial crabbers who hold crab pot licenses but derive no income from potting, and the recreational crabbers who do not hold licenses. While these sectors do not contribute to marketable harvest levels, they do contribute to total harvest levels in the fishery. Table 21 shows harvest estimates for the commercial, non-commercial, and recreational crab potting sectors in Virginia. The commercial estimate comes from the base case of Chapter 5, while the non-commercial estimate comes from using the simulation model of Chapter 4 to predict harvest levels for the non-commercial respondents.

The recreational estimate comes from a report published by the US Department of Commerce in 1985 on recreational shellfishing in the United States. Using the report's estimates of the number of annual recreational shellfishing days in Virginia and the number of recreational shellfishers, and assuming that recreational fishers catch 1/4 of a bushel of hard crabs a day, the recreational catch in Virginia was estimated to be approximately 16 percent of the commercial catch. These numbers show that the commercial harvest is only 84.5 percent of the total harvest of blue crabs in Virginia. This result demonstrates that harvest levels, which are usually reported only as commercial landings, may be significantly underestimated, and may not be a true indicator of the total effort applied to blue crab population levels.

The policy simulations of Chapter 5 spoke only to the first-round effects of
TABLE 21 Sectoral Blue Crab Harvest Levels in Virginia

<table>
<thead>
<tr>
<th>Fishery Sectors:</th>
<th>Blue Crab Harvest Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Pot Harvest</td>
<td>60,700,029 lbs.</td>
</tr>
<tr>
<td>Non-Commercial Pot Harvest</td>
<td>1,433,515 lbs.</td>
</tr>
<tr>
<td>Recreational Harvest</td>
<td>9,786,712 lbs.</td>
</tr>
<tr>
<td>Total Harvest</td>
<td>71,920,256 lbs.</td>
</tr>
</tbody>
</table>
already implemented policies. Policies often have second-round effects that occur once watermen begin to observe the first-round effects and change their fishing behavior accordingly. The next section examines some of these dynamic effects and also presents a new policy, the transferable quota, which addresses the question of long-term efficiency in the fishery.

6.2 Dynamic Adjustments

Because survey data was gathered over only one potting season, the policy simulations of Chapter 5 could only be static in nature, i.e. they could not account for the effects which might occur over a longer period of time. As management policies are implemented, watermen will change their behavior based on various economic signals they receive. Table 19 presented the first-round effects of alternative policies. The following sections take these effects and outline what could happen to the fishery in the long-run if these policies were implemented.

6.21 Input Restrictions

Limited entry reduces labor supply in the fishery. This raises the average product of effort for those left in the fishery. This result, however, assumes that those left in the fishery do not increase the scale of their operations, i.e. fish more pots. There may, however, be no increase in net revenues if the people left in the fishery increase the number of pots they fish to the point where effort rises back to the initial level. People will be motivated to fish more pots if they see that their average product of effort is increasing (as there are more crabs to be caught in a
fewer number of pots) or if they see the prices they are receiving increase.

These flows are shown in figure 14. Initially effort is at E1 in panel A. When limited entry is implemented, the ES curve shifts in to ES2, as effort supply is decreased. This causes effort to fall to E2, which in turn causes harvest to drop from H1 to H2 in panel B. This causes an increase in the price from P1 to P2 in panel C. This price increase will shift the average revenue curve outward and thus increase effort to a new level, say E3 in panel D. E3 may be less than, equal to, or more than the original level of effort E1. There is no guarantee, therefore, that this policy can cause a drop in total effort. There is also no evidence that watermen's incomes will increase in the long-run. Initially, watermen will have higher incomes due to the price increase, but if they increase their effort (and thus increase both costs and harvest level) their income may not stay at the higher level.

A second means of controlling inputs that was simulated was a limit on the number of pots a person can fish each day. Theoretically, this reduces the level of effort (if the limit is set so that some watermen must scale down their operations) and increases the average product of effort. There may also be some loss of labor in the fishery, because larger operators may no longer find it profitable to continue potting at the lower level of effort. This decrease of labor supply, however, was not simulated in Chapter 5.
Figure 14 - Second-Round Effects of Alternative Policies
There is, however, nothing to prevent new people from entering the fishery and fishing any number of pots up to the limit or for people who are currently fishing below the pot limit to increase the scale of their operations. This may occur because as the average product of effort increases, along with prices, the opportunity cost of fishing is lower and people will find it more attractive to crab pot than to do something else. This leads to the same round of effects in Figure 14.

The main problems with policies that attempt to control the input side of the fishery is that they are generally limiting only one factor of effort for an individual fisherman and cannot control for substitution of effort factors within the industry. A policy which limits both entry and pot use is more effective in controlling effort. However, there are problems of social acceptance, costs of monitoring and enforcing, and difficulty of implementation with all of these policies which will be discussed in Section 6.3. The next section outlines the dynamic effects of output restrictions and presents alternative methods for implementing quotas in the fishery.

6.22 Output Restrictions

Quotas are the main method use to control output within a fishery. They increase net revenue by reducing harvest and thus increasing prices paid to the watermen. Three types of quotas will be considered for the blue crab fishery - an individual daily quota with no overall fishery quota, an individual quota with an overall fishery quota, and a transferable individual quota with an overall fishery quota. Chapter 5 modeled an individual quota without an overall fishery quota (10
bushel limit a day).

The first policy is one that has already been suggested for the blue crab fishery - that each waterman is limited to catching a certain number of bushels of crabs per day. While this may reduce the output of an individual firm, there is no guarantee that output for the industry will decrease, as people are free to enter the fishery, which they will be motivated to do if exvessel prices increase. This is not really a quota regulation because there is no cap on overall harvest levels in the fishery. This policy may distribute catch more evenly among watermen (like a pot limit), but it is not a revenue increasing policy for the fishery as a whole.

An individual quota which is based on an overall quota for the fishery does put a cap on total harvest levels for the industry and is the only one of the policies which has the ability to directly increase prices, assuming that harvest levels are set at lower than current levels. A quota system of this type would allocate either a certain number of bushels to each license holder or a certain percentage of the allowable harvest. Because there is a limit on total harvest, there is a limit on the number of people who can be allocated a portion of this catch. In this way, quotas are able to control for the problems of open access.

The idea of transferable versus non-transferable quotas is a question of firm-level efficiency. If firms are forced to catch a certain institutionally determined amount, it is possible they will be forced to operate at a point that is cost inefficient, ie., not at the minimum point on the average cost curve. Transferability of quotas
allows firms to trade quota amounts so that they are at a more cost efficient level. A simple example will demonstrate this point. Suppose a TAH of 10,000 bushels is established for the industry and quotas are distributed in 100 units increments to 10 firms, so that each firm receives a 1000 bushel quota for the season. Figure 15 shows the cost structures for firms 1 and 2. Each firm faces a horizontal marginal revenue curve (MR) because effort at the firm level cannot effect price. Firm 1’s marginal cost for harvesting 1000 bushels is above its marginal revenue, while firm 2’s marginal cost for harvesting 1000 bushels is below its marginal revenue. Both firms are better off, if firm 1 purchases 1 quota unit (100 bushels) from firm 2, as long as firm 1 pays firm 2 less for the quota than firm 1 will make off of the extra harvest. The price of the quota will be determined by opportunity and transactions costs. After the trade both firms are operating "efficiently".

Another important consequence of this type of policy is that it motivates producers to find new technologies that lower the real cost of producing effort. As firms become more efficient, the industry as a whole becomes more efficient, and it is possible that industry effort will be closer to the sole owner rather than the open access equilibrium. Rents, to the people left in the fishery, will have increased, thus increasing individual net revenues.
FIRM LEVEL EFFECTS OF TRANSFERABLE QUOTAS

Figure 15 - Individual Transferable Quotas
The distribution of quotas is often a controversial subject. If they are to be transferable, then distribution is not so much of a problem, but if they are non-transferable, there are questions of both equity and efficiency to be addressed. Also, the establishment of an overall quota for the fishery is dependent on accurate data on population dynamics, the relationship between harvest and stock size, and the variability of the stock size.

6.23 Marketing Adjustments

Policies will have effects beyond the harvesting sector of the fishery. As harvest levels begin to drop, there will be adjustments in the processor, wholesale, and retail sectors. Anecdotal evidence suggests that when Virginia harvest levels are down, processors can and will obtain live crabs and/or picked meat from other states and even from Mexico. In 1992, one crab processing plant in Virginia attempted to get approval from the Virginia Department of Health to import blue crabmeat from India. The issue has not yet been resolved.

These effects are important because they indicate that there is the possibility of substitution for Virginia blue crabmeat, which implies that the increased price effect of decreased harvest levels may not hold, as the market adjusts over a period of time.

6.3 Reality Check

In order to run the simulations of Chapter 5, many simplifying assumptions were made. Among these were the assumptions that those policies were
implementable and enforceable. To broaden the scope of the analysis, these assumptions must be relaxed to account for political and practical realities. Policies which appear to be theoretically possible often face practical barriers.

One of the main problems of real-world policies are the costs of monitoring and enforcement. The crab pot fishery in Virginia encompasses over 2500 people, who crab in many different rivers and creeks in addition to the Chesapeake Bay. There are private and public docks and close to half a million pots in the water. Talks with crabbers and VMRC personnel indicate that the enforcement of current regulations in the fishery is problematic, with only sporadic checks and inadequate personnel. In the survey, over 80 percent of the respondents agreed that better enforcement of size and catch limits was needed in the fishery.

One problem with limiting the number of pots is enforceability. It is rather difficult (nearly impossible) to monitor how many pots each waterman is fishing. Unless each gear unit is licensed in some way that can be enforced and monitored, the policy will be ineffective. How many bushels each waterman catches may be difficult to determine is he sells his crabs through more than one marketing channel or retails them directly. Monitoring must be done at the dock rather than at the processing plants to ensure compliance.

The literature on enforcement costs has shown that the number of violations against a particular law is a function of the following factors:

- Probability of being caught * penalty for being caught

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- Profits from illegal activity

- Social acceptance of the policy and its goals

A study done by Furlong of fishery law violations in Canada found that the highest violation rate out of six different fisheries was in the offshore crab fishery. The policies considered in this study for crabs were gear unit limits and size of catch limits. Furlong concludes that violations are high in the crab fishery because, "monitoring is more costly and therefore less pronounced." (Furlong, 1991)

These issues demonstrate that when deciding what types of policies to implement, fishery managers must consider how enforceable the policy is and how much support there is for such a policy among watermen. The most easily enforceable policies considered in this study are limited entry and a limited potting season.

These policies, however, may have problems of political palpability. One of the problems with a limited entry scheme is where to set the limit on the number of people allowed in the fishery. If the limit is set only so that new people cannot obtain a gear license, then there is no reduction in labor supply. If the limit is set below the current level of labor in the fishery, there is the question of who gets a license. Limited entry schemes have historically been socially unacceptable with regard to the basis for limiting entry (Rickhus, 1992). However, 41 percent of the survey respondents agreed strongly that limits on the number of hard crab pot licenses issued were needed.

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A 1988 publication by the Mid-Atlantic Fishery Management Council concludes, "If a regulation cannot be adequately enforced (and particularly if it is considered unfair), it will be widely ignored and ultimately cause contempt for the system which created it" (MFMC, 1988).

6.4 Looking Ahead

One of the main goals of this study was to gather accurate and relevant economic data on the Virginia blue crab pot fishery. The monthly survey, conducted from March to November was an attempt to fulfill this goal. Chapter 3 outlined the reasons why the exact form of the survey was used. Using a monthly survey enabled the gathering of accurate and honest information, as crabbers only had to provide variable input and catch data for one month. The survey only asked financial questions about the watermen's fixed costs, which they were willing to provide. The results of this data gathering exercise appear to be satisfactory, with a response rate of 62 percent, and a low occurrence of skipped questions, except on the monthly calendar section. One possible alternative to asking crabbers to fill in their daily catch may be to ask for a weekly or monthly average. All of the respondents, however, appeared willing to provide cost and input data for their operations, as well as characteristics of their firm. In the survey 60 percent of the respondents agreed strongly or somewhat agreed that most watermen would be willing to provide catch data to the VMRC, while 45 percent disagreed that watermen would be willing to
report cost and revenue data to the VMRC.

The important information the survey provided on the people in the fishery, as well as the ability of the data to work well within the simulation model, provide a justification for continuing and expanding this method of data collection over a period of years and also to include the winter dredge fishery. Since mandatory reporting in now in effect in the blue crab fishery, reporting forms could be based on the form of the survey used in this study. This is especially important, given that harvest and price levels have been underreported by a large amount in the past.

Another area where better and more complete data are needed is in the marketing chain. The survey showed that many marketing channels for crabs are utilized. Talks with crabbers have indicated that there are large price differentials among alternative channels (Wesson, Whittaker, 1993). No time series data is currently available on the percent of crabs going to various markets. This information would be helpful for getting a more accurate picture of price determination in the fishery, especially in the case of peeler crabs.

Another important finding of the study is the presence of a large non-commercial sector in the pot fishery and the characteristics of this sector. 32 percent of the people who hold crab pot licenses claim not to derive any of their income from potting. Since these people's motives will tend not to be income-driven, but rather pleasure-driven, different sets of policies need to be considered for them. Finding out who these people were, how much they catch, and what they do with
their catch was an important result of this study.

When deciding what types of fishery management policies to implement, consideration needs to be given not only to the initial effects of the policies, but also to possible long-term effects as well as the costs of monitoring and enforcing the policies. Decision makers should have reliable data not only on the characteristics of people in the fishery, but also on the population dynamics of the blue crab, the available marketing channels, and watermen’s responses to imposed changes in their fishing behavior. When evaluating policies for recreational and non-commercial potters, consideration should be given to the values people put on their recreational crab-potting experiences and what effect they have on the commercial market.

While this study has mainly focused on the economic aspects of fishery management policies, it should be recognized that policy decisions are not made in a theoretical vacuum. Philosophical underpinnings, special interests, and ease of administration are all important players in the political process of policy-setting. Despite the economic inefficiencies created by systems of open access, such systems are often publicly desirable because they allow the exercise of individual freedom, whereas placing restrictions on who can use a public resource and how this resource should be used limits this freedom and makes the assumption of an omniscient administration, which decides the best use for the resource.

In the end, this study has attempted to provide accurate and timely information on Virginia’s blue crab pot fishery, in an effort to fill in one piece of the
complicated and constantly evolving puzzle of fisheries management. This piece must be connected with biological, social, and political considerations so that a clear picture of the fishery can be viewed as decisions about the future of the industry are made.
REFERENCES


APPENDIX A: SURVEY INSTRUMENTS AND COVER LETTERS
Survey 1: Entry/Exit

Survey Instrument:

The first 11 questions are for 1990 (or 1989).

1. In 1990, what else did you fish for?
   ____ Oysters  ____ Finfish  ____ Clams  ____ Other

2. How would you describe your off water employment in 1990?
   ____ held another job in addition to commercial fishing
   ____ retired
   ____ student
   ____ unemployed

3. In 1990, how much of your annual income was earned from commercial fishing?
   ____ less than 50 percent
   ____ 50 - 75 percent
   ____ more than 75 percent

4. Which of the following describes your crabbing activity in 1990?
   ____ I was a crew member on someone else's boat.
   (if you were a crew member you need not answer any additional questions. Thank you for returning the survey)
   ____ I operated my own crab boat.
   ____ I operated my own boat and was a crew member on another boat.

5. Fill in the information about the vessel you used for crabbing in 1990.
   a. the length of the vessel was ____ feet
   b. the age of the vessel was ____ years
   c. the age of the engine was ____ years
   d. the engine was ____ inboard  ____ outboard (check one)

6. Circle the months that you crab potted in 1990.
   Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov
7. When you fished peeler pots in 1990, about how many pots did you normally set out?
   _____ pots
   _____ I did not fish for peelers in 1990 (skip to question 9)

8. When you fished peeler pots, how many days per week did you normally fish?
   _____ days per week

9. When you fished for hard crabs in 1990, about how many pots did you normally set out?
   _____ pots
   _____ I did not fish for hard crabs in 1990 (skip to question 12)

10. When you fished for hard crabs, how many days per week did you normally fish?
    _____ days per week

11. In 1990, what percent of your hard crab catch did you sell to picking houses?
    _____ percent

Now we want to ask questions about 1991 (this year).

12. Did you purchase a Virginia crab pot license for 1991?
    _____ yes (skip to question 14)
    _____ no

13. What was the most important reason you are not crabbing this year?
    (Check only one and then skip to question 15)
    _____ I have a full-time job off the water.
    _____ I cannot make enough money in crabbing.
    _____ I have boat/motor problems.
    _____ The work is too difficult for me.
    _____ Other (write in)
           ____________________________________________

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14. What is the most important reason you decided to continue crabbing in 1991 (check only one.)

- [ ] It is a tradition. I have crabbed for many years.
- [ ] I made a good income last year.
- [ ] Other (write in)

15. Do you plan to buy a license for 1992 (next year) ?

- [ ] yes  
- [ ] no

16. How old are you? _____ years.

17. How many years of crabbing experience do you have? _____ years

Thank you for your time.

Return to:  Leonard Shabman 
Department of Agricultural Economics
Virginia Tech
Blacksburg, VA 24061-0401
SURVEY 2: 1992 PROFILE OF THE FISHERY
Joe Crabber  
123 Pot Lane  
Chesapeake, VA

Dear Joe Crabber,

In the fall of 1991, we conducted a survey of crab potters in Virginia. We appreciated your response to that survey, and we have enclosed a copy of the results. As part of our ongoing effort to develop a comprehensive understanding of the blue crab industry, we hope you would be willing to complete one other survey.

Protecting the Chesapeake Bay blue crab is vital for Virginia’s watermen and the state. In the 1992 session, the General Assembly passed measures calling for mandatory reporting from all commercial fishermen and giving VMRC the authority to implement delayed or limited entry in some fisheries.

The Department of Agricultural Economics at Virginia Tech, with support from the Virginia Sea Grant Program, is preparing an important report on the economics of the Virginia blue crab fishery. We will be determining how the General Assembly bills and other policies might effect your income as a waterman. The main beneficiary of our work will be you, a crab potter in Virginia.

This survey is divided into two parts. Part I, in blue, contains general questions for everyone to answer. You need only answer Part II (green) if you hard crab or peeler crab potted in the month of September. If you did not crab pot in this month, please return the survey, leaving Part II blank.

Thank you for your time and assistance. Please return the survey in the postage paid envelope we have provided. If you have any questions about the survey, please feel free to call Anne Giuranna at (703) 552-5521. If you would like a copy of the survey results, please check the box on the back of the survey.

Sincerely,

Anne Giuranna  
Project Manager
Joe Crabber  
123 Pot Lane  
Chesapeake, VA

Dear Joe Crabber,

Protecting the Chesapeake Bay blue crab is vital for Virginia’s watermen and the state. In the 1992 session, the General Assembly passed measures calling for mandatory reporting from all commercial fishermen and giving VMRC the authority to implement delayed or limited entry in some fisheries.

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This survey is divided into two parts. Part I, in blue, contains general questions for everyone to answer. You need only answer Part II (green) if you hard crab or peeler crab potted in the month of September. If you did not crab pot in this month, please return the survey, leaving Part II blank.

Thank you for your time and assistance. Please return the survey in the postage paid envelope we have provided. If you have any questions about the survey, please feel free to call Anne Giuranna at (703) 552-5521. If you would like a copy of the survey results, please check the box on the back of the survey.

Sincerely,

Anne Giuranna  
Project Manager
Dear Survey Correspondent,

Two weeks ago a survey was sent to you about your crabbing activities during 1992. If you have already returned the survey, please accept our thanks. If not, we would appreciate you returning it today. Your response is vital to policy-making in the blue crab fishery. If you have any questions, please feel free to call Anne Giuranna at (703) 552-5521. You may call collect.

If you did not receive a survey or it has been misplaced, you will receive another one in about 2 weeks.

Thanks again for your help.

Sincerely,

Anne Giuranna
Project Manager
Joe Crabber  
123 Pot Lane  
Chesapeake, VA 12345  

Dear Joe Crabber,  

About four weeks ago, we sent you a survey about crab potting in Virginia. As of today, we have not received your completed questionnaire. We are writing to you again because your response is important to us as we try to discover how fishery policies will affect your income as a waterman.

We assure complete confidentiality. The return survey has an identification number on it for mailing purposes only. All responses to the survey will be aggregated, so that only averages for all crab potters will be reported.

This survey is divided into two parts. Part I, in blue, contains general questions for everyone to answer. You need only answer Part II (green) if you hard crab or peeler crab potted in the month of September. If you did not crab pot in this month, please return the survey, leaving Part II blank. Feel free to make any comments you have about the fishery on the last page of the survey.

In the event your survey has been misplaced, a replacement copy is enclosed. If you have already completed the survey and returned it, please accept our thanks. If not, we would appreciate you returning it to us today. Again, thank you for your time and assistance. If you have any questions about the study or survey, please feel free to call Anne Giuranna at (703) 552-5521. You may call collect.

Sincerely,

Anne Giuranna  
Project Manager
IF YOU DO NOT HAVE A CRAB POT LICENSE OR DO NOT PLAN TO BUY ONE FOR 1992, PLEASE CHECK THIS BOX AND RETURN SURVEY

VIRGINIA TECH

1992 SURVEY OF CRAB POTTERS

IN THE CHESAPEAKE BAY
PART I

GENERAL SURVEY

1. Currently Virginia is considering a mandatory reporting program and a new license fee system for commercial watermen. Other proposals to protect the fishery may be made. By responding to the following statements, you can express your thoughts about some of these proposals.

Please indicate whether you agree or disagree with the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree</th>
<th>Agree Somewhat</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>There should be a limit on the number of crab pot licenses issued for hard crabs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>There should be a limit on the number of crab pot licenses issued for peeler crabs</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>There should be better enforcement of size and catch limits</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I am concerned about the winter dredge fishery in Virginia</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Watermen do not receive fair prices for their catch</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Most crabbers would be willing to report their daily catch to the VMRC</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Most crabbers would be willing to provide price and cost information for their business to the VMRC</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
2. Now we would like to know about the boat you use for crabbing:

Age of vessel ____ years

Length of vessel ____ feet

Age of engine ____ years    Type of engine (circle one)

Inboard    Outboard    In/Out

Type of fuel (circle one)
Gas    Diesel

Estimated fuel use per hour _______ gallons

In order to accurately represent the costs watermen face when trying to earn a living from crabbing, we would like you to give your best estimate for the following questions.

3. How much do you pay for boat insurance in a year?  $_______

4. How much do you pay in docking fees in a year?  $_______

5. How much do you pay for maintenance and repairs in a year?
   Engine $_______
   Boat $_______
   Do you do this work yourself? (circle one)
      yes    no

6. Do you own a truck specifically for use in your crabbing operation? (circle one)
      yes    no  (if no, skip to question 9)
   Age of truck _______ years
   Mileage ________ miles
   Percent of mileage each year for your crabbing business
      ___________ percent
Now we would like to know more about you:

7. How many years of crabbing experience do you have? _____

8. In what county do you live? ________________.

9. In what county is your vessel docked? ____________

10. How old are you? ______ years

11. a. What percent of your income comes from crab potting? _____

   b. What percent of your income comes from other fishing? _____

12. How many of the following do you normally fish per day?
   (please write in a number)

   _____ peeler pots

   _____ hard crab pots

13. On average, how many days per week do you do the following?
    hard crab pot ______ days per week
    peeler pot ______ days per week

14. Please check each month in which you will peeler pot in 1992.

   ___ March ___ April ___ May ___ June ___ July ___ August
   ___ September ___ October ___ November


   ___ March ___ April ___ May ___ June ___ July ___ August
   ___ September ___ October ___ November
PART II

MONTHLY SURVEY

IF YOU HARD CRAB OR PEELER CRAB POTTED IN THE MONTH OF AUGUST, PLEASE CONTINUE WITH PART II OF THE SURVEY. IF YOU DID NOT, PLEASE RETURN PART I OF THE SURVEY. THANK YOU FOR YOUR TIME.

There are over 2600 crab pot license holders in Virginia. You are one of only 100 people who are receiving a survey this month. The information you provide will be held in strictest confidence. We are only asking you to provide catch data for one month. This data will combined with all of the other responses from other months and only reported in this aggregated form, as an average for the industry. Your response is critical to the validity of the survey and to assuring that any new regulations are not an unneeded burden on watermen.

The following page contains a day-by-day calendar for the month of August. Two types of catch are listed - peeler crabs and hard crabs. Please give us your best estimate of the number of bushels of each that you caught each day.
| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

**IN THE SPACE PROVIDED PLEASE INDICATE THE NUMBER OF BUSHELS OF PEELED CRABS AND/OR HARD CRABS THAT YOU CAUGHT BY POTTING EACH DAY**

---

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If you peeler potted on any day in the month of August, please answer the following questions. If you did not, skip to the next page.

1. On the average, during August, how many peeler pots did you fish per day?
   ______ pots

2. What percent of your pots did you buy?
   ________ percent

3. How many times a day did you pull your pots? ___

4. How long did your daily crabbing run take?
   _____ hours

5. How many crew did you hire? ___ (if no, skip to no. 6)
   Did you pay your crew by wage or share?
   _____ wage    _____ share

6. Did you shed your own peeler crabs during August?
   ___ yes    ___ no (if no, skip to question 7)

7. What percent of your total catch of peelers did you shed?
   ______ percent
   Which of the following did you use?
   _____ floats    _____ recirculating system

8. Please indicate the percentage of your catch which went to each of the following channels during August:
   shedder _____ percent    personal use _____ percent
   fish bait _____ percent
   other (please describe) ______ percent

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If you hard crab potted on any day in August, please answer the following questions. If not, skip to the back page for any additional comments you wish to make.

1. On the average, during August, how many hard crab pots did you fish per day?  
   ____pots

2. What percentage of your pots do you buy?  
   ______percent

3. During August, how much bait did you use per day?  ______

4. How many times a day did you pull your pots? ____

5. How long did your daily crabbing run take? ______ hours

6. How many crew did you hire? ____ (if none, skip to no. 7)  
   Did you pay your crew by wage or share?  
   ____wage    ____share

7. What is the lowest price at which you would be willing to sell your crabs?  
   $________

8. Please indicate below any reasons other than low price which would cause you to not crab on a given day:

9. Please indicate the percentage of your catch which went to each of the following channels:
   
   Picking house ____ percent

   Sold live to other than picking house ____ percent

   Sold steamed to other than picking house ____ percent

   Sold as picked meat ____ percent

   Personal use ____ percent

   Other (please explain) ____ percent

   _______ _______
ADDITIONAL COMMENTS:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________


IF YOU WOULD LIKE A COPY OF THE SURVEY RESULTS, PLEASE CHECK THIS BOX

PLEASE RETURN SURVEY TO:

ANNE GIURANNA
DEPARTMENT OF AGRICULTURAL ECONOMICS
VIRGINIA TECH
BLACKSBURG, VA 24061-0401
(703) 552-5521
B-1 Distribution of All 1992 Crab Pot License Holders
ALL TRANSIENT WATERMEN

MARYLAND POTTERS 3.6 %

VIRGINIA COMMERCIAL 29.6 %

NON-COMMERCIAL 66.8 %

PEELER AND HARD CRAB 13.2 %

HARD CRAB ONLY 13.2 %

PEELER CRAB ONLY 3.2 %

part-time 4.4 %

full-time 8.8 %

part-time 6.4 %

full-time 6.8 %

part-time 2.4 %

full-time .8 %

1 - 2.0 %

1 - 5.2 %

1 - 0.0 %

1 - 1.2 %

1 - 2.0 %

1 - 0.8 %

2 - 2.4 %

2 - 2.0 %

2 - 4.4 %

2 - 3.2 %

2 - 0.0 %

2 - 0.0 %

3 - 0.0 %

3 - 1.6 %

3 - 2.0 %

3 - 2.4 %

3 - 0.4 %

3 - 0.0 %

B-2 Distribution of Transient Crab Pot License Holders
APPENDIX C: POLICY SIMULATIONS
The following pages present the policy simulation results for the following firm classes:

TH - Average hard and peeler crab harvest

TR - Average Total Revenue

TC - Average Total Costs

NR - Average Net Revenue

H and P = peeler and hard crab potting firm
H only = hard crab potting firm only
P only = peeler crab potting firm only

Reg1 = see region 1 classification in Section 3.1
Reg2 = see region 2 classification in Section 3.1
Reg3 = see region 3 classification in Section 3.1

P-T = part-time crab potters
F-T = full-time crab potters

Statistics are first presented for the industry as a whole and for the average firm.
### 1. Limited Entry removing transient watermen

<table>
<thead>
<tr>
<th></th>
<th>Ind.</th>
<th>Avg.</th>
<th>H&amp;P only</th>
<th>H only</th>
<th>P only</th>
<th>Reg 1</th>
<th>Reg 2</th>
<th>Reg 3</th>
<th>P-T</th>
<th>F-T</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH</td>
<td>88.7</td>
<td>100.3</td>
<td>92.9</td>
<td>100.5</td>
<td>102.9</td>
<td>101.4</td>
<td>101.1</td>
<td>96.5</td>
<td>102.1</td>
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### 8. Ten percent increase in wholesale prices

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Anne Giuranna was born on November 4, 1969 in Lansdale, Pennsylvania. Beginning in 1987, she studied communications at Pace University in Pleasantville, New York for two years. In 1989, she transferred to Virginia Tech to study agricultural economics, where she received her B.S. in 1991. In the fall of 1991 she began work on her masters’ degree at Virginia Tech in agricultural and applied economics. She received her masters’ degree in July 1993.

Anne M. Giuranna