December 12th, 2006

Mr. Mike Rosecrans
Office of Vessel Activities
United States Coast Guard
2100 2nd Street, SW
Washington, DC 20593

Dear Mr. Rosecrans:

You will find enclosed our final report entitled Commercial Fishing Vessel Safety: Determining Exposure. This report outlines the project that was completed at the USCG Headquarters from 23 October 2006 to 13 December 2006. Introductory research was completed in Worcester, Massachusetts prior to our arrival in Washington DC. Copies of this report are being submitted simultaneously to Professors David Lucht and Peter Hansen for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library of Worcester Polytechnic Institute. We greatly appreciate the time, help, and advice that you and Mr. Jack Kemerer have given to us for the duration of this project.

Sincerely,

Robert Caison
Elisabeth Curylo
Amanda Ruksznis
Kurt Wivagg

Commercial Fishing Vessel Safety:

Determining Exposure

OFFICE OF VESSEL ACTIVITIES
FISHING VESSEL SAFETY DIVISION

By:

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UNITED STATES COAST GUARD

COMMERCIAL FISHING VESSEL SAFETY: DETERMINING EXPOSURE

An Interactive Qualifying Project
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

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December 12th, 2006

Abstract

This project, done in conjunction with the US Coast Guard (USCG), responded to the dangerous nature of commercial fishing by determining how long fishermen are on the water so realistic fatality rates for fisheries could be calculated. We performed background research and interviewed government agencies who supplied us with the data necessary to complete our goal. After we obtained our results, we prepared conclusions and recommendations for the USCG, assisting in the achievement of their maritime safety mission.

Executive Summary

The Earth's oceans have long been used as a means of transportation and as a supply of natural resources. For more than 4,000 years, people have been using the oceans to successfully yield a food supply. Originating as simply subsistence fishing from shore with the use of a spear and net, fishing has evolved to what is now a commercial industry which is both productive and dangerous. Frequently working long hours, commercial fishermen are constantly at risk of something going wrong: bad weather, equipment failure, and vessel sinking. According to the Bureau of Labor Statistics (BLS), commercial fishing is the most dangerous occupation with a fatality rate nearly 30 times greater than the fatality rate of all occupations (BLS, 2006). Because of this statistic the United States Coast Guard is not only looking into methods to improve safety, but to also better understand fatality rates within various sectors of the commercial fishing industry.

The Coast Guard knows that the number of fatalities have been in a downward trend since the implementation of the Commercial Fishing Industry Vessel Safety Act of 1988, but they are not sure why (Bensyl, et.al. NIOSH, 2002). There could be fewer fishermen overall or commercial fishing could actually have become safer, resulting in fewer deaths. Unfortunately, the Coast Guard does not know how accurate the fatality rates are because they do not have a good denominator for determining this value. The denominator is defined by the BLS as the number of workers, or fishermen in this case, working an equivalent of 2,080 hours a year (Full Time Equivalent workers; FTE).

The goal of this project was to develop a method to determine the time spent on the water by fishermen in order to calculate the FTE. With this number, we could determine the number of fatalities per 100,000 workers according to the BLS standard. Because of this,

particular sectors or fisheries in the industry can be compared to each other and other occupations to determine which is more dangerous.

To do this, we evaluated FTE determination processes used by other studies based on important variables such as crew size and trip length. Using this information, we developed our first method. We multiplied crew size, trip length, number of trips per vessel and number of vessels in the fishery all together, and divided by 2,080 to determine the FTE. We allowed for preparatory time, (loading time, transit time, etc.) in the equation, but after speaking with representatives from the National Oceanic and Atmospheric Administration (NOAA), we determined that it was too difficult to obtain, and therefore it would not be included.

We then found the FTE for commercial fishermen in three specific fisheries with the data we obtained using a different method than the one just described. Since the data was retrieved in an Excel spreadsheet, we used Excel to directly count the total man-hours spent on the water. By finding that number and dividing by 2,080, a much more accurate FTE was found. We compared the two methods and determined that our first method was not applicable to small scale fisheries and this direct count methodology, entitled "WPI Direct Count Methodology" should be used for further studies. Lastly, with the known FTEs, we calculated fatality rates for each fishery, and with those results, we performed an analysis on several aspects of the FTEs and fatality rates.

The analysis was geared towards comparing the fatality rates with each other and with the national standards. The Northeast Scallop fishery was found to be roughly four times more dangerous than the Multispecies fishery for the year 2005. Compared to the BLS calculated average of 4 deaths per 100,000 workers for all occupations, both fisheries examined were well above that rate at 250 and 62 deaths per 100,000 workers, respectively.

We also conducted a sensitivity analysis where we entered arbitrary values for preparatory time to see whether it was statistically significant to include in the overall methodology since we were unable to attain the actual data. We observed that FTE and fatality rates were sensitive to preparatory time; therefore it was shown to be an important variable to include in future studies to increase the accuracy. However, whether prep time is included or not, the difference in fatality rates between fisheries remains the same, and therefore does not undermine our results. Lastly, we explored historical data from the Red King Crab and the Red Snapper fisheries to determine if there was any correlation between individual variables and exposure time. At present, we are unable to find any relationship, but with further study and more historical data, one indeed may be found.

It is recommended that the Coast Guard use the WPI method to target dangerous fisheries in order to focus their support where it is needed most. We suggest areas for further study, including but not limited to: the study of past fatality rates, the implementation of preparatory time and the study of relationships between catch, vessel count and exposure. Above all else, we recommend the Coast Guard investigate new ways to record, document and keep track of exposure data. One of the major obstacles in this project was the collection of appropriate data needed to determine exposure and fatality rates. Each region and each fishery has different types of permits, different requirements for recording time spent at sea, and different agencies that collect and hold such data. If time spent at sea by each vessel were uniformly collected, the data could easily be placed into a database, making exposure, FTE and the resulting fatality rate calculations much easier.

It is our hope that the results and recommendations provided in this project will give the Coast Guard an improved tool for setting program priorities where they are most needed, and reduce the number of deaths because of better safety initiatives focused on the most hazardous fisheries.

Acknowledgements

We would like to first thank the United States Coast Guard for sponsoring this project and giving us this opportunity along with the staff at Headquarters, especially Rob Trevino and Kenneth Vasquez for all their help and hospitality. We would like to especially thank Ted Harrington, Bob Higgins, Bob Garret and Lt. Ryan Hamel in their respective Coast Guard positions along with Pete Christopher, Mike Judge, Steve Turner, and Stanley Wang all from National Marine Fisheries Services (NMFS) and Geoffrey White from the ACCSP. Special thanks to Kevin McCarthy and John Witzig of the National Oceanic and Atmospheric Administration (NOAA), more specifically the Fishery Logbooks System and the Fisheries Statistics Office for providing us with well-formatted data as complete as possible. We would also like to thank Commander Chris Woodley of the USCG and Dr. Jennifer Lincoln of the Centers for Disease Control (CDC) for their original ideas in this subject, their advice and willingness to help us at any point and especially their feedback. In addition, we would like to thank our advisors, Professors David Lucht and Peter Hansen. Lastly, we would like to thank Jack Kemerer and Mike Rosecrans, our liaisons for the project, for their constant support and feedback in order to make this project the best it could be, and lastly for their good humor.

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*NOTE: All group members were equally involved with the overall completion of the project.

1: Introduction

For over one hundred years, workplace safety has been a priority in the United States. Beginning in the late1800s, child labor laws and unions started to form to protect workers from occupational hazards. The modern day incarnation of this concern for workplace safety is evident in the United States Department of Labor and the Occupational Safety and Health Administration and their attempts to evaluate and improve workplace conditions and reduce accidents. Despite these efforts, commercial fishing is still one of the most dangerous occupations in the country, proven by current fatality rates (Lincoln, 2006).

The United States Coast Guard realizes that commercial fishing is dangerous, but they also realize that the number of deaths within the industry is decreasing. There could be fewer fishermen overall or commercial fishing could actually have become safer, resulting in fewer deaths. The Coast Guard is dissatisfied with the accuracy of current fatality rates and has begun research into improving that accuracy.

Fatality rates are the ratio of fatalities per Full Time Equivalent (FTE) worker multiplied by 100,000 workers. Full Time Equivalent means the equivalent number of workers in a given occupation working 40 hours a week, 52 weeks a year. The BLS is the national standard for measuring fatality rates; however, they do not go into depth measuring the FTE for each occupation. They assume 40 hour work weeks for all occupations and although that is very accurate for most, commercial fishing is an outlier. The BLS methods are time-proven, accepted measurements and used among all occupations for comparisons, but due to the sporadic nature of fishermen’s hours, a more accurate measurement of FTE is needed.

Commander Chris Woodley of the USCG and Dr. Jennifer Lincoln of the Centers for

Disease Control (CDC) have attempted to revise the method of calculating the FTE to try and provide a more accurate estimate. They have focused on the Northwest fisheries, especially in Alaska, and have therefore devised very specific methods to count fishermen's time on the water (exposure) that may or may not be applicable to all fisheries in the United States.

This project developed for the United States Coast Guard a methodology of quantifying exposure of commercial fishermen that can be expanded to apply to any US fishery. In order accomplish this, we evaluated current exposure assessment processes, gathered data pertaining to exposure, developed our own methodology to measure the exposure and tested it on various US fisheries. We then drew conclusions and made recommendations for the Coast Guard based on the analysis of our results. With this in depth research and analysis, the Coast Guard will then be able to say with greater certainty whether or not commercial fishing is actually becoming safer. Such findings would enable the Coast Guard to assess whether the existing regulations have been effective and to suggest where additional research and/or safety standards might be needed.

2: Background

This section will detail the background information that is most important to the context of our project. To discover the best way to determine exposure for commercial fishermen, it is necessary to have a good understanding of the environment, the variation inherent to the industry, and previous work that has been done. The combination of these factors creates a well rounded picture of the fisherman's lifestyle, therein developing a sturdy basis for our study.

2.1: Commercial Fishing Environment

Because of the unique nature of commercial fishing, the Coast Guard has expressed its desire to learn more about the overall culture of this occupation. This knowledge is also necessary to better understand and develop an accurate measurement of time spent fishing. Due to the unique nature, many studies have attempted to grasp the culture and explain why commercial fishing is so dangerous. Although this particular project does not have the time or resources to explore this issue, the following section will provide a brief background into the many nuances of commercial fishing.

2.1.1: Commercial Fishing Legislation

Although the Coast Guard does not know the extent of the danger involved with commercial fishing, they have suggested many regulations in an attempt to constantly improve safety. Only a few have actually been passed into law; for instance in 1988, the Commercial Fishing Vessel Safety Act (CFVSA) was passed by Congress. This act required fishing vessel owners to report any and all injury data to the insurer of the vessels. While the fishing vessel owners were required to report these injuries and casualties to the insurer, they were not required to report them to the Coast Guard. However, in the Code of Federal Regulations title 46 Section 4, fishermen are required to “notify the nearest Marine Safety Office, Marine Inspection Office or Coast Guard Group Office whenever a vessel is involved in a marine casualty” (NARA, 2002). The Act also required the Coast Guard to create a plan to license all operators of any sort of fishing vessel. While a great idea in theory, this licensing plan was ultimately too time-consuming and difficult to do, and because of this, the program was canceled. The CFVSA also helps out injured crew members, requiring crew members to promptly notify the operator of the fishing vessel of any injury, illness or disability incurred while working on the vessel. This is helpful in not only quantifying data about injuries on fishing vessels, but also allows the information to be gathered more easily. Rather than the operator having to track down his crew members to report to the insurer, he has all the information when the incident happens.

The CFVSA was implemented in 1990. A study done in Alaska evaluated the effectiveness of the new act. The figure below shows the match between the new implementations and the reduced number of injuries in Alaska:

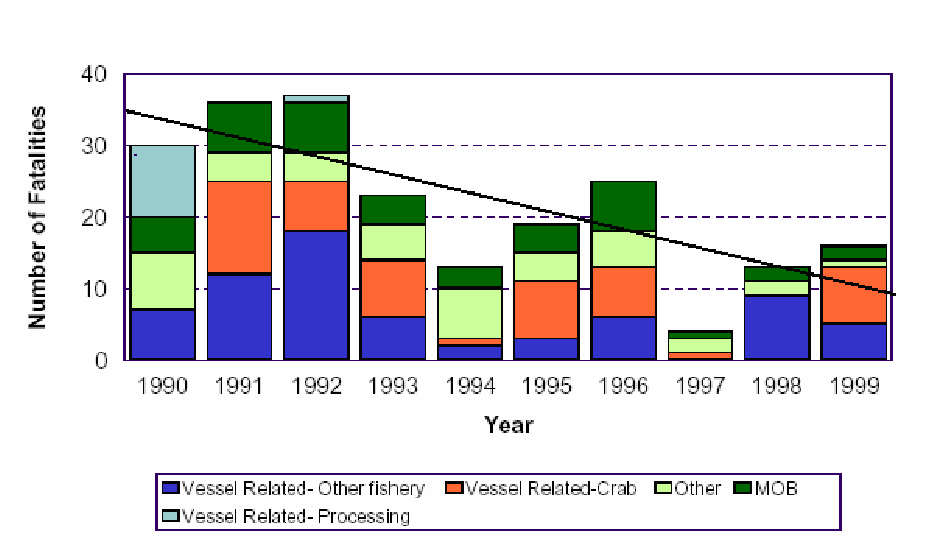

Figure 1 (Bensyl, et.al. NIOSH, 2002)

A program titled the *Coast Guard Authorization Act of 2005 (S.1280)* was proposed in 2005. The act would have amended definitions in other acts, defined management of Coast Guard resources, as well as implemented the United States Ocean Commission. At the same time, a program to inspect previously un-inspected fishing vessels was also proposed. The program was to begin on the date of enactment and would be implemented at five to ten ports where a Coast Guard safety inspection program did not currently exist, and would run for five years. The pilot program, "Dockside Crew Survivability Examination," had three major goals. Although this provision was ultimately dropped, it is clear to see from the objectives, that the Coast Guard is as dedicated to making commercial fishing safer as it always was. The first goal would have been to check the vessels for adherence to both national and local safety laws pertaining to that particular size of vessel and also make sure the vessel has the necessary safety equipment required by national and local laws for that size vessel. The second goal was to examine the vessel's stability to make sure that it meets the requirements set forth by law for that size vessel. The third and final goal was to examine and observe the crews familiarity with survival equipment, safety, and emergency procedures which are designed to prevent the loss or damage to the vessel and crew. The pilot program would have determined how well mandatory examinations prevent the loss of life and damage to the vessel.

Both the CFVSA and the *Authorization Act of 2005* are aimed at reducing accident and fatality rates. Despite the *Authorization Act of 2005* not being passed in its entirety, the Coast Guard is still doing everything possible to ensure the safety of commercial fishermen. The best way to do this is for the Coast Guard to have a good grasp on the culture of the fishermen. With this knowledge, the Coast Guard can properly regulate the industry.

One instance of the USCG's attempt to increase safety awareness is the dockside exam. If a vessel partakes in a dockside exam, no penalties or fines will be incurred if the vessel does not meet the minimum safety requirements. However, if the safety requirements are not met, then the vessel does not receive an examination sticker indicating that it has passed. As the Coast Guard has the ability to board any vessel it deems necessary, if the vessel does not have an examination sticker, the owner of the vessel will be fined.

2.1.2: Fishermen's Views on Safety and Regulations

It has been shown that "fishermen's perceptions regarding safety can vary greatly from those of the government, including the Coast Guard, and that there needs to be a better understanding of the fishing culture and ways in which safety is viewed" (Kaplan, 2000). In a study of fishermen in New Bedford, it was determined that most fishermen feel underrepresented and unheard. Management Councils in place have attempted to listen more as they are made up of fishermen themselves. Most of these same fishermen from New England have expressed that they understand and accept the danger of the trade.

Similar to many trades including forestry and construction, the workers harbor certain resentment towards the government. They have a "why bother?" attitude that stems from the belief that they are not heard. Why bother giving information to the government or even telling them our opinions if they won't listen anyways? "Unfortunately, many people in the fishing sector are unwilling to come forward and openly discuss problems of safety and management of fisheries because they believe they will not have a voice in what the alternative regulations will be" (Kaplan, 2000). Even the "Coast Guard readily acknowledge[s] that they lack an occupational perspective" (Van Noy, 1995). This general consensus of under representation can be proven by actual regulations that increase the danger to fishermen.

In the New Bedford study, the fishermen group these regulations into three categories. The first is the most hazardous one in that it reduces crew size. There are limits to how many fishermen a captain can take out on his vessel and therefore, there is less room to train inexperienced fishermen and also causes overworking and fatigue among the rest of the crew. In a West Coast survey, "the three most serious human factor safety problems identified were inexperienced personnel, inattention, and fatigue" (Van Noy, 1995). Therefore, the fishermen see this limit on crew size and only identify it with negative effects. The other two categories are the limited fishing periods and limited fishing areas. Aimed to save the fish stock, fishermen are forced to go out for only a certain period of time and also only in certain areas. This increases their need to go out in bad weather and navigate their way through congested waters. Grouping more fishermen in smaller areas and pressuring them to go out when the conditions may be bad is only asking for trouble. Because of these regulations, the Fisheries Management Council which was created to represent the fishermen in legislative decisions is actually viewed as just another part of the government that pays no attention to them. The fishermen see them as "'the same thing [as the government] because they're doing the same'" (New Bedford captain, Kaplan, 2000).

Despite the discontent with certain regulations, it seems to be common opinion that fishing is a risky business and it always will be. Over two-thirds of the fishermen interviewed in New Bedford stated that "they feel comfortable with the level of risk in their lives." It comes with the territory and the fishermen seem to accept that. "'There will always be risk from Mother Nature. It's like driving a car. It's always there'" (New Bedford vessel owner, Kaplan, 2000). It appears that only a serious accident can change that inane attitude. For example, the attitude at the local fishery changed drastically after the tragedy 45 miles off Nantucket in December of 2004 when five out of six crew members were killed in a vessel accident. In a Boston Globe article on the subject, the author states, “fishermen are embracing safety, organizing and attending training classes in unprecedented numbers, and inviting more Coast Guard inspectors on board their vessels for safety checks” (Daley, 2006).   In the same way, of the people interviewed in the New Bedford survey, only one had actually been seriously hurt, losing most of his fingers on one hand and he was the only one of two that “expressed serious concern about their personal risk”.

In most cases the Coast Guard and the fishermen share different views on the risk and safety of their occupation. The next section will discuss the different types of accidents, fatalities and the nuances of reporting these.

2.1.3: Reporting of Accidents and Fatalities

Although accidents and fatalities are independent of exposure, when determining accident or fatality rates, the nature of such accidents and fatality rates needs to be known. Sections 2.3.2, 4.1.3 and 5.2 specifically discuss fatality rates. This section will examine the numerator of such rates (see equation below). However, before examining the different types of accidents and fatalities, one must look at how reliable the accident data is.

$$\frac{Accidents / Fatalities}{Exposure} = Rate$$

One of the biggest problems with evaluating the causes of accidents and fatalities of commercial fishing is the under-reporting of accidents. The Coast Guard cannot evaluate or measure how dangerous fishing is if they do not have records of the majority of incidents.

> “Accurate historical and current data on vessels, fishermen, professional experience, hours and nature of exposure and safety performance of personnel and equipment are fundamental to assessing safety problems, monitoring results of safety programs and measuring the effectiveness of safety improvement strategies” (Loughran, 2005)

However to encourage or enforce the reporting of accidents it must first be determined what sort of accidents are going under the radar and why.

The first possible reason for under-reporting is the exceptions that apply to the safety regulations within the Commercial Fishing Industry Vessel Safety Act of 1988. The act “requires most vessels to carry life-saving equipment and mandates monthly safety drills on vessels” (Daley 2006), but this only applies to federally documented vessels. Because a vessel is not required to be federally documented unless over 5 net tons and is either passing over the boundary line or has 16 or more people aboard, not all vessels have the safety equipment necessary for a dangerous situation due to lack of time, money, or space. But even in the documented vessels, the CFIVSA “provides no way to ensure that fishermen participate in the drills, and it does not require safety inspections” (Daley 2006). If fishermen do not see an incident as a safety violation, they would feel no need to report it. Reporting of every incident in such cases might give the reputation of a fisherman and crew to be unsafe, unreliable and a general hazard to a fishing company.

That leads to the second possible reason of under-reporting. There is a certain resistance of fishermen to government intervention. After a startling and fatal accident in New Bedford, an article was written in the Boston Globe discussing the event, the possible reasons for the accident and how it has changed the fishing community in that area. “The fishing industry has long bridled against mandatory safety rules, saying they are too costly and time-consuming. Fishermen say they do not want any more government intrusion on their livelihood" (Daley, 2006). Reporting of every incident would only be submission, in the fishermen's eyes, and an opportunity to open their fishery to unwanted scrutiny and inspections. One other factor in under-reporting can be seen in statistics on accidents to vessels. As can be seen in Figure 2, the prevailing recorded cause of accidents is machinery damage.

Accidents to vessels by accident type in period from 1994 to 1999

Contributor to accidents	Percentage
Machinery damage	64.40
Foundering and flooding	14.23
Grounding	10.25
Collisions and contacts	5.74
Fires and explosions	2.89
Capsizing and listing	1.58
Heavy weather damage	0.56
Missing vessels	0.07
Others	0.28
Total	100

Figure 2 (Wang, 2005)

Lower on the list are mostly human-caused errors such as collisions or listing. It would be to a fisherman's advantage to report machinery damage so that not only can it be fixed, but also so that the blame for any resulting accidents would be on the machinery itself and not the fisherman or any of his crew. Therefore such incidents would naturally be the most commonly reported.

Despite the inaccuracies of reported incidents, causes of the reported incidents can still be looked at. The following table from the fishing vessel injury and death database gives a brief glimpse of the numerous causes of fatalities amongst fishermen.

VESSEL NAME	O.N.	LOCATION	GEN CASUALTY	SPECIFIC CAUSE	OTHER	VSL LOST
TEXAS	D247286	21NM S MORICHES	DEATH	ILLNESS	*HEART ATTACK	
WARRIOR	D693641	50NM E NANTUCKET	DEATH	MAN OVERBOARD	O/B W/ DREDGE	
LADY LINDA	D625981	30NM E BRIGANTINE	DEATH	SINKING	CRUSHED	X
SHOAL WATER	ME4343B	3NM E JONESPORT	DEATH	WIRE	PARTED	
LEADER	D617728	OFF NJ COAST	DEATH	ILLNESS	*HEART ATTACK	
MAX & ANDREW	D585667	2NM E HIGHLAND LT	DEATH	WIRE	RIGGING FAILURE	
CHEERIOS	RI3168V		DEATH	DIVER		
CAPE MAY	D250339	60NM E NANTUCKET	DEATH	MAN OVERBOARD	RIGGING	
STRIDER	D271920	4NM S HYANNIS	DEATH	SINKING	STRUCTURAL	SAL
LONELY HUNTER	D528930	30NM E NANTUCKET	DEATH	COLLISION	WATCH	X
CANDY B II	D259452	40NM SE NANTUCKET	DEATH	SINKING	UNK	X
ATLANTA	D1123523	27NM ESE CHATHAM	DEATH	CAPSIZED	STABILITY	X
NORTHERN EDGE	D607574	41NM SE NANTUCKET	DEATH	CAPSIZED	HUNG DOWN	X
LEGACY	D617568	150NM E CAPE COD	DEATH	MOB		
NORTHERN WIND	D620851	40NM SE NANTUCKET	DEATH	CAPSIZING		X

Table 1 (FV INJ/DT DB, 2005)

Of the fifteen fatalities shown here, two were caused by illness – possibly nothing to do with the actual fishing itself – while seven (nearly half) of the fatalities were from sinking, collision, and capsizing which can be considered an overall vessel loss. The causes of accidents and fatalities essentially open the door to a whole new field of research that cannot possibly be contained within the limits of this project. What can be contained and defined however is the second category of variables within fishing – different types of fisheries.

2.2: Variations within Commercial Fishing

The different types of fisheries make it nearly impossible to evaluate exposure with one process for all methods of fishing. This creates an interesting problem. The methodology to determine exposure which we will develop must be adaptable to all different types of fishing. This section will outline the different types of fisheries that will be studied for this project.

2.2.1: Definition of a Fishery

Similar to other issues in this project, the idea of a fishery needs to be defined for the working purpose of this report. With an accurate method of exposure being the goal in mind, narrowing down the definition of a fishery to be concrete helps make data collection easier. The word itself can be used in many ways. The Code of Federal Regulations defines "fishery" in 50 CFR § 600.10 as:

1. One or more stocks of fish that can be treated as a unit for purposes of conservation and management and that are identified on the basis of geographic, scientific, technical, recreational, or economic characteristics, or method of catch; or
2. Any fishing for such stocks.

The important part of this definition in item 1 is that a fishery is a "stock of fish…treated as a unit." The data used to develop the exposure methodology comes from the National Marine Fishery Service (NMFS). Therefore, using their defined fisheries is easiest. The NMFS defines a fishery by the species or species combination, the method of fishing that is used, and a general geographic location. Then the NMFS creates a permit for this fishery (assuming that the fishing is being done in federally regulated waters). There is however a different way to look at fisheries.

The NMFS's Sustainable Fishery Division, in conjunction with Fishery Management councils, a group of representatives from areas in commercial fishing, creates fishery management plans for specific fisheries in different locations. These fishery management plans can encompass many species or just one, depending on similarities in the species and methods of fishing for them. The plans may regulate geographical fishing areas, how much fish can be harvested, methods of harvesting, and allowable days at sea spent fishing. Using a definition of a fishery as all methods of fishing, species fished for, and geographical areas fished that are managed by the NMFS fishery management plan will be most productive for the purpose of this study.

In order to understand better how each fishery works, we spoke with Lieutenants Parrish and German from the Coast Guard's Office of Law Enforcement. Emphasizing that the vessel permits are very complicated, we were able to obtain a basic outline of how they work.

The NMFS issues permits within each fishery detailing specifically what fishermen are allowed to catch and for how long and where. NMFS uses two different types of permits, a Limited Entry Permit (LEP), and an open access permit. The two types vary in their allowed amounts of effort and catch.

LEPs are for the larger commercial fishing vessels/operations. An LEP can be distributed several ways, depending on how the fishery management plan dictates. A common way is to set a limit on the number of LEPs that will be allowed in the fishery. The LEP details effort level in several ways. In the North East, LEPs are broken down into three levels, full-time, part-time, and occasional use. Each level of participation has an accompanying allotted Days at Sea (DAS) time. In some fisheries, such as the Atlantic Sea Scallop, an LEP also has an allotted Access Area trip. An access area trip is a trip to specific geographically limited fishing grounds. The fishermen are allowed to fish as long as they can in that area, but there is an allowable catch limit for the entire trip.

LEPs also have gear endorsements. In many fisheries, an LEP will only be valid for a specific type of fishing gear (i.e. trawling, longline, gillnet etc.). There are also varying restrictions on catch limit for each gear type. Certain fisheries in the North West also have a size endorsement on the LEP. The LEP limits the Length Over All (LOA) of the vessel. A fisherman can, however, purchase another LEP and combine the two to allow a larger LOA. Another restriction applies only to species combination fisheries. These LEPs have an individual quota on each species within the fishery.

The other type of permit is an Open Access permit. This type is for smaller fishermen that aren't exactly on the commercial scale that an LEP holder might be. Open Access allows an unlimited number of day trips with a limited catch quota for each day. The quotas are assigned so that the Open Access fishery will only catch 10% of what the LEP fishery will catch over the entire season. The next sections will give a brief background on the three fisheries we will be using in this project.

2.2.2: Scalloping

The scallop fishery is an important and large fishery in the northeast, or Coast Guard District (CGD) 1. To fish for scallops, vessels that average about 80 feet in length pull up to two dredges. Each dredge consists of a metal rectangular frame that is connected to a metal mesh net. These dredges are pulled through the bottom of the ocean, picking up not only scallops but whatever else might happen to be on the bottom of the ocean. Some scalloping crews might have up to 11 people on board.

Because scalloping is such an important fishery in the northeast, when the population of scallops began to decrease in the mid 90s, regulations were put in place to impede the depletion of scallop numbers. After the government and NMFS completed a study about growth of scallops in what they called 'closed conservation areas' (CCAs), they realized the best idea would be to rotate the CCAs in order to keep a somewhat steady population of scallops available to the fishermen. Also implemented was a limitation for days at sea, and the crew size was downgraded. Because of these regulations, the fishery is closely observed to make sure it is following the correct protocols.

2.2.3: Northeast Multispecies Groundfish

The northeast has a fishery that is labeled under the broad term of “multispecies”. This term incorporates approximately fifteen types of fish that can be found by bottom trawling, or dragging a net across the bottom of the ocean floor.

The primary method for catching types of fish known as groundfish is bottom trawling. While most any size vessel can feasibly trawl, the bigger the vessel is the bigger the net can be, and therefore, the bigger the catch. Most of the vessels fall in the 35-80 foot range. While similar to scalloping in that a device to catch the fish is dragged along the bottom of the water column, trawling uses a trawl net as opposed to a steel dredge.

The basic design and function of all trawl nets is fundamentally the same. Most trawl nets have a piece of chain along the opening of the net which is usually referred to as a tickler chain. The tickler chain is what causes the bottom to vibrate, causing fish to be disturbed. The net is dragged along the bottom, disturbing animals that are residing there, causing them to swim up, and into the approaching net. The fish will eventually get tired of swimming, and drift into the back of the net, or cod end.

Trawl nets are required by NMFS regulations to have a minimum mesh size. This is to allow smaller fish to easily escape the net, while preventing legally catch-able fish from doing the same.

2.2.4: Gulf of Mexico Red Snapper

The red snapper found in the Gulf of Mexico are part of the larger Gulf of Mexico multi-species reef fish fishery (Barker et. al, 1998). This fishery is the Gulf’s third most valuable fishery, “from which more than 20 million pounds worth about $40 million are harvested annually" (Goodyear, 1995). While a very profitable commercial fishery, red snapper are also fished for recreation.

Typically, commercial vessels in the Gulf of Mexico are small in size, usually thirty-eight feet in length and use a method of fishing called 'bandit' fishing. Bandit fishing is a somewhat mechanized version of handlining, one of the oldest kinds of fishing. In handlining, a lure is simply attached to a single fishing line, and jigged up and down to attract fish. Bandit fishing allows for a few people to simultaneously use many different handlines. Some of these are even mechanized so that they can be reeled in faster.

2.2.5: Definition of Risk/Binary Risk

Between a virtually uncountable amount of accident/fatality types and dozens of different types of fisheries, it is required for this project to narrow down the variables that affect risk. As with any scientific experiment, conclusions cannot be drawn if there are too many variables at stake. Section 2.2.1 sets up a strict definition of fishery to be used in this project. The only other variable that needs to be strictly defined in this project is "risk". For the purposes of this project, risk will be defined as "the danger a fisherman is exposed to when he is out on the water". Since there are different levels of risk in commercial fishing and this project is only focusing on fishermen's exposure to risk, this project will define risk as binary.

For this project, at any given time, a fisherman is either at risk or not at risk. Assessing specific levels of risk associated with certain actions is very difficult to do. There are too many factors that go into deciding how much risk different situations represent. For instance, a fisherman is more at risk while he is pulling in nets than when he is sleeping on board. Therefore, when measuring exposure to risk, a weighting system is often used. In order to put that system into a usable equation for all fisheries within the United States would take years of professional statistical analysis which is a resource that we do not have.

At this point, with there being no method that can universally evaluate different levels of risk for any given fishery, it is necessary to use just a binary risk for this project so that we can put our attention on the important variables that more directly affect exposure in commercial fishing such as crew size, trip length and even preparatory time. Therefore, there will be no weighting of variables; all situations that imply risk will be equal.

For example, casualty reports will be used not to determine which aspects of fishing need more attention when measuring exposure, but at what times while a fisherman is working is he at risk. If there are a significant percentage of fatalities while the vessel is moored, time spent at dock will be counted in hours towards the exposure. The point in defining risk as binary will strictly define those hours at dock by the number they are and not weight them. If there is a large enough chance of fatality, those hours will have the same importance as any other time where there is a chance of fatality.

2.3: Processes to Evaluate Exposure

There have been previous attempts to quantify exposure within a single fishery and these attempts can be studied to determine what may or may not work in a general methodology that can be applied to multiple fisheries. By examining other theses, statistics and methods, a picture of exposure can be constructed.

2.3.1: Definition of Exposure

Determining casualty and fatality rates requires two different statistics. One is the number of injuries or deaths that have occurred in a year or other specified time frame. The other statistic required is the denominator – the exposure. This is the number of workers working a forty hour work week all year (multiplied by one hundred thousand, to get a rate of deaths per hundred thousand workers) (Bureau of Labor Statistics, 2006). However, not everyone works exactly forty hours a week for fifty two weeks out of the year. This is where the Full Time Equivalent (FTE) number comes in. FTE is defined by the Department of Labor as “a personnel charge to the grant equal to 2,080 hours per year” (DOL, 2006). An employee working twenty hours a week would be a .5 FTE. This number is how the DOL and its agency the Bureau of Labor Statistics (BLS) standardize fatality and injury rates across all occupations. For more information on how the Department of Labor measures FTE, see section 2.3.2.

The problem for the commercial fishing industry lies in the absence of a standard work week. Fishing seasons are not all year long. Weather has a major effect on whether or not the fishermen can actually work. The methods of determining FTE for other occupations are practically useless when applied to fishermen. One cannot count how long a fisherman is pulling in nets on the water and use just that time to determine an FTE. The exposure of a commercial fisherman needs to be derived from all the time that he/she is exposed to risk while performing duties related to the job. Traveling to and from port, unloading nets at port and fishing at sea must all be accounted for when determining a commercial fisherman’s exposure, and thus calculating the FTE. For the purpose of this report, a broad definition of exposure will be used. Occupational exposure will be defined as the amount of time a fisherman is exposed to any type of risk while performing job duties. Exposure will then be used to determine FTE for fishermen, taking into account that fisherman often go out for weeks at a time and then stop fishing for half a year.

2.3.2: Department of Labor/Bureau of Labor Statistics

The Department of Labor's Bureau of Labor Statistics (BLS) is currently the governing agency in measuring the fatality rate in employment and then in specific occupations. Since the fatality rate is used to determine the most dangerous occupation, the process to determine fatality rate must be evaluated. There is a simple equation used to measure fatality rate as shown below:

Fatality rate = (N / W) x 100,000
N = the number of worker fatalities, workers aged 16 and older (Census of Fatal Occupational Injuries)
W = the annual average number of employed workers aged 16 and older (Current Population Survey, Department of Defense figures)
(BLS, 2006)

Essentially, the Department of Labor wants to find out the numerator (number of fatalities) for a specific denominator (100,000 workers) and by using this equation, standardizes that denominator for all occupations. For example, in 1999, the following data was retrieved from the Current Population Survey and Department of Defense:

N = 6,028
W = 134,666,000
Fatality rate = (N / W) x 100,000
Fatality rate = (6,028 / 134,666,000) x 100,000 = 4.5
Fatality rate = 4.5 fatalities per 100,000 workers
(BLS, 2006)

The number of fatalities along with the number of workers must be determined. The number of fatalities is determined from the Census of Fatal Occupational Injuries. At the end of each calendar year, the Federal-State cooperative program completes as accurate a census as possible using "multiple sources to identify, verify, and profile fatal worker injuries"

(BLS, CFOI, 2006). From the profiles, an official count is made totaling the number of deaths within the current labor force (N).

To determine the number of workers within the labor force, (W) the Bureau of Labor Statistics uses the Current Populations Survey. The CPS is done annually and is a sample survey that estimates the number of persons over age 16 employed and unemployed. The BLS defines people as employed if they “did any work at all for pay or profit during the survey week” and includes people who are working but may have been absent from work during the survey week due to vacation, illness, industry dispute and several other reasons. Persons unemployed are classified as such if they “do not have a job, have actively looked for work in the prior 4 weeks, and are currently available for work” (BLS CPS FAQ, 2006). The number of unemployed and employed are then added together to get the total number of persons within the labor force for the current year.

To create a standardized ratio, the number of fatalities is divided by the number of workers and multiplied by 100,000 to provide a simple concise number of fatalities per 100,000 workers. For example, using the data from 1999, the average national occupational fatality rate was 4.5 fatalities per 100,000 workers. A number above that average in the fishing industry would send a red flag indicating it as a dangerous occupation. The denominator itself is referred to as the FTE or Full Time Equivalent. The FTE as defined in section 2.3.1 is the equivalent number of workers in a given occupation working 40 hours a week, 52 weeks a year. This project calculated the FTE and from that, the fatality rate for specifically commercial fishing.

2.3.3: Basic Exposure Assessment Processes

Although the Department of Labor is the governing agency in calculating FTE through the Current Population Survey, there has been individual work within the field of commercial fishing to quantify FTE in a more accurate manner. As seen above, the DOL/BLS uses a very broad method to determine FTE for each occupation. Due to the resulting high fatality rate of commercial fishing, the USCG along with other agencies desires a more accurate measurement. Dr. Jennifer Lincoln of the Centers for Disease Control and Commander Chris Woodley of the USCG have spent years in this particular field of research and have determined accurate methods to measure exposure on the West Coast and in Alaska. This following sections review the basic concepts of each exposure assessment process.

2.3.3.1: Woodley/McDowell Study (2000)

A study of a rock lobster commercial fishery in South-Eastern Australia took an ethnographic approach to studying the fishing industry and the occupational risks associated with commercial fishing. The article, entitled "Not drowning, waving!: Safety management and occupational culture in an Australian commercial fishing port," speaks mostly to the reduction of injury by reducing Individual Allowable Catch (IAC), but also contains pertinent information on occupational exposure of commercial fishermen. To assess whether the methods of reducing injury and fatality rates were effective, the author, Benjamin Brooks, had to use a very personal approach to determine the exposure of fishermen. The author immersed himself in the culture for twelve weeks and went on five different fishing vessels and interviewed twelve different fishermen. This made it possible for the author to evaluate fishing time, deep-sea fishing time, and travel to and from port. This method is not conducive to evaluating the exposure at multiple fisheries, as it takes time and significant personal involvement.

An author cited by Brooks, USCG Commander Chris Woodley, wrote a master's thesis which directly addresses the issue of unreliable data on commercial fishermen exposure. The Department of Labor uses fatalities per one-hundred-thousand full time equivalent (FTE) fishermen. Full time employment is defined as working forty hours per week for one year (Woodley, 2000). The USCG's current method of determining FTE is by using "household surveys," but the numbers vary greatly (Woodley, 2000). The thesis then goes on to describe how the National Institute of Occupational Safety and Health (NIOSH) developed a process for determining fishermen exposure in Alaska. The process is as follows:

1. Determine an average crew size for a given fishery.
2. Multiply those crew numbers by the season length (in months).
3. Divide this product by 12 (months in the year).
4. Multiply item #3 by the number of vessels participating in the fishery.
5. The final result is an estimated Annual Employment Equivalent (AEE). (Woodley, 2006)

Woodley's master's thesis (Woodley 2006) presents this solution to quantifying exposure of fishermen in Alaska's fisheries. This was compiled from a study completed by the McDowell Group in 1989. Using crew size, season length, and the number of vessels participating in the given fishery, the process determines an FTE estimate for the given fishery.

2.3.3.2: Lincoln's Current Work

Considered number one in the field of quantifying exposure of commercial fishermen, Dr. Jennifer Lincoln is the leading expert and best source for other methodologies. She is currently working in Alaska for the Centers for Disease Control and has been working there alongside the National Institute for Occupational Safety and Health and contracting with Natural Resource Consultants for many years in an attempt to understand and quantify numerous unknown aspects of the commercial fishing industry. She assisted in Commander Chris Woodley's thesis and is one of the authors of the process that is currently being used to estimate denominators or the exposure for the fishing fleet in Alaska.

Having helped Commander Woodley, their methodologies are very similar. Lincoln outlined her process in an email originally sent to Mike Rosecrans (of the USCG's Fishing Vessel Safety Division):

`(#of vessels) X (operational days) X (avg. crew/vessel) = crew days`
(Lincoln, personal communication, November 6, 2006)

The number of vessels, operational days and average crew per vessel are all determined by multiple sources investigated by the NRC. To account for different season lengths, fisheries with shorter seasons are given more weight due to the probability of longer days at sea. More specifically, as Lincoln puts it, "if a fishery is open for less than 15 days, we multiply crew days by 3. If a fishery is open for 15 days - 50 days, we multiply crew days by 2. If a fishery is open for more than 50 days we use the existing crew days" (Lincoln email, 2006).

This method requires in depth research by the NRC, but once the numbers are determined and the crew days calculated, it is a very simple process to calculate an overall denominator for the fisheries counted or individual denominators for each fishery. This denominator is the FTE and thus a standard to compare to other occupations as well.

2.4: Conclusion

There are an uncountable number of articles, statistics, studies and regulations all aimed at determining the cause for accidents and fatalities at sea and hopefully decreasing the frequency of such. However, there has been little work on the measurements of fishermen's exposure and therefore it is challenging to find such information. As can be seen by the analysis of these previous studies, there are many variables that affect exposure and need to be taken into account. Between the unique environment of commercial fishing, the many nuances and differences within the occupation and the limited current attempts to quantify fishermen's exposure, our project worked to envelope all of these details into a process to precisely measure exposure at any given fishery. This gave the Coast Guard a good way to evaluate the effectiveness of their regulations that have been in place for years. It will finally be possible to determine whether or not the commercial fishing industry is becoming safer and in which areas.

3: Methodology

This project develops for the United States Coast Guard a method that quantifies exposure of commercial fishermen at a specific fishery and is expandable to apply to any US fishery. There are four steps that we used to develop the methodology and retrieve the results:

1. Evaluation of current exposure assessment processes
2. Assessment and acquisition of data pertaining to exposure
3. Development of a methodology to measure exposure
4. Evaluation of pilot fisheries

See next page for a flow chart that describes this process (Figure 3). The first three steps were completed in a cyclical progression simultaneously throughout the first four weeks of the project. Once the methodology itself was determined and the data was gathered and processed, step 4 was completed in the fifth week. Conclusions and recommendations followed this process being researched and developed in the last two weeks of the project. All major steps were completed and findings were presented to the United States Coast Guard on Tuesday December 12th 2006.

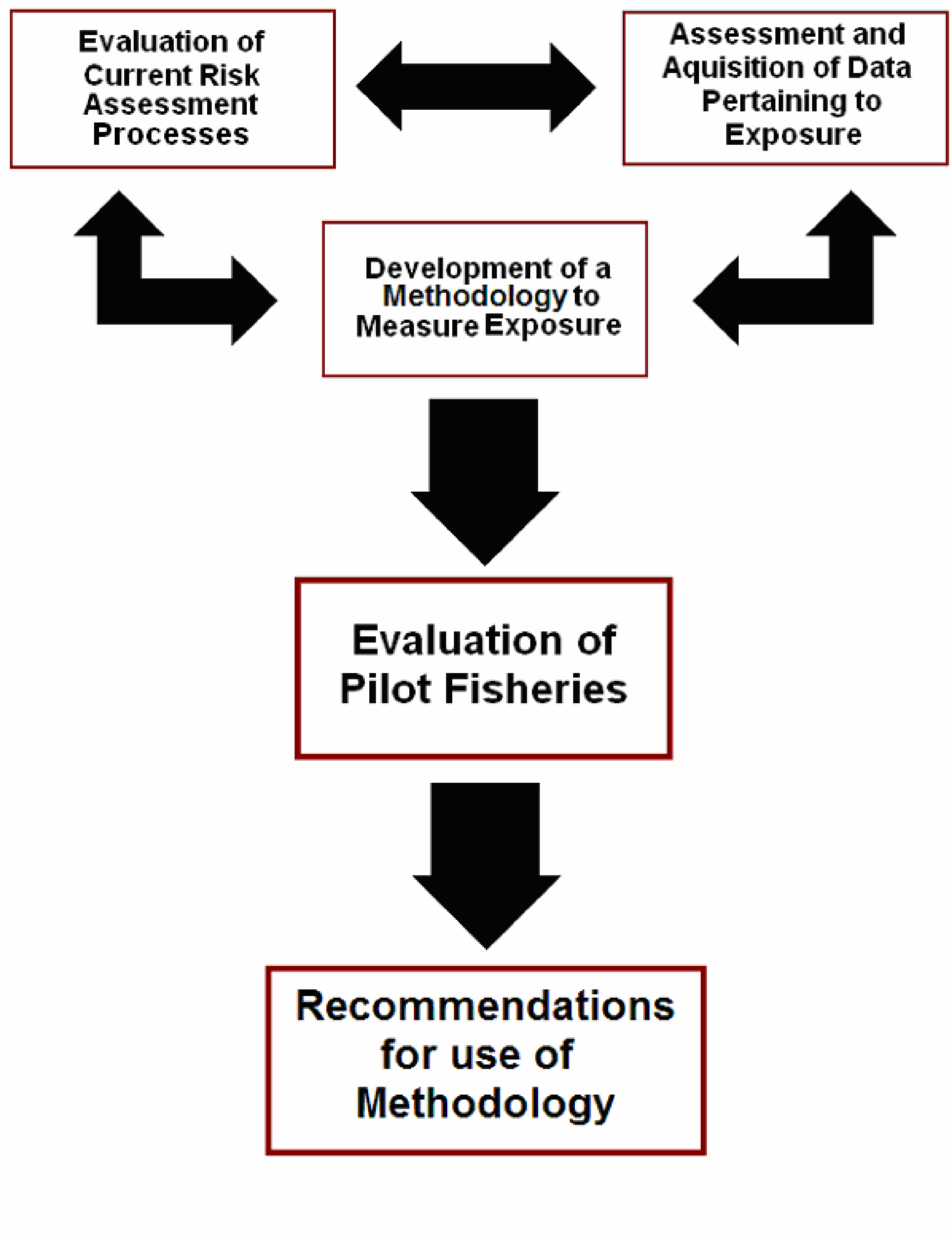

Figure 3: Methodology Flowchart

3.1: Evaluation of Current Exposure Assessment Processes

Exposure assessment processes outlined in publications and theses developed by researchers in the field or by certain government institutions such as the Department of Labor create a picture of how the exposure of fishermen is currently measured and how it can be measured more accurately. We evaluated such information, along with background information such as the difference of fisheries and current attempts at quantifying exposure. We saw what sort of data was being neglected and therefore created a more thorough methodology of measuring time at risk (exposure).

The National Institute of Occupational Safety and Health (NIOSH) is currently using the process developed by Lincoln in order to evaluate Full Time Equivalent workers and thus determine fatality rates in Alaskan fisheries. We have researched and analyzed these methods along with the national standards used by the Department of Labor (see section 4.1). We used FTE as a measure of exposure because it is the national standard. If one has the FTE for commercial fishing, they can potentially be able to compare it to almost every single other occupation in the United States. Table 2 in section 4.1 explains the positive and negative aspects for each process that we analyzed including our own.

To be able to compare these processes to our own, we had to produce our own basic outline of a methodology. We used previous practices to create this outline, determined what may have been neglected in these previous processes and then added those areas to ours. See section 3.3 for how we created a specific methodology with variables. The following three steps outline the development of our own methodology before actual data was collected.

- Determine if the previous process can be applied to commercial fishing.
- If applicable: what are the strengths and weaknesses?
- Incorporate strengths of each process into ours

Using this basic analytical process along with determining what data was available, we were able to develop a rough algebraic equation that would calculate exposure of commercial fishermen. Section 3.3 contains the final result of that equation.

3.2: Assessment and Acquisition of Data Pertaining to Exposure

Along with evaluating other processes, we determined the variables that affect exposure as outlined by the same previous methodologies. We then assessed what data was readily available to use in our equation or needed to be collected. This process helped us to develop a methodology that uses available data but is still accurate.

The basic requirements for quantifying exposure for a specific fishery that we determined are as follows:

1. Average crew size
2. Average length of fishing excursion (including all time away/working at port)
3. Average number of excursions (or catches) per season
4. Number of vessels participating in fishery
5. Preparatory Time (ex. loading time, transit time, etc)

The Coast Guard does not collect this data but it is available from the National Oceanic and Atmospheric Administration (NOAA). NOAA is the agency that essentially documents as much trip and vessel info as possible and has the authority to make sure that commercial fishermen are following regulations. Because of this, the data that we need such as listed above, is recorded by NOAA. Specifically, the National Marine Fisheries Service within NOAA records this data. See Appendix B for more information on NOAA.

For this project, we were not able to take into account preparatory time. Preparatory time, transit time and offloading times are not specifically recorded in logbooks and thus not documented by NMFS. When interviewing Commander Chris Woodley on 2 November 2006, we asked him how he determined the time of preparatory time. He clearly stated that the best and only way to accurately measure preparatory time was to “ask the fishermen” (Woodley, personal communication, November 2, 2006). In doing this, there is no guarantee that the information will be accurate. Due to time, geographical and cost restraints, we were unable to determine an average preparatory time. This is a crucial variable in the process however and should be taken into account (see sections 5.3 and 6.3). Statistics show that between 5 to 15% of all vessels are lost while at dock or transiting to the fishing site and thus contribute to fatalities. (USCG (1), 2006) Section 4.4 goes into detail on how preparatory time should be looked at when more time is available.

To gather the other four requirements, we began by contacting Patricia Kurkul at the New England Regional Office (NERO) for NMFS. She is currently the NE regional administrator. She gave us the contact information for John Witzig who works in NOAA’s department of statistics. Along with the help of his staff, he was able to organize their confidential statistical information in the areas that we want, and give us a comprehensive table with all the data that is necessary for the Northeast fisheries. Kevin McCarthy gave us the data for the Gulf of Mexico Red Snapper fishery. Section 4.2 goes into the details of the data acquisition process.

3.3: Development of a Methodology to Measure Exposure

Using the strengths from step one of our methodology (section 3.1) and the available data from step two (section 3.2), we created a mathematical equation to calculate the FTE for any given fishery. Because every other industry has solid methods, with little to no variability in exposure due to extraneous circumstances, commercial fishing needs this type of accuracy to be able to compare fatality rates between fisheries and to other industries. See section 2.3.2 in background for the review of the Department of Labor's current methods of measuring exposure. Other occupations are measured in days and number of workers. The most accurate direction to head in with a methodology for commercial fishing is an exposure method that quantifies hourly exposure and then converts to the FTE estimate. Since fishermen are at risk for more or less than the average 8 hour working day, it is necessary to determine FTE from a more accurate hourly estimate of workers than the method used by all other occupations that measures workers by an average 40 hours a week, 52 weeks a year. For more background information see section 2.3.2. Section 4.1.3 develops the analysis of such methods.

Fortunately, there is a wealth of information on the variables we need. Unfortunately, it is not particularly well organized, and very difficult to access. The database containing our data was too large even to fit into a Microsoft Excel spreadsheet. There were 24,000 entries total for the scallop fishery alone that represent all of the trips taken, crew size, start date, and end date. This data took many, many hours to decipher (as outlined in 4.2). As stated earlier, including preparatory problem would be most useful, but even more difficult and time consuming than the other data. Therefore, we only used the most important data that was readily available.

Multiplication of the four variables discussed in section 3.2 provided an estimate of hours of exposure. This methodology includes a variable that takes into account any sort of preparatory time important to quantifying exposure including: downtime at sea, traveling to/from port, and time spent at port preparing or working with catch. These factors are grouped under the heading “special instances of exposure” because every fishery will have different preparatory times leading up to the hour measurement in this group.

$T = \frac{(C \times L \times E \times V) + (S \times V)}{2{,}080}$ **WHERE:**	
C:	Average crew size per vessel
L:	Length of excursion (in hours) per vessel
E:	Average number of excursions per vessel
V:	Number of vessels in fishery
S:	Special instances of exposure (in hours)
T:	Full Time Equivalent (FTE) workers

Table 2: WPI Averaging Method

The FTE estimate was then reached by dividing the number of exposure hours by 2,080 (hours worked by full time employee in one year). This method is simple yet effective at providing an accurate FTE estimate that is based on actual exposure times, as proved in section 4.1.4.

3.4: Evaluation of Pilot Fisheries

We tested this final methodology with data obtained from three major fisheries in the United States. Two were from the East Coast, and one was from the Gulf of Mexico. In using such variable data, we hoped to validate that our methodology would be useful in the full range of fisheries.

In the Northeast, we used the Scallop and the Multispecies fisheries. As explained in section 2.2.2, the scallop fishery has many important regulations placed upon it. Because the regulations are watched so closely by NMFS, data such as time of excursion, return of excursion, crew size, and number of trips each vessel takes, is recorded and stored for reference reasons. This data is imperative to our study, and because the scallop fishery is a limited access fishery, the information is comparatively accurate. In a similar way, the Multispecies fishery is just as important to our data. It is a highly regulated area of fishing, so there is a large quantity of information that we need. The following aspects of those two Northeast Fisheries confirmed our decision:

- Available, complete records – needed in order to gather good data
- Regulated efficiently – important because fishery will be watched closely and good data will be kept
- Variability – helps us prove the methodology works on all sorts of fisheries

In the Gulf of Mexico we chose the Red Snapper fishery. After talking to Ted Harrington, the Coast Guard director of commercial fishing vessels in District 1 and deciding upon two different northeastern fisheries to analyze, we decided that we would use a more diverse fishery and choose a much smaller scale fishery from the Gulf coast to finally test our method. This would give us the ability to compare vast arrays of fishing data and see if our method works on different types of fisheries, as planned.

The data that was received was in a Microsoft Excel spreadsheet organized by trip by vessel. We therefore used Excel to calculate man-hours per trip and then total those hours to give us an exact exposure time. We then divided by 2,080 to convert to FTE, giving us a solid estimate for commercial fishermen. This became a new methodology entitled "WPI Direct Count Methodology" and is outlined in section 5.1. All results can be found in section 4.

Once we had FTE's for each fishery we determined fatality rates that would be useful in further analysis. Since the tally of total man-hours is exact according to the data, no averages as outlined by the WPI Averaging Method (Table 2) were needed. Since not all fisheries have such a precise count of hours however, we then used Excel to calculate the averages outlined in our methodology and from those averages, calculate the FTE. The accuracy of the WPI Averaging Method vs. the WPI Direct Count Methodology is compared in section 5.1 to begin our analysis.

From the calculated FTEs and fatality rates, we were able to explore several areas dealing with the accuracy and usability of our methodology. We began by discussing the implications of the fatality rates as compared to national standards. We then completed a sensitivity analysis to determine the importance of preparatory time. Lastly we looked into the possibility of any relationships between certain variables such as catch or vessel count and exposure. All analysis and conclusions can be found in section 5 with subsequent recommendations in section 6.

4: Results

This section presents the results obtained from completing the steps outlined in the previous methodology section. These results were obtained in the hope of presenting the United States Coast Guard with not only a method to determine exposure but validation that such a methodology can be applied to any given fishery. We began by analyzing processes by Dr. Jennifer Lincoln, Commander Chris Woodley, the Department of Labor that are currently in use to measure exposure. We then analyzed our own methodology in comparison to the other three. Next we sorted and summarized the data retrieved that would be used in the exposure equation. Finally we applied the equation to the summarized data, thus calculating the FTE for each fishery and analyzing the calculated results. Although only three distinct fisheries out of hundreds within the United States were used, multiple data sources and the natural diversity these three provide, account for the use of our equation on any given fishery.

4.1: Evaluation of Current Exposure Assessment Processes

As explained in section 3.1, we looked at various processes that measured exposure for commercial fishermen. The following sections detail each process, looking at the positive and negative aspects of each including our own methodology. Table 3 summarizes this data at the end of the section.

4.1.1: Lincoln and Natural Resources Consultants

The process developed by the Natural Resources Consultants in conjunction with Dr. Jennifer Lincoln is quite accurate in quantifying the exposure of commercial fishermen. The study uses the approach of estimating the number of vessels, total number of operational days per vessel, and the average crew size to estimate exposure numbers. Although it starts with an estimate, the "vessel counts are assumed to be accurate because of the highly regulated and enforced management that exists in these fisheries" (Bensyl, et. al., 2006). There are several key aspects of the process that are similar to others, and some that are unique.

The vessel count estimates are a number of vessels that made a delivery in the specific fishery in a year. This has been generally the accepted method of counting vessels. Fisheries maintain lists of the vessels participating in the fishery, but sometimes vessels do not actually land any catch due to various reasons. Because of this, vessel counts, as in this specific process, ignore vessels that go to sea but do not land any catch. In smaller fisheries where there may only be ten to twenty vessels this makes a rather large significance. In larger fisheries with upwards of one to two thousand vessels such as the ones we are using, the difference of one or two vessels is not significant to the overall exposure.

The study used knowledge of each fishery, as well as the permit requirements' limit of crew size to determine the average crew size. This method requires knowledge of the individual fishery in question and may require some personal interviews. With fisheries that limit crew size to a specific number, it may be relatively safe to use the maximum crew size, but that could be an over estimate. In certain fisheries, however, fishermen are required to report the number of crew aboard the vessel each time they make a landing. This method, while not always possible, would be more accurate.

The most unique aspect of this process was the use of operational days per vessel. This required knowing the days at sea that an average vessel spent fishing during the season. Therefore, included was transit time, time needed for gear, offloading catch time, and other various times of exposure. This is an excellent way to include the preparatory time that a fisherman spends throughout the season, but it requires a lot of study of each fishery. The preparatory time was estimated in terms of days, and while not as accurate as an hourly approach, seems more manageable.

The nature of the fisheries in the area of Lincoln's study made it more difficult to estimate time spent on the water. Some fisheries have long, drawn out seasons with quota systems that required an estimate of days at sea to be made that might be just as accurate as using the hard data. This was necessary though because of the lack of information in the area. Another complication was catcher/processor vessels that might compete in multiple fisheries in one trip and are out at sea for months at a time. These vessels can be hundreds of feet in length, and the standard twenty-four hours of exposure seemed to be an overestimate. The crew work in shifts, and thus the process scaled back the exposure for the fishermen accordingly. This measure was necessary to prevent having so called "super-fishermen" (Lincoln interview) that were being counted as working non-stop for three months.

One final aspect of the process was that it was able to include both federally and state managed fisheries. This is an advantage in areas where many fisheries may be state run, such as the bluefish or striped bass fisheries. Overall, Lincoln's process for measuring exposure is very accurate for the fisheries it evaluates in Alaska due to the individual study of each fishery: determining crew size, preparatory time and trip length. Our goal is to use the accurate aspects of this process and adapt and apply them to be used on any given fishery within the United States without having to conduct the extensive in depth research needed for each fishery.

4.1.2: McDowell/Woodley

As part of his master's thesis, Commander Chris Woodley uses and adapts a basic process to determine exposure that was developed by the McDowell Group in 1989. For information on the study and the actual process, see section 2.3.3. The advantage of the McDowell methodology that Woodley noted is that it is applicable to any fishery or region. Woodley also noted that the process accounted for fishermen working before and after the season. Although it only uses the number of months that the season is open and does not appear to account for the preparatory work, since the equation is a simple algebraic model, preparatory time can be easily added in. The Centers for Disease Control (CDC) and Natural Resources Consultants (NRC) are currently doing just that in Alaska. However, the only way to account for that preparatory time is to interview and get an average from each individual fishery. This is very time consuming and not an applicable answer to all fisheries.

Although it is very similar, Woodley also describes the problematic issues with the McDowell methodology before moving on to his description of better methods. According to Woodley, by assuming that fishermen only spend eight hours a day fishing, there is an under counting of exposure. Woodley explains this by saying that fishermen are actually on the water twenty-four hours a day in certain fisheries. To account for this discrepancy, Woodley uses 8, 16 or 24 hour workdays depending on the fishery. The only way to determine which number to use is to interview the actual fishermen and determine an average. Although this is an improvement on McDowell's method, it still rounds to the nearest eighth hour and requires an in depth analysis of each fishery to be evaluated.

Woodley then goes on to describe how observers are used to track exposure in certain fisheries, as an observer is required to be on board whenever a vessel is fishing in that specific fishery. This observer data would be quite accurate for exposure times, as it counts all time at sea by the vessel. This only applies to a select few fisheries that require the observer, and thus cannot be generalized as an exposure assessment process for all fisheries. Woodley continues describing nuances of specific fisheries and how certain techniques can be applied to quantify exposure.

Within Woodley's thesis on occupational exposure are several key strengths, despite the fact that it is only an appendix. Woodley's adaptation is general enough to be easily applied to any fishery or region, a requirement in writing our methodology. Another positive feature is that it does not double count exposure when a fisherman is participating in multiple fisheries.

An area that could be improved upon in Woodley's adaptation of the McDowell methodology is where he is relies on the basic assumptions of 8, 16 or 24 hour workdays. A more accurate exposure assessment process, while still looking similar to the style of McDowell/Woodley, would need to be developed with a focus on actual exposure time (in more specific hours, not rounded fractions of days) and then converting to the FTE estimate.

In Woodley's Appendix A, the fishermen are only listed as going out to sea for 8 hour intervals. His current work in Alaska has updated this to account for longer days at sea. However, there is still a more accurate way to adjust for longer days. Woodley's strength of using preparatory time is restrained by the fact that he blocks this work by distinct amounts of days, when something such as preparatory time is most likely not going to run by an exact number of days.

4.1.3: Department of Labor

The process the Department of Labor (DOL) uses also affected our methodology. Since the DOL uses national standards to measure exposure for fishermen, we realized the need to have our methodology also use the national standard of FTE. This made it easy to compare to other occupations. For more information on how FTE is calculated, see section 2.3.2. The DOL's or more specifically the Bureau of Labor Statistics' (BLS) methods have long been the standard for measuring and comparing accident and fatality rates among occupations. Their method is indeed accurate for most occupations that use the standard 40 hour work week. For unique occupations such as commercial fishing however, the method is not as useful. Their method has a few limitations that for the most part only marginally affect the fatality rates for other occupations but are a more serious concern for commercial fishing.

There are numerous notes on the Bureau of Labor statistics describing the limitations of these fatality rates. As pertaining to our situation are the following:

1. The Current Population Survey counts workers by their State of residence, whereas the Census of Fatal Occupational Injuries counts them by State of injury. Although these numbers are proportionally small when considering national data, fatality rates may be affected significantly in States with large numbers of commuters, migrant workers, business travelers, and workers in interstate transportation. The data reveal that truckers in the transportation industry, for example, incur a large number of occupational fatalities outside of their domiciliary States.

2. The Current Population Survey categorizes workers according to their primary job, which may differ from the job at which the deceased was working when fatally injured as reported in the Census of Fatal Occupational Injuries.

3. Employment-based fatality rates measure the incidence of a fatal injury for all workers in the group regardless of exposure time. Such measures are experimental and do not reflect the movement of persons into and out of the labor force, the length of their work week or work year, or the effect of multiple jobholders.

4. The rates are based on employment. They factor out differences in the number of fatal work injuries between worker groups due to different employment levels. They do not take into account differences in the number of hours worked. Hours-based rates, which factor out these differences, are generally considered more accurate. However, because of limitations in the availability of data on hours worked, the rates are employment based. (BLS, 2006)

The first point may seem insignificant at first when dealing with such large numbers but must be taken into account when dealing with fishing. Commercial fishermen often fish out of more than one port and even then out of more than one state. When the Current Population Survey and the Census of Fatal Occupational Injuries already have a discrepancy between what state to count employees in, fishermen with occupational residence in more than one state will only skew results.

The second bullet acts more as a disclaimer in the event that a death is counted towards a person's main occupation when the fatality may have occurred when they weren't working. Due to the serious nature of fatalities, the cause of death is usually known. This limitation is just to note that a man who is primarily a fisherman might die while on a side job and the death would be counted towards commercial fishing deaths. On the large scale that the BLS operates on, that does not pose a serious problem but when looking at individual fisheries as our project has done, one death can mean a significant change in fatality rate. To adjust for this, we gathered data on fatalities from more localized sources such as the New England Regional Office within the Coast Guard.

The third and fourth bullets all relate to the idea that fishermen are exposed 24 hours a day. The third point is the most crucial when it comes to commercial fishing as exposure time is so different from other occupations and therefore must be taken into account and as stated, it currently is not. In terms of the fourth limitation, whereas other fields only work specified shifts and are not at risk when off shift, for this project, commercial fishermen are considered at risk 24 hours a day for as many days or weeks they may be on the water. This is noted in the fourth limitation that states that the fatality rates would be more accurate if based on hours worked rather than on the number of workers themselves. Our project changed this denominator to the standard FTE calculated by hours worked and therefore produced a fatality rate that can be better compared to other occupations.

4.1.4: WPI Averaging Method

After taking into account the strengths and weaknesses of the two previously discussed methodologies and using analytical reasoning, we developed our own methodology (see section 3.3). Our main goal was to provide as accurate a number as possible for exposure with as broad a method as possible. The broader the method, the more applicable to different fisheries it is. In the end, compared to current exposure methods, our methodology is more precise in the sense that it measures time at sea by the hour rather than by the day. Unlike most other occupations, fishermen do not work an average 8 to 10 hour day. Using the measurement of hours, the process follows the similar path of Lincoln and Woodley by multiplying by crew size and number of vessels in a fishery to eventually estimate the FTE. Although we were unable to obtain preparatory times, our process accounts for such a variable and if measured in the same way using hours versus days, a more precise exposure number can be reached.

After a review of our process a weakness began to show itself. Because our methodology is so data-specific with calculating specific hours, a drawback is that the information is very difficult to find. Fishery-specific data is necessary in order to compare different fisheries to properly assess which are the most dangerous. Data like this can be difficult to find because of regulations and permits that are in place within the commercial fishing industry. Each region within the United States has a different method to organizing and classifying fisheries. In Alaska where Woodley and Lincoln did most of their work, the fisheries are state managed whereas on the East Coast fisheries are defined by either Coast Guard district or by permit. NMFS holds the data classified by permit while the Coast Guard records number of deaths uses their own districts. These discrepancies make it difficult to obtain consistent, accurate data on fisheries.

In conclusion, in the table below, each method is listed with an outline of the positive and negative aspects of each previously analyzed process.

Process	Pros	Cons
Jennifer Lincoln	1. Very accurate 2. Includes preparatory time and other special cases in certain fisheries	1. Requires extensive research for each fishery 2. Applicable only to Alaska/West Coast
Woodley/McDowell Group	1. Broad and applicable to many fisheries 2. Builds in accounting for preparatory time	1. Uses either an 8 hour or 24 hour workday 2. Lumps prep. time into distinct amounts of days
Department of Labor	1. Uses national standards 2. Easy to compare to other occupations	1. Based on Current Population Survey 2. Does not account for 24 hour work days
WPI Averaging Method	1. Accounting by the hour (specificity) 2. Flexible incorporation of preparatory time	1. Requires specific data for each fishery 2. Data may not be available

Table 3: Comparison of Methodologies

4.2: Northeast Exposure Calculations

From data supplied by John Witzig of the National Marine Fisheries Service's New England Regional Office (NERO), we were able to determine total exposure time of all fishermen working in both the Northeast Multispecies Fishery and the Scallop Fishery.

We received the data on a disk, which held two Excel spreadsheets: The first was for the scallop fishery and it included data from 24,854 trips taken by various vessels. The second spreadsheet contained data from the multispecies fishery, and included 111,205 trips. All of these trips were taken in the 2005 fishing season. The data was superbly formatted in a Microsoft Excel Spreadsheet, which provided a means to perform calculations without having to transcribe data. We saw the opportunity to use Excel to directly count every hour spent on the water rather than taking averages as our methodology calls for (WPI Averaging Method – see Table 2). We eventually calculated the averages and compared the accuracy of such to the direct count of every hour spent on the water as can be seen in section 5.1. The following section goes into detail on how we used Excel to obtain FTE without taking the averages.

The following excerpt, containing columns A through F, will be used in explaining calculations:

A	B	C	D	E	F
VESSEL_ID	DATE_SAIL	TIME SAILED	DATE_LAND	TIME LANDED	# CREW
114	19-Apr-05	7:00	19-Apr-05	15:00	1
114	5-Jun-05	6:00	5-Jun-05	15:00	1
114	9-Jun-05	6:00	9-Jun-05	17:00	1
114	13-Jun-05	6:00	13-Jun-05	16:30	1
114	18-Jun-05	7:00	18-Jun-05	15:30	1

Table 4: Scallop Fishery Data Excerpt

Step one in determining total exposure time was to determine exactly how long the fishing trips were. This was done by simply subtracting a start time (time sailed) and dates, from the end time (time landed) and date. In this case, we needed to do this twice, once, for the number of days, and a second time for the actual hours. As Excel is capable of determining the number of days between two dates (columns B and D), a simple subtraction formula was used for calculating the number of days a trip spanned. Column G was set to the following formula:

=D:D-B:B = column G (# days in trip)

In Excel, this formula simply takes the value of a cell in column D, and subtracts the value of the cell in column B which belongs to the same row. For example, the calculation for row 2 would be as follows:

=(19-Apr-05)-(19-Apr-05)
= 0

Excel recognizes that these two dates are the same, and as such, returns the value zero. In the event that there is one or more days in between the day the vessel began its trip and the day the vessel ended its trip, Excel recognizes this and returns the appropriate value.

Next, to determine the number of hours, another simple subtraction formula was used. Though columns C and E are formatted as time values, Excel can still perform arithmetic operations on these values. While some trips spanned more than one day, simply subtracting the time the vessel began its trip from the time the vessel ended its trip, would give the number of hours between the start of the trip and the end of the trip. This was inserted into Column H:

=(E:E-C:C)*24 = column H (# hours in trip)

In Microsoft Excel, when one time value is subtracted from another, the result is returned in Excel Serial form, which is a decimal number. In order to convert this number to a number of hours, Excel’s help file says to multiply the serial form number by 24, which is shown in the above equation. This formula used on row 2 would produce the following result:

```
=(15:00-7:00)*24
=8 = number of hours
```

In addition, if the vessel's trip spanned more than one day, this was taken into account by multiplying the number of days by 24 hours, then adding to this the number of hours (Column H) and finally, multiplying by the number of crew (Column F). The following formula was placed in Column I:

```
=(G:G*24+H:H)*F:F
```

This results in an accurate representation of the exposure time per trip, and is evaluated for row 2 as follows:

```
=(0*24+8)*1
=8
```

The result in Column I is now the total exposure time per trip. To get Full-Time Equivalency workers from this requires a few more calculations, first, the total exposure time must be calculated. This is calculated for Column I by the following formula:

```
=SUM(I:I)
```

With this formula, Excel automatically sums all number values in the column and outputs the number into the designated cell. In our spreadsheet we put this value in cell K3 in order to separate it from the rest of the data and to draw attention to it. To calculate FTE hours from the total exposure time, we used a simple formula in cell K4:

```
=K3/2080 = FTE estimate
```

Excel takes the value of cell K3 and divides it by 2080, resulting in FTE workers. The advantage to performing such calculations in Excel is that data can be added to the spreadsheet, and the values will adjust according to what the newly entered data is. In some cases, the Time Sail and Time Land, values are in number format, 700 as opposed to 7:00. It is possible to use Excel to change these number values to time values by using the following equation, which assumes the column with times in number format is column C:

```
=IF(LEN(C:C)=1,"00:0"&C:C,IF(LEN(C:C)=2,"00:"&C:C,(LEFT(C:C,LEN(C:C)-2)&":"&RIGHT(C:C,2))+0))
```

This formula simply takes the number values of column C and puts a colon in them. After the column is formatted as 24-hr time values, Excel recognizes them as times, and the calculations can be performed as mentioned above. This same method was used in determining FTE workers for both the Scallop fishery and the Multispecies fishery.

From the data supplied by John Witzig, we were able to determine the length of each scallop fishing excursion in hours. This gives us a total amount of time that fishermen spend at risk, and therefore, is the “denominator” that we were seeking. We used three different calculations in Microsoft Excel to determine the total amount of crew hours over the entire length of the scallop fishing season. This added three more columns to the spreadsheet, which are highlighted in yellow in the following table:

A	B	C	D	E	F	G	H	I
VESSEL ID	DATE SAIL	TIME SAILED	DATE LAND	TIME LANDED	# CREW	Days > 1	Total Hours	Man Hours
114	19-Apr-05	7:00	19-Apr-05	15:00	1	0	8	8
114	5-Jun-05	6:00	5-Jun-05	15:00	1	0	9	9
114	9-Jun-05	6:00	9-Jun-05	17:00	1	0	11	11
114	13-Jun-05	6:00	13-Jun-05	16:30	1	0	10.5	10.5
114	18-Jun-05	7:00	18-Jun-05	15:30	1	0	8.5	8.5

Table 5: Scallop Fishery Excerpt with Calculations

The Excel spreadsheets that contained our data had over 3 million cells, and as such, the spreadsheets in their entirety are not be included this report. The final calculations for the Scallop fishery were computed in Excel and are shown in table 9:

While the method used to formulate results for the Multispecies fishery was identical to the method used in determining FTE workers for the Scallop fishery, the results were understandably different. The Scallop fishery had just under 25,000 trips taken during the 2005 season, while the Multispecies fishery had over 100,000 trips. A data excerpt with the calculated columns highlighted is as follows:

A	B	C	D	E	F	G	H	I
VESSEL ID	DATE SAIL	TIME SAILED	DATE LAND	TIME LANDED	# CREW	Days > 1	Total Hours	Man Hours
12	6-Jun-05	6:00	6-Jun-05	11:00	1	0	5	5
12	9-Jun-05	7:00	9-Jun-05	12:00	1	0	5	5
12	18-Jun-05	6:00	18-Jun-05	11:00	1	0	5	5
22	4-Jan-05	5:45	4-Jan-05	19:00	2	0	13.25	26.5
12	6-Jun-05	6:00	6-Jun-05	11:00	1	0	5	5

Table 6: Multispecies Fishery Excerpt with Calculations

The final results for the Multispecies fishery were significantly different from those of the Scallop fishery. There were several thousand more trips, and the number of FTE workers was significantly higher. The results in table 9 show this.

4.3: Gulf of Mexico Exposure Calculations

The Red Snapper data was supplied and compiled by Kevin McCarthy and the NOAA regional office for the Gulf of Mexico. This particular data set was emailed to us, and contains 56,240 different trips over a period of 13 years. While we did not specifically ask for this historical data, we are grateful for it being sent, and are presented with the advantage of being able to compare different years to one another.

The data was organized similar to the scallop and multispecies fisheries in that it contained a vessel identifier, date sailed, date landed, and a number of crew members. Additionally, there were columns for the area fished, and the date that the catch was unloaded. There were several other columns of data that we were supplied with, but were not essential to determining FTEs. These data types included, schedule, gear type, and pounds landed by species. An excerpt of the data (not including pounds landed) is as follows:

VESID	Gear	AREA	STARTED	LANDED	UNLOAD	AWAY	CREW
HGMHME	E	6	2/1/2002	2/10/2002	2/10/2002	10	1
HGMHME	H	5	2/1/2002	2/10/2002	2/10/2002	10	1
HGMHME	L	5	2/1/2002	2/10/2002	2/10/2002	10	1
HGMHME	L	6	2/1/2002	2/10/2002	2/10/2002	10	1
47CEEKQF	S	11	9/9/1999	9/10/1999	9/14/1999	2	2

Table 7: Red Snapper Data Excerpt

As the data included has a column specifically stating the number of days at sea, but not times started and landed, we simply assumed that the fishermen were fishing all day long, providing a total exposure time of 24 hours per day. We cannot calculate exactly how long the fishermen were fishing and so this assumption is used for all of the red snapper data. Since most if not all trips were multiple days long, 24 hours per day is a good estimate. While not as accurate as the other two fisheries, using this assumption on all the Gulf of

Mexico trips will result in a precise FTE for that fishery.

The total time spent fishing per trip was simple to calculate by creating a formula in an empty column which multiplies the number of days fished by 24 hours. This formula was placed in column P. Since the data spans 13 years and we wanted to do a historical analysis of those years, we decided to calculate FTE by year. To do that we created one column with a formula that derived the year from date landed, but only if the vessel caught red snapper on that trip. The equation is as follows:

```
=IF(O:O<>"",YEAR(F:F),"")
```

In this formula, column O is the column which contains the amount of Red Snapper caught, which signifies whether or not Red Snapper were caught on the particular trip. Column F contains the date landed, which is the year the trip was recorded in. The above formula simply checks column O for a value, and if there is one, it outputs the year from column F. For us, this formula was placed in column Q. After this, thirteen columns were created, one for each year of data. The formula (example from column R, year 1993) for these columns is as follows:

```
=IF($Q:$Q=R1,$P:$P,"")
```

This formula, again for the year 1993 which is column R for us, simply checks the value in column Q, to see if it matches the value in the first cell of column R, which is the year 1993. If the years match, than the corresponding value in column P is placed into column R. (The dollar signs in this formula prevent Excel from using incorrect cells.) Modifying this formula by simply incrementing R1 to S1, for the year 1994 (T1, U1 and so on for the years 1995 through 2005) allows us to determine total exposure time by year. To determine the total exposure time for a specific year, the column for that year is simply summed using the =SUM(value1,value2…) formula in Excel. An example for the year 1993:

```
=SUM(R:R)
```

Doing this in empty cells for the other years will allow comparison across the time period. However, to make the FTE comparison easier, a different formula (as follows) was used:

```
=SUM(R:R-R1)/2080
```

This formula sums the cell values in column R, subtracts the year (which although is a column heading, Excel treats as a number in the column) and divides the result by 2080 to get an FTE. Using this formula (incrementing columns as necessary) will provide FTEs by year so that comparisons may be made. An excerpt of the final values is as follows:

Year	FTE
2000	373
2001	402
2002	425
2003	447
2004	485
2005	437

Table 8: Red Snapper FTE Excerpt

For each year the total man hours and subsequent FTE were calculated. To compare to the other fisheries, the data is shown in Table 11 in the next section.

4.4 Final Results

For each of the fisheries the total man-hours, total trip hours, and average crew were calculated. However, only the total number of man-hours will assist us in determining FTE workers. This data is summarized below:

Fishery	Scallop	Multispecies	Red Snapper
Total Man Hours	5,828,160	11,342,240	908,960
FTE	**2802**	**5453**	**437**

Table 9: FTE Results 2005

For each fishery, FTE was fairly easily found once the equations in Excel were sorted out. A summary of the FTE's and other important numbers can be found in Appendix C. The next section will begin to use these numbers to provide useful studies and analysis for the United States Coast Guard.

5: Analysis and Conclusions

The following section will analyze and manipulate previously calculated values in an effort to examine the quality of the determined FTE's and then work with the FTE's to provide different values important to the United States Coast Guard. Using Excel to directly tally man-hours and thus calculate a precise FTE, we examined the accuracy of such a method versus the accuracy of our original planned methodology. Next we observed fatality rates of each fishery. Using simple calculations, the rates were determined and analyzed for any correlation between the fisheries. Last are two important possible implications of the calculated FTE's and fatality rates. The first is a sensitivity analysis that will evaluate the statistical significance of including preparatory time. The second looks at possible mathematical correlations between the number of vessels or catch harvested in the fishery and exposure to see if there is any simple equation that can be used to determine exposure if only the number of vessels or catch is known.

5.1: WPI Averaging Method vs. WPI Direct Hours Calculations

The original methodology, WPI Averaging Method as outlined in section 4.1.4 would calculate exposure of fisherman using a series of average values, which would be multiplied together, resulting in total exposure time for the fishing season based on average data. However, once the data for this project was acquired, it was more efficient to use Excel to perform individual calculations on each trip taken for that season. These direct calculations multiplied trip length by the number of crew, and summed all the trip length values resulting in a total exposure time based on raw data (see section 4.2).

To compare the difference in accuracies of the two methods, (our methodology of averaged data versus the direct count of total man-hours), we used Excel to calculate the needed averages and then apply those numbers to our methodology. Since the data was broken into trips by vessel, we were able to calculate average crew size, average trip length and average number of trips per vessel. Then multiplying those numbers by the total number of vessels in each fishery and dividing by 2,080 we had an FTE as outlined by the WPI Averaging Method. Below are the equations used to find FTE by each method, and the summary of data calculated:

WPI Direct Count Method:

$$\text{Fishery FTE} = \frac{\sum(\text{Man hours per trip})}{2080}$$

Where Man hours per trip = $TimeLanded - TimeSailed \times Crewsize$

WPI Averaging Method:

$$\text{Fishery FTE} = \frac{(C \times L \times E \times V)}{2080}$$

*For definitions of variables see table below

	Scallop	Multispecies	Red Snapper
Average Crew Size per vessel (C)	4.01	2.80	2.91
Average Trip Length per vessel (L)	89.476	50.767	65.949
Average # of Trips per vessel (E)	24.656	29.208	34.413
Total # of Vessels (V)	1,008	2,526	486
WPI Averaging Method FTE	4,287	5,142	1,543
WPI Direct Count Method FTE	**2,802**	**4,833**	**437**

Table 10: Original Methodology vs. WPI Direct Hours Data

While using averages would result in a total exposure time, counting everything individually would result in a much more accurate total exposure time. This is because every hour would then be accounted for, whereas in an average, if there are many large values, they will skew the result towards the large values; the same is true if there are many smaller values and only a few large values.

For the scallop fishery, our original methodology resulted in an FTE of 4,287 while the direct calculations, counting everything, resulted in an FTE of 2,802. The original methodology resulted in a higher FTE because a high average number of trips and high average length of trip offset the small trip length values and number of trips. There is a 35% difference between the two numbers showing how much difference averages versus straight calculations make. This is a significant difference and if that much difference is possible at one fishery, it is possible at multiple fisheries. This suggests that our original WPI Averaging method may not be applicable across the United States.

The multispecies fishery being much larger than the scallop fishery with 2,526 vessels (over twice as many as the scallop fishery with 1,008) and nearly 111,000 trips (over four times as many as the scallop fishery with 25,000), will naturally have a more accurate average FTE than the scallop fishery. Although still fairly inaccurate compared to the direct man-hours calculations for the above mentioned reasons, because of the sheer amount of data, the FTE from our original methodology was calculated out to be 5,142 compared to 4,833, a difference of only 309 compared to the scallop fishery that had a difference of 1485 – over half of the direct hours calculated FTE.

The Red Snapper fishery follows the trend of the scallop fishery with an average FTE much higher than a directly calculated FTE. As stated earlier, the larger the fishery the more accurate the data and thus, with a fishery as small as the red snapper fishery with only 437 FTE workers, it goes to follow that the averages and then the averages of averages will be much more inaccurate. Between an FTE of 1543 versus 437, there is a 72% increase. This confirms that our original methodology, although capable of calculating FTE, is not applicable to small scale fisheries.

In conclusion, the formula called “WPI Direct Method” allows for the most accurate representation of the data in the spreadsheet. As the data was supplied in a spreadsheet, we did not see a need to transfer it to a different program or even to pen and paper in order to perform the calculations by hand. Excel could calculate the values using all the data and we saw no reason to do otherwise. With our original methodology, we calculated FTE workers by using average values, and then averages of those averages. As can be seen by the Scallop fishery numbers, this can create upwards of a 35% difference in values. Therefore, we conclude that our original methodology, although accurate for large fisheries, is not reliable for smaller scale fisheries. However, our second, new methodology, titled the “the WPI Direct Count Method” is applicable to any fishery across the United States, provided the data is available.

5.2: Fatality Rates

The next step in analyzing the FTE’s was to calculate and analyze the resulting fatality rates. Section 2.3.2 describes how fatality rates are determined. Simply put, it is the number of deaths divided by the FTE and then multiplied by 100,000 for a standard, concise number. The calculations for the fatality rate of each fishery can be found in Appendix D. Unfortunately, no fatality rate was available for the Red Snapper fishery due to the lack of fatality data. Within Coast Guard District 8 (see Appendix E), recorded fatalities are not always classified by type of fishing and therefore it was not possible to determine how many deaths occurred within the Red Snapper fishery alone. The fatality rates of the Scallop and Multispecies fishery can still be calculated and compared as seen in the following analysis.

Looking at just the FTE and number of deaths for each fishery, the fatality rates can be estimated. With an FTE of 4,833 in the multispecies fishery and 2,802 for the scallop fishery, it can be seen that multispecies fishermen spend almost twice as long at risk as the scallop fishermen. Then when one looks at the number of deaths, there are over twice as many deaths in the scallop fishery than the multispecies fishery. With twice as many deaths for half as much exposure time, it would follow that the Scallop fatality rate will be much higher than the Multispecies rate. After the calculations, the resulting rates can be seen below and are summarized as follows: 250 deaths per 100,000 workers in the Scallops fishery and 62 deaths per 100,000 workers in the multispecies fishery.

	SCALLOP	**MULTISPECIES**
FTE	2,802	4,833
# FATALITIES	7	3
=FATALITY RATE (deaths/100,000 workers)	250	62

Table 11: Fishery Fatality Rates

In comparison to each other, these rates show that there is a four times greater chance of fatality in the Scallop fishery than there is in the Multispecies fishery and thus the Scallop fishery was much more dangerous than the Multispecies fishery for the year 2005. However, the number of deaths in each fishery is small and varies year to year which can greatly impact the overall fatality rate. For instance, one more death in the multispecies fishery would result in a fatality rate of 83 – an increase of 25%. Therefore, to truly determine which fisheries are the most dangerous, it becomes necessary to examine past years to make sure the year in question is not an outlier. We were only able to receive fatality information on past years for Coast Guard District 1 (see Appendix E). We took the average of past years and compared to 2005 to check the credibility of fatalities for that year. To determine outlier years, looking at fatalities alone would be the first course of action. With such low numbers such as 3 and 7, before fatality rates are even looked at, one can first see outliers in fatalities alone. The following table shows the number of deaths from both fisheries for those years:

Year	Scallop Fishery	Multispecies Fishery
1993	3	3
1994	0	11
1995	1	0
1996	1	0
1997	1	2
1998	1	1
1999	0	1
2000	1	10
2001	0	8
2002	1	0
2003	9	0
2004	5	0
2005	2	2
Average:	1.92	2.92

Table 12: Past Fatalities

As can be seen by the averages, 2005 is not an outlier year. Outliers can be seen however. For example, in the year 2000, there were 10 deaths in the multispecies fishery. Had we been examining data and fatality rates from 2000, we would have to take that into account. To be able to draw conclusions on each fishery throughout the years, FTE would need to be estimated for each year and due to the time restraints of this project, we were unable to obtain such data.

Since the exposure was calculated in the same way for each fishery it is possible to draw conclusions from a comparison of the above results. For 2005, the Bureau of Labor Statistics (BLS) declared that for 48 deaths in the commercial fishing industry that the fatality rate was 118 deaths per 100,000 workers. As described in section 2.3.2 and 4.1.3, this is from the Current Population Survey which takes a random sample survey to determine the number of equivalent workers in each occupation. Therefore, 118 deaths per 100,000 workers is derived from an average of equivalent workers or fishermen in this case throughout the entire United States. This rate is not specific to any particular fishery, nor is it an average of workers from each fishery. Our data suggests that the Multispecies fatality rate falls far below the national average of 118 with 62 deaths per 100,000 workers and the Scallop fishery far over it at approximately 250. We can then draw the conclusion that for the year 2005, the Scallop fishery was more dangerous than the average fishery and the Multispecies fishery was less dangerous than the average fishery.

We can also compare these rates to the national occupational fatality rate for all occupations. Since the majority of occupations can be accurately measured by a 40 hour work week, the national fatality rate of approximately 4 deaths per 100,000 workers for all occupations is also an accurate measurement. The same goes for individual occupations that also go by a 40 hour work week. The following figure summarizes the highest fatality rates by occupation for the year 2005:

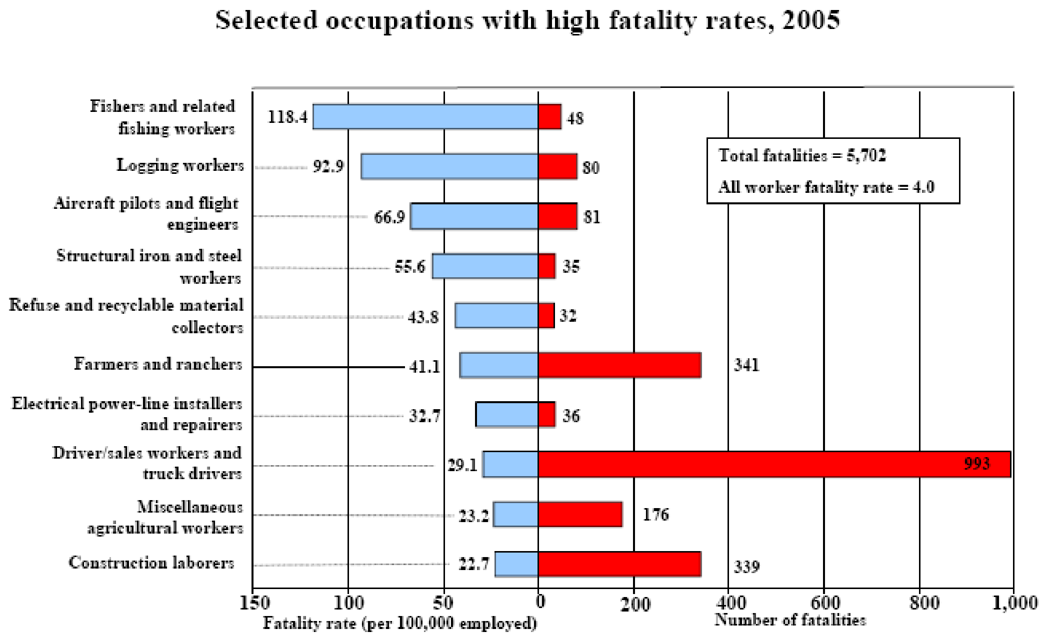

Figure 4: Occupational Fatality Rates for 2005 (BLS, 2005)

The fishing occupation is considered the most dangerous in the United States with a fatality rate of 118.4 deaths per 100,000 workers. Although the deaths are far less numerous than other occupations such as farmers, drivers and construction laborers, the exposure is also less resulting in a higher fatality rate. With the average at 118 and the Scallop fishery at 250, these rates far surpass any other occupation. The Multispecies fishery would fall into place as the fourth most dangerous occupation right after Aircraft pilots and flight engineers. In comparison to occupational fatality rates across the United States, calculated by the BLS, the scallop and multispecies fishery in the Northeast estimated by our methodology show those fisheries to be significantly more dangerous for the year 2005.

Although this conclusion shows fishing to be more dangerous than any other occupation, it may be more useful for the Coast Guard to know what individual fisheries are more dangerous than others. Therefore, our focus will remain on comparing fishery to fishery. As previously noted, we estimated the Scallop fishery had a fatality rate of roughly four times that of the Multispecies fishery for 2005. The main conclusion that can be drawn from this statistic is that for the calendar year of 2005, the Northeast Scallop fishery is much more dangerous than the Multispecies fishery although for a truly accurate representation, one would need to evaluate fatality rates over the course of many years.

5.3: Sensitivity Analysis of Preparatory Time

Looking back at section 3.2 and the stated Coast Guard statistics where 5-15% of all vessel losses occur while at dock, we realize that preparatory time needs to be evaluated for its statistical impact on the FTE and resulting fatality rate. However, due to the inability to gather exact data on preparatory time and in an effort to determine whether the extra time is even significant or not, we decided to do a relatively simple sensitivity analysis on the Scallop and Multispecies fisheries. We were unable to perform the analysis on the Red Snapper fishery due to the data being measured in days and not hours. The goal in this was to determine how sensitive the FTE and fatality rate results would be to differing values of preparatory time.

We first decided to gauge the overall effect of preparatory time by adding 5 hours, 10 hours and 20 hours to each crew member for each trip. In doing this, we found a linear relationship. We saw that for every 5 hours of time added, total man hours were increased by approximately 6 to 8 percent. Since the calculation of FTE from man hours is simply dividing by 2,080, the percent change in FTE was also 8.2%. The following table shows the values for each calculation. When plotted, they result in a linear relationship with a regression of 0.99. This confirms the relationship between man-hours and FTE and shows the consistency of adding arbitrary values of preparatory time. When fatality rates are added in, the percent change also remains the same as FTE and man hours since the calculation of fatality rate is also a simple act of division. The minor differences are only a result of rounding. These results show that when only 5 hours of preparatory time are added for each crew member, each trip, the resulting fatality rate is approximately 8% lower than the original.

Time Added	Man Hours	% Change	FTE	% Change	Fatality Rate	% Change
0 Hours	5,828,160	0	2,802	0	250	0
5 Hours	6,348,829	8.2	3,052	8.2	229	8.4
10 Hours	6,782,084	14.1	3,261	14.1	215	14.0
20 Hours	7,648,594	23.8	3,677	23.8	190	24.0

Table 13: Linear Relationship Values between Time and FTE

These numbers show a potential for preparatory time to be significant so we decided to evaluate more realistic numbers. In a new column, we added 4 hours of preparatory time to the vessels that went on trips that lasted a day or less. For the longer trips, we added 10 hours of prep time to the excursion length, assuming more preparatory time would be needed for the longer trips. Four hours for shorter trips and ten hours for longer trips are a relatively low estimate in preparatory time, especially if any transit is involved. Therefore, if there is a significant change in FTE and fatality rates from only 4 or 10 hour additions, preparatory time can be deemed as a significant variable to be added in since we proved earlier that there is a linear relationship between added hours and fatality rates. Once the 4 and 10 hours were added in to their respective trips, we had new FTE's and then we calculated the resulting fatality rates. We then compared that value to the originals and calculated the percent change in FTE and in deaths per 100,000 fishermen.

Scallops		Multispecies	
# Deaths	7	# Deaths	3
FTE	2,802	FTE	4,833
FTE (prep)	3,145	FTE (Prep)	5,609
Fatality Rt.	250	Fatality Rt.	62
Fatality Rt. (Prep)	222	Fatality Rt. (Prep)	54
% Δ FTE	10.9%	% Δ FTE	13.8%
% Δ Fatality Rate	-11.2%	% Δ Fatality Rate	-13.0%

Table 14: Sensitivity Analysis Data

The scallop fishery FTE was increased by 10.9%, while the fatality rate changed by 11.2%; again a difference by rounding. Since these are the lowest estimates for preparatory time and on average, would only increase from here, 11% differences can be deemed significant. For the multispecies fishery, we calculated the FTE which included preparatory time in the exact same way as with the scallop fishery; however the FTE changed more in this particular fishery. We calculated the new FTE to be 5,609, which is a percent change of 13.8%. This value is higher because within such a large fishery with so many trips, preparatory time counts for a larger percentage of total time. In calculating the fatality rates, we obtained a value of 54 deaths per 100,000 fishermen. This is a 13% decrease in fatality rate. This is a large enough initial change, implying once again, that in the multispecies fishery, preparatory time is important to account for.

Although the 4 and 10 hours are only estimates, any additional preparatory time would result in a greater change and thus shows that no matter what the estimate, FTE and fatality rates are sensitive to preparatory time. Therefore, we can conclude, that to increase the accuracy of FTE and fatality rate measurements, preparatory time should be included. This would also eliminate any doubts as to fatality rates if there were fatalities that occurred during preparatory time which as noted in the introductory paragraph, occurs 5 to 15% of the time.

Although this conclusion may seem to undermine the accuracy of our original FTE and fatality rate estimates, for the purpose of this project, it does not. As shown in sections 5.2 and 6.2, the purpose of these FTEs and fatality rates are to compare fisheries and whether preparatory time is added in or not, the difference in fatality rates for each fishery remains the same. Whether the fatality rate decreases from 250 to 220 or 62 to 54, the scallop fishery is still more dangerous than the multispecies fishery for 2005. Lastly, although the fishery statistics do change with preparatory time, in the full overview, the change is still not enough to imply that fishing is safer. When the national average FTE is 4 (BLS, 2006), a fatality rate of 62 decreasing to 54 does not change the danger level of commercial fishing, and still emphasizes the need to lower this statistic.

5.4: Possible Relationships between Vessel Count and Exposure

While examining all the data that we acquired, an interesting idea was proposed by the head of the Commercial Fishing Vessel Safety Division, Mike Rosecrans. If a linear correlation could be found between number of vessels and FTE, then an FTE estimate could be more easily derived for almost any fishery in the US. Vessel counts are the most common and available statistic for fisheries; vessel trip reports and other detailed information only exist in certain fisheries.

To find a general relationship requires first proving that a linear relationship can be found in one specific fishery. The initial fishery that we examined was the Red King Crab fishery in the Bering Sea off the coast of Alaska. This fishery was used because data of vessel counts and an accurate FTE estimate were both readily available (Woodley, 2006).

While initially analyzing the data, it became apparent that FTE was not only related to vessel counts, but a third variable existed. This particular fishery has been managed for many years by the Global Harvest Limit (GHL). The GHL was a set maximum amount of catch that all participating vessels could collaboratively harvest. When surveys had estimated that the GHL had been reached, the fishery was closed. This provided for a fluctuation in the length of each season. Thus, the FTE needed to be divided by the length of the season in days (see below). The table and figure below show calculations of FTE per vessel per day vs. year:

Year	FTE	Season Length (days)	Vessels	FTE per vessel per day
1990	2821	148	190	0.100320057
1991	3185	159	220	0.09105203
1992	2376	97	251	0.097589025
1993	1545	59	254	0.103096223
1994	1330	45	273	0.108262108
1995	971	33	253	0.116301353
1996	1069	45	234	0.101519468
1997	1325	65	226	0.090197413
1998	1346	64	237	0.088739451
1999	1308	64	229	0.089246725
2000	404	7	229	0.252027449
2001	413	11	207	0.181379007
2002	554	24	191	0.120855148
2003	350	9	192	0.202546296
2004	338	8	189	0.223544974
2005	269	5	173	0.310982659
2006	359	42	80	0.106845238

Table 15: Historical Red King Crab Data

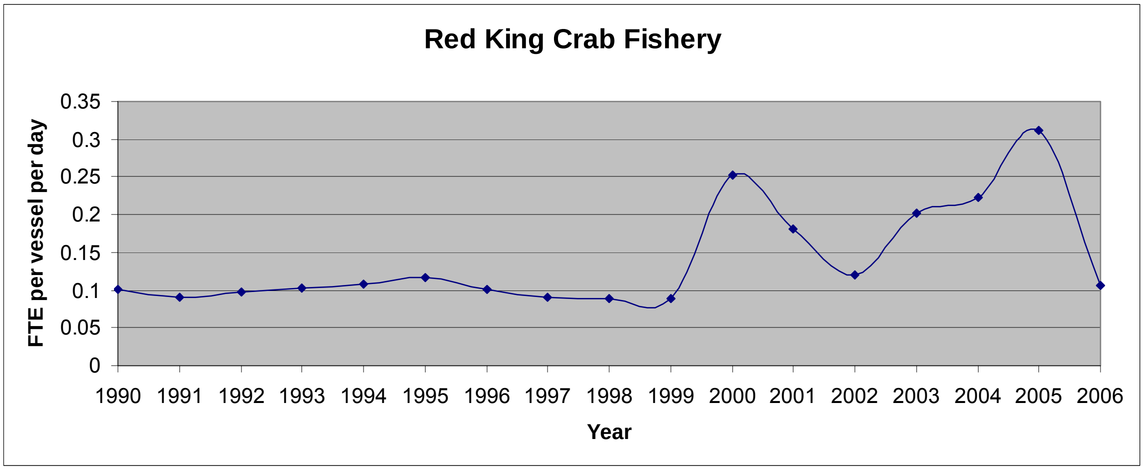

Figure 5: Red King Crab Fishery FTE vs. Year

The level was relatively constant until 2000. In 1990 the harvestable catch was 182 million pounds of crab. This was reduced to 30 million by the year 2000. This reduction in GHL forced the fishermen to fish faster to obtain their share of the smaller allowable catch. Thus, the Red King Crab fishery turned into a derby fishery, with seasons lasting around 6 days therefore affecting the FTE. For the 2006 Fishing Year, the fishery was rationalized, meaning that owners of licensing permits for the fishery were each given an individual fishing quota based on historic catch amounts. This allowed the fishermen to fish more slowly and catch the same amount. Thus in 2006, a reduction in FTE is visible in figure 4 at about the level of years past.

However, analysis of a second fishery, the commercial Red Snapper, out of the Gulf of Mexico, illustrated something entirely different. The commercial Red Snapper fishery has a quota for the year which has remained at a constant 4.65 million pounds of catch, between 1995 and 2005. The fishery opens each year on February 1st and then closes when the quota is reached. The fluctuations in season length were included in the same calculations as the Red King Crab fishery however the results were different.

Year	FTE	Season	Vessels	FTE per vessel per day
1993	285.2885	104	564	0.004863756
1994	287.4	78	502	0.007339871
1995	217.5	52	416	0.010054549
1996	303.1385	86	466	0.00756409
1997	322.7654	71	490	0.009277533
1998	320.8731	67	454	0.010548789
1999	380.1346	64	510	0.011646281
2000	372.9462	58	512	0.012558801
2001	402.1962	79	496	0.010264295
2002	425.25	254	491	0.003409802
2003	446.6077	254	490	0.003588363
2004	485.2615	312	496	0.003135737
2005	436.95	332	486	0.002708054

Table 16: Historical Red Snapper Data

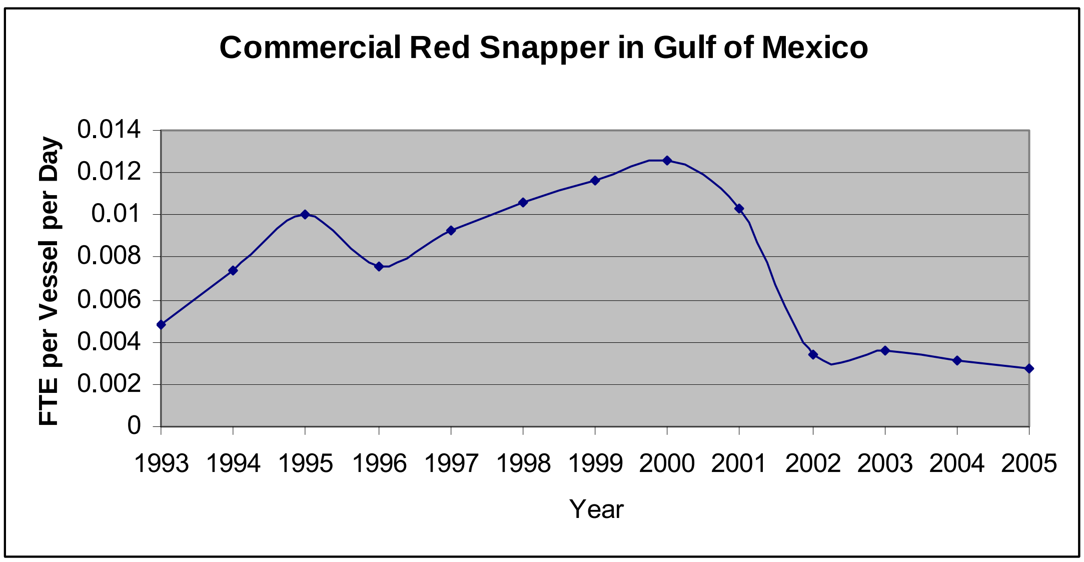

Figure 6: Red Snapper Fishery FTE vs. Year

The above chart shows that there has been no linear relationship between vessel count, season length, and FTE in the commercial Red Snapper fishery. It is also of interest to note that the two fisheries studied are not on the same order of magnitude for FTE per vessel per day. Further study would be needed to determine the additional variables.

With the additional data from each fishery, the conclusion can be made that in the case of these two fisheries, there is no linear relationship. This is not to say that a linear relationship does not exist within the fisheries in the United States. If a linear relationship were possible, it would only be a general estimate of FTE for all of commercial fishing and would still require more data from other fisheries. With further research to possibly define a relationship, a multiplication factor could be found and used to estimate the FTE of all fishermen.

The research needed to come up with this multiplicative factor would have to include sampling various fisheries across the states, and estimating an accurate FTE for each. To deal with the added variable of crew size, a possible way to tackle it would be to look at the amount of harvestable catch per season divided by the amount of harvestable catch per trip. This would standardize the fisheries where comparing pounds of catch is not practical (i.e. a tuna fishery versus a shrimp fishery). The idea here is that fishermen would be catching the same percentage across the board with the same amount of crew. This would need to be verified, and most likely is not possible. Fisheries using a fishery management plan (the direction every fishery has gone, if not currently headed) have information on harvestable catch and number of vessels. With just the information of how much is being harvested per trip, one might be able to determine the FTE of the fishery if the linear relationship can be shown to exist for all fisheries.

6: Recommendations

This section discusses recommendations for further study and improvements to the exposure calculations. These are made with the hopes of increasing estimate accuracy for fishermen's hours of exposure and therein fatality rates. We will look at the precision of our methodology, the calculated fatality rates thus derived, a sensitivity analysis of preparatory time and lastly, important relationships between vessel count and exposure time. The final recommendations can be outlined as follows and are elaborated below:

1. Use "WPI Direct Count Method" rather than the "WPI Averaging Method"
2. Regulate and standardize recording of trip data and create universal database for it
3. Further study into past fatality rates at every fishery to determine most dangerous fisheries and consider allocating resources to improving safety in those fisheries
4. Further study into gathering prep time data; possibly random sample
5. Further study of relationships between fishery variables and exposure

Our ultimate goal in these recommendations is to aid the Coast Guard in using our methodology to eventually improve safety on the water.

6.1: Use WPI Direct Count Method

The goal of this project was to develop for the United States Coast Guard a methodology that quantifies exposure of commercial fishermen at a specific fishery and is expandable to apply to any US fishery. We determined the FTE in a simple and precise manner at three fisheries varying in fishing type, geographical location and overall size of fishery by two different methods. In doing such, we have shown that the WPI Averaging Method does not apply to all fisheries by showing upwards of a 35% difference in values between the Averaging Method and the Direct Count Method. It can be useful for extraordinarily large fisheries that have over 100,000 trips per season. However, our second methodology, described as the WPI Direct Count Method, is applicable to any US fishery provided the data required is available. The FTE found by this method can then be used to estimate fatality rates for each fishery which can then be used to compare each one to other occupations and other fisheries themselves, again, provided the data is available. Therefore, for future studies, it is suggested that Excel, or another database program be used in order to make direct tallies of man-hours as precise and accurate as possible. This will allow all of the data to be counted without having less accurate results due to averages.

We were very fortunate to receive the data in such a usable format and understand that not all fisheries record and log their data in such a manner. Therefore, along with straight calculations of man hours per trip, we recommend that the Coast Guard along with NOAA and state fisheries put further study into implementing a system for logging and organizing trip data per vessel per fishery. This leads into our next recommendation.

6.2: Universal Database

At the present time, it is very hard to organize all the data and truly estimate fatality rates because of the road blocks involved with actually obtaining the data. The data that is currently available describing fishermen and how many hours they are exposed to occupational risks is widely scattered and varied in its depth. Some fisheries maintain detailed records of when every vessel leaves and comes back to port. Others just maintain vessel counts and amount of catch harvested. This combined with the fact that the data is spread among federal and state agencies all over the US, contributes to the difficulty in obtaining accurate employment statistics. If there were national requirements on all fisheries that required reporting of time on the water and crew members, and all this data was then sent to one central database, an FTE estimate could be more easily obtained.

As a side note, to be able to determine fatality rates, one must also have the number of deaths. Therefore, we recommend the Coast Guard make it a specific point to classify each death by type of fishing. This will allow the Coast Guard to establish which fishery each death is attributed to and thus determine fatality rates by fishery. Most Coast Guard Districts including Districts 1 and 5 (see Appendix E) already do this and that allowed us to evaluate the fatality rates for the Northeast fisheries. However the Gulf of Mexico district, or district 8, does not. This data could also be included in the suggested master database.

There have already been attempts to create this database. The Atlantic Coastal Cooperative Statistics Program (ACCSP) had been coalescing data from the entire eastern seaboard, but as of yet has not been able to acquire the data necessary to do an in depth FTE estimate. Many of the state fisheries that the ACCSP has vessel counts on do not even track vessels leaving and returning to port. The research into programs such as these is crucial to eventually understanding how long fishermen work. Once it becomes simple, concise and quick to calculate FTE, fatality rates can also be easily calculated and thus interpreted as explained in the next section.

6.3: Fatality Rates: Use Thereof and Area for Further Study

Our third recommendation for the USCG is for the calculations of the fatality rates; it would be to use them in determining which fisheries in the United States are more dangerous than others. This project is only a small sample of all the fisheries and thus a serious study would have to be completed to calculate the fatality rates of every fishery. They would all have to be calculated in the same method so they could be accurately compared. This project provides an example of how a methodology can be applied to demonstrate what areas within commercial fishing need the most attention. For instance, our method demonstrated the difference in fatality rates between the Scallop fishery and the Multispecies fishery. With a difference of 188 deaths per 100,000 workers, we showed that the Scallop fishery is much more dangerous than the Multispecies fishery for 2005. With this example, we hope the Coast Guard can determine the most dangerous fisheries and allocate their available resources to eventually reduce the number of fishing casualties. The ability to identify the area where the greatest amount of lives are lost, and then move into a position where those fatalities can be reduced, will greatly enhance the Coast Guard's ability to carry out their mission.

Our results indicate the feasibility of our method to compare fisheries as stated above, but due to the time restraints of our project, we are unable to do a thorough study of fisheries over the years. We recommend that the Coast Guard put further study into this area as it would sort out not only which fisheries are more dangerous for 2005 but which fisheries are more dangerous over the course of time.

6.4: Preparatory Time: Area for Further Study

The previous two recommendations dealt with obtaining and working with FTE's and fatality rates. Our fourth recommendation is similar to the first in that it focuses more on the accuracy of the overall methodology to find FTE. As can be seen in section 5.3, FTE and fatality rates are sensitive to preparatory time and therefore, we recommend that in future studies, it would be best to include preparatory time data. Where estimates of 4 and 10 hours cause an 11 to 13 percent change, any additional preparatory time would cause subsequent larger changes in FTE and fatality rate. In this particular case, preparatory time did not change the fact that the Scallop fishery was four times more dangerous than the Multispecies fishery, but including preparatory time would increase the accuracy of calculated FTEs and fatality rates.

Although difficult to obtain, a small random sample of fishermen may be used to give a good estimate of average time spent preparing for voyage. This number could then be added to all trip length data per season, so a more accurate FTE could be calculated. Preparatory time was shown to be an important percentage of exposure data, so it should be included to make it more precise. This would also resolve any issues with data that may be distorted due to a death that did not happen while a vessel was in recorded transit.

In a further study, it would be worthwhile to assess methods of gathering the preparatory time data to create an easy, accurate and efficient way to add the time to overall exposure time. If there was a quicker way to determine preparatory time, it would definitely be worth adding and there would be no drawbacks to obtaining and including the data. We assumed in our study that there is most likely a difference in preparatory time depending on how long a ship is at sea – the longer the trip, the more preparatory time needed. This would most likely be due to increased amounts of equipment to prepare, as well as cargo to be brought on the ship so the crew can be sustained for the longer trip. This is not something that we originally accounted for in our methodology, but would be something to look at in the future.

6.5: Variable Relationships: Area for Further Study

Our last recommendation deals with our study of historical fishery data in an attempt to find a relationship between various variables and exposure. We recommend that more study be put into this area as there are many possible methods of developing an FTE for a fishery using different assumptions. Our study has dealt with a basic approach requiring specific data. Historical data from the Red Snapper fishery and the Red King Crab fishery were analyzed to evaluate any possible relationships between vessel count, catch harvested and exposure. Although there began a trend in the Red King Crab fishery, by 2000, season length changed and no relationship existed. The same held true for the Red Snapper fishery.

Generalizations can be made of FTE estimates that are not within the realm of this study. Further research into the relationships between FTE data and fishery populations can branch out in many directions most of which would be evaluating different variables and their effects on exposure. The important point to note is that the study of employment statistics of fishermen is ongoing. This study can hopefully be useful in bringing up to date the current statistics so they are equally as accurate as other occupations.

Ultimately, the way to make commercial fishing safer is to begin by looking to prevent deaths. While the Coast Guard is able to prevent many deaths already, it would be a significant help if they knew which geographical area had the highest fatality rate in a certain fishery. This would allow them to prioritize the allocation of available resources. It is our hope that our method, having shown its ability to adapt to varying fisheries, will assist the Coast Guard in attaining their objective of maritime safety by saving fishermen’s lives.

Appendix A: US Coast Guard: Mission and Organization

The Coast Guard today is a consolidation of five different maritime organizations. Created in 1790 by the First Continental Congress, the first predecessor to the Coast Guard was the Revenue Cutter Service. Earlier in the same year, Alexander Hamilton passed the Tariff Act of 1790, and in order to “suppress smuggling and ensure duties and taxes were paid” (United States Coast Guard [USCG], 2002) the Revenue Marine was created. Shortly after the inception of the Revenue Cutter Service and the Revenue Marine, Senator William Newell saw to the creation of the Life-Saving Service and the building of stations all along the Nation's coastlines. In 1915, these two organizations were merged together, and the United States Coast Guard was officially formed.

The U.S. Lighthouse Service, originally created in 1789, was assimilated into the Coast Guard in 1939. Also assimilated into the Coast Guard in 1946 were the Steamvessel Inspection Service (created in1838) and the Bureau of Navigation (created in 1884). The compilation of these organizations and agencies makes up what we know as the Coast Guard today. The main roles of the Coast Guard as “America's Maritime Guardians” are as follows:

- Maritime Safety
- Maritime Security
- Protection of Natural Resources
- Maritime Mobility
- National Defense

These objectives each have different divisions within the Coast Guard dedicated to their fulfillment. Each of these divisions naturally has its own budget for personnel costs, maintenance costs, and supply costs. As the Coast Guard continues expanding, assuming more responsibilities, and increasing the size of its fleet, the necessary budget required to uphold its mission increases.

Presently, the Coast Guard owns approximately 1500 vessels of varying length from 12 ft up to 420 ft. They operate 211 aircraft. With about 40,000 active duty personnel, the Coast Guard is able to use all of their assets to fulfill their goals listed above. The Fishing Vessel Safety Division was established to keep tabs on the Maritime Safety and Security involved with commercial fishing. This division watches commercial fishermen closely to make sure they are abiding by the protocols established. This is done in many ways a couple of which are the voluntary dockside safety exams and the boarding of suspected delinquent vessels. It is still a difficult area to examine- even the Coast Guard with their vast resources still cannot determine just how many fishermen there are.

This project is intended to develop a methodology to determine the exposure of commercial fishermen. The success of our methodology will allow the Coast Guard to strategically place its available resources in order to be in a position to save as many lives and provide the greatest amount of assistance possible. This will ultimately allow the Coast Guard to more successfully attain its objective of maritime safety.

Appendix A-1: Relationship to Agency

The Fishing Vessel Safety Division belongs to the Prevention Division (see Appendix A-2) which is a division of the Marine Safety, Security, and Environmental Protection Division. The mission of this particular department is "to meet the goal of reducing fatalities in the fishing community so that it is not more dangerous than any other segment of the maritime industry" (USCG (4), 2006). The head of this division reports to the Coast Guard Chief of Staff who then reports to the Vice Commandant and Commandant of the Coast Guard. The Commandant of the Coast Guard reports to the Secretary and Deputy Secretary of the Department of Homeland Security (DHS). The United States Coast Guard was previously a division of the Department of Transportation, but presently, belongs as a section of the DHS.

We directly worked with Mike Rosecrans who is the head of the Fishing Vessel Safety Division, as well as Jack Kemerer, LT Trevino and LCDR Vazquez of the Fishing Vessel Safety Team.

See figure A-6 for a detailed map of the relationship of the Coast Guard departments.

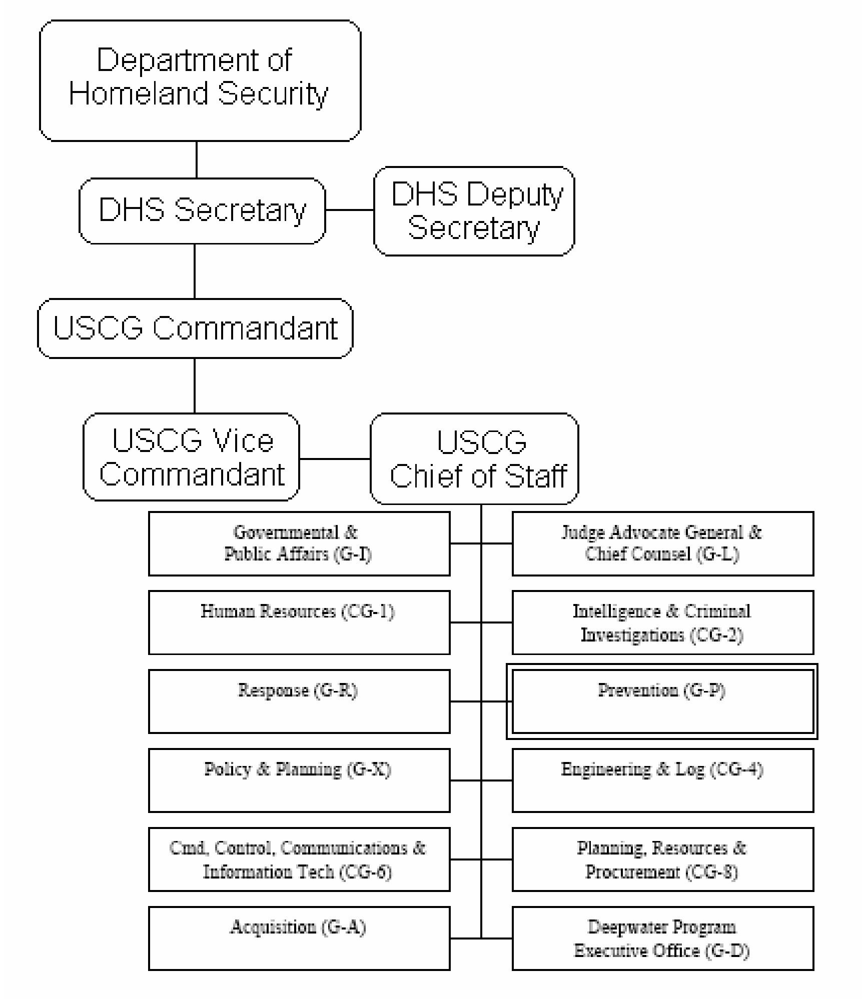

Figure A-7: Relationship to Agency Organization Chart

Appendix A-2: Prevention Division

The Prevention Division of the Coast Guard is comprised of three major teams: the Domestic Compliance Division, the Foreign and Offshore Compliance Division, and the Fishing Vessel Safety Division. Led by Mr. Mike Rosecrans, objective of the Fishing Vessel Safety Division is to "increase compliance with the minimum safety requirements found in Title 46 Code of Federal Regulation, Part 28—Requirements for Commercial Fishing Industry Vessels" (USCG (3), 2006). In order to achieve this objective, the Fishing Vessel Safety Team, led by Mr. Jack Kemerer, needs to focus on areas of high exposure. Our project is intended to develop a methodology to more accurately determine exposure, which will in turn, allow the Fishing Vessel Safety Division to focus efforts in areas with higher exposure rates, thus reducing casualties.

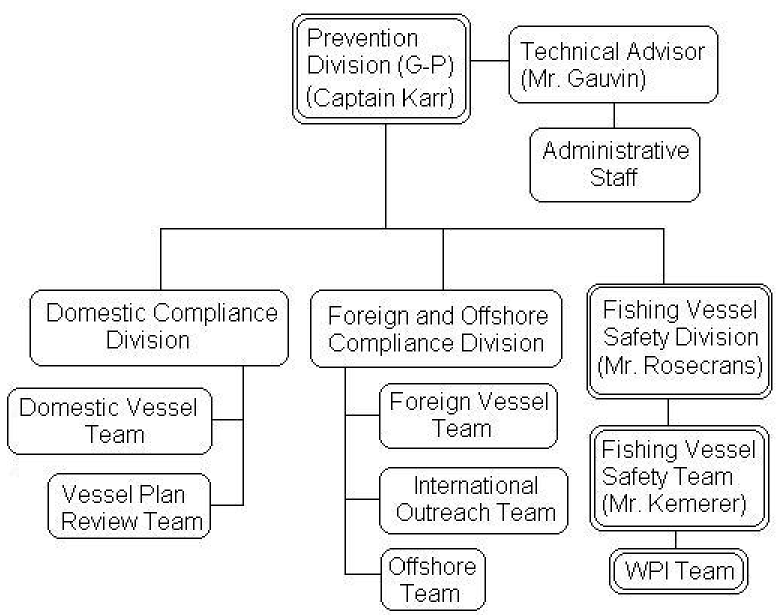

Figure A-8: Vessel Activities Office Organization Chart

Appendix A-3: Original Project Description

U.S. Coast Guard: Fishing Vessel Safety Division: Commercial Fishing Safety

Within the U.S. Coast Guard: "the Marine Safety Center works directly with the marine industry, the Commandant and Coast Guard field units in the evaluation and approval of commercial vessel and systems designs, development of safety standards and policies, response to maritime casualties and oversight of delegated third parties in support of the Coast Guard's marine safety and environmental protection programs." Part of that mission involves understanding risk, exposure, frequency, and extent of injuries/fatalities within the maritime industry.

Commercial fishing used to be the most dangerous occupations in America. According to the Department of Labor, it is now the third most dangerous. Nonetheless, it is by far the most dangerous maritime occupation. The Coast Guard is confident that all fatalities within the commercial fishing industry are captured through our reporting systems. Those systems show that the annual number of casualties is significantly fewer since passage of the Commercial Fishing Industry Vessel Safety Act of 1988.

As the commercial fishing industry continues to shrink from reduced fish stocks and ever increasingly tight restrictions meant to protect the environment and fish stocks, the number of commercial fishing vessels and fishers continues to shrink. This makes it difficult for the Coast Guard to assess the impact of regulations on safety. The number of deaths is down but the Coast Guard doesn't know if the rate of fatalities is decreasing. To be able to know the fatality rate, we must know the exposure of fishers, i.e., the denominator. This project is to determine a methodology for determining the exposure of commercial fishers.

The WPI team will:

- Investigate methods for determining exposure. Since the management practices limiting fishing varies by fishery, different fisheries may need a separate methodology. Several New England fisheries will be selected for investigation.
- Understand the culture and unique characteristics of specific fishing regions and specific types of fishing industries.
- Pilot test the method(s) on fishers' exposure in sample fisheries.
- Make recommendations for a methodology that can be used in other fisheries to estimate exposure.
- Investigate and recommend protocols, appropriate to the target audience, aimed at reducing exposure, injuries, and fatalities.

Appendix B: Additional Agencies

While our project is sponsored by the United States Coast Guard, the data required for our project could not be solely attained from the Coast Guard's databases. The data we acquired came from additional agencies. Our liaisons within the Coast Guard gave us contact information for people who work for the National Marine Fisheries Service (NMFS), a division of the National Oceanic and Atmospheric Administration (NOAA).

NOAA has long had a role in environmental research and analysis including managing the survival of marine resources. NMFS is in charge of prolonging marine resources by regulating the fishing industry. One of the NMFS' tasks is to monitor fishing vessels in order to make sure the fisheries are following the regulations put in place to ensure the conservation of marine resources.

Throughout this project, we contacted NMFS in order to learn more about its various commercial fishing related programs. One of these programs, the Observer Program, was designed to monitor selected fishing vessels to ensure their compliance with NMFS regulations regarding the fisheries. Through data recorded in this program and others, NMFS was able to give us the following specific data from 2003-2005:

- Scallop and Multispecies fisheries – Coast Guard Districts 1 and 5
- Length of excursions (hours)
- Number of excursions per season
- Crew size
- Number of vessels
- Season length

Appendix B-1: National Oceanic & Atmospheric Administration

NOAA, like the Coast Guard is an assimilation of several older agencies. Created from the United States Coast Survey (established in 1807), the United States Weather Bureau (established in 1870), and the United States Commission of Fish and Fisheries (established in 1871), NOAA was the first agency in the United States explicitly created for “observation and study of the atmosphere, and … to study and conserve natural resources” (NOAA, 2006).

Due to the work of these agencies, and many descendant agencies, the United States has become a recognized world leader in several fields of earth science, including oceanography, marine biology and marine ecology. Also, the drive given to various types of engineering, as well as much mathematical advancement, by these organizations was and still is a “major contribution to the welfare and well-being of our Nation” (NOAA, 2006).

Contributing to the Nation’s well-being are the efforts of several other NOAA divisions, including the Coast Survey. Navigating with the aid of nautical charts, “millions of passengers and trillions of tons of cargo” have safely arrived in the United States. The national economy has saved countless sums money due to improved weather forecasting, and many lives have been saved as a direct result of the efforts of the Weather Bureau. The Fish and Fisheries Commission, and its descendant organizations, have been the leaders in fighting to save the nation’s fisheries in order to ensure their survival for future generations.

While not a military organization, NOAA and its organizations have loyally served our Nation in times of both war and peace. These personnel have worked everywhere imaginable, remote regions of our Nation and the high seas. They have experienced all sorts of hardships, including violent weather and separation from their families, but they have always preserved and carried on to loyally serve their organization, and Nation.

Appendix C: Data Compilation

This table outlines the important information involved with each fishery for the calculations that we computed. For each fishery, the date of the data, the number of vessels, number of trips, and number of deaths is listed. The following tables describe the imperative data calculations that were used throughout our report.

Scallops

Jan-Dec 2005
1,008 Vessels
24,853 Trips
7 Deaths in NE

Original Data Calculations

Total Man Hours	5,828,160
FTE	2,802

With Prep Time:

Total Man Hours	6,534,614
FTE	3,142

Change in FTE	10.9%

Fatality Rate per 100,000 workers

Original Data	250
Prep Time	222
Difference	-11.2%

Multispecies

Jan-Dec 2005
2,526 Vessels
111,204 Trips
3 deaths in NE

Original Data Calculations

Total Man Hours	10,052,640
FTE	4,833

With Prep Time

Total Man Hours	11,666,720
FTE	5,609

Change in FTE	13.8%

Fatality Rate per 100,000 workers

Original Data	62
Prep Time	54
Difference	-13.0%

Figure A-9: Data Summary

Red Snapper:
Jan.-Dec. 2005
486 Vessels
4626 Trips

Total Hours Spent on the Water by Vessel	333,024
Average Crew per Vessel	2.91
Total Man Hours	908,856
FTE Workers	**437**

Table A-17: Red Snapper Data Summary

1993-2005 FTEs:

Year	FTE
1993	285
1994	287
1995	218
1996	303
1997	323
1998	321
1999	380
2000	373
2001	402
2002	425
2003	447
2004	485
2005	437

Appendix D: Fatality Rate Calculations

	SCALLOP	**MULTISPECIES**
FTE	2,802	4,833
# FATALITIES	7	3
=FATALITY RATE (deaths/100,000 workers)	250	62

Table A-18: Fatality Rates Summary

$$\frac{\#\,deaths}{FTE} \times 100{,}000 = FatalityRate$$

Scallop Fishery:

$$\frac{7}{2802} \times 100{,}000 \cong 250$$

Multispecies Fishery:

$$\frac{3}{4833} \times 100{,}000 \cong 62$$

Scallop Fishery with Prep. Time

$$\frac{7}{3142} \times 100{,}000 \cong 222$$

Multispecies Fishery with Prep. Time

$$\frac{3}{5609} \times 100{,}000 \cong 54$$

Appendix E: Coast Guard Districts

For organizational purposes, the Coast Guard breaks down the United States into districts. For the Vessel Activities division, each district has at least one contact that looks into and maintains information on each vessel and each type of fishing. This project looked at fisheries within districts 1, 5 and 8.

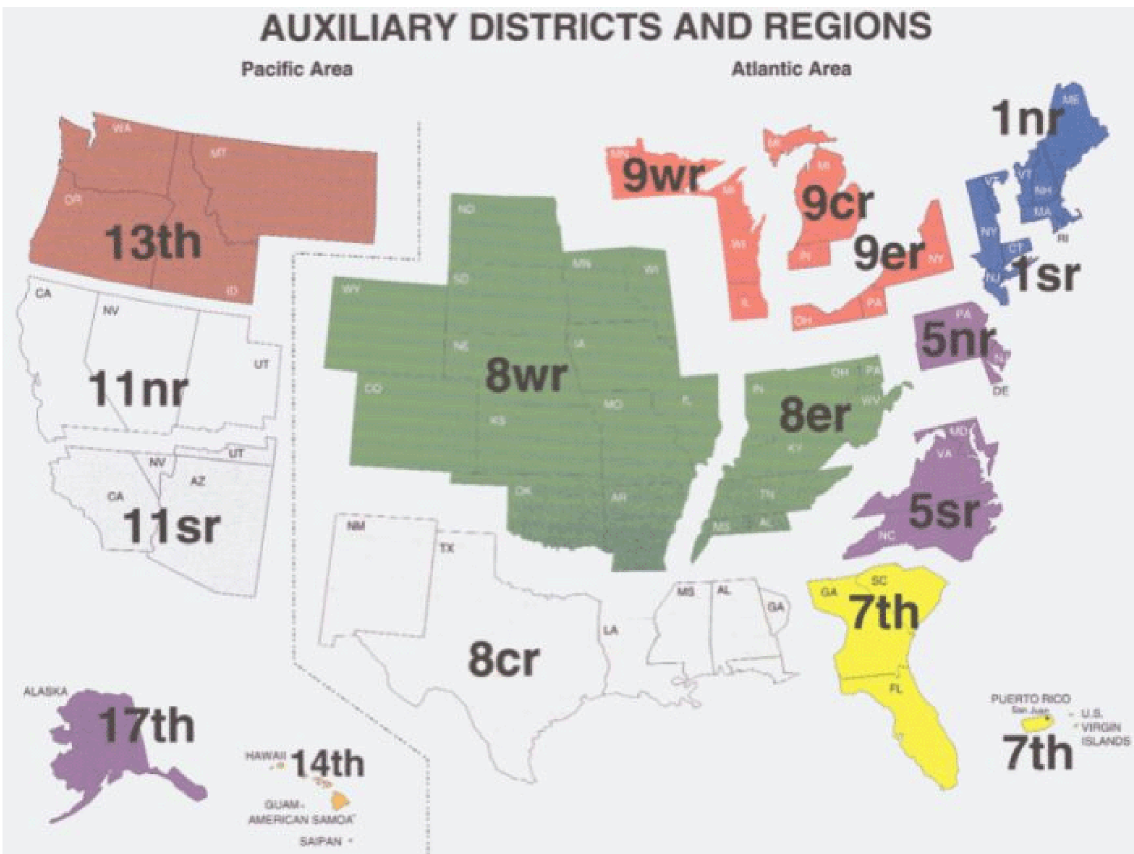

Figure A-10: Coast Guard Districts

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