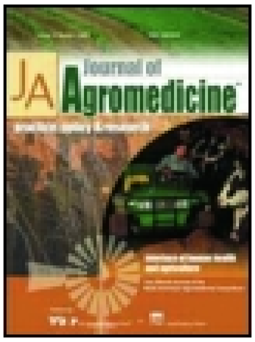


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# Work-time Exposure and Acute Injuries in Inshore Lobstermen of the Northeast United States

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Abstract:

The objective of this study was to inform efforts to reduce risk for musculoskeletal disorders among commercial lobstermen by characterizing and quantifying injuries that occur to people while harvesting lobsters commercially in the northeast United States. We aimed to estimate a denominator of exposure to lobstering in Full Time Equivalents (FTEs), to estimate a fatality

rate, and to calculate incidence rates for acute injuries within the sample population. Captains were randomly selected from those licensed to fish in Maine and Massachusetts. Data on work exposure and injuries with rapid onset that occurred on the boat ("acute injuries") were collected using a survey, which was administered quarterly via phone or face-to-face interview with the captain. The quarterly survey assessed the number of weeks worked during the quarter, average crew size, number of trips per week, and average trip length in hours. In addition, this survey captured relevant information (body segment affected, type of injury, and whether treatment was received) on all acute injuries occurring during the quarter. FTEs were estimated using fishermen days and fishermen hours. The annual FTE estimated using days was 2,557 and using hours was 2,855. As expected, the summer months (3rd quarter) had the highest FTE and the winter (1st quarter) the lowest FTE. Fall (4th quarter) and spring (2nd quarter) ranked second and third, respectively. The incidence rate for all injuries (49.7/100 FTE) and injuries requiring treatment (15.0/100 FTE) was much higher than those reported in other studies of fishing that used Coast Guard data.

## INTRODUCTION

The remote nature of commercial fishing has been one obstacle for certain aspects of occupational research such as exposure assessment through observational methods. It has also contributed to the remarkable fact that an industry with such high risk had been given relatively little attention in academic studies until about 20 years ago.[1] In 2001, Matheson's analysis of occupational safety and health literature found two predominant methodological difficulties for making comparable analyses worldwide: the uncertainty of population denominators, and the inconsistency or insensitivity of numerator data collection systems.[2] In the United States, more recent work has begun to overcome the methodological challenges for determining comparable magnitude of observable health outcomes across fisheries, allowing a response to findings from an occupational health and safety perspective with fishery-specific knowledge of exposures and outcomes.[3-5]

Despite studies examining mortality rates due to cancers, as well as a finding that the healthy worker effect in commercial fishing is strong, the Standard Mortality Ratios for accidents, and water-related accidents in particular, have been very high.[6-8] The United States Coast Guard (USCG) collects data on vessel-related casualties, and publishes some data on their website. The data are available through query and, in some cases, have represented knowledge limited by the circumstances of casualty investigation or technique, or may have been restricted because of confidentiality. The National Institute for Occupational Safety and Health (NIOSH) reviewed USCG investigation data in combination with multiple other sources, such as local news reports and state level occupational fatality data, to develop the sensitivity and specificity of national surveillance on commercial fishing fatalities in a study of the occupational fatalities of US fishermen that occurred during the years 2000-2009.[9] They found very high fatality rates in various fisheries around the country. From 2000 to 2009 there were 88 commercial fishing fatalities in the Northeast United States (which include the coastal states from Maine to New Jersey) in the multi-species groundfish, Atlantic scallops, and lobster fisheries. The northeast multi-species groundfish fishery had the highest occupational fatality rate (600/100,000 Full Time Equivalent; FTE) of any fishery in the country. There were more fatalities among the scallopers (44) than the groundfish fishermen (26), but the scallopers had a much higher effort (10,384 FTE) than the groundfish fishermen (4,340 FTE).[9]

Non-fatal injuries and musculoskeletal disorders have been recognized as a significant occupational health concern of fishermen.[10] Norum and Endresen[11] found that acute hand and finger injuries accounted for 35% of all injuries in their study of Scottish Coast Guard surveillance data. These values are similar to those found by Jensen et al.,[12] who reported that finger injuries constituted 33%, and hand and wrist injuries 17%, of all injuries in the fishing industry in Denmark. Lipscomb et al.[13] found that symptoms causing work interference in the last 12 months were reported by 38.5% of their cohort of North Carolina fishermen. They also found low back symptoms were the most common cause of work impairment (17.7%) followed equally by pain in the hands/wrists or shoulders (7%). Kaerlev et al.[14] found high relative risk of rotator cuff, shoulder lesions, carpal tunnel syndrome, and hip arthrosis associated with fishing in Denmark. Lawrie et al.[15] found musculoskeletal disorders to be a leading complaint in a survey of Scottish fisherman.

The workers in the lobster harvesting industry, which is commonly referred to as “lobstering” just as commercial fish harvesting is referred to as “fishing,” are predominantly male, and workers who harvest lobsters are referred to as “lobstermen.”[17] The NIOSH study[9] utilized federal data (generated by reportable mandate to the National Marine Fisheries Service) to estimate the denominator (FTE) for the mortality rate. The majority of the lobster landings are harvested from state-regulated water by state-licensed lobstermen,[16] and consequently, an FTE for the lobster industry, a large sector of the region, was not calculated by NIOSH because the federal data mandate did not apply to lobstermen. Otherwise, comparative analyses of morbidity and mortality between this fishery and others would be a straightforward comparison of rates. In addition, although data are available on the number of deaths in the industry, there are currently no studies published on data available on non-fatal injuries for lobstermen.

One specific aim of this paper, then, was to estimate the denominator for rates of morbidity or mortality as a FTE for the industry. We also aimed to calculate incidence rates for acute injuries within this population to help inform the greater objective of developing interventions for work-related injuries that might have greatest impact on individual health and productivity. The design of data collection and analysis relied on previous work as a basis for comparison and as a starting point for reasonable assumptions in the determination of a sampling strategy from which to collect the original data to represent the entire region.[9,16] The data presented in this report were collected in the first two years of a four year exposure period that will be completed at the end of 2015.

# METHODS

## Definitions

The individual identified on each state's lobstering permit list was referred to as the "permit holder." The person who was in command of the vessel while it was engaged in actual lobstering (typically, but not necessarily the permit holder) was referred to as the "captain." Any individual who worked on the vessel while it was actively engaged in lobstering during the previous three-month quarter was referred to as the "crew."

Injuries caused by a precipitating event and had a rapid onset that occurred within the three month period of record were defined and recorded as acute. Injuries with an indefinite onset or with a precipitating event occurring at any time before the quarter of record were considered to be chronic or cumulative trauma, and were not recorded as injuries in that quarter. Thus, recorded injuries represented incidence of acute injury only. The categories for type of injury were based on the categories used by the Bureau of Labor Statistics (BLS) for the nature of injury in their nonfatal occupational injury report.[20] The data collection instrument included a category for non-specific or unidentified pain to correspond with the BLS's "soreness, pain, including back", as long as the subject could identify that it was an acute incident. Strictly speaking, the incidence rates were measures of incidence density rather than cumulative incidence, as the denominator was person-time, and a single subject was allowed to contribute more than one case to the numerator. For this report, the term "incidence rate" will be used.

## Study Population

The study population was defined as the crews of all vessels that were licensed to harvest lobsters commercially within the 3 mile coastal waters (inshore) of Maine and Massachusetts at the initial time of the study. As shown in Table 1, these two states represented over 90% of the estimated state-licensed individuals in the northeast lobster industry at the time of this study (2010-2011) and more than 75% of lobstering fatalities during the previous decade. Therefore, we excluded the other states in the Northeast (Connecticut, New Hampshire, New Jersey, New

York, and Rhode Island) in order to balance a rigorous study design with the feasibility of covering a large geographical area.

## Sampling Frame and Exclusion Criteria

The contact information for the lobster permit holders was available electronically for a small fee from the state licensing offices. A random sample of lobster permit holders was selected from each state's list using a table of random numbers. Lobster permit holders who were only licensed to fish beyond the three-mile state territorial limit (a small segment of lobstering known as the “offshore fleet”) were excluded. Lobster permit holders holding both inshore and offshore licenses were eligible, but the study only utilized work exposure data within state territorial waters (three-mile limit) for this group. The important characteristic of the inshore fleet for the purpose of the method of analysis was the fact that all their trips would be completed in less than a 24-hour period. The inshore fleet is known to make “day trips”. Further exclusions included seasonal, student, or recreational licenses, or any restriction that inhibited full participation in the maximum extent of time and equipment usage in the fishery.

## Sample Size Calculations

The Gulf of Maine Research Institute’s[16] socioeconomic study of the Maine lobster industry provided estimates of some of the parameters (average crew size and the number of trips per week) used in NIOSH’s calculations of FTE in federally regulated fisheries.[4] Since Maine represents the largest segment of the northeast lobstering industry, we believed that estimates obtained from Maine, particularly those relating to variance, were most generalizable to the other

Northeast states. Using these prior estimates, and assuming maximal number of weeks worked and length of trip, a sample size of 120 permit holders in the two states of Maine and Massachusetts was selected so that the margin of error would be less than 10% of 95% of the expected mean annual exposure estimates. In order to allow for 15% subject attrition, 138 permit holders from each state was the sample size targeted for enrollment.

## Recruitment and Survey Protocol

The study used mail, phone, and face-to-face contact during the recruitment phase of the study in an effort to maximize the response rate.[18,19] The randomly selected permit holders were initially mailed an invitation containing a study overview, an offer of compensation for participating, and a prepaid postcard that was to be returned indicating the invitee's choice to participate or decline. Any permit holder who did not return the post card within one month received a second mailing that contained a copy of the two survey forms and the consent form, and was contacted by telephone within three weeks of this second mailing. When additional attempts were necessary in order to make the initial phone contact, callers made attempts at various times of the day. Specifically, an attempt was made to contact each selected permit holder using a minimum of two daytime, two afternoon, two nighttime, and one weekend phone call. This protocol was modified as necessary if a person other than the subject was reached and such person indicated a specific time of day as the best time to call. If a randomly selected participant could not be enlisted for any reason, another name from the randomly selected list would be entered into the recruitment protocol.

Permit holders who agreed to participate in the study were asked if they were the boat's captain. If the permit holder was not the boat's captain they were asked to provide the captain's contact information and the above telephone contact protocol was repeated in an attempt to reach him/her.

In order to assess seasonal variation, the captain was resurveyed every three months after initial recruitment. These quarterly interviews were conducted in April (for the 1st quarter ranging from January 1 to March 31), July (for the 2nd quarter, April 1 to June 30), October (for 3rd quarter, July 1 to September 30), and January (for the 4th quarter, October 1 to December 31), or as soon as feasible in cases where the subject was difficult to contact or simply not active for the season. In the instances where subjects were unavailable for interview during a quarter, data for the missing quarter were collected along with data for the current quarter. The captain was given an incentive of $20 at recruitment and an additional $10 for each quarterly follow-up as compensation for their time.

The data collection instrument was a questionnaire designed to collect data on work exposure and acute injuries. The survey was administered quarterly via phone interview with the captain, and once per year in person, if feasible. Thus, three of the four quarters of data were collected by phone, and one quarter per year was collected in person. In-person interviews were scheduled into organized data collection field trips to regions where subjects were reasonably clustered together. If it was impossible to meet the captain at the time of a field trip, the interview would be completed by phone, nevertheless.

After obtaining verbal informed consent (as approved by the UMass Lowell Institutional Review Board), the captain was offered the option of completing the first quarterly survey, over the phone at the time of recruitment. During this initial phone call, identifying information about the boat and its location were collected to enable an ensuing visit to the boat.

This report is a preliminary report on two years of completed data collected before the full 4 years of prospective data collection was completed. Data collection was on-going at the time this manuscript was submitted for publication.

## Data Management and Analysis

Survey data were collected on scannable paper forms for both the telephone and face-to-face interviews. Captains were allowed to select to respond via email if they preferred, and on the rare occasion that this happened, the data were transferred to a paper data collection instrument. The quarterly survey assessed the number of weeks worked during the quarter, average crew size, number of trips per week, and average trip length in hours. In addition, this survey captured relevant information (body location, type of injury, whether medical treatment was sought, and whether the injury prevented normal work) on all acute injuries occurring during the quarter. The data were scanned into a Microsoft Access database using a Canon scanner (DR-2080C) and Cardiff Teleform Desktop software (v10.4.1). Samples of scanned data were examined to address possible errors introduced by the transfer from paper to electronic data. If necessary, data were recopied and rescanned until the electronic data were accurate.

FTEs were estimated in three ways. The first utilized methods similar to those used in NIOSH's reports on mortality variation among US fisheries.[5,9,17] In these studies, "fishermen days" were computed by factoring together reported days at sea, number of crew, and the length of the season. The length of the trip was then factored in to estimate a FTE. For each captain surveyed, we calculated "fishermen days" as the product of the number of weeks worked during the quarter, average crew size, and average number of trips per week. The sum of "fishermen days," divided by the number of boats surveyed, multiplied by 65 days, yielded FTEs as a percentage of available days per license. The second method was the same as the first except the standard multiplier for days per quarter, 62.5, consistent with the BLS assumptions, was used. The BLS method assumes 250 8-hour days per year, or 50 40-hour weeks with 2 weeks of vacation, which may not be a realistic assumption in commercial fishing.

The third estimation method multiplied fishermen days by the average trip length (in hours). This estimate of fishermen hours was divided by the number of captains surveyed multiplied by 500 hours to get FTE as a percentage of available hours. Annual FTE estimates were done similarly except 260 days, 250 days, and 2000 hours were used in the respective denominators to get percentages. Actual FTEs were then calculated by multiplying these percentages by the total number of licenses in Maine and Massachusetts.

The use of three methods to estimate FTEs was chosen to examine and illustrate how calculation method could affect outcome. Each method had been used previously. As stated above, the use of 65 days per quarter was the method used to assess FTE in fisheries by NIOSH[3,4,9] and the use of 2000 hours per year, which is equivalent to 62.5 8-hour days per year, is also a standard formula used by the Bureau of Labor Statistics for employment in industries regulated by normal schedules. Calculations were made using these methods to allow appropriate comparisons.

Two-way Analysis of Variance (ANOVA) was used to determine differences in FTEs between states and seasons and any interaction effect. Tukey post-hoc comparisons were employed to further examine the variation in seasons. This analysis was performed using IBM SPSS Statistics (version 23).

Fatality rates were calculated for 2000–2009 using the 2012-13 estimates of FTE as a percentage of fishermen days to be comparable with Lincoln and Lucas.[8] This was multiplied by the average number of licenses in 2000–2009 to get a denominator for the rate calculations. We also calculated the fatality rate using the standard 250 days/yr FTE. Injury incidence rates were calculated by dividing the total number of injuries by the fishermen hours calculated above for both years of observation, and then multiplied by 200,000 hours to normalize to 100 FTEs.[20] For ease in making comparisons within this document, all non-fatal FTEs were reported as normalized to 100FTEs, whether or not they were generated from our original data.

# RESULTS

A sampling pool of 431 lobstermen was randomly selected from each state's list of license holders. Among both states, 11 lobstermen were found to be deceased, 130 ineligible, and 87 had phone numbers that were incorrect or out of service. Of the remaining subjects from both states, 206 did not respond to an exhaustive number of recruitment calls, and 142 declined to participate. The sample size derived from the sampling pool, after the recruitment protocols were completed, was 286 subjects. In Maine, 146 subjects agreed to participate, and in Massachusetts, 140 subjects agreed to participate. By dividing the number of subjects enrolled by the total number who received recruitment calls (excluding those deceased, ineligible, and unable to be contacted because of inaccurate phone numbers), we arrived at an initial participation rate of 46.9% in Maine and 43.3% in Massachusetts.

During the 2 years, 10 subjects from Massachusetts and 2 from Maine elected to drop out. The overall drop-out rate, then, was 12/286 (4.2%; 6.4% in Massachusetts, 1.4% in Maine). Three lobstermen from Massachusetts and one from Maine were substituted for the drop outs as they represented acquaintances or family members of, or recommended by, the subject choosing to drop out. Although these four subjects were not selected at random, they were demographically similar to the other subjects, and it is believed that they did not detract from the representativeness of the sample. One subject from Maine died during the exposure period but not during actual lobstering. Subject recruitment occurred over four months in Massachusetts, and five months in Maine, and therefore extended into the second quarter of the first year of the study.

There was an annual average of 4,991 (2012: 5043; 2013:4938) permits issued in Maine and 1,201 (2012: 1214; 2013: 1188) in Massachusetts over the two years. Estimates of exposure time are presented in Tables 2, 3, and 4. These were calculated using 65 days, 62.5 days, and 500 hours per quarter, respectively.

Total exposure as measured by both fisherman days and hours was significantly different between states ($p<0.001$), and among seasons ($p<0.001$), as was the interaction between state and season (p<0.001). Post hoc tests showed all four seasons to be different from each other (Tukey, p<0.001). The FTE in Maine was higher for all seasons (Figure 1). Differences between the states are larger for the summer and fall quarters, with minimal effort for both states in the winter.

In order to compare with Lincoln and Lucas,[8] a rate was calculated for the fourteen fatalities recorded in Maine and Massachusetts between 2000–2009 using the FTE estimates generated in this study (from estimates displayed in Table 2) and license numbers from 2000–2009. The average number of licenses in Maine in this period was 5,661 and in Massachusetts 1,442. In the years 2000–2009, there were 10 fatalities in Maine (38.6/100,000FTE) and 4 in Massachusetts (82.6/100,000FTE), resulting in an overall fatality rate of 49.6/100,000FTE. If we used the standard BLS method (250 days/yr) for calculating FTE, then the average fatality rate in Maine was 37.0/100,000FTE and 79.5/100,000FTE in Massachusetts, and 47.7/100,000 total for the same years, 2000–2009.

Tables 5 and 6 display the types and locations of acute injuries, respectively. The overall incidence rate for all reported injuries is 49.7 per 100 FTE. The rate drops to 15.0 per 100 FTE for those receiving treatment and down to 7.6 when cuts, sprains, and bruises are excluded. While 14 of the 33 low back injuries affected work, only four received treatment. For the wrist/hand, 29 of 108 injuries were reported to have affected work. On the right wrist/hand alone, 20 of 53 affected work and 16 received treatment.

# DISCUSSION

Occupational safety and health research should play a role in reducing the risk and improving the health of working people. The awareness of risks in the commercial fishing industry is well established. The nature of going to sea and harvesting living resources has always been associated with extreme risk and sometimes catastrophic consequences. The cultural, sociopolitical, and accessibility factors influencing a greater attention to larger, land-based industries from occupational health study than to commercial fishing in the United States is both understandable and explanatory of a deficit in scientific knowledge about comparable rates of morbidity and mortality. Increased attention to surveillance measures, such as the data from this study, should help to inform decisions on how to meet industry-wide challenges given the limited resources available and the variability of specific fisheries.[1] Thus the data responded to the two methodological difficulties described by Matheson.[2]

The average annual FTE calculated for the lobstermen of 2,458 is higher than all fisheries presented by Lincoln and Lucas[8] except Alaska salmon (3,429 FTE). As expected, the summer months (3rd quarter) had the highest FTE, and the winter (1st quarter) the lowest FTE. Fall (4th quarter) and spring (2nd quarter) ranked second and third, respectively. The FTE calculated using fishermen hours was on average 16% larger than the FTE calculated using 260 days/year and 14% larger than the FTE calculated with the standard 250 days/year.

We used the FTEs per license estimated in this study for the years 2012–2013 multiplied times the average number of licenses in 2000–2009 as a denominator for the 14 fatalities in the decade between 2000 and 2009 and found a fatality rate of 49.6/100,000 FTE. Our method excluded the federally licensed offshore fleet, which obviously would have increased the denominator and thus lowered the rate. This estimated lobster industry fatality rate for 2000–2009 was much lower than the rate reported by Lincoln and Lucas [8] for the northeast multispecies groundfish (600/100,000 FTE), the Atlantic scallop (425/100,000 FTE), or the Dungeness crab (310/100,000 FTE) fisheries. The fatality rate was also lower than Alaska salmon, cod, and halibut rates—115, 120, and 130/100,000 FTE respectively—from the same report. This may be due to the near shore nature of the fishery and the reduced likelihood of a vessel casualty. Lincoln and Lucas[8] also found that lobstering fatalities were proportionately more likely due to falls overboard than vessel casualties in comparison to other fisheries, and Jin et al.[21] found that smaller boats have the lowest vessel accident probability. Jin et al also found that accident probability is higher closer to shore. However, the case fatality rate may be lower, as search and rescue would be more accessible.

To our knowledge, this is the first study of lobstermen that reported rates of non-fatal injuries. In fact, few studies of any commercial fishery have reported non-fatal injury rates, and those that do have reported rates with different denominators that are not directly comparable.[1] The study by Kucera et al.,[22] of injuries in North Carolina fishing, found a crude rate of 1.54 per 1000 work days for crab fishermen, a comparable fishery in terms of work methods, postures and repetitive motion. Norrish and Cryer [23] reported a rate of 104 per 1000 fishermen per year receiving compensation for injuries in New Zealand's commercial fishing industry. These denominators are not comparable, however.

In this study, the incidence rate for all injuries (49.7/100 FTE) and injuries requiring treatment (15.0/100 FTE) was much higher than the overall rate (2.1/100 FTE) of reportable injuries in all of fishing and hunting.[20] It should be noted that the Bureau of Labor Statistics does not collect data from the self-employed, whereas most lobsterman are in fact self-employed. Day et al.[24] counted 225 non-fatal injuries reported to the US Coast Guard Marine Safety and Pollution Database occurring in the New Jersey fishing fleet between 2001 and 2007, and calculated a rate of 1.188 injuries/100 FTEs. A recent analysis of USCG Marine Information for Safety and Law Enforcement (MISLE) data reported 465 non-fatal injuries from 2002-2011 in the North Pacific commercial fishing industry (data specifying fishery were not reported).[25] In Alaska, from 2003-2012, MISLE data showed a non-fatal injury rate of 4.3 and 3.5 per 100 FTE, depending on the type of fishery.[1] The injury rates observed in this study were much higher than any of these published estimates, which suggested that non-fatal injuries may be underreported to the USCG.

Typically, lobstermen described minor cuts, punctures, and bruises as routine, an observation supported by the substantial difference between all injuries and those that received treatment, as well as the USCG data above. Most of the cuts, punctures and bruises that may have been minor were to the wrist and hand area, reflecting abrasive materials, sharp objects, and the fast pace of hand work. However, work demands in the lobster fishery limit accessibility to treatment, so minor injuries may not really be negligible and, for the purposes of guiding thoughts on future interventions, should not be ignored.

It is very interesting to recognize that the low back and the wrist/hand areas are affecting work more than other body segments, though the low back injuries are by-and-large not receiving treatment. Conversely, many of the wrist/hand injuries did receive treatment. This may indicate that the wrist/hand injuries tend to be too severe to work through, while the low back injuries are not as debilitating. In addition, three fractures, reportedly, did not receive treatment. Overall, it is objectively clear that work takes priority over receiving treatment, which is a very strong supportive statement for efficient and effective ergonomics.

Injury severity may typically be interpreted by days away from work. In our questionnaire, we asked whether normal work was affected by the injury, to assess the potential impact of interventions for work-related injuries on individual health and productivity. However, we had no measure for length of time of days away from work, a common indication of severity, which may be viewed as a limitation to the data. Anecdotal comments from lobstermen indicated that some rest or recovery was taken on days that the traps did not need to be hauled. If the workforce were following a regulated work week, a day of recovery such as this would be counted as a lost day. Also, median days at work per week was only slightly higher than 4, even in the most active quarter, so anecdotal description of lobstermen taking a “day off” for injury recovery while still maintaining routine work pattern is supported by our data. In other words, a “length of days away from work due to an injury” means something different in this work environment than it would in a typical, regulated, employer-employee constituted workplace. Whether or not they felt the injury affected their work is the key measure.

The fatality rate of lobstermen was not as high as other fisheries. Estimates of injury rates were high in comparison to land-based industry rates established by the BLS, while the comparison to other fisheries may be inconclusive due to likely under-reporting outside of the active data collection methodology of this study. Occupational safety and health research and advocacy should place emphasis on its goals and objectives accordingly

This study was limited to self-reported data and the inherent problem of recall.. It is also possible that acute pains or injuries of the crew were under-reported by the captains, who were the only sources of data in this study.

While achieving an aim to estimate total occupational exposure, we did not examine specific characteristics of the work environment that could have been causally related to observed outcomes. Nevertheless, outcomes research is indicative and relevant to interventions. Therefore, from this report, interventions to reduce exposure to low back injuries and hand/wrist injuries should be considered. Future research on causality or interventions should be focused on these outcomes with specific attention to specific work elements.

We suggest that the participatory ergonomics methodology, a form of action research dedicated to improving ergonomics based on research subject experience and input, would be most effective as future research. The participatory action research model is a community-driven, results-oriented model that builds capacity of and within the research subject community to improve health and prevent musculoskeletal disorders. It is based on evidence that the research subjects are the most capable of designing effective interventions for themselves. It utilizes a model of a series of organized discussions centering on how to improve ergonomics and reduce risk to the types of aches, pains, discomforts, and injuries described by prior descriptive or analytic epidemiology or experienced by the subjects themselves.[26] The outcome data of this study could suggest areas that a participating group or crew might consider for development of their own creative solutions to ergonomic risk in their environment. This would require some ergonomic training to help lobstermen analyze the risk. The process for the development of creative solutions from participatory ergonomics might also stimulate the broader support for a forum for ergonomics in lobstering than existed at the time of this investigation. Support could be in the form of shore-based resources to respond to identified needs through equipment redesign, for example. In addition to dissemination through academic journals, the data generated by this study ought to be disseminated through networks and associations serving the lobstermen.

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**TABLE 1:** Estimated Lobstering Licenses and Fatalities by State in the Northeast United States

| State | **Licenses* (%)** | **Fatalities**** | **Fatalities Percentage** |
|---|---|---|---|
| Maine | 8300 (78) | 10 | 56 |
| Massachusetts | 1300 (12) | 4 | 22 |
| New Hampshire | 365 (3) | 2 | 11 |
| New York | 300 (3) | 1 | 6 |
| Connecticut | 200 (2) | 0 | 0 |
| Rhode Island | 80 (1) | 1 | 6 |
| New Jersey | 70 (1) | 0 | 0 |
| Total | 10615 (100) | 18 | 100 |

***** Non-official estimates, given by state licensing personnel, 2011

**Fatalities for the years 2000-2009 (CDC 2010).

**TABLE 2:** Annual Full Time (assuming 65 days/quarter, or 1yr of 8hr work days) Equivalent (FTE) calculated using days* worked per license, 2012-2013

| | **Maine** | | | **Massachusetts** | | | **Total** | | |
|---|---|---|---|---|---|---|---|---|---|
| Qtr | Days | %FTE | FTE | Days | %FTE | FTE | Days | %FTE | FTE |
| 1 | 7.2 | 11.1% | 556.2 | 5.9 | 9.1% | 109.1 | 6.6 | 10.1% | 626.5 |
| 2 | 26.9 | 41.4% | 2067.7 | 20.6 | 31.7% | 380.5 | 23.7 | 36.4% | 2254.5 |
| 3 | 50.5 | 77.8% | 3881.0 | 37.1 | 57.1% | 685.6 | 43.9 | 67.5% | 4177.0 |
| 4 | 34.4 | 52.9% | 2641.6 | 23.8 | 36.6% | 439.1 | 29.2 | 44.9% | 2778.7 |
| Annual | 119.1 | 45.8% | 2285.9 | 87.4 | 33.6% | 403.5 | 103.3 | 39.7% | 2458.2 |

*days (average number of days worked per license = number of crew * number of trips per week * number of weeks worked)

**TABLE 3:** Annual Full Time (assuming 62.5 days/quarter, or 1yr of 8hr work days with two weeks vacation) Equivalent (FTE) calculated using days* worked per license, 2012-2013

| | **Maine** | | | **Massachusetts** | | | **Total** | | |
|---|---|---|---|---|---|---|---|---|---|
| Qtr | Days | %FTE | FTE | Days | %FTE | FTE | Days | %FTE | FTE |
| 1 | 7.2 | 11.6% | 578.4 | 5.9 | 9.5% | 113.5 | 6.6 | 10.5% | 651.6 |
| 2 | 26.9 | 43.1% | 2150.4 | 20.6 | 33.0% | 395.7 | 23.7 | 37.9% | 2344.7 |
| 3 | 50.5 | 80.9% | 4036.3 | 37.1 | 59.4% | 713.0 | 43.9 | 70.2% | 4344.1 |
| 4 | 34.4 | 55.0% | 2747.2 | 23.8 | 38.0% | 456.6 | 29.2 | 46.7% | 2889.9 |
| Annual | 119.1 | 47.7% | 2380.7 | 87.4 | 34.9% | 419.1 | 103.3 | 41.3% | 2557.3 |

*days (average number of days worked per license = number of crew * number of trips per week * number of weeks worked)

**TABLE 4:** Annual Full Time Equivalent (FTE) calculated using hours* worked per license, 2012-2013

| | Maine | | | Massachusetts | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| Qtr | Hours | %FTE | FTE | Hours | %FTE | FTE | Hours | %FTE | FTE |
| 1 | 73.6 | 14.7% | 734.9 | 57.4 | 11.5% | 138.0 | 65.6 | 13.1% | 811.8 |
| 2 | 236.8 | 47.4% | 2363.1 | 172.6 | 34.5% | 414.6 | 203.7 | 40.7% | 2522.1 |
| 3 | 459.4 | 91.9% | 4585.4 | 306.8 | 61.4% | 736.9 | 383.4 | 76.7% | 4747.3 |
| 4 | 323.9 | 64.8% | 3232.7 | 211.2 | 42.2% | 507.3 | 268.5 | 53.7% | 3324.4 |
| Annual | 1093.7 | 54.7% | 2730.1 | 748.1 | 37.4% | 449.2 | 921.1 | 46.1% | 2854.5 |

* hours (average number of hours worked per license = number of crew * number of trips per week * number of weeks worked * length of trip)

**TABLE 5:** Injury incidence rates by type

| Type of Injury | **All reported injuries** | | **Injuries receiving treatment** | |
|---|---|---|---|---|
| | N | Rate | N | Rate |
| Cuts | 82 | 16.4 | 21 | 4.2 |
| Sprains | 74 | 14.8 | 32 | 6.4 |
| Bruises | 40 | 8.0 | 6 | 1.2 |
| Unidentified pains | 43 | 8.6 | 11 | 2.2 |
| Fractures | 7 | 1.4 | 4 | 0.8 |
| Burns | 2 | 0.4 | 0 | 0.0 |
| Amputations | 1 | 0.2 | 1 | 0.2 |

| | | | | |
|---|---|---|---|---|
| Total | 249 | 49.7 | 75 | 15.0 |
| Incidence rate = (N/EH)*200,000; EH = Employee hours = 1,001,023 total hours of lobstering in the sample for two years | | | | |

**TABLE 6:** Acute injury incidence rates by body location

| | Total reported | | Affected work | | Required treatment | |
|---|---|---|---|---|---|---|
| Body location | N | Rate | N | Rate | N | Rate |
| Head Face | 16 | 3.2 | 0 | 0.0 | 2 | 0.4 |
| Neck | 2 | 0.4 | 0 | 0.0 | 0 | 0.0 |
| Shoulder, Upper Arm | | | | | | |
| Right | 18 | 3.6 | 5 | 1.0 | 9 | 1.8 |
| Left | 14 | 2.8 | 5 | 1.0 | 8 | 1.6 |
| Both | 3 | 0.6 | 0 | 0.0 | 1 | 0.2 |
| Elbow, Forearm | | | | | | |
| Right | 11 | 2.2 | 2 | 0.4 | 6 | 1.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Left | 8 | 1.6 | 3 | 0.6 | 4 | 0.8 |
| Both | 4 | 0.8 | 1 | 0.2 | 2 | 0.4 |
| Wrist, Hand | | | | | | |
| Right | 53 | 10.6 | 20 | 4.0 | 16 | 3.2 |
| Left | 25 | 5.0 | 7 | 1.4 | 8 | 1.6 |
| Both | 30 | 6.0 | 2 | 0.4 | 4 | 0.8 |
| Back | | | | | | |
| Upper Back | 5 | 1.0 | 1 | 0.2 | 2 | 0.4 |
| Low Back | 33 | 6.6 | 14 | 2.8 | 4 | 0.8 |
| Lower Extremities | | | | | | |
| Hips, Thigh | 3 | 0.6 | 2 | 0.4 | 1 | 0.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Knees, Shins | 19 | 3.8 | 5 | 1.0 | 7 | 1.4 |
| Ankles, Feet | 5 | 1.0 | 2 | 0.4 | 1 | 0.2 |
| Incidence rate = (N/EH)*200,000; EH = Employee hours = 1,001,023 total hours of lobstering in the sample for two years | | | | | | |

**Figure 1:** Average hours worked by lobstermen per season in Maine and Massachusetts, 2012-2013.