ERGONOMIC ASSESSMENT AND LOW BACK PAIN AMONG COMMERCIAL FISHERMEN

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ABSTRACT

KRISTEN L. KUCERA: Ergonomic Assessment and Low Back Pain among Commercial Fishermen
(Under the direction of Dana Loomis)

Low back pain (LBP) is a significant problem for commercial fishermen. Little research has been done to investigate the ergonomic stress of occupational fishing tasks, and no previous study has explored the link between low back stress and LBP in fishing. This study quantified low back stresses during commercial crab and gillnet fishing tasks and determined the association between those stresses and LBP occurrences reported in a prospective cohort study of North Carolina commercial fishermen conducted April 1999 to October 2001.

Two ergonomic methods measured the percent of time fishermen were exposed to low back stress in a sample of 29 commercial fishermen. Fishing task frequency was evaluated in a telephone questionnaire with cohort crab pot and gillnet fishermen (n=105). Multivariate generalized Poisson regression modeled the occurrence rate ratios (RR, 95% CI) of LBP that limited or interrupted work (severe LBP) by percent time exposed to high low back stress and self-reported task.

The rate of severe LBP was 0.69 per 1000 person-days (95% CI: 0.47, 0.90). Age, years of experience and previous severe LBP were associated with severe LBP. Handling heavy loads during loading and unloading produced high compression (3400 to 5315 Newtons) and lifting index values (3.0 to 5.4), but contributed little to overall work time (0-14%). Unloading the boat with or without use of a lifting aid was associated with an increased rate of severe LBP. Sorting catch, due to the large portion of time in static, non-neutral trunk postures (83% task time, 27-53% total work time), was associated with an increased rate of LBP (1.80 95% CI: 0.78, 4.13). Overall, increased rates of LBP were associated with the percent of time fishermen were exposed to awkward postures, spine compression >3400 Newtons, and NIOSH lifting index >3.0.

Our results demonstrate that neither fishing task frequency nor ergonomic measure alone consistently predict LBP. Age, history of LBP, and self-selection out of tasks were likely important contributors to the patterns of low back stress and outcomes we observed. Research should involve fishermen in future intervention studies to account for these behaviors and increase adoption and diffusion of beneficial interventions.

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LIST OF ABBREVIATIONS

3DSSPP™,	Three-Dimensional Static Strength Prediction Program (University of Michigan)
95% CI,	95% confidence interval
BMI,	body mass index
CABS,	Continuous Assessment of Back Stresses
Kg,	kilograms
LBP,	low back pain
Lbs,	pounds
LI,	lifting index
LMM,	Lumbar Motion Monitor™ (Ohio State University)
Log_e,	natural log
MMH,	manual materials handling
MSD,	musculoskeletal disorder
N,	Newtons
NC,	North Carolina
NIOSH,	National Institute of Occupational Safety and Health
NIOSHLE,	National Institute of Occupational Safety and Health Revised Lifting Equation
OWAS,	Ovako Work Posture Analyzing System
PATH,	Posture, Activity, Tools, and Handling
PHRGM,	probability of high risk group membership from LMM
P-T,	person-time
RR,	rate ratio
RWL,	Recommended weight limit

US, United States

I. BACKGROUND AND SIGNIFICANCE

A. Commercial Fishing

Occupations such as farming, agricultural work, construction, logging, and fishing present many challenges for researchers that strive to characterize the nature of the work and health hazards that are present. These occupations often do not have documents or records that allow workers to be easily identified, and they are practiced in a variety of settings influenced by the natural environment. Many workers in these outdoor manual occupations are exposed to hazardous working conditions and have the highest mortality and morbidity rates. Commercial fishing is one of these occupations.

Commercial fishing is a dangerous and strenuous occupation worldwide (Conway 2002). Fishermen work long hours, often days at a time, and, in many fishing areas, access to health care is limited. Commercial fishing is also associated with high morbidity from vessel losses (Jin, Kite-Powell et al. 2001) and traumatic injuries from falls, slips, being hit by gear and equipment, handling catch, and maintenance activities (Norrish and Cryer 1990; Torner, Karlsson et al. 1995; Torner and Nordling 1999/2000; Jensen 2000; Thomas, Lincoln et al. 2001; Jensen, Stage et al. 2003; Marshall, Kucera et al. 2004; Jensen, Stage et al. 2005). Because fishing includes exposure to heavy loads, handling fishing gear, balancing on a moving surface caused by rough water and boat motion, and exposure to elements (wind, cold, rain, etc.), musculoskeletal disorders (MSD) are common in the fishing population and therefore a concern for occupational health professionals and researchers (Torner, Blide et al. 1988; Torner, Blide et al. 1988; Torner, Zetterberg et al. 1990; Torner, Zetterberg et al. 1991; Torner, Almstrom et al. 1994; Torner, Karlsson et al. 1995; Torner and Nordling 1999/2000; Lipscomb, Loomis et al. 2004).

Current epidemiological literature on commercial fishing consists predominantly of studies of mortality associated with deep sea fishing operations in Alaska and Northern Europe (Schilling 1966; Reilly 1985; MMWR 1993; Schnitzer, Landen et al. 1993; Bratteboe and Aasjord 1994; Driscol, Ansari et al. 1994; Kennedy, Veazie et al. 1994; Lincoln, Perkins et al. 1996; Conway 2002; Roberts 2002; Roberts 2004). Commercial fishing has been identified world-wide among occupations with the highest mortality rates ranging from 98.2 to 143 deaths per 100,000 worker-years (Driscol, Ansari et al. 1994; Loomis, Richardson et al. 1997; Report on the safety and health in the fishing industry. 1999; Conway, Lincoln et al. 2002; Roberts 2002; Roberts 2004). Knowledge of the epidemiology of morbidity related to fishing has increased in the past 15 years, but like studies of mortality, is limited primarily to deep-sea fishing operations. The most commonly studied non-fatal outcomes of previous morbidity studies are "accidents" and traumatic injury (Moore 1969; Moore 1969; Schilling 1971; Richardson 1974; Jacobson, Goblirsch et al. 1990; Norrish and Cryer 1990; Grainger 1993; Torner, Karlsson et al. 1995; Van Noy 1995; Jensen 1996; Drudi 1997; Husberg, Conway et al. 1998; Conway and Husberg 1999; Guard 1999; Smith 1999; Torner and Nordling 1999/2000; Jensen 2000; Jin, Kite-Powell et al. 2001; Thomas, Lincoln et al. 2001; Jensen, Stage et al. 2003; Jensen, Stage et al. 2005; Matheson, Morrison et al. 2005). Studies of Northern European and Alaska fishermen have shown that the most common causes of traumatic injury are falls (Torner, Karlsson et al. 1995; Jensen 2000; Thomas, Lincoln et al.

2001; Jensen, Stage et al. 2003). There are few studies of musculoskeletal disorders in commercial fishing however (Torner, Blide et al. 1988; Torner, Zetterberg et al. 1990; Lipscomb, Loomis et al. 2004).

B. Commercial Fishing in North Carolina

North Carolina's geography forms a unique work environment for the state's commercial fishermen. A chain of barrier islands known as the Outer Banks runs the length of the coastline, separating the Atlantic Ocean from the Albemarle-Pamlico estuarine system. This is a meeting point for five rivers and streams that fill the estuary. Referred to as the sound, it has a maximum depth of 9 meters and averages between 3 and 5 meters providing a rich environment for many species of finfish and shellfish. This marine and freshwater ecology is unique to North Carolina fishing and offers a different kind of fishing when compared to the deeper ocean fishing done in Alaska, the Pacific Coast region, and Northern Europe.

Fishing is financially important to North Carolina (NC) and to the families that depend upon it for their livelihood. North Carolina Division of Marine Fisheries estimates there are over 7000 commercial fishermen with “endorsement to sell” licenses. This number underestimates the number of fishermen in NC, as crewmembers do not have to be licensed. In 2000 NC commercial fishing catch landings peaked bringing in 154.1 million pounds of fish and shellfish to NC docks (News from the Fisheries 2001). Current statistics show that hard crabs continue to be NC’s top catch, bringing in 32.1 million dollars in 2000 (Donald 2001). Associated with high mortality and one of the ten leading industries in NC, commercial fishing’s unintentional fatal trauma rate, relative to all industries, was 19.2, second to logging, and its fatality rate due to environmental conditions was number one at 48.3 (Loomis, Richardson et al. 1997). Fishing in NC is not just an occupation; it is also a family business and a way of life in many cases.

Crab pots and gill nets are the most commonly used fishing gear in NC (Loomis, Marshall et al. 2004; Hesselman, Mumford et al. 2005). The process of fishing for crabs with pots and finfish with gillnets has been described previously (McDonald, Loomis et al. 2004; Mirka, Shin et al. 2005). Crab pots, made from sheets of plastic coated chicken wire formed around a metal bar box frame 0.6 x 0.6 x 0.5 meters, weigh 6 kg when empty, and have three openings: one for the crabs to enter the pot, one for the bait, and one to empty the pot which is closed with an elastic bungee cord (see Photo 4.1). A buoy is attached to each pot with a 1 to 2 meter rope. Pots are set individually in lines along the sound or river bottom where the buoy marks the spot. As the fisherman approaches the first pot, they grab a metal hook and catch the rope around the buoy. Pulling the buoy to the side, they either loop the rope around a hydraulic puller which pulls the pot up, or pull the rope in by hand. They lift the pot in, dump out old bait, unhook the bungee cord to open the pot, and shake out the crabs onto a work surface or into a box. Once empty, the pot is hooked closed, re-baited with two to three fish, and reset. If working with another crewmember, one fisherman drives the boat while another empties and baits the pot so they will have reached the next pot when the current pot is ready to be set. Otherwise, a fisherman working alone either circles the pot or idles the boat during this cycle. Culling (sorting by size and shell hardness to remove illegal sized crabs) is required by law and is performed on the boat between pots or lines.

Gillnets are comprised of a monofilament mesh that is attached on the top and bottom to two lines. The top line has cork floats attached while the bottom line is free so that the net sits vertical in the water column (see Photo 4.2). Each end of the net is marked by a buoy and an anchor holds the net in place. Fish swimming into the net get caught in the mesh holes around their gills. Catch type determines the size of the mesh net holes, the depth the net is set, and gear used. For example, flounder swim on the bottom, so the net sits lower in the water column. Fishermen use a metal hook to catch the rope attached to the buoy, pull the buoy to the side, unhook the buoy, and feed the rope into a hydraulic puller. Once the anchor is pulled up it is also removed. When the net appears, the line is removed from the puller and put around a net reel, a large metal drum that rotates, which pulls the net in and down a wooden chute or table. Without a puller or net reel fishermen perform this work by hand. The fishermen pick out the fish from the net as it is pulled aboard and toss them into boxes. Once the end of the net is reached, buoy and anchor are removed, and the net is reset in another location. Net length varies by fisherman and fishing location.

C. Musculoskeletal Disorders and Injuries in the Workplace

Musculoskeletal disorders and injuries have a major impact on US workers and constitute the major component of the total cost of work related injury. The Bureau of Labor Statistics reported in 1997 that one third of the total cases involving lost days from work were due to over exertion or repetitive motion (National Occupational Research Agenda (NORA) for Musculoskeletal Disorders: Research Topics for the Next Decade. A report by the NORA musculoskeletal disorders team. 2001). Almost three quarters of these cases involved manual materials handling tasks of lifting, pulling or pushing, holding, carrying, or turning (433,801/603,096) (National Occupational Research Agenda (NORA) for Musculoskeletal Disorders: Research Topics for the Next Decade. A report by the NORA musculoskeletal disorders team. 2001). Furthermore 63% of overexertion injuries affected the back (National Occupational Research Agenda (NORA) for Musculoskeletal Disorders: Research Topics for the Next Decade. A report by the NORA musculoskeletal disorders team. 2001). National Institute of Occupational Safety and Health (NIOSH) in its 2001 National Occupational Research Agenda (NORA) has specified low back musculoskeletal disorders as one of its priority research agenda areas (National Occupational Research Agenda (NORA) for Musculoskeletal Disorders: Research Topics for the Next Decade. A report by the NORA musculoskeletal disorders team. 2001).

Musculoskeletal disorders are conditions that involve the nerves, tendons, muscles, and supporting structures of the body (Bernard 1997). Musculoskeletal injuries are the result of traumatic events causing damage or disruption to tissues (Kumar 2001). Injuries are acute in their onset and may result in a functional disorder, while disorders are generally characterized by gradual or unknown onset and may or may not be a result of disruption of tissues (Kumar 2001). Regardless of onset, both conditions are identified by pain or loss of normal function resulting from the injury event or the disorder. Few studies have been able to determine definitively which outcomes, injury or disorder, are represented in work injury claims and therefore the estimate of the proportions, injury and disorder, are unknown (Kraus, Gardner et al. 1997). Therefore, it is appropriate to address both outcomes where applicable. Kraus, et al. (1997) state, "the advantage of considering both back pain and injuries as a mixture of conditions related to instantaneous and long-term events is that it allows the investigator to incorporate risk factors related to both types of possible etiologies in the study design (page 158)."

Measurements of these outcomes in epidemiologic studies are through a variety of means, including self-report, insurance claims, work injury or incident reports, and medical diagnosis. Data from administrative systems are incomplete since not all work-related MSD are reported in the work place or compensated by insurance carriers (Punnett and Wegman 2004). Diagnostic criteria for MSD are not standardized and often inconsistent from provider to provider (Punnett and Wegman 2004). Therefore, self-reported symptoms are an accepted method used commonly in occupational and ergonomic epidemiology research to evaluate the presence of musculoskeletal disorders (Punnett and Wegman 2004). For example, the Nordic Questionnaire consists of a general questionnaire and more detailed body part-specific questionnaire about the presence of ache, pain, or discomfort (Kuorinka, Jonsson et al. 1987). Studies have reported that the best measurements for low back musculoskeletal symptoms are self-reported symptoms or pain with less than one year recall (Burdorf 1992; Hagberg 1992; Burdorf, Rossignol et al. 1997).

D. Risk Factors for Low Back Pain and Injury

There are some differences in risk factors for injuries versus disorders. Injuries are attributed to an acute event and therefore experience factors such as age, lack of training or supervision as well as intense exposures, fatigue or overuse, and unfamiliar work have been identified as potential risk factors for injuries (Kraus, Gardner et al. 1997). Musculoskeletal disorders are often described by a cumulative trauma model where personal factors such as history of previous injury, disc degeneration, body mass index (BMI), and aging as well as work-related factors such as frequent exposures and years at job are described as risk factors (Kraus, Gardner et al. 1997). Kraus, et al. (1997) present these risk factors in a unified model of acute and chronic injury recognizing the need to consider the whole spectrum of factors in order to describe low back outcomes. Specifically, risk factors for work-related low back musculoskeletal disorders and injuries have been identified in previous literature for other occupations and industries and include heavy physical work, lifting and forceful movements, bending and twisting (awkward postures), whole body vibration, and static work postures (Bernard 1997; Punnett and Wegman 2004). In addition to occupational risk factors such as years at particular jobs and years of employment, several individual risk factors have been suggested such as BMI, age, gender, and smoking (Bernard 1997; Kraus, Gardner et al. 1997). Most studies of work-related low back disorders are cross sectional in nature, with few cohort studies, and most employ poor measures of ergonomic exposures (most qualitative and not quantitative), varied low back outcome measures, and poor control and measurement of confounders (Burdorf 1992; Hagberg 1992; Burdorf, Rossignol et al. 1997). In order to evaluate the association of potentially modifiable occupational risk factors, such as work task, researchers must be able quantify them.

E. Low Back Outcomes among Commercial Fishermen

Several studies have reported prevalence and incidence of low back outcomes among commercial fishermen. Norrish and Cryer, using hospital discharge and health insurance claims data from New Zealand commercial deep-sea fishermen, reported that two thirds of all musculoskeletal injuries were back strains (Norrish and Cryer 1990). Lifting, lowering, loading, or unloading boxes were responsible for over one third of the injuries and 36% of total reimbursement costs (Norrish and Cryer 1990). Jensen, in a retrospective follow-up study of Danish fishermen, found 10% of all injuries were sprains and strains and

10% of all injuries were to the back (Jensen 1996). A study found that strains and sprains were ranked fourth in length of incapacity during fishing after dislocation and fractures, contusions, infected traumas among Grimsby (UK) deep-sea fishermen (Moore 1969).

Musculoskeletal symptoms were common among Swedish fishermen and were influenced by age, years as a fisherman, fishing type, and job tasks (Torner, Blide et al. 1988). Seventy-four percent of participating fishermen, of whom 87% had been fishing for 21-30 years, reported some type of musculoskeletal symptoms in the last 12 months. Reported symptoms varied depending on fishing types, whether net fishing or trawling, as well as whether the fisherman was a crewmember or captain (Torner, Blide et al. 1988). Studies of isometric lifting strength and musculoskeletal injuries found that torso lifting strength was higher in the group who never reported back pain when compared to the group who had reported back pain during the previous 12 months (Torner, Zetterberg et al. 1990). An aspect of commercial fishing setting it apart from other non-industrial occupations is that workers perform their tasks on a moving surface, i.e. the boat. Studies of boat motion on musculoskeletal injury found that motion was responsible for increased stress on the musculoskeletal system, particularly in the lower extremity and lumbar region (Petersen, Torner et al. 1989; Torner, Almstrom et al. 1994).

A study of North Carolina commercial fishermen described traumatic injuries self-reported at entry into the cohort (Marshall, Kucera et al. 2004). At baseline, 39% of commercial fishermen had a traumatic injury event in the last year. Half of the strains and sprains were to the back and 70% were caused by lifting or moving heavy objects. The results of these findings indicate that at baseline back injuries from manual material handling activities were an important outcome. Prevalence and incidence of low back symptoms were measured in this cohort over two years (Lipscomb, Loomis et al. 2004). Half of fishermen at baseline reported prevalence of low back symptoms. In addition, 18% reported that low back symptoms limited work activity in the last year (Lipscomb, Loomis et al. 2004). Prevalence of back pain at baseline was elevated for fishermen age 35 to 49, male gender, fishing less than full-time, and having no other job but fishing. Of those who did not report prevalence of symptoms in the previous 12 months, incidence of low back symptoms was 33.1 (95% CI: 23.1, 46.0) per 100 person-years. Reported rates of new low back symptoms that interfered with work stratified by presence and absence of baseline LBP was 13.1 (95% CI: 6.8, 22.9) and 6.4 (95% CI: 2.8, 12.6) per 100 person-years respectively (Lipscomb, Loomis et al. 2004).

F. Measuring Ergonomic Exposures

Ergonomics is defined as a "systematic and rational means of fitting the work to the person (Chaffin, Andersson et al. 1999)." Its primary goal is to improve "worker performance and safety through the study and development of general principles that govern the interaction of people and their working environment (Chaffin, Andersson et al. 1999)." Ergonomics is concerned with a variety of occupational factors such as lighting, noise levels, and vibration. Exposure variables in ergonomic epidemiology studies of work-related musculoskeletal disorders are posture, motion and repetition, material handling, work organization, and external factors such as vibration (Hagberg 1992).

Previous studies have used a variety of methods to measure task and job-related, or ergonomic, risk factors both qualitatively and quantitatively. Employment records and self-reports detailing the presence or absence of ergonomic risk factors in the workplace are valuable tools for determining exposure – especially past exposure – to physical strain. Job title and years on the job are other qualitative measures commonly used in epidemiology to determine exposure to ergonomic hazards, yet research has shown variation in postures and speed of work within job titles (Hagberg 1992; Punnett and Wegman 2004). Questionnaires that ask workers to describe their exposure to ergonomic hazards are also subject to errors and underestimation.

Recent reviews of the literature have found quantitative measures of ergonomic stress to be the preferable method when determining appropriate risk factors for work-related MSD and injury (Bernard 1997; Burdorf, Rossignol et al. 1997; Kraus, Gardner et al. 1997; Kuiper, Burdorf et al. 1999). In a review of 81 original studies, only 42% had attempted to characterize exposure to ergonomic risk factors quantitatively through any of three methods: questionnaires, observational methods, or direct measurement techniques (Burdorf 1992). Questionnaires that go beyond presence or absence of risk factor and strive to assign duration and intensity of exposure are useful for epidemiology yet are still subjective in nature. Observational methods have become more popular in recent research as have direct measurement techniques (Burdorf, Rossignol et al. 1997).

Observational methods use work-sampling approaches through direct observation of the worker or video tape. Postures, loads, and activities are recorded or sampled for a period of time and provide frequencies for these ergonomic exposure variables. Direct measurement techniques focus on measuring specific biomechanical factors like spine compression or spine forces and have the highest level of precision (Burdorf, Rossignol et al. 1997). Direct measurement is more costly, time consuming, and is difficult to use in an epidemiological study compared to observational methods and questionnaires. These methods are useful for quantifying ergonomic stress, however unless exposure variability between and within worker is incorporated the measures are subject to exposure misclassification (Punnett and Wegman 2004).

G. Measurement of Ergonomic Exposure: Introduction to PATH and CABS Methods

Two well established ergonomic assessment methods originally developed for the construction industry were used in this study. The Posture, Activity, Tools, and Handling (PATH) methodology (Buchholz, Paquet et al. 1996) is an observational ergonomic assessment technique used to describe the postures and tasks associated in occupations with varied work activities. It describes the frequencies of tasks and represents the variability of work tasks between workers and within workers. Previous studies using PATH have been in construction (Paquet 1998), orchard harvesting work (Fulmer, Punnett et al. 2002), and fishing (Fulmer and Buchholz 2002). This methodology is based on the Ovako Work Posture Analyzing System (OWAS) (Karhu, Kansi et al. 1977; Karhu, Harkonen et al. 1981) which categorizes postures for the whole body in four classes ranging from normal posture to “the load of the posture is extremely harmful.” PATH utilizes OWAS posture categories in conjunction with descriptions of activities, tools used during the activity, and materials handled. The goal of PATH is to identify awkward postures (e.g. lumbar flexion greater than 20 degrees, laterally bent and twisted lumbar postures) and strenuous manual materials handling activities (Buchholz, Paquet et al. 1996). Previous studies with apple harvesters indicated high physical loads to the shoulder and strain to the back (Fulmer, Punnett et al. 2002).

The Continuous Assessment of Back Stress (CABS) methodology (Mirka, Kelaher et al. 2000) is an ergonomic assessment technique for occupations with varied tasks and generates a distribution that represents the range of total biomechanical stress experienced by each worker in a day of work. CABS uses three assessment tools well established in the field of ergonomics to directly measure spine stress: Revised NIOSH Lifting Equation (NIOSHLE) (Waters, Putz-Anderson et al. 1993; Waters, Putz-Anderson et al. 1994); University of Michigan Three-Dimensional Static Strength Prediction Program™ (3DSSPP) (Chaffin, Freivalds et al. 1987; Chaffin and Erig 1991); and the Ohio State University Lumbar Motion Monitor™ (LMM) (Marras, Lavender et al. 1993; Marras, Lavender et al. 1995). Each assessment tool addresses an important factor in the risk of low back disorder and injury. When combined with time values from work tasks summed over the work day, CABS provides estimates of level and duration of stress.

Mirka et al. reviewed the goals of each of these methods (Mirka, Kelaher et al. 2000). NIOSHLE was developed for measuring static postures and two-handed lifts at fixed speeds over an eight-hour workday. Considering the nature of commercial fishing, this method alone will not adequately characterize the biomechanical stress. LMM was developed for repetitive jobs without rotation and often high-risk activities are missed. 3DSSPP is better suited for acute trauma risks and limited for cumulative trauma. Combining these three techniques as a hybrid allows researchers to better represent work with variable tasks. A study of 28 male and female construction workers showed that these workers activities required an evaluation method that could account for different stresses to the low back in a probabilistic manner (Mirka, Kelaher et al. 2000). This direct measurement method allows researchers to estimate stress to the low back and relate that with each task and ultimately a job. Other previous intervention work using CABS has been with furniture manufacturing and carpentry.

Both of these methods are well suited for studying the occupational stress involved in commercial fishing and can be employed in a multivariate model. Measures from the PATH method in the current epidemiological study of risk factors for low back outcomes included the percent of time exposed to postures, forces or loads, and tasks. Measures from the CABS method included the percent of the work day exposed to a range of low back stress levels expressed as NIOSHLE Lifting Indices (0 to 10), LMM probability of high risk low back disorder group (1% to 100%), and 3DSSPP spine compression measures 0 to 6600+ Newtons). These measures and how they were operationalized are discussed in more detail in the Methods section.

PATH and CABS have different ways of measuring biomechanical stress (Lavender, Oleske et al. 1999). CABS is a rigorous biomechanically based methodology that provides quantitative measures of spine stress. PATH is an observational assessment technique designed to be used in the field and describes the frequency of exposure to postures and forces but does not quantify the magnitude of these forces directly. The three components of the CABS method (NIOSHLE, LMM, and 3DSSPP) and two risk factor checklists (comparable to the PATH method) were compared in a study of 178 autoworkers from 93 randomly selected production jobs at an auto metal fabricating plant to see if their primary variables were similar. Correlations between methods ranged between 0.21 and 0.80 (Lavender, Oleske et al. 1999).

H. Ergonomics in Commercial Fishing

Torner and colleagues videotaped and photographed Swedish fishermen as they performed fishing tasks in order to identify activities that were particularly strenuous for the musculoskeletal system and target possible areas for intervention (Torner, Blide et al. 1988). The OWAS system was employed to analyze working postures and loads from video tape and results were reported for a small-scale coastal fishery done on small, open boats with up to two workers. For the 30 minutes of time observed, fishermen spent 3% of time with back flexed >20 degrees, 24% of time with back bent to the side or twisted, and 1% of time bent and twisted. Eighty-eight percent of the time their upper arms were lifted out from trunk and 100% of time they handled loads less than 10 kilograms (kg) (<100 Newtons) (Torner, Blide et al. 1988).

In order to describe the ergonomic processes involved in Northern US fishing tasks, Fulmer and Buchholz identified hazardous tasks involved in commercial gillnetting, trawling, and lobster fishing in Gloucester and Fairhaven, Massachusetts using PATH (Fulmer and Buchholz 2002). They characterized lobster fishing as involving repetitive tasks and exposure to awkward trunk postures when hauling up the lobster traps and culling (sorting and removing illegal size lobsters) the catch (Fulmer and Buchholz 2002).

Pilot work on North Carolina three-man and two-man crab potting crews was conducted using the CABS methodology (Mirka, Shin et al. 2005). Results identified 28 different crab potting subtasks. Sixty-five percent of the workday was spent without weight in upright tasks, such as driving the boat and working with the catch, and 14% of the day engaged in manual materials handling (MMH) tasks, such as loading and moving. Distribution of low back stress differed between three and two man crews and between job titles. The captain spent the most time upright in a neutral spine position driving the boat and hooking the buoy. The mate was engaged in the highest risk activities for acute injury: loading, unloading, lifting pots from side of the boat, and repeated shaking to dislodge crabs. The third man maintained awkward forward flexed postures for extended periods of time in sorting and culling catch on the boat (Mirka, Shin et al. 2005).

These studies helped identify factors that are related to musculoskeletal stress and that describe the fishing process. This study aimed to determine the association between self-reported low back pain and exposure to ergonomic low back stress in the context of commercial fishing. Fishermen are especially vulnerable to low back musculoskeletal disorders and injuries because of the dynamic nature of their work. Research in this area is important because many do not have health insurance and a lost day of work means they will not have income for that day. Furthermore, commercial fishing has not been fully evaluated in an ergonomic context. Characterizing the way fishermen perform their tasks and identifying quantitatively the ergonomic stresses associated with those tasks that act on the musculoskeletal system will provide a more thorough understanding of why low back pain and injuries occur in fishing and ultimately how they can be reduced.

I Summary

In summary, studies have shown that commercial fishing, irrespective of geographic region, is associated with high morbidity. Their work is influenced by external forces including regulations that limit licensure, the time of year for fishing, geographic fishing areas, amount caught, etc. Fishermen are forced to work long hours, sometimes in poor weather conditions, to make a living wage. These external pressures have put fishermen at an increased risk for many health outcomes. Fishermen are exposed to work hazards that increase their risk for traumatic injuries such as strains and sprains, but also may lead to reports of musculoskeletal disorders and symptoms. Commercial fishing can be highly repetitive and handling heavy loads on a moving surface is common. Tasks also differ from one crewmember to another, putting some at increased risk for musculoskeletal stress and injury.

In order to characterize differences in risk, and ultimately to identify modifiable tasks or equipment for possible future intervention, information is needed about the tasks performed by different crewmembers and the frequency and duration of workers' exposures to specific tasks and stresses. The degree to which these tasks are associated with biomechanical stress was addressed in this research using the PATH and CABS assessment techniques in conjunction with data from a cohort of North Carolina commercial fishermen. This study provided information about biomechanically stressful tasks that could be generalized to other non-industrial occupations that have similar work tasks, thereby helping develop methodology for research on this class of occupations.

II. STUDY AIMS

Aim 1: To measure low back biomechanical stress associated with different processes and jobs in commercial crab pot and gillnet fishing in North Carolina using the PATH and CABS methods. Additionally, to measure variability in ergonomic stress quantified between and within fishing type, crew size, job and worker. Results for PATH and CABS assessment techniques were compared and contrasted.

Aim 2: To determine the association between the occurrence of low back pain that limited or interrupted fishing work and 1) self-reported fishing tasks and 2) mean percent of work day exposed to high ergonomic stress to the lower back as measured with PATH and CABS in Aim 1.

Rationale: Commercial fishing is a unique occupation and is characterized by a work setting in the natural environment. A lack of documents or records that allow workers to be easily identified requires innovative techniques to measure exposures and investigate health risks. In order to understand why musculoskeletal symptoms are a problem for fishermen it is important to determine which work activities produce stress and how these stresses vary according to fishing method, crew size, and job characteristic. Case studies have used a variety of methods to quantify ergonomic stress of fishing work tasks. However no study has quantified variability in exposure by these job-related variables.

Low back pain (LBP) is a problem for commercial fishermen. Studies have reported risk factors for LBP including age, years of experience, type of fishing performed, and working more than one job. Little is known regarding the relationship between specific fishing tasks, the frequency with which they are performed, and the duration of exposures and low back pain. Fishing studies have described job tasks that produced low back stress, but no study has evaluated which tasks and biomechanical measures were associated with LBP in a fishing population. This epidemiologic investigation strives to link quantified ergonomic exposure with established techniques in the field of ergonomics and low back outcomes evaluated over time. Aim 2 was designed to take advantage of a previously established NIOSH funded cohort study of fishermen that were followed for two years for musculoskeletal symptoms and injuries.

III. RESEARCH DESIGN AND METHODS

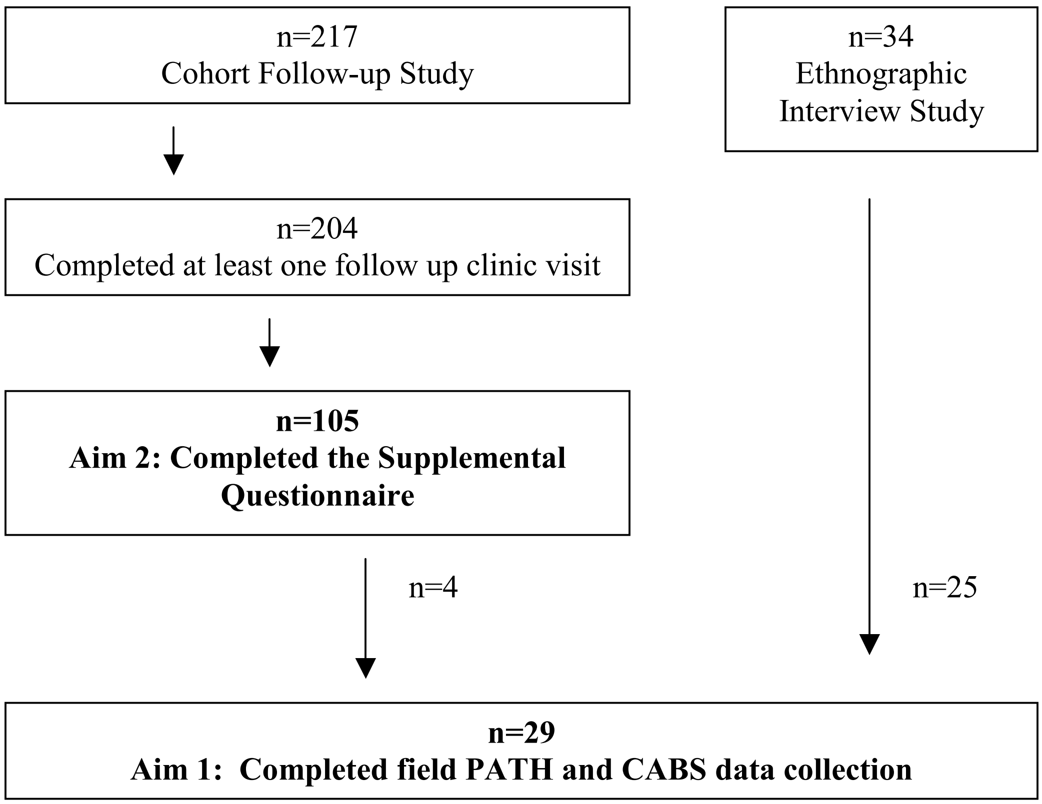
A. Overview

Previous studies of commercial fishermen and ergonomic assessments of that occupation using PATH and CABS methods demonstrated that fishing is characterized by awkward body postures and stress to the lumbar spine (Torner, Blide et al. 1988; Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Lipscomb, Loomis et al. 2004; Mirka, Shin et al. 2005). The overall objectives of this study were to quantify the biomechanical stress for commercial crab pot and gillnet fishing tasks and to determine the relationship of this exposure to LBP. Both the PATH and CABS assessment methods provide a picture of the stresses for each crew and crewmember during a defined time period. PATH and CABS ergonomic measures were initially obtained in a sample of commercial crab pot and gillnet fishermen. Low back pain and fishing exposure information were previously collected in the Occupational Injuries among Commercial Fishers Study that examined injuries and MSD in a cohort of commercial fishermen. The days at risk and type of fishing performed were reported at follow up clinic visits and telephone interviews. The ergonomic exposures were assigned to cohort participants and examined in a multivariate model to determine their relationship with reported LBP from the cohort study. Multivariate generalized Poisson regression modeled the occurrence rate ratios (RR, 95% CI) of LBP that limited or interrupted work (severe LBP) by percent time exposed to high low back stress and self-reported task adjusted for age, crew, and other fishing methods.

B. Study Population

The parent study of a cohort of commercial fishermen in North Carolina (Occupational Injuries among Commercial Fishers Study) examined the risks associated with traumatic injuries and musculoskeletal disorders in the context of the natural environment. The study employed innovative techniques of ethnography and ergonomic assessment to help in the understanding of exposures to hazards and the stresses associated with fishing tasks. Together with the epidemiological data from clinic visits and telephone interviews, this study had a broad and rich context from which to study risks associated with commercial fishing. Three sources of data were utilized for the current study: cohort follow-up study, ethnographic interview study, and a Supplemental Questionnaire assessment (Figure 3.1). The University of North Carolina, School of Public Health Institutional Review Board approved all study procedures.

Figure 3.1. Cohort, Ethnographic, and Supplemental Questionnaire study populations



1. Cohort Follow-up Study

From over 7000 licensed commercial fishermen in North Carolina, a cohort of commercial fishermen was originally assembled between April 1999 and May 2000 for the purpose of studying "possible estuary-associated symptoms (Moe, Turf et al. 2001)." The population recruited for this purpose included 217 individuals 18-65 years of age who worked on estuaries or the ocean for at least 20 hours per week at least six months of the year. Participants were recruited through a variety of means. Information about the study was mailed to licensed commercial fishermen and followed up by phone calls. In addition, researchers disseminated information via radio, television, and newspaper as well as distributed brochures at trade shows, association meetings, and fish houses. As part of the original study protocol, individuals underwent baseline physical examination and full medical history as well as routine follow-up at six-month intervals. In addition, for a series of exposure or symptom related conditions, individuals were asked to return for "trigger visits" (visits when they were experiencing symptoms). Final clinic evaluations were completed in October of 2001. Full details of recruitment and the original study protocol have been previously reported (Moe, Turf et al. 2001).

The Nordic Musculoskeletal Questionnaire (Kuorinka, Jonsson et al. 1987) was employed to evaluate the presence of musculoskeletal disorders in this population. As described previously, the Nordic questionnaire assesses presence of pain, discomfort, or ache in areas of the body. The Nordic questionnaire was administered by NC Commercial Fishing study nurses to participants in the clinic at baseline and a modification of the questionnaire was administered at each follow-up visit. The information collected in the clinic by study nurses included 12-month prevalence of LBP at baseline and in follow-up visits, the occurrence of LBP since last visit. For both baseline and follow up visits, participants were asked if this reported LBP limited or interfered with work and leisure activities.

Fishing exposure and traumatic injury information was collected in weekly (March through November) and biweekly (November to March) phone interviews. Fishermen were asked about their work activities for the week including: type of fishing done and gear used; boat size; days and hours on the water; and days and hours off the water. They were also asked if they had an injury event that week and to describe details about their injury event.

Copies of the baseline and follow-up clinic and telephone follow up questionnaires are located in Appendix E.

2. Ethnographic Interview Study

Another component of the parent study included ethnographic interviewing methods to obtain detailed, first-hand information on the work of 34 fishermen (McDonald, Loomis et al. 2004). Information was gathered on a wide range of topics to supplement the information from the clinic and phone interviews. Pilot ergonomic measures using CABS methodology were obtained for a subset of this group of fishermen (Mirka, Shin et al. 2005). Information from ethnographic sources was used to inform our ergonomic data collection procedures in Aim 1.

3. Supplemental Questionnaire Assessment

From April to October 2004 members of the cohort follow-up study and the ethnographic interview group were interviewed by telephone about their history as a commercial fisherman, the tasks they performed for different types of fishing, and other non-fishing related job exposures. At the end of the interview fishermen were asked if they would allow a researcher to observe, photograph, and video tape them while they worked. A copy of this questionnaire is located in Appendix E. Of the 81% (176/217) of cohort members and 94% (32/34) ethnographic study participants that were available for telephone interview, 60% (105/217) and 41% (13/34) completed the questionnaire.

C. Aim 1: Assessment of Ergonomic Low Back Stress

The first study aim measured ergonomic stress associated with different processes and jobs in commercial crab pot and gillnet fishing using the PATH and CABS methods. Fishermen from the Ethnographic Interview group (n=34) and Supplemental Questionnaire participants from the cohort who were willing to take a researcher out fishing (n=54) were eligible to participate in the ergonomic assessments if they fished with crab pots or gillnets. Random sampling is the most desirable method for enlisting participants for exposure surveys, but was not feasible due to the need for direct observation of fishing work. Instead, a purposive sample was selected based on whether the participant fished with crab pots or gillnets and whether they fished alone or with others. Based on considerations of cost and feasibility we aimed to observe 10 fishing crews for this study. In addition, we included the pilot work from CABS analysis of five fishermen (Mirka, Shin et al. 2005).

1. Data Collection

Fishing work activities and tasks needed to be identified for both ergonomic methods prior to fishing trips. In previous pilot work the CABS method was used to analyze the video tapes of five crab pot fishermen fishing on two crews (Mirka, Shin et al. 2005). Fishing activities were broken down into a series of functional subtasks (e.g., “hook buoy”, “shake pot”, “load bait”). An example of captain’s tasks on a three-man crab potting crew is shown in Table 3.1. Complete listings of CABS fishing subtask descriptions are in Appendix A.

Table 3.1. Description and fishing task coding for captain on three-man crab potting crew

Code	Title	Description
D	Drive and steer boat	Begins when Captain gets behind the secondary cockpit and touches the steering or accelerator. Ends when Captain lifts hand from steering.
GH	Grab hook	Begins after hand leaves steering to grab the hook. Ends after he brings the hook around and just as he changes direction to reach out with the hook.
HB	Hook buoy	Begins as he starts reaching the hook out and down toward buoy. Ends after he hooks and just as he changes direction to pull the buoy toward the boat.
FPP	Feed pot puller	Begins as he pulls the buoy up to the boat. Ends when the hook releases the rope.
SDH	Set down hook.	Begins after the rope is released. Ends when the hook is as close to horizontal as possible and hands touch steering.

The PATH method's defined hierarchy for work evaluation consists of activities, tasks, postures, tools, and handling. Therefore, PATH fishing tasks were subdivided into activities that corresponded to CABS subtasks while maintaining the PATH hierarchy. In addition to CABS subtasks described above (Mirka, Shin et al. 2005) and detailed interviews with commercial fishermen (McDonald, Loomis et al. 2004), previous work with lobster fishermen (Fulmer and Buchholz 2002) informed the PATH data collection instrument. The final template contained the following information in a checklist type format: posture (lumbar spine, neck, legs, arms, hands); fishing task; activity performed; tools used; manual handling of material; force or weight handled; coupling; and position of the material relative to the body (PATH Templates, Appendix A). The template was loaded onto a hand held computer enabling active coding of information while observing the fishermen (Inspect-Write™ Inspection Management software 7.0, PenFact, Inc., Boston, MA). The observer for this study (Kucera) completed a formal training in PATH collection with videos and direct observations with lobster fisherman prior to this study. Previously recorded video footage was coded with PATH prior to the fishing trips in order to refine the template and practice.

Once the data collection instruments were ready, fishermen were selected and contacted for the field study. After obtaining consent from the participant, two researchers accompanied the fishing crews during a full day of work. One researcher video taped participants performing fishing tasks on and off the water while the second researcher collected direct observations with the PATH method at regular 90 second intervals using a hand held computer (real-time PATH). When more than one crew member was present PATH observations were collected every 60 seconds alternating between workers every 20 minutes. We obtained real-time PATH on 13 of the 29 commercial fishermen.

2. Video Analysis

The analysis of video taped fishing work involved several steps. Videos were viewed to record PATH observations on the hand-held computer every 90 seconds for each worker (simulated real-time). Once all 29 fishermen had been observed and coded, PATH data collection was completed.

For CABS analysis, videos were viewed with a computer-based video coding system (OCS Tools™, Triangle Research Collaborative, Inc., Research Triangle Park, NC) to code pre/post fishing activities (loading and unloading, etc.) and three or more samples of fishing work on the water. The OCS coding system quantified the time and frequency workers spent performing CABS subtasks during the sampling period. For example, video tapes were digitally stamped with a time code allowing the coder to apply a time for each task. Time was noted at the end of each subtask in order to calculate the amount of time per subtask. Subtask times were summed over the frequency that the subtask was performed during the sampling period to result in an overall time value. Once all the video tapes were viewed and time coded, low back stress could be modeled using the three CABS methods.

3. Three-Dimensional Modeling

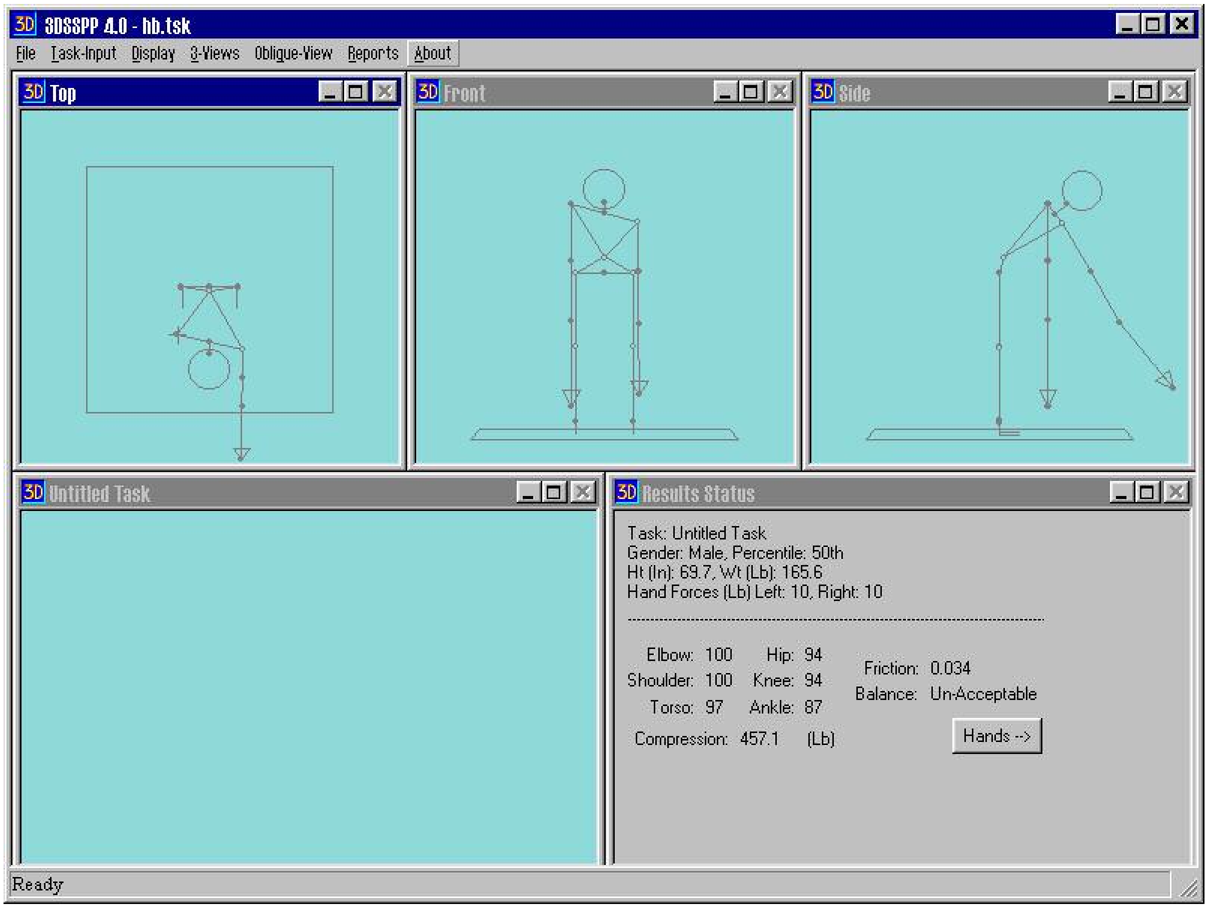
Three-dimensional stick figure models were constructed based on observation of crewmembers performing each subtask (examples from Table 3.1 and all subtasks in Appendix A) using the 3-D Static Strength Prediction Program computer program (3DSSPP™ 4.0, University of Michigan, Ann Arbor, MI). For example, Photo 3.1 shows a real life example of a crab pot fisherman hooking a buoy.

Photo 3.1. Crab pot fishing crew captain hooking the buoy

Photo by Joshua Levinson, MSA for North Carolina Commercial Fishing Study, 2001

The fisherman's posture was determined from the videotaped image and the computer stick figure was adjusted to match the video image. Figure 3.2 represents the general modeled posture of hooking the buoy. The model for static subtasks represented the static posture (e.g. drive modeled fisherman standing upright) while the model for dynamic subtasks represented the peak stress position (e.g. lift down modeled fisherman bent over grasping object).

Figure 3.2. Three-Dimensional Static strength Prediction Program (3DSSPP) figure representation of a fisherman hooking a buoy (HB) for CABS analysis



Inputting major joint angles and direction and magnitude hand forces to 3DSSPP provides 3-D moments about the L5/S1 joint and spine compression values (Chaffin and Erig 1991). Combined with a human strength capacity database, 3DSSPP yields the percent of the population that would have adequate back strength to perform the modeled task and estimates the muscle forces and compressive forces acting on the spine through the incorporation of 3-D biomechanical model (Chaffin and Erig 1991; Lavender, Oleske et al. 1999). The main measure for this study is the percent of time at various levels of spine compression measured in Newtons.

4. Trunk Kinematics Data

Fishing subtasks were simulated in the lab with the Lumbar Motion Monitor (LMM) in order to estimate force vectors involved in performing each subtask. The LMM is a device designed to be worn by the worker and shadows the motion of the lumbar spine. As a worker moves, the monitor sends signals to a computer to record the instantaneous position, velocity, and acceleration of the lumbar spine (Marras, Lavender et al. 1995). Researchers viewed video footage of fishermen performing subtasks. Then over multiple trials, a researcher simulated that subtask wearing the LMM (see CABS subtask descriptions in Appendix A for simulated subtasks). The ergonomic variables obtained using the LMM are lift rate in lifts per hour, average twisting velocity in degrees per second, maximum moment in Newton-meters, maximum sagittal flexion in degrees, and maximum lateral velocity in degrees per second (Marras, Lavender et al. 1993; Marras, Lavender et al. 1995). These five variables were combined in a multivariate model to predict an individual's average probability of being in the high risk low back disorder group based on the measurements of tasks and ranges from 0 to 100%. A high risk low back disorder group is defined operationally as a job with greater than 12 low back disorder incidents per 200,000 hours of exposure (Marras, Lavender et al. 1993; Marras, Lavender et al. 1995).

5. NIOSH Lifting Equation Calculations

Tools and materials were weighed and measured to input in the NIOSH Lifting Equation (NIOSHLE). The NIOSHLE produces a lifting index (LI) calculated from the object weight divided by the appropriate weight that can safely be lifted by most of the working population (the recommended weight limit, RWL) (Waters, Putz-Anderson et al.

1993). In order to obtain the RWL the following multipliers were measured and input into the model: horizontal distance between the object lifted and the body, initial lift height, vertical displacement of the load, frequency of lifting, the lift asymmetry, and the quality of the hand container coupling (Waters, Putz-Anderson et al. 1993; Waters, Putz-Anderson et al. 1994). The LI provides estimates of the relative physical demand on the lumbar spine for the tasks and ranges from 0 to 10. For example, a lifting index of 2.0 means that the worker was lifting twice what NIOSH would recommend for that task.

6. Data Analysis

Because we did not have real-time PATH for all fishermen, simulated real-time PATH was the primary result. Variable frequencies and distributions were reported for PATH observations stratified by type of fishing (crab pot or gillnet), size of crew (1-man, 2-man, or 3-man (crab pot only)), and job type (captain, mate, or 3rd man). PATH exposure variables were categorized based on previous occupational studies and included the percent of time exposed to non-neutral trunk postures, awkward body postures, forces or loads, materials handling tasks, or the combined effects of non-neutral trunk posture and forces or loads (Table 3.2). These variables are described in more detail in Results chapter, section A.

Table 3.2. PATH low back stress exposure variables

Method	Variable	Defined
PATH	Non-neutral trunk posture	Includes: Trunk flexion >20 degrees, Lateral bend and twist >20 degrees, or Lateral bend, twist, and flex >20 degrees,
	Awkward posture	Includes: Trunk flexion >45 degrees, Lateral bend and twist with or without trunk flexion, Any arm above shoulder height, Legs flexed >35 degrees, Kneeling, Squatting, or Standing on one foot
	Forces or loads	Any weight in hands or force exerted
	Manual material handling	Includes lift, lower, push, pull, slide, carry, or hold
	Non-neutral trunk and forces	Both present

CABS output variables, including spine compression, lifting indices, and probability of high risk group membership were merged with OCS subtask time and frequency to produce time-weighted histograms which described the amount of time spent by fishermen at different levels of biomechanical stress in a day of fishing. For this study, we constructed one 3DSSPP model, one LMM simulation, and one lifting index per CABS subtask (Appendix A) and generalized each model to apply to the fishermen in our sample. Therefore, the individual component for CABS measures were encompassed by the OCS subtask time and frequency values assigned to each CABS measure. Sensitivity of CABS subtask models were measured for tasks that indicated high variability between workers and crews and given alternate models. For example, a second hook buoy model was created in which the fisherman held the hook with two hands in a different trunk posture. Because some fisherman did not use a hook, another model was created for fishermen who reach down and grab the buoy by hand.

CABS measures (Table 3.3) were categorized as follows. NIOSH has established levels for lifting index ratios of 3.0 and greater as a potential risk for most healthy industrial workers (Waters, Putz-Anderson et al. 1994). 3DSSPP spine compression measures were assessed at the L5/S1 level in a study by Lavender, et al (Lavender, Oleske et al. 1999) and indicated that spine forces over 3433 Newtons were medium risk for low back pain. LMM identifies through the application of the modeled average of all 5 factors that lifts with greater than 35% overall probability of high risk group membership will be categorized as exposed (Marras, Lavender et al. 1993).

Table 3.3. CABS low back stress exposure variables

Method	Variable	Defined
CABS	3DSSPP spine compression	Greater than 3400 Newtons at L5/S1 joint
	NIOSHLE Lifting Index 3.0	Greater than 3.0
	NIOSHLE Lifting Index 1.0	Greater than 1.0
	LMM probability of high risk group membership	Greater than 70%

Results obtained from the two biomechanical assessment techniques were compared in the context of commercial fishing. Specifically, we were interested in whether CABS and PATH methods generally agreed on which fishing tasks were categorized as higher low back stress and overall the percent of time fishermen were exposed to low back stress. Basic descriptive frequencies and correlation coefficients were used to compare them. Finally, the methods were compared qualitatively in terms of cost, time, and feasibility.

Real-time PATH data was not available for all 29 fishermen. Because PATH data was collected in two forms, real-time and simulated real-time from video, validation of the PATH method was determined by comparing the PATH video coded material to the material coded in real-time for the n=13 fishermen. Real-time coding was considered the gold standard and both forms were coded by the same observer. Differences were determined by comparing sampling frequencies for both methods.

7. Variability of low back stress

Variability between and within fishing type, crew size, job type, and worker for the percent of time exposed to low back stress was quantified with a decomposition of variance using multi-level (mixed) linear models (Littell, Milliken et al. 1996). In the models, the intercept was suppressed, there were no fixed effects, and random effects were included for four categorical nesting variables: worker (i=21), job type (j=3), crew size (k=3), and type of fishing (m=2). Models started with the highest order class variable (fishing type) and lower order class variables were added one at a time to determine their contribution to the overall variance (Table 3.4). For fishing type, the fully adjusted model examined exposure variability between type of fishing, between crew sizes within type of fishing, and between job types within crew size within type of fishing:

Equation 1) $Y_{j(k(m))} = a_m + w_{k(m)} + s_{j(k(m))} + r_{jkm}$

Where $Y_{j(k(m))}$ was the dependent variable or mean percent time exposed to low back stress (e.g. non-neutral trunk posture (see Tables 3.2 and 3.3 for complete list)) for jth job on a crew of size k performing the mth type of fishing; a_m was the effect of the mth type of fishing performed by the crew (gillnet or crab pot) and was normally distributed with variance σ^2_F ; $w_{k(m)}$ was the effect of the size of the kth crew size (1-man, 2-man, or 3-man) performing the mth type of fishing and was normally distributed with variance σ^2_C; $s_{j(k(m))}$ was the effect of performing the jth job (captain, mate, or 3rd man) on a crew of size k performing the mth type of fishing and was assumed to be normally distributed with variance σ^2_J. The residual variance not explained by job, crew size, and fishing type was r_{jkm} and assumed to be normally distributed with estimate of σ^2. The percent of total variance attributed to the random effect variable was calculated by dividing the covariance parameter for that variable (e.g. covariance parameter for between fishing type, σ^2_F) by the sum of all the covariance parameters for the model (e.g. Full model: $\sigma^2_{TOT} = \sigma^2_F + \sigma^2_C + \sigma^2_J + \sigma^2$).

Table 3.4. Decomposition of variance by fishing type: unadjusted and adjusted for crew size and job using multi-level mixed linear regression model

Model	Fixed effects	Random effects variables	Covariance parameter	Source of variation
Unadjusted	Fish type	None	none	Fishing type as fixed effect assumes that the data are sampled from two independent distributions and that the variability within fish types is due to sampling error.
Mixed #1	None	Fish type	σ^2_F	Between fishing type
		Crew size nested within fish type	σ^2_C	Between crew size within fishing type
		Job nested within crew size nested within fish type	σ^2_J	Between job, within crew size, within fishing type
		Residual variance	σ^2	Residual or between worker and within worker and day
Mixed #2	None	Fish type	σ^2_F	Between fishing type
		Crew size nested within fish type	σ^2_C	Between crew size, within fishing type
		Residual variance	σ^2	Residual or within crew, between/within job, and between/within worker
Mixed #3	None	Fish type	σ^2_F	Between fishing type
		Residual variance	σ^2	Residual or within fishing type, between/within crew, and between/within job, and between/within worker

Lacking a 3-man crew and repeated measures for gillnetting, nested models examined exposure variability in crab pot fishing between crew size, between job type within crew size, and between workers within job type within crew size (Table 3.5):

Equation 2) $Y_{i(j(k))} = a_k + w_{j(k)} + s_{i(j(k))} + r_{ijk}$

Where $Y_{i(j(k))}$ was the dependent variable or mean percent time exposed to low back stress (e.g. non-neutral trunk posture (see Tables 3.2 and 3.3 for complete list)) for ith worker of jth job on a crew of size k for crab potting; a_k was the effect of the kth crew size performed by the worker and was normally distributed with variance σ^2_C ; $w_{j(k)}$ was the effect of the jth job on the crew of size m and was normally distributed with variance σ^2_J; $s_{i(j(k))}$ was the effect of performing the ith worker performing the jth job on a crew of size m and was assumed to be normally distributed with variance σ^2_W. The residual variance not explained by worker, job, and crew size was r_{ijk} and assumed to be normally distributed with estimate of σ^2.

Previous studies have modeled the variability for percent time in trunk flexion and handling loads using a log-transformed variable (Burdorf 1992) and non-transformed variables (van der Beek, Kuiper et al. 1995). We did not log transform our dependent variables due to the difficultly in interpreting the results. While extreme departures from normality can yield spurious results (Kleinbaum, Kupper et al. 1998), the distributions of the dependent variables in our data followed an approximately normal distribution.

Table 3.5. Decomposition of variance in crab pot fishing by crew size: unadjusted and adjusted for job and worker using multi-level mixed linear regression model

Model	Fixed effects	Random effects variables	Covariance parameter	Source of variation
Unadjusted	Crew size	None	none	Crew size as fixed effect assumes that the data are sampled from three independent distributions and that the variability within crew size is due to sampling error.
Mixed #1	None	Crew size	σ^2_C	Between crab crew sizes
		Job nested within crew size	σ^2_J	Between crab job types within crew size
		Worker nested within job nested within crew size	σ^2_W	Between crab workers within job types within crew size
		Residual variance	σ^2	Residual or within crab worker and within worker day variation
Mixed #2	None	Crew	σ^2_C	Between crab crew sizes
		Job nested within crew size	σ^2_J	Between crab job types within crew size
		Residual variance	σ^2	Residual or within crab job type and between/within worker
Mixed #3	None	Crew	σ^2_C	Between crab crew sizes
		Residual variance	σ^2	Residual or within crab crew size, between/within job, and between/within worker variation

D. Aim 2: Low Back Pain and Ergonomic Stress

The second aim of the study determined the association between the occurrence of LBP that limited or interrupted fishing work and low back stress measured by self-reported fishing tasks and the percent of the work day fishermen were exposed to low back stress measured with PATH and CABS. Participants for this analysis included commercial fishermen in the cohort follow-up study who responded to the supplementary questionnaire (n=105).

1. Analysis Variables

The occurrence of severe LBP since last visit was measured via the Nordic Questionnaire (Kuorinka, Jonsson et al. 1987) in follow up clinic visits using the question: "Since your last study visit, has low back pain caused you to reduce your work activity (at home or away from home)?" Time at risk for the outcome was estimated as number of days since the last clinic visit.

Ergonomic exposure definitions: Exposure to low back stress was measured two ways for crab pot or gillnet fishing. First, self-reported fishing tasks (Table 3.6) reported by crab pot and gillnet fishermen in the supplementary questionnaire (n=89) was determined by response to: "When you crabbed (or gillnet) by yourself (or in a 2-man crew) during 1999 to 2001 did you…? How often…?" A Likert rating scale (1 to 5) quantified the frequency of task performance: never, less than half the time but more than never, half the time, more than half the time but less than always, or every time or everyday.

Table 3.6. Self-reported crab pot and gillnet fishing tasks

Crab pot	**Gillnet**
Drive the boat	Drive the boat
Load bait and supplies	Load supplies
Use dolly or lift to load bait and supplies	Use dolly or lift to load supplies
Pull in gear: hook or pull in pot	Pull in gear: hook or pull in net
Run pot puller	Run net reel
Empty gear: shake crab pot	Empty gear: pick fish from net
Bait pot	-
Set gear: toss or push pot overboard	Set gear: run out net or toss net overboard
Sort catch on the boat	Sort catch on the boat
-	Ice down catch
Unload catch and supplies	Unload catch and supplies
Use dolly or lift to unload catch and supplies	Use dolly or lift to unload catch and supplies
Sort catch at the fish house	Sort catch at the fish house
Clean boat	Clean boat
Perform routine maintenance on boat or gear	Perform routine maintenance on boat or gear

Ergonomic exposure to low back stress was measured in the sample of 29 fishermen using PATH and CABS (Results from Aim 1). Mean percent of time exposed to low back stress was expressed as a continuous variable. Adjusted means accounted for exposure variability between fishing type, between crew size within fishing type, and between jobs within crew size and fishing type in a mixed multi-level linear model. CABS variables of interest were the percent of time exposed to spine compression > 3400 Newtons, lifting indices > 3.0 and >1.0, and LMM probability of high risk group membership greater than 70%. PATH variables of interest were the percent of time in non-neutral trunk postures, awkward body postures, forces or loads, materials handling, and the combined effects of non-neutral trunk posture and force.

Exposure Assignment: Estimated exposure to self-reported tasks or mean percent time exposed to ergonomic stress was first assigned for each clinic interview period by the fishing type reported in that period (crab pot or gillnet). If both fishing types were reported, the participant was assigned the higher value (crab pot or gillnet) for that exposure. For example, if crab pot fishing had a greater mean percent of time in non-neutral trunk posture than gillnet fishing, then a fisherman who performed both would be assigned the value for crab pot fishing for that interval. If they reported neither they were assigned a zero. In order to examine other exposure assignment strategies and potential exposure misclassification we assigned exposures by crew size (fished alone or with others during follow up) and self-reported job title (captain or mate).

Covariates: The following covariates were considered in our analyses based on work-related low back disorder and injury literature (Kraus, Gardner et al. 1997) and previous commercial fishing studies (Table 3.7) (Torner, Blide et al. 1988; Torner, Blide et al. 1988; Norrish and Cryer 1990; Jensen 1996; Lipscomb, Loomis et al. 2004).

Table 3.7. Variable coding for Aim 2 analyses of the rate of severe low back pain occurrence

Variable	**Measured**	**Categories**	**Type**	**Referent category**
Outcome:				
Severe LBP	Follow-up	1 or 0	Count	0
Exposures:				
Self-reported task	Supplemental questionnaire	Performed task over half the time (1)	Binary	Performed task half the time or less (0)
<u>PATH (Aim 1)</u>				
Non-neutral trunk posture	PATH	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
Awkward posture	PATH	Mean percent of time in exposed crab pot or gillnet	Continuous percentage	1 unit increase
Handling materials	PATH	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
Force or weight handled	PATH	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
Non-neutral trunk and force	PATH	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
<u>CABS (Aim 1)</u>				
Compression >3400 Newtons	3DSSPP	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
Lifting Index >3.0	NIOSHLE	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
Lifting Index >1.0	NIOSHLE	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase
PHRGM >70%	LMM	Mean percent of time exposed crab pot or gillnet	Continuous percentage	1 unit increase

Table 3.7. (continued) Variable coding for Aim 2 analyses of the rate of severe low back pain occurrence

Variable	**Measured**	**Categories**	**Type**	**Referent category**
Covariates:				
History of severe LBP	Baseline and follow up	Yes (1) or no (0)	Binary	No (0)
Visit type	Baseline and follow up	Trigger (1) or regular (0)	Binary	Regular
Sex	Baseline	Female (1)or male (0)	Binary	Male
Age	Baseline	18-21, 22-29, 30-39, 40-49, 50-69	Four indicator variables	Age 30 to 39
Body Mass Index	Baseline	Obese (>30 kg/m2), Overweight (>25 to <=30 kg/m2), Normal (<=25 kg/m2)	Two indicator variables	Normal BMI
Smoking history	Baseline	Current (1) or past or never (0)	Binary	Past or never smoker
Worked regularly on someone else's boat	Baseline	Yes (1) or no (0)	Binary	No
Fished full-time	Baseline	32 or more hours per week (1)	Binary	Less than full-time (0)
Fished year round	Baseline	9 or more months per year (1)	Binary	Less than year round (0)
Second non-fishing related job	Baseline	Yes (1) or no (0)	Binary	No second job (0)
Fished other fishing types besides crab or finfish	Follow up interval	Yes (1) or no (0)	Binary	Crab or fin fish (0)
Fished with more than one fishing type	Follow up interval	2 or more fishing types (1)	Binary	1 fishing type (0)
Average hours on the water last work day	Telephone follow up	0 to 4, over 4 to 6, over 6 to 10, over 10 hours	3 indicators	Over 6 to 10 hours
Years fishing experience	Supplemental questionnaire	0-9, 10-19, 20 to 29, 30+ years	3 indicators	30+ years
History of fishing with others	Supplemental questionnaire	With others (1) or alone (0)	Binary	Fished alone

Table 3.7. (continued) Variable coding for Aim 2 analyses of the rate of severe low back pain occurrence

Variable	**Measured**	**Categories**	**Type**	**Referent category**
Fishing with others during the study	Supplemental questionnaire	With others (1) or alone (0)	Binary	Fished alone
Other non-fishing related job that required	Supplemental questionnaire	Frequent bending or twisting at waist (1)	Binary	No (0)
		Awkward postures (1)	Binary	No
		Lift repetitively (> 3 lifts per minute) (1)	Binary	No
		Lift 25 pounds or less, lift >25 pounds, or lift greater than 50 pounds	2 indicators	Lift 25 pounds or less

2. Data Analysis

The occurrence of severe LBP was modeled using generalized Poisson regression with the days at risk included as an offset term. Poisson regression is flexible, robust and allows for convenient estimation of adjusted incidence rate ratios as measures of association (Frome 1983). The general form of the log-linear model for Poisson regression, where E[Y] is the expected number of events, P-T is the estimate of person-time, B_0 is the intercept or $\log_e$ baseline rate of events in the referent category across all covariates, B_1 is the $\log_e$ rate ratio for the risk factor of interest (X_1), and $B_2, B_3,\ldots, B_k$ represent the $\log_e$ rate for a number of covariates ($X_2, X_3,\ldots, X_k$), is:

Equation 3) $$\log_e (E[Y]) = \log_e (P\text{-}T) + B_0 + B_1X_1 + B_2X_2 + B_3X_3 + \ldots + B_kX_k$$

The Poisson regression model used to predict the rate of severe LBP was expressed as the $\log_e$ of the dependent variable Y (number of occurrences of severe LBP), minus the model offset variable ($\log_e$ (P-T)) (number of days since last visit), which equals the intercept (baseline rate of severe LBP with all covariates at referent level) plus the first beta coefficient for the main risk factor, X_1 (mean percent of time exposed to low back stress), plus the beta coefficients for any additional covariates X_2, X_3,…, X_k (age, years experience, other fishing types, etc). Generalized Estimating Equations (Liang and Zeger 1986; Zeger and Liang 1986) were used to account for the statistical dependence between multiple clinic visits and multiple severe LBP occurrences per fishermen. We considered all occurrences of severe LBP at follow up in this investigation, therefore an occurrence of severe LBP could be new or recurrent. Occurrence rate ratios (RR) were reported with 95% confidence intervals (95% CI) for both exposures.

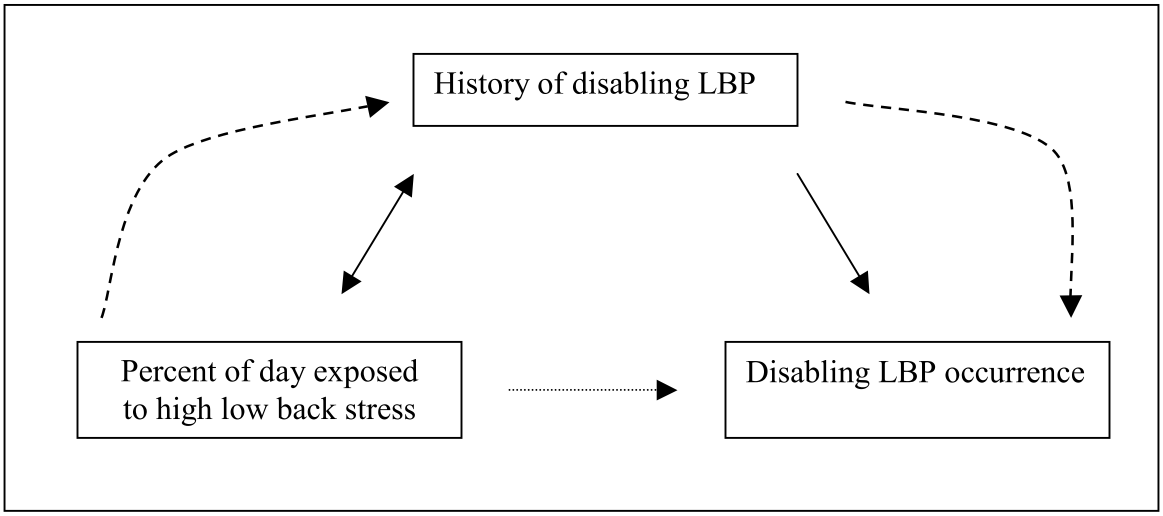
Covariates were considered in the full model if the strength of association was greater than 1.25 or if they were identified as important risk factors in other studies. Using a step-wise backwards elimination strategy we included covariates in the final model if there was a > 20% change in the rate ratio from the model without the covariate (crude RR) compared to the model with the covariate (adjusted RR) or if the covariate was independently associated with the outcome.

Equation 4) Percent change in RR = ((crude RR – adjusted RR) / crude RR) x 100

For crab pot and gillnet fishermen who answered the supplemental questionnaire, we modeled the occurrence rate of severe LBP by low back stress exposure measured with self-reported fishing task (e.g. load the boat) and the mean percent of time exposed to low back stress measured with PATH (e.g. non-neutral trunk posture) and CABS (e.g. lifting index > 3.0) adjusted for age and other fishing types. See Tables 3.2, 3.3, and 3.6 for self-reported fishing tasks and ergonomic variables.

We included fishermen with a previous history of LBP in our analysis. Previous studies indicate that history of LBP is a strong risk factor for subsequent LBP (Punnett and Wegman 2004) and potentially mediates workers' exposure to ergonomic stress (Figure 3.3). In addition, workers exposed to high low back stress may be more likely to have a history of LBP (double headed arrow, Figure 3.3). Further complicating this analysis is history of LBP potential role as a causal intermediate between the occurrence of LBP and exposure to ergonomic stress (dashed curved arrows, Figure 3.3). The conceptual relationships between these three variables meant we could not examine this variable within the multivariate model as a confounder. Therefore, we stratified results by history of LBP using non-overlap of confidence intervals to determine any heterogeneity between fishermen with and without a history of LBP. However, this comparison was limited by the decrease in precision associated with stratifying the data.

Figure 3.3. Conceptual relationships between history of severe low back pain, subsequent occurrence of severe low back pain over follow up, and exposure to fishing-related low back stress



E. Validity and Limits of Measurement Instruments

The Nordic Questionnaire measures self-reported MSD symptoms or pain. For this study, the perception of symptoms or pain is the gold standard and not necessarily medical diagnosis. Kuorinka et al. reported validity and reliability studies of the Nordic questionnaire in 1987. Reliability of results from test-retest methods ranged from 77%-100% (Kuorinka, Jonsson et al. 1987). Validity of results compared against clinical history indicated the number of non-identical answers ranged from 80% to 100% (Kuorinka, Jonsson et al. 1987). Furthermore, results for the low back questions were reported to be the best (Kuorinka, Jonsson et al. 1987). Outcomes defined by presence or absence of pain do not always agree with medical diagnosis. However, physical exam findings appear to be correlated with recent and more severe episodes of pain (Punnett, Fine et al. 1991).

The PATH method has been validated for construction work. Previous studies have shown the intra-observer reliability of 0.9 for pooled data of arm and leg posture and 0.65 and 0.73 for neck and trunk respectively (Buchholz, Paquet et al. 1996). In a detailed validation study, Paquet et al. reported the largest discrepancies were shoulder posture measures above 90 degrees of flexion (Paquet, Punnett et al. 2001). Other difficulties were measuring neutral and flexed knee positions and isolating trunk posture from the influences of neck, hip, and knee postures (Paquet, Punnett et al. 2001). The authors recommend evaluating trunk postures in three categories: < 20 degrees, 20 to 45 degrees, and over 45 degrees of flexion.

CABS is a hybrid of three established ergonomic analysis techniques: Revised NIOSH Lifting Equation (NIOSHLE), Ohio State University Lumbar Motion Monitor model (LMM), and University of Michigan 3-D Static Strength Prediction Program (3DSSPP). Mirka et al. reviewed the limitations of each of these methods (Mirka, Kelaher et al. 2000). NIOSHLE was developed for measuring static postures, two-handed lifts, fixed speed, and in eight-hour workdays. Considering the nature of commercial fishing, this method alone will not adequately characterize the biomechanical stress. LMM was developed for repetitive jobs without rotation and often high-risk activities are missed. 3DSSPP is better suited for acute trauma risks and limited for cumulative trauma.

Validity and reliability of self-reported exposure to ergonomic risk factors have been reported in previous studies (Burdorf and Laan 1991; Wiktorin, Karlqvist et al. 1993; Burdorf 1995; Viikari-Juntura, Rauas et al. 1996). The agreement between questionnaire and observational techniques quantifying duration and frequency of trunk flexion and physical loads ranged from 0.27 to 0.65 (Wiktorin, Karlqvist et al. 1993; Burdorf 1995; Viikari-

Juntura, Rauas et al. 1996). Questionnaires performed poorly when increasing detail was required with some evidence of differential reporting by presence or absence of back pain (Viikari-Juntura, Rauas et al. 1996). This study examined self-reported work task frequencies of performing the specific tasks more than half the time.

IV. RESULTS PAPER 1

A. Quantifying ergonomic stresses in North Carolina commercial crab pot and gill net fishermen

1. Abstract

Background: Injuries and musculoskeletal pain are common among fishermen. Few studies have comprehensively evaluated the ergonomic demands of fishing work. This study aimed to measure low back biomechanical stress associated with crab pot and gillnet fishing and quantify the variability between and within fishing type, crew size, job title, and worker.

Methods: Participants were recruited in a telephone interview with two groups of eastern North Carolina commercial fishermen (n=119). We observed 162 person-hours of fishing work in 27 fishermen on 16 crews. Postures and forces during fishing tasks were measured through direct and indirect observation using two methods to determine the percent of time fishermen were exposed to low back stress. A multi-level linear model quantified exposure variability by four nesting variables: fishing type, crew size, job title, and worker.

Results: Fishermen pulled in and set crab pots or gillnets for 80% of the workday. Twenty-five percent of that time was spent handling gear. Gillnetting crewmembers were exposed to loads 88% of the workday compared to only 45% of the workday in crab potting. Handling heavy loads produced high compression (3400 to 5315 Newtons) and lifting index values (3.0 to 5.4), but contributed little to overall work time (0 to 13.9%). Variation in low back stress exposure was accounted for in most measures by fishing type (93% to 49%) and job type. For crab pot fishing, variability in low back stress was due to crew size (88% to 46%)

and job type. Job type was most important for compression >3400 Newtons and lifting index >3.0. Conclusion: Fishermen are exposed to significant musculoskeletal loads and stresses on the job. The quantity and duration of these stresses and loads vary by the type of fishing and the tasks performed by the worker.

2. Introduction

Commercial fishing is physically demanding work characterized by high rates of mortality (Driscol, Ansari et al. 1994; Drudi 1997; Loomis, Richardson et al. 1997; Thomas, Lincoln et al. 2001; Conway, Lincoln et al. 2002; Roberts 2004), acute traumatic injury (Norrish and Cryer 1990; Jensen 1996; Torner and Nordling 1999/2000; Jensen 2000; Thomas, Lincoln et al. 2001; Loomis, Marshall et al. 2004; Marshall, Kucera et al. 2004), and musculoskeletal pain (Torner, Blide et al. 1988; Norrish and Cryer 1990; Torner, Zetterberg et al. 1990; Lipscomb, Loomis et al. 2004). Surveillance systems developed to track fatal and non-fatal injuries indicate that commercial fishing is a dangerous occupation and that injury rates differ by type of fishing and work process (Conway, Lincoln et al. 2002; Jensen, Stage et al. 2005). Classification systems developed to identify the causes surrounding injury events provide evidence that prevention should be fishery and work process specific (Jensen, Stage et al. 2003; Jensen, Stage et al. 2005). A study of injuries in large scale northern European industrial fishing operations revealed that work activities involving gear and nets differed across fishing methods (Jensen, Stage et al. 2005). Differences in musculoskeletal symptoms have also been noted among fishermen. Prevalence of musculoskeletal symptoms in Swedish fishermen ranged from 11% for foot and ankle to 51% in the low back and varied across fishery, job type, and by experience level

(Torner, Blide et al. 1988). In a study of North Carolina commercial fishermen low back symptoms were a common cause of work impairment (17%) and prevalence differed by fishing type (Lipscomb, Loomis et al. 2004). In order to understand why low back musculoskeletal symptoms are a problem for fishermen it is important to determine which work activities produce low back stress and how these stresses differ across fishing types, crew size, and job characteristics.

Few studies have quantitatively described the physical demands of commercial fishing work accounting for differences by fishery, job, and activity. Three case studies of fishing determined that non-routine gear and catch handling, time distribution and lack of job rotation, work pace, and boat motion contributed to musculoskeletal strain (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005). These studies described ergonomic stress in different fishing operations, but were limited by case study design and were unable to comprehensively represent differences between and within crews, and between and within workers across fishing types.

The purpose of this study was to measure low back biomechanical stress associated with different jobs and crew sizes in crab pot and gillnet fishing employed by fishermen in inland rivers and sounds of eastern NC. To address previous limitations we employed two methods to measure ergonomic stress in different crews and jobs: Posture, Activity, Tools, and Handling (PATH) (Buchholz, Paquet et al. 1996)—a work-sampling based approach—and Continuous Assessment of Back Stress (CABS) methodology, a hybrid of three assessment methods (Mirka, Kelaher et al. 2000). We quantified the variability between and within type of fishing, size of crew, and job. A secondary objective was to compare results from PATH and CABS, two methods appropriate for non-routine jobs with varied work tasks, in the context of commercial fishing.

3. Methods

Study Population

Participants for this study were recruited through a telephone interview from two groups of previously studied commercial fishermen from eastern North Carolina (Moe, Turf et al. 2001; Lipscomb, Loomis et al. 2004; Marshall, Kucera et al. 2004; McDonald, Loomis et al. 2004; Mirka, Shin et al. 2005). The first group included a cohort of 217 commercial fishermen age 18 to 65 originally recruited to study possible health effects of exposure to an estuarine organism (Moe, Turf et al. 2001). The second group consisted of 33 commercial fishermen age 18 to 80 who had participated in a previous ethnographic study about their work as commercial fishermen (McDonald, Loomis et al. 2004). During the telephone interview participants were asked if they would allow a researcher to observe, photograph, and video tape them working. A total of 119 fishermen were interviewed by phone and asked to participate in this study; 45% (54/119) were willing to be observed while fishing. Due to time and financial constraints, the study population was a convenience sample of 29 crab pot and gillnet fishermen. The University of North Carolina at Chapel Hill School of Public Health Institutional Review Board approved all study procedures. Full details of recruitment and study protocols for the cohort and ethnography group have been previously reported (Moe, Turf et al. 2001; Lipscomb, Loomis et al. 2004; Marshall, Kucera et al. 2004; McDonald, Loomis et al. 2004; Mirka, Shin et al. 2005).

Fishing in North Carolina

North Carolina has a unique estuary system of shallow sounds and rivers formed and protected by a chain of barrier islands. It supports an industry of small-scale, independent commercial fishing operations along the coast (Marshall, Kucera et al. 2004; McDonald, Loomis et al. 2004). Fishing is one of the top industries in North Carolina (NC). In 2000, over 154.1 million pounds of fish and shellfish were sold at NC docks (News from the Fisheries 2001), and hard crabs were the top money catch bringing in 32.1 million dollars (Donald 2001). North Carolina offers a supportive setting for studying the variation in ergonomic stress among fishermen.

Crab pots and gill nets are the most commonly used fishing gear in North Carolina (Loomis, Marshall et al. 2004; Hesselman, Mumford et al. 2005). The process of fishing for crabs with pots and finfish with gillnets has been described previously (McDonald, Loomis et al. 2004; Mirka, Shin et al. 2005). Crab pots, made from sheets of plastic-coated wire formed around a metal bar box frame 0.6 x 0.6 x 0.5 meters, weigh 6 kilograms (kg) when empty, have three openings, and are set individually, marked by buoys, in rows along the sound or river bottom (Photo 1). To pull the pots up, fishermen catch the rope around the buoy with a metal hook and wind the rope around a hydraulic puller or alternatively pull the pot in by hand. They lift the pot in, dump out old bait, unhook the pot opening, and shake out crabs onto a work surface or box. Once empty, the pot is hooked closed, re-baited with two to three fish, and reset.

Gillnets are comprised of a monofilament mesh that is strung between two lines. The top line has cork floats attached so that the net sits vertically in the water column (Photo 2). Each end of the net is marked by a buoy and an anchor. Fishermen use a metal hook to catch the buoy and feed the line into a hydraulic puller. After removing the anchor, the line is wound around a large metal rotating drum that pulls the net in and down a wooden chute or table. With no puller or net reel, fishermen alternatively pull lines and nets in by hand. The fishermen pick out fish as the net is pulled along and toss them into boxes. Culling (sorting catch to remove illegal sized finfish or crabs) is required by law and performed on the boat.

Overview of Ergonomic methods

Two methods were used to quantify ergonomic exposure. The first, Posture, Activity, Tools and Handling (PATH) (Buchholz, Paquet et al. 1996) was developed for the construction industry and measures the frequency of tasks, postures, material handling activities, and tool use in real-time and simulated real-time. By linking work tasks and activities to posture codes from the Ovako Work Posture Analyzing System (Karhu, Kansi et al. 1977), PATH yields the percent of work time that workers are exposed to non-neutral or awkward postures and handling heavy loads. Because PATH samples postures and activities throughout the entire workday, quantification of the variability of postures and loads is possible.

The second, the Continuous Assessment of Back Stress methodology (CABS) (Mirka, Kelaher et al. 2000), was also developed for the construction industry and utilizes three well-established ergonomic assessment methods to evaluate biomechanical stress of occupational activities: the Revised National Institute of Occupational Safety and Health Lifting Equation (NIOSHLE) (Waters, Putz-Anderson et al. 1993), the Ohio State University Lumbar Motion Monitor model (LMM) (Marras, Lavender et al. 1993), and the University of Michigan Three-Dimensional Static Strength Prediction Program™ (3DSSPP) (Chaffin, Freivalds et al. 1987; Chaffin and Erig 1991). The NIOSHLE and LMM have been shown to be better for repetitive jobs with lower peak loads consistent with long-term cumulative trauma risks, whereas the 3DSSPP best addresses acute trauma risks from awkward postures and one-time heavy lifts (Mirka, Kelaher et al. 2000). The measures from these assessment tools (lifting index from the NIOSH equation, probability of high risk group membership from the LMM model, and the compression from the 3DSSPP) combined with time-coded subtasks produce histograms illustrating the proportion of the workday that workers experience varying levels of low back stress.

Data Collection

Two researchers accompanied crab pot and gillnet commercial fishing crews during a full day of work. One researcher video taped all aspects of fishing work on and off the water. The second researcher collected direct observations with the PATH method using a hand-held computer at regular intervals (Inspect-Write™ Inspection Management software 7.0, PenFact, Inc., Boston, MA). Templates containing job titles, tasks, and activities for crab pot and gillnet fishing were created prior to the trips based on the videos and interviews gathered previously from the ethnographic group fishermen (McDonald, Loomis et al. 2004), direct observations, and previous fishing industry studies (Torner, Blide et al. 1988; Torner, Blide et al. 1988; Fulmer and Buchholz 2002). We captured the following PATH variables: job title; trunk, leg, and arm postures; fishing task; activity performed; tools used; material handling; force or weight handled; coupling; and position of the material relative to the body. Based on a sampling equation for PATH data collection (Buchholz, Wellman et al. 1997) and previous studies (Fulmer and Buchholz 2002; Mirka, Shin et al. 2005), observations were collected every 90 seconds for each worker by one observer (real-time PATH). When more than one worker was present on the boat, observations were collected every 60 seconds alternating between workers every 20 minutes. We collected data for crab pot and gillnet fishing crews of various size (1-man, 2-man, 3-man (crab pot only)). Most crews were observed only once, but two crews were observed on multiple fishing days.

Video Analysis: The videos were first viewed in order to determine the amount of time on and off the water and to guide ergonomic analyses. Videos were viewed a second time to record PATH observations on the hand-held computer every 90 seconds for each worker (simulated real-time PATH). On average each member of the fishing crew was measured for real-time PATH during a full day and whenever they were visible on the video tape for simulated real-time PATH. The final viewing used a computer-based video coding system for the CABS analysis (OCS Tools™, Triangle Research Collaborative, Inc., Research Triangle Park, NC) to code pre/post fishing activities (loading and unloading, etc.) and three or more samples of the fishing work cycle. Fishing activities were broken down into a series of functional subtasks (e.g., "hook buoy", "shake pot", "load bait"). The OCS coding system quantified the time and frequency workers spent performing CABS subtasks during the sampling period. For example, time was noted at the end of each subtask in order to calculate the amount of time per subtask, and then summed over the frequency that the subtask was performed during the sampling period to result in an overall time value.

Three-dimensional modeling: After viewing and coding the video tapes, three-dimensional stick figure models were constructed for each CABS subtask using the 3DSSPP computer program (3DSSPP™ 4.0, University of Michigan, Ann Arbor, MI). A worker's posture was determined from the videotaped image and the computer stick figure was adjusted to match the video image. The model for static subtasks represented the static posture while the model for dynamic subtasks represented the peak stress position. Inputting major joint angles and direction and magnitude of forces provided X, Y, and Z moments about the spine as well as compression values at the L5/S1 joint in Newtons (N).

Trunk kinematics data collection: After viewing video footage of the fisherman performing the subtask, fishing tasks were simulated in the lab by a researcher wearing the Lumbar Motion Monitor. Three-dimensional position, velocity, and acceleration of the lumbar spine were recorded over multiple trials per task. The probability of high risk group membership (PHRGM) was derived from: lift rate (lifts/hour), average twisting velocity (degrees/second), maximum moment (Newton-meters), maximum sagittal flexion (degrees), and maximum lateral velocity (degrees/second). The high risk low back disorder group is defined operationally as a job with greater than 12 reported low back disorder incidents per 200,000 hours of exposure (Marras, Lavender et al. 1993; Marras, Lavender et al. 1995).

The 3-D models and laboratory simulations were used to obtain NIOSHLE measures to calculate a lifting index (LI): object weight divided by the recommended weight limit (RWL) defined as the appropriate weight that can safely be lifted by most of the working population. RWL is calculated from: horizontal distance between object and body, initial lift height, vertical displacement of the load, frequency of lifts, lift asymmetry, and quality of the hand-container coupling. The lifting index estimates the relative physical demand on the lumbar spine for tasks ranging from 0 to 10. For example, a lifting index of 2.0 would indicate that the worker is lifting twice what NIOSH would recommend.

Data Analysis

Variable frequencies and distributions were reported for PATH observations stratified according to fishing type (crab pot or gillnet), size of crew (1-man, 2-man, or 3-man), and job type (captain, mate, or 3rd man (crab only)). Real-time PATH observations were not available for all fishermen. Therefore simulated real-time observations are presented as the only PATH result. However, we compared real-time PATH results to the simulated real-time PATH results in the fishermen measured with both.

CABS subtask compression, lifting index, and the probability of high risk group membership measures were merged by subtask with each fisherman's subtask OCS time and frequency values to produce time-weighted histograms. For example, a fisherman who was observed pulling in the pot 20% of total OCS time was assigned the corresponding pulling in the pot CABS measure for 20% of the day. For low back compression the histograms represent the percent time in a workday that each worker or crew is exposed to that range of spine compression. For lifting index and probability of high risk group membership the histograms represent the relative frequency of lifts at the given index or probability.

For this study, we constructed one 3DSSPP model, one LMM simulation, and one lifting index per CABS subtask and generalized them to apply to the fishermen in our sample. Therefore, the individual component for CABS measures were encompassed by the OCS subtask time and frequency values assigned to each CABS measure. Sensitivity of CABS subtask models were measured for two subtasks that showed high variability between workers and boats and given alternate models. For example, Model A for "hook buoy" has the worker hooking the buoy with one hand. Model B for "hook buoy" has the worker hooking the buoy with two hands. CABS values for Models A and B were compared and

50% of sampled time was assigned to each subtask model for time weighted histograms. We also quantified and compared the effects of using a metal hook and pot puller versus performing those subtasks by hand.

PATH and CABS exposure variables were created using cut points established from previous occupational studies by calculating the percent of time workers were observed exceeding these levels of low back stress. Non-neutral trunk postures, lifting >4.5 kg at least once per minute, awkward postures, and material handling tasks have been associated with an increased risk of low back pain (Karhu, Kansi et al. 1977; Punnett, Fine et al. 1991). Non-neutral trunk postures were defined as any one of the following: trunk flexion >20 degrees, lateral bend and twist >20 degrees, or lateral bend, twist, and flex >20 degrees. The combination of non-neutral trunk posture with any force was examined to capture the multidimensionality of these two exposures. We were interested in the frequency to which fishermen were observed in extreme or awkward postures. Awkward postures were defined as trunk flexion >45 degrees, lateral bend and twist with or without trunk flexion, any arm above shoulder height, or legs flexed >35 degrees, kneeling, squatting, or standing on one foot. Workers exposed to compression values greater than 3400 N are at increased risk for low back pain (Lavender, Oleske et al. 1999). Lifting indices greater than 1.0 have been associated with low back pain while indices over 3.0 are reported as a potential problem for most workers (Waters, Putz-Anderson et al. 1993; Lavender, Oleske et al. 1999; Waters, Baron et al. 1999). Probability of high risk group membership of 35% or more has been identified as a problem for industrial workers (Marras, Lavender et al. 1995).

Variability between and within fishing type, crew size, job type, and worker for the percent of time exposed to low back stress was quantified with a decomposition of variance using multi-level (mixed) linear models (Littell, Milliken et al. 1996). In the models, the intercept was suppressed and random effects included for four nesting (class) variables: worker (i=21), job type (j=3), crew size (k=3), and type of fishing (m=2). Models started with the highest order class variable (fish type) and lower order class variables were added one at a time to determine their contribution to the overall variance. For fishing type, the fully adjusted model examined exposure variability between type of fishing, between crew sizes within type of fishing, and between job types within crew size within type of fishing.

$$Y_{j(k(m))} = a_m + w_{k(m)} + s_{j(k(m))} + r_{jkm}$$

Where $Y_{j(k(m))}$ was the dependent variable or mean percent time in non-neutral trunk posture for j^{th} job on a crew of size k performing the m^{th} type of fishing; a_m was the effect of the m^{th} type of fishing performed by the crew (gillnet or crab pot) and was normally distributed with variance σ^2_F ; $w_{k(m)}$ was the effect of the size of the k^{th} crew size performing the m^{th} type of fishing and was normally distributed with variance σ^2_C; $s_{j(k(m))}$ was the effect of performing the j^{th} job on a crew of size k performing the m^{th} type of fishing and was assumed to be normally distributed with variance σ^2_J. The variance not explained by job, crew size, and fishing type was r_{jkm} and assumed to be normally distributed with estimate of σ^2. Lacking a 3-man crew and repeated measures for gillnetting, nested models examined exposure variability in crab pot fishing between crew size, between job type within crew size, and between workers within job type within crew size. Previous studies have modeled the variability for percent time in trunk flexion and handling loads using a log-transformed variable (Burdorf 1992). We did not log transform our dependent variables due to the difficulty in interpreting beta coefficients for a log transformed variable as an adjusted mean. While extreme departures from normality can yield spurious results (Kleinbaum, Kupper et al. 1998), the distributions of the dependent variables in our data followed an approximately normal distribution.

Finally, results from PATH and CABS were quantitatively and qualitatively compared in their ability to predict stressful tasks for the low back and to assess cost and efficiency. Percent of fishing subtask time exceeding the cut points for low back stress was calculated and compared between methods. Overall exposure to low back stress from combined task and activities during the workday measured with PATH and CABS was compared using the correlation coefficient.

4. Results

Field Data Collection

Participants observed were predominantly male (90%) and white, non-Hispanic (93%). We observed 162 person-hours of fishing work by 25 (20 crab pot; 5 gillnet) fishermen on 16 crews (12 crab pot; 4 gillnet) of which 108 person-hours were captured on video (Table 4.1). We included the observations of two fishermen and two fish house employees who helped with loading, unloading, and sorting tasks (n=4). For crab potting, the time to pull, empty, and reset one crab pot averaged 76 seconds (range 46 to 117) for the four 1-man crews, 41 seconds (range 30 to 47) for the five 2-man crews, and 35 seconds (range 34 to 36) for the two 3-man crews. One-man crews pulled on average 169 pots per day (range 84 to 321), 2-man crews averaged 310 pots per day (range 188 to 478), and 3-man crews averaged 645 pots per day (range 637 to 653).

Posture, Activity, Tools, and Handling

Over 108 person-hours of video footage of 29 fishermen, 3079 observations were coded simulated real-time using the PATH method. As coded by PATH, by far, the most common tasks for either fishing type were pulling in and setting pots or nets (79%) followed by traveling to fishing grounds (6%), loading and unloading (5%), sorting catch (3%), with the remaining time spent cleaning (2%), docking and casting off (1%), and other activities (4%). The most common activities performed while pulling or setting fishing gear were handling/operating pots or nets (25%), operating controls to the boat, puller, or net reel (17%), and handling/guiding lines (14%) (Figure 4.1). The percent of time spent pulling or setting fishing gear varied by fishing type. For crab potting operations, fishermen spent more time operating controls (32% crab pot vs. 3% gillnet), but in gillnetting, fishermen spent more time handling lines (21% gillnet vs. 6% crab pot), handling gear (35% gillnet vs. 18% crab pot), and picking nets (32%). Additional differences were observed by job title within and between fishing types (Figure 4.2). Crab pot captains spent half the time operating controls versus gillnet captains who guided lines a majority of time. Compared to captains, mates spent more time handling gear. Gillnet mates spent more of their day handling gear (80%) compared to crab pot mates (40%). The 3rd man for crab potting spent the majority of time sorting catch (41%).

Fishermen handled materials (e.g. baskets or boxes of catch) 28% of the time with mates handling materials more (32%) than the captain (26%) and the 3rd man (23%). Fishermen exerted forces or handled loads during half the workday. Of that time, heavy loads (greater than 18 kg) were observed infrequently (4%), while loads 9 to 18 kg were more common (19%), and loads less than 9 kg were observed most often (77%). During gillnetting crewmembers were exposed to loads 88% of time compared to less than half the time for crab potting (45%). Loads and forces varied by job title. The 3rd man was exposed to loads and forces more frequently (74%) than mates (59%) and captains (43%).

Overall non-neutral trunk postures were observed 24% of time. Moderate flexion (20 to 45 degrees) was observed most often (15%) compared to severe flexion (>45 degrees) (7%), and twisting and lateral flexion (1%). On average trunk postures did not appear to vary between crab potting or gillnetting nor when stratified by crew size. However, trunk postures differed by job title. The 3rd man spent 51% of the time in non-neutral trunk postures, 32% of time in severe flexion, whereas mates and captains spent 29% and 18% of the time in non-neutral trunk postures, and only 9% and 3% in severe flexion.

We collected real-time PATH observations for 13 of 25 fishermen (7 of 16 crews). When two crewmen were working on the boat, the captain was under sampled in simulated real-time (42% real-time vs. 52% simulated real-time) compared to the mate (58% real-time vs. 48% simulated real-time). Otherwise, results for fishing activities, postures, and forces were consistent except for time traveling to and from fishing grounds (13% real-time vs. 8% simulated real-time).

Continuous Assessment of Back Stress

Analyses of the 108 person-hours of video footage by 27 fishermen identified 43 subtasks for crab pot and gillnet fishing. Of these, 31 represented independent subtasks (sort catch, shake pot, drive, etc.). The remaining subtasks were weight dependent (i.e. lift up 18 kg basket versus lift up 36 kg box) or required slightly different postures (i.e. pick net upright versus pick net bent). Compression, lifting index and PHRGM mean and range are presented for selected CABS subtasks (Table 4.2). One subtask, lift down tote (36 kg), was considered by all three methods as high risk (Table 4.2).

For CABS histograms, 63 person-hours of video were sampled from 15 fishermen (12 crab pot; 3 gillnet) representing eight crews (6 crab pot; 2 gillnet). Although loading bait totes produced high compression values and lifting index values, these subtasks contributed little to the crew's overall work time (0 to 14%) compared to subtasks like driving the boat (29 to 81%), sorting catch (27 to 53%), and picking nets (48 to 53%) which contributed larger proportions of time to the workday and produced low levels of stress. The overall percent of time at lower lifting indices indicated that light hand-held loads represented most of the workday.

Overall, spine compression and PHRGM distributions varied by fishing type. LMM modeling illustrated the repetitive nature of both fishing types with PHRGM ranging from 40% to 100%. Half of the crab potting crew workday was spent in 0 to 680 N compression values, whereas 50% of the gillnetting workday was at 680-1360 N of spine compression (Figure 4.3). Compression, PHRGM, and lifting index distributions varied by job type. Crab pot and gillnet captains within different crew sizes experienced the largest variability. For crab potting, the three-man crew crab pot captains and one 2-man crew captain spent the majority of time (78%, 91%, and 89%) from 0-680 N compression compared to both 1-man captains (44% and 51%) and the other 2-man captain (59%). Crab pot mates experienced the highest peak compression values (3400 N to 5315 N) and lifting index values (3.0 to 5.4) less than 10% of the work day during loading and unloading and overall spent greater than 40% of the workday at PHRGM 80%. The 3rd man spent half the workday exposed to midrange compression values from 1360 to 2040 N. Likewise, gillnet crewmembers' stresses differed between jobs (Figure 4.4), the greatest experienced by the 2-man crew mate whose main task was pulling and picking fish from the net.

Sensitivity of modeling subtasks: Hooking the buoy two ways showed differences in three CABS measures while feeding the pot puller two ways showed variability in only the compression measure (Table 4.2). When retrieving the buoy from the water, the use of a metal hook (grab rope with hand versus hook buoy) decreased the overall compression value but made no difference in LI or PHRGM values. The use of the pot puller (feed pot puller versus pull pot rope by hand) made a difference in all three measures (Table 4.2).

Variability of PATH and CABS exposures by fish type, crew size, job, and worker

Decomposition of the variance in percentage of work time exposed to low back stress with nested models indicated variability between and within grouping variables. Fish type accounted for the majority of variability in all PATH and two CABS low back stress exposures (range 93.3% to 49.2%) when we accounted for crew size and job (captain, mate, and 3rd man). Conversely, the majority of the variability in percentage of work time in compression >3400 N and lifting index >3.0 was accounted for by job type (63.5% and 46.0%) followed by fishing type (16.6% and 24.2%). Crew size contributed little to variability over all exposures. Residual variation was highest for percent of work time in awkward postures (36.7%) and lifting index >3.0 (29.8%) and includes different workers in the same job and different days within workers—a composite of within-job and between and within-worker variation.

To quantify variation within job and between workers, nested models were limited to crab pot fishing containing random effects for crew size, job type, and worker (Table 4.3

and 4.4). Crew size and job were responsible for a majority of the variability except for percent time in spine compression >3400 N and lifting index >3.0. Job type contributed most to percentage of work time >3400 N of spine compression and >3.0 lifting index. Worker contributed little to total variability except for percentage of work time in awkward postures, spine compression >3400 N, and lifting index >1.0. Residual variation remained high for lifting index >3.0 and represents within-worker and within-day variation.

Comparing PATH and CABS

For task results, all material handling tasks were identified by PATH and at least one CABS hybrid measure as higher risk for low back stress (Table 4.2 measures in bold). For fishing specific activities, PATH identified pulling in and handling gear and handling catch as higher risk, while only CABS PHRGM identified those tasks as high risk. Combining task and time information for each fisherman, the overall percent of the workday exposed to low back stress measured by PATH and CABS was poorly correlated (Pearson r range 0.03 to 0.52) except for percent of day at lifting index >1.0 and handling materials (Pearson r = 0.79).

5. Discussion

This study quantified low back stress in two types of fishing with methods developed for non-routine work and illustrated the variability between and within fishing type, crew size, job, and worker. PATH and CABS results demonstrated that crab pot and gillnet fishing tasks are repetitive in nature and have light hand-held loads for a majority of the day along with rare, high intensity lifts with awkward postures during loading and unloading. Decomposition of variance with multi-level models supported the differences seen in descriptive results. Our study results were in general agreement with previous ergonomic case studies of commercial fishing (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005), and in addition, demonstrated variability was a key component of low back stress in commercial fishing work.

Low back stress exposures varied between fishing types. Gillnet fishermen were exposed to loads during almost 90% of the workday compared to about half of the workday for crab pot fishing. Gillnet fishermen were constantly handling the net as it was pulled in and picked clean of fish with or without the assistance of a net reel. Conversely, crab pot fishermen handled pots a large proportion of the time but used the work table and boat for support when they opened, emptied, baited, and closed the pots. Comparing gillnet and crab pot fishing by the upward shift in compression and lifting index histograms (Figure 4.3) confirmed the difference in low back stress observed by fishing type. Further, decomposition of variance revealed that fishing type was responsible for a large proportion of the variability in exposure to low back stress except for percent workday in compression >3400 N or LI>3.0. This remained after adjustment by crew size and job.

A previous study comparing a 3-man and 2-man crew of eastern North Carolina crab pot fishermen found low back stress exposure differed between crewmembers and between different crew sizes. High stress activities were more evenly distributed between captain and mate in the 2-man crew, whereas with the 3-man crew the mate performed high force exertions and the 3rd man experienced static awkward postures (Mirka, Shin et al. 2005). Therefore, crew size was important in determining a worker's exposure to stress. With the benefit of more crews observed than in other studies, we demonstrated that the independent effects of crew size were important within type of fishing (Table 4.3 and 4.4) but less so when examined between fishing types.

Division of labor (tasks) between crewmembers is integral to determining exposure to musculoskeletal stress (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005). Depending on how captains divided the work tasks, a 2-man crew captain's low back stress distribution may resemble a 3-man crew captain. Likewise, task differences were also seen between the mates. Handling heavy loads in potentially awkward postures occurred for brief time intervals at the beginning and end of the workday. Loading and unloading subtasks such as handling 36 kg totes and boxes with or without trunk flexion and rotation produced 3DSSPP compression and NIOSH lifting index measures that suggest risk for acute injury. If more than one person was working, mates most often performed these subtasks regardless of assistance from the captain. With a third crewmember, sorting catch by size for sale could be done on the boat by the 3rd man rather than at the end of the work day by the crew or fish house employees. Our study results confirmed that time distribution and lack of rotation of tasks between job types contributed to the overall stress.

We focused our ergonomic assessments on crab potting and gillnetting, two common fishing types in North Carolina. Lacking ergonomic assessments that describe other types of fishing, these results cannot be generalized beyond crab pot and gillnetting. Due to the nature of commercial fishing work, the difficulties in reaching these workers at home, and scheduling trips we were unable to observe a random, statistically representative sample of fishermen. However, extensive interviews with fishermen and information obtained from detailed telephone questionnaires suggest that the fishermen observed provide a representative description of the work practices for these two types of fishing (McDonald, Loomis et al. 2004).

Data collection on a freely moving, unstable vessel with limited space and frequent obstruction of lines of sight created many challenges. One observer collected all real-time PATH data while another video-taped the fishing work. In both cases, researchers were not free to move about for the best view of each worker and were unable to maintain both workers in the video camera frame 100% of the time. This is reflected in the low agreement between real-time and simulated real-time PATH sampling frequencies between the captain and mate (4% vs. 12% difference simulated real-time). Previously collected fishing footage was not comprehensive in its inclusion of all fishing activities (McDonald, Loomis et al. 2004). For CABS histograms we substituted load and unload footage from the same 2-man crew. This substitution could spuriously attenuate within-worker and between-day results. Despite these limitations, given the high number and variable size of crews we observed on average, these data are likely to represent the experiences and exposures of these fishermen.

Trunk postures and forces can be difficult to measure accurately (Burdorf, Derksen et al. 1992; Paquet, Punnett et al. 2001). Previous studies of trunk postures found direct observations at fixed intervals were correlated with continuous measurement techniques. Though trunk postures can be misclassified, on average the percent of time at various flexion levels is considered reasonably reliable. In our study, 3DSSPP models for dynamic subtasks represented the peak stress positions and did not represent the full range of potential postures. Sensitivity analyses of alternate models suggested some variability for certain subtasks and we incorporated these alternate models in CABS histograms. Unlike CABS use of peak stress positions for each task, PATH provides a granular assessment of posture for each activity by repeated sampling of that activity over the workday. We were unable to directly measure forces involved with some subtasks on the boat, so the estimation of the results may be subject to misclassification. For the LMM modeling, fishing subtasks were simulated in the lab instead of the field. CABS 3DSSPP models and LMM simulations were generalized so they could be assigned to any fisherman whereas PATH measures are sampled for each individual.

Despite these limitations, we were able to quantify within and between fishing type, crew size, job, and worker variability with both ergonomic methods using an analysis of variance. The variance we could not account for in our analysis ranged from 0.8% to 22.7%. This residual includes different workers in the same job, crew size, and type of fishing plus variability from day to day and within day. CABS and PATH results suggested within-worker and between and within-day variation. Quantification of these class variables was limited by our lack of repeated measures on all fishermen. The small size of our sample, the rarity of 3-man crab crews, the non-existence of 3-man gillnet crews fishing the sound, and only one observed 2-man gillnet fishing crew limited our analysis and produced small cell sizes for some combinations of variables.

Though CABS compression and lifting index were high for a number of fishing subtasks (Table 4.2), histograms incorporating the time fishermen were exposed to high low back stress indicated that these subtasks represented a small percentage of total work day and differed by crew size and job type. Conversely PHRGM task measures (Table 4.2) indicated single subtasks were highly repetitive (PHRGM > 35%) and that fishermen were exposed for a large portion of the work day. Without the benefit of the histograms, a single PATH activity measure like feed pot puller (Table 4.2) indicated fishermen spent 33% of that activity's time in non-neutral trunk posture yet when considered in the context of other fishing activities (Figure 4.1), feed pot puller contributed less than 5% to the overall work day. Both methods indicated that a single task or activity may be associated with high levels of low back stress but this data is of limited use unless frequency and duration are also quantified.

The main exposure measures from PATH and CABS were poorly correlated. Each method approaches low back stress from a different perspective, illustrating the importance of a holistic approach to obtain a full picture of the physical demands. Previous studies comparing ergonomic assessment methods identified trade-offs. Detailed and precise measures require technological expertise and equipment at substantial time and cost. On the other hand, simple, efficient, low-cost and generalizable methods can be applied to a wide variety of work situations (Winkel and Mathiassen 1994; Neumann, Well et al. 1999). Both have their value and place when assessing musculoskeletal stress. We found that employing both, as we did here, provided a more comprehensive picture of work stresses.

PATH employed solely in the field was more time and cost efficient than using CABS in the lab to analyze video tapes. Furthermore, PATH has the potential to evaluate more commercial fishing crews for only the time of the trips but requires a trained observer in the field. Once the trip is complete, data was downloaded and ready for analysis. PATH's strength lies in its ability to characterize jobs with variable tasks and postures providing aggregated posture-based exposure measures useful for epidemiologic analyses. However, the increased generalizability of PATH results is gained at the loss of detailed biomechanical exposure measures that are essential to determining individual risk. CABS best addresses individual risk through quantification of spine stress using three different biomechanical assessment tools that are well established in occupational ergonomics. This multi-tool approach provides a biomechanical link between low back stress and outcomes that informs areas for intervention.

Some unique exposures were difficult to quantify and could not be fully accounted for when assessing exposures. For example, fishermen with small boats and less gear set fewer pots or nets and may work fewer hours. Lack of hydraulic pullers and net reels requires fishermen to pull pots or nets by hand which takes longer and is more strenuous. Work surfaces on the boats also vary. Some fishermen attach metal plates on the side of the boat and use this as an area to work and rest their gear. Some build low tables while others simply use a stack of plastic totes. Lack of a stationary work surface is problematic considering the boat will pitch, roll, and yaw with the waves. Rough days on the water make fishing more challenging for the workers. Other commercial fishing studies have found vessel motion and engine vibration posed musculoskeletal risks to workers (Torner, Almstrom et al. 1994) but we were unable to account for these exposures in this study.

Conclusion

Fishing is a unique occupation with a non-industrial work setting which requires innovative techniques to measure exposures and investigate health risks. Our results indicated crab pot and gillnet fishing work was repetitive and cyclic in nature with awkward postures and rare, heavy exertions. PATH and CABS were well-suited for these varied work demands and provided a comprehensive picture of lumbar spine stress. Our findings support the suggestions of other researchers (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005) that commercial fishermen could make use of mechanical aids for loading and unloading tasks and distribute tasks across crewmembers within the limits of the established hierarchy of captain and crewmember. Also, tasks with static awkward postures should be considered a priority area for intervention. Unlike previous studies, we quantified the variability in exposure to low back stress within and between type of fishing, crew size, job, and worker, which has implications for future ergonomic and epidemiological studies. Contribution of these nesting variables to exposure variability differed across dependent variables. In order to examine the relationship between exposure and outcome these nesting variables should be considered when quantifying and assigning exposure to workers in future epidemiologic studies of work-related health outcomes.

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Table 4.1. Number of crew types and workers observed, Posture, Activities, Tools, and Handling (PATH) and Continuous Assessment of Back Stresses (CABS) observations, and person-hours of fishing observed for commercial crab pot and gillnet fishing in North Carolina, US

	Crew size	Job	Number of crews n (%)	Number of workers n (%)	Days	PATH Workers included in real-time	Real-time observations*	Simulated real-time observations†	CABS Workers Included in histograms
Type of Fishing									
Crab pot									
	1-man	Captain	4 (33%)	4 (18%)	1	2	226	583	2
	2-man[1]		6 (50%)				741	1472	
		Captain		6 (27%)	1	4			2
		Mate		6 (27%)	1	4			2
	3-man		2 (17%)				--	559	
		Captain[2]		1 (5%)	2	0			2
		Mate[2]		1 (5%)	2	0			2
		3rd man		2 (9%)	1	0			2
	Other (helpers)		--	2 (9%)		2	--	--	--
	Total		**12 (75%)**	**22 (76%)**		**12**	**967**	**2614**	**12**
Gillnet									
	1-man	Captain	3 (75%)	3 (60%)	1	1	25	125	1
	2-man[1]		1 (25%)				--	321	
		Captain		1 (20%)	1	0			1
		Mate		1 (20%)	1	0			1
	Total		**4 (25%)**	**5 (17%)**		**1**	**25**	**446**	**3**
Other									
	Fish house employees		**--**	**2 (7%)**		**0**	**--**	**19**	**--**
Total			**16 (100%)**	**29(100%)**		**13**	**992**	**3079**	**15**
Person					Hours		Hours	Hours	Hours

hours				
Observed	162	48		--
Video	108		108	63

[1] One 2man crew measured crab pot and gillnet fishing

[2] Captain and mate on crab pot 3man crew observed on two days

*Real-time observations measured with researcher present on boat and sampling work directly

†Simulated real-time observations measured from video tape with researcher in the lab

Table 4.2. Selected low back stress measures for Continuous Assessment of Back Stresses (CABS) subtasks and Posture, Activities, Tools, and Handling (PATH) task activities in commercial crab pot and gillnet fishing in North Carolina, US

CABS				PATH				
Subtask	Compression[1] (Newtons)	Lifting Index[2]	PHRGM[3] mean (range)	Task	Activity	Non-neutral trunk[4]	Force > 9 kg[4]	Non-neutral trunk and force > 9 kg[4]
Drive	311.4 (2.9)	0.0	-	Pull or set gear	Operate controls	6 (1.0)	0 (0.1)	0 (0.1)
Feed puller A, arms down, hook perpendicular to body	578.0 (24.3)	0.2	41.8 (30.5-52.1)	Pull or set gear	Feed puller	**33 (6.5)**	**29 (6.4)**	12 (4.4)
Feed puller B, one arm up, hook parallel to body	1372.4 (87.9)	0.3						
Grab 18 kg anchor, front of body	**3585.6 (280.8)**	2.2	**74.4 (64.8-84.9)**					
Grab 18 kg anchor, side of body	2846.5 (200.2)	**3.0**	**87.4 (80.3-93.8)**					
Grab rope and buoy with hand	2222.0 (187.7)	0.8	**72.2 (68.1-76.8)**	Pull or set gear	Grab rope with hand	**100 (1.1)**	**50 (17.7)**	**50 (17.7)**
Hook buoy A, one hand at side	1503.2 (104.2)	1.3	**84.2 (70.8-92.0)**	Pull or set gear	Hook buoy	**43 (5.2)**	**46 (5.2)**	12 (3.4)
Hook buoy B, two hands front	1137.6 (68.0)	0.4	**71.7 (58.5-84.4)**					
Lift down 18 kg basket	3239.6 (255.3)	1.7	**88.1 (82.5-92.3)**	Other[5]	MMH[6]=lower	**77 (11.7)**	**54 (13.8)**	**38 (13.5)**
Lift down 36 kg tote	**5314.9 (420.4)**	**3.3**	**81.5 (75.1-87.2)**					
Lift pot (>9 kg) to side of boat	2429.9 (178.3)	1.2	**83.1 (76.6-88.6)**	Pull or set gear	Handle/operate pot	20 (2.0)	**41 (2.5)**	10 (1.5)
Lift, tilt, and shake pot	1228.7 (77.0)	0.9	**84.5 (79.8-86.4)**					
Lift up 18 kg basket	1550.0	1.7	**89.0**	Other[5]	MMH[6]=lift	**58 (7.8)**	**55 (7.9)**	**35 (7.5)**

	(93.4)		**(78.7-98.9)**				
Lift up 36 kg tote	2187.3 (136.7)	**3.3**	-				
Pick net, bent posture	1529.8 (107.9)	0.1	46.3 (40.0-52.0)	Pull or set gear	Pick net	**41 (5.5)**	1 (1.2)	0 (0.4)
Pull net, bent posture	1507.6 (107.7)	0.8	**77.2 (60.5-87.8)**	Pull or set gear	Handle/pull net	**30 (4.3)**	7 (2.4)	4 (1.9)
Pull pot in by hand	1998.2 (142.3)	1.1	**78.1 (72.7-86.9)**					
Sort crabs	1833.0 (132.7)	0.1	52.3 (45.5-55.3)	Pull or set gear	Sort and cull catch	**83 (2.7)**	0 (0.2)	0 (0.2)
Turn and grab 36 kg tote	**3989.1 (318.6)**	**5.4**	-					

[1] Low back compression measured in Newtons at L5/S1 joint with University of Michigan 3D Static Strength Prediction Program (Chaffin, Freivalds et al. 1987; Chaffin and Erig 1991)
[2] NIOSH Lifting Index, object weight divided by Recommended Weight Limit (Waters, Putz-Anderson et al. 1993)
[3] PHRGM, probability of high risk group membership measured with Ohio State University Lumbar Motion Monitor (Marras, Lavender et al. 1993)
[4] Percent of sampled time during that PATH task and activity, % (se); non-neutral trunk includes flexion >20 degrees, bend & twist >20 degrees, or lateral flexion, bend, and twist >20 degrees
[5] Other PATH tasks include pre and post fishing, load and unload, and docking and casting off
[6] Manual materials handling and includes lift, lower, carry, push/pull, slide, or hold
Note: Measures in bold considered to be higher risk for that exposure measure

Table 4.3. Estimated contribution of different sources of variance to the total variability of mean percent time exposed to low back stress measured with Posture, Activities, Tools, and Handling (PATH) in a sample of crab pot commercial fishermen (n=20) with a three-level nested (mixed) linear model with no fixed effects and random effects between crew size, between job type within crew size, and between worker within job within crew size

		Unadjusted	Model #1	Model #2	Model #3
Non-neutral posture[1]	Parameter	Percent contribution			
	σ^2_C		85.2%	75.3%	75.3%
	σ^2_J			19.7%	19.7%
	σ^2_W				0.0%
	σ^2		14.8%	5.0%	5.0%
	Total		779.11	816.18	816.16
		Mean (se)			
	1man crew	21.5 (1.26)	20.61 (5.25)	16.82 (11.56)	16.83 (11.56)
	2man crew	18.8 (3.17)	18.48 (3.36)	16.53 (8.62)	16.53 (8.62)
	3man crew	35.17 (5.88)	34.18 (4.32)	32.03 (7.41)	32.03 (7.41)
Any force[1]	Parameter	Percent contribution			
	σ^2_C		85.6%	71.8%	72.0%
	σ^2_J			25.3%	24.9%
	σ^2_W				1.2%
	σ^2		14.4%	2.9%	1.9%
	Total		2247.46	2277.20	2281.26
		Mean (se)			
	1man crew	48 (1.29)	46.07 (8.81)	35.21 (20.86)	35.38 (20.78)
	2man crew	36.6 (5.02)	36.00 (5.64)	31.00 (15.81)	31.09 (15.72)
	3man crew	48.17 (10.33)	46.85 (7.24)	42.84 (13.45)	43.0 (13.48)
Non-neutral trunk and any force[1]	Parameter	Percent contribution			
	σ^2_C		68.7%	50.4%	50.8%
	σ^2_J			39.6%	38.4%
	σ^2_W				6.7%
	σ^2		31.3%	10.0%	4.0%
	Total		442.40	498.08	504.25
		Mean (se)			
	1man crew	15 (0.91)	13.47 (5.57)	8.17 (10.69)	8.30 (10.70)
	2man crew	11.7 (3.32)	11.19 (3.64)	8.28 (8.57)	8.37 (8.55)
	3man crew	25 (6.70)	23.24 (4.63)	19.30 (7.56)	19.58 (7.70)

[1] Percent of observed work day

[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; and legs bent >30 degrees, kneel, squat, or stand one foot

[3] Lift, lower, carry, push/pull, slide, or hold

Note: Proportion of total variance: between crew size (σ^2_C), between job type within crew size (σ^2_J), and between worker within job within crew size (σ^2_W), and residual (σ^2)

Table 4.3 (continued). Estimated contribution of different sources of variance to the total variability of mean percent time exposed to low back stress measured with Posture, Activities, Tools, and Handling (PATH) in a sample of crab pot commercial fishermen (n=20) with a three-level nested (mixed) linear model with no fixed effects and random effects between crew size, between job type within crew size, and between worker within job within crew size

		Unadjusted	Model #1	Model #2	Model #3
Awkward posture[1,2]	Parameter	Percent contribution			
	σ^2_C		57.3%	42.6%	46.1%
	σ^2_J			31.1%	25.1%
	σ^2_W				24.9%
	σ^2		42.7%	26.3%	3.9%
	Total		377.13	399.43	412.12
		Mean (se)			
	1man crew	15 (2.83)	12.65 (5.82)	7.96 (8.93)	8.82 (8.85)
	2man crew	12.5 (3.22)	11.63 (3.87)	8.76 (7.13)	9.36 (6.90)
	3man crew	18.83 (7.54)	16.76 (4.88)	13.99 (6.61)	15.16 (6.94)
Handling materials[1,3]	Parameter	Percent contribution			
	σ^2_C		82.6%	72.9%	77.0%
	σ^2_J			16.3%	10.4%
	σ^2_W				8.1%
	σ^2		17.4%	10.8%	4.4%
	Total		779.77	772.52	760.19
		Mean (se)			
	1man crew	30.75 (3.97)	29.21 (5.68)	24.40 (10.78)	26.14 (9.37)
	2man crew	22.9 (3.12)	22.43 (3.65)	20.33 (7.95)	21.12 (6.74)
	3man crew	23.33 (6.43)	22.54 (4.68)	21.23 (7.13)	21.17 (6.71)

[1] Percent of observed work day
[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; and legs bent >30 degrees, kneel, squat, or stand one foot
[3] Lift, lower, carry, push/pull, slide, or hold
Note: Proportion of total variance: between crew size (σ^2_C), between job type within crew size (σ^2_J), and between worker within job within crew size (σ^2_W), and residual (σ^2)

Table 4.4. Estimated contribution of different sources of variance to the total variability of mean percent time exposed to low back stress measured with Continuous Assessment of Back Stresses (CABS) in a sample of crab pot commercial fishermen (n=12) with three-level nested (mixed) linear model with no fixed effects and random effects between crew size, between job type within crew size, and between worker within job within crew size

		Unadjusted	Model #1	Model #2	Model #3
Compression>3400[1]	Parameter	Percent contribution			
	σ^2_C		22.5%	9.9%	13.9%
	σ^2_J			75.3%	79.9%
	σ^2_W				25.2%
	σ^2		77.5%	14.8%	6.8%
	Total		30.08	31.08	27.81
		Mean (se)			
	1man crew	0.52 (0.52)	0.19 (2.07)	0.055 (1.65)	0.065 (1.64)
	2man crew	2.31 (1.34)	1.24 (1.77)	0.44 (1.57)	0.52 (1.54)
	3man crew	4.69 (2.58)	2.98 (1.57)	1.23 (1.50)	1.30 (1.48)
Lifting Index>3.0[1]	Parameter	Percent contribution			
	σ^2_C		25.4%	12.8%	12.8%
	σ^2_J			64.5%	64.5%
	σ^2_W				0.0%
	σ^2		74.6%	22.7%	22.7%
	Total		24.34	24.98	24.98
		Mean (se)			
	1man crew	1.44 (0.08)	0.58 (1.92)	0.21 (1.65)	0.21 (1.65)
	2man crew	3 (0.96)	1.73 (1.62)	0.76 (1.55)	0.76 (1.55)
	3man crew	3.91 (2.30)	2.63 (1.43)	1.32 (1.46)	1.32 (1.46)
Lifting Index>1.0[1]	Parameter	Percent contribution			
	σ^2_C		61.5%	47.3%	50.6%
	σ^2_J			39.6%	29.2%
	σ^2_W				19.4%
	σ^2		38.5%	13.1%	0.8%
	Total		829.85	809.82	797.60
		Mean (se)			
	1man crew	27.04 (2.11)	20.61 (11.03)	13.69 (13.75)	15.21 (13.28)
	2man crew	27.32 (9.35)	23.63 (8.31)	18.36 (11.21)	19.67 (10.63)
	3man crew	19.47 (7.76)	17.63 (6.94)	14.69 (9.69)	14.47 (9.63)
PHRGM>70[1,2]	Parameter	Percent contribution			
	σ^2_C		91.2%	88.1%	88.2%
	σ^2_J			9.0%	8.3%
	σ^2_W				1.9%
	σ^2		8.8%	2.9%	1.7%
	Total		3186.18	3151.14	3130.11

		Mean (se)			
	1man crew	61.58 (2.65)	58.76 (11.54)	55.07 (17.14)	55.27 (16.81)
	2man crew	52.06 (6.31)	50.84 (8.25)	49.15 (12.46)	49.25 (12.21)
	3man crew	50.16 (8.20)	49.37 (6.76)	48.25 (10.27)	47.53 (10.34)

[1] Percent of observed work day

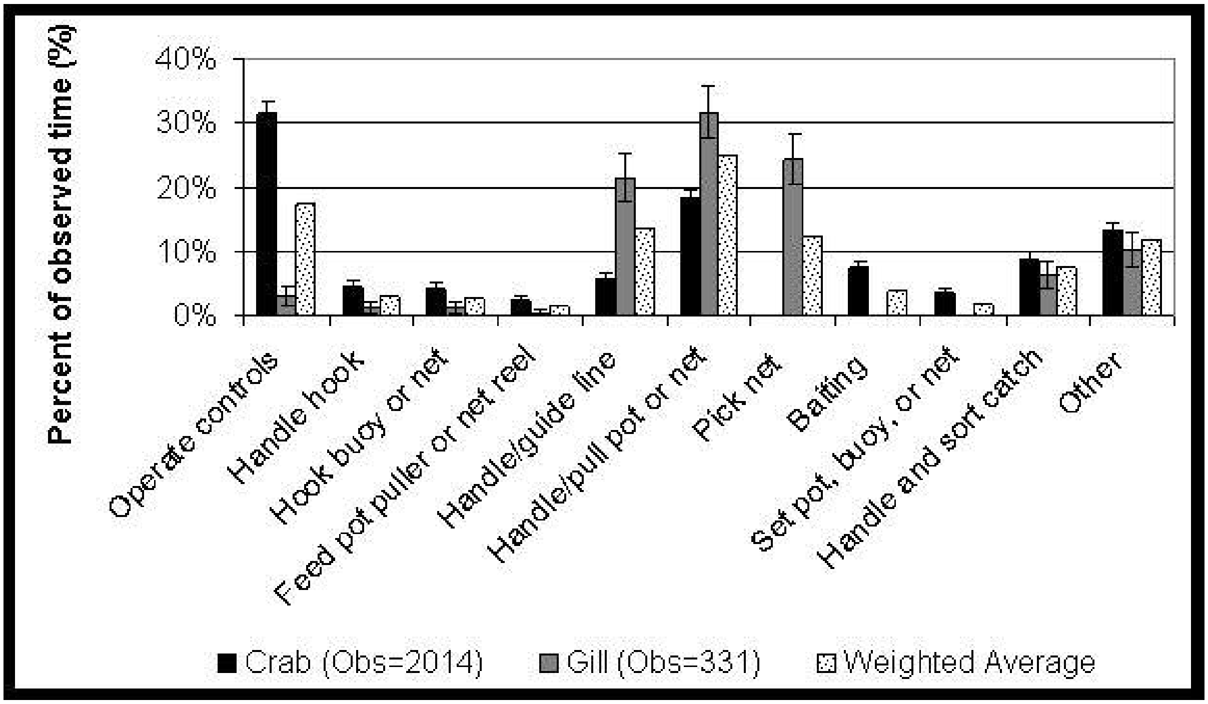
[2] PHRGM, probability of high risk group membership

Note: Proportion of total variance: between crew size (σ^2_C), between job type within crew size (σ^2_J), and between worker within job within crew size (σ^2_W), and residual (σ^2)

Photo 4.1. Commercial crab pot fisherman emptying crab pot, North Carolina (Photo by Josh Levinson, 2001).

Photo 4.2. Gillnet fishermen handling the net, North Carolina, (Photo by Josh Levinson, 2001).

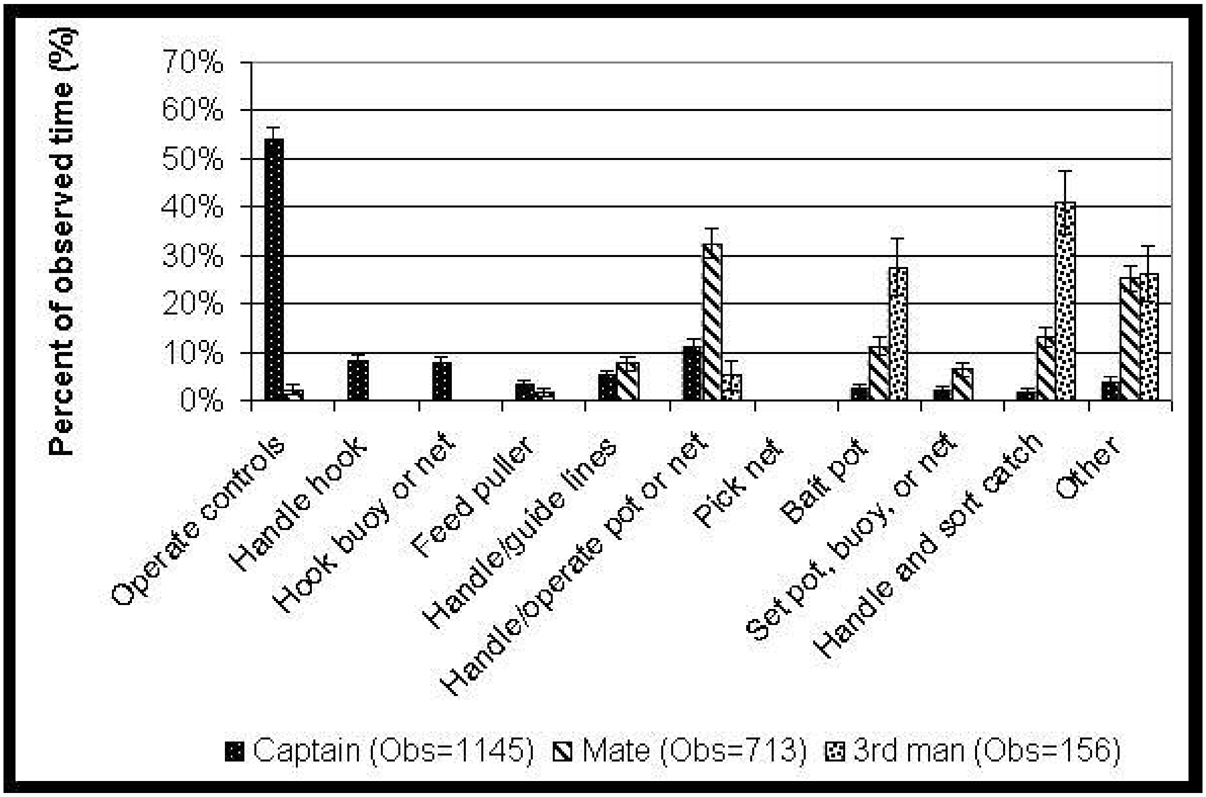
Figure 4.1. Percent of time observed in commercial fishing activities for “pulling in gear” task by crab pot (n=20) or gillnet (n=5) fishermen and weighted average for both using Posture, Activities, Tools, and Handling (PATH) method



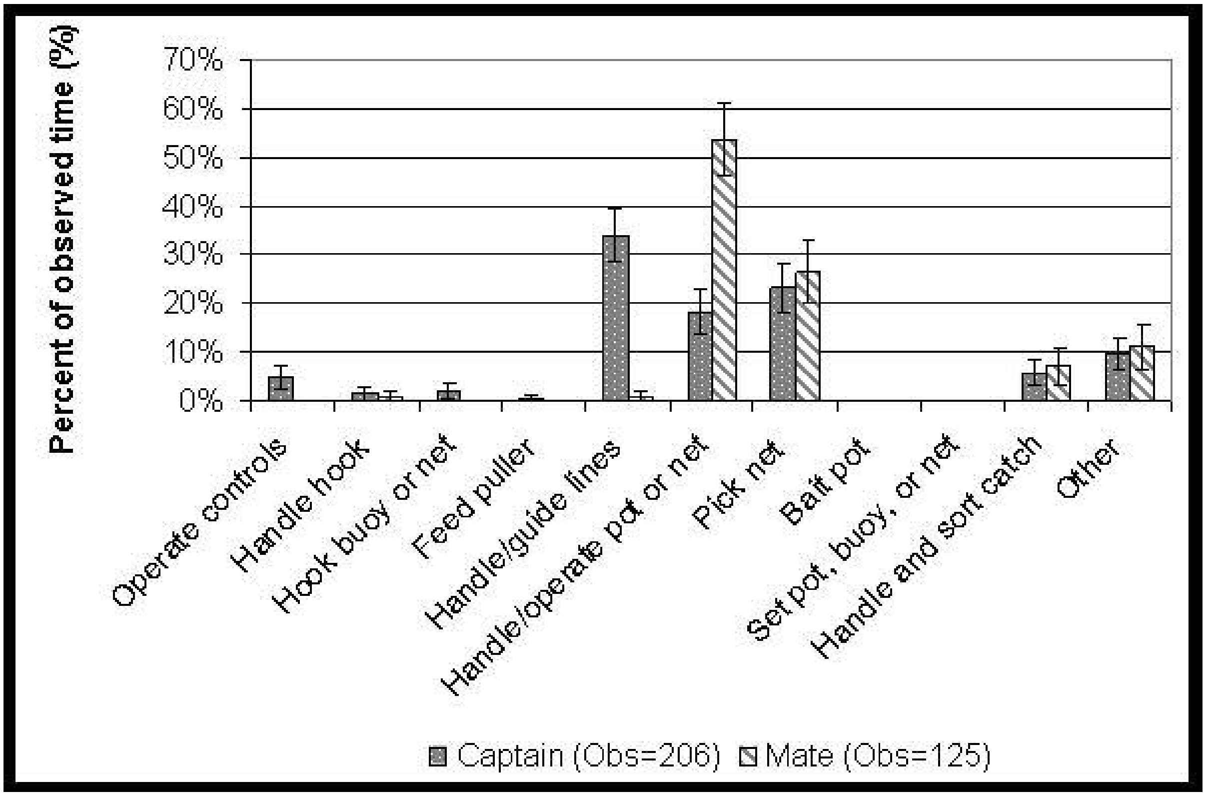
Note: Other tasks include clean boat, repair gear, prepare bait, and idle time

Figure 4.2. Percent of time observed in commercial fishing activities for task "pulling in gear" stratified by job title for Posture, Activity, Tools, and Handling method (PATH)

4.2.a. For crab pot (10 captains, 6 mates, and 2 third men) fishermen

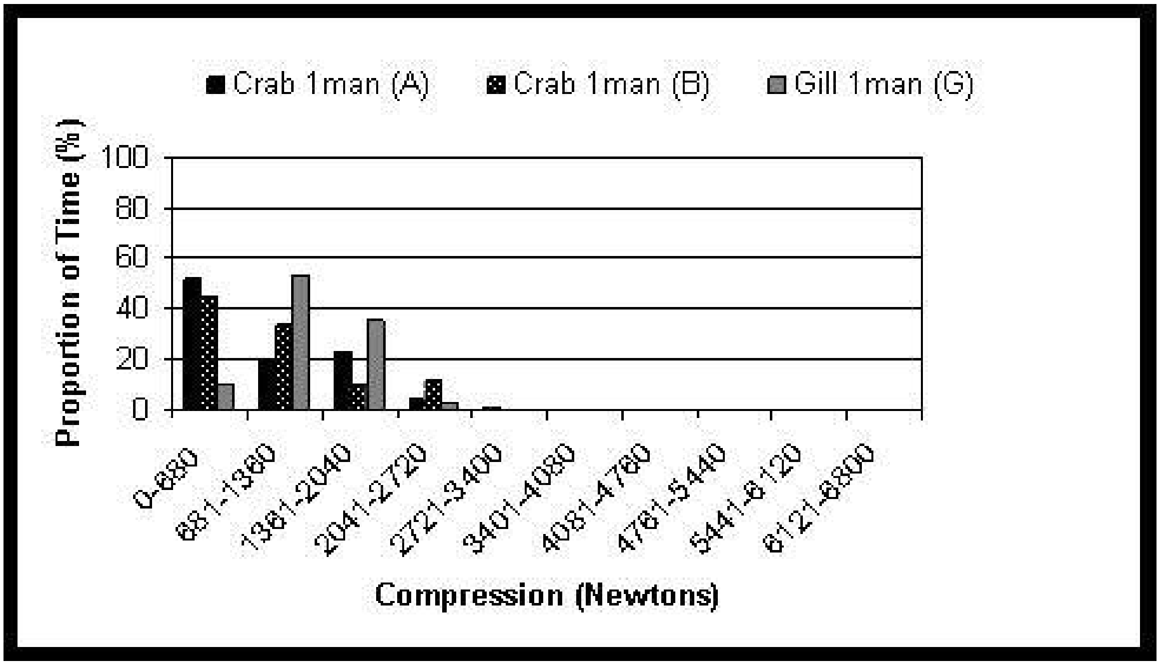


4.2.b. For gillnet (4 captains and 1 mate) fishermen



Note: Other tasks include clean boat, repair gear, prepare bait, and idle time

Figure 4.3. Histogram of lumbar spine compression (Newtons) comparing crab pot and gillnet commercial fishing crews, Continuous Assessment of Back Stress method (CABS)



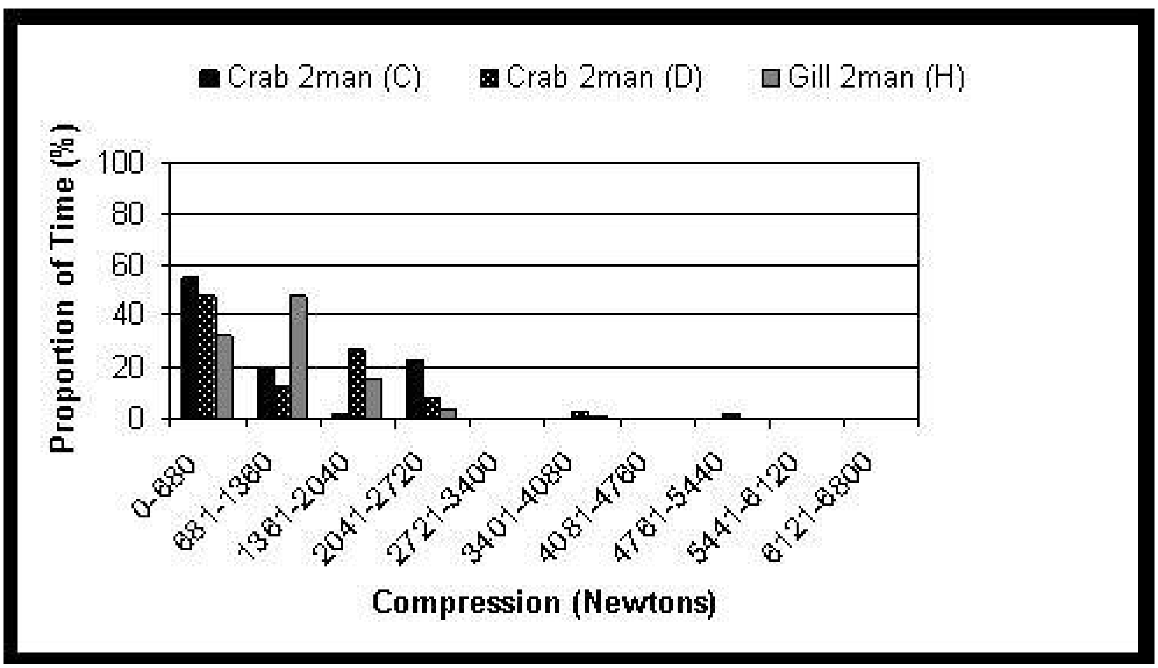
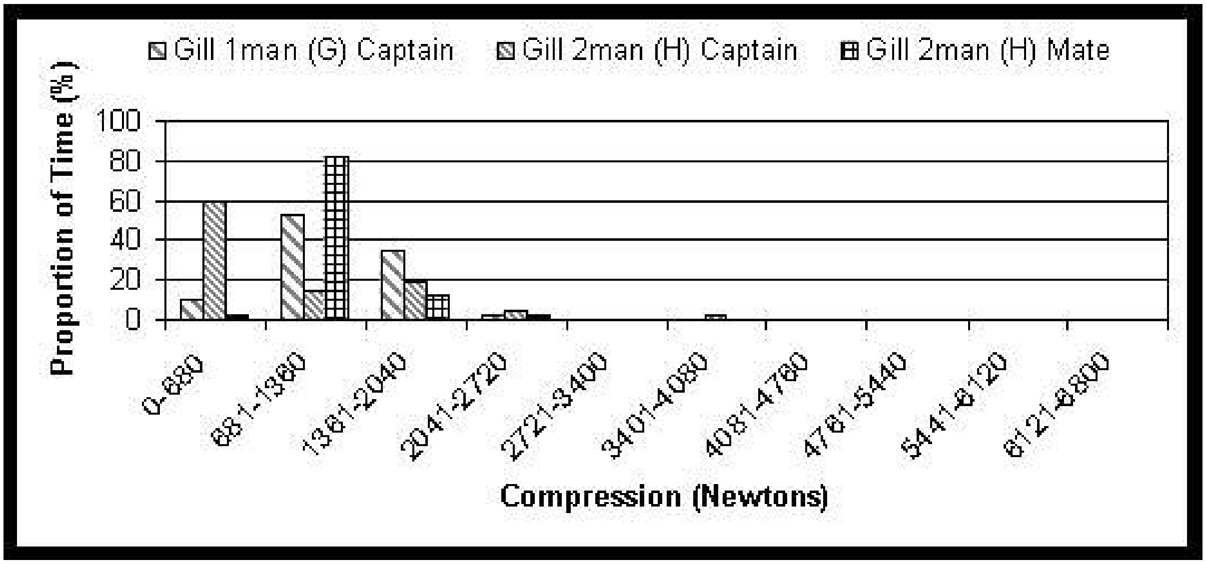
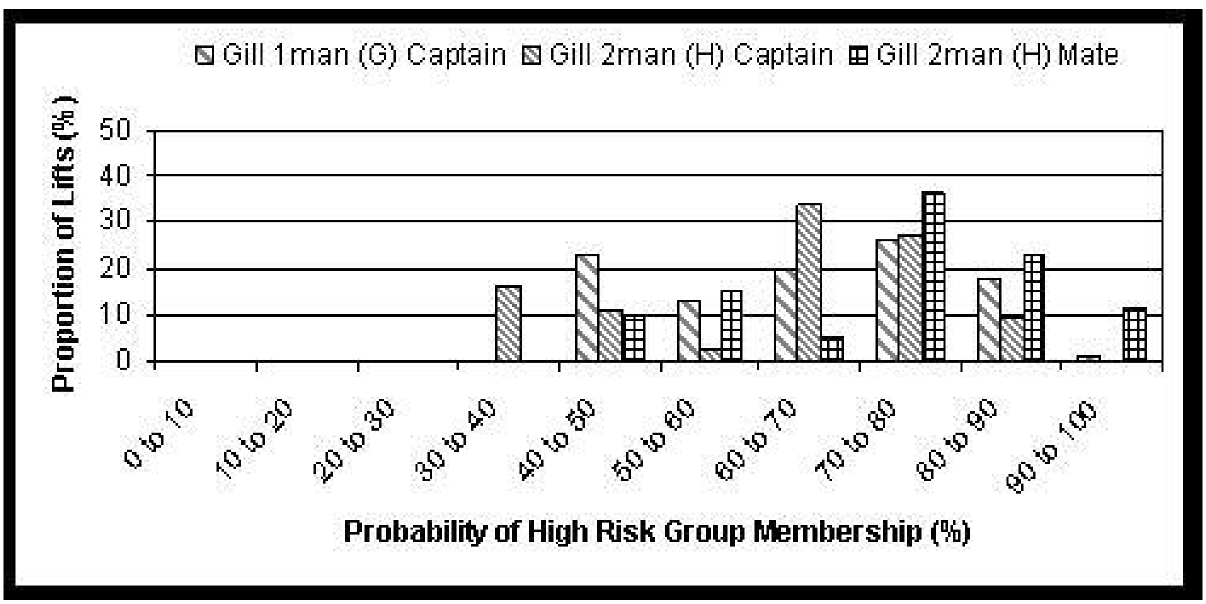
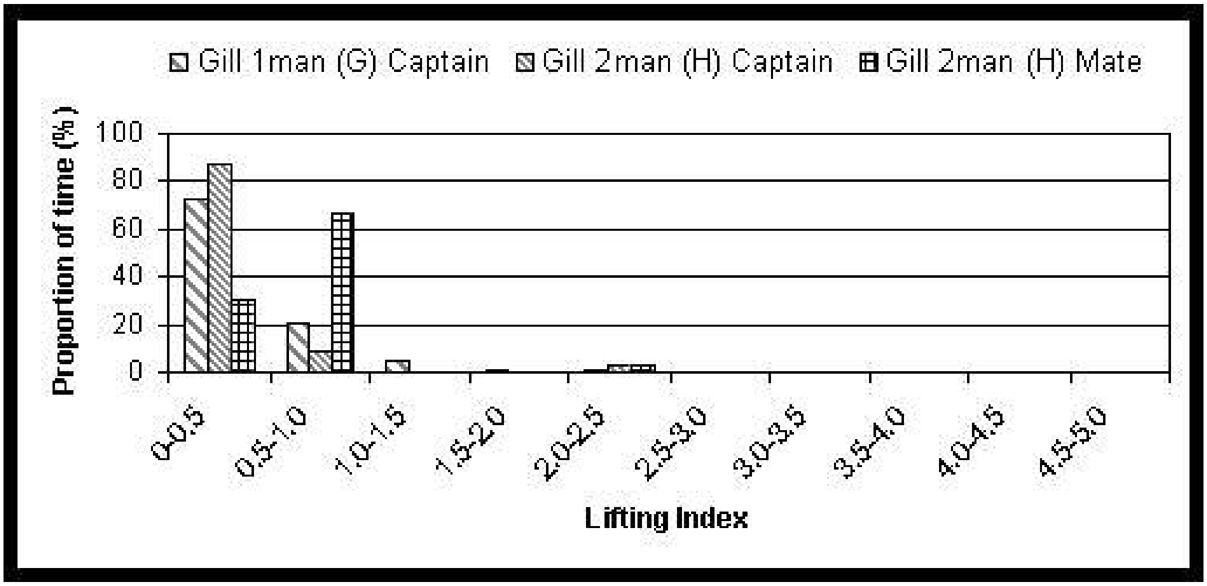


Figure 4.4. Histogram of lumbar spine compression (Newtons), Probability of High Risk Group Membership, and Lifting Index for gillnet fishing captains and mates across different crew sizes, Continuous Assessment of Back Stress method (CABS)






Gill 1man (G) Captain
Gill 2man (H) Captain
Gill 2man (H) Mate
Proportion of time (%)
100
80
60
40
20
0
0-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
4.5-5.0
Lifting Index

V. RESULTS PAPER 2

A. Biomechanical risk factors for low back pain in North Carolina crab pot and gillnet commercial fishermen

1. Abstract

Background: Low back pain (LBP) is common among commercial fishermen. The objective of this research was to determine the association between LBP that limited or interrupted fishing work and biomechanical stress measured by 1) self-reported task, and 2) two ergonomic measures of low back stress. Methods: Participants were a cohort of North Carolina commercial fishermen followed for LBP in regular clinic visits from 1999 to 2001 (n=204). Work history, including crab pot and gillnet fishing task frequency, was evaluated in a telephone questionnaire. Ergonomic exposures measured in previous study of 29 fishermen were applied to work histories of the fishermen to estimate exposure to low back stress. The occurrence rate of LBP that limited or interrupted fishing work since last visit was evaluated in a multivariate generalized Poisson regression model. Results: The rate of severe LBP for fishermen who responded to the telephone questionnaire (n=105) was 0.69 per 1000 person-days (95% CI: 0.47, 0.90). For crab pot and gillnet fishermen (n=89) use of dolly or lift to load or unload, running pullers or net reels, sorting catch, unloading catch, and maintenance work were associated with an increased rate of LBP while loading bait, working with fishing gear, and cleaning the boat were not associated with LBP. Percent of time in awkward postures, spine compression >3400 Newtons, and National Institute of Occupational Safety and Health lifting indices >3.0 were associated with LBP.

Conclusion: Tasks characterized by higher biomechanical low back stress in this study (unloading boat and sorting catch) were associated with the occurrence of severe LBP. Tasks characterized by lower back stress (running puller or net reel and use of a dolly or lift for unloading) were also associated with LBP in this population. Our results demonstrated that neither fishing task frequency nor ergonomic stress alone consistently predict LBP. History of LBP, addition of crew members, and self-selection out of tasks were likely important contributors to the patterns of low back stress and outcomes we observed.

2. Introduction

Back pain is a common occupational problem and commercial fishermen are no exception. In a cross-sectional study of Swedish deep-sea fishermen, half of fishermen experienced low back symptoms during the last 12 months (Torner, Blide et al. 1988). Low back symptoms were the most common cause of work impairment among a cohort of North Carolina commercial fishermen (Lipscomb, Loomis et al. 2004). Risk factors for prevalence of low back symptoms include age, length of time in the occupation, type of fishing and gear, job title, and fishing part-time or working more than one job (Torner, Blide et al. 1988; Lipscomb, Loomis et al. 2004). However, the importance of these personal factors is limited by the degree to which they are modifiable. Little is known regarding the relationship of LBP with specific fishing tasks, their frequency, or their duration. Fishermen have described performing strenuous tasks (Torner, Blide et al. 1988; Lipscomb, Loomis et al. 2004; McDonald, Loomis et al. 2004), and ergonomic studies have quantified biomechanical low back stress for fishing tasks (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005; Kucera, Mirka et al. To be submitted 2006). However, no study has evaluated specific tasks and biomechanical measures as risk factors for low back pain in a population of fishermen.

Previous studies have described characteristics of fishing work such as static, awkward working postures, shoveling and lifting tasks which produce strain to the low back area (Torner, Blide et al. 1988; Lipscomb, Loomis et al. 2004; McDonald, Loomis et al. 2004). Ergonomic analyses of commercial fishing crews revealed that work tasks were repetitive and cyclic with high intensity lifts during loading and unloading activities (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005; Kucera, Mirka et al. To be submitted 2006). More specifically, low back stress varied by the type of fishing performed, size of the crew, job, and task performed (Kucera, Mirka et al. To be submitted 2006). While certain job characteristics may produce low back stress, their association with low back pain in fishermen is undetermined.

The objective of this research was to determine the association between low back stress measured by 1) self-reported task, and 2) the percent time of exposed to low back stress (measured with two ergonomic assessment methods) and LBP that limited or interrupted fishing work. A secondary objective was to look at the influence of other covariates such as previous history of severe LBP, age, and years fishing experience. Our study population was a group of southeastern US commercial fishermen who fished with crab pots and gillnets in small-scale, independent operations on coastal or inland waters.

3. Methods

Study Population

Participants in this study were members of a cohort of commercial fishermen originally assembled during the period of April 1999 to May 2000 for the purpose of studying exposure to a toxic marine micro-organism and possible neurological symptoms (Moe, Turf et al. 2001). The population recruited for this parent study included 204 licensed commercial fishermen 18-65 years of age who fished on inland rivers and sounds or on the ocean for at least 20 hours per week for at least six months of the year. Individuals completed self-administered questionnaires at baseline and at six month intervals during medical clinic visits. Information was gathered on presence of musculoskeletal pain, traumatic injuries, and fishing activities and other exposures. In addition to regular visits, fishermen were encouraged to come in for "trigger" visits defined by conditions relating to exposure to toxic micro-organisms (e.g. skin lesions, memory loss, cognitive impairment) or if they were exposed to diseased fish (Moe, Turf et al. 2001). In addition to clinic visits, fishermen were interviewed every one to two weeks by phone from August 1999 to May 2002 about work-related injuries, fishing activities, and other exposures of interest. Details of clinic visits and follow-up of the cohort have previously been reported (Lipscomb, Loomis et al. 2004; Loomis, Marshall et al. 2004; Marshall, Kucera et al. 2004). A Supplemental Questionnaire was administered by telephone in April of 2004 to retrospectively assess more detail on history of fishing and non-fishing work exposures and whether they performed specific fishing tasks. The University of North Carolina at Chapel Hill School of Public Health Institutional Review Board approved all study procedures.

Low Back Pain

A revised version of the Nordic Musculoskeletal Questionnaire (Kuorinka, Jonsson et al. 1987) was administered in all clinic exams to determine the presence and severity of LBP at baseline and subsequent follow-up visits. Information collected included 12-month prevalence of low back pain at baseline and occurrence of LBP since last clinic visit. For both baseline and follow-up clinic visits, participants were asked if this low back pain limited (reduced work level or tasks) or interfered with (unable to work for a day or more) work and, if so, how long they were unable to work. For this study, severe LBP was defined as any reported LBP that limited or interfered with normal fishing work activity. We could not determine whether reports of LBP at follow up were new or recurrent, therefore we consider all occurrences of LBP in this study.

Exposure Assessment

During the follow-up clinic visits fishermen reported the fishing method (e.g. pots, gillnets, trawl, dredge) and type of catch (crab, finfish, shrimp, clam, oyster, other) since last visit. In weekly (March through November) and biweekly (December through February) telephone interviews, the fishermen reported the type of catch, number of days spent on and off the water, and estimated the number of hours they spent on the water for the most recent day fishing. Detailed exposure information was gathered in the supplemental questionnaire for crab pot and gillnet fishermen and included average number of days and hours on and off the water by fishing method and crew size, and the frequency respondents performed specific fishing tasks (e.g. driving the boat, pulling in gear, unloading boat). Fishermen were considered exposed to a particular self-reported task if they performed that task during the study period on average “more than half the time” or “always.”

Ergonomic Exposure Assessment

In a previous study, ergonomic exposure to low back stress was measured in 29 commercial crab pot and gillnet fishermen using two ergonomic assessment methods appropriate for non-routine work (Kucera, Mirka et al. To be submitted 2006). Researchers observed and video taped fishing work on and off the water for a full day. Video tapes were coded for each fisherman using two different methods.

The first method, a work sampling based method, Posture, Activity, Tools and Handling (PATH) (Buchholz, Paquet et al. 1996), linked work tasks and activities with posture codes to estimate the percent of time workers spent in various situations stressful to the low back. The percent of time fishermen were observed in low back stress for PATH measures was quantified as: percent of time in non-neutral trunk postures (>20 degrees flexion, bend or twist, and bend, twist or lateral flex), percent of time handling loads or exerting forces, percent of time handling materials (defined as lifting, lowering, carrying, holding, and pushing or pulling boxes, crates, baskets, etc.), percent of time in awkward postures (trunk flexion >45 degrees, trunk bend, twist, or lateral flex, one or both elbows above shoulder height, or legs bent >30 degrees, kneel squat or stand on one foot), and the combined effects of handling loads in non-neutral trunk postures.

The second method, Continuous Assessment of Back Stress methodology (CABS) (Mirka, Kelaher et al. 2000) utilized three well-established ergonomic assessment methods to evaluate biomechanical stress of occupational activities: the revised National Institute of

Occupational Safety and Health Lifting Equation (NIOSHLE), the Ohio State University Lumbar Motion Monitor™ (LMM), and the University of Michigan Three-Dimensional Static Strength Prediction Program™ (3DSSPP). Low back compression from 3DSSPP, lifting index from NIOSHLE, and probability of high risk group membership from LMM were measured for defined fishing subtasks (e.g. driving the boat, pulling in gear) and combined with the estimated time and frequency fishermen were exposed to these tasks. These values were summed for an overall estimate of time exposed to different levels of stress. The percent of time fishermen were exposed to low back stress for CABS measures was defined as the percent of time at > 3400 Newtons of spine compression, the percent of time with lifting index > 1.0 or > 3.0, and the percent of time with greater than 70% probability of high risk group membership.

Exposure assignment

For self-reported fishing task frequency and PATH and CABS measures, exposure was assigned to participants according to whether they fished with crab pots or gillnets during follow-up. If fishermen fished with both methods during the period they were assigned the fishing task and the higher ergonomic mean by type (crab pot or gillnet). If they performed neither crab pot or gillnet fishing they were assigned a zero. In order to examine potential ergonomic exposure misclassification by group assignment, we alternatively assigned ergonomic exposure by presence or absence of crew and by self-reported job title (captain, mate or co-captain).

Data Analysis

Descriptive statistics were calculated by baseline demographic and work history characteristics as well as by fishing types at follow-up and self-reported job tasks from the supplemental questionnaire.

The occurrence rate of severe LBP was modeled using generalized Poisson regression (Rothman and Greenland 1988) with log person-days at risk included as an offset term. Days at risk were calculated from days between clinic visits. Generalized Estimating Equations (GEE) (Liang and Zeger 1986; Zeger and Liang 1986) were used to account for the statistical dependence between multiple clinic visits and multiple severe LBP occurrences per fisherman. Outcome-covariate rate ratios (RR) and 95% confidence intervals (95% CI) were computed from the model and stratified by previous history of severe LBP. Non-overlap of stratum-specific confidence intervals indicated heterogeneity by previous severe LBP. Covariates of interest at baseline were: gender, age, smoking history, BMI, type of visit, fishing full time (at least 32 hours/week) or year round (at least 9 months of the year), fishing on someone else's boat, and working a second job. Follow-up covariates included more than one type of fishing during the follow-up interval, fishing type and gear, and average hours per day on the water. Variables of interest from the supplemental questionnaire included years of fishing experience, initiating fishing career with crew versus alone, and work exposures during the study, such as fishing with crew versus alone, working a non-fishing job during follow-up that required frequent bending or twisting at the waist; work in awkward postures; frequent lifting (>3 lifts per minute); and lifting > 50 or > 25 pounds.

For multivariate analyses covariates were included in the initial model if associated with LBP in previous studies or if the bivariate outcome-covariate RR in our analysis was 1.25 or greater. We employed a step-wise backwards elimination strategy and kept covariates that were associated with the outcome in the model.

For crab pot and gillnet fishermen who answered the supplemental questionnaire, we modeled the rate of severe LBP by low back stress exposure measured with self-reported fishing task and PATH and CABS methods adjusting for age and other covariates. Mean percent time exposed to low back stress was estimated for the 29 crab pot and gillnet fishermen in two different ways: 1) crude mean by fishing type and 2) a multi-level mixed linear model that accounted for variability between and within fishing type, crew size within fishing type, and job type within crew size within fishing type (Kucera, Mirka et al. To be submitted 2006). PATH and CABS means were included in Poisson regression models as continuous variables. The unadjusted and adjusted exponentiated parameters represent the change in the rate of severe LBP per 1 unit change in mean percent time exposed to low back stress measures.

4. Results

Descriptive statistics

The majority of fishermen who answered the supplemental telephone questionnaire (105/204) were male, between the ages of 30 and 59, and all except one were white, non-Hispanic (Table 5.1). Most fished at least 32 hours per week for at least 9 months of the year. At baseline, 61% reported experiencing any LBP in the last 12 months and 24% experienced LBP that limited or interrupted their work in the past 12 months.

The 105 fishermen accumulated 58,143 person-days of follow-up during the study. Crab pot and gillnet were the most common type of catch and fishing method reported. Over 40% reported spending on average 4 to 6 hours on the water their most recent day of fishing. Over follow-up, 61% (64/105) of fishermen reported 132 occurrences of any LBP since the last visit and 26% (27/105) of fishermen reported 40 occurrences of severe LBP. Sixty-eight percent of severe LBP occurrences (27/40) prevented working activity for at least a day: 52% (14/27) interrupted work 1 to 7 days, 33% (9/27) 8 to 30 days, and 15% (4/27) over 30 days. When asked if LBP had ever caused them to change the way they fish, 37% said it had.

Participants began fishing at a young age. Over half had 20 or more years of experience as a commercial fisherman and most identified with being a captain for most of their career (Table 5.2). During the study period, 68% of fishermen worked with crewmembers and most fished with others on a boat they owned (61%). Participants who worked a second non-fishing related job during the study reported some form of low back stress in that job. Most were required to twist or bend frequently at the waist or lift >25 pounds; fewer worked in awkward postures, lifted frequently, or lifted >50 pounds.

General risk factors for the occurrence of severe LBP

The overall crude rate of severe LBP was 0.69 per 1000 person-days (95% CI: 0.47, 0.90) or 0.25 per person-year. The final multivariate model contained age, current smoking, fishing on someone else's boat, fishing types other than crab or finfish, fishing full-time and average hours on the water (Table 5.3). Fishing on someone else's boat became protective when adjusted for all other covariates. In general, fishermen who averaged the fewest and the most hours on the water had higher occurrence of severe LBP compared to fishermen averaging 6 to 10 hours on the water. Fishing year round, working a second job, BMI above 25 kg/m^2, and fishing types other than crab or finfish at follow-up were associated with severe LBP but their RR's were attenuated with adjustment for other covariates.

In general, the occurrence of severe LBP decreased as years of fishing experience increased (Table 5.3). Participants who started fishing with others, or fished during the study with others, experienced an increased occurrence of severe LBP compared to those who fished alone. Workers with non-fishing related jobs during the study that required twisting or bending frequently, or lifting >25 pounds, had decreased occurrences. Frequent lifting was associated with increased occurrence of LBP while awkward postures and lifting > 50 pounds were not. The final work history model included age, years fishing experience, fishing with crew during the study versus working alone, and working a non-fishing related job that required them to bend or twist frequently, work in awkward postures, lift frequently, or lift >50 pounds or between 25 and 50 pounds (Table 5.3). Age remained a strong predictor after adjustment for covariates as did years of fishing experience and fishing with crew during follow-up. Poor precision of the non-fishing related job stress covariates limited our ability to interpret the adjusted results for these variables.

Having a history of severe LBP was strongly associated with subsequent occurrence at follow-up (6.09 95% CI: 3.06, 12.11). However, we did not adjust for this variable because of its hypothesized role as an intermediate. Among fishermen with a previous history of severe LBP, smoking, working a non-commercial fishing related job, and fishing full-time were associated with an increased occurrence rate. Among fishermen without a previous history of LBP, increased occurrence rates were observed for finfishing (specifically gillnets) and performing more than one type fishing. Lifting over 25 or over 50 pounds at a non-commercial fishing related job showed heterogeneity by severe LBP history status, but imprecise 95% CIs hamper our interpretation of these RRs.

Low back stress measures as risk factors

For those who fished with crab pots and gillnets (n=89), the majority fished alone (crab pots 70% and gillnets 64%). Fishermen reported performing an average of 8.7 (SE 3.7) fishing tasks over half the time (range 1 to 14). Over 90% of fishermen reported loading bait and supplies, pulling in, emptying, and setting gear, and cleaning the boat more than half the time (Table 5.4). Few regularly used a dolly or lift to load and unload their boats. A third operated pullers and net reels and helped sort catch at the fish house. The majority of crab pot fishermen reported baiting pots (83%) and the majority of gillnet fishermen iced down catch (84%). Frequency of tasks varied by the fishing method and crew size.

A multivariate analysis of self-reported tasks with these 89 crab pot and gillnet fishermen (313 visits) indicated that use of a dolly or lift to load or unload, running the puller or net reel, sorting catch (on boat or at fish house), unloading catch or supplies, and performing maintenance work more than half the time were each independently associated with an increased occurrence rate of severe LBP compared to those who performed those tasks half the time or less (Table 5.4). Loading bait and supplies, pulling in gear, setting gear, and cleaning the boat more than half the time were associated with a decreased occurrence rate of severe LBP while driving the boat and emptying gear were not associated. When adjusted for age, presence of crew and other fishing types, using a dolly or lift for loading bait and supplies was associated with decreased occurrence of severe LBP, though the confidence interval width indicates these results should be interpreted with caution.

Little evidence for dose response was observed for the combined number of tasks performed (RR=1.05 95% CI: 0.92, 1.20). Stratifying tasks by potential exposure to low back stress revealed no difference between static tasks including driving the boat, running the puller or net reel, setting gear, sorting catch on the boat or at the fish house, cleaning or maintenance of boat and gear (RR=1.16 95% CI: 0.87, 1.54) versus dynamic tasks including loading or unloading the boat, using a dolly or lift for loading/unloading, and pulling in or emptying gear (RR=0.92 95% CI: 0.64, 1.32).

When examining the ergonomic characteristics of the 89 crab pot and gillnet fishermen, severe LBP increased with unadjusted mean percent time exposed to awkward postures, > 3400 Newtons of spine compression, and lifting index > 3.0. The rate of severe LBP was unassociated with non-neutral trunk postures, force, lifting index >1.0, and PHRGM >70%. When means adjusted for the variation between crew sizes and between job within crew size and fishing type were included in the model, we observed a similar pattern of association for all variables (Table 5.5). Adjusting for age and fishing types other than crab or finfish attenuated some estimates and decreased precision (Table 5.5). Exposure assignment by group influenced the rate of severe LBP by low back stress. We observed inconsistent results when we assigned exposure by presence of crewmembers or by self-reported job title, indicating that fishing type, crew size, and job should be accounted for in the exposure measure. Collectively, it appears for this subset of fishermen that percent of time in awkward postures, high compression values, and lifting indices were associated with increased occurrence of severe LBP.

5. Discussion

In this cohort of North Carolina commercial crab pot and gillnet fishermen differences were observed in the occurrence of severe LBP by self-reported fishing task and by biomechanical low back stress. Operating pullers and net reels, using a dolly or lift to unload catch and supplies, and sorting catch on the boat were strongly associated with severe LBP, even when adjusting for age, presence of crew, and other fishing types. However, we observed a decreased risk for use of a dolly or lift to load bait and supplies after adjustment for covariates. Similarly, tasks that increased in strength of association with adjustment included driving the boat, pulling in or emptying gear, and maintenance work. These results, though imprecise, indicated that age and addition of a crew member possibly mediated the intensity and frequency of these single task exposures. Dose response for task frequency was not observed in this group nor was there a difference observed between static or dynamic tasks.

PATH and CABS averaged low back stress across all fishing tasks for a sample of fishermen (Kucera, Mirka et al. To be submitted 2006). Mean percent time exposed to awkward postures and high compression and lifting index values were associated with the occurrence of severe LBP with and without adjusting for age and other fishing types. In order to account for the variability in mean percent time in low back stress by crew size and job within fishing type, we modeled adjusted means and saw similar results across measures. We presented the adjusted results because of the importance of crew size and job for exposure to low back stress found in other studies (Torner, Blide et al. 1988; Fulmer and Buchholz 2002; Mirka, Shin et al. 2005).

Results for PATH and CABS measures supported the independent self-reported task findings. Sorting catch on the boat, a task characterized by static, awkward postures and repetitive motions performed extensively by a mate or third man (Mirka, Shin et al. 2005; Kucera, Mirka et al. To be submitted 2006), occurred more frequently in larger crew sizes and was associated with severe LBP. Unloading catch or supplies, with or without a dolly, was a task characterized by high compression and lifting index values (Kucera, Mirka et al. To be submitted 2006). We observed an association with severe LBP for this task and to high compression and lifting index measures. Previous studies of manual lifting occupations have reported associations with any LBP and lifting indices from 1 to 2, 2 to 3, and >3 (Waters, Baron et al. 1999).

When we adjusted for age, presence of crew, and other fishing types, use of lifting aids for unloading catch was strongly associated with severe LBP, yet use of lifting aids for loading appeared protective. These results likely reflect differences in task performance by fishing type (e.g. gillnet fishermen do not use bait; therefore have less to load) and suggest that task frequency data without biomechanical information, is limited in predicting severe LBP. Differences could also be attributed to age and the addition of crew members which could reflect distribution of tasks between captains and mates as well as self-selection into tasks by age or job. Without specific information regarding task-selection and temporality, we were limited in our ability to quantify these potential risks.

We observed age and years of experience were associated with the occurrence of severe LBP. Torner, et al. found higher prevalence of LBP for Swedish fishermen age 41 to 50 but prevalence decreased thereafter (Torner, Blide et al. 1988). In addition, fishermen with fewer years experience (20 to 29 years) had more LBP when compared to those who fished over 40 years (Torner, Blide et al. 1988). We observed similar results for years experience in our subset population. Like the ocean-going Swedish fishermen, many started fishing at young ages. However, the age participants began fishing ranged from 5 to 54 years. Those who started their career later, had fewer years experience, and this could explain why we did not see decreasing occurrence rates with increasing age.

Compared to other fishing populations, this group of small-scale independent fishermen worked mainly in protected sounds and rivers. We included both fishing full time and average hours on the water in the full model since some fishermen could work long hours on the water per day yet still consider themselves part-time workers and vice versa. The occurrence of severe LBP was elevated for full time fishing as well as fishing on average less than 6 and more than 10 hours on the water.

Subjective self-reported work-related causes of low back stress were reported differently by job. Captains have been reported to attribute low back stress to static work postures (driving and running puller) while mates identified dynamic tasks and postures (shoveling and lifting) (Torner, Blide et al. 1988). Interviews with North Carolina commercial fishermen indicated that loading and unloading bait and boxes of catch were stressful for the low back (Lipscomb, Loomis et al. 2004; McDonald, Loomis et al. 2004), and we hypothesized that tasks with higher low back stress measured with PATH and CABS (e.g. loading, unloading, pulling or emptying gear, and sorting on the boat) would be associated with severe LBP. However, we found varying results that depended on age, whether crew members were present, or whether other fishing types were performed. These fishermen were largely an independent group of workers and often mediate their exposures in many ways including choice of fishing type, addition of crew, decreasing hours on the water or volume of catch set, or task selection (Lipscomb, Loomis et al. 2004; McDonald, Loomis et al. 2004).

These findings likely reflect a survivor or healthy worker effect (HWE) with those who fished longest having the lowest occurrence of severe LBP. They continue to fish because they can, are healthy enough, or because they may hire others to perform the harder tasks. The fishing task results in our study provide some evidence of this self-selection of tasks or addition of crew, because some tasks with higher biomechanical stress values appeared to be protective for occurrence of severe LBP. The results obtained when stratifying by history of severe LBP supports the hire of crewmembers to perform the tougher tasks. However, we could not determine in our data whether fishermen hired crew or selected out of tasks because of previous LBP or if these practices lead to LBP. Our findings for years experience are consistent with HWE reported in other studies of commercial fishermen (Torner, Blide et al. 1988; Lipscomb, Loomis et al. 2004).

History of LBP is a strong risk factor for subsequent LBP (Punnett and Wegman 2004), and we included fishermen with a previous history of severe LBP in our analyses. It was not possible to enroll subjects upon entry into the fishing occupation since most fishermen begin their careers young and long before they are licensed or even consider themselves as professional commercial fishermen. Considering the individual variation among commercial fishing workers, including those with a history of severe LBP more accurately represents the target population of workers that we wanted to make inferences about. Because of the role of previous severe LBP as an intermediate and independent risk factor for both exposure to ergonomic stress and subsequent severe LBP, we stratified the covariates by history of LBP. Frequent bending or twisting and lifting greater than 25 or 50 pounds demonstrated heterogeneity but small sample size prevented us from examining its effect in the full model. Since this variable was quantified in a questionnaire after follow-up in the study, we were unable to establish whether these exposures mediated or precipitated occurrences of LBP.

The population recruited for the cohort study included licensed commercial fishermen. However, not all fishermen need a license and most mates are not licensed. Therefore a self-defined “mate” in the cohort may not be the same as the “mates” for whom we measured biomechanical stress with PATH and CABS (Kucera, Mirka et al. To be submitted 2006). They were largely unlicensed, young workers employed to help the captains. This should be kept in mind when trying to generalize results. We obtained detailed work history information retrospectively on a subset (47%) of the cohort of fishermen. Supplemental questionnaire participants reported a higher occurrence of severe LBP compared to the whole cohort which provides some evidence for possible selection bias.

We did not have complete information on everyone in the cohort, therefore our analysis was limited to the 105 who answered the supplemental questionnaire and supplied information on fishing work history. Our sample size limited our ability to look at the combined effects in our analyses, illustrated by the wide confidence intervals. Our task and ergonomic analyses were restricted to the 89 crab pot and gillnet fishermen reducing precision further.

We used previous PATH and CABS exposure measures from a group of fishermen (n=29) (Kucera, Mirka et al. To be submitted 2006) to estimate individual ergonomic stress in crab pot and gillnet fishermen who answered the supplemental questionnaire. Group assignment of exposure can lead to misclassification of exposure and potential bias in our estimates. However, in the case of high within or intra-person variation compared to between person variation (e.g. percent of time in awkward posture), group assignment of exposure could be less biased than individual assignment (Loomis and Kromhout 2004). Results for exposure assigned by fishing with others and job indicate that this is possible for some ergonomic measures but the magnitude and direction of bias was unknown due to lack of precision in our estimates.

Presence of LBP was self-reported. Reliability for the Nordic Questionnaire from test-retest methods ranged from 77 to 100% and validity of the instrument compared to clinical history ranged from 80 to 100%. Results from low back questions were reported to be the best (Kuorinka, Jonsson et al. 1987). Exposures were also self-reported and could bias estimates away from the null if they were reported differentially by LBP status.

Age was an important risk factor for LBP and a determinant of exposure to low back stress in this study and we adjusted for age in all multivariate models. We did not measure biomechanical stress of other fishing types or non-fishing related work but included variables to account for these effects. Finally, previous studies have reported boat motion increase musculoskeletal strain for fishermen. We observed this qualitatively (Kucera, Mirka et al. To be submitted 2006); however, magnitude of motion is affected by weather and self-correction, and we were unable to account for this variable in our analyses.

Despite some limitations, we were able to quantify in a unique population of small-scale, independent commercial fishermen the association between the occurrence of severe LBP and crab pot and gillnet fishing tasks and biomechanical low back stress adjusting for other established risk factors. This is the first study to use ergonomic fishing work exposure measures accounting for variation between crew sizes and job types. Sorting catch and unloading the boat, tasks characterized by higher biomechanical low back stress, increased the occurrence of severe LBP. Results for ergonomic measures supported these two task findings. However, lower exposure tasks such as running puller or net reel and use of a dolly or lift for unloading were also associated with LBP in this population. This could be attributed to task selection differences between those with and without a history of LBP.

Conclusion

Our results demonstrate that neither fishing task frequency nor ergonomic measure alone consistently predict LBP. History of LBP, addition of crew members, and likely self-selection out of tasks were important contributors to low back stress and outcomes. We observed variability in the way fishing work was conducted but were limited in our ability to account for reported differences in our analysis. Possible explanations for this discrepancy are revealed by the fishermen themselves. Fishermen who said they changed the way they fished due to LBP did so by doing less (lift less or work slower), being more careful, using or bending legs when lifting, and lifting with help. Several reported using a puller or net reel, a back brace, anti-fatigue mat, or a longer pole while some adjusted the sorting table height or changed the way they shook the crab pot. One fisherman reported re-outfitting the boat to fish off the left side. We can only speculate as to how these modifications might mediate or prevent severe LBP. Future research should focus on both, stressful tasks identified with ergonomic assessments and tasks associated with LBP (e.g. sorting catch, loading and unloading, maintenance work). It is important to know how fishermen might adjust their exposures but equally important is why.

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Table 5.1. Baseline demographic and follow up information for North Carolina commercial fishermen who participated in a supplementary questionnaire (n=105), 1999-2001

	n	%
Age		
18 to 21	3	2.9%
22 to 29	8	7.6%
30 to 39	19	18.1%
40 to 49	36	34.3%
50 to 59	28	26.7%
60 to 69	11	10.5%
Mean (SE) Range	46.2 (11.1)	19 to 65
Gender		
Male	87	82.9%
Female	18	17.1%
Smoking History		
Current	39	57.4%
Past	30	44.1%
Never	37	35.2%
Baseline work exposures		
Own a boat	102	97.1%
Work regularly on someone else's boat	20	19.0%
Fish full time (32 or more hours per week)	84	80.0%
Fish year round (9 or more months of the year)	62	59.0%
Work any non-fishing related job	49	46.2%
Since last visit did you fish for…		
Crab	82	78.1%
with crab pot gear	74	70.5%
Finfish	78	74.3%
with gillnet gear	69	65.7%
Shrimp	43	41.0%
Oyster	19	18.1%
Clam	23	21.9%
Other type	26	24.8%
Average hours on the water per day during interview period		
up to 4 hours	35	34.0%
over 4 to 6 hours	42	40.8%
over 6 to 8 hours	17	16.5%
over 8 to 10 hours	4	3.9%
over 10 to 12 hours	5	4.9%
over 12 hours	0	0.0%
missing	2	-
Mean (SE) Range	4.9 (2.2)	1.3 to 11.6
Number of clinic visits per person		
1	105	100%
2	103	98.1%
3	86	81.9%
4 to 6	43	41.0%
Mean (SE) days between follow up visit Range	162 (72)	38 to 736

Table 5.2. Current and historical fishing and other work exposure information North Carolina commercial fishermen (n=105), 1999-2001

	n	%
Years as commercial fisherman		
0 to 9 years	6	5.7%
10 to 19 years	21	20.0%
20 to 29 years	32	30.5%
30 to 39 years	30	28.6%
40+ years	16	15.2%
Mean (SE) Range	26.6 (11.5)	3 to 54
Age began fishing		
Mean (SE) Range	19 (12.1)	5 to 54
Self identified job title most often held…		
Captain	80	76.2%
Mate	18	17.1%
Co-captain	7	6.7%
When first starting to fish, did you fish…		
…alone	55	52.4%
…with crew	82	78.1%
...alone only	23	21.9%
...with crew only	50	47.6%
...alone and with crew	32	30.5%
<u>During 1999 to 2001 did you fish…</u>		
…alone	34	32.4%
…with crew	71	67.6%
Fish with crab pots	71	67.6%
Alone only	28	39.4%
With others only	21	29.6%
Alone and with others	22	31.0%
Fish with gillnets	55	52.4%
Alone only	26	47.3%
With others only	20	36.4%
Alone and with others	9	16.4%
Work a non-fishing job during the study?		
Yes	47	44.8%
Did that job require you to…		
…twist or bend frequently?	28	59.6%
…work in awkward postures?	16	34.0%
…lift repetitively (>3 lifts/min)?	10	9.5%
…lift >25 pounds?	28	59.6%
…lift >50 pounds?	16	34.0%
Total	105	100%

Table 5.3. Multivariate modeling of rate ratios and 95% confidence intervals† of low back pain occurrences that interrupted or limited work for North Carolina commercial fishermen (n=105, visits=358), 1999 to 2001

	Severe LBP occurrences	Days at risk	Unadjusted RR†	95% CI	Demographic model†‡*	95% CI	Work history model†‡	95% CI
Age								
18 to 21	4	1680	9.90	2.40, 40.88	8.74	1.36, 56.29	13.51	2.41, 75.78
22 to 29	6	4401	5.26	1.31, 21.10	4.76	1.23, 18.38	4.94	1.16, 20.99
30 to 39	4	10,073	referent		referent		referent	
40 to 49	12	20,027	2.68	0.81, 8.84	2.53	0.83, 7.72	2.34	0.65, 8.40
50 to 69	14	21,962	3.81	1.31, 11.10	3.26	1.11, 9.56	4.57	1.32, 15.89
Current smoking	20	21,346	1.75	0.83, 3.67	1.66	0.80, 3.45		
No	20	36,797	referent		referent			
Work on someone else's boat	9	10,162	1.47	0.61, 3.53	0.82	0.28, 2.43		
No	31	47,981	referent		referent			
Other fishing types	12	25,690	0.55	0.27, 1.10	0.49	0.25, 0.94		
Crab or finfish	28	32,453	referent		referent			
Fishing full-time (>=32 hrs/wk)	34	45,995	1.54	0.59, 4.03	1.84	0.75, 4.51		
Fishing less than full-time	6	12,148	referent		referent			
Average hours on the water/day*								
0 to 4	12	18,892	2.02	0.53, 7.72	1.24	0.34, 4.44		
>4 to 6	20	24,029	2.70	0.73, 10.03	1.33	0.37, 4.84		
>6 to 10	4	9584	referent		referent			
>10	4	4479	5.01	1.25, 20.08	5.52	1.05, 28.97		

† Poisson regression estimates are adjusted for multiple visits per subject with GEE
‡ Final model adjusted for all other covariates in the column
Unadjusted average hours on the water and all fully adjusted model estimates n=103, visits=352

Table 5.3 (continued). Multivariate modeling of rate ratios and 95% confidence intervals† of low back pain occurrences that interrupted or limited work for North Carolina commercial fishermen (n=105, visits=358), 1999 to 2001

	Severe LBP occurrences	Days at risk	Unadjusted RR†	95% CI	Demographic model†‡*	95% CI	Work history model†‡	95% CI
Years fishing experience								
0 to 9	5	3157	2.69	0.93, 7.75			2.38	0.83, 6.80
10 to 19	9	11,916	1.29	0.51, 3.26			0.72	0.27, 1.89
20 to 29	12	17,678	1.14	0.42, 3.08			1.46	0.56, 3.78
Over 30	14	25,392	referent				referent	
Fished with crew 1999 to 2001	32	38,722	2.41	0.94, 6.17			2.37	1.08, 15.19
Fished alone 1999 to 2001	8	19,421	referent				referent	
<u>Other job required you to:</u>								
Twist or bend frequently	8	15,295	0.68	0.24, 1.92			0.14	0.01, 2.39
No	32	42,848	referent				referent	
Work in awkward postures	7	8980	1.16	0.38, 3.55			0.91	0.24, 3.37
No	33	49,163	referent				referent	
Lift frequently (>3 lifts/min)	7	5621	1.89	0.65, 5.55			13.69	1.34, 139.7
No	33	52,522	referent				referent	
Lift <=25 pounds	24	33,723	referent				referent	
Lift >25 pounds	9	15,413	0.35	0.09, 1.41			0.70	0.06, 7.81
Lift >50 pounds	7	9007	1.02	0.36, 2.92			2.10	0.45, 9.76

† Poisson regression estimates are adjusted for multiple visits per subject with GEE
‡ Final model adjusted for all other covariates
* Unadjusted average hours on the water and all fully adjusted model estimates n=103, visits=352

Table 5.4. Crab pot and gillnet fishermen: rate ratios and 95% confidence intervals for self-reported fishing task frequency and low back pain occurrences that interrupted or limited work (n=89, 313 visits)

	Fishermen perform task over half the time n (%)	Unadjusted RR†	95% CI	Adjusted RR†‡	95% CI
Fishing tasks*					
Drive boat	79 (89%)	1.22	0.44, 3.42	1.73	0.66, 4.53
Load bait and/or supplies	85 (96%)	0.92	0.30, 2.86	1.13	0.42, 3.02
Use dolly or lift to load bait and/or supplies	14 (16%)	1.29	0.42, 3.97	0.89	0.35, 2.27
Pull in gear (hook/pull in pot or pull in net)	84 (94%)	0.89	0.34, 2.32	1.08	0.48, 2.41
Run puller or net reel	29 (33%)	2.52	1.16, 5.48	2.14	0.81, 5.70
Empty gear (shake crab pot or pick fish from net)	83 (93%)	0.82	0.30, 2.28	0.91	0.35, 2.38
Set gear (toss/push pot or run out net or toss net overboard)	80 (90%)	1.05	0.39, 2.84	0.99	0.41, 2.40
Sort catch on the boat	53 (63%)	1.86	0.80, 4.32	1.80	0.78, 4.13
Unload catch and/or supplies	79 (89%)	1.46	0.46, 4.64	1.23	0.37, 4.12
Use dolly or lift to unload catch and/or supplies	13 (15%)	2.48	1.10, 5.62	1.76	0.69, 4.48
Clean boat	82 (92%)	1.00	0.36, 2.82	1.05	0.44, 2.52
Perform routine maintenance on boat or gear	72 (81%)	1.29	0.50, 3.30	1.49	0.61, 3.60

† Poisson regression estimates are adjusted for multiple visits per subject with GEE
‡ Each task adjusted for age, fished with crew, and other fishing types (shrimp, clam, oyster, eel, etc)
*Referent: performing that task half the time or less

Table 5.5. Crab pot and gillnet fishermen: rate ratios and 95% confidence intervals for mean percent time exposed to low back stress adjusted with multi-level mixed linear model with three nesting variables (fish type, crew size within fish type, and job within crew size within fish type) and low back pain occurrences that interrupted or limited work (n=89, 313 visits)

	Fishing type	Percent time exposed to low back stress[1]	Inter-quartile range	Unadjusted Parameter (se)†	RR	95% CI	Adjusted Parameter†‡	RR	95% CI
PATH		Mean (se)							
Non-neutral trunk posture	Gillnet	24.04 (7.58)	14.0	0.0337	1.03	0.96, 1.11	0.0293	1.03	0.96, 1.11
	Crab pot	25.64 (5.35)	13.5	(0.0359)			(0.0378)		
Any force	Gillnet	85.56 (10.21)	10.0	0.0024	1.00	0.99, 1.02	0.0047	1.00	0.99, 1.02
	Crab pot	43.68 (6.92)	28.0	(0.0064)			(0.0070)		
Awkward posture[2]	Gillnet	6.29 (5.44)	13.0	0.0548	1.06	0.97, 1.15	0.0417	1.04	0.95, 1.14
	Crab pot	14.26 (3.41)	20.0	(0.0436)			(0.0455)		
Handling materials[3]	Gillnet	39.16 (7.98)	3.0	0.0079	1.01	0.98, 1.04	0.0125	1.01	0.98, 1.05
	Crab pot	23.91 (5.12)	10.0	(0.0150)			(0.0170)		
Non-neutral trunk and any force	Gillnet	18.66 (7.04)	9.0	0.0393	1.04	0.95, 1.13	0.0391	1.04	0.94, 1.15
	Crab pot	17.40 (4.90)	10.0	(0.0444)			(0.0505)		
CABS									
3DSSPP spine compression	Gillnet	0.31 (1.52)	1.9	0.3354	1.40	0.81, 2.36	0.2441	1.28	0.74, 2.20
>3400 Newtons				(0.2661)			(0.2786)		
	Crab pot	1.84 (1.25)	4.6						
NIOSHLE Lifting Index > 3.0	Gillnet	0.09 (1.47)	0.3	0.2448	1.28	0.87, 1.89	0.1743	1.19	0.79, 1.79
	Crab pot	2.25 (1.12)	4.1	(0.1988)			(0.2077)		
NIOSHLE Lifting Index > 1.0	Gillnet	31.14 (11.05)	56.8	0.0133	1.01	0.97, 1.05	0.0183	1.02	0.97, 1.07
	Crab pot	21.67 (7.62)	26.4	(0.0203)			(0.0235)		
LMM PHRGM > 70%	Gillnet	48.76 (9.37)	33.7	0.0166	1.02	0.98, 1.05	0.0145	1.01	0.98, 1.05
	Crab pot	51.94 (6.10)	23.4	(0.0177)			(0.0186)		

†Poisson regression estimates are adjusted for multiple visits per subject with GEE

‡Adjusted for other fishing types (shrimp, clam, oyster, eel, etc.) performed during follow up and age

[1] Mean percent time in low back stress measured in sample of fishermen adjusted with multi-level mixed linear model with three nested variables: fish type, crew nested within fish type, job nested within crew within fish type

[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; and legs bent >30 degrees, kneel, squat, or stand one foot
[3] Lift, lower, carry, push/pull, slide, or hold

VI. DISCUSSION

A. Summary of Findings

The rate of severe LBP was 0.69 per 1000 person-days (95% CI: 0.47, 0.90). Handling heavy loads during loading and unloading produced high compression (3400 N to 5315 N) and lifting index values (3.0 to 5.4), but contributed little to overall work time (0 to 14%). Sorting catch, due to the large portion of time in static, non-neutral and awkward postures (83% task time, 27% to 53% total work time), was associated with increased rate of severe LBP (1.80 95% CI: 0.78, 4.13). Tasks known to be unassociated with high low back stress, driving and running puller or net reel, were also associated with LBP. Overall the percent of time fishermen were exposed to awkward postures, spine compression >3400 Newtons, and NIOSH lifting index >3.0 were associated with an increased rate of severe LBP.

PATH and CABS methods were well suited for measuring exposure to low back stress in this occupation and each quantified different components of low back stress. Fishing tasks stressful for the low back identified by PATH included pulling in the buoy (45% time non-neutral trunk posture, 46% time > 9 kg force), feeding the puller (33%, 29%), handling pots and nets (20%, 41%), and loading and unloading (31%, 50%). CABS PHRGM >70% supported the PATH findings for these tasks, while 3DSSPP compression and NIOSH Lifting Index measures were high only for loading and unloading subtasks. Sorting catch was identified by both PATH and CABS due to the large portion of time in static, non-neutral trunk postures (83% task time and 27% to 53% of total work time).

Though we were able to identify fishing tasks with higher low back stress, we found inconsistent results for the association between self-reported fishing tasks and severe LBP. Tasks characterized by higher biomechanical low back stress in this study, unloading the boat (1.23 95% CI: 0.37, 4.12) and sorting catch (1.80 95% CI: 0.78, 4.13), were associated with an increased occurrence of severe LBP. However, tasks typically considered not to be associated with high low back stress, namely driving the boat (1.73 95% CI: 0.66, 4.53), running puller or net reel (2.14 95% CI: 0.81, 5.70) and use of a dolly or lift for unloading (1.76 95% CI: 0.69, 4.48), were also associated with LBP in this population. With higher compression and lifting index values we expected loading the boat to be strongly associated with LBP, however we did not observe such an association.

Overall ergonomic exposure to low back stress throughout the day differed by fishing type, crew size, and job title. Captains between crew sizes had the largest variability in low back stress. A 2-man crew's captain exposure profile could resemble a 3-man crew's captain or a 1-man crew's captain depending on the division of labor. Irrespective of crew size, mates and 3rd men were often exposed to non-neutral trunk postures, forces, and higher compression and lifting index values. An increased occurrence rate was observed for percentage of time in awkward postures, spine compression >3400 Newtons, and NIOSH lifting index >3.0. Adjusting for age and other fishing types attenuated some estimates and decreased overall precision.

Previous studies of automotive industry workers found non-neutral trunk postures (OR 8.09 95% CI: 1.5, 44.0) and handling 44.5 Newtons (10 pounds) frequently (OR 2.16 95% CI: 1.0, 4.7) were associated with reports of back disorders (Punnett, Fine et al. 1991). Occupational research indicates that the percent of time in non-neutral trunk postures and handling physical loads vary between and within occupational groups and workers and the contribution of between and within variance is different (Burdorf 1992; Burdorf 1992; Burdorf 1993; Burdorf 1995; van der Beek, Kuiper et al. 1995; Peretz, Goren et al. 2002). In this study, fishing type (17% to 93%) and job title (5% to 64%) were responsible for most of the variability in low back stress exposure variables. However, the proportion of variability between and within nesting variables was not consistent across all exposure measures and supports the concept that PATH and CABS variables represent different aspects of ergonomic stress for fishermen.

Individual level exposure measures are often expensive and time consuming to obtain, therefore exposure assessment and assignment by occupational group is common for epidemiologic studies (Checkoway, Pearce et al. 2004; Loomis and Kromhout 2004). In this study, ergonomic measures were taken in a sample of crab pot and gillnet fishermen. We adjusted the mean exposures by sub-grouping factors (type of fishing, crew size, and job) to obtain the least biased estimate of mean percent time in low back stress. Exposure assignment strategy made a difference when characterizing the risk of LBP in this population. Since fishing type comprised the majority of variability in exposure to low back stress for most measures (49% to 93%), we believed this was the best choice in the absence of individual measures.

However, to explore the potential for misclassification in our assignment strategy, a sensitivity analysis was performed for greater than 20% of time exposed to non-neutral trunk postures estimated with PATH (Appendix E). PATH measurements were considered the “gold standard” and were compared against calculated means by grouping factors. The combination of crew size and job title (94% sensitivity and 78% specificity) followed by job title alone (78% sensitivity and 81% specificity) performed best compared to PATH measurements. Fishing type alone performed poorly (33% sensitivity and 88% specificity). In this study, we assigned and expressed ergonomic stress as a continuous measure for mean percent of time exposed rather than a dichotomous or categorized outcome.

Age was an important risk factor for LBP as well as a determinant of exposure to low back stress in this study. The age at which participants began fishing ranged from 5 to 54 years old, indicating that this cohort included a diverse group of workers. On one end, we had fishermen who started fishing at a young age and continued fishing over their lifetime in a progression from crewmember, to mate, to captain. On the other, we had individuals who started fishing later, after retirement, or part-time with their spouse to earn an extra income. Many maintained a smaller operation by fishing alone or employed a family member or spouse to help out. Most fishermen reported fishing for 20 or more years, but we could not account for effects of cumulative exposure.

Fishermen as an occupational group have been described and think of themselves as robust to work-related injury and MSD (Pollnac, Poggie et al. 1995). Fishermen have reported continuing to work despite serious injury and infections (Marshall, Kucera et al. 2004). These attributes could imply varying degrees of pain threshold and suggest pain must be severe for fishermen to adjust their work. The self-reported task results offer evidence to support the hypothesis that fishermen put themselves on “light-duty” by hiring crew members, getting help with strenuous tasks, or doing less (e.g. fish fewer pots or hours). Among fishermen who reported changing the way they work due to past LBP we observed a decreased occurrence of LBP for use of lifting aids while loading (RR=0.50 95% CI: 0.11, 2.31) versus among fishermen who did not change their work patterns (RR=3.39 95% CI:

0.84, 13.70). We could speculate that fishermen who changed the way they worked had less LBP when using a lifting aid but self-reported tasks were retrospectively reported. However, due to the design of the study, we do not know if these changes in work practices took place before or after LBP.

B. Strengths

A prospective cohort design was employed to assess LBP and fishing types performed over a two year follow-up period. Previous studies of LBP in commercial fishing utilized cross sectional and retrospective designs (Torner, Blide et al. 1988; Norrish and Cryer 1990; Jensen, Stage et al. 2005). Use of a prospective cohort design generally decreases the chance of survivor bias.

History of severe LBP was prevalent (24% at baseline) and was a strong predictor of subsequent LBP in this population (6.09 95% CI: 3.06, 12.11). Stratifying our estimates by history of LBP allowed us to include a group of participants other studies normally exclude from the analysis. Including workers with this history provided a better representation of the target population of fishermen about whom we wanted to make inferences.

This study was innovative in that it employed established methods of ergonomic assessment developed for the construction industry to help in the understanding of exposures to hazards and biomechanical stresses associated with commercial fishing tasks. The ability to link the ergonomic measures obtained from a sample with fishing type, presence of crew, and job was a significant advantage of this study. To date, CABS used as an assessment of exposure had not been employed in an epidemiologic study.

Detailed interviews with commercial fishermen from the ethnographic study furthered our understanding of the fishing process and informed our ergonomic analysis. Together with the detailed epidemiological data from telephone interviews and clinic visits, this study had a broad and rich context from which to study low back pain associated with commercial fishing work.

C. Limitations

The nature of commercial fishing as an occupation selects for healthy and strong workers. The effect of selection bias for LBP is expected to be minimal if absent since this study used a cohort of fishermen who volunteered for a parent study of estuary-related illnesses associated with a marine micro-organism and not a study of back pain or injury. However, workers more susceptible to injury or musculoskeletal disorders could have left the occupation prior to the study and consequently may not be represented in this cohort. If present, this selection bias would not invalidate results but may have attenuated risk estimates toward the null.

Fishermen in this study were encouraged to come in for “trigger” visits if experiencing symptoms such as skin lesions or memory and cognitive impairment or if they suspected exposure to the organism (Moe, Turf et al. 2001). In our study, trigger visits were associated with higher rates of severe LBP in the whole cohort (RR 1.51 95% CI: 0.86, 2.66) but not in the supplemental questionnaire group (RR 1.15 95% CI: 0.53, 2.52), and were not a confounder in multivariate analyses. Although the supplemental questionnaire group reported higher occurrence of severe LBP over follow up (26%) compared to the entire cohort (16%), the multivariate model results were similar for each group.

Loss to follow up and censoring were present in this study. Fishermen had differing intervals of time between clinic visits and some participants dropped out before completing the full two years of follow up. Commercial fishermen work long hours and were many times unable to make regular clinic visits. Poisson regression analysis of rates controlled for different follow up time. However, if loss to follow up was due to a busy fishing work schedule, fishermen who worked the longest hours and the most days may be underrepresented in this study. It is less likely that fishermen dropped out due to injury or MSD since they would be more likely to keep their clinic appointments.

Subjective assessment of low back pain is problematic (Punnett and Wegman 2004), therefore we examined occurrences of LBP that limited or interfered with work. Going beyond symptom level, this study aimed to illuminate information about ergonomic effects on the severity of LBP. Since we could not determine from the questionnaire if reports of LBP were incident or recurrent, we examined the occurrence of severe LBP using Generalized Estimating Equations (Liang and Zeger 1986; Zeger and Liang 1986) to accommodate correlated events. However, we could have missed some events due to recall bias or if commercial fishermen did not consider or report their LBP pain as work-limiting.

This study was underpowered as evidenced by the wide confidence intervals for effect estimates. A larger study with individual level ergonomic exposure data might have improved the precision of our estimates and addressed potential bias. However, obtaining individual-level ergonomic and task exposure information from these workers was equally difficult whether observing work or administering a questionnaire. Participants in the cohort were licensed commercial fishermen and the majority self-identified as captains. Therefore, differences may exist between the cohort and the sample of fishermen we collected ergonomic exposure.

Because one 3DSSPP, LI, and PHRGM model was created per subtask, within and between worker variability was underestimated for CABS measures. However, PATH does account for this variability by sampling posture, tasks, and activities throughout the work day. Residual variation was minimal for most measures (2% to 8%) except for percent time in awkward postures (37%) and lifting index >3.0 (30%) indicating that variation between and within worker was important for these two variables. We sampled work at 90 second intervals with PATH, and our ability to capture rare postures or loads (e.g. severe flexion or loads >40 pounds) during load and unloading tasks which generally represented 5% (range 0 to 14%) of total work time was limited. Adjusting PATH sampling frequencies to 10 second intervals would improve the capture of rare postures or loads but would be difficult for one observer to record in the field.

Task-based assignment of ergonomic stress was beyond the scope of this study. However, we did examine retrospective self-reported frequency of fishing tasks. Retrospective assessment implied we could not establish temporality of tasks and occurrences of severe LBP. Recall of fishing task frequency beyond one year could bias our estimates. If exposure misclassification by task is non-differential with respect to outcome status, then the estimate would be biased toward the null. Differential recall of work task duration by LBP status has been reported in previous studies (Wiktorin, Karlqvist et al. 1993; Viikari-Juntura, Rauas et al. 1996).

This study did not include measures of psychosocial risk factors, such as job satisfaction and level of decision making, boat motion, or the presence of full body vibration.

Review of the literature indicates these factors may be important predictors of LBP in this population (Torner, Blide et al. 1988; Fulmer and Buchholz 2002).

Despite some limitations, our results suggest that grouping variables such as type of fishing, crew size, and job are important predictors of low back stress and ultimately of LBP. Furthermore, age, history of LBP, and self-selection out of and modification of tasks were likely important contributors to the patterns of low back stress and outcomes we observed.

D. Recommendations

Research consistently shows that LBP is common problem for fishermen. Tasks associated with high ergonomic low back stress did not universally predict whether a worker experienced severe LBP. Our findings indicated that fishermen self-limit or adjust their work load in the presence of current LBP or past LBP (the opposite of the HWE). Working independently was an advantage (control over working hours and frequency, addition of crew, and task performance) or a disadvantage (absence of health insurance or worker's compensation, increased pressure to work under dangerous conditions) depending on the risk factor. As researchers it is important to consider the full picture of the worker in their environment, including economic considerations, since despite the physical toll of the work they must work and find ways to compensate. Data collection methods, analyses, and interpretations should include and account for these modifications.

We found variability in exposure was important for these workers. Future research should account for the variability of individual exposures - self-imposed (e.g. self-selection into and out of tasks, use of special equipment or gear, presence of crew) or external (e.g. season, weather, water conditions and boat motion, catch volume).

There are several characteristics of this occupation that cannot be easily factored into analyses but must be understood in order to progress forward. Interviews with commercial fishermen indicate that regulation and market flux has had a strong effect on NC fishermen (McDonald, Loomis et al. 2004). Competition and different regional regulations drive fishermen to work longer and harder – perhaps resulting in greater risk-taking behavior. Traditionally fishing in North Carolina is family driven and many descend from several generations of fishermen. Yet it has become increasingly difficult to make a “good” living as a small-scale independent commercial fisherman.

Previous research identified barriers to the adoption of safety measures including lack of information, cost, recognition of risk, and risk-taking behaviors (Torner, Cagner et al. 1999/2000). Research such as ours will inform interventions to decrease work-related low back stress and ultimately LBP. Our research indicates that fishermen are willing participants in studies and able to be included in the beginning of study designs. This will likely increase adoption of beneficial changes and address recognized worker needs that are cost efficient. This study demonstrated that a multi-disciplinary approach that combined ethnographic techniques and detailed ergonomic assessments with epidemiologic outcome and exposure data can lead to interventions that will hopefully improve the work environment and productivity for commercial fishermen.

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VIII. APPENDICES

A. Graphs and Tables used in ergonomic analyses

1. PATH crab pot data collection template

	Observation Number															
Crab pot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1) Worker number																
a) 1																
b) 2																
c) 3																
d) 4																
2) Trunk																
a) Neutral, (0 to <20 deg)																
b) Moderate flexion (20 to <45 deg)																
c) Severe flexion (45+ deg)																
d) Lateral bend/twist																
e) Bend twist flex																
f) No																
3) Shoulder																
a) Arms down																
b) 1 up (elbow above shoulder)																
c) 2 up																
d) no																
4) Legs																
a) Stand																
b) Stand knees bent																
c) Squat																
d) Walk																
e) Kneel																
f) Sit																
g) Stand 1 leg																
h) no																
5) Hand1																
a) Gross grasp																
b) Pinch																
c) Empty																
d) Other																
e) no																
6) Hand2																
a) Gross grasp																
b) Pinch																
c) Empty																
d) Other																
e) no																

7) Crabbing tasks																
a) Traveling																
b) Pull Pots																
c) Set pots																
d) Cull/sort/pack																
e) Clean																
f) Docking/cast off																
g) Load/unload																
h) Pre/post																
i) Other																
j) no																
8) General activities																
a) Operate controls																
b) Handle hook																
c) Hook buoy																
d) Feed puller																
e) Handle/guide line																
f) Handle/operate pot																
g) Baiting																
h) Set pot/buoy																
i) Handle/sort catch																
j) Brush/sweep/hose																
k) Idle																
l) Other																
m) no																
9) MMH																
a) Push/pull																
b) Slide																
c) Lift																
d) Carry/hold																
e) Lower																
f) Other																
g) no																
10) Coupling																
a) Near																
b) Far																
c) no																
11) Usage																
a) One hand																
b) Two hands																
c) no																
12) Tools/equipment																
a) Hook																
b) Box/tote																
c) Basket																
d) Pallet																
e) Crate																
f) Ice chest																

g) Pot																
h) Hose																
i) Brush																
j) Other																
k) no																
13) Force																
a) Light, <20 lbs																
b) Medium, 20-40 lbs																
c) Heavy, >40 lbs																
d) no																

2. PATH gillnet data collection template

	Observation Number															
Gillnet	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1) Worker number																
a) 1																
b) 2																
c) 3																
d) 4																
2) Trunk																
a) Neutral, (0 to <20 deg)																
b) Moderate flexion (20 to <45 deg)																
c) Severe flexion (45+ deg)																
d) Lateral bend/twist																
e) Bend twist flex																
f) No																
3) Shoulder																
a) Arms down																
b) 1 up (elbow above shoulder)																
c) 2 up																
d) no																
4) Legs																
a) Stand																
b) Stand knees bent																
c) Squat																
d) Walk																
e) Kneel																
f) Sit																
g) Stand 1 leg																
h) no																
5) Hand1																
a) Gross grasp																
b) Pinch																
c) Empty																
d) Other																

e) no																
6) Hand2																
a) Gross grasp																
b) Pinch																
c) Empty																
d) Other																
e) no																
7) Gillnet tasks																
a) Traveling																
b) Pull/pick nets																
c) Set nets																
d) Cull/sort/pack																
e) Clean																
f) Docking/cast off																
g) Load/unload																
h) Pre/post																
i) Other																
j) no																
8) General activities																
a) Operate controls																
b) Handle hook																
c) Hook buoy or net																
d) Feed puller and/or net reel																
e) Handle/guide line																
f) Handle/pull net																
g) Pick net																
h) Set net																
i) Handle/sort catch																
j) Brush/sweep/hose																
k) Idle																
l) Other																
m) no																
9) MMH																
a) Push/pull																
b) Slide																
c) Lift																
d) Carry/hold																
e) Lower																
f) Other																
g) no																
10) Coupling																
a) Near																
b) Far																
c) no																
11) Usage																
a) One hand																
b) Two hands																
c) no																

12) Tools/equipment																
a) Hook																
b) Box/tote																
c) Basket																
d) Pallet																
e) Crate																
f) Ice chest																
g) Net																
h) Hose																
i) Brush																
j) Other																
k) no																
13) Force																
a) Light, <20 lbs																
b) Medium, 20-40 lbs																
c) Heavy, >40 lbs																
d) no																

3. CABS Subtask descriptions for OCS time codes

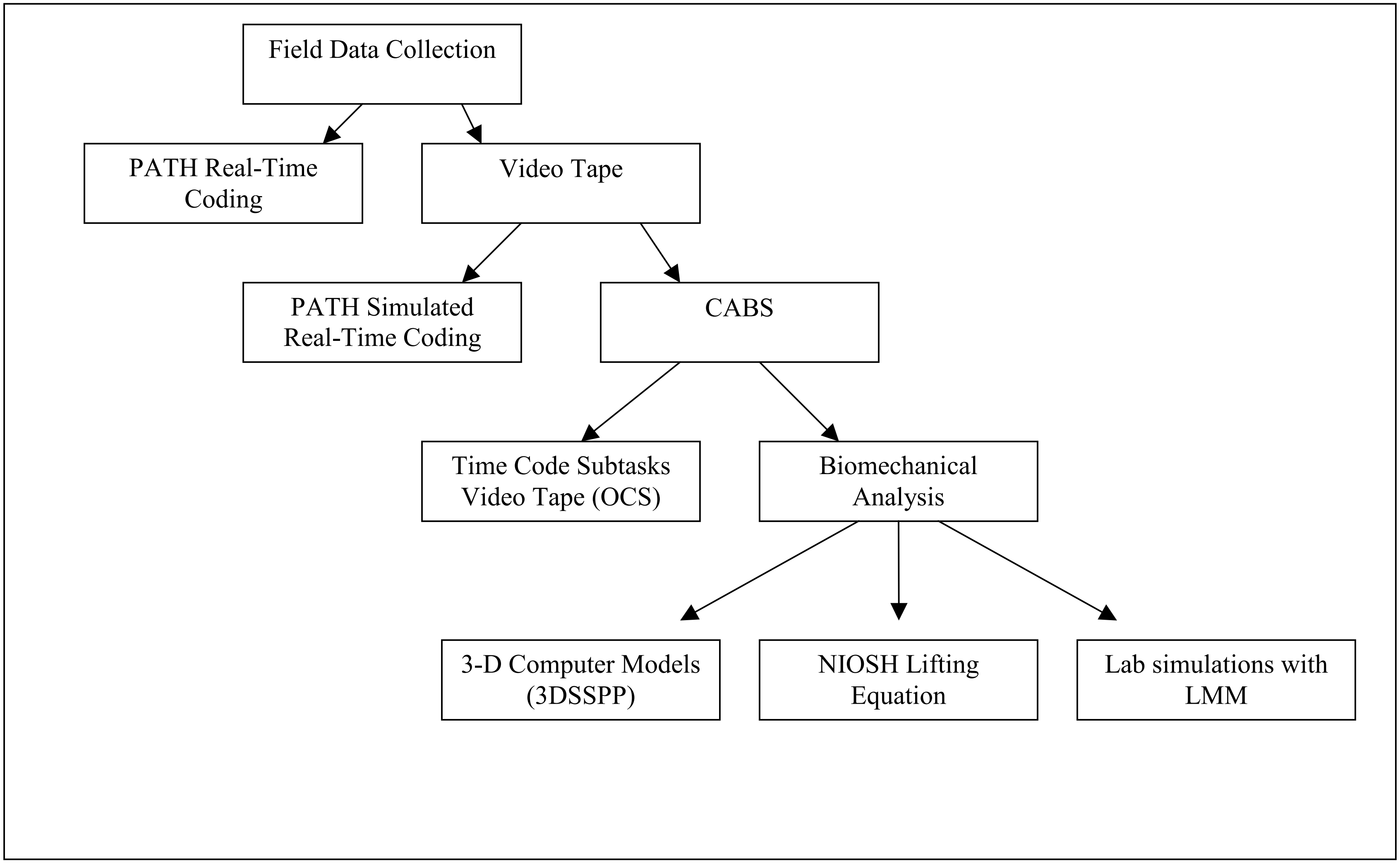
Time Code	CABS Subtask	Description	Fishing type	Activity
BO	Bend over	Begins when worker bends down to grab basket or bin. Ends when worker grips the basket and changes direction to lift it up.	Both	Load/unload
CAR	Carry	Begins when basket/tote is at waist height. Ends when worker releases object or lifts the object over waist height to place it on the ledge.	Both	Load/unload
CD	Closes crab pot door*	Begins as worker moves hand to door clip. Ends when worker grabs the pot with both hands.	Crab	Pull/set gear
D	Drive	Begins when worker touches the steering or accelerator. Ends when worker lifts hand from steering.	Both	Pull/set gear
FNR	Feed line into the net reel	Begins as worker grabs line/net and pulls toward net reel. Ends when hand releases line/net.	Gillnet	Pull/set gear
FPP	Feed line into pot puller*	Begins as worker pulls the buoy up to the boat. Ends when the hook releases the rope. Performed one handed or two handed.	Both	Pull/set gear
GA	Grab the anchor*	Starts when worker reaches for the anchor (bends down). Ends as worker stands. 3-D and NIOSH models will distinguish between postures in this task.	Both	Pull/set gear
GB	Grab the bait*	Begins when worker turns towards the bait box to grab a fish. Ends right before worker lifts their arm to put bait in the pot.	Crab	Pull/set gear
GH	Grab hook*	Begins after hand leaves steering to grab the hook. Ends after worker brings the hook around and just as worker changes direction to reach out with the hook.	Both	Pull/set gear
GL	Guides line through puller	Begins when worker grabs line or buoy. Ends after worker swings the rope from out of the puller and guides the pot around the puller.	Both	Pull/set gear
GR	Grab rope*	Starts just as worker starts to bend over and grab the rope (no hook used here). Ends just as worker is standing at a neutral position getting ready to feed the pot puller or begins pulling the rope in by hand.	Both	Pull/set gear
HB	Hook the buoy*	Begins as worker starts reaching the hook out and down toward buoy. Ends after worker hooks the buoy, just as they	Both	Pull/set gear

		change direction to pull the buoy toward the boat. Performed one handed or two handed.		
HN	Handle gill net	Used when person is handling net (not pulling or picking). Used when untangling the net or laying net out before setting. Worker may be sitting or standing or bent over for this task. 3-D and NIOSH models will distinguish between postures in this task.	Gillnet	Pull/set gear
LB	Load bait into crab pot*	Begins as worker's arm raises toward the pot. Ends when worker bends to sort the crabs.	Crab	Pull/set gear
LD	Lift down basket/tote*	Begins when worker puts both hands on basket/bin and grips it. Ends after object is lifted down and reaches the ground.	Both	Load/unload
LPS	Lift crab pot to edge*	Begins when worker begins to pull the pot up towards the boat. Ends after the pot hits the table.	Crab	Pull/set gear
LTS	Lift, tilt, shake crab pot*	Begins as worker's arms begin upward motion to lift/tilt the pot. Ends when the pot touches the table or worker's hand is released to close the door.	Crab	Pull/set gear
LU	Lift up to edge at waist height/or lifted to waist height*	Begins after worker grips the basket/bin and movement is started in upward direction. Ends when the object is placed on the ledge/or stopped at waist height for a carry.	Both	Load/unload
OD	Open crab pot door	Begins when worker moves hand to door clip. Ends when worker grabs the pot with both hands to lift the pot.	Crab	Pull/set gear
PBO	Crab pot and buoy off*	Begins when worker grabs the pot with both hands sliding the pot over and off the boat. Ends when worker grabs the rope or buoy coming through the pot puller.	Crab	Pull/set gear
PIC	Pick fish from gill net*	Anytime worker is handling the catch in the net and trying to pick it out. 3-D and NIOSH models will distinguish between postures in this task.	Gillnet	Pull/set gear
PN	Pull gill net*	Begins when worker pulls net in the boat or towards body. Ends when worker stops to pick the net or handle the net in the same place. 3-D and NIOSH models will distinguish between postures in this task.	Gillnet	Pull/set gear
PPH	Pulling the pot in by hand*	Start when worker begins pulling the rope in or up from the water. Ends before worker changes direction to start lifting the pot to the edge.	Crab	Pull/set gear

PUL	Pull object towards body*	Begins when worker grips the basket/bin with one hand ready to pull it towards body. Ends when motion of basket/bin stops and worker lets go or grabs it with two hands--one on either side.	Both	Load/unload
S	Stand	Begins as worker straightens or ceases movement. Ends as activity starts. Key: in general, neutral posture, not walking or sitting.	Both	
SC	Sort catch*	Begins when worker bends or moves arms to sort catch. Ends when worker releases catch and straightens up to stand.	Both	Pull/set gear
SDH	Set down hook	Begins after the rope is released. Ends when the hook is as close to horizontal as possible and hands touch steering.	Both	Pull/set gear
SET	Set gill net*	Begins as worker moves to set net in water (not pulling or handling net). Includes dropping net in water, tossing net in water, or feeding net out by hand. If driving boat out to set the net then use code for drive.	Gillnet	Pull/set gear
SL	Slide basket/bin	Begins when worker has a grip on the basket/bin and begins to move it in a direction along a surface. Ends when motion of basket/bin stops.	Both	Load/unload
TG	Turn and grab basket/tote	Begins when worker lets go of basket/bin. Ends after worker rotates and flexes trunk down and grabs the basket/bin.	Both	Load/unload
TP	Tilt/flip pot*	Begins after worker grabs the pot and moves to flip or tip pot up. Ends when pot comes to rest or worker's hand reaches down to open the door.	Crab	Pull/set gear
TS	Tuck sack with tool	Use a tool (hook, pole, or oar) to tuck the sack into the box. Body in upright posture with arms pushing tool downward.	Both	box change
WA	Walk	Begins when activity before is stopped. Hands are free and unweighted. Ends when worker begins another task.	Both	Load/unload

*Indicates tasks simulated with the Lumbar Motion Monitor

3. Ergonomic Data Collection Schematic



B. Additional Results for Paper #1

Table 8.1. Addendum to Table 4.1. All low back stress measures for Continuous Assessment of Back Stresses (CABS) subtasks and Posture, Activities, Tools, and Handling (PATH) tasks in crab pot and gillnet commercial fishing in North Carolina, US

CABS Subtask	Compression[1] Newtons (SE)	Lifting Index[2]	PHRGM[3] mean (range)	PATH Task	Activity	Non-neutral Trunk[4]	Force > 9 kg[4]	Non-neutral trunk And force > 9 kg[4]
Bend over, 18 kg basket	1949.6 (149.1)	0.0						
Bend over, 36 kg tote	2150.8 (165.1)	0.0						
Carry 18 kg basket	1563.2 (94.4)	1.1		Other[5]	MMH[6]=carry	8 (4.4)	**39 (7.9)**	8 (4.4)
Carry 36 kg tote	2214.8 (138.9)	2.2						
Close door of pot	671.0 (35.4)	0.1	68.2 (52.9 to 81.6)					
Drive	311.4 (2.9)	0.0		Pull or set gear	Operate controls	6 (1.0)	0 (0.1)	0 (0.1)
Feed puller A, arms down, hook perpendicular to body	578.0 (24.3)	0.2	41.8 (30.5 to 52.1)	Pull or set gear	Feed pot puller	**33 (6.5)**	**29 (6.4)**	12 (4.4)
Feed puller B, one arm up, hook parallel to body	1372.4 (87.9)	0.3						
Grab 18 kg anchor, front of body	**3585.6 (280.8)**	2.2	**74.4 (64.8 to 84.9)**					
Grab 18 kg anchor, side of body	2846.5 (200.2)	**3.0**	**87.4 (80.3 to 93.8)**					
Grab bait	343.4 (21.6)	0.5	**71.8 (64.2 to 76.5)**	Pull or set gear	Baiting	**29 (3.6)**	1 (0.6)	1 (0.6)
Grab hook	824.9 (44.4)	0.2	68.9 (60.0 to 73.0)	Pull or set gear	Handle hook	17 (3.9)	0 (0.3)	0 (0.3)
Guide line	1406.4 (94.6)	0.1		Pull or set gear	Handle/guide line	**32 (4.3)**	15 (3.3)	5 (2.0)
Grab rope and buoy with hand	2222.0 (187.7)	0.8	**72.2 (68.1 to 76.8)**	Pull or set gear	Grab rope with hand	**100 (1.1)**	**50 (17.7)**	**50 (17.7)**

Hook buoy A, one hand at side	1503.2 (104.2)	1.3	**84.2 (70.8 to 92.0)**	Pull or set gear	Hook buoy	**43 (5.2)**	**46 (5.2)**	12 (3.4)
Hook buoy B, two hands front	1137.6 (68.0)	0.4	**71.7 (58.5 to 84.4)**					
Load bait into crab pot	719.2 (36.9)	0.5	66.6 (60.3 to 78.1)					
Lift down 18 kg basket	3239.6 (255.3)	1.7	**88.1 (82.5 to 92.3)**	Other[5]	MMH[6]=lower	**77 (11.7)**	**54 (13.8)**	**38 (13.5)**
Lift down 36 kg tote	**5314.9 (420.4)**	**3.3**	**81.5 (75.1 to 87.2)**					
Lift pot (>9 kg) to side of boat	2429.9 (178.3)	1.2	**83.1 (76.6 to 88.6)**	Pull or set gear	Handle/operate pot	20 (2.0)	**41 (2.5)**	10 (1.5)
Lift, tilt, and shake pot	1228.7 (77.0)	0.9	**84.5 (79.8 to 86.4)**					
Lift up 18 kg basket	1550.0 (93.4)	1.7	**89.0 (78.7 to 98.9)**	Other[3]	MMH[4]=lift	**58 (7.8)**	**55 (7.9)**	**35 (7.5)**
Lift up 36 kg tote	2187.3 (136.7)	**3.3**						
Open door of pot	781.7 (42.1)	0.1						
Push pot and buoy into water	1331.2 (85.6)	0.3	60.4 (54.1 to 65.0)	Pull or set gear	Set pot and buoy	4 (2.3)	3 (1.9)	0 (0.4)
Pick net, bent posture	1529.8 (107.9)	0.1	46.3 (40.0 to 52.0)	Pull or set gear	Pick net	**41 (5.5)**	1 (1.2)	0 (0.4)
Pick net, upright posture	1095.0 (68.0)	0.1	42.1 (34.2 to 49.4)					
Pull net, bent posture	1507.6 (107.7)	0.8	**77.2 (60.5 to 87.8)**	Pull or set gear	Handle/pull net	**30 (4.3)**	7 (2.4)	4 (1.9)
Pull net, upright posture	898.4 (53.6)	0.5	65.5 (49.2 to 75.9)					
Pull crab pot in by hand	1998.2 (142.3)	1.1	**78.1 (72.7 to 86.9)**					
Pull 18 kg basket	1003.6 (64.1)	1.1		Other[5]	MMH[6]=pull/push	**31 (12.8)**	**69 (12.8)**	23 (11.7)
Pull 36 kg tote	1140.9 (81.1)	2.3	**76.1 (71.5 to 80.8)**					
Stand	275.3 (0.2)	0.0		Pull or set gear	Idle	5 (1.4)	0 (0.2)	0 (0.2)
Sort crabs	1833.0 (132.7)	0.1	52.3 (45.5 to 55.3)	Pull or set gear	Sort & cull catch	**83 (2.7)**	0 (0.2)	0 (0.2)
Set down hook	968.8 (58.9)	0.2						
Set net, 1man gillnet	1087.8 (66.9)	0.1	65.2 (56.1 to	Pull or set gear	Set net	20 (8.0)	4 (3.9)	4 (3.9)

			74.2)					
Slide 18 kg basket	636.2 (27.5)	1.1		Other[5]	MMH[6]=slide	**50 (25)**	**50 (25)**	25 (21.7)
Slide 36 kg tote	1028.7 (60.1)	2.3						
Turn and grab 18 kg basket	3019.8 (234.0)	2.7						
Turn and grab 36 kg tote	**3989.1 (318.6)**	**5.4**						
Tilt pot	1542.3 (97.9)	0.9	**91.5 (89.2 to 97.5)**					
Tuck sack into box with tool	318.9 (9.3)	0.6						
Walk	497.0 (18.1)	0.0						

[1] Low back compression measured in Newtons at L5/S1 joint with University of Michigan 3D Static Strength Prediction Program (Chaffin, Freivalds et al. 1987; Chaffin and Erig 1991)
[2] NIOSH Lifting Index, object weight divided by Recommended Weight Limit (Waters, Putz-Anderson et al. 1993)
[3] PHRGM, probability of high risk group membership measured with Ohio State University Lumbar Motion Monitor (Marras, Lavender et al. 1993)
[4] Percent of sampled time during that PATH task and activity, % (se); non-neutral trunk includes flexion >20 degrees, bend & twist >20 degrees, or lateral flexion, bend, and twist >20 degrees
[5] Other PATH tasks include pre and post fishing, load and unload, and docking and casting off
[6] Manual materials handling and includes lift, lower, carry, push/pull, slide, or hold
Note: Measures in bold considered to be higher risk for that exposure measure

Table 8.2. Percent of observed workday exposed to low back stress expressed by Continuous Assessment of Back Stresses (CABS) and Posture, Activities, Tools, and Handling (PATH) in a sample of crab pot and gillnet commercial fishermen (PATH n=25 and CABS n=15)

			PATH					CABS			
Fishing type	Crew type	Job	Non-neutral trunk posture[1]	Any force[1]	Non-neutral trunk and any force	Awkward posture[1,2]	Any MMH[1,3]	Compression >3400 N[1]	Lifting Index > 3.0[1]	Lifting Index > 1.0[1]	PHRGM > 70[1]
Crab pot	1man	Captain	21	49	16	23	23	1.0	1.5	24.9	58.9
	1man	Captain	21	45	13	15	36	0.0	1.4	29.1	64.2
	2man	Captain	13	43	11	9	28	5.0	5.0	19.8	63.0
		Mate	42	56	39	38	13	4.2	4.2	27.2	56.1
	2man	Captain	13	11	0	8	8	0.0	1.0	9.2	33.9
		Mate	27	52	12	18	36	0.0	1.8	53.1	55.3
	3man	Captain[5]	16	12	27	2	6	0.0	0.0	3.8	46.7
		Mate[5]	40	59	44	16	38	13.9	13.8	40.4	69.9
		3rd man	54	67	10	17	7	0.0	0.0	0.0	26.7
	3man	Captain[5]	24	23	10	2	17	0.5	0.0	7.5	61.2
		Mate[5]	30	52	19	24	43	11.5	7.4	43.9	69.9
		3rd man	47	76	44	52	29	2.2	2.2	21.1	26.7
Gillnet	1man	Captain	21	74	16	5	53	0.1	0.3	27.5	44.6
	2man	Captain	13	83	12	2	15	2.0	0.3	12.8	36.5
		Mate	35	93	32	8	48	0.5	0.0	69.7	70.3
Crab pot	*1man*	*Captain*	*25*	*47*	*17*	*11*	*25*				
	1man	*Captain*	*19*	*51*	*14*	*11*	*39*				
	2man	*Captain*	*11*	*24*	*6*	*3*	*21*				
		Mate	*15*	*53*	*11*	*6*	*34*				
	2man	*Captain*	*15*	*19*	*6*	*15*	*10*				
		Mate	*23*	*46*	*11*	*10*	*24*				
	2man	*Captain*	*8*	*25*	*6*	*4*	*24*				
		Mate	*21*	*37*	*15*	*14*	*31*				

Gillnet	*1man*	*Captain*	*30*	*90*	*25*	*5*	*40*
	1man	*Captain*	*39*	*96*	*16*	*23*	*73*

[1] Percent of observed work day
[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; or leg flexion > 35 degrees, kneel, squat, or stand one foot
[3] Manual materials handling and includes lift, lower, carry, push/pull, slide, or hold
[4] Same crew measured on two different days performing two types of fishing
[5] Captain and mate were measured on two different days
Note: italics represent workers and crews not included in CABS histograms

Table 8.3. Percent of observed workday exposed to low back stress averaged across crew expressed by Continuous Assessment of Back Stresses (CABS) and Posture, Activities, Tools, and Handling (PATH) in a sample of crab pot and gillnet commercial fishermen (PATH n=25 and CABS n=15)

			PATH					CABS			
Fishing type	Crew type	Job	Non-neutral trunk posture[1]	Any force[1]	Non-neutral trunk and any force	Awkward posture[1,2]	Any MMH[1,3]	Compression >3400 N[1]	Lifting Index > 3.0[1]	Lifting Index > 1.0[1]	PHRGM > 70[1]
Crab pot	average	2crew	20	30		13	21	0.0	1.4	30.5	44.6
	average	2crew	28	49		23	20	4.6	4.6	23.4	59.6
	average	3crew	37	48		12	19	5.9	5.8	18.1	47.7
	average	3crew	34	51		26	30	5.4	5.2	25.9	52.6
Gillnet	average	2crew	26	89		5	34	1.2	0.1	40.1	53.4
Crab pot	*average*	*crew*	*13*	*38*		*4*	*27*				
	average	*crew*	*19*	*32*		*12*	*17*				
	average	*crew*	*14*	*31*		*8*	*27*				

[1] Percent of observed work day

[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; or leg flexion > 35 degrees, kneel, squat, or stand one foot

[3] Manual materials handling and includes lift, lower, carry, push/pull, slide, or hold

[4] Same crew measured on two different days performing two types of fishing

[5] Captain and mate were measured on two different days

Note: italics represent workers and crews not included in CABS histograms

Table 8.4. Estimated contribution of different sources of variance to the total variability of exposure to low back stress measured with Posture, Activities, Tools, and Handling (PATH) in crab pot and gillnet commercial fishermen (n=25) with a three-level nested (mixed) linear model with no fixed effects and random effects between fish type, between crew size within fish type, and between job type within crew size within fish type

		Unadjusted	Model #1	Model #2	Model #3
Non-neutral trunk[1]	Parameter	Percent contribution			
	σ^2_F		81.3%	80.2%	77.4%
	σ^2_C			5.5%	1.5%
	σ^2_J				15.7%
	σ^2		18.7%	14.3%	5.4%
	Total		803.44	811.43	853.22
		Mean (se)			
	Gillnet	27.6 (4.73)	26.39 (5.35)	25.51 (6.55)	24.04 (7.58)
	Crab pot	24.25 (2.81)	23.98 (2.72)	24.23 (4.54)	25.64 (5.35)
Any force[1]	Parameter	Percent contribution			
	σ^2_F		94.3%	94.3%	93.3%
	σ^2_C			0.1%	0.0%
	σ^2_J				5.2%
	σ^2		5.7%	5.6%	1.5%
	Total		4917.03	4926.57	5027.73
		Mean (se)			
	Gillnet	87.2 (8.81)	86.15 (7.45)	86.12 (7.61)	85.56 (10.21)
	Crab pot	42.35 (4.02)	42.22 (3.74)	42.46 (4.01)	43.68 (6.92)
Non-neutral trunk and any force[1]	Parameter	Percent contribution			
	σ^2_F		70.5%	73.1%	66.3%
	σ^2_C			4.5%	0.0%
	σ^2_J				25.2%
	σ^2		29.5%	26.9%	8.5%
	Total		481.92	469.45	546.48
		Mean (se)			
	Gillnet	21.4 (3.49)	19.75 (5.12)	19.39 (5.72)	18.66 (7.04)
	Crab pot	16.35 (2.82)	16.02 (2.64)	16.27 (3.65)	17.40 (4.90)

[1] Percent of observed work day

[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; and legs bent >30 degrees, kneel, squat, or stand one foot

[3] Lift, lower, carry, push/pull, slide, or hold

Note: Proportion of total variance: between fish type (σ^2_F), between crew size within fish type (σ^2_C), and between job within crew size within fish type (σ^2_J), and residual (σ^2)

Table 8.4. (continued). Estimated contribution of different sources of variance to the total variability of exposure to low back stress measured with Posture, Activities, Tools, and Handling (PATH) in crab pot and gillnet commercial fishermen (n=25) with a three-level nested (mixed) linear model with no fixed effects and random effects between fish type, between crew size within fish type, and between job type within crew size within fish type

		Unadjusted	Model #1	Model #2	Model #3
Awkward posture[1,2]	Parameter	Percent contribution			
	σ^2_F		50.8%	50.8%	49.2%
	σ^2_C			0.0%	0.0%
	σ^2_J				14.1%
	σ^2		49.2%	49.2%	36.7%
	Total		278.66	278.72	288.96
		Mean (se)			
	Gillnet	8.6 (3.72)	7.21 (4.79)	7.21 (4.79)	6.29 (5.44)
	Crab pot	14.9 (2.75)	14.21 (2.56)	14.21 (2.56)	14.26 (3.41)
Handling materials[1,3]	Parameter	Percent contribution			
	σ^2_F		87.6%	87.6%	82.4%
	σ^2_C			0.0%	0.0%
	σ^2_J				9.2%
	σ^2		12.4%	12.4%	8.4%
	Total		1498.92	1498.92	1331.56
		Mean (se)			
	Gillnet	45.8 (9.43)	44.54 (6.02)	44.54 (6.02)	39.16 (7.98)
	Crab pot	24.6 (2.56)	24.43 (3.04)	24.43 (3.04)	23.91 (5.12)

[1] Percent of observed work day

[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; and legs bent >30 degrees, kneel, squat, or stand one foot

[3] Lift, lower, carry, push/pull, slide, or hold

Note: Proportion of total variance: between fish type (σ^2_F), between crew size within fish type (σ^2_C), and between job within crew size within fish type (σ^2_J), and residual (σ^2)

Table 8.5. Estimated contribution of different sources of variance to the total variability of exposure to low back stress measured with Continuous Assessment of Back Stresses (CABS) in a sample of crab pot commercial fishermen (n=15) with three-level nested (mixed) linear model with no fixed effects and random effects between fish type, between crew size within fish type, and between job type within crew size within fish type

		Unadjusted	Model #1	Model #2	Model #3
Compression >3400 [1]	Parameter	Percent contribution			
	σ^2_F		20.9%	20.9%	16.6%
	σ^2_C			0.0%	0.0%
	σ^2_J				63.5%
	σ^2		79.1%	79.1%	19.9%
	Total		24.02	24.02	22.09
		Mean (se)			
	Gillnet	0.83 (0.58)	0.37 (1.67)	0.37 (1.67)	0.31 (1.52)
	Crab pot	3.2 (1.38)	2.43 (1.10)	2.43 (1.10)	1.84 (1.25)
Lifting Index>3.0[1]	Parameter	Percent contribution			
	σ^2_F		27.4%	27.4%	24.2%
	σ^2_C			0.0%	0.0%
	σ^2_J				46.0%
	σ^2		72.6%	72.6%	29.8%
	Total		18.52	18.52	17.55
		Mean (se)			
	Gillnet	0.19 (0.10)	0.10 (1.54)	0.10 (1.54)	0.09 (1.47)
	Crab pot	3.2 (1.17)	2.62 (0.96)	2.62 (0.96)	2.25 (1.12)
Lifting Index>1.0[1]	Parameter	Percent contribution			
	σ^2_F		69.3%	69.3%	65.2%
	σ^2_C			0.0%	0.0%
	σ^2_J				25.8%
	σ^2		30.7%	30.7%	9.0%
	Total		1200.86	1201.34	1241.23
		Mean (se)			
	Gillnet	36.67 (17.03)	31.94 (10.35)	31.95 (10.35)	31.14 (11.05)
	Crab pot	23.35 (4.80)	22.51 (5.45)	22.51 (5.45)	21.67 (7.62)
PHRGM>70[1,2]	Parameter	Percent contribution			
	σ^2_F		91.3%	91.1%	90.5%
	σ^2_C			0.0%	0.0%
	σ^2_J				6.3%
	σ^2		8.7%	8.9%	3.2%
	Total		2867.65	2866.08	2872.6
		Mean (se)			
	Gillnet	50.46 (10.17)	48.87 (9.09)	48.86 (9.09)	48.76 (9.37)

	Crab pot	52.7 (4.53)	52.27 (4.60)	52.27 (4.60)	51.94 (6.10)

[1] Percent of observed work day
[2] PHRGM, probability of high risk group membership
Note: Proportion of total variance: between fish type (σ^2_F), between crew size within fish type (σ^2_C), and between job within crew size within fish type (σ^2_J), and residual (σ^2)

Table 8.6. Pearson Correlation (r) between dependent variables of percent of work time exposed to low back stress from Continuous Assessment of Back Stresses (CABS) and Posture, Activities, Tools, and Handling (PATH) in crab pot and gillnet commercial fishing, North Carolina, US

		CABS Compression >3400 Newtons	Lifting Index > 3.0	Lifting Index > 1.0	PHRGM > 70
CABS	Compression > 3400 N	1.00	0.95	0.30	0.47
	Lifting Index > 3.0	-	1.00	0.32	0.48
	Lifting Index > 1.0	-	-	1.00	0.64
	PHRGM > 70	**-**	**-**	**-**	1.00
PATH	Non-neutral trunk flexion[1]	**0.24**	**0.25**	**0.17**	**0.15**
	Any force[1]	**0.10**	**0.03**	**0.48**	**0.05**
	Non-neutral trunk flexion and any force[1]	**0.18**	**0.16**	**0.17**	**0.18**
	Awkward posture[1,2]	**0.23**	**0.27**	**0.15**	**0.16**
	Any MMH[1,3]	**0.30**	**0.30**	**0.79**	**0.52**

[1] Percent of observed work day
[2] Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; or leg flexion > 35 degrees, kneel, squat, or stand one foot
[3] Manual materials handling and includes lift, lower, carry, push/pull, slide, or hold

Figure 8.1. Percent of time observed in commercial fishing tasks by crab pot (n=20) and gillnet (n=5) fishermen using Posture, Activities, Tools, and Handling (PATH) method

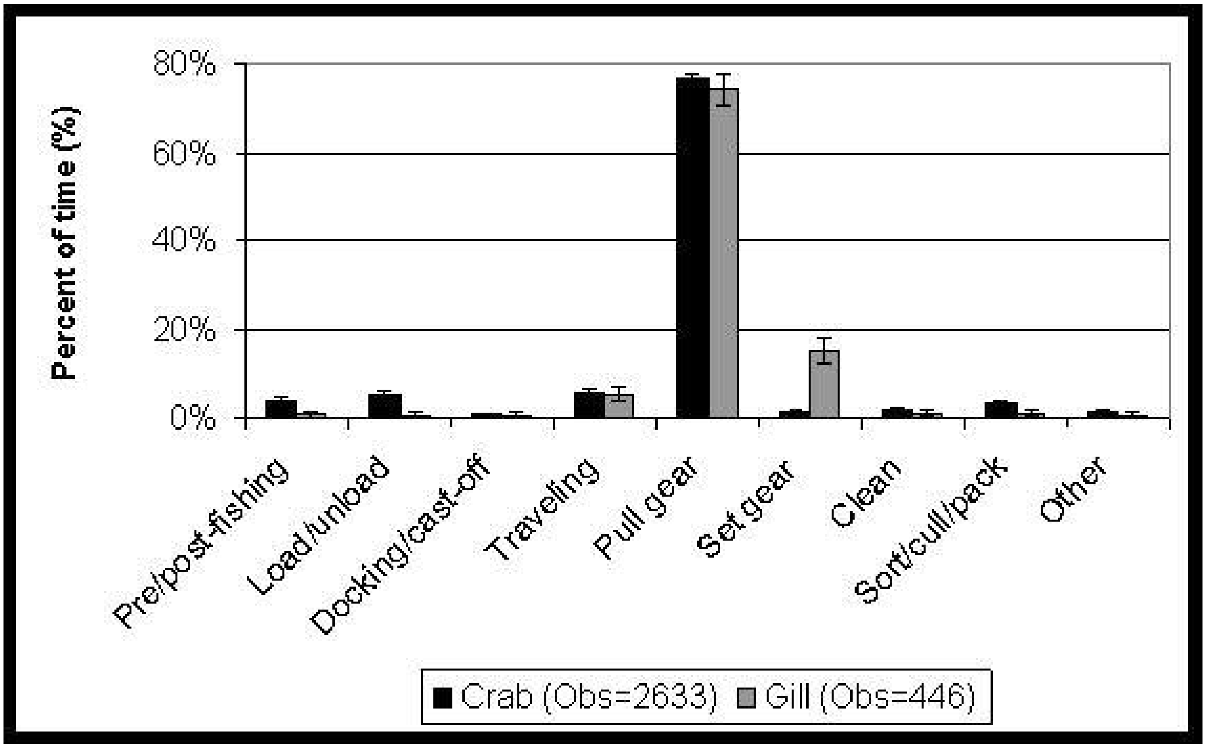


Figure 8.2. Percent of time observed handling loads or forces stratified by job title, captain (n=15), mate (n=8), 3rd man (n=2), helper (n=2), or fish house employee (n=2), for crab pot and gillnet fishing combined using Posture, Activities, Tools, and Handling (PATH) method

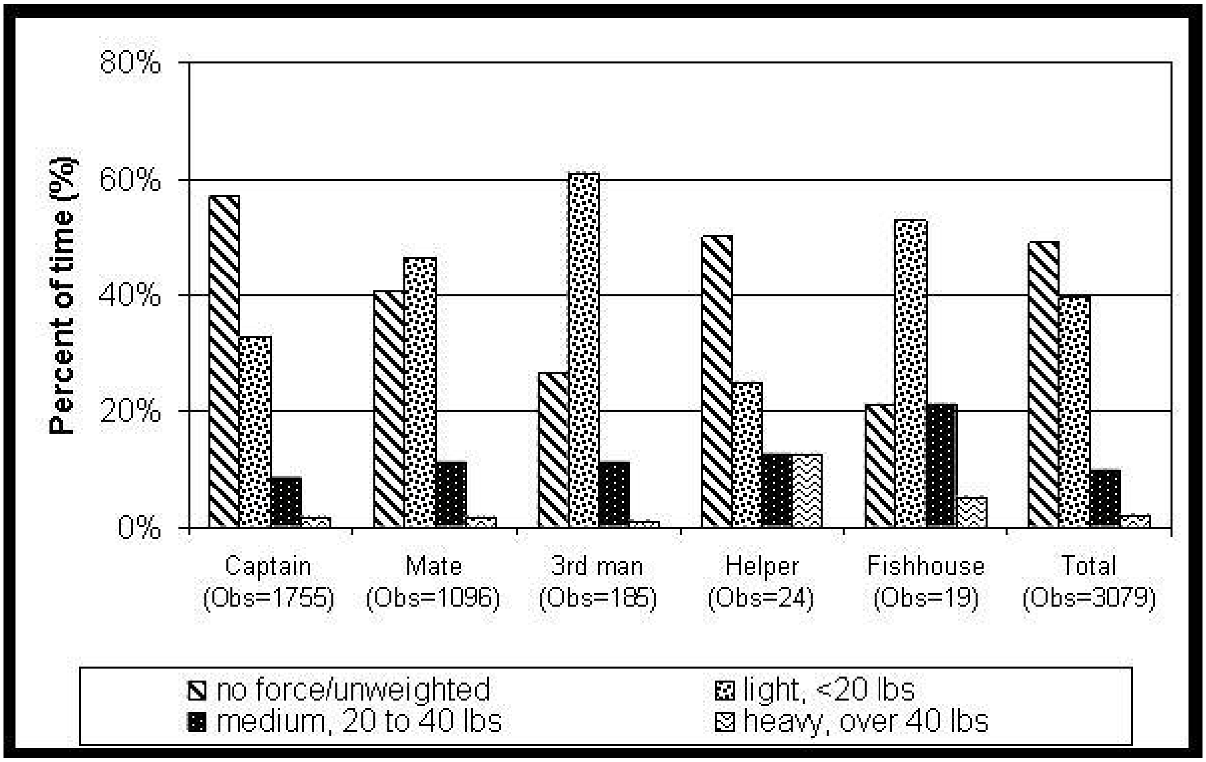


Figure 8.3. Addendum to Figure 4.3. Histogram of 3DSSPP lumbar spine compression (Newtons) comparing crab pot and gillnet commercial fishing crews using Continuous Assessment of Back Stress (CABS) method

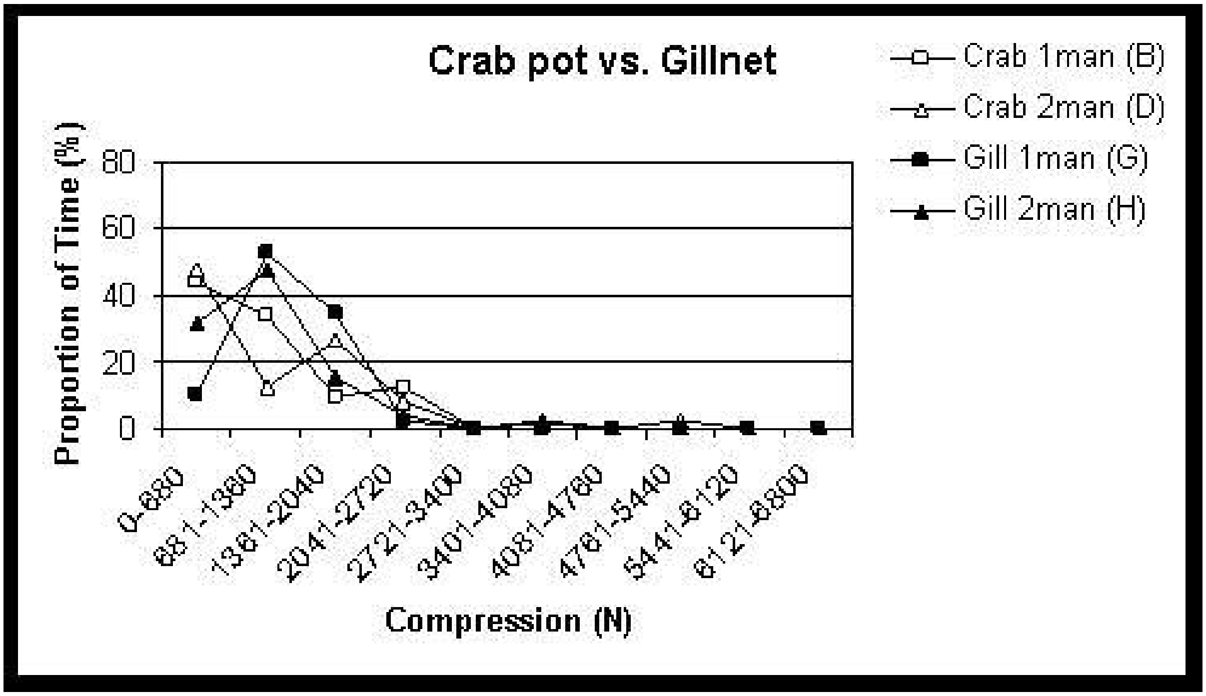
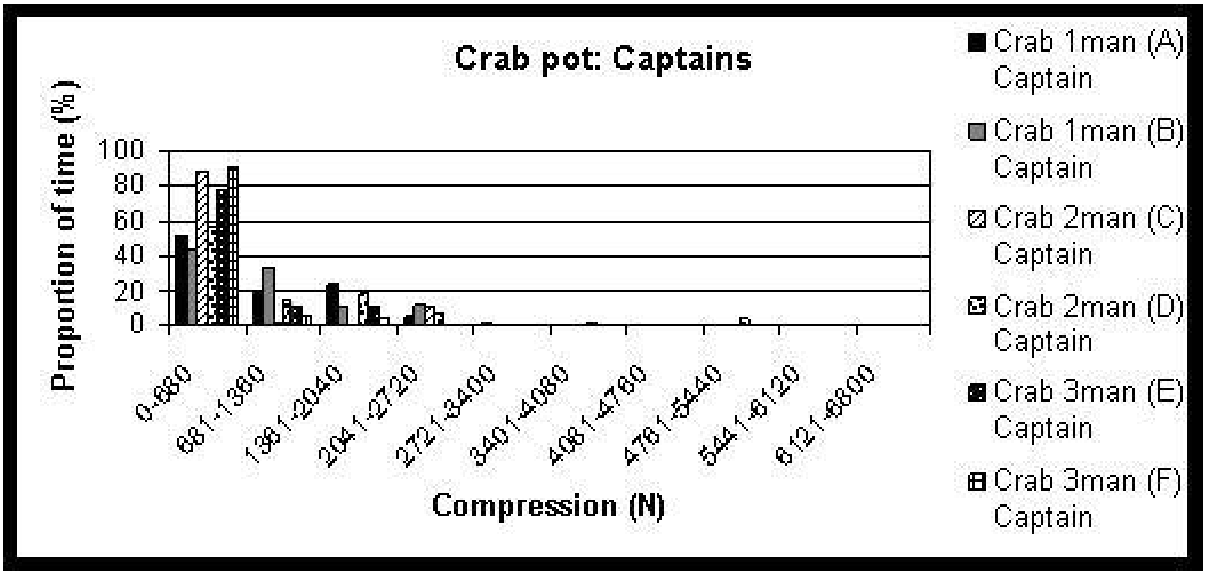
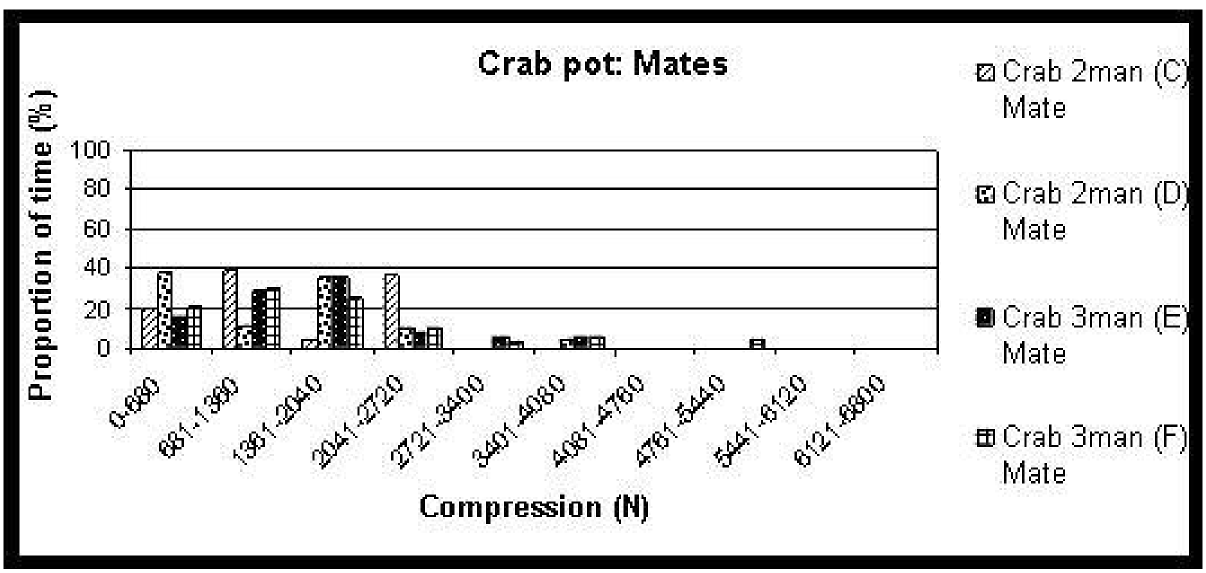


Figure 8.4. Histogram of 3DSSPP lumbar spine compression (Newtons) for crab pot fishing captain, mate, and 3rd man across different crew sizes using Continuous Assessment of Back Stress (CABS) method





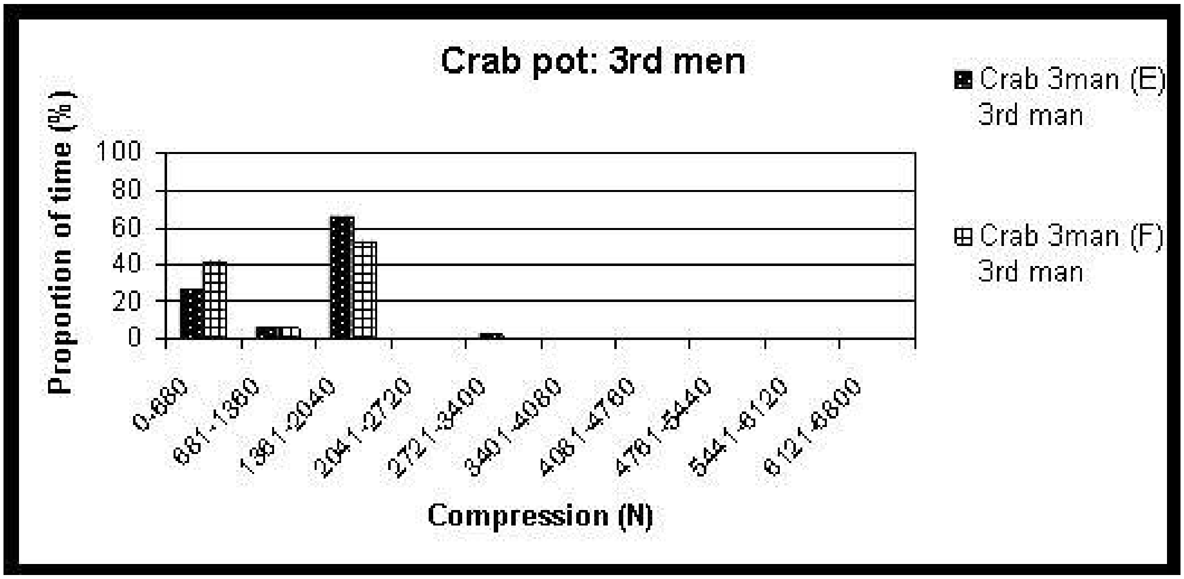
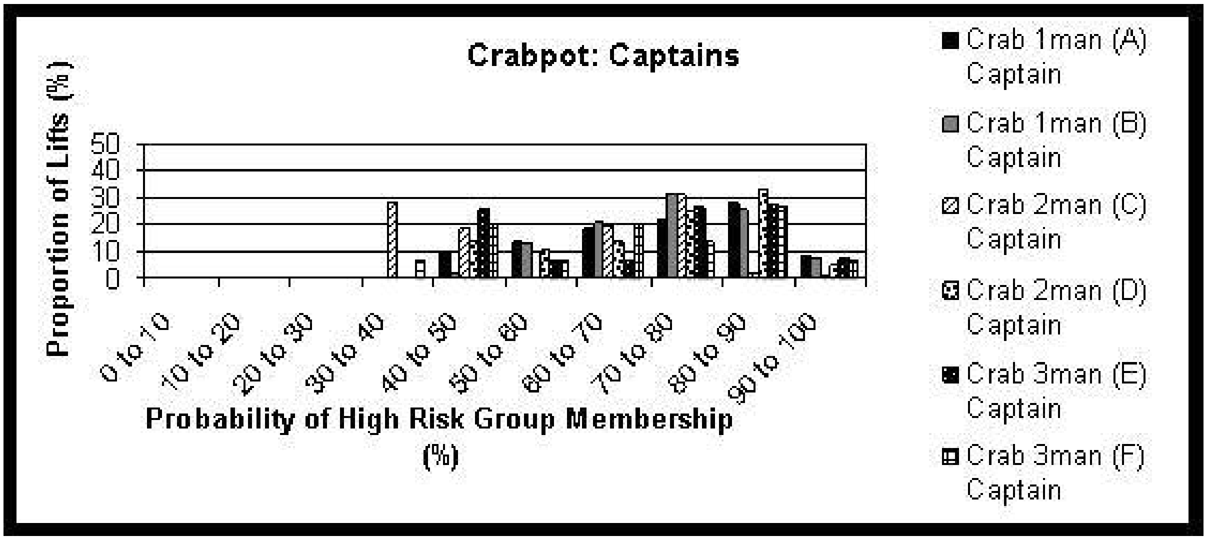
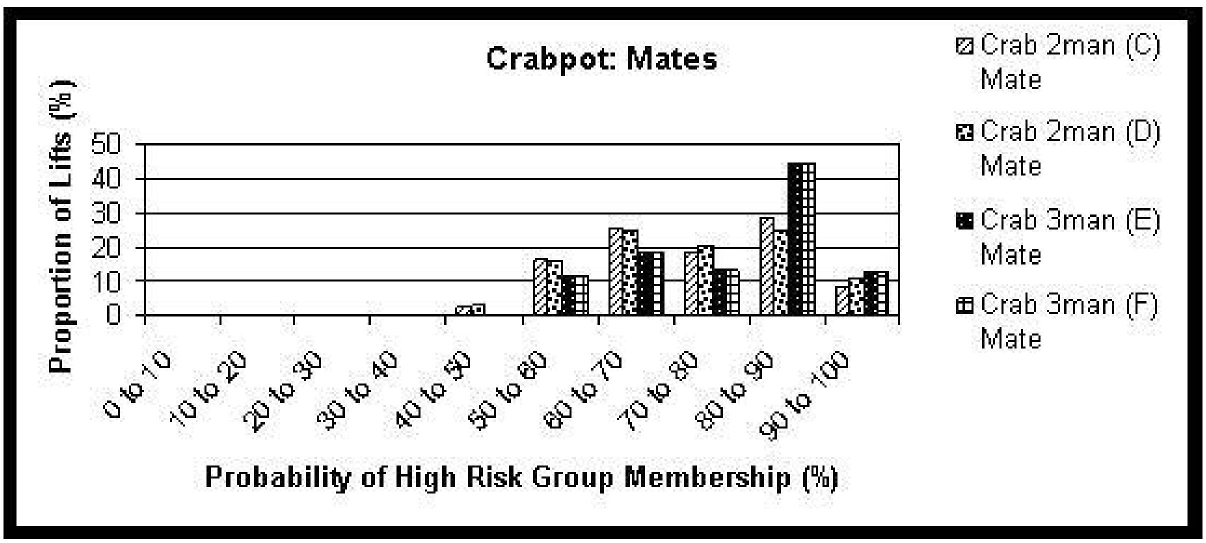

Crab pot: 3rd men
Crab 3man (E) 3rd man
Crab 3man (F) 3rd man
Proportion of time (%)
100
80
60
40
20
0
0-680
681-1360
1361-2040
2041-2720
2721-3400
3401-4080
4081-4760
4761-5440
5441-6120
6121-6800
Compression (N)

Figure 8.5. Histogram of LMM probability of high risk group membership for crab pot fishing captain, mate, and 3rd man across different crew sizes using Continuous Assessment of Back Stress (CABS) method





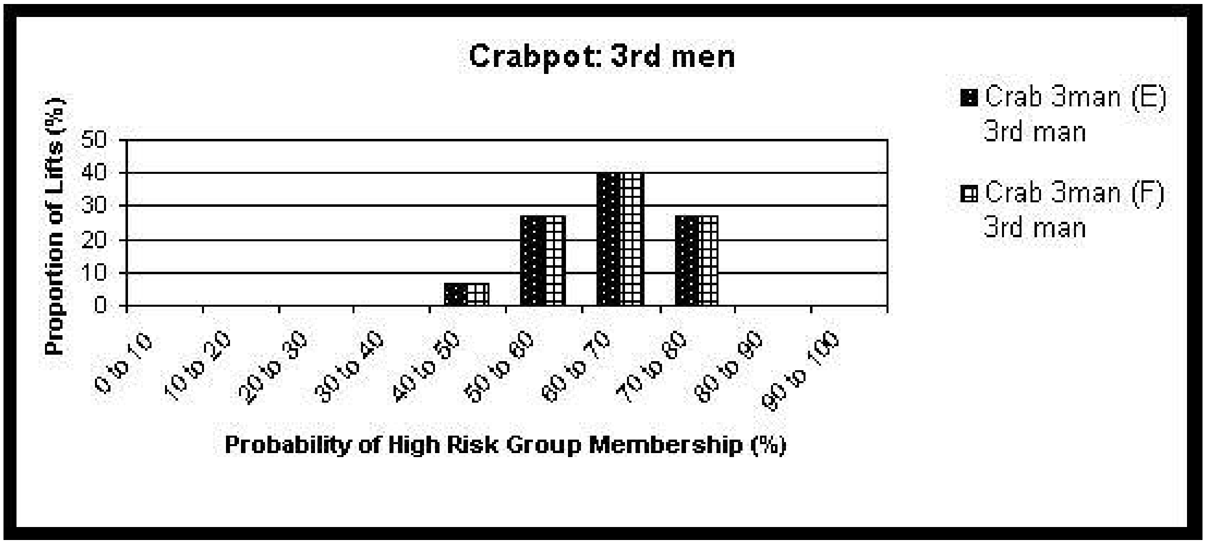
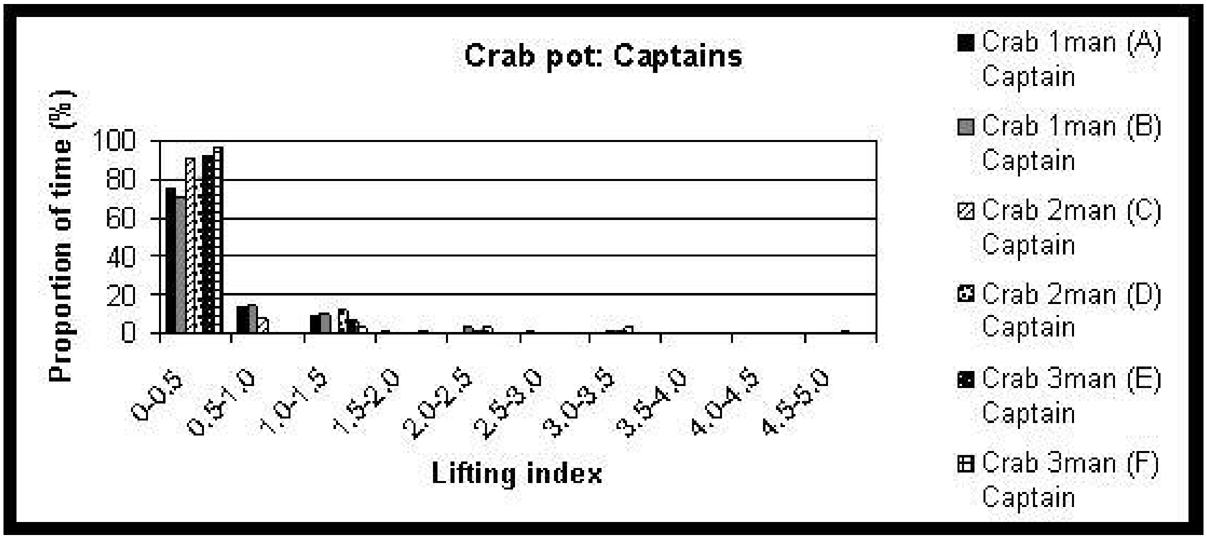
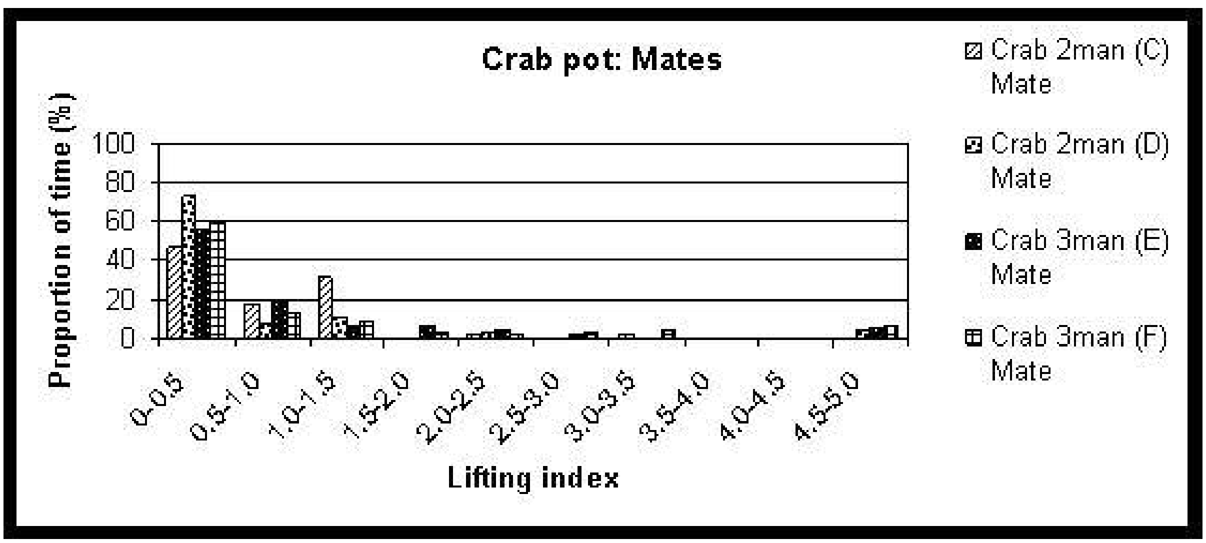

Crabpot: 3rd men
Crab 3man (E) 3rd man
Crab 3man (F) 3rd man
Proportion of Lifts (%)
50
40
30
20
10
0
0 to 10
10 to 20
20 to 30
30 to 40
40 to 50
50 to 60
60 to 70
70 to 80
80 to 90
90 to 100
Probability of High Risk Group Membership (%)

Figure 8.6. Histogram of NIOSHLE Lifting Index for crab pot fishing captain, mate, and 3rd man across different crew sizes using Continuous Assessment of Back Stress (CABS) method





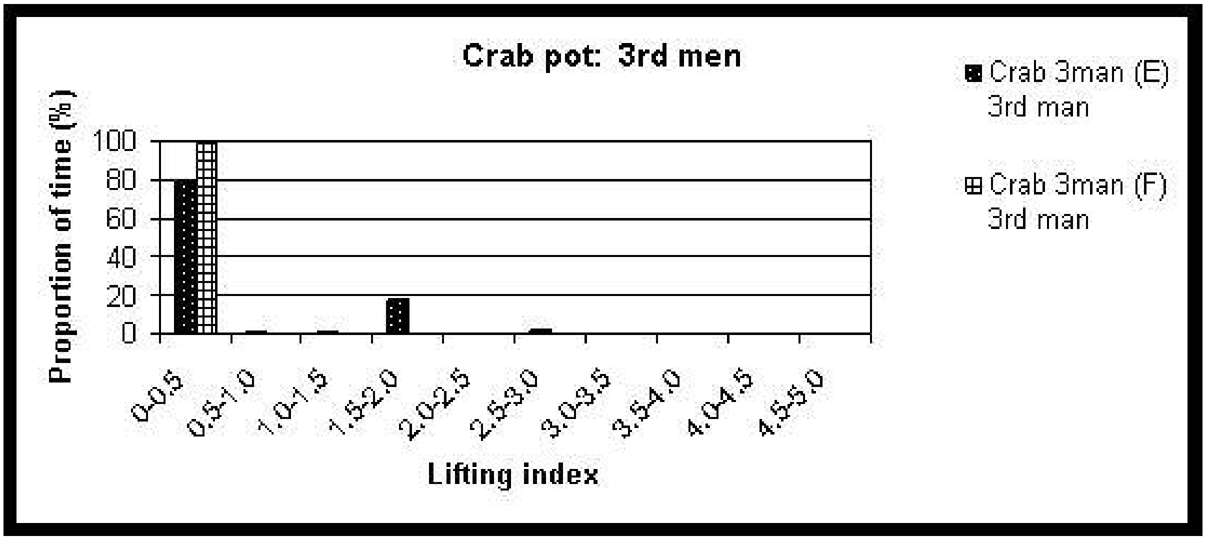
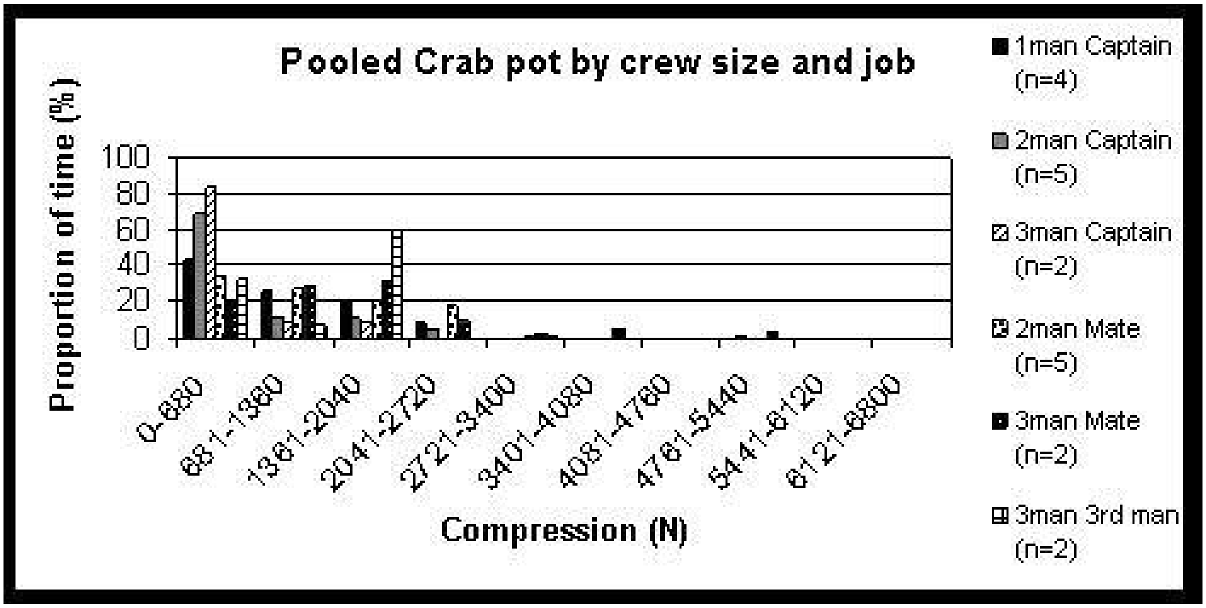

Crab pot: 3rd men
Crab 3man (E) 3rd man
Crab 3man (F) 3rd man
Proportion of time (%)
100
80
60
40
20
0
0-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
4.5-5.0
Lifting index

Figure 8.7. Histogram of 3DSSPP Compression for crab pot fishing pooled for crew size by job and by crew size using Continuous Assessment of Back Stress (CABS) method



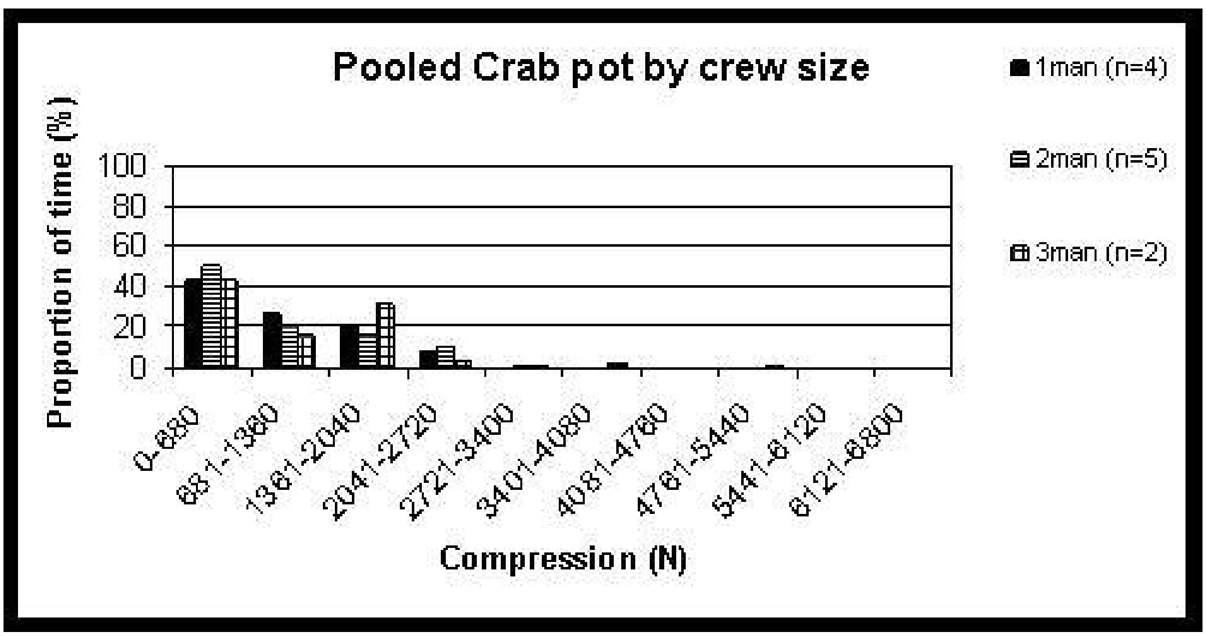
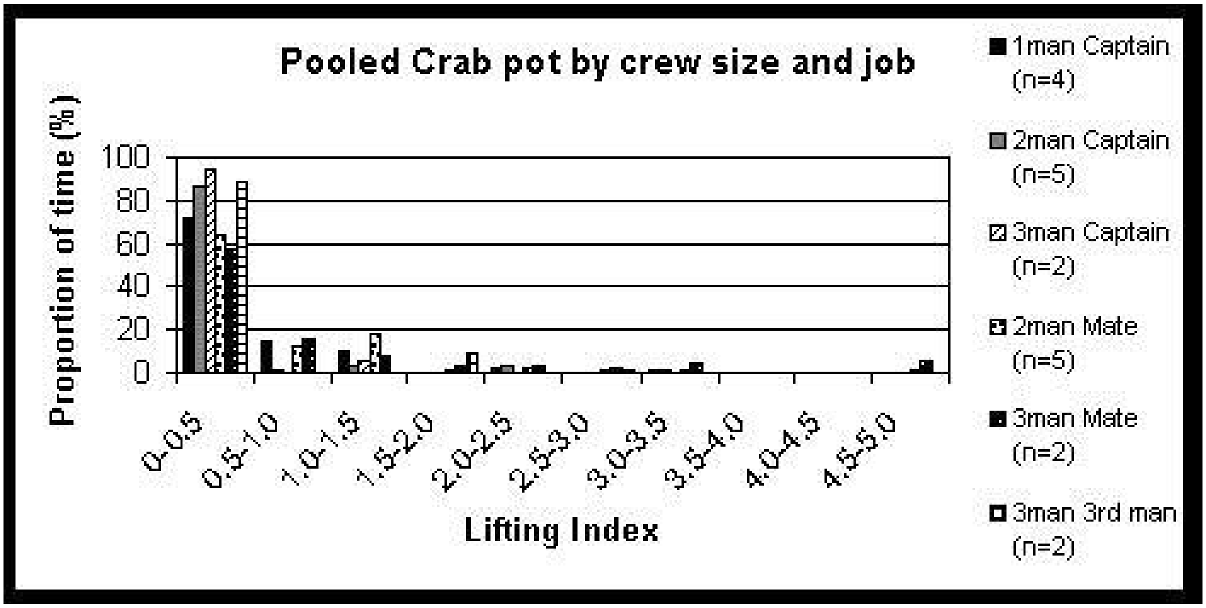


Figure 8.8. Histogram of NIOSH Lifting Index for crab pot fishing pooled for crew size by job and by crew size using Continuous Assessment of Back Stress (CABS) method



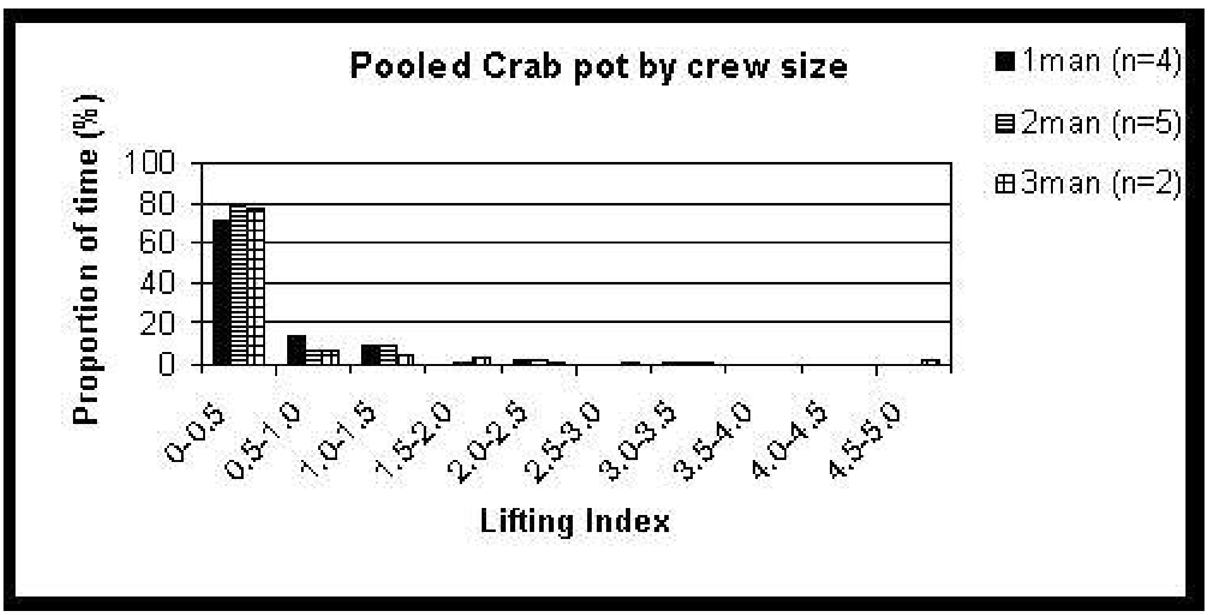
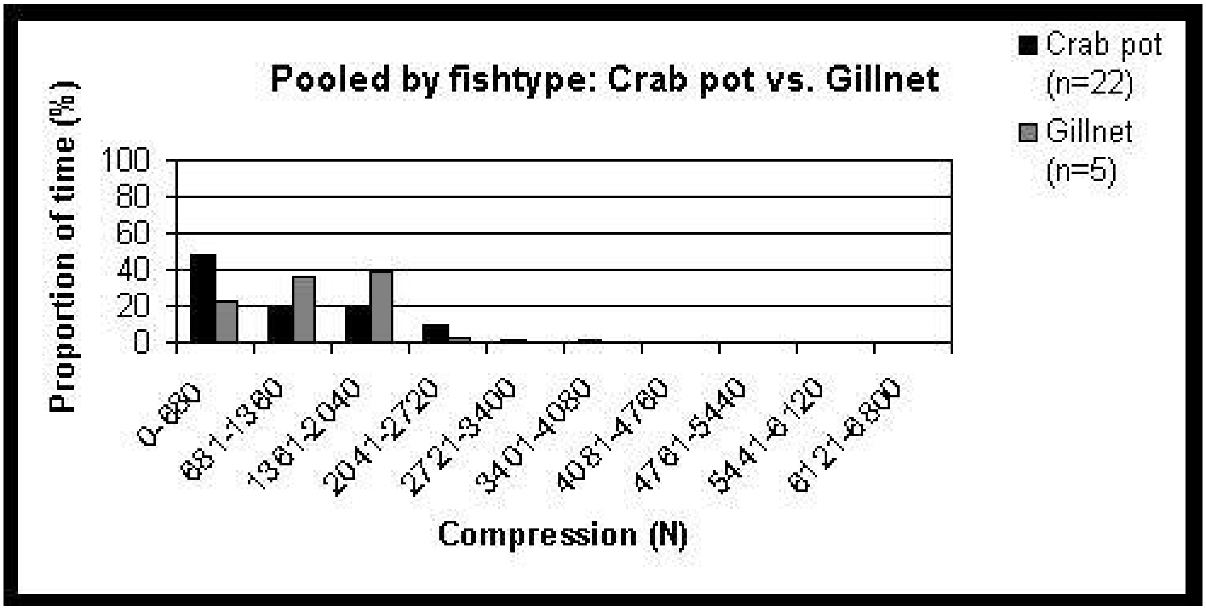
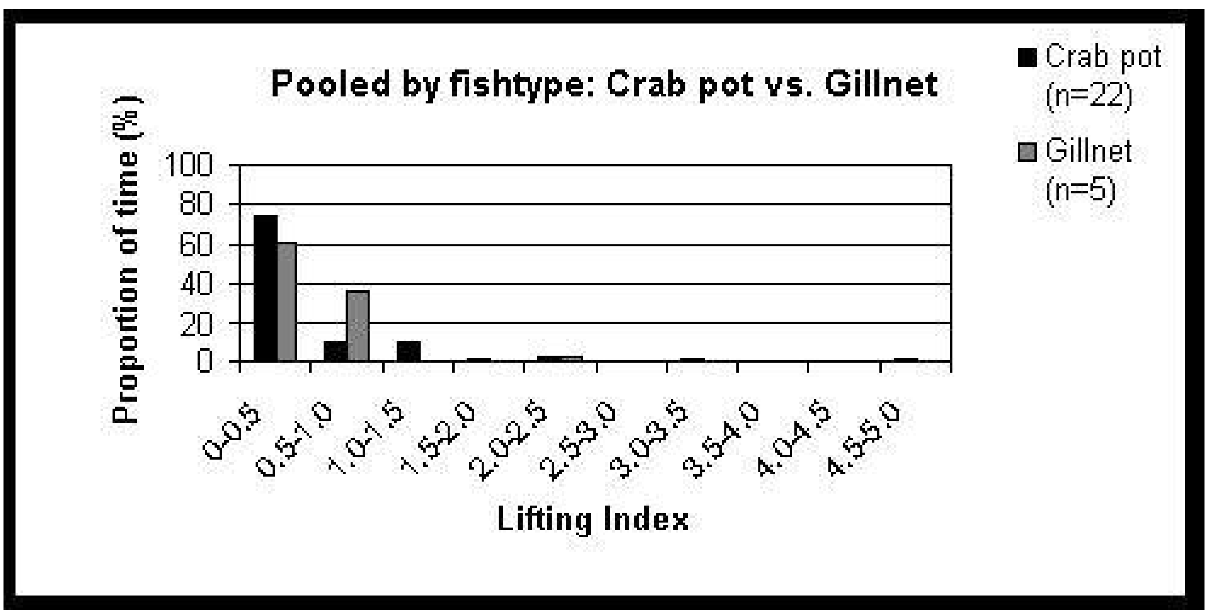


Figure 8.9. Histogram of 3DSSPP Compression and NIOSH Lifting Index pooled across fishing type crab pot and gillnet using Continuous Assessment of Back Stress (CABS) method





C. Additional Results for Paper #2

Table 8.7. Crab pot and gillnet fishermen: rate ratios and 95% confidence intervals for mean percent time exposed to low back stress and low back pain occurrences that interrupted or limited work (n=89, 313 visits)

	Fishing type	Percent time exposed to low back stress[1]	Inter-quartile range	Unadjusted Parameter†	RR	95% CI	Adjusted parameter†‡	RR	95% CI
PATH		Mean (se)							
Non-neutral trunk posture	Gillnet	27.6 (4.73)	14.0	0.0241	1.02	0.97, 1.08	0.0259	1.03	0.96, 1.09
	Crab pot	24.25 (2.81)	13.5	(0.0282)			(0.0329)		
Any force	Gillnet	87.2 (8.81)	10.0	0.0021	1.00	0.99, 1.01	0.0044	1.00	0.99, 1.02
	Crab pot	42.35 (4.02)	28.0	(0.0062)			(0.0067)		
Awkward posture[3]	Gillnet	8.6 (3.72)	13.0	0.0580	1.06	0.96, 1.17	0.0451	1.05	0.95, 1.15
	Crab pot	14.9 (2.75)	20.0	(0.0484)			(0.0501)		
Handling materials[4]	Gillnet	45.8 (9.43)	3.0	0.0051	1.01	0.98, 1.03	0.0093	1.01	0.98, 1.04
	Crab pot	24.6 (2.56)	10.0	(0.0122)			(0.0134)		
Non-neutral trunk and any force	Gillnet	21.4 (3.49)	9.0	0.0237	1.02	0.96, 1.09	0.0296	1.03	0.96, 1.11
	Crab pot	16.35 (2.82)	10.0	(0.0317)			(0.0373)		
CABS									
3DSSPP spine compression >3400 Newtons	Gillnet	0.83 (0.58)	1.9	0.2091 (0.1643)	1.23	0.89, 1.70	0.1545 (0.1721)	1.17	0.83, 1.64
	Crab pot	3.2 (1.38)	4.6						
NIOSHLE Lifting Index > 3.0	Gillnet	0.19 (0.10)	0.3	0.1751	1.19	0.90, 1.57	0.1251	1.13	0.85, 1.51
	Crab pot	3.2 (1.17)	4.1	(0.1416)			(0.1480)		
NIOSHLE Lifting Index > 1.0	Gillnet	36.67 (17.03)	56.8	0.0093	1.01	0.98, 1.04	0.0140	1.01	0.98, 1.05
	Crab pot	23.35 (4.80)	26.4	(0.0163)			(0.0186)		
LMM PHRGM > 70%	Gillnet	50.46 (10.17)	33.7	0.0160	1.02	0.98, 1.05	0.0141	1.01	0.98, 1.05
	Crab pot	52.7 (4.53)	23.4	(0.0173)			(0.0183)		

†Poisson regression estimates are adjusted for multiple visits per subject with GEE

‡Adjusted for other fishing types (shrimp, clam, oyster, eel, etc.) performed during follow up and age

1 Mean percent time in low back stress by fishing type measured in sample of fishermen

2 Awkward posture includes any of the following: trunk flexion >45 degrees, lateral bend or twist, trunk flexion with lateral bend or twist; one or both elbows above shoulder height; and legs bent >30 degrees, kneel, squat, or stand one foot
3 Lift, lower, carry, push/pull, slide, or hold

Table 8.8. Multivariate modeling of rate ratios and 95% confidence intervals† of low back pain occurrences that interrupted or limited work stratified by history of LBP limiting/interrupting work for North Carolina commercial fishermen (n=105, visits=358), 1999 to 2001

	History of severe LBP† n=36, visits=99		No history of severe LBP† n=80, visits=259	
	RR	95% CI	RR	95% CI
Trigger visit vs. regular visit	0.86	0.31, 2.38	1.92	0.63, 5.80
Sex - Female vs. male	1.47	0.70, 3.07	0.76	0.18, 3.10
Age‡				
18 to 21	4.59	1.21, 17.39	13.39	1.12, 160.8
22 to 29	4.71	1.73, 12.84	3.90	0.26, 58.9
30 to 39	1.00		1.00	
40 to 49	2.14	0.63, 7.31	3.13	0.36, 27.3
50 to 69	2.11	0.70, 6.35	6.80	0.87, 53.0
BMI*				
Obese	1.17	0.37, 3.7	0.87	0.24, 3.21
Over	1.27	0.39, 4.16	0.66	0.15, 2.79
Normal	1.00		1.00	
Current smoker vs. not	**2.07**	**0.95, 4.47**	**0.82**	**0.26, 2.58**
Non-commercial fishing job	**1.84**	**0.82, 4.13**	**0.61**	**0.19, 1.92**
Second job vs. no second job	**1.84**	**0.82,4.13**	**0.61**	**0.19, 1.92**
Fishing full-time (>=32 hrs/wk)	**2.79**	**0.48,16.12**	**0.60**	**0.20, 1.84**
Fishing year round (>=9 mo/yr)	0.90	0.39, 2.09	1.28	0.44, 3.74
Work on someone else's boat	1.36	0.57, 3.22	0.91	0.21, 3.93
Fishing type during follow up				
Finfish	**0.53**	**0.24, 1.16**	**2.10**	**0.61, 7.20**
Crab	1.08	0.52, 2.24	2.59	0.58, 11.57
Not crab or finfish	0.43	0.22, 0.84	0.63	0.20, 1.99
Shrimp	0.95	0.40, 2.25	0.63	0.14, 2.77
Clam	0.44	0.08, 2.47	0.58	0.07, 4.63
Oyster	0.34	0.06, 2.04	1.56	0.35, 6.96
Other	0.62	0.27, 1.39	1.32	0.30, 5.71
Greater than 1 fishing type	**0.57**	**0.27, 1.18**	**1.53**	**0.49, 4.74**
Gear=Gillnet	**0.60**	**0.27, 1.32**	**2.03**	**0.65, 6.29**
Gear=Crab pot	1.22	0.59, 2.51	3.30	0.74, 14.77
Average hours on the water per day*				
0 to 4	3.71	0.57, 24.0	0.68	0.14, 3.24
>4 to 6	4.07	0.61, 27.1	1.10	0.29, 4.22
>6 to 10	1.00		1.00	
>10	4.41	0.67, 29.2	2.48	0.32, 19.4
Years as a commercial fisherman				
0 to 9	2.69	1.48, 4.88	2.22	0.30, 16.3
10 to 19	1.18	0.31, 4.43	2.26	0.64, 7.99
20 to 29	1.49	0.55, 4.00	1.02	0.24, 4.38
30+ (ref)	1.00			

History of fishing with crew & alone versus only alone	0.60	0.19, 1.89	No estimate Parameter 25.11	
Self-identified job title held most often				
Captain	0.86	0.25, 2.95	0.13	0.04, 0.38
Mate	0.87	0.19, 4.00	0.27	0.08, 0.99
Other	1.00			
During the study 1999-2001				
Fished with crew vs. alone?	0.80	0.30, 2.14	1.59	0.51, 4.94
Work non-commercial fishing job	**1.23**	**0.56, 2.73**	**0.49**	**0.16, 1.55**
Did that job require you to:				
Twist or bend frequently	**1.16**	**0.47, 2.85**	**0.22**	**0.03, 1.72**
Work in awkward postures	1.17	0.43, 3.20	0.52	0.07, 4.17
Lift repetitively	1.80	0.74, 4.43	0.92	0.11, 7.53
Lift				
<=25 pounds	1.00‡		1.00	
>25 pounds	0.00‡	0.00, 0.00	1.46	0.36, 5.98
>50 pounds	**1.82‡**	**0.73, 4.50**	**0.44**	**0.06, 3.32**

†Poisson regression confidence intervals are adjusted for multiple visits per subject with GEE

‡ Age category confidence intervals are not adjusted for multiple visits per subject (no GEE)

* Missing values for BMI (n=2, visits=6) and average hours on the water (n=2, visits=6)

Estimates in bold are those where confidence intervals do not overlap estimates

Note: Fishermen can be in more than one stratum (i.e. in history negative strata until an occurrence of severe LBP putting them in history positive strata for next visit)

Table 8.9. Crab pot and gillnet fishermen: rate ratios and 95% confidence intervals for self-reported fishing task frequency and low back pain occurrences that interrupted or limited work stratified by history of LBP limiting/interrupting work (n=89, visits=313)

	History of severe LBP† n=36, visits=99		No history of severe LBP† n=80, visits=259	
Fishing Tasks*	RR	95% CI	RR	95% CI
Drive boat	**0.72**	**0.28, 1.84**	**3.52**	**0.47, 26.6**
Load bait and/or supplies	0.62	0.25, 1.51	No estimate Parameter 24.11	
Use dolly or lift to load bait and/or supplies	0.94	0.29, 3.04	0.77	0.10, 6.26
Pull in gear (hook/pull in pot or pull in net)	0.60	0.26, 1.41	1.24	0.31, 4.93
Run puller or net reel	**0.91**	**0.39, 2.17**	**3.40**	**1.21, 9.54**
Empty gear (shake crab pot or pick fish from net)	0.51	0.23, 1.16	No estimate Parameter 24.13	
Set gear (toss/push pot or run out net or toss net overboard)	0.64	0.29, 1.41	No estimate Parameter 24.17	
Sort catch on the boat	1.07	0.42, 2.69	2.45	0.79, 7.62
Unload catch and/or supplies	0.54	0.25, 1.19	No estimate Parameter 25.23	
Use dolly or lift to unload catch and/or supplies	1.30	0.54, 3.10	3.05	0.87, 10.7
Sort catch at the fish house**	0.87	0.29, 2.66	1.20	0.40, 3.56
Clean boat	**0.49**	**0.22, 1.09**	**3.09**	**0.43, 22.5**
Perform routine maintenance on boat or gear	**0.72**	**0.32, 1.62**	**4.98**	**0.66, 37.6**

† Poisson regression estimates are adjusted for multiple visits per subject with GEE
*Referent: performing that task half the time or less
Estimates in bold are those where confidence intervals do not overlap estimates

Note: Fishermen can be in more than one stratum (i.e. in history negative strata until an occurrence of severe LBP putting them in history positive strata for next visit)

D. Sensitivity Analysis

Exposures assigned by group status are subject to potential misclassification and could potentially bias risk estimates. If exposure misclassification is independent of outcome status (non-differential), the estimate will generally be biased toward the null (Checkoway, Pearce et al. 2004). If exposure is assigned by group status (e.g. job title from self-report or work records) and the individual is assigned to the wrong group (information bias) or there is high variability of exposure within the group there could be inherent misclassification of exposure. The magnitude of overlap in the exposure distributions can be applied in sensitivity analyses to determine the amount and direction of bias (Burdorf 1993).

Studies have reported sensitivity and specificity of exposure assignment by job title for non-neutral trunk posture (97%, 68%) and heavy weight handling (85%, 58%). Confounding bias in the back injury rate ratio was 25% for postures and 45% for heavy weight handling (Gardner, Landsittel et al. 2000). To explore the potential for misclassification in our assignment strategy, a sensitivity analysis was performed for greater than 20% of time exposed to non-neutral trunk postures estimated with PATH (Appendix Figure 7.1). PATH measurements were considered the "gold standard" and were compared against calculated means by grouping factors. The combination of crew size and job title (94% sensitivity and 78% specificity) followed by job title alone (78% sensitivity and 81% specificity) performed best compared to PATH measurements. Fishing type alone performed poorly (33% sensitivity and 88% specificity).

Figure 8.10. Sensitivity and Specificity of percent time exposed to PATH non-neutral trunk posture in 25 crab pot and gillnet fishermen

Exposure Missclassification

Truth - measured

		Exp	Unexp	
Classified	Exp	a	b	Sensitivity =a/(a+c)
	Unexp	c	d	
		a+c	b+d	Specificity =d/(c+d)

Percent of time in nonneutral postures

JOB TITLE

		PATH >20% Nonneut	<=20% Neutral		
>20%	Mate (29%)	9	1	Sens	56%
<=20%	Captain (19%)	7	8	Spec	89%

note: 3rd man=50%

		PATH >25% Nonneut	<=25% Neutral		
>25%	Mate (29%)	7	3	Sens	78%
<=25%	Captain (19%)	2	13	Spec	81%

CREW SIZE

		PATH >20% Nonneut	<=20% Neutral		
>20%	Alone (26%)	6	1	Sens	38%
<=20%	With others (19.7%)	10	8	Spec	89%

note: 3man=35%

		PATH >25% Nonneut	<=25% Neutral		
>25%	Alone (26%)	2	5	Sens	22%
<=25%	With others (19.7%)	7	11	Spec	69%

CREW SIZE & JOB TITLE

		PATH >20% Nonneut	<=20% Neutral		
>20%	1man capt 2man mate 3man mate 3man 3rd	15	2	Sens	94%
<=20%	2man capt 3man capt	1	7	Spec	78%

		PATH >25% Nonneut	<=25% Neutral		
>25%	1man capt (25.1%) 2man mate (27%) 3man mate (35%) 3man 3rd (51%)	9	8	Sens	100%
<=25%	2man capt (12%) 3man capt (20%)	0	8	Spec	50%

FISHTYPE

		PATH >20% Nonneut	<=20% Neutral		
>20%	Crabpot and gillnet	16	9	Sens	100%
<=20%	Other	0	0	Spec	0%

note: 3man=35%

		PATH >25% Nonneut	<=25% Neutral		
>25%	Gillnet (27.6%)	3	2	Sens	33%
<=25%	Crabpot (24.3%)	6	14	Spec	88%

Studies have found differential reporting in self-reported duration and frequency of work exposures by LBP status (Viikari-Juntura, Rauas et al. 1996). We did not see evidence of any differential reporting in the frequency of task performance.

E. Instruments

1. Supplemental Questionnaire

<u>Second Time Questionnaire:</u>
<u>Occupational Injuries Among NC Commercial Fishermen Study</u>

Some of you have answered a few of these questions in a previous questionnaire. We appreciate your time and ask that you answer them anyway. Some of these questions may seem repetitious. We appreciate your patience and request that you answer them anyway.

Part I: Work history
This first part will ask you questions about your work history as a commercial fisherman/fisherwoman.

SQ1) How old were you when you learned to fish commercially? _______________years

SQ2) When you first started to fish, did you ever work alone? *(Circle one)*YES / NO
When you worked alone: SQ2a) Did you finfish?YES / NO
SQ2b) Did you oyster?YES / NO
SQ2c) Did you crab? YES / NO
SQ2d) Did you clam?YES / NO
SQ2e) Did you shrimp? YES / NO
SQ2f) Did you do other types of fishing? YES / NO
SQ2fspec) Please specify:____________________________

SQ3) When you first started to fish, did you ever work with others as a crewman? *(Circle one)*YES / NO
When you worked with others: SQ3a) Did you finfish?YES / NO
SQ3b) Did you oyster? YES / NO
SQ3c) Did you crab? YES / NO
SQ3d) Did you clam? YES / NO
SQ3e) Did you shrimp? YES / NO
SQ3f) Did you do other types of fishing? YES/ NO
SQ3fspec) Please specify:_______________________

SQ4) *Coded in from answers to a-c*
SQ4a) Did you make money as a fisherman when you were in High School? YES/NO
SQ4b) Did you work as a commercial fisherman during the summer? YES / NO
SQ4c) Did you work also while you were in school? (during the school year) YES / NO
Code: 1= never in HS 2= summer only 3= school year only 4= both

SQ5) Who taught you to fish commercially? *Record:* ___________________
Code:
1=father
2=other family
3=friend
4=other
5=spouse
6=self
7=other fisherman
8=grandfather

SQ6) How many years have you worked as a commercial fisher(man/woman)?
Record: ________ years
Prompt: What year did you start? Calculate from birth date.

SQ7) For this study, we defined full-time as working at least 6 months of the year and working over 20 hours per week. Of the __________ *years* you said you worked as a commercial fisher(man/woman), how many years did you work full-time? *Record:* ________ years

SQ8) When fishing full time what title best describes the job you held most often as a commercial fisherman/woman, was it: a captain, a mate, a third man or a co-captain?
Record: _____________
Code:
1=Captain or crew captain
3=mate
4=3rd man
5=co-captain
2=other, specify: _______________

FOR INTERVIEWER TO HELP WITH ANSWERS
CAPTAIN*: OWNS BOAT, IN CHARGE, DRIVES, EMPLOYS CREW, OR WORKS ALONE /DOES EVERYTHING*
CO-CAPTAIN: *TWO PEOPLE SHARING RESPONSIBILITIES, TASKS, & AUTHORITY EQUALLY*
MATE: *EMPLOYED BY CAPTAIN, DOESN'T SHARE IN AUTHORITY*
3RD MATE: *USUALLY YOUNG, DOES A FAIR AMOUNT OF SORTING, LIFTING, UNLOADING, ETC.*

Part II: History during 1999-2001
This next part asks you about fishing work and activities during the time of the study, 1999-2001.

SQ9) During the time of the study, did you own the boat you worked on? *(Circle one)* YES/NO

IF NO, SKIP TO SQ10. IF YES, SKIP TO SQ9A

SQ9a) Did you work *only* on your own boat? *(Circle one)* YES / NO

IF YES, SKIP TO SQ10. IF NO, SKIP TO SQ9B

SQ9b) Did you work more on someone else's boat or your own boat? *(Circle one)*

Someone else's / Own

SQ10) Did you fish with other people/crew? *(Circle one)* YES / NO

SQ11) How would you describe the job you had on the boat during the time of the study 1999-2001?

**PROMPTS: DESCRIBE PROCESS, WHAT TASKS DID YOU DO ON THE BOAT, DID YOU DRIVE, ETC.*

**IF RETIRED ASK WHAT DID IN THE YEAR PRIOR TO RETIREMENT*

WRITE IN REMARKS VERBATIM HERE.

Part III: Crab potting during 1999-2001

We are going to ask you about activities related to crab potting during the study period 1999-2001.

SQ12) We understand from the telephone interviews that you fished with crab pots.

Is this correct? YES / NO

***********IF NO, GO TO GILL NETTING, GREEN PAGES: PAGE 11**************

SQ13) When you crabbed, did you work alone, with others crewmen, or both?
Record: ___________

Code: *1=alone* *2=others* *3=both*

↓ ↓

SQ13a) Including yourself, how many crewmen were usually on the boat when you worked with others? *Record:*______ people

Code: *2 = 2-man* *3 = 3-man* *4 = other*

IF CRABBED WITH CREW, ESTIMATE THE DIVISION OF TIME FOR EACH TYPE.

Probe: How much of the time (days/week) did you work alone vs. with x-man crew?

In an average week, how many days did you spend working alone and with others?

SQ13a1) *Record*: _________ days/week crab alone

SQ13a2) *Record:* ________ days/week crab on 2-man crew

SQ13a3) *Record:* ________ days/week crab on 3-man crew

SQ13a4) *Record:* ___________ days/week other

*******************RECORD RESPONSES ON RECALL STICKER IN FOLDER*****************

SQ13b) Does this vary by month? *(Circle one)* YES / NO

WRITE REMARKS HERE:

I'm now going to ask you about crab potting during each month of the year during the time of the study, 1999-2001. I'll ask you each month if you crabbed, how many pots on average you pulled per day during that month, and what size crew you usually work with each month. If your answers are the same for several months you can indicate that otherwise I will ask you the information about each month.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
SQ14) Did you crab in…? *(circle one)*	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
SQ15) How many pots on average did you pull per day during the month of…? *Record range*	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max
SQ16) What crew size did you usually work with during the month of…? *Record range*												

SQ17) On a day when you crabbed, how many hours did you spend on the water? I mean from the time you left the dock to the time you got back to the dock?

Season non-specific: *Record:* ___________ hours

SQ18) *Prompt if given only one number…*Did this vary by time of year? *Record:* YES / NO

SQ18a) Early spring/late Fall: *Record:* ___________ hours

SQ18b) Summer: *Record :*___________ hours

SQ19) What time did you usually leave the dock?

Season non-specific: *Record:* ______:______AM PM

SQ20) *Prompt if given only one number…*Did this vary by time of year?
Record: YES / NO

SQ20a) Early spring/late Fall:
Record:_______:______ AM PM

SQ20b) Summer:
*Record:*______:______ AM PM

SQ21) What time did you get back to the dock?

Season non-specific: *Record*: _______:_____ AM PM

SQ22) *Prompt if given only one number…*Did this vary by time of year?
Record: YES / NO

SQ22a) Early spring/late Fall:
Record:______:______ AM PM

SQ22b) Summer:
Record:______:______ AM PM

SQ23) On a day that you crabbed, how long did it usually take you to load up bait, gas, and other supplies to get ready to get on the water? *(not including your commute)*
Record: ____ minutes hours

SQ24) Now, after you returned to the dock after crabbing, how long did it usually take you to unload the boat, get the catch to the fish house and finish whatever other fishing related activities were necessary? *(not including your commute)*
Record: ____ minutes hours

I'm now going to ask you about the tasks that you do while crab pot fishing. You indicated that you fish:

********REFER TO THE RECALL STICKER IN THE FOLDER *********

Circle one:	**IF FISHES:**	ALONE	2-MAN	3-MAN	OTHER
	ASK:	SQ25	SQ26	SQ27	

<<<<<<<<<<<<<<<<<<<<<<<<< **ALONE** >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

SQ25) When you crabbed by yourself during 1999-2001 did you…? How often? *(circle one)*

Alone	**Never**	**Less than half**	**About half**	**More than half**	**Everytime**	*Code*
SQ25a) …use a dolly or lift to load your boat?	0	1	2	3	4	
SQ25b) …sort catch on boat?	0	1	2	3	4	
SQ25c) …unload catch from boat?	0	1	2	3	4	
SQ25d) …use a dolly or lift to unload?	0	1	2	3	4	
SQ25e) …sort catch at the fishhouse?	0	1	2	3	4	

SQ25f) …clean boat	0	1	2	3	4	
SQ25g) …do routine maintenance for boat or gear?	0	1	2	3	4	

Uses the likert scale below for responses:
0 = NEVER
1 = LESS THAN HALF THE TIME BUT MORE THAN NEVER
2 = HALF THE TIME
3 = MORE THAN HALF AND LESS THAN ALWAYS
4 = EVERYTIME OR EVERYDAY

<<<<<<<<<<<<<<<<<<<<< 2-MAN CREW >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

SQ26) When you crabbed in a 2-man crew during 1999-2001 did you…? How often? *(circle one)*

Two man crew	**Never**	**Less than half**	**About half**	**More than half**	**Everytime**	*Code*
SQ26a) …drive boat?	0	1	2	3	4	
SQ26b) …load bait or supplies?	0	1	2	3	4	
SQ26c) …did you use a dolly or lift to load?	0	1	2	3	4	
SQ26d) …pull/hook pots?	0	1	2	3	4	
SQ26e) …run pot puller?	0	1	2	3	4	
SQ26f) …empty pots?	0	1	2	3	4	
SQ26g) …bait pots?	0	1	2	3	4	
SQ26h) …set pots?	0	1	2	3	4	
SQ26i) …sort catch on boat?	0	1	2	3	4	
SQ26j) …unload catch from boat?	0	1	2	3	4	

SQ26k) … use a dolly or lift to unload?	0	1	2	3	4	
SQ26l) …sort catch at the fishhouse?	0	1	2	3	4	
SQ26m) …clean boat?	0	1	2	3	4	
SQ26n) … do routine maintenance for boat or gear?	0	1	2	3	4	

Uses the likert scale below for responses:
0 = NEVER
1 = LESS THAN HALF THE TIME BUT MORE THAN NEVER
2 = HALF THE TIME
3 = MORE THAN HALF AND LESS THAN ALWAYS
4 = EVERYTIME OR EVERYDAY

<<<<<<<<<<<<<<<<<<<<<< **3-MAN CREW** >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

SQ27) When you crabbed in a 3-man crew during 1999-2001 did you…? How often? *(circle one):*

Three man crew	**Never**	**Less than half**	**About half**	**More than half**	**Everytime**	*Code*
SQ27a) …drive boat?	0	1	2	3	4	
SQ27b) …load bait or supplies?	0	1	2	3	4	
SQ27c) … use a dolly or lift to load?	0	1	2	3	4	
SQ27d) …pull/hook pots?	0	1	2	3	4	
SQ27e) …run pot puller?	0	1	2	3	4	
SQ27f) …empty pots?	0	1	2	3	4	
SQ27g) …bait pots?	0	1	2	3	4	
SQ27h) …set pots?	0	1	2	3	4	
SQ27i) …sort catch on boat?	0	1	2	3	4	
SQ27j) …unload catch from boat?	0	1	2	3	4	
SQ27k) … use a dolly or lift to unload?	0	1	2	3	4	

SQ27l) …sort catch at the fishhouse?	0	1	2	3	4	
SQ27m) …clean boat?	0	1	2	3	4	
SQ27n) … do routine maintenance for boat or gear?	0	1	2	3	4	

Uses the likert scale below for responses:
0 = NEVER
1 = LESS THAN HALF THE TIME BUT MORE THAN NEVER
2 = HALF THE TIME
3 = MORE THAN HALF AND LESS THAN ALWAYS
4 = EVERYTIME OR EVERYDAY

Part IV: Gill Net Fishing during 1999-2001

We are going to ask you about activities related to gill net fishing during the study 1999-2001.

SQ28) We understand from your telephone interviews that you fished with gill nets.
Is that correct? YES / NO

IF NO, GO TO GENERAL AND MUSCULOSKELETAL QUESTIONS ON WHITE PAPER PAGE 17*

SQ29) When you gill netted, did you work alone, with other crewmen, or both?
Record: ___________
Code: *1=alone* *2=others* ↓ *3=both* ↓

SQ29a) Including yourself, how many crewmen were usually on the boat when you worked with others?
Record: _____ people

Code: *2= 2-man* *3= 3-man* *4= other*

IF GILL NETTED WITH CREW, ESTIMATE THE DIVISION OF TIME FOR EACH TYPE.

In an average week, how many days did you spend working alone vs. working with others?

SQ29a1) *Record:* _________ days/week gill net alone

SQ29a2) *Record:* _________ days/week gill net on 2-man crew

SQ29a3) *Record:* _________ days/week gill net on 3-man crew

SQ29a4) *Record:* ____________ days/week other

*******RECORD RESPONSES ON RECALL STICKER IN FOLDER*******

SQ29b) Did this vary by month? *(Circle one)*
YES / NO

WRITE REMARKS HERE:

I'm now going to ask you about gill net fishing during each month of the year in the time of the study, 1999-2001. I'll ask you each month if you gill netted, how many nets on average you set and pulled per day during that month, and what size crew you usually work with each month. If your answers are the same for several months you can indicate that otherwise I will ask you the information about each month.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
SQ30) Did you gill net during the month of…? *Circle one*	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
SQ31) How many nets did you set/pull per day during the month of…? *Record range*	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max	____ min ____ max
SQ32) What crew size did you gill net with during the month of…? *Record range*												

SQ33) On a day when you fished with gill nets, how many hours did you spend on the water? I mean from the time you left the dock to the time you got back to the dock?

Season non-specific: *Record:* ___________ hours

SQ34) *Prompt if given only one number…*Did this vary by time of year?
Record: YES / NO

SQ34a) Early spring/late Fall: *Record:*___________ hours

SQ34b) Summer: *Record:*___________ hours

SQ35) What time did you usually leave the dock?

Season non-specific: *Record:* ______:______ AM PM

SQ36) *Prompt if given only one number…*Did this vary by time of year?
Record: YES / NO

SQ36a) Early spring/late Fall: *Record:*______ : _______ AM PM

SQ36b) Summer: *Record:*_______ : ______ AM PM

SQ37) What time did you get back to the dock?

Season non-specific: *Record:* _____ : _____ AM PM

SQ38) *Prompt if given only one number…*Did this vary by time of year?
Record: YES / NO

SQ38a) Early spring/late Fall: *Record:* ______ : ______ AM PM

SQ38b) Summer: *Record:* ______ : ______ AM PM

SQ39) On a day that you gill netted, how long did it take you to load up gas and other supplies to get ready to go out on the water at the dock? *(not commute time)*
Record: _______ minutes hours

SQ40) Now, after you returned to the dock after gill netting, how long did it usually take you to unload the boat, get the catch to the fish house and finish whatever other activities were necessary? *(not commute time)*

Record: _______ minutes hours

I'm now going to ask you about the tasks that you do while gill net fishing. You indicated that you fish:

******* ***REFER TO THE RECALL STICKER IN THE FOLDER*** ***********

Circle one:	**IF FISHES:**	ALONE	2-MAN	3-MAN	OTHER
	ASK:	SQ41	SQ42	SQ43	

<<<<<<<<<<<<<<<<<<<<<<<<<<< **ALONE** >>>>>>>>>>>>>>>>>>>>>>

SQ41) When you gill netted by yourself during 1999-2001 did you…? How often? *(circle one)*

Alone		**Never**	**Less than half**	**Half**	**More than half**	**Everytime**	*Code*
SQ41a)	…use a dolly or lift to load supplies?	0	1	2	3	4	
SQ41b)	…sort catch on boat?	0	1	2	3	4	
SQ41c)	…unload catch from boat?	0	1	2	3	4	
SQ41d)	…use a dolly or lift to unload?	0	1	2	3	4	
SQ41e)	…sort catch at fishhouse?	0	1	2	3	4	
SQ41f)	…clean boat?	0	1	2	3	4	
SQ41g)	…do routine maintenance for boat or gear?	0	1	2	3	4	

Uses the likert scale below for responses:
0 = NEVER

1 = LESS THAN HALF THE TIME BUT MORE THAN NEVER
2 = HALF THE TIME
3 = MORE THAN HALF AND LESS THAN ALWAYS
4 = EVERYTIME OR EVERYDAY

<<<<<<<<<<<<<<<<<< 2-MAN CREW >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

SQ42) When you gill netted in a 2-man crew during 1999-2001 did you…? How often? *(circle one)*

Two man crew	**Never**	**Less than half**	**Half**	**More than half**	**Everytime**	*Code*
SQ42a) …drive boat?	0	1	2	3	4	
SQ42b) …load gear & supplies?	0	1	2	3	4	
SQ42c) …use a dolly or lift to load?	0	1	2	3	4	
SQ42d) …run net reel? *(skip if boat doesn't have net reel)*	0	1	2	3	4	
SQ42e) ...set net?	0	1	2	3	4	
SQ42f) ...pull net?	0	1	2	3	4	
SQ42g) …pick net?	0	1	2	3	4	
SQ42h) …sort catch on the boat?	0	1	2	3	4	
SQ42i) …ice down catch?	0	1	2	3	4	
SQ42j) …unload catch from boat?	0	1	2	3	4	
SQ42k) …use a dolly or lift to unload?	0	1	2	3	4	
SQ42l) …clean boat	0	1	2	3	4	
SQ42m) …do routine maintenance for boat or gear?	0	1	2	3	4	

Uses the likert scale below for responses:
0 = NEVER
1 = LESS THAN HALF THE TIME BUT MORE THAN NEVER
2 = HALF THE TIME
3 = MORE THAN HALF AND LESS THAN ALWAYS
4 = EVERYTIME OR EVERYDAY

<<<<<<<<<<<<<<<<<<< 3-MAN CREW >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

SQ43) When you gill netted in a three man crew during 1999-2001 did you…? How often? *(circle one)*

Three man crew	**Never**	**Less than half**	**Half**	**More than half**	**Everytime**	*Code*
SQ43a) …drive boat?	0	1	2	3	4	
SQ43b) …load gear & supplies?	0	1	2	3	4	
SQ43c) …use a dolly or lift to load?	0	1	2	3	4	
SQ43d) …run net reel? *(skip if boat doesn't have net reel)*	0	1	2	3	4	
SQ43e) ...set net?	0	1	2	3	4	
SQ43f) ...pull net?	0	1	2	3	4	
SQ43g) …pick net?	0	1	2	3	4	
SQ43h) …sort catch on the boat?	0	1	2	3	4	
SQ43i) …ice down catch?	0	1	2	3	4	
SQ43j) …unload catch from boat?	0	1	2	3	4	
SQ43k) …use a dolly or lift to unload?	0	1	2	3	4	
SQ43l) …clean boat	0	1	2	3	4	
SQ43m) …do routine maintenance for boat or gear?	0	1	2	3	4	

Uses the likert scale below for responses:
0 = NEVER
1 = LESS THAN HALF THE TIME BUT MORE THAN NEVER

2 = HALF THE TIME
3 = MORE THAN HALF AND LESS THAN ALWAYS
4 = EVERYTIME OR EVERYDAY

Part V: General and Musculoskeletal Questions

SQ44) During the time of the study 1999-2001, in a typical week during the fishing season, how many hours did you spend on the water?

*Record:*_______ *Hours x* _______*Days/week =* __________Hrs/week

SQ45) During the fishing season, how many hours did you do fishing related work off the water during a typical week? (e.g. like building nets, repairing boats, motors or fishing gear, or trailering a boat)

*Record:*_______ *Hours x* _______*Days/week =* __________Hrs/week

I'm now going to ask you about any aches or pains that you may have had in your muscles or joints in the last 12 months. In the last 12 months have you had…: *(circle one)*

		If yes to a:	*IF yes to b:*	*IF no to b:*
	a)…symptoms including ache, pain, or discomfort…?	b) Did these symptoms interrupt your work activities…?	c) What is the total length of time *(days)* these symptoms interrupted work activity…?	d) Did you have to change your activities…?
SQ46) In your low back?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ47) Neck?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ48) Upper back?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ49) Shoulders?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ50) Elbows/forearms?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ51) Wrist/hands?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ52) Hips/thighs?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ53) Knees?	YES NO	YES NO	0 1-7 8-30 30+	YES NO
SQ54) Ankles/feet?	YES NO	YES NO	0 1-7 8-30 30+	YES NO

NOTES:

SQ55) Have low back problems in the past made you change the way you do your fishing work?

If YES, ask SQ55a. If NO, skip to SQ56.

YES / NO

SQ55a) In what way have you changed the way you work?

Prompts: did you lift less, get help to do things, were you more careful, did you not do certain activities, etc.

WRITE IN REMARKS:

SQ56) During the time of the study, 1999-2001 did you have a job that was not commercial fishing?

If YES, ask SQ55a. If NO, skip to SQ56.

YES / NO

Did any of these jobs require you to…

SQ56a) …lift or carry more than 25 pounds? YES / NO

SQ56b) …lift or carry more than 50 pounds? YES / NO

SQ56c) …twist or bend at the waist frequently? YES / NO

SQ56d) …work in awkward postures, by that I mean having to stay bent over for awhile or hold arms up or in uncomfortable position for awhile? YES / NO

SQ56e) …lift repetitively, by that I mean more than 3 lifts per minute? YES/ NO

A researcher on this study is interested in observing commercial fishing work processes. She is interested in fishing activities that may lead to low back injuries. Would you be interested in taking a researcher out on your boat so she may observe and video tape your fishing process? An incentive will be offered for you time and effort.

Yes: She will get in touch with you
No: Thank you

End of interview: On behalf of the entire project staff, I would like to thank you for you loyalty to this project and for the time that you have spent giving us the information that we need to learn more about injuries that commercial fishermen get as a result of their work. In the next week, we will send you a check for the incentive we offered you for answering these questions. If you have any questions for us, please call us at the number given on the fact sheet. Thank you.

2. NCSEARCH Questionnaires

NC SEARCH Baseline Injury Questionnaire

Form BLIQ-058-3.0 – Version A - 6/29/99

1. Study ID Number: ☐☐☐☐☐☐☐

2. Study Volunteer Initials:____/____/____

3. Study Visit: BL (visit 1) Other______

4. Date of Examination:☐☐/☐☐/☐☐☐☐

A. INJURIES

*This part of the interview is about **accidents** and **injuries**.*

*By **"accident"**, we mean an event that damaged your body, and required:*
First aid at the time of injury, OR,
Medical care at some later time, OR,
Time away from work.

*The person who gave **first aid**, or **medical care**, may have been yourself, one of your coworkers, a family member, a friend, a doctor, a nurse, a dentist, or an ambulance crew member.*

*By **"accident at work"**, we mean an accident that happened in your fishing work. This includes off-the-water activities such as repairing your boat, motor, or fishing equipment, loading or unloading your boat, driving your car to the dock.*

5. During the previous 12 months, did you have any **accidents or injuries** at work?

☐ yes ☐ no → **SKIP TO QUESTION 29-SECTION B on PAGE 5**

Please pick the work-related **injury** *or* **accident** *that you consider the worst during your most recent fishing season, and answer questions 6 to 28.*

6. What were you doing immediately before this accident happened? (PLEASE RECORD A SHORT DESCRIPTION)

____

____

____

____

7. What activity were you doing right before the accident? (PLEASE CHECK ALL THAT APPLY)

☐ loading boat
☐ preparing nets, pots, lines, or hooks
☐ maintaining or repairing equipment
☐ lowering nets, pots, or lines
☐ hauling up nets, pots, or lines
☐ working with catch on boat
☐ unloading boat
☐ walking to/from work
☐ driving to/from work
☐ land transportation - walking or driving to/from work
☐ other, ______________________

8. Please tell me about the accident itself and how it happened.

____

____

____

____

9. Which of the following events were involved in the injury (PLEASE CHECK ALL THAT APPLY)

☐ contact with hook or knife
☐ contact with other sharp object
☐ contact with part of boat
☐ fall (landed in water)
☐ Fall (landed on hard surface)
☐ contact with cable, chain, rope, or wire
☐ contact with winch or pulley
☐ contact with other moving machinery
☐ contact with finfish, shellfish, or other sea animal
☐ fire on board boat
☐ boat collided with other object
☐ boat swamped or over-turned
☐ lifting/moving heavy object
☐ motor vehicle crash (car, truck, motorcycle or off-road vehicle)
☐ non-motor vehicle crash (bicycle)
☐ other, ____

*The next 4 questions (10-13) ask about your injuries in this accident. By **"injury"** we mean damage to your body that required:*
First aid at the time of injury, OR,
Medical care at some later time, OR,
Time away from work.
The person who gave first aid, or medical care, may have been yourself, one of your coworkers, a family member, a friend, a doctor, a nurse, a dentist, or an ambulance crew member.

10. How many injuries did you have in this accident? ☐☐

An example of two injuries from one accident would be: Fell from boat onto dock, causing (1) cuts to face and (2) broken arm.

11. What parts of your body were injured? (PLEASE SEE TOP HALF OF PAGE 12 & "BODY SITE CODES" AND PAGE 13 "BODY DIAGRAM")

Injury 1: ☐☐ Injury 2: ☐☐ Injury 3: ☐☐

12. In what way was each part injured? (PLEASE SEE LOWER HALF OF PAGE 12 "TYPE OF INJURY CODES")

Injury 1: ☐☐ Injury 2: ☐☐ Injury 3: ☐☐

13. Did this injury become infected?

a. Injury 1 ☐ yes ☐ no ☐ not applicable

b. Injury 2 ☐ yes ☐ no ☐ not applicable

c. Injury 3 ☐ yes ☐ no ☐ not applicable

14. Did you hit your head in this accident?

☐ yes ☐ no **[Please skip to Question 16]**

15. After your head was hit, did you….. (PLEASE CHECK ALL THAT APPLY)

☐ Black out, even for a few seconds
☐ Have trouble concentrating on what you were doing
☐ Have trouble remembering things, for less than half an hour
☐ Have trouble remembering things, for half an hour or longer
☐ Get a headache
☐ Feel queasy or feel like throwing up
☐ Throw up

☐ Feel dizzy or unsteady on your feet
☐ Have a ringing sound in your ears
☐ Find loud noises painful
☐ Find bright lights painful
☐ Have pains in your neck
☐ Have trouble seeing straight
☐ Get tired or irritable

16. What was the date of the accident: ☐☐/☐☐/☐☐☐☐

17. What time of day was the accident? ☐☐:☐☐ ☐a.m. or ☐ p.m.

18. At the time of the accident were you on the water, or off the water?

☐ On the water (includes working in a docked boat)→(SKIP TO QUESTION 20)

☐ Off the water (includes working on a dock)→ (GO TO QUESTION 19)

19. Where were you at the time of accident?

☐ On a dock
☐ On a road or highway
☐ At home, doing fishing work
☐ Other: (please specify) ____

[SKIP TO QUESTION 21]

20. Where were you at the time of accident? (Please use study map to identify zones and circle or mark all that apply)

☐ Albermarle Sound	Where?	A1	A2	A3	A4	A5	A6	☐ No
☐ Neuse River	Where?	N1	N2	N3	N4			☐ No
☐ Pamlico River	Where?	TP1	TP2	TP3	TP4	TP5	TP6	☐ No
☐ Pamlico Sound	Where?	S1		S2				☐ No
☐ Ocean								☐ No

☐ Other, (please specify)____

21. On the day of the accident, did you fish?

☐ yes ☐ no [skip to Question 24]

22. What type(s) of fishing did you do that day? (PLEASE CHECK ALL THAT APPLY)

- ☐ finfishing
- ☐ oystering
- ☐ crabbing
- ☐ clamming
- ☐ shrimping
- ☐ other, (please specify)_____________________

23. How long is the boat you were working on the day of the accident? ☐☐☐ (feet)

24. After the accident, did you get injury care from: (PLEASE CHECK ALL THAT APPLY)

- ☐ An ambulance crew
- ☐ Emergency room doctor or other emergency room staff
- ☐ Other doctor, nurse practitioner, nurse, or dentist (not emergency)
- ☐ Co-worker
- ☐ Friend
- ☐ Family member
- ☐ Yourself
- ☐ No-one
- ☐ Other (please specify):____

25. Did you have to take time off work because of this accident?

☐ yes [skip to Question 27] ☐ no [Go to Question 26]

26. Did the injury (injuries) slow you down at work? ☐ yes ☐ no

[SKIP TO QUESTION 28]

27. How much time?

- ☐ Part of day
- ☐ All of day
- ☐ 2-3 days
- ☐ 4-6 days
- ☐ One week or more, but less than one month
- ☐ 1 month or more

28. In your mind (or view), how could this accident/injury have been prevented?

____

____

____

B. NEAR-MISSES

29. During your most recent fishing season, were there any near-misses or close calls on the boat you worked on?

☐ yes ☐ no **[Please skip to Question 31 on Page 6]**

30. Pick the one near-miss that came the closest to causing an accident. Please tell me about it.

____

____

____

C. GENERAL SAFETY

31. If some item of fishing equipment was re-designed to make it much safer, would you buy it, even if it was slightly more expensive than the standard item?

☐ Never
☐ Yes, when my present item needed replacing
☐ Yes, when funds permitted
☐ Yes, immediately

32. How well can you swim?

☐ Not at all
☐ A little
☐ Adequately
☐ Good swimmer
☐ Excellent swimmer

33. When driving a car, how often do you wear your seat belt?

☐ Never
☐ Occasionally
☐ About half the time
☐ Often
☐ Always

34. In your opinion, what percent of fishing accidents could be prevented?

☐ None
☐ Less than one-quarter
☐ About one quarter
☐ About half
☐ About three-quarters

☐ Almost all
☐ All
☐ Other (please specify):_________________________________

D. Aches, Pains, or Discomfort (Musculoskeletal Disorders)

The following questions ask about aches, pains, or discomfort in various parts of your body. In the attached body picture ***(page 13)*** *you can see the approximate positions of the parts of the body referred to in these questions. Limits are not sharply defined, and certain parts overlap. You should decide for yourself in which part you have or have had trouble (if any).*
35. If you answer YES in column A, please answer columns B and C.

Column A Have you at any time during the last 12 months had trouble (ache, pain, or discomfort) in:	**Column B** Have you at any time in the past 12 months been prevented from doing your normal work (at home or away from home) because of trouble in:	**Column C** Have you had trouble at any time in the past 7 days in:
35.a. **ELBOWS** No ☐ [Skip to 35.b.] Yes ☐,in right elbow→ Yes ☐, in left elbow→ Yes ☐, in both elbows→	**ELBOWS** Yes ☐ No ☐	**ELBOWS** Yes ☐ No ☐
35.b. **Wrists/Hands** No ☐ [Skip to 35.c.] Yes ☐,in right wrist/hand→ Yes ☐, in left wrist/hand→ Yes ☐,in both wrist/hand→	**Wrists/Hands** Yes ☐ No ☐	**Wrists/Hands** Yes ☐ No ☐
35.c. **Upper Back** No ☐ [Skip to 35.d.] Yes ☐→	**Upper Back** Yes ☐ No ☐	**Upper Back** Yes ☐ No ☐
35.d. **One/Both Hips/Thighs** No ☐ [Skip to 35.e.] Yes ☐→	**Hips/Thighs** Yes ☐ No ☐	**Hips/Thighs** Yes ☐ No ☐
35.e. **One or Both Knees** No ☐ [Skip to 35.f.] Yes ☐→	**Knees** Yes ☐ No ☐	**Knees** Yes ☐ No ☐
35.f. **One/Both Ankles/Feet**	**Ankles/Feet**	**Ankles/Feet**

No ☐ [Skip to Question 36] Yes ☐→	Yes ☐ No ☐	Yes ☐ No ☐

36. Have you ever had **low back trouble** (ache, pain, or discomfort)?

yes ☐ no ☐ **[Please skip to question 37]**

a. Have you been hospitalized because of low back trouble?

yes ☐ no ☐

b. Have you ever had to change jobs or duties because of low back trouble?

yes ☐ no ☐

c. What is the total length of time that you have had low back trouble during the last 12 months?

☐ 0 days→ **[Please Skip to Question 37]**
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days, but not every day
☐ Every day

d. Has low back pain caused you to reduce your activity during the last 12 months?

1. Work activity (at home or away from home)? yes ☐ no ☐
2. Leisure activity? yes ☐ no ☐

e. What is the total length of time that low back trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?

☐ 0 days
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days

f. Have you been seen by a doctor, physiotherapist, chiropractor or other health care provider because of low back pain during the last 12 months?

yes ☐ no ☐

g. Have you had low back pain at any time during the last 7 days?

yes ☐ no ☐

37. Have you ever had **neck trouble** (ache, pain, or discomfort)?

yes ☐ no ☐ **[Please skip to question 38]**

a. Have you ever hurt your neck in an accident?

yes ☐ no ☐

b. Have you ever had to change jobs or duties because of neck trouble?

yes ☐ no ☐

c. What is the total length of time that you have had neck trouble during the last 12 months?

☐ 0 days→ **[Please skip to question 38]**
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days, but not every day
☐ Every day

d. Has neck trouble caused you to reduce your activity during the last 12 months?

1. Work activity (at home or away from home)? yes ☐ no ☐
2. Leisure activity? yes ☐ no ☐

e. What is the total length of time that neck trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?

☐ 0 days
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days

f. Have you been seen by a doctor, physiotherapist, chiropractor or other health care provider person because of neck trouble during the last 12 months?

yes ☐ no ☐

g. Have you had neck trouble at any time during the last 7 days?

yes ☐ no ☐

38. Have you ever had **<u>shoulder</u>** trouble (ache, pain, or discomfort)?

yes ☐ no ☐ **[Stop, Thanks for completing this questionnaire]**

a. Have you ever hurt your shoulder in an accident?

yes ☐, my right shoulder no ☐
yes ☐, my left shoulder
yes ☐, both shoulders

b. Have you ever had to change jobs or duties because of shoulder trouble?

yes ☐ no ☐

c. Have you had shoulder trouble during the last 12 months?

yes ☐, my right shoulder no ☐
yes ☐, my left shoulder
yes ☐, both shoulders

d. What is the total length of time that you have had shoulder trouble during the last 12 months?

☐ 0 days→ **[Stop, Thanks for completing this questionnaire]**
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days, but not every day
☐ Every day

e. Has shoulder trouble caused you to reduce your activity during the last 12 months?

1. Work activity (at home or away from home)? yes ☐ no ☐

2. Leisure activity? yes ☐ no ☐

f. What is the total length of time that shoulder trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?

☐ 0 days

- ☐ 1-7 days
- ☐ 8-30 days
- ☐ More than 30 days

g. Have you been seen by a doctor, physiotherapist, chiropractor or other health care provider person because of shoulder trouble during the last 12 months?

yes ☐ no ☐

h. Have you had shoulder trouble at any time during the last 7 days?

yes ☐, my right shoulder no ☐
yes ☐, my left shoulder
yes ☐, both shoulders

Thank you for taking the time to complete this questionnaire.

Coordinator use only:

39. Date Keyed: ☐☐/☐☐/☐☐☐☐

40. Name of person keying data:____

41. Date Verified: ☐☐/☐☐/☐☐☐☐

42. Name of person verifying data:____

CODES FOR INJURY SITE AND TYPE

Body Site Codes (Codes for SITE)

01	Eye	20	Finger
02	Ear	21	Multiple sites on hand/wrist
03	Nose (code TYPE to 11)	22	Back (include spine)
04	Face	23	Ribs
05	Chin and Jaw	24	Chest (other)
06	Mouth (include lips, tongue)	25	Abdomen
07	Teeth (code TYPE to 12)	26	Pelvis/Hips/Groin/Buttocks
08	Scalp	27	Upper leg (include thigh, hamstring)
09	Brain (code TYPE 13)	28	Knee (include kneecap)
10	Head (not elsewhere classified)	29	Lower Leg (include shin, calf)
11	Neck	30	Multiple sites on leg
12	Shoulder	31	Ankle
13	Upper Arm	32	Foot (include heel)
14	Elbow	33	Toe
15	Forearm	34	Multiple sites on foot/ankle
16	Multiple sites on arm	35	Whole body (code TYPE to 14, 15, 16, 17, or 18)
17	Wrist	97	Other (please specify)
18	Hand	98	Don't know
19	Thumb	99	Refused

Type of Injury (Codes for TYPE)

01	Scrape or Scratch (Abrasion)
02	Bruise (Contusion)
03	Cut (Laceration)
04	Puncture (hole-like wound)
05	Sprain or strain
06	Dislocation
07	Broken bone (fracture, include stress fracture)
08	Blisters
09	Burn
10	Crush
11	Broken or blood nose (code SITE to 3)
12	Broken, chipped, or loose tooth (code SITE to 7)
13	Concussion or other brain injury (code SITE to 9)
14	Heat exhaustion (includes heat stroke, code SITE to 35)
15	Extreme cold (hypothermia, code SITE to 35)
16	Near-drowning (code SITE to 35)
17	Electrical Shock (code SITE to 35)
18	Poisoning (code SITE to 35)
97	Other (please specify)

98	Don't Know
99	Refused

In this picture, you can see the approximate position of the parts of the body referred to in the questionnaire. Limits are not sharply defined and certain parts overlap. You should decide for yourself in which part you have or have had your trouble (if any).

NC SEARCH Follow-Up Injury Questionnaire

Form FUIQ-059-3.0 – Version A – 6/29/99

1. Study ID Number: ☐☐☐☐☐☐☐

2. Study Volunteer Initials:____/____/____

3. Study Visit: V2 V3 V4 V5 Other______

4. Date of Examination: ☐☐/☐☐/☐☐☐☐

A. INJURIES

This part of the interview is about **accidents** *and* **injuries**.

By ***"accident"****, we mean an event that damaged your body, and required:*
First aid at the time of injury, OR,
Medical care at some later time, OR,
Time away from work.

The person who gave ***first aid****, or* ***medical care****, may have been yourself, one of your coworkers, a family member, a friend, a doctor, a nurse, a dentist, or an ambulance crew member.*

By ***"accident at work"****, we mean an accident that happened in your fishing work. This includes off-the-water activities such as repairing your boat, motor, or fishing equipment, loading or unloading your boat, driving your car to the dock.*

5. Since your last study visit, did you have any **accidents or injuries** at work?

☐ yes ☐ no → **SKIP TO QUESTION 29-SECTION B on Page 6**

Please pick the work-related **injury** *or* **accident** *that you consider the worst during your most recent fishing season, and answer questions 6 to 28.*

6. What were you doing immediately before this accident happened? (PLEASE RECORD A SHORT DESCRIPTION)

____

____

____

____

7. What activity were you doing right before the accident? (PLEASE CHECK ALL THAT APPLY)

- ☐ loading boat
- ☐ preparing nets, pots, lines, or hooks
- ☐ maintaining or repairing equipment
- ☐ lowering nets, pots, or lines
- ☐ hauling up nets, pots, or lines
- ☐ working with catch on boat
- ☐ unloading boat
- ☐ walking to/from work
- ☐ driving to/from work
- ☐ land transportation - walking or driving to/from work
- ☐ other, ____

8. Please tell me about the accident itself and how it happened.

____

____

____

9. Which of the following events were involved in the injury (PLEASE CHECK ALL THAT APPLY)

- ☐ contact with hook or knife
- ☐ contact with other sharp object
- ☐ contact with part of boat
- ☐ fall (landed in water)
- ☐ fall (landed on hard surface)
- ☐ contact with cable, chain, rope, or wire
- ☐ contact with winch or pulley
- ☐ contact with other moving machinery
- ☐ contact with finfish, shellfish, or other sea animal
- ☐ fire on board boat
- ☐ boat collided with other object
- ☐ boat swamped or over-turned
- ☐ lifting/moving heavy object
- ☐ motor vehicle crash (car, truck, motorcycle or off-road vehicle)
- ☐ non-motor vehicle crash (bicycle)
- ☐ other, ____

The next 4 questions (10-13) ask about your injuries in this accident. By ***"injury"***
we mean damage to your body that required:
First aid at the time of injury, OR,
Medical care at some later time, OR,
Time away from work.

The person who gave first aid, or medical care, may have been yourself, one of your coworkers, a family member, a friend, a doctor, a nurse, a dentist, or an ambulance crew member.

10. How many injuries did you have in this accident? ☐☐

An example of two injuries from one accident would be: Fell from boat onto dock, causing (1) cuts to face and (2) broken arm.

11. What parts of your body were injured? (PLEASE SEE TOP HALF OF PAGE 12 & "BODY SITE CODES" AND PAGE 13 "BODY DIAGRAM")

Injury 1: ☐☐ Injury 2: ☐☐ Injury 3: ☐☐

12. In what way was each part injured? (PLEASE SEE LOWER HALF OF PAGE 12 "TYPE OF INJURY CODES")

Injury 1: ☐☐ Injury 2: ☐☐ Injury 3: ☐☐

13. Did this injury become infected?

a. Injury 1	☐ yes	☐ no	☐ not applicable
b. Injury 2	☐ yes	☐ no	☐ not applicable
c. Injury 3	☐ yes	☐ no	☐ not applicable

14. Did you hit your head in this accident?

☐ yes ☐ no **[Please skip to Question 16]**

15. After your head was hit, did you….. (PLEASE CHECK ALL THAT APPLY)

☐ Black out, even for a few seconds
☐ Have trouble concentrating on what you were doing
☐ Have trouble remembering things, for less than half an hour
☐ Have trouble remembering things, for half hour or longer
☐ Get a headache
☐ Feel queasy or feel like throwing up

☐ Throw up
☐ Feel dizzy or unsteady on your feet
☐ Have a ringing sound in your ears
☐ Find loud noises painful
☐ Find bright lights painful
☐ Have pains in your neck
☐ Have trouble seeking straight
☐ Get tired or irritable

16. What was the date of the accident: ☐☐/☐☐/☐☐☐☐

17. What time of day was the accident? ☐☐:☐☐ ☐a.m. or ☐ p.m.

18. At the time of the accident were you on the water, or off the water?

☐ On the water (includes working in a docked boat)→(SKIP TO QUESTION 20)

☐ Off the water (includes working on a dock)→ (GO TO QUESTION 19)

19. Where were you at the time of accident?

☐ On a dock
☐ On a road or highway
☐ At home, doing fishing work
☐ Other: (please specify) ____

[SKIP TO QUESTION 21]

20. Where were you at the time of accident? (Please use study map to identify zones and circle or mark all that apply)

☐ Albermarle Sound	Where?	A1	A2	A3	A4	A5	A6	☐ No
☐ Neuse River	Where?	N1	N2	N3	N4			☐ No
☐ Pamlico River	Where?	TP1	TP2	TP3	TP4	TP5	TP6	☐ No
☐ Pamlico Sound	Where?	S1	S2					☐ No
☐ Ocean								☐ No

☐ Other, (please specify)____

21. On the day of the accident, did you fish?

☐ yes ☐ no **[Please skip to Question 24]**

22. What type(s) of fishing did you do that day? (PLEASE CHECK ALL THAT APPLY)

☐ finfishing
☐ clamming
☐ oystering
☐ shrimping
☐ crabbing
☐ other, (please specify)________________________________

23. How long is the boat you were working on the day of the accident? ☐☐☐ (feet)

24. After the accident, did you get injury care from: (PLEASE CHECK ALL THAT APPLY)

☐ An ambulance crew
☐ Emergency room doctor or other emergency room staff
☐ Other doctor, nurse practitioner, nurse, or dentist (not emergency)
☐ Co-worker
☐ Friend
☐ Family member
☐ Yourself
☐ No-one
☐ Other (please specify):____

25. Did you have to take time off work because of this accident?

☐ yes [skip to Question 27] ☐ no [Go to Question 26]

26. Did the injury (injuries) slow you down at work? ☐ yes ☐ no

[SKIP TO QUESTION 28]

27. How much time?

☐ Part of day
☐ All of day
☐ 2-3 days
☐ 4-6 days
☐ One week or more, but less than one month
☐ 1 month or more

28. In your mind (or view), how could this accident/injury have been prevented?

B. NEAR-MISSES

29. Since your last study visit, were there any near-misses or close calls on the boat you worked on?

☐ yes ☐ no **[Please skip to Question 31]**

30. Pick the one near-miss that came the closest to causing an accident. Please tell me about it.

[Questions 31-34 deleted from follow-up questionnaire. Please go to Question 35]

D. Aches, Pains, or Discomfort (Musculoskeletal Disorders)

*The following questions ask about aches, pains, or discomfort in various parts of your body. In the attached body picture **(page 13)** you can see the approximate positions of the parts of the body referred to in these questions. Limits are not sharply defined, and certain parts overlap. You should decide for yourself in which part you have or have had trouble (if any).*
35. If you answer YES in column A, please answer columns B and C.

Column A Since your last study visit, have you had trouble (ache, pain, or discomfort) in:	**Column B** Since your last study visit, have you at any time in the been prevented from doing your normal work (at home or away from home) because of trouble in:	**Column C** Have you had trouble at any time in the past 7 days in:
35.a. **ELBOWS** No ☐ [Skip to 35.b.] Yes ☐,in right elbow→ Yes ☐, in left elbow→ Yes ☐, in both elbows→	**ELBOWS** Yes ☐ No ☐	**ELBOWS** Yes ☐ No ☐
35.b. **Wrists/Hands** No ☐ [Skip to 35.c.] Yes ☐,in right wrist/hand→ Yes ☐, in left wrist/hand→ Yes ☐,in both wrist/hand→	**Wrists/Hands** Yes ☐ No ☐	**Wrists/Hands** Yes ☐ No ☐
35.c. **Upper Back** No ☐ [Skip to 35.d.] Yes ☐→	**Upper Back** Yes ☐ No ☐	**Upper Back** Yes ☐ No ☐
35.d. **One/Both Hips/Thighs** No ☐ [Skip to 35.e.] Yes ☐→	**Hips/Thighs** Yes ☐ No ☐	**Hips/Thighs** Yes ☐ No ☐
35.e. **One or Both Knees** No ☐ [Skip to 35.f.] Yes ☐→	**Knees** Yes ☐ No ☐	**Knees** Yes ☐ No ☐
35.f. **One/Both Ankles/Feet** No ☐ [Skip to Question 36] Yes ☐→	**Ankles/Feet** Yes ☐ No ☐	**Ankles/Feet** Yes ☐ No ☐

36. Since your last study visit, have you had **<u>low back trouble</u>** (ache, pain, or discomfort)?

yes ☐ no ☐ **[Please skip to question 37]**

a. Since your last study visit, have you been hospitalized because of low back trouble?

yes ☐ no ☐

b. Since your last study visit, have you had to change jobs or duties because of low back trouble?

yes ☐ no ☐

c. Since your last study visit, what is the total length of time that you have had low back trouble?

☐ 0 days→**[skip to Question 37]**
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days, but not every day
☐ Every day

d. Since your last study visit, has low back pain caused you to reduce your activity?

1. Work activity (at home or away from home)? yes ☐ no ☐

2. Leisure activity? yes ☐ no ☐

e. Since your last study visit, what is the total length of time that low back trouble has prevented you from doing your normal work (at home or away from home)?

☐ 0 days
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days

f. Since your last study visit, have you been seen by a doctor, physiotherapist, chiropractor or other health care provider because of low back pain?

yes ☐ no ☐

g. Have you had low back pain at any time during the last 7 days?

yes ☐ no ☐

37. Since your last study visit, have you had **neck trouble** (ache, pain, or discomfort)?

yes ☐ no ☐ **[Please skip to question 38]**

a. Since your last study visit, have you hurt your neck in an accident?

yes ☐ no ☐

b. Since your last study visit, have you had to change jobs or duties because of neck trouble?

yes ☐ no ☐

c. Since your last study visit, what is the total length of time that you have had neck trouble?

☐ 0 days→ **[Please skip to question 38]**
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days, but not every day
☐ Every day

d. Since your last study visit, has neck trouble caused you to reduce your activity?

1. Work activity (at home or away from home)? yes ☐ no ☐

2. Leisure activity? yes ☐ no ☐

e. Since your last study visit, what is the total length of time that neck trouble has prevented you from doing your normal work (at home or away from home)?

☐ 0 days
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days

f. Since your last study visit, have you been seen by a doctor, physiotherapist, chiropractor or other health care provider person because of neck trouble ?

yes ☐ no ☐

g. Have you had neck trouble at any time during the last 7 days?

yes ☐ no ☐

38. Since your last study visit, have you had **<u>shoulder</u>** trouble (ache, pain, or discomfort)?

yes ☐ no ☐ **[Stop, Thanks for completing this questionnaire]**

a. Since your last study visit, have you hurt your shoulder in an accident?

yes ☐, my right shoulder no ☐
yes ☐, my left shoulder
yes ☐, both shoulders

b. Since your last study visit, have you had to change jobs or duties because of shoulder trouble?

yes ☐ no ☐

c. Since your last study visit, have you had shoulder trouble?

yes ☐, my right shoulder no ☐
yes ☐, my left shoulder
yes ☐, both shoulders

d. Since your last study visit, what is the total length of time that you have had shoulder trouble?

☐ 0 days→ **[Stop, Thanks for completing this questionnaire**]
☐ 1-7 days
☐ 8-30 days
☐ More than 30 days, but not every day
☐ Every day

e. Since your last study visit, has your shoulder trouble caused you to reduce your activity?

1. Work activity (at home or away from home)? yes ☐ no ☐
2. Leisure activity? yes ☐ no ☐

f. Since your last visit, what is the total length of time that shoulder trouble has prevented you from doing your normal work (at home or away from home)?

- ☐ 0 days
- ☐ 1-7 days
- ☐ 8-30 days
- ☐ More than 30 days

g. Since your last visit, have you been seen by a doctor, physiotherapist, chiropractor or other health care provider person because of shoulder trouble?

yes ☐ no ☐

h. Have you had shoulder trouble at any time during the last 7 days?

yes ☐, my right shoulder no ☐
yes ☐, my left shoulder
yes ☐, both shoulders

Thank you for taking the time to complete this questionnaire.

Coordinator use only:

39. Date Keyed:☐☐/☐☐/☐☐☐☐

40. Name of person keying data:____

41. Date Verified:☐☐/☐☐/☐☐☐☐

42. Name of person verifying data:____

CODES FOR INJURY SITE AND TYPE

Body Site Codes (Codes for SITE)

01	Eye	20	Finger
02	Ear	21	Multiple sites on hand/wrist
03	Nose (code TYPE to 11)	22	Back (include spine)
04	Face	23	Ribs
05	Chin and Jaw	24	Chest (other)
06	Mouth (include lips, tongue)	25	Abdomen
07	Teeth (code TYPE to 12)	26	Pelvis/Hips/Groin/Buttocks
08	Scalp	27	Upper leg (include thigh, hamstring)
09	Brain (code TYPE 13)	28	Knee (include kneecap)
10	Head (not elsewhere classified)	29	Lower Leg (include shin, calf)
11	Neck	30	Multiple sites on leg
12	Shoulder	31	Ankle
13	Upper Arm	32	Foot (include heel)
14	Elbow	33	Toe
15	Forearm	34	Multiple sites on foot/ankle
16	Multiple sites on arm	35	Whole body (code TYPE to 14, 15, 16, 17, or 18)
17	Wrist	97	Other (please specify)
18	Hand	98	Don't know
19	Thumb	99	Refused

Type of Injury (Codes for TYPE)

01	Scrape or Scratch (Abrasion)
02	Bruise (Contusion)
03	Cut (Laceration)
04	Puncture (hole-like wound)
05	Sprain or strain
06	Dislocation
07	Broken bone (fracture, include stress fracture)
08	Blisters
09	Burn
10	Crush
11	Broken or blood nose (code SITE to 3)
12	Broken, chipped, or loose tooth (code SITE to 7)
13	Concussion or other brain injury (code SITE to 9)
14	Heat exhaustion (includes heat stroke, code SITE to 35)
15	Extreme cold (hypothermia, code SITE to 35)
16	Near-drowning (code SITE to 35)
17	Electrical Shock (code SITE to 35)
18	Poisoning (code SITE to 35)
97	Other (please specify)
98	Don't Know
99	Refused

In this picture, you can see the approximate position of the parts of the body referred to in the questionnaire. Limits are not sharply defined and certain parts overlap. You should decide for yourself in which part you have or have had your trouble (if any).

NC SEARCH Baseline Exposure Questionnaire Form

Form EXP-010-2.0 – Version A – 3/29/99

A. Demographic Section

1. Study ID Number: ☐☐☐☐☐☐☐

2. Study Volunteer Initials: _____/_____/_____

3. Study Visit: BL (visit 1) V2 V3 V4 V5 Other_________

4. Date of Exam: ☐☐/☐☐/☐☐☐☐

5. Location of exam (i.e. Beaufort County Health Dept): _______________________

6. County of Residence: ☐Beaufort ☐Carteret ☐Craven ☐Dare

☐Hyde ☐Onslow ☐Pamlico ☐Other____________________

7. How far is your house from the water?

☐within 50 feet ☐201 feet - a mile
☐51- 200 feet ☐ greater than one mile

a. What type of water do you live near?

☐ocean/marine ☐rivers and sounds ☐pond or fresh water

8. How many people live in your home? ______________

9. Do you have a job? ☐Yes, please specify___________________________

☐No [Skip to Q. 10.]

a. Do you work at this job full-time? ☐Yes ☐No [Skip to Q. 10.]

b. How many hours per week do you work at your full-time job on average?

☐Greater than or equal to 32 hours per week
☐20 to 31 hours per week
☐19 hours or less per week
☐other, please specify______________________

c. Do you work at this job year round? ☐Yes [skip to Q.10.] ☐No

d. If no, how many months a year do you work?______________

10. Do you have another job? ☐Yes ☐No [skip to Q.11.]

a. What is your other job? ____

b. How many hours per week do you work at this other job on average?

☐Greater than or equal to 32 hours per week
☐20 to 31 hours per week
☐19 hours or less per week
☐Other, please specify______________________

c. Do you work at this job year round? ☐Yes [skip to Q. 11.] ☐No

d. If no, how many months a year do you work?_______________

B. Exposure Details – Waterworkers

11. Do you spend at least 25 hours per week on North Carolina waters (ocean, rivers, or sounds)?
☐ Yes ☐ No

12. Which kinds of activities/work do you do on the water (check all that apply)?

☐ Commercial fishing for finfish or shellfish
☐ Taking passengers on fishing trips
☐ Taking passengers on tours
☐ Transporting other paying passengers
☐ Research and/or fish kill investigations
☐ Other, please specify___________________________________

13. Do you own your own boat? ☐ Yes ☐No [skip to Q. 15.]

a. Please describe the boat (If you own more than one boat please describe all)?

1. Length_______________ feet

2. Type of engine: ☐ outboard
☐ inboard→ a. gasoline or b. diesel (circle one)

3. Does the boat have a cabin? ☐Yes ☐No

4. What equipment do you have on the boat (i.e. GPS, Mechanical Winch, etc.)?____________________________________

5. What kinds of fishing do you do on this boat (please check all that apply)?

☐ finfish ☐ clams ☐ crabs ☐ oysters ☐ shrimp

☐ scallops ☐ Other, ___________________________________

14. Do you own another boat? ☐ Yes ☐ No [skip to Q. 15.]

a. Please describe the boat:

1. Length_______________ feet

2. Type of engine: ☐ outboard
   ☐ inboard→ a. gasoline or b. diesel (circle one)

3. Does the boat have a cabin? ☐ Yes ☐ No

4. What equipment do you have on the boat (i.e. GPS, Mechanical Winch, etc.)?____

5. What kinds of fishing do you do on this boat (please check all that apply)?

☐ finfish ☐ clams ☐ crabs ☐ oysters ☐ shrimp

☐ scallops ☐ Other, ___________________________________

15. Do you work regularly on someone else's boat?

☐ Yes ☐ No [Skip to Q. 16.]

a. Please describe that boat:

1. Length_______________ feet

2. Type of engine: ☐ outboard
   ☐ inboard→ a. gasoline or b. diesel (circle one)

3. Does the boat have a cabin? ☐ Yes ☐ No

4. What equipment do you have on the boat (i.e. GPS, Mechanical Winch, etc)? ____

5. What kinds of fishing do you do on this boat (please check all that apply)?

☐ finfish ☐ clams ☐ crabs ☐ oysters ☐ shrimp
☐ scallops ☐ Other, ____________________________

6. How often did you work on this boat?____________________

16. In the last year, what type of fishing have you done (please circle all that apply)?

☐ Finfish [Please complete Questions 17-19]
☐ Oyster [Please complete Questions 20-22]
☐ Crabs [Please complete Questions 23-27]
☐ Clam [Please complete Questions 28-30]
☐ Shrimp [Please complete Questions 31-33]
☐ Other type of fishing, ________________[Please complete Questions 34-36]

FINFISH

17. What equipment did you use to finfish (please circle all that apply)?

1. Gill netting 2. Pound Nets 3. Hook and Line 4. Long-Haul

5. Other, please specify____

18. Where did you finfish (please use study map and check all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes,where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes,where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

19. Typically when did you finfish in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

OYSTER

20. What equipment did you use to oyster (please circle all that apply)?

1. Hand Tongs 2. Dredging 3. Other, please specify________________

21. Where did you oyster (please use study map and circle all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

22. Typically when did you oyster in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

CRAB

23. What equipment did you use to crab (please circle all that apply)?

1. Pots 2. Trot Lines 3. Dredging 4. Netting

5. Shedding 6. Other, please specify__________________________________

24. Where did you crab (please use study map and circle all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

25. Typically when did you crab in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

26. If you fished with crab pots this past year how many did you work on average?

☐ 0 ☐ 1-49 ☐ 50-99 ☐ 100-500 ☐ > 500

27. Do you do peelers? ☐Yes ☐No ☐DK

CLAM

28. What equipment did you use to clam (please circle all that apply)?

1. Raking 2. Dredging 3. Hand tongs

4. Other, please specify____________________________________

29. Where did you clam (please use study map and circle all that apply)?

a. Albermarle Sound?☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

30. Typically when did you clam in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

SHRIMP

31. What equipment did you use to shrimp (please circle all that apply)?

1. Trawler 2. Other, please specify_____________________________

32. Where did you shrimp (please use study map and circle all that apply)?

a. Albermarle Sound?☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

33. Typically when did you shrimp in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

OTHER TYPE OF FISHING

34. What equipment did you use to [other type of fishing] (please circle all that apply)?

1. Seine 2. Dredge 3. Trawl 4. Hook and Line 5. Gill Net

6. Pound Net 7. Long-Haul 8. Other, specify______________

35. Where did you do [other type of fishing] (please use study map and circle all that apply)?

a. Albermarle Sound?☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

36. Typically when did you do [other type of fishing] (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

[Questions 37-42 deleted]

PERSONAL PROTECTIVE EQUIPMENT (PPE)

43. When you are on the water which items below do you wear (check all that apply)?

		Sometimes	Always	Never
1.	☐ Waterproof pants [oilskins]			

			Sometimes	Always	Never
		(overalls)	☐	☐	☐
2.	☐	Waterproof jacket with sleeves	☐	☐	☐
3.	☐	Waterproof boots	☐	☐	☐
4.	☐	Respirator	☐	☐	☐
5.	☐	Mask/goggles/glasses	☐	☐	☐
6.	☐	Sunglasses	☐	☐	☐
7.	☐	Hat	☐	☐	☐
8.	☐	Sunblock	☐	☐	☐
9.	☐	Mosquito repellant	☐	☐	☐

44. Do you wear gloves when working pots, peelers, or handling fish?

☐Yes ☐No [skip to Q.45.]

a. When do you wear the gloves?
☐All of the time
☐Most of the time
☐Some of the time

b. What type of gloves?
☐ Rubber/latex
☐ Cloth
☐ Other, specify_________________________

45. During the last year while you were on the water did your clothes frequently get wet?

☐ Sometimes ☐ Always ☐Never

46. During the last year while you were working on the water did you use the water from the rivers and sounds to wash off?

☐ Yes ☐ No [Skip to Q. 47]

a. How many times per day? ☐ <1 ☐ 1-5 ☐ >5

47. During the last year, while you were working on the water were any of your activities in the area of fish with sores?

☐ Yes
☐ No [skip to Q. 48.]

a. What were your activities in that area? ____

b. Did you handle any of the fish with sores? ☐Yes ☐No

c. Did you wear gloves while handling these fish with sores? ☐Yes ☐No

48. While on the water have you ever smelled an odor like a rotten egg or sulfur?

☐ Yes ☐ No ☐ Don't Know

C. Recreational Activities on North Carolina Rivers and Sounds

49. How often do you do recreational activities on NC rivers and sounds?

☐ Every day
☐ Not every day, but at least once a week
☐ Not every week, but at least once a month
☐ Not every month, but a least a few times every year
☐ Once a year or less

50. Within the last year, how did you spend most of your recreational time (please check all that apply)?

☐ Swimming
☐ Jet Skiing
☐ Water Skiing
☐ Boating
☐ Diving
☐ Sailing
☐ Any type of Fishing, please specify______________________

☐ Other, please specify__________________________________

D. Exposures to Solvent, Pesticides, or Toxins

51. Have you done any of the following within the last year?

	Sometimes	Always	Never
a. Apply tar ("net coat"/antifouling paint) to net/traps?	☐	☐	☐
b. Use gasoline to clean your hands and/or equipment?	☐	☐	☐
c. Use mineral spirits to clean your hands and/or equipment?	☐	☐	☐
d. Use acetone?	☐	☐	☐
e. Use copper oxide solution (antifouling paint to bottom of boat)?	☐	☐	☐
f. Use glue, epoxies, or resin?	☐	☐	☐

g. Use Clorox (chlorine bleach)? ☐ ☐ ☐

52. Have you done any of the following within the last year? If so, when was the last time you did this?

	Month/Year	
a. Worked on boat motors or other mechanical equipment on a boat?	☐yes,______________	☐no
b. Other mechanical work like on cars, trucks, motorcycles, or mowers?	☐yes,______________	☐no
c. Repaired fiberglass boats?	☐yes,______________	☐no
d. Painted or varnished a boat or parts of a boat?	☐yes,______________	☐no
e. Painted a house or building?	☐yes,______________	☐no
f. Removed paint with chemical strippers?	☐yes,______________	☐no
g. Used degreasers, gasoline, or other chemicals (carburetor cleaner, "brake-kleen") to clean parts or equipment?	☐yes,______________	☐no
h. Welding or cutting metal with a torch?	☐yes,______________	☐no
i. Any other kind of metal work, like cutting, machining, fabricating, or casting?	☐yes,______________	☐no
j. Used a spray or liquid to kill insects?	☐yes,______________	☐no
k. Used insect repellent (Off, "DEET"etc.) to keep bugs off yourself?	☐yes,______________	☐no
l. Sprayed weed killer?	☐yes,______________	☐no
m. Had your house sprayed for bugs?	☐yes,______________	☐no
n. Applied wood preservatives	☐yes,______________	☐no
o. Made fishing weights (sinkers), ammunition, or other things out of lead?	☐yes,______________	☐no

53. Questionnaire completed by:

☐ Study Volunteer ☐ NC SEARCH Staff, ______________________

To be completed by study personnel:

54. Date Keyed: ☐☐/☐☐/☐☐☐☐

55. Name of person keying data:____

56. Date Verified: ☐☐/☐☐/☐☐☐☐

57. Name of person verifying data:____

NC SEARCH Follow-up Exposure Questionnaire Form

Form FEXP-011-2.0 - Version A – 3/29/99

A. Demographic Section

1. Study ID Number: ☐☐☐☐☐☐☐

2. Study Volunteer Initials: _____/_____/_____

3. Study Visit: V2 V3 V4 V5 Other_________

4. Date of Exam: ☐☐/☐☐/☐☐☐☐

5. Location of exam (i.e. Beaufort County Health Dept): _______________________

6. County of Residence: ☐Beaufort ☐Carteret ☐Craven ☐Dare

☐Hyde ☐Onslow ☐Pamlico ☐Other____________________

7. Since your last visit, have you moved? ☐Yes ☐No [Skip to Q. 8]

a. How far is your house from the water?

☐within 50 feet ☐201 feet - a mile
☐51- 200 feet ☐ greater than one mile

b. What type of water do you live near?

☐ocean/marine ☐rivers and sounds ☐pond or fresh water

8. Since your last visit, has anyone moved in or out of your house?

☐Yes ☐No [Skip to Q. 9]

a. How many people now live in your home?_________

9. Since your last visit have you changed jobs?

☐Yes ☐No [Skip to Q. 10.]

a. What is your new job?_______________________________________

b. Do you work at this job full-time? ☐Yes ☐No [Skip to Q. 10.]

c. How many hours per week do you work at your full-time job on average?

☐Greater than or equal to 32 hours per week
☐20 to 31 hours per week
☐19 hours or less per week
☐Other, please specify______________________

d. Do you work at this job year round? ☐Yes [skip to Q.10.] ☐No

e. If no, how many months a year do you work?______________

10. Since your last visit have you worked at another job? ☐Yes ☐No [skip to Q.11.]

a. What is your other job? ____

b. How many hours per week do you work at this other job on average?

☐Greater than or equal to 32 hours per week
☐20 to 31 hours per week
☐19 hours or less per week
☐Other, please specify______________________

c. Do you work at this job year round? ☐Yes [skip to Q. 11.] ☐No

d. If no, how many months a year do you work?_______________

B. Exposure Details – Waterworkers

11. Since your last visit, have you spent at least 25 hours per week on North Carolina waters (ocean, rivers, or sounds)?

☐ Yes ☐ No

12. Since your last visit, which kinds of activities/work have you done on the water (check all that apply)?

☐ Commercial fishing for finfish or shellfish
☐ Taking passengers on fishing trips
☐ Taking passengers on tours
☐ Transporting other paying passengers
☐ Research and/or fish kill investigations
☐ Other, please specify___________________________________

13. Since your last visit did you buy a boat? ☐ Yes ☐No [skip to Q. 15.]

a. Please describe the boat (If you own more than one boat please describe all)?

1. Length_______________ feet

2. Type of engine: ☐ outboard
☐ inboard→ a. gasoline or b. diesel (circle one)

3. Does the boat have a cabin? ☐Yes ☐No

4. What equipment do you have on the boat (i.e. GPS, Mechanical Winch, etc.)?____

5. What kinds of fishing do you do on this boat (please check all that apply)?

☐ finfish ☐clams ☐crabs ☐ oysters ☐ shrimp

☐ scallops ☐ Other, ____

14. Since your last visit, have you bought another boat? ☐ Yes☐ No [skip to Q. 15.]

a. Please describe the boat:

1. Length________________ feet

2. Type of engine: ☐ outboard
☐ inboard→ a. gasoline or b. diesel (circle one)

3. Does the boat have a cabin? ☐Yes ☐No

4. What equipment do you have on the boat (i.e. GPS, Mechanical Winch, etc.)?____

5. What kinds of fishing do you do on this boat (please check all that apply)?

☐ finfish ☐clams ☐crabs ☐ oysters ☐ shrimp

☐ scallops ☐ Other, ____

15. Since your last visit have your worked regularly on someone else's boat?

☐Yes ☐No [Skip to Q. 16.]

a. Please describe that boat:

1. Length________________ feet

2. Type of engine: ☐ outboard
☐ inboard→ a. gasoline or b. diesel (circle one)

3. Does the boat have a cabin? ☐Yes ☐No

4. What equipment do you have on the boat (i.e. GPS, Mechanical Winch, etc)?
____

5. What kinds of fishing do you do on this boat (please check all that apply)?

☐ finfish ☐ clams ☐ crabs ☐ oysters ☐ shrimp
☐ scallops ☐ Other, ___________________________

6. How often did you work on this boat?_____________________________

16. Since your last visit, what type of fishing have you done (please check all that apply)?

☐ Finfish [Please complete Questions 17-19]
☐ Oyster [Please complete Questions 20-22]
☐ Crabs [Please complete Questions 23-27]
☐ Clam [Please complete Questions 28-30]
☐ Shrimp [Please complete Questions 31-33]
☐ Other type of fishing, ________________[Please complete Questions 34-36]

FINFISH

17. What equipment did you use to finfish (please circle all that apply)?

1. Gill netting 2. Pound Nets 3. Hook and Line 4. Long-Haul

5. Other, please specify____

18. Where did you finfish (please use study map and please circle all that apply)?

a. Albermarle Sound? ☐ If Yes,where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, whereTP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

19. Typically when did you finfish in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

OYSTER

20. What equipment did you use to oyster (please circle all that apply)?

1. Hand Tongs 2. Dredging 3. Other, please specify________________

21. Where did you oyster (please use study map and circle all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

22. Typically when did you oyster in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

CRAB

23. What equipment did you use to crab (please circle all that apply)?

1. Pots 2. Trot Lines 3. Dredging 4. Netting

5. Shedding 6. Other, please specify_________________________________

24. Where did you crab (please use study map and circle all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

25. Typically when did you crab in this area (please check all that apply)?

☐ March-May ☐ June-August ☐ Sept.-Nov. ☐ Dec.-Feb.

26. If you fished with crab pots this past year how many did you work on average?

☐ 0 ☐ 1-49 ☐ 50-99 ☐ 100-500 ☐ > 500

27. Do you do peelers? ☐ Yes ☐ No ☐ DK

CLAM

---

28. What equipment did you use to clam (please circle all that apply)?

1. Raking 2. Dredging 3. Hand tongs

4. Other, please specify___________________________________

29. Where did you clam (please use study map and circle all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐ No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐ No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐ No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐ No

e. Ocean? ☐ Yes ☐ No

f. Other, please specify____

30. Typically when did you clam in this area (please check all that apply)?

☐ March-May ☐ June-August ☐ Sept.-Nov. ☐ Dec.-Feb.

SHRIMP

---

31. What equipment did you use to shrimp (please circle all that apply)?

1. Trawler 2. Other, please specify______________________________

32. Where did you shrimp (please use study map and circle all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐ No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

33. Typically when did you shrimp in this area (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

OTHER TYPE OF FISHING (1)

34. What equipment did you use to [other type of fishing] (please circle all that apply)?

1. Seine 2. Dredge 3. Trawl 4. Hook and Line 5. Gill Net

6. Pound Net 7. Long-Haul 8. Other, specify_______________

35. Where did you do [other type of fishing] (please check all that apply)?

a. Albermarle Sound? ☐ If Yes, where A1 A2 A3 A4 A5 A6 ☐No

b. Neuse River? ☐ If Yes, where N1 N2 N3 N4 ☐No

c. Pamlico River? ☐ If Yes, where TP1 TP2 TP3 TP4 TP5 TP6 ☐No

d. Pamlico Sound? ☐ If Yes, where S1 S2 ☐No

e. Ocean? ☐Yes ☐No

f. Other, please specify____

36. Typically when did you do [other type of fishing] (please check all that apply)?

☐ March-May ☐ June-August ☐Sept.-Nov. ☐ Dec.-Feb.

6. Pound Net 7. Long-Haul 8. Other, ____________________

[Questions 37-42 deleted]

PERSONAL PROTECTIVE EQUIPMENT (PPE)

43. Since your last visit, while you were on the water which items below did you wear (check all that apply)?

		Sometimes	Always	Never
1.	☐ Waterproof pants [oilskins] (overalls)	☐	☐	☐
2.	☐ Waterproof jacket with sleeves	☐	☐	☐
3.	☐ Waterproof boots	☐	☐	☐
4.	☐ Respirator	☐	☐	☐
5.	☐ Mask/goggles/glasses	☐	☐	☐
6.	☐ Sunglasses	☐	☐	☐
7.	☐ Hat	☐	☐	☐
8.	☐ Sunblock	☐	☐	☐
9.	☐ Mosquito repellant	☐	☐	☐

44. Since your last visit, did you wear gloves when working pots, peelers, or handling fish?

☐Yes ☐No [skip to Q.45.]

a. When do you wear the gloves?
- ☐ All of the time
- ☐ Most of the time
- ☐ Some of the time

b. What type of gloves?
- ☐ Rubber/latex
- ☐ Cloth
- ☐ Other, specify_________________________

45. Since your last visit, while you were on the water did your clothes frequently get wet?

☐ Sometimes ☐ Always ☐Never

46. Since your last visit, while you were working on the water did you use the water from the rivers and sounds to wash off?

☐ Yes ☐ No [Skip to Q. 47.]

a. How many times per day? ☐ <1 ☐ 1-5 ☐ >5

47. Since your last visit, while you were working on the water were any of your activities in the area of fish with sores?

☐ Yes ☐ No [skip to Q. 48.]

a. What were your activities in that area? ______________________________________

b. Did you handle any of the fish with sores? ☐Yes ☐No

c. Did you wear gloves while handling these fish with sores? ☐Yes ☐No

48. Since your last visit, while on the water have you ever smelled an odor like a rotten egg or sulfur?

☐Yes ☐No ☐ Don't Know

C. Recreational Activities on North Carolina Rivers and Sounds

49. Since your last visit, how often did you do recreational activities on NC rivers and sounds?

☐ Every day
☐ Not every day, but at least once a week
☐ Not every week, but at least once a month
☐ Not every month, but a least a few times every year
☐ Once a year or less

50. Since your last visit, how did you spend most of your recreational time (please check all that apply)?

☐ Swimming
☐ Jet Skiing
☐ Water Skiing
☐ Boating
☐ Diving
☐ Sailing
☐ Any type of Fishing, please specify_____________________

☐ Other, please specify__________________________________

D. Exposures to Solvent, Pesticides, or Toxins

51. Since your last visit, have you done any of the following?

	Sometimes	Always	Never
a. Apply tar ("net coat"/antifouling paing) to net/traps?	☐	☐	☐
b. Use gasoline to clean your hands and/or equipment?	☐	☐	☐
c. Use mineral spirits to clean your hands and/or equipment?	☐	☐	☐
d. Use acetone?	☐	☐	☐

e. Use copper oxide solution (antifouling paint to bottom of boat)? ☐ Sometimes ☐ Always ☐ Never

f. Use glue, epoxies, or resin? ☐ ☐ ☐
g.Use Clorox (chlorine bleach)? ☐ ☐ ☐

52. Since your last visit, have you done any of the following? If so, when was the last time you did this?

	Month/Year
a. Worked on boat motors or other mechanical equipment on a boat?	☐yes,______________ ☐no
b. Other mechanical work like on cars, trucks, motorcycles, or mowers?	☐yes,______________ ☐no
c. Repaired fiberglass boats?	☐yes,______________ ☐no
d. Painted or varnished a boat or parts of a boat?	☐yes,______________ ☐no
e. Painted a house or building?	☐yes,______________ ☐no
f. Removed paint with chemical strippers?	☐yes,______________ ☐no
g. Used degreasers, gasoline, or other chemicals (carburetor cleaner, "brake-kleen") to clean parts or equipment?	☐yes,______________ ☐no
h. Welding or cutting metal with a torch?	☐yes,______________ ☐no
i. Any other kind of metal work, like cutting, machining, fabricating, or casting?	☐yes,______________ ☐no
j. Used a spray or liquid to kill insects?	☐yes,______________ ☐no
k. Used insect repellent (Off, "DEET"etc.) to keep bugs off yourself?	☐yes,______________ ☐no
l. Sprayed weed killer?	☐yes,______________ ☐no
m.Had your house sprayed for bugs?	☐yes,______________ ☐no
n. Applied wood preservatives	☐yes,______________ ☐no
o. Made fishing weights (sinkers), ammunition, or other things out of lead?	☐yes,______________ ☐no

53. Questionnaire completed by:

☐ Study Volunteer ☐ NC SEARCH Staff, ____________________

To be completed by study personnel:

54. Date Keyed: ☐☐/☐☐/☐☐☐☐

55. Name of person keying data:____

56. Date Verified: ☐☐/☐☐/☐☐☐☐

57. Name of person verifying data:____