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AN ABSTRACT OF THE DISSERTATION OF

Laura N. Syron for the degree of Doctor of Philosophy in Public Health presented on December 8, 2017.

Title: Occupational Safety and Health in Alaska's Seafood Processing Industry.

Abstract approved: \_\_\_\_\_  
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Although the seafood processing industry is vital to Alaska's economy, limited research has addressed workers' safety and health. Federal and state regulators have classified both offshore and onshore seafood processing worksites in Alaska as high-hazard environments; however, there is a dearth of published information on safety and health outcomes in the industry. There is evidence from the Survey of Occupational Injuries and Illnesses that these workers are at high risk for nonfatal injuries and illnesses. Nonfatal incidents can be severe, resulting in workers' lowered productivity, lost worktime and wages, lowered quality of life, and disability. Research is needed to inform targeted injury and illness prevention strategies in this economically important and understudied industry. To conduct surveillance research on safety and health in this industry, we utilized two data sources – one which captured information on offshore worksites, and another which captured information on onshore worksites. To research safety and health programs at Alaskan worksites, we engaged stakeholders who directed and managed these programs.

US Coast Guard reports were utilized to determine patterns of traumatic injury characteristics and circumstances, as well as identify modifiable worksite hazards, among offshore seafood processors working in Alaskan waters during 2010-2015. One fatal and 304 nonfatal injuries were reported to the Coast Guard across multiple fleets of catcher-processor and mothership vessels. The most frequently occurring injuries were: by nature of injury, sprains/strains/tears (75, 25%), contusions (50, 16%), and fractures (45, 15%); by body part affected, upper extremities (121, 40%) and trunk (75, 25%); by event/exposure resulting in injury, contact with objects and equipment (150, 49%), and overexertion and bodily reaction (76, 25%); and by source of injury, processing equipment and machinery (150, 49%). The work processes most frequently associated with injuries were: processing seafood on the production line (68, 22%); stacking blocks/bags of frozen product (50, 17%); and repairing/maintaining/cleaning factory equipment (28, 9%). Some injuries, such as serious back injuries, intracranial injuries, and finger crushing or amputations, had the potential to lead to long-term disability.

Alaska workers' compensation claims data were utilized to (a) estimate the risk of nonfatal injuries and illnesses, (b) determine patterns of incident characteristics and circumstances, and (c) identify modifiable workplace hazards among onshore workers in the seafood processing industry during 2014-2015. During the study period, 2,194 claims were accepted for nonfatal injuries and illnesses. The average annual claim rate was 48 per 1,000 workers. The most frequently occurring injuries and illnesses, were: by nature, sprains/strains/tears (747, 36%), contusions (353, 17%), and lacerations/punctures (227, 11%); by body part, upper extremities (880, 43%)

and trunk (422, 21%); and by event/exposure, contact with objects and equipment (721, 36%) and overexertion and bodily reaction (697, 35%). Incidents resulting from line production activities (n=623) frequently involved: repetitive motion; overexertion while handling trays/pans, basket/buckets, and fish/shellfish; and coming into contact with fish/shellfish, trays/pans, and processing machinery. Incidents resulting from material handling activities (n=339) frequently involved overexertion while handling boxes/cartons/bags, and falls/slips/trips.

Interviews with safety and health directors/managers were conducted to investigate: (a) offshore and onshore worksite and workforce characteristics; (b) safety and health program features; (c) economic factors influencing programs; and (d) program challenges and successes. Based on the common findings across these topics, we identified workplace factors that could be modified to improve safety and health. Interview participants reported directing/managing programs for 68% of the 25,000 workers in this Alaskan industry. The 14 participants represented 13 companies that operated 32 onshore plants and 30 vessels, employing an estimated 17,000 workers at peak season, of which 84% were processors. Participants noted widely varying degrees of program buy-in and engagement from management and workers, ranging from basic compliance with standards to full partnerships for carrying out best practices. While some participants reported that fostering a proactive safety culture and “prevention mindset” were among their greatest successes, others discussed the challenges of overcoming an “old guard mentality” that did not prioritize safety. Most participants noted that language barriers among the diverse workforce presented difficulties when communicating, especially during training. Ergonomic hazards and long work hours were frequently reported as areas of concern.

The epidemiologic studies identified similar patterns of injuries and modifiable hazards in offshore and onshore worksites. Among both seafood processors in vessels, and workers of various occupations in plants, preventing musculoskeletal injuries – particularly to the upper extremities and trunk – is paramount for improving occupational health. In offshore work environments, hazard control measures should target: (a) overexertion from lifting and lowering objects and equipment; (b) equipment and boxes falling and striking workers; (c) workers being caught in running machinery during regular operations; and (d) slips, trips, and falls. Similarly, in onshore plants, hazard control measures should target: (a) repetitive motion, overexertion, and contact with equipment during line production; (b) overexertion due to manually lifting, lowering, pushing, and pulling materials and equipment; and (c) slips, trips, and falls. Interviewing safety and health directors and managers uncovered additional workplace factors that could be modified in order to improve workers’ safety and health. These factors included: worksite manager training; worker training; adoption of ergonomics; work hours; knowledge sharing within the industry; and organizational aspects related to safety culture. Participants reported that fully engaging workers in all aspects of their safety and health programs was beneficial to their programs’ success.

To assist industry members with protecting workers’ safety and health, occupational health practitioners and researchers could support the development and evaluation of training for limited-English-speaking-workers, fatigue risk management systems, and ergonomic solutions. In the long-term, this research project will help prevent injuries and illnesses among workers in the seafood processing industry.

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Occupational Safety and Health in Alaska's Seafood Processing Industry

By

Laura N. Syron

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Laura N. Syron, Author

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Laura N. Syron  
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## CONTRIBUTION OF AUTHORS

Laura N. Syron, MPH, conceptualized and designed the research, collected and analyzed the data, and drafted the manuscripts.

Dr. Laurel D. Kincl supervised the research, assisted with the study design, assisted with the interpretation of findings, and provided editorial comments to the manuscripts.

Drs. Viktor E. Bovbjerg, Carolyn A. Mendez-Luck, and Devin L. Lucas assisted with the study design, assisted with the interpretation of findings, and provided editorial comments to the manuscripts.

Samantha L. Case, MPH, assisted with data collection and coding, interpretation of findings, and editorial comments to the first manuscript.



## TABLE OF CONTENTS

	<u>Page</u>
CHAPTER 1: INTRODUCTION.....	1
Safety and Health in the Seafood Processing Industry.....	1
Alaska’s Seafood Processing Industry.....	2
Occupational Safety and Health Frameworks.....	4
Research Approach and Purpose.....	5
References.....	6
 CHAPTER 2: OCCUPATIONAL TRAUMATIC INJURIES AMONG OFFSHORE SEAFOOD PROCESSORS IN ALASKA, 2010-2015.....	 11
Abstract.....	12
Introduction.....	13
Methods.....	15
Case Definition.....	15
Data Sources.....	15
Measures.....	16
Analysis.....	17
Results.....	17
Incident Characteristics.....	17
Worker Demographics.....	18
Injury Characteristics.....	18
Injury Circumstances.....	18
Work Process Associated with Injury.....	19
Injury Severity.....	20
Injury Response.....	21
Injury Reporting to US Coast Guard by Vessel and Fleet.....	21
Discussion.....	22
Nonfatal Injury Characteristics.....	22
Nonfatal Injury Circumstances & Prevention Strategies.....	23
Limitations.....	25
Future Research.....	26
Acknowledgements.....	27
References.....	27
 CHAPTER 3: INJURY AND ILLNESS AMONG ONSHORE WORKERS IN ALASKA’S SEAFOOD PROCESSING INDUSTRY: AN ANALYSIS OF WORKERS’ COMPENSATION CLAIMS, 2014 2015.....	 31
Abstract.....	32
Introduction.....	33
Methods.....	35
Claims Data.....	35
Claims Coding.....	35
Analysis and Workforce Data.....	36
Results.....	37
Rates.....	37
Worker Demographics.....	38
Injury and Illness Characteristics .....	39
Injury and Illness Circumstances.....	39
Injury and Illness Associated with Work Activity.....	41
Injury and Illness Not Associated with Work Activity.....	42
Injury and Illness Responses and Outcomes.....	43
Discussion.....	43
Claim Frequency and Rates.....	43

## TABLE OF CONTENTS (Continued)

	<u>Page</u>
Injury and Illness Characteristics.....	44
Injury and Illness Circumstances and Potential Prevention Strategies.....	45
Utility of Alaska Workers' Compensation Claims.....	47
Limitations.....	47
Future Research.....	48
Acknowledgments.....	50
References.....	50
 CHAPTER 4: SAFETY AND HEALTH PROGRAMS IN ALASKA'S SEAFOOD PROCESSING INDUSTRY: INTERVIEWS WITH CORPORATE AND UPPER MANAGEMENT STAKEHOLDERS.....	 57
Abstract.....	58
Introduction.....	59
Methods.....	60
Sample.....	60
Data Collection.....	61
Analysis.....	61
Results.....	62
Participant Characteristics.....	63
Worksite and Workforce Characteristics.....	63
Management and Workers' Roles.....	64
Safety and Health Training.....	65
Reporting, Identifying, and Analyzing Hazards.....	67
Hazard Controls.....	68
Economic Factors.....	68
Program Challenges.....	69
Program Successes.....	70
Modifiable Workplace Factors.....	71
Discussion.....	73
Worksite Manager Training.....	73
Worker Training.....	74
Adoption of Ergonomics.....	74
Work Hours.....	75
Knowledge Sharing within Industry.....	76
Safety Culture.....	76
Limitations.....	77
Future Research.....	77
Acknowledgments.....	78
References.....	78
 CHAPTER 5: GENERAL CONCLUSIONS.....	 83
 BIBLIOGRAPHY.....	 85
 APPENDICES.....	 96

## LIST OF TABLES

<u>Table</u>	<u>Page</u>
1.1. Nature and body part of nonfatal traumatic injuries among offshore seafood processors, 2010-2015.....	18
1.2. Source of event/exposure of nonfatal traumatic injuries among offshore seafood processors, 2010-2015.....	19
1.3. Work processes and event/exposure resulting in nonfatal traumatic injuries among offshore seafood processors, 2010-2015.....	20
1.4. Work process and severity of nonfatal injuries among offshore seafood processors, 2010-2015.....	21
2.1. Alaska workers' compensation claim frequency, percentage, and rate per 1,000 workers: All-industry, by onshore seafood processing industry, and by geographic region of the onshore seafood processing industry, 2014-2015.....	38
2.2. Alaska onshore seafood processing claims by worker demographics, 2014-2015.....	38
2.3. Alaska onshore seafood processing claims by nature and body part, 2014-2015.....	39
2.4. Alaska onshore seafood processing claims by event/exposure and nature, 2014-2015.....	40
2.5. Alaska onshore seafood processing claims by work activity, source, and event/exposure, 2014-2015.....	42
2.6. Alaska onshore seafood processing claims by initial treatment and claim type, 2014-2015.....	43
3.1. Interview topics.....	62
3.2. Modifiable workplace factors identified through participant responses across interview topics.....	72

## LIST OF APPENDICES

### Page

Appendix A. Injury Severity Scale Adapted from the Abbreviated Injury Severity Scale Utilized by United States Coast Guard Investigators.....	96
Appendix B. Interview Guide.....	97

## Chapter 1: INTRODUCTION

### SAFETY AND HEALTH IN THE SEAFOOD PROCESSING INDUSTRY

The seafood processing industry in the United States (US) comprises onshore factories and vessels operating offshore that engage in production and packaging activities. These activities include: eviscerating fresh fish by removing heads, fins, scales, bones, and entrails; shucking and packing fresh shellfish; processing marine fats and oils; smoking, salting, and drying seafood; canning seafood; and freezing seafood (NAICS, 2017). Historically, the public has shown more concern over seafood safety for consumers than the well-being of workers (Griffith, 1995). This sentiment dates back to the early twentieth century. In the 1860s, animal slaughtering became a mass-production industry after the conveyor belt was introduced to increase speed and efficiency (Fitzgerald, 2010). In 1906, when Upton Sinclair published the novel *The Jungle* on Chicago's meatpacking industry, the public was not horrified by the plight of the workers who were dismembered or died on the job, as Sinclair had intended, but rather they were repulsed by the poor quality of their food (Anderson & Anderson, 1991). Sinclair famously stated of his novel's impact that, "I aimed at the public's heart, and by accident I hit it in the stomach" (Sinclair, 1906).

Since that time, US workers in animal processing industries have experienced similarities in their working conditions and continue to be at high risk for injuries and illnesses (Griffith et al., 1995). In these mass-production industries, facilities are designed for rapid processing on a production line, and then movement of the packaged product for storage and transport, requiring strenuous and repetitive manual labor. Much more occupational safety and health research has been conducted on the meat and poultry processing industries than the seafood processing industry, with meat and poultry processing having received national attention (Cartwright et al., 2012; GAO, 2016; NIOSH, 2014 & 2015a; OSHA, 2013 & 2017a; Quandt et al., 2006).

In the US during 2015, there was an annual average of 830 establishments and 36,624 workers in the seafood processing industry, with the Pacific region employing the most workers (BLS, 2017). According to national estimates from the Survey of Occupational Injuries and Illnesses for 2015, workers in the seafood processing industry experienced 7.3 nonfatal injuries/illnesses per 100 full-time workers, which was more than twice the US all-industry rate of 3.3 per 100 workers (BLS, 2016). Limited research has investigated worker safety and health in the seafood processing industry. Around the globe, hazards in this industry include exposures to: bioaerosols containing allergens, microorganisms, and toxins; bacterial and parasitic infections; excessive noise levels; temperature extremes; contact with machinery, equipment, and the packaged product; poor workplace organization; and poor ergonomic practices (Bang et al., 2005; Jeebhay et al., 2004; Lucas et al., 2014; Neitzel & Seixas, 2006; Syron et al., 2017).

Despite increased automation in the seafood processing industry, it remains labor-intensive as many tasks are done by hand, with some processors making up to thousands of repetitive motions each day at high speeds

(Griffith et al., 1995; Stimpfle, 2012). Seafood processors are at high risk for musculoskeletal injuries and disorders, with risk factors including: highly repetitive and forceful upper extremity movements; localized mechanic stress; awkward and/or static postures at workstations; prolonged standing; and temperature extremes (Aasmoe et al., 2008; Kim et al., 2004; Kuruganti & Albert, 2013; Nag et al., 2012; Ólafsdóttir & Rafnsson, 2000; Quansah, 2005). Seafood processors are also at high risk for developing dermatologic and respiratory allergic reactions, including occupational asthma, from exposures to high-molecular-weight proteins in various species of fish and shellfish (Aasmoe et al., 2005; Beaudet et al., 2002; Bønløkke et al., 2012; Dahlman-Höglund et al., 2012; Gautrin, 2010; Jeebhay & Lopata, 2012; Ortega et al., 2001; Shiryayeva et al., 2015; Žuškin et al., 2012). Recent studies on the Pacific Northwest seafood processing industry have shown high rates of accepted workers' compensation claims (Anderson et al., 2013; Syron et al., 2017).

### **ALASKA'S SEAFOOD PROCESSING INDUSTRY**

The seafood processing industry plays a critical role in bringing to market one of Alaska's most valuable natural resources. During 2015, Alaskan fishermen harvested the majority of the nation's seafood, at 6 billion pounds, and generated the largest portion of the national revenue, at \$1.7 billion, with subsequent processing adding value to the product (NMFS, 2016). Seafood-related work directly employs more people than any other Alaskan industry, and is the third-largest overall job creator, following oil/gas and visitor industries (ASMI, 2017).

In Alaska, the seafood processing industry includes onshore factories and two types of vessels that operate offshore. Catcher-processor vessels both harvest seafood using various types of fishing gear, and then process, package, and freeze it in a factory below deck. Processor vessels – also known as floating factories or “motherships” – receive seafood harvested by other vessels. In 2016, the Alaska Division of Environmental Health approved seafood processing permits for 169 high-production worksites with the capability to produce over 5,000 pounds of seafood per day, including 86 onshore factories, 70 catcher-processors, and 13 motherships. In some instances, single companies operated multiple worksites. Thirty-nine companies operated the onshore factories, with some operating vessels as well, and another 45 companies operated only vessels (Alaska Division of Environmental Health, 2017). During 2015, there were approximately 25,000 workers in the Alaskan seafood processing industry, 30% of whom were Alaskan residents, and 22% of whom worked in the industry year-round (Alaska Department of Labor, 2017a & 2017b). Positions are mainly seasonal, given that species are harvested during various times of the year in different locations. Many out-of-state workers are recruited to meet the seasonal labor demand. In remote locations and onboard vessels, employers provide room and board, either for free or charging a daily rate (Stimpfle, 2012; Strong, 2014).

In Alaska, the US Coast Guard and the Federal Occupational Safety and Health Administration (OSHA) share jurisdiction over regulating worker safety and health onboard catcher-processors and motherships (OSHA, 2010). The Coast Guard has identified safety and operational risks for vessels that require a sizeable crew, utilize processing and freezing machinery, and can operate in remote areas far from search and rescue support (USCG, 2006). Working offshore presents unique risks, including the potential for vessel disasters and falls overboard.

Federal OSHA has also determined that offshore seafood processing is a high-hazard industry and therefore developed a Local Emphasis Program for it, which has been in effect for over a decade, and established policies and procedures for regularly-programmed inspections (OSHA, 2016; OSHA, 2017b). For onshore factories, the state-run Alaska Occupational Safety and Health Section (AKOSH) has regulatory authority and provides consultation and training services. AKOSH has identified onshore seafood processing as a high-hazard industry and likewise put in place a Local Emphasis Program (AKOSH, 2013). During October 2015 through September 2016, AKOSH's consultation and training section conducted 23 training events, with the goal of addressing the industry's specific needs (AKOSH, 2017a, 2017b).

Despite regulators classifying Alaska's seafood processing industry as high-risk, information on worker safety and health outcomes is limited. The Census of Fatal Occupational Injuries (CFOI) did not report any fatalities in the Alaskan seafood processing industry during 2014-2015 (Alaska Department of Labor, 2017c). Although the risk of operational fatalities in this industry is low, there is evidence that the risk of nonfatal injuries and illnesses could be elevated compared to others. The Survey of Occupational Injuries and Illnesses (SOII) reported that for Alaska in 2015, the broad "food manufacturing" industry experienced a rate of 8.3 injuries and illness per 100 full-time employees, which was twice the state's all-industry rate of 4 per 100 full-time employees (Alaska Department of Labor, 2017d). Within the broad food manufacturing category, SOII data on seafood processing, specifically, are unavailable. However, in Alaska, workers in the seafood processing industry constitute over 90% of all food manufacturing workers (Alaska Department of Labor, 2017e).

Workers in Alaska's seafood processing industry are understudied and face workplace hazards as well as socioeconomic factors that put them at risk for injuries and illnesses. These workers are often on-duty for long hours every day (e.g., 16 hours per day) for weeks at a time. Depending on several factors, including the labor supply at their plant and fishery season length, they can struggle to keep up with meeting production demands (Cole, 2017; Zak, 2017). Interviews with Filipino seafood processors in Dutch Harbor, Alaska identified challenges related to insufficient time allowances for rest breaks, as well as sleep disruptions in employer-provided dormitory rooms. Nevertheless, interviewees reported that it was much better to work for their company than for others operating in Alaska, citing their company's better commitment to safety and health. They noted that work shifts being limited to 12 hours was preferable to the 15- to 18-hour shifts at other companies (Garcia & de Castro, 2017). Long hours and shift work increase safety and health risks, as well as decrease productivity, and can result in errors that negatively impact the product quality. With very long shifts, and when 12-hour shifts combine with more than 40 hours of work a week, workers' physiological performance deteriorates and they experience increased injury rates and more illness (NIOSH, 2004). Many of these workers are seasonal, low-paid, and recruited from around the world. Although published statistics on all workers' demographics are unavailable – including annual income, formal education, language, race/ethnicity, and citizenship status – there is evidence to suggest that this is a vulnerable worker population (Arcury, 2013; Cole, 2017; Garcia & de Castro, 2017; Zak, 2017).

## OCCUPATIONAL SAFETY AND HEALTH FRAMEWORKS

The public health model can be utilized to address injuries and illnesses among workers in the seafood processing industry. This systematic process involves: (1) identifying and quantifying problems through surveillance; (2) identifying risk and protective factors; (3) developing and testing prevention strategies; (4) assuring widespread adoption of strategies; and (5) evaluating and monitoring the results (CDC, 2014; Stout & Linn, 2002). Similarly, the National Institute for Occupational Safety and Health (NIOSH) promotes a “Research to Practice” approach, which focuses on the use, adoption, and adaptation of knowledge, interventions, and technologies within the workplace. The first step in this approach involves collaborating with partners and stakeholders to identify needs (NIOSH, 2015b). This research covers the first steps outlined in these approaches, by identifying and quantifying problems through surveillance, as well as engaging stakeholders to determine what challenges they face and what opportunities there may be for improvement.

Likewise, this research draws on multiple occupational safety and health frameworks for preventing injury and illness. Industrial hygiene programs implement methods for anticipating, recognizing, evaluating, and controlling health hazards, such as chemical and biological hazards. To recognize hazards, exposure assessment programs involve characterizing the workplace, workforce, and environmental agents (Huey & Toy, 2002). To evaluate hazards, field surveys are often conducted, which follow the flow of materials into the facility and through various operations. Field surveys allow the industrial hygienist to talk with workers and operators, and to learn the language of facility operations. During field surveys, communicating with supervisors and other health and safety personnel is essential to understanding the sources and effects of hazards, and for planning future sampling and analysis (Gross & Pechter, 2002). Similarly, job safety analyses involve the following steps: (a) examining a job by breaking it down into a series of tasks; (b) identifying all hazards that could be produced by the environment or conditions associated with the job; and (c) recommending actions or procedures to eliminate or minimize the hazards that could lead to an incident (Rice, 2002; OSHA, 2002).

Ergonomics is the science of fitting workplace conditions and job demands to workers’ capabilities. Ergonomic programs, which are often implemented to prevent musculoskeletal injuries, follow a systematic process for identifying, analyzing, and controlling workplace risk factors. These risk factors can include repetitive movement, forceful exertions, and awkward postures. Programs follow these steps: (1) identifying risk factors; (2) involving and training management and workers, including giving workers the opportunity to discuss problems; (3) collecting health and medical evidence; (4) implementing controls – such as using mechanical assist devices or reducing materials’ weights; (5) evaluating the program; and (6) maintaining management and worker involvement in the program (NIOSH, 2017).

The Haddon Matrix is a model that informs injury epidemiology and prevention through the identification of causal factors and countermeasures (Haddon, 1968). The model incorporates the public health concept of host-agent-environment with the concepts of primary, secondary, and tertiary prevention. Runyan (1998) proposed expanding the original matrix to incorporate criteria for deciding between potential interventions. These criteria



include: effectiveness; cost; potential compromised freedom to reach the prevention goal; equity among individuals; avoidance of stigmatization; preferences of the affected individuals; and feasibility, which covers technological capabilities, political considerations, and financial resources (Runyan, 1998). When identifying potential prevention strategies, it is vital to consider these criteria. Engaging stakeholders is essential for understanding the value-based criteria.

## **RESEARCH APPROACH AND PURPOSE**

This research used a mixed-methods approach, by utilizing quantitative data from US Coast Guard injury reports and Alaska workers' compensation claims, as well as qualitative data from stakeholder interviews. Mixed method approaches can achieve richness and depth while also extending findings to a larger population. For topics that lack a developed literature, qualitative research provides insight and clarity. Qualitative data are useful for supplementing, validating, and illuminating quantitative data gathered from the same setting (Frattaroli, 2012; Miles et al., 2013).

The long-term goals of this research are to inform injury and illness prevention strategies, as well as identify areas for future studies and collaboration between industry members, researchers, and occupational health practitioners. In addition to informing injury and illness prevention strategies in Alaska, these findings and recommendations could be applicable to the US seafood processing industry as a whole. To accomplish these research goals, three studies were conducted. Each study addressed a specific aim:

***Aim 1:*** To utilize US Coast Guard reports to determine patterns of traumatic injury characteristics and circumstances, as well as identify modifiable worksite hazards, among offshore seafood processors working in Alaskan waters during 2010-2015.

***Aim 2:*** To utilize workers' compensation claim reports to (a) estimate the risk of nonfatal injuries and illnesses, (b) determine patterns of incident characteristics and circumstances, and (c) identify modifiable workplace hazards among onshore workers in Alaska's seafood processing industry during 2014-2015.

***Aim 3:*** To interview safety and health managers to investigate: worksite and workforce characteristics; safety and health program features; economic factors influencing programs; and program challenges and successes.

This research produced three manuscripts, which are presented in the following chapters, and will be submitted to scientific journals for publication.

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**CHAPTER 2: FIRST MANUSCRIPT****OCCUPATIONAL TRAUMATIC INJURIES AMONG OFFSHORE  
SEAFOOD PROCESSORS IN ALASKA, 2010-2015**Laura N. Syron <sup>a,b</sup>Laurel D. Kincl <sup>a</sup>Viktor E. Bovbjerg <sup>a</sup>Devin L. Lucas <sup>b</sup>Samantha L. Case <sup>b</sup>

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**ABSTRACT**

**Introduction:** The US Coast Guard and Federal Occupational Safety and Health Administration have identified the Alaskan offshore seafood processing industry as high-risk. This study used Coast Guard injury reports to describe patterns of traumatic injury among offshore seafood processors, as well as identify modifiable hazards.

**Methods:** From the reports, we manually reviewed and abstracted information on the incident circumstances, injury characteristics and circumstances, and vessel characteristics during 2010-2015. Traumatic injury cases were coded using the Occupational Injury and Illness Classification System, as well as a Work Process Classification System. Descriptive statistics characterized worker demographics, injuries, and fleets.

**Results:** One fatal and 304 nonfatal injuries were reported to the Coast Guard across multiple fleets of catcher-processor and mothership vessels. The most frequently occurring injuries, were: by nature of injury, sprains/strains/tears (75, 25%), contusions (50, 16%), and fractures (45, 15%); by body part affected, upper extremities (121, 40%) and trunk (75, 25%); by event/exposure resulting in injury, contact with objects and equipment (150, 49%), and overexertion and bodily reaction (76, 25%); and by source of injury, processing equipment and machinery (150, 49%). The work processes most frequently associated with injuries were: processing seafood on the production line (68, 22%); stacking blocks/bags of frozen product (50, 17%); and repairing/maintaining/cleaning factory equipment (28, 9%). Some injuries, such as serious back injuries, intracranial injuries, finger crushing or amputations, have the potential to lead to long-term disability.

**Conclusion:** Preventing musculoskeletal injuries, particularly to workers' trunk and upper extremities, is paramount. Hazard control measures should target: (a) overexertion from lifting and lower objects and equipment; (b) equipment and boxes falling and striking workers; (c) workers being caught in running machinery during regular operations; and (d) slips, trips, and falls. Safety and health professionals and researchers can use these detailed results and discussion to inform future intervention efforts in this industry.



## INTRODUCTION

Offshore seafood processors work in a demanding environment that combines the occupational safety and health challenges faced in the commercial fishing and food manufacturing industries. The US seafood processing industry comprises onshore establishments and vessels operating at sea that engage in the following activities: eviscerating fresh fish by removing heads, fins, scales, bones, and entrails; shucking and packing fresh shellfish; processing marine fats and oils; smoking, salting, and drying seafood; canning seafood; and freezing seafood (NAICS, 2017). Two types of vessels engage in extensive seafood processing. Catcher-processors have the capacity both to harvest seafood using various types of gear on deck, and then to process, package, and freeze the catch in a factory below deck. Processor vessels – also known as floating factories or “motherships” – receive the catch that is harvested by other vessels and then process, package, and freeze it. Vessels’ specific processing and packaging activities, seafood products (e.g., fillets, surimi, roe), and crew sizes vary by fleet. Fleets are groups of vessels that operate in the same geographic region, fish for and/or process the same species, and use the same type of gear (e.g., trawl, longline, pot).

In Alaska, processing seafood is a critical step in the supply chain that brings this valuable natural resource to market. During 2015, Alaskan fishermen harvested the majority of the nation’s seafood, at 6 billion pounds, and generated the largest portion of the national revenue, at \$1.7 billion, with subsequent processing adding value to the product (NMFS, 2016). That year, Alaska’s Division of Environmental Health approved seafood processing permits for 87 vessels that had the capability to process over 5,000 pounds of seafood per day (Alaska Division of Environmental Health, 2017). Approximately 3,500 people worked onboard these catcher-processors and motherships, with only 6% being Alaska residents (Alaska Department of Labor, 2017). Working onboard these vessels in Alaska is difficult, requiring physical and mental endurance. When recruiting employees, companies describe how the vessels operate in remote locations, are wet, cold, and noisy environments, and the living conditions at sea are cramped. They explain that processors’ work shifts are long, and tasks typically monotonous, with prolonged periods of standing, repetitive movements, and heavy lifting (Glacier Fish Company, 2017; Premier Pacific Seafoods, 2017; Signature Seafoods, 2017; Trident Seafoods, 2017).

The US Coast Guard and the Federal Occupational Safety and Health Administration (OSHA) share jurisdiction over regulating worker safety and health onboard catcher-processors and motherships in Alaska, with OSHA’s jurisdiction extending to ‘uninspected vessels’ under 5,000 gross tons when operating within 3 nautical miles from the coastline (OSHA, 2010). Both agencies have identified offshore seafood processing as high-risk. Coast Guard regulations for processing vessels are more stringent than regulations for vessels that only harvest the catch, including classification and load line requirements (USCG, 2009). Factors that increase the safety and operational risks to fleets that engage in extensive processing activities within a factory include: having sizeable crews; utilizing processing and freezing machinery; using hazardous gases in refrigeration systems; and having the ability to freeze and store the catch, allowing crews to operate in remote areas that are far from search and rescue support (USCG, 2006). For all fleets, the Coast Guard’s fatality prevention activities focus on vessel safety and emergency

preparedness. OSHA determined that offshore seafood processing was a high-hazard industry in Alaska and therefore developed a Local Emphasis Program (LEP), which is an enforcement strategy to address hazards that pose a particular risk to workers (OSHA, 2017a). The LEP has been in effect for over a decade and established policies and procedures for regularly-programmed inspections (OSHA, 2016). OSHA's activities focus on preventing fatal and nonfatal injuries and illnesses among offshore processing workers.

Working offshore presents unique risks, including the potential for vessel disasters and falls overboard. Risks vary by vessel and fleet. In July 2016, the F/V Alaska Juris, an aging freezer-trawler built in the 1970s, sank in the Bering Sea more than 126 miles west of Adak, putting at risk the lives of 46 crewmembers, who successfully abandoned ship and were rescued (NTSB, 2017). Recently, a report assessed vessel disasters and fatalities due to traumatic injury during 2002-2014 in the Bering Sea/Aleutian Islands Pollock fleet (AFA fleet), which includes catcher vessels, catcher-processors, and motherships. Among the processor crewmembers, two fatal falls overboard in Alaskan waters occurred in 2003 and 2007. In terms of fatality and vessel disaster frequency, this fleet was found to be among the safest as compared with other Alaskan fleets. However, the report also found that future research was necessary to identify safety hazards related to nonfatal injuries (Case et al., 2017). Nonfatal injuries and illnesses constitute the vast majority of workplace incidents and can be severe, resulting in lowered productivity, lost worktime and wages, lowered quality of life, and disability.

Working in a factory to manufacture food presents additional risks. Hazards in the onshore seafood processing industry include exposures to: bioaerosols containing allergens, microorganisms, and toxins; bacterial and parasitic infections; excessive noise levels; low temperatures; poor workplace organization; poor ergonomic practices; and contact with machinery and equipment (Jeebhay et al., 2004). Risk factors for musculoskeletal disorders in this industry include: highly repetitive and forceful upper extremity movements; localized mechanic stress; awkward and/or static postures at workstations; prolonged standing; and temperature extremes (Aasmoe et al., 2008; Kim et al., 2004; Nag et al., 2012; Ólafsdóttir & Rafnsson, 2000; Quansah, 2005). Recent studies of onshore seafood processing in Washington State and Oregon have shown high rates of accepted workers' compensation claims in this industry compared to others (Anderson et al., 2013; Syron et al., 2017).

Few occupational safety and health studies of the Alaskan commercial fishing industry have discussed nonfatal injuries and illnesses among processors (Beaudet et al., 2002; Neitzel et al., 2006; Lucas et al., 2014; Syron et al., 2016; NIOSH, 2016a). To date, no epidemiologic study has focused solely on offshore processors across the multiple catcher-processor and mothership fleets in Alaska. This study's objectives were to determine patterns of traumatic injury characteristics and circumstances among offshore seafood processors working in Alaskan waters during 2010-2015, as well as identify modifiable hazards. The long-term goal of this research is to inform injury prevention strategies.

## **METHODS**

### ***Case Definition***

Companies that operate commercial fishing industry vessels are legally required to report to the Coast Guard any “injury that requires professional medical treatment (treatment beyond first aid) and, if the person is engaged or employed on board a vessel in commercial service, that renders the individual unfit to perform his or her routine duties” (Code of Federal Regulations, Title 46, Section 4.05-1). Companies use the “CG-2692 Report of Marine Casualty” form to document the details of incidents, including writing a narrative description of what occurred (USCG, 2013). This study included all cases of fatal and nonfatal traumatic injuries among seafood processors working in Alaskan waters during 2010-2015 that were reported to the US Coast Guard. A traumatic injury was defined as: “any wound or damage to the body resulting from acute exposure to energy... caused by a specific event or incident within a single workday or shift” (BLS, 2016). Not included in this study were disorders resulting from cumulative trauma (e.g., carpal tunnel syndrome, repetitive motion strains, and noise-induced hearing loss) or illnesses (e.g., infections, heart attacks, and diabetes-related complications). Offshore seafood processors were considered at work and exposed to potential hazards any time while at sea, even if they were off duty. Processors complete tasks in the factory and freezer, as well as offloading the frozen product from the vessel once it returns to shore. Workers onboard catcher-processor vessels sometimes perform a combination of tasks related to both harvesting and processing the catch. For this study, if “combination” workers were injured while performing deckhand duties related to harvesting the catch, then they were not included as cases.

### ***Data Sources***

The National Institute for Occupational Safety and Health (NIOSH) Western States Division manages the Commercial Fishing Safety Research and Design Program. This program’s ongoing surveillance activities include collecting data on fatal traumatic injuries and vessel disasters in the US commercial fishing industry. The only circumstance under which nonfatal traumatic injury data are collected as part of the program’s routine surveillance is when nonfatal injuries occur during vessel disasters (i.e., not during regular operations). The Commercial Fishing Incident Database (CFID) houses data on these fatalities and vessel disasters. Data on fatal traumatic injuries were obtained from this database (CFID, 2017).

For this study, NIOSH and Oregon State University collaborated on data collection on all reported nonfatal traumatic injuries – including those occurring during regular operations. NIOSH and the Coast Guard have a memorandum of agreement which allows NIOSH to utilize information collected by the Coast Guard for safety and health research (USCG, 2014). For this study, the research team manually reviewed the Coast Guard reports of nonfatal incidents – both brief notifications and full investigations – to identify cases of nonfatal, traumatic injuries in any Alaskan fleet and among all crewmembers (e.g., captains, deckhands, engineers, processors, etc.). The only way to determine the crewmembers’ position was to manually review all reports. Relevant information from the reports was abstracted, coded, and manually entered into a study database. Cases that met the study’s inclusion criteria (i.e., traumatic injuries among processors) were included for analysis.

This study was reviewed by the Oregon State University Institutional Review Board and determined to be exempt from full board review, because data abstraction from existing sources did not include abstracting personally identifying information (study number 6386).

### ***Measures***

The data collected for each case included: incident circumstances (date, geographic location, vessel activity, fishery); worker demographics (age, gender, job title, years of experience); injury characteristics and circumstances (nature, body part, event/exposure, source, work process, severity, injury response); and the vessel characteristics (vessel type, gear type, fleet).

The Occupational Injury and Illness Classification System (OIICS) was used to code the nature of injury, body part affected, and the event/exposure resulting in injury (BLS, 2012). For NIOSH's research on the commercial fishing industry and for this study, the standard OIICS rules for selecting event/exposure codes were slightly modified, so that cases which would typically be coded as "water vehicle incidents" were instead assigned codes that more precisely described the incident that occurred on the vessel. For instance, a crewmember falling onboard the vessel would be coded in the relevant "falls/slips/trips" subcategory, rather than as a "water vehicle incident." Additionally, rather than using the standard OIICS codes for the source of injury, which were developed for use across multiple industries, NIOSH researchers have developed a list of source codes that apply specifically to the commercial fishing industry. Typically, according to OIICS rules, when events are coded as "water vehicle incidents" the corresponding source code must be "commercial fishing vessel." Instead, the NIOSH source codes specify which gear, equipment, structures, environments, etc., were involved. NIOSH researchers expand the list of source codes as data are collected and new sources identified. NIOSH's source codes were utilized in this study.

Injury severity was coded with the severity scale that is utilized by Coast Guard investigators in their reports, which is an adaptation of the Abbreviated Injury Scale (AIS) (USCG, 2012). The Coast Guard severity scale contains the same levels and general definitions as AIS (minor, moderate, serious, severe, critical), but has some modifications, and allows for coding cases that lack clinical diagnosis information, which is typical for the Coast Guard reports on nonfatal incidents (see Appendix A). When sufficient information was available in the reports to code severity, each case was assigned a single severity score. If multiple injuries of different severities were sustained during a single event, the case was coded with the highest severity score (e.g., an event involving a lacerated hand and fractured arm would be coded with the higher severity corresponding to the fracture).

The processors' work task at the time of injury (i.e., work process) was determined by reviewing narrative descriptions of the incident in the Coast Guard reports. When possible, each case was assigned a code from NIOSH's Work Process Classification System (WPCS). The purpose of this classification system is to identify occupational injury causes and specific hazards in each commercial fishing fleet. The WPCS was originally developed and pilot tested in Danish fleets by Jensen et al. (2003, 2005 & 2006) and has been modified for use in US fleets (Lucas et al, 2014.; Case et al., 2015; Syron et al., 2016). During data collection for national surveillance,

NIOSH researchers utilize the modified WPCS, and develop codes as needed, when additional work processes associated with traumatic injuries are identified in various US fleets.

Vessel type and fleet were coded using information from Coast Guard reports and publicly-available databases. Coast Guard reports included the following information about the vessel: (a) name; (b) official number; (c) length; and (d) type. Vessels of any fleet that had the capability to harvest and process seafood were classified as 'catcher-processors.' Vessels of any fleet that only processed seafood (i.e., 'floating factories') were classified as 'motherships.' The Coast Guard report narrative descriptions oftentimes described the vessel's gear type and/or the seafood species that was being targeted and/or processed onboard the vessel. If the report did not provide sufficient information to code the fleet, then the vessels' name, official number, and length, as well as the date and location, were used to collect additional information from permit databases. These included the State of Alaska's Commercial Fisheries Entry Commission search engine, which provided permit and vessel records (CFEC, 2017), as well as the National Oceanic and Atmospheric Administration's Alaska Regional Office's lists of permits and licenses (NOAA, 2017). For this study, the Alaskan fleets were coded using categories from commercial fishing workforce estimates data that were produced by Natural Resources Consultants Inc. (NRC, 2013).

### ***Analysis***

Descriptive statistics, including frequency, percent distributions, and cross-tabulations, were calculated in Stata version 14.2 (StataCorp, 2015) to determine injury patterns and characteristics. For clarity and concision in reporting the injury characteristic and circumstance in the Results section, detailed OIICS and WPCS code names were oftentimes slightly modified from the original system. This process involved: (a) collapsing multiple detailed codes into a more general main category, (b) creating a new main category for a single detailed code that occurred frequently, or (c) slightly renaming codes to match language that is commonly used in the industry.

## **RESULTS**

During 2010-2015, one fatal and 304 nonfatal injuries were reported to the US Coast Guard among offshore seafood processors working in Alaskan waters. No injuries were attributed to vessel disasters or falls overboard. The single fatal injury that met the study's inclusion criteria occurred in 2010 and involved the worker becoming wedged between a conveyor belt and a wall in the freezer hold causing mechanical asphyxia. The 304 nonfatal injuries are described in the following sections.

### ***Incident Characteristics***

During the 6-year study period, an average of 51 nonfatal injuries were reported each year, ranging from 56 in 2010 to 44 in 2012. The vessel's latitude and longitude at the time of injury were reported for 267 cases (88%). The median distance from shore was 33 miles (0-264 miles). Almost all of the injuries occurred onboard the vessel, with only two injuries occurring onshore while workers were at the dock. Vessel activity was reported for 216 cases (71%), with the vessel's activity including fishing (104, 48%), transiting between shore and fishing grounds (44, 20%), being anchored (38, 18%), and being moored (30, 14%). Vessel type could be identified for all cases, with 75% of reported injuries occurring on catcher-processors of any fleet and 25% on motherships.

### **Worker Demographics**

Gender was reported for almost all nonfatal injury cases, with the vast majority (97%) involving men and only 10 cases involving women. Age was reported for 249 cases (82%), with a median age of 31 years (18-63 years). The amount of work experience in this industry was reported for 225 cases (74%), with the median amount of experience being 2 years (0-29 years). Of those cases reporting years of experience, 32% of the workers had less than a year of experience. Coast Guard reports rarely included information on crewmembers' race or ethnicity.

### **Injury Characteristics**

The nature of injury and body part injured could be coded for all cases. Table 1.1 presents the cross-tabulation of the nature of injury and broad-category body parts. Of injuries to the upper extremities, the majority were to hands and fingers (85, 70%). Of the injuries to the trunk, most involved the back (51, 68%). Of injuries to the lower extremities, almost half were to the legs (24, 44%). By nature of injury, almost a third of the injuries to the upper extremities involved fractures (35, 29%), followed by lacerations/punctures (26, 21%) and amputations (16, 13%). These upper-extremity amputations mainly involved fingertips and entire fingers; however, two incidents involved workers' hands. Half of the injuries to the trunk involved sprains/strains/tears (38, 51%). Likewise, many of the injuries to the lower extremities involved sprains/strains/tears (22, 41%). Among head injuries, almost half were intracranial injuries (16, 43%). A single incident involving an ammonia line leaking onboard a vessel resulted in the three poisoning cases, with the entire crew being evacuated.

<b>Table 1.1. Nature and Body Part of Nonfatal Traumatic Injuries among Offshore Seafood Processors, 2010-2015</b>								
	<b>Body Part (n=304)</b>							
<b>Nature of Injury (n=304)</b>	<b>Upper Extremities</b>	<b>Trunk</b>	<b>Lower Extremities</b>	<b>Head</b>	<b>Multiple</b>	<b>Neck</b>	<b>Body System</b>	<b>Total (row %)</b>
Sprain/Strain/Tear	13	38	22	0	0	2	0	75 (25)
Contusion/Abrasion	10	14	14	5	6	1	0	50 (16)
Fracture	35	2	4	4	0	0	0	45 (15)
Laceration/Puncture	26	0	3	6	0	0	0	35 (12)
Amputation	16	0	3	0	0	0	0	19 (6)
Intracranial injury	0	0	0	16	0	0	0	16 (5)
Pain/Swelling	1	7	2	1	1	0	0	12 (4)
Hernia	0	10	0	0	0	0	0	10 (3)
Burn	1	0	1	5	1	0	0	8 (3)
Crushing	7	0	1	0	0	0	0	8 (3)
Dislocation	5	1	1	0	0	0	0	7 (2)
Poisoning	0	0	0	0	0	0	3	3 (1)
Other	7	3	3	0	3	0	0	16 (5)
Total (column %)	121 (40)	75 (25)	54 (18)	37 (12)	11 (3)	3 (1)	3 (1)	304 (100)

### **Injury Circumstances**

The event/exposure that resulted in injury and the source of injury could be coded for all cases. Table 1.2 presents the cross-tabulation of the injury source and the broad-category event/exposure. Of the cases involving contact with objects and equipment, the most frequent events were workers being struck by falling objects or equipment (50, 33%), being caught in running machinery during regular operations (22, 15%), and being compressed or pinched by shifting objects and equipment (17, 11%). Of the cases involving overexertion and bodily reaction, one-third involved overexertion from lifting and lowering (28, 36%). Of the cases involving

slips/trips/falls, over half were falls on the same level (35, 54%), followed by falls to a lower level (14, 22%), and slips/trips without falls (12, 18%). By source, freezer pans constituted over half the cases involving processing equipment/machinery (45, 53%). Vessel was coded as the source of injury for falls/slips/trips from vessel surfaces. The majority of falls/slips/trips occurred in the factory (27, 42%) or the freezer (20, 29%), with a few cases occurring on deck (5, 8%) and other locations around the vessel.

Workers' location onboard the vessel at the time of injury could be determined for most of the cases (272, 89%), with over half occurring in the factory (161, 59%), followed by the freezer (98, 36%), holds (7, 3%), and on deck (6, 2%). Rough seas were reported as a contributing factor for seven cases. In four cases, the vessel movement resulted in workers losing their balance in the factory, on deck, and in the fishmeal hold. In three cases, the vessel rolling caused processing equipment and freezer pans in the factory to fall onto workers.

Source of Injury (n=304)	Event/Exposure (n=304)				Total (Row %)
	Contact with Objects/ Equipment	Overexertion & Bodily Reaction	Falls/ Slips/ Trips	Exposure to Substance/ Environment	
Processing Equipment/ Machinery	61	23	1	0	85 (28)
Vessel Interior/ Exterior	14	0	48	0	62 (20)
Box Frozen Fish/ Product	37	21	0	0	58 (19)
Bodily Motion	0	28	11	0	39 (13)
Conveyor	21	0	1	0	22 (7)
General Tool/ Equipment	10	2	3	0	15 (5)
Unpackaged Seafood - Fresh or Frozen	7	2	0	2	11 (3)
Chemical	0	0	0	9	9 (3)
Temperature/ Boiling Water	0	0	0	2	2 (1)
Dock	0	0	1	0	1 (1)
Total (Column %)	150 (49)	76 (25)	65 (22)	13 (4)	304 (100)

### **Work Process Associated with Injury**

The work process associated with injury could be coded for the vast majority of cases, with only six cases lacking sufficient information in the narrative description. Table 1.3 presents the cross-tabulation of the work process by general-category event/exposure.

Processing the catch (also known as working on the "slime line") accounted for almost a quarter of injuries. Of these cases, roughly half of the narrative descriptions did not specify the exact processing task. For cases in which detailed information was available, the most frequently occurring tasks were "heading the catch" (10), "counting/sorting the catch" (7), "packing fish in pans" (6), and "cleaning the catch" (3). On the slime line, the pieces of equipment most frequently involved were conveyor belts and header blades. Of the seven cases involving exposure to harmful substances while on the slime line, three involved an ammonia leak incident, two involved exposure to boiling water, and two involved fish slime and scales getting into workers' eyes.

Stacking blocks/bags of frozen product was the second-most frequently occurring work process associated with injury. While stacking the frozen product, almost half of workers' injuries resulted from contact with objects and equipment – mainly boxes of frozen fish striking workers. The majority of overexertion/bodily

reaction cases associated with this work process involved strains, with a few cases involving twisted knees and ankles.

Repairing, maintaining, and cleaning the factory equipment was the third-most frequently occurring work process associated with injury. During repair, maintenance, and cleaning, workers were frequently caught in or compressed by the processing machinery (9) or conveyors (3). While cleaning factory equipment, facial injuries – particularly to the eyes – resulted from chemical exposures (6).

<b>Table 1.3. Work Process and Event/Exposure Resulting in Nonfatal Traumatic Injuries among Offshore Seafood Processors, 2010-2015</b>					
<b>Work Process (n=298)</b>	<b>Event/Exposure (n=304)</b>				<b>Total (Row %)</b>
	<b>Contact with Objects/ Equipment</b>	<b>Overexertion &amp; Bodily Reaction</b>	<b>Falls/ Slips/ Trips</b>	<b>Exposure to Substance/ Environment</b>	
Process Catch on Slime Line	38	15	8	7	68 (22)
Stack Blocks/Bags Frozen Product	23	17	10	0	50 (17)
Repair/Maintain/Clean Factory Equipment	15	3	4	6	28 (9)
Offload the Product	16	3	3	0	22 (7)
Unload Plate Freezers	10	11	0	0	21 (7)
Crack Freezer Pans	13	5	1	0	19 (6)
Walk: Factory	3	2	10	0	15 (5)
Climb/Descend Ladders/Stairs	1	1	9	0	11 (4)
Walk: Freezer	4	1	5	0	10 (4)
Walk: Deck, Corridors, Dock	1	0	7	0	8 (3)
Load Plate Freezers	3	5	0	0	8 (3)
Remove Frozen Product Conveyor/Slide	8	0	0	0	8 (3)
Clean Up Vessel	3	1	4	0	8 (3)
Bag/Case Frozen Product	3	3	1	0	7 (2)
Off Duty	2	2	1	0	5 (2)
Move Carts of Frozen Product	0	4	0	0	4 (1)
Other	4	1	1	0	6 (2)
Missing	3	2	1	0	6 (-)
Total (Column %)	150 (49)	76 (25)	65 (22)	13 (4)	304 (100)
a Valid percentages (which exclude missing values from the denominator) were used for all percent calculations					

### ***Injury Severity***

Injury severity could be coded for all but eight cases. Table 1.4 presents a cross-tabulation of injury severity and work process. The Abbreviated Injury Scale is an anatomical-based coding system and the US Coast Guard's adapted system provided levels of treatment corresponding to the severity categories. Minor severity cases (158, 53%) did not require professional medical treatment (e.g., minor lacerations, bruises, or strains/sprains). Moderate severity cases (116, 39%) might have required professional treatment (e.g., broken or amputated fingers or toes, dislocated joints, or severe strains/sprains). Serious severity cases (22, 8%) might have required significant medical/surgical treatment (e.g., broken or partially amputated limbs). None of the nonfatal injury cases were coded as severe or critical. All of the work processes associated with injury had a range of injury severity scores. The following work processes included cases with serious injury severity scores: processing the catch on the slime line (6); stacking blocks/bags of frozen product (4); repairing/maintaining/cleaning factory equipment (4); removing frozen product from conveyors/slides (2); cleaning up the vessel (2); cracking freezer pans (1); and bagging frozen product (1).



<b>Table 1.4. Work Process and Severity of Nonfatal Injuries among Offshore Seafood Processors, 2010-2015</b>					
<b>Work Process (n=298)</b>	<b>Injury severity (n=296)</b>				<b>Total (Row %)</b>
	<b>Minor</b>	<b>Moderate</b>	<b>Serious</b>	<b>Missing</b>	
Process Catch on Slime Line	33	29	6	0	68 (22)
Stack Blocks/Bags Frozen Product	29	16	4	1	50 (17)
Repair/Maintain/Clean Factory Equipment	13	11	4	0	28 (9)
Offload the Product	8	12	0	2	22 (7)
Unload Plate Freezers	12	8	0	1	21 (7)
Crack Freezer Pans	9	9	1	0	19 (6)
Walk: Factory	8	5	0	2	15 (5)
Climb/Descend Ladders/Stairs	8	2	0	1	11 (4)
Walk: Freezer	8	2	0	0	10 (4)
Walk: Deck, Corridors, Dock	5	3	0	0	8 (3)
Load Plate Freezers	7	1	0	0	8 (3)
Remove Frozen Product Conveyor/Slide	2	4	2	0	8 (3)
Clean Up Vessel	2	4	2	0	8 (3)
Bag/Case Frozen Product	6	0	1	0	7 (2)
Off Duty	3	2	0	0	5 (2)
Move Carts of Frozen Product	1	3	0	0	4 (1)
Other	2	1	2	1	6 (2)
Missing	2	4	0	0	6 (-)
Total (Column %)	158 (53)	116 (39)	22 (8)	8 (-)	304 (100)

### ***Injury Response***

The crew's response to an injury was reported infrequently, for only 40% of cases. Of these cases, most responses involved the injured worker initially being treated on the vessel, and then either seeking treatment at a clinic later (68, 37%), continuing work (59, 33%), or returning home (9, 5%). In some instances, the vessel was moored and the injured worker could be treated at a clinic right away (21, 12%). Other times, the vessel was out at sea and returned to shore immediately so that the injured worker could receive advanced medical treatment (16, 9%). Eight cases (4%) required Coast Guard medical evacuation.

### ***Injury Reporting to US Coast Guard by Vessel and Fleet***

During the 6-year study period, 60 processor vessels reported at least one nonfatal injury to the Coast Guard. The number of reported injuries varied greatly by vessel. Among the 60 vessels, the number of injuries reported during the study period ranged from 1 to 31 injuries, with 10 vessels reporting 10 or more injuries. The reports from these 10 vessels constituted half of all cases in the study. It is unknown if this variation in reporting reflects an actual variation in how many injuries occurred on each vessel (which could be influenced by the crew size), or if reporting practices simply vary by vessel. For example, there could potentially be either (a) under-reporting of actual injuries, or (b) over-reporting of very minor incidents that do not technically meet the Coast Guard's minimum threshold for reporting.

The number of reported injuries varied by fleet as well. Fleet could be determined for all but one case. Almost half of the cases were reported in the Bering Sea/Aleutian Islands (BSAI) Pacific Cod and Other Groundfish Freezer-Trawl fleet (132, 43%), followed by the BSAI Pollock Freezer-Trawl fleet (58, 19%), the state-wide Multi-Species Mothership fleet (48, 16%), the BSAI Pacific Cod Freezer-Longline fleet (39, 13%), and the BSAI Pollock Mothership fleet (26, 9%). Natural Resource Consultants Inc. provided estimates of how many vessels operate in

each fleet. Based on these estimates, it was possible to determine how many vessels in each fleet reported at least one injury during the study period. All of the vessels in the small Pollock Mothership fleet reported at least one injury, as did almost all of the vessels in the Pollock Freezer-Trawl fleet. Approximately 60% of the vessels operating in the larger Pacific Cod and Other Groundfish Freezer-Trawl fleet and Pacific Cod Freezer-Longline fleet reported at least one injury. One-quarter of the vessels in the Multi-Species Mothership fleet reported at least one injury.

## **DISCUSSION**

This is the first epidemiologic study to characterize patterns of traumatic injuries and identify modifiable hazards among offshore seafood processors working across multiple Alaskan fleets. During 2010-2015, one fatal and 304 nonfatal traumatic injuries were reported to the US Coast Guard. The fatal injury due to mechanical asphyxia highlights the potential danger of working in freezer holds around conveyor systems. Among the nonfatal injuries, severity ranged from minor to serious, with many cases resulting in lost work time and requiring advanced medical treatment. The detailed results presented in this study should inform injury prevention strategies and future research efforts in this industry.

### ***Nonfatal Injury Characteristics***

The majority of reported injuries occurred among men, with at least a quarter of all injured processors having less than a year of experience in the industry. Further research is needed to estimate workforce demographics and turn-over rates in this industry, in order to calculate injury rates by gender and work experience, and thereby determine if these characteristics are associated with higher risk of injury.

Sprains, strains, and tears, which frequently occurred in both the trunk and extremities, constituted a quarter of all injuries. Main contributors to these injuries were overexertion from handling boxes of frozen fish and using processing equipment and machinery. Processors' upper extremities – especially hands and fingers – often experienced fractures, lacerations/punctures, crushing, and amputations. Serious back injuries, as well as finger and thumb crushing and amputations, may have resulted in long-term disability. Of special concern were the head injuries, almost half of which were intracranial injuries. Intracranial injuries were caused primarily by boxes and bags of frozen product falling and striking processors, as well as processors themselves falling and striking their heads.

These results, which demonstrate the importance of preventing sprains, strains, and tears, as well as preventing various types of injuries to upper extremities, are consistent with prior research. A recent study of Oregon workers' compensation disabling claims in this industry found that, (a) by nature, incidents most frequently involved traumatic injuries to muscles, tendons, ligaments and joints – primarily to the trunk and upper extremities; and (b) by body part, workers' upper extremities were most frequently injured, including open wounds and musculoskeletal disorders (Syron et al., 2017). Over the past 25 years, musculoskeletal symptoms and disorders, particularly to the upper extremities, have been described in various studies of onshore seafood processing (Aasmoe et al., 2008; Babski-Reeves & Crumpton-Young, 2003; Chiang et al., 1993; Kim et al., 2004; Nag

et al., 2012; Ohlsson et al., 1994; Ólafsdóttir & Rafnsson, 2000; Silverstein et al., 1998). For offshore seafood processing specifically, previous studies of traumatic injuries among all commercial fishermen (deckhands, engineers, captains, processors, etc.) have not specified the patterns of injuries by nature and body part among the injured processors. However, two studies of the Alaskan commercial fishing industry have identified similar types of injuries and hazards as those found here. These include: (a) processing tasks being responsible for most of the lacerations, punctures, avulsions, amputations, and poisonings among all crewmembers, with the most frequent causes including being caught in running processing equipment and slipping knives (Lucas et al., 2014); and (b) tasks involving handling frozen fish resulting in sprains, strains, tears, and fractures, and tasks involving hands-on processing resulting in lacerations, punctures, amputations, and fractures (Syron et al., 2016).

The injury patterns identified in this and other studies of the seafood processing industry are similar to those found in the poultry processing industry. In both industries, facilities are designed for rapid line production and then movement of the packaged product for storage and transport, all of which involves strenuous and repetitive manual labor. Poultry processors are at high-risk for musculoskeletal injuries and disorders, particularly in the upper extremities (Cartwright et al., 2012; NIOSH, 2015; OSHA, 2013; Quandt et al., 2006).

#### ***Nonfatal Injury Circumstances and Potential Prevention Strategies***

Offshore seafood processors faced hazards while working in factories and freezers, as well as moving throughout the vessel, both on- and off-duty. Injury prevention strategies should target the work processes and events that are associated with the most frequently-occurring and severe injuries. When deciding upon and implementing hazard controls, the hierarchy of controls should be followed, with elimination of hazards and engineering controls favored over administrative controls and personal protective equipment, in order to provide the most effective protection (NIOSH, 2016b).

As expected, seafood processors most frequently experienced injuries while completing processing tasks on the production “slime line” in the factories. By severity, the largest number of serious injuries occurred during this work process as well. Hazards on the slime line ranged from contact with conveyors and header machines, to overexertion, and falls, slips, and trips. Following lockout procedures could potentially prevent injuries due to contact with machinery and conveyors during cleaning and maintenance (OSHA, 2014). Ergonomic solutions that have been successfully utilized in other food manufacturing industries, such as poultry processing, to avoid overexertion and musculoskeletal injuries could potentially be translated to this factory setting, with interventions tailored to the unique work processes. Potential engineering controls could include: (a) adjusting workstations and standing work surfaces to fit the worker height and the angle of the tasks being performed; (b) arranging work stations so that any lifting is done in front of workers without twisting; and (c) utilizing mechanical devices that tilt or invert containers in order to reduce manual removal of products. Administrative controls could include: (a) performing routine and preventive maintenance to assure that equipment is working properly; (b) allowing employees pauses to rest fatigued muscles, as well as breaks in warmer areas of the vessel; (c) designing job rotation schedules between different tasks to “reduce exposure to any single risk factor and to allow body parts to

either rest completely, work at slower rates, use less force, or work in more neutral postures” (OSHA, 2013; OSHA 2017b). The extent to which working long hours over extended periods might contribute to musculoskeletal injury is an area for further research.

While stacking the frozen product, processors were frequently struck by the boxes and bags. This also occurred while removing boxes of frozen product from conveyors/slides, and then offloading them once the vessels returned to shore. To prevent workers from being struck by frozen boxes and bags of product, engineering controls should be utilized in areas in which the product is stored and moved. These work processes were also associated with injuries due to overexertion. Various strategies are available to prevent injuries from manual handling and repetitive motion: (a) reduce the size and weight of the load, by reducing packaging sizes, or by workers sharing the load; (b) when possible, rotate work tasks; and (c) adjust or design work heights to reduce working with the back bent and allow for elbows to stay close to the body (SHARP, 2001). Hiring ergonomists and safety engineers to help redesign factories and holds in order to improve the safety of material handling processes is a more effective control measure than *only* utilizing administrative controls, such as training workers to use safe material handling techniques. The concept of “prevention through design” involves eliminating hazards as early as possible in the life cycle of equipment and workplaces. Worker safety is incorporated into the design, redesign, and retrofit of new and existing tools, machinery, facilities, and work processes (NIOSH, 2013). This concept is especially relevant as new catcher-processors and motherships are designed and built. For example, in 2016, a Seattle company debuted a state-of-the-art freezer-longliner, the F/V Blue North, to operate in the Bering Sea/Aleutian Islands Pacific Cod fleet. The vessel was equipped with cutting-edge technology to enhance production efficiency, reduce environmental impact, and also provide a safe workplace for crewmembers:

A size-sorting component for headed and washed fish will make packing simpler and more efficient, while automatic horizontal plate freezers increase product throughput and minimize crew needs. A semi-automatic packing line for both H-G and Shatter Pack product will also minimize labor needs in the case up area. The new vessel's factory is also fitted with a system that automatically loads product into the cargo hold elevator, which also saves labor and offers a safer way to handle the product. Finally, a full circle round-about conveyor system in the cargo hold, with automatic in-feed into the offload elevator, makes the whole offload process easier and safer for the crew (Philips, 2015).

These designs could potentially help prevent the types of injuries identified in this study, many of which occurred while: stacking blocks/bags of frozen product; offloading the product; loading and unloading plate freezers; removing frozen product from the conveyor/slide; and bagging/casing frozen product.

Walking throughout the vessel – including areas such as the factory and freezer, which are often wet or icy – and climbing/descending ladders and stairs resulted in slips, trips, and falls. To prevent slips, trips, and falls, passageways should be kept clear of obstructions and substances/seafood should be cleaned up as frequently as possible. Given the wet nature of this work environment, proper drainage should be maintained, with appropriate gratings, mats, or raised platforms provided, and surfaces designed to increase adhesion (OSHA, 2017b).

Hazards associated with repairing, maintaining, and cleaning the factory equipment included being caught in or compressed by processing machinery and conveyors, as well as exposure to chemicals. Again, following

regular maintenance and lockout procedures could potentially prevent injuries due to contact with machinery and conveyors. Cleaning product formulations that present fewer hazards to workers should be utilized when possible, and appropriate personal protective equipment should always be worn to prevent contact with the eyes and skin. A single incident involving an ammonia line leak resulted in the three poisoning cases, with the entire crew being evacuated. This event highlights the importance of following safety requirements and recommended best practices for the repair and maintenance of refrigeration systems that use ammonia and halocarbons, which have been outlined by OSHA (OSHA, 2015).

A hazard unique to the offshore environment is vessel movement caused by rough seas. This study identified cases of processors losing their balance in the factory, on deck, and in the fishmeal hold due to vessel movement, as well as vessel rolling causing processing equipment and freezer pans in the factory to fall onto processors. To the extent possible, engineering solutions should be developed to secure objects and equipment from falling or shifting suddenly. Two other hazards unique to offshore work - vessel disasters and falls overboard – were not identified as contributing to traumatic injuries. However, given that vessel disasters and falls overboard can result in fatalities, companies should require all crewmembers to wear personal flotation devices while on deck and adhere to Coast Guard regulations (NIOSH, 2017). The Coast Guard's regulatory activities cover: vessel stability; navigation; fire protection, electrical, and engineering equipment; communication systems; and emergency instructions, drills, and safety orientations, including using survival craft and cold-water immersion suits (USCG, 2009). In contrast, OSHA's regulatory activities are aimed at fatal and nonfatal injury prevention, and are relevant to many of the nonfatal injuries discussed here. Their activities cover: lockout/tagout; maintenance and repair of factory areas; onboard cranes; onboard powered vehicles; fall protection; chemical and respiratory protection; hazard communication; noise; materials handling and storage; and ergonomics (OSHA, 2010).

### ***Limitations***

Nonfatal injury rates for offshore seafood processors could not be calculated due to lack of workforce estimates by occupation in the Alaskan commercial fishing industry. Future research is needed to estimate the number of processors in each fleet. Potential inconsistent injury reporting to the Coast Guard is also problematic when attempting to determine risk. It is likely that some vessels underreport injuries and only notify the Coast Guard of incidents that require assistance such as medical evacuation, while others report injuries that do not meet the severity threshold for what is legally required to be reported (e.g., minor lacerations that do not render the worker unfit for regular duties). In a previous study, when analyzing injury data from both Coast Guard investigative reports and the National Marine Fisheries Service Observer Survey, Lucas et al. (2014) found evidence of underreporting to the Coast Guard, with approximately 25% of injuries in the freezer-trawler fleet and 50% of injuries in the freezer-longliner fleet not having been reported to the Coast Guard. In this study, a limitation of using the Coast Guard's injury severity scale, which is based on Abbreviated Injury Scale (AIS) scores that represent an injury's threat to life, is that the scale does not take into account the potential disability associated with severe nonfatal injuries. To our knowledge, no such injury severity scales have been validated for widespread use.

**Future Research**

While this study investigated only traumatic injuries, musculoskeletal disorders (MSDs) and illnesses are areas of concern for seafood processors. In Alaskan catcher-processor fleets specifically, studies have found that exposure to crab allergens resulted in respiratory symptoms (Beaudet et al., 2002) and that almost all crewmembers were exposed to work shift and 24-hour noise levels that exceeded the relevant limits, with the primary noise sources coming from engine room machinery and processing machinery on the factory decks (Neitzel et al., 2006). Future research is needed to determine the extent of illnesses and MSDs among offshore processors. An additional area for future investigation is how chronic conditions – heart disease, diabetes, etc. – might impact safety and health in this population that works in remote areas, far from advanced medical treatment. The extent to which working long hours for extended periods could contribute to musculoskeletal injuries and disorders is another area for study. Analyzing OSHA reports of injuries and illnesses, as well as collaborating with companies to analyze their insurance claims data, are potential sources of information on safety and health in this worker population.

Future epidemiologic work is planned to study worker safety and health in the Alaskan commercial fishing industry that could overcome some of the limitations of the current study. As mentioned in the Methods section, the research team manually reviewed the Coast Guard reports of nonfatal incidents – both notifications and investigations – among all crewmembers (captains, deckhands, engineers, processors, etc.). The team plans to utilize these data for all crewmembers during 2012-2016 and link these cases with nonfatal injury and illness cases from the Alaska Trauma Registry and Alaska Fishermen's Fund. By linking data sources and including cases among all crewmembers, this study would capture additional types of incidents that are not typically reported to the Coast Guard (MSDs, health conditions, and illnesses) and determine nonfatal injury and illness rates by industry and fleet. A second study, which utilizes qualitative research methods, will engage members of the Alaskan seafood processing industry – both onshore and offshore – in characterizing their worker safety and health programs. Interviews with corporate-level safety and health managers will identify program challenges and successes, as well as characterize workforce demographics.

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**CHAPTER 3: SECOND MANUSCRIPT****INJURY AND ILLNESS AMONG ONSHORE WORKERS IN ALASKA'S SEAFOOD PROCESSING INDUSTRY:  
AN ANALYSIS OF WORKERS' COMPENSATION CLAIMS, 2014 – 2015**

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**ABSTRACT**

**Background:** The State of Alaska's Occupational Safety and Health Section has identified onshore seafood processing as a high-hazard industry. This study's objectives were to use Alaska workers' compensation claims data to estimate the risk of nonfatal injuries and illnesses, determine patterns of incident characteristics and circumstances, and identify modifiable hazards for onshore seafood processing workers.

**Methods:** Accepted claims data from 2014-2015 were manually reviewed and coded with the Occupational Injury and Illness Classification System, Standard Occupational Classification System, geographic region, and work activity associated with the incident. Alaska workforce data were utilized to calculate claim rates per 1,000 workers.

**Results:** During the study period, 2,194 nonfatal injuries and illnesses claims were accepted for compensation. The average annual claim rate was 48 per 1,000 workers. By region, 38% of the claims occurred in the Aleutians and Pribilof Islands, which also had the highest average annual claim rate of 56 per 1,000 workers. The most frequently occurring injuries and illnesses, were: by nature, sprains/strains/tears (747, 37%), contusions (353, 18%), and lacerations/punctures (227, 11%); by body part, upper extremities (880, 43%) and trunk (422, 21%); and by event/exposure, contact with objects and equipment (721, 36%) and overexertion and bodily reaction (697, 35%). Incidents resulting from line production activities (n=623) frequently involved: repetitive motion; overexertion while handling trays/pans, basket/buckets, and seafood; and coming into contact with seafood, trays/pans, and processing machinery. Incidents resulting from material handling activities (n=339) frequently involved overexertion while handling boxes/cartons/bags, and slips/trips/falls.

**Conclusions:** Hazard control measures should target: (a) repetitive motion, overexertion, and contact with equipment during line production; (b) overexertion due to manually lifting, lowering, pushing, and pulling materials and equipment; and (c) slips, trips, and falls. Implementing ergonomic solutions to prevent musculoskeletal injuries – especially to workers' upper extremities – is vital for improving occupational health.

## INTRODUCTION

Although the seafood processing industry plays a critical role in producing one of Alaska's most valuable natural resources, limited research has addressed workers' safety and health. This industry comprises vessels operating offshore as well as onshore factories that engage in production and packaging activities. These activities include: eviscerating fresh fish by removing heads, fins, scales, bones, and entrails; shucking and packing fresh shellfish; processing marine fats and oils; smoking, salting, and drying seafood; canning seafood; and freezing seafood (NAICS, 2017). In Alaska, offshore seafood processing involves two types of vessels: catcher-processors that both harvest seafood using various types of gear on deck, and then process, package, and freeze it in a factory below deck; and processor vessels – also known as floating factories or “motherships” – that receive seafood harvested by other vessels. During 2014-2015, the State of Alaska's Division of Environmental Health approved seafood processing permits for the following worksites: 14 motherships; 83 catcher-processor vessels; 102 onshore large-scale factories with the capability to produce over 5,000 pounds of seafood per day; and 105 onshore small establishments, including custom processors and direct marketers. Large companies frequently operated multiple worksites. Fifty companies operated the large onshore factories, and in some instances operating catcher-processors and motherships as well (Alaska Division of Environmental Health, 2017).

During 2014-2015, Alaskan fishermen harvested the majority of the United States' seafood, with an annual average of 5.8 billion pounds, and generated the largest portion of the annual average national revenue, at \$1.7 billion, with subsequent processing adding value to the product (NMFS, 2016). Seafood-related work directly employs more people than any other industry in the state of Alaska, and is the third-largest overall job creator, following oil/gas and visitor industries (ASMI, 2017). During 2015, there were 24,863 workers in the Alaskan seafood processing industry, 30% of whom were Alaskan residents, and 22% of whom worked in the industry year-round (Alaska Department of Labor, 2017a & 2017b). Positions are mainly seasonal, given that species are harvested during various times of the year in different locations. Many out-of-state workers are recruited to meet the seasonal labor demand. In remote locations and onboard vessels, employers typically provide room and board, either free or at a daily rate. While workers' wages vary by occupation and experience, many new workers make minimum wage. These jobs are physically and mentally demanding, frequently requiring workers to perform repetitive tasks in cold and wet environments, oftentimes 12 to 18 hours per day (Stimpfle, 2012; Strong, 2014).

In Alaska, the US Coast Guard and Federal Occupational Safety and Health Administration (OSHA) share jurisdiction over regulating worker safety and health onboard catcher-processors and motherships (OSHA, 2010). In contrast, at the state level, the Alaska Occupational Safety and Health Section (AKOSH) has regulatory authority over onshore seafood processing factories and provides consultation and training services. AKOSH has identified onshore seafood processing as a high-hazard industry and developed a local emphasis program to improve safety and health through compliance and consultation assistance (AKOSH, 2013; AKOSH, 2017a & 2017b). Despite the designation as a high-hazard industry, there is a dearth of information on occupational safety and health outcomes.

The Census of Fatal Occupational Injuries (CFOI) did not report any fatalities in the Alaskan seafood processing industry during 2014-2015 (Alaska Department of Labor, 2017c). Although the risk of operational fatalities in this industry is low, there is evidence that the risk of nonfatal injuries and illnesses could be elevated compared to other industries. The Survey of Occupational Injuries and Illnesses (SOII) reported that in Alaska during 2015, the broad “food manufacturing” industry experienced a rate of 8.3 injuries and illness per 100 full-time workers, which was twice the all-industry rate of 4 per 100 full-time workers (Alaska Department of Labor, 2017d). Within that broad category, SOII data on seafood processing, specifically, are unavailable. However, workers in the seafood processing industry constitute over 95% of all food manufacturing workers in the state (Alaska Department of Labor, 2017e). Nonfatal injuries and illnesses merit attention because they constitute the vast majority of workplace incidents and can be severe, resulting in workers’ lowered productivity, lost worktime and wages, lowered quality of life, and disability.

Limited research has investigated hazards and risk factors in the seafood processing industry. Hazards include exposures to: bioaerosols containing allergens, microorganisms, and toxins; bacterial and parasitic infections; excessive noise levels; low temperatures; contact with machinery and equipment; poor workplace organization; and poor ergonomic practices (Jeebhay et al., 2004; Kuruganti & Albert, 2013). Seafood processors are at high risk for developing dermatologic and respiratory allergic reactions, including occupational asthma, from exposures to high-molecular-weight proteins in various species of fish and shellfish (Aasmoe et al., 2005; Beaudet et al., 2002; Bønløkke et al., 2012; Dahlman-Höglund et al., 2012; Gautrin, 2010; Jeebhay & Lopata, 2012; Ortega et al., 2001; Shiryayeva et al., 2015; Žuškin et al., 2012). Risk factors for musculoskeletal disorders in this industry include: highly repetitive and forceful upper extremity movements; localized mechanical stress; awkward and/or static postures at workstations; prolonged standing; and temperature extremes (Aasmoe et al., 2008; Kim et al., 2004; Nag et al., 2012; Ólafsdóttir & Rafnsson, 2000; Quansah, 2005). Recent studies on the Pacific Northwest seafood processing industry have shown high rates of accepted workers’ compensation claims (Anderson et al., 2013; Syron et al., 2017).

Workers’ compensation claim reports provide a rich source of information for safety and health research and surveillance (NIOSH, 2014a; Utterback et al., 2012). In Alaska, the Division of Workers’ Compensation is the state agency charged with administering the Alaska Workers’ Compensation Act, which requires employers or their insurance carriers to pay for injured or ill employees’ work-related medical, disability, and reemployment benefits. Employers are required to report to the agency all claims involving employees’ medical treatment beyond first aid and/or loss of wages (Alaska Department of Labor, 2013). In the seafood processing industry, there are unique issues surrounding workers’ compensation coverage for offshore and onshore workers.

Under the Alaska Workers’ Compensation Act, commercial fishermen are not considered “employees” and do not qualify for coverage; however, crewmembers who engage only in processing activities onboard “floating fish processing vessels” can be considered employees and qualify for coverage under certain circumstances (Alaska Stat. § 23.30.230; Alaska Stat. § 16.05.940). In the maritime industries, it can be difficult for

employers and courts to determine whether injured and ill workers qualify under the state workers' compensation act, the federal Longshore and Harbor Workers' Compensation Act, or the federal Merchant Marine Act, which is commonly known as the Jones Act (Johnson, 2014). Under the Jones Act, crewmembers who become injured or ill in the course of employment can elect to make claims and collect from vessel owners (46 US Code § 30104), and therefore owners carry protection and indemnity insurance to cover such expenses (Johnson, 1996). For these reasons, Alaska workers' compensation claims are not a comprehensive source of information on injuries and illness among workers in the offshore portion of the seafood processing industry. For onshore factory workers – who are more uniformly covered by the Alaska Workers' Compensation Act – the “remote site doctrine” can apply in certain geographic locations. The principle behind this doctrine is that workers at remote sites are required as a condition of their employment to eat, sleep, and socialize on the employers' premises. Therefore, injury and illness caused by personal activities on these premises must be compensated by workers' compensation (Kalamarides, 2004).

For onshore workers in the Alaskan seafood processing industry, this study aimed to (a) estimate the risk of nonfatal injuries and illnesses, (b) determine patterns of incident characteristics and circumstances, and (c) identify modifiable workplace hazards. The long-term goal of this research is to inform injury and illness prevention strategies.

## **METHODS**

### ***Claims Data***

The Alaska Division of Workers' Compensation and NIOSH have a memorandum of understanding that allows NIOSH to analyze injury and illness claims among Alaskan workers, with the goal of identifying priorities for protecting and enhancing worker safety and health (NIOSH, 2015a). The Division provided the dataset for analysis in February, 2017. For inclusion in this study, claims had to represent incidents that: occurred during 2014-2015; were nonfatal; occurred in Alaska (i.e., were not extraterritorial); and had been approved for compensation. Claims for the seafood processing industry were identified by the North American Industrial Classification System code 3117 (NAICS, 2017). Manual review of the dataset identified seafood processing industry claims that had occurred in onshore factories. In addition to industry codes, the dataset included the following information needed to administer the claims: (a) employer information; (b) employee demographics; (c) “accident site” information; (d) a freeform narrative field describing the injury/illness; (e) coding using the Workers' Compensation Insurance Organizations (WCIO) system for the nature of injury/illness, body part affected, and cause of injury/illness (WCIO, 2016); and (f) information on injury/illness follow-up and outcomes.

### ***Claims Coding***

To determine if a claim in the seafood processing industry occurred onshore, the following variables were manually reviewed: employer name; “accident site street” (including vessel name); “accident site city;” “accident site postal code;” and narrative description. Incident site variables included open-entry fields that did not provide standardized categories. The geographic region in which an incident occurred was manually coded from these

variables, with region categories matching those utilized by the Department of Labor (e.g., Southeast, Southcentral, Bristol Bay, etc.) (Alaska Department of Labor, 2017f). To code workers' occupation with the Standard Occupational Classification System (BLS, 2010), the open text-entry 'occupation description' was utilized.

To provide an increased level of detail and quality control, claims were manually reviewed and coded with the Occupational Injury and Illness Classification System (OIICS), which describes the nature of injury or illness, body part affected by injury/illness, event/exposure resulting in injury/illness, and source of injury/illness (BLS, 2012). For OIICS coding, the dataset's freeform narrative descriptions of the injury/illness characteristics and circumstances were utilized. If the descriptions lacked sufficient information, then the existing WCIO codes were referenced.

For each claim, the narrative description was also utilized to code the work activity associated with the injury or illness, when applicable. Work activity codes were developed inductively during the data review, following an interpretive content analysis approach (Drisko & Maschi, 2015; Elo & Kyngäs, 2007; Saldaña, 2015). The lead author reviewed the narrative descriptions multiple times to: (1) become familiarized with the data; (2) determine if the narrative description provided information on the injury/illness circumstances; (3) decide if the injury/illness was associated with a work activity; and (4) assign an inductive or "in vivo" code to each claim, based on the language used in the narrative. Codes were then organized and grouped under higher order categories, based on the lead author's knowledge of the main types of activities performed in the industry. In the results section, examples of the detailed codes that formed higher order categories are provided.

For quality control, during both OIICS coding and work activity coding/categorization, the lead author flagged any low-confidence code assignments for further review by co-authors (DL and LK). Any coding discrepancies between study team members were resolved through consensus.

### ***Analysis and Workforce Data***

To identify patterns and describe characteristics in the claims data, descriptive statistics, including frequencies, percent distributions, and cross-tabulations, were calculated in Stata version 14.2 (StataCorp, 2015). To calculate rates, worker count data from the Research and Analysis Section of the Alaska Department of Labor were utilized. To compare the onshore seafood processing industry's average annual claim rate to the all-industry rate, a rate ratio and 95% confidence interval were calculated in Stata.

The Research and Analysis Section manages the Occupational Database (ODB), which includes employer-provided information on workers' industry, occupation, place of work, and wages (Alaska Department of Labor, 2017g). For the seafood processing industry, the Research and Analysis Section provides publicly-available data on annual worker counts, as well as the number of workers in each geographic region (Alaska Department of Labor, 2017a & 2017f). However, these data combine onshore and offshore worker counts. For the purposes of this study, we requested that the Research and Analysis Section query the database to identify how many workers within the seafood processing industry only worked *offshore* during 2014 and 2015. To determine the annual *onshore* worker count by year, we subtracted the number of offshore-only workers from the overall-industry



count. For the onshore industry worker count, each person who was employed in the industry at any point during the year was counted once. However, for the worker counts by geographic region, a single worker who moved during the year and worked in multiple regions was counted in each region. Therefore, summing the “geographic region” worker counts gives a larger number than the “onshore industry” total. In addition to data for the seafood processing industry, we requested the state-wide, all-industry worker counts for 2014 and 2015 from the Research and Analysis Section (ODB, 2017).

The NIOSH Institutional Review Board (IRB) determined that this study met the IRB definition of “research,” but not “research involving human subjects” because (1) the data were originally collected for the purpose of workers' compensation claim reporting, not for the research project and (2) the researchers could not readily ascertain the identity of the individuals to whom the coded data pertain (NIOSH IRB no. HSFB 15-WSD-NR02). Likewise, the Oregon State University IRB found that this study met their definition of research but did not involve human subjects and therefore did not require full board review (study number 7561).

## **RESULTS**

For all industries in Alaska during 2014-2015, there were 37,240 claims for nonfatal injuries and illnesses that occurred in Alaska and were approved for compensation. Of the 40 fatalities excluded from this analysis, none occurred in the seafood processing industry. For the entire seafood processing industry (NAICS code 3117) there were 2,344 claims, which included incidents that occurred both onshore and offshore. Claims for offshore incidents (108) and those in unknown locations (42) were excluded from the analysis. Therefore, 2,194 claims among onshore workers in the seafood processing industry were included in this study.

### ***Rates***

Table 2.1 presents the claim frequency/percentage, worker count, and claim rate for: (a) all industries in the state; (b) the onshore seafood processing industry; and (c) the geographic regions of the onshore seafood processing industry for the study years. The onshore seafood processing industry's average annual claim rate, at 48 claims per 1,000 workers, was statistically significantly higher than the all-industry rate of 44 claims per 1,000 workers (rate ratio = 1.08, 95% CI = 1.04 – 1.13). The claim rate in the onshore seafood processing industry increased from 44 claims per 1,000 workers in 2014, to 52 claims per 1,000 workers in 2015. By region, over one-third (38%) of the claims occurred in the Aleutians and Pribilof Islands region, which also had the highest rate of claims over the study period, at 56 claims per 1,000 workers.

**Table 2.1. Alaska workers' compensation claim frequency, percentage, and rate per 1,000 workers: All-industry, by onshore seafood processing industry, and by geographic region of the onshore seafood processing industry, 2014-2015**

	2014			2015			2014 and 2015		
	Claims	Workers	Rate	Claims	Workers	Rate	Claims	Workers	Rate
	No. (%)*			No. (%)*			No. (%)*		
<b>Alaska All-Industry</b>	18,719 (100)	422,560	44	18,521 (100)	422,828	44	37,240 (100)	845,388	44
Onshore Seafood Processing Industry	1,053 (6)	24,000	44	1,141 (6)	21,990	52	2,194 (6)	45,990	48
<b>Geographic Region (n=2,080)</b>									
Aleutians/ Pribilofs	354 (36)	7,506	47	441 (40)	6,721	66	795 (38)	14,227	56
Southeast	176 (18)	4,825	36	236 (22)	5,215	45	412 (20)	10,040	41
Bristol Bay	157 (15)	4,800	33	147 (14)	4,866	30	304 (15)	9,666	31
Kodiak	141 (14)	3,049	46	132 (12)	2,998	44	273 (13)	6,047	45
Southcentral	128 (13)	4,153	31	111 (10)	4,268	26	239 (11)	8,421	28
Anchorage/ MatSu	29 (3)	834	34	25 (2)	829	30	54 (2.5)	1,663	32
Western/ Yukon	3 (1)	802	NC	0 (-)	529	NC	3 (0.5)	1,331	NC
Northern	0 (0)	470	NC	0 (-)	530	NC	0 (0)	1,000	NC
Unknown	65 (-)	(-)	NC	49 (-)	(-)	NC	114 (-)	(-)	NC
<b>Total</b>	<b>1,053 (100)</b>	<b>†</b>	<b>NC</b>	<b>1,141 (100)</b>	<b>†</b>	<b>NC</b>	<b>2,194 100</b>	<b>†</b>	<b>NC</b>

\*Valid percentages (which exclude missing values from the denominator) were used for all percent calculations.

NC: Rates not calculated for "unknown" categories, those with fewer than 20 claims (to avoid instability), or geographic region totals.

†For the "onshore seafood processing industry" total worker counts, each worker was counted only once. However, throughout the year, workers in this industry moved between different geographic regions. In these instances, the same worker was counted in multiple "geographic region" categories. Therefore, the "geographic region" total worker counts are higher than the "industry" totals.

### Worker Demographics

Table 2.2 presents the frequency and percentage of claims in the onshore seafood processing industry by workers' occupation, age, and sex. By occupation, the vast majority of claims (78%) were among production workers, who process seafood by hand and by operating machinery. Information on workers' occupation in the dataset was often limited and therefore detailed occupation categories could not be coded (e.g., detailed categories within "production" could include "fish cutters and trimmers," "fish roe technicians," etc.). Workers' ages ranged from 16-79 years, with a median of 38 years. Most claims (83%) were among men. Information on workers' date of hire was missing for 75% of the claims.

<b>Table 2.2. Alaska onshore seafood processing claims by worker demographics, 2014 – 2015</b>			
	No. (%)		No. (%)
<b>Occupation (n=1,876)</b>		<b>Age (n=2,193)</b>	
Production	1,460 (78)	16-24	422 (19)
Material Mover	169 (9)	25-34	527 (24)
Maintenance, Repair, Installation	86 (5)	35-44	421 (19)
Kitchen Worker & Server	30 (2)	45-54	482 (22)
Quality Assurance/Control	26 (1)	55-64	285 (13)
Janitor, Maid & Housekeeper	25 (1)	65-79	56 (3)
Construction	19 (1)		
Mechanical Engineer	15 (1)	<b>Sex (n=2,190)</b>	
Electrician	12 (0.5)	Male	1,180 (83)
Office & Administrative Support	11 (0.5)	Female	380 (7)
Manager – General/Operations	10 (0.5)		
Retail Sales	5 (0.25)		
Manager – Safety & Health	4 (0.25)		
Motor Vehicle Driver	4 (0.25)		
Unknown	318 (-)		

### ***Injury and Illness Characteristics***

Table 2.3 presents the cross-tabulation of the nature of injury/illness (i.e., the “incident”) and the body part affected. Sprains, strains, and tears were the leading type of incident, accounting for over one-third of all claims. These injuries occurred primarily to workers’ upper extremities and trunk, with many affecting the lower extremities as well. By body part, the majority of incidents involved upper extremities. Among these, incidents that were potentially severe or could have resulted in disability included: lacerations/punctures; musculoskeletal disorders (MSDs); fractures; crushing; burns/corrosions; and amputations. Many cases of irritation to workers’ faces involved dirty water, fish, particles, or chemicals splashing into workers’ eyes. In addition to traumatic injuries, cases of illnesses and health conditions included musculoskeletal disorders, infections, hearing loss, and cardiovascular events. In the “other” category, 92 claims were for workers who were potentially exposed to tuberculosis and required medical testing. There were a few instances in which one worker who had tuberculosis could have potentially exposed many others and subsequent testing was required.

Nature (n=2,091)	Body Part (n=2,052)								Total (%)
	Shoulder, Arm, Hand	Back, Chest, Abdomen	Leg, Foot	Head, Face	Multi. Parts	Body System	Neck	Unknown	
Sprain, Strain, Tear	283	265	152	0	38	0	5	4	747 (36)
Contusion	172	47	89	34	10	0	0	1	353 (17)
Laceration, Puncture	168	2	19	34	3	0	0	1	227 (11)
Pain, Inflam., Irritation	60	27	35	60	9	0	3	0	194 (9)
Fracture	44	6	14	9	1	0	0	0	74 (4)
Musculoskeletal Disorder	46	5	6	0	4	0	0	0	61 (3)
Infection	4	6	6	29	0	13	0	1	59 (3)
Poisoning, Allergenic Effect	1	12	0	14	0	20	1	6	54 (2.5)
Crushing	35	1	5	0	0	0	0	0	41 (2)
Burn, Corrosion	12	1	5	10	0	0	0	0	28 (1)
Abrasion, Scratch, Blister	2	1	5	13	0	0	1	0	22 (1)
Dermatitis	10	0	1	5	0	0	2	3	21 (1)
Hernia	0	19	0	0	0	0	0	0	19 (1)
Dislocated Joint	8	1	3	0	0	0	0	0	12 (0.5)
Hearing Loss	0	0	0	11	0	0	0	0	11 (0.5)
Amputation	10	0	0	0	0	0	0	0	10 (0.5)
Concussion	0	0	0	9	0	0	0	0	9 (0.5)
Loss of Consciousness	0	0	0	0	0	0	0	9	9 (0.5)
Reduced Temp. Effect	2	0	2	1	0	1	0	0	6 (0.25)
Cardiovascular Disease	0	5	0	0	0	0	0	1	6 (0.25)
Other	5	9	1	6	0	9	3	95	128 (6)
Unknown	18	15	5	10	33	1	0	21	103 (-)
Total (%)	880 (43)	422 (21)	348 (17)	245 (12)	98 (4)	44 (2)	15 (1)	142 (-)	2,194 (100)

### ***Injury and Illness Circumstances***

Table 2.4 presents the cross-tabulation of the event/exposure resulting in incidents (both general and detailed event/exposure categories) and the incidents’ nature. By event type, contact with objects and equipment, as well as overexertion and bodily reaction, each comprised roughly one-third of all claims. Slips, trips, and falls, as well as exposures to harmful substances or environments also resulted in hundreds of claims.



### ***Injury and Illness Associated with Work Activity***

Most injury or illness claims (1,920, 88%) were associated with a specific work activity. Of these, three-quarters (1,430) had sufficient detail in the narrative description to code that activity. Of the one-quarter (490) that were related to a work activity but did not provide adequate information for coding, examples of narrative descriptions included: "squatting while working, lost balance and fell;" "slipped on fish guts and fell;" "lifting, pushing heavy items;" and "foot caught between forklift and rack." In these instances, it was evident that the injured person was at work, but their specific activity at the time of injury was unclear.

The most frequent work activities resulting in claims were: line production (623); material handling (339); walking or climbing/descending stairs/ladders unburdened (200); maintenance or repair (108); and cleaning (98). Within the broad "line production" category, specific examples of tasks involving the product included: operating processing machinery or canning machinery; heading; gutting; filleting; sorting; grading; handling/moving the product while standing on the production line; as well as loading and unloading plate freezers and breaking freezer pans. "Material handling" included activities such as: pushing or pulling carts and racks; packaging the product; carrying/moving/stacking packaged product; and operating pallet jacks or forklifts. In contrast to material handling, the category of "walking or climbing/descending stairs/ladders unburdened" involved workers' movement throughout the facility that did not involve carrying or moving objects.

Table 2.5 presents the cross-tabulation of work activity, source of injury or illness, and event/exposure. Sources of injury or illness are presented beneath the associated work activity. For example, during line production, 227 workers were injured by contact with objects and equipment, the most common of which were fish/shellfish (66), trays/pans (54), processing machinery (36), and knives (14). Overexertion during line production resulted in the largest number of claims among all combinations of activities and events, with over 300 incidents. Overexertion during line production was most frequently due to repetitive motion and handling trays/pans, fish/shellfish, and baskets/buckets. Exposure to fish/shellfish was associated with infections, allergic reactions, dermatitis, and scratches.

During material handling activities, claims were most frequently associated with overexertion. Roughly one-third of these incidents were due to handling boxes, cartons, and bags. Causes of overexertion also included workers' repetitive motions and bodily position, as well as handling carts, fish/shellfish, pallets/pallet jacks, and racks. All of these objects and equipment frequently struck workers as well. While handling materials, workers slipped, tripped, and fell.

Moving throughout the facility unburdened (i.e., not handling materials or equipment) resulted in workers falling, slipping, and tripping. Walking on surfaces inside and outside the facility, including climbing/descending stairs, resulted in the most claims. During maintenance and repair activities, workers were most frequently injured by contact with machinery. Hazards during cleaning activities included: exposures to chemical and cleaners; slips, trips, and falls; and contact with processing machinery.

Table 2.5. Alaska onshore seafood processing claims by work activity, source, and event/exposure, 2014 – 2015							
Work Activity & Source	Event/Exposure						Total
	Contact with Obj./Equip.	Overexertion & Bodily Reaction	Falls, Slips, Trips	Exposure to Subst., Temp	Other	Unknown	
<b>Line Production (n=623)</b>	<b>227</b>	<b>317</b>	<b>29</b>	<b>40</b>	<b>2</b>	<b>8</b>	<b>623</b>
Bodily motion or position	0	147	1	0	0	0	148
Fish, shellfish	66	43	0	25	2	0	136
Tray, pan	54	57	0	0	0	0	111
Processing machinery	36	6	0	3	0	0	45
Basket, bucket	8	30	0	0	0	0	38
Floor, stairs, ground	0	0	23	0	0	0	23
Knife	14	0	0	0	0	0	14
Other	49	34	5	12	0	8	108
<b>Material Handling (n=339)</b>	<b>117</b>	<b>174</b>	<b>39</b>	<b>3</b>	<b>2</b>	<b>4</b>	<b>339</b>
Box, carton, bag	22	57	0	0	0	0	79
Fish, shellfish	18	12	0	1	0	0	31
Floor, stairs, ground	0	1	30	0	0	0	31
Bodily motion or position	0	28	0	0	0	0	28
Cart	12	13	0	0	0	0	25
Tray, pan	13	9	0	0	0	0	22
Pallet, Pallet Jack	9	11	1	0	0	0	21
Rack	8	11	0	0	0	0	19
Other	35	32	8	2	2	4	83
<b>Walking, Climbing (n=200)</b>	<b>31</b>	<b>29</b>	<b>139</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>200</b>
Floor, stairs, ground	1	9	109	0	0	0	119
Ladder	0	3	17	0	0	0	20
Bodily motion	0	12	2	0	0	0	14
Building structure	9	1	2	0	0	0	12
Other	21	4	9	0	0	1	35
<b>Maintenance, Repair (n=108)</b>	<b>64</b>	<b>19</b>	<b>7</b>	<b>16</b>	<b>0</b>	<b>2</b>	<b>108</b>
Processing machinery	13	0	0	0	0	0	13
Machinery, general	11	0	0	0	0	0	11
Other	40	19	7	16	0	2	84
<b>Cleaning (n=98)</b>	<b>33</b>	<b>16</b>	<b>17</b>	<b>32</b>	<b>0</b>	<b>0</b>	<b>98</b>
Chemical, Cleaner	0	0	0	18	0	0	18
Floor, stairs, ground	0	0	13	0	0	0	13
Processing machinery	10	0	0	0	0	0	10
Other	23	16	4	14	0	0	57
<b>Construction (n=19)</b>	<b>8</b>	<b>9</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>19</b>
<b>Food Services (n=17)</b>	<b>5</b>	<b>9</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>17</b>
<b>Quality Control (n=11)</b>	<b>6</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>11</b>
<b>Other (n=15)</b>	<b>6</b>	<b>6</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>15</b>
<b>Unknown (n=490)</b>	<b>209</b>	<b>91</b>	<b>86</b>	<b>45</b>	<b>0</b>	<b>59</b>	<b>490</b>
<b>Total</b>	<b>706</b>	<b>672</b>	<b>321</b>	<b>142</b>	<b>4</b>	<b>75</b>	<b>1920</b>

### ***Injury and Illness Not Associated with Work Activity***

Of the 274 claims (12%) not associated with a specific work activity, 22 claims were for health conditions, such as cardiovascular disease or appendicitis. Another nine incidents covered under the remote worksite doctrine involved: falling in the shower (2); entering/exiting bunkbeds (2); being bitten by insects or inhaling smoke while asleep (3); an injury of unknown origin while intoxicated (1); and assault outside of the plant while off-duty (1). An additional seven assault cases occurred inside the factories during work hours. Communicable diseases, such as influenza or tuberculosis, resulted in 39 claims, with another 92 claims resulting from workers' potential exposure to tuberculosis. Motor vehicle incidents accounted for 24 claims, with a single crash injuring 19 workers. Ill-fitting

boots, gloves, and jackets that abraded workers' skin caused 11 claims. Noise-induced hearing loss also resulted in 11 claims.

### ***Injury and Illness Response and Outcome***

Table 2.6 presents the frequency and percentage of claims by initial treatment and claim type. Initial treatment was defined as "the extent of medical treatment received by the employee immediately following the accident." Almost three-quarters of incidents were initially treated with minor clinic/hospital remedies or diagnostics. Incidents requiring emergency evaluation, diagnostics, or procedures spanned across all nature of injury or illness categories, with the most frequent including: sprains, strains, tears (39); contusions (31); lacerations/punctures (31); crushing (13); and pain/inflammation/irritation (12). Incidents initially requiring hospitalization over 24 hours included: fractures (2); concussion (1); cardiovascular event (1); and lower back strain (1). By claim type, almost two-thirds were classified as medical only.

In the workers' compensation claims dataset, a "physical restrictions indicator" variable indicated the "presence of physical restrictions upon the employee's release and/or return to work." Data on this variable were missing for 57% of claims. Of the 949 claims for which information was available, 233 (25%) indicated that workers did have a physical restriction upon their release and/or return to work.

<b>Table 2.6. Alaska onshore seafood processing claims by initial treatment and claim type, 2014 – 2015</b>	
	No. (%)
<b>Initial Treatment (n=2,168)</b>	
Minor Clinic/ Hospital Remedies/Diagnostics	1,571 (72)
No Medical Treatment	242 (11)
Emergency Evaluation, Diagnostics, Procedures	181 (8)
Future Major Medical/Lost Time Anticipated	98 (5)
Minor Onsite Remedies by Employer	71 (3)
Hospitalization > 24 Hours	5 (1)
<b>Claim Type (n=2,194)</b>	
Medical Only	1,388 (63)
Lost Time/Indemnity	659 (30)
Notification Only	147 (7)

## **DISCUSSION**

This is the first epidemiologic study to estimate risk, characterize safety and health outcomes, and identify modifiable hazards among onshore workers in Alaska's seafood processing industry. Analyzing accepted workers' compensation claims data for 2014-2015 provided detailed results that can inform nonfatal injury and illness prevention strategies, as well as identify areas for future study and collaboration between industry members, researchers, and occupational safety and health practitioners.

### ***Claim Frequency and Rates***

In the workers' compensation claims dataset, there were no fatalities among workers in the seafood processing industry. This finding is consistent with CFI data demonstrating that workers in this industry are at low-risk for operational fatalities (Alaska Department of Labor, 2017c). However, the frequency and rate of accepted claims for nonfatal injuries and illnesses are concerning. Each year, workers in the onshore seafood

processing industry experienced over 1,000 injuries and illnesses for which they received compensation for medical treatment and/or lost work time.

Compared to the Alaska all-industry average annual rate of 44 claims per 1,000 workers, the average annual rate among onshore workers in the seafood processing industry was slightly elevated at 48 claims per 1,000 workers. Issues related to using worker counts as the denominator (exposure) measure for calculating rates and determining risk, especially for a highly seasonal industry, are discussed in the limitations section. Studies in the Pacific Northwest seafood processing industry have identified high rates of accepted workers' compensation claims. Research examining which industries in Washington State were high-risk for common, high-cost injuries found that the seafood processing industry experienced a rate of 31.1 claims per 1,000 FTEs during 2002-2010 (Anderson et al., 2013). Disabling claims are a subset of all claims, and represent only the most severe incidents, which result in an employee missing three or more days of work, overnight hospitalization, or likely permanent disability. In Oregon during 2007-2013, there was an average annual rate of 24 disabling claims per 1,000 workers in the seafood processing industry, which was nearly two and a half times higher than the all-industry disabling claim rate (Syron et al., 2017).

In this study, 38% of the claims occurred in the Aleutians and Pribilof Islands, which also had the highest average annual claim rate of 56 per 1,000 workers. Further research is needed to determine if regional claim rates reflect true variations in risk, or if variations could be due to other factors, such as differences in nonfatal injury/illness reporting between worksites and/or companies. For all claims, most were among production workers and men. Additional research is needed to estimate workforce demographics among onshore workers, in order to calculate rates and determine if these characteristics are associated with higher risks. Currently, the Department of Labor's demographic data only represent workers who are Alaskan residents, and residents constitute only 30% of this workforce (Alaska Department of Labor, 2017b).

### ***Injury and Illness Characteristics***

Sprains, strains, and tears constituted over one-third of all incidents and most frequently affected workers' upper extremities and trunk. Additionally, workers' upper extremities frequently experienced MSDs as well as reported "pain" and "inflammation," which could have been symptoms of musculoskeletal injury. These results, which demonstrate the importance of preventing traumatic and cumulative musculoskeletal injury to workers' upper extremities and trunk, are consistent with prior research in this industry. Over the past 25 years, musculoskeletal injuries, disorders, and symptoms – particularly to the upper extremities and back – have been highlighted in studies of onshore seafood processing worksites around the world (Aasmoe et al., 2008; Babski-Reeves & Crumpton-Young, 2003; Chiang et al., 1993; Kim et al., 2004; Kuruganti & Albert, 2013; Nag et al., 2012; Ohlsson et al., 1994; Ólafsdóttir & Rafnsson, 2000; Silverstein et al., 1998; Syron et al., 2017; Tomita et al., 2010). Like seafood processors, poultry processors are at high-risk for musculoskeletal injuries and disorders, particularly in their upper extremities (Cartwright et al., 2012; NIOSH, 2014b & 2015b; OSHA, 2013; Quandt et al., 2006). In both of these animal processing industries, facilities are designed for rapid line production and then movement of



the packaged product for storage and transport, requiring strenuous, repetitive manual labor and awkward postures. Given these similarities, interventions in the poultry processing industry might be translatable to seafood processing.

Following musculoskeletal injuries/symptoms/disorders, the next most common types of incidents were contusions, lacerations/punctures, and fractures – the majority to workers’ upper extremities. Exposure to seafood substances resulted in infections, dermatitis, and allergic reactions – including respiratory symptoms, which is consistent with the other findings (Aasmoe et al., 2005; Beaudet et al., 2002; Bønløkke et al., 2004 & 2012; Dahlman-Höglund et al., 2012; Gautrin, 2010; Jeebhay & Lopata, 2012; Ortega et al., 2001; Shiryaeva et al., 2010 & 2015; Žuškin et al., 2012). Despite occurring less frequently, the 70 incidents that involved crushing injuries, hearing loss, amputations, and concussions were concerning because of their potential for causing workers’ long-term impairment.

### ***Injury and Illness Circumstances and Potential Prevention Strategies***

In onshore factories, workers faced ergonomic, physical, biological, chemical, and psychosocial hazards. When deciding upon and implementing hazard controls, the hierarchy of controls should be followed, with elimination of hazards and engineering controls favored over administrative controls and personal protective equipment, in order to provide the most effective protection (NIOSH, 2016).

The most frequently occurring events were “contact with objects and equipment” (n=721) and “overexertion/bodily reaction” (n=697). As expected, the work activities most frequently resulting in incidents were line production and material handling. Incidents resulting from line production activities (n=623) frequently involved: (a) repetitive motion; (b) overexertion from handling trays/pans, basket/buckets, and fish/shellfish; and (c) coming into contact with fish/shellfish, trays/pans, and processing machinery. Incidents that resulted from material handling activities (n=339) frequently involved: (a) overexertion from handling boxes/cartons/bags, the workers’ bodily motion/position, as well as handling carts, fish/shellfish, and trays/pans; and (b) coming into contact with all of these objects. Implementing ergonomic solutions, which fit the workplace conditions and job demands to workers’ capabilities, is vital for improving safety and health in this industry. The concept of “prevention through design” involves eliminating hazards as early as possible in the life cycle of equipment and workplaces. Using this approach, worker safety is incorporated into the design, redesign, and retrofit of new and existing tools, machinery, facilities, and work processes (NIOSH, 2013).

To address hazards associated with material handling, companies’ safety and health managers should implement ergonomic programs that include worker participation (Cohen, 2006; NIOSH, 2017). Managers can find a variety of improvement options within NIOSH’s “Ergonomic Guidelines for Manual Material Handling” resource (NIOSH, 2007). Additionally, there is evidence from research in the food manufacturing industry that training supervisors to improve their responses to worker safety and health concerns, including early reports of musculoskeletal discomfort, can substantially reduce injury claim frequency and disability (Shaw et al., 2006).

Worksite ergonomic assessments should include slip resistance testing, to establish the current environment's slip potential and any possible alternative designs (Redfern & Rhoades, 2006). Slips, trips, and falls occurred frequently, resulting in over 325 claims. To prevent slips, trips, and falls, passageways should be kept clear of obstructions and substances/seafood should be cleaned up as frequently as possible. Given the wet nature of this work environment, proper drainage should be maintained, with appropriate gratings, mats, or raised platforms provided, and surfaces designed to increase adhesion (OSHA, 2017a).

Various types of hazards were associated with maintaining, repairing, and cleaning equipment. These included exposure to chemicals and seafood substances, as well as being caught in or compressed by processing machinery and conveyors. Performing regularly-scheduled preventive maintenance, following appropriate lockout procedures, and properly guarding machinery and equipment could potentially prevent injuries due to contact with these pieces of equipment (OSHA, 2002 & 2007). Cleaning product formulations that present fewer hazards to workers should be utilized when possible, and appropriate personal protective equipment should always be worn to prevent chemicals from coming into contact with the eyes and skin. Potential strategies for controlling workers' dermal and respiratory exposure to seafood substances, which resulted in infections, dermatitis, and allergic reactions, include wearing proper personal protective equipment on the processing line and while cleaning, as well as improving ventilation systems (Jeebhay et al., 2004 & 2012).

The eleven claims for noise-induced hearing loss highlight the importance of following safety standards and best practices for noise abatement and control, as outlined in an OSHA technical manual (OSHA, 2017b). Workers' health conditions that resulted in claims, including cardiovascular events, can pose challenges in these remote worksites, which are often far from advanced medical care. Among all accepted claims, fewer than 10% fell under the remote site doctrine. However, employers who operate remote worksites need to consider the safety of all areas on their premises, including dormitories, cafeterias, recreational areas, and the surrounding grounds.

Work organization factors potentially could have contributed to the injuries and illnesses identified in this study. In mass production manufacturing environments, physical and psychosocial stressors can include repetitive and monotonous tasks, rigid work pace with physically intensive work cycles, highly-regulated break patterns, and low decision-authority and skill discretion (MacDonald et al., 2001). Workers in Alaska's seafood processing industry are often on-duty for long hours every day (e.g., 16 hours per day) for weeks at a time (Cole, 2017; Zak, 2017). In a study by Garcia and de Castro (2017), interviews with Filipino seafood processors in Dutch Harbor, Alaska noted that work shifts being limited to 12 hours at their company was preferable to the 15- to 18-hour shifts at other companies (Garcia & de Castro, 2017). With very long shifts, and when 12-hour shifts combine with more than 40 hours of work a week, workers' physiological performance deteriorates and they experience increased injury rates and more illness (NIOSH, 2004). Strategies for reducing fatigue-related risks include: (a) allowing workers to have input on the design of their schedules; (b) providing frequent and adequate rest breaks; (c) scheduling short naps; (d) breaking up monotonous tasks to prevent fatigue; and (e) providing training for

management and labor on basic sleep information, circadian rhythm, and fatigue physiology, as well as good practices and behaviors to get adequate sleep (Caruso, 2011).

### ***Utility of Alaska Workers' Compensation Claims***

The Alaska workers' compensation claims dataset proved to be a valuable source of information for investigating safety and health in this industry. Cleaning and coding the dataset in preparation for analysis was labor-intensive. Although the dataset had been coded with the WCIO classification system for nature, body part, and cause of injury/illness variables, this classification system's categories provided less detail, and were deemed less beneficial for meeting the study's aims, than the OIICS categories for nature, body part, event/exposure, and source. Manually coding OIICS was time-consuming; however, reviewing each claim's narrative description in order to code the OIICS variables provided an additional level of data quality control. Likewise, extensive cleaning and coding were necessary to analyze the open-entry fields that described incidents' geographic locations and workers' occupations. Physical restriction data were largely missing from the dataset and medical costs were unavailable; however, cost data might be available for future analyses. Despite the level of effort needed to prepare the dataset for analysis, it was encouraging that the majority of narrative descriptions were sufficiently detailed to allow for work activity and OIICS coding.

### ***Limitations***

There were several limitations to this analysis. First, workers' compensation claim reports have limitations as a source of data for occupational safety and health research. Due to a wide variety of factors involving reporting and compensability, claims data likely underrepresent the true burden of nonfatal injuries and illnesses, and are more representative of risk for acute injuries than illnesses and chronic/cumulative injuries (e.g., musculoskeletal disorders or noise-induced hearing loss).. These factors include: (a) workers not being aware of workers' compensation and their eligibility, especially in non-unionized workplaces; (b) workers not understanding that a health condition was caused by work, or believing that the injury/illness was not severe enough to qualify for benefits; (c) workers' fear of job loss or other forms of retaliation by employers; (d) workers' concern over navigating a complex system that can involve repeated and frustrating interactions with physicians, lawyers, and insurance company representatives; (e) workers' fear of stigma, being labeled a "fraud," or pressure from co-workers not to report, especially if safety programs create disincentives for reporting; and (f) barriers to approval and actual receipt of benefits (Fan, 2006; NIOSH, 2014a; Rosenman, 2000; Shannon, 2002; Spieler, 2012).

Second, using worker counts as the exposure estimate to calculate rates and make risk comparisons is problematic, because this exposure estimate does not take into account the varying lengths of time that workers spend on the job throughout the year. It is especially problematic for highly seasonal industries such as seafood processing, in which the size of the workforce fluctuates from a high of 20,500 in July to a low of 3,900 in December (Alaska Department of Labor, 2017e). Even though seafood processors oftentimes work long hours for weeks or months at a time, using worker counts might overestimate their exposure compared to workers in industries that follow a more typical schedule throughout the year. Therefore, this claim rate potentially

underrepresents the true risk of nonfatal injuries and illnesses in the onshore seafood processing industry. Using full-time equivalent worker (FTE) estimates, which take into account the number of hours worked, would have provided a better measure of risk, but FTE data currently do not exist. Future studies utilizing Alaska workers' compensation claims data are needed to rank the frequency and rates of nonfatal injuries and illnesses among Alaskan industries.

Third, this analysis was limited by the inability to calculate claim rates by workers' occupation, age, and sex, due to the lack of workforce demographic data. Fourth, the dataset did not provide information on long-term disability outcomes and incident severity was not coded. Fifth, cases were identified through NAICS codes in the dataset, which could have potentially been misclassified if companies reported the incorrect industry code to the Workers' Compensation Division. Finally, the work activity coding for cumulative trauma incidents was based on the claim report narrative descriptions, which might not have taken into account the possibility that multiple types of activities – both on- and off-duty – could have contributed to the injury/disorder. Despite these limitations, this study successfully met its aims of providing a high level of detail on incident characteristic and circumstance patterns, as well as modifiable hazards, to inform targeted injury and illness prevention strategies.

### ***Future Research***

Future research is needed to evaluate if methods for automating the OIICS coding process that have been successfully utilized for other datasets, such as the Ohio Bureau of Workers' Compensation claims dataset (Bertke et al., 2016), would be successful for the Alaska workers' compensation claims dataset. NIOSH plans to utilize the Alaska workers' compensation claims dataset for additional studies and therefore is currently completing additional cleaning and coding of the entire dataset. This additional OIICS coding could be used as a training set for automation.

For Alaska's onshore seafood processing industry, FTE denominator data are needed for calculating injury and illness rates and demographic data are crucial to allow risk comparisons. To develop a detailed work activity classification system, researchers could collaborate with companies to visit factories that produce and package various species of seafood, and record all stages of the process – from offloading the seafood from vessels to shipping out the packaged product – following an example of classification system development from the Danish fishing industry (Jensen et al., 2003 & 2005). To better identify high-risk activities and the specific mechanisms of injury, researchers could also perform ergonomic assessments, such as the assessment recently conducted in an Atlantic Canadian seafood processing plant (Kuruganti & Albert, 2013). Following that type of assessment, research is needed to develop, test, and evaluate ergonomic interventions in seafood processing factories.

Other areas for study include investigating the extent to which injuries and illnesses are associated with certain times of the season (i.e., during peak production days) and work shifts, as well as the number of hours/days worked and fatigue. The remote location of many worksites, away from advanced hospital care, might influence when and how workers are treated for conditions (including if they file for workers' compensation) and the subsequent injury and illness outcomes, including severity and disability. Our research team plans to interview

corporate and upper-level managers in this industry to explore their experiences and views regarding: management and workers' roles in their safety and health program; systems for identifying, analyzing, reporting, and controlling hazards; safety training; as well as program challenges and successes. Further research directly engaging workers is necessary to explore their experiences and needs.

In contrast to the seafood processing industry, worker safety and health in the poultry and meat processing industries has received national attention. Recently, the US Government Accountability Office (GAO) made recommendations to increase efforts to study injuries, illnesses, and incident reporting among poultry and meat processing workers (GAO, 2016). The seafood processing industry faces hazards and challenges similar to those found in poultry and meat processing, and likewise merits attention, support, and resource investments. Investing resources in worker safety and health programs that proactively seek to eliminate and control hazards has been shown to effectively prevent injuries and illnesses, as well as improve product quality and company profits (OSHA, 2016). There are encouraging examples of such investment within the Alaskan seafood processing industry. AKOSH's Voluntary Protection Program (VPP) and Safety and Health Achievement Recognition Program (SHARP) acknowledge employers and employees who have made outstanding efforts to achieve exemplary safety and health at their worksites (AKOSH, 2017c & 2017d). Currently and in the past, Alaskan seafood processing worksites have earned VPP and SHARP status (AKOSH, 2017e & 2017f). This is evidence that seafood processing companies that are committed to safety and health can create an environment that protects their most valuable asset – the workers. Industry members should share their best practices for protecting workers' safety and health in the onshore processing plants. Seafood processing industry associations, as well as organizations that promote safety and health, could assist with disseminating best practices. Researchers in academia and government, public health practitioners, and regulators should support industry members when they face challenges. Collaborations between these groups could effectively identify, develop, and evaluate safety and health interventions that are tailored for this unique work environment.

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**CHAPTER 4: THIRD MANUSCRIPT****SAFETY AND HEALTH PROGRAMS IN ALASKA'S SEAFOOD PROCESSING INDUSTRY:  
INTERVIEWS WITH CORPORATE AND UPPER MANAGEMENT STAKEHOLDERS**

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**ABSTRACT**

**Background:** Although the seafood processing industry is critical to Alaska's economy, limited research has addressed workers' safety and health. Safety and health program management is a decisive factor in preventing occupational injuries and illnesses. Through stakeholder interviews, this study investigated safety and health program characteristics.

**Methods:** Semi-structured interviews were conducted with 14 corporate and upper-level directors/managers who oversaw safety and health programs for Alaskan seafood processing worksites. Interviews were audio-recorded and transcribed, with responses validated by participants. Quantitative content analysis was utilized to describe participant, worksite, and workforce characteristics. Qualitative content analysis techniques, including inductive coding, were utilized to explore participants' experiences and views regarding: management and workers' roles in the program; systems for identifying, analyzing, reporting, and controlling hazards; safety training; economic factors influencing programs; as well as programs' challenges and successes. Based on the findings across these topics, workplace factors that could be modified to improve safety and health were identified.

**Results:** Participants reported directing and managing programs for 68% of the 25,000 workers in this Alaskan industry. The 14 participants represented 13 companies that operated 32 onshore plants and 30 vessels, employing an estimated 17,000 workers at peak season, of which 84% were processors. Participants described widely varying degrees of program buy-in and engagement from management and workers, ranging from basic compliance with standards to full partnerships for carrying out best practices. While some participants reported that fostering a proactive safety culture and "prevention mindset" were among their greatest successes, others discussed the challenges of overcoming an "old guard mentality" that did not prioritize safety. Ergonomic hazards and long work hours were frequently reported as areas of concern. Most participants noted that language and cultural barriers among the diverse workforce presented difficulties when communicating, especially during training. Based on participants' responses, we identified the following workplace factors that could be modified to improve safety and health: worksite manager training; worker training; adoption of ergonomics; work hours; knowledge sharing within the industry; and organizational aspects related to safety culture.

**Conclusions:** Participants reported that fully engaging workers in their safety and health programs was beneficial to protecting workers' well-being. Future research is needed to explore workers' experiences and needs. Occupational safety and health practitioners and researchers could support the development and evaluation of safety and health training for limited-English-speaking-workers, ergonomic solutions, and fatigue risk management systems.

## INTRODUCTION

Occupational safety and health programs that proactively seek to eliminate and control workplace hazards have been shown to effectively prevent injuries and illnesses, as well as improve product quality and company profits (OSHA, 2016a). Although the seafood processing industry is vital to Alaska's economy (ASMI, 2017; NMFS, 2016), no studies have described its worker safety and health programs or engaged the managers who run these programs. This industry comprises onshore factories and vessels operating offshore that: eviscerate fresh fish by removing heads, fins, scales, bones, and entrails; shuck and pack fresh shellfish; process marine fats and oils; smoke, salt, and dry seafood; can seafood; and freeze seafood (NAICS, 2017).

In 2016, the Alaska Division of Environmental Health approved seafood processing permits for 169 high-production worksites with the capability to produce over 5,000 pounds of seafood per day, including 86 onshore factories, 70 catcher-processor vessels that both harvest and process seafood, and 13 floating factory vessels (i.e., "motherships"). Thirty-nine companies operated the onshore factories, with some of these companies operating vessels as well, and another 45 companies operated only vessels (Alaska Division of Environmental Health, 2017). During 2015, there were approximately 25,000 workers in the industry, 30% of whom were Alaskan residents, and 22% of whom worked year-round in the industry (Alaska Department of Labor, 2017a & 2017b). Given the seasonal nature and geographically remote location of many worksites, out-of-state workers are frequently recruited to meet the labor demand, including foreign workers. In remote locations and onboard vessels, employers provide room and board, either for free or charging a daily rate. While workers' wages vary by occupation and experience, many new workers make minimum wage. These jobs are physically and mentally demanding, frequently requiring workers to perform repetitive tasks in cold and wet environments, oftentimes 12 to 18 hours per day for weeks at a time (Cole, 2017; Stimpfle, 2012; Strong, 2014).

Federal and state regulators have identified Alaska's seafood processing industry as a highly hazardous work environment. The US Coast Guard and the Federal Occupational Safety and Health Administration (OSHA) share jurisdiction over regulating worker safety and health onboard catcher-processors and motherships (OSHA, 2010). The Coast Guard has identified safety and operational risks for vessels that require a sizeable crew, utilize processing and freezing machinery, and can operate in remote areas far from search and rescue support (USCG, 2006). Federal OSHA has determined that offshore seafood processing is a high-hazard industry and therefore developed a Local Emphasis Program in Alaska, which has been in effect for over a decade (OSHA, 2016b; OSHA, 2017). For onshore factories, the state-run Alaska Occupational Safety and Health Section (AKOSH) has regulatory authority and provides consultation and training services (AKOSH, 2017a, 2017b). AKOSH has identified onshore seafood processing as a high-hazard industry and likewise put in place a Local Emphasis Program (AKOSH, 2013).

Despite regulators classifying the industry as high-risk, information on worker safety and health is limited. The Census of Fatal Occupational Injuries (CFOI) did not report any fatalities in the Alaskan seafood processing industry during 2015 (Alaska Department of Labor, 2017c). Although the risk of operational fatalities in this industry is low, there is evidence that the risk of nonfatal injuries and illnesses might be elevated compared to

other industries in Alaska. The Survey of Occupational Injuries and Illnesses (SOII) reported that in Alaska during 2015, the broad “food manufacturing” industry (of which over 90% is seafood processing) experienced a rate of 8.3 injuries and illness per 100 full-time employees, which was twice the state’s all-industry rate of 4 per 100 full-time employees (Alaska Department of Labor, 2017d & 2017e). Globally, hazards in this industry include exposures to: bioaerosols containing allergens, microorganisms, and toxins; bacterial and parasitic infections; excessive noise levels; temperature extremes; contact with machinery, equipment, and the packaged product; poor workplace organization; and poor ergonomic practices (Aasmoe et al., 2008; Bang et al., 2015; Beaudet et al., 2002; Bønløkke et al., 2012; Jeebhay & Lopata, 2012; Kuruganti & Albert, 2013; Lucas et al., 2014; Nag et al., 2012; Neitzel & Seixas, 2006; Quansah, 2005; Shiryayeva et al., 2015; Ortega et al., 2001; Syron et al., 2017).

This is the first published study to engage stakeholders at the corporate and upper-management levels in order to explore factors that influence occupational safety and health in the Alaskan seafood processing industry. This study investigated factors influencing the safety and health of onshore and offshore workers in this industry. Specifically, interview questions sought to identify: worksite and workforce characteristics; safety and health program features; economic factors influencing programs; and program challenges and successes.

## **METHODS**

A mixed method research approach, utilizing qualitative and quantitative analytical techniques, was chosen to provide richness and depth in exploring the experiences and views of a previously unstudied population. Qualitative methods are well-suited for studying topics that lack a developed literature because they can provide insight and clarity into the meanings that people assign to the events, processes, and structures of their surrounding social world (Frattaroli, 2012; Miles et al., 2013).

### ***Sample***

A purposive sampling strategy was utilized to recruit directors/managers who worked for major seafood processing companies with high-production operations in Alaska. Purposive (or judgmental) sampling is a nonprobability method in which researchers apply expert knowledge of a population to select a sample of elements that represent a cross-section of that population (Battaglia, 2011). This sampling strategy is subjective and generally considered most appropriate for small samples that are drawn from a limited geographic region and/or restricted population definition (Battaglia, 2011), such as safety and health managers in Alaska’s seafood processing industry. Participant eligibility criteria included being at least 18 years of age, proficient in English, and having at least one year of experience directing/managing an occupational safety and health program in this industry. To recruit participants, the lead author contacted companies by phone and email, providing the study recruitment flier and interview guide to key decision-makers and managers. Three organizations that serve the industry and have an interest in promoting safety and health assisted with recruitment efforts by sharing the recruitment materials with major companies and by providing the lead author with contact information for key decision-makers. Organization names are omitted here in order to help ensure participant confidentiality. Prior to the interviews, each participant had a chance to review the consent and interview guides. For research utilizing



nonprobability sampling, there is growing evidence that interviewing 10-20 knowledgeable people within the population of interest is sufficient to uncover and understand the study's core categories (Bernard, 2013; Drisko & Maschi, 2015).

### ***Data Collection***

Semi-structured interviews were conducted over five months, during April through August 2017. The 30 open-ended interview questions covered: participant backgrounds; worksite characteristics (months of operation, seafood species processed, workforce size); workforce characteristics; safety and health program characteristics (management and worker roles; safety training; reporting, identifying, analyzing, and controlling hazards); economic factors influencing the programs; and the programs' challenges and successes (Appendix B). Questions regarding safety and health program characteristics were based on the major elements included in Federal OSHA's safety and health program management guidelines (OSHA, 1989 & 2016a). Interview questions sought to identify a broad array of factors that affect workers' safety and health. All participants agreed to have their interviews audio recorded and transcribed. All but one of the interviews were conducted over the phone, with one conducted in-person.

A member checking process was utilized prior to data analysis, to allow participants an opportunity to review and approve their responses, as well as to ensure the accuracy of descriptions and explanations (Carlson, 2010; Miles et al., 2013). The lead author reviewed the verbatim transcripts and produced "streamlined" versions by editing for grammar and condensing the narrative flow of responses that would be useful for analysis, while maintaining participants' actual words and sentence structure (Carlson, 2010). Participants who wished to review this version of their responses were asked to correct any inaccuracies, approve the language that had been highlighted for potential inclusion as direct quotes in the manuscript, and provide any other feedback on the content. In an effort to ensure confidentiality, this process allowed each participant the opportunity to identify and remove any information that they believed could potentially identify them. Participants' corrections and revisions were then incorporated into the original, verbatim transcripts for analysis. Given that there are relatively few major seafood processing companies with high-production operations in Alaska, the information on participant characteristics was aggregated and presented in general terms in the Results section in order to ensure participant confidentiality. The Oregon State University Human Research Protection Program reviewed this study and determined it to be exempt from full board review (study number 7813).

### ***Analysis***

Transcripts were imported into ATLAS.ti 8.0 software to facilitate data management and content analysis. Rather than building theory, a content analysis approach aims to identify and highlight the most relevant and meaningful aspects of texts (such as interview transcripts) by extracting categories and then illustrating the variations found within those categories (Cho & Lee, 2014; Drisko & Maschi, 2016). Interview responses related to the participant, worksite, and workforce characteristics were analyzed quantitatively, by identifying categories, organizing categories in a spreadsheet, and calculating frequency, percent, and range distributions. All other

responses were analyzed qualitatively. Qualitative content analysis allows for examining and classifying large amounts of both manifest and latent content in texts by reducing and summarizing the material into an efficient number of categories that represent similar meanings (Hsieh & Shannon, 2005; Schreier, 2012). Following a qualitative content analysis process, the lead author: (a) read the transcripts multiple times to become immersed in the data; (b) while reading, wrote notes in the margins describing each section of the transcripts; (c) for each section, assigned inductive or “in vivo” codes and phrases from the actual language and phrases spoken by participants; (d) collected codes from all transcripts into a single spreadsheet; (e) grouped the codes under higher order headings; and (f) developed data-grounded categories that prioritized participants’ voices (Elo & Kyngäs, 2007; Saldaña, 2015). Based on common findings across the various interview topics (e.g., safety and health program characteristics, programs challenges and successes), which were reported frequently by multiple participants, we identified workplace factors that could be modified to improve safety and health. To validate the lead author’s analytical decisions and assist with category construction and naming, a co-author (LK) independently reviewed and assessed the data underlying each category.

## RESULTS

The lead author approached 20 major companies operating seafood processing worksite in Alaska to recruit study participants. Directors/managers from 13 companies (65%) consented to participate in the study. For most companies represented in the study, one director/manager from each company participated; however, there was not a one-to-one match in all cases. In some instances, companies that declined to participate were interested in the study, but (a) their safety and health managers did not have spare time for interviews, or (b) they did not have well-established programs with a designated safety and health director/manager. Other companies were nonresponsive to recruitment efforts. In total, 14 participants completed interviews. Twelve participants asked to review their responses as part of the member checking process. Of these, seven participants provided feedback after reviewing the “streamlined” responses. This feedback included only minor revisions, such as correcting the species processed at their facilities, or removing trademarked names that could have identified their companies.

Table 3.1 lists the interview topics that are presented in this section. The Results section ends with a description of the modifiable workplace factors that were identified based on common findings across these various topics.

<b>Table 3.1. Interview Topics</b>
Participant Characteristics
Worksite and Workforce Characteristics
Management and Workers’ Roles
Safety and Health Training
Reporting, Identifying, and Analyzing Hazards
Hazard Controls
Economic Factors
Program Challenges
Program Successes

### ***Participant Characteristics***

All 14 participants directed or managed safety and health programs. Twelve were corporate-level directors/managers. Two were upper-level managers who oversaw programs at the plant- and vessel-level. There was an even distribution of participants who oversaw programs for onshore versus offshore worksites. Participants' years of experience in this industry ranged from 1-37 years, with a median of 8.5 years. Six participants (43%) had worked fewer than 5 years in the industry, and three participants (21%) had worked in it 30 years or more. Participants' years of experience in positions involving occupational safety and health responsibilities ranged from 3-36 years, with a median of 23.5 years of experience. Two participants (14%) had fewer than 5 years of experience handling safety and health issues, and nine participants (64%) had 20 or more years of experience. In preparation for managing safety and health programs, almost all participants had on-the-job training and experience in this and other industries, extensive certifications, and participated in continuing education. Many had military and other service-related backgrounds. A few had college degrees that specifically focused on occupational safety and health.

### ***Worksite and Workforce Characteristics***

In total, participants managed programs for 32 onshore plants and 30 vessels. The onshore plants represented multiple geographic regions throughout the state, with some operating year-round and others during a single season. These onshore plants processed Pollock, salmon, cod, crab, halibut, sablefish, and flatfish. During peak season, the onshore plants employed approximately 13,630 workers, of which 11,650 (85%) performed processing and packaging tasks. Likewise, the vessels represented multiple fleets operating in Alaskan waters and processed Pollock, cod, sablefish, salmon, and flatfish. The vessels employed approximately 3,380 crewmembers, of which 2,600 (77%) performed processing and packaging tasks.

In the onshore plants, participants reported that workers' ages ranged from their 20s to 60s, with some in their 70s. Onboard vessels, participants reported the workforce was somewhat younger, with crewmembers' ages ranging from their 20s to 50s, with a few in their 60s. For both onshore plants and vessels, half of the participants asserted that the workforce was aging. For the onshore plants, participants reported that men constituted approximately 60% of the workforce; although at certain plants the percentage of male workers could be as low as 20% or high as 80%. In contrast, the vessels had a more male-dominated workforce, typically constituting 90-100% of the crewmembers. However, on certain vessels, the percentage of male crewmembers was as low as 50-70%. For both onshore plants and vessels, participants estimated that workers' formal education varied widely, from less than high school to advanced college degrees. Most participants stressed the diversity of the workforce, describing how workers came from around the US and the world. In addition to English, the most frequently reported languages spoken among workers were: Spanish; Tagalog; Samoan; French; Somali; and Arabic; as well as various Micronesian, African, Eastern European, and Native Alaskan languages.

Across plants and vessels, participants estimated that workers' turnover rates between seasons varied widely, from as low as 5% to more than 50%. Participants discussed a few factors that contributed to either high

retention or high turnover rates at their worksites. For example, working on vessels that participated in more profitable fisheries, on which crewmembers earned higher pay, was more attractive. Additionally, crewmembers getting along with one another and having schedules that allowed for more rest between shifts (i.e., working a maximum of 12 hours per day rather than 16-18 hours) contributed to higher retention. For both vessels and onshore plants, participants believed that providing a supportive and safe work environment was important for retaining workers:

“A plant that’s well-managed and the people feel cared for, which safety is a huge part of that, has less turnover. How you treat people will help you have a higher return rate. And then they’ll bring family members or relatives. That’s good.”

While some workers enjoyed the beauty and adventure of living and working in remote Alaskan locations, onshore and offshore workers who did not like “being in the middle of nowhere” were less likely to return the following season. For crewmembers, spending extended lengths of time at sea, away from family, friends, and social networking, also resulted in burnout.

### ***Management and Workers’ Roles***

Participants described their various roles and responsibilities within the safety and health programs, some of which included: (a) overseeing and implementing safety management systems; (b) developing and updating policies, procedures, and trainings; and (c) setting budget priorities. At the corporate level, participants provided tools and resources to site managers who administered the programs on a daily basis. Onboard vessels and in plants, various types of supervisors and managers played a role in the programs, including those with primary responsibilities in areas such as production or human resources. At some worksites, separate programs and different managers focused on worker safety versus health/wellness. However, not all worksites had managers devoted primarily to safety and health functions:

“In fact, we don’t have dedicated HSE [health, safety, and environment] people at any of the plants. It’s not a focused position like I’d like it to be. We had a couple of lousy seasons in a row, so money’s tight, but I want to really address this.”

All participants were either located onsite or visited worksites regularly, carrying out: (a) inspections/audits; (b) hazard elimination or control measures; and (c) education/training. Participants’ positions required communicating with people at all levels within the company, including owners, executives, department heads and managers, line-level supervisors, and workers.

There was consensus that company leadership – owners, executives, and high-level directors/managers – set the tone for safety. In all interactions, participants promoted and advocated for a positive safety culture. They discussed the dual nature of their roles, which involved: (a) ensuring regulatory compliance and enforcing company policies, i.e., being a “cop,” while also (b) encouraging positive efforts and achievements by being a “coach” or “cheerleader.” Participants described the ways in which they supported workers:

“We want to give [workers] the tools and the training, and also encourage them to speak up when something’s not right. We explain that there’s not going to be any reprimand, because they come from other companies, and sometimes there’s a few people who are afraid to speak up.”

All participants emphasized how strongly they encouraged workers to “say something” if the workers identified unsafe conditions or practices, and when problems or incidents arose.

According to participants, workers’ roles in the programs included, at a minimum: (a) receiving training for job skills and safety; (b) following regulations, policies, and procedures; and (c) reporting any hazards, problems, or concerns. In certain instances, the extent of workers’ roles in the program depended on the length of their employment. Whereas year-round workers might have an active role in the program, participants found it more challenging to fully involve transitional workers who were only onsite for short seasons, which might last two months. Across companies and worksites, there was great variation in the extent to which workers were engaged in the programs, ranging from basic compliance with standards to full partnerships between management and workers. One participant reported the difficulty of achieving basic compliance with standards:

“A lot of these people have never had any safety training. You’re putting them into these dangerous environments and it’s a lot of responsibility to keep them from getting hurt, as you can imagine. Simply getting them to obey the rules regarding PPE [personal protective equipment] is a big push.”

Formal, or fully established, safety committees were not present at all worksites and some participants noted that they hoped to create committees in the future. Multiple participants noted that workers had to be self-sufficient while working in remote environments, especially in terms of emergency preparedness and response. Many participants reported encouraging pro-active safety mindsets and behaviors among workers:

“Everybody is responsible for not only their own personal safety, but the safety of those around them, and for the conditions that we work in. I try to emphasize in our training and face-to-face sessions that we’re each responsible for our environment. If you see something, don’t just say something but do something about it.”

Some participants stressed the value of open communication and collaboration with workers:

“[Workers] are partners with us. You’ve always got to write something down when you’re looking at equipment, but then you’ve got to ask them, too, ‘Hey, show me your work here. Where are you having issues and concerns? What’s hard for you?’ And you listen to them.”

This type of dialogue between management and workers created opportunities for improvements, for example:

“We invite workers to attend safety meetings and provide us feedback on any improvement we can do to our safety program. Most of the time, great recommendations are coming from our front line employees.”

In some instances, workers were trained to support and assist with implementing aspects of the program as well, as described in the following sections. Participants agreed that managers and supervisors being accountable to workers, and building trust with them, were essential elements of an effective program and contributed to a positive safety culture.

### ***Safety and Health Training***

All participants reported that their worksites provided safety and health training for new workers, orientations at the beginning of each season for all workers, and “refresher” training for returning workers. OSHA and Coast Guard requirements, including emergency procedures, were covered. Certain topics, including those that applied to a subset of workers, such as Hazardous Waste Operations and Emergency Response, followed

specific schedules for training. Given that many workers traveled to their remote worksites, or arrived onsite before vessels left shore, participants cited logistical difficulties in finding time for training. For onshore plants, it could be difficult to predict “when the fish would hit.” Once workers had arrived onsite, it could be challenging to balance training with production:

“If we're in full production it's hard to pull people away from the lines to provide training. Now, if we're not producing fish, then they're not here. I can't provide the training if they're not here.”

Participants reported various methods of instruction: (a) classroom/presentations; (b) videos; (c) online interactive systems; (d) drills, including in-water drills for all crewmembers; and (e) hands-on training. Some participants wished for additional time and support to provide more small group, hands-on, interactive training sessions. Given the linguistic diversity of the workforce, and that many workers had limited English skills, there was agreement that visual training techniques were essential:

“When I do the trainings, it's mainly picture-based. More pictures than words, so that when I go through the [presentation], everybody understands. Then we do a lot of hands-on training. If its blood-borne pathogens training, I have people come up and put on all the equipment – the face mask and all that, so they can see how they put it on. They practice it and then we do games afterwards to make sure they understand the information and to reiterate that training.”

Written materials and verbal instructions were sometimes translated from English into the other languages spoken at worksites. Translators included bilingual managers and workers who assisted each other. Participants expressed concerns over both the utility of visual instruction strategies, as well as the reliability of informal translations:

“There's a lot of value in using visuals, but there's also a lot of room for misunderstanding when all you're using is pictures. I've worked in a number of multicultural businesses, and in my experience, translators - particularly company employees - are not always reliable. You get a lot of nodding, 'Yes, I understand,' and there really isn't the comprehension that you need.”

Participants described how to confirm workers' comprehension of, and comfort level with, performing new tasks safely by providing hands-on training:

“We give them one-on-one training on how to perform their jobs within the factory. When that first bag of fish arrives, those new crewmembers have somebody with them and are shown the job step-by-step, until they're ready to say, 'Okay I can do this now.'”

Workers also helped to instruct each other in certain areas, such as addressing ergonomic hazards, by providing coaching and peer monitoring:

“One of our biggest issues is ergonomics and soft tissue injury. We took members out of each of the vessels, each of the departments, to participate. They have additional training above and beyond everybody else to be an instructor. They have an observation form that they use to monitor people during the year. It involves coaching and improvement. Instead of trying to put a negative spin on it, they highlight what people are doing right and then what they can do better.”

Resources for training materials and educational systems that were tailored for the offshore environment included those produced or provided by the North Pacific Fishing Vessel Owners' Association (NPFVOA), Det Norske Veritas Germanischer Lloyd (DNV GL), Maritime Training Services, and the Coast Guard. A few participants highlighted the utility of training managers, supervisors, and workers on job safety analysis and risk assessment techniques. This

type of training enables and empowers worksite managers/supervisors and workers to be active in the program and help ensure the program's effectiveness.

### ***Reporting, Identifying, and Analyzing Hazards***

Participants described various methods that workers used to report hazards: (a) verbally to their supervisors or the safety manager – either in-person or over the phone; (b) discussions at safety committee meetings, as well as other types of meetings; and (c) through written communications, including anonymous drop boxes or by email. Participants' programs were at various stages of development for reporting near-misses. Some participants planned on creating or increasing methods to report near-misses, while others had systems in place. A participant described their communication out to the boats with regards to reporting hazards, near-misses, abnormal events, and incidents:

"We have a 'Zero Harm Card.' We make it clear that any time you see something that you think is unsafe, or you see something you think is an excellent practice that should be incorporated vessel-wide or company-wide, then you can file these cards. They get routed up through the wheelhouse and then to the office, and eventually to me and the safety committee. We have incentive programs tied to it, in order to encourage buy-in."

At onshore and offshore worksites, methods for identifying hazards included: (a) inspections during walkthroughs and factory tours; (b) discussions during safety committee meetings; (c) worker reporting; (d) preventive maintenance; and (e) outside consultants and investigators, including: AKOSH consultations and inspections, Coast Guard inspectors, and loss control representatives. One participant highlighted that crewmembers using tablet computers to record information when conducting safety inspections at sea was a particularly useful technique, despite some technological challenges due to the remote locations:

"A picture is worth a thousand words. So when they see a hazard at sea or a problem, they can get that back into the office quickly. We have a phone call, I can look at their pictures, and we can come up with a mitigating solution to whatever this issue is, relatively quickly and efficiently. While it took some time culturally, especially the old timers to use [a tablet], it's worked extremely well. I think that is definitely the way of the future. Paper is inefficient."

Both onshore and offshore sites have identified and implemented hazard/risk analysis strategies that had been feasible and effective. For onshore plants, a participant described how their company's tailored job safety analyses had been "the best." Their company used mainly pictures, with a maximum of five words, because they "have so many non-English speakers – the key is understanding." Likewise, another participant discussed the process for analyzing risks in offshore work environments, and also cited the benefit of limiting the process to five steps:

"We rely heavily on a simple risk assessment, which is not the documented procedure. Rather, it is a chronic template that workers will rely upon to go through a checklist that has five steps to identify risks and potential controls that they execute in a habitual manner. Five is a good number because that's how many fingers you have on your hand. And we want everybody to keep all their fingers. They get used to counting it off on their fingers. It's also a small enough number that we actually have little vest pocket cards and it's on stickers. [...] So, they have constant reminders."

In describing this habitual risk assessment process, the participant stressed that it had been much more useful at promoting a safety culture than asking personnel to stop and do paperwork. The participant believed that requiring excessive paperwork encouraged people to take shortcuts and "pay lip service" to the safety

management system, which were negative outcomes. In the same way that programs were at various stages of development for reporting near-misses, the managers/department heads/supervisors across worksites had received varying levels of training on techniques for identifying and analyzing hazards.

### ***Hazard Controls***

Participants had utilized various hazard control measures at their worksites, some of which had been more effective than others. There was agreement that ergonomic hazards were an issue in this industry. One participant discussed an administrative control that had been effective when a screw press with multiple panels needed to be lifted for cleaning:

“Depending on the crewmember, most could handle it on their own, but some are smaller and are unable to do that. They decided that regardless of a person's size, that it's a two-person job, period. The smaller or less strong individual has the assistance necessary and it's taken care of so it won't cause a problem.”

Participants discussed how engineering controls, when feasible, were the most protective solutions, but that there could be difficulties with implementation:

“We're trying to develop strategies for dealing with these muscle strains and sprains but it's a tough nut to crack. They're very complicated.”

One participant highlighted how their company had made a substantial investment to eliminate hazards that had resulted in lifting injuries in a vessel's fishmeal bagging room:

“We took a broader look at it to see what we could do, hired an ergonomic consultant, and redesigned the whole bagging area. We blew out a wall and put in conveyor belts and squeezers to help eliminate the lifting hazards. Before, the crew were lifting a bag, which might weigh 77 pounds apiece, seven times. They do roughly 6,000 bags per trip. Now they are only lifting a bag to stack it, put it on the conveyor belt, and then offload it. So we eliminated four of the seven lifts.”

### ***Economic Factors***

Cost factored into many participants' decision-making about which hazard control measures they could afford to implement. For example, one participant was working on making the case for a long-term investment to eliminate noise hazards. Participants had to prioritize how to manage risks. Especially for smaller companies and those that operated during short seasons, there were economic challenges:

“When you're only running for two months, it's tough to justify spending half a million dollars on some machine that's going to automatically palletize something. [...] Certainly you want to protect your employees. But if this half million dollars is not going to get paid back for 20 years, well, then you find a different way to do it that maybe isn't as effective.”

Participants discussed conducting cost-benefit analyses and determining risk acceptance levels. Given that ownership and upper-level managers were focused on the company's finances, some participants explained that their role as a safety manager was to educate leadership about how the safety program could benefit company profits, including through cost avoidance:

“When you bring cost benefit analyses into the discussion, it changes the thoughts about what safety is and the value it has to the company. Nobody wants to see any worker get hurt. But at the corporate level, we're talking about risk acceptance.”



In addition to educating leadership about how investing in worker protections benefited the company's economic health, participants also described how they discussed economic issues with worksite managers:

"First you talk about the pain and suffering, and then you get down to the dollars and cents. Each plant, companywide, this is what we're spending on workers' compensation, and on our insurance policy. What does that translate into profits, alright? If we spend \$500,000 paying doctor bills, how much fish do we have to sell to make \$500,000? And that's a lot of fish."

Other participants emphasized the corporate-level support for their safety and health programs, and how leadership valued workers' well-being:

"I'm fortunate that the president and the CEO understand the value of safety, not just bottom-line dollars and cents, but that our people are our best asset and we don't want our people to get hurt."

Additionally, bad seasons when "the fish don't show up" resulted in companies having fewer resources to invest in their safety and health programs. Making improvements that were "more of a wish than a requirement" could be put on hold until resources were available. Another economic consideration was that, in remote locations, if a worker became injured or ill and was no longer able to perform their duties, then a replacement might not be readily available to take over for them and that affected production.

### ***Program Challenges***

Participants faced challenges in directing and managing their programs. They described varying degrees of program buy-in and engagement from workers, managers, and corporate leadership. By far, the most commonly reported challenge was handling language barriers among workers who came from around the world often had limited English-language skills. Only one participant did not cite language barriers as a challenge, and they explained that their company verified prospective workers' English language proficiency before hiring them. Other challenges included: (a) recruiting/retaining workers, and managing an aging workforce; (b) workers' hesitancy to report incidents or admit their lack of understanding; (c) workers' complacency and behaviors that violated regulations/policies; (d) maintaining worker engagement in the program; (e) cultural differences; (f) managing health issues and chronic conditions, including frustrations with the Jones Act for offshore worksites; and (g) the industry's seasonality.

Participants described their perceptions of their organizations' safety culture. Among workers in onshore plants, a participant noted:

"The culture change that we're looking for is the mindset of being safe. [...] That doesn't matter where they come from, some people just get that production mindset, 'Have to get it done as quickly as possible,' not realizing you need to be safe as well. I'd rather have you go home with all your fingers and toes and your life."

This type of production mindset was described among crewmembers as well:

"There's the 'old guard mentality.' For too many years, it was the attitude that you get it done, no matter how you get it done. Just get it done. That's kind of changed with the onset of OSHA regulations and the fact that they are now being enforced and not looked upon as a piece of paper that you have on your shelf. That's the culture that we're fighting."

Participants reported that managers' lack of safety and health education contributed to misconceptions that following safety procedures would decrease productivity, and that these managers prioritized production over safety:

"Production still trumps safety to a large extent and it's very disappointing to be fighting those battles. Part of this is lack of education of our upper management people; they've never been in the OSHA classes to get a good grasp on the issues. [...] It comes down to training and doing it right all the time, to where it's second nature. We're not there yet... Hopefully, with this additional training [for managers], we're going to have more accountability and develop ownership in the program. We'll be able to help turn this culture around."

When participants described challenges, typically they were hopeful that their continued efforts would successfully address the problems, even if improvements would take time and/or increased resource investments.

### ***Program Successes***

Participants reported successfully improving their programs and achieving goals. They emphasized improvements in managers' and workers' level of safety knowledge, behaviors, and working relationships. For example, in terms of improving managers' understanding of safety and health principles:

"We've had training for managerial personnel and the department heads to understand different techniques for doing root cause analysis and trying to get at the underlying factors. They've gone through the hierarchy of controls. They've actually shown marked improvement in the last few years at getting better corrective action to remove hazards rather than have controls to work around hazards."

For an offshore worksite, a participant noted that despite being seasonal and drawing labor from all over the world, workers' depth and breadth of safety knowledge was quite good:

"They look out for themselves and take a preventative approach. It is a very active environment. It is by its nature a 'get it done, get it done, get it done' process and environment. But, I can see over 20-some years that I've been involved in the industry, that it has gone from 'get it done' to 'get it done safely, get it done right.' The culture has changed."

Another participant cited the importance of workers providing feedback on safety issues:

"Having people come up to me and report safety concerns, and then following through on addressing those concerns, that makes for nice processes where workers feel comfortable bringing issues to me and knowing that I'll resolve them the best that I can."

Building trust between management and workers was seen as essential for an effective program, and participants acknowledged that this trust had to be earned over time, rather than decreed:

"Really, integrity is your stock and trade. If somebody comes to you for help and you blow them off, they're not going to come to you again. [...] Involve everybody from the bottom up. That way, there's opportunity for voices to be heard."

Participants also noted that mitigating worker fatigue improved safety. One participant explained that their company limited work shifts to 12 hours, because experience had shown that shifts over 12 hours were associated with injuries. Another participant reported that, in the past, the processors on their vessels had worked 16 and a half hour days, because they simply needed more people in the factory; however, ten years ago they changed the schedule to rolling eight-hour rounds:

“Because they’re getting more rest, the safety improved quite a bit. That could be one of the reasons other vessels within the industry are having safety problems. Adjusting the amount of hours worked to prevent fatigue is helpful.”

Additional examples of program successes included: (a) increasing the safety budget; (b) fall/slip/trip prevention; (c) improved confined space procedures; (d) vessel watertight integrity; (e) in-house testing and PPE fitting; (f) improved chemical labeling; as well as (g) welcoming, quality orientations for new workers arriving from around the world.

For offshore processing, participants described trends toward improved worker safety and health. One explained the history of consolidation in the fishing industry, and how larger companies with long-term investment horizons had recognized the importance of investing resources into safety and health programs. These larger companies understood that protecting the workforce was “a key driver of our competitiveness in the world marketplace.” Looking to the future, another participant noted building new vessels will improve factory safety:

“All of these older boats were conversions - they were built to be something else; most of them were not purpose-built to be at-sea processors. So, as we purpose-build fishing vessels and design them the right way to do business from the front end, I think it’s going to make some big, dramatic improvements. Safety through design is a challenge with older boats. Let’s do it smarter, do it right the first time, so we build it safely for the people that are using it, and mitigate hazards through elimination rather than administrative controls.”

Participants discussed being stewards of the industry and wanting everyone to meet a high standard for worker protections. For both onshore and offshore worksites, participants mentioned talking with their safety and health counterparts at other companies about their strategies for protecting workers, including working together on emergency preparedness at remote worksites. While their companies were competitive in certain respects, of course, they felt that worker safety and health was an area that involved collaboration. In addition to talking with one another and attending conferences, they also mentioned learning about best practices by reading scientific journal articles, safety magazines, and OSHA publications.

### ***Modifiable Workplace Factors***

Table 3.2 presents the modifiable workplace factors that were identified across participants’ responses to the various interview topics. Although company leadership cannot change certain aspects of the industry (e.g., the seasonality and remote worksite locations), they can modify other factors that ultimately influence worker safety and health.

Table 3.2. Modifiable workplace factors identified through participant responses across interview topics						
Interview Topics	Modifiable Factors					
	Worksite Manager Training	Worker Training	Adoption of Ergonomics	Work Hours	Knowledge Sharing	Safety Culture
Worksite and Workforce Characteristics		X		X		
Management and Workers' Roles	X					X
Safety and Health Training	X	X	X			
Reporting, Identifying, and Analyzing Hazards	X	X				X
Hazard Controls			X			
Economic Factors			X			X
Program Challenges	X	X				X
Program Successes	X	X		X	X	X

Participants noted that increasing worksite managers' training had improved workers' safety and health outcomes. For example, some participants stated that educating these managers on the hierarchy of controls resulted in the implementation of hazard control measures that more effectively prevented injuries and illnesses. Other participants noted that worksite managers who lacked education and training on OSHA regulations prioritized short-term production speed over following best practices for safety.

Almost all participants noted that language barriers among the diverse workforce presented difficulties when communicating, especially during safety and health trainings. Some participants wished that they had more time to provide training, including hands-on training. Hands-on training and using visuals were reported as two methods for overcoming language barriers during trainings; however, one participant highlighted the limitations of only using visuals during trainings.

Participants frequently cited ergonomic hazards as an area of concern at their worksites. Many explained that when they decided upon and implemented hazard controls related to material handling activities, they tried to follow the hierarchy of controls. However, participants also noted that identifying the most protective controls for ergonomic hazards, as well as finding feasible and affordable solutions, was sometimes a challenge. While discussing factory layouts and work processes, one participant brought up the concept of "prevention through design."

A couple of participants noted that long work hours had contributed to worker injuries, and that they witnessed safety improvements by modifying work schedules and limiting shifts to 12 hours. Additionally, some participants noted that they talked with their safety and health counterparts at other companies about their strategies for protecting workers. They appreciated that safety and health was a collaborative endeavor in an otherwise competitive industry.

Finally, participants frequently referred to the 'safety culture' when discussing management's and workers' commitment to safety, and their subsequent decision-making and behavior. While some participants reported that fostering a proactive safety culture and "prevention mindset" were among their greatest successes,

others discussed the challenges of overcoming an “old guard mentality” that did not prioritize safety. For example, sometimes managers/supervisors and workers had the misperception that following proper safety procedures impeded production, and that production should be prioritized over safety. Leadership’s commitment to the safety and health programs could be understood in part through their resource investments. Participants described decision-making processes for spending funds, including: considering ethical responsibilities to protect workers; prioritizing hazard control measures based on risk; conducting cost-benefit analyses; and balancing a hazard control measure’s affordability with its effectiveness when there were budget constraints.

## **DISCUSSION**

This was the first study to engage directors and managers who were responsible for running safety and health programs in Alaska’s seafood processing industry. The study’s sample size of 14 participants was appropriate for meeting the study objectives of investigating factors that influenced occupational safety and health, including characterizing safety and health programs. Participants represented major companies with high-production onshore and offshore worksites that operated throughout the state. Participants reported being responsible for directing and managing programs for 68% of the 25,000 workers in this industry, which is considerable. Effective management of safety and health programs is a decisive factor in preventing injury and illness, as well as reducing incident severity. The major elements of an effective occupational safety and health program include: (a) management leadership; (b) worker participation; (c) hazard identification and assessment; (d) hazard prevention and control; and (e) education and training (OSHA, 1989 & 2016a).

During the interviews, participants noted widely varying degrees of program buy-in and engagement from management and workers, ranging from basic compliance with standards to full partnerships for carrying out best practices. Likewise, they reported different successes and challenges in protecting workers’ safety and health. Therefore, injury and illness interventions cannot be “one size fits all” throughout the industry, but must be tailored to meet the unique circumstances of each worksite. Despite these variations, this study identified commonalities between the companies and worksites, and uncovered areas in which multiple participants were making efforts to improve their programs. This section discusses the workplace factors that could be modified to improve worker safety and health, and corresponding recommendations for improvement.

### ***Worksite Manager Training***

Participants described how worksite managers and supervisors had varying levels of education and training on occupational safety and health issues, including how to prevent injuries and illnesses. Research has shown that developing and investing in safety and health leadership among middle managers positively influences safety outcomes among workers. For example, middle managers are role models, and workers rely on these managers’ instructions and social cues to decide what to value and prioritize in the workplace (Sheehan et al., 2016). Additionally, there is evidence from research in the food manufacturing industry that training supervisors to improve their responses to workers’ safety and health concerns, including workers’ early mentions of musculoskeletal discomfort, can substantially reduce both the frequency of workers’ compensation claims for

musculoskeletal injuries and disability outcomes. In that study, the training message shared with supervisors was that “supportive, proactive, and collaborative communications with employees about ergonomic risk factors and musculoskeletal pain and discomfort would likely reduce disability costs and improve employee morale, productivity and retention” (Shaw et al., 2006, p.109).

### ***Worker Training***

Almost all participants noted that language barriers among the diverse workforce presented difficulties when communicating, especially during trainings. In an analysis of the essential elements of effective occupational safety and health training programs for under-served communities, O'Connor et al. (2014) discussed the challenges involved in training limited/non-English-speaking workers. They described how interpreters are often bilingual intermediaries who “may have the best of intentions, but often have limited abilities in the face of complex challenges of interpretation.” Therefore, they stated that it is far better to hire a professional interpreter when financially feasible. The authors also described the value of “train-the-trainer programs,” which involve organizations investing in the education and ongoing support/coaching of trusted individuals (“worker-trainers”) who in turn provide training to their peers (O'Connor et al., 2014).

Additionally, directors/managers should keep in mind that straight translation of educational materials from English into other languages does not necessarily guarantee that they are literacy, language, or culturally appropriate (Arcury et al., 2010). Proposed guidelines for designing and developing educational materials for limited/non-English-speaking workers include: (a) using a native-speaking translator who has in-depth knowledge of the topic; (b) keeping materials at a limited literacy level; (c) using plenty of clear and realistic illustrations, graphics, and photographs; (d) conducting pilot tests with workers; and (e) including basic education on OSHA laws and workers' rights to safe and healthy conditions in the workplace (Brunette, 2005).

For workers of all languages and literacy levels, there is evidence that training is more effective at improving safety knowledge and performance when it involves higher learner-engagement (e.g., behavioral modeling, simulation, and hands-on training) versus low-engagement methods (e.g., lecture, video, and pamphlets) (Burke et al., 2006). A systematic review of the scientific literature on training's effectiveness found that (a) training had a positive impact on workers' safety practices, and (b) training should be utilized as one aspect of a larger safety management system (Robson et al., 2012). Directors/managers should ensure that workers have the ability to communicate their questions, concerns, and feedback for improvement at any time.

### ***Adoption of Ergonomics***

Participants cited ergonomic hazards as an area of concern at their worksites. Ergonomics is the science of fitting workplace conditions and job demands to worker capabilities (NIOSH, 2017). Hiring expert consultants, such as ergonomists and safety engineers, could help companies to redesign factories and/or processes in order to improve the safety of material handling tasks, when feasible. Administrative controls alone, such as training workers to use safe lifting techniques, are not as effective at preventing musculoskeletal injuries. The concept of “prevention through design” involves eliminating hazards as early as possible in the life cycle of equipment and

workplaces. Using this approach, safety is incorporated into the design, redesign, and retrofit of new and existing tools, machinery, facilities, and work processes (NIOSH, 2013).

To prevent musculoskeletal injuries, managers should implement ergonomic programs that follow these steps: (1) identifying risk factors; (2) involving and training management and workers, including giving workers the opportunity to discuss problems; (3) collecting health and medical evidence; (4) implementing controls – such as using mechanical assist devices or reducing materials’ weights; (5) evaluating the program; and (6) maintaining management and worker involvement in the program (NIOSH, 2017). Participatory ergonomic interventions involve engaging workers in problem solving, as well as providing workers with sufficient background/technical knowledge to understand ergonomic principles and the power to influence their own work activities. There is evidence that participatory ergonomic interventions have a positive impact on reducing musculoskeletal symptoms and injuries, workers’ compensation claims, and days away from work (Cohen, 2006; Rivlis et al., 2008).

### **Work Hours**

Participants mentioned that working long hours affected safety and health. The long work hours in the Alaskan seafood processing industry have been discussed in a previous study and in the news media. In a study by Garcia and De Castro (2017), interviews with Filipino seafood processors in Dutch Harbor, Alaska identified challenges related to insufficient time allowances for rest breaks, as well as sleep disruptions in employer-provided dormitory rooms. Nevertheless, interviewees reported that their company was much better to work for than others operating in Alaska, including having a better commitment to safety and health. They noted that work shifts being limited to 12 hours was preferable to the 15- to 18-hour shifts at other companies (Garcia & de Castro, 2017). In a recent news article, Cole (2017) described how companies operating plants in Alaska during a short summer season recruited foreign workers to meet labor demands, paying \$10 an hour straight time and \$15 an hour overtime. A teacher from Belgrade, Serbia who worked in a Valdez plant on a temporary visa was quoted as saying: “It’s very hard to work 16 hours a day, but after three weeks you receive your first paycheck... You do not want to have a day off because in Serbia you cannot earn that amount of money for sure” (Cole, 2017).

Long hours and shift work increase safety and health risks, as well as decrease productivity, and can result in errors that negatively impact product quality. With very long shifts, and when 12-hour shifts combine with more than 40 hours of work a week, workers’ physiological performance deteriorates and they experience increased injury rates and more illness (NIOSH, 2004). Management should implement a fatigue risk management system, which has been discussed in detail by the American College of Occupational and Environmental Medicine’s Task Force on Fatigue Risk Management (Lerman et al., 2012). When scheduling work shifts, managers should consider that the average person requires 8 hours of sleep to allow for restorative sleep and prevent fatigue associated with sleep loss. Therefore, non-work time (i.e., the amount of time off-duty) should last longer than 8 hours, in order to allow for “true sleep opportunity” after workers have engaged in necessary personal activities, such as eating and personal hygiene (Lerman et al., 2012). Strategies for reducing fatigue-related risks include: (a) allowing workers to have input on the design of their schedules; (b) providing frequent and adequate rest breaks; (c) scheduling short

naps; (d) breaking up monotonous tasks to prevent fatigue; and (e) providing training for management and labor on basic sleep information, circadian rhythm, and fatigue physiology, as well as good practices and behaviors to get adequate sleep (Caruso, 2011).

### ***Knowledge Sharing within Industry***

A few participants at different companies noted that they appreciated how safety and health was a collaborative endeavor in an otherwise competitive industry. More industry members could share best practices for protecting workers' safety and health. This study identified instances in which one participant had identified a successful solution for a problem that another participant was struggling to address. Industry associations, as well as organizations that promote safety and health, could assist with disseminating best practices. Additional opportunities for networking and sharing information include trade expos, American Society of Safety Engineers meetings, the Alaska Governor's Safety and Health Conference, as well as workshops and career development training provided through the University of Alaska's Sea Grant program.

### ***Safety Culture***

Participants frequently referred to the 'safety culture' when discussing management's and workers' decision-making, behavior, and commitment to the programs. Safety culture is a multidimensional concept that has various definitions in the scientific literature. An organization's safety culture can be defined as:

“...the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style of and proficiency of, an organization's health and safety management” (Lee, 1996).

'Safety culture' and 'safety climate' are related concepts that are often used interchangeably in the literature and practical application, due to a lack of clear and consistent definitions. However, '*climate*' can be understood as the more “superficial” and visible expression – or “snapshot” – of an organization's underlying '*culture*,' which is “deep,” “stable,” and composed of strongly held beliefs and convictions (Guldenmund, 2000; Seo et al., 2004). The extent to which an organization's safety climate/culture is a “leading indicator,” or predictor, of occupational safety and health outcomes has been studied in various industrial settings. There is evidence that safety climate is significantly correlated with workers' safety knowledge, motivation, performance, and outcomes (Christian et al., 2009; Clarke, 2006). Safety culture types, ranging from poor to excellent, have been described as:

- “Pathological: Who cares about safety as long as we are not caught?”
- Reactive: Safety is important; we do a lot every time we have an accident.
- Calculative: We have systems in place to manage all hazards.
- Proactive: We try to anticipate safety problems before they arise.
- Generative: HSE is how we do business around here” (Parker et al., 2006).

Through sustained effort, it is possible for companies to improve aspects of their organization in order to bolster the safety culture, and develop the following positive traits: (a) all organization members understand worksite hazards, and are alert to the ways in which the safety management system could fail to prevent incidents; (b) a system is in place to collect, analyze, and disseminate the knowledge gained from incident and near-miss reports; and (c) there is a fair culture that supports incident reporting, in which workers understand what unacceptable



behaviors merit disciplinary action, and managers do not punish worker errors or incidents simply to “obscure systemic deficiencies and to blame one of the victims” (Reason, 1998). In this study, participants emphasized that building trusting relationships between management and workers was essential for an effective program, and that trust was founded on management’s accountability to workers and responsiveness to their needs.

### ***Limitations***

The results of this study are not generalizable to Alaska’s seafood processing industry as a whole. Although the study design and sample size were appropriate for utilizing a content analysis approach to identify categories in the data, they were not sufficient to produce generalizable results or develop theory. Large companies with a proactive safety culture might have had directors/managers with more of an interest in, and ability to, participate in this study than others. Smaller companies, and those with less-developed programs that did not have a designated safety and health director/manager available to interview, were not represented in this study. As corporate and high-level directors/managers, participants’ experiences and views might have differed from those of other managers within their own companies, such as onsite department heads or line-level supervisors. Workers likely have unique experiences and views on their safety and health programs, including facing challenges that were not identified by the study participants.

Given that interview responses were self-reported, the information is subject to recall and social desirability bias. The lead author emailed the interview guide to companies and prospective participants prior to scheduling interviews and therefore it was possible that participants’ responses were influenced by discussing questions with other people beforehand, or by having additional time to consider their responses. However, having more time to review and reflect might have helped participants to formulate and better articulate their responses, especially for interviews conducted over the phone. Additionally, this type of transparency about the interview questions might have helped recruitment efforts by alleviating any doubt or concerns among prospective companies and participants about this research project. Despite its limitations, this research successfully engaged stakeholders in discussions about topics that had previously been unstudied in their industry.

### ***Future Research***

Across industries in the US, an increase in the cooperation and collaboration between government, industry, labor, and occupational safety and health professionals/researchers has contributed to progress in occupational injury prevention (Stout & Linn, 2002). For Alaska’s seafood processing industry, additional study is needed to characterize the views and experiences of workers, as well as mid- and line-level managers/supervisors, regarding occupational safety and health. Researchers in academia and government, occupational health practitioners, and regulators should support industry members in addressing the challenges that they face in protecting workers from injury and illness. Collaborations between these groups could effectively identify, develop, and evaluate safety and health interventions that are tailored for this unique work environment. In particular, additional research on training for limited-English-speaking workers, ergonomic interventions, and fatigue risk management systems would be beneficial for improving worker safety and health in this industry.

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## CHAPTER 5: GENERAL CONCLUSIONS

This research contributed to the field of occupational safety and health in Alaska's seafood processing industry by (a) characterizing the burden of injury and illness among onshore and offshore workers; (b) identifying modifiable worksite hazards that could be controlled to prevent injury and illness; (c) describing safety and health programs at major companies and recommending areas for improvement; (d) proposing topics for future study; and (e) suggesting opportunities for collaboration between industry members, researchers, and occupational health practitioners. Each specific aim of this research was accomplished. The findings from each of the three studies (presented in chapters 2, 3, and 4) are summarized below and followed by general conclusions from the project as a whole.

The first specific aim was to utilize US Coast Guard reports to determine patterns of traumatic injury characteristics and circumstances, as well as identify modifiable worksite hazards, among offshore seafood processors working in Alaskan waters during 2010-2015. Preventing musculoskeletal injuries, particularly to workers' trunks and upper extremities, is paramount. Hazard control measures should target: (a) overexertion from lifting and lower objects and equipment; (b) equipment and boxes falling and striking workers; (c) workers being caught in running machinery during regular operations; and (d) slips, trips, and falls.

The second specific aim was to utilize workers' compensation claim reports to (a) estimate the risk of nonfatal injuries and illnesses, (b) determine patterns of incident characteristics and circumstances, and (c) identify modifiable workplace hazards among onshore workers in Alaska's seafood processing industry during 2014-2015. Implementing ergonomic solutions to prevent musculoskeletal injuries – especially to workers' upper extremities – is vital for improving occupational health. Hazard control measures should target: (a) repetitive motion, overexertion, and contact with equipment during line production; (b) overexertion due to manually lifting, lowering, pushing, and pulling materials and equipment; and (c) slips, trips, and falls.

The third specific aim was to interview safety and health directors/managers to investigate: worksite and workforce characteristics; safety and health program features; economic factors influencing programs; and program challenges and successes. According to participants, engaging workers in their safety and health programs was beneficial to their programs' success. Workplace factors that could be modified to improve safety and health included: worksite manager training; worker training; adoption of ergonomics; work hours; knowledge sharing within the industry; and organizational aspects related to safety culture.

Using a mixed-methods research approach provided richness and depth for exploring the safety and health of an understudied and high-risk worker population that is vital to Alaska's economy. To investigate patterns of injury and illness in both of the industry's unique worksite locations – offshore and onshore – we utilized two sources of information. NIOSH's partnerships with the US Coast Guard and the Alaska Division of Workers' Compensation allowed for data sharing to conduct the analyses. Offshore and onshore workers were most frequently injured by coming into contact with objects/equipment, as well as overexertion. The epidemiologic studies' major finding – that ergonomic interventions were needed to prevent musculoskeletal

injuries to workers' upper extremities – was consistent with prior research that has been conducted around the globe on the seafood processing industry. To prevent injuries and illnesses, companies operating in Alaska should implement the concept of “prevention through design” and eliminate hazards as early as possible in the life cycle of machinery/equipment, facilities, and work processes. Major limitations of the epidemiologic studies included the inability to calculate rates using full-time equivalent worker (FTE) estimates to measure and compare risks, and the potential underreporting of nonfatal injury and illness among offshore and onshore workers.

Although the epidemiologic studies successfully identified hazards that could be controlled in order to prevent injuries and illnesses, they did not provide information on additional factors that could have influenced occupational safety and health outcomes. We successfully engaged stakeholders to collect qualitative data on the broader context in which injuries and illnesses occurred in this industry, and to determine companies' strategies for protecting their workforce. Interviews with industry members who directed/managed safety and health programs for large companies validated that ergonomic hazards were a major area of concern, and that addressing these hazards was oftentimes difficult. This study uncovered additional challenges facing safety and health directors/managers, such as overcoming language barriers when communicating with limited-English-speaking workers from around the world. Participants also provided examples of how they had successfully engaged workers to foster a proactive safety culture and had implemented hazard control measures to prevent injuries and illnesses. Many participants reported the benefits of investing in safety and health programs in order to protect workers' well-being. To be competitive in a global market and act as stewards of the industry, companies could share their best practices and learn from each other's successes.

Researchers in academia and government, occupational health practitioners, and regulators should support industry members in protecting workers from injury and illness. Collaborations between these groups could effectively identify, develop, and evaluate safety and health interventions that are tailored for this unique work environment. In particular, additional research on ergonomic interventions, fatigue risk management systems, and training for limited-English-speaking workers would be beneficial for improving worker safety and health in this industry. Future research is needed to explore workers' experiences and needs. In addition to informing injury and illness prevention strategies in Alaska, the findings of this research could potentially be applicable to other seafood processing worksites in the US.



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## APPENDICES

<b>Appendix A. Injury Severity Scale Adapted from the Abbreviated Injury Severity Scale Utilized by United States Coast Guard Investigators</b>		
<b>Injury Severity</b>	<b>Definition</b>	<b>Examples</b>
Minor	The injury is minor or superficial. No medical treatment was required.	Minor/superficial scrapes (abrasions); minor bruises; minor cuts; digit sprain; first degree burn; minor head trauma with headache or dizziness; minor strain.
Moderate	The injury exceeds the minor level, but did not result in broken bones (other than fingers, toes, or nose) loss of limbs, severe hemorrhaging, muscle, nerve, tendon, or internal organ damage. Professional medical treatment may have been required. If so the person was not hospitalized from more than 48 hours within 5 days of the injury.	Broken fingers, toes, or nose, amputated fingers or toes; de-gloving of fingers or toes; dislocated joint; severe strain/sprain; second or third degree burn covering 10% or less of the body (if face is included move up one category); herniated disc.
Serious	The injury exceeds the moderate level and requires significant medical/surgical management. The person was not hospitalized for more than 48 hours within 5 days of the injury.	Broken bones (other than fingers, toes, or nose) partial loss of limb (amputation below elbow/knee); de-gloving of the entire hand/arm or foot/leg; second or third degree burns covering 20-30% of the body (if face included move up one category); bruised organs.
Severe	The injury exceeds the moderate level and requires significant medical/ surgical management. The person was hospitalized for more than 48 hours within 5 days of the injury and, if in intensive care, was in for less than 48 hours.	Internal hemorrhage; punctured organs; severed blood vessels; second/third degree burns covering 30-40% of the body (if face included, move up one category), loss of entire limb (amputation of whole arm/leg).
Critical	The injury exceeds the moderate level and requires significant medical/surgical management. The person was hospitalized and intensive care for more than 48 hours within 5 days of the injury.	
Not survivable	Injuries sustained in accident where the individual would not be able to survive under any circumstances.	Decapitation.

## Appendix B. Interview Guide

### I. Participant Background

1. What is your job title?
2. How long have you worked in this industry?
3. How long have you held positions involving occupational safety and health?
4. What types of education, training, and/or on-the-job experience have prepared you for handling occupational safety and health issues?
5. Are you involved with an occupational safety and health program for onshore facilities and/or onboard vessels? How many worksites do you cover?

### II. Worksite Characteristics

6. Which species are processed at your facility?
7. During which months of the year does your facility operate?
8. During peak season, how many workers total are onsite/onboard?
9. During peak season, approximately how many workers perform seafood processing and packaging tasks?

### III. Safety & Health Program

10. What is the management team's role in the safety and health program?
11. What is the worker's role in your health and safety program?
12. How are worksite hazards identified and analyzed?
13. Is there a system for workers to report hazards? If so, what type?
14. Following an injury or illness, what is the program's protocol, or method, for addressing it?
15. Could you tell me about one or two examples of a hazard control measure that your program has implemented that have been very effective?
16. Could you tell me about one or two examples of a hazard control measure that your program has tried, but that have been less effective than you expected?
17. What safety and health training is provided for workers?
18. How often is safety and health training provided for workers?
19. In what language(s) is the training provided?

### IV. Program Challenges & Successes

20. What are the two biggest difficulties or challenges facing your safety and health program?
21. What are two of your safety and health program's most important successes?

### V. Regulatory & Economic Factors

For these next questions, examples of regulations could be from OSHA, the EPA, the FDA, etc.

22. Do any regulations negatively influence your worker safety and health program? If so, how?
23. Do any regulations positively influence the program? If so, how?
24. Do economic factors influence your safety and health program? If so, how?

### VI. Workforce Characteristics

For the following questions, please provide estimates or general impressions:

25. What is the age range for workers?
26. What percentage of workers are men versus women?
27. What are workers' educational backgrounds? For example, categories could be: less than a high school degree, a high school degree, or some college and college degrees.
28. What languages are spoken among workers?
29. What are workers' racial or ethnic backgrounds?
30. What is the worker turn-over rate?

Is there anything else that you would like to mention related to protecting workers' safety and health in your industry?