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Relationship of personal, situational, and environmental factors to injury experience in commercial fishing

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Abstract

Introduction: Commercial fishing work involves a variety of activities and is hazardous. While much is understood to mitigate fatalities in this industry, research must further explore nonfatal injury characteristics, factors related to injury, and potential injury prevention strategies. This paper determines if fishing experience is associated with injury risk and explores common work activities associated with injury.

Method: Key informant interviews and a survey of fishermen were conducted to refine work activity codes and collect injury experiences. Independent sample t-tests compared the means of the years fishing by injury incident for all crab fishermen then stratified by position. Descriptive statistics explored the nature of injury in relation to work activity.

Results: The level of experience was significantly lower for injured fishermen compared to fishermen who reported no injuries, but when stratified by position at the time of the injury, the association of injury to experience was only significant for owners. This stratified result demonstrates that the work activity, rather than experience, drives the apparent relationship of experience to injury. Being tired (24%) and weather (26%) were indicated as contributing factors at the time of injury.

Conclusion: Modifying the work environment to better control hazards would benefit all fishermen, regardless of their experience, age, or position. Further work into effective interventions that fishermen would adopt is needed to reduce injury risk. Any formal or informal training of new fishermen should focus on the most hazardous activities, but more experienced fishermen would also benefit. Additionally, effective training or interventions for fatigue management, and decision support tools for weather- and navigation-related decisions would further reduce risk of at sea injuries.

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Author contributions

L.K., V.B and D.L. substantially worked on conception and design of the study. L.K., A.V. and L.S. substantially contributed to the acquisition of data. L.K., V.B., L.S. substantially contributed to analysis and interpretation of data. L.K. substantially worked on the writing of the manuscript. All authors worked on revising of the manuscript critically for important intellectual content, and final approval to be published.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Practical Applications: Injury prevention training, for all fishermen, regardless of their position and years of experience, should cover the most hazardous tasks, fatigue risk management strategies, and weather decisions.

Keywords

Fishermen; Work processes; Crew experience; Crew position; Injury prevention

1. Introduction

Commercial fishing work includes a wide variety of activities.Tasks can include everything from standing watch to preparing, setting, and hauling gear to sorting or processing the catch. In the United States, commercial fishing is a hazardous occupation with a fatal injury rate (77.4 per 100,000 full time equivalent workers (FTE)), second to only logging workers (97.6 per 100,000 FTE), which is over 22 times higher than all workers (3.5 per 100,000 FTE) (Civilian occupations with high fatal work injury rates,2022). In the US Pacific Northwest, the Dungeness crab is a common species and consistently the most valuable single-species. The Dungeness crab fleet has been recognized as a hazardous fleet based on vessel disasters and fatalities (Commercial Fishing Fatality Summary West Coast Region, n.d.). Little was known about the nonfatal injury experience of this fleet, until the Fishermen Led Injury Prevention Program (FLIPP) engaged Dungeness crab fishermen in participatory research to understand the patterns of injury and to explore opportunities for injury prevention (Case et al., 2015; Pillai et al., 2019; Bovbjerg et al., 2019; Kincl et al., 2019). FLIPP is a collaboration of public health researchers, Oregon Sea Grant, and Pacific Northwest fishermen and has conducted various research and outreach projects since 2014.

FLIPP first explored injury information reported to the U.S. Coast Guard (USCG) that involved Dungeness crab fishermen. During 2002–2014, fishermen reported 28 fatalities and 45 nonfatal injuries (Case et al., 2015). Following the initial study of USCG reports, Dungeness crab fishermen participated in facilitated focus groups to consider the reported injury information, and to help develop a FLIPP survey to collect new information directly from fishermen on their injury experiences and opinions on safety (Kincl et al., 2019). The purpose of the FLIPP survey was to estimate nonfatal injury rates, learn more about injury characteristics, uncover factors related to injury, and identify potential injury prevention strategies. Of the 426 fishermen surveyed, 21% reported an injury in the previous year and most received either first aid (34%) or no treatment at all (27%) (Bovbjerg et al., 2019).

Further findings from our FLIPP survey revealed that fishermen commonly cited heavy workload (21.9%), poor mental focus (19.9%), and crew inexperience (14.3%) as the most common causes of injury (Pillai et al., 2019). For injury prevention, risk factors that are perceived as modifiable by the fishermen to reduce the risk of injury must be identified. In the FLIPP survey, fishermen reported the following factors for staying safe: awareness (36.1%), well-maintained fishing gear/vessel (10.4%), and best marine practices (9.9%) (Pillai et al., 2019). Modifiable factors can further be influenced by the specific work activity and the environment associated with injury. A Danish researcher, Olaf Jensen, developed a work process classification system to better understand the commercial fishing activities and their relation to injury (Jensen et al., 2003; Jensen et al., 2005; Jensen et al., 2006; Lucas et al., 2014; Syron et al., 2016). This system included the general activities of all fishermen, regardless of fishery, as well as work activity codes that are specific to gear type, which depend on the fishery. This system has been used within specific commercial fishing fleets, including research on the Dungeness crab fleet using injury information reported to USCG. Case et al. (2015) (Case et al., 2015) found that almost half (47%) of the nonfatal injuries among Dungeness crab fishermen occurred when hauling the gear (i.e., hauling crab pots when harvesting).

The FLIPP project sought to further expand this work process classification system for U.S. fishing fleets, using the Dungeness crab fleet for demonstration, and requesting fishermen's expert feedback to develop fleet-specific work activity codes. Dungeness crab is commercially fished using crab pots and is classified as a sustainable fishery (Rasmuson, 2013). Each vessel must have a license, which restricts the number and size of crab pots that can be set. The pots are set in a line (string) that is pulled up to harvest by a hydraulic crane (block). Deck crew handle the pot to empty the crab onto a table, which is on the deck, reset the pot with bait, then set the pot back to "soak" for future crab harvesting. At times, they move the pot to the deck to store the string of pots to move to a different fishing ground. The number of crew in Dungeness crab fleet can vary, however, there are distinct positions when fishing. Typically, a new crew member will start as a deckhand that works on the side of the table opposite the block. This crew member's work can involve chopping bait, setting gear, hauling gear, sorting crab, handling, and prepping the gear on deck. As a crew member gains experience, they might move to operating the crab block while still assisting the other crew in handling the pot to harvest crab and then potentially move into the role of deck boss. The deck boss helps to organize the work on deck and coordinates with the captain. A crew member with more experience may become a captain who drives the vessel and makes the fishing decisions. The captain, depending on crew size and fishing intensity, may also work on the deck to harvest crab. Therefore, extent of fishing experience and one's crew position is likely to be associated but flexible.

Previous research from a variety of industries and injury reporting systems shows that newer workers experience disproportionately higher injury rates (Breslin et al., 2019; Margolis, 2010; Siskind, 1982; Breslin and Smith, 2006). While newer workers may have more injuries, older workers (>65 years) suffer more serious work-related injuries and overexertion injuries (Margolis, 2010; Mitchell, 1988; Wiatrowski, 2022). One study of commercial fishing injuries in Alaska focused on child (<17 years) injury claims and demonstrated that children participate in the industry and experience occupational injuries (Rudolphi & Berg, 2021) but did not conduct a study comparing the various age groups and experience levels.

The purpose of this paper is twofold and presents further findings from the FLIPP survey. First, the intent was to determine if fishing experience is associated with injury risk, after accounting for crew position. Second, the intent was to explore common work activities associated with injury and the further information collected about work activities through Dungeness crab key informant interviews. We hypothesized that the injuries related to specific work activities are associated with the crew position, which is independent of experience (i.e., owners or captains with more experience may sometimes work as a deckhand and are just as likely to be injured hauling crab pots as a deckhand with less experience).

2. Materials and methods

2.1. Participants

Participants included commercial fishermen who were at least 18 years of age. To recruit fishermen to participate in the key informant interviews as well as the FLIPP survey (a paper survey), our study team included Oregon Sea Grant extension agents and community researchers (Kincl et al., 2019). Fishermen were recruited and data collected in the main commercial fishing ports in Washington, Oregon, and Northern California. Study procedures were approved by the university's Institutional Review Board (Protocol # 6748). All fishermen provided informed consent to participate.

2.2. Key informant interviews

Using purposive sampling, community researchers in the various ports recruited experienced fishermen who were in owner/-captain or deckhand positions. Key informant interviews with experienced crab fishermen were conducted in the summer of 2015. The purpose of the interviews was to refine the work activity codes and language used to describe the code to include in the injury questions in the FLIPP survey. From the analysis of the USCG nonfatal injury data with this fleet (Case et al., 2015), we extracted the relevant work activity codes for fisheries using pots. As a study team, and with the Dungeness crab fishery experience of our Sea Grant extension agents, we adapted the names of the codes (to vernacular language used by the fishing industry), code definitions, and codes relevant for the fishery. We prepared 15 major codes with 62 sub-codes in a table for the interview guide. The table included the name of each specific activity code and space for inserting additional detail of the activity. The table also included space for estimates of the time spent in pre-season (prepping gear and loading gear to vessel), dump days (when they place their pots for the initial soak before the season starts), early season (when they are fishing intensively as crab is more plentiful and price is best), and regular season (when fishing is more "relaxed"). The interviewer and fishermen revised the work activities on the form during the interview, and the session was recorded for validation of discussion. Each interview lasted approximately one hour.

2.3. FLIPP survey

The survey data collection and content has been described previously (Pillai et al., 2019; Bovbjerg et al., 2019; Kincl et al., 2019). Briefly, the survey was collected in person from owners, captains, and deckhands in ports in Washington, Oregon, and California prior to the Dungeness crab season starting in December 2015. The survey included 27 items that reported commercial fishing activities (number of years commercially fishing and number of years commercially fishing crab), injury experience in the previous year, safety opinions, and demographics. For the injury information, the fishermen reported what they were doing at the time of injury (work activity), crew position at time of injury, vessel activity and length, fishery, body part injured, nature of injury, and if they thought being tired or the weather conditions contributed to the injury.

2.4. Analysis

From the key informant interviews, descriptive statistics were used to tabulate the average task times and the proposed code modifications. For the FLIPP survey data, the demographic information was summarized for all the respondents with descriptive statistics (mean, standard deviation, and range) by age, gender, position, and the total months spent fishing in the past year. Data were also summarized for experience as number of years fishing (any fishery, even if multiple fisheries) and number of years crab fishing, whether they were injured in the past year, and ever injured during their career.

For each analysis examining the association of injury to experience, data were restricted to Dungeness crab fishermen. Because we were interested in the factors relating to injury, the unit of analysis was the injury and not the fisherman. To determine if experience is related to injury, we compared the means of the years fishing and crab fishing by injury incident using independent sample t-tests for all the fishermen then stratified by their current position (owner, captain, and deckhand). To determine if our results were influenced by the non-normal distribution of the data, we repeated these analyses using nonparametric tests using independent samples and the Mann-Whitney-Wilcoxon test and obtained similar results (not shown).

We further explored the injury incidence within the current positions, the positions and work activities reported at the time of the injury, and to discern factors related to the injuries. To explore the work activities and nature of injury reported for all the injuries, we cross tabulated to summarize the results. To estimate how often fisherman reported being tired and that weather conditions were related to the injury, frequency counts were calculated since these questions were only asked if the fishermen reported an injury.

3. Theory

While there are several theories of injury/accident causation (Safety and Health for Engineers, 2022), this work combines principles from both injury epidemiology theory and systems theory. Injury epidemiology theory focusses on the causal relationship between the host and injury. The host can have predispositional characteristics that relate to their perceptions and environment as well as situational characteristics that relate to the situation the person is immersed in (Yates, 2020). Considering the commercial fishing industry and applying epidemiology principles, we seek to explore the relationship between the predisposition of the fishermen (age, fishing experience, tiredness), and their situational characteristics (work activities, role on the vessel, weather) with injury incidence. It is also appropriate to apply a systems theory approach that allows us to explore the relationship among interacting components–the person, machine, and environment – all acting as one system (Yates, 2020). Considering that in the commercial fishing industry, the fishermen, gear, and surroundings make up a system where each component contributes to potential failure, resulting in an injury.

4. Results and discussion

4.1. Key informant interviews

Thirteen Dungeness crab fishermen were interviewed in seven ports: eight were captains (with one who sometimes worked as deckhand on the vessel) and six were deckhands (with three who we considered novice and had only one season of experience). From their review of the original work activity codes, we identified revisions and language clarification. Fishermen agreed that activities vary widely between positions and by time within the season (pre-season, dump days, early season, and regular season). As expected, captains reported spending most of their time at the helm operating the vessel, and deckhands reported their time was distributed among gear handling activities (setting and hauling gear). Table 1 provides the range and average days reported for the various times in the Dungeness crab season. The preseason and early season both lasted about a month on average, with the regular season lasting 46 days. The “dump” days—when crab pots are dropped— are dictated by state or tribal regulations, so the range was shorter and averaged two days. In summary, the total involvement in a crab season lasts approximately three and a half months on average but can last up to seven months.

From the key informant interview results, we designed the FLIPP survey (Table 2) for fishermen to report what they were doing (work activity) at the time of injury. The fishermen were asked to check one activity that indicated what they were doing at the time of their injury and/or to write in any details in a space provided with each activity, although some fishermen checked more than one activity. Examples for each work activity were provided.

4.2. FLIPP survey

Out of the 426 fishermen surveyed, 96% were male. Tables 3 and 4 contain the demographic information and characteristics of the fishermen surveyed. There was a wide range of ages and experience in the study population. Since we surveyed before the crab season, as the fishermen were prepping gear for the new season, some deckhands were recently hired and therefore had not yet been out commercially fishing (i.e., 0 years fishing or crab fishing). While 21% of the fishermen reported having at least one injury in the past year (range 1–6 injuries), 51% reported having an injury in their fishing career (range 1–30 injuries). Half of the fishermen responding to the survey were deckhands (50%) and most were Dungeness crab fishermen (85%), which was expected, since the fishermen were recruited from the gear yards during gear preparation before the start of the crab season. This provided an unusual opportunity for the participation of deckhands in safety research.

For the remaining results, only Dungeness crab fishermen were included in the analyses. As expected, the age of the fishermen and their reported years crab fishing experience were closely correlated ($r = 0.641$, $p < 0.001$). Because of the strong association between age and experience, we were not able to model their independent contribution. Table 5 shows the results of comparing the means (t-test) of experience by injury incidence. Both the years fishing and crab fishing are significantly lower for the injured fishermen as compared to the fishermen who reported no injuries. Table 6 shows the results of comparing the means of experience by injury incidence with the fishermen stratified by their current position reported. Only the results of "owners" show that the number of years fishing and years crabbing were lower for the injured fishermen, while there was no relationship between experience and injury for the "captains" and "deckhands."

In addition to fishermen providing their current position, they were asked to report the position they held at the time of the injury. We looked further at the fishermen who reported their current position as "owner" to explore their position and work activities at time of injury. Four out of the 11 injured owners self-reported that they were acting as a deckhand at the time of injury. When looking at the work activity reported by the injured owners, 9 out of the 11 were doing activities associated with handling the gear and the catch, which are typical deckhand activities. By conducting this stratified analysis and looking into the work activities of the owners at the time of injury, it demonstrates that the work activity, rather than experience per se, drives the apparent relationship of experience to injury. In our data, injury seems to be associated with work tasks rather than experience, with the overall association of experience to injury largely an artifact of the association of experience with crew position, and crew position with work tasks.

Table 7 shows the number of injuries by the reported activity at time of injury and the nature of the injury. The tasks "at watch" and "mooring," and nature of injuries of "amputation" and hypothermia," did not have any reported injuries and are not shown in the table. Working with the fishing and other gear, either preparing, setting, hauling, or handling gear, resulted in the most injuries. The most common injury nature reported was musculoskeletal, sprain/strains (n = 23), with cuts (n = 17) and bruises (n = 20) also being common. These results have led to further efforts to test injury prevention ideas from fishermen to improve the ergonomics of harvesting crab. Previous studies by Lucas et al (2014) (Lucas et al., 2014) and Syron et al (2016) (Syron et al., 2016) conducted in Alaskan fleets using different gear types (dive, gillnet, seine, and pot/trap gear) found that the most common work activities leading to injury were traffic on board, handling frozen fish and processing the catch before any activity related to handling gear, demonstrating differences in fleets/ gear operating in the two regions.

For 18 of the 77 injured Dungeness crab fishermen (23%), being tired at the time of the injury was cited as a factor. When the crab fishermen provided further context for this response, common themes were apparent: "always," "going too hard," "long days," and "very tired." Additionally, the findings reported elsewhere from the FLIPP survey of open-ended responses of causes of injury, the most common cause reported by fishermen was heavy workload (Pillai et al., 2019), which included "fatigue," "pushing too hard," "long hours," and "overworked."

For 19 of the 77 injured Dungeness crab fishermen (25%), weather conditions were cited as a factor. Rain and waves were often reported as related to the injury as well: "always a factor, good or bad weather," "big rolling seas," "rough seas," and that the "pot was slippery/bad weather make it hard to hold." In the Pacific Northwest of the United States, where this study was conducted, the Dungeness crab season is during the winter months when storms are common. Also, commercial fishing ports are at the mouths of rivers where crossing a bar is necessary where waves can be treacherous. These factors may relate to the experience weather and sea conditions of our study population.

5. Limitations

While this work has many strengths, we acknowledge that it has some limitations. Surveys were not collected from fishermen who may have left commercial fishing due to injury or other circumstances before our sampling in ports was completed. Since our data rely on self-reported information there is a risk of potential recall and social desirability bias. As some studies show injuries are more likely to occur in early months on the job, our survey asked about the injury experience for an entire year. Also, since asking the fishermen retrospectively about their injury experience, we cannot account for the hours worked at the time of injury, which can be an independent risk factor for injury. Because our survey did not capture the duration of task/activity exposure, we cannot predict risk per unit time of exposure to a given activity.

6. Conclusions

In this study collecting primary injury information from commercial fishermen, we were able to identify that work typically done by deckhands, specifically handling, and hauling fishing gear, was related to the most injuries. Anecdotally, fishermen share their perception that “greenhorns,” or fishermen with little experience, may be at higher risk for injury. Our study shows that injury incidence may depend as much or more on changes in work activities as fishermen gain more experience, as on experience leading to safer work practices. While some studies show newer workers are exposed to greater risks, it seems in commercial crab fishing that injury is primarily a function of the work activities in which crew members engage, rather than only the number of seasons crew members have been at sea.

Injury control efforts should focus on the most hazardous activities and conditions, regardless of fishermen’s experience or position. Following a hierarchy of controls, interventions to control hazards through elimination, substitution, or engineering are more effective than administrative controls that require significant effort from workers. Modifying the work environment to better control hazards would benefit all fishermen, regardless of their experience, age, or position. While not explored in this study, further studies are currently being conducted to evaluate modifications to the sorting table such as adjusting the height and adding a banger bar for harvesting crab from the pot. Further work into effective interventions that fishermen would adopt is needed to reduce injury risk. Any formal or informal training of new fishermen should focus on the most hazardous activities identified in this study, but more experienced fishermen would also benefit.

With a quarter of the injuries citing “being tired” as a contributing factor, consideration of the physical nature of the work tasks as well as sleep practices while on vessels fishing should be further explored. To date, very few studies have examined the impact of sleep deprivation among commercial fishermen (Elliott et al., 2022; Gander et al., 2008; Wilbur et al., 2018; Sorensen et al., 2022), but it has been extensively studied in other industries

(Factors, 2022; Kuwahara et al., 2018; Hege et al., 2018; Wada et al., 2007). Also, physical fatigue and sleep deprivation can be intertwined and difficult to study in worker populations, such as commercial fishermen. Further studies into appropriate fatigue risk management interventions could improve the incidence of sleep deprivation and fatigue in this industry (Elliott et al., 2022).

Other factors related to injury incidence in this study were inclement weather and sea conditions. Completely avoiding all inclement weather is not practical in commercial fishing and must be acknowledged as a hazard that cannot be eliminated but can be managed. Captains should use the best available technology, information, and good judgment to predict and avoid especially hazardous weather and working conditions. New solutions to make working on deck safer during rough weather should be developed and tested on fishing vessels. Fishery management officials also have a role in promoting a safe fishery and should consider mechanisms to reduce pressure on captains to fish in hazardous conditions. Decision support tools for weather- and navigation-related decisions could further reduce risk of on deck and gear injuries due to weather and sea conditions.

7. Practical applications

Injury prevention training for all fishermen, regardless of their position and years of experience, should cover the most hazardous tasks, fatigue risk management strategies, and weather decisions.

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Disclaimer

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References

Civilian occupations with high fatal work injury rates, 2022. Accessed August 9, https://www.bls.gov/charts/census-of-fatal-occupational-injuries/civilian-occupations-with-high-fatal-work-injury-rates.htm.

Commercial Fishing Fatality Summary West Coast Region. 10.26616/NIOSHPUB2017172.

Case S, Bovbjerg V, Lucas D, Syron L, & Kincl L (2015). Reported traumatic injuries among West Coast Dungeness crab fishermen, 2002–2014. International Maritime Health, 66(4), 207–210. 10.5603/IMH.2015.0041. [PubMed: 26726891]

Pillai S, Bovbjerg VE, Vaughan A, Jacobson KR, Syron LN, & Kincl LD (2019). Dungeness crab fishermen perceptions of injury causation and factors in staying safe. International Maritime Health, 70(1), 55–60. 10.5603/IMH.2019.0008. [PubMed: 30931518]

Bovbjerg VE, Vaughan AM, Syron LN, Jacobson KR, Pillai S, & Kincl LD (2019). Non-Fatal injuries and injury treatment in the west coast dungeness crab fishery. Journal of Agromedicine, 24(4), 316–323. 10.1080/1059924X.2019.1638860. [PubMed: 31335297]

Kincl L, Nery M, Syron LN, Bovbjerg V, & Jacobson K (2019). Dungeness crab commercial fishermen's perceptions of injuries inform survey development. American Journal of Industrial Medicine, 62(3), 265–271. 10.1002/ajim.22948. [PubMed: 30637793]

Jensen OC, Stage S, Noer P, & Kaerlev L (2003). Classification of working processes to facilitate occupational hazard coding on industrial trawlers. American Journal of Industrial Medicine, 44(4). 10.1002/ajim.10292.

Jensen OC, Stage S, & Noer P (2005). Classification and coding of commercial fishing injuries by work processes: An experience in the Danish fresh market fishing industry. American Journal of Industrial Medicine, 47(6), 528–537. 10.1002/ajim.20163. [PubMed: 15898090]

Jensen O, Stage S, & Noer P (2006). Injury and time studies of working processes in fishing. Safety Science,44,349–358. 10.1016/j.ssci.2005.11.001.

Lucas DL, Kincl LD, Bovbjerg VE, Lincoln JM, & Branscum AJ (2014). Work-related traumatic injuries onboard freezer-trawlers and freezer-longliners operating in Alaskan waters during 2001–2012. American Journal of Industrial Medicine, 57(7), 826–836. 10.1002/ajim.22310. [PubMed: 24585666]

Syron LN, Lucas DL, Bovbjerg VE, Bethel JW, & Kincl LD (2016). Utility of a Work Process Classification System for characterizing non-fatal injuries in the Alaskan commercial fishing industry. International Journal of Circumpolar Health, 75(1), 30070. 10.3402/ijch.v75.30070. [PubMed: 26782030]

Rasmuson LK (2013). Chapter Three - The Biology, Ecology and Fishery of the Dungeness crab, Cancer magister. In Lesser M (Ed.) Advances in Marine Biology: Vol. 65 (pp. 95–148). Academic Press. 10.1016/B978-0-12-410498-3.00003-3. [PubMed: 23763893]

Breslin FC, Dollack J, Mahood Q, Maas ET, Laberge M, & Smith PM (2019). Are new workers at elevated risk for work injury? A systematic review. Occupational and Environmental Medicine, 76(9), 694–701. 10.1136/oemed-2018-105639. [PubMed: 31147382]

Margolis KA (2010). Underground coal mining injury: A look at how age and experience relate to days lost from work following an injury. Safety Science, 48 (4), 417–421. 10.1016/j.ssci.2009.12.015.

Siskind F. (1982). Another look at the link between work injuries and job experience. Monthly Labor Review, 105(2), 38–40.

Breslin FC, & Smith P (2006). Trial by fire: A multivariate examination of the relation between job tenure and work injuries. Occupational and Environmental Medicine, 63(1), 27–32. 10.1136/oem.2005.021006. [PubMed: 16361402]

Mitchell OS (1988). The relation of age to workplace injuries. Monthly Labor Review, 111(7), 8–13.

Wiatrowski WJ (2022). Older Workers and Severity of Occupational Injuries and Illnesses Involving Days Away from Work. Accessed August 10, https://fraser.stlouisfed.org/title/monthly-labor-review-6130/july-2005-598218/older-workers-severity-occupational-injuries-illnesses-involving-days-away-work-566460.

Rudolphi JM, & Berg RL (2021). Injuries and illnesses to children in commercial fishing in Alaska: A brief report. American Journal of Industrial Medicine, 64(5), 398–402. 10.1002/ajim.23232. [PubMed: 33616281]

Safety and Health for Engineers (2022). (2nd ed.). Wiley. Wiley.com. Accessed August 10, 2022. https://www.wiley.com/en-us/Safety+and+Health+for+Engineers%2C+2nd+Edition-p-9780471750932.

Yates WD (2020). Accident Causation and Investigation Techniques. In Safety Professional's Reference and Study Guide. (3rd ed.). CRC Press.

Elliott KC, Lincoln JM, Flynn MA, Levin JL, Smidt M, Dzugan J, & Ramos AK (2022). Working hours, sleep, and fatigue in the agriculture, forestry, and fishing sector: A scoping review. American Journal of Industrial Medicine, 65(11). 10.1002/ajim.23418.

Gander P, van den Berg M, & Signal L (2008). Sleep and sleepiness of fishermen on rotating schedules. Chronobiology International, 25(2), 389–398. 10.1080/07420520802106728. [PubMed: 18533331]

Wilbur RE, Griffin JS, Sorensen M, & Furberg RD (2018). Establishing digital biomarkers for occupational health assessment in commercial salmon fishermen: Protocol for a mixed-methods study. JMIR Research Protocols, 7 (12), e10215. [PubMed: 30530453]

Sorensen J, Kincl L, Weil R, Dzugan J, & Christel D (2022). Fisheries governance and associated health implications: Current perspectives from US commercial fishermen. Marine Policy, 141. 10.1016/j.marpol.2022.105119.

Human Factors in Aviation. (2nd ed.). - SILO.PUB. Accessed August 10, 2022. https://silo.pub/human-factors-in-aviation-2nd-edition.html.

Kuwahara K, Imai T, Miyamoto T, et al. (2018). Sleep duration modifies the association of overtime work with risk of developing Type 2 Diabetes: Japan epidemiology collaboration on occupational health study. Journal of Epidemiology, 28(7), 336–340. 10.2188/jea.JE20170024. [PubMed: 29398682]

Hege A, Lemke MK, Apostolopoulos Y, & Sönmez S (2018). Occupational health disparities among U.S. long-haul truck drivers: the influence of work organization and sleep on cardiovascular and metabolic disease risk. PLoS One, 13(11). 10.1371/journal.pone.0207322 e0207322. [PubMed: 30439996]

Wada K, Sakata Y, Theriault G, Narai R, Yoshino Y, Tanaka K, & Aizawa Y (2007). Associations of excessive sleepiness on duty with sleeping hours and number of days of overnight work among medical residents in Japan. Journal of Occupational Health, 49(6), 523–527. 10.1539/joh.49.523. [PubMed: 18075214]

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Table 1

The average and range of days (time estimates) reported by the time of the season.

Time of Season	Range (Days)	Average (Days)
Pre-Season	10–56	27
prepping gear and loading gear to vessel		
Dump Days	1–4	2
placing pots for initial soak before the season starts		
Early Season	14–42	28
fishing intensively, crab is plentiful and price is best		
Regular Season	5–108	46
fishing is more "relaxed"		

Table 2

Work activity options and examples included in the FLIPP survey.

Work Activity	*Example*
Walking	*Getting on/off vessel, on dock, inside vessel*
At watch	*Helm or anchor*
Preparing fishing gear in port/at sea	*Repairing/cleaning gear*
Setting the gear	*Throwing pots/nets, baiting, changing line*
Hauling the gear	*Operating block/winch, landing pots/net*
Handling gear on deck	*Securing gear, stacking pots manually*
Handling catch at sea	*Emptying catch from pot/net, counting/measuring catch*
Handling catch on shore	*Offloading catch, pumping hold*
Preparing other gear on deck (other gear that doesn't go in the water)	*Repairing, greasing*
Working in the engine room	*Inspecting, maintenance*
Mooring	*Handling vessel or lines*
Working in the galley	*Cooking*
Off duty on vessel	*Sleeping, on deck off duty*

Table 3

Demographic information for fishermen surveyed in FLIPP.

Variable	All Fishermen Mean (S.D.)	Crab Fishermen Mean (S.D)
Age (years)	39.7 (14.6)	39.4 (14.3)
Years fishing	17.4 (14.2)	17.5 (13.9
Years crab fishing	11.8 (11.1)	12.0 (10.9)
Total months fishing in the past year? *	8.1 (3.1)	8.1 (3.1)

* Included from November 2014 through November 2015 so 13 months possible.

Table 4

Injury, position, and fishery characteristics of fishermen surveyed in FLIPP.

Variable (N responding)*	**n (%)**
Fishermen injured in the past year (N = 425) *	91 (21.4%)
Fishermen injured anytime during career (N = 395) *	203 (51.4%)
Current position ** (N = 408) *	
Deckhand	213 (52.2%)
Owner	144 (35.3%)
Captain	51 (12.5%)
Fishery *** (N = 426) *	
Crab	365 (85.7%)
Salmon	166 (39.0%)
Other groundfish	96 (22.5%)
Albacore Tuna	91 (21.4%)
Shrimp	40 (9.4%)
Whiting	11 (2.6%
Other fish	58 (13.6%)

* Percentages are calculated from the total number of participants responding to a given question.

** Since they could select more than one position, the current position is the highest position selected by the fishermen. For example, if a fishermen selected owner and captain, it would be indicated as owner.

*** Many commercial fishermen in the Pacific Northwest fish in more than one fishery so the total will not add to 100%.

Table 5

Experience and injury incidence of Dungeness crab fishermen surveyed in FLIPP.

Experience	No-injury		Injury		p value*
	n	**Mean (SD) years**	**n**	**Mean (SD) years**	
Years fishing	283	19.2 (14.2)	77	11.1 (10.3)	**<0.001**
Years crab fishing	286	13.1 (l1.3)	76	8.1 (8.1)	**0.001**

*Results of independent samples t-test.

Table 6

Experience and injury incidence stratified by the current position reported by the Dungeness crab fishermen surveyed in FLIPP.

Variable	No-injury		Injury		p value*
	n	Mean (S.D) years	n	Mean (S.D) years	
Owners					
Years fishing	115	29.0 (13.4)	10	18.5 (10.6)	**0.018**
Years crab fishing	115	19.3 (12.2)	10	8.2 (7.2)	**0.006**
Captains					
Years fishing	33	21.6 (11.2)	6	21.2 (5.8)	0.931
Years crab fishing	33	14.2 (10.3)	6	14.2 (7.4)	0.992
Deckhands					
Years fishing	128	10.0 (9.0)	55	9.0 (9.5)	0.483
Years crab fishing	131	7.4 (7.4)	55	7.4 (7.9)	0.986

* Results of independent samples t-test.

Table 7

Work activity and nature of injury of Dungeness crab fishermen reporting injuries in FLIPP.

Work Activity	Sprain/strain	Other	Surface wound/bruise	Cut	Puncture	Fracture	Tear	Burn	Hernia	Total
Preparing other gear on deck	3	3	6	2	2	1		1		18
Hauling gear	5	2	2	2	3	2			1	17
Handling gear on deck	5	4	4		1	1		1		16
Handling catch at sea	2	2	3	5	3	1	1			17
Preparing fishing gear	5	3	1	4	1		1			15
Setting gear	2	3	1	3	1	3	1			14
Off duty on vessel	1	1	1		1					4
Walking			1	1						2
Handling catch on shore		1	1							2
Working in the engine room										0
Working in the galley								1		1
Total	**23**	**19**	**20**	**17**	**12**	**8**	**3**	**3**	**1**	**106** *

* Some fishermen reported more than one nature of injury.