

Is It Safe On Deck? Fatal and Non-Fatal Workplace Injuries Among Alaskan Commercial Fishermen

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Background Commercial fishing in Alaska accounts for an occupational fatality rate that is 28 times the rate for all U.S. workers. Most deaths are attributed to vessel sinking or capsizing. However, many deaths and most non-fatal injuries are not related to vessel loss. This paper describes injuries that occur on the dock or on the fishing vessel.

Methods Data from fishing fatalities and non-fatal injuries between 1991–1998 were analyzed using the Alaska Occupational Injury Surveillance System and the Alaska Trauma Registry.

Results There were 60 workplace deaths unrelated to vessel loss; most from falls overboard, others from trauma caused by equipment on deck. There were 574 hospitalized injuries, often from falls on deck, entanglement in machinery, or being struck by an object.

Summary Fishing boats are hazardous working environments. Further efforts are required to prevent falls overboard and on deck, and to redesign or install safety features on fishing machinery and equipment. *Am. J. Ind. Med.* 40:693–702, 2001.

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KEY WORDS: fishing; commercial; fatalities; injuries; Alaska

INTRODUCTION

“Fisherman died after being crushed between two 700 pound crab pots when one pot was dislodged from the launcher by a wave.”

“Fisherman died after he was crushed when his rain slicker was caught in the purse line and he was pulled through the winch drum.”

“Fisherman got his foot caught in a line as it was going out, the injury led to a below-the-knee amputation.”

“Fisherman fell 15 ft into the hold of a fishing vessel, resulting in a fractured femur.”

These descriptions typify the dangers of commercial fishing in Alaska. Until recently, this occupation accounted for the largest number of deaths and serious injuries for all occupations in Alaska. A previous study showed that between 1991 and 1996 there were 146 deaths among commercial fishermen in Alaska, equating to an annual fatality rate of 140/100,000 full-time equivalent (FTEs) fishermen [NIOSH, 1997]. This was 28 times the average annual fatality rate of 4.4/100,000 workers for all workers in the United States [Centers for Disease Control and Prevention, 1998]. Commercial fishing is a major industry, accounting for over half of the fish harvested in the United States, and it is the largest private employer in the state [NRC, 1991].

While most of these commercial fishing fatalities were attributed to the loss of the vessel due to capsizing or sinking, a significant proportion were workplace injuries and did not involve such an event. They were attributable to events such as a fall or other machine-related injury on the dock or on a deck of a fishing vessel. The deck of a fishing boat is an unusually hazardous working environ-

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ment. Not only are workers often exposed to adverse weather but also the deck affords an unstable work platform, as it is constantly moving. These decks are often congested with machinery and fishing equipment. In addition, deck surfaces may be covered in oil, ice, water, and fish-slime. In its study on fishing vessel safety, the National Research Council noted: "The apparent high incidence of workplace accidents suggest inadequately-designed safety features in machinery, deck layouts, and fishing gear" [NRC, 1991].

The safety and health of fishermen in the fishing industry is under the jurisdiction of the United States Coast Guard (USCG) and the Occupational Safety and Health Administration (OSHA). OSHA regulations apply to areas of industry not covered by another federal agency and are limited to each state's territorial waters (3 miles from shore). OSHA has therefore ceded jurisdiction to the USCG to a large degree [NIOSH, 1994]. In 1988, Congress passed the Commercial Fishing Industry Vessel Safety Act (CFIVSA). The CFIVSA requires vessels to carry safety and survival equipment such as life rafts, survival suits, and emergency position indicating radio beacons (EPIRBs) and requires the crew to perform regular emergency drills. Currently the main emphasis of the USCG in commercial fishing safety has been on addressing the survival of individuals in the event that a vessel is lost with a focus on search and rescue, education, and enforcement of fishing vessel safety requirements [NIOSH, 1997].

Published data on injuries and fatalities in the commercial fishing industry in the U.S. are somewhat limited. Because many fishermen are self-employed, and work aboard vessels with fewer than 11 employees, they are not included in the data collected on the commercial fishing industry by the U.S. Department of Labor (USDOL). Furthermore, data on employment and work-related injuries and fatalities that are distributed by USDOL aggregate fishing industry statistics with agriculture and forestry, which makes it difficult to use these data to analyze the commercial fishing industry or compare fishing with other industries.

Since the implementation of the CFIVSA, there has been a decline in the number of fatalities in Alaska's fishing industry. This has been noted most dramatically in the decrease in fatalities due to vessel loss, from 25 in 1991 to 9 fatalities in 1998 [Lincoln and Conway, 1999]. The number of deaths not related to vessel loss, but occurring on the deck of a fishing vessel, or on the dock while in port, has not declined, and the proportion of these deaths among fishermen is increasing.

The focus of this paper is to describe the work-related injuries and fatalities that are not a result of vessel loss. Injury prevention strategies are discussed that focus on the fisherman and his safety in the workplace environment rather than on vessel stability or the survival of individuals in the event that a boat sinks or capsizes. The National

Institute for Occupational Safety and Health, Alaska Field Station (NIOSH, AFS) has previously published statistics and comprehensive recommendations for the prevention of vessel-related fatalities [NIOSH, 1997].

MATERIALS AND METHODS

Two sources of data were used to analyze injuries and fatalities in the commercial fishing industry the Alaska Occupational Injury Surveillance System (AOISS) and the Alaska Trauma Registry (ATR). A work-related injury is defined according to the "*Guidelines for Determination of Injury at Work*" used by the U.S. Department of Health and Human Services [NIOSH, 1993].

AOISS is a database of all work-related fatalities within Alaska. NIOSH, AFS has maintained this database since 1991. Information is collected on all work-related fatalities in Alaska, including those in the commercial fishing industry. Data are obtained from multiple sources including jurisdictional agencies such as the U.S. Coast Guard (USCG), state and federal OSHA, state troopers and other public safety officers, the Bureau of Vital Statistics, state medical examiners, newspaper clipping services, and several other sources, Alaska Department of Health and Social Services (AKDHSS), Federal Aviation Administration (FAA), National Transportation Safety Board (NTSB), and the Department of Labor (DOL). The database includes information on vessel location, type of fishery, circumstances of the incident, and demographics of the victim. The cause of death is derived from the death certificate, and further details are obtained from a narrative field describing the event. Fatalities are then classified as either being vessel related (capsizing or sinking) or workplace injury events not related to the loss of a vessel. Data are available for 1991–2001.

The ATR is maintained by the AKDHSS, Division of Public Health, Section of Community Health and Emergency Medical Services in Juneau Alaska, with support and technical assistance from the NIOSH, AFS. Data are abstracted from hospital records on patients admitted to all 24 hospitals in Alaska and discharged with diagnosis of traumatic injury as defined by the International Classification of Diseases, Clinical Modification 9th edition [ICD-9-CM] diagnosis codes 800.00–995.89. Patients also have to be admitted to a hospital, transferred from a hospital in Alaska to another hospital with a higher level of care, or declared dead in the hospital emergency department. In addition to demographic data, information is obtained on the cause and nature of injury. Information is recorded on whether the injury is work-related or not and which industry the worker was in when injured. A narrative text field gives additional information on the circumstance of injury. The external cause of injury is coded according to the ICD-9-CM, external cause of injury code (E-Code), and the

nature of injury is coded according to ICD-9-CM, N-Codes. The 1985 revision of the Abbreviated Injury Scale (AIS) is used to classify injury severity in the ATR. Cases are scored from 1 to 6 in order of increasing severity from minor to essentially not survivable injury. For this analysis, data were available for 1991 through 1998. This analysis reviewed data from the initial hospitalization only and did not include any of the fatal injuries.

A unique table was established to allow for more specific categorization of non-fatal fishing injuries based on details obtained from the narrative field in the ATR. This was done because of the non-specific nature of some E-Codes (i.e., “machinery” is not specified any further into types of machinery).

The causes of injury were separated into five main categories:

1. Machinery, e.g., winches, pulleys, crab pot launchers and lines, cables, and chains.
2. Fish catching/cleaning equipment, e.g., crab pots, nets, hooks, and knives.
3. Falls, same level, between levels not specified, into hold, down steps/ladder, overboard, while boarding or disembarking, and from dock.
4. Vessel related, e.g., fires, collisions with another vessel or dock, or structures such as hatch covers and doors.
5. Others, e.g., assault, diving, struck by miscellaneous objects, and motor vehicle accidents.

All chi-square tests for linear trend were performed using the Epi-Info computer program using methods taken from Schlesselman [CDC, 1994].

Denominators are difficult to establish in an industry that is seasonal in nature and where many of the fishermen are not working year-round. The Department of Labor does not maintain data on self-employed workers. This includes most fishermen, many of whom do not work for a salary, but for a percentage of the vessel earnings. We established two different denominators, one based on the total number of individuals involved in commercial fishing and the other based on FTEs. Both FTEs and total numbers are used in the published literature.

To establish an approximate figure for the total number of fishermen working in Alaska, data were obtained on the number of individuals who purchased fish permits (every boat is required to have a person with a permit to fish in a fishery), from the Commercial Fishing Entry Commission and the number of commercial crew licenses sold by the Alaska Department of Fish and Game (these are not fishery specific). The average annual number of fishermen working in Alaska between 1991 and 1998 was approximately 49,000. There has been a 27% decline in the total number of fishermen obtaining state permits and crew licenses over this 8-year period. To establish the approximate FTE for

TABLE I. Annual Full Time Equivalents in the Main Fisheries in Alaska and the Gear Type Used in the Fishery

Fishery	Gear Type	Annual FTE (17,500)	Percent FTE
Salmon	Gillnet, seine, troll	4,600	26
Herring	Gillnet, seine, spawn	500	3
Shellfish	Pots	2,200	13
Groundfish	Trawl, pots	5,300	30
Halibut	Longline	1,100	6
Processor/ tender	Trawls/pots	3,800	22

FTE, full time equivalent.

fishermen working in Alaska, data were obtained on the number of vessels operating in each opening¹ in Alaska, the length of the opening, and the average size of the crew for 1991 and 1995–1998. We multiplied these factors to come up with “worker days” and then modified this number based on the number of hours worked each day. The work of the National institute for occupational safety and health, AFS staff in determining FTEs included consideration of compatibility of fatality rates with other countries and industries. The rates assume that workers are on duty 24 h a day during the opening of fishing seasons lasting less than 15 days. The rates also credit fishermen with 12-h workdays for seasons that last up to 50 days in an opening. However, if a person worked on a vessel for more than 50 days, (i.e., they resided on the vessel), they were only counted as working eight hours per day. The approximate annual FTEs for each fishery in 1991 through 1998 show that groundfish accounted for 30 of all FTEs, salmon 26, shellfish 13%, and the remainder 9% (Table I). There has been a 21% decline in the FTE in Alaska from 1991–1998. The decline in total number and FTEs may be due to various factors, such as the switch in 1995 to the federally-controlled Individual Fish Quota (IFQ) system for halibut, sale of IFQs to larger consortiums, and the decline in fishermen with non-transferable permits and limited entry permits (unpublished communication).

Rates derived from use of both denominators (FTEs and total employment) will be mentioned in the paper to allow comparisons with rates of other countries and with other industries within the United States.

RESULTS

Fatalities

There were a total of 167 fatalities from 1991 through 1998 in the Alaskan commercial fishing industry. Of these,

¹ An opening means a fishing season or fish opening. It is the period when a fisherman can catch a particular type of fish in a specified area.

TABLE II. Annual Number of Fatalities Due to Vessel Loss and Workplace Injury, 1991–1998; Alaska

Year	Vessel loss fatalities	Workplace injury fatalities
1991	26	10
1992	26	11
1993	14	7
1994	5	8
1995	12	7
1996	13	11
1997	2	2
1998	9	4
Total	107	60
Annual rate/100,000 FTE	74	46
Chi square for linear trend	$\chi^2 = 17.4; P < 0.001$	$\chi^2 = 14; P = ns$
Annual rate/100,000 fishermen	30	16
Chi square for linear trend	$\chi^2 = 15.7; P < 0.001$	$\chi^2 = 1.9; P = ns$

60 (36%) were not attributed to vessel loss. There were 107 fatalities due to vessel loss that showed a decline from 26 in 1991 to 9 in 1998. The overall annual rate for all fatalities was 119/100,000 FTEs (43/100,000 fishermen). Trend analysis indicates a significant decline in vessel loss fatalities but no significant decline in workplace fatalities unrelated to vessel sinkings (Table II).

Due to limited years in the ATR, we limited the analysis of fatalities to the same period, i.e., 1991–1998. (However, current information is available in AOISS.) The statistical trends remained the same through 2000. However, in April 2001, the F/V Arctic Rose disappeared with 15 fishermen lost. It is unclear how this will affect further analysis.

Demographics

Analysis of all deaths showed that 97% of the deaths occurred among males, ranging in age from 10 to 67, with the average age being 33 years; 89% were white, 10% were Alaska Native, and the remaining 1% were Asian Pacific. Fifty-one percent of the deaths were among fishermen from Alaska, 40% from the Pacific Northwest, and the other 9% from other parts of the U.S. and other countries.

Regional distribution

Over half (51%) of the deaths occurred in the Aleutian/Pribilof/Bering sea region, 16% occurred in the south east, 15% around Kodiak and the Gulf of Alaska, and 18% among other fishing regions around the state.

Monthly distribution

The months with the highest number of fatalities are January, February, September, and November. During these months, the shellfish fishery accounted for 73% of the fatalities. During July and August, the salmon fishery accounted for 61% of the deaths.

Fishery-specific rates

The shellfish fishery accounted for 46% of all fatalities and 38% of the workplace injury fatalities. Comparison of rates based on the proportion of FTEs established for each fishery shows that shellfish and herring have the highest risk for workplace injury death, although the total numbers for the herring fishery are small (Table III). Interestingly, the processing fleet did not account for any workplace injury deaths and the halibut fishery only accounted for one.

TABLE III. Fatalities by Fishery and Vessel Loss or Personal Injury, 1991–1998; Alaska

Fishery	Fatal vessel loss events	Vessel loss fatalities	Workplace injury events	Workplace injury fatalities (rate/100,000 FTE/yr)	Total fatalities
Shellfish	19	53	23	23 (131)	76
Salmon	13	16	12	12 (33)	28
Groundfish	5	12	5	5 (12)	17
Halibut	6	11	1	1 (11)	12
Herring	2	6	3	4 (100)	10
Processor/ tender	3	3	0	0 (0)	3
Other/unknown	6	6	15	15 (n/a)	21
Total	54	107	59	60	167

Causes of fatality

The main causes of the 60 workplace injury deaths were drowning/hypothermia, trauma, and asphyxiation (Table IV). The most common cause was drowning/hypothermia, which accounted for 70% of all the workplace injury deaths. Eighty-six percent of these drowning deaths were due to falls overboard. A fifth (21%) of the falls overboard were unobserved, 32% were due to being dragged overboard after entanglement in lines or nets, 26% supplied insufficient information to determine cause, and 21% were washed overboard in heavy weather. Forty-four percent of these deaths occurred in the shellfish fishery, 28% in the salmon fishery, 11% in the groundfish fishery. None of the deceased were wearing personal flotation devices.

Trauma accounted for 12 (20%) of the workplace deaths, most from being crushed by equipment, five of them on crab boats. Vessel machinery accounted for four of the workplace trauma deaths, these included being crushed in a winch, crushed by a crab pot launcher, and being struck in the chest when a boom supporting crab pots broke. Vessel equipment accounted for three deaths, with three victims being crushed by crab pots. Other causes of trauma death included being crushed while working beneath boats, falling from a dock, and being struck by engine propellers while diving. Asphyxiation by carbon monoxide, and freon poisoning accounted for three deaths.

Twelve deaths did not occur on a fishing boat. These included falls from the dock, complications of diving in the dive-related fisheries and vessel maintenance activities, an aircraft crash (while flying to go fishing), and being crushed while sorting fishing gear on land. Alcohol was a contributing factor in some of the workplace injury deaths, however the data on alcohol is incomplete. In addition 39% of the fishermen were never recovered for autopsy or testing.

Non-Fatal Injuries

There were a total of 574 hospitalizations of fishermen for injury from 1991 through 1998, equivalent to an annual

TABLE IV. Causes of Workplace Fatal Injuries, 1991 – 1998; Alaska

Cause of death	Circumstance	Frequency
Drowning/hypothermia (42)	Man overboard	36
	Diving	4
	Fall from dock	2
Trauma (12)	Crushed by machinery/equipment/vessel	10
	Fall from dock	1
	Diving entanglement	1
Asphyxiation (3)	Carbon monoxide/freon	3
Other (3)		3

TABLE V. Annual Number of Non-Fatal Injuries, 1991 – 1998; Alaska

YEAR	Hospitalized injuries	AIS > 2
1991	86	17
1992	103	29
1993	82	15
1994	60	15
1995	56	13
1996	71	18
1997	69	16
1998	47	11
Total	574	134
Rate/100,000 FTE	410	96
Rate/100,000 fishermen	146	35
Chi square for linear trend	$\chi^2 = 4.1; P < 0.04$	$\chi^2 = 0.55; P = 0.45$

rate for serious hospitalized injuries of 410/100,000 FTEs or 146/100,000 fishermen (Table V). Trend analysis indicates a significant decline in hospitalized injuries over the eight-year period ($\chi^2 = 4.1, P = 0.04$), and a slight, but not significant decline in the more severe injuries with AIS scores > 2 (i.e., injuries categorized as serious or worse). At least 90% of the injuries occurred on a vessel, 5% occurred on land, usually on the dock, and the location of the other 5% could not be determined.

Demographics

Ages ranged from 10–77, with a mean age of 34 years. Ninety-three percent of the injured were males and seven percent were females. For 539 injury cases, where race was recorded, whites constituted 79%, Alaska Natives 12%, Asians 8%, and African-American 1%. Alaska residents constituted 57% of the injured, 24% were from the Pacific Northwest, 14% were from other parts of the U.S., and 5% were not U.S. residents.

Monthly distribution

The distribution of injuries shows a bimodal pattern with a peak in February/March and a peak in June/July/August. The peaks correspond to the busy shellfish and salmon seasons, respectively, although the ATR does not include data on the type of fishery involved in the injury.

Geographical distribution

Forty percent of the injuries occurred near the Aleutian Islands or in the Bering Sea, 18% in SE Alaska, 15% around Kodiak, 12% in Bristol Bay, and the remaining 15% in the Kenai, Prince William Sound, and Yukon Kuskokwim

regions. There is a lack of regional denominator information corresponding with the ATR data so no regional rates could be determined.

Causes of injury

Falls were the most common cause of injury accounting for 153 (26%) of the hospitalizations (Table VI). Twenty-four of these injuries did not take place on a vessel; most of these occurred as a result of a fall off the dock. Falls on the same level constituted 31% of all falls and many occurred on the deck. Among falls from different levels, falls into holds, surface openings, or through hatches were the most commonly identified cause (18%). Other falls in this category were falls from steps or ladders (14%), falls between levels on the vessel (11%), falls overboard (11%), falls while boarding or disembarking (7%), and falls from the dock (5%) and others (3%). As one would expect, most of the more severe injuries occurred among falls between levels. Eighty-eight, (58%) of the injuries were fractures, of which 57% were of the lower extremity. Other injuries included contusions, concussions, dislocations, open wounds, and sprains/strains. Forty-one percent of all the fall injuries involved the lower extremity, 10% the spine, and 10% the upper extremity. Twenty-eight percent of the fall injuries had an AIS > 2.

Machinery on the vessel accounted for 117 (20%) of the injuries. Over half (52%) of these injuries were due to being entangled, trapped, or struck by a line or cable breaking under tension. The most common types of injury were fractures and amputations. The upper extremity was most often affected. Thirty-five percent of the machinery injuries were caused by being trapped in a winch or pulley. These injuries resulted most often in fracture of the upper extremity. Being struck by crab pot launchers accounted for 8% of the injuries. Twenty-eight percent of the machinery injuries had an AIS > 2.

Fishing equipment, such as crab pots, knives, nets, and hooks accounted for 117 (20%) of all injuries. Fifty-three (45%) were due to crab pots, 38% of these resulted in fractures to the lower extremity and 25% fractures to the upper extremity. Other injuries included fractures of the skull, pelvis, spine, and face, contusions, concussions, and open wounds. Twenty-one percent of the equipment injuries had an AIS > 2, 76% of these being due to crab pots.

Vessel-related injuries included a variety of causes that were attributed to the vessel and vessel infrastructure. Crush injuries and fractures due to hatch covers and doors or due to being caught between the boat and another boat or the dock accounted for 38% of these injuries. Burns due to fires or hot liquids or chemicals resulted in 31% of these injuries. Six of the hospitalizations were due to near drowning or hypothermia due to actual vessel loss. Fourteen percent of the vessel related injuries had an AIS > 2.

TABLE VI. Main Causes of Non-Fatal Injury, 1991 – 1998; Alaska

Cause of injury	Total hospitalized	
	injuries	AIS > 2
Falls		
Same level	47	11
Between levels-unspecified	20	5
Into holds, through hatch	15	7
Overboard	17	4
Boarding/disembarking	11	3
From steps or ladder	22	10
Fall from dock	7	3
Total	153	43
Machinery on vessel		
Cables, chains, lines, ropes, anchor	61	14
Winches, pulleys	41	13
Crab pot launcher	9	4
Machinery-other	23	6
Total	117	33
Fishing equipment		
Crab pot	53	19
Knives	30	1
Net	8	2
Hooks	14	0
Tote, fish box	9	3
Fishing equipment-other	3	0
Total	117	25
Vessel		
Burns: fire/explosion/hot liquid/chemical	29	4
Collision with other boat or dock	23	4
Vessel hatches/doors	12	2
Vessel loss	8	0
Toxic effects: chemical/gas/liquid	4	0
Vessel-other	15	3
Total	91	13
Other		
Struck by miscellaneous objects	43	11
Overexertion	12	2
Assault	14	4
Fish	5	0
Motor vehicle accident	5	1
Diving	4	0
Other	13	2
Total	96	20

Other injuries, most often due to being struck by miscellaneous objects, included such injuries as being struck in the eye by a foreign object, struck by waves and slammed into a structure on the boat, or being struck by

falling objects which were not part of the vessel machinery or fishing equipment. Twenty-one percent of these injuries had an AIS > 2.

Types of injury

Fractures constituted 48% of all the injuries, of which lower extremity fractures constituted 42%, the upper extremity 34%, and other regions 24%. Other types of injury included open wounds (13%), contusions (12%), burns (5%), sprains (5%), amputations (5%), and others (12%). The upper and lower extremities were involved in 33 and 29% of all the injuries, respectively. Hand injuries alone accounted for 22% of all injuries.

Disposition

Sixty-one percent (348) of the injuries were admitted directly to the hospital nursing units, 18% (105) were taken immediately to the operating room, 14% (79) were transferred immediately to another facility (many hospitals in rural Alaska do not have surgical or intensive care capabilities), and 6% (34) were admitted to intensive care or step-down units. Hospital deaths have not been included in the analysis. Eighty percent were discharged to home after their hospitalization, 20% were transferred either immediately or after the initial hospitalization, and 2% were discharged to a rehabilitation facility.

Severe injuries; AIS > 2

One hundred and thirty-four (22%) cases had an AIS score greater than two. There was a slight, but non-significant, decline in the number over the 8 years ($\chi^2 = 0.56$, $P = 0.46$). Eighty-three (62%) of these injuries were fractures, and 54% involved the extremities. Over 78% were discharged to their home and 18% to an acute care facility, and 6% were discharged to inpatient rehabilitation facilities. The median hospital stay was 5 days with a mean of 7.7 days.

DISCUSSION

Impressive progress has been made in the 1990s in reducing mortality related to vessel sinkings. This has been accomplished by keeping fishermen, who have evacuated vessels, afloat and warm (using immersion suits and life rafts), and by being able to locate them readily through EPIRBs. These interventions emphasize the use and availability of safety equipment during and after an emergency incident at sea [Lincoln and Conway, 1999]. In earlier NIOSH reports we have recommended augmenting this approach by preventing such emergency incidents and also identified other critical factors that must be addressed

including safety on deck of fishing vessels [Lincoln and Conway, 1999; NIOSH, 1997].

The main cause of fishermen fatalities in Alaska was vessel loss, accounting for 64% of the deaths. This is fairly consistent with studies elsewhere: United Kingdom (1971–1980) 55% [Hopper and Dean, 1989]; New Zealand (1975–1984) 78% [Norrish and Cryer, 1990]; and Spain (1981–1987) 56% [Carbajosa, 1986]. As previously noted, the fatality rate due to vessel loss has been decreasing over the 8-year period. However, there has not been a decline in the fatalities that are due to workplace injuries not related to the loss of a fishing vessel. These constitute an average of 36% of the fatalities; occurring while working on the vessel (either on deck or below), from machinery on deck, falls, and/or being struck by objects.

Efforts are needed to better define the relationship between the vessel, fishing equipment, and the fishermen. The NIOSH, AFS started an engineering design project in October 2000 to address some of these issues. This project is first addressing safety concerns on board crab boats. Since solutions must not interfere with the quality of the catch or the speed of the operation, an approach to the problem has been to examine what solutions the fishermen have already instituted and promote these safety processes to the rest of the fleet and to other fleets with similar fishing procedures.

It is necessary to continue to study the causes of these deck injuries, develop strategies to prevent them, and evaluate safety practices that some crews already have in place. This information could be communicated to other fishermen, captains, and vessel owners to increase awareness of the problem. These ideas could then be personalized and individually implemented with the intent of increasing safety awareness and preventing these types of injuries.

The overall fatality rate for this period 1991–1998 was 119/100,000 FTEs/yr or 43/100,000 fishermen. This use of FTEs allows a more accurate and meaningful comparison with other industries, however most studies reporting national rates of injury among fishermen have used the total number of fishermen as the denominator. Whether this accurately reflects the actual annual exposure time working in the fishing industry is not always clear. Absence of FTE data prohibits an accurate comparison with other nations. Analysis of USCG data between 1980–1989 established a national rate of 47/100,000/yr, with a rough estimate of the denominator [Van Noy, 1995]. The following are rates based on 'total fishermen', reported for Sweden, Norway, and United Kingdom one–two decades previously: Sweden (1975–1986), 110/100,000/yr [Torner et al., 1995]; Norway (1961–1975), 150/100,000/yr; and United Kingdom (1971–1980), 170/100,000/yr [Hopper and Dean, 1989]. New Zealand reported a higher rate of 260/100,000/yr for the period 1975–1984 [Norrish and Cryer, 1990].

The overall rate for workplace injury fatalities not due to vessel loss was 46/100,000 FTEs/yr (United Kingdom, 1971–1980, 77/100,000/yr) [Hopper and Dean, 1989]. The workplace injury death rate is still 10-times greater than the risk of death for all workers in the U.S. Drowning accounted for a high proportion of the workplace fatalities (70%), trauma for 20%, asphyxiation for 5%, and others causes 5%.

Analysis of fishery-specific rates of workplace injury deaths showed the herring fishery to be one of the most dangerous. However, the denominator is small, such that one or two deaths can greatly affect the rates calculated (e.g., two of the deaths resulted from carbon monoxide poisoning due to a stove, which was not a fishery-specific injury). The shellfish fishery also had a high rate of deck-related injury deaths. This fishery accounted for 44% of the man overboard deaths and 42% of the trauma deaths on fishing boats during the period 1991–1998. Interestingly, the halibut fishery resulted in 10% of the deaths due to vessel loss, but only accounted for one of the workplace injury deaths.

The annual rate for hospitalized injuries was 410/100,000 FTEs (or 146/100,000 fishermen). No national data on fishing injuries requiring hospitalization are available for comparison. The ATR information for the fishing injuries compares to other known high-risk industries in Alaska, such as construction and mining with rates of 630/100,000 workers and 540/100,000 workers, respectively (These figures are not based on FTEs.) [Husberg et al., 1998].

A comparison to other countries is complicated by the use of different criteria and databases for obtaining the information on injury. The New Zealand study (1980–1987) reports a rate of 600/100,000/yr for hospitalized injuries [Norrish and Cryer, 1990]. This study and the New Zealand study report a significant decline in hospitalized injuries. There are perhaps several reasons for this: increased safety awareness among fishermen; a shift in the U.S. to outpatient treatment without hospitalization; or a decreased tolerance for the use of alcohol/drugs on fishing vessels.

The main areas that need to be addressed are: Preventing Man Overboard events (MOB); preventing falls and; redesigning or installing safety features on vessel machinery and vessel equipment.

Preventing Man Overboard Events (MOB)

Drowning was the main cause of death not related to vessel loss. Deaths from drowning due to falling overboard accounted for 60% of all the workplace injury deaths (UK, 1961–1980; 76%, Norway, 1980–1982; 39%) [Hopper and Dean, 1989] and 22% of all the fishing deaths. Other countries also report similar rates of deaths due to falls overboard; New Zealand 13% [Norrish and Cryer, 1990] and Spain 25% [Carbajosa, 1986]. The known causes of

these events included entanglement in lines or rough weather, however, 21% of the man-overboard events go unobserved. Many of the boats have loud diesel engines prohibiting adequate communication. If a person falls overboard they may not be heard and if the event is unobserved, it may be some time before a search is initiated. Forty-four percent of these events occurred in the crab fishery, which represents only 13% of the employment, again illustrating the increased risk of this fishery. The information not available is the number of persons who fall overboard and survive. These events may never be reported unless medical attention is sought. The increased risk for the crab fishery may be confounded by the colder and darker winter months when this fishery takes place, reducing the chances for survival or for being located. However, the fact that 80% of the man-overboard deaths due to entanglement were in the crab fishery indicates a serious problem. Information on floatation device worn is available on 87% of the man-overboard deaths. None of these victims were wearing a personal floatation device.

Interventions to prevent man-overboard events and to mitigate the consequences need to be promoted. Prevention methods include more enclosed workplaces and higher gunwales [Hopper and Dean, 1989]. Separation of the fishermen and the gear to reduce entanglement is needed. In smaller stationary gear fisheries, such as the lobster fleet or small crab vessels, line lockers and line bins provide this protection. Improved survival and retrieval strategies include the promotion of comfortable personal flotation devices (PFDs); practical work coats and vests are available that inflate on contact with water [NIOSH, 1994]. A recent survey by the USCG and NIOSH/AFS showed that 88% of skippers on crab boats require their crewmembers to wear PFDs when climbing on “the stack” of crab pots, but only 13% of them required wearing of PFDs while working the gear [Ess, 2001]. Other interventions include implementing the “buddy system” while underway; man-overboard alarms; emergency lifelines which can be thrown more accurately and for greater distances than life rings; and rescue nets which can be thrown to a man in the water and are easier to climb onto. Rescue nets are compulsory on board Icelandic vessels [Hopper and Dean, 1989]. It is also imperative that crews conduct regular emergency drills that include the retrieval of a MOB victim.

Preventing Falls

Falls constituted the most common cause of non-fatal workplace injury (26%). This is similar to rates seen in other studies (31, 30%) [Carbajosa, 1986; Torner et al., 1995]. Prevention of falls on deck include: the regular removal of oil, grease, fish slime, ice, and obstacles; use of non-skid deck grating, non-slip paint and high-traction

boots; adequate lighting on deck; installing rails around hatches or man hole covers made from deck grating; handholds on steps and ladders; and use of safety harnesses for fall protection when appropriate.

Redesigning or Installing Safety Features

Injuries due to vessel machinery accounted for four of the workplace trauma deaths and 20% of the hospitalized injuries. These were mostly caused by being struck or trapped by cables and lines, being trapped in winches or pulleys, and being struck by crab pot launchers. Emphasis needs to be placed on being alert to the position of hands on lines, methods to minimize the need for handling lines under high tension or redesigning the deck layout to decrease the likelihood of being trapped by a line (e.g., line lockers and line bins). The importance of winch guards, appropriate layout to ensure level winding and avoid the need for manual adjustment, and the installation of emergency shutoff switches adjacent to all work stations has been discussed in previous studies [CFER, 1998]. In addition, improved coordination between the person at the control of the hydraulics and other workers is essential. The wearing of close-fitting clothing with no exposed buttons to avoid getting caught in winches or other gear should also be encouraged [WCB, 1994]. Many injuries occur while working around the crabpot launcher. However, there is little in the scientific literature about the hazards of these devices. At a minimum, the decks of crab boats should have good lighting, the launcher should be made very visible (e.g., with bright paint) and the area in which it operates should be well demarcated.

Fishing equipment also accounted for about 20% of the workplace trauma deaths and injuries. Being struck by falling or swinging crab pots constituted the single-most common cause of injury due to equipment. Crab pots are large metal cages weighing up to 800 pounds when empty and they are often stacked 4–6 high on the deck. Transferring these heavy pots in rough seas can be hazardous for those working on the deck. Interventions that establish methods of transferring crab pots safely in rough seas would significantly reduce the number of deaths and injuries. Examples of methods to reduce injury include: marking cranes so the operator can see when the crane is aligned with the launcher to minimize extra motion of pots over the working deck, (also saving on time); avoiding turning one's back to a pot; only unlash one pot at a time; positioning hydraulic operators in a place where they have an adequate view of the working area and all other workers, and encouraging the use of helmets, goggles, and reinforced gloves could prove to be effective in preventing injuries.

Among vessel injuries, burns from various causes were a common cause of hospitalization. Anecdotal reports from National Marine Fishery Survey (NMFS) observers suggest that fires are fairly common occurrences on fishing vessels.

SUMMARY

This study illustrates the various causes and types of serious and fatal injury sustained in the fishing industry. Intervention strategies that are described in detail elsewhere have been briefly noted. Factors that have not been addressed include the human component to injuries including; knowledge/experience, fatigue, and turnover of the workforce on the vessel. In addition, limited information on physical factors—such as illumination, noise, and weather conditions—is available only in AOISS but not in the ATR. The data on alcohol is insufficient and there are no data given on psychological or physical condition of the fishermen. Obtaining more extensive data on the root causes of many of these injuries would require more extensive investigation into the events.

Although data are lacking on the human component, additional strategies to improve safety need to address the interaction between the vessel, its equipment and machinery, and the worker. Behavior can be modified through training or passive systems can be designed that circumvent potential “human error.” Improvements can be made in design of deck layouts, lighting, machinery, and fishing gear [Hopper and Dean, 1989; CFER, 1998]. Improvements to safety have been experienced on an individual basis among fishermen and fishing vessels. However, there is an urgent need for more decisive action in monitoring the safety of the fisherman on the dock and on deck of commercial fishing vessels and preventing these severe injuries.

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REFERENCES

- Carbajosa J. 1986. Work accidents aboard Spanish fishing vessels. In: Centro de Estudios Technico Maritimos (CETEMAR). Technical-Maritime study centre. p 77–83.
- Centers for Disease Control and Prevention (CDC). 1994. Epi-Info Version 6 [Computer Program]. MS-DOS Version. Atlanta (GA): Analytic software.
- CDC. 1998. Fatal occupational injuries—United States, 1980–1994. *MMWR* 47:297–302.
- Center for Fisheries Engineering Research (CFER). 1998. Safety first for winch design. In: Fishing vessel topics: reprints from commercial fisheries news, p 5–7.
- Ess C. 2001. Man overboard. In: National fishermen. p 22–23.
- Hopper AG, Dean AJ. 1989. Safety engineering and equipment for fishing vessels under 20 m: results of trials on two vessels—MADALA and SILVERLINE. In: Sea fish industry authority, United Kingdom: p 354.
- Husberg BJ, Conway GA, Moore M, Johnson M. 1998. Surveillance for non-fatal work-related injuries in Alaska, 1991–1995. *Am J Ind Med* 493–498.
- Lincoln JM, Conway GA. 1999. Preventing commercial fishing deaths in Alaska. *Occup Environ Med* 56:691–695.
- National Institute for Occupational Safety and Health (NIOSH). 1993. Fatal injuries to workers in the United States, 1980–1989: a decade of surveillance, DHHS (NIOSH). Pub. No. 93-108S.
- NIOSH. 1994. Proceedings of the national fishing industry safety and health workshop, DHHS (NIOSH). Pub. No. 94-109.
- NIOSH. 1997. Current intelligence bulletin #58, commercial fishing fatalities in Alaska, risk factors and prevention strategies. DHHS (NIOSH). Pub. No. 97-163.
- Norrish AE, Cryer PC. 1990. Work-related injury in New Zealand commercial fishermen. *Br J Industr Med* 47:726–732.
- National Research Council (NRC). Marine Board, Committee on Fishing Vessel Safety (NRC). 1991. Fishing vessel safety: blue print for a national program. National Academy Press.
- Torner M, Karlsson R, Saethre H, Kadefors R. 1995. Analysis of serious occupational accidents in Swedish fishery. *Saf Sci* 21:93–111.
- Van Noy M. 1995. Toward a systematic approach to safety in the commercial fishing industry. *J Saf Res* 26(1):19–29.
- Workers' Compensation Board (WCB). 1994. Gearing up for safety. Safe work practices for commercial fishing in British Columbia. British Columbia.