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Lifejackets and Lobstermen: Giving Safety Equipment a Competitive Advantage

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ABSTRACT

Background: Falls overboard are the most frequent cause of death in the Northeast lobster fishing industry. National Institute for Occupational Safety and Health (NIOSH) surveillance indicates every victim of a fall overboard who has been found was not wearing a lifejacket. Preliminary research conducted in Maine and Massachusetts indicates lifejacket use is relatively uncommon among lobstermen due to barriers such as comfort, practicality, and social norms.

Methods: This study highlights an initiative to: (1) trial various lifejacket designs with lobstermen; (2) identify the most popular designs; and (3) identify other features that could encourage use of lifejackets. In 2017, nine designs were trialed with lobstermen in Maine and Massachusetts during the winter and summer fishing seasons. Participants were recruited dockside, and lifejackets were randomly assigned. Participants completed surveys at 1 week and 4 weeks to assess positive and negative design features and to understand the importance of survival technology that can be used in conjunction with lifejackets.

Results: 181 lobstermen in Maine and Massachusetts agreed to participate. Recruitment rates were 90.5%, while the survey completion rate was 88.4%. Survey results identified no clear preference for a specific lifejacket design; however, the ability to choose from many options appeared to be an important factor.

Conclusion: Previous studies have indicated that lifejacket preferences are fisheries specific. In the Northeast lobster fishery, however, individual preferences varied. Our research demonstrates that a range of devices covering different buoyancies, wear type, and retrieval systems should be made more available to lobstermen.

KEYWORDS
Buoyancy aid; falls overboard; lifejacket; lobstermen; personal flotation device (PFD)

Introduction

In a recent assessment of one of the most deadly industries in the United States, the National Institute of Occupational Safety and Health (NIOSH) indicated that drowning is a primary cause of death in commercial fisheries.[1] The great majority of U.S. fisheries fatalities are caused by either vessel sinkings (51%) or falls overboard (FOB) (30%).[1] Additional data provided in U.S. Coast Guard (USCG) fatality reports demonstrate that not one of the victims was wearing a lifejacket or a personal flotation device (PFD).[1]

From 2000 to 2014, an average of 15 commercial fishing fatalities per year was reported on the East Coast, with the highest single percentage occurring in the Northeast lobster fishery (16% of total fatalities).[2] State-specific data show that Massachusetts commercial fishermen experienced the second highest number of fatalities in the entire United States between the years 2003 to 2009.[3] Lobster fishermen account for a significant proportion of commercial fishery workers in Massachusetts, as well as in Maine (two states in the Northeast with the highest number of commercial fishing landings). In Massachusetts, for example, there were 1,591 license holders[4] and over 17 million pounds of lobsters[5] caught in Commonwealth waters in 2017. In Maine, the annual 2017 catch was reported as nearly 111 million pounds,[6] with 6,021 lobster licenses[7] registered in the state. Although formal assessments have not been made to date regarding the proportion of lobster fishermen in either state that wear lifejackets regularly, a qualitative study conducted in both states found little evidence of widespread use.[8] This is problematic, given the complexity of commercial fishery rescues and the impact of cold water immersion, the combination of which can make lifejackets essential on commercial fishing vessels.

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Research on the effects of cold water shock shows individuals immersed in cold water have roughly 30 min of unimpaired decision-making ability[9] and roughly 10 min before cold water incapacitation sets in (i.e., the inability to swim, grip, or climb back onboard a vessel). In an experiment conducted, by the U.S. Coast Guard,[1] volunteers were asked to enter water registered at 45°F without a lifejacket. After 10 min, volunteers' "fingers and arms stopped working … and [they] succumbed to swim failure". Additional volunteers were given lifejackets, and these individuals were able to keep their heads above water until mild hypothermia set in, roughly 60 min.

Given the challenges of immediately identifying a man-overboard event and launching an organized rescue response, it is logical to assume that a 10-min window for rescue is insufficient. A study conducted by NIOSH provides support for this conclusion. In a retrospective study of 228 commercial fishing fatalities from the Alaska Occupational Surveillance System, victims were "far less likely to have used PFDs than were survivors of events where cold water drowning occurred."[10] The successful rescue of workers who experience cold water immersion would, thus, be greatly enhanced by the use of lifejackets.[10,11]

Considerable research has been conducted in the last decade to identify barriers and motivators to lifejacket use in the U.S. commercial fishing industry, starting with the NIOSH Alaska Pacific Regional Office in 2012.[12] In these initial assessments of lifejacket use, researchers asked fishermen in the Southwest and Southcentral regions of Alaska to use and evaluate six different lifejacket designs over the course of the fishing season. Lifejackets were randomly assigned to fishermen, and they were asked to evaluate the designs after both one day and 30 days of use.[12] This initial trial, conducted with crabbers, longliners, gillnetters, and trawlers indicated barriers to lifejacket use largely related to comfort (too bulky, get in the way). The trial also indicated that lifejacket preference is largely fishery specific, with some lifejackets getting high marks for specific fishery sectors.[12]

While this initial study led to a valuable understanding of what could be done to increase the use of lifejackets in fisheries typically found in the Pacific Northwest, there have been no previous assessments of lifejacket models in the Northeast lobster industry. Although a 2016 qualitative study gained valuable information regarding lobster fishermen's barriers (comfort, ease of use, social stigma) to lifejacket use, actual field assessments of various lifejacket designs in this population have not been previously conducted with lobstermen.

The purpose of this research study was to identify lifejacket designs that address identified barriers to lifejacket use, such as comfort and ease of use. Results from the trial, as well as information gathered on the value of additional survival technology, are presented.

Material and methods

To identify potential designs for inclusion in the study, a list of 20 commercially available lifejackets and buoyancy aids were created using previous research studies, manufacturer suggestions, commercial fishing safety trainer input, and internet searches. In the preliminary selection process, researchers sought to identify a wide range of possibilities from which the lobstermen could choose. To select a viable number of options for the field trial, lobstermen attending lobster fishing association meetings in Maine and Massachusetts were asked to narrow the options by choosing eight models from the assembled list. At these meetings, lobstermen advocated for both a winter and summer field trial, citing the difference in ambient air temperatures, which can range from 25^0 Fahrenheit in the winter to 70^0 in the summer, thus affecting the relative of comfort of various lifejacket options. In response, researchers decided to trial designs in both the winter and summer fishing seasons. A ninth model was added to the summer trial at the request of the fishermen. Additionally, researchers sought to ensure a variety of lifejacket designs (belt, suspender, bib, shirt), buoyancy technology (inherently buoyant, manual inflation, automatic inflation), and buoyancy levels (11–38 lbs), as well as approval status (non-USCG approved, USCG approved, ISO approved). Although fishermen are required to have a USCG approved lifejacket onboard the vessel, there are no regulations that prevent them from wearing lifejackets on the vessel that are not USCG approved. Since many designs that are not yet

approved (which can take many years) are comfortable and user-friendly, these options were included in the trial. Table 1 provides a comprehensive list of the lifejacket and buoyancy aid models that were featured in the summer and winter trials.

Subject eligibility

Captain and crew members over 18 years-of-age who were commercial lobstermen fishing from ports in Maine and Massachusetts were eligible to participate in the trials. Crew were only allowed to participate with the permission of their captain, as researchers were concerned about interfering with any mandatory lifejacket policies captains may have had on their vessels. Individuals already wearing a lifejacket on a daily basis were excluded from the study, as were any individuals who had previously participated in baseline measures of lifejacket use conducted in the initial phase of the overall study.

Subject recruitment

Based on conversations with stakeholders, commercial fishing organizations, the NIOSH Maritime Fishing Safety Office, and fishermen, the most ideal method of trial recruitment appeared to be dockside recruitment. Given this feedback, study researchers, fishing safety trainers from Fishing Partnership Support Services (FPSS), and McMillan Offshore Survival Training (MOST) drove to ports in Maine and Massachusetts and invited individuals to participate. Recruiters described the purpose of the study, as well as the expectations for participants. All those agreeing to trial a lifejacket were randomly assigned one of the models (eight models in the winter, nine models in the summer) based on a randomization table developed prior to recruitment and were also asked to sign an informed consent. If several individuals from the same boat agreed to participate, all participants on that boat were assigned the same lifejacket model. Recruiters carefully described the features of each lifejacket, advising the participant on the specific aspects of correctly using it, should the need arise. All participants were asked to wear the lifejacket while working for one month and to complete a survey at week 1 and week 4. Participants were also given written information for the lifejacket they were assigned and the objectives of the research project, along with a NIOSH DVD and handouts addressing FOB prevention.

Survey data collection

Contact information was gathered at the time of recruitment to facilitate the survey data collection process, which was conducted over the phone by research staff. Survey questions were constructed so participants could rate their lifejackets' comfort, workability, and design preferences, as well as giving each participant a chance to list suggested changes to the designs. Demographic questions were also included in the survey and covered total years of fishing, boat size, and boat type (open transom vs. closed). Survey responses were collected and entered directly into Survey Monkey. Participants who could not be reached by phone were mailed paper copies of the survey, and in a few instances, dockside follow-up was provided by FPSS staff. Any surveys that were collected through the mail were double-entered for accuracy. Following the completion of the 1-week and 4-week surveys, participants were mailed a $25 Amazon gift card ($50 total if both surveys were completed). Participants were also allowed to keep the lifejacket they used in the trial.

Human subjects

Human subjects research guidance and approval was provided by the Bassett Healthcare Network Institutional Review Board (#2038). All participants gave written consent prior to participating.

Survey data analysis

Lifejacket utility was assessed via phone surveys after 1 week and 4 weeks of use. Lobstermen were asked to rate the overall comfort of the lifejacket on a scale of 1 (least comfortable) to 10 (most comfortable). Questions regarding ease of working in the lifejacket were assessed on a 4-point Likert Scale, with positive responses scored higher. For

Table 1. Lifejackets and buoyancy aids selected for trial.

Model #	Picture	Manufacturer	Model	Design	Flotation type
1		Mustang Survival	MD3075 Inflatable Belt Pack	Belt Pack	Manual Inflation. 38lb. USCG approved Type III
2		Kent Safety Products	Kent Rogue II Fishing Vest	Vest	Inherent Flotation. 12lbs. Buoyancy Aid. Not USCG approved.
3		Quatic	Quatic Inflatable Rashguard	Other	Manual Inflation. 12-15lbs. Buoyancy Aid. Not USCG approved.
4		Hyde Sportswear	Hyde Wingman	Vest	Manual Inflation. 22.5lbs. USCG approved Type V with Type III performance.
5		Kent Safety Products	Kent First Responder	Vest	Inherent Flotation. 15.5 lbs. USCG approved Type III.
6		Stormline	662 Heavy Duty Oilskin Flotation Bib and Brace	Bib	Inherent Flotation. 11 lbs. Buoyancy Aid. Not USCG approved.
7		Mullion	Compact Wipe Clean	Suspender	Auto Inflation. 150N. EN ISO 12402 certified. Not USCG approved.
8		Mustang Survival	MD5283 HIT Inflatable Work Vest	Suspender	Auto Inflation. 38lbs. USCG approved Type V
9		Spinlock	Deckvest Duro[used only in summer trial]	Suspender	Automatic Inflation. 170 N. ISO 12402–3 certified. Not USCG approved.

example, "How much does the PFD constrict or limit your motion?" was coded as (1 = very much; 2 = somewhat, 3 = very little, 4 = not at all). A general workability score was assessed by "All things considered, how satisfied are you with the ability to work in the lifejacket you tested" on a scale from 1 (least satisfied) to 10 (most satisfied).

Responses to comfort/workability questions were averaged across 1-week and 4-week questionnaires for each lobsterman, such that each subject contributed a single score for each question. These scores were then averaged for each question according to lifejacket model. Average scores by model were converted to reflect an overall scoring scheme ranging from 1 to 5. These scoring methods were conducted separately for the summer and winter trials; however, for reasons explained in the Results section, these summer and winter values were ultimately pooled into single values.

The relationship of the six composite variables with overall satisfaction was measured using Spearman's Rank Order Correlation. To control the experiment-wide alpha as much as possible, the eight individual models were not compared across each of the seven component variables. Rather, a single comparison was made for overall satisfaction using one-way analysis of variance.

Results

A total of 181 lobstermen, 90 from Maine and 91 from Massachusetts participated in either the winter or summer trial of lifejacket models. The participation rates for the winter and summer trials were 93.3% and 88.4%, respectively. Completion rates (wearing a lifejacket and completing both week 1 and week 4 surveys) were 85.6% for winter and 90.8% for summer. The average combined completion rate for both trials was 88.4%.

Only 2 of the 181 trial participants were female. The average age of the participants was 43.2 years, with a range of 18 to 73 years-of-age, while the average number of years fishing was 23.5, with a range of 0.02 to 60.0 years. Slightly over half of the boats (43.9%, n = 61) fished 3 or more miles from shore, with 13.7% (n = 19) fishing within 3 miles of shore. The remaining 42.5% (n = 59) reported fishing both inside and outside the 3-mile demarcation. Just over half of the boats (n = 71, 51.1%) were open transom design, with the remaining 68 (48.9%) being closed transom. There was little variability in these demographics from winter to summer trials.

Table 2 contains responses for the following survey questions:

- On a scale of 1 to 10, how comfortable was the PFD you tested?
- Please rate the ease of putting on the PFD. (Ease)
- How much does the PFD constrict or limit your motion? (Motion)
- How much does the bulkiness of the PFD bother you? (Bulkiness)
- How often does the PFD get snagged by gear? (Snags)
- How much does the PFD interfere with your work? (Interfere)
- All things considered, how satisfied are you with your ability to work in the PFD you tested? (Satisfaction)

Prior to creating Table 2, the responses to each of the seven questions were compared between summer and winter for each of the PFD models using

Table 2. Scores for summer and winter trial of lifejacket models combined (Ratings from 1 to 5, 1 being an unfavorable score and 5 being the most favorable score).[a,b]

	Hyde Wingman	Kent 1st Responder	Kent Rogue II	Mullion	Mustang Elite	Mustang Belt Pack	Quatic	Stormline	Spinlock
Comfort	3.7	2.5	3.3	2.5	3.4	3.3	3.6	4.0	3.1
Ease	4.6	4.3	4.8	4.3	4.7	4.7	4.2	3.8	4.1
Motion	4.4	2.6	3.2	3.4	3.3	3.9	4.2	4.2	3.5
Snags	4.4	3.2	4.1	3.9	3.7	4.0	4.6	4.6	3.4
Bulkiness	4.4	2.4	2.6	3.0	3.5	3.4	4.6	3.8	3.3
Interfere	4.5	2.6	3.4	3.3	3.6	3.8	4.3	4.5	3.2
Satisfaction	**4.2**	2.3	2.9	2.7	3.6	3.4	3.9	**4.2**	2.8

[a] As stated in the methods section likert scale responses to questions, such as "not at all" or "very much", were converted to numerical scales to reflect a more consistent rating system for comparisons across lifejacket models.
[b] Bolded scores reflect the most popular models.

the Wilcoxon Rank Sum Test. Of the resulting 64 hypothesis tests, only 5 were statistically significant at $p < .05$ (these included responses to overall satisfaction and ease of use for the Wingman, ease of use for the Mullion, and interfere with work and the total score for the Quatic). These five significant results were considered to be within the experiment-wide alpha; therefore, responses for the summer and winter were pooled for simplicity.

In terms of overall satisfaction, the models appeared to cluster into two groups either above or below the mid-range score of 3. The Kent 1st responder (2.3), the Kent Rogue II (2.9), the Mullion (2.7), and the Spinlock (2.8) scores were below the mid-range, indicating these models were less popular with fishermen. Two of these designs (the Kent Rogue II and the Mullion) were not USCG approved. The group of models in the upper-range consisted of the Hyde Wingman (4.2), the Mustang Elite (3.6), the Mustang Belt Pack (3.6), the Quatic (3.9), and the Stormline (4.2). Of these, two models (the Quatic and Stormline bibs) were not USCG approved.

The two highest scoring PFD models in terms of overall satisfaction were the Stormline and the Hyde Wingman, with both models having an overall score of 4.2. The Stormline was found to have a significantly higher score than either the Kent First Responder ($p = .003$) or the Mullion ($p = .021$). The Wingman also had a significantly higher rating than either of these two models (Kent $p = .004$, Mullion $p = .025$). These two were followed closely in rating by the Quatic (3.9). However, the Quatic was not rated significantly different than any other individual model, nor were there any other significant pairwise differences other than the four noted above. The two strongest predictors of overall satisfaction with the PFD (satisfaction) were "comfort" and "interfere" (both rho = .78, $p < .0001$). These were followed in importance by "limit" (rho = .70, $p < .0001$), "bulkiness" (rho = .70, $p < .0001$), "often snagged" (rho = .42, $p < .0001$), and "ease" (rho = .19, $p = .014$). Of the scored responses to the six remaining questions relating to "comfort", "ease", "motion","snags", "bulkiness", and "interfere" in Table 2, only the Kent 1st Responder had a majority of values below 3.0.

Of the 90 inflatable lifejackets distributed to participants, only one individual reported that a lifejacket had inflated unintentionally over the course of the trial. At week 1, the average wear rate was 88% (range 10–100%), while at week 4 the average was 60.5% (range 0–100%). According to survey responses, fishermen stated they would be willing to pay roughly $104 for a lifejacket. Broken out by lifejacket type, the average ideal cost was $153 (range $0–$450) for lifejackets with inherent flotation, $160 (range $35–$500) for lifejackets with manual flotation, and $196 (range of $50–$650) for lifejackets with automatic inflation. The average retail price for lifejackets featured in the trial was $176 (roughly double the ideal cost), with a range in pricing from $75 to $250. The average cost of lifejackets with inherent flotation ($126) was actually less than the average ideal cost ($153) of these designs, while the ideal cost for manual devices ($160) was roughly equivalent to the average retail price ($156). The average retail cost for hydrostatic devices, however, was quite a bit higher ($246), than the average ideal cost ($196).

In addition to rating lifejackets, respondents were also asked to list survival equipment that "matters to them" and were asked to choose these from a list provided by the surveyor (subjects were allowed to choose more than one option). Responses are featured in Table 3. In general, safety items that facilitate being located while lost at sea were the most favored.

Lastly, trial participants were asked to pick from a list of items that would either encourage them or discourage them from wearing their lifejacket. Subjects were allowed to pick more than one option from this list. As illustrated in Table 4, environmental factors or activities most likely to

Table 3. % of subjects indicating which survival equipment matters.[a]

	Summer Wk 4, *n* = 79	Winter Wk 4, *n* = 68
Reflector	**91.1% (72)**	**89.7% (61)**
Personal locating beacon	**78.5% (62)**	**79.4% (54)**
Strobe	**76.0% (60)**	**76.5% (52)**
Whistle	73.4% (58)	60.3% (41)
Knife clip	69.6% (55)	60.3% (41)
Flare	50.6% (40)	30.9% (21)
D-ring	46.8% (37)	50.0% (34)
Dye Marker	46.8% (37)	30.9% (21)
Kill Switch	45.6% (36)	39.7% (27)
Signal mirror	34.2% (27)	29.4% (20)
Hydration pouch	31.7% (25)	23.5% (16)
Cell phone pocket	30.4% (24)	13.2% (9)

[a] Bolded items scored highest.

Table 4. Facilitators and barriers of LifeJacket use.

Facilitators	% Selecting	Barriers	% Selecting
Storm or high sea	74.8%	Uncomfortable	74.2%
Emergency	73.5%	Interferes w/ movement	66.5%
Hauling/setting	34.8%	Use survival suit	61.9%
Darkness	34.2%	Entanglement	49.0%
On deck in transit	17.4%	Makes me feel foolish	15.5%
Crossing shoal	16.8%	None	7.7%
Being on deck	13.5%	Peer pressure	6.5%
None	7.1%		

encourage lifejacket use were those associated with an increased risk of FOB, such as storms, high seas, or setting or hauling traps. Barriers to lifejacket use included discomfort, restricted movement, and the alternate option of a survival suit, which fishermen are required to carry on vessels and which they believe provide them with an adequate form of protection from drowning. Fishermen were also concerned about the potential of the lifejacket to become entangled in traps or lines, thereby increasing their risk of FOB. Entanglement concerns also extended to the possibility of getting a leg wrapped in a trapline, getting dragged off the boat, and then having an automatically inflating lifejacket deploy.

Discussion

The goal of this study was to assess whether it is possible to find commercially available lifejacket designs that are functional enough for lobster fishermen to work in, an issue that was raised in previous qualitative interviews with fishermen in both Maine and Massachusetts.[8] Identifying potentially workable designs and areas for lifejacket design improvement would not only allow researchers to share existing options with lobster fishermen, but it would encourage further improvements in lifejacket designs to increase lifejacket use in this fishery sector. Our research results demonstrate that potentially viable options already exist on the market, some of which require little maintenance or behavior change (i.e., Stormline flotation bibs, which are inherently buoyant and similar to what is already worn by fishermen). It is also interesting to note that retail costs of these designs were fairly similar to the ideal costs that fishermen quoted, with the exception of hydrostatic devices. However, several of the designs that rated highly in our study, were not USCG approved devices. This indicates a need to test a wider range of lifejacket options and to expedite the approval process. Additionally, lobstermen in our study indicated that having flotation incorporated into clothing would be beneficial. In Norway, this approach was used with the development of Regatta oilskins, which were designed to be part of standard fishing clothing but provide flotation for fishermen as well.[13] Similar results were found in NIOSH lifejacket trials conducted in the Pacific Northwest,[12,14] although these trials indicated that preferred designs tended to cluster within various fisheries sectors.

Lifejacket designs that were most popular in our study tended to be those with low profiles that did not limit visibility or motion. For example, two of the most popular models, the Quatic inflatable rashguard and the Hyde Wingman were designed for surfers or for triathletes and, thus, attempted to balance flotation requirements with mobility and comfort. However, responses to questions relating to additional survival equipment may indicate that lifejackets like the Mullion, a 150N device that includes a strobe light and personal locating beacons on newer designs might be more popular if they widely advertised these additional features. This observation is based on feedback from lobstermen in our study, as well as a barrier to lifejacket use expressed by lobstermen in a prior study where they shared concerns regarding not being found.[8] Although several designs rated very highly, most of the lifejacket designs trialed received at least average ratings on many factors. Given this and the strong feelings shared by the fishermen about inflation preferences, such as automatic inflation (concerns about being unconscious when going overboard), manual inflation (desire to choose when to inflate the lifejacket, if the trap line was around their leg) or inherent flotation (requires less maintenance and is cheaper), presenting fishermen with a variety of buoyancy options may be the most ideal approach.

Additionally, based on the research teams' interactions with lobster fishermen at commercial fishing shows and over the course of subject recruitment, donning and doffing lifejackets could be an important consideration for fishermen considering various lifejacket options. For example, several models require the wearer to pull their arms back to slip them into straps or buckles, such as the Mullion or Mustang models. However, due to the prevalence of

musculoskeletal disorders among lobstermen in Maine and Massachusetts, their range of mobility can be fairly limited.[15]

Additional findings, which will be helpful in addressing the issue of lifejacket use in commercial fisheries, are the realization that fishing season (winter or summer) appears to have little impact on lifejacket preference, at least with the models tested in our study. To our knowledge, no prior assessments of lifejackets have looked at the impact of seasonality on lifejacket preferences in the commercial fishing industry. The closest example we could identify in the literature was a Norwegian study comparing requirements for work clothing for fishermen in the Mediterranean and a northern fishing fleet, which did find differences in lifejacket preference based on geographic differences. More specifically, these researchers found that while both fleets prioritized work clothing that allowed them to move freely and was easy to don and doff, the northern fleet also prioritized work clothing that "keeps you afloat in water".[16]

It is also important to note that survival suits were listed as a prominent barrier to lifejacket use by research participants. More specifically, research subjects expressed concern about having adequate time to remove the lifejacket before donning the survival suit if the vessel was sinking. As indicated by research subjects, survival suits were viewed as a viable option, replacing the need for wearing lifejackets on the commercial fishing vessels, with the assumption they could don the survival suit for flotation without addressing the sudden, unexpected nature of FOB. While prevention of FOB remains the most effective measure for survival, FOBs happen in a split second, often from loss of balance, slipping, or gear entanglement. In a survey of 103 lobstermen, the Harvard School of Public Health and NIOSH found 73% of study participants had been entangled in line.[17] According to the CDC/NIOSH, the majority of FOB are not witnessed and efforts to reduce these fatalities could be addressed by "including lifeline tethers, line management, personal flotation devices (PFDs), man-overboard alarms, recovery devices, and rescue training".[11] In a 10-year analysis of lifejacket use and drowning prevention in the United Kingdom, potentially 82% of the drownings could have been prevented if a lifejacket had been worn.[18] These findings indicate an important need to increase fishermen's awareness of FOBs through educational materials or safety training curriculum, as well as the factors that contribute to FOBs and the role PFDs can play in preventing FOB fatalities.

Perhaps one of the most important issues identified over the course of this study is the relative lack of distribution and/or marketing of lifejackets amongst commercial marine suppliers. Over the course of recruiting subjects and conducting follow-up surveys, it became clear that many fishermen were unaware of the variety of lifejacket designs that have been developed. As the research team became increasingly aware of this gap, they decided to visit a number of commercial marine suppliers in popular fishing ports in Maine and Massachusetts. Although a few suppliers offered several lifejacket options, many offered only one or two relatively unappealing options. Upon further inquiry, many suppliers indicated that fishermen were not interested in purchasing lifejackets, so they did not keep them in stock. This provides an important consideration in efforts to increase lifejacket use in commercial fishing populations; distribution channels can be just as important as finding appealing designs.

Lastly, one of the most surprising results from our study was the widespread engagement from the lobster fishing community in lifejacket trials. Although the research team conducted a considerable amount of outreach with the lobster fishing community prior to the study, incentives were minimal and participants were asked to complete paperwork, trial the options, and complete two surveys. Summer trials also fell at a particularly busy time for participants, yet despite this, many agreed to trial lifejacket designs and complete all phases of the study. This provides some indication that fishermen are indeed interested in finding prevention and survival solutions, and perhaps lack of knowledge regarding workable options has impeded widespread use of these life saving devices.

Limitations and strengths

The participants included in this study were commercial lobstermen fishing from ports in Maine and Massachusetts. Although these ports account for the majority of lobster fishing landings in the Northeast, it is possible that the results of our study may not be

generalizable to lobster fishermen in other Northeastern states or even lobster fisheries outside the United States. In particular, the number of female lobster fishermen in the sample was relatively low (only two). The authors did attempt to locate data on gender ratios in lobster fisheries workers in Maine and Massachusetts, but could find no accurate or updated data sources. As a result, it is impossible to assess how the ratio of men to women in our sample differs from the general population. Given the small sample of women in the study, our results are undoubtedly more representative of male lobster fishermen's preferences than females. However, randomized recruitment strategies and high participation rates provide some reassurance that our findings are generalizable to the majority of lobster fishermen in the Northeast lobster fishing industry.

Conclusions

The results of both summer and winter trials of lifejacket designs amongst lobster fishermen in Maine and Massachusetts indicate there are a number of promising options that reduce barriers to use such as comfort and ease of use. In particular, our study identified several designs that received almost perfect scores on a number of essential design factors. Additionally, feedback from fishing participants indicates that a number of additional components could be included with lifejackets to increase their appeal, such as personal locating beacons, strobe lights, or reflectors. Factors likely to increase the use of lifejacket use were also identified and include storms, high seas, setting/hauling traps, and designs that are comfortable to wear.

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