A preliminary study for

Improving survivability of cusk bycatch in the Gulf of Maine lobster trap

Final report prepared

by

Yong Chen and Jocelyn Runnebaums

School of Marine Sciences

University of Maine

Orono, Maine 04469

Email: ychen@maine.edu

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Summary

Cusk (*Brosme brosme)* are a National Marine Fisheries Service (NMFS) "Species of Concern," as well as a "Candidate Species" under the Endangered Species Act. Cusk distribution is thought to co-occur with the Maine lobster trap fishery when fishermen move offshore to follow the lobster during the spring and fall. Cusk spawn in the spring, making this overlap critical to reproduction and recruitment. Data collected by the Maine Department of Marine Resources' (DMR) lobster sea sampling program suggests that cusk are part of the bycatch in lobster traps. However, the occurrence as bycatch in traps and subsequent survivability after being discarded is poorly documented or unknown. This small-scale project is a preliminary study designed to accomplish the following tasks: develop and test the experimental protocol; identify and recruit fishermen who caught cusk in their lobster traps in the past and are willing volunteers for this project; meet with fishermen to discuss this project and go over the experiment protocol; and work with fishermen conducting fieldwork to collect preliminary data for analysis.

We have accomplished all the tasks. This preliminary study suggests that with appropriate treatments, cusk caught as a bycatch species in the lobster trap fishery can survive the discarding process.

Introduction

Cusk (*Brosme brosme)* are a groundfish species in the gadoid family and the only member of the genus *Brosme*. In the U.S., cusk are a National Marine Fisheries Service (NMFS) "*Species of Concern,*" as well as a "*Candidate species*" under the Endangered Species Act (ESA) as NMFS is currently conducting a status review of the species. In 2012 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reassessed cusk as threatened and cusk are under consideration for legal listing under Canada's Species at Risk Act (SARA). Cusk are a data poor species; little information exists about their life history, their stock structure is unknown, and current biomass is thought to be low. Cusk are not managed as a fishery or as bycatch in the U.S., but cusk bycatch landings have been managed in Canada. Cusk are thought to be found in moderately deep water, on hard, rocky substrates, and in relatively cold temperatures (6-10^0 C) on both sides of the North Atlantic (Bigelow and Schroeder 1953, Lough 2004). The greatest concentration of cusk is found in the central Gulf of Maine (GOM) extending onto the Western Scotian Shelf (O'Brien, 2010).

Cusk are thought to consist of highly localized populations with limited movement (Bigelow and Schroeder, 1953), however very little is actually known about their life history (Oldham, 1972), migration, or dispersal capacity (Kunsten et al., 2009). Lobstermen involved in this study generalize that cusk are found on hard bottom in 40 – 100 fathoms (80- 200 meters) of water in the spring and in the fall when lobster harvesting typically takes place offshore.

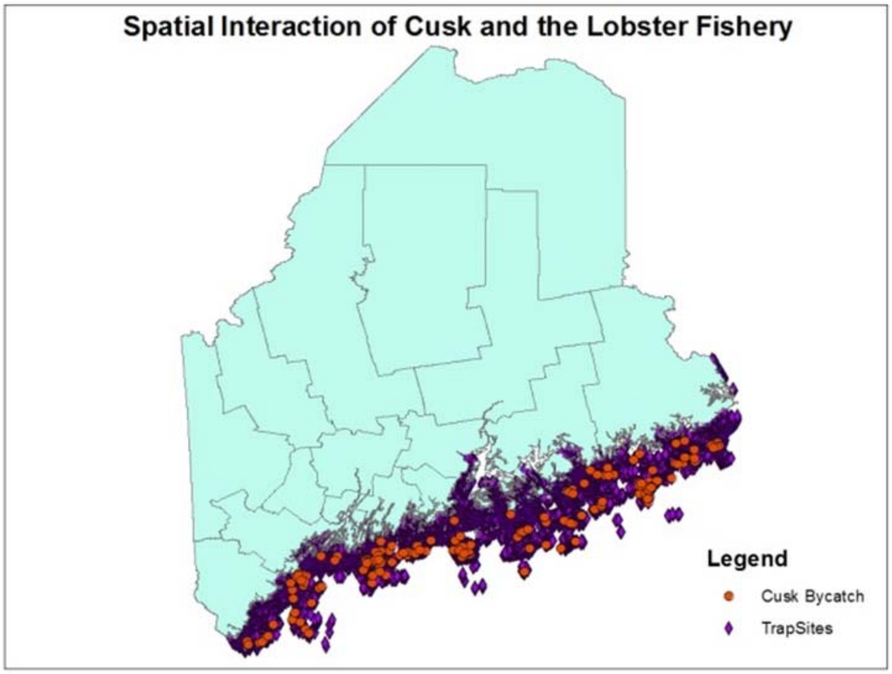


Figure 1. Lobster Sea Sampling data provide locations for lobster traps and their catch. The purple are traps sampled from 2006 to 2011. The orange are locations where cusk were recorded as bycatch.

In the GOM, cusk are known to overlap with the lobster trap fishery (Fig. 1); however the majority of the interaction is seasonal (Fig. 2). Seasonal fishing patterns in the Maine lobster fishery have been noted by lobstermen involved in this research as well as Maine Department of Marine Resources (DMR). Fishing pressure in the summer months is much greater than in the late fall, winter, and spring. Anecdotally, fishermen move offshore in the fall to follow migrating lobsters. Figure 2 shows this pattern of offshore fishing interacting more frequently with cusk than inshore summer fishing. It is the fall, winter, and spring fishery that tends to have a relatively high cusk bycatch in the lobster fishery, thus posing a potential risk to the cusk population. Cusk have anecdotally been seen to remain positively buoyant for extended periods of time at the surface upon discarding, making them vulnerable to predators such as birds and seals. Predation alone will likely result in high discard mortality of cusk.

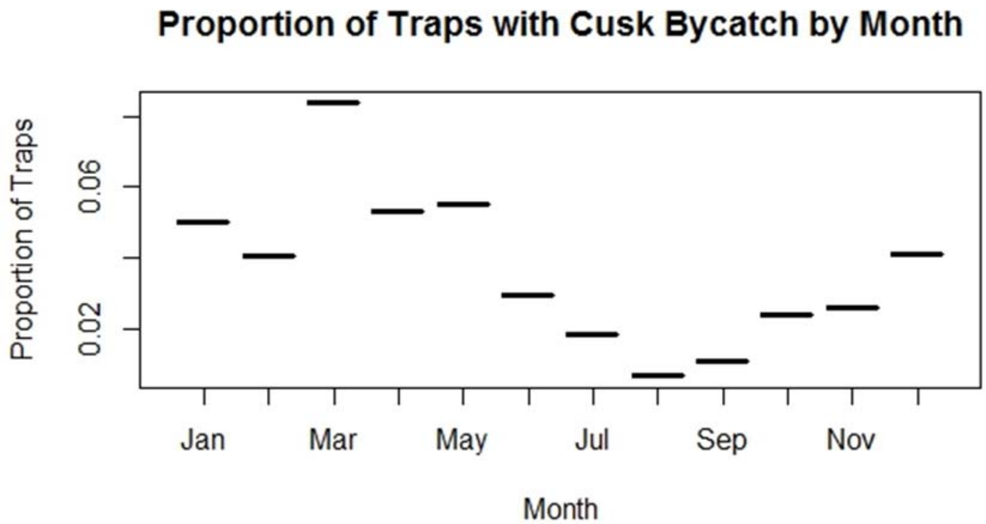


Figure 2. Maine DMR lobster sea sampling data by month with all the yearsaccumulated. Indicates the proportion of traps with cusk bycatch

As noted above, lobstermen involved with this research indicate that the fall, winter, and spring fishery happens predominately offshore in federal waters. The explanation for this fishing behavior is the presumption that lobsters migrate offshore in the colder months and migrate inshore in the summer months. There are approximately 5000 state lobster/crab license holders in Maine (DMR), but only a proportion possess a federal lobster license. Approximately 1793 licenses have been issued for Area 1 (NERO), and those are shared between Maine, New Hampshire, and Massachusetts fishermen.

Cusk are a physoclistous species, their swim bladders are disconnected from their esophagus. This makes them incapable of quickly altering their buoyancy during a forced surfacing event, unlike physostomous species such as salmon which "inhale" or "exhale" to become neutrally buoyant (Nichol and Chilton, 2006; Hannah et al., 2008a; Pribly et al., 2009). Instead, cusk use a gas gland to change the volume of air in their swim bladder, altering their buoyancy, a slow process taking up to several days (Campbell et al., 2010). During surfacing events, such as being hauled to the surface by a lobster trap, these animals are subject to the Combined Gas Law which states that the gas volume will change with changes in pressure and temperature (Smith and Croll, 2011). The two most important aspects of the Combined Gas Law are Boyle's Law, as pressure decreases gas volume will increase, and Charles's law, gases expand when heated. Bottom temperatures in the Gulf of Maine are cooler than sea surface temperatures in spring, summer and fall which could increase swim bladder expansion during these seasons in addition to the pressure changes experienced.

Physical trauma is inflicted to the animal due to gas expansion. This trauma includes overexpansion or rupture of the swim bladder, stomach eversion, exophthalmia, intestinal protrusion through the cloaca, external hemorrhaging, organ torsion, subcutaneous gas bubbles, and ocular gas bubbles (Rummer and Bennet, 2005; Hannah et al., 2008b; Rogers et al., 2008;

Campbell et al., 2010; Pribly et al., 2009; Butcher et al., 2012). Currently two methods of barotrauma treatment are recommended in the literature, recompression and venting (Brown et al., 2010). Research on Pacific rockfish has shown that the effects of barotrauma can be reversed by rapidly sending the fish back down to capture depth for recompression treatment. Recompression in the Pacific rockfish research showed an increase in the rate of survival from barotrauma by more than 75% (Jarvis and Lowe, 2008; Hannah et al., 2008a; Rogers et al., 2011). Venting is the use of a hollow, hypodermic needle to relieve air pressure from an inflated swim bladder through the body cavity. Treatment experiments on snapper showed venting to provide the quickest release of air pressure (Butcher et al., 2012).

This project is a preliminary study designed to accomplish the following tasks: develop and test the experiment protocol; identify and recruit fishermen who caught cusk in their lobster traps in the past and are willing to be volunteers for this project; meet with fishermen to discuss this project and go over the experiment protocol; and work with fishermen to conduct preliminary fieldwork to collect preliminary data for analysis.

Methods

Logbooks

To date, nine volunteer lobster harvesters are participating in this research. These lobster harvesters were contacted at the recommendation of Maine DMR, Sea Grant extension, or from the lobster cooperatives. Recommended individuals were approached with the objectives of the research. Of the fishermen approached, some were willing to collect data, others were willing to collect data and have research conducted on board, while others wished not to participate. In all, nine lobstermen agreed to collect data using a logbook (Fig. 3) developed by a University of Maine (UMaine) graduate student, Maine DMR, and a lobster harvester. It is impossible to validate the logbook data when the UMaine graduate student was not on board. However, because the involvement of all the fishermen in this study is voluntary we have every reason to believe that their data are likely accurate.

Cusk Logbook									
Vessel:			Captain:						
Date	**Location**	**Bottom Type**	**Depth**	**Bait**	**Fish Condition**	**Number of Traps Hauled**	**Time at Surface**	**Days Betwee n Haul**	**Signs at Next Haul**
5/24/2013	Lat, Lon preferred but any measure is fine	H(hard) G (gravel) M (mud)	Fathoms	F (fresh), S (salted), A (alewife), P (pogie), H (herring)	A (alive), D (dead), SE (everted stomach), BE (bug eyes), SB (skin bubbles)	# of traps hauled in the one day (200, 400, etc.)	Mins	How many days did the bait fish for?	B (bits or bones), A (alive), D (dead)

Figure 3. Example of information collected by volunteer lobstermen on the logbooks.

Barotrauma Treatment

Of these nine volunteers, five have allowed research to be conducted during their normal fishing trips. Opportunistic sampling methods have proven to be a reliable method of finding cusk. The lobster harvesters indicate a good day to accompany them based on the location they plan to fish and the bycatch they have seen recently. The first two weeks in May 2013 were spent talking with fishermen and accompanying them on fishing trips to establish a better understanding of what could and could not be accomplished on a working vessel. During these trips participating fishermen were asked to change their discarding practice by placing the cusk in the front part of the traps (i.e., kitchen). When the traps were hauled again a week later the status of the fish was recorded on the logbooks. This aspect of the research was exploratory in nature to best determine how to effectively proceed with recompression experiments. Utilizing their own commercial gear, lobstermen replaced the cusk in the front part of the trap where the entrance is located (i.e. the "kitchen"). The traps are marked to indicate the presence of a cusk recompressed, and deployed normally. When these traps are hauled the following week, lobstermen have reported finding cusk in the marked traps alive or no evidence of the cusk, assuming escape. Again, we need to stress that the logbook information was reported voluntarily by the nine fishermen trained by a UMaine graduate student. Given the preliminary nature of the project and small amount of funding, it was not feasible for an onboard observer to cover many trips.

Videography

As this project involved *preliminary* research, a better understanding of how to conduct research on operating fishing vessels and how to utilize commercially available equipment beyond their rated depths in t waters where cusk are normally found needed to be established. During this study, camera equipment was tested from existing equipment provided by Maine DMR. A deepwater housing unit was obtained as well as a camera and miniature digital video recorder (DVR) recording system with a separate camera. The first obstacle, given the depth cusk are found, was lighting. Rountree and Juans (2010) documented that cusk behavior seemed to be unaffected by white light. With the understanding that unnatural light at any depth can change organism's behavior, we found white light to be a possible solution to capture cusk behavior within the traps. An LED Princeton Tec APEX head lamp with 200 Lumens and 150 hours of burn time provided the best light for deep water. Cyalume 6" chemical snap lights were used to provide extra light further away from the camera and main light source. The camera and DVR recording system were antiquated technology and proved to be unsuccessful. To be able to obtain video, a GoPro Hero 3 was determined to be the best available technology at a reasonable price to gather data on cusk behavior within the traps. The GoPro camera is rated to 60 meters the headlamp was rated to 1 meter. This equipment was deployed to 84 meters within an acrylic housing rated to 305 meters in November 2013. When it was hauled 5 hours later the housing had imploded and all the equipment inside had been destroyed, the cause of the failure is unknown. Five minutes of video were recorded and recovered showing the deployment of the gear to depth. With this setback the housing and lighting situation has been reevaluated.

Results

Preliminary findings from volunteer lobster harvesters indicate cusk survive recompression. Utilizing their own commercial gear, lobstermen replaced the cusk in the front part of the trap where the entrance is located. The traps are marked to indicate the presence of a cusk recompressed, and deployed normally. When these traps were hauled the following week, lobstermen reported finding cusk in the marked traps alive or with no evidence of the cusk, assuming escape. Onboard researchers have verified cusk survival with barotrauma treatment in the short-term (i.e. approximately 5 hours). Specifically, cusk that were placed in traps to be videoed all came back up alive after being back at depth for five to six hours.

Onboard sampling revealed symptoms reported in the literature as noted above, in addition to other possible symptoms such as internal bleeding visible from the mouth and damage to the gills from stomach eversion (Fig. 4). Our preliminary testing revealed that cusk will not only experience barotrauma but can experience other physical trauma while captive in the traps. Some specimens brought on board had damaged fins, lesions from either the traps or the lobster, or were dead.

To date, participating fishermen documented 46 cusk in their lobster traps. Over 80% of the cusk caught in the lobster traps were still alive when brought to the surface. After the recompression treatment, over 45% of these cusk were found alive, 30% of the cusk were found dead, and the condition of the remaining cusk was not reported in the logbook (Fig. 5). Because we had to depend on fishermen's volunteers for this work and we did not have resources to send scientific observers, we were unable to pinpoint the reasons for lack of the information on the condition of these cusk. An evaluation of symptoms of barotrauma presented at time of surfacing shows that the most common symptoms are bug eyes and stomach eversion (Fig. 6).

(a)

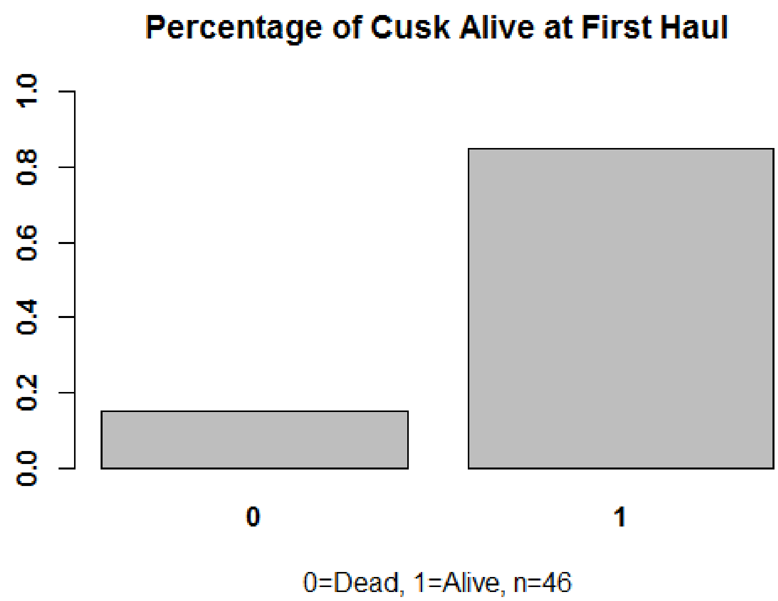
(b)

(c)

(d)

(e)

Figure 4. (a) cusk caught at 51 fathoms, exhibits stomach eversion, exophthalmia, ocular gas bubbles, and subcutaneous gas bubbles; (b) capture depth unknown, exhibits exophthalmia, ocular gas bubbles, subcutaneous gas bubbles, and fin damage from the trap; (c) caught at 56 fathoms, exhibits stomach eversion, exophthalmia, ocular gas bubbles, subcutaneous gas bubbles, and external hemorrhaging; (d) capture depth unknown, exhibits stomach eversion, exophthalmia, and subcutaneous gas bubbles; (e) capture depth 49 fathoms, exhibits exophthalmia, ocular gas bubbles, and external hemorrhaging.



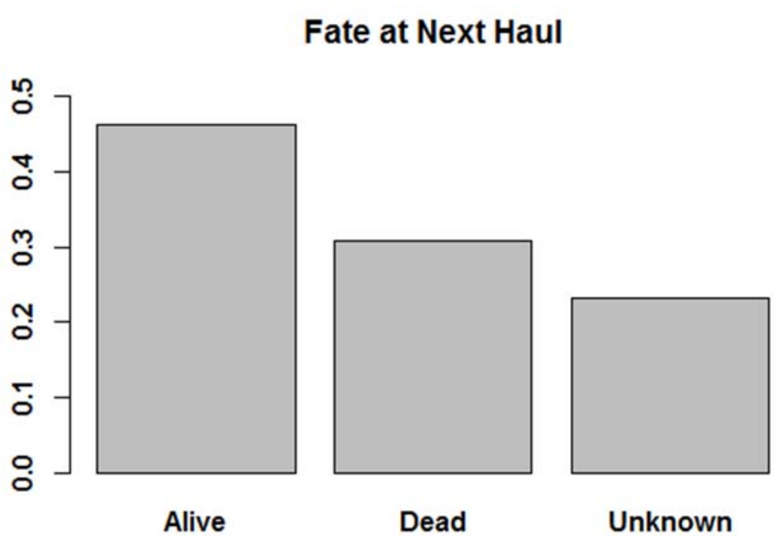


Figure 5. Survivability of cusk at the first capture (first haul) and at the re-examination of the conditions of cusk after recompression treatment in lobster traps for a few days.

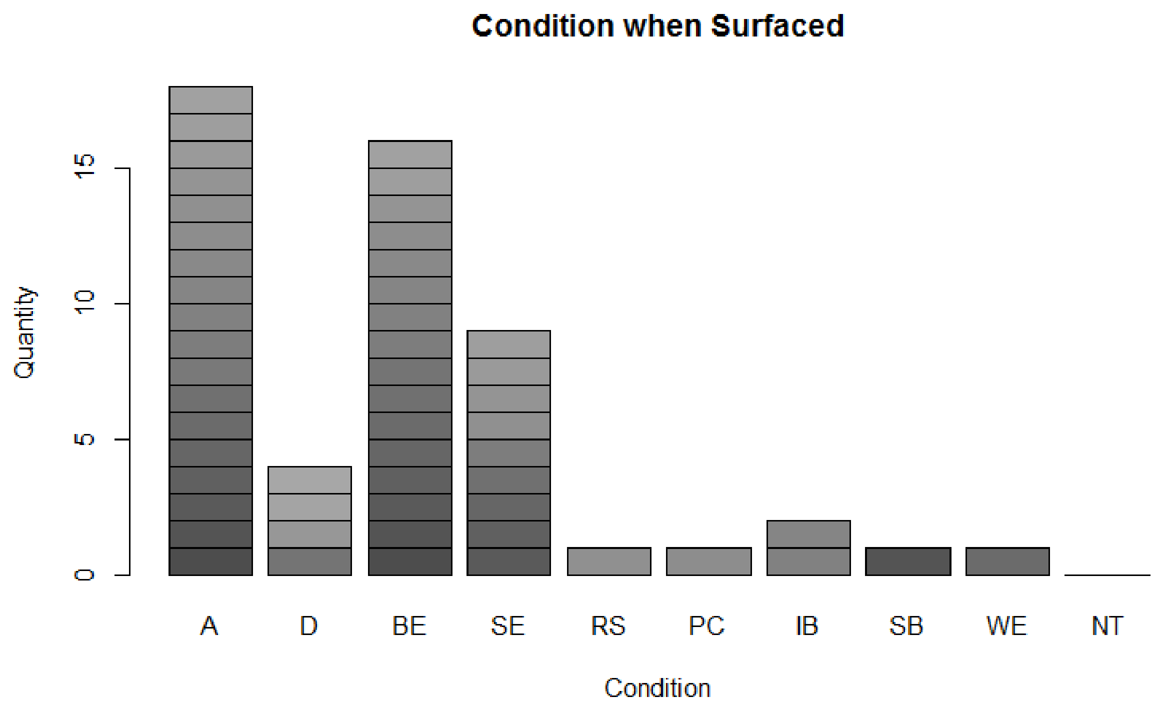


Figure 6. Physical symptoms present in cusk at the time of surfacing, includes cusk that were both alive (A) and dead (D). These symptoms were bug eyes (BE), stomach eversion (SE), ripped stomach (RS), prolapsed cloaca (PC), internal bleeding (IB), skin bubbles (SB), white eyes (WE), not trauma (NT).

Discussion

We documented various barotrauma symptoms for cusk in the field (Fig. 4). Hannah et al. (2008a) determined that presence of physical trauma was not indicative of survival during recompression during their rockfish recompression experiments. Our preliminary result of cusk being able to survive this process is consistent with the results derived by Hannah et al. (2008a). This anecdotal success needs to be further tested to evaluate the percentage of cusk that survive recompression and the potential for escape. Fish condition will be documented along with length, weight, obvious spawning condition, and environmental variables such as depth, bottom type, and sea surface temperature. Peripheral data such as bait type and number of days the trap fished will also be recorded to evaluate other possible correlations to incidental catch. The fish will be replaced in the "kitchen" or front part of the trap and redeployed with the rest of the lobster harvester's gear for that site. In general, gear fished in deeper waters, which more likely overlap cusk habitat, are hauled once a week. When this gear is re-hauled lobster harvesters will record the fate of the cusk in the marked trap, i.e. alive, dead, not present, bones only. Barotrauma treatment methods will be tested with a two-fold purpose: (1) to validate a condition index, in development, for preliminary assessment of cusk; and (2) to confirm the validity of the treatment on cusk. We have secured some funds from the University of Maine's Sustainability Solution

Initiative (SSI) program for this work and have also submitted a research proposal to continue this study.

Based on preliminary data we have collected (Figs 4, 5 and 6), it appears that physical trauma from captivity combined with barotrauma affect the overall condition of the fish when surfaced. It is thought that this overall condition will affect whether the fish have the capacity to survive recompression. We plan to test this anecdotal evidence by developing a condition index based on the practicality of execution by commercial lobster harvesters. Reflex action mortality predictors (RAMP) are one possible method to evaluate the overall condition of the fish; this will test automatic reflexes such as opercula flare, tail curl, or biting response. Another possible method will be derived from the Canadian Department of Fisheries and Oceans cusk condition index for barotrauma (Harris et al., 2003) which looks specifically at physical symptoms present upon surfacing.

Future development of RAMP testing will be derived from Campbell et al. (2010) who established barotrauma-reflex (BtR) modified from Davis and Ottmar's (2006) RAMP procedures. BtR scores reflect the presence or absence of a barotrauma symptom and reflex such as gag, opercula, dorsal spine, vestibular-ocular, and tail-flex (Campbell et al., 2010). An unimpaired state received zero and an impaired state received one, the score is the sum divided by the total number possible and subtracted from one (Campbell et al., 2010). Barotrauma symptoms included in the evaluation were stomach eversion, intestinal protrusion, extended abdomen to indicate an expanded air bladder, exophthalmia, subcutaneous hemorrhaging, and activity levels. The reflexes tested were an automatic gag reflex by inserting a tube to see if it would be expelled, opercula flare in an attempt to ventilate, returning the dorsal spine to the upright, defensive position after being laid down, laying the fish on its side to test vestibular-ocular response by seeing if the fish could rotate its eye to fixate on the observer, and automatic tail-flex to stimulus. A low score, close to zero, indicated less impairment while a higher score, close to one, indicated a fish with severe impairment (Campbell et al., 2010). "Higher BtR scores resulted from increased frequency of external traumas and decreased reflex responses" (Campbell et al., 2010). A RAMP index would not be this detailed for cusk as lobstermen are unlikely to incorporate this into their daily fishing routine. However, fishermen are likely to give the fish a rapid assessment to determine, in their best judgment, if the cusk would survive. Currently, lobstermen believe that an everted stomach is indicative of death for cusk. This seems to not be the case based on anecdotal accounts from lobster harvesters. The development of a standard for fishermen to base an assessment of cusk on could potentially increase the chance of survival of individuals that might otherwise thought to be dead already. The success of the potential index will be validated utilizing recompression experiments as the predominately accepted method for relieving barotrauma (Brown et al., 2010).

Further investigation of cusk following recompression is the next step in determining if utilizing lobster traps is beneficial to the survival of incidentally caught cusk. Video monitoring of traps will be used to examine fish behavior in the traps. For fishing locations where volunteer lobstermen have had recent interactions with cusk, an observer will accompany them on fishing trips to deploy the camera. An un-baited trap will be rigged with the camera as well as a white light because cusk behavior seemed to be unaffected by white light. (Rountree and Juans, 2010). The trap for videography will not be attached to commercial fishing gear but instead will be a stand-alone trap with its own marker for easy retrieval and to not be mistaken for commercial gear. A GoPro Hero 3 camera will be used with an aluminum deep water housing made by Cam-Do rated to 4000psi, or the equivalent of 3000m, with independent light sources rated to an equal depth . To preserve battery life time lapse shots will be taken using an aftermarket SD card incorporated into the Cam-Do deep water housing that turns the camera on and off for each picture taken. The normal battery life for a GoPro Hero 3 is four hours, continuously running, the aftermarket SD card is expected to significantly increase the battery life depending on the frequency of photos being taken.

Participating lobstermen have described a practice similar to venting where they use the baiting tool to deflate the stomach. Fishermen who have reported this practice indicated that the fish swam away and sometimes they find cusk with a scar on the stomach indicative of this practice. Despite deflating the wrong organ and utilizing a tool that could introduce infection, the idea of venting already exists in the fishing community to a certain extent. However, because of complexity of this procedure and lack of resources in our project, we will be focused on the recompression treatment. Venting practice, which may require a lot of more resources (e.g., tagging) and different treatments (e.g., venting positions and durations), may complicate this study and should be explored in a separate study.

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