Technical Reports

Massachusetts Division of Marine Fisheries
Technical Report TR-69

Characterization of Fishing Activity and Trap Loss in the Massachusetts Recreational American Lobster Fishery

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Charles D. Baker, Governor
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Ronald S. Amidon, Commissioner
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David E. Pierce, PhD, Director

Abstract: Recreational lobster fishing is a coastal activity that many Massachusetts residents and visitors enjoy each year. In 2015, the Massachusetts Division of Marine Fisheries (DMF) issued 6,842 non-commercial lobster permits and more than half of them were reported as fished. Participants reported setting nearly 19,000 traps and spending 21,500 hours diving to capture the benthic crustaceans for personal consumption. Although participation is high, little information has been collected to characterize how the fishery is carried out. Due to the ongoing concern of ghost fishing by derelict gear, more specifically the mortality of American lobster (*Homarus americanus*) and other marine species caught in lost or abandoned traps, DMF implemented a survey in 2015 to better understand recreational lobstering trends. Results from 1,429 survey responses (roughly 33% of permit holders) elucidated seasonality of effort, gear configurations, trap loss rates, participant experience, and interest in pertinent educational topics. Annual trap loss in the recreational fishery was estimated at 26% of traps fished. Limited experience with proper gear rigging and frequent conflict with recreational vessel traffic may be factors contributing to gear loss in recreational sector. Importantly, nearly all survey respondents were interested in education that could reduce unintentional trap loss and improve compliance with fishery regulations, including instruction on proper gear use and background on lobster biology and conservation measures. DMF has produced video tutorials and informational guides to address this need, and the agency continues to develop strategies to reduce ghost fishing and improve Massachusetts' marine resources for all stakeholders.

Introduction

The accumulation of accidentally lost and intentionally abandoned fishing gear in marine waters is a global problem common across many gear types and fisheries. Lost nets tend to fish indiscriminately, while pots and traps target marine crustaceans and benthic fishes (Bullimore et al. 2001). This 'ghost' gear in the marine environment is pervasive, with high rates of trap and gear loss in many of the world's crustacean fisheries.

Traps in many fisheries are often concentrated within accessible coastal waters and are left unattended for the duration of the soak time (Smolowitz 1978a). As a result, traps and their associated lines and buoys are subject to factors that can increase their likelihood of becoming lost including vessel traffic, vandalism, extreme tidal events, and storms (Carr and Harris 1997, Macfadyen et al. 2009, Scheld et al. 2016). Trap composition typically influences longevity, whereby modern traps constructed from durable materials fish longer but when lost can persist in the environment and cause damage to seafloor habitats for many years (Bullimore et al. 2001, Brown and Macfadyen 2007, Cochrane and Garcia 2009, Arthur et al. 2014).

Contrary to popular belief, derelict traps often continue to catch target and non-target species well after the original bait source is gone. Trapped organisms die in and cyclically self-bait the traps (von Brandt 1984, Havens et al. 2008) in a phenomenon known as ghost fishing, which can result in local fishery declines (e.g. blue crab in the mid-Atlantic, Guillory 1993; Dungeness crab in Alaska, Antonelis et al. 2011; black sea bass in Virginia, Bilkovic et al. 2014). Even animals that are able to escape may experience sublethal effects of stress and injury and later die (Morgan and Chuenpagdee 2003). Together, these losses are difficult to quantify and account for in stock assessment models. In addition to reduced resources, socio-economic impacts of ghost fishing include the costs of replacing lost gear, reduced efficiency of adjacent actively-fished gear, and time spent mitigating entanglements in derelict gear (Anotonelis et al. 2011, Scheld et al. 2016). Ghost gear may also contribute to marine animal entanglements (MacFadyen et al. 2009).

In the northwest Atlantic, only a few studies have looked at the effects of ghost fishing by lost traps, as there is a perception that these traps have little impact (Macfadyen et al. 2009). Traps used to target crustacean species in US waters are generally designed with degradable components (e.g., escape panels, rot cords, or twine, jute, or wood used in trap construction) which are expected to release and prevent continued fishing. However, the time period until the gear becomes inactive varies from months to years depending on gear type and its condition upon loss, and on characteristics of the local environment including water temperature, and presence of fouling organisms (MA DMF 2012, Arthur et al. 2014, PCCS 2014, Butler and Matthews 2015). On popular fishing grounds, the quantity of lost or abandoned gear found to be capable of fishing often exceeds what would be predicted using anticipated breakdown times, even if degradable releases are installed properly (Arthur et al. 2014, Butler and Matthews 2015). Under calm conditions and without exposure to air, many traps remain functional well past their expected life span, negating the intended conservation benefits of the various mandated release mechanisms (MA DMF 2012, PCCS 2014).

In the US, the America lobster (*Homarus americanus*) commercial fishery is worth more than $500-million and is predominantly fixed-gear, with more than 3.4 million traps deployed annually (ASMFC 2015). In this expansive fishery, mortality of lobster and other marine species caught in ghost traps has long been a subject of concern to fishermen, fisheries scientists, and managers, although information on impacts is scarce due to the difficulty of gathering long-term data on trap persistence and catch in lost gear. Biodegradable escape panels have been required in the American lobster fishery since 1992 (see MA Regulations (CMR) 322 Div. of Marine Fisheries, Sec. 6.02, MA saltwater lobster/crab trap requirements: http://www.eregulations.com/massachusetts/fishing/saltwater/lobstercrab-trap-requirements, accessed 3/25/19; Dept. of Marine Resources Regulations 13 188, Chap. 25.80, Lobster trap construction regulation: https://www.maine.gov/dmr/laws-regulations/regulations/documents/dmrchapter25_11242018.pdf, accessed 3/25/19; and, Code of Federal Regulations (CFR) Title 50, Chap. VI, Part 697, Subpart B, Sec 697.21, Gear identification and marking, escape vent, max trap size, and ghost panel requirements: https://ecfr.io/Title-50/se50.13.697_121, accessed 3/25/19). These rules were intended to ensure that lost traps would become disabled and stop retaining catch after 12 months. However, degradation of commonly used components (e.g. ferrous metal hog rings) is inconsistent in traps that are not brought to the surface regularly due to slower rates of corrosion at depth. Research on escape panel failure has shown that even properly configured traps, when not hauled, can continue to fish for well over two years in Massachusetts coastal waters (MA DMF 2012, PCCS 2014). When improperly/illegally configured (e.g. use of stainless steel hog rings or wire ties to hold escape panels in place), traps can fish much longer, with derelict traps as old as 11 years found intact and capable of retaining catch (PCCS 2014).

Anecdotal reports of estimated coastwide gear loss in the American lobster fishery range from 5% to 30% annually (Smolowitz 1978b, Breen 1990), with Massachusetts commercial lobstermen reporting an annual loss rate of 2 to 5% of traps fished (MA DMF 2012). Pot loss estimates in other US fisheries have ranged 8 to 18% of Dungeness crab pots fished (Muir et al. 1984, Breen 1987, Antonelis et al. 2011), 20 to 30% of blue crab traps fished (Casey 1990, Guillory et al. 2001), and around 18% of commercial spiny lobster pots fished (Butler and Matthews 2015). Rates of gear loss in the American lobster fishery are comparatively low, however the magnitude of gear in the water (i.e., number of lobster traps fished) far exceeds that of the other species (ASMFC 2015).

To date, efforts to research or mitigate derelict gear have largely focused on commercial fisheries. The recreational fixed-gear sector has generally been overlooked although participation rates in recreational fisheries can be high and may have a greater risk of gear loss due to equipment limitations and relative inexperience of its participants. In Massachusetts, approximately 7,000 to 12,000 permits were issued annually from 2000 to 2015 to fish recreationally for lobster (MA DMF 2016 unpub. data). Each permit endorses an individual (or household) to fish up to ten traps and/or to dive (SCUBA or free-dive) for lobster within state waters. The potential and realized nearshore recreational trapping effort is extensive and spatially overlaps with some commercial lobster activity. One major factor influencing loss is the inherent "part time" nature of recreational fishing, whereby traps may be left untended for extended durations. Proper tending includes regular visits to remove encrusting growth from marker buoys and traps, relocate of gear ahead of storms, disentangle lines from rocks or other obstructions, recover gear that has moved or drifted, and/or replace worn buoys, lines, and traps. Due to expense, accessibility, or lack of training, recreational participants may not have the capability (i.e. vessel, tools, or expertise) to perform these tasks as often as they should.

To begin characterizing gear loss generated in the recreational lobster fishery, the Massachusetts Division of Marine Fisheries (DMF) implemented a survey of its participants. The intent of the survey was to document recreational fishing practices including seasonality of effort, history/experience in the fishery, and the extent of gear typically fished and lost. Information obtained from participants was used to supplement existing fisheries statistics submitted by permit holders on their annual catch reports; DMF non-commercial lobster catch reports include an individual's total annual effort (number of traps and/or hours spent diving) and total annual lobster catch (number landed). Additionally, the survey was used to evaluate participants' interest in educational topics pertinent to the recreational fishery, in order to develop instructive tools that will foster responsible fishing practices and reduce the generation of derelict gear.

This work represents one of several DMF initiatives directed at better understanding, mitigating, and developing prevention strategies to reduce the impacts of ghost gear and derelict fishing, with the goal of improving Massachusetts' marine resources for all stakeholders.

Methods

Three sources of data were examined to characterize trends in the Massachusetts recreational American lobster fishery: 1) non-commercial (i.e., recreational) lobster permits issued from 2000 to 2015, 2) annual catch and effort statistics reported to DMF by recreational lobster permit holders for fishing years 2000 to 2015, and 3) responses from a 2015 web-based survey of recreational lobster permit holders on recreational lobster fishing practices. Overlap in the pool of respondents among the data sets was assumed but could not be verified as participation in the web-based survey was voluntary and anonymous. Demographic data were collected on permit applications but were not asked in the recreational survey (other than years of fishing experience). Trends in recreational fishing activity reported on catch reports and through the web survey were summarized. The total number of survey responses relevant to each analysis or comparison was indicated (n=x); and error was reported as the standard error (± SE) of the mean when applicable.

Recreational Lobster Fishery Statistics (2000–2015)

A Massachusetts non-commercial lobster permit allowed holders to harvest lobsters and edible crabs in Massachusetts state waters by means of trapping (maximum of ten traps per permit), diving, or a combination of the two methods. The daily bag limit for trappers and divers was 15 lobsters, and sale of the catch was prohibited. Massachusetts General Law (Ch. 130 sec. 38b) requires recreational lobstermen to file an annual catch report by January 31 for the preceding calendar year. Permit holders reported total annual recreational harvest and fishing effort including (as applicable): 1) number of hours diving, 2) maximum number of traps fished, 3) number of lobsters taken while diving, and 4) number of lobsters taken with traps. When lobster harvest was reported as count rather than weight, a conversion factor of 1.46 pounds per live lobster was used to calculate landings, consistent with the conversion used for the commercial fishery (pers. comm. DMF Fisheries Statistics program, 2017).

Data presented in this report were based on non-commercial lobster fishery application and catch report statistics submitted as of December 2015. In keeping with DMF and Atlantic Coastal Cooperative Statistics Program confidentiality policies, any grouping of data that represented less than three individuals was not shown.

2015 Recreational Lobstering Survey

In September 2015, DMF staff notified all individuals who were issued a 2015 Massachusetts recreational lobster permit (who had a valid e-mail address on file) of the availability of an online survey on recreational lobster fishing practices. The emailed notification provided a short description of the survey and a link to the website address (Appendix 1). The survey was not

Table 1. Web-based survey on recreational lobster fishing activity available to 2015 Massachusetts non-commercial lobster permit holders.

Question 1:	How many years have you fished for lobster recreationally?
Question 2:	How do you fish for lobster (traps, SCUBA, traps & scuba, other)?
Question 3:	If you use traps, what month do you set your traps?
Question 4:	If you use traps, what month do you remove your traps?
Question 5:	If you use traps, how many traps do you fish?
Question 6:	How many traps do you lose per year?
Question 7:	If you fish traps, are they all set as singles (a buoy line on each trap), or are multiple traps attached together with a single buoy line?
Question 8:	The Division intends to enhance education programs for recreational lobster fishery participants. What topics are you interested in seeing covered (check all that apply)?
	1. Lobster life history
	2. Trap design, including escape panels and ghost panels
	3. Conservation rules, such as bag limits, size limits, and release of v-notched females
	4. Buoy line material and practical methods of rigging to avoid losing traps
	5. Marking of buoys and buoy lines
	6. SCUBA rules

publicized aside from the emailed notification to permit holders, however it was accessible by anyone visiting the website address. Participation was entirely voluntary. The web-based survey platform "SurveyMonkey" (www.surveymonkey.com, ©1999-2016) hosted the survey and was used to collect responses.

A total of 4,327 e-mail notices were sent to the 2015 permit holders, after duplicate and undeliverable e-mail addresses (n=393) were removed. This represented 63% of all 2015 recreational lobster permit holders (n= 6,842). While the e-mail method did not reach all recreational permit holders (those without an e-mail address on file were not notified via other means by DMF), it provided a timely and cost-effective approach to survey distribution and data collection and appeared to reach a majority of the 2015 recreational lobster fishery participants.

The online questionnaire comprised the eight ordered questions given in Table 1. Open-ended responses were collected for six of the questions (#1, 3, 4, 5, 6, and 8), selections from drop-down lists of predetermined responses were collected for three of the questions (#2, 7, and 8), and both options to respond were provided for the last question (#8). The survey did not reference a specific timeframe, thus interpretation of fishing patterns was assumed to be generalized across years with the expectation that recent fishing seasons would be more prone to recall by respondents.

The survey was accessible for approximately five months from September 29, 2015 to March 1, 2016. DMF staff accessed and retrieved the raw data from the survey platform, then analyzed and interpreted the responses.

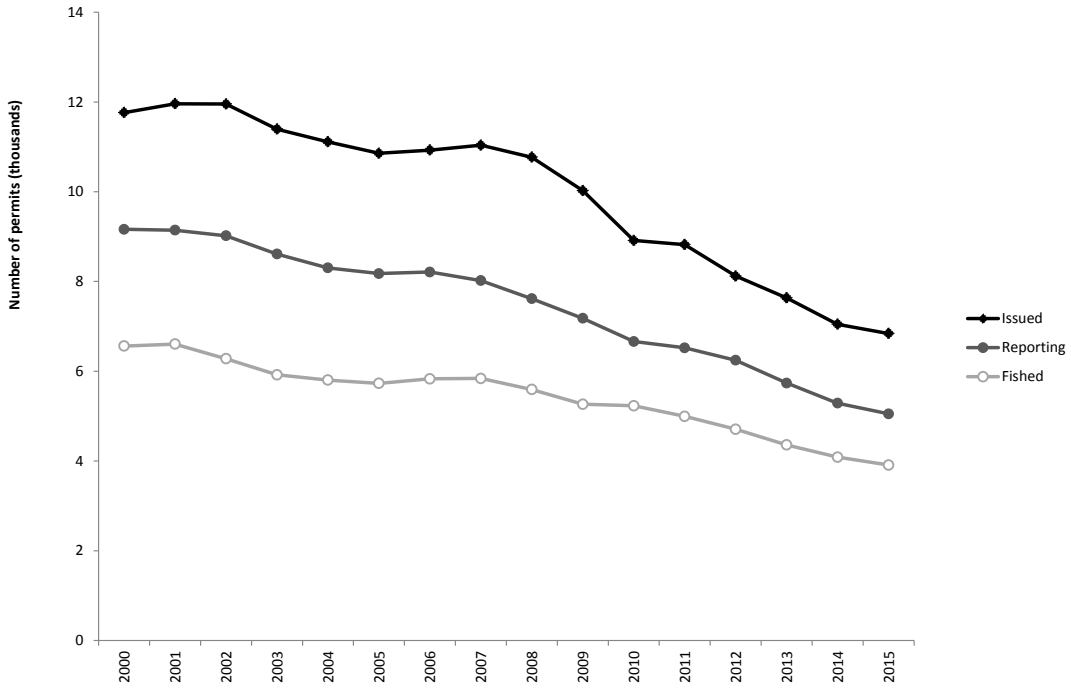

Figure 1. Permit information for the Massachusetts recreational lobster fishery, 2000–2015. 'Reporting' represents permits reported as 'fished' or 'did not fish' (combined).

Table 2. Permit information for the Massachusetts recreational lobster fishery, 2011–2015.

	2011	2012	2013	2014	2015
Issued	8,822	8,121	7,635	7,046	6,842
Fished	4,995	4,708	4,358	4,086	3,911
Did Not Fish	1,527	1,537	1,379	1,203	1,140
Did Not Report	2,300	1,876	1,898	1,757	1,791

Results

Recreational Lobster Fishery Statistics

The number of Massachusetts recreational lobster permits issued declined by 42% over the fifteen year period from 2000 to 2015 (Figure 1). While permit fees remained unchanged from 1989 to 2014, a fee increase (from $40 to $55 for residents and $60 to $75 for non-residents) from 2014 to 2015 was coincident with a slight downtick (1%) in permits issued. This reduction was not out of trend with the decline seen across the time series.

Twenty-six percent of recreational permit holders failed to file a catch report in 2015, consistent with the reporting rate observed from 2011 to 2015 (Table 2, Figure 1) and the 75% reporting rate characteristic of this fishery (Dean 2010). Although number of permits issued declined over the time series, the portion of permits reported as fished (versus not fished) increased from 72% in 2000 to 77% in 2015 (average of 73% across the time series; Table 2, Figure 1).

Beginning in 2010, recreational permit applicants were asked to designate the DMF Statistical Reporting Area (SRA) where they intended to set the majority of their non-commercial lobster traps; SRAs 1 through 14 include all waters under the jurisdiction of the Commonwealth of Massachusetts (see permit application, Appendix 2). In 2015, 100% of permit holders specified the area that they intended to fish. By SRA, the greatest number of recreational harvesters indicated that they planned to fish around Cape Ann (SRA 2), in Boston Harbor to Cape Cod Bay (SRAs 4–7), and in Buzzards Bay (SRA 14) (Figure 2). Slightly fewer reported that they would fish in the other inshore areas, including around the north shore (SRAs 1 and 3) and east and south of Cape Cod (SRAs 9, 10, 13). The fewest number of harvesters specified that they would fish in offshore state waters (outer Cape Cod Bay, SRA 8; or south of the Islands, SRAs 11 and 12). These results approximate activity by area, as permit holders were neither limited to fishing within the area specified, nor asked to report ultimate fishing area on catch reports.

Trapping (exclusively) represented the most common strategy to capture lobsters under the recreational permit, with an increasing trend throughout the time series from 40% of the 6,562 active permit holders in 2000 to 52% of the 3,911 active permit holders in 2015 (Table 2, Figure 3). The combined method of 'trapping and diving' was the second most common designation,

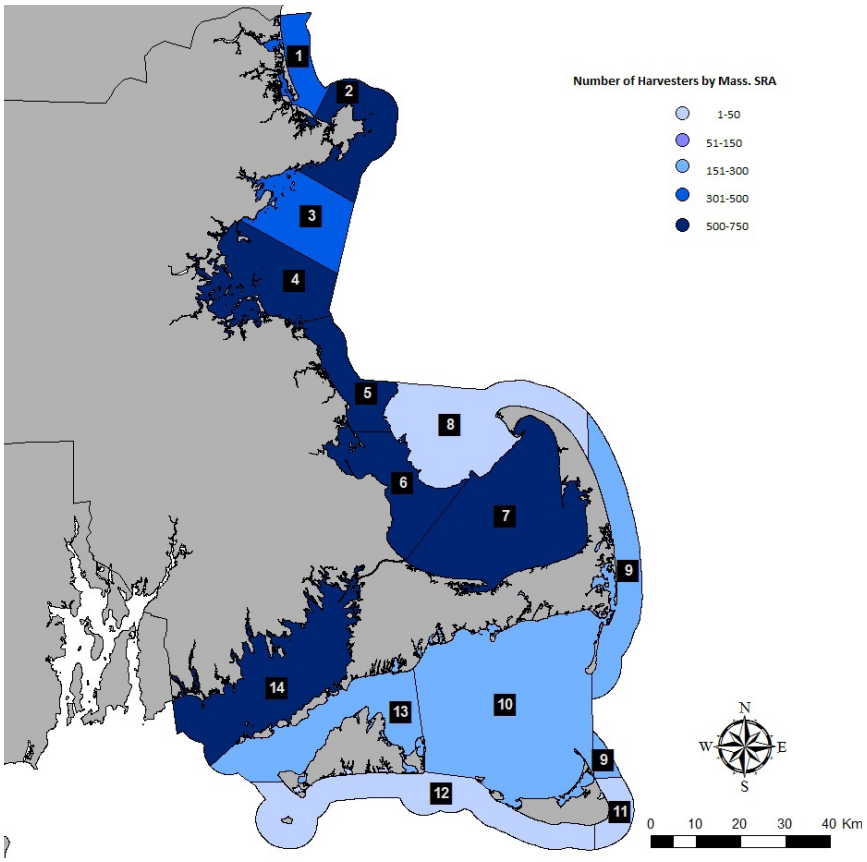

Figure 2. Number of 2015 permits holders designating each of the DMF Statistical Reporting Areas (SRA) as the area they intended to set the majority of their non-commercial lobster traps on permit applications.

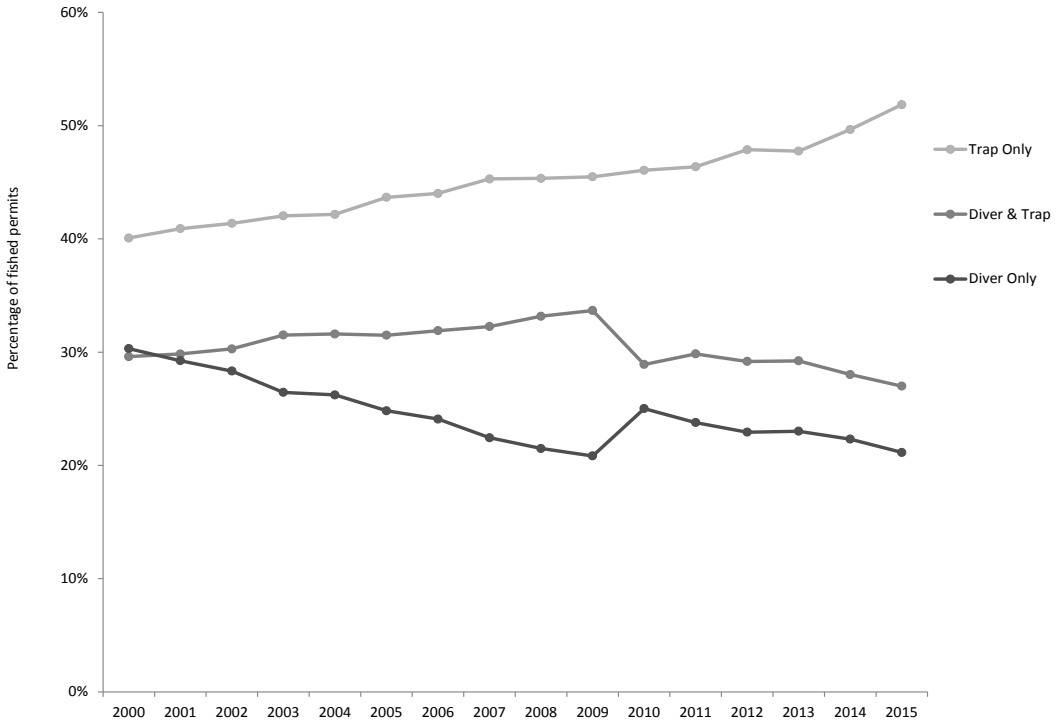

Figure 3. Percentage of total fished permits by method of capture (trap only, trap and diver, or diver only) designated on an individual's catch report in the Massachusetts recreational lobster fishery, 2000–2015.

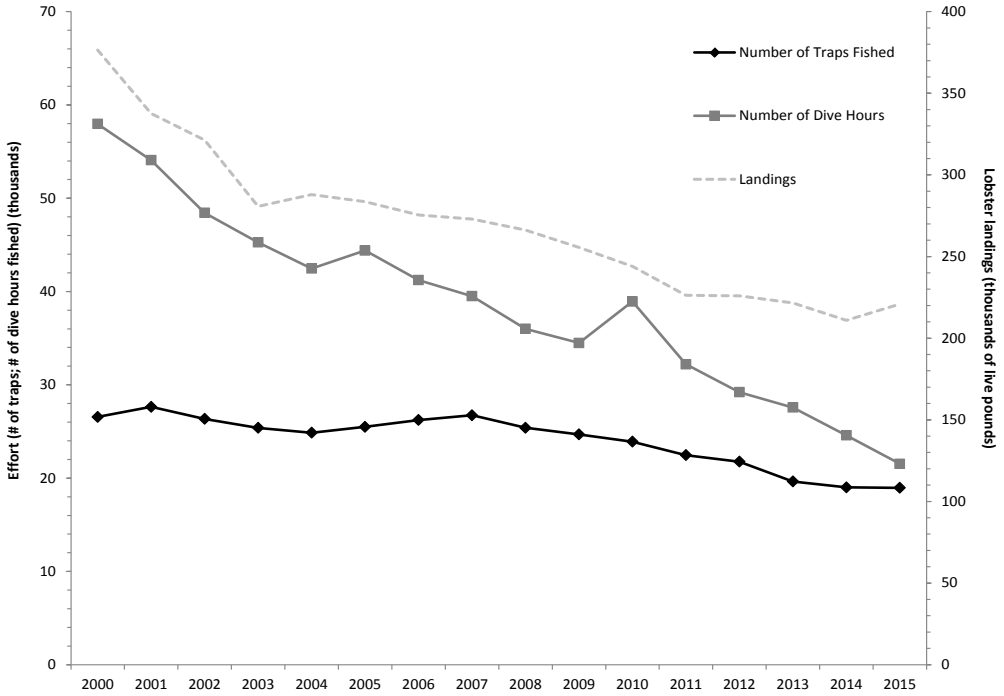

Figure 4. Effort (total number of traps and total number of dive hours) and landings (live pounds) reported in the Massachusetts recreational lobster fishery, 2000–2015. Landings were estimated using an average lobster weight of 1.46 lb/lobster to convert count to live pounds.

Table 3. Reported catch and effort information in the 2015 Massachusetts recreational lobster fishery. Permits reporting includes those reported fished and not fished.

	Trap Only	Diver & Trap	Diver Only	**Total**
Permits Reporting	2,536	1,431	1,084	**5,051**
Traps Fished	13,913	5,041		**18,954**
Hours Diving		7,129	14,403	**21,532**
Pounds of Lobster*	140,074	61,981	18,809	**220,864**

*estimated using average lobster weight of 1.46 pounds

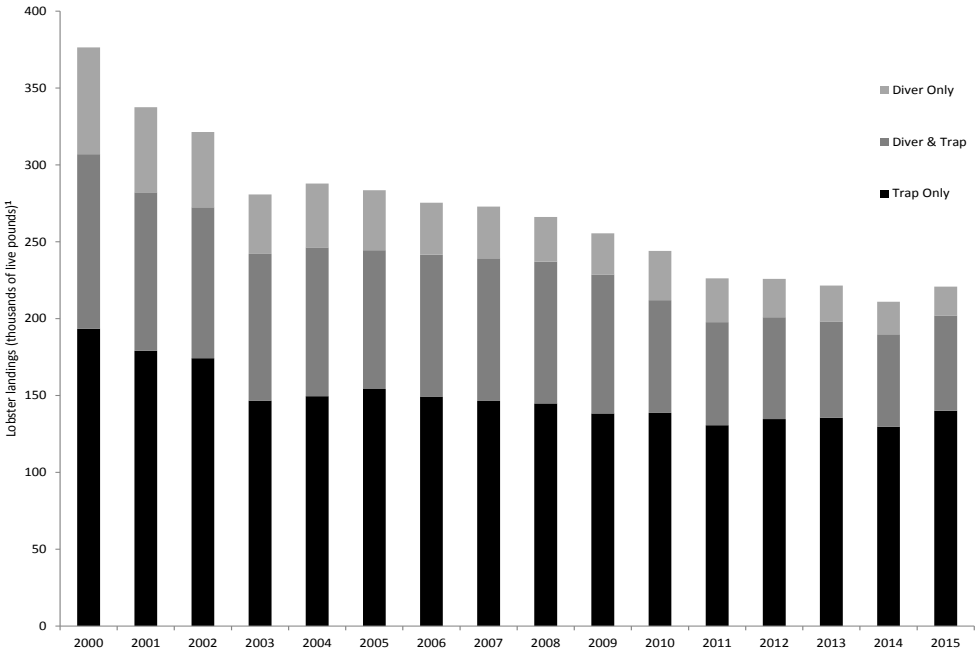

Figure 5. Lobster landings (live pounds) by reported method of capture in the Massachusetts recreational lobster fishery, 2000–2015. Landings were estimated using an average lobster weight of 1.46 lb/lobster to convert count to live pounds.

employed by an average of 30% (± 0.5) of active participants from 2000-2015 and 27% in 2015. Thirty percent of permits were fished by diving only in 2000; participation by this method decreased over the time series to 21% in 2015 (Figure 3).

Both effort and catch of lobsters declined from 2000 to 2015. From 2000 to 2002 annual recreational catch averaged 345,123 lb (±16,349) landed by 6,482 fishermen (± 102). This decreased steadily to a time series low in 2014 with 210,961 lb landed by 4,086 fishermen. Landings were slightly higher in 2015, at 220,864 lb from 3,911 active fishermen (Table 2, Table 3, Figure 1, and Figure 4). Over the time series, the total number of traps reported fished decreased by 29% and the total number of hours diving for lobster declined more rapidly, by 63% (Figure 4). In 2015, permit holders reported fishing 18,954 recreational traps and diving for 21,532 hours for lobster (Table 3, Figure 4).

A majority of the 2015 recreational lobster catch was landed using traps (63% trap-only; Table 3, Figure 5). Dive-only harvest represented 8% of the 2015 catch and about 13% (± 0.6) of total pounds across the time series. On average 31% (± 0.6) of landings were from the combined designation of 'traps and diving' across the time series and 28% of the 2015 catch (Table 3, Figure 5).

2015 Recreational Lobstering Survey

DMF received a total of 1,429 anonymous responses to the recreational lobster survey, representing a response rate of 33% of the 4,327 permit holders who were sent an e-mail invitation. Twenty-five of the returned sur-

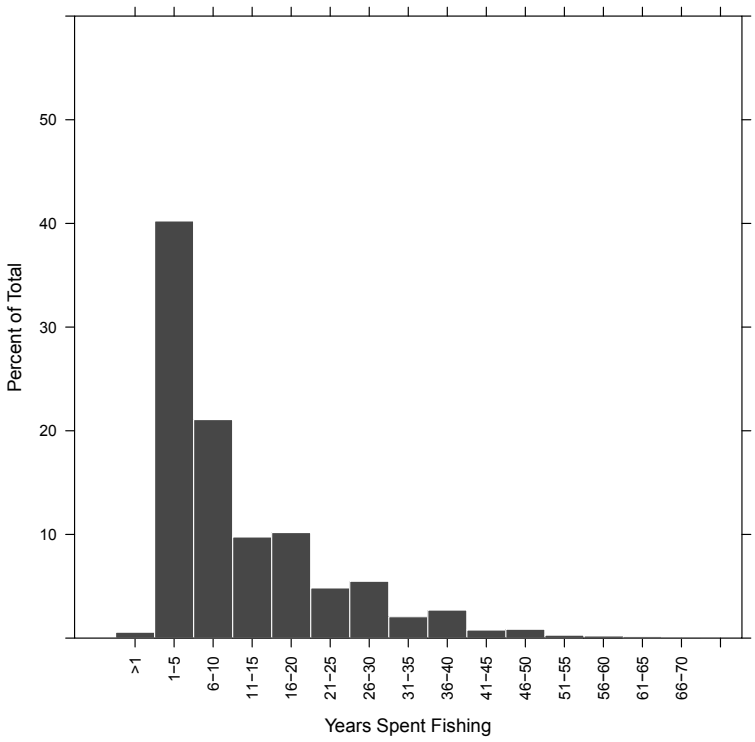

Figure 6. Years of fishing experience, in five-year increments, by percentage of total respondents from the 2015 Massachusetts recreational lobster survey (n=1,393).

veys were excluded from analysis as respondents did not provide an answer to any of the questions or stated having had no recent fishing activity. The remaining 1,404 surveys were used in further analyses. Respondents were assumed to have actively fished in 2015 unless otherwise noted in an individual's comments. This occurred in less than 1% of responses, where nine individuals specified they had not fished in 2015 yet provided effort information; these data were maintained for analysis. Ninety percent of surveys were completed in the first month that the survey was active, with the majority of responses obtained within two days of the invitation.

Fifty-six percent of survey respondents fished for lobster exclusively with traps, 31% exclusively used diving, and 12% used both traps & diving (n=1,402). One respondent did not provide a method, and one other reported fishing for lobsters using other means. Three respondents indicated that they primarily target crabs (blue crab and unspecified spp.) rather than lobsters. Variations in the interpretation of "diving" were commented out by several respondents. Twenty-three individuals noted that they skin dive instead of using SCUBA and five people reported a combination of skin diving and using traps. Respondents may have provided clarification because the online survey referred specifically to SCUBA, while the permit application does not limit the definition of diving. All methods of diving were categorized as such for analyses.

For experience in the fishery, participants reported that they had fished recreationally for lobster for a median of eight years, with responses ranging from zero (i.e., first-year participants) to 65 years (n=1,393; Figure 6). Just over 40% reported five or less years of experience, with another 21% having up to ten years (Figure 6). Those who fished exclusively traps had a median of six years of experience (range 0–65 years, n=787). Those who both trapped and dived had a median of 15 years of experience (range 0–56 years, n=169). And, those who solely dived reported a median of 10 years of experience (range 0–64 years, n=435). Eleven respondents did not provide information on fishing experience and two respondents did not provide fishing method.

To gauge seasonality of recreational trapping in Massachusetts, responses from those who trapped and those who trapped and dived were combined. On average, individuals kept traps in the water for a duration of 4.9 (± 0.1) months per year (n=908). Many individuals reported setting out in May or June and removing traps in September or October; however, the range of effort was widespread with set-month varying from January to October (n=920) and retrieval moth from March to December (n=908) (Figure 7a). Fishing activity peaked

in July and August, with 95% of respondents having traps in the water during those two months (Figure 7). Less than one-percent of respondents (<1%) fished in the winter months of January or February (Figure 7).

Of respondents who fished traps, the gear configuration of one trap per buoy line (i.e., singles) was strongly favored (95% of respondents) over multiple traps per buoy line (i.e., pairs or strings/trawls; 2% of respondents) (n=942). Three percent of trap fishers did not indicate gear configuration.

Thirty-four percent of respondents fished the permitted limit of ten traps (for regulations, see: https://www.mass.gov/service-details/recreational-saltwater-fishing-regulations#recreational-lobster-regulations, accessed 3/25/19) (n=923; Figure 8). Most participants (66%) fished fewer than ten traps, with five traps being the second most common (13%) response, after ten. On average, individuals fished a total of seven (± 0.01) traps each regardless of whether they fished singles (ave. 6.8 ± 0.6) or pairs/trawls (ave. 7.1 ± 0.1).

On the topic of gear loss, 74% of recreational fishers reported losing at least one trap annually (n=902). Reported loss ranged from zero to ten traps, with an average of 1.7 (± 0.1) traps lost per individual per year (Figure 9a). The 1.7 traps lost represent 26% (± 0.8) of the average number of traps that participants reported having fished (Figure 8). Individual losses ranged from zero to 200% of traps fished in a year (Figure 9b). Gear losses over 100% were reported by four individuals who fished fewer than five traps, thus presumably explained as the loss of replacement traps within a fishing season. Loss rates were similar for the two gear configurations, where 26% (± 1) of traps set as singles and 24% (± 7) of traps set as pairs or trawls were lost per year (n=902). Only 2% of respondents fished more than one trap per buoy line so confidence in this comparison is limited.

When asked about interest in educational programs, responses varied but 91% were interested in at least one of the subject matter areas suggested in the survey (n=1,404; see Table 1, Question 8). Trap design (including escape/ghost panels), rigging of gear to prevent gear loss, and marking of buoys and lines were of interest to 39%, 43%, and 32% of respondents, respectively, indicating that those topics should be covered in available educational resources (Figure 10). Over half of participants also wanted to learn more about lobster life history and lobster conservation rules (e.g., bag limits, size limits, release of v-notched females), 55% and 51%, respectively. Several general themes were described in the write-in field, including further education on: 1) how to avoid gear conflict with commercial fishers or divers, 2) handling/dealing with ghost gear, 3) shell disease, and 4) how to target, capture, or hold lobsters. Designated method of fishing reflected an individual's preferred topics, as trap fishermen were more likely to be concerned with trap configuration, while divers were more interested in SCUBA-specific rules (Figure 10).

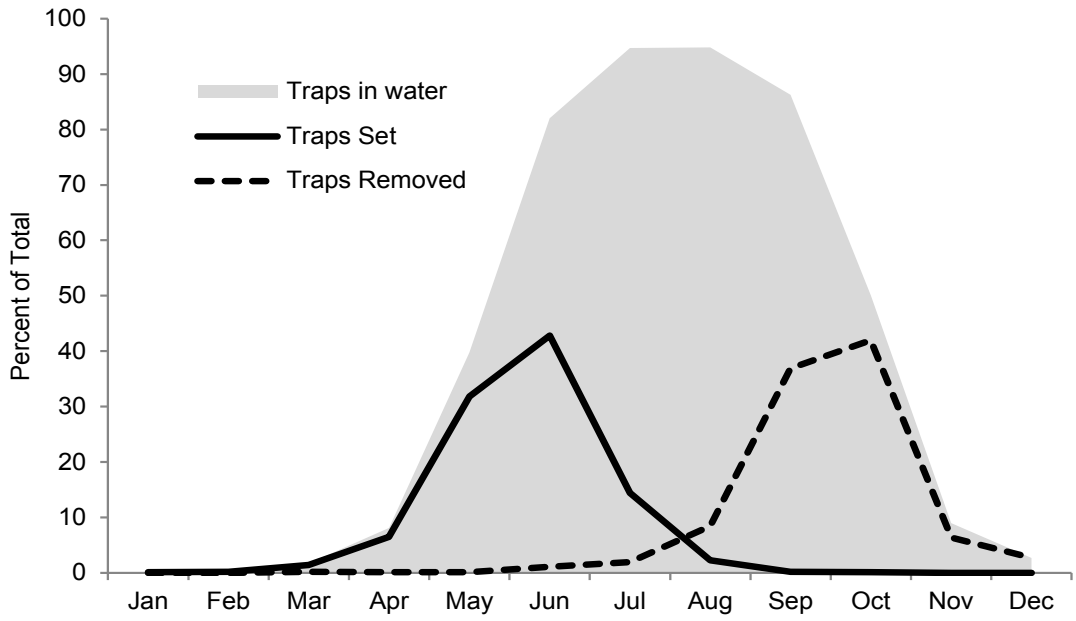

Figure 7. Seasonality of fishing (gray area) determined from the month traps were reported set (solid line; n=920) and removed (dashed line; n=908) by percentage of total respondents from the 2015 Massachusetts recreational lobster survey.

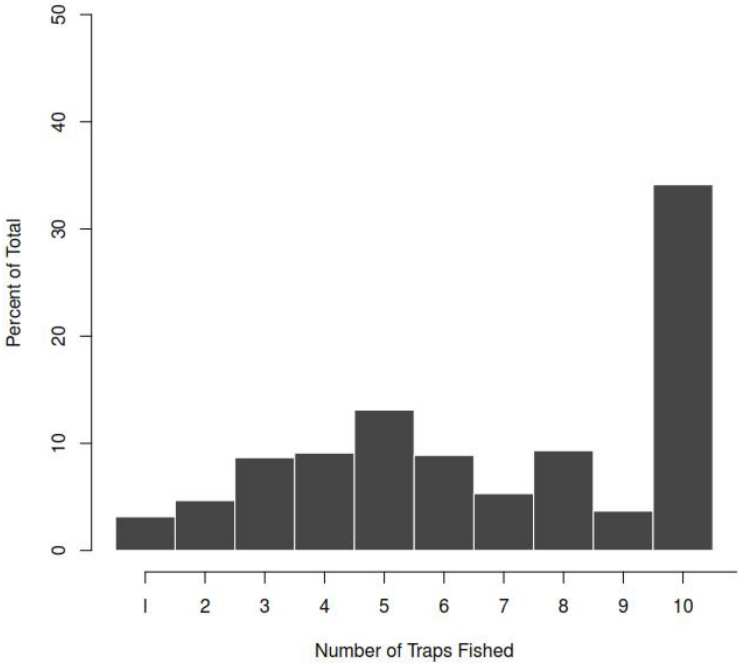

Figure 8. Number of recreational lobster traps fished (from 1 to 10) per individual, by percentage of total respondents from the 2015 Massachusetts recreational lobster survey (n=923).

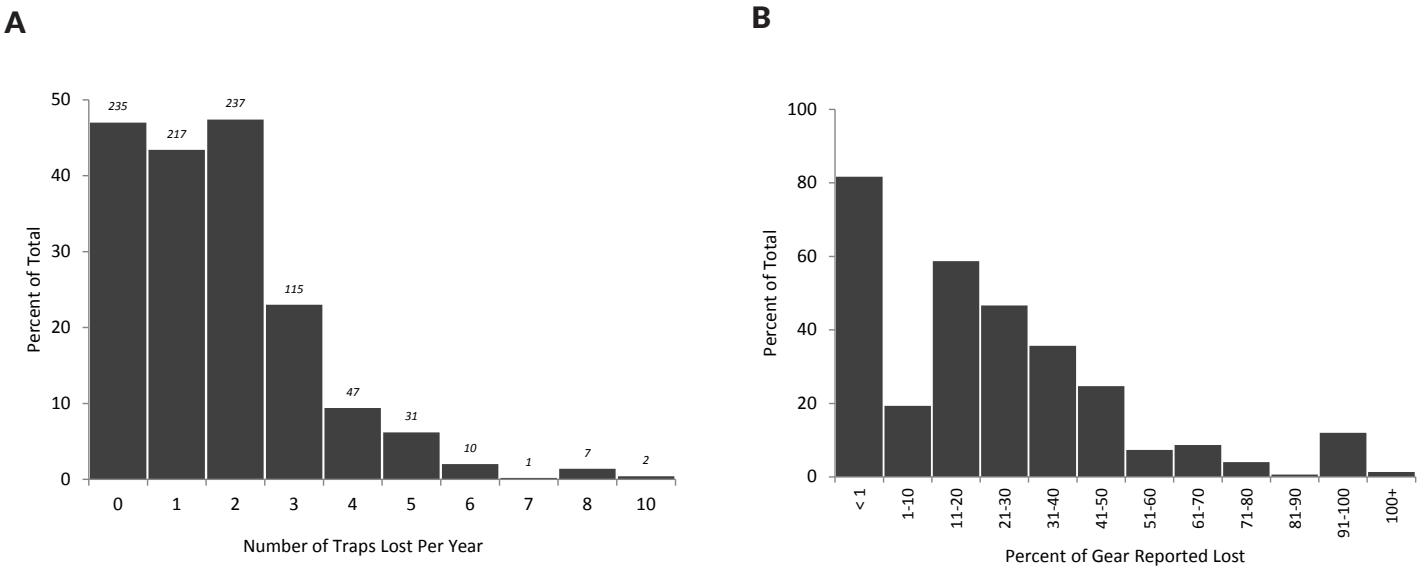

Figure 9. Number (A) and percentage (B) of recreational lobster traps reported lost per individual per year, by percentage of total respondents from the 2015 Massachusetts recreational lobster survey (n=902). Note: number of respondents per category indicated (A); percent of lost traps (B) was determined from number reported fished and lost.

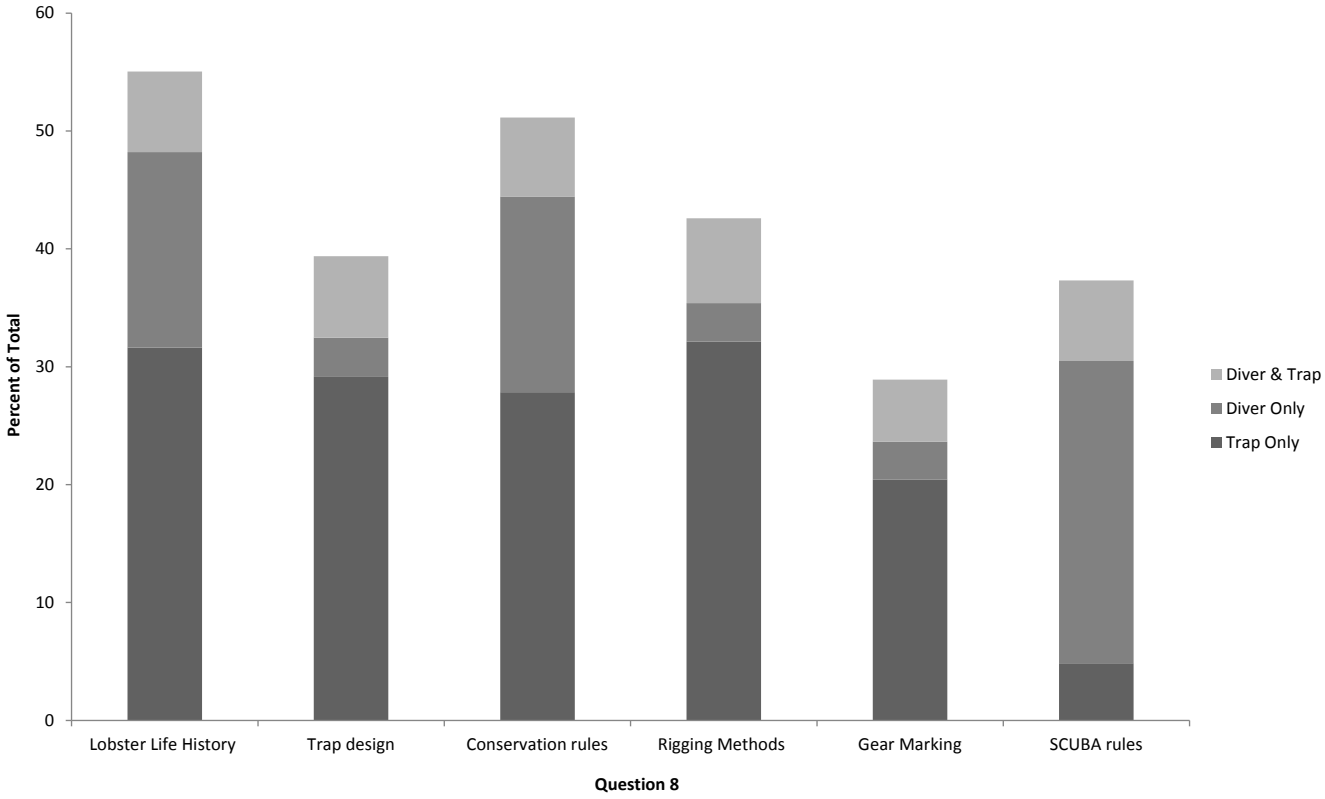

Figure 10. Percent of respondents (by fishing method) reporting interest in educational topics pertinent to recreational lobstering, from the 2015 Massachusetts recreational lobster survey (n=1,404). See Table 1, Question 8 for full description of each educational topic.

Discussion

Effort in the Massachusetts recreational lobster fishery has declined over the last decade, however in 2015 alone, more than 6,800 permits were issued and over 220,000 pounds of lobster were landed. Over three-quarters of the active 2015 permit holders set a total of nearly 19,000 traps in Massachusetts coastal waters. Although this is only about 5% of the commercial trap effort in the state (377,939 commercial traps reported fished 2015), the recreational sector becomes significant when considering concentrations of fixed gear near shore. Damage or loss of gear is likely to be higher along the coastline as a wide variety of interests compete for space especially in summer months.

Rough calculations from catch data indicate that on average, each recreational trap fished in 2015 caught a total of 10 pounds of lobster (or seven whole lobsters using the conversion factor) for the season. Also in 2015, 1.3 pounds of lobster (or less than one whole lobster using the conversion factor) was landed for every hour of dive time. While these catch rates seem reasonable for active participants, self-reported catch information is subject to recall error inherent with post-season reporting. Information on the number of trap-hauls or trips taken per year are not collected at this time through catch reporting but would be beneficial in assessing actual effort and understanding how often recreational gear is tended.

About 36% of the active recreational permit holders were represented in the survey, if we assume that all of the 1,404 anonymous survey participants were also those individuals who reported having recreationally fished for lobster in 2015. Using this same assumption, 39% of permitted trappers, 16% of combination trappers/divers, and 55% of divers took the survey (see Table 3 for number of permits by method). While it is not possible to confirm these response rates because the survey was anonymous, it appears that fishing activity reported in the survey generally reflected trends derived from the recreational catch reports. For example, a similar majority of survey respondents and active permit holders used traps exclusively (56% and 52%, respectively). Those who dived to capture lobsters were somewhat overrepresented in the survey (31% of respondents vs. 21% of fished 2015 permits) and those

who employed both traps and diving were underrepresented (12% of respondents vs. 27% of fished 2015 permits). With discretion, the survey responses can be used to draw conclusions about the recreational fishery.

Survey participants indicated that the recreational lobster fishery in Massachusetts is very seasonal, with the greatest effort occurring in summer and early fall. Traps are commonly set in May or June and retrieved prior to November. Seasonality of diving was not collected in the survey but this activity is expected to trend similarly to trapping, with increased outdoor maritime activities occurring during warm summer months and extended daylight hours. Very few respondents reported having gear in the water continuously throughout year, specifically in winter months. Lower effort January through March is consistent with the nearshore commercial trap fishery (MA DMF 2009), and related to factors such as unfavorable weather, limited accessibility (i.e., launch infrastructure removed in winter), reduced activity of lobster, and the seasonal trap closure in Cape Cod Bay February to April (M.G.L. c. 130 and 322 CMR Cape Cod Bay Large Whale Trap Seasonal Trap Gear Closure).

Given the timing of the recreational fishery and nearshore component of the commercial fishery, efforts to remove derelict gear would be more efficient if conducted during winter months. Other fisheries have implemented seasonal restrictions or closures to allow for cleanups within hotspots of trap activity (Guillory et al. 2001, Bilkovic et al. 2014). However, without geographic trap density information it is unclear whether this approach is warranted for Massachusetts. While the intended fishing location in a DMF statistical area has been reported on recreational permit applications since 2010, these geographic areas are too large to detect locally-relevant trap densities. Permit holders are not required to report the area in which they actually fished at the end of the season. Increasing the spatial resolution of effort data in the recreational (and commercial) fishery is a logical next step for ghost gear research. Identification of gear concentrations and their overlap with known factors for heightened loss (e.g., uncharted obstructions, conflicts with other fisheries, vessel traffic, strong currents) would be instructive for designing prevention approaches and in targeting derelict gear removal initiatives.

From the survey, we found that recreational traps are predominantly set as singles, and are lost at an average rate of 26% of the gear fished each year. This equates to two to three traps lost per ten recreational traps fished. The reported recreational loss rate is consistent with estimates from other trap fisheries, such as the blue crab fishery in some areas of the Chesapeake Bay where 20% of traps are lost annually (Bilkovic et al. 2014), and with previous estimates in the commercial American lobster fishery (Smolowitz 1978a). In the Massachusetts commercial fishery, we have found that gear configuration influences loss. Commercial lobstermen reported an annual trap loss rate of around 5% of traps for those fishing trawls (strings of three or more traps). Those who fished single or paired traps reported a substantially higher loss rate of around 20% of traps fished annually (MA DMF 2012). This rate is lower than but much closer to estimated loss in the recreational sector. The lighter weight of single and paired traps may allow gear to move further offsite in storms, and shorter groundlines may limit the success of recovery grappling as compared to longer strings of traps. Limited experience with proper gear rigging and increased buoy loss due to conflict with coastal vessel traffic may be some of the factors contributing to higher rates of gear loss in the recreational fishery.

In 2010, the estimated total number of traps lost by Massachusetts commercial lobstermen was between 7,000 and 17,000 (based on a survey conducted in 2011; MA DMF 2012). This figure, coupled with estimated recreational gear loss (26% of the 23,908 recreational traps fished) results in an estimated annual total of around 13,000 to 23,000 traps lost in 2010 in the Massachusetts lobster fishery alone. Estimated trap loss in 2015 is similar at just over 20,000 pots, derived from loss of 5% of the 325,000 commercial pots fished added to 26% of 18,954 recreational pots reported fished in Massachusetts coastal waters. These approximations are coarse but the order of magnitude indicates the significance of the ghost fishing problem to the American lobster resource, particularly when considering annual accumulation of lost traps over time as well as losses in other states.

To accurately characterize the recreational lobster fishery and understand the scale of potential gear loss, DMF should work with fishery participants to improve catch reporting compliance and enhance the accuracy and types of data collected. At present, individual trap loss are not accounted for in the permitting/reporting process. If surveys of participants are again employed to gather these ancillary data, future efforts should explore communication options beyond email, recognizing that not everyone maintains or wishes to share an email address. Surveys questions should expand upon information collected in the 2015 survey and confirm a respondent's participation in the fishery during an explicit timeframe (e.g. permit holder in 'year x'; reported catch and effort to DMF for 'year x'). This is necessary

for comparing trends across time and data sources with greater certainty and fewer assumptions.

The utility of recreational catch data would be improved if information were collected on the number of trips taken each year (for traps or diving), whether trips were shoreside or boat-based, depth and general location of fishing, where and/or when gear was lost, and suspected reason(s) for trap/gear loss (e.g., could not be relocated due to missing buoy, malicious intent, conflict, or unable to tend gear regularly). These factors could aid development of loss prevention strategies and indicate where gear loss is chronic to target ghost gear recovery efforts. Following up with individuals who did not report may increase compliance or at least identify reasons for the high failure to report (25% non-response rate) characteristic of this fishery.

Despite variability in participants' years of fishing experience (see Figure 6), nearly all (91%) indicated that they were receptive to education on topics that could result in better compliance with fishery regulations and fewer unintentional gear losses. Gear in some other trap fisheries is inexpensive and easily replaceable, and participants may be less interested in appropriate maintenance or recovery (Matsuoka et al. 2005). However, initial investment in the American lobster fishery is substantial even for recreational participants, with new traps costing upwards of $75 each, retail. Thus education to reduce incidence of gear loss would be beneficial to harvesters as well as to the resource and environment. Some of the curiosities and concerns identified by participants included how to properly configure, mark, and maintain traps/buoys/line, protect their gear in storms, avoid gear conflicts and ghost gear, and target and properly handle lobsters. Training sessions or tutorials on best practices for recreational lobster fishing appear to be both necessary and desired.

DMF recently refined its existing outreach materials and developed new formats to disseminate information on recreational lobster fishing in response to this need. Regularly updated educational resources include summaries of the rules governing harvest and gear configuration posted on DMF's website (https://www.mass.gov/service-details/recreational-saltwater-fishing-regulations#recreational-lobster-regulations, accessed 3/25/19), printed in the annual Massachusetts Saltwater Recreational Fishing Guide (http://www.eregulations.com/massachusetts/fishing/saltwater/recreational-lobster-crabbing-regulations/, accessed 3/25/19), and posted on www.eregulations.com under Massachusetts saltwater fishing. For the sake of brevity these sources do not generally provide background on the intent/purpose of conservation measures, or techniques on how to ensure that your gear is compliant. In 2017, DMF published a series of videos designed to foster responsible recreational lobstering and provide participants with a more comprehensive understanding of the fishery (MA DMF 2017). The videos are available on DMF's website: ("Learn about recreational lobster harvest", https://www.mass.gov/service-details/learn-about-recreational-lobster-harvest, accessed 3/25/19), and compose eight segments, entitled:

1–Introduction to the Basics of Recreational Lobster Harvest
2–Preventing Lobster Gear from Becoming Marine Debris
3–Getting Your Recreational Lobster Permit
4–Getting Your Recreational Lobster Gear
5–Getting Ready to Lobster
6–Getting Your Lobster Pots in the Water
7–Checking Your Pots
8–Knowing Your Regulations

The video segments can be viewed individually or continuously as a tutorial. Each demonstrates best practices on an important aspect of recreational lobstering, with special emphasis on techniques to minimize gear loss and marine debris. This educational tool was developed in partnership with the Massachusetts Lobstermen's Association, Massachusetts Environmental Police, and Woods Hole SeaGrant to offer diverse perspectives and representation. The videos have since garnered extensive viewership and positive feedback. As such, DMF is currently exploring the efficacy of placing an educational standard upon the issuance of a lobster permit. For example, in the state of Maine, the permit application process is integrated with education where prospective recreational lobster participants must review a guide on lobster biology, gear configuration, and regulations and submit exam answers along with their non-commercial license application (see Lobster & Crab Harvesting Non-commercial 2019: https://www.maine.gov/dmr/commercial-fishing/licenses/documents/2019/2019%20Lobster%20Noncommercial.pdf; "A Guide to Lobstering in Maine", https://www.maine.gov/dmr/commercial-fishing/licenses/documents/2018/GuideToLobstering.pdf, and Non-commercial Lobster/Crab License Exam, https://www.maine.gov/dmr/commercial-fishing/licenses/documents/2018/Noncommercial%20Lobster%20Test.pdf, accessed 3/25/19). In Massachusetts, permit applicants may soon be asked to demonstrate knowledge of the fishery and fluency in conservation measures which can be gained through review of available materials.

The impacts of ghost fishing and marine debris are multi-faceted and not limited to any particular fishery. The results presented here may be useful to fisheries managers, fishers, and conservationists working to account for and develop strategies to reduce trap gear losses. This and other DMF projects have documented rates of trap loss and duration that derelict traps continue fishing, and have quantified unintentional harvest due to ghost traps. However, further study on the release timing of trap escape panels and on the extent, disposition, and impacts of derelict traps is warranted. The importance of loss prevention cannot be overstated, particularly when considering the high cost and low return characteristic of most derelict fishing gear clean-up efforts. DMF continues to develop approaches to understand and reduce ghost fishing to improve Massachusetts' marine resources for all stakeholders.

Acknowledgements

Funding for development of the recreational lobstering survey and series of eight educational videos on responsible recreational lobster fishing was provided to the Massachusetts Division of Marine Fisheries through a grant from the National Fish and Wildlife Foundation's Fishing for Energy Fund in 2015, for the project "Reducing derelict gear through educational tools for the recreational pot fishermen (MA)", NFWF Project ID 0304.15.049238. DMF would like to thank the non-commercial lobster permit holders who voluntarily completed the online survey and provided feedback on the educational videos.

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APPENDIX 1 – E-mail notice of online recreational lobster survey from DMF to 2015 non-commercial lobster permit holders

Subject: MA recreational lobster fishery survey
Date: Wednesday, September 23, 2015 2:35:00 PM

To all of our recreational lobster fishery participants:

As the summer winds down, we hope you have had a safe, enjoyable, and productive lobster season.

The Massachusetts Division of Marine Fisheries is conducting a brief survey (link below) to learn more about recreational lobster fishing practices and to assist in improving the education and outreach to fishery participants. You have been sent this survey because you hold a recreational lobster permit. This survey should take only a few minutes of your time.

After you complete the brief survey, if you have any other comments or concerns about the sport of recreational lobster fishing, feel free to send them to the Division's general email: marine.fish@state.ma.us.

Click here to begin the survey.

Your participation is greatly appreciated!

MarineFisheries
Commonwealth of Massachusetts

Form DMF-RL1

Recreational Lobster Fishing

Permit Application Form

Instructions: This form may be used to apply for or renew a recreational lobster permit. Please provide all requested information. Incomplete forms may result in the delay of permit issuance.

Section 1.

Applicant Information			
Last Name:	**First Name:**	**MI:**	**Suffix:**
Date of Birth:	**MA Resident:** ☐**Yes** ☐**No***	**US Citizen:** ☐**Yes** ☐**No***	

Residency Address		
Street 1:		
Street 2:		
Zip code:	**City:**	**State:**

Mailing Address (if different than above)		
Street 1:		
Street 2:		
Zip code:	**City:**	**State:**

Other Information (*required)	
***Phone #:**	**Cell Phone:**
e-mail address:	

*Additional restrictions apply for Non-Resident and Non-US Citizens. See other side of this form.

Section 2. Please select the type of permit you are applying for and complete requested information:

☐ Resident: $55 fee ☐ *Non-Resident: $75 fee (see other side of form)

Check Here ☐ if **DIVING**
Check Here ☐ if Using **POTS**, and List your Buoy Colors:_____ _____ _____
(choose up to three colors)

Pots Use Question: When using pots to harvest lobster, where will most of your non-commercial lobster fishing activity take place? Select only **ONE** area from the map on the back of this form, and write the corresponding number for your Area of Lobster Harvest here:..... ☐

Section 3. Complete this catch report only if you held a non-commercial permit in the previous year

Recreational Lobster Catch Report			
Number of hours diving for lobster:		Maximum number of pots used:	
Number of lobsters taken by diving:		Number of lobsters taken by pots:	

Section 4. Certification/Signatures

I certify under the pains and penalties of perjury that all information contained in the application is true and accurate to the best of my knowledge and belief.

Applicant:_____ _____
(Signature of applicant) Date

Parent or Guardian:_____ _____
(Parental or Legal Guardian consent needed if child is under 17 years old). Date

Purchase your Recreational Permits On-Line!

You can purchase your non-commercial lobster permit at: **http://www.mass.gov/massfishhunt**

- To log in to the system, you will need to use the 3rd 'search' option on the webpage and enter your last name, DOB and first name as they appear on the front of this renewal application.
- If your information page needs to be updated, you can hit the 'Edit Customer Information' link at the top of the page. If your information is correct, hit the "Enter Sales" button, and select the "Recreational Lobster" link.
- Answer all required questions. Submit your credit card information, and print your permit from your home computer.

Division of Marine Fisheries (617)626-1520

RESIDENCY REQUIREMENTS FOR NON-COMMERCIAL LOBSTER PERMIT

1. Non-resident of Massachusetts, but citizen of U.S. needs:
   a. To be temporarily residing in a Mass. coastal town
   b. To own more than $5,000 worth of real estate in Massachusetts as confirmed by tax records.

2. Non-U.S. Citizen, but a resident of Mass. needs:
   a. To have an alien registration card from the I.N.S.
   Note: If permit is handled by mail, i.e. application is mailed to DMF, aliens must attach a copy of their I.N.S. registration card.

3. Non-U.S. Citizens and Non-Mass. residents need:
   a. To be temporarily residing in a Mass. coastal town
   b. To have an alien registration card for I.N.S.
   c. To own more than $5,000 in Mass. real estate as confirmed by tax records.

NON-COMMERCIAL NON-RESIDENT LOBSTER PERMIT AFFIDAVIT
(Must be Notarized)

M.G.L. c. 130, s38 requires that **non-residents of Massachusetts** complete BOTH of the following statements to be eligible for a non-commercial lobster permit:

I, _____, do hereby depose and state the following:

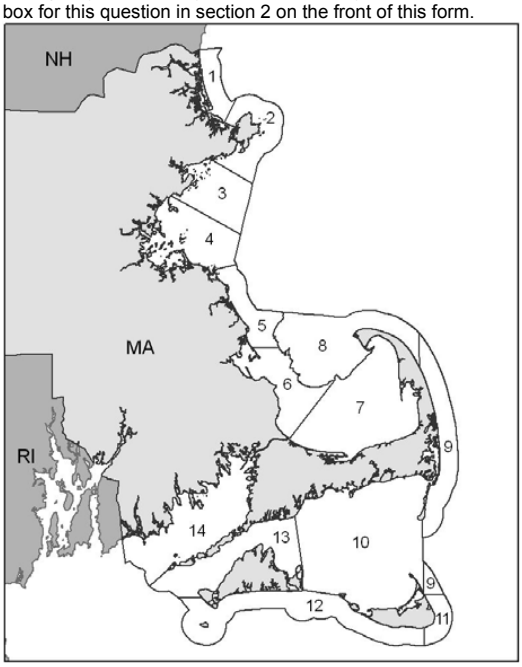
1. I own more than five thousand dollars in real estate within the Commonwealth of Massachusetts in the city or town of _____, MA as determined by tax records.
2. I am a non-resident of the Commonwealth of Massachusetts and a citizen of the United States, temporarily residing or intending to temporarily reside in the Massachusetts coastal city or coastal town of _____, MA.

Signed under the pains and penalties of perjury this _____ day of _____, 20_____.

Applicant's signature:_____

Use this map to answer the **Pots Use Question** in Section 2 on the front of this form.

Where will the majority of your non-commercial lobster fishing activity take place? This includes lobster harvest by Pot fishing only. Select only 1 area, and write your selection in the box for this question in section 2 on the front of this form.



(Space for Notary)

Division of Marine Fisheries
251 Causeway Street, Suite 400
Boston, MA 02114