



Assessing the Feasibility of On-Demand Gear in New England Lobster Fisheries





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Executive Summary

The Massachusetts Division of Marine Fisheries (DMF) has led the way in managing lobster fisheries to be prosperous while reducing the negative impact of the fishery to protected and endangered species. DMF has done this in close partnership with industry stakeholders, conservation organizations, academic experts, and fellow agencies throughout the Commonwealth and the region. In late 2020, with funding provided by the National Fish and Wildlife Foundation through the support of Shell USA and the National Oceanic and Atmospheric Administration, DMF began work under a grant to fully engage on some of the most pressing emerging issues in lobster fishery conservation and management. DMF must balance its duties to responsibly manage the Commonwealth's public trust resources with its obligations to conserve all marine life impacted by the activities it permits. By commissioning this study to comprehensively evaluate the issues, challenges, and opportunities of on-demand fishing gear, also known as "ropeless" gear, DMF is continuing to advance the leading edge of North Atlantic right whale conservation discussions.

On-demand fishing gear is a type of fishing equipment used in some fixed gear fisheries, or fisheries that use gear fixed in place over time, to capture fish and crustaceans. On-demand fishing gear replaces traditional static, or persistent, vertical buoy lines, which can result in entanglements with marine mammals including North Atlantic right whales, with new gear retrieval and virtual marking methods. Most on-demand fishing gear systems consist of submerged buoyancy devices that are activated using time-release mechanisms or acoustic signals transmitted from the surface.

The use of on-demand fishing gear has the potential to reduce the impact of entanglement on the North Atlantic right whale population. It also represents a sea change for the fishermen who would use the gear or interact with it on the fishing grounds. This diverse and complicated set of issues warrants a thorough analysis, and the urgency of this important conservation and economic issue is motivating DMF to act quickly to advance the discussion about on-demand gear and characterize its compatibility with the Commonwealth's iconic lobster fishery.

While a great deal of work has focused on how on-demand fishing gear might be used to reduce risk to endangered marine life, this report is the first of its kind designed to evaluate how implementation of the gear would impact lobster fisheries and ocean governance across all issues from all perspectives. Using interviews with experts in the field and a two-day workshop, this report synthesizes perspectives across diverse sectors including fishermen, scientists, and law enforcement officials, and analyzes the operational, technological, legal & regulatory, and socioeconomic challenges and opportunities of on-demand fishing gear. This report presents these issues fully, in many cases through the words of the experts themselves. It concludes with a set of recommendations for further study and policy development work.

Using on-demand fishing gear necessitates significant changes to individual fishing operations and would likely alter operational and cultural dynamics on fishing grounds significantly. Some on-demand gear manufacturers have worked with fishermen to engineer highly reliable retrieval systems, while others are in earlier stages of design and development. On-demand fishing gear testing programs have not yet evaluated the performance of the gear in high-density fishing. This report makes the following recommendations to evaluate these operational issues:

- Continue to broaden and diversify collaborative approaches to on-demand gear engineering, development, and testing
- Fully evaluate on-demand gear performance against benchmarks set by the fishery today
- Develop and demonstrate procedures for the safe operation of on-demand gear under normal fishing conditions
- Demonstrate procedures for safe single-hand operation of on-demand gear under normal fishing conditions
- Evaluate on-demand gear rough weather performance and the potential for loss reduction
- Determine how densely on-demand fishing gear can be efficiently and effectively operated
- Develop and demonstrate effective techniques for lost on-demand gear recovery

On-demand fishing gear uses advanced technological approaches including the latest in underwater acoustic communication and may require new approaches to telecommunications, database management, and remote sensing. Technological approaches to address gear conflict across and between segments of the fishing industry are in development but have not been fully tested or are not yet mature. This report makes the following recommendations to test and evaluate new and existing on-demand gear technologies:

- Develop an open-source, interoperable underwater acoustic communication standard that minimizes impacts to marine biota
- Establish universal open-source, interoperable gear marking and location standards across on-demand gear platforms
- Develop universal open-source, interoperable standards for the integrated display of on-demand gear deployment information
- Demonstrate the performance and effectiveness of hull-mounted transducers
- Establish standards for gear detection distance
- Demonstrate the performance and effectiveness of electronic methods to avoid gear conflict
- Explore opportunities for collection of oceanographic data using on-demand gear
- Develop standards and procedures for on-demand gear telecommunication and data fields

The legal and regulatory environments in which on-demand fishing gear would operate are highly specialized and procedural. On-demand gear testing to date has occurred under experimental gear testing programs, which are likely to continue and advance, but there are numerous paths for management and permitting of the gear across jurisdictions, each with unique statutory and regulatory challenges. No matter the regulatory course, however, maritime law and issues of gear conflict are likely to be addressed in the courts, and further evaluation of the legal issues associated with on-demand gear is warranted. This report makes the following recommendations to explore the legal and regulatory issues of on-demand gear:

- Establish standards and protocols for on-demand gear testing and reporting, and implement equitable testing programs across jurisdictions
- Establish a clear regulatory pipeline/process for on-demand gear, including the assignment of regulatory responsibilities across state and federal jurisdictions
- Develop law enforcement agency standards and procedures for inspecting on-demand gear and enforcing relevant laws and regulations
- Facilitate coordination on regulatory and management issues between the New England Fishery Management Council, Mid-Atlantic Fishery Management Council, and the Atlantic States Marine Fisheries Commission

- Facilitate continued coordination between fishing industry groups for the establishment of cooperative agreements
- Develop standards and responsibilities for on-demand gear database management and address confidentiality issues
- Investigate legal and regulatory processes that would require fishing vessel operators to use systems to detect on-demand gear

Conversations about on-demand gear come at a time of accelerating change for New England fisheries. The implementation of on-demand fishing gear would have substantial and widespread economic impacts on the lobster fishery, other marine users including fisheries and other sectors, and regulatory agencies, likely costing hundreds of millions of dollars. The social implications of on-demand fishing gear are widespread, yet they are poorly characterized and are not underwritten with support systems for the health and wellbeing of individuals and communities. This report makes the following recommendations to address socioeconomic issues associated with adopting on-demand gear:

- Broaden collaborative on-demand gear development and testing efforts with fishing industry members and organizations
- Coordinate across agencies and jurisdictions to require the use of open-source standards and interoperable platforms/systems to prevent monopolies, reduce costs, and disincentivize fishing fleet consolidation
- Develop gear acquisition pipelines for the retail market
- Demonstrate the scalability and integrability of on-demand gear, including use and acquisition, across sizes/locations/harvester demographics
- Initiate and complete comprehensive socioeconomic studies and cost-benefit analyses of on-demand gear
- Identify funding to support the acquisition of on-demand gear
- Establish and fiscally support on-demand gear training and education programs
- Begin mental health and wellness benchmarking in the lobster fishery and develop and implement new health and wellness programs

Through scores of interviews and days of discussion, one common theme has emerged: on-demand fishing gear requires significant thoughtful, intentional, intelligent experimental testing and policy discussion if we are to determine where, how, and by whom it can be used in New England lobster fisheries and what impacts it will have to communities and the marine environment. This report takes a significant step in outlining the next phases of on-demand gear research and testing, benchmarked against the operational characteristics that have made lobster fisheries some of the most valuable in the country. If a common understanding of these issues is to be developed across diverse interests, each of the issues of utility, technology, legal & regulatory issues, and socioeconomics must be invested in and advanced concurrently and with equal priority. Through diligent and collaborative research and evaluation of on-demand gear, the numerous unanswered questions about feasibility, compatibility, and impacts of this emerging technology can ultimately be addressed.



Introduction

“We need to keep in mind that this technology exists. It is proven, it works, and really what we’re talking about now is its suitability for this commercial fishery.”

- Sean Brilliant, Canadian Wildlife Federation¹

“It won't work. You have tides. You have a million guys trying to fight for an inch. This technology will never work for Mass state lobstering. It might work someplace for some crab fishery offshore or something to that effect, but you'll never actually get it to be able to work in the field. So that's- I know all the guys around my area here, and my family, well, we all think it's a bad idea and it has no future.”

- Justin Mahoney, Massachusetts lobster fisherman²

“To ignore this technology and just try to brush it back under the table and, like, act like it doesn't exist I think is the wrong avenue for the lobstermen.”

- Mike Lane, Massachusetts lobster fisherman³

“I think ironically these conversations just highlight what fishermen and right whales have in common, which is a tremendous loss of habitat and impacts beyond their control, because right whales are also taking those same issues from offshore energy and shipping and climate and moving prey and, you know, all of the same things that- The industry is right, that those are real issues and they are also real issues that are being faced by right whales. And you know, right there they can find some common ground.”

- Conservation organization staff member

Switching to fishing gear that can reduce the risk of North Atlantic right whale entanglements has been a primary focus of take reduction efforts for years. Rarely in the history of US fishery management has so much been said by so many about one singular issue. Last year more than 200,000 people engaged in the North Atlantic Large Whale Take Reduction Plan implementation process by providing public comment or other forms of input. Hundreds of millions of dollars are on the line for the commercial lobster fishing industry, which just experienced its highest grossing season in history. Litigation on the issue swirls through the courts. While resource managers seek solutions and resource users grapple with potentially drastic changes, the North Atlantic right whale remains critically endangered.

Emerging from the groundswell of general public interest in right whale conservation and the lobster fishing industry's interest in self-preservation, all rational participants in the discourse surrounding right whale conservation agree that the species must be further protected in order to avoid continued

¹ Idlebrook, C. (2021, April 14). *Is ropeless fishing ready for prime time?* The Working Waterfront <https://www.islandinstitute.org/working-waterfront/24982/>

² Mass. Division of Marine Fisheries virtual public hearing, “*Proposal for Authorization to Conduct Ropeless Fishing Activity Within Certain Areas of the Massachusetts Trap Gear Closure Area Using On-Demand Vertical Buoy Lines Systems.*” January 12, 2022.

³ *Ibid.*

declines or extinction. However, that is the extent of the general consensus. Of all the divisive issues pertaining to right whale recovery, differences of opinion come into sharpest relief in discussions of on-demand fishing gear, often referred to as ‘ropeless’ gear. To some it is panacea and represents the glide path to right whale recovery; to others it is synonymous with economic peril and the termination of a way of life.

Ultimately, it is a gear switching question grounded in the public policy frameworks and sociocultural institutions that govern New England fisheries. These institutions’ capacity to intelligently engage to find a solution to this issue is dependent on, among other things, a comprehensive and dispassionate assessment of the impacts that on-demand gear would have on lobster fisheries and fishing businesses. It is the goal of this project to outline the terms of such an assessment, which in turn will likely take several years to complete.

A gear switching program in the New England lobster fishery transitioning in whole or in part from persistent buoy lines to on-demand gear systems would likely be the most significant in the history of US fishery management by any measure and would require coordination across numerous state, regional, and federal agencies. Gear switching programs in US fisheries have a complex track record. Numerous programs aimed at reducing bycatch of marine mammals and other organisms have been developed, many leading to regulatory action requiring changes to fishing gear. A summary of some of these gear switching efforts can be found in Appendix 1. While some gear switching efforts have been developed and implemented cooperatively, others have resulted in protracted policy fights involving years of litigation and loss of trust between fishermen and managers.

On-demand fishing gear is a class of equipment that allows the marking and retrieval of fixed gear without using a persistent vertical line and buoy. The gear generally consists of submerged buoyancy devices that are actuated by time-release mechanisms or acoustic signals transmitted from the surface. The various types, configurations, and manufacturers of on-demand fishing gear systems have been documented extensively in the literature, most comprehensively in a report entitled *Ropeless is Real*.⁴ On-demand fishing gear and the lobster fishery itself are highly complex and specialized systems; this report assumes that the reader has at least a basic understanding of both.

On-demand fishing gear is one of several types of equipment that have been proposed or are being evaluated for their capacity to reduce entanglements with right whales and other species, as well as their feasibility for use in US commercial fixed gear (trap and gillnet) fisheries. While evaluating the level of risk reduction that switching to on-demand fishing gear might provide relative to other contrivances is a major area of discussion and research effort today, it is not the purpose or focus of this project. This report does not evaluate or discuss relative risk of entanglement or the take reduction value of any particular gear type nor does it evaluate the benefits of switching to on-demand gear relative to other risk reduction measures or the *status quo*. Instead, this project was undertaken to provide an overview of the practical issues associated with switching to on-demand gear, the impacts and hurdles to implementing on-demand fishing gear within existing knowledge and regulatory systems, and the areas of research and development where near-term efforts should be focused.

⁴ Sawicki, K. (2020). *Ropeless is Real: A Solution for Fishermen and the North Atlantic Right Whale*. Sustainable Seas Technology, Inc., Middle Haddam. Available from <https://sustainableseasdotblog.files.wordpress.com/2020/05/ropeless-is-real-final-ks-2.pdf>

The widespread deployment of on-demand fishing gear in New England fixed gear fisheries would have wide-ranging technical, legal, regulatory, social, and economic consequences. On-demand fishing gear has been and continues to be tested, and discussions regarding the development of performance standards are beginning to occur. Stakeholder involvement in these conversations is slowly increasing. However, most practical issues around implementation have not yet been fully scoped or addressed, and broad stakeholder engagement in planning and testing conversations is currently not taking place, for political and practical reasons.

A limited but growing amount of technical and academic literature describes the dynamics of on-demand fishing gear. The body of technical and experiential information pertaining to the use of the gear exists within the knowledge base of the individuals who have designed, studied, and used the equipment, those who have been exposed to the concept of on-demand fishing gear and have contemplated the implications of its use, and those who are knowledgeable about the legal, regulatory, and operational environments in which on-demand fishing gear would exist. Their experiences and knowledge represent the most important source material for any project designed to assess the current issues, challenges, and opportunities of the equipment.

This project was undertaken in three phases with discrete goals: 1) contact and learn from a plurality of the community of people who have expertise in the field and a representative set of fishing industry stakeholders who possess a deep understanding of the current context; 2) develop and present a snapshot of the current status of on-demand gear development and the numerous, relevant legal, regulatory, and socioeconomic aspects of lobster fisheries and fishing communities; and 3) develop a set of recommendations, grounded in this body of knowledge and the current status of on-demand gear development, for benchmarking progress and framing future research and permitting enterprises.

The bulk of this report describes the current status and impressions of on-demand fishing gear and discusses the issues in context. Much of the discussion is presented in the words of the project participants, who provided their valuable time and expertise to the project through interviews and/or workshop attendance. This project would not have been possible without their willingness to engage in discussions of this high-profile issue. These discussions can be found in Sections 1-4.

The report concludes with recommendations that are divided into two parts: 1) advancing the collaborative research enterprise, and 2) an on-demand gear research status and benchmarking report card. These can be found in Section 5.

The policy landscape surrounding on-demand fishing gear is constantly shifting and evolving. During the preparation of this report, NOAA finalized the 2021 North Atlantic Large Whale Take Reduction Plan and Environmental Impact Statement⁵, significant appurtenant legal decisions have been issued, a Letter of Authorization for the use of on-demand fishing gear in the Massachusetts Restricted Area was requested, and the Right Whale Coexistence Act of 2022 (S. 3664/H.R. 6785) was introduced. Hundreds of relevant conversations have taken place between individuals and organizations. Despite these iterative advances, a significant amount of work remains if stakeholders, agencies, advocates, and the public are to determine the feasibility of on-demand gear in the lobster fishery. The issue framing and recommendations contained in this report could chart the course for improved stakeholder engagement and an objective analysis of practical issues over the coming years.

⁵ The ALWTRP notably prohibits the use of persistent buoy lines in existing and newly implemented seasonal restricted areas, rather than prohibiting lobster fishing operations.

Methods

The challenges, opportunities, and requirements of on-demand fishing gear can be divided into four focal areas: 1) utility, 2) technology, 3) laws and regulations, and 4) socioeconomics. These four categories are used throughout this report and frame its research and benchmarking recommendations.

There is a diverse array of knowledge and experience that is relevant to the four focal areas of this project. The people who possess the technical knowledge and expertise that informed this report can be divided into six groups: 1) fixed gear fishery stakeholders, 2) mobile gear fishery stakeholders, 3) fishery managers, 4) gear technologists, 5) scientists/economists, and 6) marine law enforcement officers. Multiple people identifying with each of these groups participated in the scoping phase of the project. The rationale for the inclusion of each group is presented in Table 1.

Table 1. Identities, examples of, and types of knowledge possessed by members of the groups who participated in the scoping phase of this project.

Group	Examples	Types of knowledge
Fixed gear fishery stakeholders	Lobster fishermen, gillnet fishermen, on-demand gear testing program participants	Stakeholders participating in fixed gear fisheries in which on-demand fishing gear may be deployed or required; possess a deep understanding of fixed gear fishing operations and interactions with mobile gear, their community and cultural dynamics, the economic environment in which they do business, and the context in which on-demand gear would operate; may have experience testing on-demand fishing gear
Mobile gear fishery stakeholders	Scallop (dredge), groundfish (trawl), pelagic species fishermen	Stakeholders participating in fisheries operating near or within fishing grounds in which on-demand fishing gear is used; possess a deep understanding of mobile gear fishing operations and interactions with fixed gear, their community and cultural dynamics, the economic environment in which they do business, and the context in which on-demand gear would operate
Managers	State, federal agency staff, NEFMC/ASMFC	Fishery managers understand the ways in which on-demand fishing gear might affect fishing effort, the regulatory environment, bycatch, habitat impacts, and the manner in which they interact with fishing gear for research and management purposes
Technologists	Gear experts, database managers, technicians	Technologists have expertise in the physical design and specifications of on-demand fishing gear including its use and maintenance requirements, costs, relevant telecommunications, mapping and marking hardware/software, digital security and encryption, marine acoustic signaling, and server/database management; may have significant experience engaging with fishing industry stakeholders on design and testing of on-demand gear
Scientists and Economists	Academic experts, federal agency specialists, conservation organization experts	Scientists and economists possess knowledge pertaining to the impacts of on-demand fishing gear to the ocean environment and the impacts of requirements to use on-demand fishing gear to various financial, social, cultural, and operational aspects of fishermen and fisheries individually and collectively; may have significant experience engaging in take reduction or fishery management processes as experts or advocates, and/or organizing and facilitating programs for the design and testing of on-demand gear
Enforcement	State, federal law enforcement officers	Marine law enforcement officers are familiar with the legal and regulatory environment in which on-demand fishing gear would operate and may understand the physical and technical requirements of remotely identifying, retrieving, interacting with, and re-deploying on-demand fishing gear

The scoping phase of this project used semi-structured interviews and a facilitated workshop to capture information and knowledge from participants. Semi-structured interviews are conducted using a predesigned set of questions while providing subjects the opportunity to expand their answers and to share additional information, opinions, and perspective.⁶ An interview guide was developed, and questions relevant to each stakeholder group were presented to each participant (see Appendix 2). Each interview was conducted telephonically, digitally recorded, and transcribed using the Trint software system.⁷ Interview participants are identified by profession in order to maintain confidentiality, which was offered to each participant in order to facilitate candid engagement. Participants were given the opportunity to provide 'off the record' information that was not recorded or transcribed.

Eighty-five people with relevant commercial fishing, fishery management, conservation advocacy, law enforcement, or on-demand gear design and use expertise were contacted via telephone or email and asked to schedule an interview. Sixty-five individuals participated in 60 primary and seven follow-up interviews, producing around 130 hours of digital audio recordings. Interviews were around two hours in length on average.

The workshop, held in Danvers, MA on October 13-14, 2021, brought on-demand fishing gear experts, fishing industry leaders, state and federal agency staff, law enforcement professionals, economists, and scientists together for an opportunity to create broad discourse and share ideas and opinions about on-demand fishing gear (see Appendix 3). Through discussion facilitated by the Consensus Building Institute, the workshop sessions and breakout session provided a valuable opportunity for participants to address and discuss issues, challenges, and opportunities of on-demand fishing gear.

⁶ Adams, William C. "Conducting semi-structured interviews." *Handbook of practical program evaluation* 4 (2015): 492-505.

⁷ Trint Ltd., London. www.trint.com



In their own words: perceptions of on-demand fishing gear

Commercial fishermen

"I think [the transition to on-demand gear is] going to be relatively quick if the boat is set up to fish it. I mean actually fish the gear. It's not going to be any different at all. It's going to be relatively the same amount of time that the buoys are going to be at the surface. You're going to grab it, you're going to start hauling and it's going to be like what I'm doing now. For the amount of times and the amount of systems I've hauled and the amount of times doing it now and what I want to see doing it, if I was fishing the gear, it's going to be no different than if you had buoys on the surface."

- *Fixed gear fishery stakeholder*

"It is light years away."

- *Fixed gear fishery stakeholder*

"I just don't think it's feasible with the way the fishing industry is in New England, with our draggers, scallopers, with the concentrations of lobster gear. ... I'm really tired of hearing about ropeless gear to tell you the truth, I've heard enough of it. I just call them guys a bunch of snake oil salesmen. The only way I can see it could possibly work is if everybody's got their own little sections of the ocean, and that's it. I don't see any other way it could work. And that would mean the end of the fishery for a lot of people."

- *Fixed gear fishery stakeholder*

"From a fisherman's point of view, right now they're taking something that's unreasonable and really drilling it down everybody's throats that it can be done right now. Well, we know damn well it can't. It may in the future, but it is absolutely detrimental at this point because it's alienating fishermen, keeping them from engaging, and not wanting anything to do with it because it's all lies right now. Rather than saying, 'hey, we need to work on this, you know?'"

- *Fixed gear fishery stakeholder*

"What concerns me with [on-demand gear] is that we, you know, there are seven or eight different technologies out there and none of them speak to each other. So I don't know how I can have seven or eight different technologies on my boat and figure out that there is fixed gear around me while I'm fishing with my mobile gear. So that's what my main concern with it is."

- *Mobile gear fishery stakeholder*

Conservation organization staff

“When you're bringing people to the table, you're opening up a discussion, letting them see that you're there to ask questions and answer things honestly so that there isn't that level of misinformation. And I mean, frankly, I'm very, very frustrated with the level of misinformation that's within the conservation community on the assumption that this is off-the-shelf and ready to go, you know, everything just needs to be permitted tomorrow, it's this easy solution, without the acknowledgment that, it's working, but gear conflict is a hard issue, gear detection is an issue, that there still are some- It's made tremendous progress. There are some more steps to it. I don't like hearing the industry relay that information about how this is never going to work and it costs too much. And you know, they say, 'it's Star Wars technology and I can't use it.' I don't want to hear that. I also don't want to hear the conservation community coming out saying, you can buy this tomorrow, and they should be mandated to use it right now because it's ready to go. So the state has an opportunity and the [federal] agency, to dispel things on both ends and to bring that promise, but not to a point of having it be an overzealous solution in all areas.”

- *Conservation organization staff member*

“But once again, no one from NOAA has stepped up to say, 'if we were to impose ropeless, here's how we would do it.' Because right now, to be honest, the people at NOAA that are involved in this are the protected species people, not the fisheries people, and I think one of the needs is we need to train the fisheries people to figure out, how is this actually going to be prosecuted? So like NOAA today stipulates, you have to have a buoy and it has to have your registration number written on it. I think that they're going to be able to dictate how ropeless fishing is to be prosecuted and specifically what devices will be compliant with their regulations. ... No one in the government has sort of recognized that they need to initiate this kind of a process.”

- *Conservation organization staff member*

“And of course, the idea of buoyless fishing gear is appealing to me because it would reduce a certain mileage [of vertical lines]. I'll be honest with you, I still have concerns about trawls. We do have cases of humpback whales, right whales getting caught up in ground line. We think it's less common perhaps than buoy lines. But that's a bias issue also. We are probably less likely to retrieve ground lines than we are other types of line.”

- *Conservation organization staff member*

“I'm not convinced that the inertia and the endless due process of those [fishery management] structures is commensurate with the nimbleness and the incontrovertible requirements as to what has to happen. Basically, we need to draw a line in the ocean as to where, where potential risk lies, at three miles or whatever, the Maine exemption line, take that as a place to start, and tell the fishery that they can go fishing [there] without end lines, period. And figure it out and we'll help you with it. And, you know, done, period. That level of, inconceivable currently, uncompromising demand is, you know, what has to happen. And you know, when it comes to, I mean, look at the TRT process and the related pieces over the last three or four years, what's happened? Nothing yet.”

- *Ocean scientist*

“From [my organization’s] perspective, we're not calling for ropeless right now everywhere. And I'm not positive we would ever call for ropeless everywhere if there's no evidence right whales are there. I mean, if they're entangling a whole bunch of humpbacks and just not right whales, that could change the equation. But I do think there's some real local ecological or bathymetric features that mean right whales just don't go there. And in those cases, I don't think we need to transition.”

- *Conservation organization staff member*

Gear developers

“I love working with my fisherman partners. They've been great people and helping us actually build a technology that maybe can work for them. And I think that fishery has an incredibly important position in this because if it does not work for them, then this is all a moot point. Everybody else can argue with all the other stakeholders, they can have their two cents, but we really do have to build something for the fisheries and that's what we've tried to focus on in interacting with them.”

- *On-demand gear developer*

“We think that there's an opportunity to get carried away with the technology because we can do a lot. Like, if you wanted to put a camera down there, we could create motive communications where, you know, we could give you live video links to all of your traps on the seafloor. How would you like that, right? If I've got a camera down there, I could look at the trap and I could use optical recognition software to tell you how many lobsters or what size there are. There's a temptation that once we start putting technology on the seafloor that we can do a lot more. There are conversations going on about bulk gear marking right now and software to manage gear marking. We've been talking about reporting to some satellite location or cellular link to a database somewhere. And you know, the conversations are like, let's report poundage. Let's report size. Let's report, when did they put it in? When did they take it out? What temperature was the water? You know, like, you could do all of that, right? The more of that that we do, the less likely fishermen are going to be able to get their heads wrapped around this and want to adopt it. So we've taken an approach: fish like you fish now.”

- *On-demand gear developer*

1. Utility

“I don't think necessarily that there's a challenge of the technical equipment working. Seems like we've proved that we can do it. We just have to refine it. I think the biggest challenge is going to be, you know, interactions with mobile gear.”

- *Fixed gear fishery stakeholder*

Evaluating the feasibility of the physical use of on-demand fishing gear in lobster fisheries requires a thorough understanding of the ways that lobster fishing gear is used today. Multiple on-demand fishing gear developers interviewed for this project described mimicking or matching many of the capabilities and performance attributes of persistent buoy line gear as a key design principle. One on-demand gear developer has trademarked the phrase “Fish like you fish now”.⁸ Understanding how fixed gear fishermen fish now in the context of on-demand fishing gear adoption and integration is the focus of the following section.

Fixed gear fishermen have developed their businesses in response to a broad and complex set of forces and factors including family history, location and community dynamics, access to fishing permits and capital, skills developed over years of learning and practice, and personal preference. The type of permit a lobster fisherman possesses and the types of markets they can access can determine the type of fishing operation that is developed. Conditioning access to certain fishing areas within state or federal waters is a feature of most lobster permits and is highly varied. Some lobster fishermen possess permits that prohibit the hiring of unlicensed crew members, and almost always fish single-handed. Regional variability influences the ways in which fishermen use their gear and, consequently, the ways in which their operations would be modified to incorporate on-demand fishing gear.

Using on-demand fishing gear requires fundamental changes to some of the operational aspects of fishing with fixed gear, and many of these changes are not well-characterized. For example, it will be necessary to assess the on-the-water dynamics and performance of on-demand gear, including the ways in which it is armed, deployed, located, retrieved, stowed, and maintained. Each of these operational steps and performance metrics should be benchmarked against existing on-demand fishing gear systems in future research efforts, and the changes that may be required in order to efficiently operate on-demand fishing gear should be quantified and described. In addition, fishery managers, scientists, and law enforcement officers who will at times inspect, use, locate, or otherwise interact with on-demand buoy gear and must modify their operations accordingly should be consulted in these assessments of operational performance and requirements.

Setting and retrieving gear

The placement of fixed gear is a well-honed skill that fishermen develop over the course of many years, even decades. Lobster fishing gear is configured in a broad array of configurations from single traps to two kilometer long trawls of 45 or more traps. While the primary consideration for most fixed gear fishermen is optimizing placement in order to maximize catch, there are numerous other factors that determine where and how gear is placed. Several fishermen interviewed for this project described the

⁸ Ropeless Systems Inc. <https://www.ropeless.us/>

techniques they use to optimize the placement of gear with persistent vertical lines, and many discussed how switching to on-demand gear would impact these techniques.

During interviews, fishermen frequently described a “sixth sense”, honed over time, that frames a dynamic awareness of their gear in time and space. This awareness exists in relation to bathymetric features, other fishermen’s gear, and ocean conditions at any particular moment. Highly skilled fishermen reported developing this sense acutely enough to keep track of when their peers set their gear, sometimes days later, in order to back-calculate tide and current conditions and set their own gear accordingly.

Fixed gear fishermen interviewed for this project described their operational approach to setting gear in relation to that of their peers as a delicate balancing act of seeking to maximize gear density on productive fishing grounds while avoiding ‘crossing’ that can lead to further problems if not appropriately addressed:

“Well, we know everybody that we fish around and we all get along for the most part. ... So we communicate with each other as far as how we're going to set in certain areas. If we get a little too close to each other we're like, 'yeah, I might have gone over you' here because a lot of times, especially in high season, we're really crammed into a small area. And with the tide going, when you're side to the tide and the tide's pulling one way you're going to set right at that buoy knowing that it's pulling away from it. I do not see fishing around each other the way we fish now, with Ropeless. I personally don't see it. It's not going to be like a dragger seeing it and alright, they can avoid it, you know. We literally are so dense setting gear with each other.”

- *Fixed gear fishery stakeholder*

Fishermen interviewed for this project generally believe that on-demand gear would reduce the pace of their operations. Fixed gear fishermen were asked to describe the typical rate at which they moved through gear. While these responses varied significantly based on factors like age, trawl configuration, and number of crew on board their vessels, several fishermen described an ideal throughput rate of 60 traps per hour. In the absence of empirical data to support the use of throughput rates across management areas and vessel types, on-demand gear design and testing programs should use a rate of 60 traps per hour as a benchmark target for current high-efficiency lobster fishing operations in order to facilitate a similar level of throughput efficiency as lobster fishing vessels using persistent vertical lines. Additional on-demand gear research and testing should focus on determining throughput rates under various operational scenarios.

Most fishermen interviewed for this project expect that using on-demand gear would at least initially result in decreased efficiency:

“We're going as fast as we can to haul as much as we can so that it's actually profitable. You go out there and play like I did as a kid, you have fun. I love fishing at that level of it, but it's really not about fun anymore because it's just a grind. So to throw something like [on-demand gear] in every trawl will really slow things down on where it's going to cut into the profitability of it.”

- *Fixed gear fishery stakeholder*

The New England lobster fishery is a volume fishery, and a profitable lobster fishing business is one that requires speed and efficient movement through large amounts of gear. Whether they have tested

on-demand fishing gear or not, nearly every fixed gear fisherman interviewed for this project expressed the same answer when asked how much time they could lose fishing and still remain profitable: “none.” Fishermen interviewed for this project who have built their businesses around high levels of gear throughput believe that they will face significant challenges competing if on-demand gear is less efficient in time and space:

“It's an evolving technology, which I completely understand. But where I step off the bandwagon on this is in the name of efficiency. One of the ways that I've been able to build my business to be able to produce the profits that I'm able to do, I learned from a very young age to fish to live, not to live to fish. It's the way I've lived my life in the business and through that belief system, I've worked to make my business as efficient as possible. To burn the least amount of fuel, to use the least amount of bait necessary to be able to accomplish the task that I'm looking to do, which is to catch the maximum amount of lobsters. And it has multiple effects. I fish trawls, and I've always fished trawls. I do that for a reason because it's the most efficient way to haul the least amount of traps, because I don't believe in polluting the ocean. And I view trap loss as pollution, unlike many fishermen. It also allows me to spend the least amount of time offshore, which is the least amount of time for me being away from my family. And it maximizes my profits.”

- *Fixed gear fishery stakeholder*

Fishermen described the compound impacts that decreased efficiency could have on their operations, indicating their belief that losses in efficiency on the water could impact their operations in multiple ways:

“There are people that think that this thing is prime time, it's so far from it. And they don't understand that the reason that an offshore boat is successful is because they're very efficient, right? They have the ability to go out and haul X amount of pots per day. ... If I lose an hour, I've lost that hour forever. I can't make it up because if I take it out of tomorrow, I've lost an hour that day. ... I can see scenarios where you're basically making the difference of being able to land and take out at six o'clock at night, right, and that way, you're done by 10 or 11 vs., oh no, we've lost three hours in that ropeless s***. Now I can't get done until nine o'clock, which means they aren't going to unload me because it will be too late. So I've lost that opportunity and I've lost those hours and we've got to start unloading at four o'clock in the morning now. They don't- nobody looks at it like that.”

- *Fixed gear fishery stakeholder*

The challenge of fishing efficiently is magnified in the winter fishing season in the Gulf of Maine, when weather windows for fishing opportunity on medium-sized and even large offshore vessels can be as narrow as 12-18 hours. For fishermen who operate during winter months, changes in their gear throughput rate might have proportionally greater impacts on efficiency and profitability:

“In the wintertime, where I really make the most of my income, the weather systems in the Gulf of Maine- we're lucky to get 12 hours in between weather systems, maybe 18. All you have to do is look at the tide charts to know just how long it takes for one weather system to come in and another weather system to leave. When you're dealing with 20 knot winds and six foot seas offshore, trying to find two balls the size of a coconut, which take probably five minutes to arise from down below, from 80 fathom of water. I don't see that as efficient.”

- *Fixed gear fishery stakeholder*

Fishermen interviewed for this project who have tested the most up-to-date versions of on-demand gear within the past year estimated a margin of between two and 10 minutes of additional time required to retrieve a trawl with on-demand gear during testing. Skilled on-demand gear users reported no additional time required to stow and redeploy the gear, although additional exploration of specific operational steps should remain a part of on-demand gear testing and reporting. Much of the additional time required to operate on-demand gear was attributed to tasks required by handheld transducers they use to send acoustic signals to and receive them from acoustic modems aboard on-demand gear systems. Handheld units are currently the only type of transducer that have been put into use in on-demand gear testing to date, although through-hull transducers are expected to be used during testing programs in the coming months. The steps fishermen currently take to retrieve on-demand gear include slowing their vessel once the deployed on-demand gear is reached, immersing a transducer by hand, calling the gear to the surface by entering a set of commands into a 'deck box', and spotting the gear at the surface, and finally bringing it aboard.

Each of the fishermen interviewed for this project with on-demand gear testing experience expressed the opinion that a hull-mounted transducer with the capacity to call gear to the surface while underway might significantly reduce retrieval time, perhaps reducing the difference in operating time between on-demand gear and vertical lines to zero. Advances in the development and deployment of hull-mounted transducer systems and practice among on-demand gear testers will be required in order to determine the differences in operating time. Documenting on-demand gear retrieval techniques and evaluating retrieval times should remain a focus of on-demand gear testing programs in order to better inform policymakers and stakeholders.

Fishermen interviewed for this project were asked whether they would anticipate needing to deploy an on-demand unit on one or both ends of their trawls. The majority of participants reported that it would be important to be able to have the option of retrieving either end of a trawl because of variable wind and current conditions. Fixed gear fishermen reported strongly preferring to haul trawls into a head tide or from a downwind bearing to prevent their vessel from being pushed over the trawl, which can lead to snarls and other serious problems including tangling lines in a rudder or propeller. On-demand gear testing programs should include the evaluation of fishing performance based on the option to haul one or both ends of a trawl under various conditions.

Distance between trawls

The density of fishing gear varies significantly across lobster fishing grounds and over time. Gear is set at the highest concentrations in inshore and near-offshore waters off the coast of Maine in the late summer and early fall.^{9,10} Interview participants reported that the lowest concentrations of lobster fishing gear are in distant offshore waters of Lobster Management Area 3. Interview participants reported that the factors that determine where and how they set their gear include the availability of harvestable lobsters, the number of permitted fishermen operating in the area, trap limits, trawl length requirements,

⁹Kelly, K. H. (1993). Determination of lobster trap density near midcoastal Maine by aerial photography. *North American Journal of Fisheries Management*, 13(4), 859-863.

¹⁰ Brehme, C.E., McCarron, P., & Tetreault, H. (2015). A dasymetric map of Maine lobster trap distribution using local knowledge. *The Professional Geographer*, 67(1), 98-109.

weather, bottom type, fishing gear closures, and cooperative agreements for the seasonal use or configuration of fishing gear.

Fixed gear fishermen interviewed for this project described the challenges associated with setting their gear at high densities. Using buoys as visual markers, lobster fishermen generally reported the ability to set trawls within 50 feet of other gear:

“I can set gear pretty tight. I mean, I've been with buddies and stuff where we can go rail to rail, he's setting one way, I am setting the other way. I mean, you know, the gear is probably 50 feet apart on bottom type of thing. You know how to play the tides and stuff. Yeah, you can squeeze it in.”

- *Fixed gear fishery stakeholder*

“So I've had in the past where the gear is so tight that you literally have to set down tide of one trawl, so close that his ends are basically rubbing, say, your port side and you say, that's the side you go down. You've got to set that tight so that way you're not on the guy that's below you, either. You sometimes set very, very close”

- *Fixed gear fishery stakeholder*

In order to allow similar gear densities as persistent buoy line gear used today and reduce gear conflict, on-demand fishing gear marking systems should target location accuracy tolerance benchmarks comparable to the accuracy of current fishing practices under various operational conditions. In areas of high gear density, these benchmark targets should be no greater than 25 feet (i.e., the level of accuracy required for two fishermen to confidently place gear while operating 50 feet apart). Establishing performance criteria at this level of accuracy may limit the utility of certain gear marking techniques, particularly GPS-based surface marking techniques, and it may not be necessary to achieve this level of accuracy in offshore lobster fisheries where gear density is lowest.

Recognizing the potential for gear conflict, lobster fishermen have established informal agreements that govern the ways in which trawls are set on fishing grounds. These collectively established trawl conventions are based on local conditions and are held as local knowledge shared through social interactions among stakeholders. Many conventions have been established for nearly a century, and can be based on depth contour, alignment relative to the shore, compass course, LORAN bearing, or GPS coordinates:

“When we fish up inside in the summertime up around the islands, that's all compass course, and there's multiple different directions that we set in. It's just directions that, oh, my father started fishing in 1938 and those directions were started way back then. And we've always stuck to those, still today, to those directions up around the islands in the summertime. And then usually by late summer as soon as I get down, say, like 25 fathoms, from 150 feet and deeper, then most places we set LORAN lines.”

- *Fixed gear fishery stakeholder*

Fixed gear fishermen interviewed for this project reported using a set of visual cues to judge the location of lobster traps or trawls on the seafloor based on the location and orientation of surface buoys and the visible portion of persistent lines in the water column. Some described regularly scanning the immediate

vicinity to determine which buoys were marking the trawls ends, and they reported consistently noting the owner of gear placed around them which, cross referenced with their knowledge of the gear configuration other fishermen use, allows them to create a highly sophisticated mental image of the three-dimensional environment around them and the gear placed within it. Combined with information including depth, tidal period, wind, and current, skilled fishermen use these cues to accurately judge where to place their own gear to avoid crossing over their own or another fisherman's deployed gear. Some fishermen interviewed for this project believe that the lack of visual cues from buoys would limit their own and/or their peers' ability to accurately determine where to place gear:

"Well, some guys can [read the tide based on surface conditions] fairly easily. Other guys are calling their friends and their family every third trawl, asking which way they have the tide. Every third trawl! There are people, the vast majority, I would say 75 percent of the guys are completely aloof to being able to look at the surface of the water and have a read on which way the tide is going by the wave pattern."

- *Fixed gear fishery stakeholder*

Limited capacity to accurately judge the location of deployed on-demand gear using a virtual mark rather than a surface mark may further constrain fishing effort using the gear if gear cannot be set at high densities without the risk of crosses and associated gear conflict. Working with highly skilled fixed gear fishermen to test the density tolerances of on-demand gear and evaluate techniques used to judge location of deployed gear based on surface conditions should be a focus of future gear testing efforts.

Non-fishing functions of gear

Over the decades, lobster fishermen have developed complex social systems on the water that facilitate self-regulation and spatial governance of fishing grounds based on territory systems, family and harbor affiliation, and other dynamics. These systems are well-documented in the social scientific literature and play an important role in the operations of lobster fisheries, particularly in inshore areas and in the northern Gulf of Maine.¹¹ Under these systems, fishing gear is used for purposes other than actively harvesting lobsters, including gaining and holding fishing ground, testing new areas or determining the migratory patterns of lobsters, or excluding competitors from certain areas. It is possible that on-demand fishing gear would significantly alter these social dynamics by changing or precluding time-worn approaches to territoriality and self-regulation on fishing grounds.

While these dynamics may not comprise core components of fishery management agencies' approaches to lobster fishery regulation, managers are aware of the issue:

"I don't know if [on-demand gear] is going to change people's behaviors and how they deal with their gear, like if they're afraid they're going to lose their bottom and they're going to leave their traps out for longer and they're not going to bring them in in the winter ... Right now, you can take care of [conflict issues] by cutting someone's line and taking your spot back and I assume that the pecking order of things takes care of that. But I'm less involved in those types of activities."

- *Fishery management professional*

¹¹ Acheson, J.M. (1988). *The lobster gangs of Maine*. University Press of New England.

Further understanding lobster fishery stakeholder's perceptions of, and response to, the potential loss of systems like marking and holding territory is a social consideration that should not be lost as conversations about on-demand fishing gear progress. If alternative systems for marking/holding territory using on-demand fishing gear are developed, they should be recognized as important elements of the complex systems governing fixed gear fisheries.

Safety at sea

Commercial fishing is one of the most dangerous occupations in the US.¹² Designing on-demand fishing gear systems that can be safely operated and integrated into existing fishing systems is a central focus of on-demand gear developers and an important concern expressed by fixed gear fishery stakeholders interviewed for this report.

Fishermen who have tested on-demand gear expressed concern about the safety of setting the gear. In a typical offshore fishing operation with 30-45 trap trawls, high-fliers, anchors, and over 50 fathom vertical lines, a crew member will set gear by throwing one high-flier buoy overboard and let the line run until it pulls the anchor overboard, pulling the string of traps overboard in turn. Setting a trawl end rigged with on-demand gear requires that a crew member push the anchor and on-demand system overboard, which poses an entanglement risk deemed unacceptable by at least one fisherman who has tested the gear:

"I won't set a ropeless system [first] right now the way they're set up. It's very difficult for me to justify or be able to ask my guys to set the ropeless end first, because there's nothing to pull it off the boat. You have to launch it off the boat and it's heavy when it's loaded with rope."

- *Fixed gear fishery stakeholder*

One fishery management expert with experience in gear safety who was interviewed for this project expressed concern about the safety of crew members who are learning how to using on-demand fishing gear:

"Lobster fishing already has the highest number of fatalities of any East Coast fishery. That's from the most recent report to come out of [the National Institute for Occupational Safety and Health].¹³ A lot of man overboards, a lot of issues with getting pulled down with gear. With any new operation, there's going to be a large learning curve that can increase the risk of an injury or fatality occurring with it."

- *Fishery management professional*

Several on-demand gear developers interviewed for this report described the ways in which their equipment might enhance safety on fishing vessels. For example, one developer of an inflatable lift bag

¹² Lincoln, J. M., & Lucas, D. L. (2010). Occupational fatalities in the United States commercial fishing industry, 2000–2009. *Journal of agromedicine*, 15(4), 343-350.

¹³ Mason, K., Case, S., Kloczko, D., Lucas, D., Syron, L., and Teske, T. (2017). Commercial Fishing Fatality Summary / East Coast Region (2010-2014). National Institute for Occupational Safety and Health, Anchorage. Available at <https://www.cdc.gov/niosh/docs/2017-173/pdf/2017-173.pdf>

device is optimistic about the safety features of the system and the ability to work with fishermen to further evaluate safety performance:

“What happens if somebody gets caught in one of these? How do you recover? If your buoy is on a line that is stuffed in a basket and you initiate that to try to rescue someone, you have to wait for the line to come up and out of that basket, right? ... You'll get our airbag system to the surface rapidly. So one of the things that we will likely be able to explore with fishermen as time goes on is the safety component to this. But at least with our system, if you do go overboard, I hate to say it out loud, but if you go overboard with our system, you can inflate the airbag immediately from the helm and it will come to the surface rapidly.”

- *On-demand gear developer*

Fixed gear fishermen interviewed for this project reported safety concerns associated with the stacking of on-demand gear. Several fixed gear fishermen also expressed the related concern that on-demand gear could take up more space than their vessel could handle to safely operate, or otherwise could impair their on-deck operations. In general, lobster fishermen expressed a strong preference for on-demand gear devices and configurations that closely mimic the shape and dimensions of their traps for ergonomics and vessel stability purposes. Several of the on-demand gear developers interviewed for this project reported that their most recent designs have incorporated this concern, and significant progress has been made in recent years. Some developers have approached this issue by designing customizable on-demand gear configurations that would allow owners to order on-demand gear to their individual specifications, thereby maximizing compatibility with their gear. It is likely that further development of on-demand gear configurations will address most of these ergonomic and deck space concerns.

There are hundreds of fishermen operating in inshore lobster fisheries who sometimes or always fish without a crew member. Several fixed gear fishermen expressed the concern that operators who choose to fish alone or whose permit conditions prohibit unlicensed crew (e.g. Maine's Class I license¹⁴) would not be able to handle and operate on-demand fishing gear while maintaining a vigilant watch:

“At my dock, there's two other guys who fish by themselves. It's going to be time consuming. You have to do everything on your boat, you know. With two guys, one guy can do something while another guy's doing something else, but if you're alone you gotta do everything. So I would say [fishing alone] would come to a screeching halt. If you've got to repack cages, all that stuff, use the spool, whatever the system is gonna end up being. I know there's different options out there, every single one of them is going to be time consuming.”

- *Fixed gear fishery stakeholder*

On-demand gear development and testing programs should continue to consider the special operational circumstances and challenges associated with fishing without crew.

Some fixed gear fishermen interviewed for this project also expressed concern about transporting compressed air cylinders, used for inflatable lift bag-based on-demand devices, aboard their vessels. While compressed air is frequently transported aboard marine vessels, this equipment would present a

¹⁴ 12 MRSA §6421(3-A)(A)

new hazard for many commercial fishermen, requiring specific safety considerations and the installation of racks that can safely transport compressed air cylinders.

Overall, on-demand fishing gear safety issues have not yet been approached in a systematic way, and safety standards for the design and deployment of the gear have not been developed. As engineering and design of on-demand gear continues to mature, safety considerations should be considered a high priority and techniques for rescuing crew members who might become entangled in the gear should be rigorously studied and implemented. Further, as on-demand gear testing programs are developed, coordinators should take particular care to work with fishermen to design and note techniques for safe handling and deployment of on-demand gear.

Over the years, NOAA and the US Coast Guard have developed internal capacity to address operational safety in US commercial fisheries.¹⁵ In the near future, NOAA and other agencies charged with developing and implementing on-demand gear requirements should consult directly with maritime safety experts to design safety standards and procedures that can assist operators in selecting safe gear or to establish minimum safety requirements for gear authorized for use in their jurisdictions.

Ghost gear & gear loss

During interviews several fixed gear fishery stakeholders expressed worry that on-demand fishing gear would be susceptible to storms and tidal action that could cause the gear to move and to either become stuck or lost. Early indications from on-demand gear point to decreased frontal drag because of its reduced profile in the water column and lack of wave action upon the surface buoy, resulting in less movement of the gear relative to the location of initial placement during strong tides or storm events. Offshore lobster fishermen who used anchors at the end of their trawls reported that the trawl ends with on-demand gear were not susceptible to movement during deployment. It is unclear whether deployed on-demand fishing gear is more or less susceptible to severe storms.

Additionally, fixed gear stakeholders expressed concern that gear that was marked at the surface and transported a significant distance away by a storm or via interaction with mobile gear would be more difficult or impossible to detect and retrieve absent some active indicator of location. Several gear technologists whose on-demand gear systems use active acoustic communication for geolocation noted that such systems may prove easier to detect during a search if they are transported from the location of initial placement.

Ghost gear¹⁶ and otherwise lost fixed gear is a concern for mobile gear fishermen interviewed for this project. Mobile gear fishermen who operate in inshore waters reported that they very frequently encounter ghost gear while trawling:

“I'd say more than 50 percent of my day trips, I have some kind of ghost gear in the net. Very rarely do we go a day without having traps in the net from either freshly cut off traps or very old traps. ... We fish a lot in state waters, and for some reason, I don't know why, but state waters is loaded with ghost lobster gear. I don't know if it's because of the storms pushing it in there and

¹⁵ Lambert, D. M., Thunberg, E. M., Felthoven, R. G., Lincoln, J. M., & Patrick, W. S. (2015). Guidance on fishing vessel risk assessments and accounting for safety at sea in fishery management design. NOAA Technical Memorandum NMFS-OSF-2.

¹⁶ Ghost gear is fishing gear that has been lost, discarded, or abandoned

the old gear just rolls in there or what, but almost every year when the season opens up, we have to- we lose like a week just cleaning up the area so we can actually fish.”

- *Mobile gear fishery stakeholder*

However, offshore mobile gear fishermen reported significantly fewer interactions with ghost gear:

“[I encounter ghost gear offshore] ten, twelve times a year. Where we fish, generally, there is not a lot of fixed gear there. When we go up inside to fish, that's where we get the interactions with fixed gear, you know? So we may have ten interactions in the course of a year.”

- *Mobile gear fishery stakeholder*

Taken together, it is possible that on-demand fishing gear could significantly decrease the prevalence of gear loss due to moderate or even severe storm and tidal events. This could provide significant benefits to both the owners of on-demand gear and mobile gear fishermen who may encounter ghost/lost gear less frequently. However, if it proves difficult to detect or locate and retrieve certain types of deployed on-demand gear that shifts location or is towed up by mobile gear operators, the gear loss benefit may be offset to a degree. Further *in situ* testing of the performance of on demand gear performance during storms and significant tidal events should be prioritized.

Grappling for gear

Experts from a range of organizations who were interviewed for this project discussed the various ways that grappling for fishing gear, either configured with persistent buoy lines or on-demand systems, might become an integral part of lobster fishing in the future. Grappling for gear involves towing a hook along the seafloor in a perpendicular direction to the alignment of a set trawl of gear in order to snag the ground line and retrieve the trawl. Grappling is used by lobster fishermen to retrieve trawls that may have moved due to storms or interactions with mobile gear, or had their buoys cut by another vessel or fisherman. Grappling for gear was proposed as a ‘ropeless’ fishing technique that would not involve the use of on-demand retrieval devices, which was described by some fishermen as preferable:

“Again, this [on-demand gear] talk is insanity, that anyone's even thinking of this when you can just run your end line out with a 10 or 15 pound weight on it and grapple it up. I mean, why are we talking about all this foolishness? It doesn't make any sense to me. And I know we're in the age of technology, but I wouldn't even answer like this all the time. I mean, my God, it's becoming more insane the longer it goes on.

- *Fixed gear fishery stakeholder*

Other fishermen described grapple fishing as a well-honed skill that they use rarely and reluctantly when gear is lost rather than as a preferred approach to retrieving gear:

“Some years I can go all year without throwing the grapple over. Other times, the last few years they've been dredging the Boston Harbor, and 24 hours a day there's a constant flow of tugs and barges coming from Boston Harbor across a lot of the fishing grounds to the Mass disposal site, which is, oh, it's just out beyond the state/federal line. So it's probably from Boston Harbor, probably about 13 to 15 miles. And it's not uncommon for one of those barges to knock the

buoys off of the trawl, off the surface. And when that happens, we do have to grapple the gear up. As long as that trawl didn't get hauled off, in other words if the tugboat or barge didn't hook onto that trawl or the buoy line in a way that it would drag it very far, you can grapple that up reasonably quick, provided it's not too rough. Rough days are very, very hard to grapple. It's too hard to keep the grapple, what we call, tending the bottom, keeping it on the bottom all the time. Because bear in mind, you're only trying to grapple up a piece of three eighths to seven sixteenths [inch] diameter rope. So as the grapple, if it's rough, the grapple kind of skips across the bottom, or it's like that, it's only got to come off the bottom for three eighths of an inch minutes to not get the trawl."

- *Fixed gear fishery stakeholder*

Conservation organization staff interviewed for this project who are familiar with on-demand gear testing and discussions about grapple fishing believe that grappling for gear should continue to be part of the conversation:

"For our captains who fish 45-trap trawls and have 40 trawls out there, it takes them a day to get out and a day to steam back and they can only fit two trawls on their boat. It would take them, I think I figured it out the other day, almost a month to get their traps in. So yeah, you couldn't get all your traps out of the water if there were an aggregation of whales there. But what you could do is go out and drop all your vertical lines and go back and grapple for them. That kind of thinking has never been part of the conversation since I've been in this discussion. And I think, you know, as everyone gets backed into corners, I hope that it will be part of the conversation. I hope the fishermen will come forward with what they think they can do in that situation. If you can't get [gear with persistent vertical lines] out of the water, what could you do to reduce risk? And I think dropping all those lines is one thing they could do. Would it take them longer to go back and grapple when you pick it up? Yeah, but you could [drop all vertical lines] probably in a day and get it done and then go back and retrieve it versus having to take 24 trips back and forth and then have the whales be gone by the time you complete it."

- *Conservation organization staff member*

If grappling were to enter widespread use, fishermen would likely be required to use virtual marking approaches to broadcast the location of their gear to other fishermen and law enforcement officers. Additionally, law enforcement agencies that physically inspect gear for law enforcement purposes would need to develop techniques to grapple gear safely and efficiently or make significant changes to their operational approaches. For some state and federal law enforcement agencies, grappling is currently unavailable as a gear retrieval or inspection technique, and significant investments in capacity, training, and safety would be required. Because grappling requires a relatively large amount of space on the seafloor in order to be successful, the technique may not be suitable for fishing grounds with high concentrations of fixed gear.

Whether or not grappling for gear becomes a widely used approach to mitigate the risk of right whale entanglement, the use of the technique to retrieve damaged or malfunctioning on-demand fishing gear is likely to remain a necessary skill for fixed gear fishermen. Grappling should be recognized as an important component of on-demand gear development and testing.

Avoiding gear conflict

Fixed gear fishermen reported that conflict between fixed and mobile gear is a frequent occurrence. Generally, lobster fishermen reported that cooperation between fishermen operating different types of gear is typical, but sometimes individuals will fail to avoid fixed gear, costing them significant amounts of money in repairs, gear replacement, and lost fishing time:

“The only way we lose gear is with gear conflicts. The draggers will get there and tow 'em up. So we kind of know where they are. Usually, it usually is pretty good communication, at least with state draggers. But the guys from [other areas] will come over and chase the squid and you can't talk to them. I don't know how to get in touch with them. And they can cost you a lot.”

- *Fixed gear fishery stakeholder*

Mobile gear fishermen interviewed for this project also described the difficulties of gear conflict between mobile and fixed gear on the fishing grounds, reporting that both cooperation and conflict regularly take place. In offshore waters, fishermen reported high levels of cooperation and communication between fixed and mobile gear operations. Unsurprisingly, inshore fishing grounds have significantly greater levels of conflict between gear types, costing fishermen on both sides of the issue time and money:

“Well, the lobstermen, you know, most of them will work with you, but a lot of them don't. And they typically just set their gear wherever they want. And unfortunately, we're fishing on the same area they're trying to fish. So it causes some trouble. There's a few fishermen that I can work with, who I work great with, and they know where to put their traps. And then just because of mutually working together and because we have a mutual respect for each other, we try to work with each other so we both can make a living. And so it's not all one way. Some other fishermen lobstermen, they don't care, and they'll just basically take over a whole area because they can, you know?”

- *Mobile gear fishery stakeholder*

Fishermen interviewed for this project who have tested on-demand gear reported that digital gear marking could improve gear conflict issues because of the certainty a mobile gear fisherman would have about the placement of gear relative to the mark (as opposed to a high flier/radar reflector):

“As far as ropeless gear goes, that technology would help in that arena because rather than just physically look out ahead and see a high flier, then try to decide which way it goes. If we can pop up on the chart plotter automatically with the gear, there's a much better chance of noticing it and avoiding it. So if properly implemented and utilized, it would definitely benefit with gear interactions.”

- *Mobile gear fishery stakeholder*

Mobile gear fishermen reported that electronic monitoring has generally changed the operational approach they and their colleagues have towards fixed gear interactions. This fundamental change could alter the ways in which mobile and fixed gear fishermen interact on the water and in the legal arena:

“We're tracked by VMS, so now it's not like the Wild West anymore. They can come after you and say, ‘Yeah, you towed up my gear and I have you on the VMS’ and they can turn you in.”

- *Mobile gear fishery stakeholder*

Most fixed gear fishermen who were interviewed indicated that they believe requirements for mobile gear fishermen to operate equipment to detect on-demand fishing gear should be mandatory:

“If this was to go forward, I can't see anything but mandatory monitoring by the dragger fleet every time they go fishing. But I just can't see the couple of dinosaurs that I deal with on a regular basis because... I couldn't picture these two, you know, two or three birds that I deal with who can't deal with the buoys when they see them, so how are they going to deal with anything else? And they have no desire to deal. But I think if this goes forward, this has to be mandatory, no questions asked, because the lobster fleet is the largest fleet in the Gulf of Maine, and if the lobster industry is gonna be forced into this then the dragger fleet is gonna be forced into it also. With penalties involved. This thing cannot be just a 'see your gear' type of thing. If they can keep track of where my gear is by an acoustic signal type of thing then they're going to have to stay away from it. There's no question about that. But they won't like having that discussion.”

- *Fixed gear fishery stakeholder*

2. Technology

“I don't like to focus on the technology because it's all solvable... I think it really comes down to, what are we willing to give up?”

- *Fishery organization staff member*

Weighted traps, vertical lines, and surface buoys are used by fishermen to accomplish three essential functions: anchor and locate gear, signify ownership of gear, and facilitate the mechanics of gear retrieval. On-demand fishing gear must replicate each of these functions in an efficient manner, subject to high throughput and repetitive use, in order to be successful.

Locating on-demand fishing gear, identifying ownership, and the related process of calling the correct gear to the surface will require significant new electronic approaches and the development and/or maturation of new technologies. Several technical approaches to each of these functions have been proposed or developed and are mostly at the conceptual or testing phases today. Efforts to collaboratively solve other technical issues including standardized approaches to displaying on-demand gear information on chart plotters should also be prioritized in the near term.

Virtual marking

Virtual marking of on-demand fishing gear is one of the most difficult and important technical challenges to be overcome in designing on-demand fishing gear systems. Further development of one or more virtual gear marking systems is necessary before on-demand fishing gear techniques can be evaluated at scale and in a variety of operational contexts.

In order to reduce costly and damaging gear conflicts, information about the position and orientation, configuration, and ownership (self/other) of on-demand fishing gear should be reliably available in real-time to all fixed and mobile gear fishermen operating in the vicinity of deployed gear. In addition, information about the person/vessel who deployed the gear, individual trap ID, and other information should be available to law enforcement and fisheries managers. There are several existing or conceptual approaches to designing a system that a fisherman would be able to use to virtually mark and locate their own or someone else's on-demand gear on the seafloor to either retrieve their gear or to avoid it.

The first approach to virtual marking, which has been used by a few on-demand manufacturers to date, is a GPS-based marking system. Currently, GPS-based gear marking approaches are the only type available for on-demand gear testing programs in the US. Using this technique, when on-demand gear is deployed, the operator presses a button to log the location from a GPS receiver. That GPS position is associated with the gear, including equipment ID, user ID, and a timestamp. On-demand gear systems would be equipped with a retrieval system, an acoustic modem, and a battery. Most gear manufacturers using this approach also capture the location of a second trawl end, in the case of a hybrid on-demand/buoy configuration, or the location of a second on-demand unit on the other end of the trawl. These systems can display the direction of a trawl set as a line on a chart. Logged deployment information can be shared with other users, including law enforcement and other fishermen, by querying a database that stores deployment information.

GPS systems come with a number of challenges. These systems require a data connection in order to provide users with a frequently or continuously updated map of deployed gear. GPS systems also require software to ensure that a virtual mark is associated with a confirmed gear deployment in order to prevent ‘phantom’ sets.¹⁷ The most commonly cited challenge with GPS-based marking systems (by gear technologists, fishery management professionals, and mobile/fixed gear fishermen) is the possibility of losing gear if it is moved an appreciable distance from the mark.¹⁸ However, GPS-based systems have significant system-wide cost advantages because fishing vessels that are not using on-demand gear would not be required to install a transducer in order to detect gear.

The second approach is acoustic ranging. Using this system, a vessel would be outfitted with a hull-mounted transducer that would periodically emit acoustic signals. Similar to GPS-based systems, acoustic ranging-based on-demand gear systems would be equipped with a retrieval system, a battery, and an acoustic modem. Deployed on-demand gear would detect, interpolate, and, if appropriately coded, immediately respond to the vessel’s signal with a return signal, which would be detected by the transducer on the vessel. The distance between the vessel and the deployed gear can be calculated, and a survey process of repeated interrogation-return signaling would allow the system to determine the location of the deployed gear. One on-demand gear manufacturer is developing a proprietary directional transducer system that could use a return signal to determine vector and distance to deployed gear, reducing the number of steps in the survey process needed to accurately determine the location of deployed on-demand gear.

The third approach is gear self-localization.¹⁹ Vessels using this type of on-demand gear system would be equipped with hull-mounted transducers that regularly broadcast an acoustic signal including the vessel’s location. Similar to acoustic ranging systems, self-localizing on-demand gear systems would be equipped with a retrieval system, a battery, and an acoustic modem. However, unlike ranging-based systems, self-localizing systems would triangulate their own locations using broadcasts from surface vessels. Self-localizing systems could be programmed with a set of rules to determine whether to communicate location to a vessel at the surface in order to preserve battery life and minimize impacts to the acoustic environment.

Challenges associated with acoustic ranging and gear self-localization include higher system cost driven primarily by the requirement to install transducers on all vessels operating in an area where on-demand gear is deployed in order to detect it.

The status of gear marking technology development today is varied. Copyright, patents, and/or open-source documentation for the three classes of marking technology discussed here have been registered, filed, or published, respectively, by gear developers. Much of the hardware is in prototype development stages, with significant refinement being necessary before commercial sales are possible. Most acoustic modems used for oceanographic research, energy, and defense applications are overengineered or otherwise far too expensive for an on-demand gear application. Because of this, some gear developers are planning to use off-the-shelf components for the next generation of purpose-built

¹⁷ Without such failsafes a user could, for example, create a virtual mark without placing gear in order to ‘hold’ fishing grounds in order to deter mobile or fixed gear fishermen from operating in the area.

¹⁸ Multiple fixed gear fishery stakeholders involved in gear testing programs detailed an incident in the summer of 2021 involving a hybrid trawl marked with a GPS-based system. The trawl was towed several miles by a mobile gear fisherman, but was ultimately retrieved by the operator after a search.

¹⁹ Baumgartner, M.F., & Partan, J. (2021). Self-localization of buoyless fishing gear and other objects on the sea floor. *JASA Express Letters*, 1(8), 086001.

acoustic modems for on-demand fishing gear, which is expected to reduce price significantly. Because sourcing of funds from retail sales to support additional technical development is not possible for some gear developers, external sources of capital are likely to be necessary for some developers focused on new technology to bring a product to market.

Acoustics

If on-demand fishing gear comes into widespread use in commercial fixed gear fisheries, it will likely become the most intensive application of marine acoustic communication in the world. Of course, marine sonar is in widespread use across numerous applications, and military and oceanographic research applications also abound, but the design constraints and challenges for on-demand fishing gear make this application unique. On-demand gear developers are currently developing standardized approaches to underwater acoustic communication approaches in their respective applications. It is likely that a single standardized open-source approach to encoding and transmitting information acoustically, across one or more discrete frequency bands, will be necessary for the safe, orderly, and cost-effective implementation of on-demand fishing gear.

This is true for several reasons. First, a standardized ‘language’ for acoustic communication will be necessary if more than one manufacturers’ acoustic equipment is in use and/or in order for gear to be compatible across platforms and systems. This will be particularly necessary if multiple manufacturers develop gear for a future Northeast US market, and to maintain law enforcement monitoring and enforcement capabilities across platforms. Several gear manufacturers interviewed for this project pointed to the JANUS standard for acoustic communication as the world-leading acoustic data communication standard and an approach that may be well-suited for on-demand fishing gear applications.²⁰ JANUS was developed to become the NATO standard for underwater acoustic communications, but it is intended to be used in non-military applications as well. It is an open-source protocol with no frequency band restrictions and a flexible approach to data cargo payloads, including allowing encrypted data and proprietary communications. It could be possible for data payloads to be divided into encrypted (e.g., owner ID, time of deployment) and unencrypted (e.g., location, device ID). There has not yet been a comprehensive effort to standardize on-demand gear communications protocols using JANUS or any other standard at this time, but it is highly likely that such a standard will be necessary if acoustic ranging or self-localizing approaches to on-demand gear are to enter widespread use.

Second, the distance that acoustic signals must be able to travel in order for the use of on-demand gear to be practical must be defined. If the design goal is to mimic the capabilities of radar and visual sightings of gear at the surface, then systems that detect deployed on-demand gear must have an operating range of a mile or more. Fishermen calling gear to the surface will likely need to be able to locate, interrogate, and actuate gear while steaming toward its location in order to maintain efficient levels of gear throughput, which may necessitate a minimum distance and a frequency maximum associated with that distance. Alternatively, if the range is too great, vessels emitting interrogation signals may ‘wake’ deployed gear unnecessarily, resulting in reduced battery life and unnecessary return signal emissions from the gear. If adopted, specific requirements for on-demand gear performance over operational

²⁰ Potter, J., Alves, J., Green, D., Zappa, G., Nissen, I., & McCoy, K. (2014, September). The JANUS underwater communications standard. In *2014 Underwater Communications and Networking (UComms)* (pp. 1-4). IEEE.

distances are likely to direct the future development of acoustic equipment including acoustic modems and vessel-mounted directional transducers.

Third, the environmental sensitivities associated with hundreds or even thousands of transducers emitting acoustic energy in the ocean will be considered under any federal regulatory scheme. In particular, the impact of changes to the acoustic environment on marine mammals, particularly to right whales themselves, must be minimized. This is a major consideration given the known acoustic sensitivity of the animals as well as the nature of marine acoustics, where the distance an acoustic signal can travel underwater is inversely proportional to frequency.

On-demand gear manufacturers believe they have found a sweet spot. The high end of North Atlantic right whale acoustic sensitivity is thought to be around 25 kHz;²¹ marine acoustic transmissions with frequencies of 22-27 kHz have an effective range of around two to four kilometers before attenuation loss. This range is similar to the effective range of a visual search and somewhat less than the effective range of a radar scan for highflier buoys equipped with reflectors. It remains to be determined whether acoustic transmissions within this frequency band are benign to right whales and other marine life, including lobsters and other harvested species. According to interview participants, coordination between marine mammal acoustics experts and on-demand fishing is ongoing, and a unified approach to acoustic emissions standards for on-demand gear may be forthcoming.

Displaying digital information

Digital representation of deployed on-demand fishing gear and accompanying metadata is becoming a central component of on-demand system design development. Currently, most on-demand gear users display information using a system developed by EdgeTech called Trap Tracker, which is an iOS and Android application that integrates the data and location display, gear deployment and retrieval, and database communication functions of on-demand gear into a single software package.²² Fishermen who have used Trap Tracker reported positive experiences overall.

Fixed and mobile gear fishermen interviewed for this project expressed fairly consistent opinions about the ways information should be displayed as well as the types of information that would be helpful to have when making operational decisions on the fishing grounds. Fixed gear fishermen generally agreed that the ideal approach to displaying on-demand gear would be integration into a chart plotter display. One mobile gear fisherman stated a preference for a dedicated display for deployed on-demand fishing gear, whereas others indicated a preference for integrated display of bottom information and gear location.

There are numerous models of chart plotters available on the market today, many of which use different or unique operating systems and communication protocols. However, many of these systems are designed to receive data encoded in universal standard languages designed by the National Marine Electronics Association (NMEA).²³ Peripheral equipment designed to be compatible with chart plotters send information in ASCII 'sentences' that use a standardized encoded prefix that allows the plotter to appropriately interpret and display the information. Displaying the location of deployed on-demand gear

²¹ Carlson, T. J., Halvorsen, M. B., Matzner, S., Copping, A. E., & Stavole, J. (2012). *Monitoring and Mitigation Alternatives for Protection of North Atlantic Right Whales during Offshore Wind Farm Installation* (No. PNNL-21959). Pacific Northwest National Lab.(PNNL), Richland, WA (United States).

²² Trap Tracker. <https://www.edgetech.com/product/trap-tracker/>

²³ National Marine Electronics Association. www.nmea.org

and associated metadata including trawl configuration could require the development of new NMEA sentence protocols or other specialized approaches to transmitting information received from an acoustic modem.

During interviews, fixed and mobile gear fishermen described the types of information they believe it would be important to display in order to efficiently operate on-demand gear and avoid conflict. Fishermen clearly indicated that displays should display trawls accurately, and that other information they would be able to determine from a visual scan should be included on a digital display. Fixed and mobile gear fishermen indicated that knowing the identity of the owner/operator of deployed on-demand gear would enhance cooperation and coordination on the water:

“I think [knowing the owner of on-demand gear on the water] would be great. I mean, I'd look at that and I think it would be important because we can figure out who we're working around and work together so we can both make a living right there.”

- *Mobile gear fishery stakeholder*

However, according to individuals familiar with the development of on-demand fishing testing programs, other fishermen may not view the display of ownership information favorably, or would prefer that information be restricted solely to other fishermen operating in the vicinity:

“I think our goal is that- the fishermen don't want the location of their gear known broadly. So we need to make sure that these systems are developed so that there is some type of limited access. So a fisherman who is within a radius of somebody else's gear would be informed that that gear was present. But if they were outside of that radius, that information wouldn't be available to them.”

- *Fishery management professional*

According to on-demand gear developers interviewed for this project, it will be possible to program GPS-based marking systems to display certain metadata and attributes for certain classes of users and to restrict the display of information from gear deployed outside a predetermined radius.

Some fishermen emphasized their belief that the development of standardized approaches to visualizing on-demand gear should be a prerequisite for the use of on-demand gear on fishing grounds:

“It can't be phased in, all those things that the different companies do. They have to get on the same page, have to have standardization, you know, whether it be like metric systems, or NMEA sentences for GPS communications. There has to be a standardized protocol that they all conform to. So that's the first thing that's happened. The second thing has to be you have to get out all the boats at the same time and then within a year or two get them installed. And then it has to be implemented with perhaps a trial period so you can see it and line it up with a screen to see if it matches. And then you could go to completely ropeless. But that's the only way I see it being feasible.”

- *Fixed gear fishery stakeholder*

Telecommunications & data management

One fundamental feature of any on-demand fishing gear system is the real-time display of virtually marked gear on the seafloor. For systems that use active acoustic signals to locate and identify gear, all information necessary to visualize the location and configuration of the gear would be obtained in a 'closed loop' manner, i.e., without the need to access a database. However, systems that rely on GPS-based surface marking require a cellular or satellite data link to transmit and receive gear deployment data. In areas where fishing gear is frequently tended, gear location data would likely need to be updated in real-time.

Most on-demand fishing gear systems currently being tested on fishing grounds use GPS-based surface marking and thus require the use of a database to store and retrieve gear location information. Most fishermen who are testing the gear use their existing satellite data service to transmit and receive gear location data. Numerous federally permitted lobster fishing vessels are equipped with satellite communication equipment to allow the use of VMS, a requirement for operation in many other federally managed fisheries and any lobster fishing vessel with permits for other fisheries including groundfish, scallop, etc.²⁴ However, a majority of lobster fishing vessels operating in the Gulf of Maine are not equipped with VMS, and it is unclear at this time how many lobster fishing vessels are equipped with satellite communications equipment. The use of on-demand gear close to shore and within range of cellular networks could obviate the need for satellite communications equipment.

On-demand gear developers familiar with acoustic ranging and self-localizing systems expressed the belief that the use of databases to log on-demand gear location information for such systems would be an important system capability for law enforcement and accountability purposes, even though these systems would not be necessary to locate the gear on the fishing grounds in real time because vessels would be actively communicating with the gear in order to locate it. It is possible that a database for logging on-demand gear deployment information for these types of gear location systems could be updated periodically rather than in real time, particularly if the systems are used by vessels taking short trips. Using this approach, on-demand gear systems aboard fishing vessels would only need to communicate with a server to upload location and use data at the end of a fishing trip. It is unclear if fishing vessels making multi-day trips would provide data frequently enough for effective spatial data inventory and law enforcement purposes.

During interviews, fishing industry stakeholders, gear developers, and fishery management experts discussed the importance of data security and confidentiality and the challenges that confidentiality requirements bring. Current laws and regulations around confidentiality could constrain the transmission of on-demand gear deployment data, inducing information to identify ownership and location generally:

"Obviously the gear has to be able to talk to the mobile fleet and you could create a map of where all those traps are, either through talking to the mobile fleet or talking to a ferry vessel that happens to be going by or a shipping vessel, because those vessels also have the ability to have some sort of transducer that communicates with these traps and then it can go into this centralized database. But knowing industry and how tight they are with their data and those concerns, I just can't imagine that they would agree to that. And the federal government allows

²⁴ Greater Atlantic Regional Vessel Monitoring System.
<https://www.fisheries.noaa.gov/new-england-mid-atlantic/enforcement/greater-atlantic-regional-vessel-monitoring-program>

for confidential data. You can't give out any information about one individual fisherman's landings. So I just wonder how you would get past being able to say where someone's traps are. If I can't tell you how much Joe Smith landed, how would I be able to put out there where Joe Smith's traps are? ... Confidentiality is a really hard thing for fisheries managers. I understand where the industry is coming from, but it really makes it difficult to do some of the things that we want to do for the industry to try to make things better for them."

- *Fishery management professional*

Data security, ownership, and warehousing capacity were also discussed by interview participants:

"You know, [confidentiality and data ownership] is a big topic of conversation right now. I think [one developer's database] currently has a lot of data that's confidential data that is eventually not- that's not a good system. Yeah, I think there needs to be some kind of third party kind of like we do with electronic monitoring. There probably needs to be some third party that holds the data. I would say the [federal] agency can hold it, except they don't seem organized enough to be good holders of the data. I think we'd be better off with a private entity."

- *Conservation organization staff member*

Some gear developers may agree that a third party should be responsible for data. Although some GPS-based gear marking systems in use today use servers owned and operated by gear developers, at least one developer does not believe that this is a viable long-term approach:

"We're willing to give [our on-demand gear location database] away to the regulators. If they want to use ours, that's fine. We don't want to have the database. We just [developed our database] because we wanted to show that we can do it."

- *On-demand gear developer*

Some on-demand gear developers are currently developing data storage and sharing solutions that could function across platforms. One group, called Earth Ranger,²⁵ has initiated a project to apply its data sharing products that integrate data from multiple platforms into a single cross-platform database to on-demand fishing gear applications.

Research opportunities

Some interview participants see an opportunity for on-demand gear technology to provide other ancillary benefits, including monitoring and scientific research. For example, on-demand gear could significantly expand agencies' monitoring of deployed acoustic tags on species of interest, including sharks, groundfish, and other species:

"[One company] has these acoustic tags that also have receivers in them that will log data from other tags that they hear. And so [if on-demand gear is deployed widely] you've just turned the Gulf of Maine into a big animal telemetry system, which would be really cool."

- *Fishery management professional*

²⁵ Allen Institute for Artificial Intelligence, Earth Ranger program. <https://www.earthranger.com/>

Other data acquisition and remote sensing opportunities raised during interviews include the deployment of hydrophones aboard on-demand fishing gear systems, which could aid in the tracking of North Atlantic right whales within or near fishing grounds, with possible dynamic or adaptive management implications. One interview participant raised the idea of enabling on-demand gear users to monetize their use of the technology by selling the oceanographic data they generate from sensors aboard their traps. However, it is unclear whether there is broad interest in this new market channel or whether such a market exists.

Performance standards

Efforts to comprehensively evaluate the features and capabilities of on-demand gear systems in order to determine tradeoffs, perform cost/benefit analyses, and establish performance benchmarks are in their early stages. Many of the on-demand gear technologies proposed for use in New England lobster fisheries will likely require years of further development. Technical specifications for and requirements of on-demand fishing gear systems in the lobster fishery have not been developed by a state or federal fishery management agency to date.

Several scientists and on-demand gear developers interviewed for this project pointed to the VMS as an area that could inform the development of hardware, software, and performance standards for on-demand gear from a process and technical standpoint:

“I think that [NOAA is] going to be able to dictate how ropeless fishing is to be prosecuted and specifically what devices will be compliant with their regulations. So there's a great- it's not even an analogy, it's a sister program for this, and that's VMS. Right now, the federal government has a program where they say you need to have VMS on your vessel, and here are the manufacturers that make compliant devices, devices that are compliant with our regulations. So at some point somewhere, someone in NOAA wrote down a bunch of specifications for requirements or specifications for an electronic device that collects GPS information and sends it back to some NOAA database, and it's done through satellite. And so they wrote down a bunch of requirements and then they must have had a bunch of manufacturers that they would tell, ‘we need these things designed and manufactured, and you can sell them to fishermen’. But fishermen can only buy from this list of compliant devices. That's the way ropeless is almost surely going to go. NOAA's going to say what these devices are supposed to do and then they have to bless manufacturers to actually make them. And because there's a precedent there with VMS, I don't think this is going to be a great new regulatory quagmire that no one knows how to get out of. We've got an example of how to do this, and it's VMS. So let's just learn, take the lessons learned from VMS and just do that again. As I said, no one in the government has recognized that they need to initiate this kind of a process.”

- *Scientist/economist*

According to experts interviewed for this project who were involved in the development of VMS standards, initial reluctance on the part of the fishing industry to adopting the systems was based on perceived cost impacts:

“I think there were some technology concerns about whether it was affordable. But a few years later, you know, I don't remember exactly how many years later, the agency came up with dollars to fund the installation of VMS, and it became widely adopted when that happened. My

recollection is the cost is relatively reasonable, I think it was somewhere on the order of, probably less than a thousand dollars to install a VMS unit. But when the money became available, it became widely adopted in the groundfish fishery. I think it was adopted earlier than that in the scallop fisheries. [The New England Fishery Management Council] had very little to do with the development of the standards for VMS. I'm not sure [the Council] had anything to do other than to say, 'you've got to have a VMS unit on board that meets the requirements established by the Fisheries Service'. Sometime around the mid 2000s or thereabouts, [National Marine Fisheries Service (NMFS)] headquarters established national standards for the VMS units that were used throughout the country, and they have to have a national certification. And I don't recall [the Council] being involved in that discussion at all. I'm not even sure [the Council] commented on any of the requirements that they proposed."

- *Fishery management professional*

Fixed gear fishermen who were interviewed for this project generally expressed negative opinions about VMS. Additionally, several fishermen who operate in state and federal waters expressed the opinion that federal requirements and performance standards for on-demand gear would be less preferable than operational performance standards developed by states for their permittees operating in state or federal waters and submitted for approval by NOAA. The stated reasons for this preference were broad; reasons included trust in one agency over another, regulatory flexibility, stakeholder participation in the regulatory process, or a preference for the ASMFC's management approaches over those of the ALWTRT or NOAA. State-based development and administration of on-demand gear performance standards is currently underway in California, which adopted performance criteria for 'alternative fishing gear' type approvals via regulation in 2020.²⁶

A dedicated program bringing fishery stakeholders, gear developers, and fishery managers together to collaboratively develop a set of performance metrics for on-demand gear to evaluate feasibility *in situ* could appropriately frame on-demand gear technology development, improve cost effectiveness, or determine whether it is appropriate for use in certain fishing areas. Indeed, if "[fishing] like you fish now" is the gold standard for on-demand fishing system performance, then several performance benchmarks are immediately available.

²⁶ 14 CCR §132.8(h)

3. Legal & regulatory issues

“I don't want to see them cut up the ocean and say, ‘well, you can fish here if you do this or if you do that’. That will be challenged ... I'd go to grappling my gear before I would do that right now, because of the sheer cost. I'm telling you where it's at right now, and I wouldn't, you know? And the reason- I thought to myself last year, we put a lot of effort into [testing on-demand gear]. It's because we see it as part of a solution, you know, not *the* solution, but maybe part of it.”

- *Fixed gear fishery stakeholder*

The legal and regulatory environment in which New England lobster fisheries operate is complex, conforming to multiple statutory frameworks with sometimes overlapping jurisdiction. Fishery managers and marine law enforcement must contend with a wide range of concerns while managing and enforcing laws and regulations and operating according to fishery management plans. Their responsibilities could be significantly affected by a switch to on-demand fishing gear. This section describes an evaluation of the legal and regulatory environment and investigated the ways on-demand fishing gear could change how fisheries are managed.

The state management role

US lobster fisheries are managed by the Atlantic States Marine Fisheries Commission (ASMFC) under its American Lobster Fishery Management Plan (FMP) and its various addenda.²⁷ The FMP governs federally permitted lobster fishing vessels and generally incorporates the requirements imposed by ASMFC member states' own laws and regulations governing their permit holders. The ASMFC's FMP in its modern form, *Amendment 3 to the Interstate Fishery Management Plan for American Lobster*, was adopted in 1997 after jurisdiction over the federal lobster fishery transitioned from the New England Fishery Management Council (NEFMC) to the Commission under the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA).²⁸ The FMP adheres to the principle of seeking to implement uniform management where practicable, although region and jurisdiction-specific measures are common. Each of the seven federal Lobster Management Areas has a Lobster Conservation Management Team associated with it, tasked with crafting management recommendations for their respective areas. Barstow (1999) provides a detailed history and analysis of this transition and related jurisdictional issues during its early years.²⁹

All states require the operators of federally permitted lobster fishing vessels to also obtain state permits in order to land their catch. Through this permitting approach, the states can impose statutory requirements on federally permitted vessels operating in federal waters. Fishermen permitted by states to harvest lobsters in state waters do not need to conform to federal fishery regulations, although state fishing effort is incorporated into the Commission's FMP and stock assessments through the cooperation of state management agencies.

²⁷ Management: American Lobster. <http://www.asmfc.org/species/american-lobster#management>

²⁸ 16 USC §5103

²⁹ Barstow, E. T. (1999). American Lobster Fishery Management Under The Atlantic Coastal Fisheries Cooperative Management Act: An Attempt At Cooperative Fishery Jurisdiction. *Ocean & Coastal Law Journal*, 4, 113.

Interview participants expressed polarized opinions about the jurisdictional issues of on-demand fishing gear regulation within state waters. Fishing industry stakeholders interviewed for this project generally expressed the belief that state regulations concerning on-demand fishing gear should apply within state waters:

“Speaking of Massachusetts, with state waters right now, we are extremely sensitive to the possibility of any interactions with right whales. So we don't want to see any further possible interactions because at the end of the day, I am so apprehensive about ropeless in state waters because we're going through this [Incidental Take Permit (ITP)] application process. Every impact is going to result in recourse or ramifications. And so I think the states need to handle state waters, and the feds can handle federal waters.”

- *Fishery organization staff member*

Conversely, conservation organization staff interviewed for this project generally expressed the belief that federal regulations concerning on-demand fishing gear should apply within state waters:

“I think that there's increasing discomfort, from a conservation perspective, unless something changes on the water pretty quickly, to let states [manage right whale entanglement risk mitigation] on their own if it's not underneath the [Take Reduction] Plan. It's one thing to have state specific gear markings as part of the federal plan, but it's another thing to have NMFS take the position of, ‘we're only going to regulate from three to two hundred miles’ and inside of three miles, it's all state regulations and it's not under the [Take Reduction Plan]. Then we don't know whether, just because state X says they're going to require things by date Y, what happens if they don't? We don't know that they're going to do that. They could change their mind. I think a lot of different things could happen. It's not a perfect system the way it is right now. It's legally flawed from our perspective.”

- *Conservation organization staff member*

The judicial record concerning the incidental take of right whales is voluminous, and it is likely to expand significantly before jurisdictional issues affecting the regulation of on-demand fishing gear are fully settled. The record does speak directly to the question of state management authority over fisheries subject to federal conservation frameworks: an oft-cited provision recognizes that Congress ‘offers States the choice of regulating that activity according to federal standards or having state law preempted by federal regulation’.³⁰

NMFS’ North Atlantic Right Whale Conservation Framework³¹ and the ALWTRP are structured accordingly. The Marine Mammal Protection Act authorizes NOAA to regulate commercial lobster fishing activities within state and federal waters in order to reduce the risk of serious injury and mortality to certain species of whales including the North Atlantic right whale.³² The agency regulates these activities for fishing activity in federal waters under the Atlantic Large Whale Take Reduction Plan (ALWTRP) as amended in 2021.³³ The Conservation Framework applies to federally managed fisheries, while fisheries

³⁰ *New York v. United States*, 505 U.S. 144 (1992)

³¹ Endangered Species Act Section 7 Consultation Biological Opinion (Consultation No. GARFO-2017-00031). NMFS, Greater Atlantic Regional Fisheries Office, Protected Resources Division. See Appendix A, pp. 473-482.

³² 16 USC 1387

³³ 86 FR 51970

permitted by states that have initiated a consultation under Section 10 of the Endangered Species Act (ESA) would operate under the provisions of an Incidental Take Permit.³⁴

Two states, Massachusetts and California, are currently seeking Incidental Take Permits under Section 10 of the Endangered Species Act (ESA) for fixed gear fisheries that have caused serious injury or mortality to ESA listed species, effectively taking Congress up on its offer to allow the management of state fisheries according to federal standards. In California's case, state-permitted fishing activity takes place within state and federal waters; in Massachusetts, the state's fishery management regime extends solely to the state/federal waters boundary. For states that have not yet sought or will not seek an ITP for their state managed lobster fisheries, the legal path forward is less clear, and is likely to be addressed in the courts in the coming years.

The federal management role

Under the ALWTRP, various requirements for the use of lobster fishing gear with persistent buoy lines have been implemented, and these requirements were modified substantially by the 2021 plan amendments. Most importantly for this project, the 2021 amendments modified the operating provisions of four seasonal restricted areas to prohibit the use of persistent buoy lines rather than to restrict the harvest of lobsters within their boundaries. This key distinction facilitates the opportunity for NMFS to issue Exempted Fishing Permits (EFP) that would exempt operators from surface marking requirements for the purpose of testing of on-demand fishing gear during periods when the seasonal restricted areas are closed to persistent buoy lines. The change in approach has prompted discussions across state and federal management agencies regarding the multiple regulatory approaches that would eventually be needed to modify surface marking requirements that would allow fishing without persistent buoy lines.

Ultimately, the approach that is used could result in significantly different outcomes for fishery stakeholders due to the statutory and regulatory frameworks governing each approach and the ways in which impacts to fishery stakeholders would be evaluated and used to inform the design of implementing regulations.

The first approach could be further amendments to the ALWTRP prohibiting the use of persistent buoy lines in certain places and/or at certain times. There is mixed opinion among interview participants about whether the ALWTRP should continue establishing the terms of the regulatory conversation around on-demand fishing gear implementation:

"I appreciate that the federal proposed role is incentivizing ropeless and allowing fishing in closures. Right now time and area closures are the only thing, though, that we know for sure will protect right whales. I appreciate that the [federal] agency is doing what it can to incentivize it. I think requiring [on-demand fishing gear] by a date certain would be great if we had answers to some of the questions we have. And certainly for fishing in state waters, I don't think it would be that hard, like in the next five years, to solve the gear conflict issue. And to answer all the questions we need to. I'm not certain we could do that in offshore [areas]."

- *Conservation organization staff member*

³⁴ *Ibid.* at 480.

“[The Take Reduction Team] should stay out of [implementing specific requirements]. You know, they said what they needed to say. And they should steer it out of it, because there's 65 members of that, and you're never going to get total agreement among 65 people. I mean, we were at the meeting in Providence. We had 64 people who agreed and one that disagreed, so they couldn't call it consensus. It's a very diverse group. I understand that. There were people of different interests. But when it comes time to work a deal out among fishermen I don't think you're going to want the Take Reduction Team at the table.”

- *Mobile gear fishery stakeholder*

The second approach could be the development of FMP addenda under the ASMFC and FMP amendments or other regulatory changes under the NEFMC governing the use of on-demand fishing gear in federal and possibly state waters. Some fishery managers expressed the opinion that the ALWTRP is likely to remain consistent with the 2021 amendments, leaving the task of regulatory implementation of on-demand fishing gear to the fishery management agencies:

“The Take Reduction Team process, I don't actually think that will be what drives ropeless necessarily. And while they'll continue to put in closures where they think those are necessary, and instead of it being a closure, they are going to word it to say it's a buoy line restricted area so you could say is not a closure of fishing, it's closure for the buoy lines. That will continue through the Take Reduction process. The take reduction process has a different goal than the ESA and the biological opinion. The goal is to meet [Potential Biological Removal (PBR)].³⁵ The ESA and the permitting of fisheries through the biological opinions has to prove negligible impact, which is a significantly different bar than the [Marine Mammal Protection Act (MMPA)]. So honestly, where is it actually going to come from versus where should it land? I don't know how it will play out, but if I had to guess, I would assume something like that will happen.”

- *Fishery management professional*

According to agency staff interviewed for this project, bringing state and regional fishery management agencies into the Take Reduction Plan conversation to further define their respective regulatory roles had been discussed by fishery managers during the development of the ALWTRP amendments:

“At this last round of take reduction meetings that happened - was it 2018? To my knowledge, that's the first time that there was discussion about having the Commission implement parts of the regulations or implement regulations that would be beneficial to the goals of the Take Reduction Plan, but not necessarily have to come down through NOAA, if that makes sense. In the end, that's not what has happened, but it is something that we did discuss.”

- *Fishery management professional*

However, other fishery managers believe that the ALWTRP is likely to govern the implementation of on-demand fishing gear requirements through plan amendments prohibiting the use of persistent buoy lines in time and space, with on-demand fishing gear as an option:

³⁵ PBR is the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

"I think that there would need to be a mandate coming down from NOAA fisheries to say that it's required through the TRT process. In the past, when regulations came through the Take Reduction Plan, oftentimes those just go straight through NOAA and then they just make requirements, whether that be breaking strength rules or highflier rules. And then the states just implement them within their state waters as required by the plan. And in some cases, it just happens. But if there was this mandate [for the use of on-demand fishing gear], then I think it would be beneficial to give the states an opportunity to work through it themselves and then doing it through the commission process would be easier for them to do that."

- *Fishery management professional*

The ways in which regulations might address conflict with mobile gear fishery are more opaque. Several individuals interviewed for this project contemplated the legal mechanisms by which a federally managed fishery with no known history of interactions with right whales might be required to use equipment to detect and avoid on-demand fishing gear. Fixed and mobile gear fishermen interviewed for this project recognized the important role that mobile gear fishermen will play if on-demand gear is used broadly on shared fishing grounds:

"In order to save these right whales, it's going to take a huge collaborative effort. And right now, the draggers have no idea. 'Why do we have to worry about whales? We don't have interactions with them,' they'll say, and same with the scallopers, 'well, that's the Lobstermen's problem. That isn't our problem.' Well, it's going to be and you're going to have to find a solution so that, unless- if you don't do that, then there won't be any lobstermen left because [mobile gear fishermen will] just tow up all the expensive gear, and you'll never be able to do any business because you'll never be able to find your traps. I know that's extreme, but there has to be some sort of collaboration between all the fisheries in order for this system to work."

- *Fixed gear fishery stakeholder*

According to multiple fishery experts interviewed for this project, collaboration between sectors may involve requirements for mobile gear fishermen to use equipment to detect deployed on-demand fishing gear. However, it is not immediately clear whether the ESA or MMPA would grant NOAA the authority to include requirements of a Take Reduction Plan that would extend requirements on mobile gear fisheries that have no known history of interactions with right whales. To the author's knowledge, no take reduction measures have been applied to fisheries that are not the focus of a take reduction plan themselves nor have requirements for ESA consultations been required for agency actions permitting gear types that have no known takes of right whales. Conservation organization staff interviewed for this project believe that there are legal avenues for the development of such requirements:

"I think [the use of systems to detect on-demand gear] could be a condition of a federal permit just like [how] you could require vessel tracking systems, and I do think there should be vessel tracking systems on all federally permitted lobster boats. Enforcement is a huge issue. And if you read the [Atlantic Offshore Lobstermen's Association] letter, they want, I mean, there's plenty of sectors of the industry that want vessel tracking systems on every boat. So I think you could require having this app on your boat, or the ability to see [deployed on-demand gear required] as part of a federal permit."

- *Conservation organization staff member*

The judicial record only tangentially speaks to this issue of ESA consultations for FMP amendments regulating fisheries with no known interactions with right whales: in *CLF v. Ross*, the plaintiff challenged NMFS' Habitat Amendment rules that would have allowed fishing activity within areas previously closed to fixed gear; the plaintiff's motion for summary judgment, which did not contest the Habitat Amendment's changes allowing scallop fishing activity to resume in the previously closed areas.³⁶ According to scallop fishing industry representatives, scallop fisheries were omitted from the plaintiff's summary judgment motion "because we demonstrated that we don't have any direct impacts to right whales or interactions."

Careful attention should be paid to determining the legal and regulatory approaches that state and federal agencies would eventually use to implement on-demand fishing gear regulations, in order to preserve the wellbeing of lobster fishing communities as well recover the North Atlantic right whale. Ultimately, the feasibility of the gear across various lobster fishing areas may determine which approaches are the most appropriate. Until such time as these feasibility questions are answered, agencies should leave the door open to all regulatory options.

In the absence of ESA consultations on FMPs for fisheries that have no known right whale interactions or Take Reduction Plan amendments requiring the use of specialized equipment by vessels permitted to use gear with no known takes of strategic whale stocks, requirements for the use of equipment enabling the detection and avoidance of on-demand fishing gear by federally permitted mobile gear fishing vessels could derive from other authorities: the NEFMC under its authority to develop and amend its FMPs, the US Coast Guard under its various authorities to promulgate maritime safety regulations, or voluntary measures taken by mobile gear stakeholders.

There was general agreement that regional fishery management councils should be involved in any future development of regulations and requirements for the use of on-demand gear:

"Hopefully they would pull in the Commission and Council to be able to [develop on-demand fishing regulations] in a way that makes sense for the fisheries, because, you know, obviously the Biological Opinion and Take Reduction Plan don't always, when they don't involve the fisheries and the states that actually regulate them, they get pretty messy."

- *Fishery management professional*

The Council has engaged in adjudicating gear conflict between lobster and groundfish fisheries in the past, as recounted by one interview participant:

"So an example of that regulatory solution is: right around the time we passed the gear conflict amendments, a little bit before that, there was a conflict in Southern New England along the 100 fathom curve, where trawlers fishing for monkfish of all things were dragging up lobster gear that was set along the 100 fathom curve. And the lobster fishermen tried to get an agreement with the monkfish fishermen. It wasn't successful. So they came to the Council and the Council adopted what we call these restricted gear areas, which are quite complicated. And basically, I don't remember the timing of the seasons, but basically in a particular season, the lobstermen would agree- well, not agreed now, they're required to get all their gear out of the area. And then during another season, the trawlers are prohibited from trawling in that area. So in

³⁶ 422 F. Supp. 3d 12 (D.D.C. 2019)

essence, to divide up the ocean into pieces and say who can fish where and when. ... That seems to have been relatively effective for that particular gear conflict. We don't really like those approaches if we can avoid them. Once you put something in regulation, if there's a change needed, then you've got to go through a whole process to make the change, and that's slower. And then once you put it in regulation, somebody has to enforce it. If it's not enforced, it doesn't work. And you know, the Coast Guard and Fisheries Service Enforcement folks aren't really thrilled with trying to enforce those types of regulations, though they do it. So that's where the industry tries to come to some kind of agreement. The industry agreements tend to take the same form, but they're informal agreements, and that makes it easier for them to adjust them if necessary.”

- *Fishery management professional*

Whether the Council’s regulatory role is constrained to focus solely on amending its FMPs to address on-demand gear issues or extends broadly, one unique tool in its regulatory toolbox is the amendments to the Northeast multispecies and scallop FMPs to address gear conflict. The gear conflict amendments established an abbreviated regulatory framework for rulemaking to adopt management approaches to solving gear conflict between fixed and mobile gear fisheries:

This final rule amends the fisheries’ framework process to allow implementation of a gear conflict management program for the FMPs and adds the following list of management measures to each FMP from which the Council could select future solutions to gear conflicts through the framework adjustment process: (1) Designation of restricted areas in one degree square increments (2700 nm), (2) mandatory monitoring of a radio channel by fishers, (3) fixed gear location reporting and plotting requirements, (4) standards of operation when gear conflicts occur, (5) fixed gear marking and setting practices, (6) gear restrictions for specific areas (including time and area closures), (7) vessel monitoring systems, (8) restrictions on the number of fishing vessels or amount of gear, and (9) special permit conditions.³⁷

Although the amendments were also added to NEFMC’s American lobster FMP, management authority transitioned to the ASMFC not long thereafter. Nonetheless, the options available to the Council to amend the Northeast multispecies and scallop FMPs to address potential gear conflict between mobile fisheries it manages and fixed gear fisheries it does not manage are based in broad and well articulated authorities. However, to date the gear conflict amendments have never been used by the Council for any of the fisheries it manages.

Industry-led cooperative agreements

Fixed and mobile gear fishery participants were unanimous in their preference for industry-led cooperative gear conflict mitigation agreements over regulatory approaches:

“We can throw regulation on, but we're way better off if we work together with the fishing fleet, and most efficiently, and not get into the regulatory process, I think. You know, keep the frickin government out of it, let us work together to figure it out. Like on the eastern edge of George's [Bank]. We have an agreement with the offshore lobstermen out there. They set the gear this

³⁷ New England Fishery Management Council:
https://s3.amazonaws.com/nefmc.org/Gear_Conflict_amendment___written_comments_1996-07-29.pdf

way and they fish on these particular lines and we fish in between those lines and, at a certain time of the year, the gear is gone so that we can go because it opens the bottom up. We are way more efficient at doing it ourselves than letting the feds or the states get involved in a regulatory process for doing that.”

- *Mobile gear fishery stakeholder*

Often called gentlemen’s agreements, cooperative agreements between fleets have been a feature of fishery operations for decades. Fishery regulators also generally expressed a preference for gentlemen’s agreements to regulatory approaches:

“To be honest, our preferred method to address [gear conflict] is to encourage fishermen to try and come to an agreement on the bottom, on the water, about how they’re going to interact with each other. And those agreements in some cases, work very well, at least for a while, and some cases don’t work well at all. In instances where they don’t work very well at all, the option is to come to the Council and seek some sort of regulatory solution to the problem. And, you know, the regulatory solutions tend to be limited to trying to restrict the times and areas where somebody fishes with a certain type of gear.”

- *Fishery management professional*

Fishery managers interviewed for this report recognized the need for a broader conversation involving the ASMFC and the NEFMC working together to explore the implications of on-demand fishing gear across segments of the fishing industry and develop approaches that could mitigate gear conflict challenges in the future. Such a conversation could involve fishery managers while enabling fishing industry leadership to develop solutions:

“There needs to be this bigger, broader conversation with some of the more major players of the different fleets. Have conversations about how [on-demand gear] works and what things have the researchers not been thinking about what other issues might need to be addressed? And I think that comes in the context of a workshop with the two industries where they’re talking through what has to be addressed. ... I don’t think the researchers and the managers, we just don’t always think of all the things that are going on in the water, the different types of technologies that different fleets have on their boats. ... At the Commission, I think we want to make sure that those conversations are happening and that it might be our role to administer such a workshop and that we would need to do that in conjunction with the New England Council. And as you know the Council has the lead on groundfish. ... I think there might be some differences of opinion on exactly who has authority over the gear conflict regulations that have been put in place in the past. And that’s something that I think we’ll have to get worked out with the leadership of the two management bodies.”

- *Fishery management professional*

Fishing industry members generally agreed that a conflict mitigation gentlemen’s agreement framework developed in response to future on-demand fishing gear use could achieve high levels of compliance in certain fishing areas:

“I think for the most part, most guys would comply with it. But you know, you’re always going to have your a*****, right? You are. You’re always going to have somebody that’s a jerk on board

and on either side. And he's not going to listen to the other guy. They have their way of weeding out. Eventually it's going to be a process. But I certainly think that we're big enough boys and we can handle that process and let guys know who aren't compliant, 'knock it off and get with the program here,' because everybody's trying to make a living. So I think we could, I don't want to say, force compliance, but we can make people comply. You know, it's basically peer pressure to comply with an agreement that one industry makes or the other. We haven't had those struggles out in Eastern Georges. Yeah, once in a while, a guy won't know about that agreement and they'll go wandering down through, the new guy coming out, then he learns real fast that that's not the thing to do."

- *Mobile gear fishery stakeholder*

On-demand gear testing & permitting

On-demand fishing gear testing has taken place for years, including various programs designed to improve upon and test the feasibility of on-demand gear for use in New England lobster fisheries.³⁸ Several fixed gear fishery stakeholders, agency staff, and conservation organization staff who have administered or participated in testing programs were interviewed for this project. Many of these experts expressed pride in the progress they have made and were optimistic about the prospects for further programs development:

"Personally, what I think is the biggest success of [the gear testing program] is the collaborative nature with the industry. But it was a small group of people, it was well-planned, well thought out. But there were a lot of initial meetings and there was a lot of collaborative input, and I think that was incredibly important to move it forward. I think one of the things that, if it becomes operational, the biggest and most important thing I can point to is the feedback from the industry and the response from, in this case, [a gear developer] to make the modifications to improve the designs based on the feedback from industry. [Fishermen] have to use [the on-demand gear]. So that part has been huge to see the transformation of some of the ways that the gear has, even if it's slight modifications to improve it, to make it more functional for use."

- *Conservation organization staff member*

NMFS's Northeast Fishery Science Center has taken the lead on developing and administering on-demand gear testing programs for the New England Lobster fishery, including the establishment of a gear cache, allowing a small number of fishermen to acquire and use on-demand fishing gear in a manner authorized by EFPs.³⁹ These programs have been administered in part by the ASMFC, which has taken on an important facilitation role that could lead to broader awareness and involvement in gear testing programs by the various states and the Commission:

"I think it's really hard, and somewhat rightfully so, for industry, as they are about to face a whole bunch of new regulations right now. Then on top of that, they have to try to figure out how to navigate a whole another set of regulations, in particular something that will largely change how they fish in a major way. And so the Commission and the States, I don't think, have

³⁸ Sawicki, 2020.

³⁹ NOAA Protected Species Gear Research (2021). Available from <https://www.fisheries.noaa.gov/new-england-mid-atlantic/science-data/protected-species-gear-research>

fully dove into some of these projects, such as that NOAA has been able to do because politically, it's easier for them to do that.”

- *Fishery management professional*

At the moment, the Northeast Fishery Science Center’s gear testing program has involved a small number of commercial fishermen who have been mostly operating ‘hybrid’ trawls, with a surface marker buoy at one end of their trawls and on-demand fishing gear systems at the other. However, initiatives to expand the testing of on-demand gear are currently being developed and proposed for state and federal waters.⁴⁰ During interviews and sessions of the on-demand gear workshop, issues of equitable access to fishing testing programs were raised:

“If you then [establish testing programs that] use the ropeless gear, it's an incentive for a small number of guys who end up going ahead and buying that gear and getting into that area. But will it be socially and economically positive for everybody that's in the industry? Probably not, because not everybody will be able to buy into that gear right away. It's going to be expensive.”

- *Fishery management professional*

However, before cost becomes a consideration, gear availability for testing programs and widespread willingness to participate in the programs will remain limiting factors. On-demand gear testing program participants do not currently face cost challenges because the gear is owned by other parties and loaned to on-demand gear testing program participants by the Science Center, allowing the program to operate in a cost-agnostic manner. At this time, NMFS is not planning on administering on-demand gear testing programs with a large number of participants. According to NMFS response to comments on the final Take Reduction Plan,

“Concerns that this experimentation will occur broadly in the near term appear to be unfounded. Due to the cost of ropeless technology, for the foreseeable future we believe that ropeless experimentation will be limited to collaborators accessing the NMFS ropeless gear cache, with perhaps an additional 10 percent of trawls being fished with other ropeless units. The NMFS gear cache also loans technology to collaborating mobile gear fishermen. For the next few years, we anticipate that the largest number of trap/pot trawls that could be supported by these efforts would approach about 330 pot/trap trawls coastwide (Maine through Florida).”⁴¹

To date on-demand gear testing programs have focused primarily on engineering improvements and other fundamental questions including deployment/retrieval success under various operating conditions. During interviews, it was commonly noted by on-demand gear testing program participants and non-participants alike that current on-demand fishing gear testing programs have not yet used experimental approaches to address numerous operational and feasibility questions generally and at scale (these are addressed in Section 5 of this report):

“We really need to bear in mind the difference between an experimental fishery and a commercial fishery as we're looking at this. Will these things work? I think they will. On a case by

⁴⁰ Letter of Authorization Request. Pioneers for a Thoughtful Coexistence, Inc. Available from https://www.mass.gov/files/documents/2021/12/22/Pioneers%20LOA%20Application%20for%20OnDemand%20Buoyed%20Gear_2022.pdf

⁴¹ 86 FR 51970

case basis, with a very small string of gear. Will it work for somebody like a guy that's got 800 traps along the coast of Maine, working up in the bays in the summertime and fishing offshore in the wintertime? I'm not too sure about it. But we shall see."

- *Mobile gear fishery stakeholder*

Current testing program participants interviewed for this project believe that broader participation in on-demand gear testing programs should be a high priority for gear testing program managers in order to address issues of scale and increase their efficacy and legitimacy:

"I think we need to get more people in the program or get more participants. There was one other boat that had signed up for it, we need to get more boats involved so that we get a very broad spectrum of testing. I think we're getting a very, very small sample size right now. ... In the offshore fishery, I'd say the majority of the fishery is owned by two companies. And then there's a need to- not either one of those companies is participating in this work right now. And yet as everything goes along, they'd be the first ones to stand up and say, 'Hey, we didn't do this.' So I think one of the first things that should happen is that- I did approach them about the ropeless, but didn't have any success in getting their participation. I think we might now. But that's what's important. In other words, we need to get a broader range of fleet participation."

- *Fixed gear fishery stakeholder*

Concerns about equity of access to and participation in on-demand gear testing programs were raised by multiple interview participants and were a significant focus of discussions during the workshop. EFPs that allow a limited number of participants to harvest lobster in closed areas while excluding fishermen who are unable or unwilling to participate are viewed by several project participants as unfair and inequitable:

"If you then change that and use the ropeless gear [in closed areas under EFPs], it's an incentive for a small number of guys who end up going ahead and buying that gear and getting into that area. But will it be socially and economically positive for everybody that's in the industry? Probably not, because not everybody will be able to buy into that gear right away."

- *Fishery management professional*

Several fixed gear fishermen believe that EFPs should only be issued for the testing of gear in experimental settings, as opposed to commercial-scale harvest within closed areas. These fishermen pointed to the potential disruptive effects that on-demand gear testing program participants might encounter, which is a legitimate concern given widely reported threats made against proponents of on-demand gear testing programs.⁴² Some workshop participants believe that EFPs should not allow commercial harvest until any fisherman became eligible to participate and on-demand gear was available to them.

⁴² Abel, D. (2022, Jan 31). *Despite threats from fellow fishermen, lobstermen press Mass. to allow ropeless fishing in closed areas*. Boston Globe. <https://www.bostonglobe.com/2022/01/31/science/despite-threats-fellow-fishermen-lobstermen-press-state-allow-ropeless-fishing-closed-areas/>

While increased participation is a goal of several on-demand gear testing proponents interviewed for this project, representatives of organizations and agencies that have been involved in litigation challenging lobster fishery management, on either side, indicated that exposure to litigation and concerns about risk were motivating their engagement on gear testing and EFPs. Some fishery stakeholders and conservation organization staff members expressed concern about EFPs that would permit on-demand gear testing in areas that have been closed because of elevated risk of entanglement:

“So if it's a dual permit holder, they need to pick where they're going to test it, or fish it. Fishing in federal waters or fishing in state waters. And the feds need to designate a PBR for ropeless, a separate PBR, because it's not just a faulty deployment that may cause harm, another concern that I find, I've brought it up over the years is if they are going to allow ropeless testing in areas of high aggregation of right whales. We don't want to see a right whale under the water covered in a trawl, because how are they going to detect that there's a right whale feeding when they're not tagged? So we don't want to see, obviously, any harm come to them, especially during a closure when there's zero chance. So I think NMFS needs to articulate more clearly the unintended consequences [of an entanglement during on-demand gear testing] and who's going to take the blame because at the end of it, it's going to come down to blame. ... I think the fishing industry has peace of mind knowing that they're not attributing any interactions with right whales [to the lobster fishery] because there's a closure in place.”

- *Fishery organization staff member*

“I think you're going to have a really hard time with some of the conservation community allowing any fishing in the Mass Bay Restricted Area because it's going from zero risk to some risk and in a species with a decline and is incredibly vulnerable. And you have basically a nursery of moms raising calves up here and it's one of the few habitats that we know of that's a solid foraging habitat in a small area. There is an incredibly high perceived risk of opening that closure to anything. And so there's concerns across the board about increasing vessel traffic, increasing noise, harassment, hauling up ground lines. So I think it's going to- I think the cultural aspects of change go across the board to both the conservation community and the industry. I think that's going to be a little bit of a harder sell.”

- *Conservation organization staff member*

Although the majority of attention and experimental approaches to evaluating the performance of on-demand gear to date has focused on fixed gear fishermen, mobile gear fishermen are beginning to participate in on-demand fishing gear testing programs and may become integral to the experimental approaches used in gear testing programs under EFPs. Conservation organization representatives involved in facilitating testing programs believe that mobile gear stakeholders should be part of their testing programs:

“I think everyone would love to have the involvement [of mobile gear participants], but I think at the end, it has to be something that there's a willingness. You don't want to set yourself up to fail. So you want participants that are interested to actually see if something can work, not to prove that it doesn't.”

- *Conservation organization staff member*

“I think there has to be this engagement and testing with the mobile gear fleet or some members of the mobile fleet to figure out in what ways will that communication work. And to test that. And then I think once you have those two pieces that can be put together where there are actually industry members who have been able to use this, found ways to make it work.”

- *Fishery management professional*

Gillnet fishermen have begun testing on-demand gear as well. One interview participant who works for a commercial fishermen’s organization reported, “We are doing some of that testing with gillnets right now because we know it’s coming for gillnets and we want to see if it could work or can’t work.” The proactive approach that some gillnet fishermen (largely those prosecuting hake and pollock fisheries in federal waters) and their representatives are taking to on-demand gear testing stands in stark contrast to the lobster industry, likely because the participants in these programs feel they are under less pressure from regulators at the moment.

Law enforcement

The issue of law enforcement was a central focus of discussions with stakeholders during interviews and the workshop, and law enforcement professionals were a target stakeholder group for engagement in this project. Unfortunately, the level of participation in the project from staff and representatives of law enforcement agencies was lower than for any other group, owing largely to the busy schedules of law enforcement officers and the interview format chosen for this project. It is likely that additional perspectives on the utility, technology, and legal/regulatory issues of on-demand fishing gear beyond those reflected here exist among marine law enforcement professionals.

During interviews with stakeholders, including a small number of law enforcement professionals and agency staff with expertise on law enforcement operations and regulations, discussions about law enforcement and on-demand fishing gear focused on two central issues: the nature and development of cases relating to the use of or damage to on-demand gear, and law enforcement officers detecting, retrieving, and inspecting on-demand fishing gear.

Many fixed gear fishery stakeholders expressed the belief that a strong law enforcement effort to establish accountability for gear conflict incidents between user groups and to deter activity on the water that would lead to destruction of on-demand fishing gear is a high priority:

“That’s something that should happen and must happen because if the federal government is remotely considering any of it, it needs to start at the top. The feds would have to operate [a monitoring and enforcement] program fully because they’re the ones that are pushing it, so they would have to mitigate, they would have to validate. And they’re the ones creating this mess. So have at it.”

- *Fishery organization staff member*

Currently, the process used to establish factual evidence in a developing gear destruction case includes verbal or written description reporting an incident and, if a case proceeds, the use of spatial data to determine which vessels may have been involved. A law enforcement professional interviewed for this project described the current approach:

“Well, let me describe a typical situation we've assisted with a gear conflict where, say, a lobsterman would reach out to law enforcement, and it would typically be one of our enforcement officers or special agents. ... So a vessel owner with lobster gear, fixed gear, who perhaps goes out to tend their gear, realizes it's missing, his trawl with some number of traps is gone. And so they know that, 'well, I lost gear, you know, I deployed it on this day and a week later, I go out and it's gone.' So they've got a time frame. And they've got a location, and they've got, obviously they can describe the markings for the gear and the amount of gear, but probably not much more. So they would give that information to an officer agent and ask if they could investigate what might have happened to the gear, is it possible to identify a vessel or vessels that were in that area? And as you can imagine, it doesn't often have a good outcome because it's very difficult to say without some sort of witness that this particular vessel pulled up the gear and still has it in their possession. An officer agent would come to me and say, 'OK, I've decided to look into the situation. And here's the information I have.' And then we would take the information and using certain tools and applications that provide us spatial and temporal information, time and location to at least try to identify a group of vessels within the time frame, particularly those that were fishing, that had gear deployed close to the area where the fixed gear was located. And we would also, for example, use VMS data. But we would also use AIS data, Automatic Identification System data. So over a period of time, they would look at it from day to day because of the amount of position data they have, to try to identify track lines of vessels that indicate the fishing activity. It's usually done simply by looking at their speed and looking at the pattern of their track line, as opposed to vessels that may be just transiting through the area without any gear deployed, and to provide a list of potential suspects, if you will, to the agent or officer to interview.”

- *Law enforcement professional*

Several state agency staff interviewed for this project stated their belief that culpatory evidence for gear destruction/molestation cases will be much easier to obtain if electronically marked on-demand fishing gear enters widespread use. This would likely result in an increase in the number of cases brought under state and federal law absent statutory or regulatory changes.

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), “It is unlawful... to negligently and without authorization remove, damage, or tamper with... fishing gear owned by another person, which is located in the exclusive economic zone”.⁴³ Under NOAA’s most recent Policy for the Assessment of Civil Administrative Penalties and Permit Sanctions, the agency considers damaging of fishing gear valued at less than \$2,000 to be a Level I violation,⁴⁴ and such damaging of gear greater than \$2,000 to be a Level IV violation.⁴⁵ Violations are assessed under a matrix of levels of culpability, which are determined by NOAA enforcement attorneys based on a set of factors.⁴⁶ Under the agency’s penalty matrix for violations of the MSA, Level I violations may result in penalties ranging from a written warning to \$2500 for unintentional culpability, a written warning to \$5,000 for negligent culpability, \$2,500 to \$7,000 for reckless culpability, and \$7,000 to \$10,000 for intentional culpability. For Level IV violations of the MSA, penalties assessed at the four levels of culpability are \$12,000 to \$18,000, \$18,000 to \$30,000, \$24,000 to \$48,000 with the possibility of permit sanction of 10-20 days for subsequent violations, and

⁴³ 16 USC §1857(1)(K)(i)

⁴⁴ Policy for the Assessment of Civil Administrative Penalties and Permit Sanctions, NOAA Office of General Counsel – Enforcement Section, pp. 30.

⁴⁵ *Ibid.* at 31.

⁴⁶ *Ibid.* at 8.

\$48,000 to \$72,000 with the possibility of permit sanction of 20-60 days for the first and subsequent violations, respectively.⁴⁷ It is unclear at this time how cases involving the destruction of on-demand fishing gear would be assessed for culpability. It is likely that any cases involving the destruction of on-demand gear would involve costs in excess of \$2,000.

According to interview participants, there has not yet been a NOAA enforcement case involving on-demand fishing gear; however, NOAA has pursued law enforcement cases against violators of gear damage provisions of the MSA. The development of federal enforcement cases against fishing vessel owners/operators involves several functions within the NOAA office of law enforcement. According to an interview participant employed by the federal agency, NOAA's VMS Program has assisted with the development of cases by analyzing VMS location data from mobile gear fishing vessels implicated in gear molestation cases.

Under Massachusetts General Law, it is unlawful to “without the consent of the owner, take, use, destroy, injure, or molest a... lobster or crab pot or other fishing gear”.⁴⁸ Under the Commonwealth's criminal penalty schedule, criminal violations of the statutory prohibition on the destruction of fishing gear are subject to a fine of between \$400 and \$10,000 and up to two and a half years imprisonment.⁴⁹ Non-criminal violations of the prohibition are subject to a fine of \$100.⁵⁰

The development of new or revised enforcement regulations pertaining to the placement, marking, and disturbance of on-demand fishing gear should involve state and federal law enforcement officials early in the development process. The inspection of lobster fishing gear is an element of marine law enforcement agencies' missions. Some agencies rely on physical inspections to achieve regulatory compliance and build enforcement cases and have built institutional capacity and procedures around this component of their missions. Other agencies rely on physical handling of lobster fishing gear for enforcement to a lesser extent or substitute visual methods of inspection for physical retrieval of gear.

The Maine Department of Marine Resources (DMR) has developed the highest level of operational capacity and practice to retrieve and inspect lobster fishing gear of all marine law enforcement agencies. DMR Marine Patrol officers frequently haul and inspect lobster fishing gear when lobster fishermen are not on site, and regularly build cases based on evidence derived from gear inspections:

“We have a bit of a unique situation in Maine because our Marine Patrol hauls a lot of gear. They're not so much doing dockside enforcement or boarding boats. They're hauling gear when fishermen aren't there. And I'm not aware of any other state or feds that actually haul gear without the fishermen being present, and that is sort of the cornerstone of how Marine Patrol is set up and functions in Maine. It drives our compliance rates. I think we have really high compliance rates because of it. So getting away from that model, that would be a complete overhaul of the system.

- *Fishery management professional*

⁴⁷ *Ibid.* at 24.

⁴⁸ M.G.L. c. 130, §31

⁴⁹ M.G.L. c. 130, §2

⁵⁰ M.G.L. c. 21A, §10H

Maine DMR may need to modify its gear inspection protocols or change the way it approaches law enforcement cases if on-demand fishing gear presents a significantly different operational profile than vertical lines:

“There are some things, if it got a lot more time consuming, that [Marine Patrol officers] wouldn't necessarily be able to do. There have been some cases where what's in question is the number of traps that a fisherman is fishing. And so Patrol will go out and haul all 800-plus traps of a particular fisherman in one day so that they can build the case that they're fishing above their allotment. I think that things like that will probably get more difficult to do if the time to recall and reset were to increase significantly, for example.”

- *State agency staff member*

Law enforcement agencies that integrate hauling on-demand fishing gear into their operations would need to develop expertise and procure equipment necessary for the retrieval and redeployment of all on-demand fishing systems permitted for use in their jurisdictions. Some fishing industry stakeholders interviewed for this project believe that this is a matter of developing experience or coordinating with fishing industry members:

“I think up in Maine, it's successful with them hauling gear and setting it back properly because they do it all the time. They're experienced at it, maybe even there's a former fisherman helping with it. But here in Rhode Island, we've had a different sort of experience where the boat, it can't even get your gear back where it was, it's set in a pile, they put it across other guys. I can't call that incompetence, its lack of experience. And it just needs to be better. My thought is, you see me hauling, come over, check my stuff out any time you want. I prefer you did it on my boat.”

- *Fixed gear fishery stakeholder*

According to agency staff familiar with ongoing conversations about the regulatory environment surrounding on-demand gear, compatibility with agencies' law enforcement missions may be a driving factor in discussions about gear standardization and what types of on-demand gear would be permitted for use :

“I think if some day down the road ropeless systems are required and if everybody is fishing them, the regulations are going to require you to fish a particular brand. Well, there could be a number of different ways that you could do it, whether it be those acoustic recall [devices] or if they're allowed to use the galvanic releases or whatever they end up choosing, Marine Patrol would have to maintain that same model. They have to have the ability to raise and reset all of those different types of gear, so they would theoretically have to be outfitted with a number of different ropeless retrieval systems. ... I think maintaining the ability to haul in and reset gear when a fisherman is not present will be tricky for them to maintain if everybody is fishing different technologies. ... They haven't quite figured out how that would work.”

- *Fishery management professional*

Federal law enforcement capacity to inspect fishing gear in the offshore environment is limited, and the increased complexity of on-demand gear would add to the agency's acknowledged inspection and

enforcement deficit. Federal law enforcement professionals interviewed for this project discussed the issue:

“To be perfectly frank here, when you're talking about the offshore environment, right now our [fishing gear inspection] capability is limited, very limited. We do operate a couple of patrol vessels, but they're not vessels that are going to go offshore. And so now you're immediately talking about collaboration with the Coast Guard, who is the primary enforcement partner with NMFS [Office of Law Enforcement (OLE)] for offshore fisheries enforcement. And how do we change that dynamic to our mutual benefit? Because we don't have the ability to get out there to inspect that gear. I guess it takes on a whole different dynamic. Right now, the reason for getting out here is there's all these lines that are entangling whales and we're trying to make sure that they're deployed according to regulation, but now with those lines removed, OK, theoretically, you don't have a whale issue anymore, but you've got different issue which is, OK, where is the gear? Particularly in relation to, say, the Canadian EEZ, which side of the line is it on, and is the gear configured the way it should be? I guess in either case, you don't know unless you actually look at the gear on the bottom.”

- *Law enforcement professional*

Agency staff expressed the belief that, in offshore waters, the use of on-demand gear could be a boon for law enforcement, who would have enhanced spatial awareness of gear location before leaving the dock:

"Enforcement-wise, I think there can be a lot of benefits of the ropeless gear because you [digitally] see everybody's traps and enforce that. And what we hear right now is that it's like the Wild West out there and the number of traps that are put out. Either folks are putting out way more traps than they're allowed to have or there are people who aren't permitted to fish for lobster that are throwing traps out there and catching whatever they want.”

- *Fishery management professional*

Federal law enforcement officials are currently exploring new approaches to inspecting deployed fixed gear in federal waters, which could conceivably be applied to inspections of and enforcement action on on-demand fishing gear and its operators. One such approach is the use of Remotely Operated Vehicles (ROV) to visually inspect fixed gear without requiring the retrieval and redeployment of the gear:

“One of our officers is testing, has tested, an ROV. They established a contract with the company and they've gone out, the ROV company and an operator, to go offshore and to use the ROV as a means to inspect the gear, the lines particularly. Do they have weak links? Do they have the proper markings? Et cetera. And so they've had some experience with that. ... They're planning to do that again this spring and summer rather than pull the gear. That's an issue. We really don't have the capability to pull that gear. And so the idea was to try and leave a gear in place, but use an ROV to inspect it. And I suppose, therefore, depending on its depth, we could look at the actual setup on the bottom, right? So they would do the inspection remotely. Part of the challenge with that, though, is they don't have good spatial resolution about where the fixed gear is located offshore.

- *Law enforcement professional*

Another solution to limited resources and capacity in federal fisheries law enforcement has been the establishment of cooperative agreements with state law enforcement agencies and the US Coast Guard. These agreements may need to be adapted to reflect the operational changes on-demand gear would bring:

“[The NOAA Office of Law Enforcement (OLE)] has a cooperative enforcement program with the states. And so OLE provides states with a certain amount of funding every year. And so the states perform certain duties to enforce the fisheries laws on behalf of NOAA. They're kind of a force multiplier, if you will. They do some of this work for us and will provide the results of their inspections to us. And that could result in an investigation and a fine because they're inspecting some of this fixed gear. And then again, in the federal waters and the offshore environment, that's got its own set of challenges regarding location of gear, ability to inspect gear. And we're working with the Coast Guard to perhaps use their buoy tenders as one way and having a nice well deck upfront to deploy the ROV and to work cooperatively.”

- *Law enforcement professional*

The issue of law enforcement having the capability to remotely locate and inspect deployed on-demand gear was raised as an issue for federal officers.

“The important thing for enforcement is, where is the gear? We need to know where that gear is just as well as the fishermen that are avoiding gear so that we have the ability to go out if we need to inspect it. And how do we inspect it? Do we have the on-call capability to bring it to the surface, and if we do, are we able to repack it and send it back to the bottom? Or do we perhaps use the ROV that we've talked about to do our offshore inspections? Again, I'm speculating here. One way or the other, I would think we would need to be able to see that gear to know whether it's compliant or not, whether we do it at the surface or perhaps do it remotely. They each have their own challenges.”

- *Law enforcement professional*

The federal law enforcement professionals interviewed for this project believed that it would be important for officers to be able to determine the precise location of deployed on-demand gear. They generally expressed a preference for gear marking technologies that used active acoustic location approaches rather than a surface mark:

“I would go directly to the transducer-based approach because enforcement would want to know specifically where the gear is deployed. Now, of course, that's particularly helpful if there are certain areas where they can deploy the traps and certain areas where they're not allowed to. So we would have to clearly know, not the position at the surface, but the position at the bottom, which can be significantly different.”

- *Law enforcement professional*

However, these conversations have not yet resolved into a formal position at OLE regarding a preference or requirement for one particular type of gear marking technology:

“There are arguments both ways. It seems to me the general opinion is that we just need to know where the gear is, not necessarily to be able to enforce it in real time. So the idea of using

some kind of cellular technology that provides the position data sometime later would be satisfactory to certain people. I know OLE hasn't really come out one way or the other that I'm aware of."

- *Law enforcement professional*

Liability

Whether in gear conflict amendments in FMPs, 'gear wars' on the water, or civil litigation in the courts, gear conflict between mobile and fixed gear fishermen off the coast of New England has been a topic of legal debate since the advent of motorized marine propulsion, and perhaps earlier. Practical answers to questions of liability for damage to on-demand fishing gear from various sources would enter a legal seascape that is well defined in some ways; several issues may require cultural, statutory, regulatory, and judicial resolution over time.

The judicial record regarding gear conflict between fixed and mobile gear operators is illuminating. The only case with an in-depth analysis of liability on this issue is *CEH, Inc. v. F/V Seafarer*⁵¹. In this case, the owner of the lobster fishing vessel *Courtney Elizabeth* sued the owners and two captains of the groundfish trawler *Seafarer* for the destruction of lobster gear.

The lobster fisherman sued on two counts: (1) a negligence claim that sought compensatory damages for the cost of the damaged and lost lobster gear, and (2) punitive damage claim based on the allegation defendants' destroyed the lobster gear by intentional, willful, malicious and/or grossly reckless misconduct.

In its analysis, the court starts from the idea "that the right of navigation is superior to the right of fishing." After additional discussion it went on to hold that "[a]s between fishermen . . . there is no priority of rights to fish in a particular area; each fisherman owes the other a duty of reasonable care. The style of fishing employed by a dragger which relies substantially on navigation does not, as a matter of course, make the dragger's rights to fish a particular area superior to that of a lobsterman who fishes with fixed traps. Rather, both vessels have an equivalent right to fish a particular area, and both vessels owe each other a duty of care, a duty to obey the 'rules of the road.'" Further, "[j]ust as the dragger must take reasonable steps to avoid the clearly marked fixed gear of the lobsterman, so too must the lobsterman clearly mark his gear in order to signal the dragger of its presence."

Ultimately, the court found for the Plaintiff on both counts. The trawler was found to be negligent because it owed a duty of care to maintain a vigilant watch, failed to do so, and therefore caused the allision with lawfully marked lobster gear. The court also awarded punitive damages because past conduct between the parties showed that the trawler acted with a minimum of malicious and/or grossly reckless misconduct. Punitive damages were assessed against one of the two captains of the *Courtney Elizabeth* as well as its owner; the court stated its intent to "[send] a message to other boat owners that, in the absence of clearly articulated and well known policies regarding the behavior of their captains, owners will be held liable for punitive damages for their captains' recklessness and intentional misconduct."

⁵¹ 880 F. Supp. 940 (D.R.I. 1995), *aff'd* *CEH, Inc. v. F/V Seafarer*, 70 F.3d 694 (1st Cir. 1995)

Of particular note in the context of on-demand fishing gear, the court used paper logbooks recording the placement of trawls and the positions of groundfish tows in order to establish that the *Seafarer* was trawling in the same place as the *Courtney Elizabeth* had set its trawls: “The precise trawls through which the SEAFARER towed can be determined by comparing the log books of the COURTNEY ELIZABETH to the log books of the SEAFARER and by scrutinizing the entries in light of oral testimony.”

Several other cases that address the issue of vessels at sea damaging fixed gear (involving a variety of lobster/fish/crab gear) including:

*Agger v. The Beatrice and Rose*⁵²

- A fishing vessel towing trawl gear ran over and destroyed gillnets.
- Court determined that “Where both [navigation and fishing] can be enjoyed, freely and fairly, that of navigation has no authority to trespass upon and injure the other.” However, “Where one only can be enjoyed, that of navigation must be the one.”

*Anderson v. Columbia Contract Co.*⁵³

- A towboat and barge damaged a fish trap.
- “Stated in general terms, the right of fishery must give way to the right of navigation. Expressed in more accurate language, the paramountcy of the right of navigation does not extinguish the right of fishery, although the former does, whenever there is a necessary conflict, limit the latter, and compel it to yield so far as the right of fishery interferes with the fair, useful, and legitimate exercise of the right of navigation.”
- “if nets are placed across the channel of a river, so as to be a bar to navigation, a vessel may, if reasonably necessary to do so, run over the nets; but, if a navigator is warned or ought to have known of his approach toward the net of a fisherman, he is liable for damage resulting from his negligent failure to avoid doing damage, if he can do so without prejudice to the reasonable prosecution of his voyage.

*Berry v. Boat Giannina B., Inc.*⁵⁴

- A commercial lobsterman brought civil damage action against the operators of two groundfish trawl vessels seeking damages for losses of lobster traps and attendant gear after they became entangled in dragger’s nets.
- The court found that the lobster traps were not likely to have been properly marked at the time they became entangled in trawl nets. It therefore found that the trawler did not intentionally take up the plaintiff’s traps in his nets; therefore, it was not liable for conversion-associated damages.

*Bordelon v. T.L. James & Co.*⁵⁵

- A fisherman brought a civil action against a dredging company seeking to recover for damage done to fishing nets.
- “...the servitude of navigation is paramount to that of fishing or other acts which may be performed in navigable waters.”

⁵² 84 F. Supp. 761 (D. Me. 1949)

⁵³ 94 Or. 171 (1919)

⁵⁴ 460 F. Supp. 145 (D. Mass. 1978)

⁵⁵ 380 So. 2d 226 (La. Ct. App. 1980)

- “Every structure or other obstruction in the water of a navigable river is subordinate to the right of navigation and subject to the obligation to suffer the consequences of the improvement of navigation, and must be removed if Congress, in the assertion of its power over navigation, shall determine that its continuance is detrimental to the public interest in the navigation of the river.”

*Rogers v. Tallman & Mack Fish & Trap Co., Inc.*⁵⁶

- There was a collision between a recreational boat and a fish trap in a designated fishing area; the operator of the recreational boat unsuccessfully sued for damages to the vessel, and the owner of the fish trap successfully countersued for damages sustained to the fish traps.
- “While it is true, as the libellants contend, that the right of navigation in Narragansett Bay is paramount to that of fishing, a navigator may not, by his own negligence, unnecessarily force those two rights into conflict and then claim the benefit of the paramount right”
- “Under the circumstances, the conclusion is inescapable that [boat owner] was negligent in failing to maintain a proper lookout that would have revealed the presence of said fish traps which in the exercise of due care he could easily have avoided.”

*Van Deursen v. Dunlap Towing Co.*⁵⁷

- A crab fisherman sued the owner of log tow vessels for loss of several crab pots allegedly destroyed by vessels.
- “Two rather divergent rules of law have emerged which deal directly with the circumstances presently under discussion. A strict or narrow rule is to the effect that when the two competing rights or interests-fishing and navigation come into conflict, the navigational interest must prevail in the absence of damage inflicted in a wanton or deliberate manner. A more moderate rule, and one which this court considers to be of broader applicability, grants to navigation the primacy due it but retreats from the strict rule by decreeing that where both rights can be enjoyed freely and fairly, the right of navigation has no authority to trespass upon and injure the right of fishing.”

In summary, through case law the courts have established three principles that are appurtenant to the question of liability for damage to on-demand gear by other fixed and mobile fishing gear operators: 1) the duty to maintain a vigilant watch; 2) the duty to properly mark fishing gear; 3) the establishment of liability for damages on the part of the party responsible for causing allision with deployed fixed gear if the second principle is met.

These issues are broadly recognized by the groups of stakeholders interviewed for this project. Several fixed gear fishermen reported that the use of electronic equipment to track fishing vessels and the deployment of on-demand fishing gear would provide proof of gear molestation that is currently unavailable to them. They further stated that they would be likely to seek remuneration from a mobile gear fisherman who towed through their gear, and whose liability for damages would be implicated by culpatory electronic information:

“If I go looking for [on-demand gear] and it disappeared, and you've got a dragger, tracked on AIS or VMS who went by where that gear was and it's gone, I want that person to pay for it. I want him to be held accountable for it. They're never held accountable now because they just tell you

⁵⁶ 234 F. Supp. 358 (D.R.I. 1964)

⁵⁷ 17 Wash. App. 281 (1977)

they didn't see the gear, but if it's on an acoustic device that everybody is supposed to have access to, that they have no excuse.

- *Fixed gear fishery stakeholder*

Conservation organization staff members who have advocated for the use of on-demand gear expressed awareness of these liability issues:

"One of the things I have heard from mobile gear fishermen is the concern of their liability if they do trawl up an on demand unit because of the cost. If they're responsible for ten thousand dollars worth of damage versus a thousand dollars worth of damage if it's a regular trawl. And that has been a concern that I have heard expressed more than one time: what is their liability if they blunder into a trawl?"

- *Conservation organization staff member*

"Obviously, the more money we're talking about, the more likely someone would pursue it legally versus saying, 'Oh, f*** that guy, you know, I'm going to drop a cigarette on his boat or something'. These [fishing gear] wars have gone on forever through, whether it's cutting traps or doing something else stupid and destructive to somebody's gear. Certainly tensions are really high with ropeless fishing, but I just don't want to act like it's this brand new, insurmountable problem because I do think you could write [rules] so that- I think there are people already towing through guys gears repeatedly and there's a lot of gear lost because of that. But it's sort of a different issue to me than whether we can figure out ropeless fishing."

- *Conservation organization staff member*

The requirement to maintain a vigilant watch is a well-established concept in admiralty law. Should it be determined via statute or regulation that installing, maintaining, and consistently using electronic equipment for the detection of deployed on-demand gear is mandatory, it is likely that the failure to avoid the gear and any resulting allision or destruction of gear would at least be indicative of a failure to maintain a vigilant watch (as with *Rogers v. Tallman & Mack Fish & Trap Co., Inc.*) or, in the case of repeat instances of damage, gross negligence (as with *CEH, Inc. v. F/V Seafarer*).

However, questions would likely remain regarding whether the placement of on-demand fishing gear and the establishment of an electronic 'mark' recording deployment location, and/or the adequate maintenance and performance of acoustic telemetry systems aboard deployed gear, would constitute proper marking of the gear. The judicial record speaks to this in part: in *Berry v. Boat Giannina B., Inc.*, establishing whether fixed gear placed on the ocean floor was properly marked at the time of allision was the determining factor in assigning liability for damage caused to lobster traps by a trawl vessel. This issue of admiralty law could be addressed by Congress or in the courts.⁵⁸

"Certainly you would need an attorney if you're going to figure out how to write a regulation so that there'd be consequences for the other guy. But I would be interested, and I might just ask for my own edification, I know their gear gets towed a lot and I know that they know, sometimes, what vessel did it because they can see them do it. ... I'm told that a trawl of forty five traps is worth, with the rope, about twenty thousand dollars to them right now. So if you

⁵⁸ See <https://www.law.cornell.edu/wex/admiralty>

add a ropeless unit, the difference is between twenty thousand and twenty four thousand dollars. And would that be enough to cause someone to go get a lawyer? I think that's the kind of thing I wonder about, you know? What would be the cost differential that really changes that equation? Or does it just piss you off more?"

- *Conservation organization staff member*

The judicial record and the various stakeholder perspectives on this issue do indeed indicate that liability is not likely to be an insurmountable problem; statutory changes or, more realistically, admiralty case law precedent, will settle these issues. However, given the frequency of gear conflict occurrences when gear is visibly marked at the surface, the introduction of new marking technologies, increased costs of on-demand gear, and the likely advent of new electronic forms of fishing gear location recordkeeping and their potential use as evidence, it is possible that gear conflict liability will become a feature of the legal discourse around the use of on-demand fishing gear. It should be viewed as a motivating concern in all on-demand fishing gear policy development discussions.

4. Socioeconomics

“That's the trouble when you give up something. You never get it back.”

- *Fixed gear fishery stakeholder*

Switching to on-demand fishing gear could have significant widespread economic and social impacts to the lobster fishery, other marine users including operators in other segments, and regulatory agencies. An evaluation of the issues with and impacts of switching to on-demand fishing gear would be incomplete without an assessment of the socioeconomic, cultural, and mental health impacts of implementation decisions. In addition to the outcomes of decision making, the approaches used to develop fishery management decisions can have widespread cultural and mental health impacts. The processes that agencies use to scope and evaluate on-demand gear implementation planning should take these impacts into consideration and work with social scientists and community health professionals to find ways to minimize them.

The billion-dollar American lobster fishery is a cultural and economic icon in New England. However, operating a business in one of the nation's most dangerous professions comes with its physical and mental tolls.⁵⁹ Most lobster fishermen are owner-operators and profit margins are often thin across segments of the industry.⁶⁰ The lobster fishing industry is relatively unconsolidated, with state owner/operator requirements being viewed positively by a plurality of fishery participants. As with any sector of the fishing economy, fixed and variable operating costs are incurred regularly and are relatively straightforward to quantify.^{61,62} However, to date there has not yet been a socioeconomic study to evaluate the economic impacts of on-demand fishing gear use.

In addition to assessing the potential costs and benefits of on-demand gear, social and economic science has a role to play in assessing impacts of on-demand fishing gear on human wellbeing. The social scientific literature on fisheries is peppered with eulogies for fishing cultures and communities that have been diminished or lost because of sweeping management decisions and *post hoc* analyses of the cultural, social, and mental health impacts of those decisions. From Florida's 1994 constitutional ban on commercial-scale fishing nets⁶³ to effort control measures leading to massive consolidation in the Western Australian rock lobster fishery,⁶⁴ significant shifts in fishery management risk severe negative outcomes for communities and individuals if they are not underwritten with policies to address socioeconomic impacts and social wellbeing. If similar outcomes are to be avoided in the effort to switch

⁵⁹ King, T. J., Turner, R., Versace, V., Abernethy, K., Kilpatrick, S., & Brumby, S. (2021). Mental health in the commercial fishing industry: Modern uncertainties and traditional risks. *Fish and Fisheries*, 22(5), 1136-1149.

⁶⁰ Zou, C., Thunberg, E., & Ardini, G. (2021). Economic profile for American lobster (*Homarus Americanus*) fleets in the Northeastern United States. Northeast Fisheries Science Center reference document 21-03.

⁶¹ Zou, C. *et al.* (2021).

⁶² Griffin, R. (2021). Supplement to Expert Report of Prof. Robert Griffin. 1:19-cv-10639-IT (D.MA 2021).

⁶³ Smith, S., Jacob, S., Jepson, M., & Israel, G. (2003). After the Florida net ban: the impacts on commercial fishing families. *Society & Natural Resources*, 16(1), 39-59.

⁶⁴ Shaw, J., Stocker, L., & Noble, L. (2015). Climate change and social impacts: women's perspectives from a fishing community in Western Australia. *Australian Journal of Maritime & Ocean Affairs*, 7(1), 38-51.

to on-demand fishing gear, significant investments and advances in the assessment of the socioeconomic issues facing fishermen and their communities should be planned and prioritized.

Gear acquisition & ownership cost

The costs of outfitting a commercial lobster fishing business with on-demand gear and the systems required to operate it have not been comprehensively evaluated or published to date. Because on-demand fishing gear prices are not widely publicized and economies of scale that might reduce prices have not been reached, a precise cost estimate would be difficult to establish. However, some fishermen interviewed for this project have estimated the cost required to equip their operations with on-demand gear, and interview participants provided information that could allow broad cost estimates to be established. Generally, fishermen interviewed for this project estimated that they would incur costs of between \$200,000 and \$400,000 to fully outfit their operations with on-demand gear; based on interviews with on-demand gear experts, this is likely an accurate estimate at current prices and economies of scale.

The majority of fixed gear fishery stakeholders interviewed for this project stated that they could not afford to pay hundreds of thousands of dollars to acquire on-demand gear. Fishermen expressed concerns about the cost of on-demand fishing gear across the fishery:

“Massachusetts knows how many buoy lines everybody's got, so to extrapolate that out for all the fishermen and how many buoys they've got, how much it's going to cost, it's going to cost \$150 million probably, which is 50 or 60 million dollars more than the industry stocks in a year. So I don't think anybody can justify anything like that because of the costs, just the cost part of it.”

- *Fixed gear fishery stakeholder*

Numerous changes to gear configuration could impact the overall cost of acquiring on-demand gear significantly. These include changes to the number of traps per trawl, number of on-demand gear units used per trawl (one or both ends), and number of traps fished when on-demand gear is in use in various time/area management scenarios. Operational/gear use variables in combination with cost estimates based on on-demand gear configuration could be combined under a scenario-based economic modeling exercise to more accurately define the costs of gear acquisition and the impacts to the economic productivity of the fishery.

For several fixed gear fishermen interviewed for this project, the cost of acquiring on-demand gear is not a significant concern because of the belief that the equipment would be paid for by another party, either through a reimbursement or leasing program:

“I don't plan on buying this stuff. This is all- there's plenty of powers that be out there, plenty of money. They're going to be paying for this stuff. They can have it. They're paying for it. I might lease it.”

- *Fixed gear fishery stakeholder*

Fixed cost impacts to mobile gear fishermen who might be required to install and operate equipment to detect on-demand gear are unknown at this time. Mobile gear fishermen interviewed for this project estimated fixed costs associated with installing transducers (~\$10,000) for acoustic ranging or self-localizing systems, or data use (\$0-300) for GPS-based surface marking systems. More significant costs to mobile gear fishermen involve variable cost impacts to their operations in the form of lost fishing time/area that might be incurred if on-demand gear conflict issues persist. The evaluation of these fixed and variable costs should be a focus of future research efforts.

Staff members of conservation organizations supporting the development and use of on-demand gear agreed that fishermen's expectations about subsidized purchase of the gear could have a high likelihood of delivering support:

"There was a lot of conversation. I don't even know that I know the right words to use about ways to lease out this equipment or ways to do other creative funding mechanisms... I don't see fishermen paying for this gear any time in the near future. And so [alternative ownership models] just [seem] like a waste of time to me. I think it has to be purchased by the federal government. So far, in every conversation I've ever had, fishermen are like, 'I'm not paying for it.' Maybe a year from now, that conversation might be different."

- *Conservation organization staff member*

The history of federal agency support for fishermen's acquisition of gear under gear switching programs points to the capacity of state and federal agencies to provide some or all of the fiscal support necessary (see Appendix 1). In some cases, state and federal appropriations have been necessary to provide gear acquisition support; in others, discretionary authority exists, typically on a more limited basis. At current projected cost levels, supporting the acquisition of on-demand fishing gear in US lobster fisheries would be the most expensive fishing gear acquisition program in history.

The most likely sources of funds for on-demand gear acquisition discussed by interview participants are Congressional appropriations and philanthropic organizations. Earlier this year, the Right Whale Coexistence Act of 2022 (S. 3664/H.R. 6785) was introduced; the bill would provide \$15 million per year for ten years to support the development of projects to reduce the lethal and sub-lethal effects of human activities on North Atlantic right whales.⁶⁵ Federal appropriations could support many of the research initiatives described in this report, but the bill's proposed funding levels and current federal funding levels would not cover acquisition of on-demand gear for a significant number of fishermen unless the costs of the equipment were reduced significantly. Interview participants who are familiar with legislative discussions about on-demand gear in Congress believe that full funding for on-demand gear acquisition would be contingent upon unified political messaging from advocates and the fishing industry:

"It's a messaging thing, but it's an important messaging thing. There's been so much lobbying for and against it, very polarized. There's lots of lobbying happening from the industry saying, don't do this, it's terrible. There's a huge amount of lobbying from the conservation community going, this is the wave of the future that just has to happen. And the Congress isn't going to allocate funds when they're hearing the industry say absolutely no way. So I think it's going to have to be one of those, if fishermen walk in [Congressional offices] with the conservation community and

⁶⁵ <https://www.congress.gov/bill/117th-congress/senate-bill/3664/text>

say, 'we want this money, we want to do this,' I think there's a good chance of that happening. But not with the dynamic that's in place right now."

- *Conservation organization staff member*

Notwithstanding Congressional appropriations, philanthropic support for on-demand gear acquisition was highlighted as a possible mechanism. Interview participants familiar with philanthropic discussions about on-demand gear believe that, like Congress, philanthropic organizations' support for large financial outlays to support on-demand gear acquisition would be contingent upon industry support, but would also require a degree of regulatory certainty:

"I think [philanthropic support for on-demand gear is] possible, but I think for those huge asks or very big asks, they would have to come with a collaborative request and they would also have to come with regulatory requests. So if there's lots of people interested and there's lots of foundations and lots of places interested in it and trying to do wise use management, for lack of a better way of putting it there. This is the win-win, we're looking for the win-win, where all the species get saved and fishing continues. And so you get this economic win, you get the cultural win, you get the conservation win. So I think the money's out there but it has to be something where there's a mandate for it, where there's a long term mandate and the way that the investment that they're bringing forward is going to be sustainable... because you're talking millions of dollars. So somebody that's going to bring in millions of dollars is not going to do it for a couple of years. ... And I think that's where the regulatory component has to come in. If this is required, it has a long term sustainable investment in that transition"

- *Conservation organization staff member*

Impacts across demographics

Just as fixed and variable costs impact segments of the fleet in different ways and at different intensities,⁶⁶ the financial impacts of adopting and successfully adapting to the use of new technologies like using on-demand gear would differ significantly across fleet segments and demographic variables.^{67,68} According to interview participants, the variables that might impact successful adoption of on-demand fishing gear include age, vessel size, gear configuration, fishing success, education, risk exposure, permit portfolio, and individual resilience & adaptability. Massachusetts lobster fishing operations are highly varied according to these variables (see Table 2 and 3), and each was addressed in detail by interview participants.

⁶⁶ Zou, C. *et al.* (2021).

⁶⁷ Levine, E., & McCay, B. (1987). Technology adoption among Cape May fishermen. *Human Organization*, 46(3), 243-253.

⁶⁸ Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of technology adoption. *Annu. Rev. Econ.*, 2(1), 395-424.

Table 2. Massachusetts lobster fishing fleet operational characteristics. Average number of traps per trawl fished according to vessel size, by management area. Data from 2019 supplemental harvester reports.

LMA	Vessel Length (ft)	Average traps/trawl (count)								Total
		1	2	3-4	5-9	10-14	15-19	20+	Unknown	
LMA1	0-20'	32	2	10	3	2				49
	20-25'	28	3	8	28	11				78
	25-30'	12	1	2	17	19	7	1		59
	30-35'	4	1		33	87	22	12		159
	35-40'	4			8	48	28	41		129
	40-45'	1		1	4	17	29	54		106
	45-50'					2	5	9		16
	50'+							1		1
	No supp. rpt								26	26
LMA1 Total		81	7	21	93	186	91	118	26	623
LMA2	0-20'	5								5
	20-25'	7								7
	25-30'	5			2					7
	30-35'	8	1		1	6	2			18
	35-40'	4			2	2	1	1		10
	40-45'		1		2		4	1		8
	45-50'	1		1			1	1		4
	No supp. rpt								5	5
LMA2 Total		30	2	1	7	8	8	3	5	64
OCLMA	0-20'	4								4
	20-25'	4								4
	25-30'	5		1						6
	30-35'	16	1	1	2	1	1	1		23
	35-40'	5				1	5	4		15
	40-45'			1		1	1	5		8
	45-50'						1			1
	No supp. rpt								4	4
OCLMA Total		34	1	3	2	3	8	10	4	65

Table 3. Massachusetts lobster fishing fleet demographics. Median age of permit holders from 2010 to 2019, by management area.

Status	LMA	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Active	LMA1	54	54	55	55	55	55	56	56	57	56
	LMA2	51	51.5	63	59	54	54	57	56	58.5	57.5
	OCLMA	52	51	57	58	53.5	50	51	50	49	50
Latent	LMA1	55	55	55.5	56.5	57	58	58	59	60	61
	LMA2	56	56	54	54	56	59	58	61	59	58
	OCLMA	52.5	55	57	58	60	59.5	63	55	58.5	57

Fishing vessel size was commonly highlighted by interview participants as the factor that could most significantly impact the capacity to adopt and adapt to on-demand fishing gear:

“If this thing proceeds and buoy lines aren't allowed, then it's obvious that you would lose that aspect of the fleet, the smaller fishermen, the seasonal fishermen, student lobstermen, the recreational lobstermen. I don't know where to start when you're eliminating buoy lines. So that's a scenario I really have trouble envisioning.”

- *Fishery management professional*

“One of my major concerns is, as we move in a direction where gear is much more expensive, as we move in a direction where you need more technology on your boat to avoid gear and for safety reasons, it continues to put small boats at a disadvantage and small businesses at more of a disadvantage and fleet diversity, both in terms of different fisheries, but also the size of vessels, size of businesses, that needs to be recognized in this conversation. And it's not [being recognized].”

- *Fishery organization staff member*

Fixed gear fishermen interviewed for this project highlighted the importance of student license programs to the future of the fishing industry and the integrity of coastal communities. Student licensees generally operate small vessels and participate in inshore fisheries seasonally or periodically while fishing single traps or small trawls. Other small boat lobster fishing operations could also be disproportionately impacted by high costs or operational constraints:

“It depends on if the managers are trying to build the fleet for those strong businesses, or are they trying to retain the characteristics of the fleet as it is now? Because the smaller mom and pop operations aren't going to be able to survive a change in the fishery that's going to make them economically invest to overhaul how they fish. The part time guys will not be able to hang on anymore.”

- *Fishery management professional*

Designing on-demand gear regulations that preserve the capacity of smaller vessels to operate profitably should be a focus of socioeconomic studies and discussion within and between management agencies. Interview participants discussed management approaches including restricting on-demand gear use to

federal waters or certain offshore areas and exemptions for student licenses or smaller vessels that cannot accommodate longer trawls to cost effectively operate on-demand gear.

Familiarity with digital technology was commonly highlighted as a prohibiting factor for fishermen's successful adaptation to the use of on-demand fishing gear:

"I would say there's a bunch of guys that couldn't deal with [on-demand gear] if they were giving it to 'em. They just wouldn't be capable of it... There's a bunch of guys today, older guys, who still don't have the technology that the younger guys do. I know a lot of guys who don't have plotters and stuff like that at my age, and I'm one of the older guys now."

- *Fixed gear fishery stakeholder*

The median age of Massachusetts commercial fishermen has increased over the past decade, indicating that fewer younger participants are entering the fishery (Table 3). Older fishermen may have a more difficult time transitioning to the use of on-demand gear if it requires the use of technologies they are unfamiliar with, including smartphones and wireless connectivity. Other factors that could preclude a fisherman's successful transition to the use of on-demand gear include literacy and learning capacity or intellectual disability status.

Some on-demand fishing gear advocates expressed the opinion that the attrition of older or less technologically literate fishermen could be an inevitable and/or acceptable outcome, and that a new generation of younger and more technologically savvy fishermen could successfully adapt:

"I don't see guys ending fishing, I don't see them not- the drive to stay in the fishery is way stronger than the potential changes that would impact it. You're going to get some attrition anyway, but I think one of the cool things about the timing of this is that the generation that's coming in the fishery is pretty software savvy, and they've grown up with a lot of electronic things. So I think that, in my opinion, there would be an investment if there was some support because the guys that are on their way out will drop out. But the guys that are young are going to come in and if- I see them invest in so much other stuff, like they upgrade their engines all the time. They're they're looking at the newest and the best. Like if they took out their Detroit and put in a Caterpillar. There's the improvements that they make to their boats that are pretty impressive. And they're not cheap, if they're having a good year, they invest heavily in their business when they're having good seasons. Not everybody, but I would say overall, they do [make] some major improvements in their business... I see them invest with some pride in their equipment. And I don't see that [on-demand fishing gear] would be different. I think the resistance is in some respects, the cost, which is a lot, but I think with some support they would do it because I just see him invest in so many other things that they have that this is no different to me. It's just another business investment."

- *Conservation organization staff member*

Fishing industry stakeholders generally expressed a less optimistic view of the prospects for young entrants. These concerns were associated with the known increased barriers to entry associated with large capital investments to acquire larger and more profitable vessels, increased permit costs associated with consolidation, and higher costs in the fishing industry overall, as well as the perceived increased costs of on-demand gear:

"I also think one of the problems is that as a fisherman, you have to buy all your own permits and quota and that just perpetuates the problem. Because you're buying it, let's say, for a million dollars. You have a period of time actively using it, so you're capturing the annual rent and then you're hoping that at some point it appreciates in value to a point where the profit again on the other end. And so you're behaving in a way that's trying to drive up both the rent and the value on an annualized basis. When it comes time for transition to the next generation, that's all but possible right? You're stripping out more and more future opportunities from the next generation because of those forces."

- *Fixed gear fishery stakeholder*

Solutions to address age or technological literacy related challenges to on-demand gear adoption could include specialized on-demand gear education programs and permit buybacks with vocational training. Several fixed gear fishermen expressed the belief that vessel or permit buybacks would become a serious policy consideration if on-demand gear had significant negative impacts across segments of the lobster fishing fleet:

"I don't know what the correct model is. There's been, since I've been involved in fisheries, so many different buybacks of different kinds in the groundfish fishery, with mixed results. I haven't done an analysis on which one worked best and why, or what pieces have worked. But I do believe that there is a strong argument that when a dramatic regulation comes into place that shifts the entire operation, fishermen have heavily invested in this to be able to harvest part of the public trust and feed people, especially if they've got bought people's permits and the game is completely changed from a regulatory action. There can be a view that, 'oh, that's their fault, their loss.' But I think that has a significant cost down the road that the whole community absorbs. And so I'm in favor of some level of a buyback, or a cushion. And if there are people who want to take that option, or job retraining."

- *Fishery scientist*

The costs, benefits, and outcomes of permit buyback programs have been studied in depth in other contexts, but designing an equitable buyback program for a fishery as large, diverse, and decentralized as the lobster fishery would be a significant challenge.⁶⁹ Such a program would likely come with very high costs. Fixed gear fishery participants interviewed for this project highlighted negative outcomes of buyback programs that could impact their businesses and fishing communities:

"I think what ultimately is going to happen is there will be some sort of buyout. And I think it's going to be, like everything else, get bought up by big corporations, especially the federal stuff. Not so much the state stuff, but especially the federal stuff. It'll just turn into just a machine like a corporation, and it'll be owned by one conglomerate. It's going to force the people that have been doing it for generations out of it. And like anything else, it's easier to control one entity than it is to control a couple hundred."

- *Fixed gear fishery stakeholder*

⁶⁹ Holland, D., Gudmundsson, E., & Gates, J. (1999). Do fishing vessel buyback programs work: a survey of the evidence. *Marine Policy*, 23(1), 47-69.

Some interview participants noted that not all time/area closures would be viewed alike by the fishing industry. For example, the long-established Cape Cod Bay closure has had a negligible financial impact on the lobster fishery overall, having been implemented during periods of lower overall productivity accounting for around 1.5% of annual lobster landings and around 1.6% of lobster fishing revenue generated in Cape Cod Bay historically.⁷⁰ The financial impact of this closure has been absorbed by impacted fishing communities or offset by harvest at other times of the year.

Some on-demand fishing gear advocates believe that the recent seasonal closure of state waters to the north of Cape Cod Bay may provide enough economic value for the incentive to continue fishing to result in on-demand fishing gear deployment:

“Aside from some individuals who, like I said, they've consistently been eager to fish within the [Mass Bay] closed area, probably the most incentivized participants are going to be the people who aren't used to having a closure. So for Massachusetts, it may be, you know, Green Harbor - north, maybe the places that were not subjected to the Mass Bay Restricted Area previously that suddenly have [closures]. Gloucester, places in state waters where they were able to fish up until this year or next year or whatever it is. That may be where, if it were, if I had the magic wand and I had to make the decisions, I'd be reaching out to the communities where the closure is right now and trying to find out if I could get some sort of investment from those people who don't want to be closed and haven't been closed, and this is a way to immediately regain access to something that they had just a short time ago. So that's where I think they're going to find the broadest investment in this.”

- *Conservation organization staff member*

Conversely, some on-demand fishing gear advocates believe that the incentive to regain access to areas that have been closed for a relatively long period of time will not be as acute:

“When I think about the Massachusetts closure, there is some drive [to regain access] by a very small, limited number of people. And in Massachusetts, they want to get into the closure, but I know a number of other fishermen who don't have the same drive to get in there. The closure has been in place long enough now ... It was different to me for the inshore fishery because it was sort of like this shocking new closure thing happening in California that was going to have to respond and react to whereas [the Massachusetts closure] was in there for a while, and most people have sort of navigated around the closure. But again, it's the same handful of individuals that I think are the ones that are most driven to get into the closure, but I haven't heard any way of it being something that's more of a broader drive than that.”

- *Conservation organization staff member*

Similarly, participants representing conservation organizations believe that the Massachusetts South Island closure will have enough economic impact to incentivize fishing industry stakeholders to use on-demand fishing gear in order to regain access:

“I think the bigger closures south of the islands would be, if it were the bigger closure, I think that you would have a lot more people willing to come to the table. And I think if you had the

⁷⁰ Massachusetts Division of Marine Fisheries Staff, *personal communication*.

new parts of Massachusetts that weren't previously closed, you might get some people coming to the table.”

- *Conservation organization staff member*

However, fixed gear fishery stakeholders pointed out that the incentive to participate in on-demand fishing gear operations could disappear if mobile gear fishermen were operating in the area or if larger numbers of fixed gear fishermen were operating in the area:

“Maybe a small number of guys could work together in a scenario like that, and just lobstermen themselves, they could probably figure it out in these areas. But there won't be that minimal number of people there. If you take the draggers out- you can't have discussions about that without having the draggers involved, multiple mobile gear fishermen.”

- *Fixed gear fishery stakeholder*

Participants observed that the amount of gear conflict that currently exists within an area, as well as the ability for fixed and mobile gear fisheries to operate in close proximity, may indicate whether fishermen would be incentivized to operate on-demand fishing gear rather than endure a seasonal closure:

“Ultimately, I think the driving force is going to be whether that means that you can fish beside [other types of] gear or you can't. Because if these guys don't want to lose ground and if they're closed out of an area and mobile guys come in and take it over and they can't get it back, that's going to be a big problem. So I would think that ultimately that's going to be the deciding factor of, how do they hold on to the ground that's important to them and if it means changing a little bit, that they get to keep their ground. I think you'll get more incentive for them to figure out how to do it.”

- *Conservation organization staff member*

The regulatory and environmental context in which on-demand fishing gear development discussions exist include other broad new spatial constraints on the fishing industry. From the perspective of lobster fishermen, spatial issues impacting their ability to fish in space and time are viewed through the same lens, regardless of which policy framework or regulatory authority is responsible. In particular, fixed gear fishery stakeholders interviewed for this project highlighted the impacts of offshore energy development to their businesses as of high concern. Many fishermen drew strong parallels between spatial constraints to their operations from closures in the Take Reduction Plan and offshore wind leasing activity in federal waters:

“I see pieces of the ocean getting taken away from fishermen, being unable to use it. More so than the monuments stuff that's been off Cape Cod. That's the beginning. The wind farms are going to be something else, but hopefully they're gonna prove that they're not going to be as successful as I think they claim they're going to be, type of thing. But the lobster industry is going to get pushed aside again. Everything that's come along, the history of it is us being pushed aside. So we're going to get condensed into smaller parts of the ocean. All these guys are in the ocean now are roaming free, basically, are not going to be able to do that in the future. If we throw them all in the same area together, it's not going to be economically possible to keep going fishing. Especially with the cost of ropeless buoy technology. The future doesn't look so good as far as any of this stuff goes.”

- *Fixed gear fishery stakeholder*

Fixed gear fishery stakeholders interviewed for this project frequently expressed reluctance to engage with proponents of on-demand fishing gear because of the fear that the use of the gear in some areas will lead to calls for its use throughout the lobster fishery:

“The government is already telling us, five more years it’s going to be a 60 percent reduction in risk and in 10 years it’s going to be 98 percent. So regardless of what the government is saying, even if another whale never gets entangled again, we’re still going to go buoyless. That’s what I hear from the government right now. So I just walked the other way, I said absolutely not. Never do buoyless as far as I’m concerned, if I have anything to say about it. Not that I’m a powerful person, but I’ll fight it tooth and nail to the end.”

- *Fixed gear fishery stakeholder*

Some conservation organization staff members interviewed for this project expressed the belief that on-demand gear should be used throughout the fishery:

“I guess what I struggle with is if you can use on demand, if you’re investing in the equipment to use on-demand part of the time, then it doesn’t make sense to me that you can’t use it all of the time. And if you can use it all of the time, then the benefit goes beyond right whales. And, you know, just because we’re not bringing humpbacks to the table, we all know that they’re getting their asses handed to them by entanglements. And turtles and fin whales.”

- *Conservation organization staff member*

However, other conservation organization staff members believe that area-specific approaches for the use of the gear could be appropriate:

“We are not calling for [on-demand gear] everywhere all the time. I know that there are parts of inshore Gulf of Maine where right whales have never been seen. Obviously, I’m not crazy about the exemption line that exists in Maine, but it’s been a long time since right whales have occurred and that kind of abundance in the Gulf of Maine, where I could see not requiring it inside that unless [right whales’] habitat use of that area dramatically changes or if it stays like it’s been for the last seven or eight years. That’s a logical place to me with a lot of [vertical] lines, that doesn’t necessarily need to transition unless we have solid evidence that right whales are using [areas] inside that exemption line. On the other hand, I think almost all of southern New England poses a risk to right whales 12 months of the year, more certainly in the winter and early spring than maybe in the middle of the summer.

- *Conservation organization staff member*

Integrating social science into management

State and federal fishery managers have a broad set of responsibilities, primarily focused on maintaining sustainable yields of the resources they manage. However, agencies are also statutorily mandated to make management decisions that consider social impacts and the fishing community context of their actions. In addition, it is broadly recognized that social scientific approaches to policy design and

communication with stakeholders and communities can enhance buy-in and trust, which in turn increases the likelihood of positive outcomes.^{71,72}

The Magnuson-Stevens Fishery Conservation and Management Act calls for fishery management council policies and regulations to “provide for the sustained participation of [fishing] communities” and “to the extent practicable, minimize adverse economic impacts on such communities”.⁷³ Similarly, the ASMFC is directed by the ACFCMA to “support and enhance State cooperation in collection, management, and analysis of fishery data; law enforcement; habitat conservation; fishery research, including biological and socioeconomic research; and fishery management planning”.⁷⁴

Recognizing this, some management agencies have invested in their social scientific capacity by hiring staff with relevant expertise. The NEFMC has a social scientist on staff, and the Northeast Fisheries Science Center has recently hired social scientists. However, the ASMFC does not have a social scientist on staff, and according to interview participants, state management agencies generally lack social scientific capacity. This capacity gap is well-recognized by fishery management professionals:

“The [ACFCMA] says that [the ASMFC] should take social and economic factors [into consideration], but it doesn't say how we have to do it. And as I'm sure you know, [with respect to] socioeconomic data and fisheries, there's often very little. That makes it difficult in particular for us to do an analysis when you don't have any data and we don't have the kind of social and economic folks who actually can do the analysis in our shop. So the management boards have, at times when there is a lack of data, used their knowledge based on what they know about their state fisheries and share that information with the management board as they are debating and deliberating their decisions.”

- *Fishery management professional*

Overall, in order for managers to adequately consider the social impacts of fishery management decisions, significant investments in social scientific capacity should be made. If agencies are motivated to develop take reduction strategies that are informed by an understanding of impacts to fishing communities, then the on-demand gear issue could be a catalyst for these investments.

Changing cultural dynamics within fishing communities may enhance the value of additional social science capacity at the agency level. Conversations about mental health and wellbeing within fishing communities and fishing industry groups are becoming more normalized, and fishermen may be more willing to seek support than in years past.⁷⁵ The use of social scientific approaches to evaluate the impacts of management decisions and to assist with designing and selecting alternatives resonated with fixed gear fishery stakeholders interviewed for this project:

⁷¹ Hartley, T. W., & Robertson, R. A. (2006). Stakeholder engagement, cooperative fisheries research and democratic science: the case of the Northeast Consortium. *Human Ecology Review*, 161-171.

⁷² Ebel, S. A., Beitzl, C. M., Runnebaum, J., Alden, R., & Johnson, T. R. (2018). The power of participation: Challenges and opportunities for facilitating trust in cooperative fisheries research in the Maine lobster fishery. *Marine Policy*, 90, 47-54.

⁷³ 16 USC §1851(a)(8).

⁷⁴ 16 U.S.C. §5103(a).

⁷⁵ Couch, C. (2021, March 16). *Mental Health and the Modern Fisherman*. Hakai Magazine. <https://hakaimagazine.com/features/mental-health-and-the-modern-fisherman/>

"It's like, well, what about fishermen? What about fishermen? And so there really, especially because of COVID, seems to be a little bit more of a push, and efforts picking up around this conversation [about mental health and wellbeing], which I'm excited about. Same with mental health conversations just being more destigmatized. It's getting easier. But I think it's just incredibly important right now. Commercial fishermen are working so hard, and a lot of them use work as a coping mechanism, so they might not even realize that they're trying to manage and deal with stress. Not to mention the fact that it's an occupation where there's a lot of stress injuries and fatigue. So why would you think that any type of physical pain or fatigue would be associated with anything other than commercial fishing and not something like depression or anxiety or stress? When I talk with commercial fishermen about stress and fatigue, it's never the fishing itself that causes the problems. It's always sort of the external factors of regulations, conversation about whales, conversations about wind development, offshore wind development. Some of the articles that vilify fishermen and all of these things, those are the things that are sort of causing the stress. Those aren't things that are going to go away. So we really need to figure out how to do a better job, not just elevating the role of fishermen in the food system, but making sure that they have the infrastructure necessary to do their job well. I say infrastructure here in the way that we should be thinking about infrastructure in any industry, and that is, what are all the means necessary for someone to be able to do their job well? Like, for parents, child care is a part of being able to do their job well. Well, for seafood harvesters, maybe mental health support services need to be a larger part of that conversation."

- *Fixed gear fishery stakeholder*

If the fishing industry's desire for on-demand gear policy discussions to be based on equity, fairness, and support for community wellbeing are not addressed by management agencies, outcomes from future processes may be severely impaired.

Social scientific studies on the impacts of significant fishery management decisions are beginning to illustrate the severe mental and emotional hardship placed on fishermen and their communities. Fishery stakeholders interviewed for this project believe that this increasing attention to social science and wellbeing could have positive policy and management outcomes:

"These [community health and wellbeing] conversations are starting to happen in a way that they haven't before. We're still not going to get to some of the old timers, that's just- But change is going to start to happen, and hopefully it will get to the point where it's able to trickle up to policy. And we're not too late on some of that."

- *Fixed gear fishery stakeholder*

Conversely, failing to incorporate mental health and wellbeing into management discussions at early stages can result in severe negative outcomes that can last for years. One recent landmark study investigating the impacts of fishery management decisions in the New England groundfish fishery found indicators of moderate or severe levels of chronic psychological stress in a majority of New England groundfish vessel captains over multiple years.⁷⁶ A similar longitudinal study of the levels of stress exhibited by American lobster fishery stakeholders would be a cost-effective way to begin to evaluate the

⁷⁶ Scyphers, S. B., Picou, J. S., & Grabowski, J. H. (2019). Chronic social disruption following a systemic fishery failure. *Proceedings of the National Academy of Sciences*, 116(46), 22912-22914.

impacts of various approaches to on-demand fishing gear development, testing, and implementation. As the study's authors remark,

Traditionally, a perceived impediment to the effective inclusion of individual-level social data has been the costs and logistical challenges associated with surveys and interviews. However, longitudinal studies to measure individual and community well-being would cost far less than what is required for biological monitoring of fish stocks. Moreover, multiple survey- and interview-based programs already exist for the purposes of monitoring fishing effort and catch, which could potentially be leveraged or expanded to incorporate key social metrics. Not only are these data necessary to provide the best available science for regulatory decisions, as is mandated by [the Magnuson-Stevens Act], but placing a higher priority on social outcomes could also bolster trust, enable more effective fisheries management, and promote environmental justice.⁷⁷

If outcomes from the New England groundfish fishery offer a cautionary tale, then the lessons to be drawn from them should be directly incorporated into on-demand fishing gear development discussions. Resources should be invested in measuring social impacts of various approaches to North Atlantic right whale risk reduction so they can be understood and be made a part of planning processes. Open and transparent communication, a key indicator of the levels of trust between fishing industry stakeholders and management agencies, can be embraced by all parties involved in on-demand fishing policy discussions. Establishing mental stress baselines could allow fishery managers to set benchmark targets and objectives for measurable indicators of stress among members of fishing communities.

Training and education programs

The establishment of training programs to teach fishermen how to operate on-demand fishing gear systems would be a prerequisite for the successful widespread use of the gear on fishing grounds. Sufficient levels of training necessary to prevent conflict, minimize damage and loss, and ensure safe operation would be essential. Fixed gear fishermen interviewed for this project who have participated in gear testing programs estimated that multiple days of experiential learning would be required for the average fisherman to become comfortable with using on-demand gear.

Developing an education program for hundreds or even thousands of owner/operators and crew to learn how to use on-demand gear could require tens of thousands of person-hours over time. Resources for such a program have not yet been identified, and on-demand gear developers interviewed for this project did not anticipate that training programs would be a part of their on-demand gear service or business models in the future. However, some gear developers have begun conversations with local educational institutions to explore a classroom-based education model for on-demand gear:

"I am also working on the side to see about education purposes as to maybe- I've got a proposal with a local community college to start an internship program where we can teach the users of ropeless or on call fishing gear, because you need to understand a little bit behind the physics of how it works, how acoustics work. It's a different way of thinking about solving the problem. So I think we're going to also need an educational aspect to this on-call fishing to make it successful. That's why I'm working with a local community college to see if we can initiate a way to help people who want to try and test this gear to be successful when they go out and use it."

⁷⁷ *Ibid.*

- *On-demand gear developer*

Other education models have been proposed for on-demand gear training. For example, a tiered learning program involving fishermen proficient in the use of the gear teaching their peers how to use it, as well as methods for teaching others to use it, has been proposed.⁷⁸ Working with technical education specialists to determine the efficacy of various training methods for on-demand gear education, balancing assessments of outcomes and knowledge transference with program costs, should be a high priority if on-demand fishing gear enters widespread use.

⁷⁸ Sawicki, 2021.

5. Recommendations

The following recommendations for testing and benchmarking of on-demand fishing gear to evaluate its performance and compatibility with the lobster fisheries of New England derive from the conversations that took place in the development of this report.

Table 4 presents a set of experimental questions and designs based on the issues that were identified by project participants. In answering these questions through further investigations or the conditioning of permits for the testing of on-demand gear, stakeholders and agencies would gain insight into the impacts that the gear would have to their operations and their bottom lines. Until these questions are answered, accurate and comprehensive cost/benefit analyses of on-demand gear and evaluation of entanglement risk profiles compared to other mitigation approaches are not likely to be possible.

Table 5 presents a 'report card' reflecting the current status of on-demand fishing gear research and the maturity of the various processes necessary to underwrite a transition to on-demand fishing gear in whole or in part. In moving these processes forward, agencies involved in researching the compatibility of on-demand gear and providing institutional, fiscal, or operational support for impacted fisheries would more comprehensively evaluate the compatibility of the gear with various aspects of New England fisheries and develop the capacity and mechanisms to fully evaluate its costs, benefits, and implications.

Advancing the collaborative research enterprise

Table 4. On-demand Fishing Gear Research Priority Recommendations: a matrix of experimental approaches to evaluate feasibility. Experimental questions and designs are presented from the four issue areas considered in this report. If applicable, benchmarks from current fixed and mobile gear fishing operations or institutional capacity are included.

ISSUE AREA	EXPERIMENTAL QUESTION	VARIABLES	EXPERIMENTAL DESIGN	BENCHMARK
I. Utility				
Operations - retrieval	What is the long-term retrieval success rate? How long does it take to reset and retrieve on-demand gear?	Gear system type; depth; bottom type; weather condition/sea state	Using a hull-mounted transducer, monitor & record retrieval operation tasks & duration; deploy at a range of depths & bottom type, sea state, and soak times	TBD
Operations - setting gear	How densely can on-demand gear be set?	Gear system type; depth; bottom type; weather condition/sea state; fisherman experience	Set on-demand gear in close proximity other to deployed gear to determine overall gear density maximum	Variable/TBD
Safety	Can procedures for the operation of on-demand gear be established to enhance safety at sea?	Gear system type; weather condition/sea state	Work with marine safety experts to simulate entanglement in on-demand gear & develop safe operating procedures	Unknown
Operations - on deck	What is the maximum throughput rate of on-demand gear?	Gear system type; depth; bottom type; weather condition/sea state	Monitoring & recording of on-deck operations tasks; record deployment tasks & duration; record incidence & duration of any maintenance activities	60 traps/hour
Gear loss	What is the loss rate of on-demand fishing gear?	Gear system type, onshore/offshore, presence/absence of	Evaluate the annual rates of gear loss over time, detailing loss incidents during testing operations	3-6%/year

mobile gear				
Grappling	Can on-demand gear be successfully retrieved by grappling?	Gear system type; weather condition/sea state	Work with experienced fishermen to test procedures for grappling for on-demand gear under simulated gear loss scenarios	Unknown
II. Technology				
GPS marking location accuracy	How accurate is GPS marking?	Depth; bottom type; weather condition/sea state (at deployment and retrieval); soak time	Measure the difference between GPS marked location and actual location under various operating conditions	25 feet
Acoustic ranging location accuracy	How accurate is acoustic ranging?	Depth; bottom type; weather condition/sea state (at deployment and retrieval)	Measure the difference between ranged location and actual location under various operating conditions including approach vector	25 feet
Gear self-localization accuracy	How accurate is gear self-localization?	Depth; bottom type; weather condition/sea state (at deployment and retrieval)	Measure the difference between marked location and actual location under various operating conditions including contact count	25 feet
Acoustic ranging operating range	At what distances can acoustic ranging gear be detected?	Depth; bottom type; weather condition/sea state	Using a hull-mounted transducer, determine the maximum interrogation distance at variable depths, bottom types, sea states, etc.	2 miles
Gear self-localization operating range	At what distances can self-localizing gear be detected?	Depth; bottom type; weather condition/sea state	Using a hull-mounted transducer, determine the maximum interrogation distance at variable depths, bottom types, sea states, etc.	2 miles
Marine acoustic impacts	Do acoustic emissions impact marine life?	Gear system type; operating frequency	Work with marine acoustics experts to evaluate potential impacts of various acoustic communication systems to marine mammals; evaluate fish and lobster responses to acoustic emissions	TBD
Displaying digital information	Can virtual display of on-demand gear function at high densities?	Gear system type; gear density	Using various on-demand gear types, set gear at varying densities and evaluate virtual marking display performance	
ISSUE AREA	EXPERIMENTAL QUESTION	VARIABLES	EXPERIMENTAL DESIGN	BENCHMARK
III. Legal/regulatory				
Legal analysis	Is there a legal basis for adopting on-demand fishing gear regulations through one or more legal frameworks?	ASMFC, ALWTRT, State agencies, etc.	Conduct a legal analysis of the possible regulatory pathways to on-demand fishing gear implementation	
Documenting gear conflict	Can on-demand gear deployment data and vessel tracking data be used to document gear conflict?	Gear system type	Simulate gear conflict scenarios and obtain VMS, AIS data to correlate with on-demand gear location data	VMS-based enforcement; civil action
Law enforcement operations	Can law enforcement agencies successfully operate on-demand gear systems?	Gear system type; weather condition/sea state	Work with law enforcement experts to determine operational capabilities under various scenarios	TBD
IV. Socioeconomics				
Catch &	Does the use of	Gear system type	Record catch per trawl, catch per trap, and	TBD

Recommendations

catchability	on-demand gear impact catch rates?		subsample catch to determine size distribution	
Cost of ownership	What are the long-term costs of on-demand gear ownership?	Fixed and variable cost inputs vs. effort & catch	Conduct an economic modeling exercise to determine individual coast	TBD
Cost of operation	What are the financial impacts of on-demand gear to the fishing industry?	Fixed and variable cost inputs vs. effort & catch	Conduct an economic modeling exercise to determine scaled cost impacts across markets and the supply chain	TBD
Education programs	What are the most effective education program models for on-demand gear?	Gear system type, learning style & capacity	Work with gear developers, fishermen and fishermen's associations, and education specialists to develop and evaluate teaching methods	Tiered learning; NEFSC training programs
Mental health & wellbeing	What are the impacts of on-demand gear development to the mental wellbeing of lobster fishermen?	Trust, occupational diversity, number of dependents, etc.	Work with fishermen's support organizations and researchers to conduct a longitudinal study to assess social and psychological stress; develop and implement support programs working collaboratively with appropriate organizations (e.g. Fishing Partnership Support Services, others)	Establish benchmark and track over time

On-demand gear research report card

Table 5. On-demand fishing gear research & policy development report card: an assessment framework for establishing benchmarks and tracking progress.

Status:  Unaddressed  In progress  Complete

Goal	Status
I. Utility	
A collaborative approach to on-demand gear engineering, development, and testing has been established	
On-demand gear systems deployment/marking/retrieval performance has been evaluated against established performance standards and benchmarks	
Procedures for the safe operation of on-demand gear have been developed and demonstrated	
Procedures for single-hand operation of on-demand gear systems have been demonstrated	
On-demand gear systems' potential for loss reduction & rough weather performance have been evaluated	
Effort density tolerances for on-demand gear systems have been demonstrated for discrete fishing areas	
Procedures for on-demand gear recovery after equipment failure have been demonstrated	
II. Technology	
An underwater acoustic communication standard has been established that minimizes impacts to marine biota	
Gear marking/location standards have been established for multiple platforms	
Standards for the integrated display of digital on-demand gear deployment information have been established (NEMA, etc.)	
Hull-mounted transducer effectiveness has been demonstrated	
Standards for minimum gear detection distance have been established	
Electronic gear marking is shown to be an effective approach to minimizing gear conflict	
Opportunities for oceanographic data collection and other gear-based programs have been evaluated	
Procedures and standards for on-demand gear telecommunication, data management, and confidentiality have been established	
III. Legal/regulatory	
Standards and protocols for Exempted/Scientific Research Permit experimental testing and information reporting have been established	
A clear regulatory pipeline/process for on-demand gear regulations has been established, with regulatory responsibilities across state and federal jurisdictions established	

State and federal law enforcement agencies have developed plans for inspecting on-demand gear	
State and federal management agencies have developed procedures for enforcing gear destruction statutes	
State and federal management agencies have established criteria for on-demand gear performance within their jurisdictions	
NEFMC and ASMFC coordination on gear conflict issues has taken place	
Cooperative agreements between fishing industry groups concerning on-demand gear have been established	
Data warehousing and confidentiality issues have been addressed; on-demand gear database management assigned to responsible entity	
A regulatory process requiring the use of equipment to detect on-demand gear has been completed	
IV. Socioeconomics	
Collaborative efforts to engage with broad segments of the fishing industry on on-demand gear development initiated	
A gear acquisition pipeline for the retail market has been established	
On-demand gear acquisition and integration scalability has been demonstrated for fishing vessels/operations across size/location/demographics	
Socioeconomic studies and cost-benefit analyses have been completed	
Fiscal support for the acquisition of on-demand fishing gear systems has been identified	
On-demand gear training and education programs have been established & fiscal support for programs has been identified	
Mental health support and benchmarking programs for fixed gear fishermen & coastal community members have been developed and implemented by appropriate organizations	



Appendix 1

A history of gear switching in US fisheries

Shallow set longline swordfish fishery

The Hawaii shallow-set pelagic longline fishery primarily targets swordfish on the high seas in the North Pacific Ocean and is managed by the Western Pacific Fishery Management Council under the Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific Region.⁷⁹ The shallow-set swordfish fishery typically comprises about 20 of the overall number of active longline vessels, and some vessels that shallow-set may also switch to deep-set fishing to target bigeye tuna during parts of the year. Protected species interactions are primarily ESA listed leatherback and loggerhead sea turtles.

Regulatory and legal history: In 2001, observer data showed the fishery exceeded their incidental take for sea turtle interactions, and the fishery was closed for over two years.⁸⁰ It reopened in 2004 with several strict management measures, which included use of 10° offset 18/0 circle hooks and fish bait (vessels had previously used narrower 9/0 J hooks with squid bait), restricted annual effort, annual limits on loggerhead and leatherback turtle take (hard caps), and 100% onboard observer coverage.⁸¹

Gear switch and impacts: The gear modification was part of a suite of bycatch reduction measures implemented to reopen the fishery. After the switch from J hooks with squid bait to wider circle hooks with fish bait, the fishery had significant and large reductions in sea turtle capture rates without impacting target species catch: capture rates of leatherback and loggerhead turtles declined by over 80% and 90%⁸², respectively, while the swordfish catch rate increased by 16% (though catch rates of non-target, marketable retained species declined).⁸³ Ex-vessel value increased by \$18 million after the switch to circle hooks and other bycatch reduction measures.⁸⁴ Extensive closure of fishing grounds to the Hawaii-based swordfish longline fishery in 2000 due to concern about the high frequency of interactions with loggerhead and leatherback sea turtles resulted in Hawai'i swordfish landings revenue decreasing 95% from \$12.8 million in 2000 to \$1.3 million in 2001. When the fishery re-opened in 2004, swordfish landings revenue increased 534% from \$1.2 million in 2004 to \$7.8 million in 2005. Landings revenue ranged from \$5.1 million to \$7.7 million from 2006 to 2012 but declined 33% from 2012 to 2013. Nationally, Hawai'i accounted for 21% of U.S. swordfish landings revenue in 2013.

The success of the gear switch, as well as the effort and interaction limits monitored with 100% observer coverage, led to less-stringent regulations in 2010 that lifted the effort cap completely. Current bycatch hard caps are 16 for leatherback sea turtles and there is no annual fleet hard cap for North Pacific loggerhead turtles.⁸⁵

⁷⁹50 CFR Parts 229, 300, 404, 600, and 665

<https://www.fisheries.noaa.gov/resource/document/hawaii-pelagic-longline-regulation-summary>

⁸⁰67 FR 40232

⁸¹69 FR 17329

⁸²Swimmer, Y., et al. 2017. Turtle Bycatch Mitigation in U.S. Longline Fisheries. *Frontiers in Marine Science*. <https://doi.org/10.3389/fmars.2017.00260>

⁸³Gilman, E., et al. 2007. Reducing sea turtle interactions in the Hawaii-based longline fishery. *Biological Conservation* 139(1):19-28.

⁸⁴Patrick, W.S., & Benaka, L.R.. 2013. Estimating the economic impacts of bycatch in US commercial fisheries. *Marine Policy* 38:470-475.

⁸⁵85 FR 57988

Industry concerns related to bycatch reduction measures seemed to center more on area closures and hard caps rather than gear switching, which arguably are much more impactful; these issues continue to be controversial for the longline industry. Additionally, gear switching in the fishery may have been helped by the availability of empirical evidence and successes with similar gear switching in the Atlantic HMS fishery.

West Coast drift gillnet fishery

The West Coast large mesh drift gillnet (DGN) fishery primarily targets swordfish and is managed federally by the Pacific Fishery Management Council under the West Coast Highly Migratory Species Fishery Management Plan. It is the last remaining DGN fishery in the U.S. Conservation concerns regarding DGN are the lack of selectivity and interactions with protected species and species of concern (ESA listed loggerhead and leatherback sea turtles, marine mammals).

Commercial fishermen and NOAA have argued that the existing bycatch reduction measures have made a significant impact in reducing bycatch⁸⁶; environmental advocates, sportfishing interests, and other stakeholders have criticized the continued bycatch impacts of the fishery.^{87,88} While bycatch has decreased, this is in part because the fleet has contracted. The number of active participants in the fishery has declined from roughly 250 active permits at its peak in the 1980s, with under 50 vessels per year since 2001, fewer than 20 active vessels per year since 2013, and an estimated 14 currently active vessels.^{89,90}

Regulatory and legal history: In 1996, NMFS convened the Pacific Offshore Take Reduction Team (TRT)⁹¹ under the Marine Mammal Protection Act, which led to gear modifications and additions including acoustic pingers and extended surface suspenders.⁹² The DGN fishery was also then subject to a number of seasonal closures in order to reduce bycatch, including two conservation areas to protect ESA listed loggerhead and leatherback sea turtles.⁹³ While historically the drift gillnet (DGN) fleet operated within federal waters off California and sometimes as far north as Oregon, it is now geographically and

⁸⁶NMFS. (2017, June 9). *Two Decades Later, Focused Efforts On Reducing Entanglements In Gillnet Fishery Still Paying Off*. <https://www.fisheries.noaa.gov/feature-story/two-decades-later-focused-efforts-reducing-entanglements-gillnet-fishery-still-paying>

⁸⁷Brennan, E. (2019, October 9). *Deep-set Buoy Gear Improves Commercial Harvesting*. The International Game Fish Association. <https://igfa.org/2019/10/09/deep-set-buoy-gear/>

⁸⁸Fears, D. (2018, April 12). *Grisly new undercover footage shows the toll of 'death nets,' activists say*. The Washington Post. <https://www.washingtonpost.com/news/animalia/wp/2018/04/12/grisly-new-undercover-footage-shows-the-toll-of-death-nets-activists-say/>

⁸⁹NMFS. (2021, July 21). *CA Thresher Shark/Swordfish Drift Gillnet Fishery (>=14 in mesh) - MMPA List of Fisheries*. <https://www.fisheries.noaa.gov/national/marine-mammal-protection/ca-thresher-shark-swordfish-drift-gillnet-fishery-14-mesh-mmpa>

⁹⁰NMFS, 2017.

⁹¹NMFS. (2021, August 30). *Pacific Offshore Cetacean Take Reduction Plan*. <https://www.fisheries.noaa.gov/national/marine-mammal-protection/pacific-offshore-cetacean-take-reduction-plan>

⁹² 62 FR 51805; 50 CFR 229

⁹³ Pacific Fishery Management Council. (2018, April 24). *Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species. As Amended Through Amendment 5*; 50 CFR 660.

temporally restricted to the southern California bight from mid-August through January due to these bycatch reduction measures.

In 2015, the Pacific Fishery Management Council unanimously approved a hard cap rule for protected species bycatch, which was finalized by NOAA in 2020.⁹⁴ The rule is currently being challenged by DGN fishermen in federal court.⁹⁵

Separately, under a 2018 California law, drift gillnet permits will be phased out by January 2024.⁹⁶ The law established a voluntary transition program, which incentivizes remaining DGN permit-holders to transition out of the fishery and claim up to \$110,000.⁹⁷ Funding for the transition program has been provided by California's budget as well as supported by NGO donations.⁹⁸ 48 licensed drift gillnet fishermen notified California Fish and Wildlife of their intent to take advantage of the buyout, but a few vocal fishermen have voiced their decision not to participate in the voluntary program⁹⁹ and others are pursuing a lawsuit¹⁰⁰ given that DGN fishing is still permitted in federal waters. Federal legislation has been introduced to align with the state's restrictions, and has previously passed the US Congress with bipartisan support though has not yet been signed into law.¹⁰¹

Gear switching and impacts: Beginning in 2011, preliminary fishing research trials showed that deep set buoy gear (DSBG) was effective in selectively targeting swordfish with lower bycatch and protected species interactions than DGN, and potentially profitable. DSBG employs a hook-and-buoy system to catch target species during the daytime in deep water, while they are feeding, with hooks commonly set at depths below 250 meters. Research conducted with EFPs from 2015-2020 has shown that DSBG has comparable catch rates to DGN and is highly selective: swordfish make up 80-90% of the catch, other marketable species make up 8-18% of the catch, and the remaining 0-2% of catch has been

⁹⁴85 FR 7246; 50 CFR 660

⁹⁵*Burke v. Coggins*, 521 F. Supp. 3d 31 (2021).

⁹⁶Commercial fishing: drift gill net shark and swordfish fishery: permit transition program. Senate Bill 1017 (2018).

⁹⁷California Department of Fish and Wildlife. *Drift Gillnet Transition Program*.

<https://wildlife.ca.gov/Conservation/Marine/Pelagic/DGN-Transition>

⁹⁸Bittenbender, S. (2021, July 5). *California budget includes final funding for drift gillnet buyout*. Seafood Source.

<https://www.seafoodsource.com/news/environment-sustainability/california-budget-includes-final-funding-for-drift-gillnet-buyout>

⁹⁹Sahagún, L. (2021, October 15). *Would you quit your job for \$110,000? This California swordfish catcher said no*. Los Angeles Times.

<https://www.latimes.com/california/story/2021-10-15/the-sun-is-setting-on-a-controversial-swordfish-industry>

¹⁰⁰Roper, G. (2020, November 3). *Blue-collar fishermen deserve to make a living*. Pacific Legal Foundation. <https://pacificlegal.org/blue-collar-fishermen-deserve-to-make-a-living/>

¹⁰¹Bittenbender, S. (2021, July 4). *Trump vetoes driftnet bill; Feinstein plans to refile*. Seafood Source. <https://www.seafoodsource.com/news/environment-sustainability/president-trump-vetoes-driftnet-bill-feinstein-plans-to-refile>

non-marketable but successfully released.^{102,103} In 2020, EFPs reported over 90% swordfish and 0% protected species caught.¹⁰⁴

The current EFP limits DSBG to 10 hooks per day, and while the low number is a concern for economic viability, in EFP fishing to date, DSBG-caught swordfish has fetched a higher price on average than DGN and longline-caught swordfish, and is nearly double the price of DGN caught swordfish.^{105,106} According to the Pacific Fishery Management Council, in 2017, five vessels fishing DSBG landed swordfish valued at \$408,874 (\$81,774 per vessel) while seventeen DGN vessels landed swordfish valued at \$890,443 (\$52,379 per vessel). Additionally, three times as many fishermen applied for exempted fishing permits to fish DSBG than are actively fishing DGN gear off the West Coast, and some of the DGN fishermen who participate in the DSBG EFPs have continued to use DSBG when they had access to DGN.

In September 2019, the Pacific Council made a final recommendation to NMFS to authorize DSBG as a legal gear type under the Highly Migratory Species Fishery Management Plan.¹⁰⁷ In August 2021, NMFS released a draft EIS for DSBG authorization.¹⁰⁸ The recommendation calls for a limited-entry fishery in the Southern California Bight, issuing up to 300 permits over a 12-year period. DSBG would also be allowed in federal waters off Northern California and Oregon for fishermen authorized to catch highly migratory species. NOAA projects that the gear could catch up to 5,400 swordfish per year with all available permits issued.¹⁰⁹

Successful expansion of DSBG would reinvigorate the fishery. Demand for swordfish remains high while the fleet has decreased and imports have increased (though imports are also priced lower and there are confounding factors beyond the decreased U.S. fleet); between 2015 and 2020, 84 percent of the total swordfish supply on the West Coast came from foreign imports. Commercial swordfish landings peaked in the 1980s at more than 7 million pounds worth close to \$13 million annually, but landings have declined to less than 1 million pounds of swordfish worth about \$2.5 million in 2019. In 2017, the DGN

¹⁰² Sepulveda, C.A., & Aalders, S.A. 2018. Exempted Testing of Deep-set Buoy Gear and Concurrent Research Trials on Swordfish, *Xiphias gladius*, in the Southern California Bight. *Marine Fisheries Review*, 80(2). <https://doi.org/10.7755/MFR.80.2.2>

¹⁰³ Pacific Fishery Management Council. (2020, June). Deep-Set Buoy Gear Exempted Fishing Permit Reports (PIER Report). <https://www.pcouncil.org/documents/2020/05/informational-report-12-deep-set-buoy-gear-exempted-fishin-g-permit-reports.pdf/>

¹⁰⁴ NMFS. (2021, June). *National Marine Fisheries Service (NMFS) Report On Exempted Fishing Permit Preliminary Recommendations*. <https://www.pcouncil.org/documents/2021/06/f-3-a-nmfs-report-1.pdf/>

¹⁰⁵ NMFS. (2021, August 19). *Draft EIS Available for Public Review: Proposed Amendment 6 to the Fishery Management Plan for West Coast Highly Migratory Species Fisheries: Authorization of Deep-set Buoy Gear*. <https://www.fisheries.noaa.gov/bulletin/draft-eis-available-public-review-proposed-amendment-6-fishery-management-plan-west>

¹⁰⁶ Sepulveda & Aalders, 2018

¹⁰⁷ Pacific Fishery Management Council. (2021, February 18). *HMS FMP Amendment 6: Authorization of a deep-set buoy gear fishery*. <https://www.pcouncil.org/actions/deep-set-buoy-gear-action/>

¹⁰⁸ NMFS, 2021

¹⁰⁹ NMFS. (2021, August 19). *Analysis of New West Coast Swordfish Fishery Weighs Benefits of Increased Domestic Catch*. <https://www.fisheries.noaa.gov/feature-story/analysis-new-west-coast-swordfish-fishery-weighs-benefits-in-creased-domestic-catch>

fleet accounted for approximately one-quarter of swordfish vessels and landed approximately the same proportions in landed weight and ex-vessel value.¹¹⁰

While many stakeholders are supportive of switching to DSBG and have reported positive results with EFPs, these regulatory and statutory changes have also been met with opposition from participants in the DGN fishery. These DGN fishermen argue that they are more highly regulated than other swordfish fisheries around the world and that further restrictions on the fleet would lead to more imports from countries with less stringent fishing guidelines.^{111,112,113} This was also cited as a reason for the veto of a bill that passed both chambers of Congress to ban drift gillnets.¹¹⁴

Those opposed to major regulatory and legal changes to DGN fishing see DSBG as an additional tool, rather than a gear substitute.^{115,116,117} Additional concerns have been related to catch volume and economic feasibility^{118,119}, as well as the consideration that DGN operations provide other products that can at times significantly contribute to trip revenue and thus makes direct profitability comparisons between DSBG and DGN more complex than just comparing swordfish alone.¹²⁰

Hawaii longline pelagic fisheries (deep set longline tuna fishery)

The Hawaii-based pelagic longline fisheries operate year-round out of Hawaii targeting bigeye tuna with deep-set longline gear and swordfish with shallow-set longline gear. The longline fisheries also catch a range of other pelagic finfish species for the fresh fish market. The fisheries consist of approximately 140 active fishing vessels in a limited entry program, and represent the largest commercial fisheries in Hawaii in both landings and revenue. The Western Pacific Fishery Management Council has valued Hawaii's longline fishery in excess of \$300 million when retail markets and support industries are factored. The deep-set longline fishery makes up the majority of the Hawaii pelagic longline fishery and targets Pacific bigeye tuna.

¹¹⁰NMFS, 2021.

¹¹¹House Natural Resources Committee Subcommittee on Water, Oceans and Wildlife. 116th Cong. (2019) (Testimony of Gary Burke). https://naturalresources.house.gov/imo/media/doc/Burke%20Testimony%20WOW%20Leg%20Hrg%2005_08.19.pdf

¹¹²Sahagún, L., 2021.

¹¹³Shaban, B. et al. (2018, August 30). *California Moves to Ban Mile-Long Fishing Nets Blamed For Killing Whales, Sharks, Dolphins, and Other Sea Life*. NBC Bay Area. <https://www.nbcbayarea.com/news/local/new-california-law-will-ban-mile-long-fishing-nets-blamed-for-killing-whales-sharks-dolphins-and-other-sea-life/209630/>

¹¹⁴Bittenbender, S., 2021.

¹¹⁵Testimony of Gary Burke, 2019.

¹¹⁶Blakely, C. (2018, October 11). *After the driftnet ban, swordfish fishery faces sustainability & market pressures*. The Coast News. <https://thecoastnews.com/after-the-driftnet-ban-swordfish-fishery-faces-sustainability-market-pressures/>

¹¹⁷Pacific Fishery Management Council. (2020, June). Deep-Set Buoy Gear Exempted Fishing Permit Reports. <https://www.pcouncil.org/documents/2020/05/informational-report-12-deep-set-buoy-gear-exempted-fishing-permit-reports.pdf/>

¹¹⁸Pacific Fishery Management Council, 2020.

¹¹⁹Arcuni, P. (2019, October 1). *Newly Approved Fishing Gear Reduces Ocean Wildlife Entanglements*. KQED.

<https://www.kqed.org/science/1948311/newly-approved-fishing-gear-reduces-ocean-wildlife-entanglements>

¹²⁰Sepulveda & Aalders, 2018.

Regulatory and legal history: The False Killer Whale TRT was established in 2010 under the Marine Mammal Protection Act due to incidental take (mortality and serious injury) that exceeded the stocks' biological removal levels.¹²¹ Regulations for the False Killer Whale take reduction plan were finalized in 2012 for both the Hawaii-based deep-set and shallow-set pelagic longline fisheries¹²², though interactions with the shallow set fishery are infrequent. The final take reduction plan included both regulatory and non-regulatory measures, including seasonal area closures, interaction/handling requirements and training, and gear modifications as well as a suite of research measures.

Gear switch and impacts: The take reduction plan required the use of circle hooks to reduce the number of incidental mortalities and injuries of false killer whales. This was based on analysis of observer data and modeling that indicated that the exclusive use of circle hooks in the deep-set longline fishery would likely reduce the number of false killer whale incidental takes (prevent some hookings) and may reduce the severity of injuries following interactions. Circle hooks are also generally weaker than the Japanese-style tuna hooks used by a portion of the longline fleet, so some false killer whales that are hooked in the lip, jaw, body, or flukes may be able to pull free more easily (straighten the hook) if tension is placed on the line.

The specific wire diameter requirement in the plan uses the size and weight disparity between the fishery's target species and other species to promote the release of larger, non-target or bycatch species while retaining target bigeye tuna catch. The initial proposal from the TRT required 'weak' circle hooks of 4mm diameter. Comments on the proposed rule highlighted economic concerns of reducing target catch with 4mm wires as well as lost revenue due to lower catch rates of incidental species such as yellowfin tuna and billfishes that are often retained and marketed. In response to these comments and insufficient information to understand weak hook impacts on catch rate^{123,124}, the final regulation was revised to a larger wire diameter (4.5mm).

The take reduction plan regulations also established a minimum 2.0 mm diameter for monofilament leaders and branch lines, and a minimum breaking strength of 400 pounds for any other material used in the construction of a leader or branch line in the Hawaii-based deep-set longline fishery, in order to allow for more tension on the line to allow the animal to straighten the hook without breaking the line or allow for disentanglement/de-hooking attempts without breaking the line. Observer data indicated that monofilament used in leaders and branch lines may break during marine mammal hookings and entanglements, which causes animals to be released with often substantial amounts of gear still attached.

While landings revenue is influenced by the entire suite of management measures and other factors, bigeye tuna continued to dominate Hawaii's landings revenue following the switch to circle hooks and other take reduction measures. Data for the fishery in the years immediately following the reduction

¹²¹75 FR 2853

¹²²77 FR 71259

¹²³Curran, D. & Bigelow, K. (2011). Effects of circle hooks on pelagic catches in the Hawaii-based tuna longline fishery. *Fisheries Research* 109:265–275. <https://doi.org/10.1016/j.fishres.2011.02.013>

¹²⁴Bigelow, K.A., et al. (2012). Catch Rates with Variable Strength Circle Hooks in the Hawaii-Based Tuna Longline Fishery. *Bulletin of Marine Science* 88(3):425-447. DOI: 10.5343/bms.2011.1052

measures showed the fishery dominates Hawaii's landings revenue (\$66 million in 2013 and \$61 million in 2014).¹²⁵

Atlantic pelagic longline fishery

The Atlantic tuna and swordfish fisheries are managed under the Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks (HMS FMP).¹²⁶ The Atlantic pelagic longline fishery is also subject to the requirements of the ESA and the Marine Mammal Protection Act.

Regulatory and legal history: Starting in 2000, the Northeast Distant (NED) statistical area (8.9 million square kilometers), a highly productive area, was partially closed and then fully closed in 2001 in response to legal action focused on interactions with loggerhead and leatherback sea turtles.¹²⁷ During the closure, research was conducted in the NED that provided evidence that the use of a (18/0) circle hook in combination with mackerel bait could significantly reduce bycatch rates of both loggerhead and leatherback sea turtles, as well as decrease the proportion of deeply ingested hooks in loggerhead turtles and increase rates of post-interaction survival.¹²⁸ Based on these findings, the closed NED area was reopened in conjunction with additional regulations for Atlantic HMS fisheries to reduce sea turtle bycatch, including the required use of circle hooks with minimum width dimensions equivalent to an 18/0 size hook and bait requirements in some areas.¹²⁹

Gear switch and impacts: From 2001 to 2003, research in the NED closed area tested methods to reduce sea turtle interactions and mortalities. Prior to the NED closure and research, the predominant hook type for pelagic longline swordfish had been J hook and squid. The NED research demonstrated that the use of large circle hooks, bait types, and careful release techniques were expected to be successful in reducing sea turtle interactions and mortality rates throughout the whole fishery. The 18/0 circle hooks maintained catch efficiency for bigeye tuna when baited with squid and for swordfish when baited with mackerel, and research found that sea turtle interactions can be significantly reduced by using circle hooks, or by using mackerel bait instead of squid, and when the two treatments use together led to a 90 percent reduction for loggerheads and 65% for leatherbacks.¹³⁰ Further evaluation of the gear switch found that in all regions in the Atlantic, rates declined by 40% and 61% for leatherback and loggerhead turtles, respectively, after the regulations; within the NED area alone, where additional restrictions limit use of squid bait, rates declined by 64% and 55% for leatherback and loggerhead turtles, respectively.¹³¹

Extensive public comment on the proposed regulations¹³² suggested that the measures could cause severe economic hardship, leading to possible business foreclosures in the mid-Atlantic, south Atlantic, and Gulf of Mexico due to the lack of flexibility for fishermen to select various hook and bait combinations; potentially reduced catches of target species, both inside and outside the NED, due to the proposed 18/0 circle hooks; and, reduced catches outside the NED due to the proposed baits (squid or

¹²⁵ NMFS. *Fisheries Economics of the United States*.
<https://www.fisheries.noaa.gov/national/sustainable-fisheries/fisheries-economics-united-states#previous-reports>

¹²⁶ 50 CFR 635

¹²⁷ 65 FR 60889

¹²⁸ Watson, J.W., et al. (2005). Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Canadian Journal of Fish and Aquatic Sciences* 62: 965–981. DOI: 10.1139/F05-004

¹²⁹ 69 FR 40733; 50 CFR 635.21

¹³⁰ Watson et al., 2005.

¹³¹ Swimmer et al., 2017.

¹³² 69 FR 6621

Atlantic mackerel only). Comments also requested consideration of overhead cost increases due to the need to buy new hooks and more expensive, non-indigenous baits outside the NED and that U.S. fishermen could be put at a competitive disadvantage to foreign vessels because of potentially increased costs and decreased revenues. The final rule provided more flexibility regarding baits, offset and non-offset circle hooks, and hook sizes outside the NED, and estimated that it would result in initial compliance costs associated with the purchase of new hooks (between \$675.25 - \$1,650.00 for 2,500 18/0 hooks, and \$697.50 - \$1,241.75 for 2,500 16/0 hooks).¹³³

¹³³69 FR 40733; 50 CFR 635.21



Appendix 2

Interview guide

Intro script

Thanks very much for taking the time to speak with me. This interview is part of a project whose purpose is to provide an overview of the fisheries management issues and challenges of on-demand fishing gear, commonly known as ropeless fishing gear, in New England. The primary goal of this project is to produce a report on the technical, regulatory, legal, and socioeconomic issues of ropeless gear. As an expert on key issues that are highly relevant to this issue, your insight is going to be incredibly helpful in informing our report.

During this interview I'm going to ask you a series of open-ended questions. The interview will be recorded so that your responses can be part of the report. The report will not identify you by name or affiliation, just by your general profession, like '[profession] or [other profession]'. If there's anything you'd like to say that you want kept off the record just let me know and I will pause the recording. Please answer questions with as much detail as you can, no topic is off the table and every detail is relevant. My goal is for us to have an in-depth back and forth conversation that gets to the heart of the issues and your opinions on them. Before we start do you have any questions about this project, the interview, or anything else?

I'm going to begin recording our conversation.

Ice breakers

1. Can you please describe your experience in fisheries over the course of your (career/lifetime)?
2. [Fishermen] What species do you fish for, and where do you operate generally?
[Others] What is your day to day like working in [fisheries/other field]?
3. a. When I say 'ropeless gear' what immediately comes to mind?
b. (Probe) Please elaborate on that a bit.
4. Please tell me what your own personal experience has been with ropeless gear. That can include conversations, observations, hands-on experience, or anything else.

Utility

The next several questions will deal with the physical use of and interactions with ropeless gear.

1. Walk me through the process of using gear on your boat, assuming I know very little about it. How do you and your crew approach setting gear, retrieving gear, stacking it, etc?
(Probe) How many traps do you fish? Do you trawl up? Around how many traps do you lose in a year?

2. Where do you fish? How do you decide where to fish? What are the depths, bottom type, current, etc. like in the areas where you fish? How much does the area you fish in vary across seasons?
3. How do you interact with other fishermen on the water? How does the way other fishermen set their gear impact the way that you fish?
4. How would using ropeless gear change the way you work through a string or multiple strings of traps?
5. How would using ropeless gear change deck operations on your vessel?
(Probe) How long does it take you or your crew to work through gear on deck? If you are familiar with the use of ropeless gear on deck, how much of a difference would there be in handling time and deck operations?
6. Are there any physical modifications would you need to make to your vessel in order to use ropeless gear?
7. What are your thoughts on fishing longer trawls?
8. What are your thoughts about grapple fishing?

Technology

The next several questions will deal with the technological aspects of ropeless gear, like the different types of gear that are available and how it would have to be integrated into your fishing operation.

1. What sorts of electronics do you use on your boat? What sort of sonar equipment do you have? Do you have satellite comms on board?
2. Do you use a plotter or a logbook to mark your gear?
3. How do you locate your gear once you're in the general area that it was set?
4. What information would you need to have displayed on a plotter or a screen in order to locate gear that isn't visible from the surface?
5. There are several remotely activated ropeless gear systems that have been developed or prototyped. Let's consider these. What are your thoughts about using [each type of gear]? What would using this equipment mean for your fishing operation?
6. Conflict between two or more ropeless gear operators has been identified as an issue. What are your thoughts about the physical interaction between ropeless gear operated by different fishermen? How would these issues have to be addressed in order to minimize conflict?
7. Conflict between ropeless gear operators and mobile gear operators has also been identified as an issue. What are your thoughts about the physical interaction between ropeless and mobile gear? How would these issues have to be addressed in order to minimize conflict?

Legal/regulatory

The next several questions will deal with the legal and regulatory aspects of ropeless gear, like time or area restrictions and law enforcement activity.

1. Do you have state and/or federal permits, and do you fish in state and/or federal waters?
2. How do jurisdictional issues from state and federal requirements impact your fishing operation? Do you have experience with or opinions on the New England Fishery Management Council, the Atlantic States Marine Fisheries Commission, the Take Reduction Team? What role do you think these organizations should have in discussions about ropeless gear?
3. What are the current reporting requirements for your (lobster/other fixed gear) fishing operation? How much time to you currently spend on reporting?
4. What are your thoughts about a seasonal requirement to use ropeless gear versus requirements to use of the gear at all times, in other words switching back and forth between ropeless and buoy line gear depending on the season?
5. What are your thoughts about an area-based requirement to use ropeless gear versus the use of the gear in all areas, in other words using ropeless gear in some areas and not in others?
6. How would the various approaches to requiring ropeless gear in certain areas or certain times that we just discussed change your fishing operation? How would it impact your community and your interactions with fellow fishermen?
7. What are your thoughts about the liability issues associated with ropeless gear interactions with mobile gear?
8. How often do you interact with marine law enforcement officers? How often do you believe marine law enforcement officers interact with your fishing gear? What are your thoughts about law enforcement officers interacting with ropeless gear that you would operate?

Socioeconomics

The next several questions will deal with the social and financial aspects of using fishing gear. Some of the questions I will ask deal with sensitive topics like income and expenses. Please remember that this is a confidential conversation, and you can ask me to pause recording at any time.

1. [If applicable] About what portion of your income comes from the lobster fishery? [If applicable] About what portion of your time is spent working on lobster fishery issues versus other fisheries or issues?
2. How do you think, specifically, that the use of ropeless gear would impact the value of your business? How would those impacts be realized over time? [If applicable] How would it impact the value of your other permits or the other fisheries you operate in?
3. How would the use of ropeless gear in combination with changes that are occurring in the ocean like population fluctuations or energy development impact you/your members?
4. Let's talk about specific financial figures, which will be very important for this report. About how much money do you/your members spend on gear per year, and how does that vary from year to year?

(Probe) Can you please break those expenses down for me?

5. About how much equipment and maintenance costs do you/your members finance versus pay for with unfinanced capital?

6. How do you think the costs of ropeless gear would impact the investments you make in your business?

7. What is your market? Do you sell to a co-op? How do you think the costs of ropeless would impact price or the value of lobster, both at the dock or at the retail level?

(Probe) Are there any other possible costs or possible benefits in price and marketability associated with ropeless gear?

8. Do you or members of your port defend territory? Are there other factors besides territory that govern where you/your members fish? If so how would ropeless gear change the way you work and defend territory?

9. How would regulations that require the use of ropeless gear in some areas but not others impact the way that you fish? How would such requirements impact price, competitiveness, and the way that the lobster fishery would operate?

10. Are there any ways that the use of ropeless gear would change or impact your community as a whole?

Wrap-up

We're nearing the end of the interview. Before we finish, are there any other issues associated with ropeless gear or related issues in general that you think I should know?

Thank you very much for your time. I may be in touch to request a follow-up conversation if there's a need for additional discussion or clarification. We will be hosting a workshop later on this year to discuss these issues in depth and, hopefully, in person, so please keep an eye out for additional information about that, which will be emailed to you.

I want to thank you for spending your time with me today. I know it's incredibly valuable, and your insights will be very helpful as we continue to advance this scoping project. Have a great day.

Appendix 3

Workshop agenda



Mass. Division of Marine Fisheries on-demand Fishing Gear Scoping Project Workshop

Day 1: October 13, 2021 – 12:00 – 5:30 pm

Day 2: October 14, 2021 – 8:00 am – 1:00 pm

DoubleTree Hotel Boston/North Shore, 50 Ferncroft Rd Danvers, MA

North Shore B Conference Room

Day 1

- I. Gather (*coffee & snacks provided*) – 12:00
- II. Opening remarks & introduction to on-demand fishing gear scoping project – 12:20
- III. Regulatory issues – 12:50
 - a. Introduction – 5 minutes
 - b. Breakout discussion (at tables) – 50 minutes
 - c. Breakout reports & group discussion – 45 minutes

Break – 30 minutes

- IV. Socioeconomics – 3:00
 - a. Introduction – 5 minutes
 - b. Breakout discussion – 50 minutes
 - c. Breakout reports & group discussion – 45 minutes
- V. Topical discussion & open forum – 4:40
- VI. Summary & adjournment – 5:15

Day 2

- I. Gather (*coffee and snacks provided*) – 8:00
- II. Day 1 recap – 8:10
- III. Operations part 1: on-deck and shoreside – 8:20
 - a. Introduction – 5 minutes
 - b. Breakout discussion – 40 minutes
 - c. Breakout reports & group discussion – 30 minutes*Break – 10 minutes*
- IV. Operations part 2: interactions with others – 9:45
 - a. Introduction – 5 minutes
 - b. Breakout discussion – 40 minutes
 - c. Breakout reports & group discussion – 30 minutes*Break – 10 minutes*
- V. Synthesis discussion – 11:20
 - a. Introduction – 5 minutes
 - b. Breakout discussion – 30 minutes
 - c. Breakout reports & group discussion – 50 minutes
- VI. Final summary & adjournment – 12:45