Developing acoustic and data standards to support on-demand fishing interoperability

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The traditional use of vertical lines connecting fixed-gear with surface buoys can result in whale entanglements, resulting in significant harm or mortality. A solution being pursued by fishery managers to reduce the risk of entanglement is the use of on-demand fishing, which replaces vertical lines and surface buoys with a fishing gear retrieval system that is paired with acoustic signaling and virtual gear marking (*i.e.*, no persistent vertical line and no surface buoy). The reduction in vertical lines is vital for reducing impacts to whales, however, the loss of surface buoys removes the visual acuity that fishermen and other ocean users have relied upon to operate in close proximity to each other. To effectively implement on-demand fishing, fishermen, managers and enforcement agencies, and other ocean users (e.g., recreational anglers, survey vessels, etc.) will require near real-time access to subsurface gear locations and other metadata to reduce fishing gear conflicts.

Collecting, transmitting, and visualizing subsurface gear location information in near real-time is quite challenging. Fishing vessels have a variety of onboard technology, most do not have internet connectivity, and there are many companies offering different approaches for deploying ropeless gear. However, it is imperative to implement an interoperable system that provides options for fishermen and a technological framework for efficiently sharing and visualizing data amongst fishermen and other ocean users. NOAA Fisheries will host an interoperability workshop in late 2023 to continue the development of standards for acoustic communications and data specifications; it will include gear manufacturers, acoustic communications experts, government agencies, fishermen, and other stakeholders to evaluate key technical components of on-demand systems. The workshop outcomes will inform a future regulatory framework for how ropeless gear will be deployed and the communication pathways to share and visualize subsurface gear location data amongst fishermen and other ocean users.

Overview of on-demand fishing progress in US Northwest Atlantic: A collaboration

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Staff at the NOAA Fisheries Northeast Fisheries Science Center (NEFSC) are collaborating with fishermen, research institutions, gear engineers and manufacturers, and conservation organizations to investigate innovative fishing technologies to mitigate large whale and leatherback sea turtle entanglements. This collaboration provides opportunities to fund gear acquisition, trial on-demand systems under real-world conditions, and improve gear performance based on data collection and industry feedback. Through a three-phased approach, all new release systems and new vessels begin with initial training and rigging of gear. In Phase 2, vessels conduct real fishing operations using the release system, which includes standardized data collection including performance feedback from the fishermen. In Phase 3, qualified vessels participate in an Experimental Fishery to conduct research fishing operations within controlled access Vertical Line Closure testing ranges. Gear availability is accomplished through a Cooperative Gear Library model that has made 300 ropeless systems available for trials from nine different manufacturers. Trials have been conducted in both inshore and offshore environments to evaluate the efficacy of on-demand gear operations under a variety of conditions. The growing gear library model enables fishermen to prioritize gear types which they feel work best for their fishing conditions as well as provide manufacturers the opportunity to improve systems based on the needs of the industry. The long-term goal of these trials is to further the development, safety, knowledge, and availability of tools for fixed gear fisheries to mitigate the impact of vertical line

restrictions, to minimize the threat of entanglement with protected species, and ultimately inform decisions to allow commercial use and authorization of on-demand systems.

Ropeless Roadmap: A strategy to develop on-demand fishing

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NOAA's Ropeless Roadmap describes the current state of on-demand, or "ropeless," fishing and outlines a path for increasing adoption of this technology in U.S. East Coast commercial fisheries. We discuss this developing technology and forecast its future path based on the status of gear development, ongoing regulatory changes, and the need to decrease whale entanglements and associated mortality under the Endangered Species Act and Marine Mammal Protection Act. The need for on-demand fishing is driven by the urgent conservation crisis facing the endangered North Atlantic right whale (*Eubalaena glacialis*). As the need for larger and longer seasonal restricted areas increases to protect right whales, on-demand fishing represents the best solution to separate rope and right whales in areas of highest risk. The Ropeless Roadmap explores the potential for on-demand fishing gear to provide substantial reductions in entanglement risk for fixed gear trap/pot fisheries in a rapidly changing Atlantic ecosystem. We recognize that there are many partners who are key to this process and strategy, particularly state fishery managers and fishery management councils and commissions. First released as a draft in 2022, we have revised the Ropeless Roadmap to incorporate feedback received during the public input process and through ongoing gear testing and regulatory developments. We will continue revising the Ropeless Roadmap over time and as a living document to provide NOAA's vision for proceeding through this rapidly evolving landscape.

Development of a system for mobile fishers to view on-demand gear location data to reduce gear conflict

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Gear conflict between mobile and fixed fishers occurs when mobile fishers tow nets or dredges through fixed fishing gear, which is a safety hazard, damages both the mobile and fixed fishing gear, and risks moving and ultimately losing the fixed fishing gear. Without an indication of where on-demand fishing gear occurs on the sea floor, mobile fishers have no way of avoiding gear conflict. The Woods Hole Oceanographic Institution is developing and testing a device suitable for mobile fishermen to access in real time information about the location of on-demand fixed fishing gear on the sea floor. The device is intended to be used on the bridge of a mobile fishing vessel, and will use satellite communications to send the vessel's location to a cloud database of on-demand gear locations maintained by EarthRanger. The cloud database will respond with a list of gear locations within 3 miles of the mobile fishing vessel's position. With these data, the device will form NMEA-like messages that will be delivered to an attached laptop computer running OpenCPN charting software (which serves as a prototype chart plotter), where the fixed gear location data will be displayed. The system will be for demonstration purposes only; there is no intention or desire by WHOI to commercially develop this product. The hardware design and software for the device on the fishing vessel will be made open source and publicly accessible for the use by any party,

including manufacturers who wish to replicate this system's functionality.

A comprehensive system for gear location marking, gear retrieval, lost gear recovery and enforcement enabled by acoustic communication standards

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The problems of gear location marking, lost gear recovery and enforcement of on-demand fixed fishing gear remain significant impediments to the legalization of commercial fishing without endlines. The federal governments of the U.S. and Canada have clearly stated that without solutions to these problems, on-demand fishing cannot move beyond the current testing and evaluation phase. As a group of independent experts with substantial experience in underwater acoustic communications, we have developed a proposed open standard for acoustic communications specifically designed for the challenges of on-demand fishing, as well as a comprehensive system that takes advantage of that standard to enable gear location marking, lost gear recovery, gear retrieval and enforcement operations. The acoustic standard is simple and robust to background noise, transmission loss, multi-path, multi-access and range rate, which are all significant challenges to reliable underwater acoustic communications faced by moving fishing vessels. The comprehensive system that uses this standard is based on requirements gleaned from stakeholder interviews, and includes functional hardware design and messaging between three critical subsystems: (1) a shore-side cloud database and processing system, (2) fishing vessels and (3) acoustic devices attached to the terminal ends of trawls on the sea floor (and in most cases attached to and capable of triggering on-demand release mechanisms). These subsystems communicate with one another to collect and share information about deployed trawls with gear owners and enforcement, verify/update the location of trawls, share location information with vessel chart plotters, identify and notify users of both lost and found fishing gear, and enable both gear owners and enforcement to query and retrieve on-demand gear.

Progress toward an adaptable, low-cost, on-demand fishing system

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Whales, sea turtles and other marine species including the critically endangered North Atlantic right whale can become entangled in the vertical lines of fishing gear, posing a significant risk of injury or mortality. Reduction or elimination of vertical lines in the water column has been identified as a major component of recent conservation efforts. Currently, these risks are managed through the imposition of time-area closures of commercial trap fisheries that represent a potential risk, thus protecting the species but also significantly impacting the fishing communities that rely on access to these fisheries for their livelihoods. On-demand fishing systems have the potential to reduce entanglement risk in areas where whales are present, as well as increase fishing opportunity in closed areas. However, these systems have faced criticism based on cost, conflict with other fixed and mobile gear, and reliability as compared to traditional methods. The focus of our efforts is to significantly increase uptake by directly addressing these ongoing impediments through broad introduction of low-cost, adaptive, on-demand fishing gear. The adaptive system incorporates shallow and deep water acoustic releases combined with gear retrofit or sled-type line handling equipment. These configurable systems allow fishers to tailor low-cost on-demand gear to their needs, both individually and locally, within the context of their regional fishing methods. Operational impacts related to geolocation

interoperability and potential gear interactions within and across fisheries are addressed via an established gear marking app (Trap Timer) with multi-manufacturer interoperability (rmwHUB). Reliability and operational efficiency are enhanced through a combination of gear innovations and fishery-tailored training efforts (Learning-Teaching-Mastery Method). Recent results from a wide range of fisheries indicate potential capitalization cost reductions of 75% compared to published costs of other widely tested systems, reliability rates of about 98%, and expanding demand for the gear due to fisher interest.

Advancing coexistence between North Atlantic right whales and snow crab harvesters: Gear on demand solutions and implementation

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Coexistence between North Atlantic Right Whales (NARW) and snow crab harvesters is a pressing challenge in the Gulf of St. Lawrence, due to the increasing presence of this endangered species on the fishing grounds, and thus the risk of entanglement in fishing gear. Over the last five years, our industry has adopted an innovative approach to address this challenge, based on collaboration, knowledge building and field measurements, aiming to protect NARW while sustaining our fishery. Working closely with Association des Crabiers Acadiens (ACA) and Association des Pêcheurs Professionnels Crabiers Acadiens (APPCA), scientists, engineers, and edgetech, our team has conducted extensive testing of "on demand" snow crab gear systems, which incorporated valuable feedback to the governmental and scientific communities to minimize impacts of our fishery on marine wildlife. Since 2022, a groundbreaking "real-life" experimental fishery is allowing our harvesters of Crab Fishing Area (CFA) 12 to access closed fishing areas with the Edgetech gear on demand systems. This year, more than 30 harvesters were equipped with 1660 Edgetech traps to be deployed during our fishing season, fostering snow crab harvesting without traditional ropes. Our results will be presented, along with the ones generated since 2018. Building on five years of knowledge, the project optimizes coexistence with NARW and develops efficient "gear on demand" solutions. During sea trials 2023, insights from experienced fishermen allowed to enhance this technology's effectiveness, as well as other technologies for sustainable fishing practices in NARW habitats, and make these solutions well adapted, efficient, and effective as soon as possible, for a situation that needs to be resolved without delay. The potential of gear on demand technology to enable full-scale commercial fishery operations in closed areas holds promise. Our findings contribute significantly to safeguarding the snow crab and other fixed gear fisheries, while preserving endangered species.

Integrating mobile and ropeless offshore fisheries using 50 KHz depth sounders

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In the absence of surface marker buoys, a particular challenge for the introduction and growth of a ropeless fixed-gear fishery is its coordination with mobile gear fleets using the same fishing grounds. While it is anticipated that ropeless equipment will be coordinated through virtual or GPS gear marking, mobile fleet vessel may not necessarily check available gear marking apps. Marks may not be up to date, in particular beyond cell phone range.

Acoustic gear marking offers a solution. But a new acoustic gear marking standard requires that all fishing vessels are outfitted with special transducers and deck equipment, raising challenges of cost and adoption. However, most offshore and many inshore vessels are already equipped with standardized acoustic equipment, namely the ubiquitous 50 KHz depth sounder.

Building on our recent design of a software defined acoustic modem under contract to DARPA, Desert Star Systems has proposed the development of a

software defined acoustic release capable of responding to 50 KHz depth sounder signals.

By detecting and then responding to such signals in an intermittent way, distinct dashed and dotted lines can be made to appear on the vessels existing sounder display. The shape and trend of these lines indicate distance, approach or departure and can serve as a simple navigational aid to avoid fixed gear.

This presentation details a 50 KHz gear marking method. Early tests at sea that demonstrate a gear detection capability in a radius of at least twice the water depth around a vessel are reviewed.

The presentation concludes with a perspective of how 50 KHz gear marking may help integrate fixed and mobile fleets in a practical way and how 50 KHz and virtual acoustic gear marks can be integrated to provide effective conflict avoidance.

A multi-standard deck box for fishery inspectors means choice for fishers

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The New England and Canadian fixed gear fisheries are diverse, and individual harvesters must manage a variety of operational requirements and financial constraints. The emerging ropeless industry has responded by offering a wide and growing selection of on-demand pop-up buoys. The price and performance characteristics of these systems depend on manufacturer's design of their on-demand underwater acoustic technology. A choice of a low operating frequency for example provides greater actuation range offshore, while higher frequency offers inshore fishers a more compact design at a lower cost. The proliferation of multiple acoustic standards, each requiring a proprietary deck box and sonar transducer, however presents a challenge for fishery enforcement who must inspect all gear.

For this reason, on-demand ropeless manufacturers Ashored, Desert Star Systems, EdgeTech, FioMarine, LiftLabs, Ropeless Systems and Subsea Sonics have joined to propose the development of a software defined multi-manufacturer / multi-standard deck box and multi-band transducer assembly to the New England Gear Innovation Fund. The deck box will be an adaptation Desert Star's recent development of a software defined acoustic modem under contract to DARPA. The initial effort will result in the support the on-demand gear of the manufacturers within our group. But a publicly available API will ease and support the implementation of future on-demand acoustic standards.

This presentation reviews the technical capabilities of the deck box, and the method of implementing acoustic standards. The operation of the deck box and transducer assembly to haul on-demand gear independent of manufacturer and within the context of acoustic gear marking is explained.

The presentation concludes with a discussion of the benefits presented by the multi-standard deck box, including its support of innovation and more choice for fishers in an industry transition to a ropeless practice.

Recent progress on developing ropeless gillnets and new efforts to develop and test ropeless gear with integrated scientific fisheries data collection packages (the "SmartRaft")

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The National Marine Fishery Service has determined that additional right whale entanglement risk reductions are required in all East Coast gillnet and trap/pot fisheries. Fishermen face additional challenges from rapidly changing ocean conditions

due to climate change. Congress delayed requirements for new regulations in New England's American lobster and Jonah Crab fisheries until December 31, 2028, but did not do so for gillnet fisheries. NMFS initiated development of these rules in August 2021 and proposed rules requiring vertical line reductions in gillnet fisheries could be published at any time for implementation in 2024.

Ropeless trap and gillnet systems can reduce entanglement risk and provide fishermen access to vertical line closures. Here, we report the results from a National Fish and Wildlife Foundation grant funding development and testing of the first ropeless sink gillnets using SMELTS ropeless systems and innovative gear marking technology. Eight SMELTs gillnet rafts were built using Teledyne and EdgeTech on-demand systems and marking technology and Blue Ocean Gear Farallon Smart Buoys. A partner fisherman conducted initial tests between August and December of 2021 in Maine waters near Jeffrey's Ledge. A partner fisherman conducted a second phase of testing near Cape Cod from June and September 2022.

We also preview two imminent projects. First, a grant from NOAA's Bycatch Reduction Engineering Program will expand testing and development of ropeless gillnet gear, including testing of the first "stowed rope" gillnet system using EdgeTech ropeless systems. Second, a grant from NOAA's Saltonstall-Kennedy Grant Program will fund development of SMELTS ropeless gear outfitted with scientific instruments ("SmartRafts") to collect acoustic data for whale detection and environmental monitoring urgently needed to build timely personal and shared databases to track changing ocean conditions. Two experienced fishermen will test SMELTS SmartsRafts and continue testing the efficacy of subsea acoustic marking systems.

LiftLabs: Developing and testing fast on-demand systems in New England

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LiftLabs' development and testing efforts over the past year have focused on the collaboration with local lobstermen. The objective of the research was to develop a viable, cost-effective, and safe solution that promotes coexistence between fishermen and whales. The project commenced by constructing subsea Lift units and prototypes of docking stations to improve the speed and efficiency of gear resetting. Valuable input from stakeholders, including lobstermen from Maine, Massachusetts, and Rhode Island, guided the design process. The outcome was the successful implementation of the Horizontal Docking Station for larger boats, and the creation of the more compact Vertical Docking Station tailored for smaller vessels. Long-term testing took place in Rhode Island with local fishers, leading to important updates such as extended battery life and enhanced usability. Collaboration with Sub Sea Sonics facilitated the integration of cost-effective acoustics into the system. Testing demonstrated that the gear's resetting time was comparable to traditional fishing methods in terms of efficiency. The availability of a spare Lift system further streamlined the process, particularly in unfavorable weather conditions. The findings highlighted the reliability, usability, and improved performance of the gear as fishers became more skilled in its operation. In conclusion, the project achieved significant progress in realizing on-demand fishing and offered an alternative approach to prevent the extinction of the North Atlantic right whale species while ensuring the profitability of lobstermen.

Commercial evaluation of a rope on command fishing system for the NL lobster & crab fisheries

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Our presentation focuses on the results of extensive research, testing and stakeholder engagement project, conducted over a 2 year period, of Rope on Command fishing systems in the province of Newfoundland and Labrador. This project, led by the Department of Fisheries and Oceans Canada in collaboration with the Centre for Fisheries Innovation (CCFI), focused on evaluating and advancing ROC technology developed by Ashored Inc. and eSonar Inc., ensuring its applicability and effectiveness in the region's fishing practices. The scope of the project covered inshore and offshore fisheries for snow crab,

lobster, and Atlantic cod, exploring fishing in both trawls/fleets and single pots, and evaluating depths ranging from 50m to 300m.

The project encompassed rigorous testing of the ROC fishing system to assess its functionality, quality, and endurance while aligning with the existing harvester fishing practices in the Newfoundland and Labrador fishery. Through comprehensive testing, deficiencies were identified, leading to informed modifications and improved prototypes before conducting CCFI harvester trials. The primary objective was to create a reliable and user-friendly system that would be readily adopted by harvesters.

Through extensive research, testing, and stakeholder engagement, the CCFI and its project team identified crucial findings, conclusions, and recommendations that will guide the further refinement and future development of ROC systems. These insights represent the practical application of the ROC system in the daily operations of Newfoundland and Labrador's fishery, accounting for inshore, mid-shore, and offshore conditions, including the deep-water settings characteristic of the region's crab fishery (with depths up to approximately 1400 ft).

Crucially, all recommendations are derived from the valuable input of experienced fish harvesters who possess an intuitive understanding of the system's feasibility, both operationally and financially. By addressing their perspectives, the project aims to ensure the successful integration of ROC technology, ultimately promoting sustainable harvesting practices and minimizing environmental impact in the Newfoundland and Labrador fisheries.

Beyond saving whales: Benefits of innovative fishing gear to fisheries and society

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Innovative fishing gear has its genesis in the conservation priority to reduce inhumane and deadly whale entanglements and to allow fisheries access to whale protected closed areas. The financial costs of innovative gear are raised as a barrier to entry, yet significant financial and safety benefits to society and fisheries have been identified. Remunerations may include reducing gear loss and ghost gear while increasing recovery of lost gear. A recent study estimated an annual global fishing gear loss of about 2% and 25 million lobster traps and crab pots. Reducing gear molestation, gear conflict, and improvements in law enforcement are explored and considered. Vertical lines going overboard at rapid speeds have resulted in fishermen being caught and pulled overboard. A 2000-2014 study of commercial fishing mortality in the United States found that there were 29 human mortalities due to gear entanglement with the majority in the NE lobster fishery. This talk will consider any potential benefits to fishermen safety. The authors believe significant benefits may be accrued to improved fishing efficiency due to innovative gear systems. Presently, fixed fishing gear systems with buoys and lines can be a significant marine safety hazard. Every year vessels become impaired due to line entanglements in propellers, or the hull features due to fixed fishing gear. In some extreme cases vessels have lost power and sunk with loss of life. In the pacific northwest ferry vessels must shut down at considerable cost after becoming ensnarled in crab fishing lines. A review of maritime safety benefits is considered. Benefits in improved ocean, whale, and fishery science may also be greatly enhanced with increased technology that comes with innovative gear. Likewise, benefits may be received from reducing the government costs of management and in providing more sustainable seafood at a higher value to conscientious consumers.

Introduction to new whale safe fishing gear

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Nova Robotics develops new and innovative technologies for responsible fishing, with a focus on both marine mammal safety and reduction of ghost gear.

The Tag Line Spring Release enables crab pots, which can weigh in excess of 2000 lbs, to be retrieved using 100% weak vertical line. The vertical line may be much weaker than the current 1700 lbs target. If a boat strike or other event breaks the weak line, a secondary recovery buoy is deployed. This prevents ghost gear and secondary whale entanglements, while also preserving conventional fishing methods.

The Electronic Release is a low-cost on-demand rope system. It can be configured as acoustic rope-on-demand or by setting a timer. Both the Spring Release and Electronic Release utilize identical and interchangeable hardware and can be swapped in a matter of seconds.

GPS Smart Buoys provide a low cost, medium range option for buoy tracking that does not rely on expensive satellite data connections which are cost prohibitive.

Sonar Reflectors are non-electronic devices which may be detected with the conventional sounders already found on every fishing vessel. These can be attached to conventional fishing gear and the ease of detection prevents trawl collisions, enabling trawl fishing in areas where it's currently impossible. By attaching Sonar Reflectors to conventional gear, ghost fishing can also be reduced as lost gear can be found.

Low-Profile Weak Links provide the benefit of easily passing through a vessel's hauler, while also reducing harm to a whale's baleen in the event of an entanglement.
Thrash Detectors utilize an in-line load cell to identify any pattern of forces indicative of an entangled whale. Once detected, it disconnects the rope and releases the trap.

Developing Canada's Whalesafe Gear Strategy

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Fisheries and Oceans Canada (DFO) has prepared a proposed Whalesafe Gear Strategy to guide the adoption of fishing gear innovations designed to reduce the risk of serious injury, mortality, and sub-lethal effects to large whales from entanglements. The Strategy spans five years from 2023 - 2028, presenting objectives, activities and milestones to support the adoption of low breaking-strength gear and on-demand gear, using a 'mosaic' approach to reflect diverse fishery conditions. The Strategy reflects Canadian gear trials to date, and provides guidance for prioritizing future trials. The July 2023 amendment to Canada's *Fishery (General) Regulations* provides new flexibility supporting the adoption of on-demand gear through specific fishery licence conditions, positioning DFO to support technological innovations as they become ready for more widespread adoption. Feedback from harvesters, Indigenous partners and others are making a vital contribution to the Strategy. Milestones and indicators provide guidance on assessing the effectiveness of the strategy, and help set up guideposts for work in subsequent years.

JASCO/SMELTS "Whale-Raft" development

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JASCO Applied Sciences Ltd and Sea Mammal Education Learning Technology Society (SMELTS) have developed a ropeless lobster raft that can in addition to enabling on-demand fishing, can also record in-situ acoustic data and will enable in-situ detections of marine mammals in the near future. The "whale-raft" concept is that while fishing, fishers can gather in-situ data to help determine marine mammal presence/absence in fishing grounds to enable fishers to help enable regulatory decisions based on better scientific data. "Whale raft" marine mammal detections could potentially be telemetered acoustically to nearby manned or unmanned vessels and then sent to fishers and regulators in near-real time. Near real-time detection data could then be used to make decisions of when to perform gear recovery operations or to help decide when closures are warranted. Prototype "whale-rafts" have been built by JASCO and delivered to SMELTS for initial testing. This presentation will explain the whale-raft concept, the functions supported by whale-raft and the results of initial whale-raft testing.

Exploring coexistence through Innovation: Testing diverse ropeless gear technologies for sustainable fishing in the Gulf of St. Lawrence

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In 2022 and 2023, Association des Crabiers Gaspésiens, supported by the Whalesafe Gear Adoption Fund and with the help of the Gear Repository, purchased and tested three different "gear on demand" systems in order to prevent and reduce entanglement risks, safeguarding endangered species like the North Atlantic right whale, while also enabling fishing activities in otherwise closed areas. Snow crab harvesters from Gaspésie tested and compared these innovative systems in different conditions of depth, currents, and bottom types, in Crab Fishing Area (CFA) 12, in the Gulf of St. Lawrence. Prototypes from Edgetech, Ashored and DevOcean were tested in summer 2022 and 2023, after detailed training sessions on the use of these technologies, and with standardized protocols. The project, developed for four harvesters, ended up inspiring seven of them to test the technologies. The preliminary results of the tests will be presented, along with the general framework of data collection developed through this project, which will grow over time to be a common database allowing harvesters to select the best possible gear on demand system to use in their context, and meeting their criteria (cost, ergonomy, performance in different oceanographic condition, adaptability, etc.). The data collection model created with this approach will form the foundation of a comprehensive and standardized dataset, serving as a powerful decision-making tool for harvesters, stakeholders, managers, and scientists. By aggregating information from these innovative technologies, the dataset will expand over time, enabling valuable insights and comparisons that can inform and guide future conservation strategies. Similarly, by fostering cooperation among fishermen and technology providers, this endeavor seeks to revolutionize fisheries practices and advance coexistence efforts with marine wildlife in the Gulf of St. Lawrence, and inspire/benefit many other areas of the world facing similar challenges.

EdgeTech Ropeless On Demand Fishing System interoperability and improvements to Trap Tracker and hardware.

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This paper will describe new features and additions to the Trap Tracker application. EdgeTech is adding one major improvement to the Trap Tracker system. This is our new Continuous Acoustic Position Ranging Improvement CAPRI. When in the transit mode the system will send out ID requests every 2 to 5 minutes depending on vessel speed. Whenever a deployed underwater unit is within range it will respond with the unique ID of that system and the App will calculate the range. The ID, the range, and the position of the vessel will be reported to and stored in the Trap Tracker cloud database. All vessels traveling within range will send the same information to the Cloud and in most cases will report multiple ranges with each passing. As the data is collected in the cloud, the processing to improve the position accuracy is performed in the cloud and then reported as the new position of the deployed system. Not only does this continuously improve the accuracy of reported positions it also eliminates or severely reduces Ghost gear.

Why smart buoys are part of the EFP: Insights from data generated by smart buoys used with on-demand gear in New England

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Blue Ocean Gear's Smart Buoys were part of the required gear configuration for fishers using on-demand gear during three vertical line closures in the Northeast as part of the Northeast Fisheries Science Center's Gear Research Team's Exempted Fishing Permit and Massachusetts Department of Marine Fisheries Letter of Authorization. The closures were located in MA state waters and federal waters offshore of Massachusetts and Rhode Island. The buoys were attached to the gear while submerged, then floated to the surface as part of the system when the release mechanism was activated. Eleven fishers used the Smart Buoys with on-demand systems

during this period to provide location coordinates immediately upon resurfacing, and to identify any unplanned or early releases via SMS alerts. Gear position at the surface was displayed on EarthRanger, Trap Tracker, and the Buoy Locator app, and the capability of display on a Time Zero chart plotter was also available. Working with the fishers and scientists during this period led to modifications of the timing and alert notifications that would better indicate what was happening, whether users were on the water or monitoring from onshore. The data collected by the buoys while underwater and at the surface provided insights about the efficiency of on-demand gear as well as understanding the needs of regulators for actionable real-time data, such as instances of gear surfacing unintentionally. These data will be presented as a manufacturer-agnostic view of on-demand gear and its operational feasibility during the season closure.

Preliminary design work towards an ultra-low-power acoustic wakeup for on-demand fishing gear

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One of the largest hurdles for commercial adoption of on-demand gear is its economic and logistical feasibility. On-demand gear on seafloor traps is almost always idle, doing nothing except listening for incoming acoustic commands. Most of the battery power is therefore consumed in the acoustic listening process, requiring either larger and more expensive battery packs, or more frequent battery servicing. By reducing the power consumption of the listening process, we can reduce battery pack sizes (and therefore gear size) and extend battery servicing intervals, improving system cost and logistics.

Acoustic listening is typically conducted by a low-power wakeup system that is independent of the system that is used to decode an incoming acoustic command. The wakeup system detects the incoming signal and triggers the powering (or "wake up") of the more sophisticated and energy intensive decoding system. Traditional acoustic wakeup detectors, using standard off-the-shelf electronics components, use on the order of 20mW of battery power, or about 1700J/day, which would be about 96% of the expected energy consumption of a trap's on-demand system. Custom chips can achieve internal parasitic power losses that are orders of magnitude lower than systems built from discrete off-the-shelf components.

We will report on the simulation results of a custom chip implementing an ultra-low-power acoustic wakeup receiver circuit that consumes approximately 500µW. The wakeup power is therefore reduced by 97% relative to a traditional 20mW wakeup receiver, and the acoustic portion of the system's overall power (not including release activation) is reduced by over 93%. With a ULP wakeup receiver, energy equivalent to a single alkaline "D" cell battery could power the acoustic functionality of an on-demand acoustic system for approximately 19 months (again not including the release activation) allowing an annual battery service interval and a small pressure housing, reducing costs and improving logistics.

Lessons learned in on-demand gear marking using ultra-short baseline acoustics

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Identifying and accurately locating gear on the seafloor is a priority for the successful adoption of on-demand fishing. Over the past year Teledyne and its partner Sea Mammal Education Learning Technology Society (SMELTS) have been developing and testing an ultra-short baseline (USBL) system based on our commercial Directional Acoustic Transponder (DAT). Our standard acoustic modem can measure range based on the travel time of a ping to a subsea trap and back. The DAT has a tetrahedral hydrophone array that can measure the three-dimensional arrival angle of a ping from a ropeless trap, yielding bearing and elevation from the DAT to the trap. Coupling both capabilities allow the calculation of the final resting position on the seafloor with more accuracy than just using the surface GPS position mark when the trap enters the water. We have learned that the fishers' user interface is critical to successfully marking gear. We have simplified our Track-it software to reduce the number of pages to navigate and selections or buttons to press. Those lessons learned are being used in our engagement with Raymarine on a ropeless interface for their chart plotter. The speed of a trawl

deployment with ropeless traps on each end especially needs attention to transition from the GPS position at the vessel to the final resting spot marked with USBL on the seafloor. The first trap must either have completed the marking process before both losing acoustic range and the point when the last trap leaves the boat, or alternately the system must be capable of marking multiple devices simultaneously. Additionally, most gear has a wakeup period needed to conserve power that must be factored in when deploying and marking traps. All these factors must be considered to successfully implement ultra-short baseline gear marking for on-demand fishing.

SMELTS advancements on seafloor and shipboard technology to eliminate entanglement risks to the critically endangered North Atlantic right whale

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SMELTS has been improving on its patented On-Demand Acoustic Lift-Bag Fishing Gear for crab, lobster and gillnet fixed gear fisheries. SMELTS has made design and material improvements for long ocean survival rates in the fixed gear fisheries as well as standardizing service requirements for SMELTS line free gear after the fishing season ends. SMELTS fishing partners have been invaluable in their evaluation of the SMELTS gear with recommendations where improvements have been needed.

SMELTS will also discuss continued development of fishing vessel systems to acoustically and automatically mark and inventory gear in and out of fisheries. Skipper Scan™ uses Radio Frequency Identification Tags and Scanners to automatically mark and inventory gear in and out of the ocean reporting its location to the EarthRanger app.

Past, present, and future of on-demand gear in the U.S. South Atlantic black sea bass pot fishery

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Snapper-Grouper FMP Regulatory Amendment 16 implemented seasonal closures in 2017 for the Black Sea Bass Trap/Pot Fishery to reduce entanglement risk to North Atlantic right whales. Since 2020, experimental use of on-demand gear has been authorized and trialed for the black sea bass trap/pot fishery. This experimental gear trial has been successful and the feedback from black sea bass fishermen has been positive. By allowing for on-demand gear in the areas currently closed to black sea bass trap pot gear, fishermen will gain access to areas that are closer to shore allowing for more efficient and economical fishing that presents minimal entanglement risk to endangered North Atlantic Right whales. This talk will present the evolution of on-demand gear in the Southeast U.S., updates from on-going efforts, and the next steps needed to make on-demand gear a reality for this fishery.

Contrasting functional differences between acoustic and traditional gear location marking methods

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The reduction of risk from fixed-gear fisheries is one management pillar that supports the recovery of the critically-endangered North Atlantic right whale population. Fixed-gear risk reduction focuses on the remove of persistent rope from the water column in various ways, including on-demand and timed retrieval systems. A critical component to expanding these systems to a fishery scale is the ability to replace the information provided to ocean users from the traditional surface buoy. Alternative gear marking methods include acoustic geolocation, where sound is used to communicate with subsea transponders from

a vessel, and plotting surface deployment locations using some chart- or map-based digital interface. The Maine Department of Marine Resources (DMR) is using Sea Grant American Lobster Program funding to conduct dedicated trials aboard commercial fishing vessels. These trials collect data useful for comparing the operational precision and accuracy of these methods. The collected data are also crucial for SUNY-Stony Brook researchers to model potential viability at different gear densities observed within the Gulf of Maine. Describing marking method functional differences through descriptive statistics and using spatial modeling to identify optimal gear implementation scenarios are steps that will inform any management approaches that facilitate the transition to using innovative and risk-reducing fishing technologies. This presentation will describe the experimental approach to collecting gear location data and summarize results to date. It will also summarize the progress made on developing gear density models that will be used in concert with the field data to evaluate the feasibility of technology under various gear densities.

The Vision for an Integrated Fishing and Marine Mammal Monitoring and Protection System (IFMAPS)

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IFMAPS recognizes that no one sensor modality is adequate for detecting and tracking a marine mammal. IFMAPS also recognizes that ocean modeling driven by large amounts of ocean data is required to optimize systems that operate in the ocean, and that the fisherman are an under-utilized asset in the quest to collect this data. IFMAPS is being presented here because the need to reduce entanglement risk and develop ropeless fishing systems present the opportunity to develop IFMAPS.

The IFMAPS vision can guide us as to an optimal, long-term, total-system design for a ropeless fixed-gear fishing system because it considers what is best for all current and future uses of our coastal ocean resource, including fishing, renewable energy, shipping, recreation/tourism, and related scientific studies. Implementation of IFMAPS requires implementation of fixed-gear fishing with no endlines. IFMAPS leverages both the need to sensorize the fishing fleet for gear marking and retrieval as well as the required collaborative effort needed for success, to ensure we add scientific sensors and build related monitoring systems in the most meaningful way. Thus, transitioning to "ropeless" fishing is a necessary first step in IFMAPS. The vision is based on the authors' combined experiences in developing distributed sonar systems for the U.S. Navy to detect and track marine mammals, divers, and underwater drones and career experiences in marine mammal and fisheries conservation. The IFMAPS design and justification is a direct extension of the Integrated Marine Mammal Monitoring and Protection System (IMAPS) development program conducted by the U. S. Navy circa 2002-2009.

An update on CanFISH: Lending on-demand gear to allow fishing in closures in Atlantic Canada

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In 2022 the CanFISH Gear Lending Program was established to facilitate the trial of on-demand (ropeless) fishing gear in commercial fisheries in Atlantic Canada. The program removes barriers to using on-demand gear by providing gear access, training, and experimental permits to commercial fish harvesters, allowing them to fish in areas closed to protect North Atlantic right whales. In the first year of the program ten harvesters in the Southern Gulf of St. Lawrence (Crab Fishing Area; CFA 12) landed more than 340,000 lbs of snow crab for commercial sale using on-demand gear from CanFISH. In 2023, a NARW closure impacted the CFA 19 snow crab fishery for the first time, closing more than 60% of the fishing grounds. Multiple requests were made to the lending program, and on-demand gear was fished in this closure. Additionally, closures impacted multiple lobster fishing grounds in the sGSL initiating collaboration between fisheries associations and CanFISH to coordinate fishing with on-demand gear in those areas. A closure impacting Lobster

Fishing Area 25 with a season from August 9th to October 10th is expected to initiate on-demand gear use this Fall. We will provide an update on all use of on-demand gear and plans for the future of CanFISH.

Real-time acoustic gear location solves gear conflict for all

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Many different systems for deploying and recovering trap/pot gear to and from the seafloor have been proven over the last several years. However, none of them resolve the primary obstacle to fishery-wide implementation - namely "Gear Conflict". To resolve gear conflict, almost all efforts have been focused on utilizing "GPS-based Gear Location Marking" with its associated cloud-based data management software, while simultaneously stating that the best and most robust solution would be a real-time acoustic location system. Ropeless Systems has designed, built, and tested such a system. It is the hands-free, chart plotter integrated, in-situ "Real-time Acoustic Gear Location" system found in the latest version of Ropeless RISER™. The complete solution to Gear Conflict is available now. There is no debate that adoption of ropeless fishing for all fixed-gear fisheries employing endlines and surface buoys requires that ALL fishing vessels know the seafloor location of ALL gear in an accurate and timely manner. As a result of this requirement, it is agreed that all fishing vessels must have NEW TECHNOLOGY installed. The choice of this new equipment is binary: either install ship-to-shore communications with a shore-side database to allow "GPS Gear Location Marking" or install an acoustic system for in-situ "Real-time Acoustic Gear Location". Each of these methods will be examined and the differences explained. It will be shown how the challenges to "GPS Gear Location Marking" are overcome by in-situ "Real-time Acoustic Gear Location". Examples of field operations employing acoustic localization with fixed and mobile gear vessels operating in close proximity will be demonstrated. Strategies for accelerated fielding and adoption will be discussed.