

## Gear Innovations Testing and Validation in the Commercial Dungeness Crab Fishery

### *Scientific Project Design*

#### BACKGROUND

The National Marine Sanctuary Foundation (Foundation) is supporting the development of cooperative research to reduce the risk of whale and other marine life entanglements in California fishing gear. Since 2013, there has been a large increase in the number of confirmed whale entanglements reported along the U.S. West Coast,<sup>1</sup> with the majority reported from California. Though about half of entanglements cannot be identified to a specific source, the most common identified source has been commercial Dungeness crab gear. The Foundation proposes to work with fishermen, resource managers, researchers and other stakeholders to test gear innovations and modifications in the California commercial Dungeness crab fishery and facilitate meaningful partnerships to advance solutions.

Marine scientists and engineers have developed innovative fishing gear technologies and modifications that could remove or reduce entanglement risks to marine life while allowing continued fishing activity. California Dungeness crab fishermen have already reviewed and conducted initial trials with some systems. In May 2018, Oceana partnered with fishermen and two gear innovators to conduct initial tests of pop-up fishing gears. In March 2019, California Department of Fish and Wildlife (CDFW) hosted a roundtable discussion with gear innovators, fishermen, and nonprofit organizations to discuss the potential for gear modifications and innovations to reduce marine life entanglement risk in the Dungeness crab fishery. In September 2019, CDFW hosted a gear demonstration day, in partnership with the Foundation and Monterey Bay National Marine Sanctuary (MBNMS), to bring together gear innovators, fishermen, nonprofits, and fishery and resource managers to collaboratively address whale and sea turtle entanglements through technology and gear innovations by demonstrating and/or learning about different gear types that may help reduce the risk of marine life entanglements in Dungeness crab fishing gear.

The pop-up systems trialed to date have predominantly been acoustically released on-demand configurations, and some of these units have backup release capability. There have also been evaluations of systems with programmable time/date releases, such as galvanic timed release devices. Following the initial evaluation of gears at the September 2019 demonstration day, in-water testing conducted under a rigorous scientific project design is needed to provide a comprehensive evaluation and comparison of multiple gear innovation systems based on the CDFW/California Dungeness Crab Fishing Gear Working Group guidelines for pop-up testing, specifically the reliability and retrievability of the gear. (It is acknowledged that, to date, a gear tracking system that allows all mariners to know where buoyless gear is located on the bottom is still under development, but the performance of the gear can currently be tested.) Specific guidelines proposed for testing effectiveness of these gear innovations are as follows:

- **Enforceable:** including means by which CDFW Law Enforcement Division (LED) can find and retrieve the gear at sea; to ensure fishermen are fishing within their trap limit allotment, are not fishing in Marine Protected Areas or other restricted areas, etc. Lost and abandoned gear should be easily traced to encourage responsible ownership and allow for enforcement actions.
  - **Detectable:** detectability by CDFW including CDFW LED, fishermen and public, including description of how location of gear is available visually or virtually;

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<sup>1</sup> Confirmed entanglements the last few years were lower than historic highs of 2015 (n=49) and 2016 (n=48) but are still high compared to pre-2014 levels when the average was less than 10 confirmed entanglements per year.

- **Economical:** The cost to obtain the new gear innovation needs to be practical relative to the economics of the fishery. In addition, there is an average loss rate which adds additional annual costs for new gear. Conversely, some gear innovations may reduce gear loss relative to current operations. Gear innovation must consider how to reduce loss rates and/or keep additional costs to a minimum. Gear innovation may test ways to reconfigure gear to reduce costs.
- **Fishable:** Gear innovation must be configured and deployed in a manner compatible with the operation of the fleet, for both small and large boat operations. Deployment and retrieval must be practical, simple, and efficient with time. In addition, the location of the gear must be easily identified by other fishermen in the vicinity; it is an added bonus if gear design prevents theft.
  - **Retrievable:** means of retrieval, including a release mechanism/equipment to deploy and/or retrieve gear, mechanism to address equipment malfunction, safeguards to prevent gear loss;
  - **Ability to Identify:** means of gear identification, including a mechanism to identify gear to fishermen both remotely when submerged and at the surface;
- **Reliable:** The gear must have demonstrated a low failure rate in varied ocean conditions (i.e., gear was consistently and successfully deployed and retrieved) and must have a functioning prototype. Projects should consider testing gear to determine failure rates of actual equipment in varied ocean conditions.
- **Safe:** The gear must be proven to be safe for use in rough ocean conditions being mindful of the fishing vessel capabilities operating the gear.
- **Minimize adverse impacts to marine life:** Gear innovation must minimize potential negative impacts to whales, sea turtles, or other species of concern, including the potential for acoustic release mechanisms to emit sounds that may disrupt the behavior or injure marine life, especially when the gear is in high concentrations.
  - **Benefit:** evidence gear reduces risk or severity of entanglement.

Discussions at the Whale Entanglement Forensic Workshop convened by the Pacific States Marine Fisheries Commission (PSMFC) and NOAA Fisheries in August 2018, revealed interest in low-tech gear innovations, especially the Novabraid “South Shore” sleeves developed and pioneered on the East Coast by the Massachusetts-based South Shore Lobster Fishermen’s Association. After discussions with the developers of the sleeve design and the fishermen using them on the East Coast, three West Coast fishermen tested them on their lines (two fishermen used a sleeve in the upper shot of the line, the third applied sleeves throughout the line) and reported that the sleeves could be fished without slowing or interfering with existing fishing practices. Washington fishermen also tested sleeves, although some were reported broken (as designed) when the hauling forces exerted on ropes to free pots that became stuck in mud exceeded the designed breaking strength.<sup>2</sup>

Low-tech gear simulations and testing on the East Coast by *Knowlton et al.* has shown that the length of a time that a whale is entangled can be reduced by having a sleeve in the line if there is sufficient weight on the line from the traps and/or if the whale is swimming fast enough.<sup>3</sup> Another paper by *Knowlton et al.*<sup>4</sup> noted: “Our results suggest that broad adoption of ropes with breaking strengths of 7.56 kN (1700 lbf) could reduce the number of life-threatening entanglements for large whales by at least 72%, and yet could provide sufficient strength to withstand the routine forces involved in many fishing operations. A reduction of this magnitude would achieve

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<sup>2</sup> PSMFC 2020. [Testing of Yale Grip Sleeves by West Coast Fishermen.](#)

<sup>3</sup> Knowlton et al. 2018. Development and Evaluation of Reduced Breaking Strength Rope to Reduce Large Whale Entanglement Severity. Final report to the Executive Office of Energy and Environmental Affairs, Boston, MA.

<sup>4</sup> Knowlton et al. 2016. Effects of fishing rope strength on the severity of large whale entanglements *Conservation Biology*, Volume 30, No. 2, 318–328.

nearly all the mitigation legally required for U.S. stocks of North Atlantic right and humpback whales.” They recommend that ropes with reduced breaking strength be developed and tested to determine the feasibility of their use in a variety of fisheries.

In recent discussions, it was noted that the modeled breaks occur when weak points of line are below the entanglement. Therefore, except in shallow waters where one sleeve can be integrated into the line within the top 10 fathoms, sleeves will likely need to be added at multiple points along the line; about every 40 feet (7 fathoms) as deep on the line as practical. Consequently, fishing with sleeves may require fishermen to modify their procedures (hauling speed, winch pressure, angle of pull, etc.) to make this innovation work in deeper water and/or more challenging conditions.

### **PROJECT OBJECTIVE**

The project objective is to systematically test the deployment and retrieval of gear innovation systems based on a robust scientific project design in realistic commercial fishing conditions over an extended period in partnership with California commercial Dungeness crab fishermen.

Gear types included in the testing and scientific project design are based on California Dungeness Crab Fishing Gear’s Working Group’s Recommendations Memo (November 2019)<sup>5</sup> and vary in cost and complexity for integrating them into fishing practices.

This project will allow for comparison of multiple pop-up systems and test integration of these systems with different fishing operations (e.g. small and large vessel sizes) based on identified criteria/data collection questions, with a focus on reliability of the retrieval mechanism. Testing will occur during a subset of the open California commercial Dungeness crab fishing season with mandatory use of a “tag” or backup line.<sup>6</sup>

The project will also support the testing of a low-tech breakaway rope design (i.e., Novabraid “South Shore” sleeves). Specifically, sleeved rope testing will examine 1) if fishermen can haul sleeved lines under normal operations and 2) identify what operational changes (e.g., hauling speed) would be needed to support the use of sleeves and the implications of those changes.<sup>7</sup>

This project’s testing will focus on answering the following guiding questions:

*For both pop-up and low-tech gear testing:*

1. Can fishermen deploy and retrieve gear using their existing set up (e.g., standard traps, hydraulics, etc.) or with minor modifications?
2. Is gear retrieval reliable in a variety of sea conditions and depths (i.e. out of 100 deployments, what % of retrievals are successful, excluding retrieval failures caused by a backup line)?

*For low-tech gear testing only:*

3. How long does the sleeve last before it begins to show signs of fatigue and/or fails?

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<sup>5</sup> California Dungeness Crab Fishing Gear Working Group’s Recommendations Memo ([November 2019](#))

<sup>6</sup> A backup fishing line on any pop-up fishing system to facilitate enforceability, detection and ability to identify the gear when submerged so as to minimize unintended impacts when testing and ensure compliance with state regulations for legal commercial Dungeness crab gear.

<sup>7</sup> Low-tech gear testing is also supported by funds and information provided by the Pacific States Marine Fisheries Commission.

## **GEAR INNOVATION TESTING**

The project will trial a number of pop-up systems (listed below) which represent a cross-section of available technologies. Selection of gear innovations to be tested was informed by a range of recommendations and considerations including: the California Dungeness Crab Fishing Gear Working Group's Recommendations Memo (November 2019), engagement in the September 2019 Gear Demo Day hosted by the CDFW in partnership with the Foundation and MBNMS, the availability of manufactured prototypes, whether the gear type has been previously tested in California, if the gear is being tested on the East Coast or in Canada, as well as available budget and project management capacity constraints. Additional gear may be added to the trials as they are identified and evaluated.

The Foundation will purchase and/or rent the pop-up systems and the sleeved and control ropes and coordinate their distribution to fishermen participants. The following gear types will be tested:

- [Longsoaker](#) Ropeless Gear Retrofit (galvanic timed release pop-up buoy)
- [Desert Star Systems](#) ARC-1 (on-demand acoustic pop-up buoy)
- [Fiomarine](#) F-Series Fiobuoy (on-demand acoustic pop-up buoy)
- [Edgetech](#) 5112 (on-demand acoustic pop-up buoy)
- [Novabraid](#) SSL 2.0 Breakaway Link (i.e., South Shore sleeves)

## **COOPERATIVE RESEARCH**

### *Commercial Fishermen Engagement*

The participation and collaboration of fishermen is essential to the testing and development of gear innovations and modifications. The Foundation will work cooperatively with commercial fishermen who can provide the expertise and feedback on the usability and reliability of experimental gears in realistic fishing conditions. Fishermen will receive a stipend contingent on meeting agreed-upon testing and data reporting requirements. A written agreement will outline the terms of the collaboration, including the amount of stipend and instructions on how to invoice for payment.

### *Training*

The Foundation will host multiple training sessions with participating fishermen to outline the project's goals, testing procedures, data collection tools and reporting. The training for pop-up gear testing will include up to two days of at-sea training for each system tested (4 days total). As part of the training, fishermen will be provided with individual pop-up units, associated deck units and gear tracking software.

Fishermen testing sleeved ropes will also receive training on the project's goals, testing procedures, data collection and reporting. Fishermen will be provided with pre-assembled sleeved rope and control rope to ensure consistency for the testing. Additional guidance and support will be provided to all participants throughout the project, as needed. Virtual training and/or smaller meetings will be considered if restrictions from COVID-19 present challenges to in-person gatherings.

### Gear Testing

Testing will be conducted during the 2021-22 commercial Dungeness crab season.<sup>8</sup> The participants and geographic area for the testing will be determined in coordination with the Foundation's Gear Innovations Manager, CDFW, OPC, PSMFC and NOAA partners (key partners). All pop-up systems will have a traditional buoy line to provide a backup in case of retrieval failure, to facilitate safe testing, and to meet state requirements for legal commercial fishing activity. All testing (pop-up and low-tech) will include a set of controls, i.e. traditional traps, that will be deployed/retrieved in conjunction with experimental gear deployments/retrievals.

### Data Management and Analysis

The Foundation will oversee data collection, input, security, and analysis during and after each trial by fishermen. The Foundation will collaborate with key partners in data collection and analysis as well as coordinate with East Coast gear innovation partners to consider consistencies with related efforts. CDFW Marine Region, OPC, and Foundation staff may ride along to observe and/or participate in data collection during deployments and retrievals.

The goal is for participants to collect a standardized set of data on each splash (deployment/retrieval cycle) based on the CDFW/Working Group guidelines and questions developed by the Foundation's Gear Innovations Manager in collaboration with key partners. Data collected will include date, time and location of deployments and retrievals, retrieval success or failure, factors thought to affect gear performance (e.g. hauling speed, equipment malfunction, presence of the safety line fouling the pop-up gear, etc.) and environmental variables such as sea state, depth, current, wind and substrate type.

Subject to agreement, vessels will be equipped with video camera systems to document testing operations and provide a secondary source of data for analysis. Fishermen will be requested to provide a thorough evaluation of each system (pop-up and low-tech) at the conclusion of testing. The Foundation will coordinate with fishermen on the submission of data and analyze the results. Updates and quarterly reports on project progress and milestones and final project reports with data summary will be made publicly available on OPC's website and a dedicated page on the Foundation's website.

## **SCIENTIFIC PROJECT DESIGN**

The Foundation has worked in coordination with key partners to develop a scientific project design to test and evaluate pop-up and low-tech gears. Review and feedback was also provided by members of the California Dungeness Crab Fishing Gear Working Group and external science partners to help refine and finalize the scientific project.

### Pop-up Gear Testing

Each participant will test two pop-up gear systems (one at a time) with the flexibility to choose their specific testing period during the open fishing season. The target testing window is November 2021 to May 2022, however the exact start and end dates will depend on when gear is acquired and training completed, as well as the end of the commercial Dungeness crab season in each management area. Participants will be requested to deploy up to 10 units of each gear, obtaining up to 160 splashes across both gear types (8 splashes per unit). Near the location (i.e., similar depths, bottom topography and sediment types, and within 1 km) of every experimental pop-up unit, participants will also deploy a control pot (i.e., traditional pot), making an experimental-control pair. Below

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<sup>8</sup> The commercial Dungeness crab season in the Central Management Area is scheduled to open on November 15 and end June 30, and the Northern Management Area is scheduled to open December 1 and end July 15. However, the exact timing of the season may be adjusted due to crab quality, human health concerns, and marine life entanglement risk.

outlines the project parameters: number of fishermen, number of fishermen testing each gear type, number of individual units tested, and total number of replicates (splashes) per gear type (across all fishermen).

Timeframe of testing	Units of each gear per fisherman	Number of fishermen participating	Number of fishermen testing each gear	Total # of splashes per gear type
Flexible	Up to 10	5	2	Up to 160

*Testing Requirements/Conditions:*

- Participants will test one pop-up system at a time (i.e., complete testing of one design before proceeding to the next).
- Participants agree to test two pop-up systems during the commercial Dungeness crab season (target testing window November 2021-May 2022).
- Participants may choose how long to spread out their testing for each gear type as long as a minimum of 8 splashes per unit are recorded for each pop-up system they test.
- Participants agree to deploy a control pot (i.e., traditional pot) in the same general area (i.e., similar depths, bottom topography and sediment types) of every experimental pot (i.e., pop-up pot).
- Participants agree to record detailed information on all experimental-control pairs using provided data log sheets.
- Gear must be deployed for a minimum of 48 hours prior to retrieval, and fishermen must adhere to the 96-hour service interval required by *Section 9004, California Fish and Game Code*.
- Gear will not be rotated between fishermen during their specified trial periods.
- All gear types will be assigned to fishermen and managed by the Foundation's Gear Innovations Manager to ensure consistency in testing.
- Participants agree not to change or modify the test gear equipment and retrieval systems unless approved by the Foundation's Gear Innovations Manager.

**Low-Tech Gear Testing**

Participants will test experimental sleeved rope with the flexibility to choose their specific testing period during the open fishing season. The target testing window is November 2021 to May 2022, however the exact start and end dates will depend on when gear is acquired and training completed, as well as the end of the commercial Dungeness crab season in each management area. Each participating fisherman will be requested to test sleeves on 15 pots, obtaining a total of 240 deployment/retrieval cycles (16 cycles per experimental line). Near the location (i.e., similar depths, bottom topography and sediment types, and within 1 km) of every experimental pot, participants will also deploy a control pot (with no sleeves), making an experimental-control pair. Each line will be labeled with a unique ID number to facilitate data collection and analysis. All experimental and control lines used for field testing will be provided to fishermen. All gear deployments and retrievals and other fishing procedures will be carried out as normal. Below outlines the project parameters: number of fishermen, number of pots rigged/percent of gear rigged, number of sleeves per pot, and total number of replicates (deployment/retrieval cycles per trap) across all fishermen.

Timeframe of testing	Number of pots	Deployment/retrieval cycles per pot	Number of fishermen participating	Number of sleeves per pot	Total number of deployment/retrieval cycles
Flexible	15 pots	16	Up to 10	Max. 13 sleeves per pot	2,400

Field observations and data will be recorded by fishermen using data log sheets. Photos of any sleeve wear and tear or breakage will also be recorded. In the event of a break, painted sleeves will be provided to indicate that they are replacements. In addition, experimental sleeved lines will be collected and visually inspected for abrasion and damage following testing by each participant. After visual inspection, all lines will be returned to fishermen, if desired. At-sea testing and data collection instructions will be provided to participants based on the procedures described in *Knowlton et al. 2018*.

### Rigging and Placement

One sleeve will be placed every 7 fathoms throughout the main line and on shots provided to accommodate deeper fishing depths. The sleeve design is achieved by inserting each end of the line 1½ feet into the sleeve with the line tucked into the sleeve at least three times to hold it. This will help ensure the rope will not pull out from the sleeves during hauling. Additional reinforcement such as electrical tape or hog rings will not be utilized during this project, though this will be considered when designing future projects.

Experimental sleeved rope will be assembled in 600-foot lengths that may be shortened (by removing sleeves) if testing will be conducted in shallower depths. Specific [written instructions](#) and a video tutorial on sleeve assembly will be provided to professional rope splicers and fishermen participating in testing. Assembly of experimental rope will be done by the same entity. This will keep rigging more consistent and reduce time and effort required of fishermen participants. To incentivize participation, fishermen will be able to keep the rope and sleeves provided by the project at the conclusion of testing.

### Testing Requirements/Conditions:

- Participants agree to test sleeves during the commercial Dungeness crab season (target testing window November 2021-May 2022).
- Participants agree to test sleeves on at least 15 pots and achieve a minimum of 240 deployment/retrieval cycles (16 cycles per sleeved line).
- Participants agree to deploy a control pot (with no sleeves) in the same general area (i.e., similar depths, bottom topography and sediment types) of every experimental pot (with sleeves).
- Participants agree to record detailed information on all experimental-control pairs using provided data log sheets.
- Fishermen must adhere to the 96-hour service interval required by *Section 9004, California Fish and Game Code*.
- Gear will not be rotated between fishermen during their specified trial periods.
- All gear types will be assigned to fishermen and managed by the Foundation's Gear Innovations Manager to ensure consistency in testing.
- Participants agree not to change or modify the test gear equipment and retrieval systems unless approved by the Foundation's Gear Innovations Manager.