At-Sea Trials of Sub Sea Sonics Timed Release Pop-up Fishing Gear in Central California Crab Fisheries: September – December 2021

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Introduction

Whale and sea turtle entanglements in fishing gear off the coast of California, USA have dramatically increased since 2014[1]. Vertical lines from conventional fixed fishing gear (e.g., pots, traps, bottom longlines, set gillnets) pose serious threats to endangered species populations by creating hazardous conditions along migration routes.

Pop-up Gear Overview

Pop-up gear technology reduces or eliminates the presence of vertical lines and buoys during fishing operations except while retrieving the gear.[2] Rather than a vertical line connecting a trap on the seafloor to a buoy at the surface, pop-up gear stores the line and buoy with the trap until fishermen are ready to retrieve the gear. Pop-up gear systems include three different components: the release trigger, release mechanism, and the surface gear management system (See Appendix 1). In addition, Virtual Gear Marking is used to record the location of the pop-up gear when deployed.

The ***release trigger*** refers to how a user activates the gear to float to the surface and can either be timed-release or on-demand release. Timed-release systems are preprogrammed by fishermen to release the buoy after a certain amount of time. On-demand release requires fishermen to send an acoustic signal to the gear using a transducer, which is a device that creates a pattern of sound underwater.

Once the unit is triggered, the ***release mechanism*** releases the line and buoy to float to the surface. Some systems include a motorized release mechanism that holds the gear in place and either rotates or opens to release the line and buoy. Other systems may include sending an electric current that disintegrates a wire holding a buoy in place. A Galvanic Time Release device is a piece of metal that disintegrates over a specific known period of time that can range from hours to days. Once disintegrated, the line and buoy are released.

[1] Saez, L., D. Lawson, and M. DeAngelis. 2021. Large whale entanglements off the U.S. West Coast, from 1982-2017. NOAA Tech. Memo. NMFS-OPR-63A, 50 p.
[2] Lebon, K.M. and R.P. Kelly. 2019. "Evaluating alternatives to reduce whale entanglements in commercial Dungeness Crab fishing gear," Global Ecology and Conservation 18:e00608

Lastly, the ***surface gear management system*** refers to the approach for storing and unraveling the line and buoy. This includes placing a coiled line and buoy on top of a trap, wrapping the line around a floating spool, or containing the line and buoy within a mesh bag. Some systems remove the need for a vertical line and instead utilize a lift bag retrieval system that inflates and floats the entire trap to the surface for retrieval.

Virtual Gear Marking (VGM) is a method of recording the location and other pertinent information about the pop-up gear through an app or computer. VGM allows enforcement and management agencies, fishermen, and other ocean users to know where pop-up gear is located without the need for a surface marker buoy. When a unit of pop-up gear is dropped in the water, either by a fisherman or an enforcement official, the location and any other necessary information will be recorded in the app.

Pop-up Gear Testing in Context

Fishermen, research entities, government agencies and NGOs have been working on pop-up gear technology for more than 20 years.[3] Currently, no jurisdictions in the United States allow the use of pop-up gear for commercial fishing; however, the federal National Marine Fisheries Service has issued Exempted Fishing Permits on the U.S. Atlantic Coast that allow for fishing that would otherwise be prohibited such as with the black sea bass pot pilot project.[4] Fishermen have also initiated projects on the East Coast in the American lobster fishery and on the West Coast in the Dungeness crab fishery.

Pop-up Gear in the California Dungeness Crab Fishery

Recent regulations to prevent whale and sea turtle entanglements off the coast of California have resulted in time-area closures that have shortened the commercial Dungeness crab fishing season. While the closures reduced entanglements, they also impacted fishery participants by delaying the start of the season and ending the season early. Authorization of pop-up gear as alternative gear under California's Risk Assessment and Mitigation Program (RAMP) regulations offer a means to continue fishing when whale or sea turtle entanglement risk is elevated.[5] To authorize the use of pop-up fishing gear, the State of California regulations require criteria be met for detectability, retrievability, ability to identify the gear owner, benefit to wildlife, and enforceability.

This report summarizes pop-up gear reliability trials conducted between September and December 2021 aimed at meeting the criteria included within the RAMP regulations. Based on feedback from commercial fishermen, we selected Sub Sea Sonics TR4RT timed-release pop-up

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[3] DeAlteris, J. 1999. "Design, testing, and evaluation of an acoustic release system for offshore lobster buoy lines," Final Report to NMFS Fisheries Engineering Group, Kingston, RI Project No. 40EANF800065 1-17. https://sustainableseasdotblog.files.wordpress.com/2020/01/dealteris_1999.pdf

[4] "Black Sea Bass Pot Pilot Project Exempted Fishing Permit Application," NOAA Fisheries, May 3, 2021, https://www.fisheries.noaa.gov/southeast/black-sea-bass-pot-pilot-project-exempted-fishing-permit-application

[5] Risk Assessment Mitigation Program: Commercial Dungeness Crab Fishery, Title 14, California Code of Regulations 132.8 (2020). Pgs. 1-9.

gear because it is relatively simple, it is lower cost, and the system technology is functional and reliable. The overall research questions associated with the trials include:

- What is the reliability of the gear over the expected range of depths and environmental conditions of the fishery?
- What supporting virtual gear marking and data accessibility are required to allow for effective tracking of deployed gear location and estimated pop-up time?
- What is the relative risk reduction for entanglement when using timed-released pop-up gear?

The goal of the experimental trials is to help establish a pathway for the authorization of alternative gear in California so that fishermen can voluntarily use pop-up gear during periods of elevated entanglement risk, when the fishery would otherwise be closed to conventional vertical line gear. Additional objectives include advancing the use and management of pop-up gear and identifying topics for future research, development, and testing.

Methods

We worked with a commercial Dungeness crab permit holder who conducted at-sea trials using the Sub Sea Sonic TR4RT Ropeless Trap Timer system with Dungeness crab traps out of Santa Cruz Harbor. We coordinated with the California Department of Fish and Wildlife (CDFW) Marine Region and Law Enforcement Division staff during all phases of testing to assure that gear was properly marked, backup buoys were in place, and traps were properly configured (see Figure 1). We conducted an initial phase of testing from September through October 2021 in the commercial rock crab fishery using Dungeness crab traps. We conducted a second phase of testing in December 2021 in the commercial Dungeness crab fishery using the same traps and configuration. We conducted the trials during the regular open season for each fishery and used conventional vertical lines with buoys as a backup in case the pop-up system failed. Because of the backup buoy, Experimental Fishing Permits were not required. For the trials, five to ten traps at a time were fitted with TR4RT release units and line handling systems. During each deployment, the gear was marked on the surface with a backup line and float and was also marked virtually using the Trap Timer app. Data collected for each trial included:

- Environmental data for the set and retrieval of the gear: current (knots), wind speed (knots) and direction, wave height (ft), air temperature (°F), depth (ft), and bottom substrate
- Coordinates for location of gear deployment
- Deployment time, release delay, pop-up time, and retrieval time
- Success with descriptions of any failures

Sub Sea Sonic TR4RT Ropeless Trap Timer

This pop-up system integrates the TR4RT Trap Timer timed release unit, the surface gear management system, and virtual gear marking (Figure 1). The concept of operation is that the pop-up system is deployed including the trap, the pre-programmed timed-release mechanism, and the line and float (Figure 2). The timed-release mechanism is preprogrammed so that the

buoy will pop up just before the fisherman plans to return, thus minimizing exposure and risk for entanglement of nearby whales.

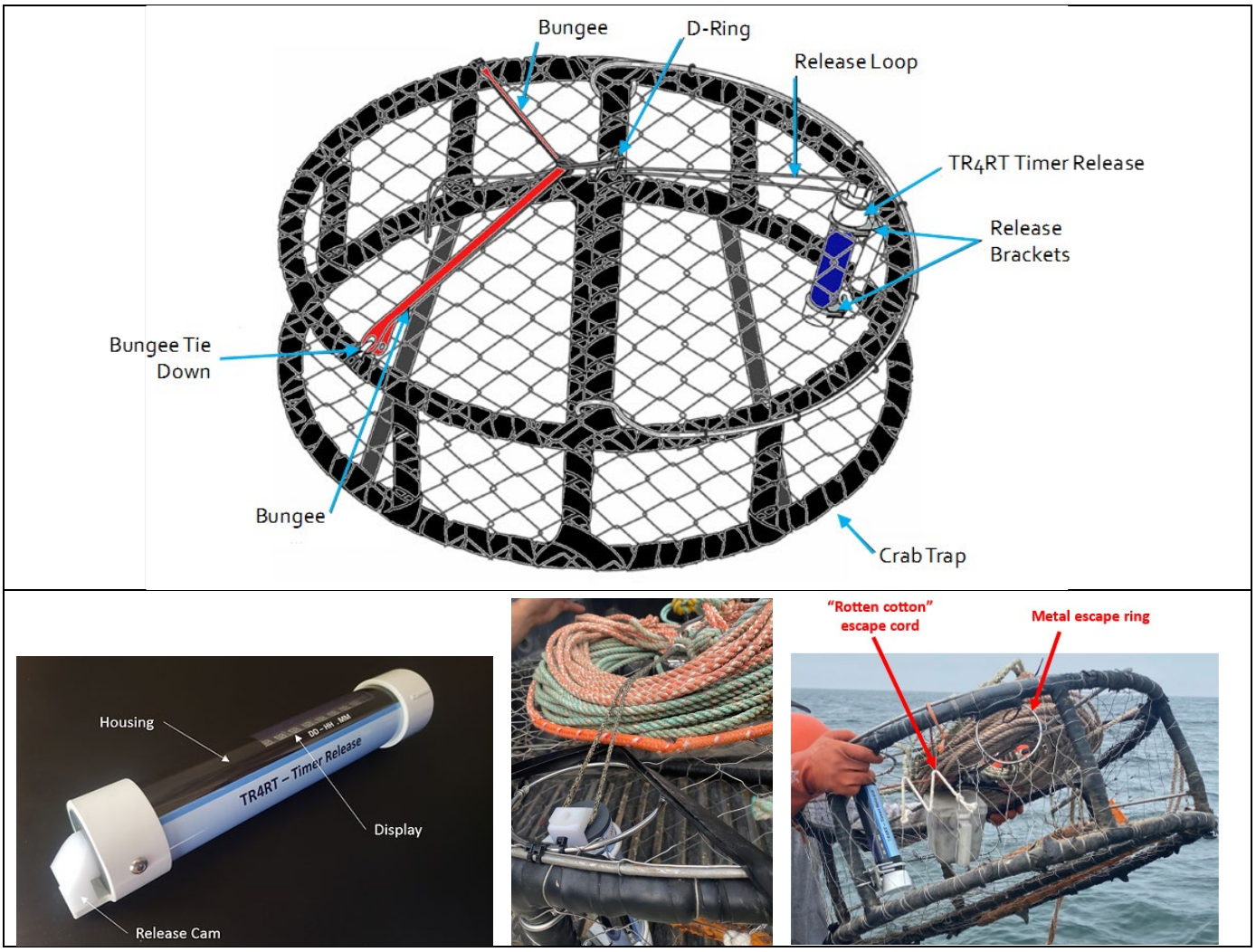


Figure 1. Top: Configuration of TR4RT unit installed on a Dungeness crab trap. Bottom left: TR4RT unis showing timer display, housing cylinder, and release cam that rotates 180 degrees to free the release loop when triggered. Bottom center: TR4RT installed on a Dungeness crab trap and ready to deploy with release loop securing the line coil in place attached to release cam. Bottom right: Configuration of "Rotten cotton" escape cord and metal escape ring used in trials to comply with commercial rock crab and Dungeness crab fishing gear regulations, allowing for crab to escape in the event of trap loss.

At the time of deployment, the real-time virtual gear marking system is used to mark the location of the trap and transmit that location to a database that houses all of the regional trap locations and other meta-data. The virtual gear marking system is also used to display the locations of other nearby traps so that interference or gear conflicts among trap locations can be avoided, and enforcement officers can detect and identify the gear. When the fisherman returns, the float is at the surface for retrieval. The trap is then recovered using existing

equipment (i.e., hydraulic hauler) that is used to recover conventional gear. The TR4RT may be re-set with the recoiled rope and buoys and the trap may be re-deployed following the sequence described above. The current market price is $200-$300 for each unit. Details of the specific sub-systems are provided below.

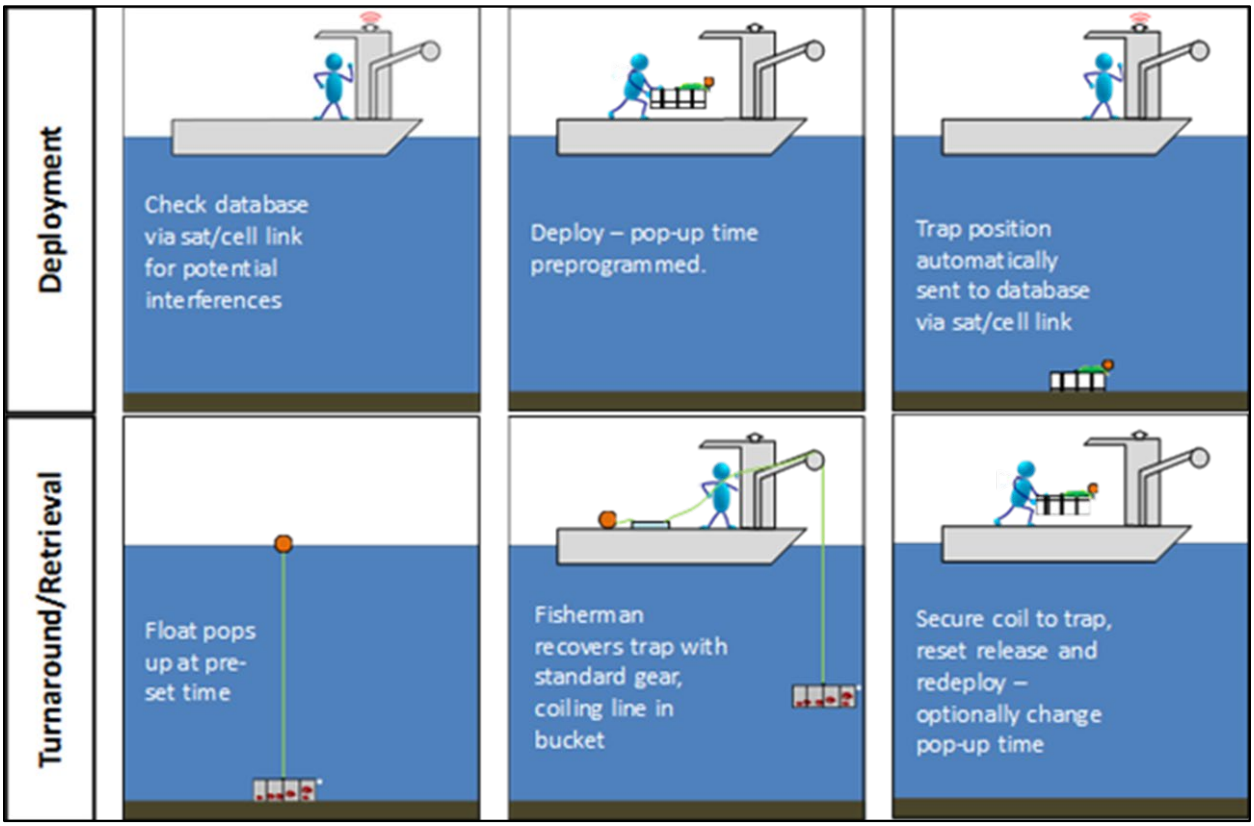


Figure 2. Concept of operations for the TR4RT Trap Timer ropeless fishing system.

Virtual Gear Marking Ropeless Trap Regulatory Dashboard – Sub Sea Sonic Trap Tracker App

California alternative gear regulations require the ability to detect and identify all deployed ropeless gear units to regulate and enforce the use of traps while preventing gear conflicts. The TR4RT system is supported by a tablet/cell-based app, a website, and a database to provide this capability. The app (Trap Timer) has versions that can be used onboard fishing boats, enforcement vessels, and public vessels. The website is setup primarily for regulatory use. Access to the app is provided through an onboarding website that requires administrative approval by Sub Sea Sonics. Administrative approval includes verification of the user identity and role (fisherman, enforcement, public). Once the user is verified, the user is established in the database, and a private link to download the app from the app store is provided. For regulatory personnel, this process also provides access to the website. The app is free and available to the public via iOS and Android operating systems. The Ropeless Trap Regulatory VGM app can be paired with any pop-up system. It allows users to indicate if a trap has been released or retrieved and includes the ability to set a release delay that it then tracks. The app records the coordinates of each individual gear that was deployed, the pop-up delay and

surface time, and the time and date of when the gear was retrieved. The app interface includes two viewing/interface options: the list view is a list in chronological order starting with the gear currently deployed, and the map view includes a real time map of where the gear is located and the time remaining in the release delay.

Results

Overview of Trial Results

We conducted a total of 130 trials during the two testing phases. Of these, 124 were successful yielding an overall success rate of 95%, exceeding the regulatory criteria of 90%. Successful trials required that a complete deployment and recovery cycle of the pop-up system be achieved without any intervention using the backup float, grappling or any other means to assist in the gear recovery. All trials were conducted in Zone 4 which extends along the California coast from latitude 36° 0'N to 37° 11'N. Testing occurred off Santa Cruz, California in Monterey Bay.

Gear Loss and Reliability Testing

We did not lose any equipment or gear during the trials. We therefore deemed a trial successful if the pop-up buoy surfaced when and where it was expected, and the gear was retrieved solely via the pop-up line and buoy. We categorized a trial as failed if the pop-up line and buoy did not surface after the expected release delay and/or if the back-up buoy was used during retrieval.

Of the six failures that occurred, two were characterized as a mechanical issue, caused by a loose battery in one of the units. Sub Sea Sonics corrected this issue and made modifications to prevent future mechanical issues.

Line tangles were the cause of three failures. We were able to confirm the unit had released properly but the rope did not fully uncoil, thus preventing the buoy from reaching the surface. We characterized this as a rope coil issue. In response, the fisherman made modifications to the rope coiling procedure, specifically by coiling the rope inside a bin with a cone in the center and ensuring the line was consistently secured before deployment. We could not determine the cause of the other failure and it was deemed unknown.

Release Delays and Depths

We tested a variety of release delay periods during the trials, ranging from 30 minutes to 42 hours (Figure 3). Depths during the trials ranged from 55 – 190 feet (ft.) (17-58 m), with most of the trials conducted between 55 – 75 ft (Figure 4). Success rates did not appear to vary based on release delay or depths fished.

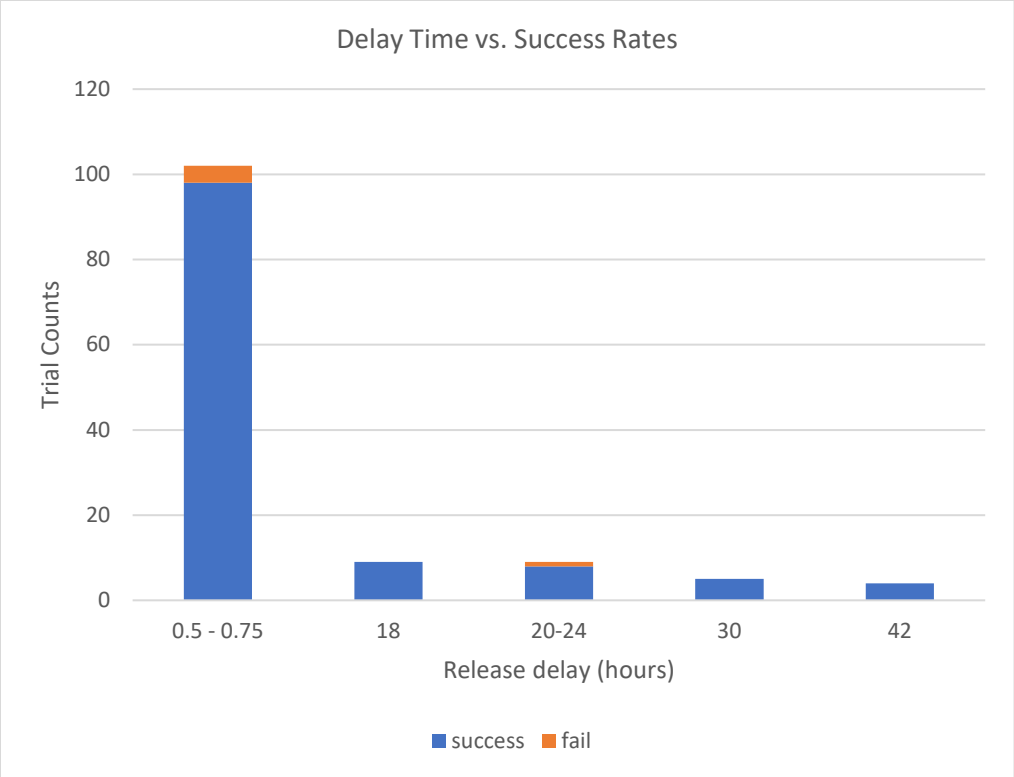


Figure 3. Delay time and success rates for the reliability trials.

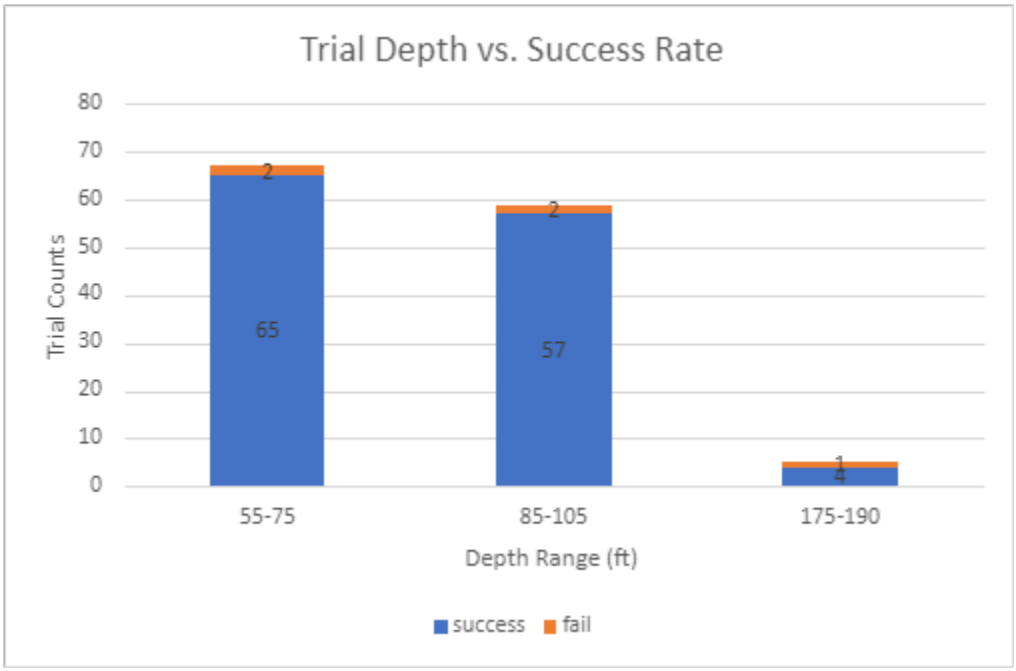


Figure 4. Depth distribution and success rates for the reliability trials.

Environmental Conditions During Trials

Trials were conducted in a variety of conditions (Figure 5 & Table 1). Wind speeds during the trials ranged from 0 to 15 knots, with most trials conducted with a wind speed of 5 knots. Wave heights ranged from 1 to 4 ft, with most trials conducted with wave heights of 2 ft. Currents ranged from 1 to 4 knots, with most trials conducted with a current of 1 knot. Air temperatures ranged from 45 to 59 degrees F and the visibility was greater than 6 miles to 10 miles. We categorized the bottom substrate as sand or mixed sand with rock for all trials based on fisherman's input and mapped all deployment locations overlaid with hard substrate and depth (Figure 6). We did not identify a relationship between success rate and the environmental variables.

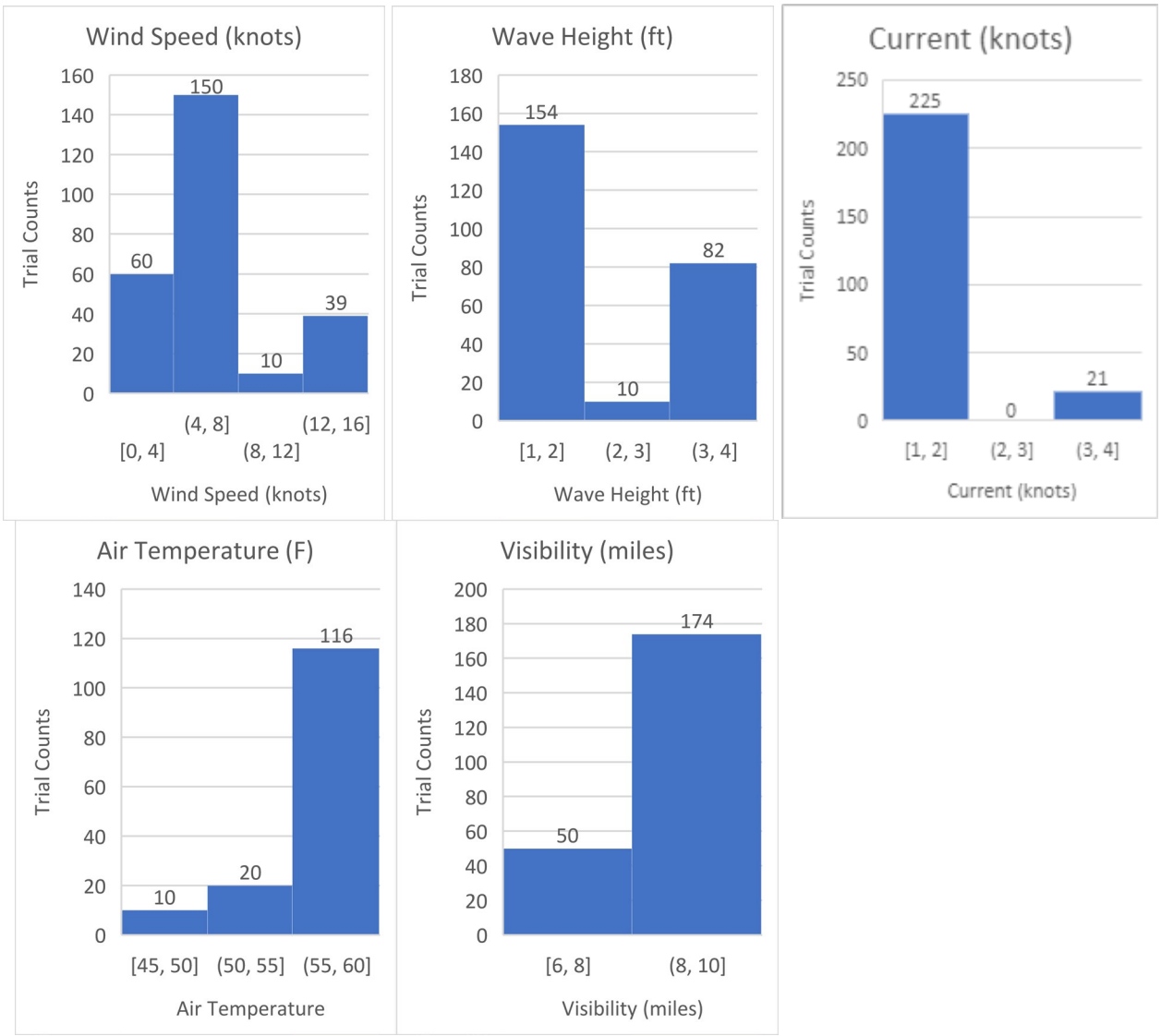


Figure 5. Environmental conditions recorded during the set and retrieval of each trial. Includes set and retrieve data points. Note some environmental data points were not collected during some sets as the data collector did not record those variables, so the total data points may differ from the number of trials.

Table 1: Ranges of environmental conditions during deployment and retrieval on at-sea trials.

Environmental Condition	*Minimum*	*Maximum*
Depth (ft)	55	190
Wind speed (knots)	0	15
Wave Height (ft)	1	4
Current (knots)	1	4
Air Temperature (f)	45	59
Visibility (miles)	6	10+ (unlimited)

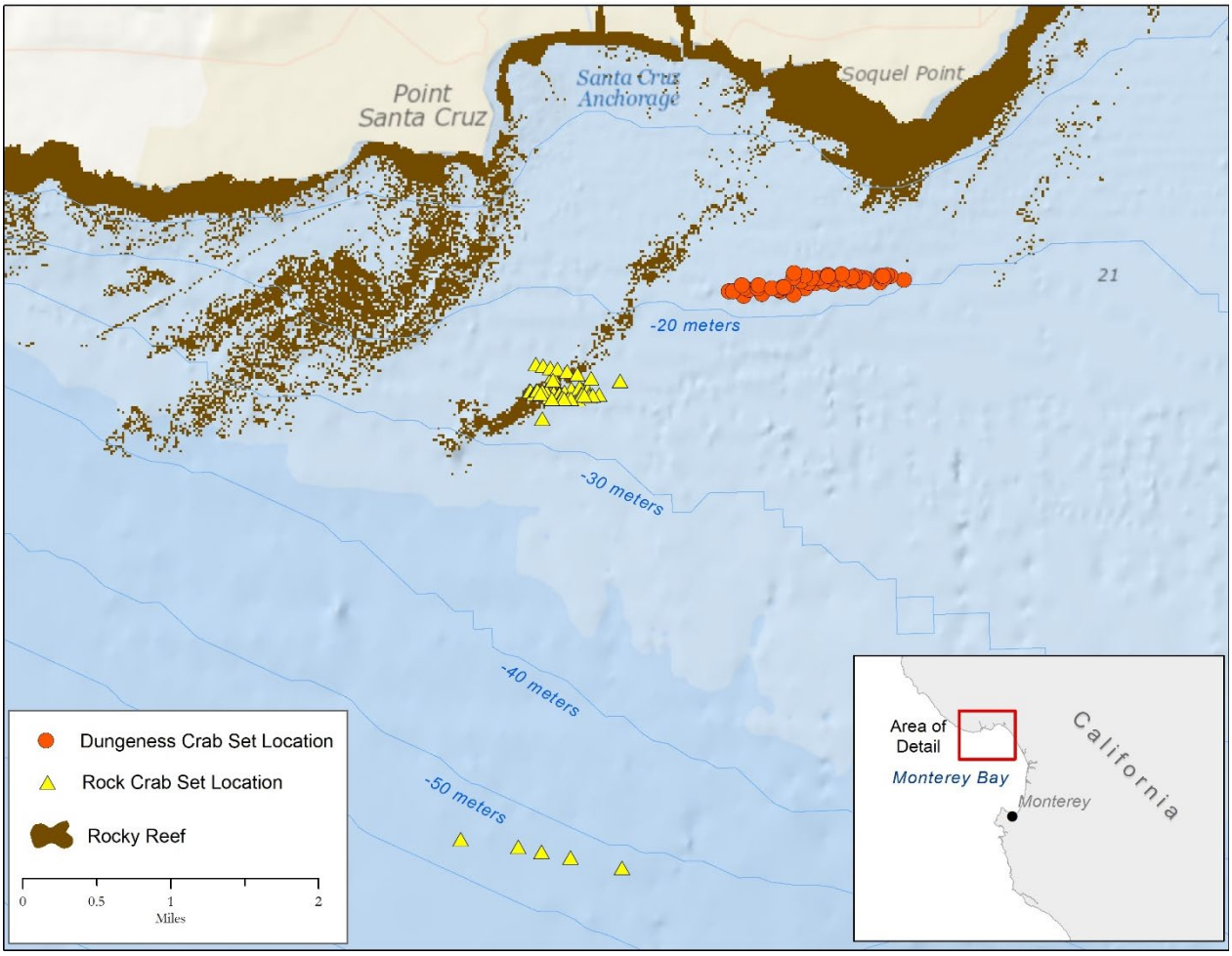


Figure 6. Map of deployment locations in northern Monterey Bay, California, showing rocky substrate layer and 10-meter depth contours. Locations are distinguished based on whether they took place in the Dungeness crab fishery (December 2021) or rock crab fishery (Sept-Oct 2021), however, the same gear and trap configurations were deployed in both fisheries. Map by Ben Enticknap, Oceana.

Discussion

Overall, the gear surfaced as expected with a 95% success rate (124 successes of 130 trials). We believe that continued work to improve reliability will achieve loss rates well below the loss rates with conventional gear, which fishery participants commonly estimated to be 5-10% per year.[6] Over time, retrieval and redeployment efficiency improved significantly. We anticipate even greater success because of the lessons learned from the few failures that we encountered. First, the cause of mechanical failure was identified and corrected in all units. Second, changes to rope coiling made after initial rope tangle failures in the initial trials resulted in no additional rope tangle failures in the second phase of trials. It is important to the reliability of the gear that the rope is coiled neatly and secured properly in the line handling system to avoid the potential for fouling or tangling.

The Trap Timer virtual gear marking app worked consistently and enabled successful gear tracking both on the fishing vessel and remotely using the website. This should enable enforcement officers to locate, retrieve, and redeploy gear using the virtual gear marking app, which indicates the precise location and time the gear is set to surface. The app also identifies the permit holder of any submerged gear.

The extent to which the gear reduces the risk of entanglement depends on the time between the preset pop-up time and the actual retrieval by the fisherman. If the fisherman arrives and retrieves the gear immediately after it surfaces, the gear will have an approximately 100% reduction in risk, similar to on-demand, acoustic gear. However, if the fisherman retrieves the trap after it has surfaced, there will be vertical line left in the water column. The virtual gear marking app is capable of tracking this and can be used to calculate the proportion of time the gear was in the water as a proxy for risk reduction at the individual trap and aggregate levels.

Conclusions

The Sub Sea Sonics TR4RT timed-release pop-up system provides safeguards against gear loss, gear conflict, and illegal use of gear while providing a simple, relatively inexpensive technology (approx. $200-$300 per unit) that can serve as an incremental approach to authorizing pop-up gear in California. This makes it accessible to all vessel sizes and a potential steppingstone to more complex, acoustic on-demand systems. The virtual gear application is simple, free, and can be used with different pop-up systems as an interim step while more complex interoperable applications are developed. These advantages combined with the ability for ongoing regulatory monitoring of the system effectiveness in risk reduction provide a practical pathway to the introduction of pop-up gear to the Dungeness crab fishery.

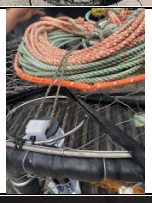
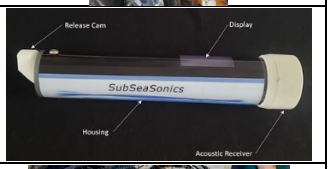
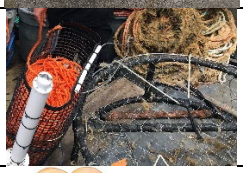
The trials described here provide information that may inform future Experimental Fishing Permits and alternative gear authorization. We suggest further trials be conducted without the presence of a back-up buoy and over a broader range of environmental conditions, geographic areas, and depths. Scaling the trials to additional units of gear will help in evaluating the

[6] CDFW. December 2021 Draft Conservation Plan for California's Commercial Dungeness Crab Fishery. Section 5.4. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=195798&inline

efficiency of the gear relative to conventional fishing gear. Additionally, participation of enforcement officials in the development and testing of enforcement protocols using the VGM app, as well as conducting realistic trials where they retrieve and deploy gear will help ensure the system can be reliably managed and enforced. There likely is not a single optimal design of pop-up gear that is a one-size-fits-all for all fixed gear fishermen. Testing multiple types of pop-up gear systems will help provide a suite of options for the diverse fleet of crab fishermen, vessel sizes, business models, and individual preferences.

This study is the result of significant investment and collaboration by fishermen, gear manufacturers, and conservation organizations. In combination with other advances, this study demonstrates that pop-up fishing gear can be a viable fishing method that could provide for an extended season and additional fishing opportunities in the context of regulatory protections that prevent whale and sea turtle entanglements in fixed fishing gears.

Appendix 1: Release triggers, release mechanisms, and line management employed by selected example pop-up systems

Pop-Up System	Release Trigger	Release Mechanism	Surface Gear Management	Example Image
Longsoaker	Galvanic timed release	Disintegrating hook	Line coil and buoy on top of trap held down with mesh	
Sub Sea Sonics TR4RT *(tested in this study)*	Digital timed release	Rotating cam hook	Line coil and buoy held down on top of trap with bungee	
Sub Sea Sonics AR4RT	Acoustic release	Rotating cam hook	Line coil and buoy held down on top of trap with bungee	
Puget Buoy	Digital timed release	Mechanical latch with magnet	Buoyant spool	
Fiobuoy F-Series	Acoustic release	Mechanical jaws	Buoyant spool	
Desert Star	Acoustic release	Electrolyzed zinc wire	Floating mesh bag with loose line and buoys	
EdgeTech	Acoustic release	Mechanical rotating screw	Rectangular compartment holding line; buoys attached to releasable top	
Ashored	Acoustic release	Mechanical rotating screw	Cylindrical compartment holding line and buoys	
SMELTS Crab Raft	Acoustic release	Compressed air cylinder	Inflatable lift bag (may bring up entire trap or a coiled line)