Industry extension of acoustic release technology for at-call access to submerged head-gear in the NSW rock lobster fishery

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Acknowledgments

This project was based on the relationship between the NSW DPI project team, commercial lobster fishers in NSW represented by the NSW Rock Lobster Industry Working Group and fishers who had purchased, at their own expense, the acoustic release system prior to the commencement of this extension project. The tremendous support for this project from Scott Westley and Mal Gorry, working on vessel *Seeking II* out of Jervis Bay and Ron and Michael Firkin, working on vessel *Babs* out of Sydney underpinned this project. Another fisher, Les Muller, also showed great interest in the acoustic release system but ultimately made the decision not to proceed with installation. Nevertheless, his initial interest in the system and his reasoning for not adopting the system was of great value to the project.

Valued support and encouragement was also provided by all members of the NSW Rock Lobster Industry Working Group.

The other key contributor to the success of this project was Marco Flagg, of *Desert Star Systems*, the USA-based manufacturer of the acoustic release system. His technical assistance with respect to maintaining and optimising the performance of the acoustic release system was invaluable and he provided this support during several visits to Australia and countless email and telephone conversations.

Executive Summary

Fishing gears set on the sea-floor, such as lobster traps, may be lost due to the head-gear (rope and floats) being cut off by commercial shipping or other vessels, vandalism or interactions with marine animals such as whales. Loss of traps and the valuable product therein is associated with economic loss to fishers and may result in ghost fishing by the lost fishing gear. Ghost fishing of lost lobster traps has been identified as a potentially significant component of fishing mortality in the NSW Rock Lobster Fishery, which targets the Eastern Rock lobster, *Sagmariasus verreauxi*. A preceding research project (FRDC 2007/038 "Study of ghost fishing in the NSW rock lobster fishery") considered strategies for reducing trap loss and the Desert Star ARC-1XDf acoustic release system was extensively tested and trialled in experiments that involved commercial lobster fishing on the mid and outer continental shelf off NSW and provided proof of concept and proof of application. Following this work, some commercial lobster fishing businesses made their own substantial investment in this acoustic release technology. There was therefore a need to (i) encourage and support this initial phase of commercial use of the system by these pioneering fishers and (ii) to provide the infrastructure for the necessary training and support of these fishers now and those that elected to invest in this technology in the future.

Objectives of this industry-extension project were to: (i) install the Desert Star ARC-1XDf acoustic release system and integrate with on-board electronics on at least 3 vessels in the NSW lobster fishery; (ii) provide training and support in the use and maintenance of the system for fishers who adopt this technology; (iii) Produce documentation (manuals, diagnostic & problem-solving tools) covering installation, use and maintenance of the system; (iv) broker changes/improvements to the acoustic release system's hardware, firmware and software with the manufacturer and (v) monitor the performance of acoustic release systems implemented in the NSW lobster fishery. Fishers were responsible for the full costs of purchase, installation and maintenance of the acoustic release system.

Methods mirrored these specific objectives and the performance of the acoustic release system, experienced by the fishers during routine commercial fishing in each of 2 fishing seasons in 2011-12 and 2012-13 for a Sydney-based vessel and 2012-13 and 2013-14 for a vessel fishing out of Jervis Bay.

Acoustic release systems were purchased by 3 fishing businesses but installation proceeded for only 2 of these businesses, on vessels fishing out of Sydney and Jervis Bay. Installation on the vessel *Seeking*, working out of Jervis Bay, was a permanent installation, with full integration with the vessels power supply and electronics (GPS-chart-plotter). The installation on the vessel *Babs*, operating out of Botany Bay Sydney, involved non-fixed (portable) components of the surface station and was not integrated with the vessel's power supply or GPS-chart-plotter. Training and support was provided through meetings and discussions with the fishers in their homes, workshops, aboard their vessels in port and at sea when deploying and retrieving gear. An operations manual and user guide was developed to provide fishers with a guide to installation options, routine use, problem-solving and maintenance. After-market modifications were made to the ARC-1XDf release units to provide increased protection for key components from physical damage. Based on feedback regarding our specific requirements, the manufacturer made several modifications to system hardware, the firmware within the release units and the system control software.

Performance of the system was evaluated in terms of the number of successful deployments of gear, releases of head-gear, retrieval of traps and the number of acoustic release units and traps lost during each of two fishing seasons for each of the two vessels. Performance differed substantially between the two vessels with the Jervis Bay vessel *Seeking II* experiencing high rates of success across all measures of performance and the Sydney vessel *Babs* experiencing problems with respect to lower rates of successful acoustic release and trap recoveries. The differences in performance were associated with differences in (i) the design of the release bag used to contain the submerged head-gear and (ii) differences in fishing practices with respect to the timeliness of accessing traps via acoustic release before backup release devices (galvanic time releases, GTRs) allowed head-gear to ascend to the surface.

An important conclusion from this project is that the acoustic release system can be used reliably and efficiently in a commercial fishing environment. Indeed, the use of this technology here represents the first routine use of this technology in a commercial fishery anywhere in the world.

As is the overarching objective of any extension project, the training and assistance offered under this project transitioned through several phases and resulted in the development of self-sufficiency, commitment to ongoing refinement and continued investment by key fishers in the industry. Attributes of the fishing businesses that initially invested in this system during this project included: (i) exposure to cut-offs of head-gear by shipping or theft of gear and product; (ii) large shareholdings and therefore large annual quotas; (iii) high catch rates of lobsters per trap-lift during peak season such that an acoustic release costing approximately $2,000 was, over a season, protecting the contents of a trap containing product worth many times this value; and (iv) recognition of health, safety and lifestyle benefits that result from not feeling compelled to go to sea and lift traps when the floats had surfaced following release by a GTR. Based on these attributes, costs and benefits will differ among fishing businesses that fish in the deep-water component of the NSW lobster fishery. Since 2013-14, there has been further adoption of the acoustic release technology by another large lobster fishing business, based on the north coast of NSW. There are currently several fishing businesses that have expressed interest in purchasing and installing the system on their vessels in the future.

The effective application of this acoustic release technology by fishers in the NSW lobster fishery has important implications for commercial fisheries internationally. Subject to the specific characteristics of other fisheries, the challenges they face and evaluation of costs and benefits, acoustic release technology provides a means to eliminate the time that ropes and floats of set fishing gear on or near the surface of the water. This technology has potential application to ameliorating problems of loss of gears and product, ghost fishing and interactions between fishing gear and cetaceans.

Keywords

Acoustic release, ghost fishing, Eastern Rock Lobster

Introduction

Eastern Rock Lobster, *Sagmariasus verreauxi*, is targeted by the NSW Rock Lobster Fishery on shallow inshore reefs and in waters out to the edge of the continental shelf. A previous research project (FRDC 2007/038 "Study of ghost fishing in the NSW rock lobster fishery") demonstrated that the large traps, used in the deep-water component of the NSW fishery, continue to catch and accumulate lobsters over time, until the traps break down after approximately 14 months due to corrosion of the wire-mesh. Ghost fishing of lost traps was identified as a potentially significant component of total fishing mortality and the Fishery Management Strategy for the NSW lobster fishery specifically identifies research into ghost fishing and minimising associated mortality as a priority. Traps may be lost due to cut-off of head-gear by commercial shipping or recreational vessels, vandalism or interactions with marine creatures (e.g. cetaceans). Loss of traps and lobsters may also result from theft.

A strategy for reducing the potential for trap loss, experimentally tested in the preceding project, involved the use of acoustic release technology that provided "at-call" access to head-gear (rope and floats) that was submerged. The Desert Star ARC-1XDf system was extensively tested and trialled in experiments that involved commercial lobster fishing on the mid and outer continental shelf off NSW. These successful experiments provided proof of concept and proof of application.

Two commercial fishing businesses, each involving a partnership of 2 commercial fishers (Ron and Michael Firkin in Sydney; Scott Westley and Mal Gorry at Jervis Bay), were closely involved with these experiments. Both these business were sufficiently impressed with the performance of the acoustic system and the potential advantages for their businesses that they made substantial investments in the technology. A third fishing business, owned and operated by Les Muller, also purchased the technology but decided not to proceed with installation on his vessel and on-sold his acoustic releases.Initial use of the system onboard the Sydney and Jervis Bay fishing vessels was based on the portable configuration of the system. This was the same way that the system had been used during the research trials. Full integration of the system into the vessel's power system, onboard electronics (GPS/plotter) and installation of in-hull transducers was a priority. In this early stage of system design and use, these fishers required considerable assistance from NSW DPI staff to set-up, configure, efficiently use the system and problem-solve. There was therefore an immediate need to (i) encourage and support this initial phase of commercial use of the system by these pioneering fishers and (ii) to provide the infrastructure for the necessary training and support of these fishers and those that elected to invest in this technology in the future.

Objectives

1. Install the Desert Star ARC-1XDf acoustic release system and integrate with on-board electronics on at least 3 vessels in the NSW lobster fishery;

2. Provide training and support in the use and maintenance of the system for fishers who adopt this technology;

3. Produce documentation (manuals, diagnostic & problem-solving tools) covering installation, use and maintenance of the system;

4. Broker changes/improvements to the acoustic release system's hardware, firmware and software with the manufacturer;

5. Monitor the performance of acoustic release systems implemented in the NSW lobster fishery

Method

As an industry-extension project, the methods used to encourage and support implementation and the practical use of the acoustic release technology, mirror the project objectives.

Installation and integration of the acoustic release system with onboard electronics in commercial fishing vessels (Objective 1) was achieved through discussion of options with the fishers and brokering discussions and correspondence among NSW DPI project personnel, the fishers and the manufacturer of the equipment (Desert Star Systems). Training and support (Objective 2) was provided by the same means and with multiple visits to the fishers in their home ports and trips aboard their vessels to assist with deployment and retrieval strategies. Production of manuals including diagnostic and problem-solving tools (Objective 3) was another key component of the training and support provided. Guidance re installation options, instructions for routine use and diagnostic and problem solving tools are outlined in the Results section of this report and described in detail in the operation manual provided in an appendix to this report.

Changes and improvements to the system (Objective 4) were made by fishers, DPI project personnel and the manufacturer, the latter based on observations and practical experience during this project.

Performance of the acoustic release system, experienced by the fishers during routine commercial fishing in each of 2 fishing seasons was monitored and assessed (Objective 5). This was done during 2011-12 and 2012-13 for the Sydney vessel and 2012-13 and 2013-14 for the Jervis Bay vessel. The two fishing businesses based in Sydney and Jervis Bay were provided with log-sheets to record details of deployments, retrievals and problems that they encountered. Performance of the acoustic release system was subsequently assessed with respect to (i) the numbers and proportions of traps deployed with the system that were successfully retrieved; (ii) whether retrieval was achieved by acoustic release, backup GTR or other means; (iii) the numbers and proportions of release units that were lost during each fishing season or were damaged and required repair.

Results

Objective 1. Install the Desert Star ARC-1XDf acoustic release system and integrate with on-board electronics on at least 3 vessels in the NSW lobster fishery

Acoustic release systems were purchased by 3 fishing businesses. These businesses operated vessels out of Botany Bay (Sydney), Jervis Bay and Narooma and trapped lobsters in depths from 100 – 200 m on the mid and outer continental shelf. Installation of equipment proceeded for the 2 vessels operating out of Sydney and Jervis Bay.

The fisher based in Narooma chose to delay installation of his equipment for a season, subsequently made the decision not to proceed and sold the gear he had purchased to the business operating out of Jervis Bay. His decision not to proceed with installation and use of the system was based on the apparent complexity, in his view, of using the computer and system software, interpreting the feedback and system diagnostics provided by the software, backing-up practices, procedures for rigging the equipment, initialising and deploying the gear, maintenance of the gear and re-rigging prior to re-deployment and necessary maintenance between fishing seasons. This fisher observed operation of the system aboard the Jervis Bay vessel and noted the advantages of the system but ultimately came to the conclusion that the challenges for him to efficiently manage and use the system, outweighed the benefits. As a consequence of this decision, the project fell short of the objective to install the system on 3 vessels, achieving installation on the 2 vessels based in Sydney and Jervis Bay.

Installation on the vessel *Seeking II,* working out of Jervis Bay, included: a full integration with the vessels power supply; linking the surface station of the acoustic release system with the vessel's GPS-chart-plotter; installation of the various components of the surface station (STM-3 onboard communications unit, computer and dedicated monitor) in the dash at the helm and bulkhead; an in-hull transducer to communicate with deployed release units; multi-directional transducer mounted in a dedicated tank outside the cabin for initialisation/deployment of release units; and a rope-coiler for packing rope into release bags (see Fig. 1).

The installation on the vessel *Babs*, operating out of Botany Bay Sydney, involved non-fixed (portable) components of the surface station (STM and laptop computer) with connections available to an in-hull transducer for communications with deployed release units and a multi-directional transducer in a bin on the deck for initialisation/deployment of release units. Laptop computer and STM onboard communication units were not connected into the vessel's power supply and required recharging of batteries following each day's use. Neither did this vessel have a rope-coiler, so release-bags were packed manually.

Objectives 2 & 3. Provide training and support in the use and maintenance of the system for fishers who adopt this technology; Produce documentation (manuals, diagnostic & problem-solving tools) covering installation, use and maintenance of the system

Training and support was provided through meetings and discussions with the fishers in their homes, workshops, aboard their vessels in port and at sea when deploying and retrieving gear. This covered all aspects of the project team's experience with respect to installation and operation of the gear, trouble-shooting, strategies relating to deployment and locating set gear, recovery of gear and maintenance procedures. This experience and the procedures and strategies that were discussed with fishers are contained in the document *Operation manual for the Desert Star Systems ARC-1XDf acoustic release control system* (see Appendix 1) which was developed during this extension project for NSW lobster fishers.

Objective 4. Broker changes/improvements to the acoustic release system's hardware, firmware and software with the manufacturer

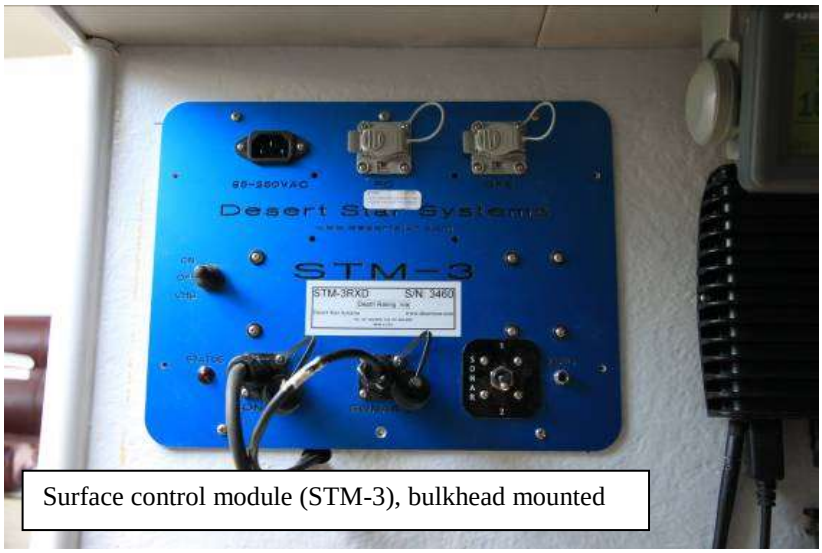
Several after-market modifications were made to the ARC-1XDf release units to provide increased protection for the release lever and terminal posts supporting the burn-wire. These are detailed on pages 18 - 21 of the user documentation in Appendix 1. Based on feedback regarding our specific requirements, the manufacturer made several modifications to system hardware, the firmware within the release units and the system control software. For example, the surface transmission unit (STM-5) was modified to facilitate switching between 2 connected transducers so that both (i) an in-hull transducer for communicating with deployed units and (ii) a transducer for initialising release units before deployment (mounted in a bin on deck) could be used. Software bugs, identified during our initial use of the system were fixed by the manufacturer with software upgrades subsequently supplied.

Several of the release units in, the initial batches purchased by the 2 fishing businesses, failed to function correctly when bench-tested prior to routine use. These were returned to and replaced by the manufacturer. This experience clearly indicated a problem with the manufacturer's quality control and quality assurance policies and practices. This was conveyed to the manufacturer and they subsequently reviewed their practices. Also of concern initially was the response time associated with the supply and repair of release units. Desert Star Systems are based in California, USA, and they do not have a technical support agent located in Australia. Consequently, any system components that require repairs that cannot be undertaken by the user must be shipped internationally.

Figure 1. System installation on *Seeking II*.

Skipper at the helm, observing computer monitor running acoustic release system software

Securing release bag pre-deployment



Surface control module (STM-3), bulkhead mounted

Release unit being initialised in tub of water with transducer

Trap and packed release-bag with acoustic release ready for deployment

The design of the release bags used by the fishers based in Sydney and Jervis Bay differed significantly. The bags used by the Sydney fishers were circular in cross-section and the 2 depth-floats were positioned vertically, one on top of the other in the top of the bag (as shown in Figs. 3.16 and 3.17 in the documentation in Appendix 1). In contrast, the release bags used by the Jervis Bay fishers were oval in cross-section so that the 2 depth-floats could be positioned side-by-side in the top of the bag (Fig. 1). There was also increased space between the floats and the sides of the bag (when open) compared to the tighter-fitting Sydney design. The rationale for this design was that the floats would be less likely to jam in the bag. This appears to have be a critically important design modification given the stark difference in system performance experienced by the Jervis Bay and Sydney fishers (see next section).

Objective 5. Monitor the performance of acoustic release systems implemented in the NSW lobster fishery

The quality and completeness of records relating to the performance of the ARC system during commercial fishing by the Sydney and Jervis Bay fishers during each of 2 fishing seasons (2011-12 and 2012-13 for Sydney; 2012-13 and 2013-14 for Jervis Bay) were variable. Records documenting the performance of acoustic releases and the fate of traps by the Jervis Bay fishers for the 2 fishing seasons were thorough and easily interpreted. It was problematic to quantitatively analyse and summarise the performance of the system for the Sydney-based vessel because records were incomplete and there remained uncertainties about the loss of acoustic release units, traps and the circumstances under which this occurred. Consequently, the performance of the system in the hands of (i) the Jervis Bay business is presented in some detail here and (ii) a more general commentary is provided for the Sydney-based fishers.

System performance - Seeking II (Jervis Bay), 2012-13 and 2013-14 fishing seasons

System performance is summarised in Figure 2.Traps were set in depths from 110 – 201 m. There were 299 trap-sets using the acoustic release system during the 2012-13 fishing season and 317 trap-sets during 2013-14. Respectively, there were 292 and 310 successful trap lifts, for which both the trap and acoustic release were successfully recovered, representing success rates of 97.7% and 97.8% in these years.

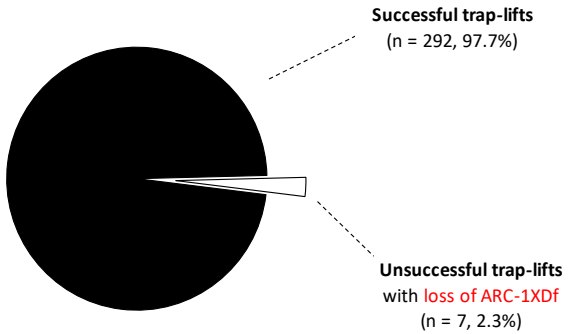
Note that in 2013-14, there were 2 additional “successful” trap-lifts for which the trap and contained lobsters were recovered but with the loss of the acoustic release and release-bag which became detached from the rope prior to or during winching of the gear.

In summary, there were 7 failures to recover set traps, lobsters and acoustic releases in 2012-13, representaing a failure rate of 2.3%. In 2013-14, there were 5 failures to recover set traps, lobsters and acoustic releases (1.6% failure rate) and an additional 2 successful lifts of traps and lobsters but with loss of acoustic release (0.6% failure rate), representing a.combined failre rate of 2.2%.

The vast majority of successful trap-lifts resulted from acoustic release of the head-gear (225/292 in 2012-13 and 307/310 in 2013-14). There were 58 instances in 2012-13 when a prolonged soak-time resulted in backup-GTRs releasing head-gear before any attempt was made to access the gear using the acoustic release. There were 2 instances in 2012-13 and 1 instance in 2013-14 when successful trap-lifts resulted from GTR releases following failures of acoustic releases due to ingress of water into the units. The backup GTR facilitated the successful retrieval of 3 traps in 2012-13 and a single trap in 2013-14 when the head-gear did not surface following acoustic release. The backup-GTR also resulted

Figure 2. Perfomance of the ARC-1XDf acoustic release system installed on "Seeking-II", fishing the mid- and outer- continental shelf off Jervis Bay during fishing seasons 2012-13 and 2013-14.

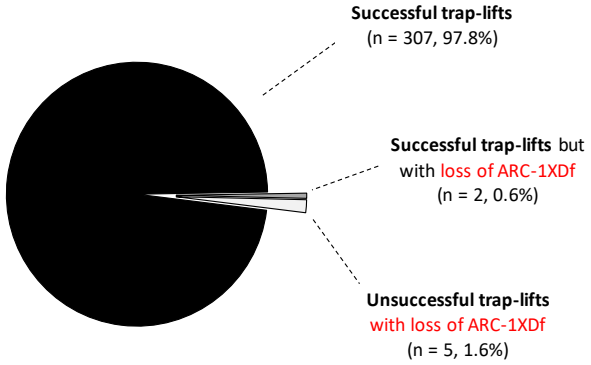
2012-13 fishing season



Successful trap lifts	**292**
Acoustic release	225
Backup GTR, no acoustic attempt	58
Backup GTR, due to ARC failure (ingress of water)	2
Backup GTR, floats did not surface after acoustic release	3
Grappled, rope snapped during winching after acoustic release	2
Tangled with another trap, no acoustic attempt	2
Successful trap lifts but with loss of ARC-1XDf	**0**
nil	0
Unsuccessful trap lifts (with loss of ARC-1XDf)	**7**
No communications / Trap missing	5
Tangled at set	1
Acoustic release, line snapped during lift	1
Total trap-sets	**299**

108	ARC1-XDf release units used during season
98	retained and functional at season end
3	requiring repair (2 x water ingress)
7	lost

2013-14 fishing season



Successful trap lifts	**310**
Acoustic release	307
Backup GTR, floats did not surface after acoustic release	1
Backup GTR, acoustic release but tangle of release cord	1
Backup GTR, due to ARC failure (ingress of water)	1
Successful trap lifts but with loss of ARC-1XDf	**2**
Acoustic, release bag and unit ripped off during winching	1
Backup GTR, no acoustic attempt, release bag & unit gone	1
Unsuccessful trap lifts (with loss of ARC-1XDf)	**5**
No communications / Trap missing	3
Floats did not surface following acoustic release	1
Unknown, details not recorded	1
Total trap-sets	**317**

107	ARC1-XDf release units used during season
98	retained and functional at season end
2	requiring repair (2 x water ingress)
7	lost

in successful retrieval of a trap in 2013-14 when the release cord was tangled with the release mechanism preventing release of the head-gear. There were 2 instances in 2012-13 trap were successfully lifted when tangled with another trap. Two traps were retrieved by grappling in 2012-13 after the rope was snapped while winching to the surface following acoustic release.

Specific causes for 5 of the 7 unsuccessful trap-lifts in 2012-13 and all 5 failures in 2013-14 could not be identified. Two instances of "operator error" occurred in 2012-13. In one instance, the gear was tangled during the initial set such that it could not subsequently be released. On the other occasion, following a successful acoustic release of the head-gear to the surface, the rope was snapped during winching, resulting in a lost trap. On one occasion in 2013-14, the head-gear did not surface following a successful activation of the release unit and confirmation from the unit that the unit had released. There were, however, 5 instances in 2012-13 and 3 instances in 2013-14 when set traps could not be located. Communications could not be established with the release units, either because (i) they were malfunctioning; or (ii) the release units were not there. There are several mechanisms by which the units (and traps) could be moved away from the location at which they were set, the most likely being entanglement in trawl gears. On several occasions, in recent years, "lost" acoustic releases have been returned after being tangled in trawl gear when fish trawlers have worked the edge of the trapping grounds.

A total of 108 ARC-1XDf release units were used for deployments in 2012-13. Of these, 98 were retained and fully functional at the end of the season, 3 required repair (2 due to ingress of water) and 7 had been lost. A total of 107 release units were used in 2013-14 with 98 retained and fully functional at the end of the season, 2 requiring repair (due to ingress of water) and 7 units had been lost.

Mean catch rate in 2012-13 was 22.9 (SD 27.5) lobsters per trap-lift over the season (traps set between September and February). During peak season (traps set between mid-December and February), mean catch rate was 31.6 (SD 29.5) lobsters per trap-lift. The typical mean weight of a lobster caught in this component of the fishery is about 0.9 kg so the mean weight of lobsters captured per trap-lift during the peak season was approximately 28.5 kg per trap lift. At a price of around $60 per kg, the mean value of lobsters captured per trap-lift was about $1,710.

System performance – Babs (Sydney), 2011-12 and 2012-13 fishing seasons

In stark contrast to the performance of the acoustic release system aboard *Seeking II*, the fishers operating the system aboard *Babs* in waters off Sydney suffered substantial losses of traps and acoustic releases. During 2011-12, they commenced the season with 50 ARC-1XDf release units but only deployed 49 because one unit failed its pre-deployment test.1 failed its pre-deployment test. They initially deployed 49 ARC-1XDf release units but by the end of the season, they retained 33 functioning units, 1 non-functioning unit and had failed to retrieve 15 units. During 2012-13, they initially deployed 29 release units but by the end of the season retained only 19 functioning units, having failed to retrieve 10 units. It was difficult to audit and therefore quantitatively summarise system performance as was done for *Seeking II*, due to missing detail and inconsistences in the records, but several important trends were obvious.

During each fishing season, there were a greater number of successful lifts that resulted from (i) GTR releases of head-gear with no prior attempt having been made to release the gear by acoustics, compared to (ii) acoustic releases. The head-gear of traps that was set with acoustic releases was frequently on the surface when the objective of using the acoustic release system was to maintain the head-gear sub-surface for the full soak-time of the trap. A consequence of the floats being on the surface in waters offshore from Botany Bay is the exposure of the head-gear to being cut-off by commercial shipping and exposure to theft. Both have been issues for this fishing business in the past. It is therefore likely that cut-offs and/or theft contributed to the high losses of traps and release units. There was clearly a mismatch between the duration of the GTRs that were used to provide a backup release and the capacity for the fishers to efficiently attempt acoustic release of traps.

The second clear trend in the performance notes provided by the fishers was the frequency with which they established communications with release units, activated a release, received confirmation of acoustic release but the floats did not immediately ascend to the surface. The fishers reported multiple instances when they found the floats on the surface later on the same day or on a subsequent trip. They also reported several instances when they subsequently grappled the gear and the floats and rope ascended to the surface during grappling or were found lodged in the bag after retrieval. Inspection of the acoustic release units confirmed that the burn wire had combusted and the release lever had opened. This clear implication was that the head-gear was not exiting the release-bag due to friction or jamming of the release cord or the floats and rope within the release bag.

Discussion, Conclusions and Implications

Initial training and assistance provided to fishers by the NSW DPI project team quickly transitioned to 3-way discussions and problem-solving among the commercial fishers, NSW DPI team and the manufacturer, *Desert Star Systems*. The work associated with objectives 1 - 4 of this project underpinned these phases of industry-extension. There was then a further phase in the development of the system and its use by the commercial fishers. The Jervis Bay fishing business, in particular, continued to refine the designs of their equipment and fine-tune their procedures, independently of the DPI team and manufacturer. Moreover, this fishing business has continued on this path and has made further investments in acoustic releases, in the years since this extension project. Development of self-sufficiency, commitment to ongoing refinement and continued investment in a new system or process represents the overarching objective of any industry extension project.

During the first 2 years that the Sydney and Jervis Bay fishing businesses used the acoustic release system to deploy and retrieve traps, there was significant contrast in their success (as monitored under objective 5 of this project). Performance of the acoustic release system onboard *Seeking II* (Jervis Bay) was superior to the performance of the system onboard *Babs* (Sydney). There were significant differences between these two fishing operations and, in combination, these differences contributed to the superior performance of the system onboard *Seeking II*. Integration of the surface station components of the release system with the vessels power supply, GPS-chart-plotter and installation of the computer monitor, keyboard and mouse at the helm facilitated comfortable and efficient control of the system. The design of the release bag used by the Jervis Bay business appears also to have been critical in reliably allowing head-gear to exit the bag and ascend to the surface immediately following acoustic release. Another contributing factor to the relative success aboard *Seeking II* related to the greater proportion of their trap retrievals achieved by acoustic release compared to the number that resulted from releases due to the backup GTR when there had been no prior attempt to perform an acoustic release. This is an important observation and not a criticism of the Sydney fishing business. There were a variety of reasons, unrelated to their desire to fish, that resulted in their soak-times exceeding the release time for their backup GTRs.

A fundamentally important conclusion from this project is that the acoustic release system can be used reliably and efficiently in a commercial fishing environment. The initial success, subsequent further investment and ongoing use of the acoustic release system by the Jervis Bay fishers are testament to this. These fishers have made the business decision that investment in the system is cost beneficial. This is not to argue that this will be the case for all deep-water lobster fishers in NSW, other NSW fisheries or fisheries in other jurisdictions. Attributes of the fishing businesses that initially invested in this system during this project included: (i) exposure to cut-offs of head-gear by shipping or theft of gear and product; (ii) large shareholdings and therefore large annual quotas; (iii) high catch rates of lobsters per trap-lift during peak season such that an acoustic release costing approximately $2,000 was, over a season, protecting the contents of a trap containing product worth many times this value; and (iv) recognition of health, safety and lifestyle benefits that result from not feeling compelled to go to sea and lift traps when the floats had surfaced following release by a GTR. Based on these

attributes, costs and benefits will differ among fishing businesses that fish in the deep-water component of the NSW lobster fishery.

Adoption of acoustic release technology by these two NSW lobster fishing vessels represents the first routine use of this technology in a commercial fishery anywhere in the world. Another lobster fishing business located on the mid-north coast of NSW has since purchased the acoustic release system and has been routinely using it for the past 2 seasons. Installation of this system was based on the experience of the Jervis Bay fishing business with the system fully integrated with the vessel's power supply, chart-plotter and computer operated from the helm position. Successful use of this system has mirrored the ongoing effective use of acoustic releases by the Jervis Bay business. There is, at present, strong interest from another two businesses that operate in the deep-water component of the NSW lobster fishery.

The adoption of acosustic release technology by several lobster fishing businesses in NSW has important implications for commercial fisheries internationally. Subject to the specific characteristics of other fisheries, the challenges they face and evaluation of costs and benefits, acoustic release technology provides a means to eliminate the time that ropes and floats of set fishing gear are on or near the surface of the water. Loss of fishing gear, valuable product and ghost fishing by lost traps can be reduced. The amount of rope in the water column can effectively be reduced and this is advantageous in fisheries for which interactions between cetaceans and ropes are a problem. The use of GTRs to submerge head-gears deep in the water column substantially reduces the amount of time that rope is on or near the surface. The use of acoustic releases goes one step further and limits the time of exposure at the surface to the few minutes its takes to retrieve the head-gear and winch the trap aboard following acoustic release of the submerged head-gear.

Ongoing Extension and Adoption

This project concerned the first stages of extending acoustic release into the NSW lobster fishery. Since 2013-14, the early adopters of this technology have hosted other NSW lobster fishers aboard their vessels to demonstrate application of the system. An additional fishing business, based on the north coast of NSW, has since invested in the acoustic release systemThere is now also strong interest from additional lobster fishing businesses that fish the deep-water component of the NSW fishery. This further phase in extension has been one mediated within the fishing industry, with experienced practitioners (the Jervis Bay fishing business) essentially mentoring another fisher with respect to practices and strategies for using the system efficiently.

Outcomes of this project and the experience of NSW fishers in using this technology have also received international exposure. Dr Liggins and Mr Westley presented a talk describing the background and practical use of the *Desert Star* acoustic release system within the NSW rock lobster fishery at the workshop 'Global Assessment of Large Whale Entanglement and Bycatch Reduction in Fishing and Aquaculture Gear' in Portsmouth, New Hampshire, USA in May 2016. The potential for 'ropeless fishing gear' to reduce the frequency of cetacean entanglements in North American fisheries received immediate media coverage (e.g. Cape Cod Times, 2016) and subsequent attention from policy makers, scientists and commercial fishers (Myers et al. 2019, Ropeless Consortium, 2020). The 'Ropeless Consortium' developed from a workshop in 2018 titled 'Overcoming Development, Regulatory and Funding Challenges for Ropeless Fishing to reduce Whale Entanglement in the U.S and Canada' led to establishment of the 'Ropeless Consortium' (Myers et al 2019). Annual meetings of this consortium, comprising policy-makers, scientists, engineers and fishers, in November 2018 and November 2019, have addressed issues of policy and alternative technologies (Ropeless Consortium 2020). Initial demonstration trials of *Desert Star* acoustic release systems and alternative technologies have been done in several North American fisheries (see agenda and presentations for the 2018 and 2019 meetings available at: Ropeless consortium 2020).

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