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FINAL REPORT

DOCUMENTING ROCKFISH BYCATCH IN, AND REMOVING DERELICT SHRIMP POTS WITH A REMOTELY OPERATED VEHICLE

PREPARED FOR:
NORTHWEST STRAITS FOUNDATION
& NATIONAL MARINE FISHERIES SERVICE, PROTECTED RESOURCES DIVISION

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Introduction

Abandoned, lost and discarded shellfish pots cause negative economic and environmental impacts in marine waters. Every year pot gear is lost due to a variety of reasons including: entanglement with debris, vessel strikes, user error, gear malfunction, gear conflicts, and vandalism. Removal of derelict fishing gear eliminates their negative impacts, as has been demonstrated in derelict gear removal projects conducted by the Northwest Straits Initiative and their partners in Puget Sound since 2002.

Derelict fishing gear removals in Puget Sound have primarily focused on gillnets from the commercial salmon fisheries, and crab pots from the commercial and recreational Dungeness crab (*Cancer magister*) fisheries. Very little efforts have been made to remove shrimp pots from the regional commercial and recreational spot prawn (*Pandalus platyceros*) fisheries, primarily due to the fact that the fishing grounds are in waters beyond maximum allowable diver safety depths of 32 m (105 ft), making focused shrimp pot removals often a cost-prohibitive endeavor. Additionally, derelict shrimp pots were not considered to pose a major threat to marine species because gear loss is relatively low compared to crab fisheries, and because shrimp pots are not equipped with one-way gates on their entry tunnels; meaning that most animals that enter, can also escape. Nevertheless, incidental removal of derelict shrimp pots in Puget Sound during crab pot recovery projects found a surprisingly large number of rockfish in relatively few derelict shrimp pots. The NOAA Protected Resources Division (PRD), the Northwest Straits Foundation (NWSF), and Natural Resources Consultants (NRC) became particularly interested in further understanding the impacts derelict shrimp pots may have on rockfish following the 2010 listing of yelloweye rockfish (*Sebastes ruberrimus*), canary rockfish (*S. pinniger*)¹, and Bocaccio rockfish (*S. paucispinis*) in Puget Sound under the U.S. Endangered Species Act (ESA) list of protected species (Endangered and Threatened Wildlife and Plants 2010). Concurrently, research conducted in British Columbia, and later in Washington State showed that juvenile rockfish bycatch is a common occurrence in active shrimp pots in the Salish Sea (Favaro et al. 2010; Rutherford et al. 2010; Antonelis et al. 2018).

In 2012, sidescan sonar surveys were conducted to quantify derelict shrimp pot presence in popular spot prawn fishing grounds where the ESA listed rockfish were known to occur; however, until now, none of the targets identified during those surveys were investigated (Figure 1), (Antonelis et al. 2018). This project builds on past efforts of the NOAA PRD, NWSF, and NRC to understand and eliminate negative impacts of lost shrimp pots in Puget Sound by using a Remote Operated Vehicle (ROV) to investigate and document rockfish bycatch in, and remove

¹ Canary rockfish were delisted from the ESA in 2017 as research concluded those in Puget Sound are not a distinct population segment from those off the West Coast (82 FR 7711)

derelict shrimp pots in rockfish habitat at water depths beyond 32 m off Mukilteo and Edmonds in Snohomish County, Washington (Figure 1).

NWSF secured funding from NOAA PRD for the derelict crab pot survey and removal operations. NWSF contracted with Natural Resources Consultants, Inc. (NRC) to manage all aspects of the field operations. NRC coordinated the removal operations with the WDFW, Tribal governments, NOAA, and the U.S. Coast Guard (USGC).

Methodology

A total of seven working days of ROV-based derelict shrimp pot investigation and removal were conducted off the 12 m (40 ft) research vessel R/V *Surveyor II*, owned and operated by Fenn Enterprises. All operations were staged out of the Everett Marina in Everett, Washington. The ROV-based derelict gear removal plan was submitted to, and approved by WDFW prior to operations.

Target Identification

The primary source of derelict shrimp pot targets investigated were identified with sidescan sonar surveys conducted in April 2012, as part of previous research aimed at quantifying derelict shrimp pot density and distribution, where 165 derelict pot targets were identified inside 2.9 km² of area covered inside spot prawn fishing grounds (NRC 2012; Antonelis et al. 2018). Additionally, WDFW provided a list of all derelict shellfish pots, with descriptions and georeferenced coordinates, encountered during ROV surveys in rockfish habitat from 2014 through 2016. A total of 157 pot targets within the Mukilteo and Edmonds area were chosen as potential targets to be investigated during the project (Figure 1). Prior to operations, project personnel decided that in order to maximize the amount of derelict shrimp pots investigated, that derelict crab pots would only be removed if they were determined to be still actively entrapping and killing crab, if that could not be determined during investigation, then the pot was removed.

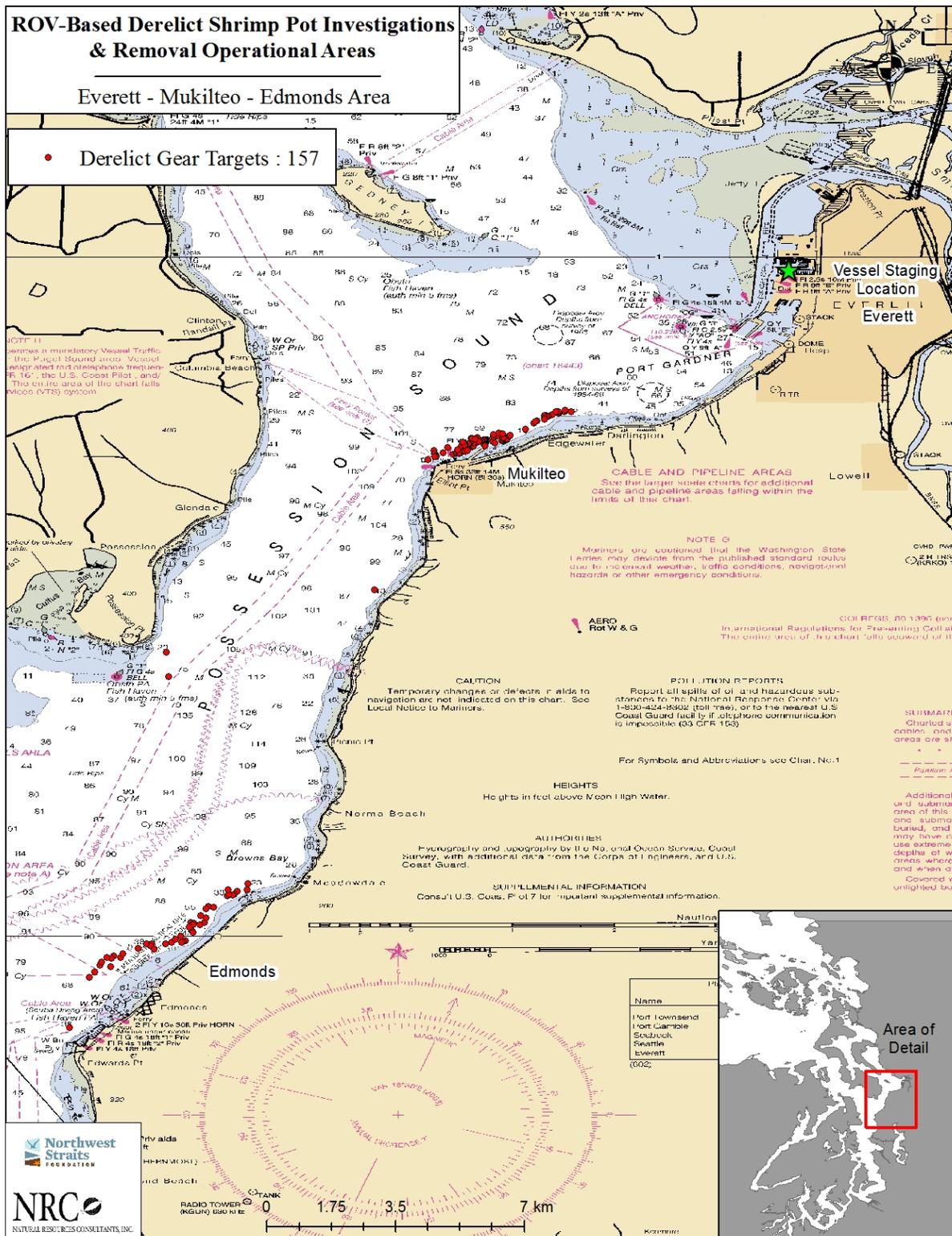


Figure 1. Derelict shellfish pot targets from previous sidescan sonar surveys and WDFW ROV surveys within the project area.

All targets were transferred into electronic navigation software on laptop computers (Nobeltec® and Coastal Explorer®). Project personnel determined which targets to investigate each day based on proximity to port (Everett Marina), weather and sea conditions, water depth, proximity to other targets, regional fishing schedules, and amount of adjacent vessel traffic. The Captain, ROV Operator, and Operations Coordinator (OC)/Scientific Observer crewed the R/V *Surveyor II*.

ROV-Based Derelict Pot Investigations & Removal

A Phantom 2+2® ROV equipped with multi-frequency sector scanning sonar, surface-feed video equipment, lighting, a fixed underwater compass, and manipulator arm with gripping tool was used for derelict shrimp pot investigations and removal (Figure 2). A 136 kg (300 lb) rectangular shaped clump weight with 2 m long bridle connected to a plastic buoy and descent line terminating at the vessel, was used at each target for location reference, and ROV descent and ascent. Two PVC cylinders each containing 15 m (50 ft) of Sampson® braided line were connected to the clump weight; one end of each line was attached to the clump weight, and the other end of each line was equipped with a small four-prong grapple hook.

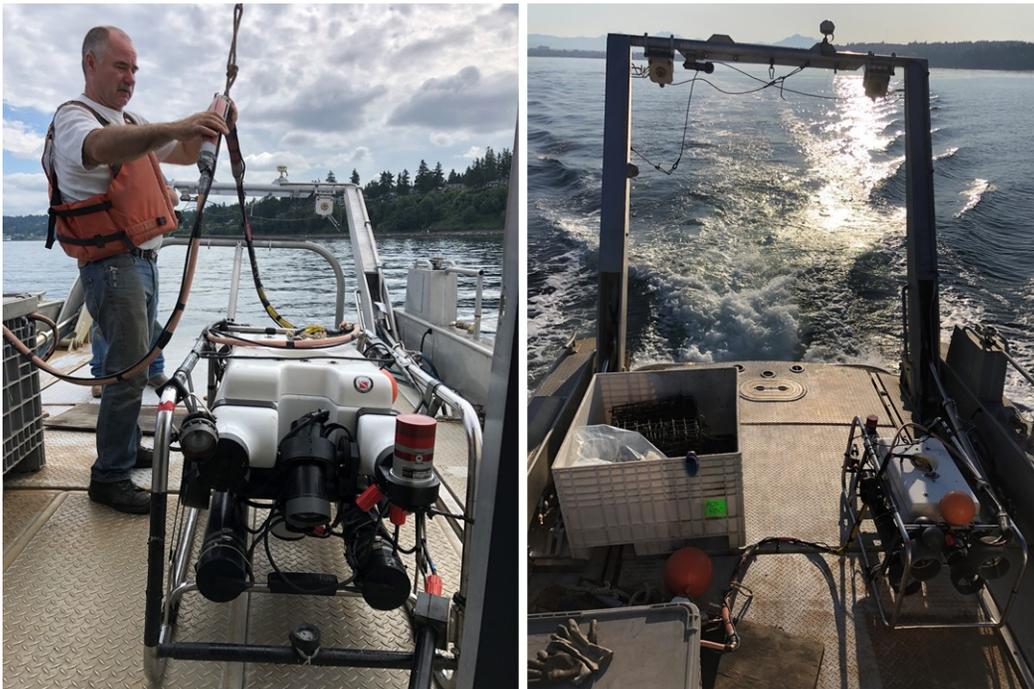


Figure 2. Crayton Fenn of Fenn Enterprises with the Phantom 2+2 ROV on deck of the R/V Surveyor II.

The ROV support vessel used the navigation software to approach the derelict fishing gear target(s) to be investigated. Prior to anchoring at each dive location, the vessel captain identified the vessel's drift pattern based on wind and sea current direction. The anchor was then deployed in a location that would allow the vessel to "lay-back" within 15 m of the target(s) to be investigated. While on anchor, the captain used the navigation software to guide slight maneuvering of the vessel until the vessel was within 5 m of the derelict pot target, at which point the clump weight was lowered to the seafloor via hydraulic crane; marking the expected location of the target. The ROV was then deployed off the stern of the vessel using an articulating davit with hydraulic winches, and remaining slightly buoyant the ROV hovered near the vessel stern until the ROV operator took controls. The ROV operator then piloted the ROV so that the down-line attached to the clump weight was in the center of view in the video feed. Using thrusters, the ROV descended through the water column to the seafloor, with the down-line continuously in view of the video feed to ensure the ROV arrived at the seafloor near the clump weight and pot target.

Upon reaching the seafloor, the video feed and sector scanning sonar displays were monitored. The scanning sonar provided the ROV operator with an image of the seabed, the nearby clump weight and buoy, and potential targets within a 30 m radius of the ROV (Figure 3). Distance and azimuth to the derelict gear targets were calculated using the scanning sonar display and the compass attached to the ROV. Tilting the video camera on the ROV, the ROV operator followed the compass course to the derelict pot target. The progress of the ROV toward the target was monitored with the scanning sonar image. When the ROV arrived within 2 m of the derelict pot target, the video camera was tilted up from the view of the compass to scan the seabed for a visual image of the target.



Figure 3. Sector scanning sonar display (right) and live video feed (left) from ROV.

A series of assessments occurred once the derelict gear targets was identified on the video screen. First, the target was identified by the source fishery; either Dungeness crab pot or shrimp

pot. Second, with closer inspection, the presence or absence of rockfish nearby and inside the pot were recorded. Third, the pot was inspected to determine whether it was disabled or still capable of entrapping animals without providing an escape route. Then to the extent possible, the species type and number of animals inside the pot was recorded. Finally, the surrounding area was surveyed for any potential snag hazards that would inhibit removal of the gear with the ROV, or endanger the ROV to become fouled or snagged in the derelict gear, especially buoy lines associated with pot gears. If the team decided to remove the derelict pot, two similar methods were used. One was simply attaching to a portion of the pot with the manipulator arm and grabbing tool, followed by slow and steady retrieval of the ROV to the vessel by hand via the umbilical. The other method included returning the ROV to the clump weight where the grabbing tool was used to grab one of the grappling hooks and take it back to, and hook into the pot. The ROV then backed away from the pot and returned to the vessel, while the clump weight and attached line, grapple hook, and derelict pot were recovered onto the vessel via the hydraulic crane. This method was used when the visual inspection of the pot suggested that removal would possibly over-stress and potentially break the manipulator arm and/or grabbing tool.

Once at the surface, the derelict pot was released from the ROV manipulator arm and secured at the stern of the vessel while the ROV was lifted onto the swim-step. The pot was then brought onboard the vessel and inspected by the OC. All live or dead animals and as much algae and plant growth as possible was returned to the sea. The number and species of live and dead animals released per pot were recorded, as was whether the pot was actively fishing, whether it had been equipped with legally compliant escape cord, if owner ID was present, if the pot had been augmented with added weight, and if the pot was likely the original target identified in the sidescan sonar surveys that occurred in 2012. Additionally, if any rockfish or other groundfish were inside the pot, they were identified to species, measured for length, then immediately descended and released at depth using a rockfish descending device to minimize the effects of barotrauma.

At each anchoring location, the ROV was re-deployed until all pot targets within the working radius of approximately 50 m were investigated and, if appropriate, removed.

Removed derelict fishing gear were stored in a secure location in King County. Pots in poor condition were recycled at the Vashon Recycling & Transfer Station; while those in fair to good condition continue to be stored for potential use in future research.

Results

ROV-based derelict shrimp pot removals in the operational areas off Mukilteo and Edmonds took place on June 26, July 24-25, and August 6-8, 2019. A total of 49 derelict pot target

locations identified in the 2012 sidescan sonar surveys were investigated, and an additional 16 derelict gear items were found; 65 total targets were investigated. Of the targets investigated, 38 were derelict crab pots (9 removed, 28 left in place, 1 disabled), 15 were derelict shrimp pots (12 removed, 3 left in place), four (4) were tires that were left in place, one (1) was a large pile of rope/line left in place, and 10 were not found. Project personnel estimated that 47 of the targets investigated, including the 10 not found, were original targets identified during sidescan sonar surveys in 2012, and 21 (18 crab pots, 3 shrimp pots) of the gear items found were deposited since the 2012 surveys. Of the original sidescan targets identified, 12 (26%) were shrimp pots, 20 (43%) were crab pots, 10 (21%) were not found, and five (5; 11%) were other debris items (tires and lines). All derelict pots were found in water depths ranging from 37 m (120 ft) to 90 m (294 ft) on mud and mixed sand/mud/gravel/vegetation substrate. Of the total 53 derelict pots identified during investigations, 28% were shrimp pots and 72% were crab pots. See Figure 4 for locations and types of derelict gear removed.

Derelict Crab Pots

Of the 38 targets identified as derelict crab pots, three (3) pots were from the commercial fisheries, and 35 were from the recreational fishery. Two (2) pots (1 commercial, 1 recreational) were deemed “fishable”, without an egress route for entrapped crab to escape. Four (4) pots were piled together along with a mass of entangled buoy lines that extended up into the water column, representing what is regionally termed a “*flower pot*”. Due to ROV entanglement concerns, the flower pot was left in place. Of the 38 crab pots investigated, 33 (2 commercial, 31 recreational) were determined to have been equipped with legally compliant escape cord, and the use of escape cord could not be discerned on five (5) pots. Twenty-seven (27) of the 35 recreational crab pots found were collapsible square Danielson® pots. Of the nine (9) recreational crab pots removed, two (2; 22%) were equipped with augmented weights, while seven (7; 78%) did not have added weights attached. Nineteen (19; 95%) of the 20 crab pots identified in the 2012 sidescan sonar surveys were not fishable and partially dilapidated, and one (1; 5%) was too entangled in other pots and lines (flower pot) to be investigated closely.

Three live male Dungeness crab and one live male red rock crab were found entrapped in the derelict crab pots removed. Derelict crab pots were identified in waters depths from 37 m (120 ft) to 87 m (286 ft). Juvenile copper and quillback rockfish were observed near 32 (84%) and inside 20 (53%) of the derelict crab pots at the time of investigation (Figure 5). Of note, the rockfish inside the derelict crab pots were not entrapped, and were observed swimming freely in and out of the pots on the video feed.

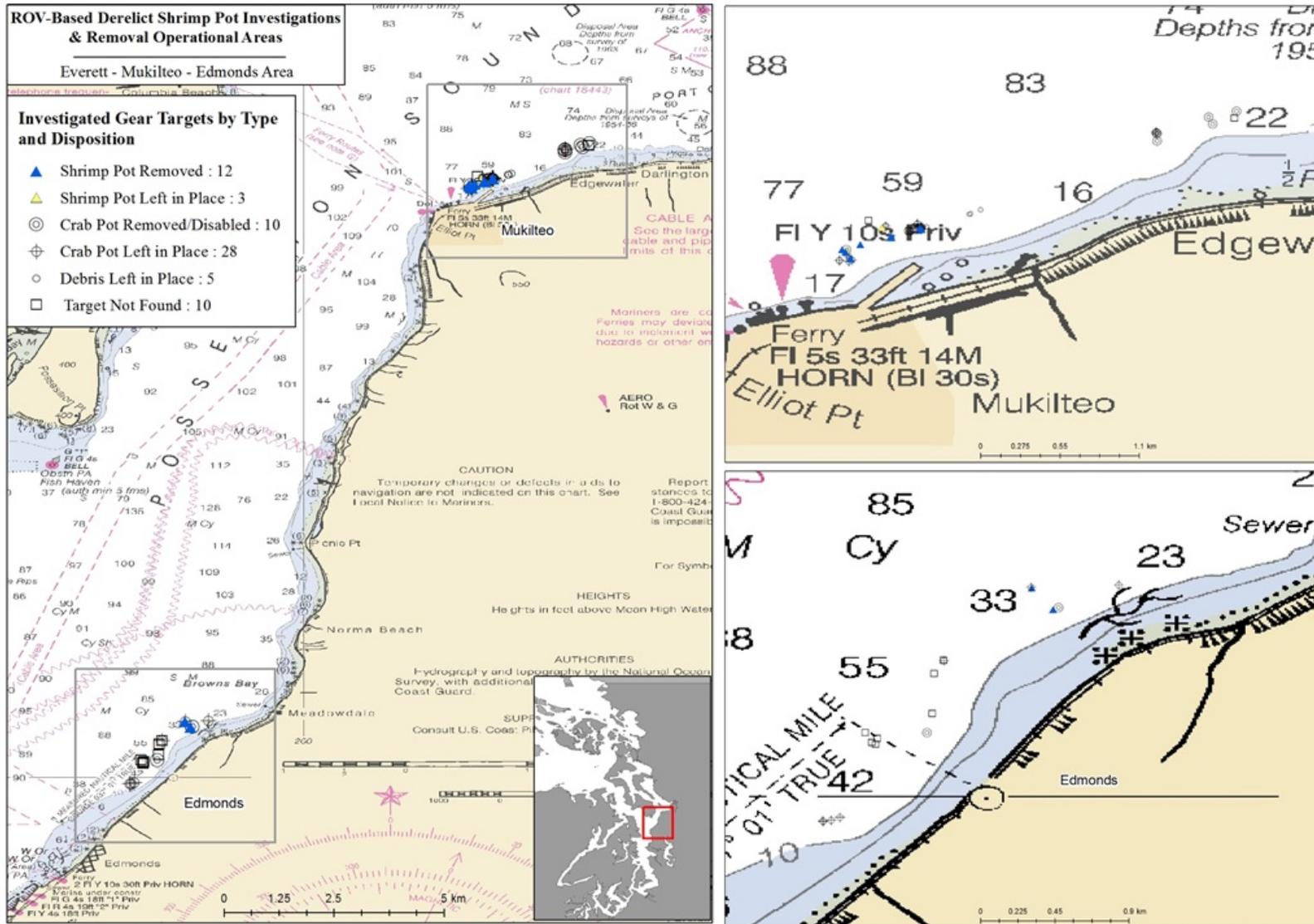


Figure 4. Type and disposition of ROV-based derelict shellfish pot investigations by entire operational area (left), Mukilteo area (top right), and Edmonds area (bottom right).

Derelict Shrimp Pots

Of the 15 derelict shrimp pots identified during ROV investigations, 13 (87%) were square wire mesh pots with two to four entry tunnels, and two (2, 13%) were metal framed truncated cones surrounded by nylon



Figure 5. Two common types of shrimp pots used in Puget Sound; wire mesh (left), nylon mesh (right).

mesh with three entry tunnels (Figure 5). The wire mesh pots are more commonly associated with the recreational fishery, and the nylon mesh pots with the commercial fisheries; however, both styles are used in each of the commercial and recreational fisheries, therefore we did not distinguish the source fishery of the shrimp pots investigated (Antonelis et al. 2018). Six (6; 40%) pots were determined to be fishable, or remiss of egress routes through which entrapped animals could escape, and nine (9; 60%) pots exhibited egress routes either by designed escape panels open after escape cord degradation, or by holes developed from rust and general degradation of the pot itself. Four (4; 27%) pots had not been equipped with escape cord, and the remaining 11 (73%) shrimp pots were equipped with escape cord. Escape cord was deteriorated



Figure 6. Juvenile rockfish using derelict shrimp pots as habitat.

on 10 wire mesh pots, but was still intact on one of the nylon mesh pots. It should be noted that shrimp pot entry tunnels are not equipped with trigger gates, meaning that they constantly remain open; therefore, in many cases animals small enough to enter the pots can also exit freely.

Seven (7; 58%) of the 12 shrimp pots identified in the 2012 sidescan sonar

surveys were not fishable and partially dilapidated, and five (5; 42%) were considered to be fishable; without egress routes beyond the entry tunnels. Three (3) of the fishable pots had not been equipped with legal escape cord, one (1) had been equipped with legal escape cord but was laying upside down on the seabed so that the escape panel was inaccessible, and one (1) had escape cord that oddly had not deteriorated.

Juvenile copper and quillback rockfish were seen at the location of 12 (80%) derelict shrimp pots, and not present at three (3; 20%) of the derelict shrimp pots investigated (Figure 6). Juvenile rockfish were observed on the video feed inside 11 (73%) of the derelict shrimp pots, and found inside four (4; 27%) shrimp pots upon gear recovery (Figure 7). A total of five (5) live rockfish (3 quillback, 2 copper) ranging from 12.7 cm (5 in) to 17.8 cm (7 in) were found inside those four shrimp pots (Table 1). Based on 12 derelict shrimp pots removed, the rockfish bycatch rate per derelict shrimp pot removed during this project equates to 0.417 rockfish per pot. Insufficient evidence was available to determine with certainty that those rockfish were entrapped inside the pots without being able to escape through the tunnels or holes in the pots.

Additional species found inside removed derelict shrimp pots upon recovery were: one (1) decorated warbonnet (*Chirolophis decorates*), three (3) red rock crab, two (2) spot prawn, and four (4) red brotula

(*Brosmophycis marginata*). The red brotula were found in pairs, and in each case the pair were exactly the same length (24.1 cm and 38.1 cm) (Figure 7) (Table 1). Additionally, several large plumose anemones (*Metridium spp.*) were attached to nearly all derelict pots investigated during the project.

Shrimp pots were investigated in water depths ranging from 50.3 m (165 ft) to 89.6 m (294 ft). Within these water depths where shrimp pots were found, 33% of pots investigated were shrimp pots, and 67% were crab pots. In water depths of 76.2 m (250 ft) and deeper, shrimp pots



Figure 7. Juvenile copper rockfish (top left, bottom left), quillback rockfish (top right), and red brotula (bottom left, bottom right) found inside recovered derelict shrimp pots.

accounted for 44% of the pots identified, supporting the expectation of project personnel that on the fishing grounds shared between the spot prawn and Dungeness crab fishery, the ratio of derelict shrimp pots to crab pots increases with depth (Figure 8).

Table 1. Number of individuals per species found inside derelict shellfish pots per gear type, with associated length of each individual finfish.

Gear Type	Common Name	Scientific Name	No. of Individuals	Finfish Length (cm)			
				Ind. 1	Ind. 2	Ind. 3	Ind. 4
Crab Pot	Dungeness crab	<i>Cancer magister</i>	3				
	red rock crab	<i>Cancer productus</i>	1				
Shrimp Pot	copper rockfish	<i>Sebastes caurinus</i>	2	17.8	12.7		
	quillback rockfish	<i>Sebastes maliger</i>	3	14.0	16.2	17.8	
	red brotula	<i>Brosmophycis marginata</i>	4	38.1	38.1	24.1	24.1
	decorated warbonnet	<i>Chirolophis decoratus</i>	1	27.9			
	red rock crab	<i>Cancer productus</i>	3				
	spot prawn	<i>Pandalus platyceros</i>	2				

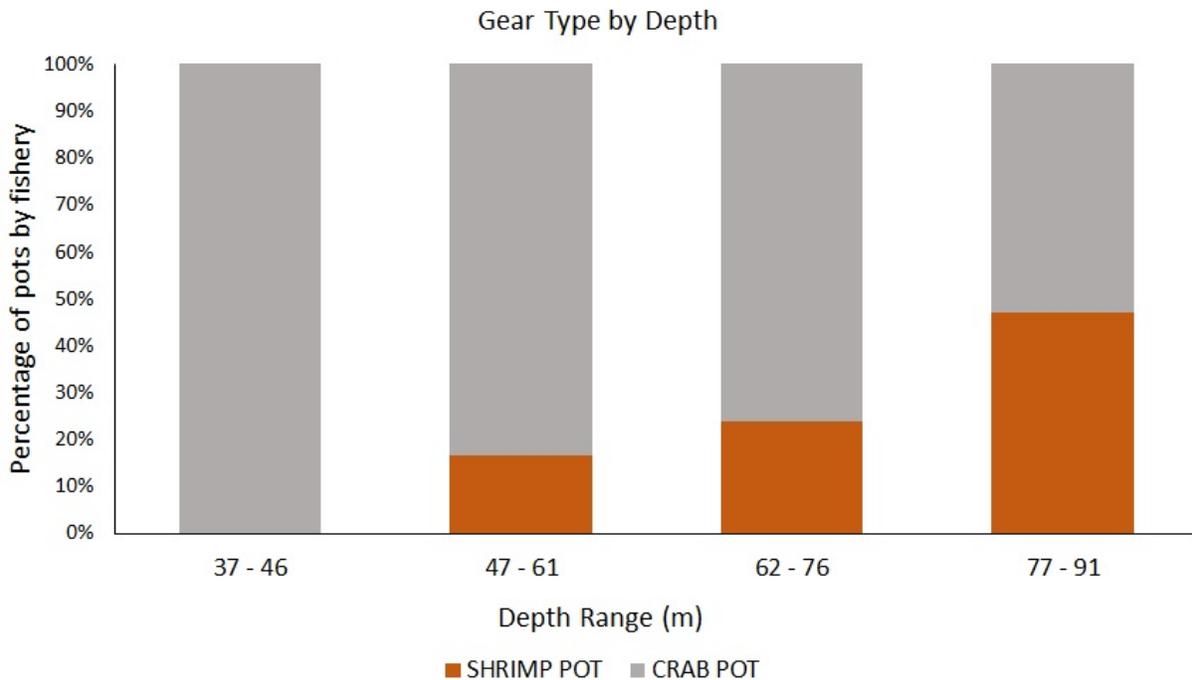


Figure 8. Percentage of pot gear by source fishery (gear type) by water depth ranges investigated during ROV-based operations.

Discussion and Conclusion

During seven days of ROV-based derelict shrimp pot removal operations, several project goals were achieved. NOAA PRD, NRC, and NWSF highly anticipated this opportunity to investigate the rockfish presence in derelict shrimp pots since they were surveyed in 2012. The bycatch rate of 0.417 rockfish caught per derelict shrimp pot removed during the project is much higher than the 0.167 catch rate observed in shrimp pots removed incidentally during NWSF and NRC derelict crab pot removals in Puget Sound (Antonelis et al. 2018). Additionally, data from this ROV-based removals suggest that 33% (4 of 12) of all derelict shrimp pots may contain ≥ 1 rockfish, whereas data from previous removals suggest only 5% (3 of 60) of derelict shrimp pots contain rockfish. While the results from this project are based on a relatively small sample size, it is possible that this difference is reflective of the water depths at which the pots were found. The 12 shrimp pots removed during this project were found in water depths more typically associated with rockfish habitat, whereas prior to this project, shrimp pot removals occurred only when found in shallower waters depths (below 32 m). Further investigations and removals of derelict shrimp pots in the primary fishing grounds from 60 m to 120 m water depth will provide a larger sample size to determine rockfish catch rates in derelict shrimp pots, and greater opportunity to find evidence of rockfish becoming entrapped in shrimp pots without capability of escapement. To this point research conducted by NOAA PRD, NWSF, and NRC has not found evidence of the ESA listed species, yelloweye or bocaccio in derelict shrimp pots; however, we believe that a larger sample size of investigated shrimp pots in rockfish habitat is needed to conclude whether or not they pose an entanglement risk to these species. Yelloweye rockfish have been documented as bycatch in shrimp pots in Canadian waters (Favaro et al., 2010).

The Phantom 2+2 observation class ROV proved to be capable of investigation and recovery of derelict shrimp pots in water depths up to 91.4 m (300 ft), and likely deeper, on steep slopes and in moderate tidal currents (< 2.5 knots). Although ROV operations are more expensive than dive operations due to equipment costs, ROV provide an additional safety advantage over dive operations; particularly in situations where derelict gear targets are beyond maximum safe diving depths. Using the buoyed clump weight as a reference point within the sector scanning image proved to be an effective method in monitoring the ROV's position relative to the support vessel, and locating derelict gear targets. Equipping the ROV with an acoustic tracking device to monitor the exact location of the ROV and targets of interest could increase efficiency in finding derelict gear targets with the ROV, particularly on steeply sloped areas that limit the range of the scanning sonar. An acoustic tracking device and the associated hardware/software comes at a relatively high-cost that did not fit within the scope of this project, and the buoyed clump weight method proved to be a cost-effective way to reference the ROV location in relation to the vessel and the investigated gear targets.

Thirty-two derelict shellfish pots (12 shrimp pots and 20 crab pots) removed during this project were targets identified during sidescan sonar surveys conducted in April 2012, suggesting that they maintained some of their structural viability for over seven years. This is not to say that these pots were all fishable, as many were partially dilapidated and exhibited missing components and sections. The 10 targets that were not found were assumed to have either moved from their original location, or had become completely dilapidated since the time of the sidescan sonar surveys. Research suggests that derelict crab pots remain structurally viable, and still fishable in the Salish Sea for approximately 2.2 years (Antonelis et al. 2011, Breen 1987), and the crab pot data from this project supports these estimates to some degree, as none of the crab pots found that were surveyed in 2012 were still fishing. Observations of shrimp pots during this project suggest that they may remain structurally viable and fishable in Salish Sea for much longer than crab pots, as 42% of those investigated that were surveyed in 2012 remained in fishable condition. These observations that shrimp pots, likely due to materials and design, do not degrade as quickly as crab pots emphasizes the importance of effective gear disabling mechanisms. Several of the wire mesh shrimp pots investigated and removed were equipped with an access door 17.8 cm x 17.8 cm (7 in x 7 in) on the topside of the pot that was held shut by a hook and strap. When equipped properly with escape cord, the hook and strap holding the access door becomes disengaged; however, there is no mechanism to ensure the access door would open, and it would likely take an amount of upward force for the access door to become an escape panel. On other shrimp pots investigated, the wire mesh tunnels were a part of a panel that completely fell away from the pot after escape cord degradation; allowing an unobstructed panel, approximately 20 cm x 20 cm (8 in x 8 in) available for any entrapped animals to escape through. Research conducted by NWSF and NRC on Dungeness crab pots found that unobstructed openings either along the wall or along the edge of the topside of a pot are significantly more effective escape mechanisms for crab entrapped in derelict pots than hinged access doors that require force beyond that of gravity to be opened (NRC 2015). While this research was not conducted on animals other than Dungeness crab, we suggest it is safe to assume that animals entrapped in a derelict pot will more easily identify and escape through an unobstructed hole in pot, rather than an obscure opening that requires force to be opened. Therefore, we recommend that, in order to reduce potential mortality of rockfish and other species, shrimp pots be equipped with escapement mechanisms that provide an open and unobstructed panel either on the side or on the topside edge of the pot after escape cord degradation.

Acknowledgements

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