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FINAL REPORT

PORT GARDNER & MUKILTEO 2018 DERELICT FISHING GEAR REMOVAL PROJECT AND STUDY AREA ANALYSIS

PREPARED FOR:

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Introduction

Every year crab pot gear is lost in Washington waters of the Salish Sea due to entanglement with debris, vessel hits, vandalism, and other reasons. These lost crab pots cause negative economic and environmental impacts.¹ Identification, location, and safe removal of derelict crab pots reduce these destructive impacts of derelict fishing gear, as has been demonstrated in previous derelict gear removal projects in the Salish Sea and elsewhere. This project builds on past efforts of the Northwest Straits Foundation (NWSF) to understand and eliminate negative impacts of lost crab pots in the Salish Sea by removing lost crab pots from marine habitats in Port Gardner and off the Mukilteo shoreline in Snohomish County.

For several years, the Snohomish County Marine Resources Committee (MRC) and the Northwest Straits Initiative (NWSI) has worked to solve the problem of derelict fishing gear in Snohomish County marine waters through education programs and support for derelict fishing gear removal operations. In 2004 and 2005, the Snohomish MRC focused survey and removal efforts in the commonly fished commercial, Tribal and recreational Dungeness crab (*Cancer magister*) fishing area of Port Gardner. In 2008, the MRC supported a survey and removal project in Port Gardner just west of Jetty Island outside the Port of Everett. The 2008 operations overlapped an area where derelict crab pot surveys and removals were conducted in 2004 and 2005. This area has been identified as the Port Gardner Study Area and repeated surveys and removal in the Study Area have been completed in 2008, 2009, 2011, 2012, 2013, 2015, 2016, and now in 2018. Along with the goals of removing derelict crab pots that impact the local resource and marine ecosystem, multiple years of completed surveys and removals within the same area provide an opportunity to analyze gear loss over time. This also allows for observing changes in the rate of compliance by fishers regarding use of legally mandated escape cord in both the commercial and recreational crab fisheries. These are important factors with respect to the impacts of derelict gear on the valuable Dungeness crab resource.

Additionally, derelict crab pot surveys and removal operations along the Mukilteo shoreline were conducted in 2008, and more recently in 2016. A portion of the previously surveyed areas were surveyed during this project in 2018, and gear was removed; allowing for an analysis of gear loss in the area between September 2016 and February 2018.

The goals of the Northwest Straits Foundation (NWSF) 2018 Port Gardner and Mukilteo derelict gear project were to locate and remove derelict crab pots (lost in the 2016 and 2017 fishing seasons) from the Port Gardner Study Area in the commonly fished commercial, Tribal and recreational Dungeness crab (*Cancer magister*) fishing area of

¹ Antonelis, K., D. Huppert, D. Velasquez and J. June. 2011. Mortality of Dungeness crabs due to lost traps and the cost benefit of removal in Washington State waters of the Salish Sea. *North American Journal of Fisheries Management*, 31:5, 880-893.

Port Gardner and Mukilteo; to document compliance with escape cord regulations; and to assess reason for pot loss. In addition to the standard gear characteristics and impact (species entrapped) information collected and summarized, in-water and out-of-water analysis of each derelict crab pot and its components were conducted to determine the most likely cause for pot loss. Additionally, derelict crab pot removal data summarizing number of pots lost and escape cord compliance in the Port Gardner Study Area during 2015 fishing seasons was compiled with data provided in NRC reports completed in December 2012, December 2013, June 2015, and November 2016, and summarized here. Combined, these report components will increase the ability to identify trends and/or anomalies in the characteristics of the lost gear in the area, and the practices of the recreational and commercial fishers utilizing these fishing grounds.

The Northwest Straits Foundation secured funding from Washington Department of Fish and Wildlife (WDFW) for derelict crab pot survey and removal operations. The Foundation then contracted with Natural Resources Consultants, Inc. (NRC) to manage the project. The removal operations were coordinated with the WDFW, Snohomish County, Tribal governments, NOAA, the U.S. Fish and Wildlife Service (USFWS) and the U.S. Coast Guard (USGC).

Scope of Work

The project consisted of 2.5 days of sidescan sonar survey fieldwork in Port Gardner and Mukilteo, with an associated 0.50 days of post-survey processing. This was followed by 7.0 days of dive removal operations for derelict crab pot targets. Dive removal operations were conducted in the commonly fished area immediately west of Jetty Island in Port Gardner, and along the Mukilteo shoreline. During derelict gear removal operations, project personnel performed data collection methods to include a visual analysis of the derelict gear removed to estimate the reason for pot loss for each target. Additionally, pot loss rate and escape cord compliance was compared to summaries of data collected from previous years in the Port Gardner Study Area and in portions of the Mukilteo survey areas.

Methodology

Sidescan Sonar Survey

Fenn Enterprises performed the sidescan sonar surveys in Port Gardner and Mukilteo on February 4, 5, and 6, 2018, followed by 0.50 days of post-survey processing. A Marine Sonic sidescan sonar system operating at 600 kHz with a differential global positioning system (DGPS) was used during the survey to locate derelict fishing gear. The sonar system employed a heavy towfish, towed off the bow of an 8 m (26 ft) survey vessel. A hydraulic winch and cable controlled the depth of the towfish. The sidescan sonar image

was projected on a monitor onboard the vessel and recorded onto a computer hard drive for later processing.

The sidescan sonar survey was conducted at an average speed of 4.63 km/hr (2.5 knots) with a sonar signal range of 50 m on both sides of the vessel for an approximate path width of 100 m (328 ft). Survey depths generally ranged from about 3 m (10 ft) to 32 m (105 ft) in order to identify derelict fishing gear within the dive depth capabilities of the recovery team.

The intent of the sidescan sonar survey was to locate derelict crab pots lost in the 2016 and 2017 fishing seasons to be removed from the previously cleaned Port Gardner Study Area and Mukilteo. Counts and precise locations of derelict fishing gear were recorded during post-survey processing of the data. The products from the sidescan sonar survey included a trackline file of the area surveyed, calculation of the area covered and the positions (latitude and longitude) of likely derelict fishing gear targets found (Figure 1).

Derelict Fishing Gear Removal

Fenn Enterprises was contracted to conduct the dive recovery operations of crab pots in the Port Gardner and Mukilteo areas. Two divers equipped with SCUBA operated off a 12 m (40 ft) dive support and gear recovery vessel, the R/V *Surveyor II*. Derelict gear target locations derived from the sidescan sonar survey were transferred into electronic navigation software (Nobeltec®) as waypoints and plotted over navigation charts of the area. The NRC Operations Coordinator (OC) selected target locations for removal.

Using GPS and Nobeltec, the dive support vessel was directed to the exact location of the potential derelict gear targets. When the vessel arrived at the target location, a clump weight with a line and float was deployed at the target location. The dive support vessel drifted nearby as a single diver was deployed, while a safety backup diver stood by on deck. A 30 m (100 ft) length of rope was passed through a loop on the rope near the clump weight and the diver held the other end. Typically, the clump weight landed within two meters of the derelict gear target and the diver visually located the derelict pot. However, in poor water visibility conditions the diver would drag the 30 m rope around the clump weight in a circle until it tangled with the derelict fishing gear and then the diver worked back along the rope to the gear. The derelict gear was freed by hand by the diver and a recovery line from the vessel was attached and it was hauled aboard the recovery vessel with a hydraulic winch.

A variety of information about each derelict crab pot was reported by the diver to the OC or observed directly onboard the support vessel. Data recorded by the OC included whether the derelict pot was from the commercial or sport (recreational) fishery, whether it was equipped with escape cord, whether the gear was actively fishing or not, and the number of live and dead Dungeness crab and other entrapped organisms. Also documented was information about the overall condition of the gear, the depth and type

of seabed where the gear was located, and if there was any evidence that would elucidate the reason the pot was lost. The OC also searched for owner identification, and if present, recorded contact information that was later used to coordinate returning gear items to their owners.

Throughout the removal project period, the derelict fishing gear was stored in a locked secure waste container in the parking lot of the 10th Street public boat ramp in the Port of Everett until pots were either returned to their owners, transferred to a secure location, or transferred to the Snohomish County solid waste facility.

Investigating Reasons for Pot Loss

In order to successfully address the derelict crab pot issue in the Puget Sound region, it is important to understand why pots are being lost. The reasons for pot loss are many, and may vary depending on the area. While the full story behind each lost pot cannot be found through inspecting a derelict crab pot, much information about the probable reasons for pot loss can be found by investigating the gear both underwater and out-of-water. Therefore, since the Snohomish County MRC Port Gardner 2013 derelict gear removal project, careful attention has been given to investigating the reason for pot loss. The anticipated reasons for pot loss were divided into twelve categories: (1) line length to water depth mismatch, (2) vessel strike, (3) barge strike, (4) vessel or barge strike (5) tampering / sabotage, (6) gear malfunction (7) user error, (8) entanglement with other gear, (9) entanglement with something else, (10) other, (11) unknown and (12) abandoned. Divers were instructed to report to the OC any visual evidence they witnessed underwater that would explain why the pot was lost. At the surface, the onboard OC further inspected the pot and its components (i.e., harness, clips, buoy lines, etc.), looking for signs that could determine how each pot was lost; such as broken gear components, cut or tangled buoy lines, evidence of tampering or sabotage, significant structural damage, and more. Photographs of each removed crab pot were taken for future reference and further investigations, if needed.

Comparing Results from Derelict Pot Removals in Port Gardner & Mukilteo

In 2008, the derelict fishing gear survey and removal project in Port Gardner successfully surveyed and cleaned a specific area of heavily concentrated Dungeness crab pot fishing effort just west of Jetty Island outside the Port of Everett. The 2008 operations overlapped an area where derelict crab pot surveys were conducted in 2004 with subsequent removals in 2004 and 2005. This area has been identified as the Port Gardner Study Area and repeated surveys and removal in the Study Area have been completed in 2009, 2011, 2012, 2013, 2015, 2016, and in 2018. Additionally, during this project survey and removal efforts were conducted along the Mukilteo shoreline in areas where similar efforts occurred in September 2017. Along with the goals of removing derelict crab pots that impact the local resource and marine ecosystem, multiple years of completed surveys and removals within the same areas provide an opportunity to analyze

gear loss over time. This also allows for observing changes in the rate of compliance by fishers regarding use of legally mandated escape cord in both the commercial and recreational crab fisheries. These are important factors with respect to the impacts of derelict gear on the valuable Dungeness crab resource.

To calculate pot loss rates over time for the sport crab fishery, we identified how many fishing seasons occurred between derelict gear operations, which part of the year those seasons occurred (summer or winter) and how many days of fishing were available for sport fishers during those seasons. A standard unit of fishing effort was established based on effort in the summer fishing season. Sport fishing effort expended during winter seasons is significantly less than summer seasons and WDFW biologists estimate winter effort at 10% to 15% that of summer effort (D. Velasquez, personal communication). Therefore, a correction factor of 0.125 was applied to winter season days available to account for the difference in effort, standardizing the unit of effort measurement to summer day equivalent (SDE).

Spatial analysis of the sidescan sonar survey areas and derelict gear targets investigated per project was conducted using ArcGIS®. A detailed description of the differences in pot loss and escape cord compliance in the Port Gardner Study Area between projects from 2004 through 2012 were provided to Snohomish County in a report from NRC dated December 31, 2012², and reports of findings after the 2013, 2014, and 2015 fishing seasons were provided to Snohomish County and NWSF in subsequent reports^{3,4,5}. This document reports on how the data collected in 2018, on pots lost in 2016 and 2017, compares to those in Port Gardner from previous years, and provides the first analysis of annual pot loss along the Mukilteo shoreline. Some derelict pots exhibiting dilapidated characteristics as the result of likely being derelict for longer than the amount of time since the previous project were identified as such and not used in the analysis (Mukilteo only). Additionally, crab pot targets that were beyond maximum diver depth (BMDD), defined as greater than a depth of 32 meters (105 feet) were not included in the analysis.

Results

Sidescan Sonar Survey and Pot Removals

In the 2.5 days of sidescan sonar surveys conducted in Port Gardner and Mukilteo on February 4, 5, and 6, 2018, 4.12 km² were covered and 231 potential derelict crab pot targets were detected or 56.1 targets/km² (Figure 1). A total of 193 of the original targets were found to be derelict crab pots and were removed by divers. Of the targets investigated but identified as not derelict crab pots: two (2) were derelict shrimp pots that

² <http://www.snocomrc.org/media/1313/nrc-snocomrc2012-finalrpt-reduced.pdf>

³ <http://www.snocomrc.org/media/1309/2013-port-gardner-derelict-fishing-gear-project.pdf>

⁴ http://www.snocomrc.org/media/1312/nrc-portgardner2015_finalrpt_6-26-2015.pdf

⁵ contact author for copy of 2016 report at kantonelis@nrccorp.com

were removed, one (1) target was a partially buried tire of similar shape and size to a crab pot and was left in place, one (1) target was a tire that was removed, one (1) target was a large bait cage from crab pot gear and was removed, one (1) target was a hollowed tree stump and removed, two (2) targets were cement mooring blocks about the size of a crab pot that were left in place, three (3) targets were large rocks or groups of rocks with anemones growing on them, and one (1) target was a large wad of steel cable that was left in place. Ten (10) targets were not found, and upon investigation 16 targets were identified as beyond the safe maximum diver depth (BMDD) of 32 m (105 feet).

Derelict Crab Pot Removal

Derelict fishing gear was removed from Port Gardner and Mukilteo on February 9, 11, 12, 13, 15, 16, 20, and 21, 2018. A total of 211 crab pots, two (2) shrimp pots, and three (3) non-derelict fishing gear debris items were removed (Figure 2). A total of 193 derelict crab pots removed were identified in the sidescan sonar surveys, three (3) pots were found and removed by divers during removal operations, four (4) removed pots were identified by their marker buoys on the sea surface, and 11 pots were found by groundline attached to one of the pots identified in the sidescan sonar surveys. Derelict crab pots were removed from water depths ranging from 3.0 m (10 ft) to 73.2 m (240 ft) from mud and mixed sand/mud substrate⁶.

Of the 211 derelict pots removed, 74 (35%) were commercial pots and 137 (65%) were sport pots (Table 1). Seventy-five (75; 36%) pots were determined to be actively fishing and 136 (64%) were no longer fishing. Of the 211 pots removed, 27 (13%) were not equipped with legal escape cord, 182 (86%) had legal escape cord and two (2; 1%) pots were too deteriorated to determine whether escape cord was used or not. Of the 182 pots equipped with legal escape cord, the escape cord had disintegrated on 115 (63%) and was still intact on 67 (32%) pots.

Of the 74 commercial pots recovered, 55 (74%) were equipped with escape cord, and 19 pots (26%) were observed to be non-compliant with escape cord regulations. Eight (8; 6%) of the 137 sport pots were not equipped with legal escape cord, 127 (93%) had legal escape cord, and the use of escape cord could not be determined on two (2; 8%) sport pots. Of the 75 crab pots found to still be fishing, 17 (23%) were not equipped with proper escape cord and 58 (77%) had legal escape cord that had either yet to deteriorate (56 pots) or were still fishing even after the escape cord had disintegrated (2 pots) due to the pot lid being inadvertently held shut by the large rubber bands that hold the door in place in conjunction with the escape cord and door hook when actively fishing.

Of the 211 derelict pots recovered, 67 (32%) pots contained a total of 344 Dungeness crab and three (3) red rock crab (*Cancer productus*) (Table 1). Of the 344 Dungeness crab recovered, 322 (94%) were live and 22 (6%) were dead. Twenty-two (6%) of the

⁶ Pots removed from beyond water depths of 32 m (105 ft) were removed by hauling the attached line through the hydraulic winch, not by divers.

Dungeness crab recovered were females (18 live and 4 dead). Three hundred twenty-two (322; 94%) were males (304 live and 18 dead). Derelict pots determined to be still actively fishing contained 290 (84%) Dungeness crab (272 live and 18 dead). Pots determined to be no longer actively fishing contained 54 (16%) Dungeness crab (50 live and 4 dead). Crab pots without legal escape cord contained 88 (26%) Dungeness crab (83 live and 5 dead). Crab pots with legal escape cord contained 256 (74%) Dungeness crab (239 live and 17 dead), 79% of which were found in pots that had escape cord still intact.

Other animals found in the crab pots removed included 60 live mottled starfish (*Evasterias troscheli*), one (1) live northern kelp crab (*Pugettia productus*), and six (6) live slender cancer crab (*Cancer gracilis*).

Four (4) non-tribal commercial pots with owner identification were returned to their owners. Tulalip Tribal marine enforcement personnel retrieved 37 Tulalip tribal pots to be returned to owners. Nineteen (19) pots with ID representing that of Suquamish tribal fishers were returned to the Suquamish Tribal Headquarters. Six (6) usable sport pots were given out to the public during offloading activities at the marina. A total of 10 sport pots in good condition and not exhibiting owner identification were transported and stored in a secure location to be used as give-away or auction material at derelict fishing gear outreach/education events sponsored by the Northwest Straits Foundation, Snohomish County MRC, and/or NRC. Pots removed from Port Gardner and Mukilteo that were not returned to owners or saved for later use were transported and disposed of at the Snohomish County Southwest Recycling and Transfer Station facility where the total weight of gear disposed was approximately 3,200 lbs.

Investigating Reasons for Pot Loss

Based on the information provided by removal divers and inspection of recovered gear on the removal vessel deck, the estimated reason for gear loss was determined for 150 (71%) of the 211 pots removed. In cases where the evidence suggested multiple reasons for pot loss, the OC decided upon the one most likely reason given the evidence, while also providing a potential alternate reason for the pot becoming derelict. Of the 140 derelict pots removed, 36 (17%) were determined to have been lost due to gear malfunction and/or user error (Table 2). This was often identified by broken gear components (i.e. clips, bridals, buoy sticks, etc.) or insufficient line capacity (too thin). Other evidence suggested that some buoys were not correctly attached to the pot, causing the line to release from the pot, and more evidence showed that buoys were released from buoy lines due to knots coming undone or knots being small enough to pass through the center hole of the buoy.

A distinction was made between vessel strikes and barge strikes based on the often mangled condition of relatively new pots, suggesting that their buoys had been snagged by a slow moving vessel (barge) and the pot was dragged across the seafloor until the line severed. Vessel strikes often exhibit a clean cut of the buoy line from a fast moving

propeller, or they leave an extremely wound-up buoy line with a much less clean cut after being wrapped multiple times in a slower-moving propeller and shaft. Vessel strikes were determined to be the cause of pot loss for 55 (26%) of the pots recovered and were evident by buoy lines being severed and sometimes wound up near the terminal end of the line. Vessel/Barge strikes were found to be the cause for 17 (8%) of the recovered pots to have been lost. (Table 2).

Evidence of tampering and/or sabotage of gear was evident in 25 (12%) of the removed pots. The term “suitcased” is used to describe a pot that has been retrieved (probably emptied) and then returned to the water after the buoy line with buoy has been coiled and secured inside the pot. This was evident in one (1) of the pots found, while one (1) pot was found to have the door left open with no line attached, and the remaining 22 pots were found to have a cleanly severed buoy line near its connection to the pot (Table 2).

A total of 16 pots removed were found to be entangled in non-derelict fishing gear related underwater obstructions. Two (2) pots had their lines wrapped around the pilings of a navigation aid marker or *dolphin*, and one (1) pot’s line was entangled with a partially buried derelict ship anchor. Thirteen (13) pots that were longlined together were categorized here since the longline eventually led to a large shipwreck, where whatever gear remaining was entangled and unable to be removed.

Twelve (12; 6%) pots with un-entangled lines and buoys at the sea surface were categorized as abandoned. Four (4; 2%) pots had attached lines that were entangled in other fishing gear (crab pot gear), and one pot was determined to have been lost due to insufficient amount of line for the water depth being fished. Finally, 45 (21%) of the 211 pots removed did not exhibit enough evidence to determine a reason for pot loss, and were therefore categorized as ‘unknown’ (Table 2).

Additionally, the OC noted that added weight, in a variety of forms of lead and steel, were added to 32 (23%) of the 137 derelict recreational pots removed, and no augmenting weights were added to 105 (77%) of the recreational pots removed.

Comparing Results from Multiple Years’ of Derelict Pot Removals in Port Gardner Study Area

Derelict pot density (pots/km²) and analysis of escape cord compliance within the Port Gardner Study Area were calculated for 2016 and 2017 fishing seasons based on data collected during this project in February 2018. Pot loss rates were calculated within the Study Area for 2016 and 2017 fishing based on survey area covered, number of available fishing day opportunities and number of confirmed derelict crab pots. They are summarized in Tables 3 and 4 along with the corresponding data from removal operations conducted in 2004/2005, 2008, 2009, 2011, 2012, 2013, 2015, and 2016.

For the 2018 derelict pot removal project, 1.96 km² of the entire 2.46 km² survey area was within the bounds of the Study Area and 1.94 km² overlapped the 2016 survey area

inside the Study Area. A total of 126 confirmed derelict crab pots (41 commercial and 85 sport) or 64.95 pots/ km² (21.13 pots/ km² commercial and 43.81 pots/ km² sport) were removed from the Study Area; all were considered to be newly lost since the previous (2016) removal operations, during the 2016 and 2017 fishing seasons, based on their age and condition (Table 3 and Figure 3). Recreational crab fishing opportunities in the Port Gardner area between removal operations in early 2016 and removal operations in early 2018 included the entire summer seasons in 2016 and 2017, and the entire winter 2016 and 2017 winter seasons. Combined, these seasons totaled 261 available fishing days (97 days in summer and 164 days in winter). To account for the significant difference in effort between summer and winter seasons we standardized the amount of available days to summer day equivalents (SDE) by applying a correction factor of 0.125 to the amount of winter days available resulting in a total of 118 SDE available for recreational crab fishing during the period. This provides a sport pot loss rate of 0.72 pots lost/SDE (0.37 pots/km²/SDE) between 2016 and 2018 derelict gear operations (Table 4). The use of escape cord could be discerned on all 41 of the newly lost commercial pots; of those, 30 (73%) were properly equipped with legal escape cord, and 11 (27%) were not equipped with legal escape cord. Escape cord use could be determined on 83 of the 85 newly lost sport pots removed; of those, 78 (94%) were equipped with legal escape cord, and five (5; 6%) were not (Table 5).

The overall number and density (pots per area) of crab pots lost within the Study Area continues to show a downward trend over time since derelict gear survey and removals began in 2004, even with the spike in total pots seen in the 2016 data (Table 3, Figure 4). The sport pot loss rate (pots lost per day) decreased in 2011 and 2012, then increased from 0.64 pots/day (0.33 pots/km²/day) in 2012 to 1.31 pots/day (0.68 pots/km²/day) in 2013; reflecting an increase of 104% from the previous period. That increase was followed by a 70% decrease from 1.31 pots/day to 0.39 pots/day (0.20 pots/km²/day) within the recreational fishery inside the Port Gardner Study Area from during the 2014 fishing seasons. The pot loss rate substantially increased to 1.46 pots/day (0.74 pots/km²/day) during 2015 fishing seasons; representing a 270% increase from the 2014 to 2015 fishing seasons. However, data collected in 2018 for the 2016 and 2017 fishing seasons show a drop in sport pot loss rates from the 1.46 pots/day reported in 2016, to 0.72 pots/day reported here (Tables 3 and 4, Figure 5).

Escape cord compliance observed in derelict commercial pots within the Study Area has generally shown an increase over time; however, 73% compliance observed in 2018 is the lowest since the 68% compliance (excluding “Unknown”) observed in 2004/2005 (Table 5, Figures 6 and 7). The average observed escape cord compliance within recovered commercial pots in the Port Gardner Study Area from 2004/2005 to present is 80.3% (99% CI = 72.5% - 88.0%). Within the sport fishery, the observed escape cord compliance went from 79% pot compliance in 2004/2005 to 100% pot compliance in pots removed in 2008. Escape cord compliance reached a low of 77% in pots removed in 2009 followed by an increase to 95% pot compliance observed in 2011 operations. Escape cord compliance then dropped to 79% in the pots removed in 2012, increased to 95% and 96%

in 2013 and 2015; it decreased to 86% in 2016, then in 2018 returned to the mid-90% range at 94% escape cord compliance (Table 5, Figures 8 and 9). The average observed escape cord compliance within recovered sport pots in the Port Gardner Study Area from 2004/2005 to present is 88.9% (99% CI = 81.9% - 95.9%).

Dungeness crab catch and mortality in derelict crab pots removed from the Port Gardner “Study Area” and nearby have been thoroughly reported in the previous section of this document, as well as in the yearly reports from the previous removal projects. Therefore, the findings of Dungeness crab catch and mortality are not included in this analysis of newly-lost pots within the “Study Area”.

Comparing Results from Multiple Years’ of Derelict Pot Removals in Mukilteo

Preliminary analysis was conducted on data collected offshore of the north-facing shoreline of Mukilteo, where in September 2016 derelict crab pot survey and removal efforts were completed clearing the area of derelict crab pots up to 32 m (105 ft) water depth. In 2016 the total pot density in the North Mukilteo area was 145.31 pots/km² (27.34 pots/km² commercial and 117.97 pots/km² sport); the relatively high density numbers representing several years of lost pot accumulation. In February 2018 the newly lost pot density in this same area was, as expected, much less at 41.53 pots/km² (8.47 pots/km² commercial and 33.05 pots/km² sport) (Table 6 and Figure 10). There were a total of 134 (48 summer and 86 winter) fishing days in the recreational Dungeness crab fishery between the two projects, equaling 59 SDE. With 39 newly lost sport pots identified in the North Mukilteo survey area during the February 2018 operations, we derive a sport pot loss rate of 0.66 pots/day or 0.56 pots/km²/day.

Discussion & Conclusions

During this project, 100% of the original 231 sidescan sonar survey targets were investigated. Divers removed 198 (86%) of the 231 potential derelict fishing gear targets found during the sidescan sonar surveys along with 18 others that were not identified in the surveys. Derelict pot surveys and removal in the north Mukilteo area in 2018 showed that significant gear accumulation had occurred following the complete removal of gear 1.5 years earlier and that continued efforts in the area would help to reduce the negative impacts of derelict crab pots to the environment and economy of the region.

This project was the fourth derelict crab pot removal operation in the Port Gardner Study area that a removal team made efforts to identify the reason for pot loss on each of the derelict pots removed. Results from this analysis showed that in the 2016 and 2017 fishing seasons, the two most common reasons for pot loss in the area were either vessels strikes or gear malfunction and user error. Yet for the first time, vessel strikes were more common than gear malfunction and user error which was down 17% since the 2016 project. While further data would be needed to support reasons for this shift, it could signal a greater comprehension of best fishing practices by the regional recreational fleet, potentially a result of targeted public outreach by NWSF, WDFW, and others on best

fishing practices used to avoid losing gear. Other reasons for pot loss that were identified were tampering/sabotage, vessel/barge strikes, and abandonment. Because sidescan sonar surveys during these projects focus on water depths that are within the maximum allowable diver safety depths of 32 m (105 feet), they do not cover the steep slope just west of the Study Area, or north of the Mukilteo survey area where the water depth quickly increases from ≤ 27 m (90 ft) to over 32 m. In surveys conducted in previous years, several derelict crab pot targets were identified along this slope in water depths beyond 32 m. We assume that a common reason for those crab pots becoming derelict can be attributed to the line length and water depth mismatch, as fishers presume they are deploying their gear on the shallow side of the slope, when actually their pot lands on the deeper side of the slope to the west. Alternatively, pots deployed along the shelf may slide down the hill into deeper waters, or be moved into deeper waters by strong currents submerging the buoy. Recreational pots in particular have a greater tendency to migrate with strong currents or high tides due to their relatively light weight structure. This can be avoided by augmenting pots with additional weights, a practice included in the recreational crab fisher outreach. During this project 23% of the sport pots removed included added weight in the form of either lead or steel. This relatively low percentage of weighted pots suggests that continued and further encouragement for the recreational fleet adding weight to pots to help avoid gear loss is worthwhile.

Results show that the number of pots lost per fishing day opportunity within the recreational crab fishery in the Port Gardner Study Area in 2016 and 2017 fishing seasons was half of the observed loss rate of 2015 fishing seasons, 1.84 times the loss rate in 2014, and 0.55 the loss rate in 2013 fishing seasons. The most recent loss rates are quite similar to the loss rates observed in the 2009, 2010, 2011, and 2012 fishing seasons. The spike in pot loss rates in the 2013 fishing seasons was concerning, as results from the 2012 report concluded that the pot loss rates were continuing downward from year to year. While the data collected in 2015 initially suggested the 2013 season increase in pot loss rates was an anomaly, the results from 2016 operations (2015 fishing seasons) suggested that the fluctuations from year to year may reflect the reality of sport pot loss in the Port Gardner Study Area. The 2018 results show a leveling-out of sorts; however, the data continue to show little sign of predictable trends. Nevertheless, in the long term sport pot loss in the Study Area has continued to decrease since this study began in 2008, as the pots lost per fishing day opportunity in the 2016 and 2017 fishing seasons was 29% of what it was in 2008 fishing season (data collected in 2009 removals). Multiple factors could contribute to the year to year variation in pot loss in the Study Area, such as:

- Amount of fishing effort
- Recreational fleet's experience and knowledge of best fishing practices
- Amount of commercial and recreational vessel traffic
- Variations in weather
- Variation in WDFW and/or Snohomish County Sheriff pot sweep efforts

While there was a 10% decrease in escape cord compliance from the 2014 to the 2015 seasons, from 96% to 86%, results from 2018 operations show a reverse in that downtick, with a 94% escape cord compliance rate on pots lost from the 2016 and 2017 seasons. The lowest observed rate of escape cord compliance, 77%, was seen on pots lost in 2008. Similar to the variety of pot loss rates, this could reflect a year to year variation in the recreational fleet's experience and knowledge of best (and in this case, legal) fishing practices.

Without full investigation of commercial fishing effort between derelict gear projects in the Port Gardner Study Area, a pot loss by effort rate is not available. The total number of derelict commercial pots in the Study Area has never again matched the 39 pots found in 2009 (lost in 2008), and were as low as 11 pots in 2013. Since then, however, there has been an increase in derelict commercial pots in the Study Area; with 27 found in 2016 (lost in 2015), and 41 found in 2018 (lost in 2016 and 2017; avg. 20.5/yr). The general decreasing trend in pot loss between 2009 and 2013 may be attributed to both a change in fisher behavior as well as a decrease in available or appropriated fishing opportunities. While there has been an increase in number of commercial pots found within the Study Area in recent years, overall the commercial pot density remains much lower than the derelict sport pot density.

When evaluating pot loss over time, there are two key considerations that have made the years since 2015 in Port Gardner unique. One is that the 2015 season was the most productive in terms of available harvestable crab in recent history, therefore providing both commercial and recreational crabbers greater opportunity and incentive to increase effort and harvest. While harvest opportunities have tempered since then, there is likely a residual effect of such a booming season where fishers may attempt to recreate previous successes with maintained effort, even while harvests gradually drop. Second, in 2015, due to court ruling one Puget Sound Treaty Tribe was granted access to harvest Dungeness crab in the Port Gardner and Mukilteo region where they had not in recent history. Therefore, the size of the commercial (tribal) fishing fleet, and associated effort in Port Gardner is likely larger than it was a few years ago. Having new participants in a specific area such as Port Gardner may increase the likelihood of crab pot loss due to site-specific inexperience, as well as the potential for increased conflicts between user groups.

Recommendations

Based on the observations and results of the derelict gear removal project and analysis of data from previous years, the following are recommendations to further reduce the impacts of derelict fishing gear in the Port Gardner and Mukilteo area.

- **Recreational crabbers should be educated on the best fishing practices that prevent crab pot loss. The following is a list of practices that can reduce pot**

- loss:**
- Avoid high vessel traffic areas, ferry, barge and log tow routes
 - Remain near pots during soak time
 - Use weighted buoy lines to reduce potential vessel strikes
 - Use buoy lines of proper length (i.e., 1/3 longer than water depth)
 - Know the depth of water where pots are set
 - Use multiple buoys in high current areas to avoid buoy submersion
 - Augment pot weight to avoid pot migration in high currents
 - Leave ample spacing between pot drops to avoid buoy entanglement
 - Augment marker buoys with additional floats and/or poles with flags to make them more visible to vessel operators
- **Education programs should continue to include suggestions to recreational fishers to test the durability and functionality of all gear components and knots prior to deploying crab pots and replace items or re-tie knots if they seem to be compromised or faulty. This could reduce gear loss through gear malfunction and/or user error.**
 - **Education programs should include information regarding proper installation of escape cord, the use of thin vs. thick strands of escape cord, and that in order to comply with regulations, escape cord must be made of biodegradable material rather than synthetics such as nylon. In addition, special attention should be placed on the placement of bait clips, bait jars, bridles, etc., that can prevent the opening of a crab pot door despite the deterioration of escape cord.**
 - **The use of legal escape cord on crab pots should continue to be enforced.**
 - **Enforcement sweeps of pots left out during non-crabbing days during the recreational crabbing seasons should be increased, and information from those sweeps should be incorporated into annual loss rate estimates.**
 - **The Study Area should be surveyed and gear removed annually to eliminate the lost harvest due to derelict crab pots in such a popular crabbing location, and to further determine crab pot loss rates and gain greater information about the commercial and recreational fishing behaviors.**
 - **Targeted sidescan sonar surveys and pot removals utilizing remotely operated vehicles (ROV) should be performed in areas deeper than 105 feet to identify and remove gear, while also gathering information on the reasons for pot loss.**

Acknowledgements

The Port of Everett kindly provided free moorage for the dive support vessel and free storage of salvageable derelict crab pots during (and after) the project, their assistance was greatly appreciated. We also wish to thank the Northwest Straits Foundation and Snohomish County MRC for their continued support for this long-term project, and their dedication to eliminating the harmful effects of derelict crab pots in Puget Sound marine waters. Don Velasquez and Don Rothaus of WDFW, and Cathy Stanley and Mike McHugh of Tulalip Fisheries, assisted in planning by providing valuable fisheries updates and information prior to derelict gear operations.

Table 1. Total number of derelict pots recovered, type of pot (commercial or sport), fishing status (fishable or not), rot cord use and numbers of live and dead Dungeness crab observed in Port Gardner and Mukilteo during the NWSF 2018 derelict fishing gear project. Source: NRC.

Fishable/Not Fishable		Fishable			Not Fishable				All Pots			
		Rot Cord Use	Rot Cord	No Rot Cord	Total	Rot Cord	No Rot Cord	Unknown	Total	Rot Cord	No Rot Cord	Unknown
Commercial	# Pots Recovered	22	14	36	33	5	0	38	55	19	0	74
	# Dungeness Crab Dead	6	5	11	4	0	0	4	10	5	0	15
	# Dungeness Crab Alive	137	82	219	28	1	0	29	165	83	0	248
	# Red Rock Crab Dead	0	0	0	0	0	0	0	0	0	0	0
	# Red Rock Crab Alive	0	0	0	0	0	0	0	0	0	0	0
Sport	# Pots Recovered	36	3	39	91	5	2	98	127	8	2	137
	# Dungeness Crab Dead	7	0	7	0	0	0	0	7	0	0	7
	# Dungeness Crab Alive	53	0	53	21	0	0	21	74	0	0	74
	# Red Rock Crab Dead	0	0	0	0	0	0	0	0	0	0	0
	# Red Rock Crab Alive	0	0	0	3	0	0	3	3	0	0	3
All Pots	# Pots Recovered	58	17	75	124	10	2	136	182	27	2	211
	# Dungeness Crab Dead	13	5	18	4	0	0	4	17	5	0	22
	# Dungeness Crab Alive	190	82	272	49	1	0	50	239	83	0	322
	# Red Rock Crab Dead	0	0	0	0	0	0	0	0	0	0	0
	# Red Rock Crab Alive	0	0	0	3	0	0	3	3	0	0	3
# Total Crab		203	87	290	56	1	0	57	259	88	0	347

Table 2. Total number of derelict pots recovered by suspected reason for pot loss observed in Port Gardner and Mukilteo during the NWSF 2018 derelict fishing gear project, including change (Δ) in category since operations conducted in 2016. Source: NRC.

Reason for Pot Loss	No. of pots	% of total 2018	Δ from 2016
Vessel Strike	55	26%	+3%
Gear Malfunction or User Error	36	17%	-17%
Tampering/Sabotage	25	12%	+1%
Vessel/Barge Strike	17	8%	+3%
Entanglement with non-DFG	16	8%	+8%
Abandoned	12	6%	+5%
Entanglement with other gear	4	2%	+2%
Line length to water depth mismatch	1	0%	0%
Unknown	45	21%	-5%
Total Pots Removed	211	100%	

Table 3. Area surveyed, number of derelict pots recovered, and average derelict pot density documented during removal operations conducted 2009, 2011, 2012, 2013, 2015, 2016 and 2018 within the Port Gardner “Study Area”. Source: NRC.

Month & Year of Removal Operations	Crab Fishing Seasons since Prior Removal	Survey Area within 'Study Area' (square km)	Total # Pots Removed/Disabled			Pot Density (per km ²)			Area w/in 'Study Area' used for New Pot Loss Analysis (square km)	# Newly Lost Pots			Pot Density (per km ²)		
			Comm	Sport	Total	Comm	Sport	Total		Comm	Sport	Total	Comm	Sport	Total
Aug 2004 & Oct 2005	NA	1.59	68	98	166	42.77	61.64	104.40	NA	NA	NA	NA	NA	NA	
May 2008	NA	1.87	69	70	139	36.90	37.43	74.33	NA	NA	NA	NA	NA	NA	
May 2009	S'08	1.72	48	106	154	27.91	61.63	89.53	1.62	39	91	130	24.07	56.17	80.25
Apr 2011	S'09, S'10	1.81	40	71	111	22.10	39.23	61.33	1.81	33	57	90	18.23	31.49	49.72
Dec 2012	S'11, W'11, S'12, W'12	1.92	33	88	121	17.19	45.83	63.02	1.92	22	74	96	11.46	38.54	50.00
Dec 2013	S'13, W'13	1.94	14	74	88	7.22	38.14	45.36	1.92	11	73	84	5.73	38.02	43.75
Jan 2015	S'14, W'14	1.93	18	23	41	9.33	11.92	21.24	1.93	16	23	39	8.29	11.92	20.21
Jan 2016	S'15, W'15	1.98	36	101	137	18.18	51.01	69.19	1.98	27	93	120	13.64	46.97	60.61
February 2018	S'16, W'16, S'17, W'17	1.94	41	85	126	21.13	43.81	64.95	1.94	41	85	126	21.13	43.81	64.95

Table 4. Recreational fishing days available, number of pots lost, and loss rates for sport pots between operational periods 2009, 2011, 2012, 2013, 2015, 2016, and 2018 within the Port Gardner “Study Area”. Source: NRC.

Month/Year of Removal Operations	Crab Fishing Seasons since Prior Removal	Summer Season Days since Prior Removal	Winter Season Days since Prior Removal	Total Summer Day Equivalent (SDE)	# Newly Lost Sport Pots	Sport Pots Lost per km ²	Sport Pots Lost per SDE	Sport Pots Lost per km ² per SDE
May 2009	S'08	37	0	37	91	56.17	2.46	1.52
April 2011	S'09, S'10	83	0	83	57	31.49	0.69	0.38
December 2012	S'11, W'11, S'12, W'12	96	155	115	74	38.54	0.64	0.33
December 2013	S'13, W'13	45	87	56	73	38.02	1.31	0.68
January 2015	S'14, W'14	45	107	58	23	11.92	0.39	0.20
January 2016	S'15, W'15	50	92	64	93	46.97	1.46	0.74
February 2018	S'16, W'16, S'17, W'17	97	164	118	85	43.81	0.72	0.37

Table 5. Escape cord compliance observed in derelict pots recovered between operational periods 2009, 2011, 2012, 2013, 2015, 2016, and 2018 within the Port Gardner “Study Area”. Source: NRC.

Month/Year of Removal Operations	Crab Fishing Seasons since Prior Removal	Newly Lost Pots Inside "Study Area"		Escape Cord Used		Escape Cord Not Used		Escape Cord Unknown		% of Total Pots Equipped with Legal Escape Cord		% of Pots Equipped with Legal Escape Cord: Excluding Unknown	
		Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport	Comm	Sport
August 2004 & October 2005	NA	68	98	28	56	13	15	27	27	41%	57%	68%	79%
May 2008	NA	69	70	52	70	16	0	1	0	75%	100%	76%	100%
May 2009	S'08	39	91	27	68	9	20	3	3	69%	75%	75%	77%
April 2011	S'09, S'10	33	57	29	54	4	3	0	0	88%	95%	88%	95%
December 2012	S'11, W'11, S'12, W'12	22	74	18	57	4	15	0	2	82%	77%	82%	79%
December 2013	S'13, W'13	11	73	11	69	0	4	0	0	100%	95%	100%	95%
January 2015	S'14, W'14	16	23	12	22	4	1	0	0	75%	96%	75%	96%
January 2016	S'15, W'15	27	93	22	78	4	13	1	2	81%	84%	85%	86%
February 2018	S'16, W'16, S'17, W'17	41	85	30	78	11	5	0	2	73%	92%	73%	94%
*Pots removed were not determined to be newly lost or old Only data within 'Study Area' used in this analysis													

Table 6. Area surveyed, number of derelict pots recovered, and derelict pot density documented during removal operations conducted in 2016 and 2018 in the North Mukilteo survey area. Source: NRC

Month & Year of Removal Operations	Crab Fishing Seasons since Prior Removal	North Mukilteo Survey Area (square km)	Total # Pots Removed/Disabled			Pot Density (per km ²)			Survey Area Overlap 2016 and 2018	# Newly Lost Pots			Pot Density (per km ²)		
			Comm	Sport	Total	Comm	Sport	Total		Comm	Sport	Total	Comm	Sport	Total
Sep 2016	NA	1.28	35	151	186	27.34	117.97	145.31	NA	NA	NA	NA	NA	NA	NA
Feb 2018	W'16, S'17, W'17	1.23	12	40	52	9.76	32.52	42.28	1.18	10	39	49	8.47	33.05	41.53

Table 7. Recreational fishing days available, number of pots lost, and loss rates for sport pots between operational periods 2016, and 2018, in the North Mukilteo survey area. Source: NRC.

Month/Year of Removal Operations	Crab Fishing Seasons since Prior Removal	Summer Season Days since Prior Removal	Winter Season Days since Prior Removal	Total Summer Day Equivalent (SDE)	# Newly Lost Sport Pots	Sport Pots Lost per km ²	Sport Pots Lost per SDE	Sport Pots Lost per km ² per SDE
February 2018	W'16, S'17, W'17	48	86	59	39	33.05	0.66	0.56

Figure 1. Sidescan sonar survey effort and derelict crab pot targets found at Port Gardner and Mukilteo during the Northwest Straits Foundation 2018 derelict fishing gear project. Source: NRC, Inc. and Fenn Enterprises.

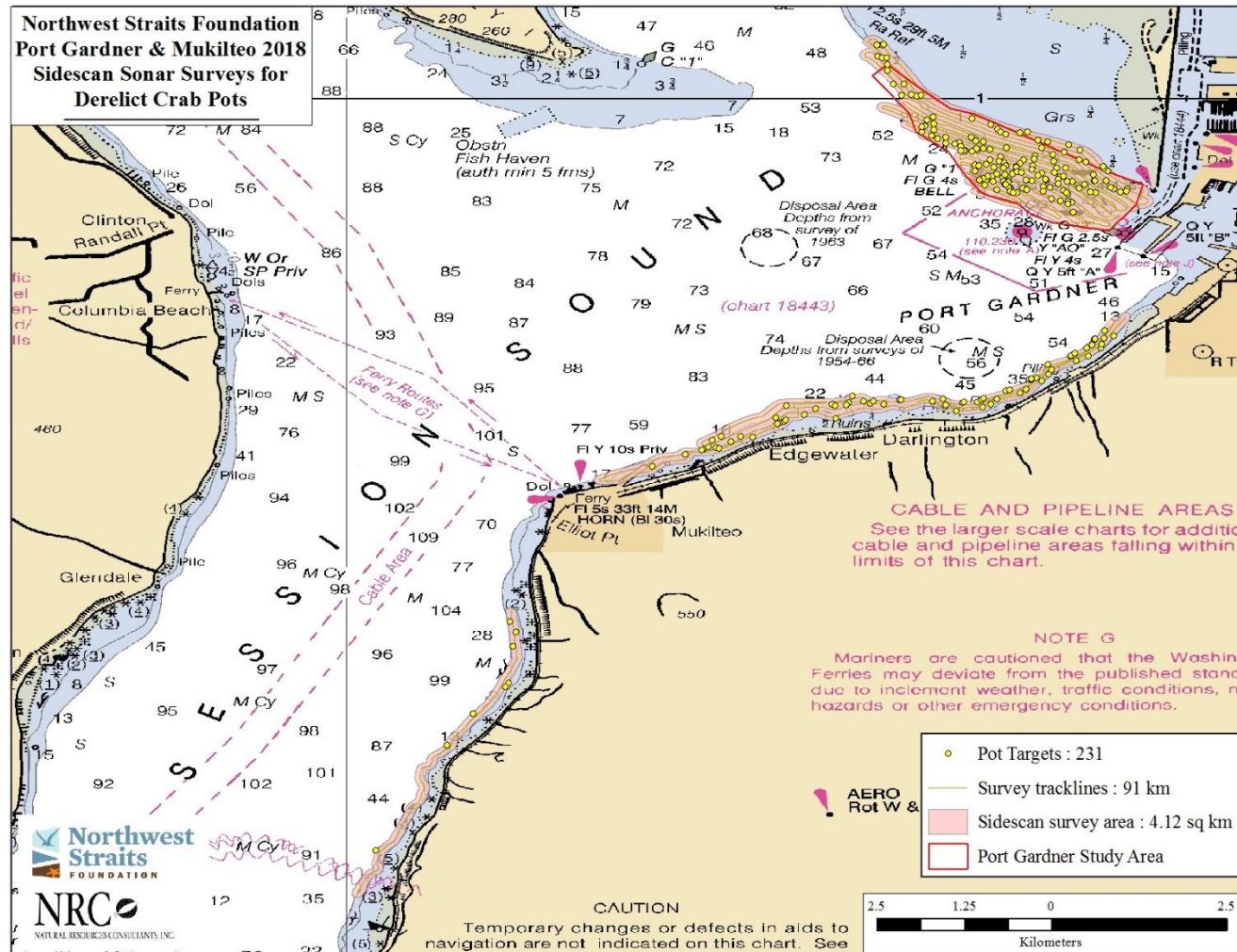


Figure 2. Sidescan sonar survey effort and disposition of derelict crab pot targets found in Port Gardner and Mukilteo during the Northwest Straits Foundation 2018 derelict fishing gear project. Source: NRC, Inc. and Fenn Enterprises.

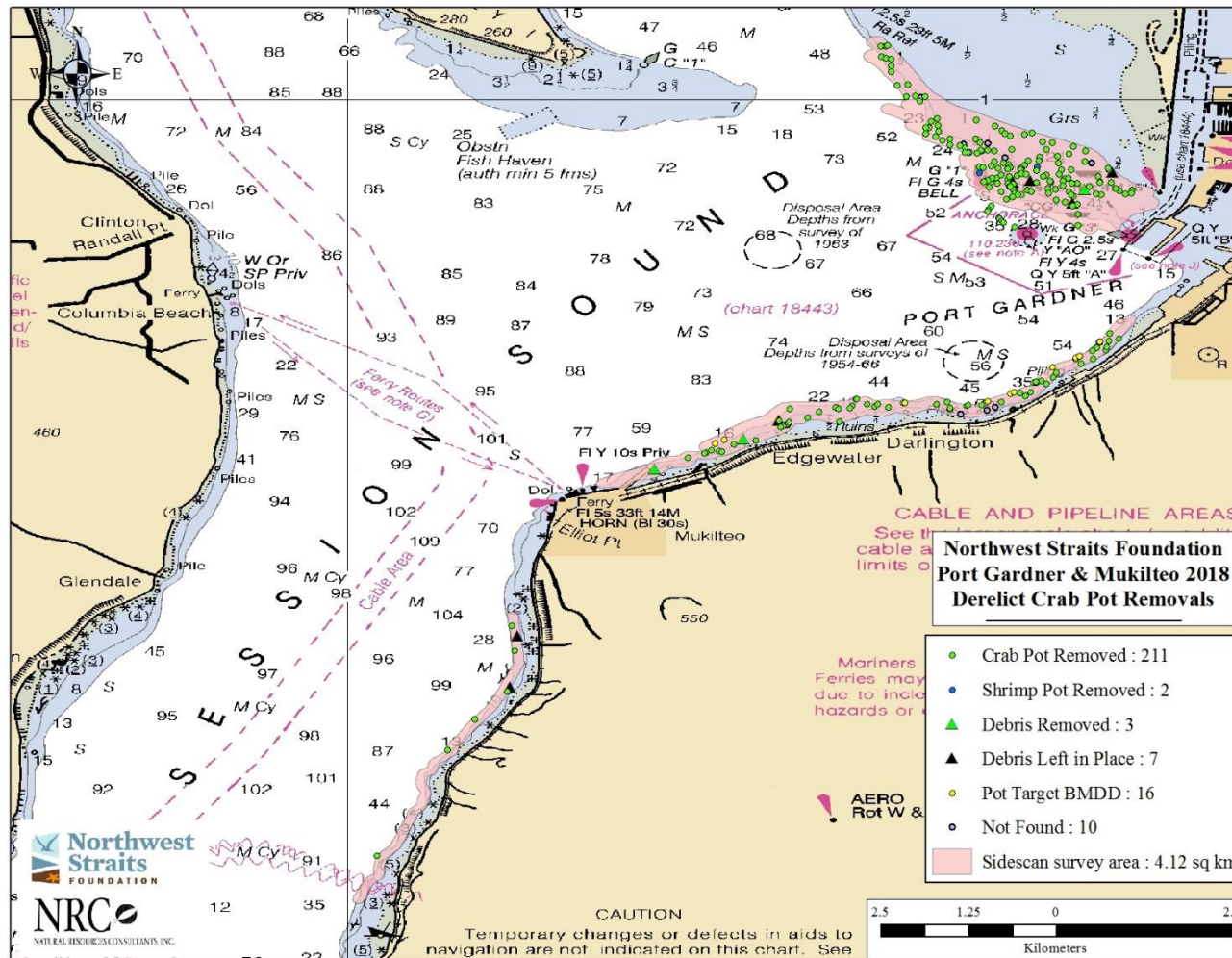


Figure 3. Derelict crab pot targets removed and area surveyed for analysis during the 2018 operations within the Port Gardner “Study Area”. Source: NRC, Inc. and Fenn Enterprises.

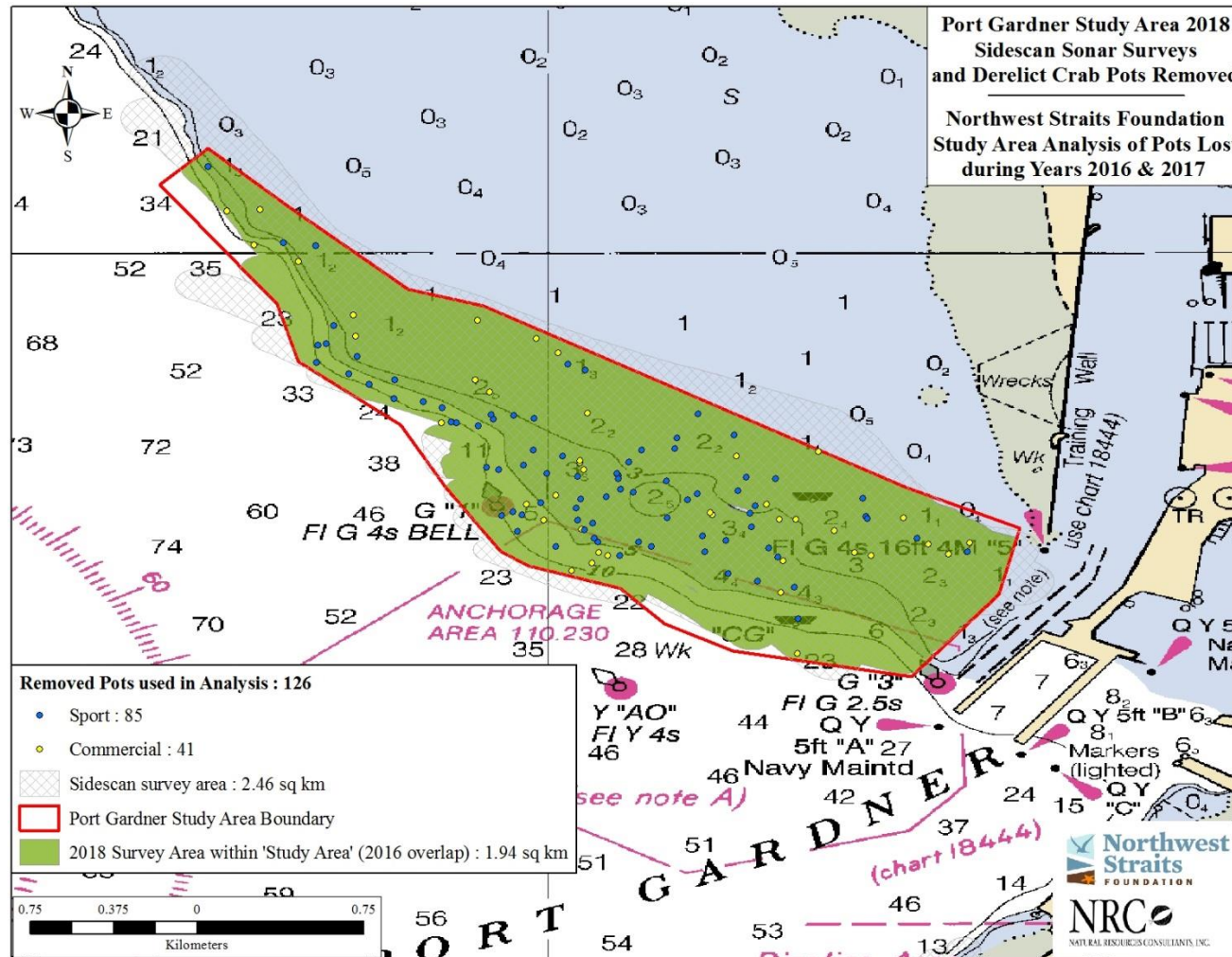


Figure 4. Number of derelict crab pots removed/disabled within the Port Gardner “Study Area” by project from 2004/2005 through 2018. Source: NRC, Inc.

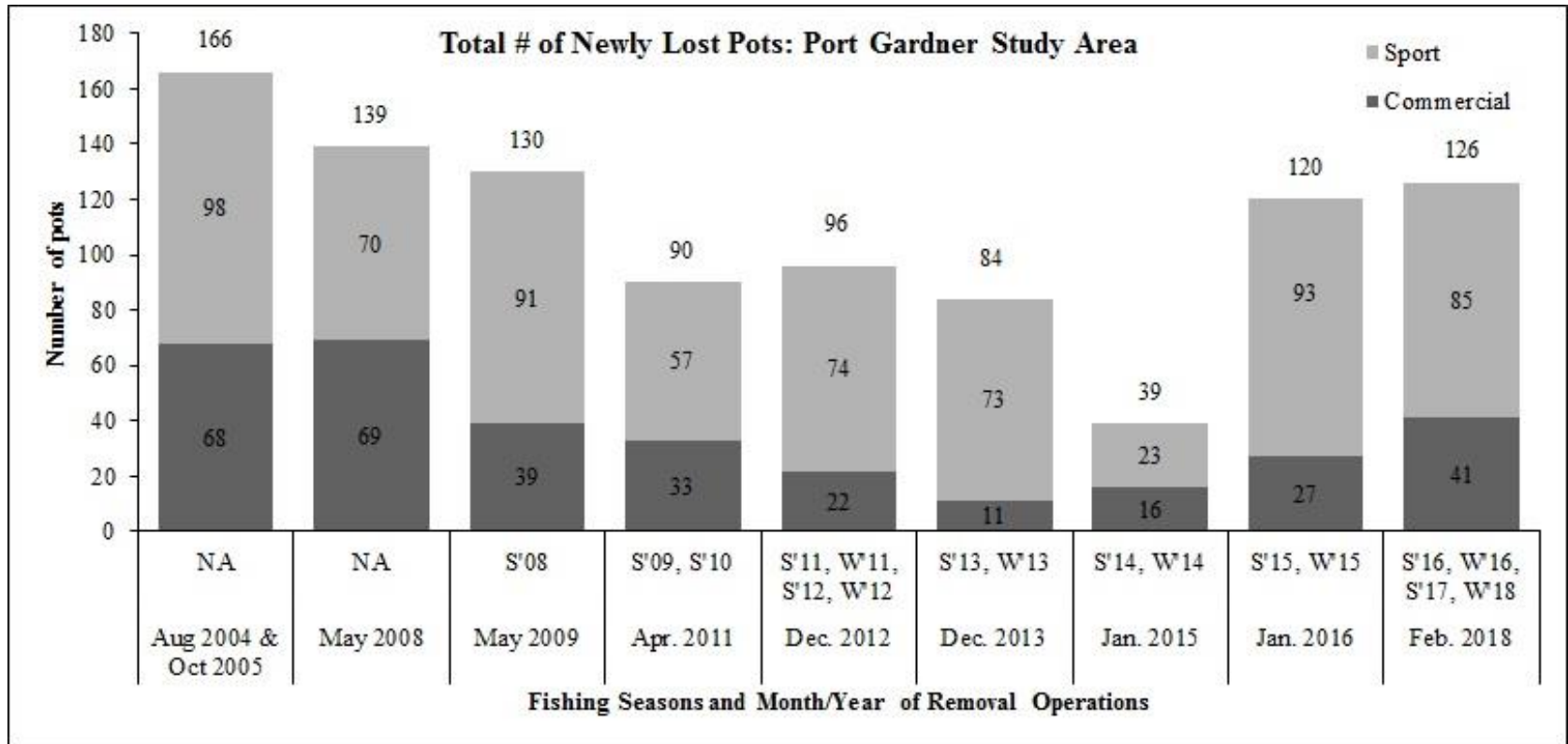


Figure 5. Observed sport pot loss per available fishing day within the Port Gardner “Study Area” by year. Source: NRC, Inc. and WDFW.

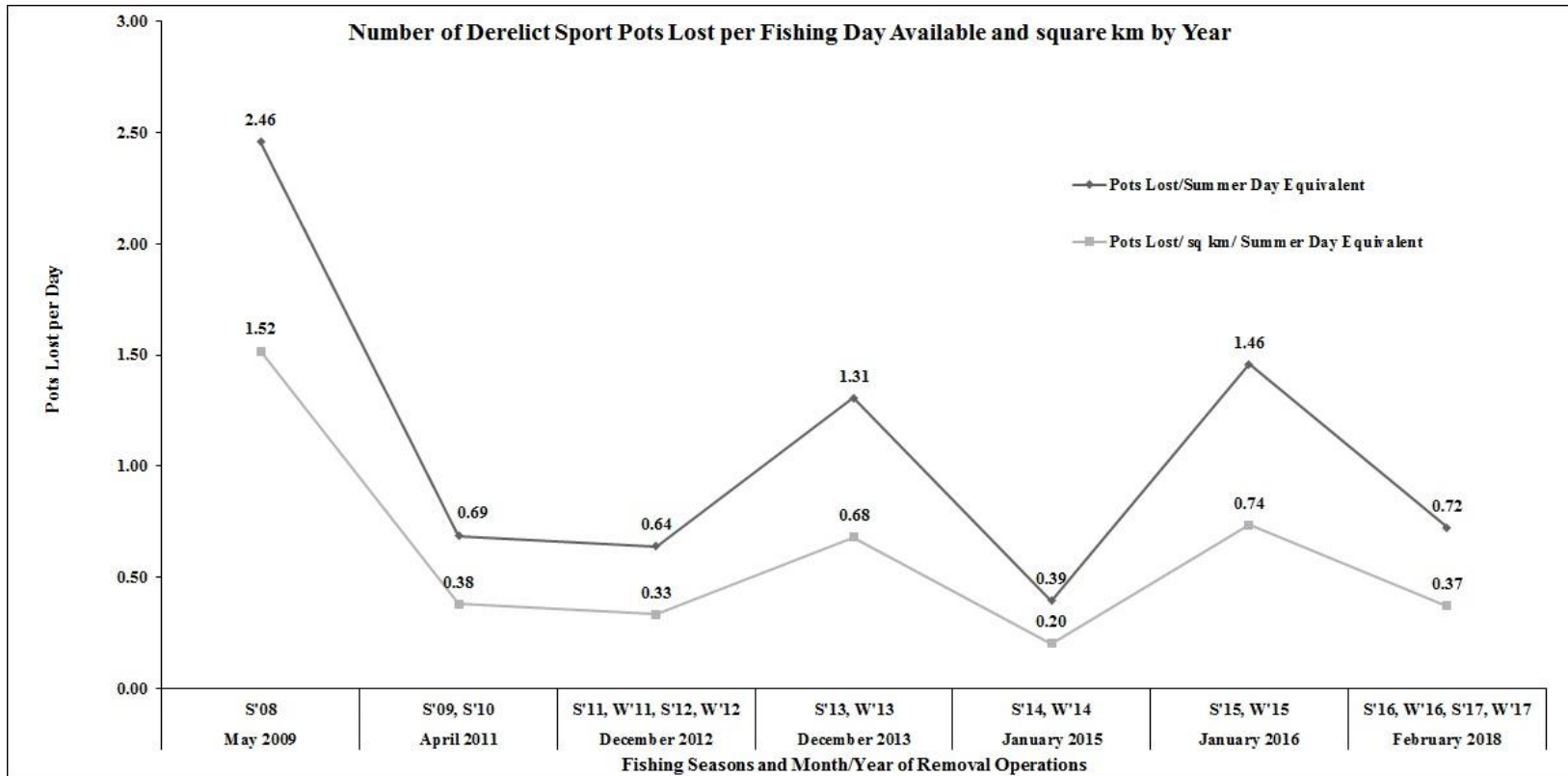


Figure 6. Summary of escape cord compliance observed on commercial derelict crab pots removed in the Port Gardner “Study Area” from 2004/2005 to 2018. Source: NRC, Inc.

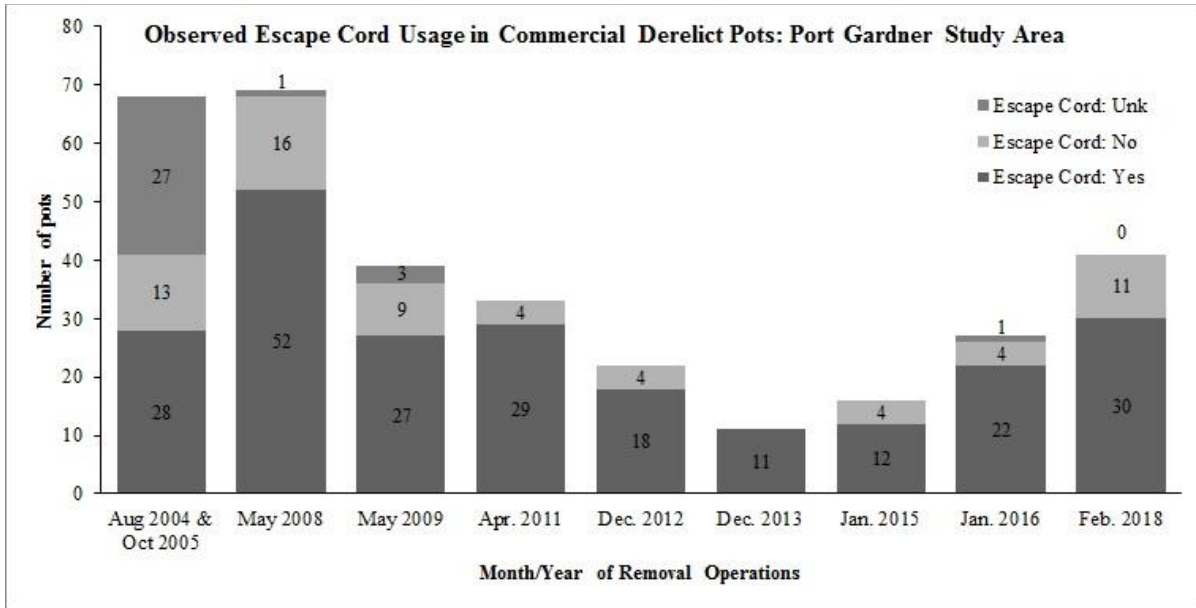


Figure 7. Percentage of legal escape cord compliance exhibited in derelict commercial pots removed exhibiting legal escape cord in the Port Gardner “Study Area” from 2004/2005 to 2018. Source: NRC, Inc.

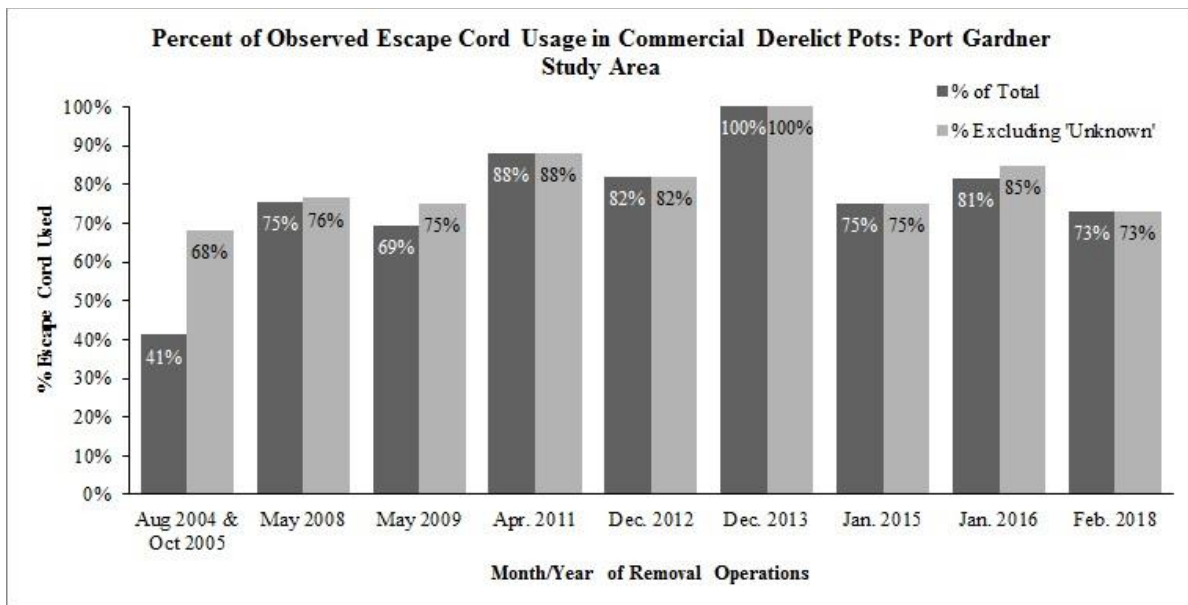


Figure 8. Summary of escape cord compliance observed on sport derelict crab pots removed in the Port Gardner “Study Area” from 2004/2005 to 2018. Source: NRC, Inc.

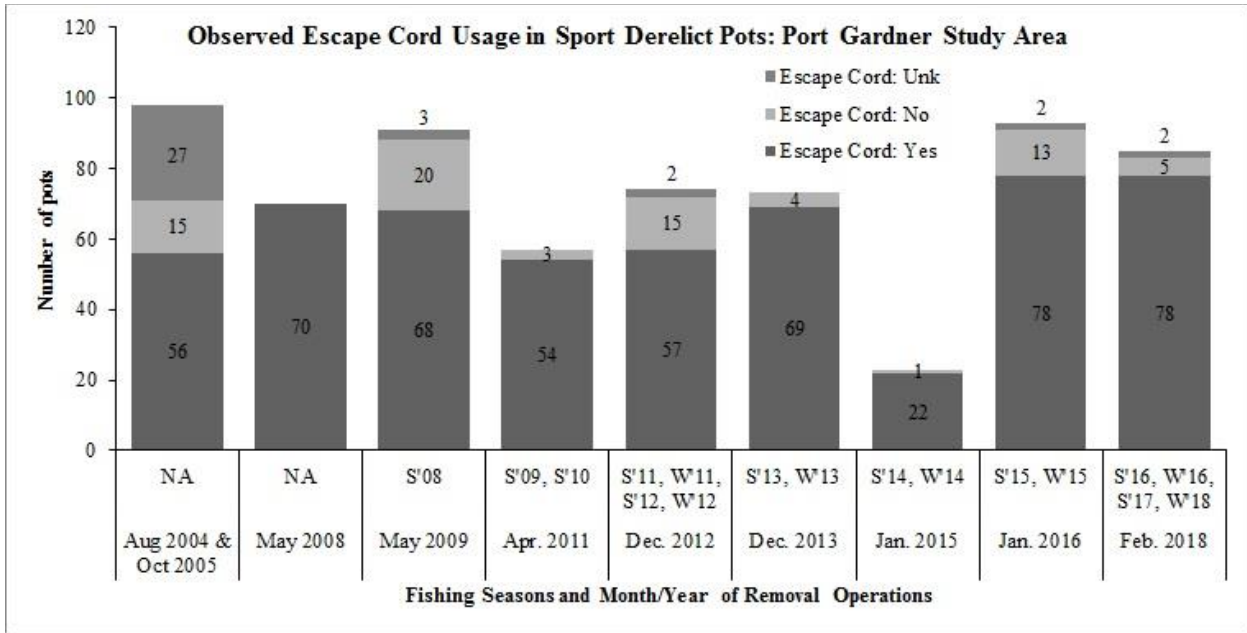


Figure 9. Percentage of legal escape cord compliance exhibited in derelict sport pots removed exhibiting legal escape cord in the Port Gardner “Study Area” from 2004/2005 to 2018. Source: NRC, Inc.

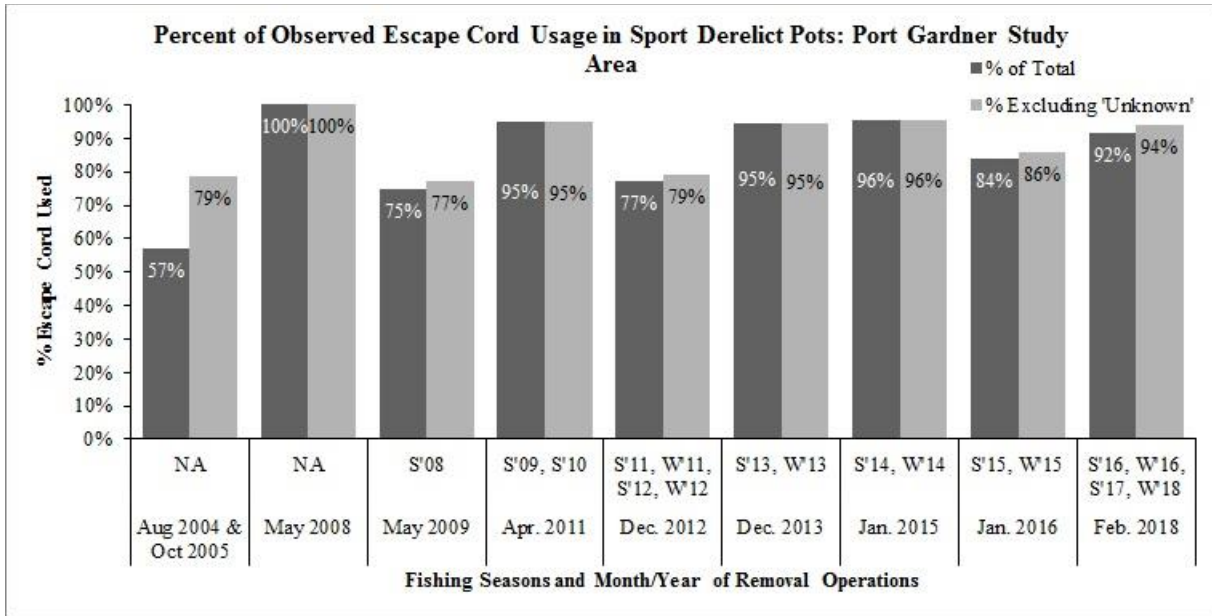


Figure 10. Derelict crab pot targets removed and area surveyed for analysis during the 2018 operations within the 2016 North Mukilteo survey area. Source: NRC, Inc. and Fenn Enterprises.

