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## Rockfish Bycatch in Shrimp Pots and Updated Estimates of the Magnitude of Derelict Shrimp Pots in Puget Sound

SUBMITTED TO:

THE NORTHWEST STRAITS FOUNDATION

SUBMITTED BY:

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August 29, 2014

## **Abstract**

Derelict fishing gear is a known stressor to rockfish populations in the Puget Sound, Washington, including three species currently listed as federally protected under the Endangered Species Act. In the Puget Sound and British Columbia, rockfish bycatch in actively fished shrimp pots has been documented in the spot prawn test fisheries, and both live and dead rockfish have been found in derelict shrimp pots encountered during derelict fishing gear removal operations in Puget Sound. This study determines rockfish bycatch rates in actively fishing shrimp pots and updates pot loss rates. Rockfish bycatch rates were determined through analysis of WDFW Spot Prawn Test Fishery Data collected from 2004 to 2013. Data from WDFW creel surveys were used to update preliminary shrimp pot loss rates. Interviews with WDFW marine enforcement officers were conducted to estimate the number of lost pots that are recovered before becoming derelict. The overall rockfish catch rates in Puget Sound and Hood Canal were 0.028 rockfish per pot drop and 0.0013 rockfish per pot hour, with considerable spatial and temporal variability. The lowest catch rates were consistently seen in Marine Area 7 (San Juan Islands and North Puget Sound); while the highest catch rates were seen in Marine Area 11 (south-central Puget Sound). The updated pot loss rate estimated for the recreational fishery is 2.33% of all pots fished. Combined with minimal pot loss in the commercial fisheries, and accounting for the number of pots removed during WDFW marine enforcement patrols, we estimate that over the years 2012 and 2013 combined, 1,340 shrimp pots became derelict in the Puget Sound. Assuming rockfish bycatch per unit effort in the commercial and recreational spot prawn fisheries are similar to those in WDFW test fisheries, this study estimates an average of 253 to 2,809 rockfish captured per year in actively fishing shrimp pots in the Puget Sound. Based on findings from this research, we put forth recommendations for research priorities to (a) reduce rockfish impacts from active and derelict shrimp pots, and (b) reduce shrimp pot loss in the Puget Sound.

## **Introduction and Background**

In this study, we assess spot prawn fishery data to determine rockfish bycatch rates and pot-loss estimates within the Puget Sound. In 2009, yelloweye rockfish (*Sebastes ruberrimus*), canary rockfish (*Sebastes pinniger*), and bocaccio rockfish (*Sebastes paucispinis*) were listed for federal protection in Puget Sound under the US Endangered Species Act (ESA) (WDFW 2011). The objective of this study was to assess whether bycatch of rockfish in active spot prawn fishing or bycatch of rockfish in lost and abandoned spot prawn fishing gear is a management concern (Figure 1). In the greater Puget Sound area, including Hood Canal, much is known about the impacts of some types of derelict fishing gear due to research, surveys and removals conducted by the Northwest Straits Marine Conservation Initiative (NWSI). For example, derelict fishing nets are a documented source of mortality for multiple species and a known stressor on ESA listed rockfish species (Good et al. 2010), (WDFW 2011), and “ghost fishing” by derelict crab pots can account for the loss of hundreds of thousands of dollars worth of Dungeness crab per year (Antonelis



Figure 1. Rockfish bycatch in derelict shrimp pot (2006). Source: NRC

et al. 2011). However, little is known about potential impacts on rockfish from derelict shrimp pots from the commercial and recreational spot prawn (*Pandalus platyceros*) fisheries for a couple of reasons. First and foremost, nearly all shrimp pot effort in the Puget Sound occurs in water depths beyond maximum allowable diver depth (BMDD) of 105 feet (32 m), significantly increasing the costs of survey and removal. Additionally, until recently, impacts to marine life and habitat associated with derelict shrimp pots have been

considered minimal in comparison with other gear types. Throughout the course

of derelict gear removal efforts in Puget Sound, a relatively small number of derelict shrimp pots have been incidentally identified and removed, and while the total number and variety of entrapped animals in these pots were low, multiple rockfish individuals (*Sebastes spp.*) were encountered, some of which were dead. At the time, this did not raise much of an alarm. However, upon the ESA listing of the three rockfish species 2009, all derelict gear data impacting rockfish was re-visited for further analysis and derelict shrimp pot gear were found to be a potentially significant threat to rockfish. Accounts of juvenile rockfish bycatch in shrimp pots have been documented by fishers and resource managers in the Puget Sound (NRC 2012). Additionally, a fishery-independent study of bycatch in active shrimp pots in British Columbia, Canada determined a rockfish bycatch rate of 0.015 rockfish caught per pot drop over a ten-year period (Favaro et al. 2010). The majority of those rockfish were juveniles, and while the bycatch rates reported in British Columbia were relatively low, the large amount of fishing effort associated with spot prawn fisheries raised concern about the overall effect this bycatch posed on the rockfish populations, especially considering the low survival rate of discarded rockfish due to the effects of barotrauma when being lifted to the sea-surface from depths (Favaro et al. 2010). These findings prompted British Columbia scientists to explore pot modifications with bycatch reduction devices (BRD) (Favaro et al 2012).

A study performed in 2012 (NRC 2012) analyzed data gathered through multiple methods to better understand the magnitude of shrimp pot loss in commercial and recreational fisheries and the potential impacts of derelict shrimp pots on rockfish populations in the Puget Sound. Data analysis provided preliminary estimates of shrimp pot loss from the recreational fishery to range from 270 to 596 annually; while estimated yearly loss from the commercial fleets (Treaty and non-Treaty combined) was 55. Effort and loss estimates were correlated with documentation of locations of ESA listed rockfish species throughout the Puget Sound and sidescan sonar surveys were conducted to enumerate the number of derelict shrimp pots present in areas of “likely rockfish habitat.” With evaluation of the geographic distribution of pot loss estimates, rockfish bycatch, likely rockfish habitat and identified survey targets, the study offered preliminary estimates of the geographic distribution of derelict shrimp pot accumulation, and the associated potential rockfish impacts. Findings also suggested, among other things, that the analysis and summarization of rockfish bycatch rates from the WDFW spot prawn test fisheries was warranted. In this study, we analyzed ten years of spot prawn test fishery data from Puget Sound and Hood Canal to determine rockfish bycatch rates within the region. Additionally, shrimp pot loss estimates were updated with new data from 2013, and WDFW Marine Enforcement officers were interviewed to elicit information related to both the number of lost shrimp pots removed per year during patrols and the number of rockfish encounters associated with the removed pots.

A thorough description of the Puget Sound spot prawn pot fishery is provided in NRC 2012, and little to no changes have occurred within the fishery since then. An updated summary of spot prawn catch throughout the Puget Sound from 2002 through 2013 is provided in Table 1.

The terminology used in this report refers to the species *Pandalus platyceros*. The terms “spot shrimp” and “spot prawn” are used interchangeably throughout the documentation of WDFW. For this reason, this report uses both terms, and uses the terminology consistent with the supporting WDFW documentation when discussing a particular facet of the fishery.

Table 1. Summary of spot prawn pot catch throughout Puget Sound from 2002 to 2013 (source: WDFW)

<b>Puget Sound Spot Prawn Catch (lbs), 2002-2013</b>							
<b>Year</b>	<b>Recreational Catch</b>	<b>Non-Treaty Commercial Catch</b>	<b>State Total</b>	<b>% Rec</b>	<b>% Comm</b>	<b>Treaty Total Catch</b>	<b>Grand Total</b>
2002	104,552	67,769	172,321	61%	39%	157,814	330,135
2003	109,267	77,187	186,454	59%	41%	167,758	354,212
2004	108,237	78,599	186,836	58%	42%	168,197	355,033
2005	109,395	83,567	192,962	57%	43%	193,322	386,284
2006	106,357	84,133	190,490	56%	44%	178,583	369,073
2007	119,768	86,930	206,698	58%	42%	221,826	428,524
2008	119,863	88,643	208,506	57%	43%	173,200	381,706
2009	125,467	92,562	218,029	58%	42%	189,683	407,712
2010	124,047	95,979	220,026	56%	44%	205,691	425,717
2011	120,076	106,372	226,448	53%	47%	249,555	476,003
2012	132,794	126,333	259,127	51%	49%	217,515	476,642
2013	178,538	103,541	282,079	63%	37%	263,380	545,459

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## **Methodology**

### *Sources of Data*

Shellfish biologists and fisheries managers from WDFW provided electronic or hard-copy versions of spot prawn test fishery datasheets for the years 2004 through 2013 from both Puget Sound and Hood Canal test fisheries; and provided contact information for WDFW Marine Enforcement officers with experience in retrieving shrimp pots that remain on (or near) the fishing grounds after the fishery has closed. Representatives from WDFW also provided updated statistical summaries of the fisheries and information from creel surveys for 2013 related to shrimp pot loss in the recreational fishery.

### *Description of the Test Fishery*

Spot prawns are one of the most important shrimp species in Washington for both sport and commercial harvesters (WDFW 2013). The main objective of the WDFW Spot Prawn Test Fishery is to estimate the stock structure of spot prawns by collecting data at selected sites before and after fisheries occur. Sites within the Puget Sound and Hood Canal are selected by WDFW for sampling in order to monitor spot prawn populations of interest, which are defined as “all populations in areas that are fished extensively” (WDFW 2012).

The WDFW Spot Prawn Test Fishery is split into two categories based on geographic region. The Hood Canal test fishery includes sampling in Hood Canal, Discovery Bay, Port Angeles and Port Townsend, with the most consistent data coming from Hood Canal and Discovery Bay. The Puget Sound test fishery includes sampling from all other regions of Puget Sound from as far south as Marine Area 11 up to Marine Area 7 (Figure 2). The Hood Canal test fishery has been conducted each year since the late 1970s, while the Puget Sound test fishery began in 2002. Sample locations throughout the Puget Sound and Hood Canal are identified by WDFW each year, with the assumption that the areas sampled will “represent the extensively fished populations of spot prawns” (WDFW 2012). Multiple sites within each designated location are sampled each year depending on the size of the spot prawn bed at each location. As per WDFW’s sampling research protocol, as a minimum, each selected sampling site will be sampled twice: once before any prawn fisheries begin in that area and once after all prawn fisheries close in that area. With some exceptions, pre-fishery sampling takes place during March or April (spring) and post-fishery sampling during September or October (fall) (WDFW 2012).

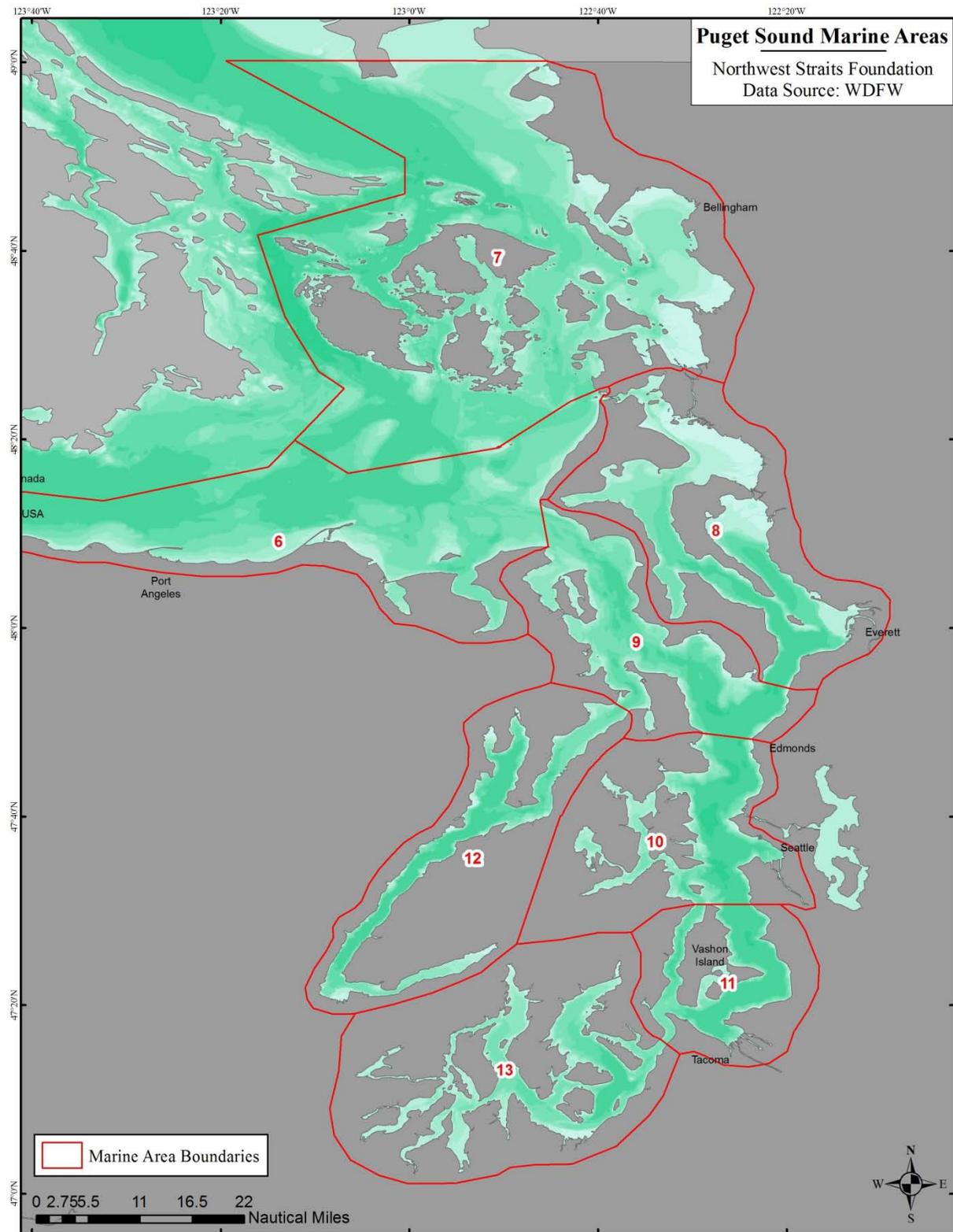


Figure 2. Administrative boundaries for Puget Sound Marine Area Codes (WAC 220-56-185). Source: WDFW.

In the Puget Sound test fishery, during each sampling period two or three strings of five pots are deployed at each site with a target soak time of 24 hours. Prior to 2007 each string consisted of ten pots. Occasionally single pots are also deployed during sampling periods as “scout pots”. Ladner 1/2” mesh ‘San Juan Island’ 30” diameter spot prawn pots baited with Skretting ‘Super Bait’ fish pellets are used in the test fishery. Typically, strings of pots are set in either two or three of the most heavily fished locations in the Marine Area or subarea (based on recreational buoy count data and/or commercial logbook data). Preset GPS waypoints assigned to the beginning and ending deployment of each ground line are used to set each string, perpendicular to depth contours. Strings generally cover approximately 100 feet of vertical change, within the approximate depth range of 200 feet to 350 feet. Pots are approximately 100 feet apart along each groundline of five pots, and 50 feet apart along each groundline of ten pots. A variety of data is collected for each pot string deployment on the Spot Shrimp Test Fishery- String Data Form. In addition to the species, size, and the sexual stage of all spot prawn caught, this form includes the location, site, number of pots per string, geographic coordinates and depth of shallow and deep anchors, and the count and identification of any bycatch contained in each pot (WDFW 2012).

In the Hood Canal test fishery, during each sampling period three strings of three pots are deployed at each site with a target soak time of 18 to 24 hours. Each string is approximately 150 feet in length, with three baited pots set at 50 foot intervals along anchored ground lines parallel to three depth contours- 60 feet, 162 feet, and 252 feet (WDFW 2010). Preset GPS waypoints assigned to the beginning and ending deployment of each ground line are used to set each string (WDFW 2010). The test fishery uses Ladner 1/2” mesh shrimp pots baited with Skretting 12mm ‘Super Bait’ fish pellets (WDFW 2010). Similar to the Puget Sound test fishery, data collected include the sampling criteria for each string such as location, date, time, depth and waypoint numbers, as well as catch data, pull date and time, spot shrimp weight, and the count and identification of any bycatch contained in each pot (WDFW 2010).

### *Rockfish bycatch estimates in Actively Fished (non-derelict) Pots*

Rockfish bycatch rates for the entire Puget Sound region (including Hood Canal and Eastern Strait of Juan de Fuca) were estimated from data collected during WDFW spot prawn test fisheries over a ten year span from 2004 through 2013. A dataset for each year from the Hood Canal test fishery was provided in electronic form (MS Excel) and compiled into one master database developed for the project. The provided Hood Canal test fishery data included all bycatch records (rockfish and otherwise) which were incorporated into the project database. Data from the Puget Sound test fishery were provided as raw string data forms (hard copies) that were copied, scanned and manually entered into the project database. The only bycatch data entered into the database for the Puget Sound test fishery were instances documenting rockfish occurrences as directed by the scope of this project.

Raw data from a total of 20 sampling periods of WDFW spot prawn test fisheries; ten spring periods (pre-season) and ten fall periods (post-season) from 2004 through 2013 were analyzed. The data included samples taken at 105 discrete sampler-identified sites in 17 locations throughout seven Marine Areas (MA 6 - MA 12). GPS coordinates provided for each site in the test fishery data were used to correlate test fishery locations and sites to commercial and recreational shellfish management areas. The total number of rockfish encountered throughout the dataset were summarized by species. Overall rockfish bycatch rates over the ten year period within the WDFW spot prawn test fisheries were determined by using the total number of rockfish encountered and the total number of pots fished, referred to as pot drops.

Additionally, rockfish bycatch per pot hour was calculated using soak times associated with each pot fished. Along with the overall bycatch rates, rockfish bycatch rates were determined temporally by year and by season; and spatially by Marine Area (MA) boundaries, and depth (50 foot intervals). Because depths are only recorded for the deep and the shallow anchor in the Puget Sound test fishery, fishing depths of each pot between the anchors were interpolated assuming a consistent distance between pots and constant slope from the beginning to the end of each string. In several instances when a string of ten pots was deployed, bycatch data was only recorded for the even numbered pots on the string. In these instances, depths for each sampled pot were calculated using the above method, with the assumption of the shallow anchor depth reading representing the first pot of the string and the deep anchor depth reading representing the tenth pot of the string.

### *Pot Loss Estimate Updates*

Preliminary shrimp pot loss estimates for the Puget Sound spot prawn fisheries reported in NRC 2012, using compiled data from WDFW creel surveys, catch and effort statistics, and an online survey questionnaire ranged from 326 to 651 pots lost annually (NRC 2012). We updated the shrimp pot loss rate estimates by including analysis of creel survey and effort data collected in the 2013 shrimp season. The 2013 data doubles the number of seasons where creel survey data included the questions: “*Did you lose any pots? Y or N*”, and “*If yes, how many?*”

We assume that with the additional questions related to pot loss in the creel surveys a significantly more accurate estimate of pot loss rate is derived from the 2012 and 2013 data; particularly since these loss rates are similar to one another, and considerably higher than those from 2007 through 2011. Therefore, the updated pot loss per pot day fished reported here only includes those rates from 2012 to 2013.

Additionally, semi-structured interviews were conducted with WDFW Marine Enforcement officers who customarily patrol the marine waters of Puget Sound following recreational shrimp fishery openings. Due to the relatively few shrimp pots removed during patrol surveys, there are little to no data logs recording shrimp pot recovery. Therefore, the semi-structured interview technique was used to elicit responses to a few specific questions focused on the frequency of encountering and recovering shrimp pots (lost or abandoned) outside shrimp fishing season, and the amount of rockfish encountered within those recovered shrimp pots. All interviews were conducted over the telephone and lasted approximately five to ten minutes. A total of five WDFW enforcement officers were interviewed for this purpose, whose combined areas of operation cover all major shrimp pot fishing grounds, with some overlap, within the Puget Sound.

Pot loss rates were calculated in the same way as was reported in NRC 2012, with added 2013 data. However, updated estimates focus exclusively on 2012 and 2013 recreational pot loss rates. Creel survey summaries provided estimates of number of shrimp pots lost in each Marine Area (MA) per year and were compared to WDFW estimates of the number of pots fished per day to obtain loss rates per “pot day” – a standard metric used to describe effort in the recreational fishery, and the one decided to be most appropriate for pot loss estimates. The Puget Sound wide yearly pot loss rate was calculated by dividing the sum of all reported lost pots from the creel surveys 2012 and 2013 by the sum of all pot days accounted for in the creel surveys, and the same was done for the data from each year independently. The projected number of lost pots per year was simply estimated by multiplying the pot loss rate by the average total number of pot days per year provided by WDFW statistical summaries. To estimate how

many of those actually become derelict, we subtracted the estimated average number of pots removed per year by WDFW Marine Enforcement from the yearly totals of pots lost.

$$(\#pots\ lost\ in\ creel / \#pot\ days\ in\ creel) * (total\ \#pot\ days / year) = \#pots\ lost / year$$

$$(\#pots\ lost / year) - (\#pots\ pulled / year) = \#pots\ becoming\ derelict / year$$

Information obtained through the interviews with WDFW enforcement officers was also used to gain a better understanding of the frequency of occurrence of the rockfish bycatch in derelict shrimp pots. All comments pertaining to number of rockfish encounters from interviewees were recorded such that they correspond with the amount of pots recovered per year during WDFW patrol surveys.

The projected annual number of pots lost, reported in NRC 2012, within the Treaty and non-Treaty commercial fisheries combined was 55, based on a loss rate of 0.068% of pots fished. Because this rate is very low, and no specific datasets are available to further refine those estimates, no further analysis of pot loss within the commercial fisheries was conducted during the study.

## **Results**

### *Rockfish Bycatch Estimates in Actively Fished (non-derelict) Pots*

We analyzed data from 4,231 pot drops from the Puget Sound and Hood Canal test fisheries combined. Pot drops per year over the ten year period ranged from 310 in 2004 to 696 in 2006, averaging 423 pot drops per year. Soak times per pot drop ranged from 3.0 to 28.7 hours, averaging 21.5 hours. Of the 4,231 pot drops, 97 (2.3%) pots contained a total of 119 rockfish, and no rockfish were encountered in 4,134 (97.7%) pots. The number of rockfish caught per pot ranged from one individual, in 78 pots, to three individuals, in three pots, while 16 pots held two individual rockfish. Species composition of the individual rockfish caught in the WDFW spot prawn test fishery included; 56 copper rockfish (*S. caurinus*), 25 quillback rockfish (*S. maliger*), 20 unidentified rockfish (*Sebastes sp.*), nine brown rockfish (*S. auriculatus*), eight Puget Sound rockfish (*S. emphaeus*) and one greenstriped rockfish (*S. elongates*) (Table 2).

Table 2. Total number of individual rockfish by species caught in WDFW spot prawn test fisheries 2004 – 2013.

Year	Rockfish Species						Total
	Quillback	Copper	Puget Sound	Brown	Greenstriped	Unidentified	
2004	1	0	0	0	0	2	3
2005	0	0	0	1	0	1	2
2006	6	9	0	7	0	7	29
2007	1	2	2	1	0	9	15
2008	1	2	0	0	0	0	3
2009	4	15	5	0	0	0	24
2010	4	16	1	0	1	0	22
2011	4	6	0	0	0	0	10
2012	4	6	0	0	0	1	11
2013	0	0	0	0	0	0	0
<b>Total</b>	<b>25</b>	<b>56</b>	<b>8</b>	<b>9</b>	<b>1</b>	<b>20</b>	<b>119</b>

The overall rockfish catch rates for the combined dataset from 2004 to 2013 was 0.028 rockfish/pot drop and 0.0013 rockfish/pot hour. Catch per unit effort (CPUE) varied considerably by year, from a low in 2013 when no rockfish were caught, to a high in 2009 of 0.063 rockfish/pot drop and 0.0027 rockfish/pot hour (Table 3). Further analysis shows that while results vary by year, the overall rockfish bycatch rates during the fall test fishery (post-season) is substantially higher than that in the spring test fishery (pre-season). Of the total 4,231 pot drops, the 2,041 (48%) deployed in the post-season contained 86 (72%) of the total number of rockfish caught. This reflects a catch rate of 0.042 rockfish/pot drop in the fall fishery, compared to the 0.015 rockfish/pot drop in the spring test fishery.

Table 3. Effort and rockfish bycatch caught in WDFW spot prawn test fisheries by year (2004 – 2013).

Year	Number of Pot Drops	Number of Pot Hours	Total Number of Rockfish Caught	Rockfish Catch Rate per Pot Drop	Rockfish Catch Rate per Pot Hour
2004	310	6,098	3	0.010	0.0005
2005	484	9,320	2	0.004	0.0002
2006	696	14,599	29	0.042	0.0020
2007	369	8,157	15	0.041	0.0018
2008	432	9,578	3	0.007	0.0003
2009	382	8,754	24	0.063	0.0027
2010	408	9,071	22	0.054	0.0024
2011	411	9,022	10	0.024	0.0011
2012	394	8,837	11	0.028	0.0012
2013	345	7,648	0	0.000	0.0000
<b>Total</b>	<b>4,231</b>	<b>91,083</b>	<b>119</b>	<b>0.028</b>	<b>0.0013</b>

Considerable variability was also identified in the spatial distribution of rockfish bycatch. The lowest catch rates are consistently seen in MA 7 (San Juan Island and North Puget Sound), with 0.005 rockfish/pot drop and 0.0002 rockfish/pot hour; while the highest catch rates exist in MA 11 (south-central Puget Sound) (Table 4 and Figure 3). Catch rates in MA 12 (Hood Canal) are slightly less than the overall rates, but are closer to the overall rates than any other Marine Area. This is not surprising, as test fishery effort in MA 12 makes up 42% of the total effort. An example of the combined spatial and temporal variability in rockfish catch rates is best depicted in MA 6 (Eastern Strait of Juan de Fuca) where the ten year average catch per pot drop and pot hour are 0.036 and 0.0020 respectively, well above the overall average. In 2006 a total of 20 rockfish were caught in only 138 pot drops in MA 6, and only four rockfish were caught in all the other nine years combined.

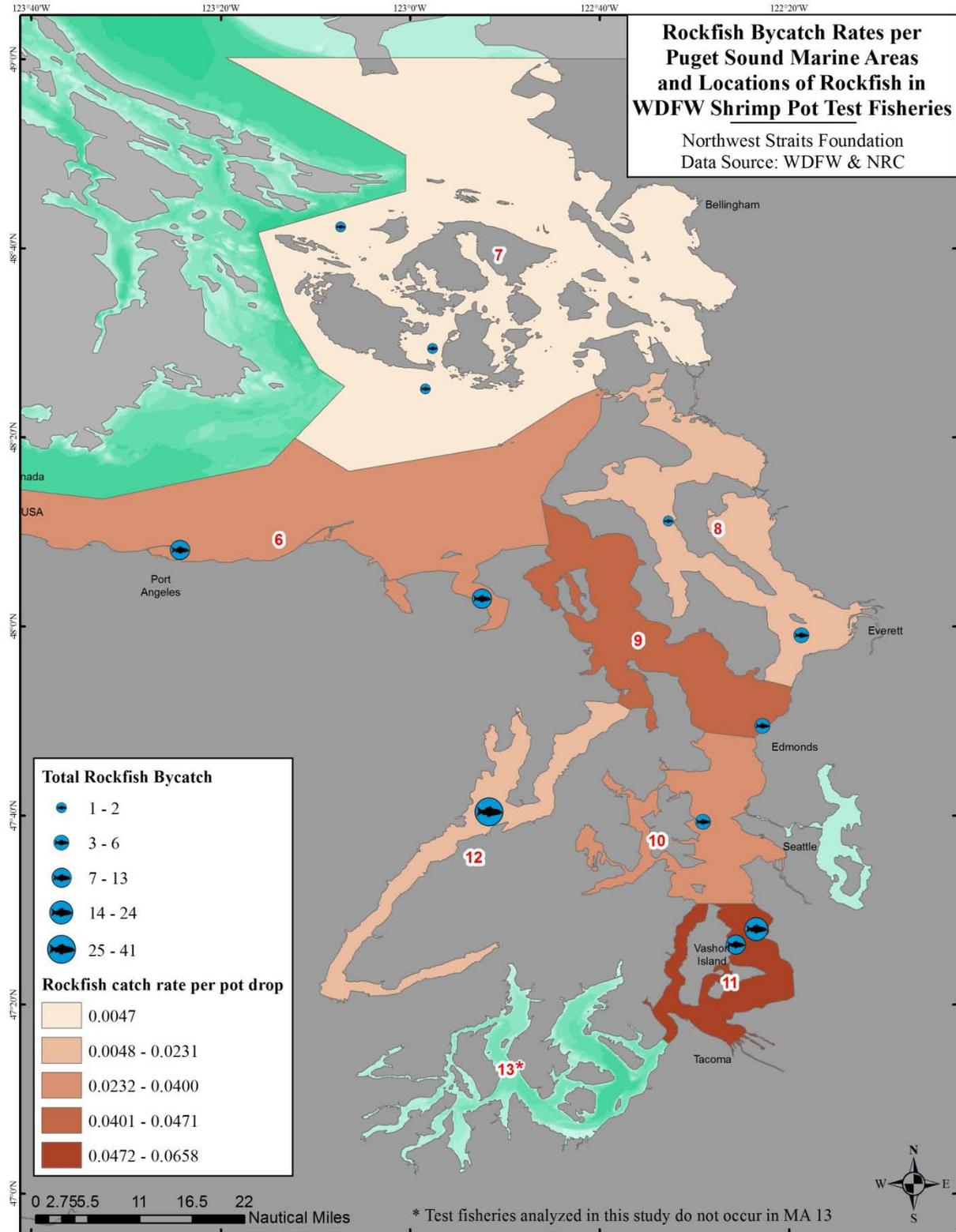


Figure 3. Spatial representation of rockfish bycatch rates by Puget Sound Marine Area with general locations where rockfish bycatch was documented.

Table 4. Effort and rockfish bycatch caught in WDFW spot prawn test fisheries by Marine Area (2004 – 2013).

Marine Area	Number of Pot Drops	Number of Pot Hours	Total Number of Rockfish Caught	Rockfish Catch Rate per Pot Drop	Rockfish Catch Rate per Pot Hour
MA 6	675	11,830	24	0.036	0.0020
MA 7	632	14,265	3	0.005	0.0002
MA 8	444	9,781	8	0.018	0.0008
MA 9	85	1,919	4	0.047	0.0021
MA 10	75	1,538	3	0.040	0.0020
MA 11	547	11,874	36	0.066	0.0030
MA 12	1,773	39,876	41	0.023	0.0010
<b>Total</b>	<b>4,231</b>	<b>91,083</b>	<b>119</b>	<b>0.028</b>	<b>0.0013</b>

A great deal of variability was seen in rockfish bycatch rates by depth, where the highest rate of 0.233 rockfish/pot drop was seen in the depth range from 350 to 399 feet; however only 1% of the total effort occurred at these depths. The lowest rates of 0.00 rockfish/pot drop were seen in the depth ranges of 100 to 149 feet and 400 to 499 feet. Effort in waters < 100 feet yielded a catch rate of 0.012 rockfish/pot drop, and the zone from 300 to 349 feet produced a catch rate of 0.009 rockfish/pot drop. The bulk of the test fishery effort (75%) was directed within depth ranges from 150 to 299 feet. Resulting catch rates of rockfish/pot drop were 0.048 from 150 to 199 feet, 0.042 from 200 to 249 feet and 0.012 from 250 to 299 feet.

*Pot Loss Estimate Updates*

In 2013, a total of 2,547 recreational fishing parties were interviewed during creel surveys, with a corresponding effort of 8,737 pot days. Of all parties interviewed, 183 (7.18%) parties reported a total of 224 pots lost. This equates to 2.56% of pots fished lost throughout Puget Sound for the 2013 season. The total pot days fished during 2013 was 38,152 and when multiplied by pots lost per pot day ratio provides the overall estimate of 978 pots lost in the recreational fishery during the 2013 season (Table 5). As reported in NRC 2012, the pot loss rate in 2012 was 2.01% of all pots fished. The combined overall pot loss for the 2012 and 2013 seasons equated to 2.33% of pots fished lost throughout Puget Sound (Table 5). Using a more complete dataset, we presume these updated estimates are a more accurate assessment of shrimp pot loss rates than were reported in 2012.

Table 5. Results, by year, of updated recreational shrimp pot loss estimates from 2012 and 2013

Period	Area	Number of Boats Surveyed (creel)	Number of Boats with Documented Pot Loss (creel)	Number of Surveyed Pots Days (creel)	Number of Surveyed Pots Lost (creel)	Percent of Surveyed Pots Lost	Total Pot Days Fished	Projected Number of Pots Lost
2012	All PS	1,897	109	6,661	133	2.01%	30,217	608
2013	All PS	2,547	183	8,737	224	2.56%	38,152	978
<b>Combined</b>	<b>All PS</b>	<b>4,371</b>	<b>357</b>	<b>15,348</b>	<b>357</b>	<b>2.33%</b>	<b>68,369</b>	<b>1,586</b>

Recreational pot loss by MA was relatively consistent between 2012 and 2013. The largest differences occurred in MA 6 and MA 9 where the pot loss rates decreased by 83% and 80%, respectively. The smallest variance was observed within the two marine areas where the highest pot loss rates occur. In MA 11, loss rate decreased by 4%, and MA 7 loss rate decreased by 5% (Figure 4).

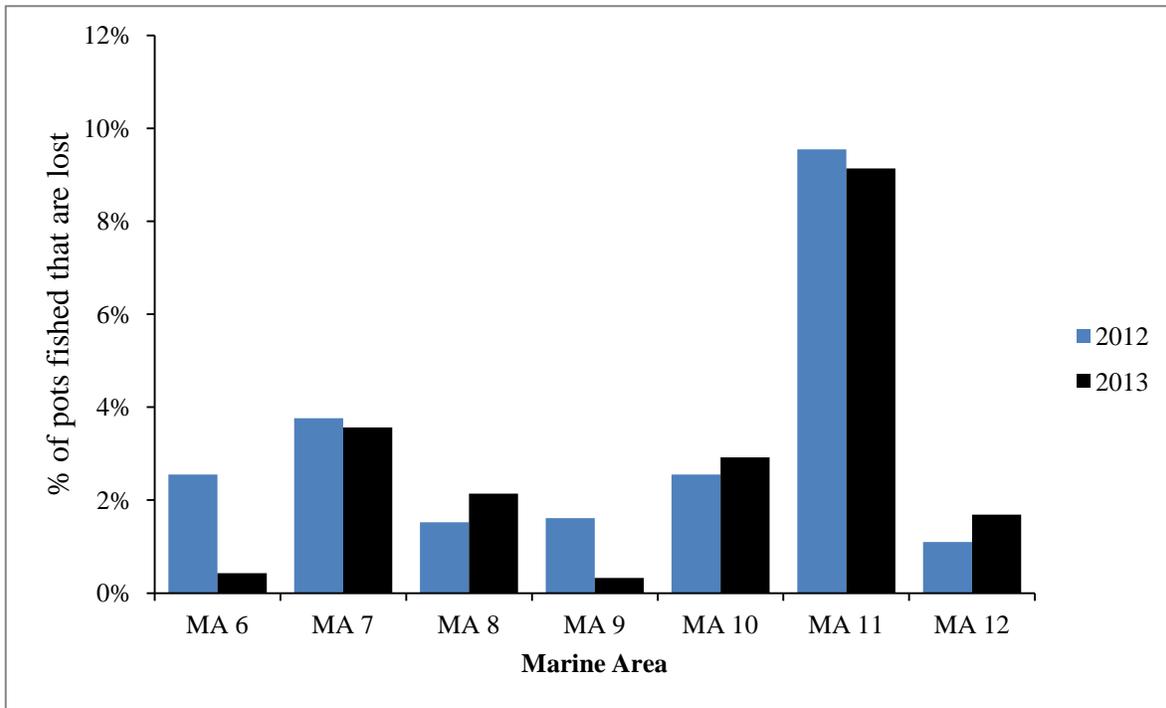


Figure 4. Comparison of recreational pot loss rates per Marine Areas for the years 2012 and 2013

Interviews with five WDFW Marine Enforcement officers provided information related to the number of lost or abandoned recreational shrimp pots that are recovered following shrimp pot season closures. All those interviewed explained that the number of shrimp pots recovered during patrols varies by year, but their reported numbers were what they consider to be the average of recent years. Officers who patrol MA 7 reported removing on average, approximately 30 shrimp pots per year since 2010. In MA 6 and MA 12, officers estimated recovering approximately 40 shrimp pots per year; all of which are recovered within a day or two after a shrimp fishery opening. Officers who frequently patrol MA 8, 9, 10 and 11 reported a combined number of shrimp pots recovered per year of approximately 70. Without logbook data available for shrimp pot recovery, these are rough estimates, but are the best available information. Therefore, we estimate that approximately 140 lost or abandoned shrimp pots are recovered by marine patrol surveys prior to their becoming derelict. Only one of the officers reported rockfish bycatch in recovered shrimp pots, saying he encounters about one rockfish per year of approximately ten shrimp pot removals. All other interviewees explained that they have not encountered rockfish in the shrimp pots that they have recovered. Conversations with recreational shrimp fishers suggest that some pots reported as lost during creel surveys are recovered by their owners, or somebody else other than WDFW marine enforcement officers, within a few days after pot loss (M. O’Toole, WDFW, personal communication). Therefore, these pots would not contribute to overall derelict shrimp pot totals; however, because there is not comprehensive documentation of such occurrences, this factor is not included in the overall calculation of derelict shrimp pots.

Combining the updated recreational pot loss estimates with the commercial estimates, and accounting for those removed by marine enforcement patrols, we estimate that in 2012 a total of 523 shrimp pots became derelict, and in 2013 the number rose to 893. Combined over the two year period we estimate a total of 1,340 shrimp pots becoming derelict within the Puget Sound marine waters.

Table 6. Combined results of estimated number of shrimp pots becoming derelict in 2012 and 2013

Period	Area	Projected Number of Recreational pots lost	Estimated Annual pot loss in Commercial Fisheries	Estimated Total Number of Pots Lost	Estimated Number of pots recovered by patrols	Total Number of Pots becoming Derelict
2012	All PS	608	55	663	140	523
2013	All PS	978	55	1,033	140	893
<b>Combined</b>	<b>All PS</b>	<b>1,586</b>	<b>110</b>	<b>1,696</b>	<b>280</b>	<b>1,340</b>

### **Discussion and Conclusion**

Results of data analysis of the WDFW spot prawn test fisheries suggest that rockfish bycatch within Puget Sound shrimp pot fisheries shows considerable annual and geographical variability, with no evident trends identified during this early analysis. Copper and quillback rockfish make up the majority (68%) of the total catch, and 17% of the rockfish encountered were unidentified. While the summaries provided here assist in understanding the overall effects of Puget Sound shrimp pot fisheries on rockfish populations, it does not include updated information directly related to the three ESA listed rockfish species in the Puget Sound. Nevertheless, similarities in preferred habitat and juvenile behavior between many of the rockfish species in the Puget Sound, including ESA listed species, should be considered when reviewing the results of this study. This is particularly true when considering that mortality rates of rockfish bycatch in shrimp pots are assumed to be high due to effects of barotrauma (ruptured swim bladders, eye protrusion, and prolapsed stomachs) (Favaro et al. 2010). Development of gear modifications and BRDs could reduce rockfish bycatch and associated mortality. Such BRDs have been developed and tested in British Columbia (Favaro 2012), and while these have been successful in reducing rockfish bycatch, they have been challenged in maintaining the spot prawn CPUE of an unmodified pot.

The overall rockfish catch/pot drop rate of 0.028 in the Puget Sound test fisheries from 2004 to 2013 is higher than the ten year average reported by Favaro et al. (2010) of 0.015 from 1999 to 2008 in British Columbia. Comparisons of rockfish catch rates in Puget Sound and British Columbia over the five year span where data temporally overlaps show considerable variance in CPUE between studies (Figure 5). Of particular interest is the difference in trends, or lack thereof. Rockfish bycatch in British Columbia show an apparent non-linear trend from 2004 to 2008, whereas the Puget Sound bycatch rates are sporadic and show no trends. Years with increased rockfish bycatch could be the result of increased local populations of juvenile rockfish, as suggested by Favaro et al. (2010), or large year class events (NRC 2012). In addition, a decreasing food source could also increase rockfish attraction to baited shrimp pots, leading to increased catch rates.

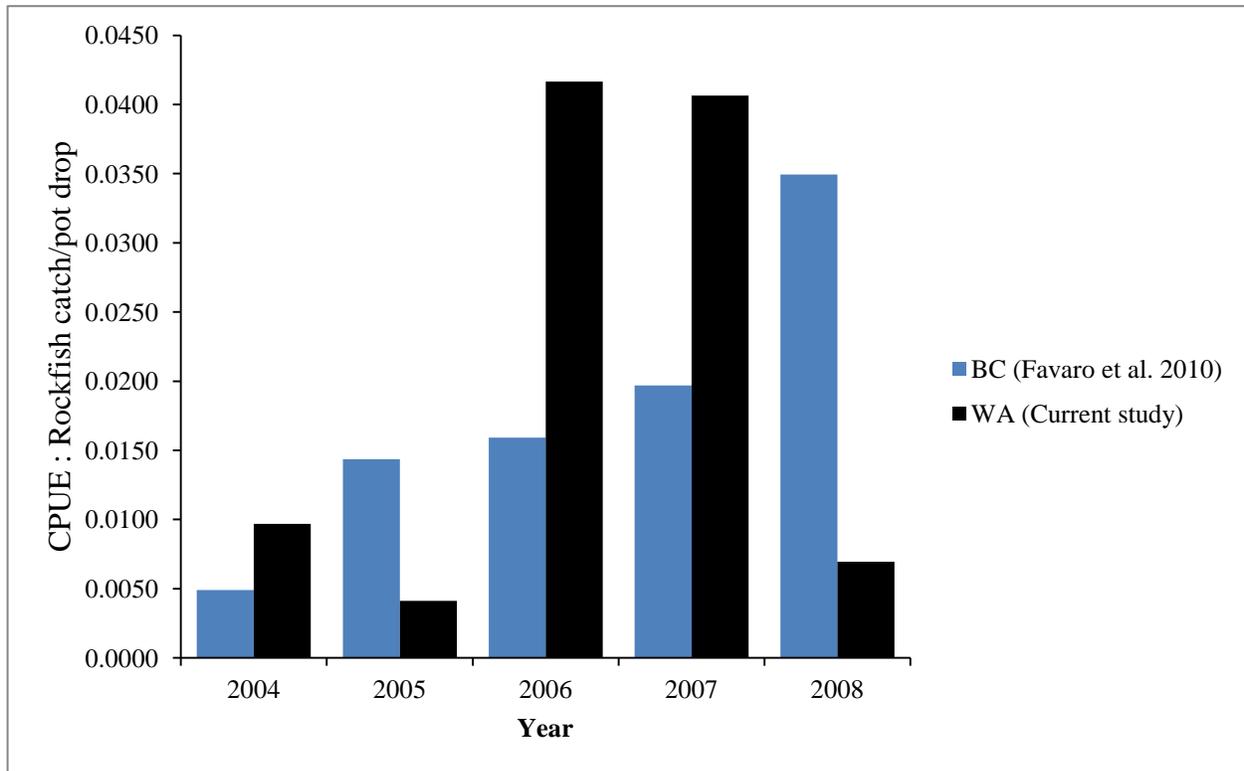


Figure 5. Comparison of rockfish bycatch rates from British Columbia (Favaro et al. 2010) and Puget Sound, WA (current study)

Based on similarities in pot style and bait used, along with locations of pot drops, we can speculate that the rockfish bycatch rates calculated in this study from the WDFW spot prawn test fisheries can be applied to both the recreational and commercial shrimp pot fisheries in the Puget Sound; and in doing so we can estimate the potential amount of rockfish bycatch that occurs each year within the entire Puget Sound shrimp pot fishery. To do this, we estimated total number of combined pot hours, across sectors (recreational, non-Treaty commercial, Treaty commercial) for each year from 2004 through 2013 from data provided in WDFW statistical summaries. Although pot drop information was not available for the Treaty fishery, CPUE per pound of shrimp caught were assumed equal in the Treaty fishery as in the non-Treaty commercial fishery. The total number of pot drops within the Treaty fishery was calculated by applying the yearly CPUE from non-Treaty commercial shrimp fishery to the total annual catch weight in the Treaty commercial shrimp fishery for each year over the period 2004 to 2013. Pot drops from the state commercial fishery and pot days from the recreational fishery were provided by WDFW statistical summaries. Two hours and 24 hours were used as the low and high range of soak times for pot drops in the commercial fisheries, while 0.75 and three hours were used for pot days in the recreational fisheries. This allows these preliminary calculations to account for the variations in soak times between and within the fishing sectors. Using this method the data suggests that between 2,534 and 28,088 rockfish were captured in the Puget Sound shrimp pot fisheries over the ten year period of 2004 to 2013, with an average annual capture of between 253 and 2,809 (Table 8).

Table 8. Preliminary estimates of rockfish bycatch by year in all Puget Sound shrimp pot fisheries combined, based on bycatch rates from shrimp pot test fisheries.

Year	Rockfish catch rate per hour	Total Min Pot Hours	Total Max Pot Hours	MIN Est. Rockfish Bycatch in Pot Fisheries	MAX Est. Rockfish Bycatch in Pot Fisheries
2004	0.00049	245,487	2,769,151	121	1,362
2005	0.00021	234,694	2,660,938	50	571
2006	0.00199	182,186	2,041,597	364	4,065
2007	0.00184	212,335	2,370,181	390	4,359
2008	0.00031	171,904	1,881,040	54	589
2009	0.00274	162,994	1,781,568	447	4,884
2010	0.00243	195,338	2,163,050	474	5,246
2011	0.00111	175,547	1,936,376	195	2,146
2012	0.00124	186,263	2,053,851	232	2,557
2013	0.00000	172,496	1,841,040	0	0
<b>Annual Average</b>	0.00131	193,924	2,149,879	253	2,809
<b>Grand Total</b>	0.00131	1,629,349	17,799,356	2,534	28,088

Refinements were made to the pot loss rates within the Puget Sound recreational shrimp pot fisheries based on another year’s worth of creel survey data that included questions regarding shrimp pot loss. The similarities in loss rates between 2012 and 2013 suggest that these rates of 2.01% and 2.56% give a more accurate depiction of the number of pots lost per season than the previous estimates derived from earlier creel survey data that did not include pot loss related questions. Additionally, the number of shrimp pots retrieved by WDFW patrols assists in calculating the amount of shrimp pots that actually become derelict per season. We estimate that a total of 1,340 shrimp pots have become derelict over the course of the 2012 and 2013 seasons. While the pot loss rates are larger than those reported in NRC 2012, we believe that they are relatively low in comparison to other pot fisheries in the Puget Sound and elsewhere. Assuming the loss rates within the fisheries and patrols conducting pot recovery remain consistent, average loss rate from 2012 and 2013 can be used to estimate number of derelict shrimp pots deposited in future years. Unfortunately for this research, the two questions related to pot loss were taken out of the creel survey questionnaire after the 2013 season; therefore unless they are added again, the 2012 and 2013 average will be the most accurate available pot loss rate to be applied to future years.

The only WDFW enforcement officer interviewed who encountered rockfish in recovered shrimp pots explained that these pots were newly lost and still freshly baited. All other interviewees had not encountered rockfish in pots removed during patrols. Therefore, evidence supporting rockfish impacts in derelict shrimp pots remains limited to the occurrences observed during derelict fishing gear removal operations conducted by NWSI, where two of 54 recovered, un-baited, derelict pots contained a total of eight rockfish (six live and two dead). This limited sample gives a relatively high rockfish bycatch rate for derelict pots (0.148 rockfish per pot) and provides speculative estimates suggesting that 3.7% of all derelict shrimp pots contain at least one rockfish, one quarter of which could be mortally entrapped. Full investigations of derelict shrimp pots in their environment, or simulated derelict pots in laboratory settings, may prove to be the most effective way of informing us on the subject of rockfish impacts from derelict shrimp pots. Additionally, there is the potential for derelict shrimp pots to affect localized, isolated populations of rockfish in areas where effort and pot loss are high. Further investigation is warranted considering the depleted status of many rockfish species in the Puget Sound.

## **Recommendations**

Based on the observations and results from rockfish bycatch estimates in the Puget Sound spot prawn test fishery, and the shrimp pot loss analysis, the following are recommendations for research priorities to further understand the potential impact to rockfish caused by derelict or active shrimp pots in the Puget Sound.

### *Reducing Rockfish Impacts from Active and Derelict Shrimp Pots*

- Update findings from this report by conducting semi-annual analysis of rockfish bycatch in WDFW spot prawn test fisheries.
- Conduct sidescan sonar surveys and investigate and possibly remove survey targets to verify they are shrimp pots and not crab pots, record presence or absence of live and dead rockfish by species and estimate length of time pots have been derelict.
- Investigate the length of time shrimp pots remain viable when derelict in order to fully understand the potential impacts shrimp pots have on rockfish.
- Consider conducting derelict shrimp pot simulation studies to gain a full understanding of rockfish (and other) bycatch in derelict shrimp pots.
- Investigate habitat effects from derelict shrimp pots.
- Investigate alterations to shrimp pots to reduce rockfish bycatch rates.

### *Reducing Shrimp Pot Loss*

- Consider reinstating two questions about pot loss in creel surveys
- Consider initiating an education program for recreational fishers to help minimize shrimp pot loss.
- Continue to time shrimp openings on days with mild tide exchanges to reduce potential pot loss rates.
- Fishers should be encouraged to release live caught rockfish at depth, similar to what is currently being proposed in the sport finfish fishery, in order to minimize mortality due to barotrauma.

## **Acknowledgements**

We thank Dan Tonnes at NOAA for his continuing efforts to better understand the links between derelict fishing gear and rockfish in the Puget Sound, and Joan Drinkwin at the Northwest Straits Foundation for securing funding for this research. We are grateful to Mark O'Toole and Brian McLaughlin at WDFW for providing valuable insight, data and access to records regarding the Puget Sound shrimp pot fisheries. We also thank the WDFW Marine Enforcement officers who provided their time to answer interview questions.

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