Status of the 5-spine (aka Green) Crab (*Carcinus maenas*) in Coos Bay: Monitoring Report 2022

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Introduction

The 5-spine crab (*Carcinus maenas*) has been transported around the world during the last century and has colonized many temperate coastlines (Behrens Yamada 2001). The trait best used to distinguish *Carcinus maenus* from other crabs along the west coast of North America are the 5 spines on either side of the eyes. In conversations with the Oregon Department of Fish and Wildlife staff the primary concern with community-based trapping programs is the potential for mis-identification and the resulting destruction of native crab species, since some have green coloration and could therefore could be mistaken for "green" crabs. We suggested changing the common name to 5-spine crab since that imparts a better identification trait than green crab. We note that in the 5-spine crab's native range in Europe, it is called the common shore crab, not the "green" crab. To advocate for the change in name we will use 5-spine crab for this report.

Photo of 5-spine crabs in Fukui trap. Note the 5 spines (marginal teeth) on either side of the eyes, which is the primary identification trait that distinguishes 5-spine crabs from native crabs in Oregon estuaries.

Numerous research studies have examined the biology and ecology of 5-spine crabs and have found the 5-spine crab to be an aggressive invader that negatively effects native species, important estuarine and marine habitats, and fisheries (Behrens Yamada, 2001; Grosholz et al., 2011; Malyshev & Quijo´n, 2011; Garbary et al., 2014; Neckles, 2015; Matheson et al., 2016; Howard et al., 2019; Green and Grosholz 2021). The 5-spine crab is currently invading the west coast of North America. 5-spine crabs became established in the San Francisco estuary prior to 1989 (Behrens Yamada, 2001). Since then, coastal currents have been seeding 5-spine crab larvae into estuaries of the Pacific Northwest, including Coos Bay (Behrens Yamada et al., 2015). In the past, this migration appears to be linked to strong northwards currents during El Niño years (Behrens Yamada et al., 2015; Behrens Yamada et al., 2021), as indicated by a mixture of high abundance years, low abundance years, and extinction events. However, since 2016 the abundance of 5-spine crabs has been continuously increasing in Coos Bay and is now at levels where negative impacts are expected to occur. The purpose of this project is to monitor changes in 5-spine crab abundance and annual recruitment in the Coos Bay Estuary. The project goals are to: 1) examine change in 5-spine crab abundance (CPUE) among sites and over time, 2) examine the young-of-the-year new recruit age class to assess size structure and determine whether recruitment is occurring from within Coos Bay.

Methods

At each of the sites (Appendix 1) we set either Fukui fish traps and/or crayfish traps (5cm trap opening) during morning low tide and retrieved traps at low tide the following morning (24 hours). Sets of traps were set as 6 traps per site. Fukui and crayfish traps were baited with raw tuna enclosed in a plastic bait container and staked in place with a 20 inch steel rod. When traps were retrieved, the number of individuals of each crab species in each trap was recorded. Dungeness crabs (*Metacarcinus magister*), red rock crabs (*Cancer productus*), and shore crabs (*Hemigrapsus oregonensis* and *H. nudis*) were counted but not measured. When possible, we recorded water quality data (salinity, pH, temperature) at the trap site using a YSI hand-held meter. European 5-spine crabs (*Carcinus maenas*) were counted in the field and then brought back to the laboratory and measured for size (carapace width, mm), weight (g), and sex (m/f). Abdomen color and missing limbs were also recorded.

Intern Sebastian Velazquez setting a Fukui trap.

Intern Colleen Walker setting crayfish and Fukui traps.

Results

We set 393 crab traps (243 Fukui, 150 crayfish) at 12 sites in Coos Bay from June through September of 2022. We captured 941 green, 413 Oregon shore, 407 Dungeness, and 129 red rock crabs. This includes data for all traps at all sites for all sampling dates from June thru September 2022.

Abundance among Coos Bay sites:

To better compare adult abundance over time, we selected only the 10 sites sampled using Fukui traps during the summer months (May-August) (Table 1). The average CPUE was highly dependent on site. 5-spine crabs were found at all sites but were most common in the mid to upper estuary sites where adult Dungeness and red rock crabs were absent (Coos History Museum, Isthmus Slough, Joe Ney Slough). Red rock crabs were present only at sites lower in the estuary (Charleston Boat Basin, Empire Docks) and adult Dungeness crabs were most abundant at low and mid-estuary sites (Empire Docks, Valino Island, Charleston Boat Basin, Transpacific Lane).

Table 1. Mean CPUE for the four most common crab species trapped during summer 2022 in Coos Bay using baited Fukui traps (see map for locations, Appendix 1). Sites are ordered by distance from mouth.

Site	Latitude	Longitude	CPUE 5-spine (mean)	CPUE Red rock (mean)	CPUE Oregon shore crab (mean)	CPUE Dungeness (mean)
Coos Estuary						
Charleston Boat Basin	43.34674	-124.32839	2.78	2.17	0.00	1.28
Empire Docks	43.39300	-124.28000	0.56	1.55	0.00	2.22
Transpacific Lane	43.44285	-124.22300	3.45	0.00	0.00	3.67
Coos History Museum	43.37506	-124.21200	15.50	0.00	0.00	0.00
Isthmus Slough	43.35635	-124.19300	6.50	0.00	0.00	0.06
South Slough Estuary						
Metcalf Marsh	43.33393	-124.32700	3.55	0.00	0.18	0.11
Joe Ney Slough	43.33929	-124.31000	6.56	0.00	0.28	0.00
Valino Island	43.31514	-124.32100	1.19	0.00	0.53	4.52
Big Cedar	43.29801	-124.32270	1.33	0.00	7.05	0.00
Hinch Bridge	43.27627	-124.31969	0.11	0.00	1.28	0.00
Average CPUE			4.15	0.37	0.93	1.19

Abundance over time:

One objective is to look at changes in adult 5-spine crab abundance over time. If we look at mean 5-spine crab CPUE from Coos Bay sites during summer months (May through August) using Fukui traps we see a consistent increase in abundance since 2016 through 2021 and then a slight decrease from 2021 to

2022 (Figure 1). We also see an increase in variability in abundance among the sites over the 20-year period (Figure 1, standard deviation).

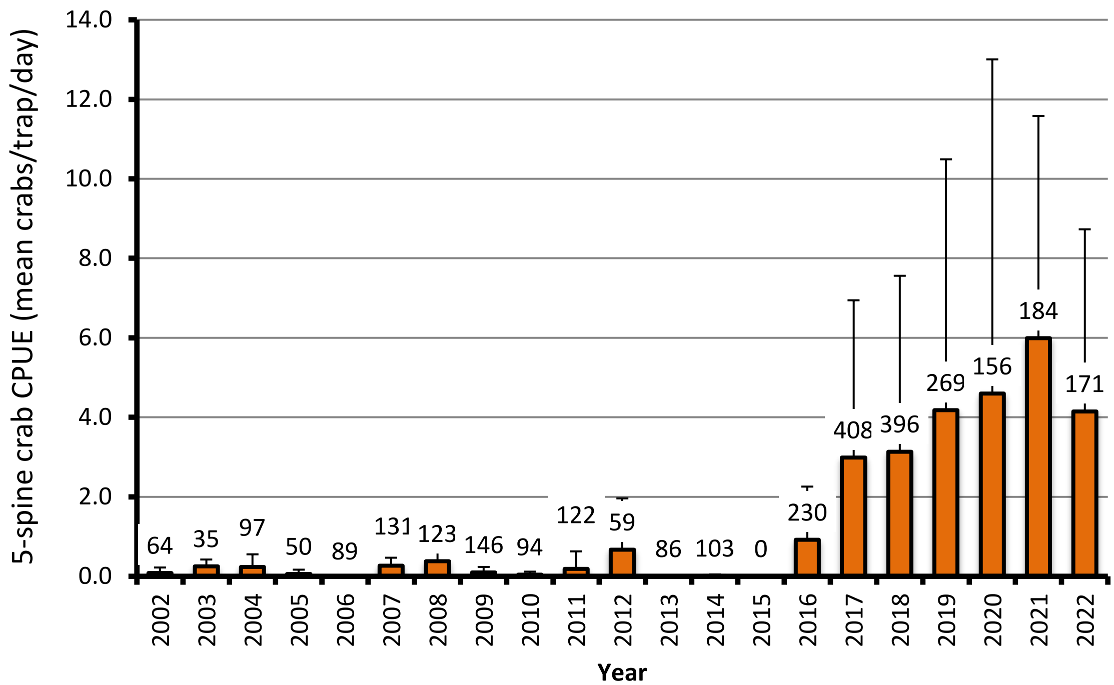

Figure 1. Mean CPUE for 5-spine crabs using Fukui traps for sites sampled in Coos Bay during summer months (May through August). Errors bars indicate standard deviation. Labels above bars indicate the total number of Fukui traps retrieved at the sites.

Variability may be caused by habitat differences among sites. We see this in the 2022 site data (Table 1). We can also examine temporal trends at each site (Figure 2). We see that the temporal trend among sites generally matches the 2022 site data with consistently more 5-spine crabs at mid to upper estuary sites (Figure 2).

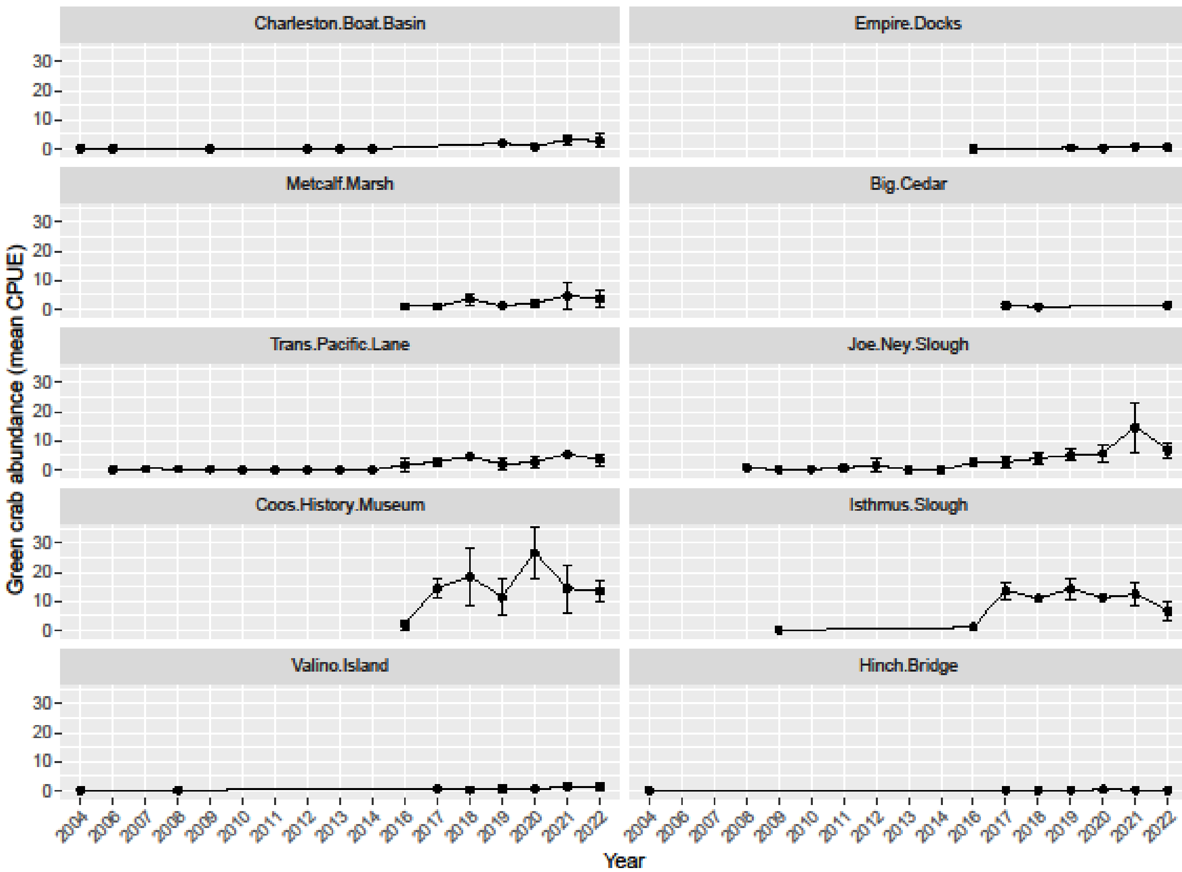

Figure 2. Mean 5-spine crab CPUE at 10 sites in Coos Bay over time trapped using Fukui traps from May – August 2004 through 2022. Error bars indicate standard deviation among sample dates at each site. Missing years indicate no sampling using Fukui traps was conducted (2005, 2015).

Size Structure of the young-of-the-year age class:

The size frequency distribution of young-of-the-year (YOTY) crabs gives some insight into the recruitment source of young crabs into the adult population. Maximum size for a YOTY crab is around 50mm, larger crabs are most likely crabs from the previous year's recruitment. A single tight bell-curve shaped distribution indicates that the larvae arrived in the estuary at approximately the same time, likely from the same location. Flat or double-humped distributions indicate that larvae may have arrived in more than one cohort, suggesting multiple sources. We examined the frequency distribution of YOTY 5-spine crabs using September and October crayfish trap data for 2017-2022 to look at change in size frequency distributions in Coos Bay over time (Figure 3). In 2018 we see a frequency distribution with two humps, possibly indicating multiple sources. In the other years we see tight bell-shaped distributions, indicating a single source. In addition, we see a shift over time from relatively more YOTY crabs in 2017-2018 to fewer YOTY crabs in 2019-2022.

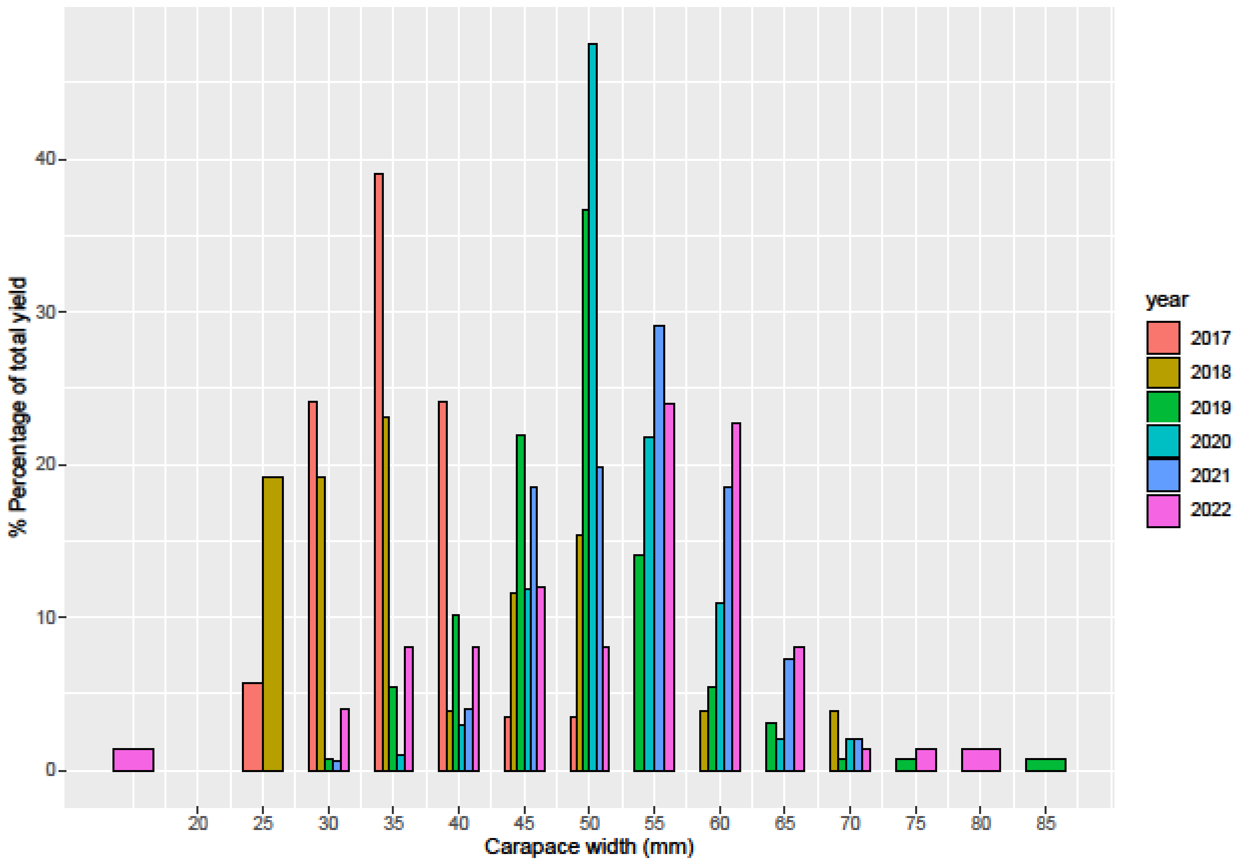

Figure 3. Crab size frequency distribution for 5-spine crabs sampled at sites in Coos Bay in September and October 2017-2022 using crayfish traps. Young-of-the-year 5-spine crabs are those less than 50 mm carapace width. Numbers for each year are relativized as percentage of yield for direct comparison.

We have been capturing relatively fewer YOTY 5-spine crab recruits since 2020. This is possibly due to several consecutive La Niña years, during which the slower-moving Davidson Current transports fewer larvae from San Francisco Bay to the Oregon Coast (Yamada et al. 2021). As the number of YOTY recruits declines we are seeing that the average size of remaining adults increased from 2021 and 2022 (Figure 4).

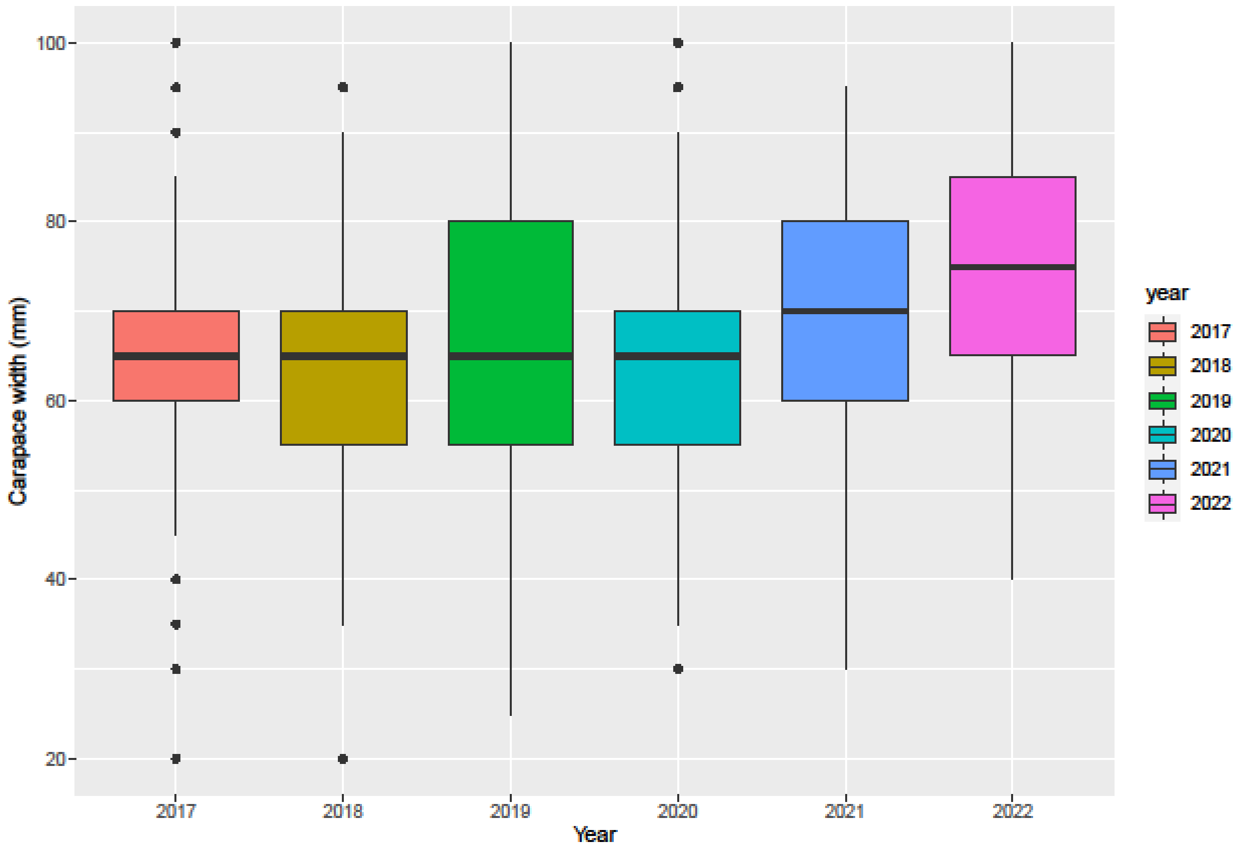

Figure 4. Box plots of 5-spine crab size distribution sampled from June – August using Fukui traps from 2017 to 2022. Thick line is the median carapace size, box indicates upper and lower quartiles, bars indicate minimum and maximum (excluding outliers), points indicate outliers.

Discussion

We found that although 5-spine crab abundance had been increasing for several years prior to 2022, in 2022 we detected a slight decrease in catch per unit effort. Most likely this is due to declines in new recruits over the recent series of La Niña years, when the Davidson current is weaker and we thereby receive fewer recruits from the south (primarily San Francisco Bay). However, the decline is not as dramatic as the declines seen during the previous series of La Niña years, suggesting that we now have recruits arriving from other sources, possibly internally from Coos Bay or from other estuaries. Despite the observed decline in adult 5-spine crabs in 2022 we expect that the populations will increase rapidly in future El Niño years, when recruitment increases. In our YOTY sampling we are finding relatively fewer new recruits and the average size of crabs has been increasing. This suggests a population with more older crabs and fewer younger crabs. If La Niña years continue, we expect to see continued declines in adult crab abundance as the older crabs die at around 6 years of age, which is their expected lifespan. Despite the overall decline in abundance, populations at some sites, particularly around the Coos Bay waterfront are still high enough to expect negative effects on shellfish and eelgrass.

Per capita Impacts of 5-spine Crabs on Shellfish Abundance

The degree of the negative impact of an invasive species is dependent on its density. Researchers have examined the relationship between the abundance of 5-spine crabs and decline in shellfish abundance. They found that negative impacts start between 10 and 20 CPUE (Green and Grosholz 2021; Grosholz et al 2011). This indicates that we are likely experiencing significant reductions in shellfish abundance in areas of the Coos and South Slough estuaries, primarily in the mid-estuary regions.

Potential Impact on Bivalves

5-spine crabs are known to negatively affect populations of clams, oysters, and mussels. Studies on the east coast of North America found that 5-spine crabs ate bivalve species including quahogs (*Mercenaria mercenaria*), eastern oysters (*Crassostrea virginica*), blue mussels (*Mytilus edulis*), and soft-shell clams (*Mya arenaria*) (Miron et al., 2005). They found predation on these species across a large range of sizes (0-40mm) with 5-spine crabs preferring to feed on mussels and clams. Therefore, we expect to see decreasing populations of native clams including littleneck, gaper, razor, butter, and cockles. We also expect 5-spine crabs to negatively affect populations of native Olympia oysters. 5-spine crabs may also affect Pacific oysters, but the widespread use of oyster shell bags for rearing will probably reduce the ability of 5-spine crabs to access oysters, at least those growing in the interior of the bags. However, small 5-spine crabs could get into the bags as juveniles and then consume oysters as they grow inside the bags.

Potential Impact on Eelgrass

Studies along the east coast of North America, where 5-spine crabs have been abundant for decades, have found that the increasing 5-spine crab populations have caused large declines in eelgrass meadows (Malyshev & Quijo´n, 2011; Garbary et al., 2014; Neckles, 2015; Matheson et al., 2016). A recent study along the coast of British Columbia found similar results (Howard et al., 2019). These studies found that 5-spine crabs destroy eelgrass meadows both directly, by eating eelgrass rhizomes, and indirectly, when digging for food (bioturbation). Since eelgrass is an important foundational habitat for many marine and estuarine organisms, we expect to see indirect impacts (secondary effects caused by the loss of eelgrass caused by 5-spine crabs) to these species as their habitat declines. For example, researchers in Newfoundland found a 10-fold decrease in abundance and biomass of fish in beach seines when comparing areas of eelgrass habitat destroyed by 5-spine crabs and nearby eelgrass meadows without 5-spine crabs (Matheson et al., 2016).

Potential Impact on Dungeness Crab

The greatest increase in 5-spine crab abundance is at mid to upper estuary sites where adult Dungeness and red rock crabs are absent or in low abundance. However, juvenile Dungeness crabs tend to forage in upper and mid estuary nursery sites. For example, in 2018 we captured over 200 juvenile Dungeness crabs per seine sample in both September and October in the upper reaches of South Slough (Sengstacken arm near Elliot Creek). Previous research has found that 5-spine crabs displace juvenile Dungeness crabs from desirable sheltered habitats, which increases their chance of being preyed upon (McDonald et al., 2001). 5-spine crabs also consistently win nocturnal foraging trials over juvenile Dungeness crabs (McDonald et al., 2001). The authors conclude that 5-spine crabs could negatively impact the Dungeness crab fishery as 5-spine crabs encroach on juvenile Dungeness crab nursery habitat, such as what is currently happening in Coos Bay. In addition, a 2019 study conducted by South Slough National Estuarine Research Reserve researchers found that red rock crabs prefer to predate on juvenile Dungeness crabs over 5-spine crabs of the same size, indicating that predation by adult crabs might reduce 5-spine crab abundance, but will not necessarily be favorable to Dungeness crab populations (Heller and Schooler, unpublished data). As described above, as 5-spine crabs increase in abundance**,** they will also destroy eelgrass habitat, which is a favored habitat of juvenile Dungeness crabs.

Conclusions

After a 6-year period of increasing abundance (2016-2021) we found a slight decrease in CPUE at our 10 annual sampling sites in 2022. This is most likely due to a series of La Niña years in which recruitment of larvae to the Coos Bay estuary has declined. Because there are fewer YOTY recruits added to the population, the total number of 5-spine crabs has slightly declined and the average size has increased. The Coos Bay waterfront appears to be a hotspot for 5-spine crabs, perhaps due to habitat structure and food availability. More research is needed to: 1) determine the potential impacts of 5-spine crabs (per capita impact) on important estuarine fisheries, species, habitats, and food webs, 2) evaluate reasons for high variability in 5-spine crab abundance, 3) determine sources of recruitment of 5-spine crabs, and 4) identify and study management options.

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Appendix 1. Map of the 10 adult 5-spine crab sampling sites sampled in 2022.