OREGON MARINE SCIENTIST AND EDUCATOR ALLIANCE

The Green Crab Invasion of Oregon Estuaries

Teacher Guide: Activity Synopsis

The big picture

Measures of central tendency (average, median, mode) are important for summarizing large datasets and for comparing different sets of measurements, but they can also hide important information in datasets. When improperly used these statistical measures can be used by unscrupulous people to create a biased summary of a dataset and can be used to fool people into believing something that is not true. This is why scientists always report variability along with the mean in scientific publications.

Averages and variability

Sometimes humans move other species, either on purpose or by accident, to new habitats where they would not occur naturally. These are called introduced, non-native, or non-indigenous species. In many cases these species do no harm, and can even be important for humans, such as the domesticated plants and animals that we cultivate for food. However, occasionally the introduced species can negatively affect humans and other species including domesticated species and native species. We call these plants, animals, or pathogens “invasive species”.

Green crabs have been proven to be invasive species in numerous countries around the world including the U.S., Canada, Australia, and South Africa. They are relatively new to the west coast of North America. The negative effects of green crabs depend on how many there are in the area we are concerned about, their density. In order to determine their potential negative effects we need to monitor their density over time. We do this by trapping crabs and then comparing the relative abundance over time. Since we sometimes use differing numbers of traps at a particular site we need to account for the number of traps we use, otherwise more traps would just mean more crabs. We do this by dividing the number we capture in all the traps by the number of traps we set, this is called the catch per unit effort or CPUE. We can then compare this number over time to monitor the density of green

crabs. Based on prior research, when green crab density reaches 10 CPUE we expect that the crabs are causing reductions in native species that are economically, culturally, and ecologically important.
We often want to compare densities across multiple estuaries to see where we expect negative effects and where we should focus management efforts. To do this we calculate a measure of central tendency, like an average (or mean) CPUE, for all the sites in a specific estuary. Then we compare these densities among estuaries along the coast. In your project you use average CPUE to compare green crab density (CPUE) between Yaquina Bay and Coos Bay over time. You will look at the trend in density over time and you will find that one, on average, has a higher density of green crabs. Do these averages indicate negative effects are occurring?

However, the average does not tell the whole story. In each estuary multiple sites were sampled. These different sites may have differing densities of green crabs, which the overall average density for the estuary does not reflect. This is called variability. Variability is a very important measure in science because it indicates how clustered the data are around the mean. If all the CPUE's from the different sites are very similar, then the variability will be small. If the CPUE's are very different then the variability will be large. There are several ways to measure variability and we will use one measure, the standard deviation, to look at variability. Scientists usually use graphs to plot the average values and then add the measure of variability to the figure to summarize the data in the most informative way. What do you see when you do this for the green crab CPUE data for the 2 estuaries? If the average CPUE is below the threshold for negative impact for the estuary, might there be sites that are above that threshold? Where are they?

Analysis Methods

1) Calculate the CPUE for each site (Table 1)

Table 1. Data for number of green crabs caught at each site.

Estuary	Site	Date	Year	Number of traps	Number Green Crabs	CPUE Green Crabs
Coos.Bay	Trans.Pacific.Lane	07/22/16	2016	6	3	0.50
Coos.Bay	Coos.History.Museum	08/18/16	2016	10	13	1.30
Coos.Bay	Joe.Ney.Slough	08/18/16	2016	13	32	2.46
Coos.Bay	Coos.History.Museum	06/27/17	2017	12	154	12.83
Coos.Bay	Joe.Ney.Slough	06/23/17	2017	3	16	5.33
Coos.Bay	Trans.Pacific.Lane	07/22/17	2017	12	36	3.00
Coos.Bay	Coos.History.Museum	07/24/18	2018	9	209	23.22
Coos.Bay	Trans.Pacific.Lane	07/12/18	2018	5	22	4.40
Coos.Bay	Joe.Ney.Slough	08/03/18	2018	10	70	7.00
Coos.Bay	Coos.History.Museum	08/14/19	2019	6	128	21.33
Coos.Bay	Joe.Ney.Slough	08/13/19	2019	6	21	3.50
Coos.Bay	Trans.Pacific.Lane	08/16/19	2019	6	15	2.50
Coos.Bay	Coos.History.Museum	08/20/20	2020	6	212	35.30
Coos.Bay	Joe.Ney.Slough	08/22/20	2020	6	44	7.33
Coos.Bay	Trans.Pacific.Lane	08/18/20	2020	6	21	3.50
Coos.Bay	Joe.Ney.Slough	06/18/21	2021	6	166	27.70
Coos.Bay	Trans.Pacific.Lane	06/15/21	2021	6	35	5.83
Coos.Bay	Coos.History.Museum	08/10/21	2021	6	127	21.20
Yaquina.Bay	HMSC.Pumphouse	06/24/16	2016	7	5	0.71
Yaquina.Bay	Oregon.Coast.Aquarium	07/16/16	2016	4	5	1.25
Yaquina.Bay	Sallys.Bend.C	08/15/16	2016	10	15	1.50
Yaquina.Bay	HMSC.Pumphouse	06/01/17	2017	5	5	1.00
Yaquina.Bay	HMSC.Pumphouse	06/30/17	2017	9	38	4.20
Yaquina.Bay	Oregon.Coast.Aquarium	06/30/17	2017	6	42	7.00
Yaquina.Bay	HMSC.Pumphouse	06/06/18	2018	8	84	10.50
Yaquina.Bay	Oregon.Coast.Aquarium	06/06/18	2018	8	98	12.30
Yaquina.Bay	HMSC.Pumphouse	07/01/19	2019	5	23	4.60
Yaquina.Bay	Sallys.Bend.C	06/29/21	2021	24	132	5.50
Yaquina.Bay	Sallys.Bend.C	07/12/21	2021	4	30	7.50

2) Calculate the average CPUE for each estuary for each year and calculate the standard deviation for each estuary for each year (Table 2).

Table 2. Mean CPUE and standard deviation

Estuary	Year	Average CPUE	Standard deviation
Coos Bay	2016	1.4	1.0
Coos Bay	2017	7.1	5.1
Coos Bay	2018	11.5	10.2
Coos Bay	2019	9.1	10.6
Coos Bay	2020	15.4	17.4
Coos Bay	2021	18.2	11.2
Yaquina Bay	2016	1.2	0.4
Yaquina Bay	2017	4.1	3.0
Yaquina Bay	2018	11.4	1.3
Yaquina Bay	2019	4.6	na
Yaquina Bay	2020	not sampled	not sampled
Yaquina Bay	2021	6.5	1.4

3) Plot the average CPUE with standard deviation for both estuaries (Figure 1).

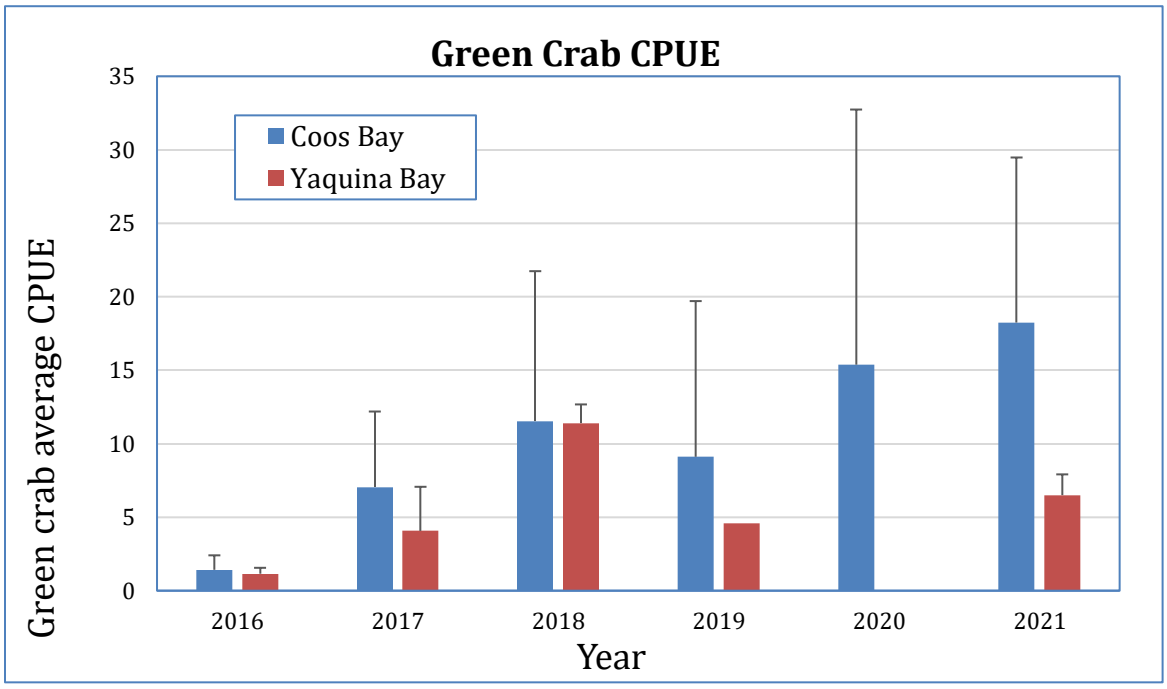

Figure 1. Green crab mean CPUE from 2016 to 2021 in Coos and Yaquina estuaries. Error bars indicate standard deviation.

Conclusions

The abundance of green crabs in Coos Bay has increased steadily over the last 6 years from an average CPUE of 1.4 (stdev=1.0) in 2016 to an average CPUE of 18.2 (stdev=11.2) in 2021. The abundance of green crabs in Yaquina Bay has fluctuated over time and is more difficult to assess due to missing years of sampling and fewer sites sampled consistently.

The standard deviation of green crab mean CPUE has also increased in Coos Bay over time. This indicates there is a lot of variability in CPUE among sites. If we look at the change in CPUE over time at the 3 sites we see different trends that are obscured in the graphs just plotting the averages. We see that the number of green crabs at the Coos History Museum site increased rapidly and then declined, the number at Joe Ney Slough stayed low for 5 years then increased dramatically, and the number at Trans Pacific Lane remained low throughout the time period (Figure 2).

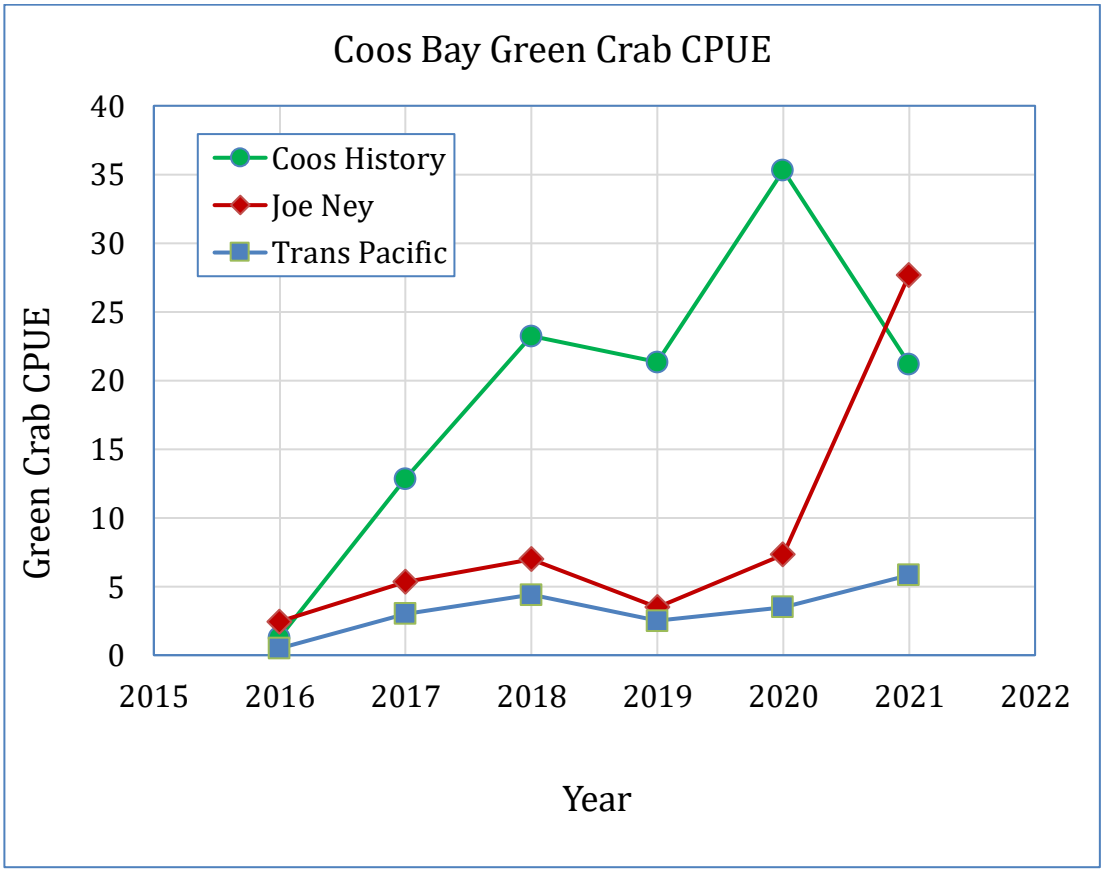

Figure 2. Green crab CPUE from 2016 to 2021 in Coos Bay.