Crab Dentition Patterns and Impacts on Their Diet

Tiffany Huang, Lauren Brandkamp, Stephanie Crofts

Marine Environmental Research Experience (FISH 479)

Fall 2012

Friday Harbor Laboratories, University of Washington, University Road, Friday Harbor, WA 98250

School of Aquatics and Fishery Sciences, University of Washington, Seattle, WA 98195

Contact Information

Tiffany Huang

School of Aquatics and Fishery Sciences

huangt3@uw.edu

Keywords: *Metacarcinus magister, Cancer productus, Cancer oregonensis, Pugettia gracilis, Pugettia richii, Pugettia producta*, *Telmessus cheiragonus, Hemigrapsus nudus, Scyra acutifrons, Oregonia gracilis, diet, dentition patterns*

Abstract

Morphological and mechanical features of crab claws reflect their functions and prey selections. This study focuses on the phylogenetic dentition patterns of crabs and the impacts it has on prey consumption. Pictures of crab carapace and the right claw were imported to Image J to measure aspect ratio, radius of curvature, propus length, and denticle position for each denticle as well as the carapace length. Generalist species such as *Oregonia gracilis* tend to have a smaller radius of curvature and a larger aspect ratio. The specialists' species such as *Pugettia richii, Pugettia gracilis, Pugettia producta, Metacarcinus magister, Cancer productus, Cancer oregonensis, Telmessus cheiragonus, Scyra acutifrons,* and *Hemigrapsus nudus* have a larger radius of curvature and a smaller aspect ratio. Generalist species commonly eat small soft marine organisms and macro algae, while the specialist species consume hard-shelled prey, such as barnacles, clams, snails, etc. Most specialist species have wider, blunter denticles at the fulcrum and become narrower, sharper towards the tip. The mechanical advantages for these crab species comes from the tip of the claw; allowing them to crush their prey. Generalist species have sharper, narrower teeth from the fulcrum to the tip of the claw. These crabs do not use their claws for crushing, but more for shredding. Denticle position and mechanical advantages heavily impact the dietary and foraging behaviors of the crabs studied. The data collected from this research could potentially jump start research on crab dentition. By understanding the use of crab denticles, we will have a greater advantage to studying crab foraging behaviors and denticle morphologies.

Introduction

Crab species that feed primarily on fast moving prey generally have fast, but weaker claws, whereas the species that feed on thicker shelled mollusks have claws that are slower, but more powerful (Yamada et al., 1998). Previous studies have shown that claw characteristics can differ geographically, for instance, crab species in the tropics may be considered specialists for attacking hard-shelled prey (Daniels et al., 2006). A study led by Yamada et al. (1998) focused on the claw morphology and the claw closing forces of the following species of intertidal crabs; *Cancer oregonensis, Cancer productus, Lophopanopeus bellus,* and *Hemigrapsus nudus.* From the study, the authors concluded that species with blunt denticles; the teeth like structures on the claws, are generalists and species with sharp overlapping denticles (scissor like) are specialists. Crab claws with greater propus; the bottom immovable finger of the claw, height and greater claw gape prefer smaller prey, while crabs with smaller propus and smaller claw gape prefer larger prey.

Crabs that feed on molluscs usually possess dimorphic claws, a larger and more powerful claw on the right hand side of the body that functions to crush prey, and one smaller, less robust, cutter claw on the left hand side of the body (Seed and Hughes, 1995). Dietl and Vega (2008) studied the fossils of large brachyuran crab species from the Late Cretaceous of Mexico. These species have specialized claws for shell breaking. The right claw is larger than the left, generally armed with several broad teeth, including curved tooth structure at the base of the dactyl. The tooth was observed on claws of many living durophagous crabs today that use it to peel, crush or chip the edges of molluscs. The morphology of the claw structure from 100 million years ago has not changed and is still seen today in many durophagous crab species. Dentition is needed to fully understand the relationship between force generation and diet (Schenk and Wainwright, 2001).

The denticles on generalist non-durophagous crab differ from the specialist durophagous ones. Durophagous organisms prefer to consume hard-shelled prey, while non-durophagous organisms have a varied diet which mainly includes soft prey items. The uses of claws vary between numerous crab species, which leads me to my question; does the radii of curvatures and aspect ratios of denticles influence the diets of crab species? My hypothesis is if the radius of the curvature is large and aspect ratio is low then the denticles would be used for crushing in specialist durophagous species. If the radius of the curvature is small and aspect ratio is high then the denticles would be used for shredding or scooping in generalist durophagous species.

Description of crab species

As shown in table 1, *Metacarcinus magister* commonly known as the Dungeness crab, occurs in sandy/muddy bottoms of shallow coastal waters from North Alaska to North Mexico (Fig 1A). Dungeness crabs scavenge the sea bottom for organisms such as shrimp, clams, barnacles, and other small crabs.

Cancer productus commonly known as the Red Rock crab inhabits soft substrates of coastal waters from Central Alaska to North Mexico. They have broad rounded teeth between the eyes and have distinctive black tips on their claws (Fig 1B). The Red Rock crabs generally prey on barnacles, bivalves, other small living crabs, and as well as dead fish.

Cancer oregonensis also known as the Pygmy Rock crab live in rocky intertidal from North Alaska to South California. They have a round carapace with numerous teeth and hairy legs (Fig 1C). The Pygmy Rock crab feed on small barnacles, small snails, molluscs, and worms.

Pugettia producta commonly known as Northern Kelp Crab have a smooth dark brown dorsal carapace surface shaped like a shield. They live in kelp bed from South Alaska to North Mexico (Fig 1D). The Northern Kelp crab primarily feed on algae, barnacles, and mussels.

Pugettia gracilis also known as Graceful Kelp Crab have spines on their legs that help them hang onto kelp and avoid being swept away. This species live in eelgrass/kelp beds from North Alaska to North Mexico (Fig 1E). The Graceful Kelp crab eats barnacles, mussels, and sometimes algae.

Pugettia richii are known as Cryptic Kelp Crab. They live in the rocky intertidal from South Alaska to North Mexico. They have a sharp lateral tooth near the middle of the carapace. Their chelae's are bright blue near the end with orange, red or white tips (Fig 1F). The Cryptic Kelp crab feeds on mussels, clams, barnacles, hard-shelled prey items.

Oregonia gracilis are known as the Graceful Decorator crab has a long rostrum (forward extension of the carapace in front of the eyes) with 2 spine-like processes instead of flattened ones. These inhabit Japan, North Alaska to Central California and live in mixed composition bottoms (Fig 1G). These guys primary feed on drift kelp (Daly et al., 2010).

Scyra acutifrons, Sharp-Nosed crab live in higher sub tidal areas from Japan, North Alaska to North Mexico. They have a triangular carapace and a flattened rostrum (Fig 1H). The Sharp-Nosed crabs prey on sessile invertebrates and detritus.

Hemigrapsus nudus, the Purple Shore crab inhabits the rocky intertidal from South Alaska to North Mexico. They do not have hairs on their legs and are usually purple, olive green, or reddish brown (Fig 1I). These guys feed on diatoms, desmids, and small green algae scraped off of substrates with the tips of their chelae (claw).

Telmessus cheiragonus, Helmet crab has a 5 sided carapace; the claws are shorter than the walking legs, and usually greenish or brownish yellow in color. They live in eelgrass; soft sediment, ranging from Japan, Korea, Siberia, North Alaska to Central California (Fig 1J). The Helmet crabs generally eelgrass, snails, algae, worms, and bivalves.

Materials & Methods

Experimental Animals

Different species of crabs were collected, photographed, and measured using Image J. The different species of crabs includes: *Metacarcinus magister, Cancer productus, Cancer oregonensis, Pugettia producta, Pugettia gracilis, Pugettia richii, Oregonia gracilis, Scyra acutifrons, Hemigrapsus nudus,* and *Telmessus cheiragonus*.

Collection of Crabs

The different species of crabs were collected in various ways. The first method was crab potting. We baited crab pots with chicken drumsticks, deployed them in 5 different locations at Brown Island in the San Juan Channel the fall of 2012, and picked up after 16 hours. Brown Island is located at (48.5380 N, 123.0037 W). The crabs were kept in tanks with circulating water and fed twice a week. The second method was going out to the docks at Friday Harbor Labs and flipping the tires or using nets to catch crabs on the pilings. The third method was going out on low tide to the shore out in front of Lab 3 and Fernald and looking under rocks. A total of 51 crabs were collected and released back to their original habitat after pictures of their carapace length and right claws were taken.

Measuring the crab species

Image J version 1.46 was used to measure the carapace length, total number of denticles, carapace length, propus length, fulcrum to denticle length, base, height, and radius of each denticle on their right claw.

To measure the carapace, I set the scale for the picture and drew a line from the left side of the carapace to the right side using the straight line tool. The line was drawn two-thirds down from the eyes where the carapace starts to pinch in. This was repeated for each crab carapace (Fig 2A).

To measure the other variables, I set the scale for the picture and used the segment line tool to measure the entire propus length starting from the fulcrum (A). Propus is the immovable finger of the chelae (claw). To measure the height (B), base (D), and fulcrum to the middle of the denticle (E), I used the segmented line tool. I repeated measuring from the fulcrum to each denticle. For instance, the Dungeness in figure 2B has a total of 9 denticles; therefore, I measured (E) 9 times. To find the aspect ratio, I divided the height measurement by the base measurement. The last measurement was to find the radius of curvature of each denticle (C). The circle tool measured the area of the denticles. It must be placed to crown the whole denticle tip itself then by applying (*pi* r^2) to the area measured, the radius of curvature was found.

Statistical Analysis

JMP version 10 was used to run linear regressions and one way ANOVAs (analysis of variance) to determine correlations between denticles of each species. The linear regressions were done for the carapace length (cm) and propus length (cm), propus length (cm) and denticle numbers, propus length (cm) and aspect ratio (AR), propus length (cm) and radius of curvature (RoC), aspect ratio and radius of curvature. The one way ANOVAs were done for species and aspect ratio (cm) and species and radius of curvature (cm). The ANOVA tests put all the data into one group and give us one P value. If the P value is less than 0.5 then there is significant data. A student t-test was also run along with the ANOVA telling us if the variation between the two groups was significant.

Results

The radius of curvature decreases as the aspect ratio increases for *Metacarcinus magister (M. magister), Pugettia producta (P. producta), Scyra acutifrons (S. acutifrons),* and *Telmessus cheiragonus (T. cheiragonus)* (figure 3). The denticles on the right claw of the *M. magister, T. cheiragonus, and Scyra acutifrons* start at the base of the fulcrum to the propus. The denticles on the dactyl (moveable finger) and propus (immovable finger) do not overlap. The denticles on the propus of *P. producta* start two-thirds in from the fulcrum. In the species listed above, the denticles tend to have a larger radius near the fulcrum and smaller radius at the tip of the propus.

The aspect ratio varies between species of crabs. *M. magister* has a lower variation in aspect ratios. *C. productus, C. oregonensis, H. nudus, O. gracilis, P. gracilis, P. producto, P. richii, S. acutifrons,* and *T. cheiragonus* all have a higher variation in aspect ratios. There is a weak correlation between the aspect ratio and species, but is significant (figure 4). The radii of curvatures also vary between species of crab. *M. magister, P. richii, P. gracilis,* and *S. acutifrons* have a low variation in radii of curvatures. *C. productus, C. oregonensis, H. nudus, O. gracilis, P. producta,* and *T. cheiragonus* have a higher variation in radii of curvatures. There is a weak correlation between the radii of curvatures and species, but is significant.

In relation to aspect ratio, *Metacarcinus magister, Cancer oregonensis, Oregonia gracilis,* and *Pugettia gracilis* are all significantly different from the other species and each other, but *M. magister* and *C. oregonensis* are closely related by characteristics to each other than to *O. gracilis* and *P. gracilis. Cancer productus, Pugettia richii, Hemigrapsus nudus,* and *Telmessus cheiragonus* are the most similar to each other (figure 4). When looking at the radius of curvature, *C. productus M. magister, P. gracilis,* and *H. nudus* are significantly different from each other and from the other species. *C. oregonensis, O. gracilis, S. acutifrons,* and *P. richii* have similar characters to each other than to the others. *P. producta* and *T. cheiragonus* are not similar or close to the other species (Fig 5).

Discussion

From this experiment, my hypothesis was correct. The radii of curvatures and aspect ratios were significant to each other. As the radius of curvature decreased, the aspect ratio increased. This is because as the radius of curvature became smaller, the denticle itself is sharper and pointier. The sharper the tooth, the more it could be used for piercing. As the radius of curvature increased, the aspect ratio decreased, forming a wider and blunter tooth. The blunter the tooth, the more it could be used for crushing. This is an observation of what I noticed from the figures 3, 4, and 5; however, the dentition for *O. gracilis* barely changes from the fulcrum to the tip of the propus. This is mainly because they are generalist durophagous crabs. They do not specialize in eating hard-shelled prey; they prefer to eat softer items.

The denticles on crab claws are an important characteristic and heavily impact their feeding behaviors. The denticles with a larger radius and lower aspect ratio are used for crushing while the denticles with a smaller radius and higher aspect ratio are used for piercing and/or shredding. Yamada and Boulding (1998) tested the hypothesis that crabs with powerful; specialized claws are more efficient predators on shelled snails than crabs with weaker more generalized claws. Through their studies they found that the "generalists are omnivores whose diet includes macro and microalgae as well as snails and seed oysters" (Yamada and Boulding, 1998). The claws of generalists have a finely serrated surface on the inner surface of the chelae and the claw tips don't overlap. This morphology is good for scraping and scooping food off of substrates. The specialists feed on hard-shelled prey; barnacles, snails, mussels, clams, oysters, and sea urchins. The selection of prey size in crabs depends on the size of claws, dentition, mechanical advantage, and closing force.

The denticles on the species *M. magister* decrease in size and width from the fulcrum to the tip of the propus. This species of crab use the tip of their claw to grip and grab things, then move it towards the fulcrum to crush. The greatest mechanical force comes from the base of their claws, the fulcrum; however, if the tip of the claw is broken off, it will heavily impact how the crab behaves and what it consumes. The mechanical advantage and where the force is exerted matches the dentition patterns on the claws for most of the species of crabs sampled. *M. magister*, *P. producta,* and *P. richii* all grip their prey with the tip of their claws and crush with the fulcrum. *M. magister* have dentition all along the propus, while the *P. producta* and *P. richii* have a gap from the fulcrum to about two-thirds of the propus where the teeth start to form. Juanes and Hartwick (1990) investigated the prey selection of the *M. magister* and evaluated the effect of claw damage on feeding efficiency. They discovered that the crabs will eat smaller clams due to the gape size of the claw itself and/or the amount of force needed to break open the shell. *O. gracilis* on the other hand were not built to crush shells or strong exoskeletons; therefore, the denticles on their claws have a higher aspect ratio and lower radius of curvature. Their teeth are narrow and sharper compared to the other species allowing them to pluck soft, small marine organisms and scavenge the sea floor better (Fig 1G).

There is a weak correlation between the radius of curvature and species, with a significance of 0.0001. There is also a weak correlation between the aspect ratio and species, with a significance of 0.0096. This could be due to the limited sample size that I had. This experiment would have better data if the sample sizes of each species were larger. Fall may not be a good season to conduct this research. Figure 4 and 5 shows the relationship between the aspect ratio and/or radius of curvature and species. The species with a lower variation (smaller error bar) have a larger sample size. The species with a higher variation (larger error bar) have a smaller sample size.

C. oregonensis and O. *gracilis* have similar characteristics in respect to aspect ratio, but are significantly different from *P. gracilis* and *M. magister,* which also share similar characteristics. This means their denticles vary in size and position, but the pointiness or the bluntness of the teeth is similar. This could mean the species that share corresponding aspect ratios use their claws for similar functions. The denticle positions may differ, but their radii of curvatures should decrease as the aspect ratios increase.

P. producta, M. magister, P. gracilis, and *H. nudus* have different radii of curvatures from each other. *C. oregonensis, O. gracilis, P. richii,* and *S. acutifrons* have similar radii of curvatures. The species with similar radii of curvatures potentially represent the prey items these species prefer. If the radii of curvatures are similar their prey preferences should be similar as well. Figure 5 shows the species grouped by families. Not all species in the same family have the same significance; however, the ones that do share the corresponding radii of curvatures could have the same denticle formation, different denticle position, but similar prey consumptions.

I found that the dentition patterns for each species of crabs have their own specific function. The aspect ratio and radius of curvature play an important part in identifying the uses of the claws. The larger the radius of curvature, the smaller the aspect ratio meaning the crab species itself would be considered a generalist. The smaller the radius of curvature, the larger the aspect ratio, meaning the crab species would be considered specialist. Shimada (1997) found that the lateral posterior teeth in *Isurus* have a stronger cutting function than teeth in *Odontaspidids* due to a broader crown width. The results that I found are important because West et al. (1991) found the chelae with molariform dentition were highly derived features among the freshwater crabs in Africa. The

Tanganyikan crabs displayed molariform instead of serrate dentition on their crushing claws. This shows evidence that the crabs have evolved to have denticles made of molariform, making it easier for them to crush hard-shelled prey.

When this experiment was conducted, the crabs were a lot smaller than expected; therefore, to avoid those smaller crabs, collecting samples year round might provide a bigger phylogenetic variation. By understanding claw dentition of different crab species, this information could potentially be used as comparisons in future studies. For instance, ocean acidification may change the CaCo3 of the chelae (claw) itself or the exoskeleton of its prey. If the morphology of the crab claws change in a way where the exoskeleton itself becomes soft, it will affect its prey consumption and/or if the morphology of its prey change, it may alter the type of prey preferred. Dentition itself is a module of the dermal exoskeleton and by collecting this data will allow us to make comparable observations later on in the future (Stock, 2001). Little has been published about the dentition of various crab species. My research could potentially give other scientists a jump start to observing the feeding behaviors of crabs in relation to their dentition patterns. Each crab species has different denticle patterns allowing them to use their claws for different functions.

Acknowledgments. Special thanks to Marianne Porter and Stephanie Crofts for comments, discussions, and meetings. Big thanks to Kevin Turner for taking his time to educate Lauren and me on different crab morphologies and taking us to Brown Island to catch *Metacarcinus magister*. Thank you to Lauren for being an amazing partner for this project! I would also like to thank Hannah and Annie for also taking us to pick up our crab pots.

Literature Cited

Daly, B., and Konar, B. (2010). Temporal Trends of two Spider Crabs (Brachyura, Majoidea) in Nearshore Kelp Habitats in Alaska, USA. *Crustaceana*. 83, 659-669.

Daniels, S.R., Stewart, B.A., Ridgway, T.M., and Florence, W. (2006). Carapace Dentition Patterns, Morphometrics, and Allozyme Differentiation amongst two Toothed Freshwater Crab Species (*Potamonautes warren* and *P. Unispinus)* (Decapoda: Brachyura: Potamonautidae) from River Systems in South Africa. *Journal of Zoology*. 255, 389-404.

Dietl, G.P. and Vega, F.J. (2008). Specialized Shell-Breaking Crab Claws in Cretaceous Seas. *Biology Letters*. 290-293.

Freeman, P.W., and Lemen, C.A. (2007). The Trade-Off between Tooth Strength and Tooth Penetration: Predicting Optimal Shape of Canine Teeth. *Journal of Zoology*. 273-280.

Juanes, F. and Hartwick, E.B. (1990). Prey Size Selection in Dungeness Crabs: The Effect of Claw Damage. *Journal of Ecology*. 744-758.

Schenk, S.C., and Wainwright, P.C. (2001). Dimorphism and the Functional Basis of Claw Strength in Six Brachyuran Crabs. *Journal of Zoology*. 225, 105-119.

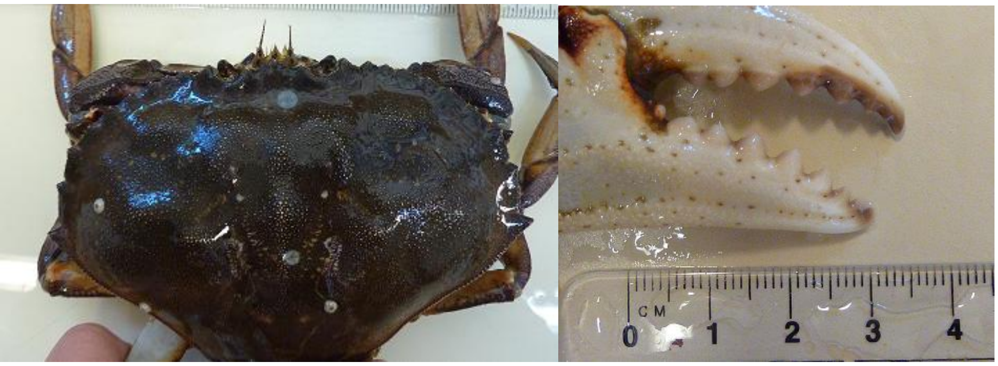
Shimada, K. (1997). Dentition of the Late Cretaceous lamniform Shark, Cretoxyrhina mantelli from the Niobrara Chalk of Kansas. *Vertebrate Paleontology*. 172, 269-279.

Stock, D.W. (2001). The Genetic Base of Modularity in the Development and Evolution of the Vertebrate Dentition. *Journal of Biological Sciences*. 356, 1633-1653.

Vermeij, G.J. (1977). The Mesozoic Marine Revolution: Evidence from Snails, Predators and Grazers. *Journal of Paleobiology*. 3, 245-258.

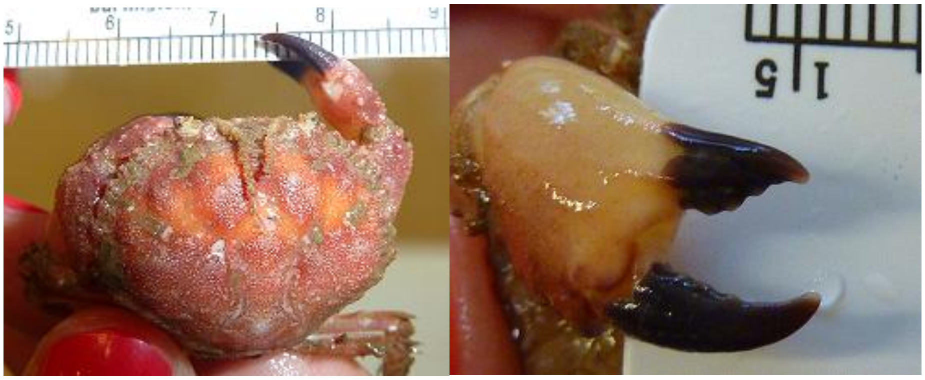
West, K., Cohen, A., and Baron, M. (1991). Morphology and Behavior of Crabs and Gastropods from Lake Tanganyika, Africa: Implications for Lacustrine Predator-Prey Coevolution. *JSTOR*. 589-607.

Yamada, S.B., and Boulding, E.G. (1998). Claw Morphology, Prey Size Selection and Foraging Efficiency in Generalist and Specialist Shell-Breaking Crabs. *Journal of Marine Biology and Ecology*. 220, 191-211.

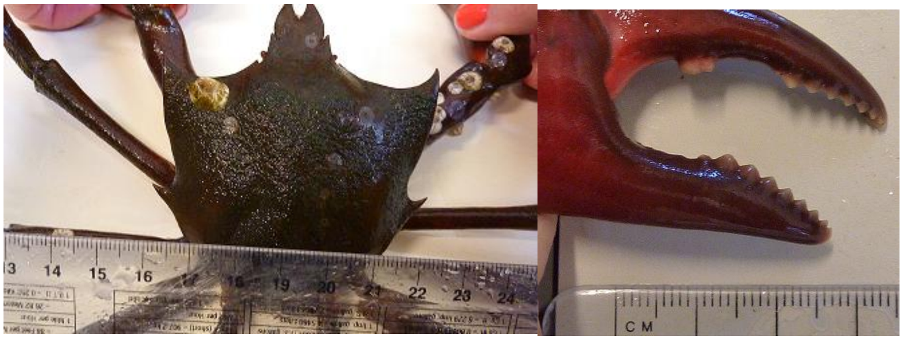


A: Dungeness Crab (*Metacarcinus magister*)

B: Red Rock Crab (*Cancer productus*)



C: Pygmy Rock Crab (*Cancer oregonensis)*



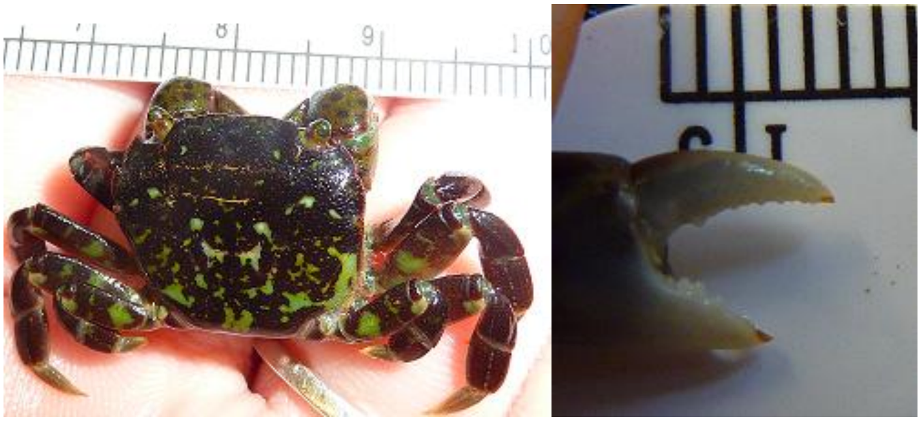
D: Northern Kelp Crab (*Pugettia producta)*

E: Graceful Kelp Crab *(Pugettia gracilis)*

F: Cryptic Kelp Crab (*Pugettia richii*)

G: Graceful Decorator Crab (*Oregonia gracilis)*

H: Sharp-Nosed Crab (*Scyra acutifrons)*



I: Purple Shore Crab (*Hemigrapsus nudus)*

J: Helmet Crab (*Telmessus cheiragonus)*

Figure 1. Photos A-J show the species studied for this research. The carapace and right claw of each species is displayed.

Figure 2A. Example of measuring carapace length of the Dungeness crab (*Metacarcinus magister)*.

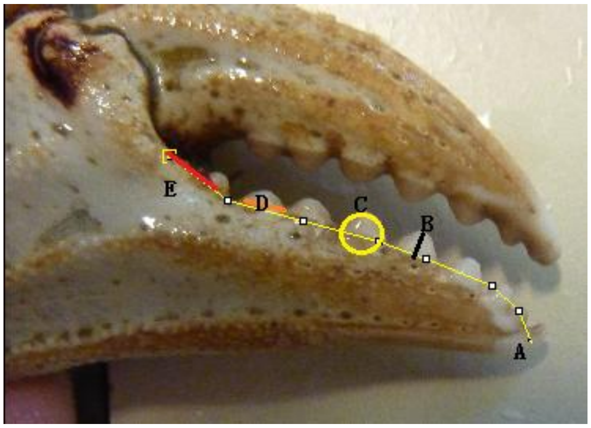


Figure 2B. Example of measuring the base, height, radius of curvature, aspect ratio, propus length, and fulcrum to denticle length using Image J per crab.

Species	**Common Species**	**Food**	**Max Carapace Length**	**Avg Claw Length**	**Habitat**
Metacarcinus *magister*	Dungeness Crab	Durophagus	28 cm across	2-3 cm	Rocky Intertidal
Cancer productus	Red Rock Crab	Durophagus	20 cm across	3 cm	Reefs and soft substrates
Pugettia producta	Northen Kelp Crab	Durophagus	9 cm across	3 cm	Kelp beds, pilings
Pugettia gracilis	Graceful Kelp Crab	Durophagus	4 cm across	0.5-1.5 cm	Eelgrass/Kelp beds, pilings
Pugettia richii	Cryptic Kelp Crab	Durophagus	4.3 cm across	0.5-1 cm	Rocky Intertidal
Oregonia gracilis	Graceful Decorator Crab	Non-Durophagus	5 cm across	0.5-1 cm	Mixed composition bottoms
Scyra acutifrons	Sharpnose Crab	Durophagus	4.5 cm across	0.5-1 cm	Higher subtidal areas, docks
Cancer oregonensis	Pygmy Rock Crab	Durophagus	5.3 cm across	1 cm	Rocky reef
Hemigrapsus nudus	Purple Shore Crab	Durophagus	5.7 cm across	0.4-0.8 cm	Rocky Intertidal
Telmessus cheiragonus	Helmet Crab	Durophagus	12.5 cm across	1-1.5 cm	Eelgrass/algae, soft bottom

Table 1: Spatial and physical characteristics of different crab species.

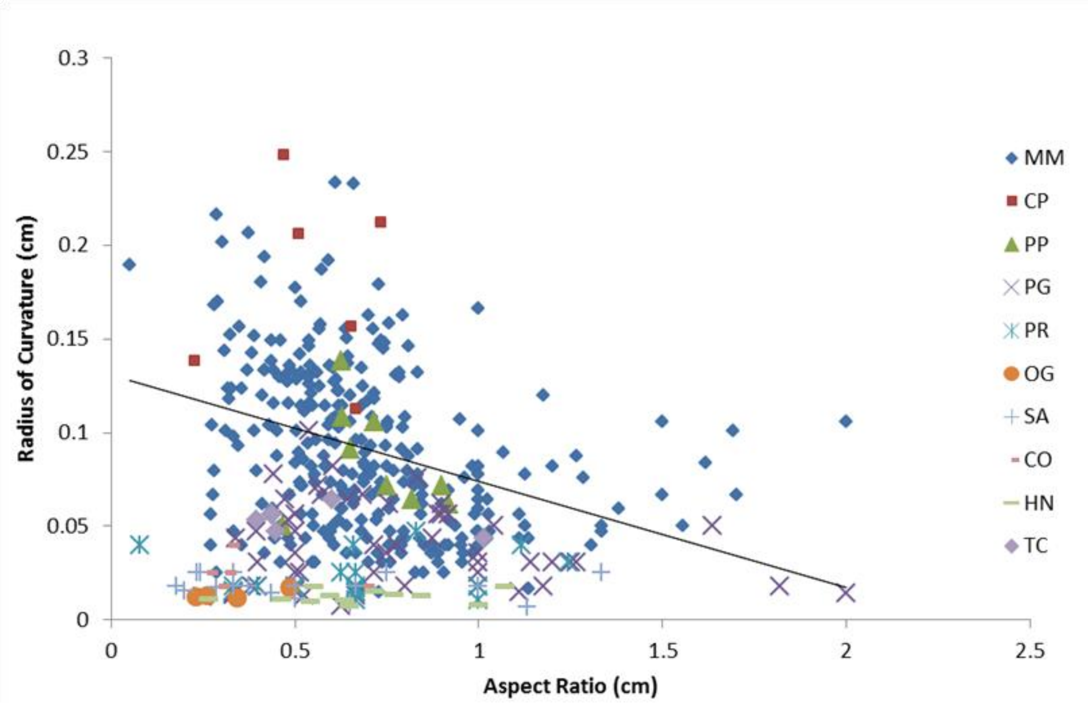


Figure 3: Comparison of aspect ratios and radii of curvatures between different crab species. Significance exists between the two variables (F9, 425=31.0251, P<0.0001); however, there is a weak correlation of 40.1% between the aspect ratios and radii of curvatures. R square value is 0.401. Abbreviations are as follows: *Metacarcinus magister, MM*; *Cancer oregonensi,s* CO; *Cancer product,s* CP; *Hemigrapsus nudu,s* HN; *Oregonia gracilis,* OG, *Pugettia gracilis,* PG; *Pugettia producta*, PP; *Pugettia richii,* PR; *Scyra acutifrons,* SA; and *Telmessus cheiragonus,* TC.

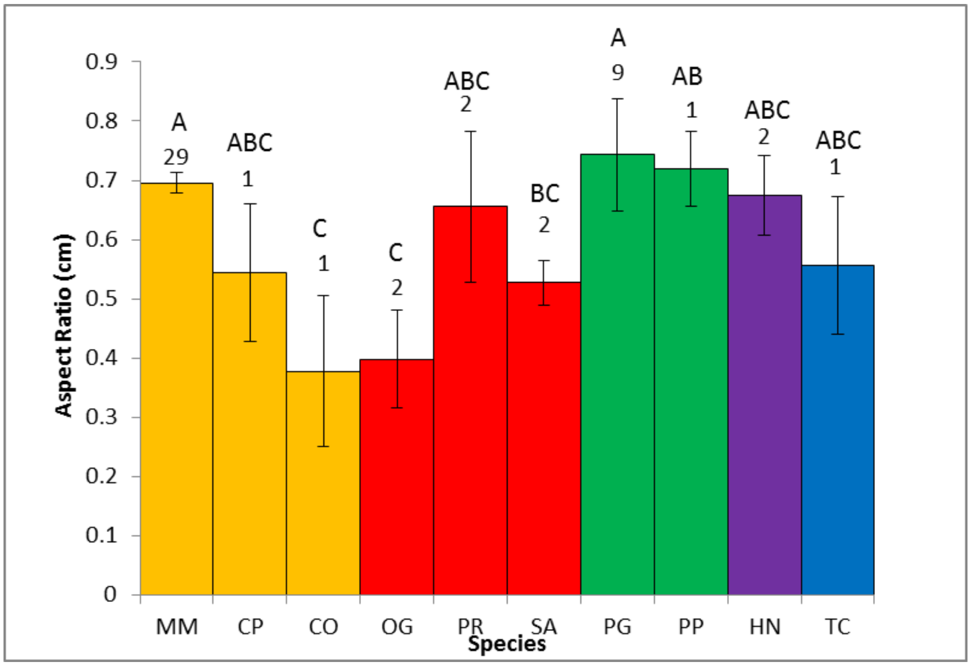


Figure 4: Aspect ratios between different species of small and large crabs. Significance exists between different crab species and aspect ratios (F9, 425=2.4628, P<0.0096). Standard deviations for mean aspect ratios are indicated by the error bars. There is a weak correlation of 5% between the two different variables. R value is 0.0505. Abbreviations are as follows: *Metacarcinus magister, MM*; *Cancer oregonensi,s* CO; *Cancer product,s* CP; *Hemigrapsus nudu,s* HN; *Oregonia gracilis*, OG, *Pugettia gracilis*, PG; *Pugettia producta*, PP; *Pugettia richii*, PR; *Scyra acutifrons*, SA; and *Telemessus cheiragonus*, TC. The numbers above the bars represent the sample numbers. The letters above the bars show the relationship between the different species. The colored bars are organized by family and are as follows: yellow; Cancridae, red; Majidae, green; Epialtidae, purple; Grapsidae, and blue;Cheiragonidae.

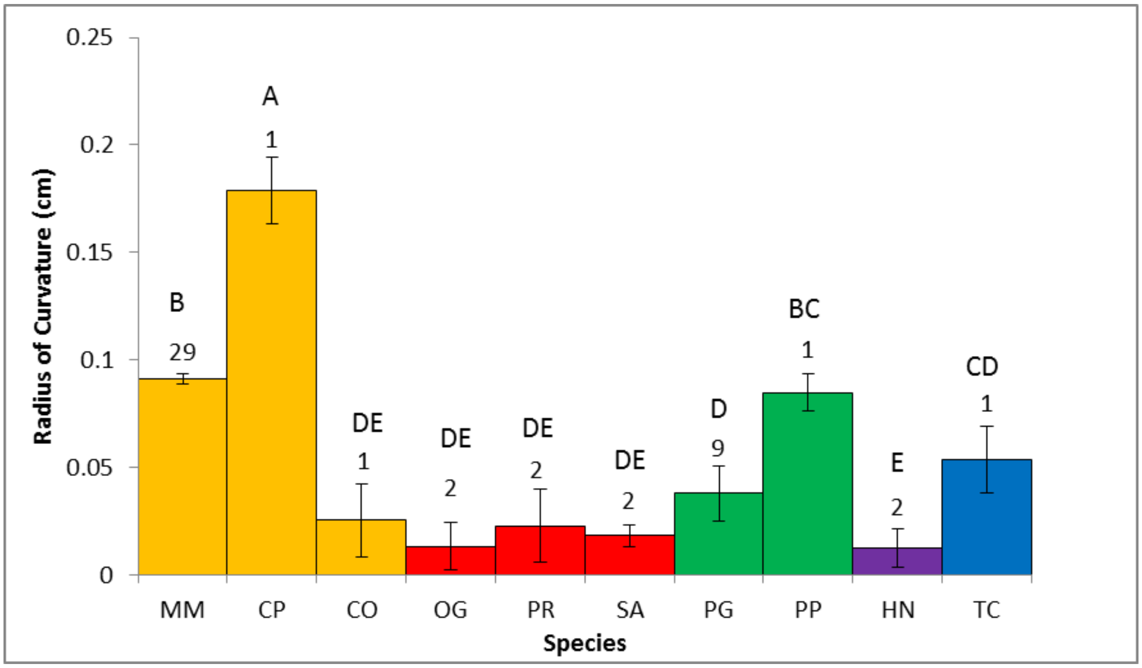


Figure 5: Radius of curvature between different species of large and small crabs. Significance in crab species exists between radiuses of curvatures (F9, 425=31.0251, P<0.0001). Standard deviations for mean radius of curvature are indicated by the error bars. The large error bar for *Oregonia gracilis* shows a big variation. There is a weak correlation of 40% between the two variables. R value is 0.401. Abbreviations are as follows: *Metacarcinus magister*, MM; *Cancer oregonensis*, CO; *Cancer productus*, CP; *Hemigrapsus nudus*, HN; *Oregonia gracilis*, OG, *Pugettia gracilis*, PG; *Pugettia producta*, PP; *Pugettia richii*, PR; *Scyra acutifrons*, SA; and *Telmessus cheiragonus*, TC. The numbers above the bars represent the sample numbers. The letters above the bars shows the relationship between the differences between the species. The colored bars are organized by family and are as follows: yellow; Cancridae, red; Majidae, green; Epialtidae, purple; Grapsidae, and blue;Cheiragonidae.