Alaska Ocean Acidification Network

Bering Sea Red King Crab and Ocean Acidification

Alaska Bering Sea Crabbers

The ocean is approximately 30% more acidic today than it was 300 years ago. This is due to increasing levels of atmospheric carbon dioxide (CO_2) emitted by humans that dissolves into the surface ocean waters, lowering the pH and increasing the acidity. This is called ocean acidification (OA). Higher acidity water can reduce the ability of shell-forming organisms to build and maintain their shells, and can also affect the growth and behavior of fish.

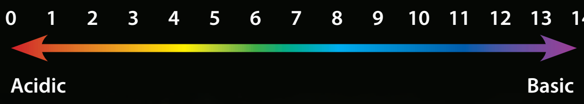
Studies in the lab have shown the sensitivity level of red king crab (RKC) to ocean acidification varies across different life stages. Here we look at exposure, vulnerability, and implications at each life stage based on what we know in the Bering Sea.

Larval Stage

Exposure: After hatching in the late spring, RKC larvae resemble little shrimp. They live closer to the surface in the water column where there is plenty of food. When they transition to a larval stage, they look like a tiny crab with a tail. They stop feeding while moving toward the ocean floor in search of good habitat. Once they find it, they settle down and molt to the first crab stage. The larval phase takes about 2-3 months in the Bering Sea. Late spring surface water conditions are strongly buffered against acidification, with relatively high pH (8.2), except for waters close to outflow from major river systems, which have relatively lower pH (8.1).

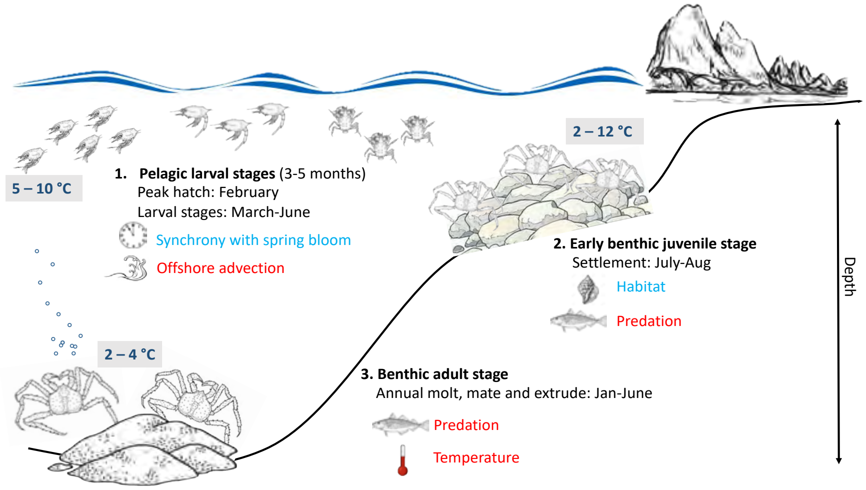
Sensitivity: The larval stage is probably the least sensitive to OA. However, at pH 7.7 or lower there is a decrease in starvation-survival time, meaning RKC larvae need to eat more and are thus more susceptible to starvation. pH values below 7.7 are projected to occur in surface waters in the latter half of the 21st century under a "business as usual" emissions scenario.

pH is a measure of the acidity of water. The pH scale ranges from 0-14 with low numbers being more acidic and high numbers being more basic. Because pH is a logarithmic scale, changes are not linear. For example, a drop from 8.1 to 7.9 indicates a 150% increase in acidity. In the recent past, the global average pH of seawater has been 8.1.



RKC larvae.

NOAA



Life cycle of the RKC.

Juvenile Stage

Exposure: For the first two years of their life RKC need complex habitat such as rocks, shells, or macroalgae to hide in or else they get eaten by predators. In the Bering Sea, this type of habitat tends to be in shallower areas near the coast where pH is strongly buffered and not very acidic. However, groundwater and river discharge might decrease pH in these highly dynamic habitats, and more research is needed to understand pH variability there. At two years old, RKC are about an inch long, and they join up with other crabs to form groups called pods. They pile up during the day and spread out to feed at night. These pods probably work their way into deeper waters as they get older and larger.

Unfortunately, juvenile RKC's preference for complex habitat makes them difficult to survey or find, so we don't have a good understanding of their typical distribution around Bristol Bay. In addition to the difficulty of locating juvenile RKC, we don't know much about conditions in the shallow, nearshore water in the Bering Sea. Oceanographic models are less reliable in these areas and we have very few direct ocean observations.

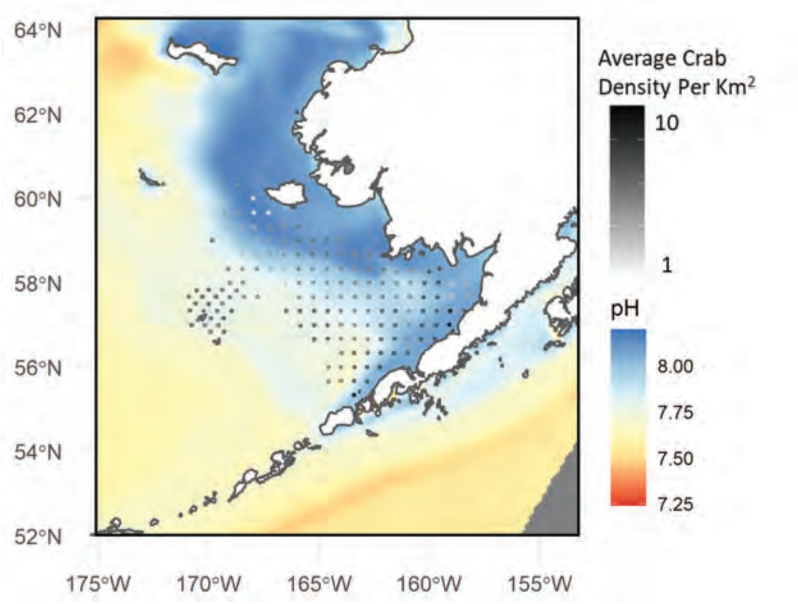
Sensitivity: Of all RKC life stages, Juveniles are the most sensitive to OA. At a pH of 7.8, juveniles in the lab had much slower growth and higher mortality than crabs at current ambient pH (about 8-8.1). When pH was lowered to 7.5 there was 100% mortality within the first 100 days of exposure.

Adult Stage

Exposure: Adult RKC tend to live in deeper waters than juveniles, more towards the center of Bristol Bay. Their distribution is at least partially driven by temperature; they prefer temperatures between 32° and 39°F. Deeper waters off the shelf are the most acidified conditions that crab will experience in their life cycle. Here, pH conditions as low as (7.7) have been observed. Model simulations suggest that outer shelf bottom waters during late summer have pH values of 7.7-7.8.

Sensitivity: Adult RKC seem to be less sensitive to OA than juveniles. Adult RKC generally only molt once per year, and this presents additional challenges when studying the effects of low pH conditions on growth. There is some evidence that pH below about 7.7 may affect their ability to molt successfully, but adult crab are not currently experiencing pH conditions below the threshold for molting stress. The effects of low pH on RKC reproductive capacity and embryo development are currently unknown.

Crab Distribution and pH



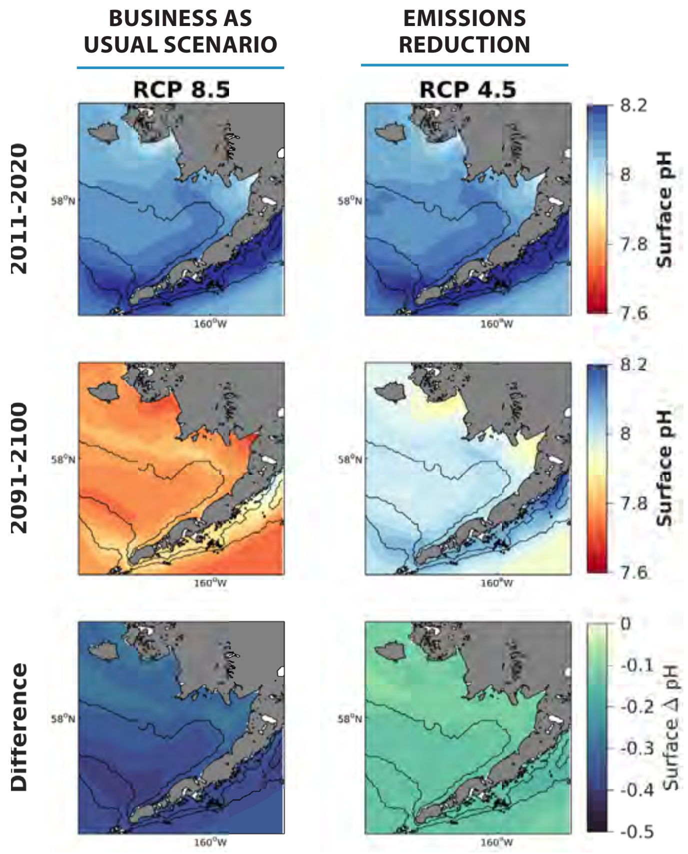
This figure overlays high adult RKC densities found by the annual bottom trawl surveys (dotted array) and the average summer bottom pH conditions from July-Sept. More crab are found along the shelf break and near there Pribilof Islands where summer pH values are the lowest (most acidific).

Implications

Red king crab's overall response to OA will likely be driven by how well juveniles fare, as the most sensitive life stage. When we combine RKC sensitivities observed in lab studies with predicted future OA levels, we may start to see negative effects on the population in Bristol Bay within about 20-30 years. Alaska's RKC fishery is one of the most iconic fisheries in the U.S. and an important resource for Alaska's coastal communities, economy, and the generations of fishing families that harvest it. With an ex-vessel value around $50 million in recent years, it is important to understand the effects OA may have on this resource, what we can do to slow the effects of OA, and how to help RKC be more resilient.

Connecting Crab Habitat to Carbon Emissions

Suitable crab habitat will be influenced by global, national, and local decisions to either continue or reduce fossil fuel emissions.



These maps show modeled projected changes in annual surface pH for the south-eastern Bering Sea over the 21st Century, under two different carbon emissions scenarios. These waters of the Bering Sea have been hospitable for RKC up until now, but this is projected to change under a "business as usual" scenario.