Tracking Crab Movements in Sand Flat versus Reef Habitats: Consequences of Differential Food Availability and Implications for Protection vs. Catchability

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Report Narrative

Executive Summary

We compared the behavior of Dungeness crabs in an open sandy substrate environment with that of crabs inhabiting an environment of mixed rocky and sandy substrate. The objective was to compare residence time of tagged crabs within the range of hydroacoustic receiver arrays. We deployed VEMCO acoustic receivers in a complementary design at two sites that differed primarily by habitat complexity. The crabs released at the North Head sandy reference array, just north of the Columbia River mouth, dispersed from the main detection area in an average of 1.2 days, were active, dispersed rapidly from the release site, and only one returned. The crabs released in the Cape Falcon reef array initially dispersed from the main detection area in an average of 12.4 days, spending considerably more time in, and returned to the main array placed near the rocky reef.

In addition to the crabs we tagged, we detected 35 green sturgeon and 7 great white sharks in the Cape Falcon Marine Reserve. Two of those sharks and 25 of the sturgeon also were detected at the Mouth of the Columbia River.

Finally, in addition to all the science we accomplished, while we were looking for the moorings in April 2019, we found a small surface float linked to 19 long-lined crab pots inside the marine reserve. We recovered the crab pots and turned them over to the Oregon State Police; the investigation is ongoing.

Motivation

Dungeness crab are ecologically and economically important and are an Oregon Nearshore Strategy species. Their distribution and movement are of particular interest due to their high commercial and recreational value with a retained catch of ~17 million pounds annually and an estimated 174 million pounds in the population. Based on Henkel's and published collections of benthic invertebrate and small fish biomass and caloric density, we find a mismatch in the amount of benthic prey on the Oregon shelf and energetic requirements of the tons of Dungeness crab landed each year. Further, previous tagging studies have found that Oregon Dungeness are highly mobile. We hypothesized that the high mobility of crabs and the success of the fishery occur because crabs are constantly foraging for limited resources in open sandy substrates and may be attracted to and less mobile in areas of sediment disturbance and/or structure such as natural or artificial reefs that could provide feeding opportunities. Based on studies documenting broad Dungeness crab movement, it has been hypothesized that the place-based protection from fishing provided by marine reserves in Oregon or the *de facto* protection provided by restriction of fishing around marine renewable energy installations would not largely affect Dungeness crab as they won't stay in these protected areas. If crabs near rocky reefs (like those in most of Oregon's Marine Reserves or artificial ones created by renewable energy installations) do not move as much because of increased foraging opportunities, perhaps they will be more protected and less available to the fishery than currently expected. On the other hand, if they are extremely food limited, then the

development of offshore artificial reefs with additional food resources, may enhance the population, allowing for increased opportunity for landing Dungeness crab.

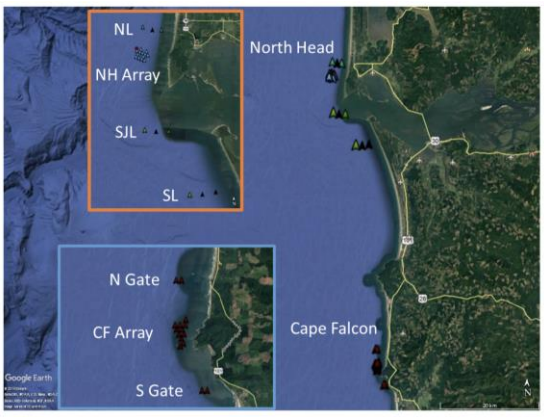
Activities

Deployment and Tagging

We deployed acoustic receivers in a complementary design at two sites that differed primarily by habitat complexity. The North Head site (NH) is a sandy substrate located around 15 m depth just north of the Columbia River mouth. Cape Falcon (CF) is a rocky site located in the Cape Falcon Marine Reserve with depths in the deployment area ranging from 13 to 26 m. At the North Head site, 13 receivers were deployed in the array formation and nine receivers were deployed in three rows of three as "gates": one row to the north and two rows to the south. At the Cape Falcon site, 12 receivers were deployed in the array formation and two gates of two receivers each were deployed: one pair on the northern boundary of the marine reserve and one pair on the southern boundary.

Arrays were receiver moorings deployed in a geometry designed to enable positions of individual crabs to be determined through telemetry. Within an array, meter-scale resolution of crab positions is achievable when 3 or more nodes receive tag signals, and these measurements allow for individual crab movements and behaviors to be determined. Gates were intended to be used to determine the timing of crabs moving from the primary release sites. At a minimum, all receivers record the timing of tagged crabs within their reception range (300-500 m), which can be used for residence time (presence/absence) and direction of movement. Details of the experimental deployments are shown in **Figure 1**. In addition to the acoustic receivers, oceanographic sensors were placed on some of the moorings in the Cape Falcon Marine Reserve by our ODFW collaborator. Temperature and salinity sensors were placed on three of the moorings and a dissolved oxygen sensor was placed on one of the moorings.

Figure 1. Location of sites and distribution of receiver gates and arrays.



Dungeness crab were caught in baited recreational crab pots at the North Head site. At the Cape Falcon site, crabs were caught in commercial crab pots. We measured carapace width and sex for the active and undamaged specimens selected for tagging. Tags were individually coded acoustic transponders. The transponders were affixed to the dorsal carapace of crabs (**Figure 2**) with fast-curing epoxy glue.

Figure 2.
Tagged crabs awaiting release.

At the NH site, where experimental sediment disposal events have occurred, we released two groups of tagged crabs into an acoustic array used as a reference for both the sediment disposal and the habitat study. The first group of nine crabs (5 males and 4 females) were released on 20 September 2018, and the second group

of ten crabs (equal males and females) was released on 28 September. At the Cape Falcon site, 20 total crabs (10 male and 10 female) were tagged and released on 3 October 2018 (Table 2). At both sites, tagged crabs were released in the center of the acoustic array (within an approximate 50 m^2 area).

We informed local fishermen and organizations (e.g. Columbia River Crab Fishers Association) of our experiments, and placed flyers at 5 locations throughout the Port of Garibaldi and at Columbia River ports Illwaco, Hammond, and Astoria to inform fishers of the deployments and the tagged crabs. We requested that if tagged crabs were caught, fishers would please share information from any recoveries (tag ID number, catch location, and catch date). These important fishery-dependent observations constitute movement data when crabs migrate from acoustic receiver range. Commercial fishery activities commenced 4 Jan 2019.

Receiver recovery

At North Head, the acoustic array and gates were recovered 24 November 2018 (total deployment time = 59 d). Upon recovery of the arrays in November, we downloaded the data and then redeployed the gate receivers at the South Jetty location with the aim of potentially detecting the tagged crabs through winter.

We were unable to make it out to the Cape Falcon site with our collaborative fisherman in November as planned; therefore, the receivers remained in the ocean through winter. However, our losses were fewer than anticipated due to wonderful citizen engagement on the north coast. Three of the four gate receivers (for which lighter anchors were used) washed up on various beaches near Cape Falcon at the end of December. The fourth gate receiver washed up on Crescent Beach on 21 January 2019. The citizen turned it into the Multnomah Sheriff's office, who shipped it to Henkel. Two of the array receivers were also recovered by citizens. One was found with the mooring line cut washed up on the beach in Long Beach, WA! The second was completely separated from its mooring *inside* someone's crab pot! The fisherman returned it to the Warrenton police department who shipped it to Henkel.

On 3 April 2019 – exactly 6 months after the deployment date – we were able to return to the Cape Falcon site with our collaborative fisherman. We ended up finding six of the remaining. Most exciting was that we recovered the mooring that had ODFW's O_2 sensor on it as well as a temperature logger. Unfortunately, the other two that had temperature and salinity loggers were not recovered.

Conclusions and Lessons Learned

As we hypothesized, the crabs that were collected from the rocky reef area and re-released nearby had longer durations in the array (i.e. residency) than those in the wide-open sand habitat. While most (13) of the tagged crabs still left the rocky reef area within a week, six stayed in the detection area (reef) for two weeks or more. Four remained in (or left and came back to) the general area of the Marine Reserve into December and January; had we not lost the gate receivers in that time period, we might have had additional detections at the perimeter.

We hypothesized that crabs near the rocky reef would have longer residencies due to suspected increased foraging opportunity around the reef. While we do not have data on benthic standing stock or productivity with the Cape Falcon reef versus the open sand habitat off the mouth of the Columbia River, the results of this study indicate that it is worth investigating. It also would be interesting to do gut content or stable isotope analysis of crabs collected near and far from rocky reefs. We did sacrifice and obtain stomachs from 20 Cape Falcon crabs at the time of tagging

(October 2018). In October 2019, we collected and sacrificed 12 crabs from open sand habitat off Newport as a comparison. Unfortunately, in both cases most of the stomachs were empty. Also in both cases, crab pots were deployed overnight. Thus, we have learned for future studies we should only soak the crab pots for a few hours so that the crabs have not digested their last feeding.

Outreach and Engagement

Sharing of findings (Outreach)

Henkel shared the findings in a presentation to HMSC Visitor Center volunteers on 14 May 2019. Mark Floyd (OSU URM) attended the meeting and wrote a press release that was released in early July 2019: https://today.oregonstate.edu/news/sounds-science-acoustic-tags-reveal-dungeness-crab-range-%E2%80%93-and-some-interesting-visitors
This got quite a bit of attention, including a story that aired 17 July on Channel 6 – KGW-TV.

Henkel has shared these results to the academic communities of both OSU and UO by presenting at the OIMB Summer Seminar Series on 24 July 2019, the Integrative Biology Fall Seminar Series on 23 October 2019, and the HMSC Seminar on 16 January 2020. The Hatfield seminar was attended by 52 people in Newport, including many ODFW staff and community members, as well as 7 people online.

Henkel and Roegner gave a joint presentation at the Pacific States Marine Fisheries Commission on 10 September 2019 to share findings with state and federal fisheries managers and other stakeholders (e.g. local and state government).

Henkel gave a community presentation to the Necanicum Watershed Council in Seaside, Oregon, on 29 January 2020. Thirty-two people attended, which was a large group for them.

Our research is the feature story for the Cape Falcon Marine Reserve in a "*StoryMap*" about Oregon's Marine Reserves on how research in Oregon's marine reserves has increased knowledge about nearshore ecosystems. This report is being prepared by Oregon Sea Grant's Scientific and Technical Advisory Committee and will be included in the State's 2023 Assessment of the Marine Reserve system.

Community Engagement

We have been impressed by the number of people who have found and turned in receivers from the Cape Falcon site as well as getting reports from fishermen about our released crab. It is clear that the northern Oregon coast has engaged citizens who support science and that the outreach efforts to fishermen (flyers in the Ports) were effective.