

Copper Rockfish as a den associate: Octopus facilitation of rockfish feeding

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Rockfish are a predatory fish often found in the rocky terrain and quick currents of the San Juan channel. They are an active area of study for marine scientists, many seeking to know their food sources for commercial and ecological purposes. The populations of rockfish have been on the decline in the Salish Sea. However, since they are a predatory fish, their trophic interactions are much more difficult to study for conservation purposes. One possible interaction to observe is with a well-known species of octopus, the giant pacific octopus (*Enteroctopus dofleini*). The largest of the octopus species, the GPO (giant pacific octopus) is found in the colder habitats of the northern Pacific, living and hunting in rocky areas. They often bring the prey back to their dens or hunt very close to their dens, creating a flurry of prey tissues and juices, leaving behind midden piles full of leftover food for scavengers. When feeding, the GPO will inject paralyzing venom, liquefying the prey as they rip it apart. The octopus pushes out the pile of rubbish and prey remains from the den to keep its area clean. This flurry of feeding activity creates a prime food source for multiple scavengers and potential prey of the rockfish. Larger fish (such as rockfish) often hunt the scavengers eating

among the midden piles; preferring benthic crustaceans, and shrimp. Our aim is to observe whether rockfish take advantage of this phenomenon. We hypothesize that rockfish have a direct feeding relationship with GPOs, using the octopus den as the hub of feeding activity.

The chain of interaction does depend on the actions and presence of the octopus, as well as rockfish feeding habits. The preferred hunting times for an octopus can affect the occurrence of den associates like rockfish. Rockfish are mainly crepuscular feeders, with most activity peaking in the evening or night. The mechanics of the octopus feeding can attract a wide variety of den associates, and studies have been done to observe active dens, with no observations focused on rockfish (Hardwick 1978).

Several studies have examined the feeding habits of the rockfish, using either studies of stomach contents or observations of feeding habits. The species of rockfish observed (*Sebastes* spp.) have a wide variety of food sources. In several studies they were noted consuming decapods, copepods, amphipods, cephalopods, fishes and many types of pelagic prey (Lorz 1983).

Fig. 1 Rossia

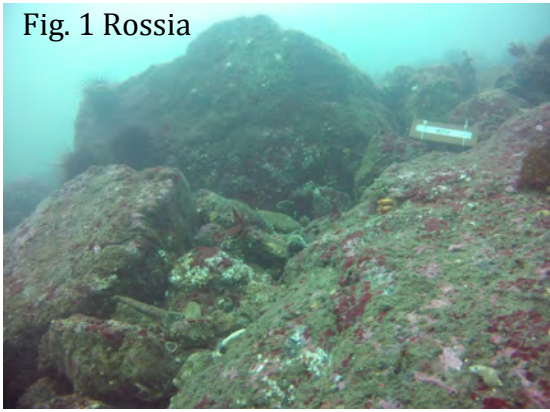


Fig. 2 Loligo

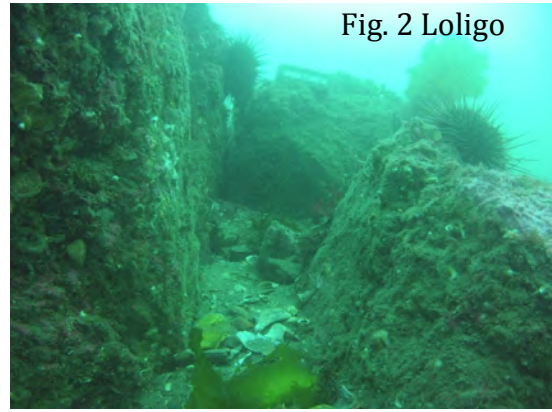


Fig. 3 FHL

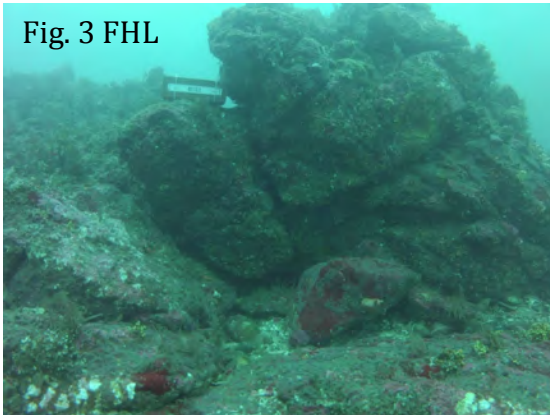
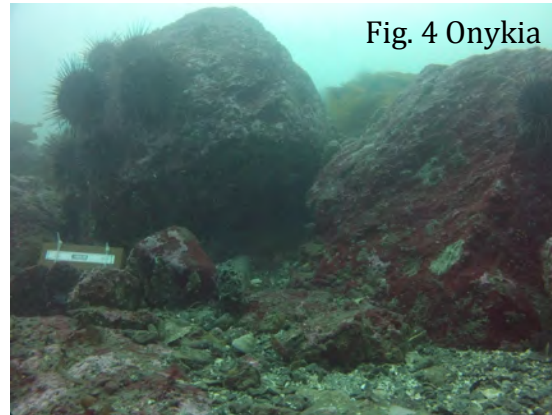


Fig. 4 Onykia



According to Brodeur (1984), the main prey is euphausiids. Five *Sebastes* species were studied; *S. pinniger*, *S. flavidus*, *S. alutus*, *S. diploproa*, and *S. crameri*. Even in fish that had more narrow prey sources, the euphausiids were still the prey of choice. A study by Barrientos (2006) found that the primary prey were mysids. In several related studies, the main prey items were found to be shrimp-like crustaceans, which are fairly abundant. These prey species are mostly scavengers, and can be found in the areas of the study in the San Juan channel and northern pacific (Butler 1980). It is a fair hypothesis that this set of prey would be found in the rocky terrain that giant pacific octopus inhabit

in the San Juan channel. Some studies have looked at the habitat ranges of the rockfish populations (Matthews 1990), but none of the literature looked into octopus den behavior and interaction.

If we are able to show a relationship between the octopus den scavengers and the rockfish, there is the potential ability to protect the dwindling rockfish population in the Salish Sea.

This study was conducted by non-intrusively placing a GoPro Hero2 camera at each of the four dens. The GoPro was set up with a Gorilla stand and fixed to a brick for stability in front of the den location. The den locations were Rossia: 13.7 meters deep below mean low water at N 48° 34.760, W

123° 00.749, FHL: 16.7 meters deep at N 48° 34.755, W 123° 00.764, Onychia: 15.2 meters deep at N 48° 34.760, W 123° 00.775, and Loligo: 16.7 meters deep at N 48° 34.780, W 123° 00.888.

Approximately once a week the cameras were picked up by divers and replaced after off loading data. Each camera was kept at a consistent location relative to the den. Using a Cam-Do GoPro Time Lapse Controller, each camera was programmed to take a single picture every ten minutes. These photos were stored on an SD card and then offloaded to an external hard drive.

Photo analysis was done using the Preview program run simultaneously with Excel. Each photo was recorded into an Excel chart with a fish count for the ten most common species of interest to the study seen around the dens: copper rockfish (*Sebastes caurinus*), Puget Sound rockfish (*Sebastes emphaeus*), quillback rockfish (*Sebastes maliger*), male kelp greenling (*Hexagrammos decagrammus*), female kelp greenling (*Hexagrammos decagrammus*), lingcod (*Ophiodon elongatus*), painted greenling (*Oxylebius pictus*), perch (*Perca* spp.), red irish lord (*Hemilepidotus*

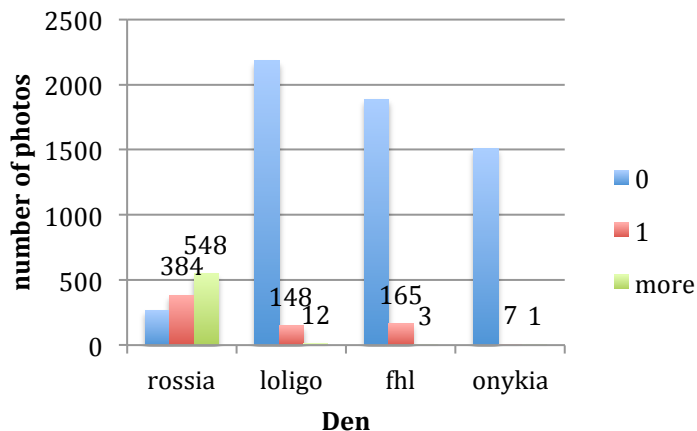
hemilepidotus), and giant Pacific octopus (*Enteroctopus dofleini*). This count was done by hand; also marking if the photo was unusable due to darkness, obstructed view, or failure of the camera intervalometer (controller chip).

The statistical analysis was done using RStudio. We separated the fish counts by placing each photo into a categorized bin of 0 fish, 1 fish, 2 or more fish. This bin set was done for every fish observed at every camera station. Focusing on copper rockfish, a chi-squared test was run to create a contingency table and create a P value. This was run for occupied vs. unoccupied, Rossia vs. Loligo, and Loligo vs. unoccupied to determine if there was a statistical significant difference.

As shown in figures five through eight, the four species that were present at both unoccupied and occupied dens in greatest numbers were copper rockfish, puget sound rockfish, lingcod, and male kelp greenlings. The other species present were quillback rockfish, perch, and female kelp greenlings. The count charts are digitally attached. Results of the chi-squared test provided

Copper Rockfish

Fig. 5

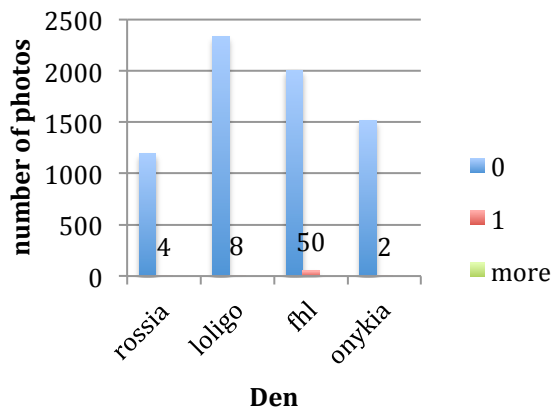


statistical conformation of significant difference for three different scenarios for copper rockfish. The chi-squared test was run for a comparison between the occupied dens (Rossia and Loligo) against the unoccupied dens (FHL and Onykia). It produced a p value of $\ll .001$, showing a significant difference with copper rockfish more abundant at the occupied dens. The next test was run with Rossia and Loligo, showing that there was a significant difference with more abundance at Rossia with a p value $\ll .001$. The last test was run with Loligo against the unoccupied dens (FHL and Onykia) that produced a p value $\ll .001$, with Loligo showing higher abundance for rockfish.

From our statistical analysis we can confidently say that in the four dens we observed the occupied dens did have significantly more rockfish visitation.

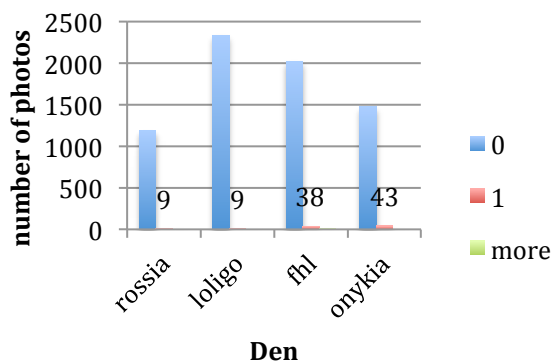
Lingcod

Fig. 6



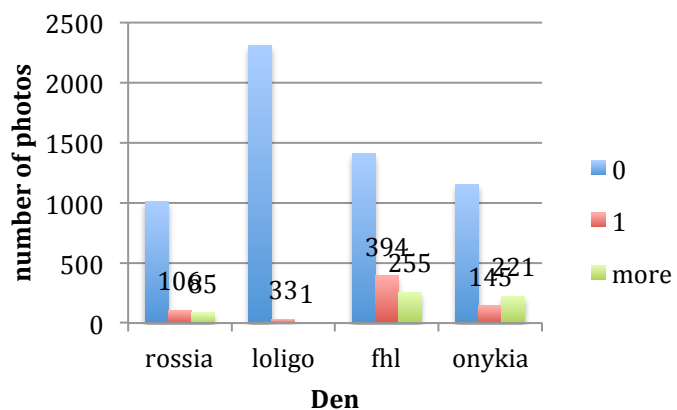
Male Kelp Greenling

Fig. 7



Puget Sound Rockfish

Fig. 8



Rossia in particular had the most on all accounts. We chose to divide the data into bins as mentioned above to make

sure that random out-liars did not affect our end result. Between Rossia and Loligo, Rossia had far more visitation, but this is possibly explainable by the position of the camera at Loligo. The camera position looked at the smallest relative viewable volume of the four dens. The scuba team in charge of placing cameras also took note that several fish (copper rockfish) were observed inside and on top of the den on multiple occasions. With a certain percentage of fish out of view of the camera, this could explain the difference between Loligo and Rossia. These results do confirm our hypothesis that copper rockfish use active octopus dens as a hub for activity. The implications of this study are considerable. Policy makers can use this information for the potential protection of the copper rockfish. The active octopus dens in the prime areas for copper rockfish can be implemented as a marine protected area (MPA). The resulting protection of the population would possibly result in a rebounding population. This would provide new abundance for food source. This is a fairly easy study to implement, and could be passed to several different institutions to continue the work. If

there is a full correlation between copper rockfish and the active octopus dens along the whole habitat reach of the rockfish there could be considerable protective measures taken. Both the octopus and the rockfish are an important part of the local ecosystem, and with both in the same location it may be easier to implement MPA policies.

There is a statistical difference in the abundance of copper rockfish between occupied and unoccupied dens. The occupied dens show a clear trend of higher levels of copper rockfish than unoccupied dens. This result should be confirmed through further extension of the study. The potential for an MPA related to copper rockfish is more likely with a specified location of activity.

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