

Tethering *Pandalus danae* as a Method for Observing Predator Prey Interactions in the San Juan Islands

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Marine Environmental Research Experience 2012
Fall 2012

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Keywords: *Pandalus danae*, *Sebastes caurinus*, *Sebastes malige*, predator prey interactions, tethering.

Abstract:

Predator prey interactions, specifically predation acts, were observed and recorded to better understand trophic level interactions and community ecology in the San Juan Islands. We looked at predation between *Pandalus danae* and predators such as *Sebastes caurinus* and *Sebastes malige*. Using a tethering method we attached *Pandalus danae* to frames and deployed them at high and low rockfish concentrated sites in the San Juan Islands. We observed predator prey interactions using a GoPro underwater camera set to time lapse photography which provided us with information on shrimp predators and showed that our method was successful.

Introduction:

Predator prey interactions shape communities and ecosystems and many marine fish species over large areas are declining creating trophic cascades. Overfishing of top predators and fishing down the food chain can create top down effects and community shifts in trophic levels. When top predators decrease, their prey increases which in-turn decreases the next trophic level. Top predators are being depleted while prey are being released from predation pressures (Myers and Worm 2003; Baum and Worm 2009; Eriksson et al. 2011). Top down controls can also exist when there is an abundance of predators that over eat their prey which increases the next trophic level and so on. This can happen when invasive predators are introduced to an area and take over. Bottom up controls can also be detrimental. When organisms lower on the food chain decrease, higher trophic levels also decreases because of the lack of food. Predator prey interactions have the potential to change ecosystems and shape community ecology.

Predator prey interactions can be seen everywhere in the marine environment. It is important to analyze these interactions because they create ecosystems and are important economically as well as ecologically therefore many methods of viewing or expressing these events has been used. Predation specifically has been a huge interaction that is studied widely and expressed in multiple ways. Tethering prey is one way to view predation; both the act itself and to quantify predation events. We used the tethering method to look at predator prey interactions between shrimp and *Sebastes caurinus* (copper rockfish) and *Sebastes maliger* (quillback rockfish). These two species were studied because they share similar niches and diets. Both species are shown to rely heavily on shrimp as their main source of nutrition as shown in figure 1 (K Turner unpublished, 2011). This reliance is why we focused on shrimp instead of other organisms, to see if shrimp really are the main source of rockfish diets in the San Juan Islands. Copper and quillback rockfish also occupy very similar rocky, relatively shallow habitats and are dispersed widely around the San Juan Islands with concentrations in places such as Neck Point (Figure 2) (K Turner unpublished, 2011).

Our main goal was to design and test a feasible method for observing and recording predator prey interactions specifically predation acts in the natural habitat of copper and quillback rockfish. Once a method was created and worked for our purpose we wanted to quantify these predation acts of copper and quillback rockfish and observe the predator prey interactions in the field. We hypothesized that in high rockfish concentrated areas the tethered shrimp would be preyed on mainly by rockfish and in low rockfish concentrated areas the shrimp would be preyed on by other predators such as greenling or lingcod. By observing these interactions and predation acts we can get a better understanding of the San

Juan community ecology, predation pressures on shrimp and the amount of shrimp copper and quillback rockfish consume.

Methods:

Organisms Used

Pandalus danae (coon-stripe shrimp) were obtained off the dock pilings at Friday Harbor Labs using small hand nets during the fall of 2012. Once caught, the shrimp were held in tanks in lab three of the Friday Harbor Labs, a wet lab with circulating seawater. Shrimp were maintained in the tank until they were used for experiments. Dead shrimp and kelp pieces were placed into the tank for food.

Two *Sebastes caurinus* (copper rockfish) were used in lab observations and testing. They were caught in San Juan Channel by Ryan Knowles and kept in a large circular tank with circulating sea water in lab 8. From October 2012 to late November 2012 they were fed shrimp. Some of the shrimp were tethered and attached to an experimental rebar frame and observed using a digital recorder on a tripod and a GoPro underwater camera.

GoPro Camera

A GoPro camera was purchased and used for visualizing predation acts and method analysis. Underwater housing by GoPro was purchased to protect the camera during the experiment. The camera was equipped with a battery pack to extend the observation time. During experimental field testing the camera was set to time lapse photography taking a picture every 10 seconds. In lab testing the GoPro was attached to an extendable pole and maneuvered around the tank manually. In field testing the camera was attached to the frame via a suction cup made and purchased from GoPro. The camera was set and turned on then

directly deployed into the water. Once retrieved the GoPro case would be rinsed with freshwater and air dried. The time lapse pictures were then loaded onto a computer and using the GoPro video software were put together into a time lapse video and analyzed.

Frame Setup

Three rectangular frames made out of rebar were used as the base for the experimental setup. Two rectangular frames were used in field experiments and one was used in lab trials (Figure 3A). Each frame was 104cm by 100cm by 36cm. Four pound dive weights were zip tied to each lower leg of the frame for weight against current and stabilization. One frame was fitted with a custom made GoPro camera mount. The GoPro camera mounted on to the suction cup which suctioned to a plastic plate on the frame. The plastic plate was zip tied to the top of the rebar frame and a stabilizing bar was also zip tied to the frame (Figure 3B). Field setups also had line attached to the top corners of the frame that extended to the water's surface with small buoys for identification and deployment/retrieval convenience.

Tethered Prey

Live prey was tethered to view predation acts. Monofilament line (4lb tested) was used to secure shrimp to a cotton string that attached across the bottom rungs of the frame. A bowline knot (Figure 4) was tied around the carapace and between the first and second paraeopodes of the shrimp. Each frame had 4 tethered shrimp equally spaced apart on the cotton string. The shrimp were measured (Figure 5) and given a color ID drawn onto the cotton line where the shrimp was tethered. The monofilament tether was only a couple inches long so the shrimp would not get tangled but still have enough length to move. Plastic containers with holes held the shrimp during transport from the lab to the study sites so they

would not get tangled. The containers were then placed in a bucket with water to submerge the shrimp. The cotton line was color coded for study site differentiation (Black tipped line went to Neck Point).

Study Sites

Two study sites were chosen for this experiment (Figure 6). Neck Point located at 48.579°N, 123.014°W and Point George located at 48.556°N, 122.985°W were used as a high and low rockfish abundance sites respectively based on Kevin Turner's dive surveys in the San Juan Island region. Both sites were reached by small motor boats for deployment and retrieval. Deployment was done either during the day or before dawn where retrieval was done at various times. Depths of 20 meters were targeted for by depth finders on the motor boats. Basic knowledge of the bathymetry for each site provided desired locations for deployment. Both sites were tested between the months of October to late November 2012.

Data Collection

Data was collected six times at each site with time lapse videos at three of the Neck Point deployments and two Point George deployments. Deployments and retrievals were targeted at slack tides and could not be done during small craft advisories. Boat hooks were used to retrieve the buoys and the frames were pulled up by hand. Deployments were also dropped by hand.

Data was also collected in lab trials. Frame testing and method analysis was done in the lab using a frame setup without the buoy, tending line or weights. A frame with the tethered shrimp set up was placed into a circular tank that held the two copper rockfish. The rockfish were then filmed using both the GoPro camera and digital video recorder that was set up on a tripod to record predation acts. Method testing was also done by deploying the

GoPro frame with the GoPro camera off the Friday Harbor Lab's dock and recorded time-lapse photography to test light receiving ability and picture quality.

Video analysis was done on a computer using the GoPro software and windows live movie maker. Time lapsed videos were analyzed for possible predators and predation acts. When a possible predator was observed it was recorded. The data was then put together for analysis.

Results:

Six frames were deployed over the October to November 2012 months at Neck Point and also at Point George. The frames were successfully deployed and retrieved in working condition. During lab testing the tethered shrimp were observed being eaten by both *Sebastes caurinus* in the tank. In the field we observed 100% predation from frames that were deployed for eighteen hours or more and 50% predation from one frame deployed at Neck Point for less than eighteen hours (Figure 7). Frames without the GoPro camera set up also went into this data.

Deployments with the GoPro underwater camera provided time lapse videos of predator prey interactions and predation acts. Predator sightings occurred at both sites with more individuals seen at Neck Point than Point George (Figure 8). Neck point showed more biodiversity than Point George in the amount of different possible predators observed in the videos (Figure 9).

Of the observed predation acts none were from a rockfish but instead were from sea stars, flatfish and greenlings. Copper rockfish were seen in the first deployment at Neck Point

and one quillback rockfish was seen in the second deployment at Neck Point and none were seen in any of the Point George deployments.

Discussion:

Our main goal was to devise a method to observe and record predator prey interactions and predation acts specifically between shrimp and rockfish. We also wanted to quantify how much shrimp were being eaten and by whom, to better understand the predation pressure of shrimp and the impact of trophic levels higher up. Predator prey interactions and predation acts were observed using our tethering method showing that our method was successful. Based on figure 7 our frames showed predation meaning predators and possible predators were not deterred from the tethered shrimp by our experimental setup. This is important to provide accurate data of predator prey interactions.

Lab testing provided visual predation acts and method testing. Testing the method in the lab allowed us to make modifications if needed and to visualize the act of copper rockfish feeding on our tethered shrimp. Tethered shrimp in the lab were consumed and showed that the tether did not deter the rockfish from eating. The monofilament line was tugged by the rockfish and broken off fully allowing the rockfish to eat the shrimp without working too hard. This means that predation was possible and occurred in both the lab and field studies.

Field studies observed and not observed by the camera both expressed predation acts. In the observed field deployments the camera showed us these predator prey interactions as well as multiple predation acts. Although predation acts by copper or quillback rockfish were not observed this does not mean that they could not have preyed upon the shrimp. Our videos showed predations acts from natural and unnatural predators such as sea stars and

crabs. This provides us with confirmation that our method worked but also shows that tethering has some down sides with allowing unnatural predators to prey on the shrimp. The unnatural predators could also have deterred natural predators from preying on the shrimp.

Our method worked to observe predator prey interactions but some modifications could be made to better quantify shrimp predation and to deter unnatural predation. Experimental changes could include the amount of time the frames were deployed and the amount of deployments made. Due to feasibility and seasonal winds many deployments and retrievals were not possible. Rockfish diet studies show that they have a seasonal variation and change based on prey availability (Patton B.G., 1973). Because of this seasonality further studies could test in multiple seasons and multiple deployment times. Multiple locations could also be tested for a wider spread in understanding the predator prey interactions in all the San Juan Islands and to better understand trophic relationships.

Predator prey interaction and predation acts are important to understand for community ecology and the impacts on the economy. Implications of trophic level interactions can give a better understanding to how ecosystems and population dynamics work. In our study, tethering methods can give a better understanding of the predation pressures of shrimp and how heavy the rockfish rely on these shrimp. Trophic interactions provide complex food webs with indirect and direct effects on species populations (Baum JK, Worm B, 2009). Knowing these interactions and fluctuations in different species can help provide better means of protecting and conserving species (Eriksson BK, Sieben K, et. al, 2011). This can directly affect fishing communities. Fishing greatly impacts our economy and culture. If there are low to no fishing communities that rely on that profit or food supply

can be affected. Looking at these trophic interactions can improve fishing to make it more sustainable and manageable.

Marine reserves and ecosystem based management specifically in the San Juan Islands could be improved with knowledge about predator prey interactions. Instead of looking specifically at species in danger prey of those species could also be looked at. Management of rockfish could be improved by looking at the shrimp populations and how heavy they rely on the abundance of shrimp. This reliance could be influenced by shrimp abundance. This could influence where marine reserves are made such as making reserves around places of high shrimp abundances to better rockfish food availability. Ecosystem based management could be a better option because it takes multiple trophic levels and the interactions between them into account. This type of management better protects species by also protecting its food source. Species interactions can influence community ecology and are important for understanding ecosystems and how they can impact our economy and conservation of species and trophic levels.

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Figures:

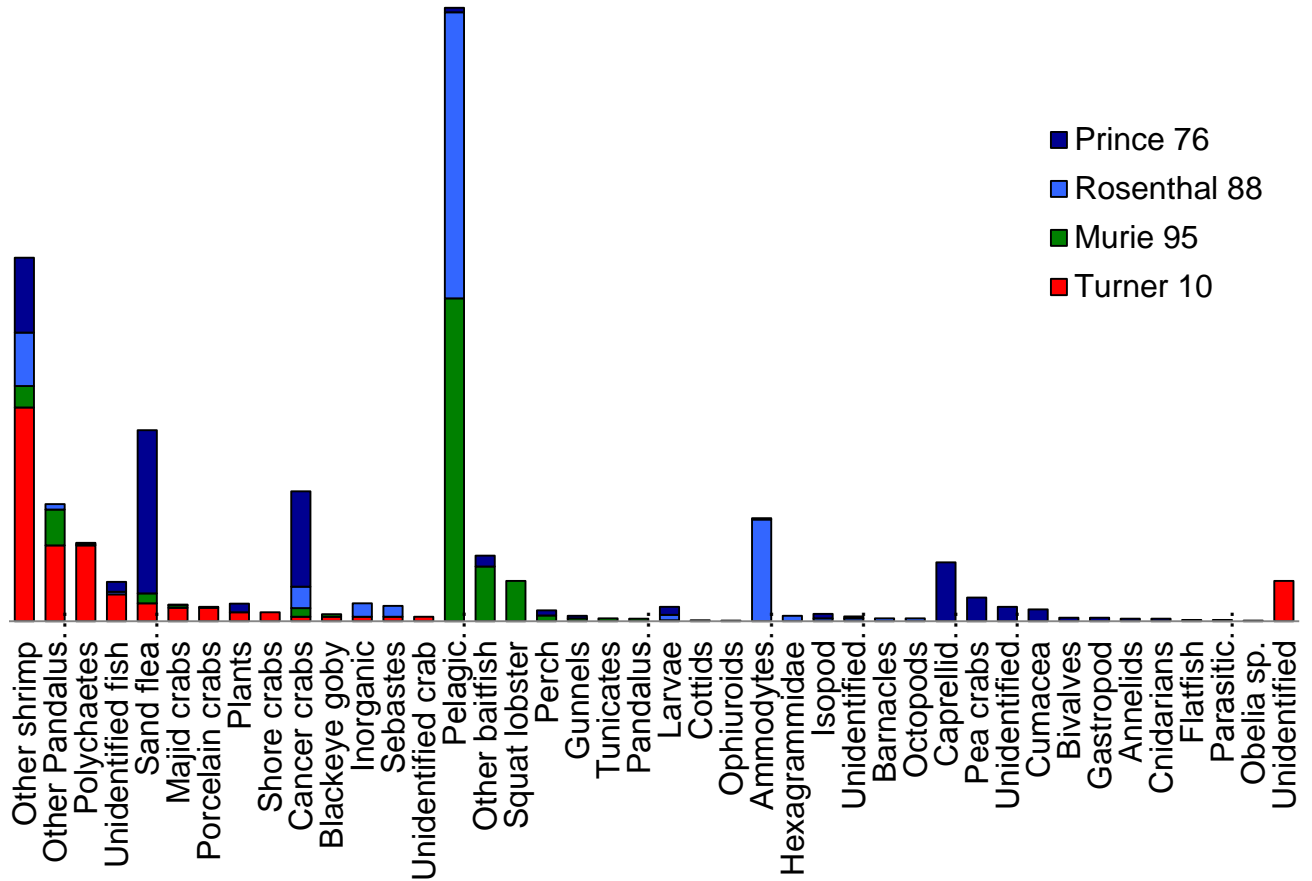


Figure 1: Researched rockfish diet compiled showing abundance of stomach contents. The red data is K Turners unpublished data of San Juan Island rockfish stomach contents using a gastric lavage technique.

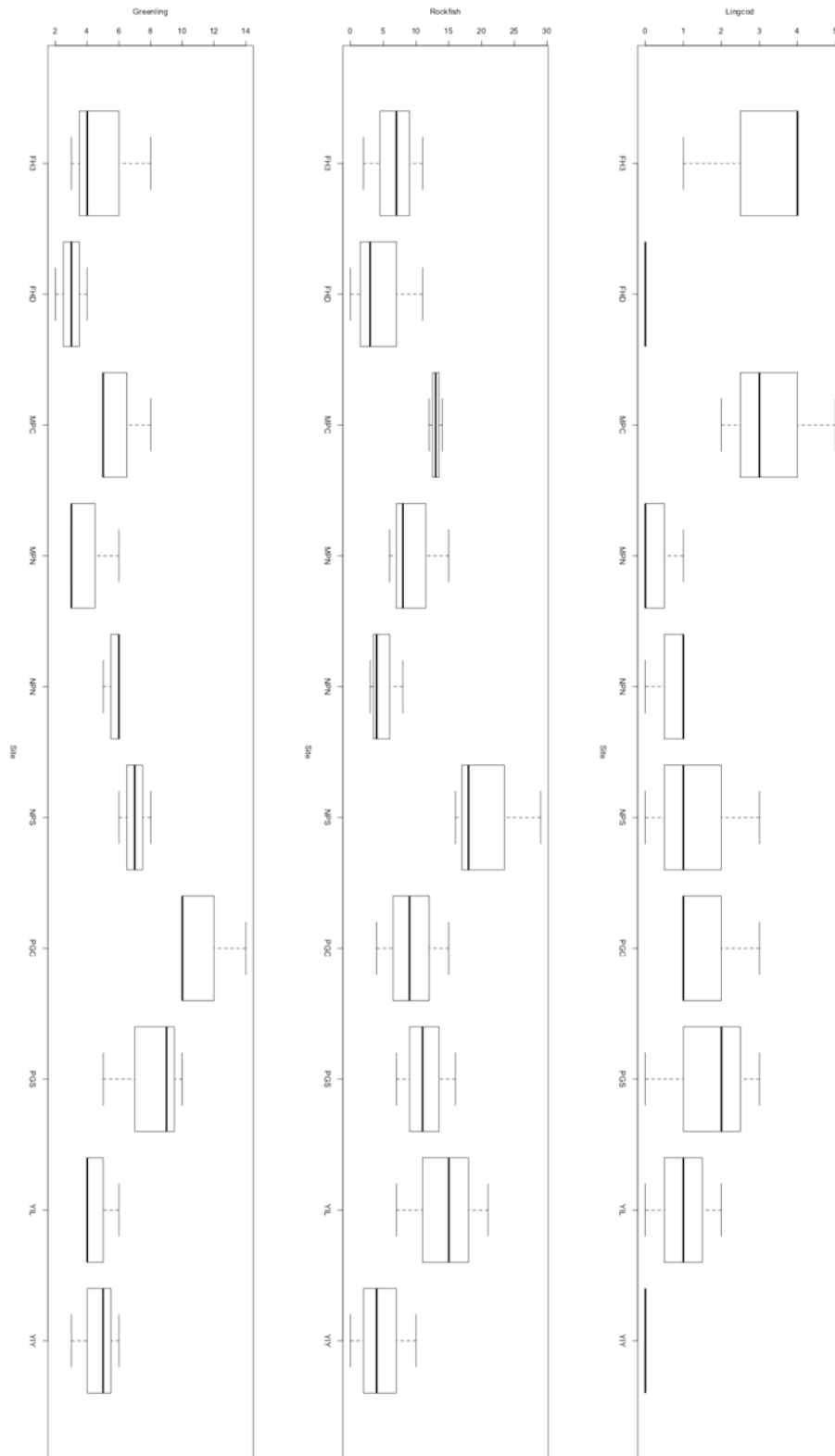


Figure 2: Fish abundance at various sites in the San Juan Islands. Provided by K Turner unpublished.

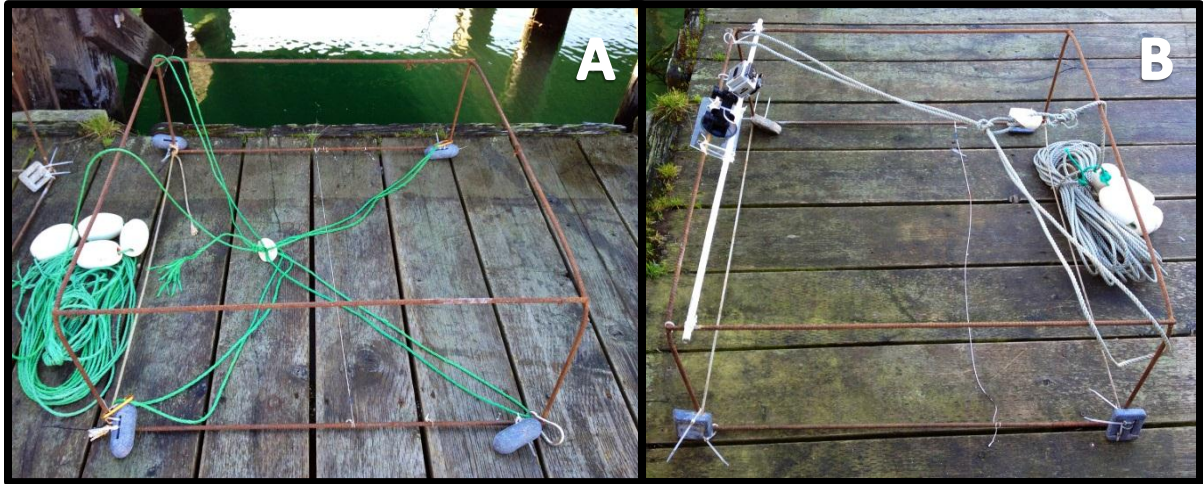


Figure 3: Frame Setup without GoPro camera (a) and with GoPro camera (b). Rectangular rebar frames acted as the experimental setup. The shrimp tether was attached horizontally to the bottom rung of the frames. A GoPro was mounted on one frame using a suction cup and zip ties. The suction cup was secured to a plate of plastic. The plastic plate is secured to the rebar frame by zip ties.

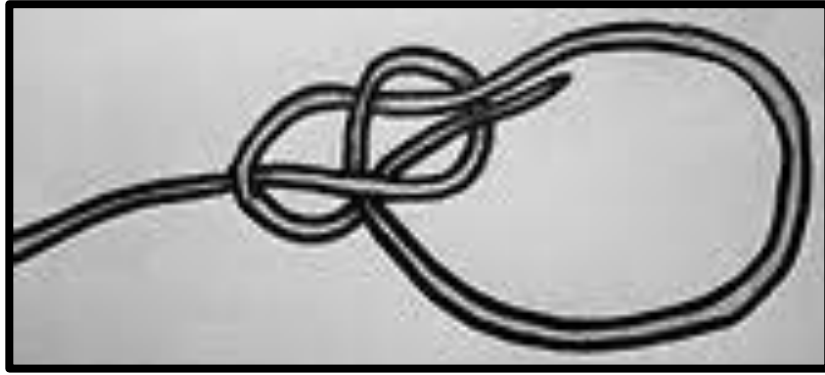


Figure 4: Bowline knot tied from monofilament line was used to secure shrimp to a cotton string which attached to the frame. The knot was tied around the carapace and between the first and second paraeopods of the shrimp.



Figure 5: Shrimp were measured from the end of the telson to the tip of the rostrum.

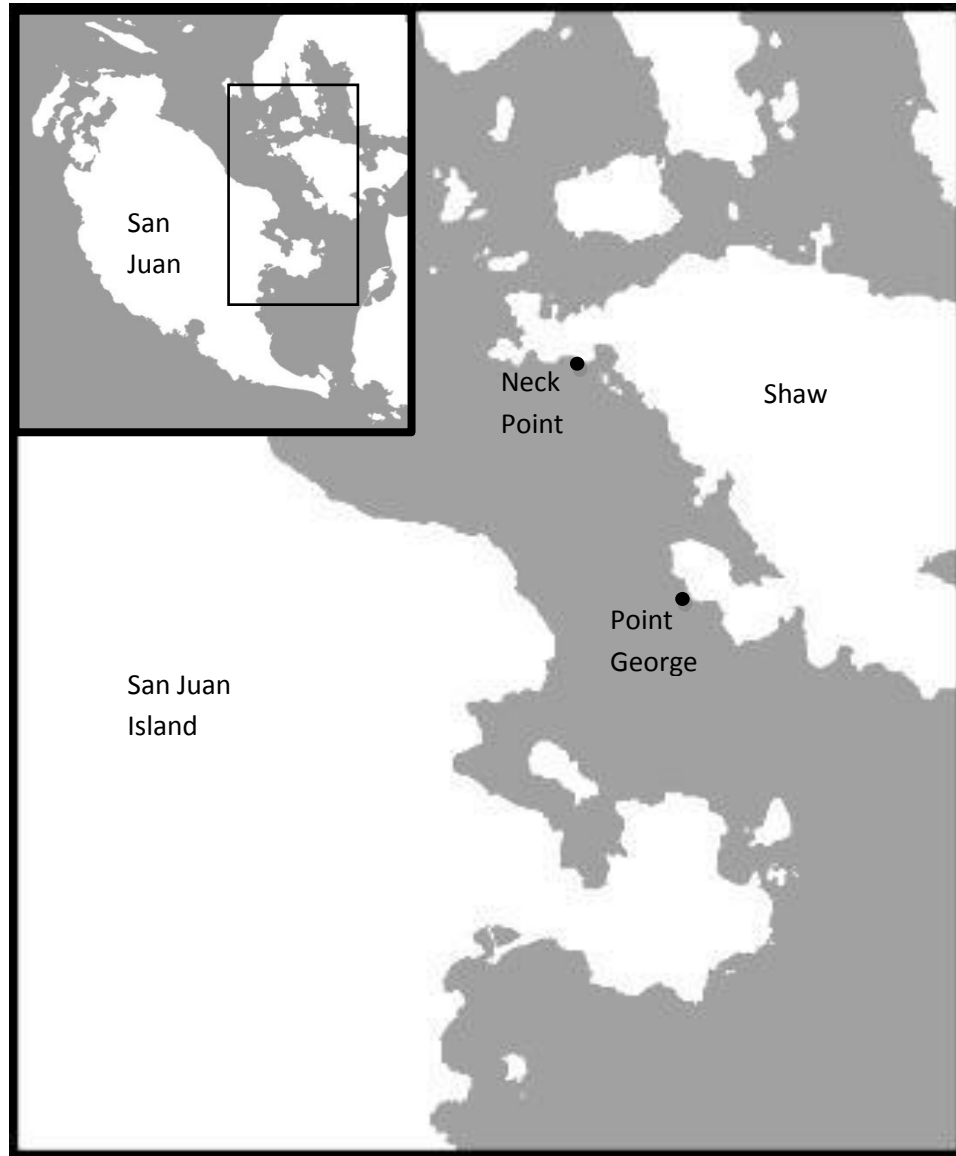


Figure 6: Study sites Neck Point and Point George. Neck Point has high rockfish concentrations and is located at 48.579°N, 123.014°W. Point George has low rockfish concentrations and is located at 48.556°N, 122.985°W.

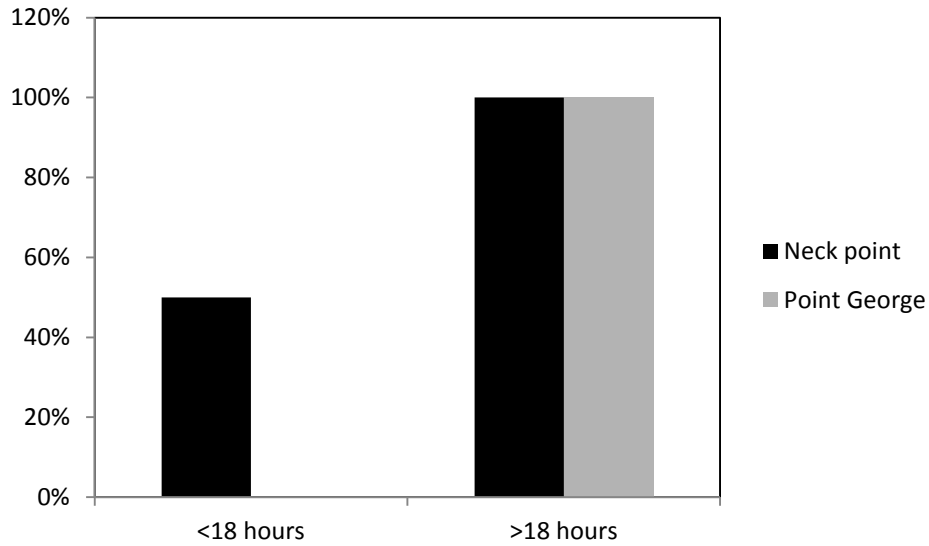


Figure 7: Average predation percentages were compared when the frame was left out for less than 24 hours versus 24 hours or longer. Predation was reported as an average percentage of the shrimp gone from the frames when they were recovered at each site. After 24 hours 100% predation was observed and less than 24 hours we observed 50% predation.

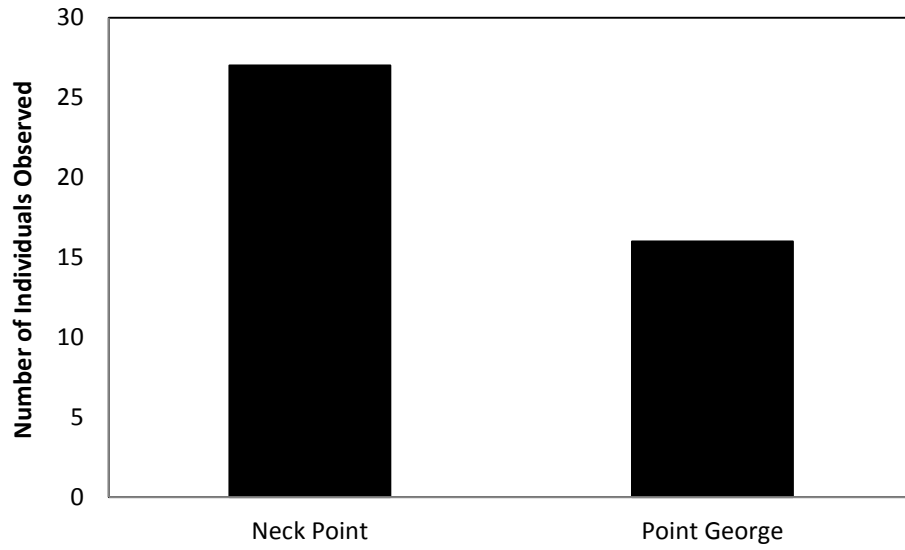


Figure 8: The average total predators were counted at each site for each frame deployment. These predator observations account for six hours of video data over two deployments at each site.

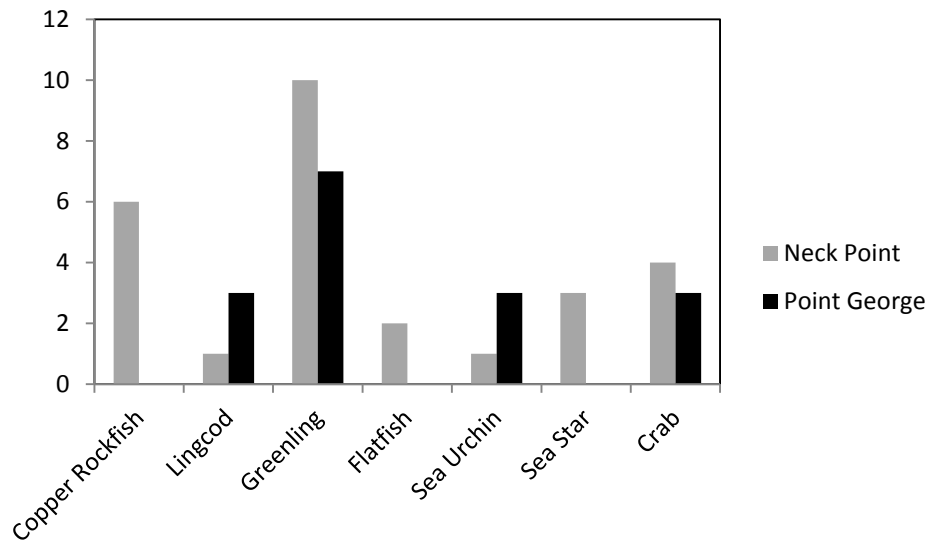


Figure 9: Possible predator sightings in GoPro videos at each site.