Size and Frequency data of *Lottia gigantean* at the James Fitzgerald Marine Reserve, Moss Beach, California

Nancy Ellen Levine

Abstract The James Fitzgerald Marine Reserve is one of the most biologically diverse marine reserves in Northern California. Although it has been a marine reserve since 1969, there is no readily available baseline data for many of the organisms at the reserve. Because intertidal habitat is subject to significant human disturbances this study aims to measure the effects of anthropogenic disturbance in order to contribute to the preservation of the biodiversity of the area. Size and frequency data for the limpet, *Lottia gigantean* was collected in order to gather representative baseline data and determine the effect of human disturbance in different areas along the reef. This particular species is subject to poaching and, due to its unique behavior, can be indicative of intertidal health. *L. gigantean* is very territorial; depressed habitat availability can lead to an increase in the abundance of smaller limpet species. Shell lengths and frequency data gathered from different parts of the reserve classified as light and heavy visitor impact intensities were compared. Mean shell lengths did not differ with varying degrees of human impact. Predator impact is thought to have a significant effect, but should be investigated in greater detail. A significant difference was found between mean shell lengths of the two heavily impacted areas. Ranger presence is thought to influence this difference. This study also aids in the biological assessment of the James Fitzgerald Marine Reserve and can supplement future studies in this under-explored habitat.

Introduction

Many studies have been demonstrated the harmful effects and significant impact of human disturbances such as exploitation, harvesting and trampling on the ecology of intertidal communities around the globe (Barry *et al.* 1995, Brosnan and Crumrine 1994). Trampling, a human disturbance threatening to many marine reserves with public access, can shift community composition to an alternate state with different dominating species (Brosnan and Crumrine 1994). The intertidal zone is subject to abusive trampling because it is the only part of the marine world that people are able to experience firsthand without leaving their own natural terrestrial environment. This makes the intertidal zone ideal for environmental education field trips for students and leisure activities for the naturalist. Human disturbance may also affect the biodiversity of such an environment through indirect influences such as exploitation, habitat destruction and pollution (Brown and Taylor 1998; Lindberg *et al*. 1998). These disturbances can seriously affect species abundances, health and community interactions.

The James Fitzgerald Marine Reserve (JFMR) (Figure 1), located off Highway 1 in Moss Beach, California, is a prime at-risk location for habitat disturbance due to human exploitation. Established in 1969 by legislative action, the reserve extends three miles from Point Montara (northern boundary) to Pillar Point (southern boundary) and 1000 feet west into the ocean. The JFMR boasts one of the most biodiverse intertidal regions in the state, renowned for a rich and diverse rocky intertidal zone (Brady/LSA 2002). Accessible at low tide, the rocky reefs and pocket beaches receive especially high levels of use due to the reserves close proximity to the dense populations of the San Francisco Bay Area. Currently under joint custodianship of the County of San Mateo Parks and Recreation Division and the California Department of Fish and Game, there is little visitor regulation and limited protection

Figure 1: Looking downcoast (southward) from Moss Beach Reef

for the species inhabiting the reserve. It is imperative to preserve the biodiversity of JFMR due to its uniqueness in Northern California.

Disturbances to the keystone species in strongly linked food webs are of particular concern when assessing the threat of human activity in the intertidal zone (Lindberg *et al*. 1998). Limpets have an important role in determining the well-being of their immediate environment (Booth 2003). Body size and frequency of mollusks are good indicators of community health because many mollusks tend to have long life spans (20-30 years) and their body size correlates directly with reproductive tendencies (Booth 2003). Furthermore, the large, territorial owl limpet (*Lottia gigantean*) is shown to control the assemblage of intertidal algae and other smaller limpets in its own territory (up to 1000 cm^2) through continuous grazing. The absence of *L. gigantean* leads to an increase in smaller limpet species which, in turn, limit intertidal algae more severely (Denney and Blanchette 2000). The owl limpet is the largest limpet native to northern California and can be found on cliff faces and rocks of surf-beaten shores in the high and middle intertidal zones from Washington State to Baja California (Light and Smith 1964). Owl limpets are also hermaphroditic; they are male when they are young and female when they grow older and larger. If owl limpets are not growing enough to fulfill the female role, reproduction could be severely limited (Herring 2004). Size and frequency of this species have been used as two indicators of the population's health. Greater mean sizes and higher frequencies tend to occur at the sites with the lowest human visitation (Kido and Murray 2003). Historically, the owl limpet was eaten by coastal Native Americans and is eaten intermittently today. Despite regulations prohibiting collection of the owl limpet from JFMR, harvesting does occur (Breen 2003, pers. comm.), which depletes the number of larger individuals.

I investigated the effects of human trampling on the size and frequency of *L. gigantean* along the JFMR. I hypothesized that at sample sites designated as low visitor impact, where human trampling is limited, I would find larger individuals. At sample sites that experience higher volumes of trampling I hypothesized I would find smaller and fewer individuals. Due to habitat variation, I was not able to prove this, but did draw some interesting conclusions.

Methods

I collected data within the James Fitzgerald Marine Reserve in Moss Beach California (Figure 2), particularly in the areas that offer rocky intertidal habitat. I sampled twelve different sites between February and April from five different areas of the reserve designated as either “heavy” or “light” impact areas. Sample sites were chosen along the areas of Moss Beach Reef (north and south of the main access point) and Pillar Point (deemed “heavy visitor impact areas”), and along Frenchman’s Reef, Ross’ Cove, and Seal’s Cove (deemed “light impact areas”) (Table 1). Heavily impacted sample site (“visitor use areas”) include mussel beds near the sea palms in Moss Beach Reef, where the majority of visitors are concentrated, and mussel beds in Pillar Point. Frenchman’s reef (south central part of the reserve) receives very light impacts and is used as a reference point. Degree of impact was determined by Brandy LSA and published in their *Fitzgerald Marine Reserve Master Plan* (Brady/LSA 2002) in combination with my own personal observations of anthropogenic activity in a particular area during my data collection.

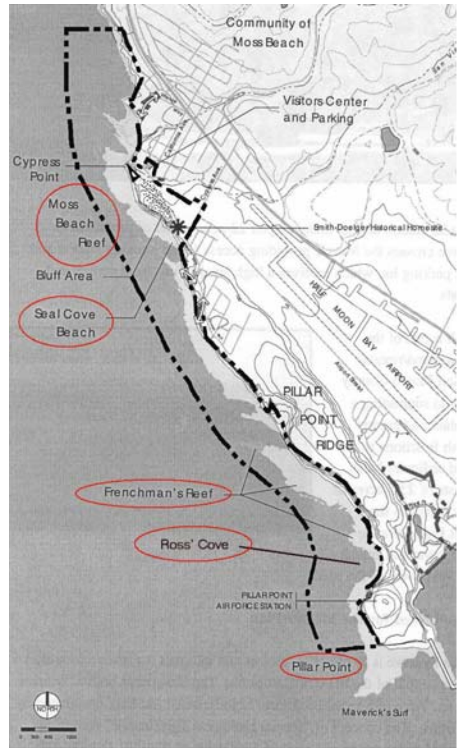


Figure 2: Map of JFMR coast line. Sample areas are circled.

Sample sites were chosen within an impact zone by degree of suitable habitat. The intertidal zone offers a plethora of diverse habitats, few of which are appropriate for the Owl limpet. Acceptable sample sites include parts of the rocky intertidal zone with mussel beds in which owl limpets like to graze, cliff faces, or rocky shore and reef areas particularly susceptible to extreme wave action (Light and Smith 1964). Due to their relative size, owl limpets can withstand harsher habitat conditions than other limpets. To determine exact dimensions of a particular site, I roped off areas with suitable habitat for owl limpets (usually a mussel bed or rock piles near the low tide line) and approximated the area of the habitat in square meters by using meter tape to make appropriate measurements with respect to the shape of the sample site. For each sample site I recorded a GPS reading using

Area/Impact	GPS Location	Sample Sites
Moss Beach - Heavy	N37°31.066' W122°31.034	3
Seal Cove Beach - Light	N37°31.874' W122°30.034	2
Ross' Cove – Light	N37°30.102' W122°29.978'	4
Fisherman’s Reef- Light	N37°30.443’ W122°29.428'	1
Pillar Point – Heavy	N37°29.654' W122°29.973'	3

Table 1: Summary of Sampled Areas

a handheld GPS unit (Etrex Personal Navigator by Garmin), counted and measured all detectable owl limpets, amount of time spent searching the area and number owl of owl limpet predators (*Asterias rubens*, common starfish) detected during search time. In order to keep my data comparable I tried to use a consistent search effort for each sample site with respect to time. By approximating the area of the sample site I was investigating I allotted an appropriate amount of searching time (minutes) to keep search effort consistent (e.g. more searching time was spent on larger sample sites) while allowing enough time to amply cover the whole area. Most search efforts approximated 2.25 minutes per meter squared. I used a dial caliper to measure shell length to the nearest millimeter at its longest axis. I did not make note of juveniles (smaller than 20mm).

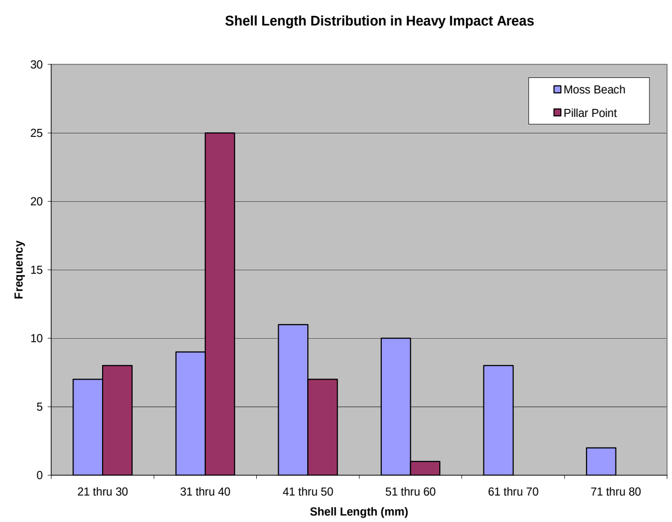
I collected most of my data during low tide at the reserve (-0.5 feet below mean sea level or lower). Typically beginning my search about two hours before low tide, this allowed the tide to have reached a low enough point to expose owl limpets and enough time to do more than one sample site for every visit.

Results

After collecting data from thirteen sample sites from all sample areas and measuring over one hundred forty two owl limpet shell lengths, I tested for a significant difference between data collected from different impact zones through analysis of variance. A single factor analysis of variance test showed that there was no significant difference between mean shell lengths from sample sites at heavily impacted areas and mean shell lengths from sample sites at lightly impacted areas ($p=0.09$). The overall mean shell length of heavily impacted sample sites was 33.68 mm; the overall mean shell length of lightly impacted sample sites was 41.44 mm. The difference cannot be deemed significant. My null hypothesis, that varying degrees of habitat impact does not affect shell length of *lottia gigantean* cannot be disproved. In my data collection I did notice a difference in the frequency of owl limpets at heavily impacted areas versus light impacted areas. Total individual count from heavily impacted areas was eighty-nine, while total count for lightly impacted areas was only fifty-three. Density of owl limpets per meter squared reveals that lightly impacted areas have a higher frequency of owl limpets than heavily impacted areas. Five hundred and twenty nine square meters of heavily impacted habitat were surveyed and a density of 0.17 owl limpets per meter squared was calculated. Only seventy three and a half square meters of lightly impacted area was sampled and showed a density of 0.72 owl limpets per meter squared.

Statistical analyses of heavily impacted areas show some interesting significant results. Mean shell length for all individuals at Moss Beach Reef was 46.85 mm while the median was 45. Mean shell length for all individuals at Pillar Point was 35.31 and median was 35.5. A single factor ANOVA for these two populations show that they are significantly different ($p<<0.05$).

Due to high frequencies of owl limpets in heavily impacted areas Moss Beach Reef and Pillar Point, I examined shell length frequency data of these two areas. Graph 1 shows the frequency of shell lengths (grouped by size category) of Moss Beach Reef data and Pillar Point data. Initial observation suggests that size frequency of Moss Beach individuals is more normally distributed than that of the population at Pillar Point; however, the Pearson's skew value for the Moss Beach distribution is larger (e.g. more skewed) at 1.74 than the skew value for the Pillar Point distribution, -0.05. These distributions could not be skew at all; it is possible that the Pillar Point distribution is leptokurtic while the Moss Beach distribution is platykurtic.



Graph 1: Frequency of shell length data from Moss Beach Reef and Pillar Point by size category.

Discussion

Shell length was not proven to vary with degree of impact on habitat. This could be due to lack of sufficient habitat in lightly impacted areas in comparison to habitat availability in heavily impacted areas. The nature of most of the habitat in lightly impacted areas was not the vast mussel beds of Moss Beach Reef and Pillar Point. Rather, there was more wave impacted rocks and sandy beaches. Nevertheless, there were some long dense mussel beds in the low tide zone within the Frenchman's Reef area. An additional possibility for a lack of significant difference in shell length data across sample areas is the confounding predator factor. It is possible that anthropogenic disturbance of habitat has more effect on the *Asterias rubens*, the common starfish (an important predator of the owl limpet) than is does on the owl limpet. If heavily impacted areas primarily restrict starfish populations, owl limpet populations should in fact grow in these areas. Although predator frequency was noted during data collection, it was not focused on, and therefore cannot be statistically analyzed. It should be noted, however, that I observed amply higher frequencies of starfish in lightly impacted areas than in heavily impacted areas. Further research should be conducted on the common starfish population at the James Fitzgerald Marine Reserve.

If, in reality, there is a skew in the distribution of the Pillar Point distribution it would be helpful to investigate why the two populations are different. I hypothesize that the presence of rangers and docents along the coast line of Moss Beach Reef has a significant impact on visitor behavior and in turn limits habitat destruction. Even though this would potentially allow for more predators to inhabit the reef, it also allows for more space for the owl limpet to grow to their full potential. Further research on the effect of ranger and docent presence and how that effects preservation of wildlife at the reserve is recommended. It is important to understand which species in the intertidal zone reveal something about the whole ecosystem in order to better monitor and protect our coastline.

Acknowledgements

I would like to thank Scott Kimura of Tenera Environmental for allowing me to work in conjunction with his biological assessment of JFMR and his assistance in study design. Thank you to Bob Breen for encouraging students to work with this project and his knowledge of the Reserve. Finally thank you to the Environmental Science department staff, especially John Latto, for their open doors, open minds and endless hours of work to help me make this research happen.

References

Barry, J.P., C.H. Baxter, R.D. Sagarin and S.E. Gilman. 1995. Climate-related, long-term faunal changes in a California rocky intertidal community. Science 267:672-675.

Brady/LSA. 2002.Fitzgerald Marine Reserve Master Plan, Part One: The Master Plan.

Breen, Bob. James Fitzgerald Marine Reserve, Head Ranger. Moss Beach, California. 2003, personal communication.

Brosnan, D.M. and L.L. Crumrine. 1994. Effects of Human Trampling on Marine Rocky Shore Communities. Journal of Experimental Marine Biology and Ecology 177:79-97.

Brown, P.J. and R.B. Taylor. 1999. Effects of trampling by humans on animals inhabiting coralline algal turf in the rocky intertidal. Journal of Experimental Marine Biology and Ecology 235:45-53.

Denny, M.W. and C.A. Blanchette. 2000. Hydrodynamics, shell shape, behavior and survivorship in the owl limpet Lottia gigantea. Journal of Experimental Biology. 203:2623-2639.

Herring, George D. Park Ranger, Cabrillo National Monument, National Park Service. The Plight of the Owl Limpet. http://www.nps.gov/cabr/tide.html, accessed April 20, 2004.

Keough, M.J. and G.P. Quinn. 1998. Effects of periodic disturbances from trampling on rocky intertidal algal beds. Ecological Applications 8:141-161.

Kido, J.S. and S.N. Murray. 2003. Variation in owl limpet Lottia gigantea population structures, growth rates, and gonadal production on southern California rocky shores. Marine Ecology-Progress Series. 257:111-124.

Light, S. F. and R.I. Smith. 1964. Intertidal invertebrates of the central California coast : S F. Light's Laboratory and field text in invertebrate zoology. University of California Press, Berkeley. 249pp.

Lindberg, D. R., J. A. Estes and K. I. Warheit. 1998. Human Influences on Trophic Cascades Along Rocky Shores. Ecological Applications 8(3):880-890.

Miller, A.W. and R.F. Ambrose. 2000. Sampling patchy distributions: comparison of sampling designs in rocky intertidal habitats. Marine Ecology-Progress Series. 196:1-14.

Parr, Ivan. 2002. Northern California Tidepools: A guide to intertidal plants and animals from Oregon to the Central Coast.

Ricketts, E. F., J.Calvin and J.W. Hedgpeth. 1985. Between Pacific Tides. 5th ed. Stanford University Press. Stanford.