

ABSTRACT

Title of Thesis: Effects of environmental variables on mole crab, *Emerita talpoida* (Say), population density along the barrier island coast of Maryland.

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The environmental variables affecting the population density of mole crabs (*Emerita talpoida*) along the barrier island coast of Maryland were examined. Physical (water and sand temperature, beach slope, sand grain size) and human impact (vehicular and pedestrian traffic and beach replenishment) parameters were measured and/or observed for twenty three months. Density differences were detected for beaches with the highest and lowest human disturbance, although no linear relationship was found. Beach replenishment and pedestrian traffic are the most effective types of human disturbance. Off Road Vehicle traffic had no visible

effect on crab density. Season had the greatest effect on crab population density. Water and sand temperature were strongly correlated with crab density. Beach slope was highly variable, and had no statistical effect. Sand grain size had no statistical effect.

DISCUSSION

Density differences are apparent between stations with high and low human impact. The original hypothesis that there would be more crabs on beaches with less disturbance was not exactly supported. The fewest crabs were found where the beach was most disturbed: at OC63 which incurred very high pedestrian traffic and underwent beach replenishment. For the most part the greatest numbers of crabs were found where the beach was least disturbed, at CWR. The station with the greatest amount of combined traffic (vehicular and pedestrian), DC1, had the second lowest total mean number of crabs. CWR's mean total was more than 300% larger than that of OC63 but only slightly less than 100% larger than that of DC1 (Table 3). These results suggest that beach replenishment is a more effective form of human-induced disturbance than traffic. Beach replenishment places offshore sand, after removal of organic material, on the beach.

During the summer months when crab density and human disturbance are both at maximum, the fewest crabs were found at stations with the highest human

disturbance. The stations with the most disturbance have higher crab densities in the Spring at 10 m and 20 m. Perhaps they then are driven out by the humans in summer. There is also some recolonization by the crabs in the Fall at the higher traffic stations.

Many studies cite high densities of *E. talpoida* on beaches subject to high wave energy (Pearse et. al., 1942; Dahl, 1953; Loesch, 1957; Diaz 1974, 1980; Leber, 1977) and (Efford, 1965; Barnes and Wenner, 1968; Ansell et. al., 1972 for *E. analoga*). Larger waves provide greater amounts of wave wash and steeper slopes, thus increasing volume and speed of water filtered. Cubitt (1969) established that higher beach slopes had higher *E. analoga* population densities. This was neither corroborated nor refuted by the present study. Beach slope was extremely variable at all stations during all seasons. OC63 most often had the largest slopes; due in part to beach replenishment, but it also had the fewest total mean number of crabs. It was thus inferred that beach replenishment reduces the mean number of crabs. Since beach replenishment filters offshore sand before placing it on the beach, organic material is lost, and there would theoretically be less for *Emerita talpoida*

to eat. Beach Slope was equally variable in seasons with and without major storm events. No correlation was observed between Slope and crab population densities. The fact that *E. analoga* is a West Coast species, and East and West coast beaches are physically different may elucidate this inconsistency. Assateague Island is a barrier island, unlike the coast of Santa Barbara to which Cubit (1969) refers, and is very narrow and flat, and is thus subject to greater fluctuations in slope.

Along all transects, the greatest crab population densities were found at SHORE (0 m), and the lowest population densities were found inland within the Off Road Vehicle Zone. Aggregations of *E. talpoida* have been found as high up the beach as 40 m from the low tide line (Diaz, 1980). However, this was not a common occurrence in the present study.

Other authors have postulated that *E. talpoida* move offshore in the winter months. Edwards and Irving (1943) first described this when they found a community several hundred yards offshore in 6 ft (1.83 m) of water. They later found crabs under 12 ft (3.7 m) of water. Williams (1965) corroborated these findings. In

the present study, crabs were found year-round on the beach, with the exception of a few observations immediately following storm events. The sampling mechanism for the present study did not allow for deep water sampling in that it was not feasible to collect crabs with a core sampler in water deeper than four feet.

Crab population densities exhibited seasonal variations, as indicated by the general linear model (Figs. 9-21). The three storm events, 1) Northeastern Storm of October 29, 1991, Season 2; 2) Northeastern Storm of January 4, 1992, Season 3; 3) Northeastern Storm of September 25, 1992, Season 6; caused major shoreline change throughout Assateague Island and Ocean City. Season is the most significant source of the variation in crab population densities.

Water and Sand Temperature vary seasonally, and it was expected that these variables would be significant in statistical analyses. It is unknown why Sand Temperature at 10 m was not significant for number of crabs at 10 m.

The other physical variables were initially expected to contribute to the variance in crab density. Since *E. talpoida* exhibit synchronous molt with the phase of the moon, a relationship between density and Moon Phase was expected. However, no relationship was evident between Moon Phase and crab density or Tide cycle and crab density.

Pedestrian Density was a significant contributor to the variance in crab density at SHORE in multiple stepwise regression. I suspect this can be attributed to the fact that the most crabs were observed at this position and it is certainly within the prevailing area of pedestrian disturbance.

Vehicular traffic did not demonstrate any statistical influence, nor was it correlated with any of the positions or transects. However, stations were initially chosen for their varying amounts of vehicular and pedestrian disturbance. The station which incurred the least traffic was found to have the highest crab densities.

Wolcott and Wolcott (1984) showed *E. talpoida* to be virtually immune to ORV damage at Cape Lookout National Seashore in North Carolina. Their study site was on the Core Banks section of Cape Lookout; a 25 km long 500 m wide barrier island with no road access to the island: all vehicles used in recreational activities were ferried across by concessionaires, and there was no marked system of crossovers between backroads and the beach. The bulk of traffic occurs in October and November (after the *E. talpoida* population density highs for the year) and fewer than 100 vehicles were ferried to and from the island per month January through September. They estimated that fewer than 5 vehicles per day drive the length of the beach from either inlet to the fish camp.

The present study site, Assateague Island, is 58 km long and an average of 800 m wide and is easily accessible by road. Assateague Island has 2.3 million visitors per year, the majority from Memorial Day through Labor Day. The National Park Service issues 7,000-8,000 ORV permits per year for recreational use, but limits the number of ORVs on the beach to 140 at a time. During peak tourism this is hard to control and

more than 140 ORVs were observed on the beach at one time (personal observation). There is a marked system of dune crossings from back road to beach in place.

Wolcott and Wolcott's (1984) estimation of vehicle use consisted of personal observations and interviews with fishermen, National Park Service and Coast Guard personnel. The present station sites along Assateague Island were chosen based on National Park Service assessments of traffic density and assumptions made on the nature of tourists driving ORVs. Estimations of vehicle use consisted of ORV counts while driving the length of the ORV Zone. Perhaps this provided only a "snapshot" of the actual use and was thus not statistically viable.

Sand grain size had no effect. The sand was not significantly different for any of the Stations or any of the Seasons. This was generally expected, as it is unlikely for the sand from the wash zone of a small barrier island to vary appreciably, although I did observe that the sand appeared coarser in winter. Additionally, I expected the sand from OC63 to be

dissimilar from the other stations since it underwent beach replenishment.

The present study was conducted during El Nino (the longest El Nino period in history: 4 years), I surmise that this at least contributed to the three major storm events and their accompanying flooding and leveling of the beaches during this study.

PROBLEMS

The only stations accessible by two-wheel drive (2WD) vehicle were NSOB, OC63, and originally (until January 1992) MCABE. Otherwise, data collection was dependent on a four-wheel drive (4WD) vehicle. A 1979 4WD Jeep Cherokee was the only research vehicle available until March 1992 when another 4WD vehicle was donated. The research vehicle was shared by 4 researchers with separate projects throughout Assateague Island National Seashore, as well as a class of students in the fall of 1991, making time when the vehicle was available for this study limited. The frequency with which it was used and the harsh effects of 4WD use in a salt and sand environment and the age of the vehicle caused it to be in the service station for repairs

often, which often thwarted data collection. Logistical impediments prevented several data collections in Winter 1992-93, and Spring 1993. The original sampling protocol was for twenty-four months. In the twenty-third month of the study one professor denied me access to my research equipment and vehicle. Urgent appeals to the University administration were of no avail. The equipment and vehicle were not returned until after the twenty-fourth month had passed; the data collection was thus terminated in the twenty-third month. While the quality of the data rests solely with me, I believe that in the absence of these hindrances the original sampling matrix could have been filled. This would have provided a more complete seasonal picture.

CONCLUSIONS

Density differences were detected for beaches with the highest and lowest human disturbance, although no linear relationship was found. Beach replenishment and pedestrian traffic are the most effectual types of human disturbance. Off Road Vehicle traffic had no visible effect on crab density.

Season was the most influential parameter in the variance of crab population density. The physical variables that vary seasonally, Water and Sand Temperature, were also significant. The storm events seem to be important factors in variance of crab population density; although the greatest changes these events effected were in slope of the beach due to dune loss and beach erosion; it still remains to be explained why beach slope did not influence crab density.

FUTURE RESEARCH IMPLICATIONS

The year-round occurrence of *E. talpoida* was established in this study. The question of whether they move offshore and if so, how far, has not been addressed. Collection methods would have to be adapted for deeper water. In depth studies of percent grain size analysis could be pursued.

MANAGEMENT IMPLICATIONS

The impact of recreational use of the beach at Assateague Island can be used to address management issues such as Off Road Vehicle regulations and

beach use by bathers. Given the results of the present study, were North/South Ocean Beach on Assateague to receive as many visitors as Ocean City, the mole crab population would decrease. This study could potentially serve as baseline data for future reference and decision making for the public use of Assateague Island National Seashore. Specifically, it could aid in the eventual decision whether or not to pump the sand that is "clogging" the Ocean City Inlet onto Assateague's north end. Widespread wildlife effects and consequences can be predicted from impacts on *Emerita talpoida* owing to their low position in the food chain. They are thus a good indicator for the health of the ecosystem.