

FISHERIES RESEARCH INSTITUTE
College of Fisheries
University of Washington
Seattle, Washington 98195

ECOLOGY OF INTERTIDAL BENCHES
OF AMCHITKA ISLAND, ALASKA

by

John F. Palmisano, Charles E. O'Clair,
and Roy E. Nakatani

FINAL SUMMARY REPORT

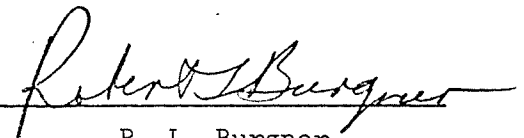
for the period August 1, 1974-December 31, 1974

Contract with

U.S. Energy Research and Development Administration
Contract AT(45-1)-2225, Task Agreement No. 36

Approved

Submitted May 23, 1975



R. L. Burgner
Director

ECOLOGY OF INTERTIDAL BENCHES
OF AMCHITKA ISLAND, ALASKA

John F. Palmisano, Charles E. O'Clair,
and Roy E. Nakatani

ABSTRACT

A comparison of western Aleutian Islands with and without sea otters shows this species to be important in determining the nearshore community at Amchitka. Sea otters control herbivorous invertebrate populations and indirectly affect wave exposure and the composition of the rocky intertidal community. Removal of sea otters causes increased herbivory and ultimately results in destruction of macrophyte (algae) associations. The observations suggest that a dense sea otter population indirectly supports island fauna associated with macrophyte primary productivity.

ECOLOGY OF INTERTIDAL BENCHES
OF AMCHITKA ISLAND, ALASKA

INTRODUCTION AND BACKGROUND

This report briefly summarizes the descriptive-comparative analysis of the ecology of the intertidal benches of Amchitka Island, Alaska, which supports sea otter populations in contrast with Attu and Shemya Islands without sea otters. This ecological work represents a more basic work which is related to the over-all mission-oriented Amchitka Research Program of Fisheries Research Institute. The practical primary mission of the Program was to assess and evaluate both the short- and long-term effects of the Milrow (October 2, 1969) and the Cannikin (November 6, 1971) underground nuclear tests on the marine environment and biota. The annual progress report for FY 1973 and the summary report, 1967 through 1973, are referenced for additional background information for the work reported here (Nakatani and Burgner, 1974).

As indicated above the main objective of this study was to compare invertebrate and algal associations from islands with (Amchitka) and without (Attu and Shemya) populations of sea otters (*Enhydra lutris*) in the western Aleutian Islands. Specifically, we considered (1) the effect of sea otter predation on size and abundance of sea urchins (*Strongylocentrotus polyacanthus*) and other prey species, (2) the effects of sea urchin grazing on kelp beds (various species of brown algae), and (3) the effect of kelp beds on community structure. We also considered the effect of sea otter predation on species richness and the stability of the communities in this area. Because of the long duration of this study (1967-1974) and the existence of technical reports, both published and in

preparation (see Appendix I), only a synopsis of our findings will be presented here.

RESULTS

Sea urchin abundance and size were found to be inversely related to sea otter abundance in the area studied. Other prey species, especially the smooth lump sucker (*Aptocyclus ventricosus*), also were rare in the presence of severe sea otter predation. Prey abundance appeared to be related to sea otter preference, capturing ability, and density, as well as to type and number of available refuges (from predation). Thus slow-moving conspicuous sea urchins were captured more readily than more motile, cryptically colored, preferred bottom fishes (i.e., greenling, *Hexagrammos lagocephalus*).

A similar inverse relationship was observed between sea urchins and extent of kelp beds. Thus, sea otter abundance and extensive kelp beds (in areas with rock bottoms) were directly related. In the absence of sea otter predation, sea urchins apparently overgrazed and destroyed kelp beds and greatly reduced the abundance of organisms associated with the high productivity of these beds. However, in the presence of sea otters, sea urchin size and densities were small, populations of these herbivores were restricted to refuges, and the kelp and associated communities flourished.

Besides providing food, habitat, and refuge for a great number of organisms, the kelp bed also modified wave exposure and thus affected the structure of rocky intertidal communities. Therefore, because of the

direct relationship between sea otter abundance and kelp bed development, the structure of rocky intertidal communities was also affected by sea otter predation. Where offshore kelp beds were extensive, intertidal exposure was reduced, sedimentation was increased, and sessile, filter feeding invertebrates (i.e., barnacles, *Balanus*; mussels, *Mytilis*) and other animals which require sediment-free rock surfaces (i.e., chitons, *Katherina*) were absent or scarce. Accordingly, organisms that relied on barnacles, mussels, and associated organisms for food (i.e., predacious sea stars *Leptasterias*, and snails, *Thais*) were small and usually less abundant here. Where these kelp beds were absent, barnacle and mussel communities were extensive and predacious sea stars and snails were of larger size and snail densities were higher.

The sea otter has a strong influence on the nearshore community of the western Aleutian Islands primarily because it indirectly controls the development of the highly productive kelp community by predation on sea urchin, which in turn is the destructive herbivore in this area. Where sea otters were abundant, sea urchin densities were low and kelp and associated communities were dominant. Where sea otter densities were absent or scarce, sea urchin abundance was high and kelp communities were absent subtidally and barnacle and mussel communities were dominant intertidally. Where present, these communities appeared to persist apparently because of (1) the dominant influence of either the sea otter or sea urchin, (2) the non-migratory habits of most community members, and (3) the restriction of migration and recolonization at island environments.

Where sea otter predation results in more three-dimensional habitats, it apparently increases species richness, but where it results in reduced primary space it apparently reduces this richness. Thus, where sea otter predation of sea urchins results in extensive kelp beds, a high species richness of fishes, invertebrates, and even certain birds and mammals associated with kelp beds will occur. However, under the same conditions, a low richness in benthic algal and invertebrate species associated with exposed, rocky intertidal areas will result. Because bald eagles, *Haliaeetus leucocephalus*, and harbor seals, *Phoca vitulina*, depend upon the highly productive kelp community for food, it is possible that their occurrence in the western Aleutian Islands is dependent upon sea otter predation which appears to be responsible for the presence of these communities.

Although there is very little supportive evidence, it seems plausible that the high nutritional demands of the sea otter may have resulted in the absence of certain prey and competitor species from the Aleutian Islands. Thus, the absence of the abalone, *Haliotis*, predacious sea stars, *Pisaster* and *Pycnopia*, and other species from these islands may be due to sea otter predation.

The recolonization of sea otters in temporarily unoccupied habitat appears to be dependent upon remoteness of the area, sea otter reproductive rate, primary productivity, and food availability. Once sea otters begin to recolonize, their densities will depend upon food abundance and quality. If prey species are not nutritional or are easily depleted, then sea otter densities will fluctuate. Although data are inconclusive, it appears that kelp communities afford more stable sea otter densities than areas lacking macrophytic primary productivity. Kelp communities

presumably support higher densities of sea otters because of the high productivity and abundance of prey. Depending upon the composition of the diet and the development of the kelp community, sea otter densities appear to be between 14 and 16 animals/km² of habitat and may even be as high as 20 to 30. This is compared to only 1.5 animals/km² of habitat in areas without macrophytic productivity such as Unimak Island (Kenyon, 1969). Sea otters tend to deplete the more accessible prey. Because the kelp community provides refuge for these prey, and also food, habitat, and refuge for more motile prey such as highly nutritional bottom fishes (i.e., greenling), sea otter food resources appear to be more stable in kelp communities than over soft bottoms. Although stable populations have not been observed in the Aleutian Islands since the sea otter began to recover from near extinction around 1911, a theoretical consideration of kelp community food resources, and observations by other investigators suggest that optimal or stable sea otter densities may be between 3 to 6 animals/km² of habitat. The value may possibly be higher as suggested by Amchitka's current density; thus the above range should be considered a tentative value until more information can be gained.

Besides benefiting in terms of food resources from the presence of kelp communities, it appears that the sea otter actually insures the continued existence of these highly productive communities. It apparently accomplishes this by continually preying upon sea urchins, which if unchecked, would eventually destroy or at least seriously diminish this community. Even though sea urchins may be small and not always nutritional, they are continually removed from the community because they are easy to capture and because younger sea otters apparently

cannot consistently capture anything else.

The relative complexity of the kelp-sea urchin-sea otter community may enable it better to withstand perturbations than the simpler kelp-sea urchin community. However, the perturbation caused by the near extinction of the sea otter was severe enough to result in an apparently unstable condition in the former system. This is suggested by the wide fluctuations in sea otter densities observed during this century in the western Aleutian Islands. Feedback mechanisms needed to restore stability invariably have time delays and if these are long compared to the natural time scale of the community, then these mechanisms can be destabilizing instead of stabilizing. Time delays in the sea otter community appear to be long (i.e., recovery time for vegetation, herbivore and sea otter populations combined) and this may account for its apparent continued instability. However, if the population fluctuations associated with this system are damped out, a relatively stable community could exist. The stabilization of sea otter food resources, which we speculate to be associated with extensive kelp communities, could eventually damp out sea otter population fluctuations and thus result in a stable community.

LITERATURE CITED

- Kenyon, K. W. 1969. The sea otter in the eastern Pacific Ocean. U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife, North American Fauna, No. 68. 352 pp.
- Nakatani, Roy E. and Robert L. Burgner. 1974. Research Program on Marine Ecology, Amchitka Island, Alaska, 1967-1973. Battelle Columbus Laboratories, BMI-171-156. 61 pp.

APPENDIX I

Published Reports

Estes, J. A. and J. F. Palmisano. 1974. Sea otters: Their role in structuring nearshore communities. Science 185:1058-1060.

Reports in Preparation

O'Clair, C. E. Ecology of intertidal invertebrates at Amchitka Island, Alaska. In proposed book on Amchitka.

O'Clair, C. E. Disturbance and rocky intertidal communities. Ph.D. Thesis, University of Washington, Seattle.

Palmisano, J. F. The role of sea otter predation in nearshore community structure. Ph.D. Thesis, University of Washington, Seattle.

Palmisano, J. F. and J. A. Estes. The impact of sea otters on nearshore community structure and dynamics at Amchitka Island, Alaska. In proposed book on Amchitka.