

Glacier Bay Affords Management Textbook Example of Interaction

Editor's Note:

The following unsolicited article was submitted to Park Science by a former participant in the University of Washington NPS/CPSU as "partial payment of the debt I owe NPS" and with the hope that it will "at the very least convey my feelings of appreciation."

By David O. Duggins

Glacier Bay National Park and Preserve (GBNPP) provides a unique opportunity to observe an ecosystem dominated by the dynamic ebb and flow of gigantic mountain and valley glaciers. Over the past 50 years, GBNPP has served as a field laboratory for scientists in such diverse disciplines as glaciology, plant ecology, and ethology. For example, early models relating to plant succession were derived in part from research along the 80 mile (200 year) path of glacial retreat. In fact it was this type of research that in the 1930's led the Ecological Society of America to lobby vehemently for the park's creation; the park's original mandate emphasizes its unique research values.

A large section of the park is, however, rarely observed by park visitors or researchers. Situated along the park's Gulf of Alaska boundary is a remote coastline, dominated by wave-swept headlands, high-energy sandy beaches, and deeply cut fjords. While physical disturbances such as violent winter storms and landslides are a common occurrence, this coastline has remained virtually untouched by man's frequently disturbing influence. This portion of GBNPP remains the only example of wave-exposed, outer coast habitat under the protection of park or preserve designation along the approximately 2000 miles between southern British Columbia and the northern Gulf of Alaska.

In the 1960s, two events occurred which led park biologists and resource managers to believe that the outer coast of GBNPP could undergo significant ecological change resulting directly from the activities of man. First was the discovery of a very large mineral deposit (nickel-copper) in the region. Under certain circumstances, mining is allowed in GBNPP; if developed, production levels from this deposit could reach 10,000 tons per day, and extend over about 30 years. In addition to potential biological impacts from the mining operation, a large community would have to be built to accommodate mine personnel and their families - all this in a remote natural area, rarely even visited by man.

The second potential human-generated disturbance event, virtually guaranteed to take place in this area, is very different in character. At the turn of the century, the northern sea otter (*Enhydra lutris*) was hunted by man to near extinction. Once common from northern Japan and the Aleutian Islands to Baja California, by the 1920s only small populations in central California and the Aleutian Islands remained. In the mid 1960s, a small number of otters (about 40) were transplanted from the Aleutians to an area just south of GBNPP. Since then, this southeast Alaskan population has grown and taken up residence within park boundaries. The elimination or re-introduction of sea otters has dramatic, wide-ranging, long-term, and predictable ramifications throughout the entire near-shore marine ecosystem. Thus, while otter reintroduc-

tion represents the "correction" of an earlier human disturbance, it will also produce major changes in the area.

Concern over these potential events led to establishment of a research program on the outer coast of GBNPP. The work involved scientists from the Universities of Alaska, Washington, Ohio, and Vermont, and included limnologists, fisheries and avian biologists, mammalogists, geologists, terrestrial plant ecologists, and marine ecologists. As a group, our goal was to gather natural history and ecological information on resident organisms in order to 1) provide a basis from which to predict potential impacts of disturbance, and 2) provide a baseline against which to evaluate changes in the various biological communities in the event that a man-made disturbance took place.

The data gathered between 1973 and 1975 were published in a series of volumes entitled *The Dixon Harbor Biological Survey* (NPS, Juneau, AK). My own work, in the area of marine ecology, has continued until the present and constituted the majority of my PhD thesis (1980, University of Washington) and subsequent published journal articles. Cooperative Park Studies Units at the Universities of Alaska and Washington played a major role in the project.

My research was designed to address several questions relating to the communities of plants and

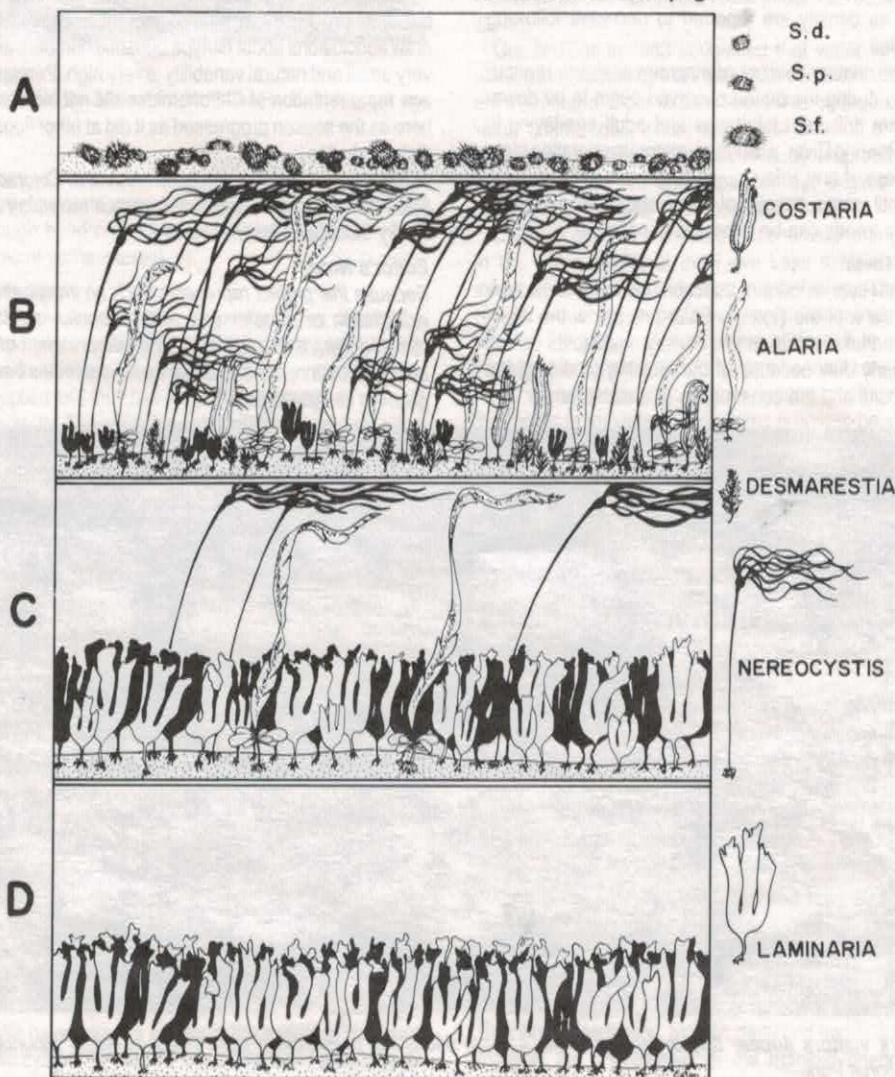
animals found in the intertidal and shallow subtidal zones along wave-swept, rocky shorelines. I was particularly interested in 1) the biological factors determining the species assemblages observed, 2) the types and frequency of natural disturbance (biological and physical) in these communities, and 3) the response of the communities to disturbance.

The rationale behind this type of ecological approach is as follows. If we know how communities are organized biologically (for example, how predator-prey or competitive interactions produce the community's patterns of distribution and abundance), then we may be able to predict how disturbance at some level in that organization will affect the community as a whole.

The methods we used to determine community structure are relatively straightforward and surprisingly powerful. On a very small scale, we (the scientists) create disturbances in a well-controlled manner and observe the community's response. We may remove or add a species or group of species, or we may remove all species and observe whether the community returns to its original configuration and how long it takes to do so. While time doesn't allow the manipulation of all possible species within a community, existing ecological literature and theory make predictions as to which organisms are likely to be most important, and this is where we begin.

For example, in the study area along GBNPP's western boundary, giant seaweeds (up to 130 feet long) called kelps are a common component of near-

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shore communities (down to a depth of about 50 feet below the 0 tidal datum). These kelps are grazed by a number of herbivores, the most conspicuous of which are the sea urchins. Sea urchins are, in turn, preyed upon by a species of very large (up to 3 feet in diameter) starfish. How do sea urchins affect seaweed biomass, species diversity, and distribution? How important are the seaweeds to the primary productivity of the community? By performing experiments in which these components of the community were manipulated, these questions were answered.

I learned that sea urchins essentially control the distribution and abundance of kelps. Normally, large urchin populations consume virtually all benthic algae. In the absence of urchins, kelp biomass (and hence productivity) reaches very high values (as high a productivity as has been measured in any system, terrestrial or marine). When sea urchins are removed for long periods of time, kelp species diversity drops to very low values as a single species of kelp outcompetes all the others – producing monospecific stands of plants. Starfish seem to have their major effect on urchin populations not so much by direct predation but by moving urchins around in space. When starfish abundance becomes high at a given site, urchins will leave the area and kelps will flourish (at least temporarily).

It is well known that sea urchins are a favorite food of the sea otter. Based on results like those above, we would predict that areas with a large population of sea otters would have few sea urchins and consequently would have dense kelp beds composed of a few competitively superior species. This is exactly what I found when I visited the area south of GBNPP where sea otters were originally transplanted. The reappearance of sea otters caused the growth of giant kelp beds, leading to greatly increased benthic primary productivity. This productivity can be utilized by higher trophic levels both directly (by grazers) and indirectly (by pelagic zooplankton, when the kelp has degraded to particulate detritus). Furthermore, kelp beds are thought to serve as important habitats for pelagic organisms such as fish and shrimp by providing habitat heterogeneity and shelter from predators.

Knowing what we now know about sea otter, sea urchin, and kelp interactions, we are in a good position to make strong predictions about the consequences of removing sea otters from communities where they are established. Inasmuch as otters are particularly sensitive to certain types of disturbance (such as oil spills – there are no fat layers under their skin, so when their pelts become soiled, they cannot thermoregulate), and since they will play such an important role in GBNPP's marine ecosystem, they probably represent the single most important marine species for resource managers to monitor.

Using these same types of techniques, many questions regarding the structure or organization of different benthic marine communities in the study area have been addressed. I learned, for instance, that the intertidal appears to be much less structured by the types of biological interactions so important in subtidal kelp beds and as a result, the response to disturbance in the intertidal zone seems much less predictable. Furthermore, following a disturbance, the intertidal community seems to take much longer to return to its original configuration. This may have to do with infrequent and variable recruitment of juvenile organisms and high year to year variation in reproductive success. Thus, were a large-scale disturbance to take place along GBNPP's outer coast, it would probably take many years for the area to return to its pre-disturbance appearance.

Mapping Barrier Island Vegetation

By Beau McCaffray

Barrier islands are some of the earth's most dynamic landforms; consequently, maps of the coastal barriers can become abruptly antiquated. Barrier island mapping techniques must accommodate the natural forces that constantly shape these coastal barriers. A mapping technique sensitive to the dynamics of coastal barriers has been developed at North Carolina State University's (NCSU) School of Forest Resources for Ocracoke Island, Cape Hatteras National Seashore (CHNS). Two features of this technique, the use of computer mapping and the available NCDOT aerial photography, combined, provide the capability to update and reproduce barrier island maps frequently and inexpensively.

First, by using a computer, island map data may be easily stored, retrieved and changed. In addition, different scales and a wide variety of data, such as fire history and wildlife nesting locations, can be added easily to the base data and graphically portrayed on a map. Perhaps the greatest benefit of using computer maps is that they are inexpensive to reproduce at multiple scales, shading configurations and overlays.

Second, by using NCDOT aerial photographs, a resource base becomes available on a frequently updated and inexpensive basis. The Department frequently takes aerial photos of its roads and highways. When severe weather events threaten or damage highways on barrier islands, the NCDOT takes aerial photos of the area to assess road status and to develop and analyze alternatives to correct problems. The low altitude/large scale photography preferred by Department professionals is inexpensive and useful

In addition to doing experiments on the organization of marine communities, we have attempted to gather a long-term set of baseline data. It is only with such background data that park resource managers will be able to determine if the marine communities are changing over time. Since most communities vary to some extent from place to place and time to time, this type of data must be gathered at the same locations and over as long a period as possible, in order to distinguish normal ecological variation from ecological response to some hypothetical disturbance. In the future, we hope to train Park Service personnel in the gathering of these data.

The structure and organization of rocky intertidal and subtidal communities along this section of coastline is now well enough understood that we can begin to make reasonable predictions regarding community response to certain types of disturbance. The NPS has made our research possible with its financial and logistical support. We hope that the results of our efforts will help park managers address future environmental problems which might arise along this pristine and dramatically beautiful coastline.

Duggins has a post-doctoral appointment at the University of Washington and is on the permanent staff at the Friday Harbor Lab.

for interpreting vegetation communities, making NCDOT photography ideal for inexpensive diagnosis of changes in vegetation and other features wrought by storms, road rerouting and other events.

For the Ocracoke vegetation map, Physiognomic - floristic vegetation zones were: defined with the assistance of Kent Turner (CHNS) and E.D. Seneca (NCSU Botany Dept.), identified (interpreted) on 1:12000 black and white aerial photographs, and then delineated on acetate overlays. Using a Bausch and Lomb stereo zoom transfer scope, the vegetation zones were transferred onto the base maps, USGS 7.5 minute topo sheets covering Ocracoke Island. The 1:24,000 vegetation map of NPS land displays 140 zones of 11 different vegetation communities for a total of 5,118 acres. The minimum mapping area was .19 acre. The State Plan Coordinate System frames the map; fire occurrence can be precisely located. A separate map report also is produced by the computer, which sequentially numbers each zone as it is plotted, giving the acreage and vegetation type of each zone. These sequence numbers also are printed in each zone on the map itself for easy reference to the map report.

A sampling procedure was developed to test photo-interpretation accuracy by stratifying all data into boundary and interior vegetation. These two strata were created based on their assumed differing levels of difficulty of classification. That is, boundary points, by virtue of their close proximity to differently identified zones, were considered harder to identify correctly than interior points. Additionally, the vegetative successional nature of many boundary areas could contribute to interpretation error, especially when the photos are more than a few years old. Interior points were considered to be less difficult to identify since these areas' texture, shading and patterns were often uniform for some distance. Sampling results revealed the overall photointerpretation accuracy to be 76%. As expected, boundary points were more difficult to correctly identify (67% accuracy rate) than were interior points (90% accuracy rate).

This mapping system provides a flexible capability to inventory data needed to manage some of the most dynamic landforms on earth.

McCaffray is a research assistant working under the direction of Prof. Hugh A. Devine, Recreation Resource Administration, North Carolina University School of Forestry.

Ruckelshaus on Science

William D. Ruckelshaus, administrator of the U.S. Environmental Protection Agency, appeared in a recent issue of *Renewable Resources Journal* (5410 Grosvenor Lane, Bethesda, MD 20814), as author of "Science, Risk and Public Policy."

"I believe," he wrote, "that part of the solution to our distress lies with the idea of science. We will not recover our equilibrium without a concerted effort to more effectively engage the scientific community."