Effects of Visitors on a Marine Environment

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Public schools for many years have instructed their students through various forms of conservation education. Yet a recent writer has felt compelled to ask: "How do we develop an ecological conscience in America? Through education, but why haven't we done so? Why aren't children taught to respect all living things?" (Donald Jackson, 1969: "Threatened America," *Life* 67 [5]: 32–43.)

The present report deals with (i) man-caused damage to the marine intertidal reefs, as exemplified by Duxbury Reef, in Marin County, California; and (ii) the effectiveness of conservation education in reducing this sort of damage.

The Problem

Most of the intertidal reefs in or near cities have been visited by the general public and by students. As a consequence, remarkable changes in the distribution of marine organisms have been noticed by ecologists. The complaint of conservationists is that these marine habitats are being stripped of their marine life.

Much of the criticism aimed at school collectors is justified. University biology teachers take their students out to collect organisms for classification. Many of these students, upon graduation, become teachers in elementary and secondary schools. They, in turn, teach their students to collect. The following advice appeared in a national publication: "Students should

Fig. 1. Two members of the general public digging into the soft shale of Duxbury Reef for clams.

Fig. 2. Dozens of school children on Duxbury Reef during the period of conservation education.

make field trips to the seashore whenever possible to study and make collections. Several low-priced pocket field guides are available to assist in identification." (E. Winslow and A. B. Bigler, 1969: "A New Perspective on Recreational Use of the Ocean," *Undersea Technology* 10 [7]: 51–55.) There appears to be an insatiable appetite among biology teachers for exhorting their students to collect and identify specimens and to make a teaching collection for the classroom:

> Time allocation is . . . flexible . . . especially on days following field trips, when sorting, keying and preservation of specimens must be done. Students are expected to learn both the common and scientific names of the flora and fauna they investigate. All specimens must be correctly identified before they are catalogued and placed in the teaching collection. (R. B. Linsky, 1967: "Marine Biology—a Summer Enrichment Course," *Science Teacher* 34 [6]: 1–2.)

Duxbury Reef Research

The effects of collecting and hunting marine organisms for specimens and gourmet foods are evident in the following brief summary of the major findings in my study of people in a marine environment.

Duxbury Reef, in Marin County, was chosen as the intertidal urban study site because it is conveniently divided into three natural parts, which I labeled *A*, *B*, and *C* for research purposes. *A* is easily accessible to visitors; *B* is moderately accessible; and *C* is rather difficult to visit. The numbers of marine organisms in *C* are stable, but the numbers in *A* and *B* are declining under the influence of people.

Although the history of what school groups have removed from the reef was tabulated, the heart of the research was conducted during a 10-week period in the summer, when the reef receives the most visitors.

The first five weeks (30 May through 3 July 1969) were the control period—a time when people did as they pleased on the reef without the influence of conservation education (fig. 1). The second five weeks (4 July through 7 August) were the treatment period—a time when conservation education in the form of lectures, tours, signs, and handouts was provided at the reef to all visitors.

All activities of the visitors were recorded by observers, and five ecologic transects were measured in each of parts *A*, *B*, and *C* to determine if the collecting behavior of people would significantly alter the distribution of marine life. Physical measurements of oxygen, salinity, and temperature were recorded to see if these parameters had any influence on the distribution of marine organisms.

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Findings

The five major findings were as follows:

1. The ranges in oxygen, salinity, and temperature remained relatively constant; these factors, then, were not significant in affecting any change in the density of marine organisms. Sections of *C* showed continual stability in density of marine organisms; thus, it is unlikely that DDT and other hydrocarbons have had any effect on the density of marine organisms on Duxbury Reef.

2. The sampling data of past years (1961–69) showed a steady increase of school visitors to the reef, along with an increase in the total amounts of marine life collected. Of the 4,278 visitors in the 10-week period in 1969, at least 83% came from Marin County and the San Francisco Bay towns. The ratio of school visitors to general visitors for each sample remained essentially the same. The control period showed 2,538 visitors; of these, almost 59% were engaged in collecting activities. In the treatment period there were 1,740 visitors, and only 21.6% were collectors.

3. In both the control and the treatment period, there were more school collectors than general collectors; however, the general collectors removed a higher percentage of animals. For example, in the control period the percentage of animals collected by school visitors was 15.3%; by the general public, 84.7%. The general public gathered far more animals that were edible (clams and snails); this accounted for the large percentage difference. School collectors took small samples of each organism available.

At least 11,000 organisms were collected in the control period and only 894 in the treatment period. The average number of organisms collected dropped from 15 animals per collector in the control period to 4 animals per collector in the treatment period. Conservation education was very effective in reducing the numbers of animals removed from the reef.

4. The research on the distribution of marine organisms showed that the number of sessile animals had been reduced by collecting and that the population of mobile animals (mostly snails) fluctuated as they moved in and out of the transects. About 71% of all organisms collected were taken from part *A* (most easily accessible part of the reef), 25% from *B*, and 4% from *C* (least accessible). Overall, during the period of conservation education there was stability in the density of marine life; during the control period, instability.

5. The use of marine conservation education with school groups was highly effective in the treatment period. The behavior of the students improved: they collected fewer animals; they replaced animals picked up; they turned rocks back over; they did not tear up seaweed; and they walked carefully on the reef (fig. 2). The percentage of school visitors who collected decreased from 65.1% in the control period to 19.4% in the treatment period. During the control period students who collected averaged 4.5 animals; in the treatment period, with conservation education, the average was reduced to 2.1 animals.

Conclusions

The collecting of marine life on Duxbury Reef and, by implication, on reefs elsewhere will eventually produce a desolate environment unless conservation and marine refuge policies are enacted. This study clearly demonstrated that marine conservation education does reduce the intensity of collecting. Therefore, there must be an acceleration of conservation education in our schools—elementary school through university—and in the public media to alert people to the fact that their unrestrained collecting habits will cause irreversible damage to reefs and other places abundant in natural resources.

Phosphorus Reserves Dwindling

A report prepared by the Institute of Ecology for the 1972 U.N. Conference on the Human Environment indicates that if the current trends continue, all known reserves of phosphorus will have been used up in 60 years by a world population that will have grown to 11 billion. It also observes that world food production could support only 2 billion people if phosphate fertilizers were not available.