Reshaping The Seas:

The ecotechnology of artificial reefs

Imagine rich seagrass meadows blooming from former oceanic deserts, producing countless tons of fish for hungry island nations. Envision undersea corrals packed with finny herds, fenced in by arrays of sonar and laser beams. Picture yourself diving through towering canyons teeming with fish and lobsters, where just months ago the sea floor lay barren. Wishful fantasies? Not at all. These are just some of the possibilities offered by artificial reef technology - the engineering of inner space.

Cities for fish rather than people. Artificial reefs come in all shapes and sizes and colors, some so bizarre that author Ray Bradbury recently called them "fascinating — pure science fiction." No longer relegated to the world of fantasy, artificial reefs are blossoming from the sea floor in every part of the world and are playing an increasing role in a variety of multi-billion dollar industries, including sport diving, commercial and recreational fishing, and conservation.

The idea is by no means new. The deliberate placement of structures in the sea for purposes of improving fishing success is at least several thousand years old. The first man-made reefs were undoubtedly little more than piles of brush, bamboo, or rocks pushed into the shallow waters of some long-forgotten shoreline. Such simple tools remain even today as time-tested aids to fishing in many remote parts of the world. And from these humble beginnings, a complex new scientific discipline has emerged, combining some of the sophisticated elements of ecology, resource management, engineering, and fisheries biology.

By loose definition, artificial reefs are structures placed by man in the aquatic environment, generally for the purpose of enhancing or managing living resources. By convention, structures actually resting on the sea floor are termed reefs, while those suspended at the surface or in midwater are termed fish aggregating devices, or FADs.

Structures in use today in various parts of the world range from small crude devices fashioned from local natural materials to multi-story, highly sophisticated works of steel, concrete, and plastics. The most common structures deployed in US waters are relatively modest in size and composed of "recycled" material – concrete rubble from demolished roads and bridges, bundles of old automobile tires, ships that have seen better days, and pi1es of quarry rock.

Reefs have been built in all oceans and both hemispheres, from the shore-line out to the margins of the continental shelves. FADs deployed far from shore form lonely fish oases in the vastness of the open sea. Artificial reefs adorn warm clear waters bordering lazy tropical islands, as well as icy half-frozen seas of polar regions. And the deployment of these structures is increasing at an ever-accelerating pace.

Why is there so much interest in artificial reefs? The answer lies in the enormous ecological, aesthetic, and economic value of marine life. Fisheries often form major components, if not the foundations of the food supplies and economies of island and coastal nations. Many of these nations are also becoming increasingly dependent upon lucrative tourist industries, derived in part from the high quality of ocean sports such as scuba diving and sport fishing - activities readily enhanced through the use of artificial reefs.

Although the economic value of artificial reef programs is inherently difficult to accurately measure, attempted assessments of direct and indirect benefits have indicated that they may be quite substantial. Dr. Wally Milon, a University of Florida economist, recently estimated that the existing artificial reef system of Dade County, Florida, may be worth over $100 million.

As one might expect, the development of a technology with such broad-scale environmental and economic impacts has not been without growing pains. One of the most serious and justifiable criticisms being leveled is that our scientific understanding of artificial reef function is far from complete and has been surprisingly slow to develop. Scientists tend to put the blame for the paucity of basic research on the extremely limited funding available for such purposes until very recently. In particular, scientists point out that during the last thirty years millions of dollars have been spent on reef deployment, while a comparative trifle was allocated for basic research on the "hows" and "whys" of artificial reef function, or on monitoring programs designed to assess the impacts and results of these efforts.

What have scientists really learned about the functioning of artificial reefs? While it is clear that in time they become inhabited by fish, there has been a great deal of disagreement on just what these new residents represent. Are they the result of an actual increase in fish production, or are they instead individuals from other nearby habitats who have simply relocated to a new "home," with no real gain to the population? This so-called "production vs. aggregation" controversy was hotly debated for years, and sometimes resulted in misguided views of artificial reefs. While some have portrayed them as a sort of magical cornucopia spewing forth boundless riches of seafood, others have characterized them as underwater pied pipers, luring hapless fishes away from their safe natural homes to wanton destruction at the hands of man.

Most reef scientists today agree that neither of these extreme views is accurate. Decades of research have documented the fact that artificial reefs have the capacity of both increase fish production and/or act as aggregators, depending on the specific situation. In most cases, they probably do a bit of both. Thus, the focus of scientific attention today is on understanding how reefs will function with regard to particular applications, and in tailoring reef design to meet particular objectives.

To understand how artificial reefs might function to actually increase production, we might begin by asking why the world is not already ten feet deep in tunas or aardvarks or bacteria. These creatures certainly have the capacity to produce enough offspring to achieve that end, and in relatively short order. Fortunately, however, all creatures are subject to certain constraints in their environments that serve to restrict population sizes. Such restrictions most commonly take the form of shortages of vital resources – water, nutrients, living space, etc. This relationship between population size and availability of a critical resource is the key to artificial reef function. If the deployment of an artificial reef provides additional "new" shelter (or food) for species that were formerly "limited" by these factors, lasting population increases may result. It follows that to be most effective at providing more fish of a desired type, artificial reefs should be designed to maximize the amount of otherwise "limiting" resources provided.

Unfortunately, such biological considerations have usually been considered secondarily if al all in most reef-building efforts. The early history of artificial reef programs in many parts of the world, including the US, has instead been characterized more by an emphases on rapid and inexpensive waste disposal than on a well-planned and environmentally sound approach to habitat enhancement. Here in the US, research and development on reefs has been left to the private sector, and until recently, industry was reluctant to invest in th technology. Early US reef-building efforts most commonly consisted of the sinking of loosely bound mountains of used automobile tires or piles of used cars and the like. Not surprisingly, many of these poorly conceived structures are no longer functioning as intended. Early tire reefs have proven particularly vulnerable. As a result, hundreds of thousands of loose tires are now scattered over thousands of square miles of the sea floor, with unknown effects. To make matters worse, their undersea life expectancy is measured in hundreds of years.

Despite such debacles, the emphasis in American reef design remains even today on waste conversion. This historical trend appears destined to continue under increasing pressure from coastal areas suffocating under growing mountains of urban refuse. The ability to incorporate waste materials into the structure of artificial reefs in a manner demonstrably compatible with a healthy marine environment is therefore a major goal of modern reef scientists and engineers. Research continues on the possible uses of such problem waste as ash residue from power generating stations and the processed remains of automobile tires as structural building materials for reefs.

Unfortunately, promising efforts of this type have sometimes suffered from the negative image of artificial reefs, created to a large extent by poorly conceived publicity stunts designed to draw attention to local reef—building programs. The carnival—like atmosphere that surrounded the recent dumping of a Rolls—Royce and piles of discarded computer discs into Florida's coastal waters has done little to foster a public image of reef—building as serious scientific business.

The current shift towards properly engineered and optimally designed (from the stand point of fish production) structures was led by the Japanese three decades ago. That country is still the acknowledged leader in reef design. With an annual program budget that has exceeded sixty million dollars per annum for nearly fifteen years. The vast majority of Japanese reefs are designed with a single purpose in mind — to enhance commercial fisheries. Despite the substantial financial investment the Japanese program represents, verification of its effectiveness in terms of commercial landing has been slow in coming. The magnitude of the Japanese program is in no small part attributable to the fact that it has been largely government funded.

Like all technologies, artificial reefs are not magic — they are simply tools that may be used constructively or destructively, and the possibility of misuse is cause for legitimate concern. One major worry has been pollution. The sustained action of sea water on materials not properly designed or treated for permanent deployment in the sea may result in the release of toxic by—products which might then become concentrated in resident sea life.

Another problem with artificial reefs relates to their structural integrity after prolonged submersion or under adverse sea conditions. Hard experience has taught us that reefs not properly designed or anchored to the sea floor may break up and become little more than flattened garbage heaps at best; at worst their broken parts are transformed into destructive juggernauts, leaving trails of devastation across the sea floor.

The use of artificial reefs is also rapidly becoming a major environmental issue. Those who view conversion into artificial reefs as a quick—fix for monumental waste problems are being countered by more cautious voices. Environmentalists point out that it would he a mistake to engage in massive environmental manipulation without a clear understanding of the threat these actions might pose for sensitive coastal environments.

Such decisions must not be made lightly, for once deployed in the sea, reefs become extremely costly to remove, if removal is feasible at all. This point is emphatically illustrated by the present dilemma over the ultimate disposal of obsolete oil platforms. The cost of complete removal of North Sea platforms alone was recently estimated to exceed seven billion dollars! Fortunately, these structures may in some cases be readily productively converted into fishing and diving reefs. Today, converted rigs are annually providing many thousands of coastal residents and visitors to the northern Gulf of Mexico with high—quality sport fishing and sport diving opportunities where none existed before.

Along with environmental concerns. artificial reef technology

brings with it a share of new social, political, and economic considerations. Do reefs "belong" to those who deploy them? Who has a right to the marine life around an artificial reef? Such questions have been fiercely contested in Florida during the last ten years. Almost all of Florida's reefs have been built for recreational purposes most often under the sponsorship of recreational groups or coastal county economic development programs. The use of commercial fishing gear and technologies has been restricted or prohibited on these structures because it is not compatible with recreational uses. When reefs have been deployed in areas traditionally used for commercial fishing, obvious conflicts have resulted. Florida's commercial fisherman vigorously (but unsuccessfully) opposed use restrictions as unacceptable infringements on their traditional livelihoods.

Despite such problems, the future of artificial reefs appears bright indeed. As Dr. Makoto Nakamura of Tokyo University stated recently. 'Aquatic habitat enhancement will represent one of the key technologies of the twenty-first century - this is because two of the most pressing problems man will face in the next hundred years are increasing the food supply and protecting the environment"

Artificial reef technology will unquestionably play an increasing role in marine conservation and in the mitigation of damage to aquatic environments. A forty—million—dollar project recently initiated by Southern California Edison will utilize a 300-acre artificial reef to assist in the restoration of marine resources presumably damaged or lost as a result of heated discharges from a nuclear generating station. In other conservation applications, artificial reefs will he used to minimize damage to sensitive coral reefs by providing alternate fishing grounds and sport diving opportunities. The US National Marine Sanctuary Program recently sank two out-dated Coast Guard cutters off the intensely used coral reefs of the Florida Keys with just such intent.

Invisible though they might be from your car or hotel window, artificial reefs are nonetheless emerging as a key technology in coastal resource management for the twenty-first century. They hold the promise of more food for a hungry world, better protection of fragile natural habitats, and nearly limitless recreational opportunities. Hidden well below the waves, they are the vanguard of a quiet revolution that will in one way or another touch us all.

By Bill Alevizon

William Alevizon. (Ph.D., Marine Ecology and Ichthyology**,** University of California at Santa Barbara, 1973).
Research Associate in Coral Conservation, Osborn Laboratories of Marine Sciences, New York Aquarium/Wildlife Conservation Society.

Dr. William Alevizon is a marine biologist specializing in the ecology and behavior of Florida/Caribbean coral reef fishes and marine conservation. He has conducted extensive scientific investigations in these areas since 1973, and has authored or co-authored two popular books and numerous scientific papers and technical reports on these subjects. From 1975-1990 Dr. Alevizon served as a Professor of Marine Biology at the Florida Institute of Technology (Melbourne), and from 1994-1998 as a Visiting Professor and Research Associate in Geography at the University of California at Berkeley, where he taught graduate and undergraduate courses on the oceans and marine conservation.

Dr. Alevizon has served as principal marine ecologist (consultant) in marine protected area planning and management for a number of Caribbean nations, including the Bahamas, Antigua, B.W.I., the Dominican Republic, Honduras, and Nicaragua. He has also served on marine resource management advisory panels for the U.S. National Research Council, the U.S. National Marine Sanctuary Program (NOAA), and the Florida and California Sea Grant programs.

Dr. Alevizon is a NAUI Dive Instructor, and in 1994 received NAUI's Outstanding Service Award for his role in developing three new NAUI marine conservation/ecology certification programs.

He currently serves as Scientific Advisor for The Marine Safety Group, Inc. (Deerfield Beach), a south Florida non-profit environmental organization.